NebulaGraph Database Manual

v3.5.0

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1. Welcome to NebulaGraph 3.5.0 Documentation

Note

This manual is revised on 2023-5-30, with GitHub commit 806647bf88.

Compatibility

In the version of NebulaGraph 3.2, the vertex without tags is allowed. But since NebulaGraph 3.3.0, the vertex without tags is not supported by default.

NebulaGraph is a distributed, scalable, and lightning-fast graph database. It is the optimal solution in the world capable of hosting graphs with dozens of billions of vertices (nodes) and trillions of edges (relationships) with millisecond latency.

1.1 Getting started

- Learning path & Get NebulaGraph Certifications
- What is Nebula Graph
- Quick start
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1.4 Symbols used in this manual

Note

Additional information or operation-related notes.

Caution

Cautions that need strict observation. If not, systematic breakdown, data loss, and security issues may happen.

Danger

Operations that may cause danger. If not observed, systematic breakdown, data loss, and security issues will happen.

Performance

Operations that merit attention as for performance enhancement.

Faq

Frequently asked questions.

Compatibility

The compatibility notes between nGQL and openCypher, or between the current version of nGQL and its prior ones.

Enterpriseonly

Differences between the NebulaGraph Community and Enterprise editions.

1.5 Modify errors

This NebulaGraph manual is written in the Markdown language. Users can click the pencil sign on the upper right side of each document title and modify errors.

Last update: January 6, 2023

2. Introduction

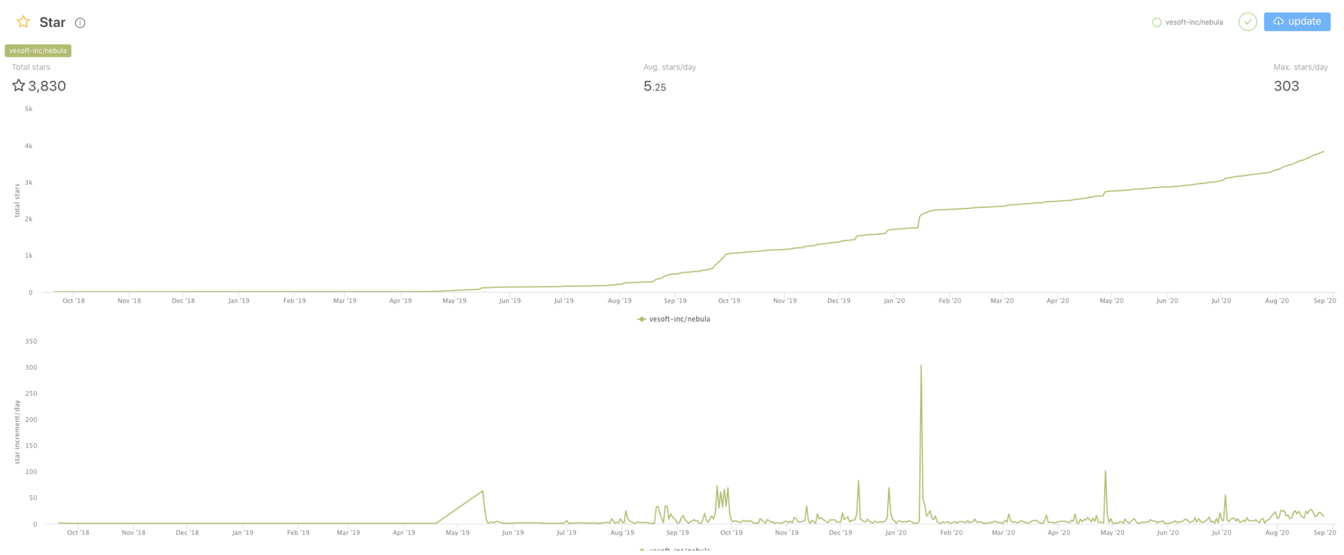
2.1 An introduction to graphs

People from tech giants (such as Amazon and Facebook) to small research teams are devoting significant resources to exploring the potential of graph databases to solve data relationships problems. What exactly is a graph database? What can it do? Where does it fit in the database landscape? To answer these questions, we first need to understand graphs.

Graphs are one of the main areas of research in computer science. Graphs can efficiently solve many of the problems that exist today. This topic will start with graphs and explain the advantages of graph databases and their great potential in modern application development, and then describe the differences between distributed graph databases and several other types of databases.

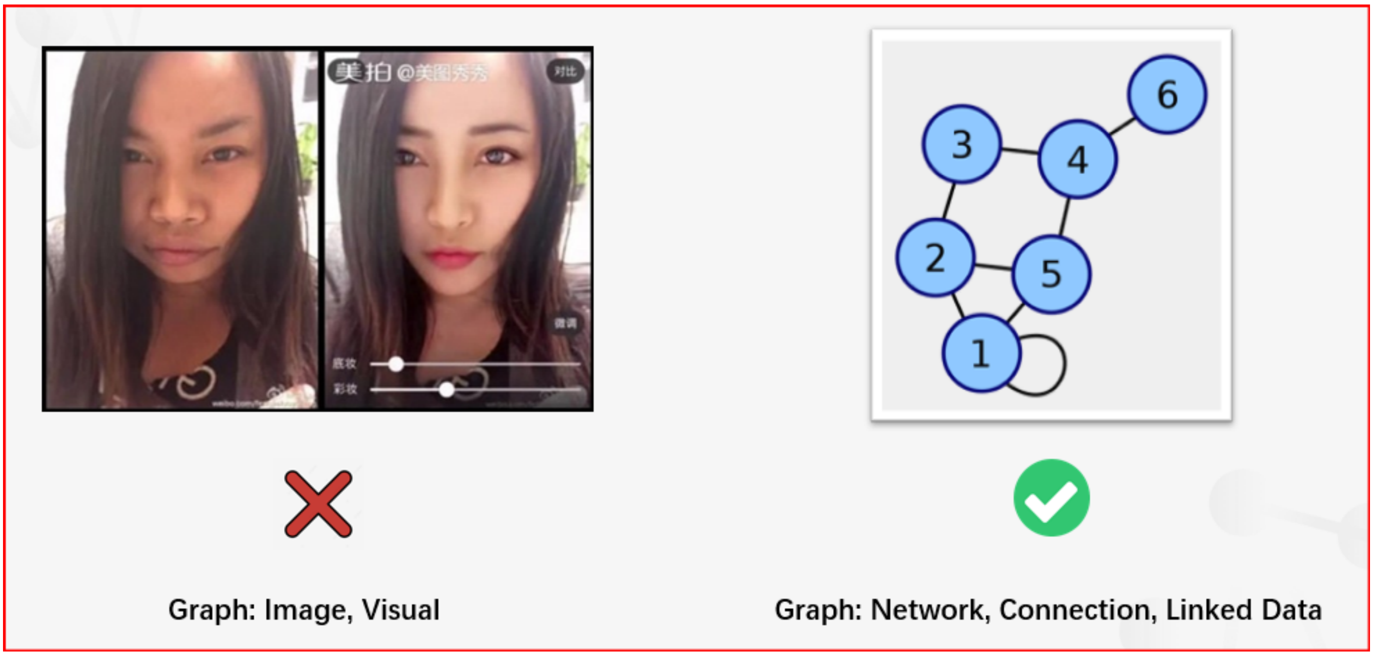
2.1.1 What are graphs?

Graphs are everywhere. When hearing the word graph, many people think of bar charts or line charts, because sometimes we call them graphs, which show the connections between two or more data systems. The simplest example is the following picture, which shows the number of NebulaGraph GitHub repository stars over time.



This type of diagram is often called a line chart. As you can see, the number of starts rises over time. A line chart can show data changes over time (depending on the scale settings). Here we have given only examples of line charts. There are various graphs, such as pie charts, bar charts, etc.

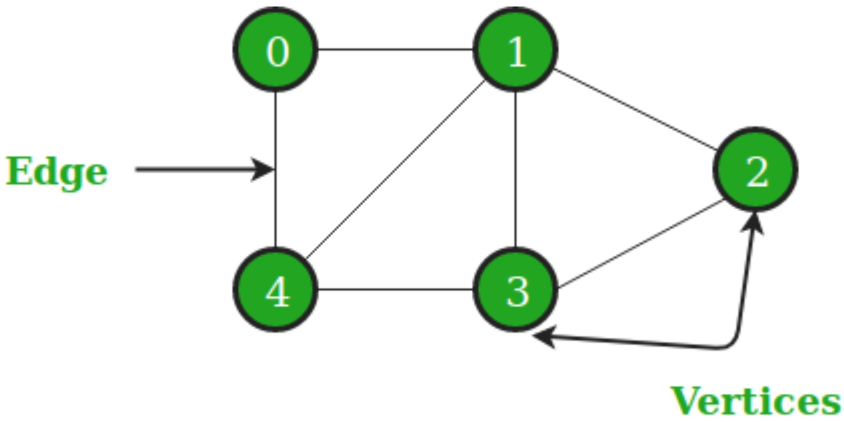
Another kind of diagram is often used in daily conversation, such as image recognition, retouched photos. This type of diagram is called a picture/photo/image.



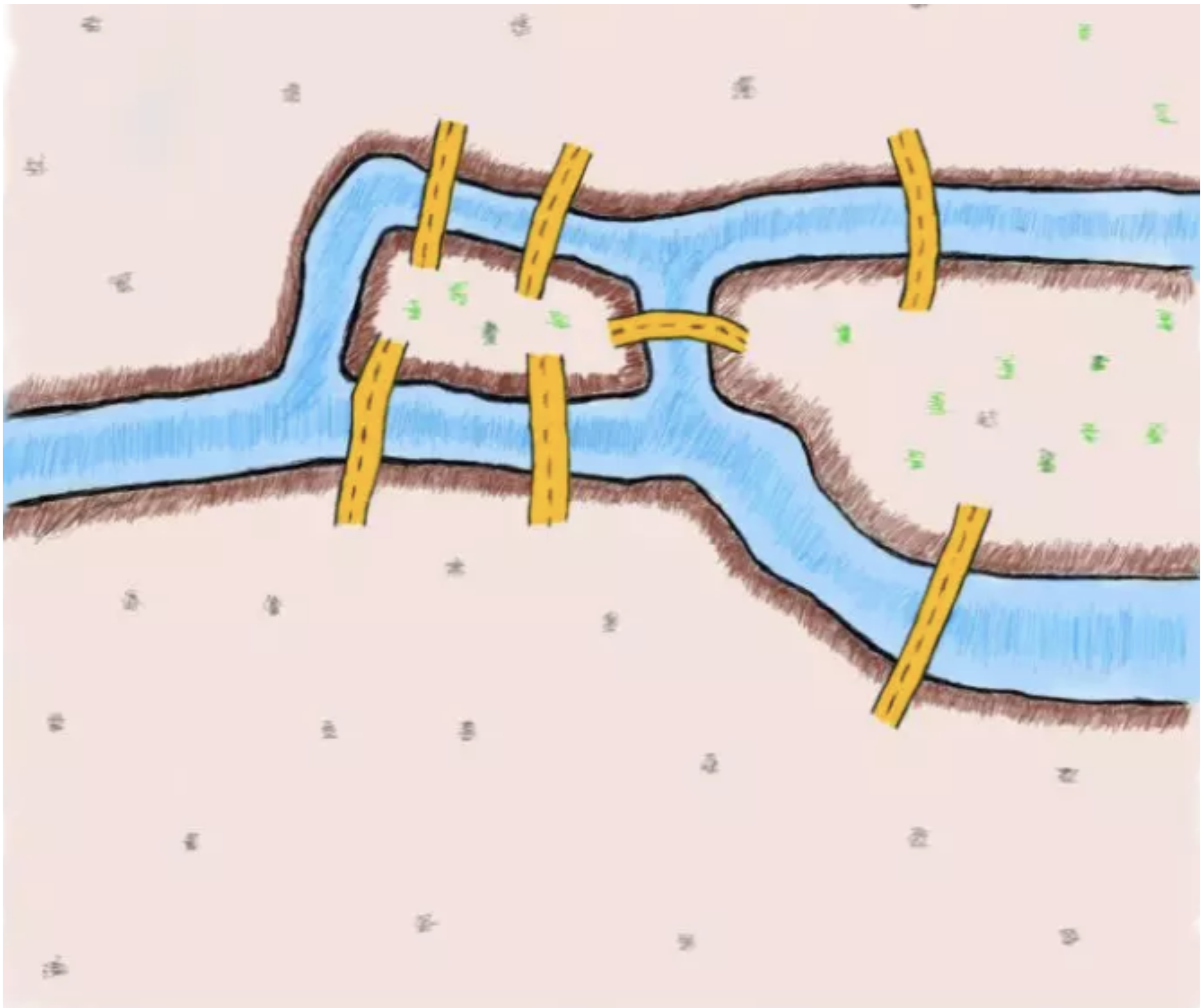
The diagram we discuss in this topic is a different concept, the graph in graph theory.

In graph theory, a branch of mathematics, graphs are used to represent the relationships between entities. A graph consists of several small dots (called vertices or nodes) and lines or curves (called edges) that connect these dots. The term graph was proposed by Sylvester in 1878.

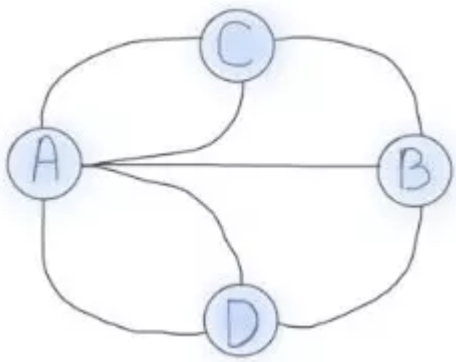
The following picture is what this topic calls a graph.



Simply put, graph theory is the study of graphs. Graph theory began in the early 18th century with the problem of the Seven Bridges of Königsberg. Königsberg was then a Prussian city (now part of Russia, renamed Kaliningrad). The river Preger crossed Königsberg and not only divided Königsberg into two parts, but also formed two small islands in the middle of the river. This divided the city into four areas, each connected by seven bridges. There was a game associated with Königsberg at the time, namely how to cross each bridge only once and navigate the entire four areas of the city. A simplified view of the seven bridges is shown below. Try to find the answer to this game if you are interested [1].



To solve this problem, the great mathematician Euler proved that the problem was unsolvable by abstracting the four regions of the city into points and the seven bridges connecting the city into edges connecting the points. The simplified abstract diagram is as follows [2].



The four dots in the picture represent the four regions of Königsberg, and the lines between the dots represent the seven bridges connecting the four regions. It is easy to see that the area connected by the even-numbered bridges can be easily passed because different routes can be chosen to come and go. The areas connected by the odd-numbered bridges can only be used as starting or endings points because the same route can only be taken once. The number of edges associated with a node is called the node degree. Now it can be shown that the Königsberg problem can only be solved if two nodes have odd degrees and the other nodes have even degrees, i.e., two regions must have an even number of bridges and the remaining regions have an odd number of bridges. However, as we know from the above picture, there is no even number of bridges in any region of Königsberg, so this puzzle is unsolvable.

2.1.2 Property graphs

From a mathematical point of view, graph theory studies the relationships between modeled objects. However, it is common to extend the underlying graph model. The extended graphs are called the **attribute graph model**. A property graph usually consists of the following components.

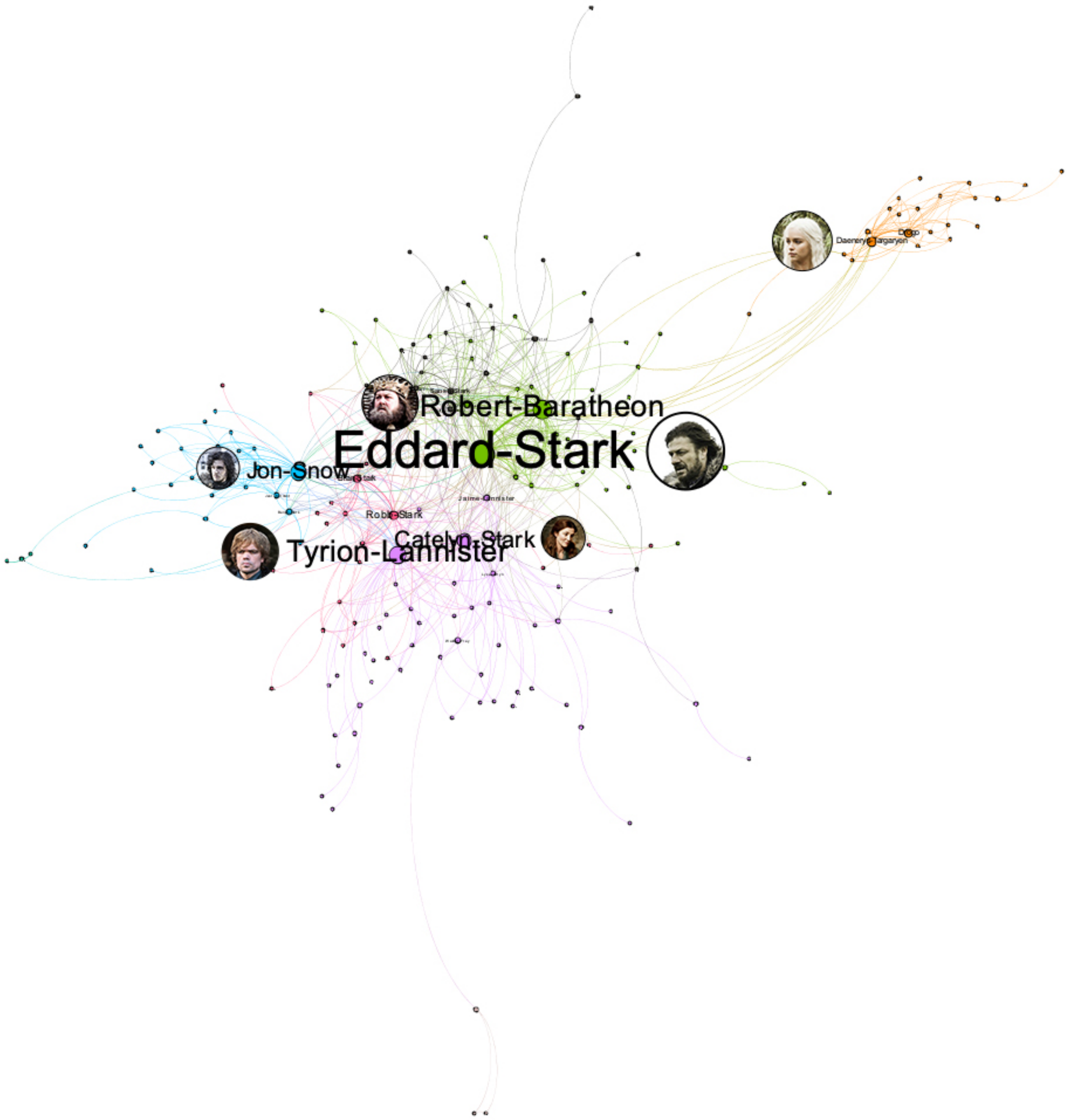
- Node, an object or entity. In this topic, nodes are called vertices.
- Relationship between nodes. In this topic, relationships are called edges. Usually, the edges can be directed or undirected to indicate a relationship between two entities.
- There can be properties on nodes and edges.

In real life, there are many examples of property graphs.

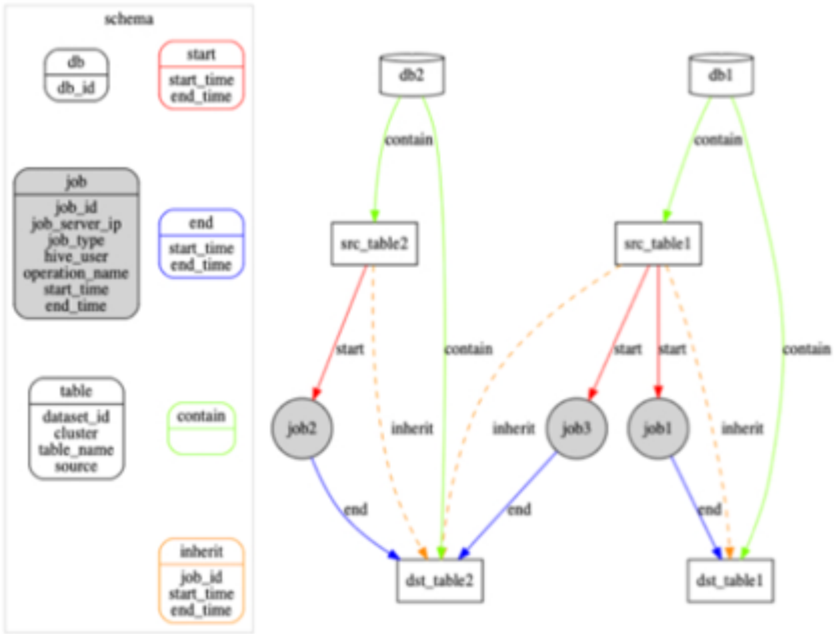
For example, Qichacha or BOSS Zhipin use graphs to model business equity relationships. A vertex usually represents a natural person or a business, and the edge represents the equity relationship between a person and a business. The properties on vertices can be the name, age, ID number, etc. of the natural person. The properties on edges can be the investment amount, investment time, position such as director and supervisor.

A vertex can be a listed company and an edge can be a correlation between listed companies. The vertex property can be a stock code, abbreviation, market capitalization, sector, etc. The edge property can be the time-series correlation coefficient of the stock price [3].

The graph relationship can also be similar to the character relationship in a TV series like Game of Thrones [4]. Vertices stand for the characters. Edges represent the interactions between the characters. Vertex properties are the character's names, ages, camps, etc., and edge properties are the number of interactions between two characters.



Graphs are also used for governance within IT systems. For example, a company like WeBank has a very large data warehouse and corresponding data warehouse management tools. These management tools record the ETL relationships between the Hive tables in the data warehouse through Job implementation [5]. Such ETL relationships can be very easily presented and managed in the form of graphs, and the root cause can be easily traced when problems arise.



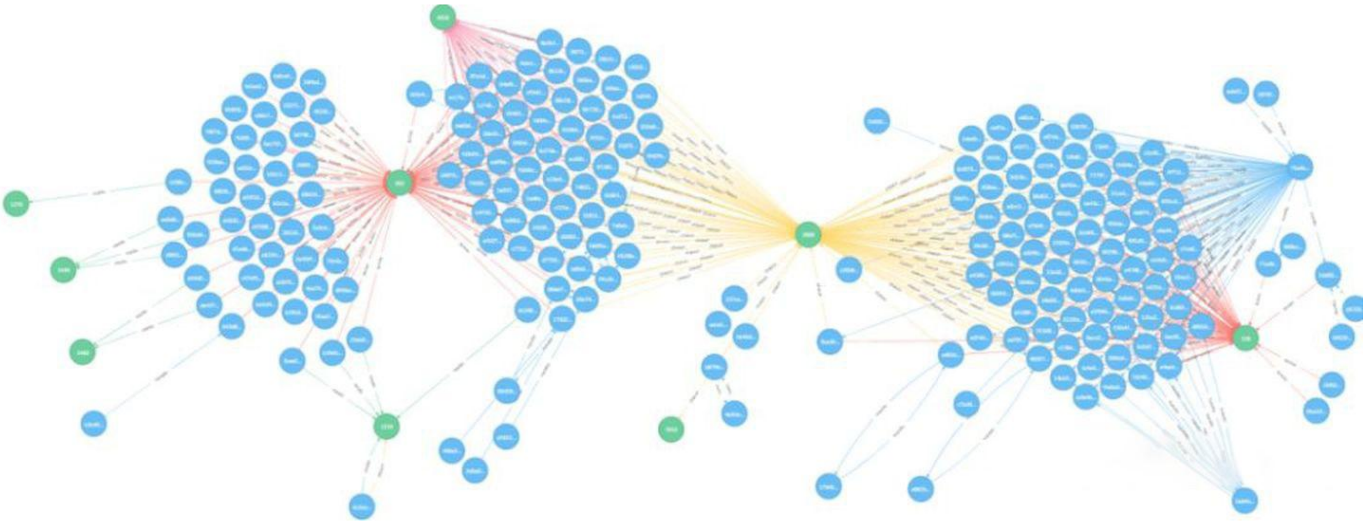
Graphs can also be used to document the invocation relationships between the intricate microservices within a large IT system [6], which is used by operations teams for service governance. Here each point represents a microservice and the edge represents the invocation relationship between two microservices; thus, Ops can easily find invocation links with availability below a threshold (99.99%) or discover microservice nodes that would be particularly affected by a failure.

Graphs are also used to record the invocation relationships between the intricate microservices [6]. Each vertex represents a microservice and an edge represents the invocation relationship between two microservices. This allows Ops to easily find call links with availability below a threshold (99.99%), or to discover microservice nodes where a failure would have a particularly large impact.

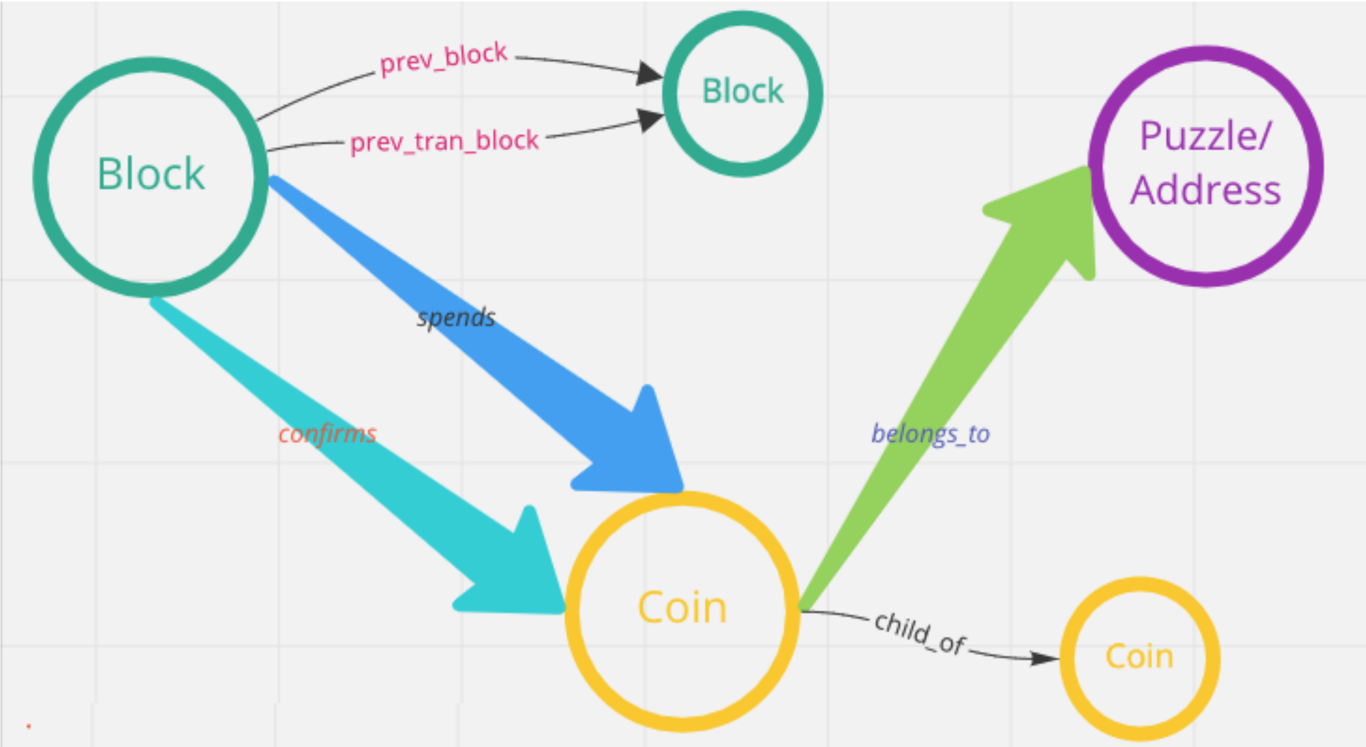
Graphs can also be used to improve the efficiency of code development. Graphs store function call relationships between codes [6] to improve the efficiency of reviewing and testing the code. In such a graph, each vertex is a function or variable, each edge is a call relationship between functions or variables. When there is a new code commit, one can more easily see other interfaces that may be affected, which helps testers better assess potential go-live risks.

In addition, we can discover more scenarios by adding some temporal information as opposed to a static property graph that does not change.

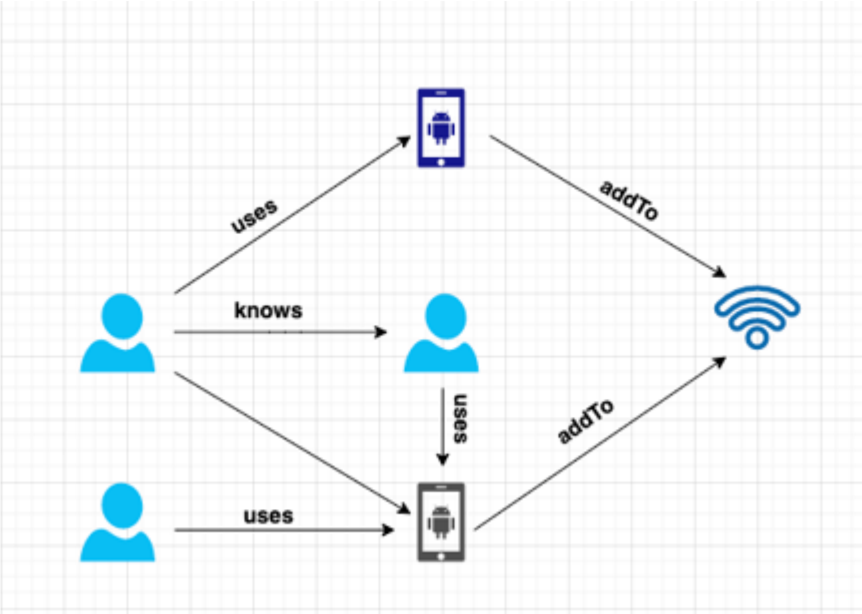
For example, inside a network of interbank account fund flows [7], a vertex is an account, an edge is the transfer record between accounts. Edge properties record the time, amount, etc. of the transfer. Companies can use graph technology to easily explore the graph to discover obvious misappropriation of funds, paying back a load to with the loan, loan gang scams, and other phenomena.



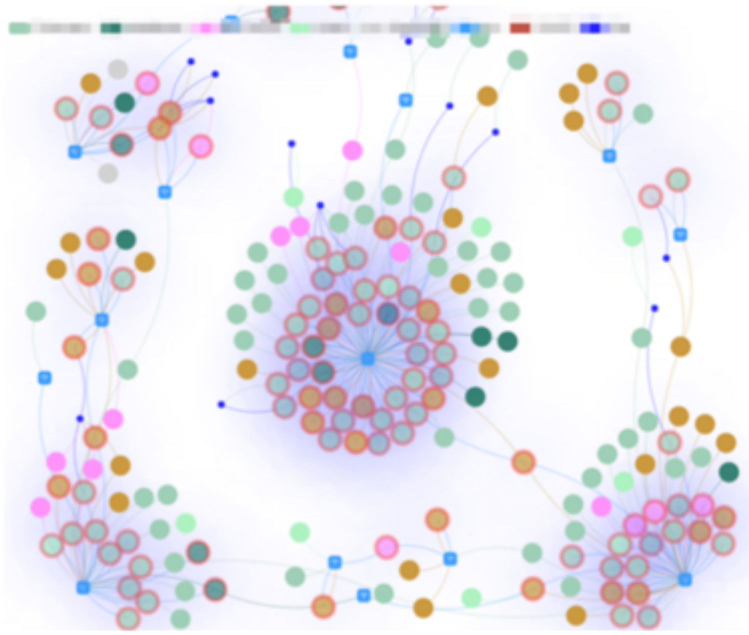
The same approach can be used to explore the discovery of the flow of cryptocurrencies.



In a network of accounts and devices [8], vertices can be accounts, mobile devices, and WIFI networks, edges are the login relationships between these accounts and mobile devices, and the access relationships between mobile devices and WIFI networks.

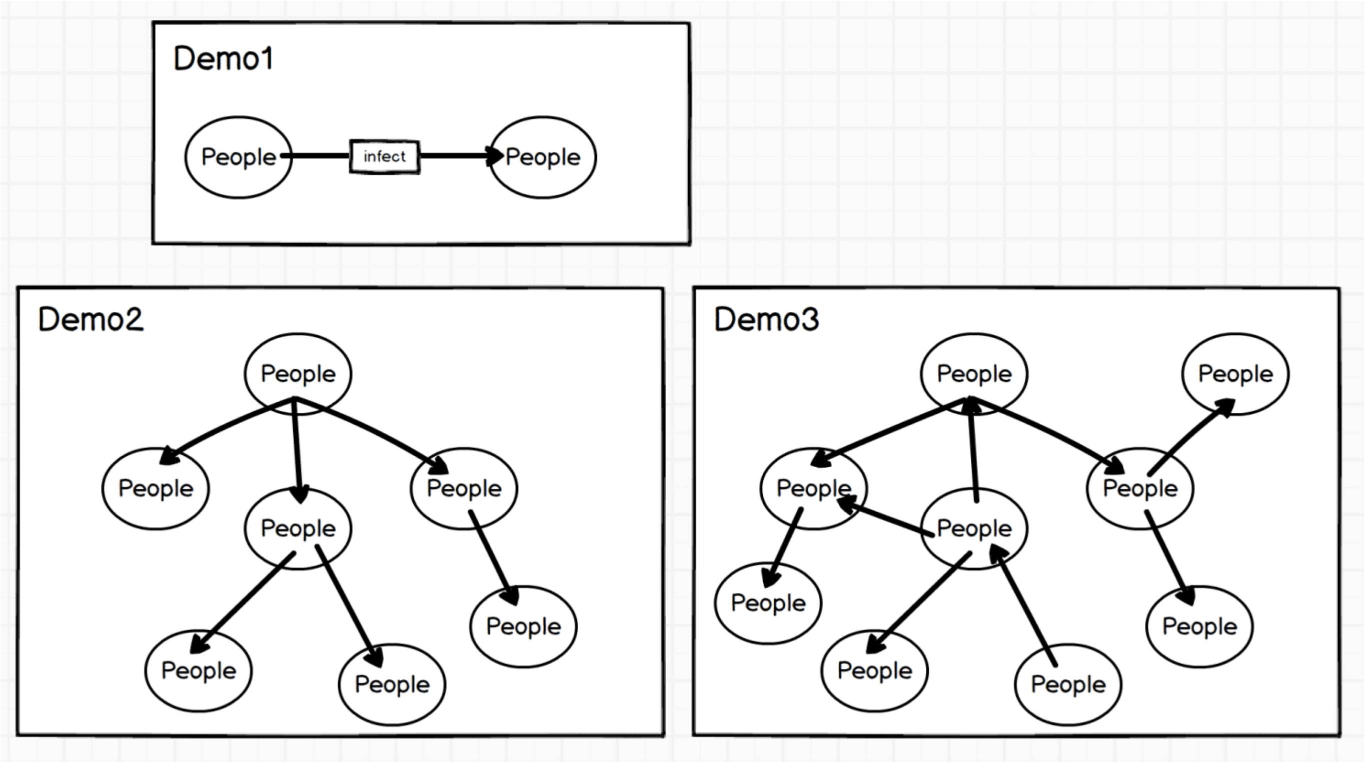


These graph data records the characteristic of the network black production operations. Some big companies such as 360 DigiTech[8], Kuaishou[9], WeChat[10], Zhihu[11], and Ctrip Finance all identified over a million crime groups through technology.



In addition to the dimension of time, you can find more scenarios for property graphs by adding some geographic location information.

For an example of tracing the source of the Coronavirus Disease (COVID-19) [12], vertices are the person and edges are the contact between people. Vertex properties are the information of the person's ID card and onset time, and edge properties are the time and geographical location of the close contact between people, etc. It provides help for health prevention departments to quickly identify high-risk people and their behavioral trajectories.



The combination of geographic location and graph is also used in some O2O scenarios, such as real-time food recommendation based on POI (Point-of-Interest) [13], which enables local life service platform companies like Meituan to recommend more suitable businesses in real-time when consumers open the APP.

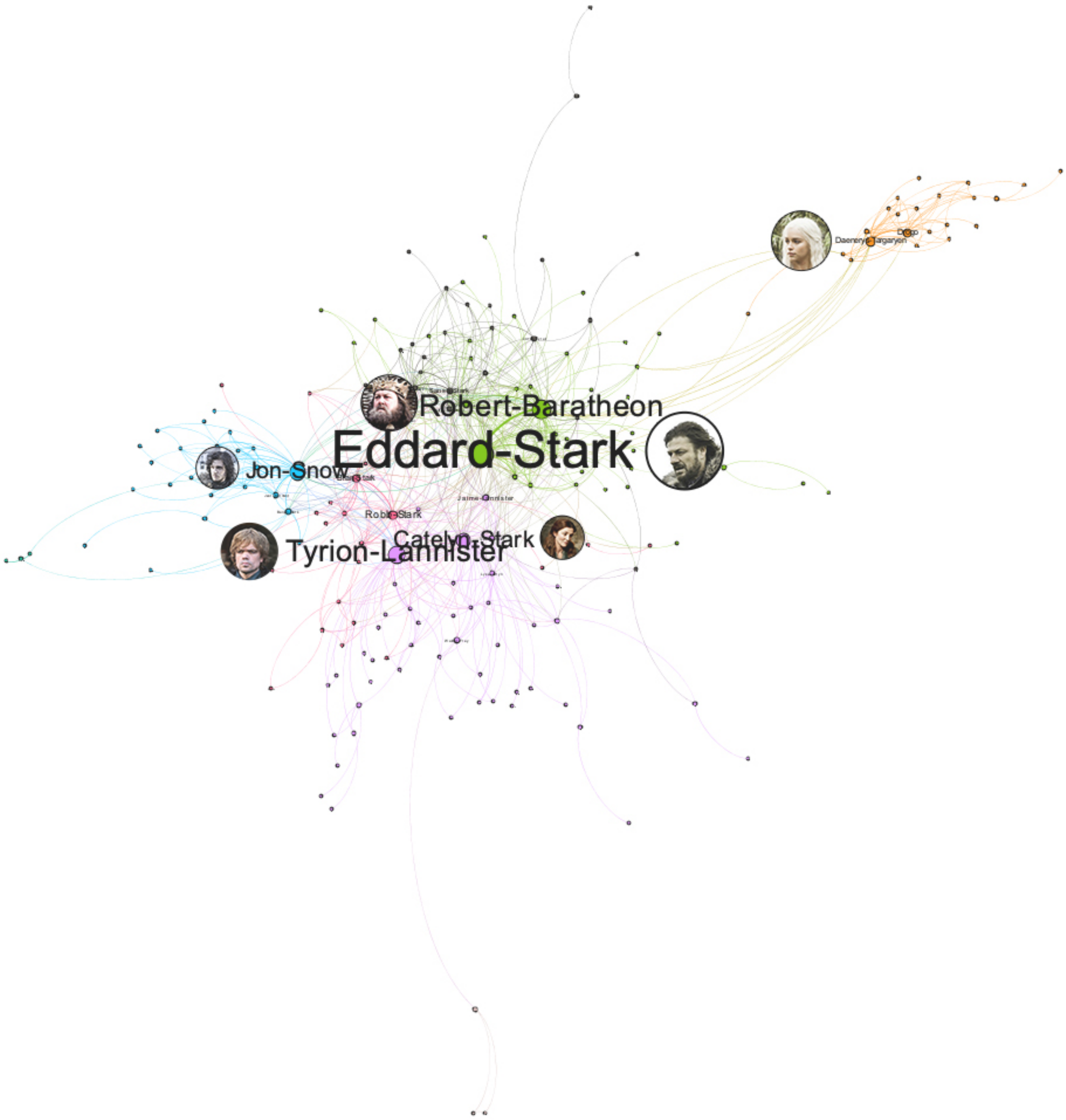
A graph is also used for knowledge inference. Huawei, Vivo, OPPO, WeChat, Meituan, and other companies use graphs for the representation of the underlying knowledge relationships.

2.1.3 Why do we use graph databases?

Although relational databases and semi-structured databases such as XML/JSON can be used to describe a graph-structured data model, a graph (database) not only describes the graph structure and stores data itself but also focuses on handling the associative relationships between the data. Specifically, graph databases have several advantages:

- Graphs are a more visual and intuitive way of representing knowledge to human brains. This allows us to focus on the business problem itself rather than how to describe the problem as a particular structure of the database (e.g., a table structure).

- It is easier to show the characteristic of the data in graphs. Such as transfer paths and nearby communities. To analyze the relationships of characters and character importance in Game of Thrones, data displayed with tables is not as intuitive as with graphs.

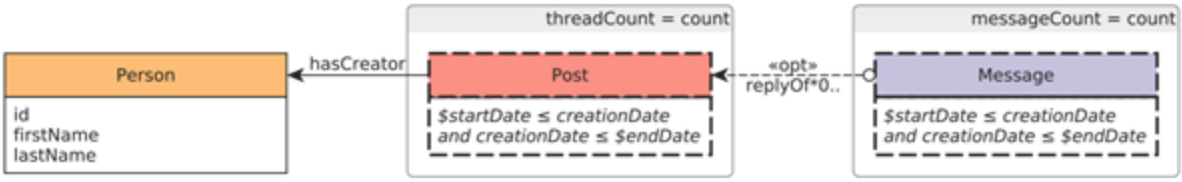


Especially when some central vertices are deleted:

Adding an edge can completely change the entire topology.

We can intuitively sense the importance of minor changes in graphs rather than in tables.

- Graph query language is designed based on graph structures. The following is a query example in LDBC. Requirements: Query the posts posted by a person, and query the corresponding replies (the replies themselves will also be replied multiple times). Since the posting time and reply time both meet certain conditions, you can sort the results according to the number of replies.



Write querying statements using PostgreSQL:

```
--PostgreSQL
WITH RECURSIVE post_all(psa_threadid
                      , psa_thread_creatorid, psa_messageid
                      , psa_creationdate, psa_messagetype
                       ) AS (
    SELECT m_messageid AS psa_threadid
         , m_creatorid AS psa_thread_creatorid
         , m_messageid AS psa_messageid
         , m_creationdate, 'Post'
      FROM message
     WHERE 1=1 AND m_c_replyof IS NULL -- post, not comment
       AND m_creationdate BETWEEN :startDate AND :endDate
  UNION ALL
    SELECT psa.psa_threadid AS psa_threadid
         , psa.psa_thread_creatorid AS psa_thread_creatorid
         , m_messageid, m_creationdate, 'Comment'
      FROM message p, post_all psa
     WHERE 1=1 AND p.m_c_replyof = psa.psa_messageid
     AND m_creationdate BETWEEN :startDate AND :endDate
)
SELECT p.p_personid AS "person.id"
     , p.p_firstname AS "person.firstName"
     , p.p_lastname AS "person.lastName"
     , count(DISTINCT psa.psa_threadid) AS threadCount
END) AS messageCount
     , count(DISTINCT psa.psa_messageid) AS messageCount
  FROM person p left join post_all psa on (
       1=1   AND p.p_personid = psa.psa_thread_creatorid
   AND psa_creationdate BETWEEN :startDate AND :endDate
   )
 GROUP BY p.p_personid, p.p_firstname, p.p_lastname
 ORDER BY messageCount DESC, p.p_personid
 LIMIT 100;
```

Write querying statements using Cypher designed especially for graphs:

```
--Cypher
MATCH (person:Person)<-[:HAS_CREATOR]-(post:Post)<-[:REPLY_OF*0..]-(reply:Message)
WHERE post.creationDate >= $startDate AND post.creationDate <= $endDate
  AND reply.creationDate >= $startDate AND reply.creationDate <= $endDate
RETURN
  person.id, person.firstName, person.lastName, count(DISTINCT post) AS threadCount,
  count(DISTINCT reply) AS messageCount
ORDER BY
  messageCount DESC, person.id ASC
LIMIT 100
```

- Graph traversal (corresponding to Join in SQL) is much more efficient because the storage and query engines are designed specifically for the structure of the graph.

- Graph databases have a wide range of application scenarios. Examples include data integration (knowledge graph), personalized recommendations, fraud, and threat detection, risk analysis, and compliance, identity (and control) verification, IT infrastructure management, supply chain, and logistics, social network research, etc.

- According to the literature [14], the fields that use graph technology are (from the greatest to least): information technology (IT), research in academia, finance, laboratories in industry, government, healthcare, defense, pharmaceuticals, retail, and e-commerce, transportation, telecommunications, and insurance.

- In 2019, according to Gartner's questionnaire research, 27% of customers (500 groups) are using graph databases and 20% have plans to use them.

2.1.4 RDF

This topic does not discuss the RDF data model due to space limitations.

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1. Souce of the picture: https://medium.freecodecamp.org/i-dont-understand-graph-theory-1c96572a1401. ↩
2. Source of the picture: https://medium.freecodecamp.org/i-dont-understand-graph-theory-1c96572a1401 ↩
3. https://nebula-graph.com.cn/posts/stock-interrelation-analysis-jgrapht-nebula-graph/ ↩
4. https://nebula-graph.com.cn/posts/game-of-thrones-relationship-networkx-gephi-nebula-graph/ ↩
5. https://nebula-graph.com.cn/posts/practicing-nebula-graph-webank/ ↩
6. https://nebula-graph.com.cn/posts/meituan-graph-database-platform-practice/ ↩↩↩
7. https://zhuanlan.zhihu.com/p/90635957 ↩
8. https://nebula-graph.com.cn/posts/graph-database-data-connections-insight/ ↩↩
9. https://nebula-graph.com.cn/posts/kuaishou-security-intelligence-platform-with-nebula-graph/ ↩
10. https://nebula-graph.com.cn/posts/nebula-graph-for-social-networking/ ↩
11. https://mp.weixin.qq.com/s/K2QinpR5Rplw1teHpHtf4w ↩
12. https://nebula-graph.com.cn/posts/detect-corona-virus-spreading-with-graph-database/ ↩
13. https://nebula-graph.com.cn/posts/meituan-graph-database-platform-practice/ ↩
14. https://arxiv.org/abs/1709.03188 ↩

Last update: August 11, 2022

2.2 Market overview of graph databases

Now that we have discussed what a graph is, let's move on to further understanding graph databases developed based on graph theory and the property graph model.

Different graph databases may differ slightly in terms of terminology, but in the end, they all talk about vertices, edges, and properties. As for more advanced features such as labels, indexes, constraints, TTL, long tasks, stored procedures, and UDFs, these advanced features will vary significantly from one graph database to another.

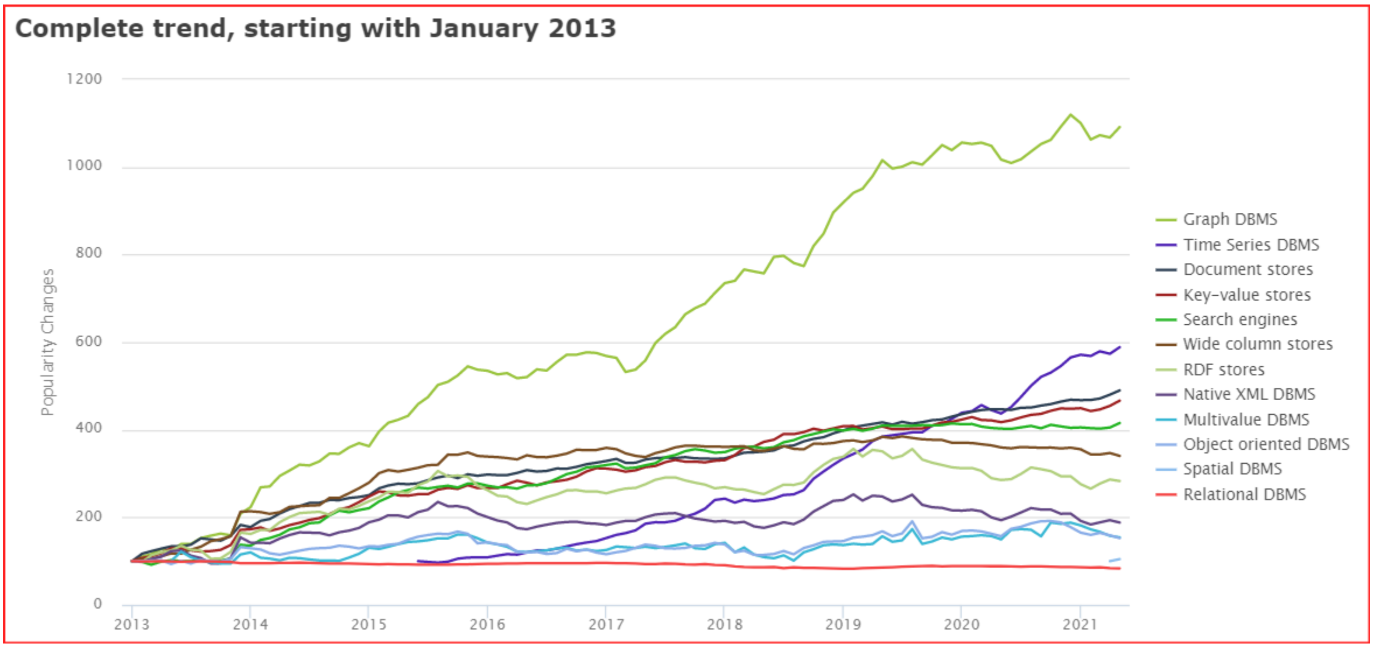
Graph databases use graphs to store data, and the graph structure is one of the structures that are closest to high flexibility and high performance. A graph database is a storage engine specifically designed to store and retrieve large information, which efficiently stores data as vertices and edges and allows high-performance retrieval and querying of these vertex-edge structures. We can also add properties to these vertices and edges.

2.2.1 Third-party services market predictions

DB-Engines ranking

According to DB-Engines.com, the world's leading database ranking site, graph databases have been the fastest growing database category since 2013 [1].

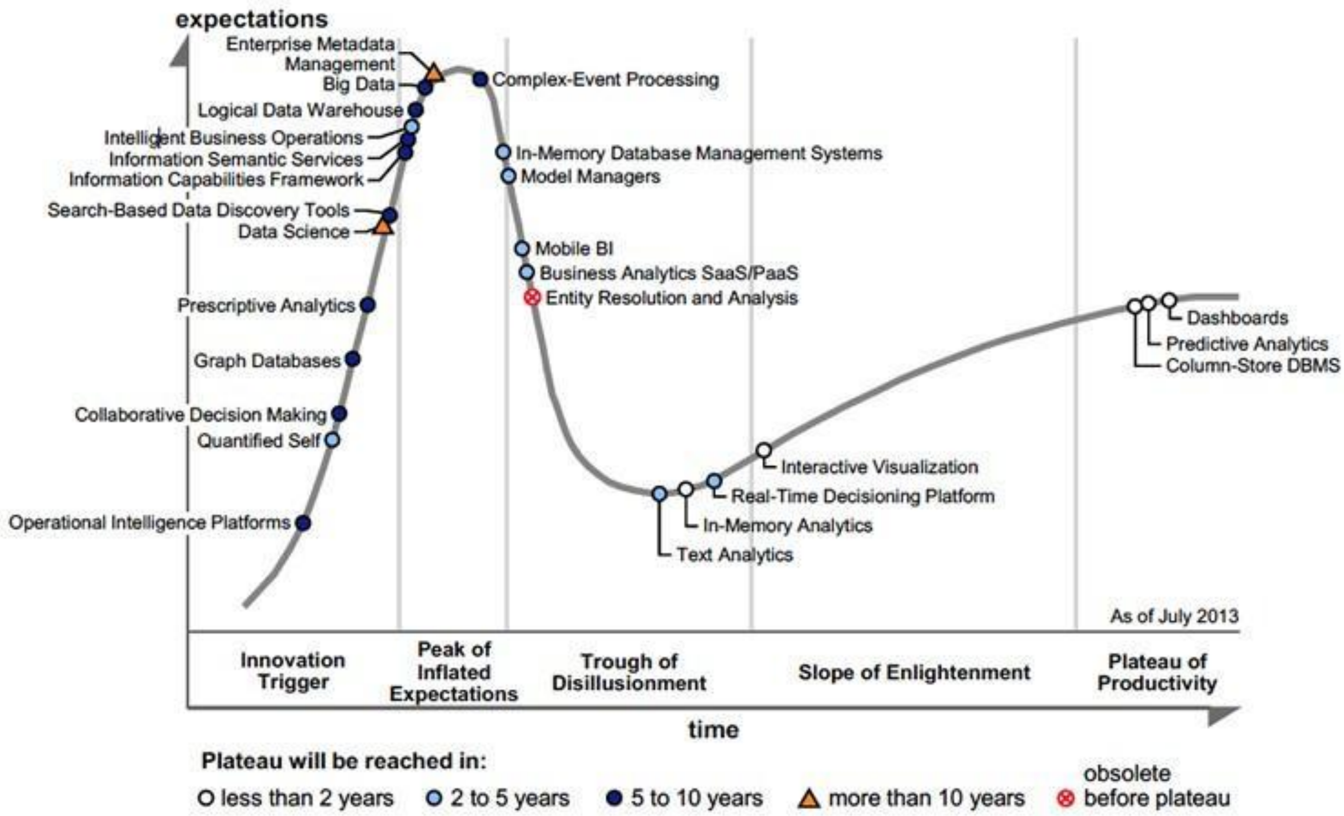
The site counts trends in the popularity of each category based on several metrics, including records and trends based on search engines such as Google, technical topics discussed on major IT technology forums and social networking sites, job posting changes on job boards. 371 database products are included in the site and are divided into 12 categories. Of these 12 categories, a category like graph databases is growing much faster than any of the others.



Gartner's predictions

Gartner, one of the world's top think tanks, identified graph databases as a major business intelligence and analytics technology trend long before 2013 [2]. At that time, big data was hot as ever, and data scientists were in a hot position.

Figure 1. Hype Cycle for Business Intelligence and Analytics, 2013



BI = business intelligence; DBMS = database management system; SaaS = software as a service; PaaS = platform as a service

Until recently, graph databases and related graph technologies were ranked in the Top 10 Data and Analytics Trends for 2021 [3].

> **Trend 8: Graph Relates Everything**

Graphs form the foundation of many modern data and analytics capabilities to find relationships between people, places, things, events, and locations across diverse data assets. D&A leaders rely on graphs to quickly answer complex business questions which require contextual awareness and an understanding of the nature of connections and strengths across multiple entities.

Gartner predicts that by 2025, graph technologies will be used in 80% of data and analytics innovations, up from 10% in 2021, facilitating rapid decision-making across the organization.

It can be noted that Gartner's predictions match the DB-Engines ranking well. There is usually a period of rapid bubble development, then a plateau period, followed by a new bubble period due to the emergence of new technologies, and then a plateau period again.

Market size of graph databases

According to statistics and forecasts from Verifiedmarketresearc[4], fnfresearch[5], MarketsandMarkets[6], and Gartner[7], the global graph database market size is about to grow from about USD 0.8 billion in 2019 to USD 3-4 billion by 2026, at a Compound Annual Growth Rate (CAGR) of about 25%, which corresponds to about 5%-10% market share of the global database market.

2.2.2 Market participants

Neo4j, the pioneer of (first generation) graph databases

Although some graph-like data models and products, and the corresponding graph language G/G+ had been proposed in the 1970s (e.g. CODASYL [8]). But it is Neo4j, the main pioneer in this market, that has really made the concept of graph databases popular, and even the two main terms (labeled) property graphs and graph databases were first introduced and practiced by Neo4j.

!!! Info "This section on the history of Neo4j and the graph query language it created, Cypher, is largely excerpted from the ISO WG3 paper *An overview of the recent history of Graph Query Languages* [10] and [9]. To take into account the latest two years of development, the content mentioned in this topic has been abridged and updated by the authors of this book.

About GQL (Graph Query Language) and the development of an International Standard

Readers familiar with databases are probably aware of the Structured Query Language SQL. by using SQL, people access databases in a way that is close to natural language. Before SQL was widely adopted and standardized, the market for relational databases was very fragmented. Each vendor's product had a completely different way of accessing. Developers of the database product itself, developers of the tools surrounding the database product, and end-users of the database, all had to learn each product. When the SQL-89 standard was developed in 1989, the entire relational database market quickly focus on SQL-89. This greatly reduced the learning costs for the people mentioned above.

GQL (Graph Query Language) assumes a role similar to SQL in the field of graph databases. Uses interacts with graphs with GQL. Unlike international standards such as SQL-89, there are no international standards for GQL. Two mainstream graph languages are Neo4j's Cypher and Apache TinkerPop's Gremlin. The former is often referred to as the DQL, Declarative Query Language. DQL tells the system "what to do", regardless of "how to do". The latter is referred to as the IQL, Imperative Query Language. IQL explicitly specifies the system's actions.

The GQL International Standard is in the process of being developed.

OVERVIEW OF THE RECENT HISTORY OF GRAPH DATABASES

- In 2000, the idea of modeling data as a network came to the founders of Neo4j.
- In 2001, Neo4j developed the earliest core part of the code.
- In 2007, Neo4j started operating as a company.
- In 2009, Neo4j borrowed XPath as a graph query language. Gremlin [11] is also similar to XPath.
- In 2010, Marko Rodriguez, a Neo4j employee, used the term Property Graph to describe the data model of Neo4j and TinkerPop (Gremlin).
- In 2011, the first public version Neo4j 1.4 was released, and the first version of Cypher was released.
- In 2012, Neo4j 1.8 enabled you to write a Cypher. Neo4j 2.0 added labels and indexes. Cypher became a declarative graph query language.
- In 2015, Cypher was opened up by Neo4j through the openCypher project.
- In 2017, the ISO WG3 organization discussed how to use SQL to query property graph data.
- In 2018, Starting from the Neo4j 3.5 GA, the core of Neo4j only for the Enterprise Edition will no longer be open source.
- In 2019, ISO officially established two projects ISO/IEC JTC 1 N 14279 and ISO/IEC JTC 1/SC 32 N 3228 to develop an international standard for graph database language.
- In 2021, the $325 million Series F funding round for Neo4j marks the largest investment round in database history.

THE EARLY HISTORY OF NEO4J

The data model property graph was first conceived in 2000. The founders of Neo4j were developing a media management system, and the schema of the system was often changed. To adapt to such changes, Peter Neubauer, one of the founders, wanted to enable the system to be modeled to a conceptually interconnected network. A group of graduate students at the Indian Institute of Technology Bombay implemented the earliest prototypes. Emil Eifrém, the Neo4j co-founder, and these students spent a week extending Peter's idea into a more abstract model: vertices were connected by relationships, and key-values were used as properties of vertices and relationships. They developed a Java API to interact with this data model and implemented an abstraction layer on top of the relational database.

Although this network model greatly improved productivity, its performance has been poor. So Johan Svensson, Neo4j co-founder, put a lot of effort into implementing a native data management system, that is Neo4j. For the first few years, Neo4j was successful as an in-house product. In 2007, the intellectual property of Neo4j was transferred to an independent database company.

In the first public release of Neo4j (Neo4j 1.4, 2011), the data model was consisted of vertices and typed edges. Vertices and edges have properties. The early versions of Neo4j did not have indexes. Applications had to construct their search structure from the root vertex. Because this was very unwieldy for the applications, Neo4j 2.0 (2013.12) introduced a new concept label on vertices. Based on labels, Neo4j can index some predefined vertex properties.

"Vertex", "Relationship", "Property", "Relationships can only have one label.", "Vertices can have zero or multiple labels.". All these concepts form the data model definitions for Neo4j property graphs. With the later addition of indexing, Cypher became the main way of interacting with Neo4j. This is because the application developer only needs to focus on the data itself, not on the search structure that the developer built himself as mentioned above.

THE CREATION OF GREMLIN

Gremlin is a graph query language based on Apache TinkerPop, which is close in style to a sequence of function (procedure) calls. Initially, Neo4j was queried through the Java API. applications could embed the query engine as a library into the application and then use the API to query the graph.

The early Neo4j employees Tobias Lindaaker, Ivarsson, Peter Neubauer, and Marko Rodriguez used XPath as a graph query. Groovy provides loop structures, branching, and computation. This was the original prototype of Gremlin, the first version of which was released in November 2009.

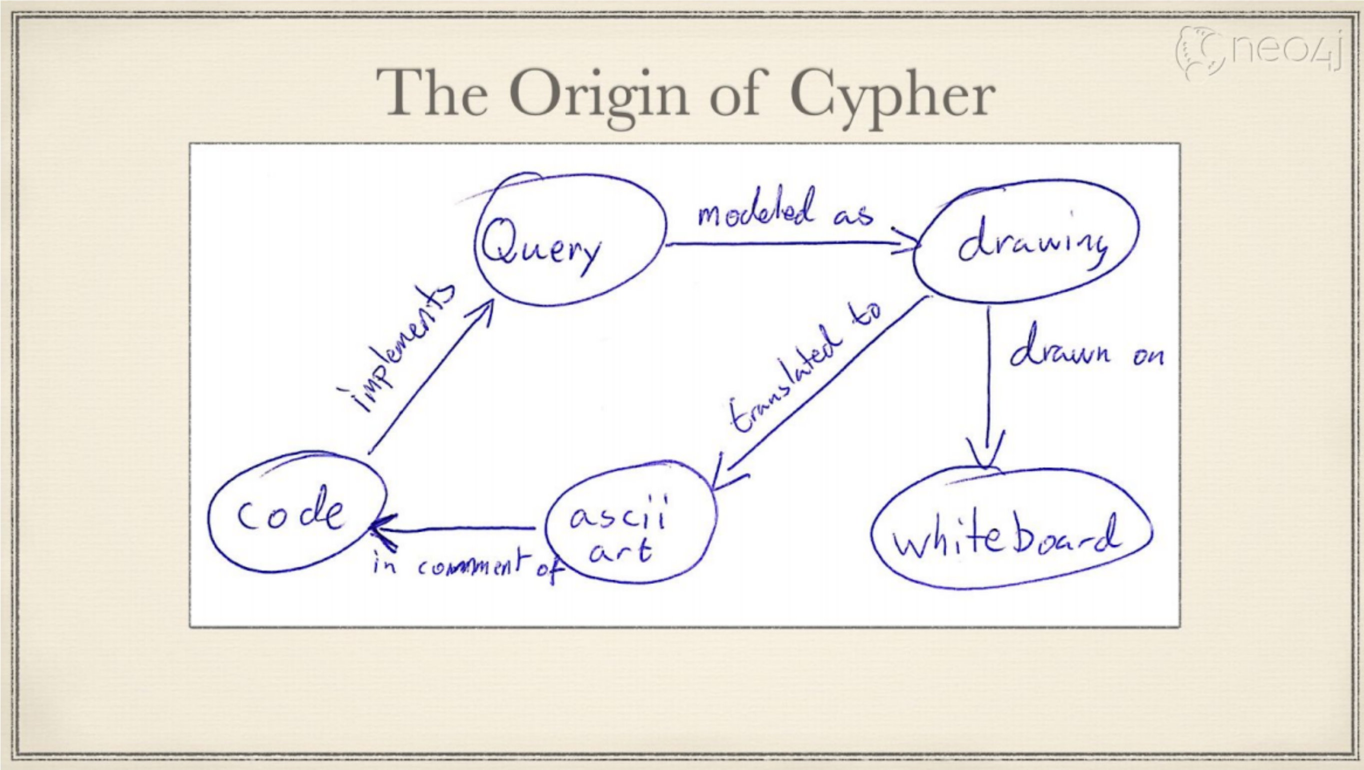
Later, Marko found a lot of problems with using two different parsers (XPath and Groovy) at the same time and changed Gremlin to a Domain Specific Language (DSL) based on Groovy.

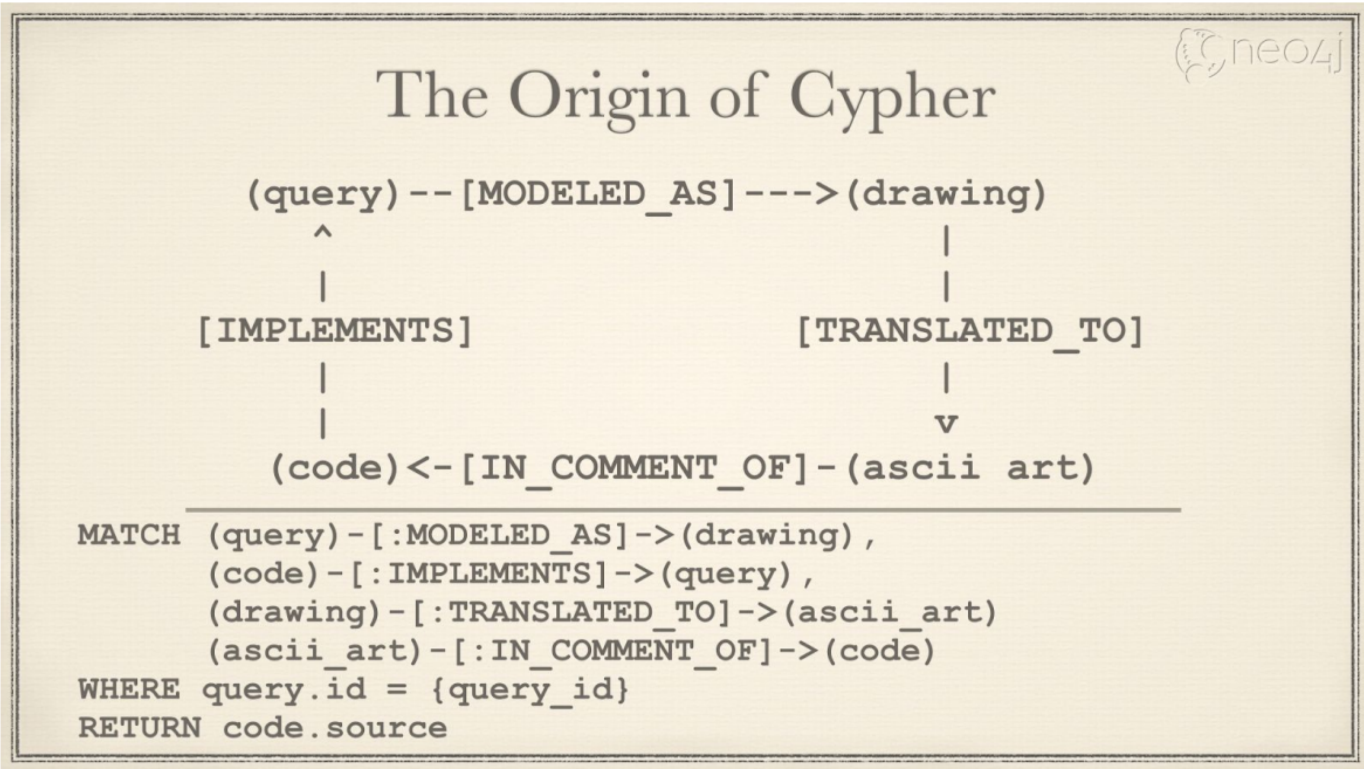
THE CREATION OF CYPHER

Gremlin, like Neo4j's Java API, was originally intended to be a procedural way of expressing how to query databases. It uses shorter syntaxes to query and remotely access databases through the network. The procedural nature of Gremlin requires users to know the best way to query results, which is still burdensome for application developers. Over the last 30 years, the declarative language SQL has been a great success. SQL can separate the declarative way to get data from how the engine gets data. So the Neo4j engineers wanted to develop a declarative graph query language.

In 2010, Andrés Taylor joined Neo4j as an engineer. Inspired by SQL, he started a project to develop graph query language, which was released as Neo4j 1.4 in 2011. The language is the ancestor of most graph query languages today - Cypher.

Cypher's syntax is based on the use of ASCII art to describe graph patterns. This approach originally came from the annotations on how to describe graph patterns in the source code. An example can be seen as follows.





Simply put, ASCII art uses printable text to describe vertices and edges. Cypher syntax uses `()` for vertices and `-[]->` for edges. `(query)-[modeled as]->(drawing)` is used to represent a simple graph relationship (which can also be called graph schema): `the starting vertex - query`, `the destination vertex - drawing`, and `the edge - modeled as`.

The first version of Cypher implemented graph reading, but users should specify vertices from which to start querying. Only from these vertices could graph schema matching be supported.

In a later version, Neo4j 1.8, released in October 2012, Cypher added the ability to modify graphs. However, queries still need to specify which nodes to start from.

In December 2013, Neo4j 2.0 introduced the concept of a label, which is essentially an index. This allows the query engine to use the index to select the vertices matched by the schema, without requiring the user to specify the vertex to start the query.

With the popularity of Neo4j, Cypher has a wide community of developers and is widely used in a variety of industries. It is still the most popular graph query language.

In September 2015, Neo4j established the openCypher Implementors Group (oCIG) to open source Cypher to openCypher, to govern and advance the evolution of the language itself through open source.

SUBSEQUENT EVENTS

Cypher has inspired a series of graph query languages, including:

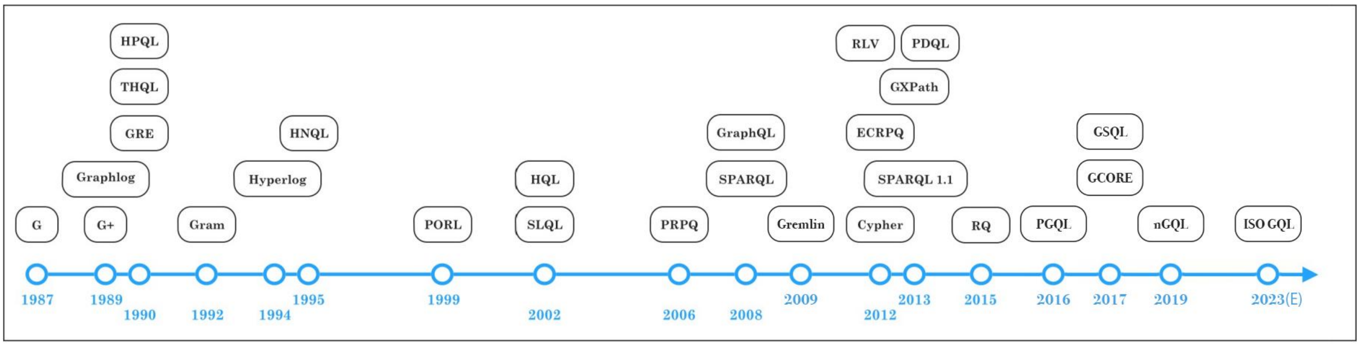
2015, Oracle released PGQL, a graph language used by the graph engine PGX.

2016, the Linked Data Benchmarking Council (short for LDBC) an industry-renowned benchmarking organization for graph performance, released G-CORE.

2018, RedisGraph, a Redis-based graph library, adopted Cypher as its graph language.

2019, the International Standards Organization ISO started two projects to initiate the process of developing an international standard for graph languages based on existing industry achievements such as openCypher, PGQL, GSQL[12], and G-CORE.

2019, NebulaGraph released NebulaGraph Query Language (nGQL) based on openCypher.



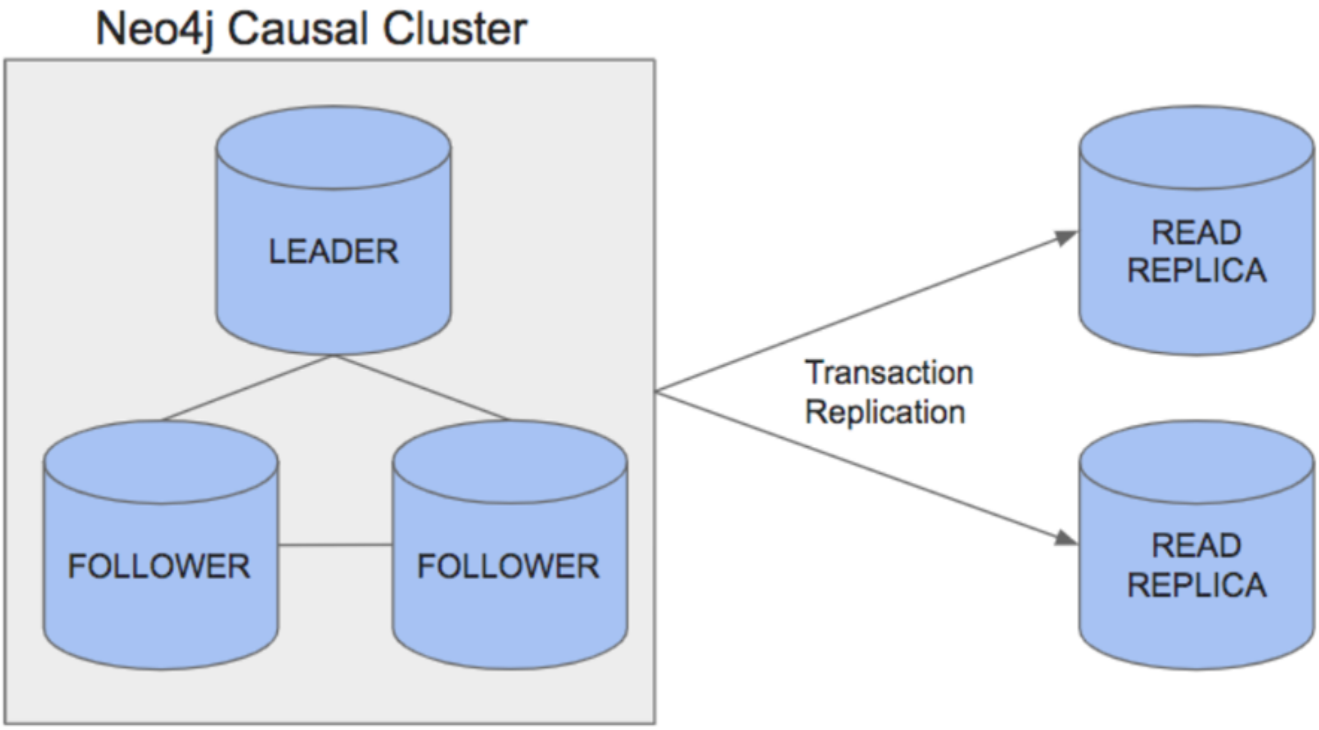
Distributed graph databases

From 2005 to 2010, with the release of Google's cloud computing "Troika", various distributed architectures became increasingly popular, including Hadoop and Cassandra, which have been open-sourced. Several implications are as follows:

1. The technical and cost advantages of distributed systems over single machines (e.g. Neo4j) or small machines are more obvious due to the increasing volume of data and computation. Distributed systems allow applications to access these thousands of machines as if they were local systems, without the need for much modification at the code level.
2. The open-source approach allows more people to know emerging technologies and feedback to the community in a more cost-effective way, including code developers, data scientists, and product managers.

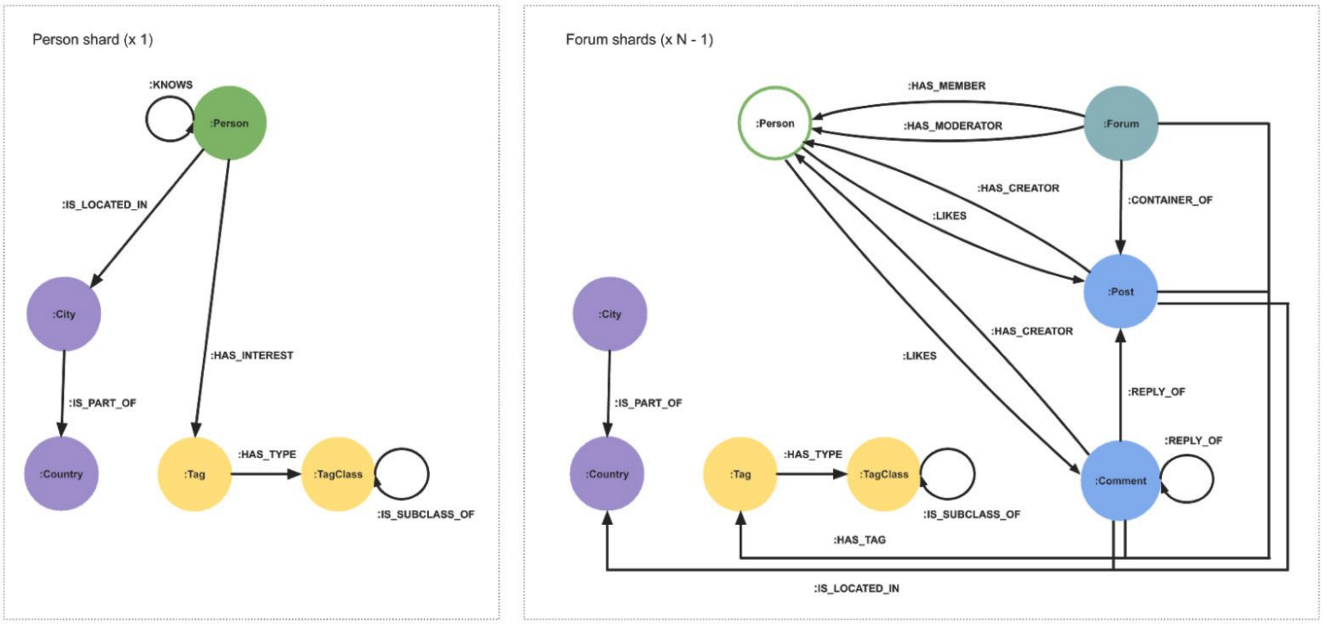
Strictly speaking, Neo4j also offers several distributed capabilities, which are quite different from the industry's sense of the distributed system.

- Neo4j 3. x requires that the full amount of data must be stored on a single machine. Although it supports full replication and high availability between multiple machines, the data cannot be sliced into different subgraphs.



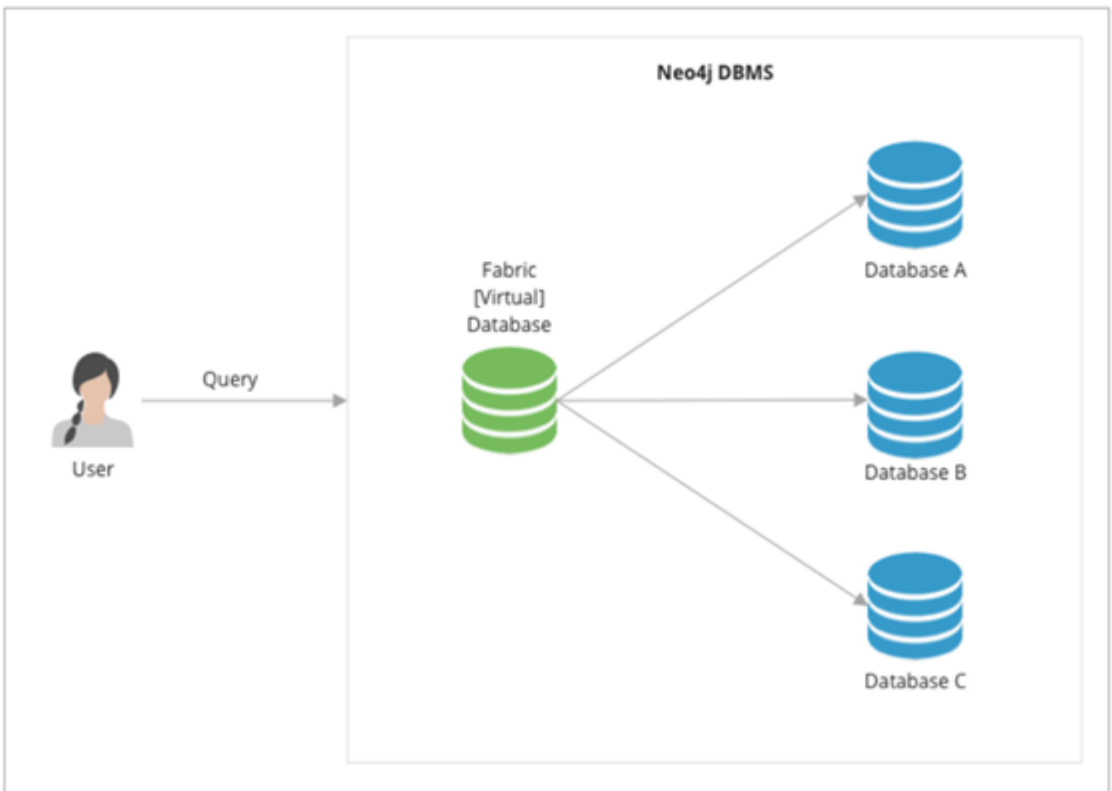
Cluster architecture

- Neo4j 4. x stores a part of data on different machines (subgraphs), and then the application layer assembles data in a certain way (called Fabric)[13] and distributes the reads and writes to each machine. This approach requires a log of involvement and work from the application layer code. For example, designing how to place different subgraphs on which machines they should be placed and how to assemble some of the results obtained from each machine into the final result.



The style of its syntax is as follows:

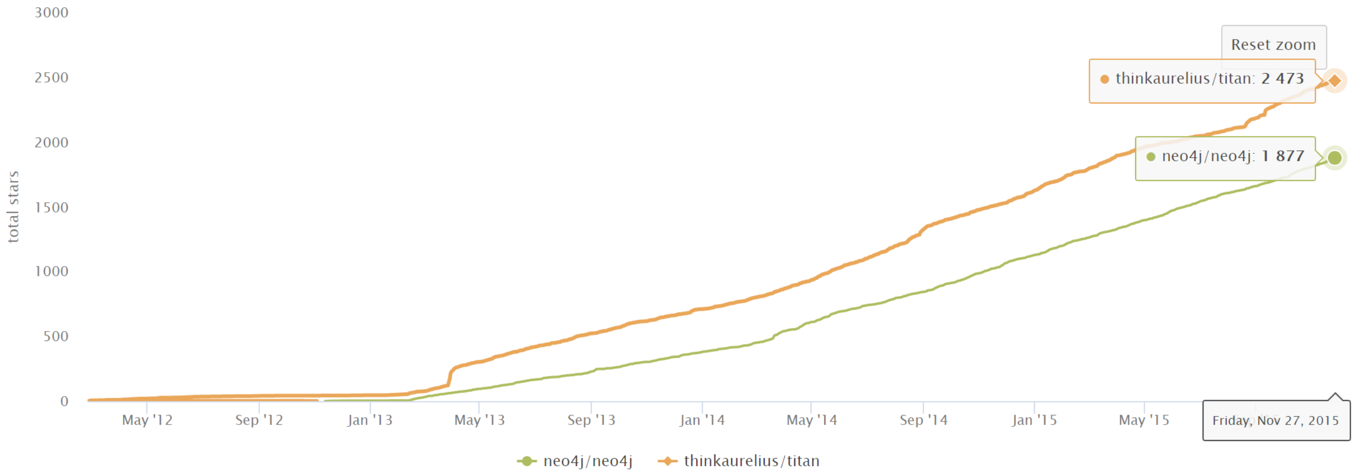
```
USE graphA
MATCH (movie:Movie)
Return movie.title AS title
    UNION
USE graphB
MATCH (move:Movie)
RETURN movie.title AS title
```



THE SECOND GENERATION (DISTRIBUTED) GRAPH DATABASE: TITAN AND ITS SUCCESSOR JANUSGRAPH

In 2011, Aurelius was founded to develop an open-source distributed graph database called Titan [14]. By the first official release of Titan in 2015, the backend of Titan can support many major distributed storage architectures (e.g. Cassandra, HBase, Elasticsearch, BerkeleyDB) and can reuse many of the conveniences of the Hadoop ecosystem, with Gremlin as a unified query language on the frontend. It is easy for programmers to use, develop and participate in the community. Large-scale graphs could be sharded and stored on HBase or Cassandra (which were relatively mature distributed storage solutions at the time), and the Gremlin language was relatively full-featured though slightly lengthy. The whole solution was competitive at that time (2011-2015).

The following picture shows the growth of Titan and Neo4j stars on Github.com from 2012 to 2015.

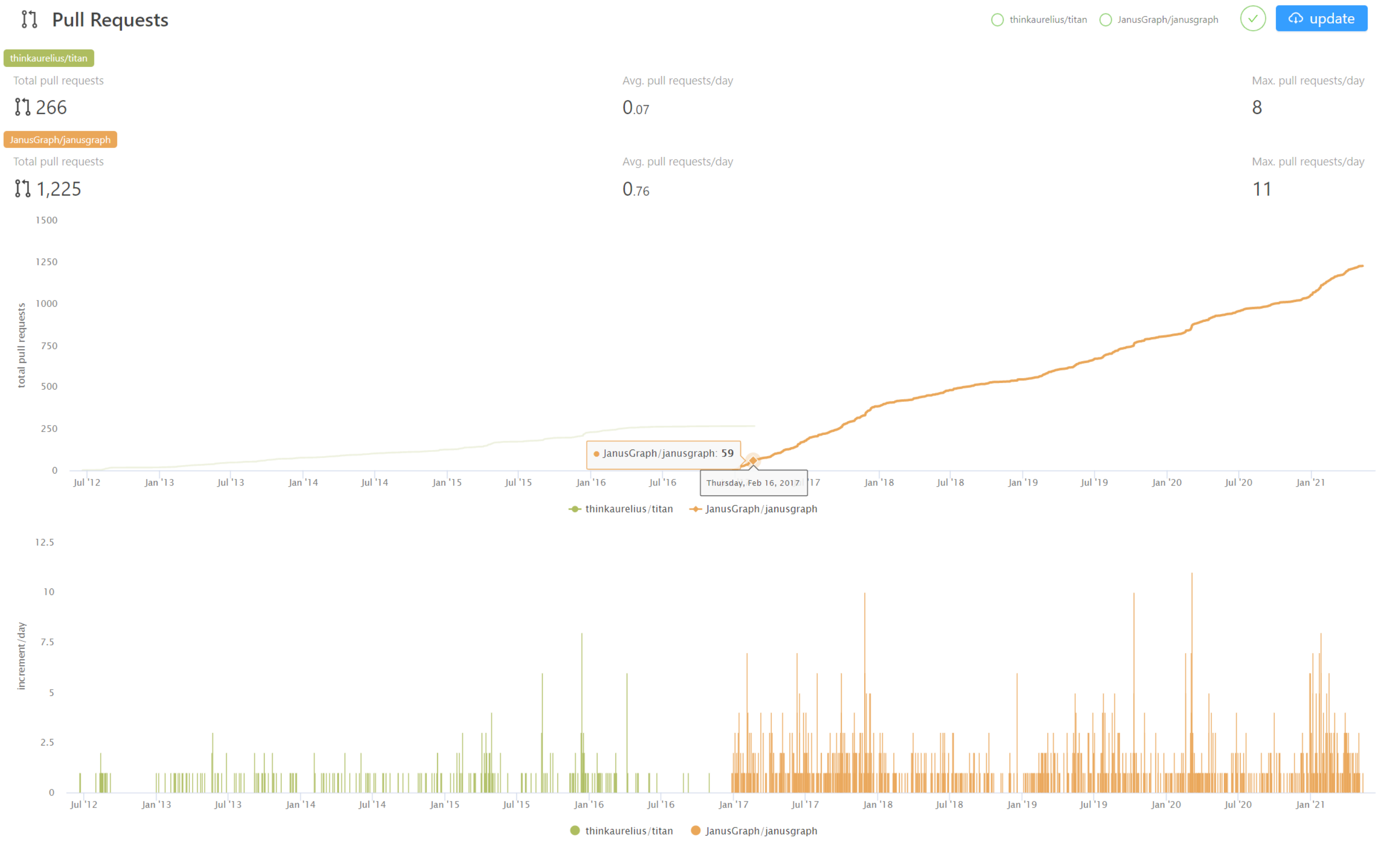


After Aurelius (Titan) was acquired by DataStax in 2015, Titan was gradually transformed into a closed-source commercial product(DataStax Enterprise Graph).

After the acquisition of Aurelius(Titan), there has been a strong demand for an open-source distributed graph database, and there were not many mature and active products in the market. In the era of big data, data is still being generated in a steady stream, far faster than Moore's Law. The Linux Foundation, along with some technology giants (Expero, Google, GRAKN.AI, Hortonworks, IBM, and Amazon) replicated and forked the original Titan project and started it as a new project JanusGraph[15]. Most of the community work including development, testing, release, and promotion, has been gradually shifted to the new JanusGraph.

The following graph shows the evolution of daily code commits (pull requests) for the two projects, and we can see:

1. Although Aurelius(Titan) still has some activity in its open-source code after its acquisition in 2015, the growth rate has slowed down significantly. This reflects the strength of the community.
2. After the new project was started in January 2017, its community became active quickly, surpassing the number of pull requests accumulated by Titan in the past 5 years in just one year. At the same time, the open-source Titan came to a halt.



FAMOUS PRODUCTS OF THE SAME PERIOD ORIENTDB, TIGERGRAPH, ARANGODB, AND DGRAPH

In addition to JanusGraph managed by the Linux Foundation, more vendors have been joined the overall market. Some distributed graph databases that were developed by commercial companies use different data models and access methods.

The following table only lists the main differences.

Vendors	Creation time	Core product	Open source protocol	Data model	Query language
OrientDB LTD (Acquired by SAP in 2017)	2011	OrientDB	Open source	Document + KV + Graph	OrientDB SQL (SQL-based extended graph abilities)
GraphSQL (was renamed TigerGraph)	2012	TigerGraph	Commercial version	Graph (Analysis)	GraphSQL (similar to SQL)
ArangoDB GmbH	2014	ArangoDB	Apache License 2.0	Document + KV + Graph	AQL (Simultaneous operation of documents, KVs and graphs)
DGraph Labs	2016	DGraph	Apache Public License 2.0 + Dgraph Community License	Originally RDF, later changed to GraphQL	GraphQL+-

TRADITIONAL GIANTS MICROSOFT, AMAZON, AND ORACLE

In addition to vendors focused on graph products, traditional giants have also entered the graph database field.

Microsoft Azure Cosmos DB[16] is a multimodal database cloud service on the Microsoft cloud that provides SQL, document, graph, key-value, and other capabilities. Amazon AWS Neptune[17] is a graph database cloud service provided by AWS support property graphs and RDF two data models. Oracle Graph[18] is a product of the relational database giant Oracle in the direction of graph technology and graph databases.

NEBULAGRAPH, A NEW GENERATION OF OPEN-SOURCE DISTRIBUTED GRAPH DATABASES

In the following topics, we will formally introduce NebulaGraph, a new generation of open-source distributed graph databases.

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1. https://db-engines.com/en/ranking_categories ↩
2. https://www.yellowfinbi.com/blog/2014/06/yfcommunitynews-big-data-analytics-the-need-for-pragmatism-tangible-benefits-and-real-world-case-165305 ↩
3. https://www.gartner.com/smarterwithgartner/gartner-top-10-data-and-analytics-trends-for-2021/ ↩
4. https://www.verifiedmarketresearch.com/product/graph-database-market/ ↩
5. https://www.globenewswire.com/news-release/2021/01/28/2165742/0/en/Global-Graph-Database-Market-Size-Share-to-Exceed-USD-4-500-Million-By-2026-Facts-Factors.html ↩
6. https://www.marketsandmarkets.com/Market-Reports/graph-database-market-126230231.html ↩
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11. Gremlin is a graph language developed based on Apache TinkerPop. ↩
12. https://docs.tigergraph.com/dev/gsql-ref ↩
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14. https://github.com/thinkaurelius/titan ↩
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16. https://azure.microsoft.com/en-us/free/cosmos-db/ ↩
17. https://aws.amazon.com/cn/neptune/ ↩
18. https://www.oracle.com/database/graph/ ↩

Last update: August 11, 2022

2.3 Related technologies

This topic introduces databases and graph-related technologies that are closely related to distributed graph databases.

2.3.1 Databases

Relational databases

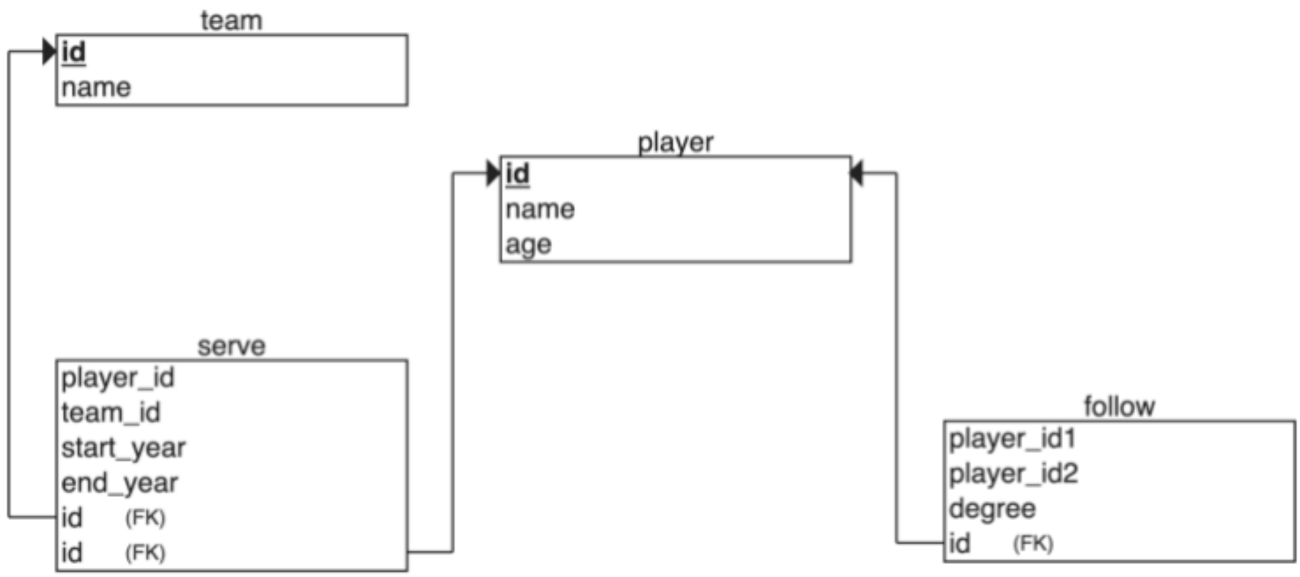
A relational database is a database that uses a relational model to organize data. The relational model is a two-dimensional table model, and a relational database consists of two-dimensional tables and the relationships between them. When it comes to relational databases, most people think of MySQL, one of the most popular database management systems that support database operations using the most common structured query language (SQL) and stores data in the form of tables, rows, and columns. This approach to storing data is derived from the relational data model proposed by Edgar Frank Codd in 1970.

In a relational database, a table can be created for each type of data to be stored. For example, the player table is used to store all player information, the team table is used to store team information. Each row of data in a SQL table must contain a primary key. The primary key is a unique identifier for the row of data. Generally, the primary key is self-incrementing with the number of rows as the field ID. Relational databases have served the computer industry very well since their inception and will continue to do so for a long time to come.

If you have used Excel, WPS, or other similar applications, you have a rough idea of how relational databases work. First, you set up the columns, then you add rows of data under the corresponding columns. You can average or otherwise aggregate the data in a column, similar to averaging in a relational database MySQL. Pivot tables in Excel are the equivalent of querying data in a relational database MySQL using aggregation functions and CASE statements. An Excel file can have multiple tables, and a single table is equivalent to a single table in MySQL. An Excel file is similar to a MySQL database.

RELATIONSHIPS IN RELATIONAL DATABASES

Unlike graph databases, edges in relational databases (or SQL-type databases) are also stored as entities in specialized edge tables. Two tables are created, player and team, and then player_team is created as an edge table. Edge tables are usually formed by joining related tables. For example, here the edge table player_team is made by joining the player table and the team table.



The way of storing edges is not a big problem when associating small data sets, but problems arise when there are too many relationships in a relational database. Specifically, when you want to query just one player's teammates, you have to join all the data in the table and then filter out all the data you don't need, which puts a huge strain on the relational database when your dataset reaches a certain size. If you want to associate multiple different tables, the system may not be able to respond before the join bombs.

ORIGINS OF RELATIONAL DATABASES

As mentioned above, the relational data model was first proposed by Edgar Frank Codd, an IBM engineer, in 1970. Codd wrote several papers on database management systems that addressed the potential of the relational data model. The relational data model does not rely on linked lists of data (mesh or hierarchical data), but more on data sets. Using the mathematical method of tuple calculus, he argued that these datasets can perform the same tasks as a navigational database. The only requirement was that the relational data model needed a suitable query language to guarantee the consistency requirements of the database. This became the inspiration for declarative query languages such as Structured Query Language (SQL). IBM's System R was one of the first implementations of such a system. But Software Development Laboratories, a small company founded by ex-IBM people and one illustrious Mr.Larry Ellison, beat IBM to the market with the product that would become known as Oracle.

Since the relational database was a trendy term at the time, many database vendors preferred to use it in their product names, even though their products were not actually relational. To prevent this and reduce the misuse of the relational data model, Codd introduced the famous Codd's 12 Rules. All relational data systems must follow Codd's 12 Rules.

NoSQL databases

Graph databases are not the only alternative that can overcome the shortcomings of relational databases. There are many non-relational database products on the market that can be called NoSQL. The term NoSQL was first introduced in the late 1990s and can be interpreted as "not SQL" or "not only SQL". For the sake of understanding, NoSQL can be interpreted as a "non-relational database" here. Unlike relational databases, the data storage and retrieval mechanisms provided by NoSQL databases are not modeled based on table relationships. NoSQL databases can be divided into four categories.

- Key-value Data Store
- Columnar Store
- Document Store
- Graph Store

The following describes the four types of NoSQL databases.

KEY-VALUE DATA STORE

Key-value databases store data in unique key-value pairs. Unlike relational databases, key-value stores do not have tables and columns. A key-value database itself is like a large table with many columns (i.e., keys). In a key-value store database, data are stored and queried by means of keys, usually implemented as hash lists. This is much simpler than traditional SQL databases, and for some web applications, it is sufficient.

The advantage of the key-value model for IT systems is that it is simple and easy to deploy. In most cases, this type of storage works well for unrelated data. If you are just storing data without querying it, there is no problem using this storage method. However, if the DBA only queries or updates some of the values, the key-value model becomes inefficient. Common key-value storage databases include Redis, Voldemort, and Oracle BDB.

COLUMNAR STORE

A NoSQL database's columnar store has many similarities to a NoSQL database's key-value store because the columnar store is still using keys for storage and retrieval. The difference is that in a columnar store database, the column is the smallest storage unit, and each column consists of a key, a value, and a timestamp for version control and conflict resolution. This is particularly useful when scaling in a distributed manner, as timestamps can be used to locate expired data when the database is updated. Because of the good scalability of columnar storage, the columnar store is suitable for very large data sets. Common columnar storage databases include HBase, Cassandra, HadoopDB, etc.

DOCUMENT STORE

A NoSQL database document store is a key-value-based database, but with enhanced functionality. Data is still stored as keys, but the values in a document store are structured documents, not just a string or a single value. That is, because of the increased information structure, document stores are able to perform more optimized queries and make data retrieval easier. Therefore, document stores are particularly well suited for storing, indexing, and managing document-oriented data or similar semi-structured data.

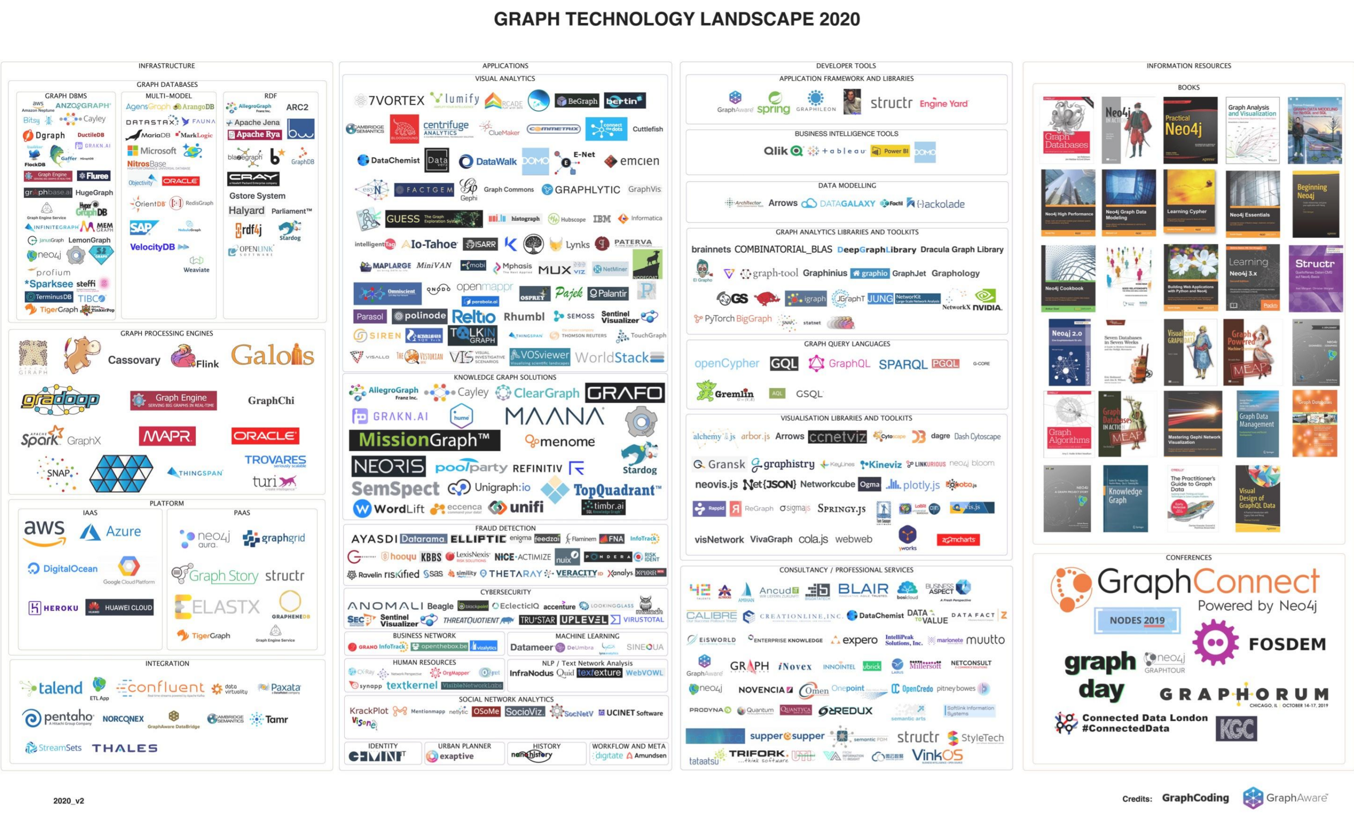
Technically speaking, as a semi-structured unit of information, a document in a document store can be any form of document available, including XML, JSON, YAML, etc., depending on the design of the database vendor. For example, JSON is a common choice. While JSON is not the best choice for structured data, JSON-type data can be used in both front-end and back-end applications. Common document storage databases include MongoDB, CouchDB, Terrastore, etc.

GRAPH STORE

The last class of NoSQL databases is graph databases. NebulaGraph, is also a graph database. Although graph databases are also NoSQL databases, graph databases are fundamentally different from the above-mentioned NoSQL databases. Graph databases store data in the form of vertices, edges, and properties. Its advantages include high flexibility, support for complex graph algorithms, and can be used to build complex relational graphs. We will discuss graph databases in detail in the subsequent topics. But in this topic, you just need to know that a graph database is a NoSQL type of database. Common graph databases include NebulaGraph, Neo4j, OrientDB, etc.

2.3.2 Graph-related technologies

Take a look at a panoramic view of graph technology in 2020 [1].



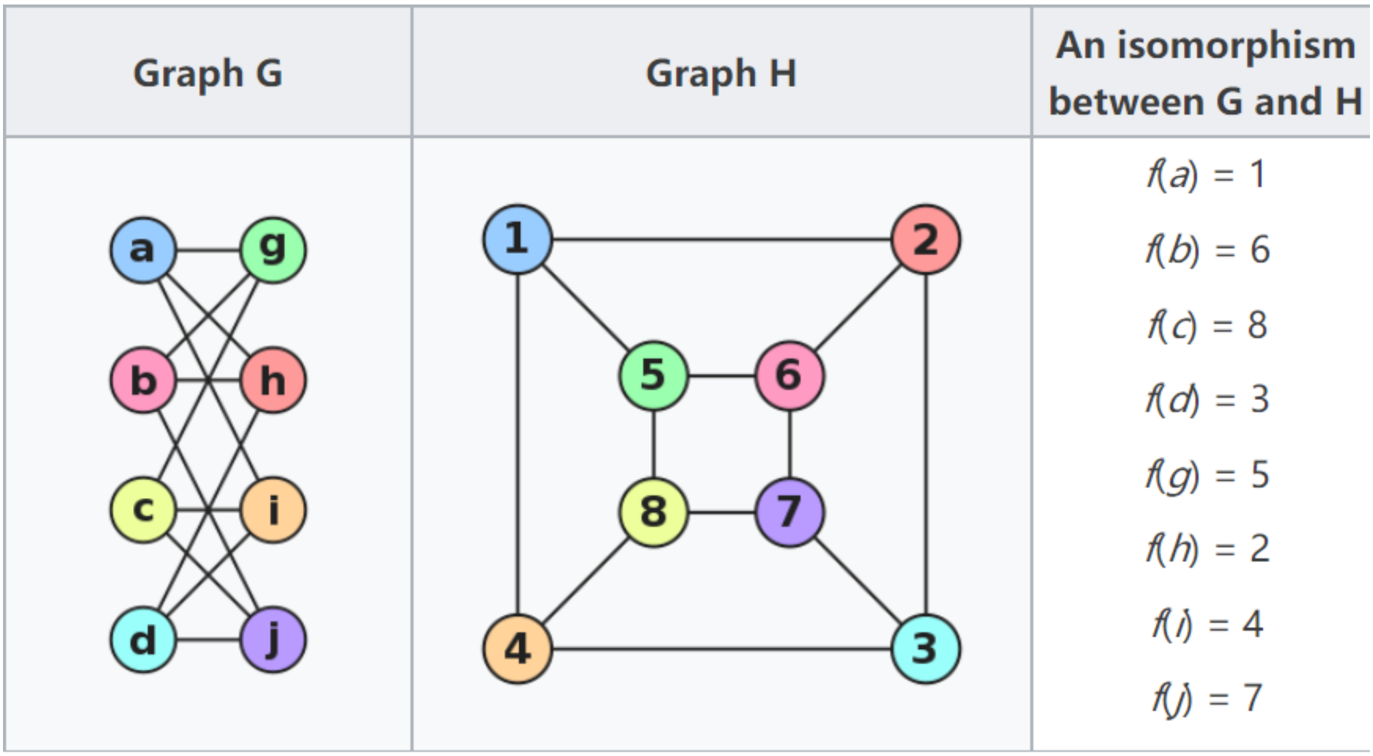
There are many technologies that are related to graphs, which can be broadly classified into these categories:

- Infrastructure: Graph databases, graph computing (processing) engines, graph deep learning, cloud services, etc.
- Applications: Visualization, knowledge graph, anti-fraud, cyber security, social network, etc.
- Development tools: Graph query languages, modeling tools, development frameworks, and libraries.
- E-books [2] and conferences, etc.

Graph language

In the previous topic, we introduced the history of graph languages. In this section, we make a classification of the functions of graph languages.

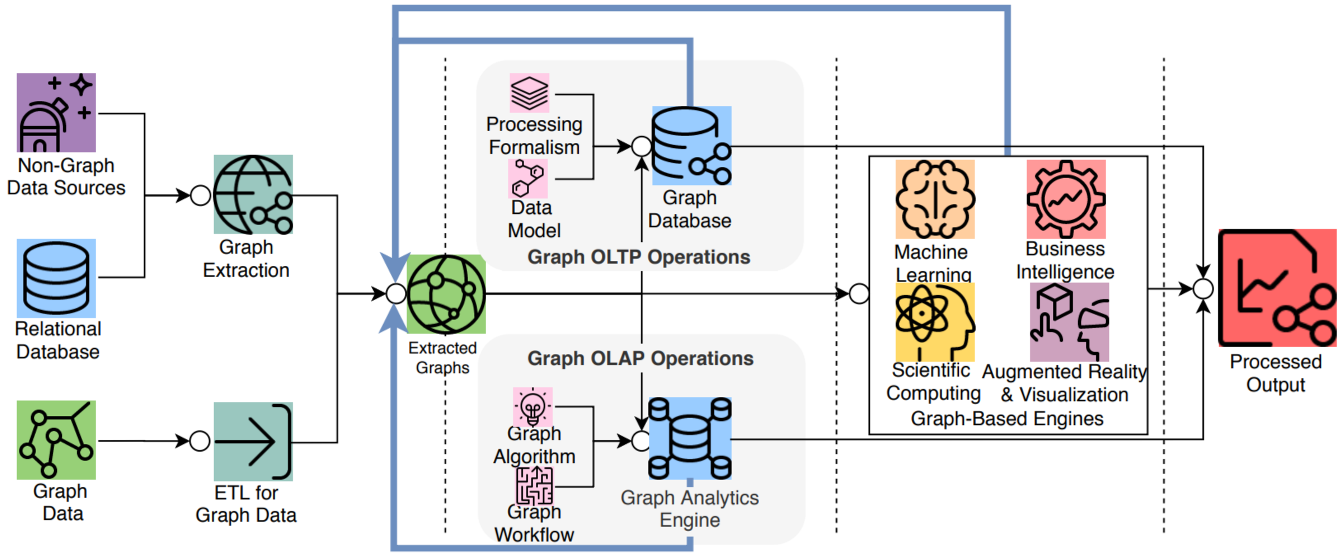
- Nearest neighbor query (NNS): Query the neighboring edges, neighbors, or K-hops neighbors.
- Find one/all subgraphs that satisfy a given graph pattern. This problem is very close to Subgraph Isomorphism - two seemingly different graphs that are actually identical [3] as shown below.



- Reachability (connectivity) problems: The most common reachability problem is the shortest path problem. Such problems are usually described in terms of Regular Path Query - a series of connected groups of vertices forming a path that needs to satisfy some regular expression.
- Analytic problems: It is related to some convergent operators, such as Average, Count, Max, Vertex Degree. Measures the distance between all two vertices, the degree of interaction between a vertex and other vertices.

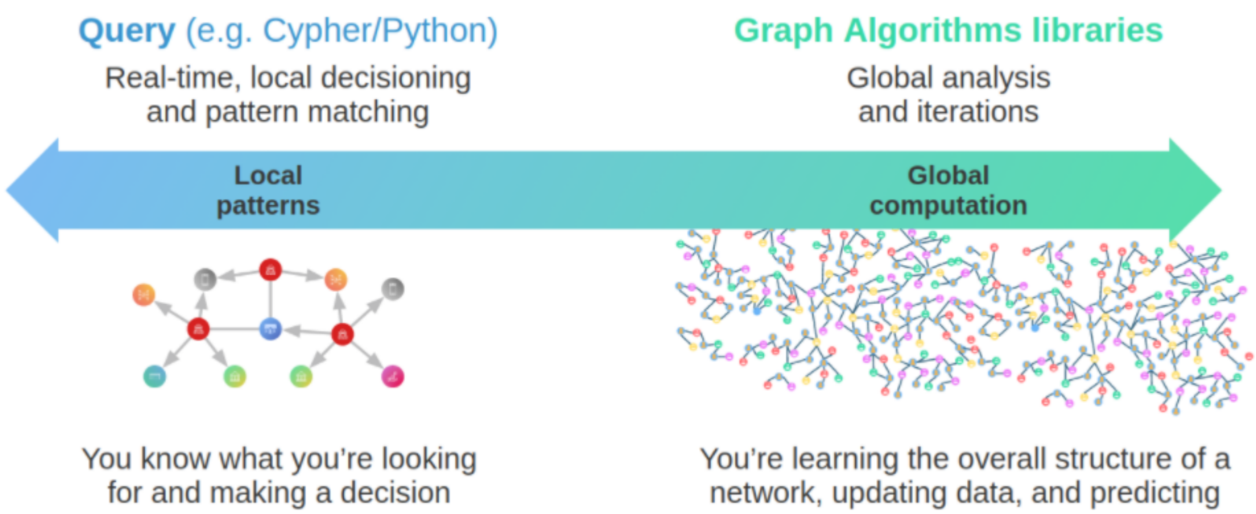
Graph database and graph processing systems

A graph system usually includes a complex data pipeline [4]. From the data source (the left side of the picture below) to the processing output (the right side), multiple data processing steps and systems are used, such as the ETL module, Graph OLTP module, OLAP module, BI, and knowledge graph.



Graph databases and graph processing systems have different origins and specialties (and weaknesses).

- (Online) The graph database is designed for persistent storage management of graphs and efficient subgraph operations. Hard disks and network are the target operating devices, physical/logical data mapping, data integrity, and (fault) consistency are the main goals. Each request typically involves only a small part of the full graph and can usually be done on a single server. Request latency is usually in milliseconds or seconds, and request concurrency is typically in the thousands or hundreds of thousands. The early Neo4j was one of the origins of the graph database space.
- (Offline) The graph processing system is for high-volume, concurrency, iteration, processing, and analysis of the full graph. Memory and network are the target operating devices. Each request involves all graph vertices and requires all servers to be involved in its completion. The latency of a single request is in the range of minutes to hours (days). The request concurrency is in single digits. Google's Pregel [5] represents the typical origin of graph processing systems. Its point-centric programming abstraction and BSP's operational model constitute a programming paradigm that is a more graph-friendly API abstraction than the previous Hadoop Map-Reduce.



6

Graph sharding methods

For large-scale graph data, it is difficult to store it in the memory of a single server, and even just storing the graph structure itself is not enough. By increasing the capacity of a single server, its cost price usually rises exponentially.

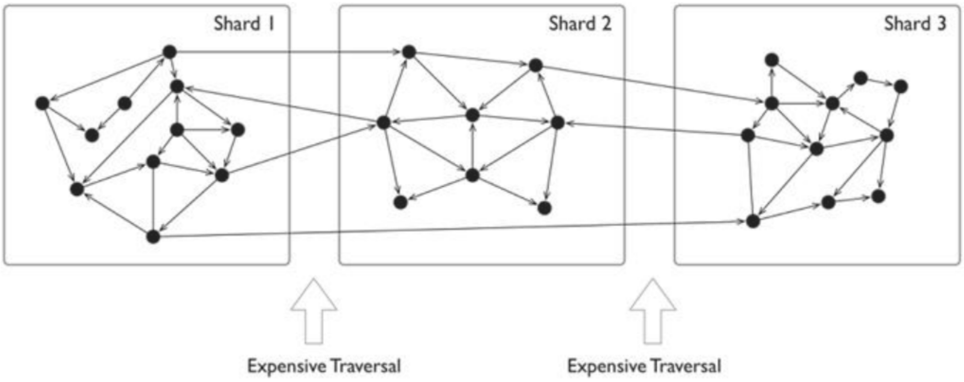
As the volume of data increases, for example, 100 billion data already exceeds the capacity of all commercially available servers on the market.

Another option is to shard data and place each shard on a different server to increase reliability and performance. For NoSQL systems, such as key-value or document systems, the sharding method is intuitive and natural. Each record and data unit can usually be placed on a different server based on the key or docID.

However, the sharding of data structures like graphs is usually less intuitive, because usually, graphs are "fully connected" and each vertex can be connected to any other vertex in usually 6 hops.

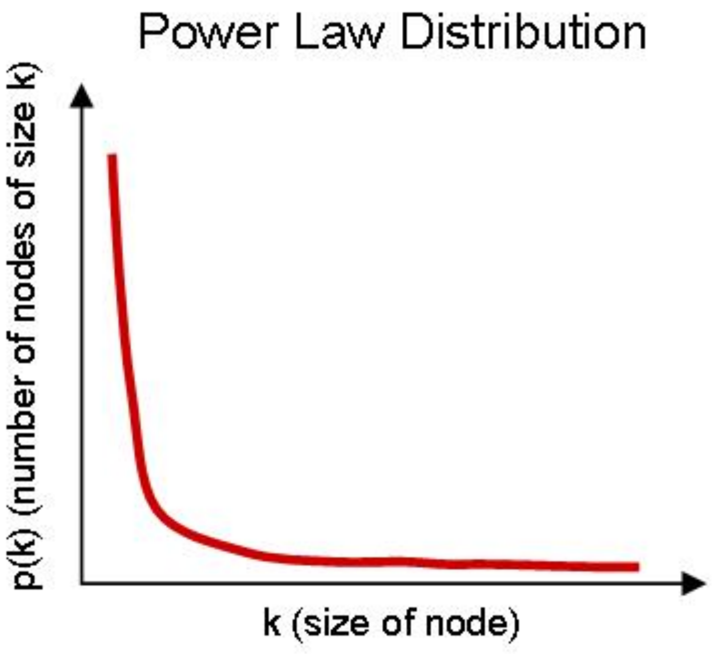
And it has been theoretically proven that the graph sharding problem is NP.

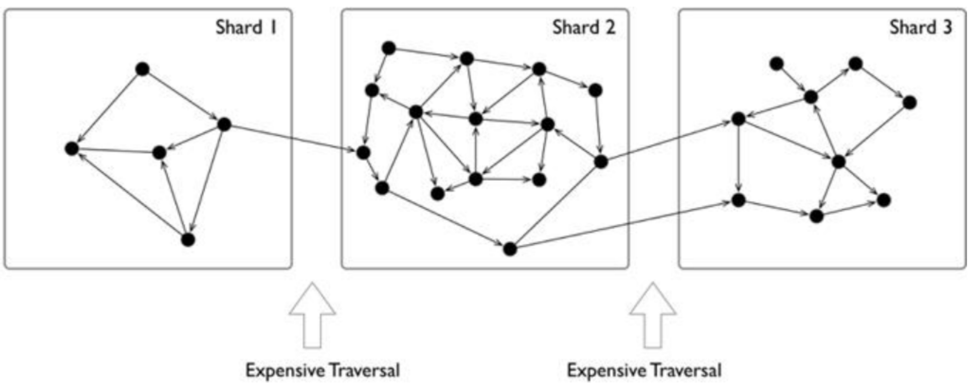
When distributing the entire graph data across multiple servers, the cross-server network access latency is 10 times higher than the hardware (memory) access time inside the same server. Therefore, for some depth-first traversal scenarios, a large number of cross-network accesses occur, resulting in extremely high overall latency.



[7]

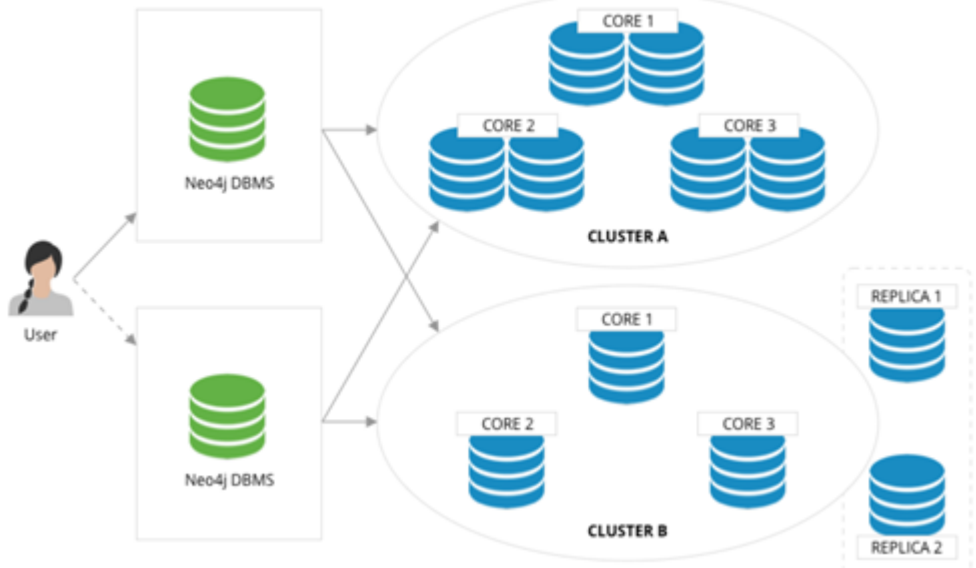
Usually, graphs have a clear power-law distribution. A small number of vertices have much denser neighboring edges than the average vertices. Though processing these vertices can usually be within the same server which reduces cross-network access, load will be far more heavier than the average.



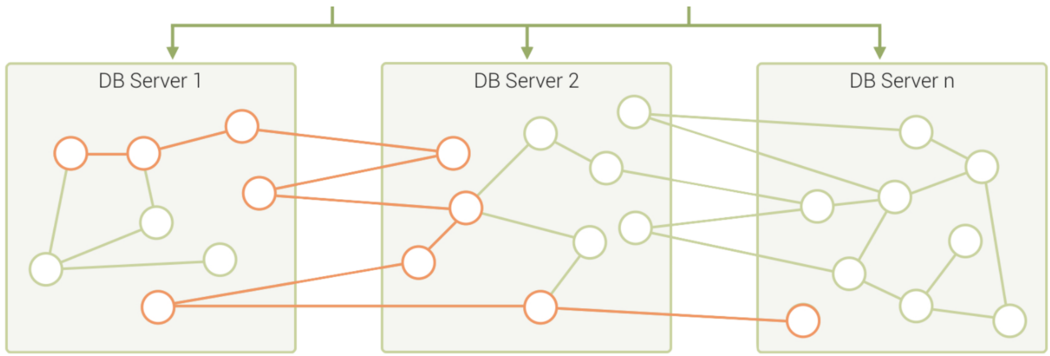


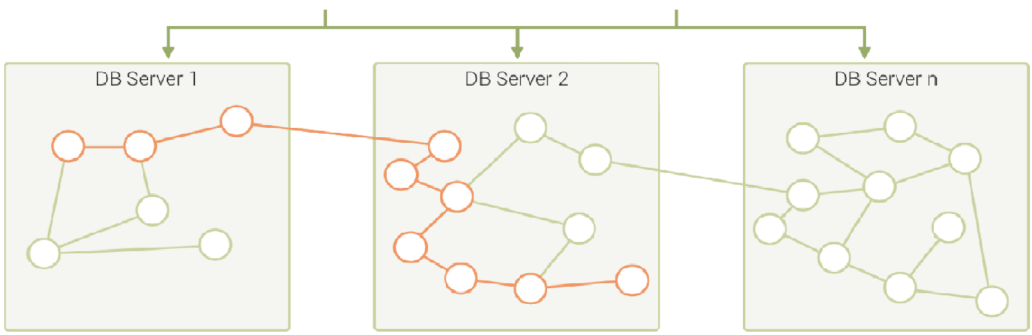
The common graph sharding methods are as follows:

- Application-level sharding: The application layer senses and controls which shard each vertex and edge should locate on based on the type of vertices and edges. A set of vertices of the same type is placed on one sharding and another set of vertices of the same type is placed on another sharding. Of course, for high reliability, the sharding itself can also be made multiple replicas. When used by the application, the desired vertices and edges are fetched from each shard, and then on the off-application side (or some proxy server-side), the fetched data is assembled into the final result. This is typically represented by the Neo4j 4. x Fabric.



- Using a distributed cache layer: Add a memory cache layer on the top of the hard disk and cache important portions of the sharding and data and preheat that cache.
- Adding read-only replicas or views: Add read-only replicas or create a view for some of the graph sharding, and pass the heavier load of read requests through these sharding servers.
- Performing fine-grained graph sharding: Form multiple small partitions of vertices and edges instead of one large sharding, and then place the more correlated partitions on the same server as much as possible. [8].





A mixture of these approaches is also used in specific engineering practices. Usually, offline graph processing systems perform some degree of graph preprocessing to improve the locality through an ETL process, while online graph database systems usually choose a periodic data rebalancing process to improve data locality.

Technical challenges

In the literature [9], a thorough investigation of graphs and challenges is done, and the following lists the top ten graph technology challenges.

- Scalability: Loading and upgrading big graphs, performing graph computation and graph traversal, use of triggers and supernodes
- Visualization: Customizable layouts, rendering and display big images, and display dynamic and updated display
- Query language and programming API: Language expressiveness, standards compatibility, compatibility with existing systems, design of subqueries, and associative queries across multiple graphs
- Faster graph algorithms
- Easy to use (configuration and usage)
- Performance metrics and testing
- General graph technology software (e.g., to handle offline, online, streaming computations.)
- ETL
- Debug and test

Open-source graph tools on single machines

There is a common misconception about graph databases that any data access involving graph structure needs to be stored in a graph database.

When the amount of data is not large, single machine memory is enough to store the data. You can use some single-machine open-source tools to store tens of millions of vertices and edges.

- JGraphT[10]: A well-known open-source Java graph theory library, which implements a considerable number of efficient graph algorithms.
- igraph[11]: A lightweight and powerful library, supporting R, Python, and C++.
- NetworkX[12]: The first choice for data scientists doing graph theory analysis.
- Cytoscape[13]: A powerful visual open-source graph analysis tool.
- Gephi[14]: A powerful visual open-source graph analysis tool.
- arrows.app[15]: A simple brain mapping tool for visually generating Cypher statements.

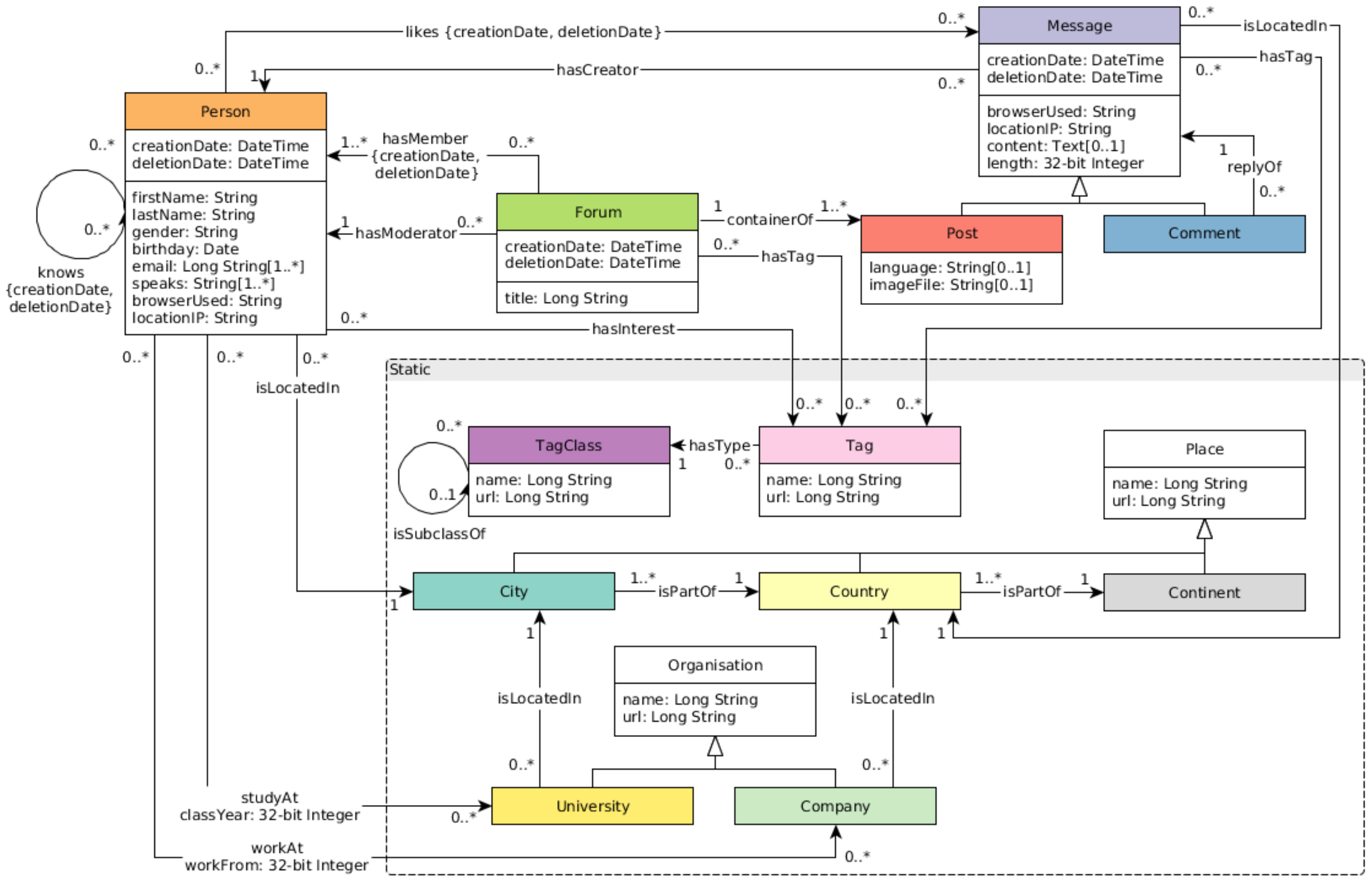
Industry databases and benchmarks

LDBC

LDBC[16] (Linked Data Benchmark Council) is a non-profit organization composed of hardware and software giants such as Oracle, Intel and mainstream graph database vendors such as Neo4j and TigerGraph, which is the benchmark guide developer and test result publisher for graphs and has a high influence in the industry.

SNB (Social Network Benchmark) is one of the benchmarks developed by the Linked Data Benchmark Committee (LDBC) for graph databases and is divided into two scenarios: interactive query (Interactive) and business intelligence (BI). Its role is similar to that of TPC-C, TPC-H, and other tests in SQL-type databases, which can help users compare the functions, performance, and capacity of various graph database products.

An SNB dataset simulates the relationship between people and posts of a social network, taking into account the distribution properties of the social network, the activity of people, and other social information.

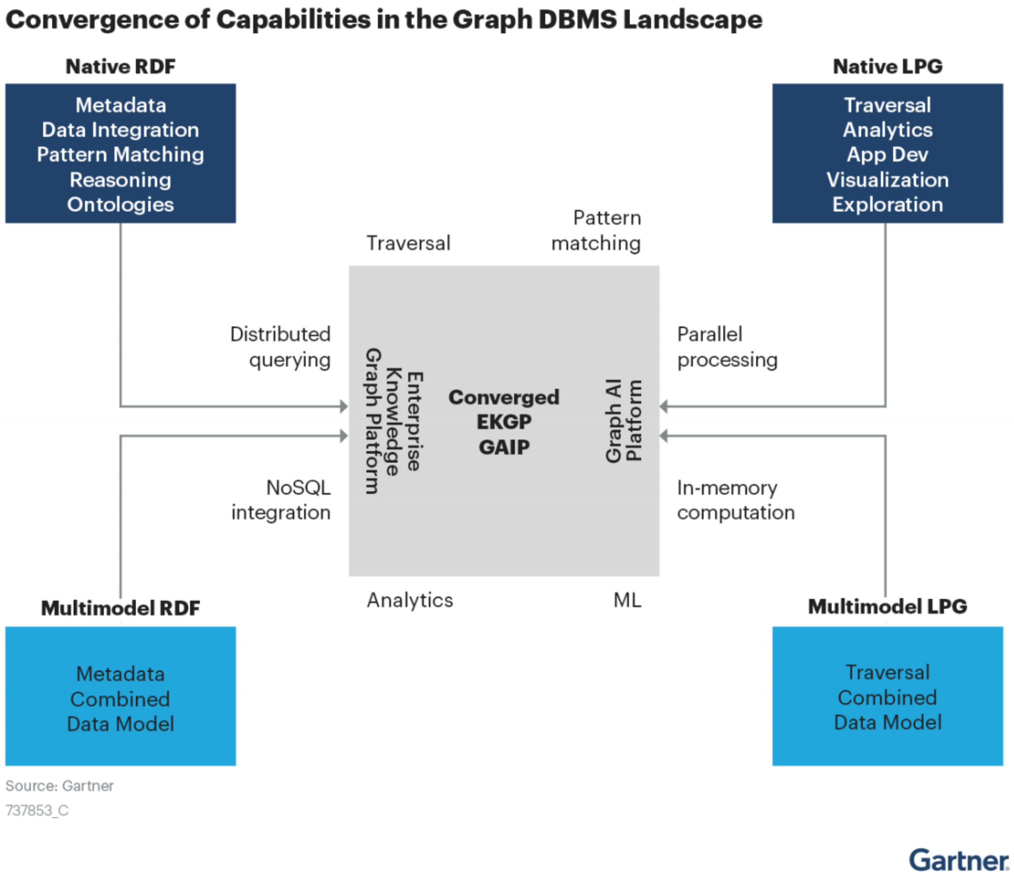


The standard data size ranges from 0.1 GB (scale factor 0.1) to 1000 GB (sf 1000). Larger data sets of 10 TB and 100 TB can also be generated. The number of vertices and edges is as shown below.

Scale Factor	0.1	0.3	1	3	10	30	100	300	1000
# of Persons	1.5K	3.5K	11K	27K	73K	182K	499K	1.25M	3.6M
# of nodes	327.6K	908K	3.2M	9.3M	30M	88.8M	282.6M	817.3M	2.7B
# of edges	1.5M	4.6M	17.3M	52.7M	176.6M	540.9M	1.8B	5.3B	17B

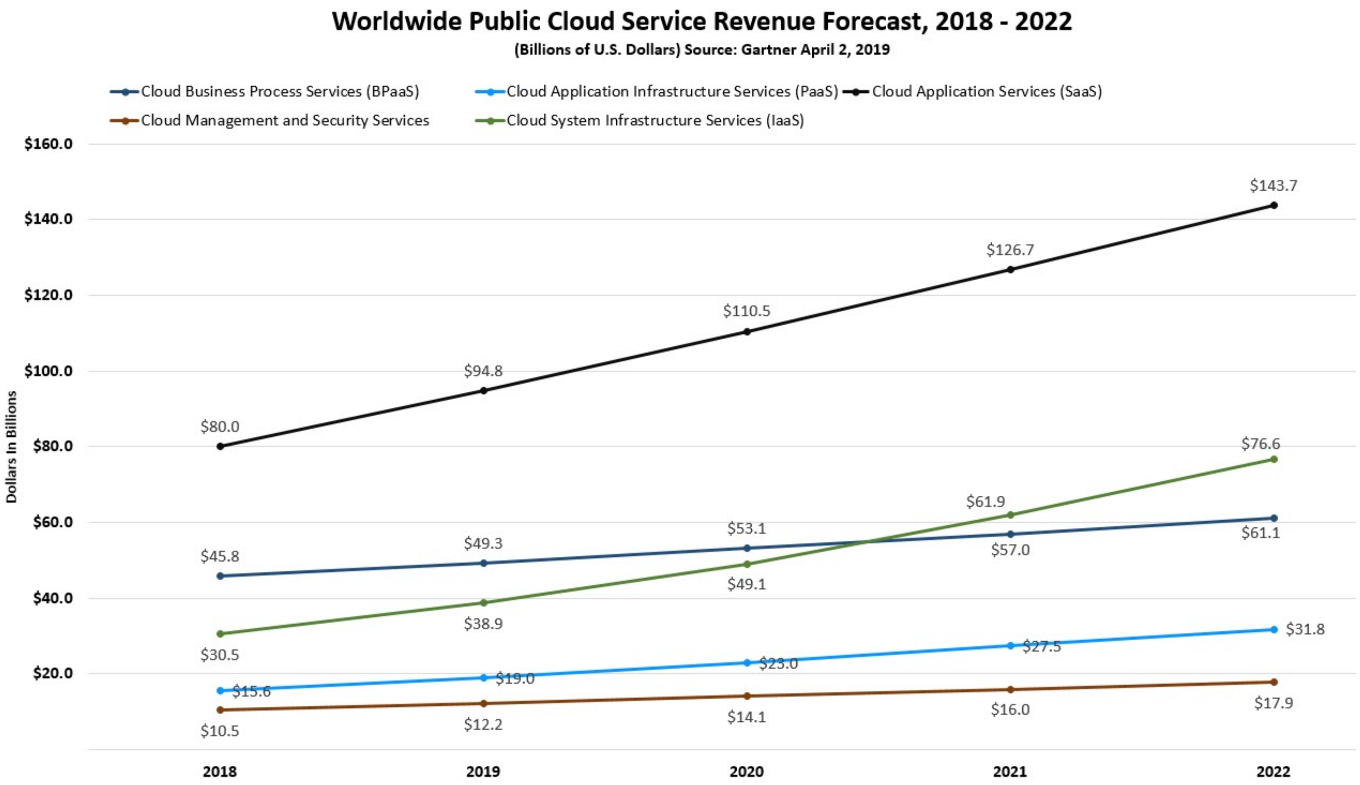
2.3.3 Trends

Graph technologies of different origins and goals are learning from and integrating with each other



The trends in cloud computing place higher demands on scalability.

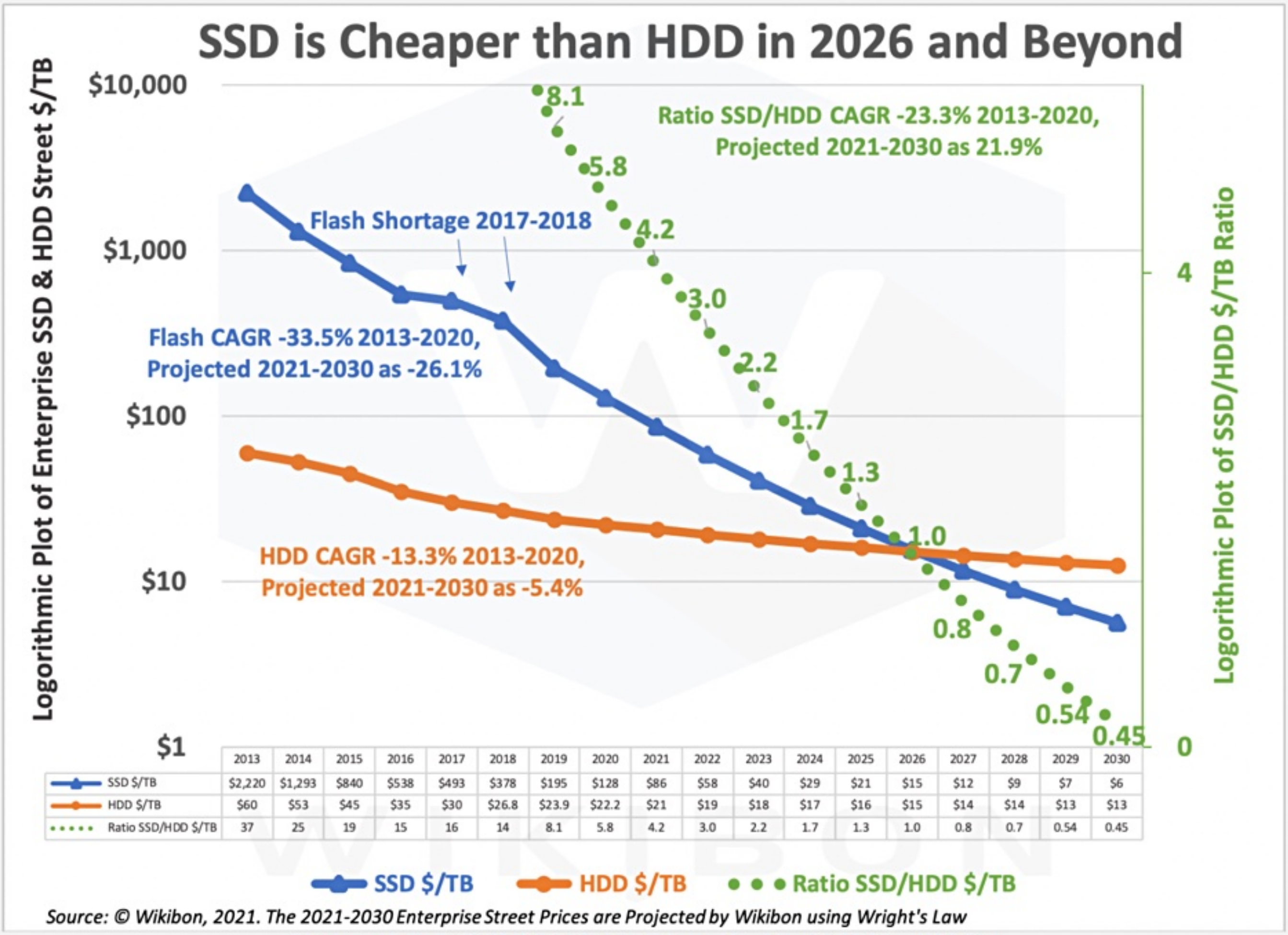
According to Gartner's projections, cloud services have been growing at a rapid rate and penetration [17]. A large number of commercial software is gradually moving from a completely local and private model 10 years ago to a cloud services-based business model. One of the major advantages of cloud services is that they offer near-infinite scalability. It requires that various cloud infrastructure-based software must have a better ability to scale quickly and elastically.



Trends in hardware that SSD will be the mainstream persistent device

Hardware determines software architecture. From the 1950s, when Moore's Law was discovered, to the 00s, when multi-core was introduced, hardware trends and speeds have profoundly determined software architecture. Database systems are mostly designed around "hard disk + memory", high-performance computing systems are mostly designed around "memory + CPU", and distributed systems are designed completely differently for 1 gigabit, 10 gigabits, and RDMA.

Graph traversals are featured as random access. Early graph database systems adopted the large memory + HDD architecture. By designing some data structure in memory, random access can be achieved in memory (B+ trees, Hash tables) for the purpose of optimizing graph topology traversal. And then the random access was converted into sequential reads and writes suitable for HDDs. The entire software architecture (including the storage and compute layers) must be based on and built around such IO processes. With the decline in SSD prices [18], SSDs are replacing HDDs as the dominant device. Friendly random access, deep IO queue, fast access are the features of SSD that differ from HDD's highly repetitive sequence, random latency, and easily damaged disk. The redesign for all software architectures becomes a heavy historical technical burden.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SSD $/TB	$2,220	$1,293	$840	$538	$493	$378	$195	$128	$86	$58	$40	$29	$21	$15	$12	$9	$7	$6
HDD $/TB	$60	$53	$45	$35	$30	$26.8	$23.9	$22.2	$21	$19	$18	$17	$16	$15	$14	$14	$13	$13
Ratio SSD/HDD $/TB	37	25	19	15	16	14	8.1	5.8	4.2	3.0	2.2	1.7	1.3	1.0	0.8	0.7	0.54	0.45

Figure 4 - SSD/HDD Pricing Ratio 2013 - 2030

Source: © Wikibon, 2021.

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1. https://graphaware.com/graphaware/2020/02/17/graph-technology-landscape-2020.html ↩
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3. https://en.wikipedia.org/wiki/Graph_isomorphism ↩
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6. https://neo4j.com/graphacademy/training-iga-40/02-iga-40-overview-of-graph-algorithms/ ↩
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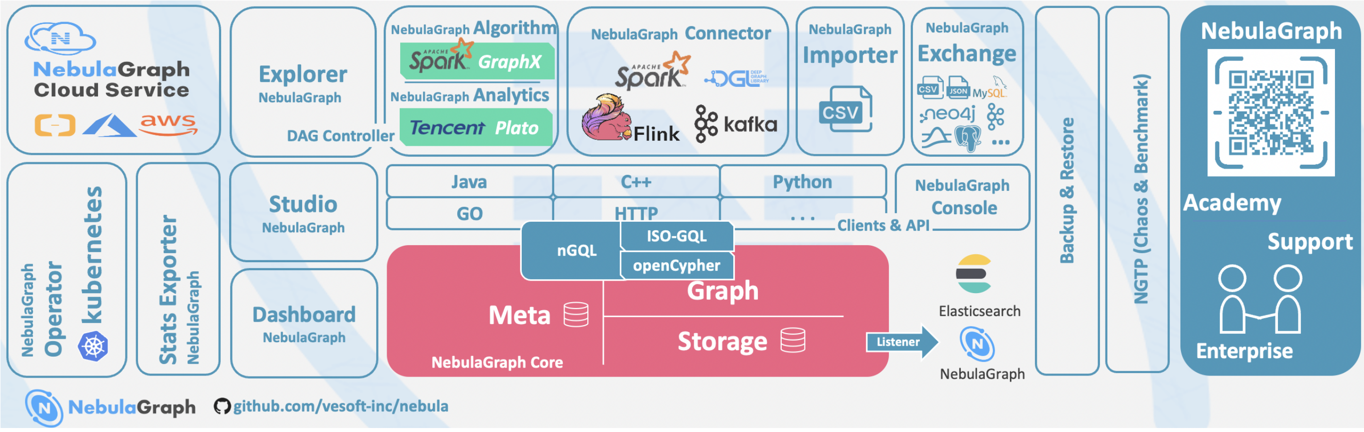
9. https://arxiv.org/abs/1709.03188 ↩
10. https://jgrapht.org/ ↩
11. https://igraph.org/ ↩
12. https://networkx.org/ ↩
13. https://cytoscape.org/ ↩
14. https://gephi.org/ ↩
15. https://arrows.app/ ↩
16. https://github.com/ldbc/ldbc_snb_docs ↩
17. https://cloudcomputing-news.net/news/2019/apr/15/public-cloud-soaring-to-331b-by-2022-according-to-gartner/ ↩
18. https://blocksandfiles.com/2021/01/25/wikibon-ssds-vs-hard-drives-wrights-law/ ↩

Last update: August 11, 2022

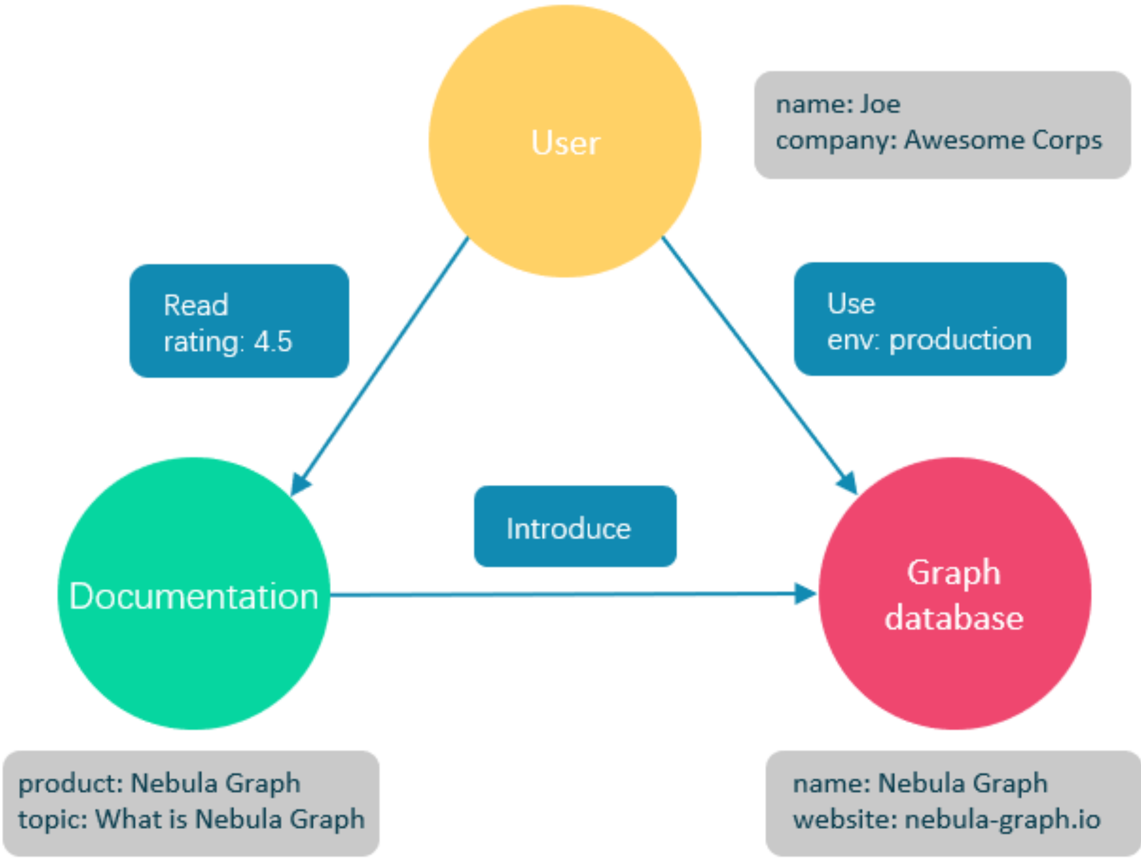
2.4 What is NebulaGraph

NebulaGraph is an open-source, distributed, easily scalable, and native graph database. It is capable of hosting graphs with hundreds of billions of vertices and trillions of edges, and serving queries with millisecond-latency.



2.4.1 What is a graph database

A graph database, such as NebulaGraph, is a database that specializes in storing vast graph networks and retrieving information from them. It efficiently stores data as vertices (nodes) and edges (relationships) in labeled property graphs. Properties can be attached to both vertices and edges. Each vertex can have one or multiple tags (labels).



Graph databases are well suited for storing most kinds of data models abstracted from reality. Things are connected in almost all fields in the world. Modeling systems like relational databases extract the relationships between entities and squeeze them into table columns alone, with their types and properties stored in other columns or even other tables. This makes data management time-consuming and cost-ineffective.

NebulaGraph, as a typical native graph database, allows you to store the rich relationships as edges with edge types and properties directly attached to them.

2.4.2 Advantages of NebulaGraph

Open source

NebulaGraph is open under the Apache 2.0 License. More and more people such as database developers, data scientists, security experts, and algorithm engineers are participating in the designing and development of NebulaGraph. To join the opening of source code and ideas, surf the NebulaGraph GitHub page.

Outstanding performance

Written in C++ and born for graphs, NebulaGraph handles graph queries in milliseconds. Among most databases, NebulaGraph shows superior performance in providing graph data services. The larger the data size, the greater the superiority of NebulaGraph.For more information, see NebulaGraph benchmarking.

High scalability

NebulaGraph is designed in a shared-nothing architecture and supports scaling in and out without interrupting the database service.

Developer friendly

NebulaGraph supports clients in popular programming languages like Java, Python, C++, and Go, and more are under development. For more information, see NebulaGraph clients.

Reliable access control

NebulaGraph supports strict role-based access control and external authentication servers such as LDAP (Lightweight Directory Access Protocol) servers to enhance data security. For more information, see Authentication and authorization.

Diversified ecosystem

More and more native tools of NebulaGraph have been released, such as NebulaGraph Studio, NebulaGraph Console, and NebulaGraph Exchange. For more ecosystem tools, see Ecosystem tools overview.

Besides, NebulaGraph has the ability to be integrated with many cutting-edge technologies, such as Spark, Flink, and HBase, for the purpose of mutual strengthening in a world of increasing challenges and chances.

OpenCypher-compatible query language

The native NebulaGraph Query Language, also known as nGQL, is a declarative, openCypher-compatible textual query language. It is easy to understand and easy to use. For more information, see nGQL guide.

Future-oriented hardware with balanced reading and writing

Solid-state drives have extremely high performance and they are getting cheaper. NebulaGraph is a product based on SSD. Compared with products based on HDD and large memory, it is more suitable for future hardware trends and easier to achieve balanced reading and writing.

Easy data modeling and high flexibility

You can easily model the connected data into NebulaGraph for your business without forcing them into a structure such as a relational table, and properties can be added, updated, and deleted freely. For more information, see Data modeling.

High popularity

NebulaGraph is being used by tech leaders such as Tencent, Vivo, Meituan, and JD Digits. For more information, visit the NebulaGraph official website.

2.4.3 Use cases

NebulaGraph can be used to support various graph-based scenarios. To spare the time spent on pushing the kinds of data mentioned in this section into relational databases and on bothering with join queries, use NebulaGraph.

Fraud detection

Financial institutions have to traverse countless transactions to piece together potential crimes and understand how combinations of transactions and devices might be related to a single fraud scheme. This kind of scenario can be modeled in graphs, and with the help of NebulaGraph, fraud rings and other sophisticated scams can be easily detected.

Real-time recommendation

NebulaGraph offers the ability to instantly process the real-time information produced by a visitor and make accurate recommendations on articles, videos, products, and services.

Intelligent question-answer system

Natural languages can be transformed into knowledge graphs and stored in NebulaGraph. A question organized in a natural language can be resolved by a semantic parser in an intelligent question-answer system and re-organized. Then, possible answers to the question can be retrieved from the knowledge graph and provided to the one who asked the question.

Social networking

Information on people and their relationships is typical graph data. NebulaGraph can easily handle the social networking information of billions of people and trillions of relationships, and provide lightning-fast queries for friend recommendations and job promotions in the case of massive concurrency.

2.4.4 Related links

- Official website
- Docs
- Blogs
- Forum
- GitHub

Last update: January 6, 2023

2.5 Data modeling

A data model is a model that organizes data and specifies how they are related to one another. This topic describes the Nebula Graph data model and provides suggestions for data modeling with NebulaGraph.

2.5.1 Data structures

NebulaGraph data model uses six data structures to store data. They are graph spaces, vertices, edges, tags, edge types and properties.

- **Graph spaces**: Graph spaces are used to isolate data from different teams or programs. Data stored in different graph spaces are securely isolated. Storage replications, privileges, and partitions can be assigned.
- **Vertices**: Vertices are used to store entities.

- In NebulaGraph, vertices are identified with vertex identifiers (i.e. `VID`). The `VID` must be unique in the same graph space. VID should be int64, or fixed_string(N).
- A vertex has zero to multiple tags.

Compatibility

In NebulaGraph 2.x a vertex must have at least one tag. And in NebulaGraph 3.5.0, a tag is not required for a vertex.

- **Edges**: Edges are used to connect vertices. An edge is a connection or behavior between two vertices.
- There can be multiple edges between two vertices.
- Edges are directed. `->` identifies the directions of edges. Edges can be traversed in either direction.
- An edge is identified uniquely with `<a source vertex, an edge type, a rank value, and a destination vertex>`. Edges have no EID.
- An edge must have one and only one edge type.
- The rank value is an immutable user-assigned 64-bit signed integer. It identifies the edges with the same edge type between two vertices. Edges are sorted by their rank values. The edge with the greatest rank value is listed first. The default rank value is zero.

- **Tags**: Tags are used to categorize vertices. Vertices that have the same tag share the same definition of properties.
- **Edge types**: Edge types are used to categorize edges. Edges that have the same edge type share the same definition of properties.
- **Properties**: Properties are key-value pairs. Both vertices and edges are containers for properties.

Note

Tags and Edge types are similar to "vertex tables" and "edge tables" in the relational databases.

2.5.2 Directed property graph

NebulaGraph stores data in directed property graphs. A directed property graph has a set of vertices connected by directed edges. Both vertices and edges can have properties. A directed property graph is represented as:

$G = < V, E, P_V, P_E >$

- **V** is a set of vertices.
- **E** is a set of directed edges.
- **P_V** is the property of vertices.
- **P_E** is the property of edges.

The following table is an example of the structure of the basketball player dataset. We have two types of vertices, that is **player** and **team**, and two types of edges, that is **serve** and **follow**.

Element	Name	Property name (Data type)	Description
Tag	**player**	name (string) age (int)	Represents players in the team.
Tag	**team**	name (string)	Represents the teams.
Edge type	**serve**	start_year (int) end_year (int)	Represents actions taken by players in the team. An action links a player with a team, and the direction is from a player to a team.
Edge type	**follow**	degree (int)	Represents actions taken by players in the team. An action links a player with another player, and the direction is from one player to the other player.

Note

NebulaGraph supports only directed edges.

Compatibility

NebulaGraph 3.5.0 allows dangling edges. Therefore, when adding or deleting, you need to ensure the corresponding source vertex and destination vertex of an edge exist. For details, see INSERT VERTEX, DELETE VERTEX, INSERT EDGE, and DELETE EDGE.

The MERGE statement in openCypher is not supported.

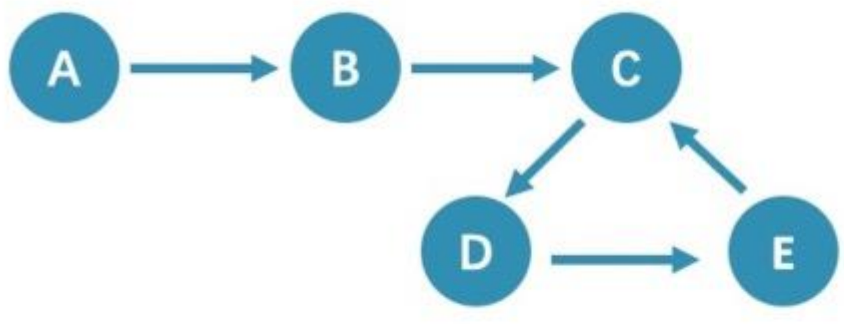
Last update: August 11, 2022

2.6 Path types

In graph theory, a path in a graph is a finite or infinite sequence of edges which joins a sequence of vertices. Paths are fundamental concepts of graph theory.

Paths can be categorized into 3 types: `walk`, `trail`, and `path`. For more information, see Wikipedia.

The following figure is an example for a brief introduction.



2.6.1 Walk

A `walk` is a finite or infinite sequence of edges. Both vertices and edges can be repeatedly visited in graph traversal.

In the above figure C, D, and E form a cycle. So, this figure contains infinite paths, such as `A->B->C->D->E`, `A->B->C->D->E->C`, and `A->B->C->D->E->C->D`.

Note

`GO` statements use `walk`.

2.6.2 Trail

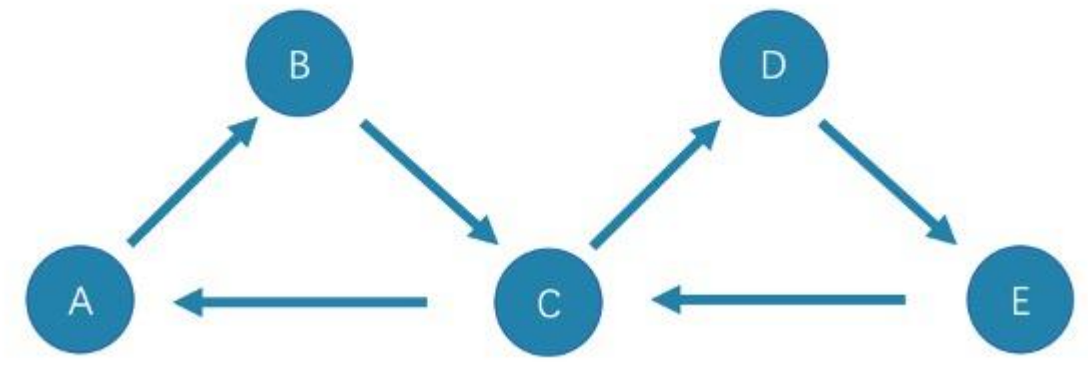
A `trail` is a finite sequence of edges. Only vertices can be repeatedly visited in graph traversal. The Seven Bridges of Königsberg is a typical `trail`.

In the above figure, edges cannot be repeatedly visited. So, this figure contains finite paths. The longest path in this figure consists of 5 edges: `A->B->C->D->E->C`.

Note

`MATCH`, `FIND PATH`, and `GET SUBGRAPH` statements use `trail`.

There are two special cases of trail, `cycle` and `circuit`. The following figure is an example for a brief introduction.



- cycle

  A `cycle` refers to a closed `trail`. Only the terminal vertices can be repeatedly visited. The longest path in this figure consists of 3 edges: `A->B->C->A` or `C->D->E->C`.

- circuit

  A `circuit` refers to a closed `trail`. Edges cannot be repeatedly visited in graph traversal. Apart from the terminal vertices, other vertices can also be repeatedly visited. The longest path in this figure: `A->B->C->D->E->C->A`.

2.6.3 Path

A `path` is a finite sequence of edges. Neither vertices nor edges can be repeatedly visited in graph traversal.

So, the above figure contains finite paths. The longest path in this figure consists of 4 edges: `A->B->C->D->E`.

Last update: March 23, 2022

2.7 VID

In a graph space, a vertex is uniquely identified by its ID, which is called a VID or a Vertex ID.

2.7.1 Features

- The data types of VIDs are restricted to `FIXED_STRING(<N>)` or `INT64`. One graph space can only select one VID type.
- A VID in a graph space is unique. It functions just as a primary key in a relational database. VIDs in different graph spaces are independent.
- The VID generation method must be set by users, because NebulaGraph does not provide auto increasing ID, or UUID.
- Vertices with the same VID will be identified as the same one. For example:
- A VID is the unique identifier of an entity, like a person's ID card number. A tag means the type of an entity, such as driver, and boss. Different tags define two groups of different properties, such as driving license number, driving age, order amount, order taking alt, and job number, payroll, debt ceiling, business phone number.
- When two `INSERT` statements (neither uses a parameter of `IF NOT EXISTS`) with the same VID and tag are operated at the same time, the latter `INSERT` will overwrite the former.
- When two `INSERT` statements with the same VID but different tags, like `TAG A` and `TAG B`, are operated at the same time, the operation of `Tag A` will not affect `Tag B`.
- VIDs will usually be indexed and stored into memory (in the way of LSM-tree). Thus, direct access to VIDs enjoys peak performance.

2.7.2 VID Operation

- NebulaGraph 1.x only supports `INT64` while NebulaGraph 2.x supports `INT64` and `FIXED_STRING(<N>)`. In `CREATE SPACE`, VID types can be set via `vid_type`.
- `id()` function can be used to specify or locate a VID.
- `LOOKUP` or `MATCH` statements can be used to find a VID via property index.
- Direct access to vertices statements via VIDs enjoys peak performance, such as `DELETE xxx WHERE id(xxx) == "player100"` or `GO FROM "player100"`. Finding VIDs via properties and then operating the graph will cause poor performance, such as `LOOKUP | GO FROM $-.ids`, which will run both `LOOKUP` and `|` one more time.

2.7.3 VID Generation

VIDs can be generated via applications. Here are some tips:

- (Optimal) Directly take a unique primary key or property as a VID. Property access depends on the VID.
- Generate a VID via a unique combination of properties. Property access depends on property index.
- Generate a VID via algorithms like snowflake. Property access depends on property index.
- If short primary keys greatly outnumber long primary keys, do not enlarge the `N` of `FIXED_STRING(<N>)` too much. Otherwise, it will occupy a lot of memory and hard disks, and slow down performance. Generate VIDs via BASE64, MD5, hash by encoding and splicing.
- If you generate int64 VID via hash, the probability of collision is about 1/10 when there are 1 billion vertices. The number of edges has no concern with the probability of collision.

2.7.4 Define and modify a VID and its data type

The data type of a VID must be defined when you create the graph space. Once defined, it cannot be modified.

A VID is set when you insert a vertex and cannot be modified.

2.7.5 Query `start vid` and global scan

In most cases, the execution plan of query statements in NebulaGraph (`MATCH` , `GO` , and `LOOKUP`) must query the `start vid` in a certain way.

There are only two ways to locate `start vid` :

1. For example, `GO FROM "player100" OVER` explicitly indicates in the statement that `start vid` is "player100".
2. For example, `LOOKUP ON player WHERE player.name == "Tony Parker"` or `MATCH (v:player {name:"Tony Parker"})` locates `start vid` by the index of the property `player.name` .

Last update: April 25, 2023

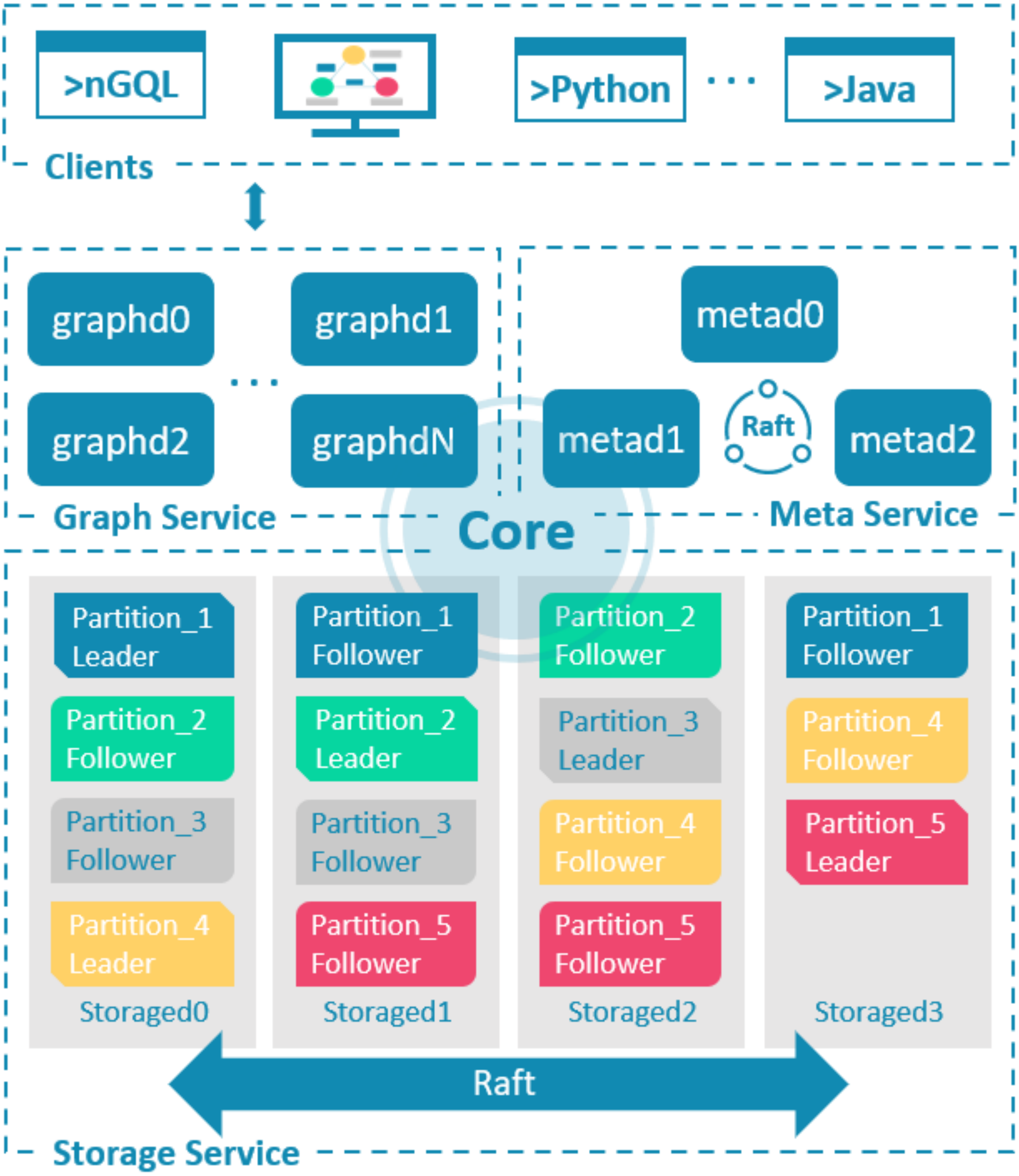
2.8 NebulaGraph architecture

2.8.1 Architecture overview

NebulaGraph consists of three services: the Graph Service, the Storage Service, and the Meta Service. It applies the separation of storage and computing architecture.

Each service has its executable binaries and processes launched from the binaries. Users can deploy a NebulaGraph cluster on a single machine or multiple machines using these binaries.

The following figure shows the architecture of a typical NebulaGraph cluster.



The Meta Service

The Meta Service in the NebulaGraph architecture is run by the nebula-metad processes. It is responsible for metadata management, such as schema operations, cluster administration, and user privilege management.

For details on the Meta Service, see Meta Service.

The Graph Service and the Storage Service

NebulaGraph applies the separation of storage and computing architecture. The Graph Service is responsible for querying. The Storage Service is responsible for storage. They are run by different processes, i.e., nebula-graphd and nebula-storaged. The benefits of the separation of storage and computing architecture are as follows:

- Great scalability

  The separated structure makes both the Graph Service and the Storage Service flexible and easy to scale in or out.

- High availability

  If part of the Graph Service fails, the data stored by the Storage Service suffers no loss. And if the rest part of the Graph Service is still able to serve the clients, service recovery can be performed quickly, even unfelt by the users.

- Cost-effective

  The separation of storage and computing architecture provides a higher resource utilization rate, and it enables clients to manage the cost flexibly according to business demands.

- Open to more possibilities

  With the ability to run separately, the Graph Service may work with multiple types of storage engines, and the Storage Service may also serve more types of computing engines.

For details on the Graph Service and the Storage Service, see Graph Service and Storage Service.

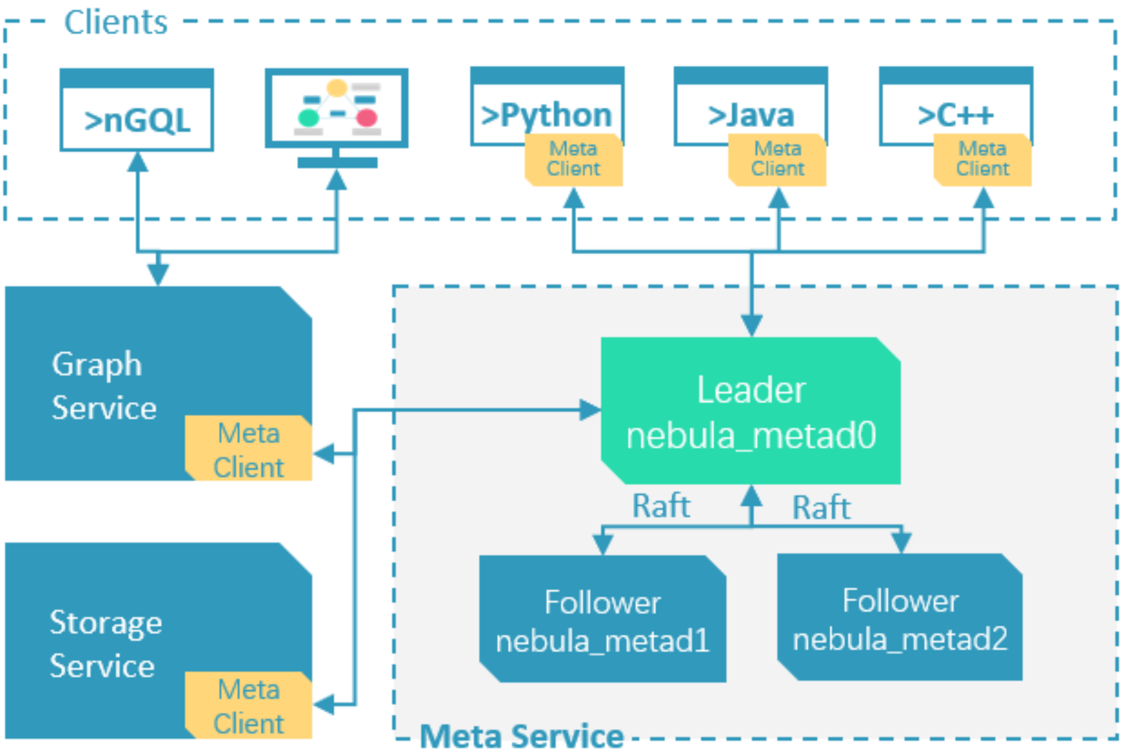
Last update: August 11, 2022

2.8.2 Meta Service

This topic introduces the architecture and functions of the Meta Service.

The architecture of the Meta Service

The architecture of the Meta Service is as follows:



The Meta Service is run by nebula-metad processes. Users can deploy nebula-metad processes according to the scenario:

- In a test environment, users can deploy one or three nebula-metad processes on different machines or a single machine.
- In a production environment, we recommend that users deploy three nebula-metad processes on different machines for high availability.

All the nebula-metad processes form a Raft-based cluster, with one process as the leader and the others as the followers.

The leader is elected by the majorities and only the leader can provide service to the clients or other components of NebulaGraph. The followers will be run in a standby way and each has a data replication of the leader. Once the leader fails, one of the followers will be elected as the new leader.

Note

The data of the leader and the followers will keep consistent through Raft. Thus the breakdown and election of the leader will not cause data inconsistency. For more information on Raft, see Storage service architecture.

Functions of the Meta Service

MANAGES USER ACCOUNTS

The Meta Service stores the information of user accounts and the privileges granted to the accounts. When the clients send queries to the Meta Service through an account, the Meta Service checks the account information and whether the account has the right privileges to execute the queries or not.

For more information on NebulaGraph access control, see Authentication.

MANAGES PARTITIONS

The Meta Service stores and manages the locations of the storage partitions and helps balance the partitions.

MANAGES GRAPH SPACES

NebulaGraph supports multiple graph spaces. Data stored in different graph spaces are securely isolated. The Meta Service stores the metadata of all graph spaces and tracks the changes of them, such as adding or dropping a graph space.

MANAGES SCHEMA INFORMATION

NebulaGraph is a strong-typed graph database. Its schema contains tags (i.e., the vertex types), edge types, tag properties, and edge type properties.

The Meta Service stores the schema information. Besides, it performs the addition, modification, and deletion of the schema, and logs the versions of them.

For more information on NebulaGraph schema, see Data model.

MANAGES TTL INFORMATION

The Meta Service stores the definition of TTL (Time to Live) options which are used to control data expiration. The Storage Service takes care of the expiring and evicting processes. For more information, see TTL.

MANAGES JOBS

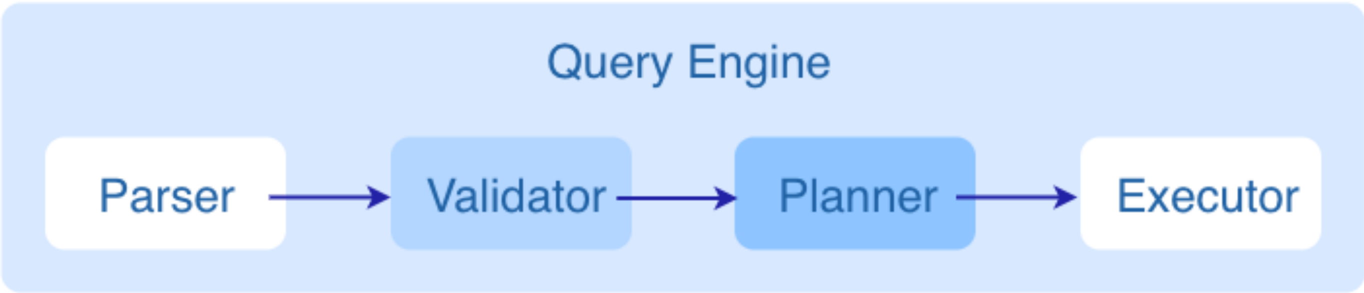
The Job Management module in the Meta Service is responsible for the creation, queuing, querying, and deletion of jobs.

Last update: August 11, 2022

2.8.3 Graph Service

The Graph Service is used to process the query. It has four submodules: Parser, Validator, Planner, and Executor. This topic will describe the Graph Service accordingly.

The architecture of the Graph Service



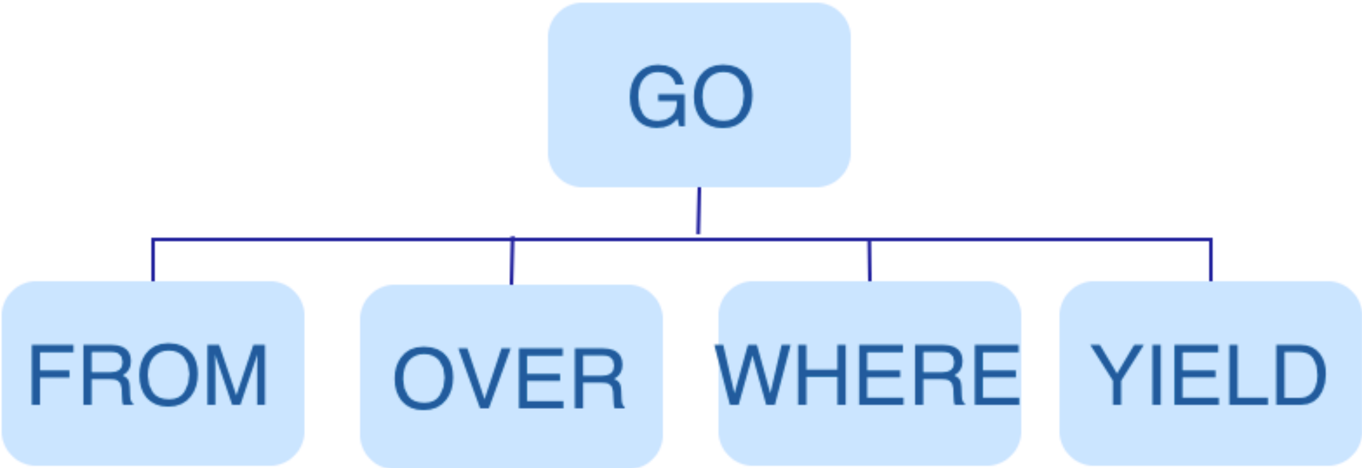
After a query is sent to the Graph Service, it will be processed by the following four submodules:

1. **Parser**: Performs lexical analysis and syntax analysis.
2. **Validator**: Validates the statements.
3. **Planner**: Generates and optimizes the execution plans.
4. **Executor**: Executes the plans with operators.

Parser

After receiving a request, the statements will be parsed by Parser composed of Flex (lexical analysis tool) and Bison (syntax analysis tool), and its corresponding AST will be generated. Statements will be directly intercepted in this stage because of their invalid syntax.

For example, the structure of the AST of `GO FROM "Tim" OVER like WHERE properties(edge).likeness > 8.0 YIELD dst(edge)` is shown in the following figure.



Validator

Validator performs a series of validations on the AST. It mainly works on these tasks:

- Validating metadata

  Validator will validate whether the metadata is correct or not.

  When parsing the `OVER`, `WHERE`, and `YIELD` clauses, Validator looks up the Schema and verifies whether the edge type and tag data exist or not. For an `INSERT` statement, Validator verifies whether the types of the inserted data are the same as the ones defined in the Schema.

- Validating contextual reference

  Validator will verify whether the cited variable exists or not, or whether the cited property is variable or not.

  For composite statements, like `$var = GO FROM "Tim" OVER like YIELD dst(edge) AS ID; GO FROM $var.ID OVER serve YIELD dst(edge)`, Validator verifies first to see if `var` is defined, and then to check if the `ID` property is attached to the `var` variable.

- Validating type inference

  Validator infers what type the result of an expression is and verifies the type against the specified clause.

  For example, the `WHERE` clause requires the result to be a `bool` value, a `NULL` value, or `empty`.

- Validating the information of `*`

  Validator needs to verify all the Schema that involves `*` when verifying the clause if there is a `*` in the statement.

  Take a statement like `GO FROM "Tim" OVER * YIELD dst(edge), properties(edge).likeness, dst(edge)` as an example. When verifying the `OVER` clause, Validator needs to verify all the edge types. If the edge type includes `like` and `serve`, the statement would be `GO FROM "Tim" OVER like,serve YIELD dst(edge), properties(edge).likeness, dst(edge)`.

- Validating input and output

  Validator will check the consistency of the clauses before and after the `|`.

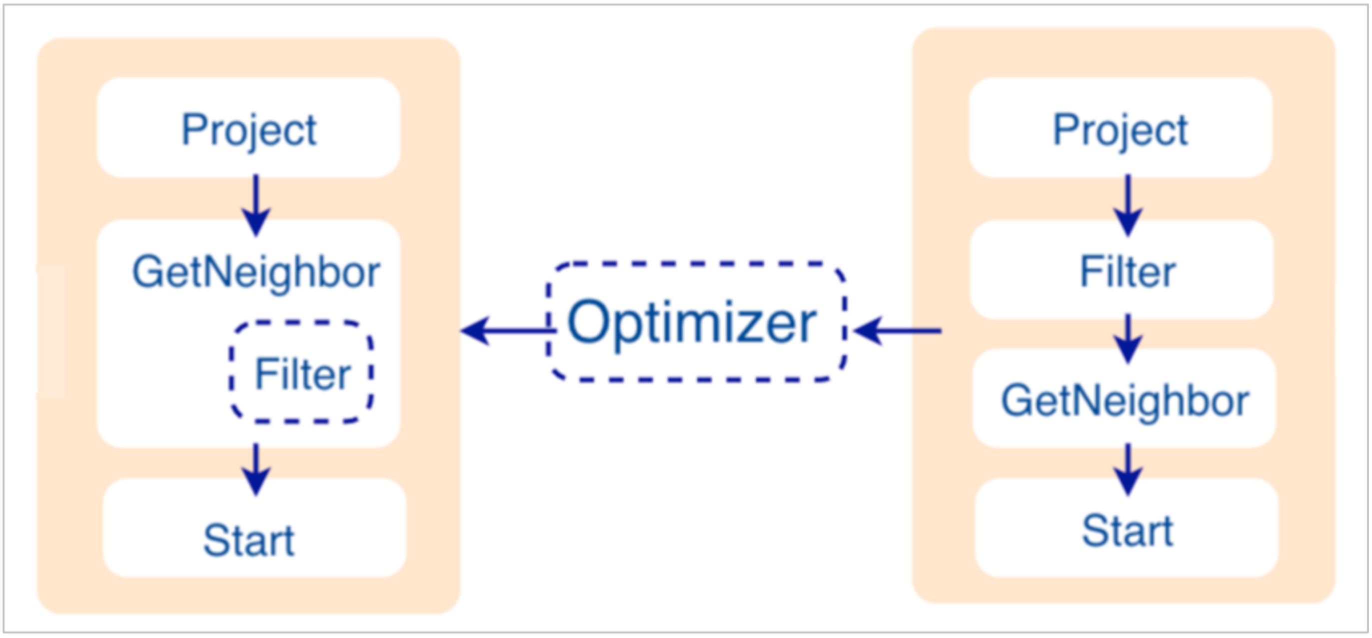
  In the statement `GO FROM "Tim" OVER like YIELD dst(edge) AS ID | GO FROM $-.ID OVER serve YIELD dst(edge)`, Validator will verify whether `$-.ID` is defined in the clause before the `|`.

When the validation succeeds, an execution plan will be generated. Its data structure will be stored in the `src/planner` directory.

Planner

In the `nebula-graphd.conf` file, when `enable_optimizer` is set to be `false`, Planner will not optimize the execution plans generated by Validator. It will be executed by Executor directly.

In the `nebula-graphd.conf` file, when `enable_optimizer` is set to be `true`, Planner will optimize the execution plans generated by Validator. The structure is as follows.



- Before optimization

  In the execution plan on the right side of the preceding figure, each node directly depends on other nodes. For example, the root node `Project` depends on the `Filter` node, the `Filter` node depends on the `GetNeighbor` node, and so on, up to the leaf node `Start`. Then the execution plan is (not truly) executed.

  During this stage, every node has its input and output variables, which are stored in a hash table. The execution plan is not truly executed, so the value of each key in the associated hash table is empty (except for the `Start` node, where the input variables hold the starting data), and the hash table is defined in `src/context/ExecutionContext.cpp` under the `nebula-graph` repository.

  For example, if the hash table is named as `ResultMap` when creating the `Filter` node, users can determine that the node takes data from `ResultMap["GN1"]`, then puts the result into `ResultMap["Filter2"]`, and so on. All these work as the input and output of each node.

- Process of optimization

  The optimization rules that Planner has implemented so far are considered RBO (Rule-Based Optimization), namely the pre-defined optimization rules. The CBO (Cost-Based Optimization) feature is under development. The optimized code is in the `src/optimizer/` directory under the `nebula-graph` repository.

  RBO is a “bottom-up” exploration process. For each rule, the root node of the execution plan (in this case, the `Project` node) is the entry point, and step by step along with the node dependencies, it reaches the node at the bottom to see if it matches the rule.

  As shown in the preceding figure, when the `Filter` node is explored, it is found that its children node is `GetNeighbors`, which matches successfully with the pre-defined rules, so a transformation is initiated to integrate the `Filter` node into the `GetNeighbors` node, the `Filter` node is removed, and then the process continues to the next rule. Therefore, when the `GetNeighbor` operator calls interfaces of the Storage layer to get the neighboring edges of a vertex during the execution stage, the Storage layer will directly filter out the unqualified edges internally. Such optimization greatly reduces the amount of data transfer, which is commonly known as filter pushdown.

Executor

The Executor module consists of Scheduler and Executor. The Scheduler generates the corresponding execution operators against the execution plan, starting from the leaf nodes and ending at the root node. The structure is as follows.

Each node of the execution plan has one execution operator node, whose input and output have been determined in the execution plan. Each operator only needs to get the values for the input variables, compute them, and finally put the results into the corresponding output variables. Therefore, it is only necessary to execute step by step from `Start`, and the result of the last operator is returned to the user as the final result.

Source code hierarchy

The source code hierarchy under the nebula-graph repository is as follows.

```
|--src
   |--graph
      |--context    //contexts for validation and execution
      |--executor   //execution operators
      |--gc         //garbage collector
      |--optimizer  //optimization rules
      |--planner    //structure of the execution plans
      |--scheduler  //scheduler
      |--service    //external service management
      |--session    //session management
      |--stats      //monitoring metrics
      |--util       //basic components
      |--validator  //validation of the statements
      |--visitor    //visitor expression
```

Last update: August 9, 2022

2.8.4 Storage Service

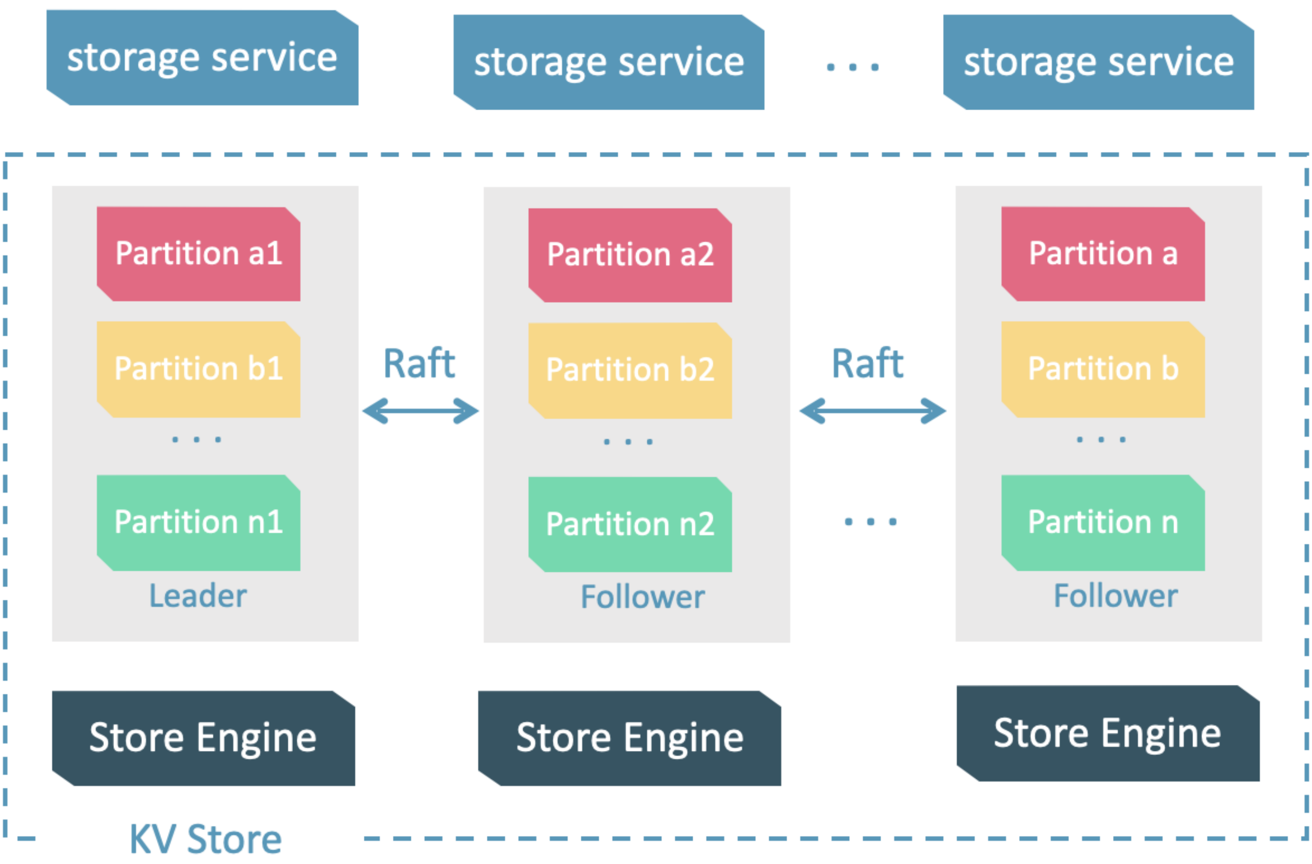
The persistent data of NebulaGraph have two parts. One is the Meta Service that stores the meta-related data.

The other is the Storage Service that stores the data, which is run by the nebula-storaged process. This topic will describe the architecture of the Storage Service.

Advantages

- High performance (Customized built-in KVStore)
- Great scalability (Shared-nothing architecture, not rely on NAS/SAN-like devices)
- Strong consistency (Raft)
- High availability (Raft)
- Supports synchronizing with the third party systems, such as Elasticsearch.

The architecture of the Storage Service



The Storage Service is run by the nebula-storaged process. Users can deploy nebula-storaged processes on different occasions. For example, users can deploy 1 nebula-storaged process in a test environment and deploy 3 nebula-storaged processes in a production environment.

All the nebula-storaged processes consist of a Raft-based cluster. There are three layers in the Storage Service:

- Storage interface

  The top layer is the storage interface. It defines a set of APIs that are related to the graph concepts. These API requests will be translated into a set of KV operations targeting the corresponding Partition. For example:

- `getNeighbors`: queries the in-edge or out-edge of a set of vertices, returns the edges and the corresponding properties, and supports conditional filtering.
- `insert vertex/edge`: inserts a vertex or edge and its properties.
- `getProps`: gets the properties of a vertex or an edge.

  It is this layer that makes the Storage Service a real graph storage. Otherwise, it is just a KV storage.

- Consensus

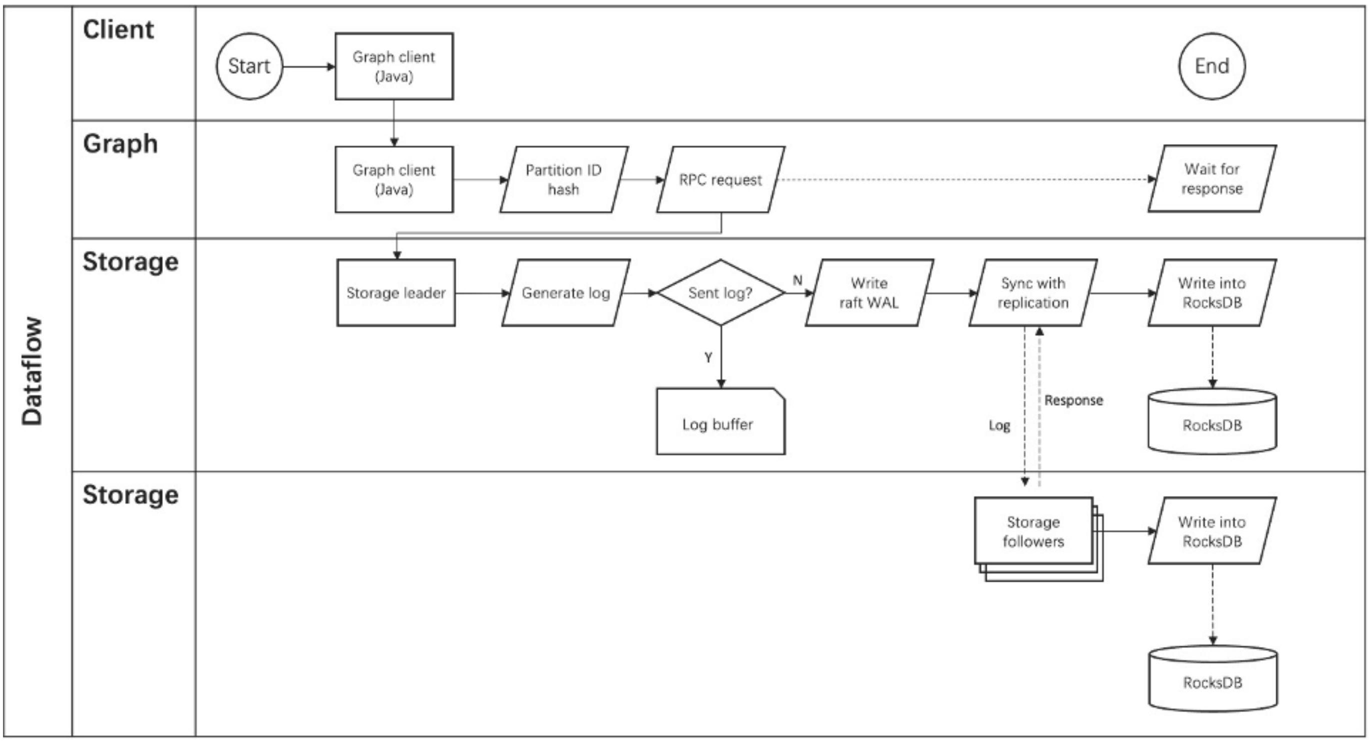
  Below the storage interface is the consensus layer that implements Multi Group Raft, which ensures the strong consistency and high availability of the Storage Service.

- Store engine

  The bottom layer is the local storage engine library, providing operations like `get`, `put`, and `scan` on local disks. The related interfaces are stored in `KVStore.h` and `KVEngine.h` files. You can develop your own local store plugins based on your needs.

The following will describe some features of the Storage Service based on the above architecture.

Storage writing process



KVStore

NebulaGraph develops and customizes its built-in KVStore for the following reasons.

- It is a high-performance KVStore.
- It is provided as a (kv) library and can be easily developed for the filter pushdown purpose. As a strong-typed database, how to provide Schema during pushdown is the key to efficiency for NebulaGraph.
- It has strong data consistency.

Therefore, NebulaGraph develops its own KVStore with RocksDB as the local storage engine. The advantages are as follows.

- For multiple local hard disks, NebulaGraph can make full use of its concurrent capacities through deploying multiple data directories.
- The Meta Service manages all the Storage servers. All the partition distribution data and current machine status can be found in the meta service. Accordingly, users can execute a manual load balancing plan in meta service.

> **Note**
>
> NebulaGraph does not support auto load balancing because auto data transfer will affect online business.

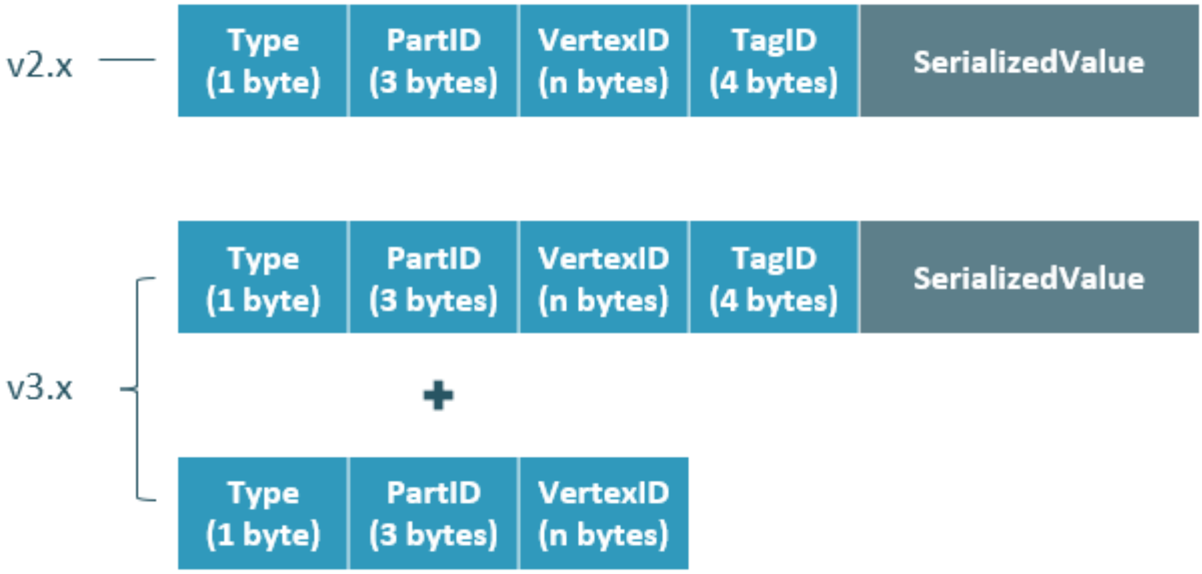
- NebulaGraph provides its own WAL mode so one can customize the WAL. Each partition owns its WAL.
- One NebulaGraph KVStore cluster supports multiple graph spaces, and each graph space has its own partition number and replica copies. Different graph spaces are isolated physically from each other in the same cluster.

Data storage structure

Graphs consist of vertices and edges. NebulaGraph uses key-value pairs to store vertices, edges, and their properties. Vertices and edges are stored in keys and their properties are stored in values. Such structure enables efficient property filtering.

- The storage structure of vertices

  Different from NebulaGraph version 2.x, version 3.x added a new key for each vertex. Compared to the old key that still exists, the new key has no `TagID` field and no value. Vertices in NebulaGraph can now live without tags owing to the new key.



Field	Description
`Type`	One byte, used to indicate the key type.
`PartID`	Three bytes, used to indicate the sharding partition and to scan the partition data based on the prefix when re-balancing the partition.
`VertexID`	The vertex ID. For an integer VertexID, it occupies eight bytes. However, for a string VertexID, it is changed to `fixed_string` of a fixed length which needs to be specified by users when they create the space.
`TagID`	Four bytes, used to indicate the tags that vertex relate with.
`SerializedValue`	The serialized value of the key. It stores the property information of the vertex.

- The storage structure of edges

Field	Description
`Type`	One byte, used to indicate the key type.
`PartID`	Three bytes, used to indicate the partition ID. This field can be used to scan the partition data based on the prefix when re-balancing the partition.
`VertexID`	Used to indicate vertex ID. The former VID refers to the source VID in the outgoing edge and the dest VID in the incoming edge, while the latter VID refers to the dest VID in the outgoing edge and the source VID in the incoming edge.
`Edge Type`	Four bytes, used to indicate the edge type. Greater than zero indicates out-edge, less than zero means in-edge.
`Rank`	Eight bytes, used to indicate multiple edges in one edge type. Users can set the field based on needs and store weight, such as transaction time and transaction number.
`PlaceHolder`	One byte. Reserved.
`SerializedValue`	The serialized value of the key. It stores the property information of the edge.

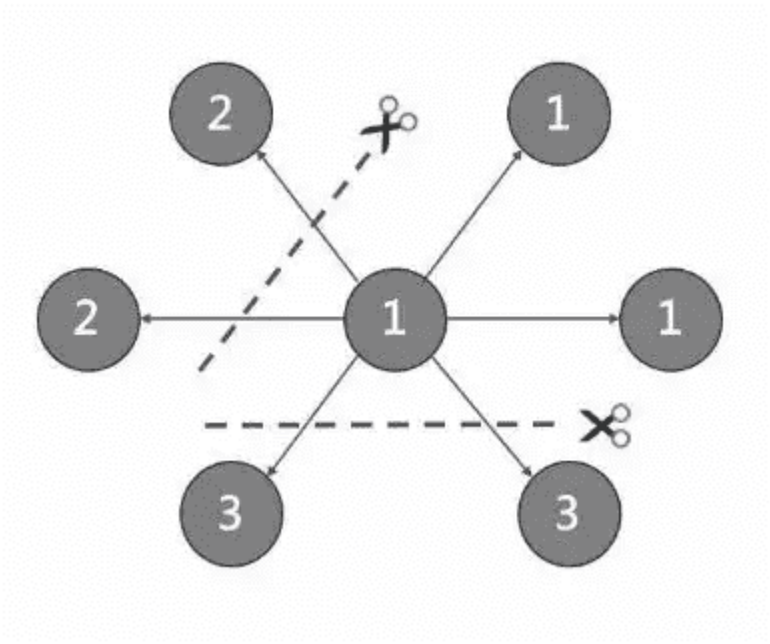
PROPERTY DESCRIPTIONS

NebulaGraph uses strong-typed Schema.

NebulaGraph will store the properties of vertex and edges in order after encoding them. Since the length of properties is fixed, queries can be made in no time according to offset. Before decoding, NebulaGraph needs to get (and cache) the schema information in the Meta Service. In addition, when encoding properties, NebulaGraph will add the corresponding schema version to support online schema change.

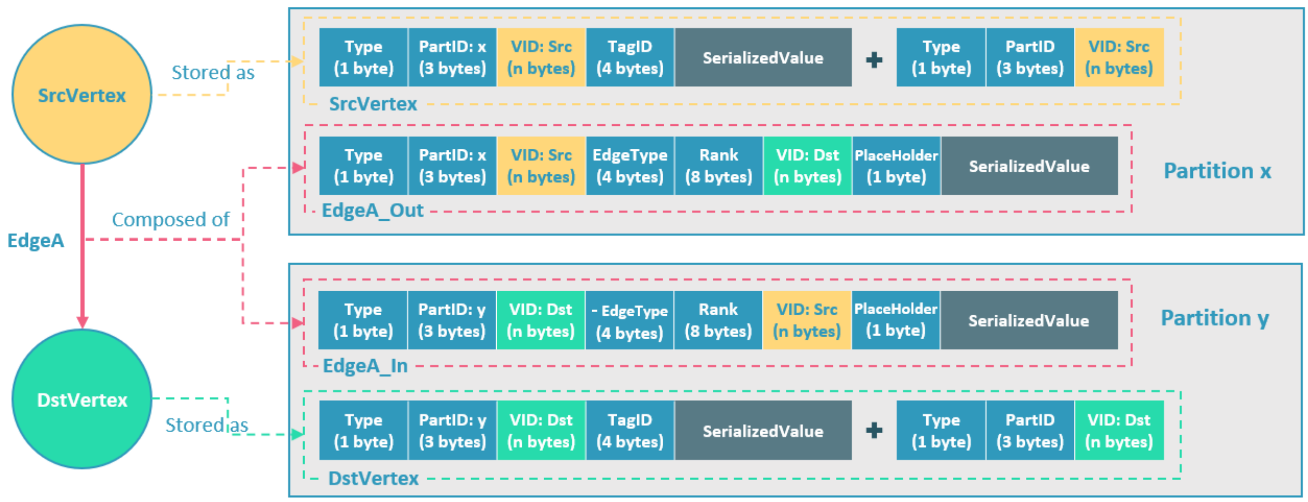
Data partitioning

Since in an ultra-large-scale relational network, vertices can be as many as tens to hundreds of billions, and edges are even more than trillions. Even if only vertices and edges are stored, the storage capacity of both exceeds that of ordinary servers. Therefore, NebulaGraph uses hash to shard the graph elements and store them in different partitions.



EDGE PARTITIONING AND STORAGE AMPLIFICATION

In NebulaGraph, an edge corresponds to two key-value pairs on the hard disk. When there are lots of edges and each has many properties, storage amplification will be obvious. The storage format of edges is shown in the figure below.



In this example, ScrVertex connects DstVertex via EdgeA, forming the path of `(SrcVertex)-[EdgeA]->(DstVertex)`. ScrVertex, DstVertex, and EdgeA will all be stored in Partition x and Partition y as four key-value pairs in the storage layer. Details are as follows:

- The key value of SrcVertex is stored in Partition x. Key fields include Type, PartID(x), VID(Src), and TagID. SerializedValue, namely Value, refers to serialized vertex properties.
- The first key value of EdgeA, namely EdgeA_Out, is stored in the same partition as the ScrVertex. Key fields include Type, PartID(x), VID(Src), EdgeType(+ means out-edge), Rank(0), VID(Dst), and PlaceHolder. SerializedValue, namely Value, refers to serialized edge properties.
- The key value of DstVertex is stored in Partition y. Key fields include Type, PartID(y), VID(Dst), and TagID. SerializedValue, namely Value, refers to serialized vertex properties.
- The second key value of EdgeA, namely EdgeA_In, is stored in the same partition as the DstVertex. Key fields include Type, PartID(y), VID(Dst), EdgeType(- means in-edge), Rank(0), VID(Src), and PlaceHolder. SerializedValue, namely Value, refers to serialized edge properties, which is exactly the same as that in EdgeA_Out.

EdgeA_Out and EdgeA_In are stored in storage layer with opposite directions, constituting EdgeA logically. EdgeA_Out is used for traversal requests starting from SrcVertex, such as `(a)-[]->()`; EdgeA_In is used for traversal requests starting from DstVertex, such as `()-[]->(a)`.

Like EdgeA_Out and EdgeA_In, NebulaGraph redundantly stores the information of each edge, which doubles the actual capacities needed for edge storage. The key corresponding to the edge occupies a small hard disk space, but the space occupied by Value is proportional to the length and amount of the property value. Therefore, it will occupy a relatively large hard disk space if the property value of the edge is large or there are many edge property values.

PARTITION ALGORITHM

NebulaGraph uses a **static Hash** strategy to shard data through a modulo operation on vertex ID. All the out-keys, in-keys, and tag data will be placed in the same partition. In this way, query efficiency is increased dramatically.

Note

The number of partitions needs to be determined when users are creating a graph space since it cannot be changed afterward. Users are supposed to take into consideration the demands of future business when setting it.

When inserting into NebulaGraph, vertices and edges are distributed across different partitions. And the partitions are located on different machines. The number of partitions is set in the CREATE SPACE statement and cannot be changed afterward.

If certain vertices need to be placed on the same partition (i.e., on the same machine), see Formula/code.

The following code will briefly describe the relationship between VID and partition.

```
// If VertexID occupies 8 bytes, it will be stored in int64 to be compatible with the version 1.0.
uint64_t vid = 0;
if (id.size() == 8) {
    memcpy(static_cast<void*>(&vid), id.data(), 8);
} else {
    MurmurHash2 hash;
    vid = hash(id.data());
}
PartitionID pId = vid % numParts + 1;
```

Roughly speaking, after hashing a fixed string to int64, (the hashing of int64 is the number itself), do modulo, and then plus one, namely:

```
pId = vid % numParts + 1;
```

Parameters and descriptions of the preceding formula are as follows:

Parameter	Description
`%`	The modulo operation.
`numParts`	The number of partitions for the graph space where the `VID` is located, namely the value of `partition_num` in the CREATE SPACE statement.
`pId`	The ID for the partition where the `VID` is located.

Suppose there are 100 partitions, the vertices with `VID` 1, 101, and 1001 will be stored on the same partition. But, the mapping between the partition ID and the machine address is random. Therefore, we cannot assume that any two partitions are located on the same machine.

Raft

RAFT IMPLEMENTATION

In a distributed system, one data usually has multiple replicas so that the system can still run normally even if a few copies fail. It requires certain technical means to ensure consistency between replicas.

Basic principle: Raft is designed to ensure consistency between replicas. Raft uses election between replicas, and the (candidate) replica that wins more than half of the votes will become the Leader, providing external services on behalf of all replicas. The rest Followers will play backups. When the Leader fails (due to communication failure, operation and maintenance commands, etc.), the rest Followers will conduct a new round of elections and vote for a new Leader. The Leader and Followers will detect each other's survival through heartbeats and write them to the hard disk in Raft-wal mode. Replicas that do not respond to more than multiple heartbeats will be considered faulty.

Note

Raft-wal needs to be written into the hard disk periodically. If hard disk bottlenecks to write, Raft will fail to send a heartbeat and conduct a new round of elections. If the hard disk IO is severely blocked, there will be no Leader for a long time.

Read and write: For every writing request of the clients, the Leader will initiate a Raft-wal and synchronize it with the Followers. Only after over half replicas have received the Raft-wal will it return to the clients successfully. For every reading request of the clients, it will get to the Leader directly, while Followers will not be involved.

Failure: Scenario 1: Take a (space) cluster of a single replica as an example. If the system has only one replica, the Leader will be itself. If failure happens, the system will be completely unavailable. Scenario 2: Take a (space) cluster of three replicas as an example. If the system has three replicas, one of them will be the Leader and the rest will be the Followers. If the Leader fails, the rest two can still vote for a new Leader (and a Follower), and the system is still available. But if any of the two Followers fails again, the system will be completely unavailable due to inadequate voters.

Note

Raft and HDFS have different modes of duplication. Raft is based on a quorum vote, so the number of replicas cannot be even.

MULTI GROUP RAFT

The Storage Service supports a distributed cluster architecture, so NebulaGraph implements Multi Group Raft according to Raft protocol. Each Raft group stores all the replicas of each partition. One replica is the leader, while others are followers. In this way, NebulaGraph achieves strong consistency and high availability. The functions of Raft are as follows.

NebulaGraph uses Multi Group Raft to improve performance when there are many partitions because Raft-wal cannot be NULL. When there are too many partitions, costs will increase, such as storing information in Raft group, WAL files, or batch operation in low load.

There are two key points to implement the Multi Raft Group:

- To share transport layer

  Each Raft Group sends messages to its corresponding peers. So if the transport layer cannot be shared, the connection costs will be very high.

- To share thread pool

  Raft Groups share the same thread pool to prevent starting too many threads and a high context switch cost.

BATCH

For each partition, it is necessary to do a batch to improve throughput when writing the WAL serially. As NebulaGraph uses WAL to implement some special functions, batches need to be grouped, which is a feature of NebulaGraph.

For example, lock-free CAS operations will execute after all the previous WALs are committed. So for a batch, if there are several WALs in CAS type, we need to divide this batch into several smaller groups and make sure they are committed serially.

TRANSFER LEADERSHIP

Transfer leadership is extremely important for balance. When moving a partition from one machine to another, NebulaGraph first checks if the source is a leader. If so, it should be moved to another peer. After data migration is completed, it is important to balance leader distribution again.

When a transfer leadership command is committed, the leader will abandon its leadership and the followers will start a leader election.

PEER CHANGES

To avoid split-brain, when members in a Raft Group change, an intermediate state is required. In such a state, the quorum of the old group and new group always have an overlap. Thus it prevents the old or new group from making decisions unilaterally. To make it even simpler, in his doctoral thesis Diego Ongaro suggests adding or removing a peer once to ensure the overlap between the quorum of the new group and the old group. NebulaGraph also uses this approach, except that the way to add or remove a member is different. For details, please refer to addPeer/removePeer in the Raft Part class.

Differences with HDFS

The Storage Service is a Raft-based distributed architecture, which has certain differences with that of HDFS. For example:

- The Storage Service ensures consistency through Raft. Usually, the number of its replicas is odd to elect a leader. However, DataNode used by HDFS ensures consistency through NameNode, which has no limit on the number of replicas.
- In the Storage Service, only the replicas of the leader can read and write, while in HDFS all the replicas can do so.
- In the Storage Service, the number of replicas needs to be determined when creating a space, since it cannot be changed afterward. But in HDFS, the number of replicas can be changed freely.
- The Storage Service can access the file system directly. While the applications of HDFS (such as HBase) have to access HDFS before the file system, which requires more RPC times.

In a word, the Storage Service is more lightweight with some functions simplified and its architecture is simpler than HDFS, which can effectively improve the read and write performance of a smaller block of data.

Last update: March 27, 2023

3. Quick start

3.1 Getting started with NebulaGraph

This topic describes how to use NebulaGraph with Docker Desktop and on-premises deployment workflow to quickly get started with NebulaGraph.

3.1.1 Using NebulaGraph with Docker Desktop

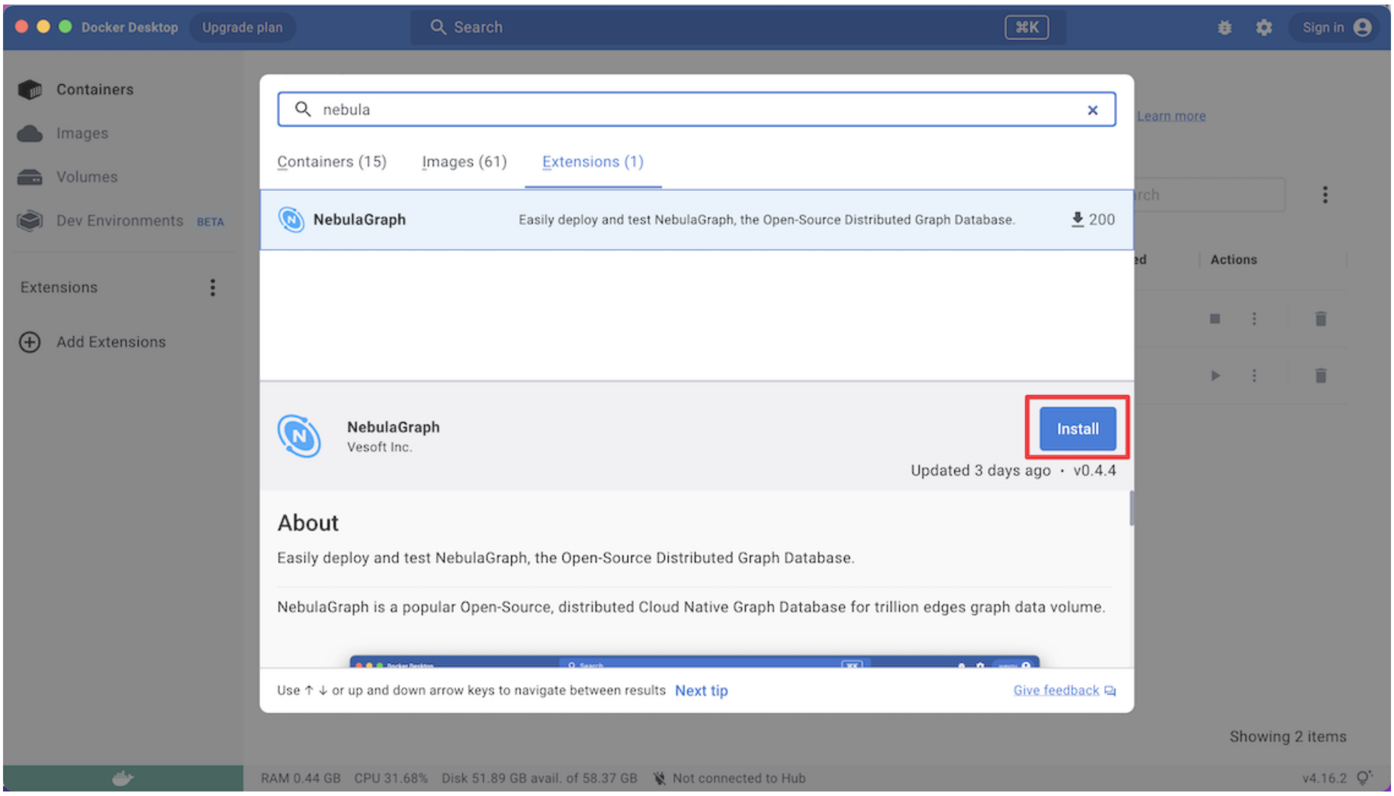
NebulaGraph is available as a Docker Extension that you can easily install and run on your Docker Desktop. You can quickly deploy NebulaGraph using Docker Desktop with just one click.

1. Install Docker Desktop
   - Install Docker Desktop on Mac
   - Install Docker Desktop on Windows

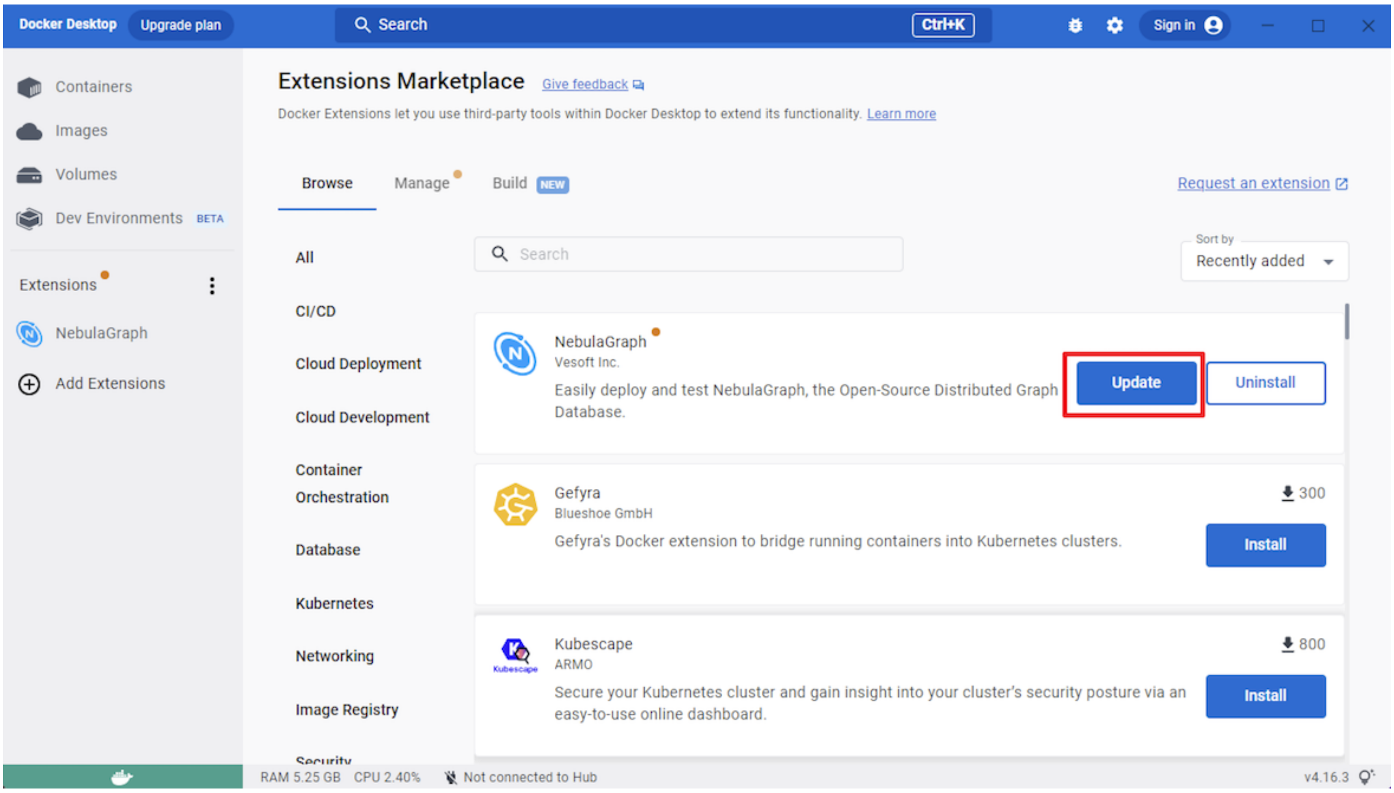
Caution

To install Docker Desktop, you need to install WSL 2 first.

2. In the left sidebar of Docker Desktop, click **Extensions** or **Add Extensions**.
3. On the Extensions Marketplace, search for NebulaGraph and click **Install**.



Click **Update** to update NebulaGraph to the latest version when a new version is available.



4. Click **Open** to navigate to the NebulaGraph extension page.
5. At the top of the page, click **Studio in Browser** to use NebulaGraph.

For more information about how to use NebulaGraph with Docker Desktop, see the following video:

3.1.2 Deploying NebulaGraph on-premises workflow

The following workflow describes how to use NebulaGraph on-premises, including deploying NebulaGraph, connecting to NebulaGraph, and running basic CRUD.

1. Deploy NebulaGraph

   Users can use the RPM or DEB file to quickly deploy NebulaGraph. For other deployment methods and the corresponding preparations, see the **Deployment and installation** chapter.

2. Start NebulaGraph

   Users need to start NebulaGraph after deployment.

3. Connect to NebulaGraph

   Then users can use clients to connect to NebulaGraph. NebulaGraph supports a variety of clients. This topic will describe how to use NebulaGraph Console to connect to NebulaGraph.

4. Register the Storage Service

   When connecting to NebulaGraph for the first time, users must register the Storage Service before querying data.

5. CRUD in NebulaGraph

   Users can use nGQL (NebulaGraph Query Language) to run CRUD after connecting to NebulaGraph.

Last update: March 13, 2023

3.2 Step 1: Install NebulaGraph

RPM and DEB are common package formats on Linux systems. This topic shows how to quickly install NebulaGraph with the RPM or DEB package.

Note

The console is not complied or packaged with NebulaGraph server binaries. You can install nebula-console by yourself.

3.2.1 Prerequisites

Wget installed.

3.2.2 Download the package from cloud service

Note

NebulaGraph is currently only supported for installation on Linux systems, and only CentOS 7.x, CentOS 8.x, Ubuntu 16.04, Ubuntu 18.04, and Ubuntu 20.04 operating systems are supported.

- Download the released version.

  URL:

```
//Centos 6
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.el6.x86_64.rpm

//Centos 7
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.el7.x86_64.rpm

//Centos 8
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.el8.x86_64.rpm

//Ubuntu 1604
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.ubuntu1604.amd64.deb

//Ubuntu 1804
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.ubuntu1804.amd64.deb

//Ubuntu 2004
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.ubuntu2004.amd64.deb
```

  For example, download the release package `3.5.0` for `Centos 7.5`:

```
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.el7.x86_64.rpm
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.el7.x86_64.rpm.sha256sum.txt
```

  Download the release package `3.5.0` for `Ubuntu 1804`:

```
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.ubuntu1804.amd64.deb
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.ubuntu1804.amd64.deb.sha256sum.txt
```

- Download the nightly version.

Danger

- Nightly versions are usually used to test new features. Do not use it in a production environment.
- Nightly versions may not be built successfully every night. And the names may change from day to day.

URL:

```
//Centos 6
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.el6.x86_64.rpm

//Centos 7
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.el7.x86_64.rpm

//Centos 8
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.el8.x86_64.rpm

//Ubuntu 1604
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.ubuntu1604.amd64.deb

//Ubuntu 1804
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.ubuntu1804.amd64.deb

//Ubuntu 2004
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.ubuntu2004.amd64.deb
```

For example, download the `Centos 7.5` package developed and built in `2021.11.28` :

```
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.el7.x86_64.rpm
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.el7.x86_64.rpm.sha256sum.txt
```

For example, download the `Ubuntu 1804` package developed and built in `2021.11.28` :

```
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.ubuntu1804.amd64.deb
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.ubuntu1804.amd64.deb.sha256sum.txt
```

3.2.3 Install NebulaGraph

- Use the following syntax to install with an RPM package.

```
$ sudo rpm -ivh --prefix=<installation_path> <package_name>
```

The option `--prefix` indicates the installation path. The default path is `/usr/local/nebula/` .

For example, to install an RPM package in the default path for the 3.5.0 version, run the following command.

```
sudo rpm -ivh nebula-graph-3.5.0.el7.x86_64.rpm
```

- Use the following syntax to install with a DEB package.

```
$ sudo dpkg -i <package_name>
```

Note

Customizing the installation path is not supported when installing NebulaGraph with a DEB package. The default installation path is `/usr/local/nebula/`.

For example, to install a DEB package for the 3.5.0 version, run the following command.

```
sudo dpkg -i nebula-graph-3.5.0.ubuntu1804.amd64.deb
```

Note

The default installation path is `/usr/local/nebula/`.

3.2.4 Next to do

- Start NebulaGraph
- Connect to NebulaGraph

Last update: August 11, 2022

3.3 Step 2: Manage NebulaGraph Service

NebulaGraph supports managing services with scripts.

3.3.1 Manage services with script

You can use the `nebula.service` script to start, stop, restart, terminate, and check the NebulaGraph services.

Note

`nebula.service` is stored in the `/usr/local/nebula/scripts` directory by default. If you have customized the path, use the actual path in your environment.

Syntax

```
$ sudo /usr/local/nebula/scripts/nebula.service
[-v] [-c <config_file_path>]
<start | stop | restart | kill | status>
<metad | graphd | storaged | all>
```

Parameter	Description
`-v`	Display detailed debugging information.
`-c`	Specify the configuration file path. The default path is `/usr/local/nebula/etc/`.
`start`	Start the target services.
`stop`	Stop the target services.
`restart`	Restart the target services.
`kill`	Terminate the target services.
`status`	Check the status of the target services.
`metad`	Set the Meta Service as the target service.
`graphd`	Set the Graph Service as the target service.
`storaged`	Set the Storage Service as the target service.
`all`	Set all the NebulaGraph services as the target services.

3.3.2 Start NebulaGraph

Run the following command to start NebulaGraph.

```
$ sudo /usr/local/nebula/scripts/nebula.service start all
[INFO] Starting nebula-metad...
[INFO] Done
[INFO] Starting nebula-graphd...
[INFO] Done
[INFO] Starting nebula-storaged...
[INFO] Done
```

3.3.3 Check the service status

Run the following command to check the service status of NebulaGraph.

```
$ sudo /usr/local/nebula/scripts/nebula.service status all
```

- NebulaGraph is running normally if the following information is returned.

```
INFO] nebula-metad(33fd35e): Running as 29020, Listening on 9559
[INFO] nebula-graphd(33fd35e): Running as 29095, Listening on 9669
[WARN] nebula-storaged after v3.0.0 will not start service until it is added to cluster.
[WARN] See Manage Storage hosts:ADD HOSTS in https://docs.nebula-graph.io/
[INFO] nebula-storaged(33fd35e): Running as 29147, Listening on 9779
```

Note

After starting NebulaGraph, the port of the `nebula-storaged` process is shown in red. Because the `nebula-storaged` process waits for the `nebula-metad` to add the current Storage service during the startup process. The Storage works after it receives the ready signal. Starting from NebulaGraph 3.0.0, the Meta service cannot directly read or write data in the Storage service that you add in the configuration file. The configuration file only registers the Storage service to the Meta service. You must run the `ADD HOSTS` command to enable the Meta to read and write data in the Storage service. For more information, see Manage Storage hosts.

- If the returned result is similar to the following one, there is a problem. You may also go to the NebulaGraph community for help.

```
[INFO] nebula-metad: Running as 25600, Listening on 9559
[INFO] nebula-graphd: Exited
[INFO] nebula-storaged: Running as 25646, Listening on 9779
```

The NebulaGraph services consist of the Meta Service, Graph Service, and Storage Service. The configuration files for all three services are stored in the `/usr/local/nebula/etc/` directory by default. You can check the configuration files according to the returned result to troubleshoot problems.

3.3.4 Next to do

Connect to NebulaGraph

Last update: August 11, 2022

3.4 Step 3: Connect to NebulaGraph

This topic provides basic instruction on how to use the native CLI client NebulaGraph Console to connect to NebulaGraph.

Caution

When connecting to NebulaGraph for the first time, you must register the Storage Service before querying data.

NebulaGraph supports multiple types of clients, including a CLI client, a GUI client, and clients developed in popular programming languages. For more information, see the client list.

3.4.1 Prerequisites

- You have started NebulaGraph services.
- The machine on which you plan to run NebulaGraph Console has network access to the Graph Service of NebulaGraph.
- The NebulaGraph Console version is compatible with the NebulaGraph version.

  Note

  NebulaGraph Console and NebulaGraph of the same version number are the most compatible. There may be compatibility issues when connecting to NebulaGraph with a different version of NebulaGraph Console. The error message `incompatible version between client and server` is displayed when there is such an issue.

Steps

1. On the NebulaGraph Console releases page, select a NebulaGraph Console version and click **Assets**.

   Note

   It is recommended to select the **latest** version.

2. In the **Assets** area, find the correct binary file for the machine where you want to run NebulaGraph Console and download the file to the machine.
3. (Optional) Rename the binary file to `nebula-console` for convenience.

   Note

   For Windows, rename the file to `nebula-console.exe`.

4. On the machine to run NebulaGraph Console, grant the execute permission of the nebula-console binary file to the user.

   Note

   For Windows, skip this step.

```
$ chmod 111 nebula-console
```

5. In the command line interface, change the working directory to the one where the nebula-console binary file is stored.

6. Run the following command to connect to NebulaGraph.

- For Linux or macOS:

```
$ ./nebula-console -addr <ip> -port <port> -u <username> -p <password>
[-t 120] [-e "nGQL_statement" | -f filename.nGQL]
```

- For Windows:

```
> nebula-console.exe -addr <ip> -port <port> -u <username> -p <password>
[-t 120] [-e "nGQL_statement" | -f filename.nGQL]
```

Parameter descriptions are as follows:

Parameter	Description
`-h/-help`	Shows the help menu.
`-addr/-address`	Sets the IP address of the Graph service. The default address is 127.0.0.1.
`-P/-port`	Sets the port number of the graphd service. The default port number is 9669.
`-u/-user`	Sets the username of your NebulaGraph account. Before enabling authentication, you can use any existing username. The default username is `root`.
`-p/-password`	Sets the password of your NebulaGraph account. Before enabling authentication, you can use any characters as the password.
`-t/-timeout`	Sets an integer-type timeout threshold of the connection. The unit is millisecond. The default value is 120.
`-e/-eval`	Sets a string-type nGQL statement. The nGQL statement is executed once the connection succeeds. The connection stops after the result is returned.
`-f/-file`	Sets the path of an nGQL file. The nGQL statements in the file are executed once the connection succeeds. The result will be returned and the connection stops then.
`-enable_ssl`	Enables SSL encryption when connecting to NebulaGraph.
`-ssl_root_ca_path`	Sets the storage path of the certification authority file.
`-ssl_cert_path`	Sets the storage path of the certificate file.
`-ssl_private_key_path`	Sets the storage path of the private key file.

For information on more parameters, see the project repository.

Last update: August 11, 2022

3.5 Register the Storage Service

When connecting to NebulaGraph for the first time, you have to add the Storage hosts, and confirm that all the hosts are online.

Compatibility

- Starting from NebulaGraph 3.0.0, you have to run `ADD HOSTS` before reading or writing data into the Storage Service.
- For NebulaGraph of versions earlier than 3.0.0 and NebulaGraph Cloud clusters, `ADD HOSTS` is not needed.

3.5.1 Prerequisites

You have connected to NebulaGraph.

3.5.2 Steps

1. Add the Storage hosts.

   Run the following command to add hosts:

   ```
   ADD HOSTS <ip>:<port> [,<ip>:<port> ...];
   ```

   Example:

   ```
   nebula> ADD HOSTS 192.168.10.100:9779, 192.168.10.101:9779, 192.168.10.102:9779;
   ```

   Caution

   Make sure that the IP you added is the same as the IP configured for `local_ip` in the `nebula-storaged.conf` file. Otherwise, the Storage service will fail to start. For information about configurations, see Configurations.

2. Check the status of the hosts to make sure that they are all online.

   ```
   nebula> SHOW HOSTS;
   +------------------+------+----------+-------------+---------------------  +------------------------+---------+
   | Host             | Port | Status   | Leader count | Leader distribution |   Partition distribution | Version |
   +------------------+------+----------+-------------+---------------------  +------------------------+---------+
   | "192.168.10.100" | 9779 | "ONLINE" | 0           | "No valid partition" | "No   valid partition"   | "3.5.0" |
   | "192.168.10.101" | 9779 | "ONLINE" | 0           | "No valid partition" | "No   valid partition"   | "3.5.0"|
   | "192.168.10.102" | 9779 | "ONLINE" | 0           | "No valid partition" | "No   valid partition"   | "3.5.0"|
   +------------------+------+----------+-------------+---------------------  +------------------------+---------+
   ```

   The `Status` column of the result above shows that all Storage hosts are online.

Last update: January 30, 2023

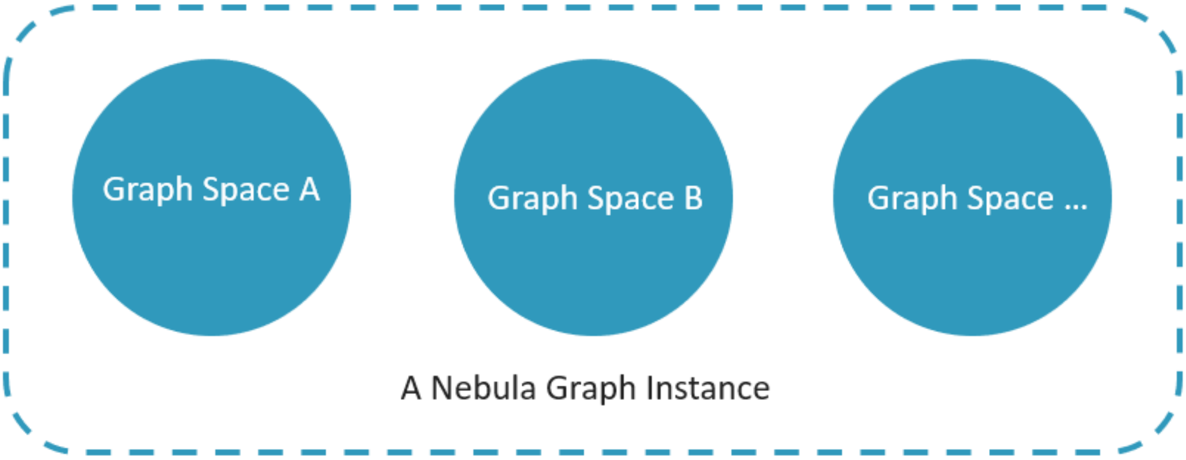
3.6 Step 4: Use nGQL (CRUD)

This topic will describe the basic CRUD operations in NebulaGraph.

For more information, see nGQL guide.

3.6.1 Graph space and NebulaGraph schema

A NebulaGraph instance consists of one or more graph spaces. Graph spaces are physically isolated from each other. You can use different graph spaces in the same instance to store different datasets.

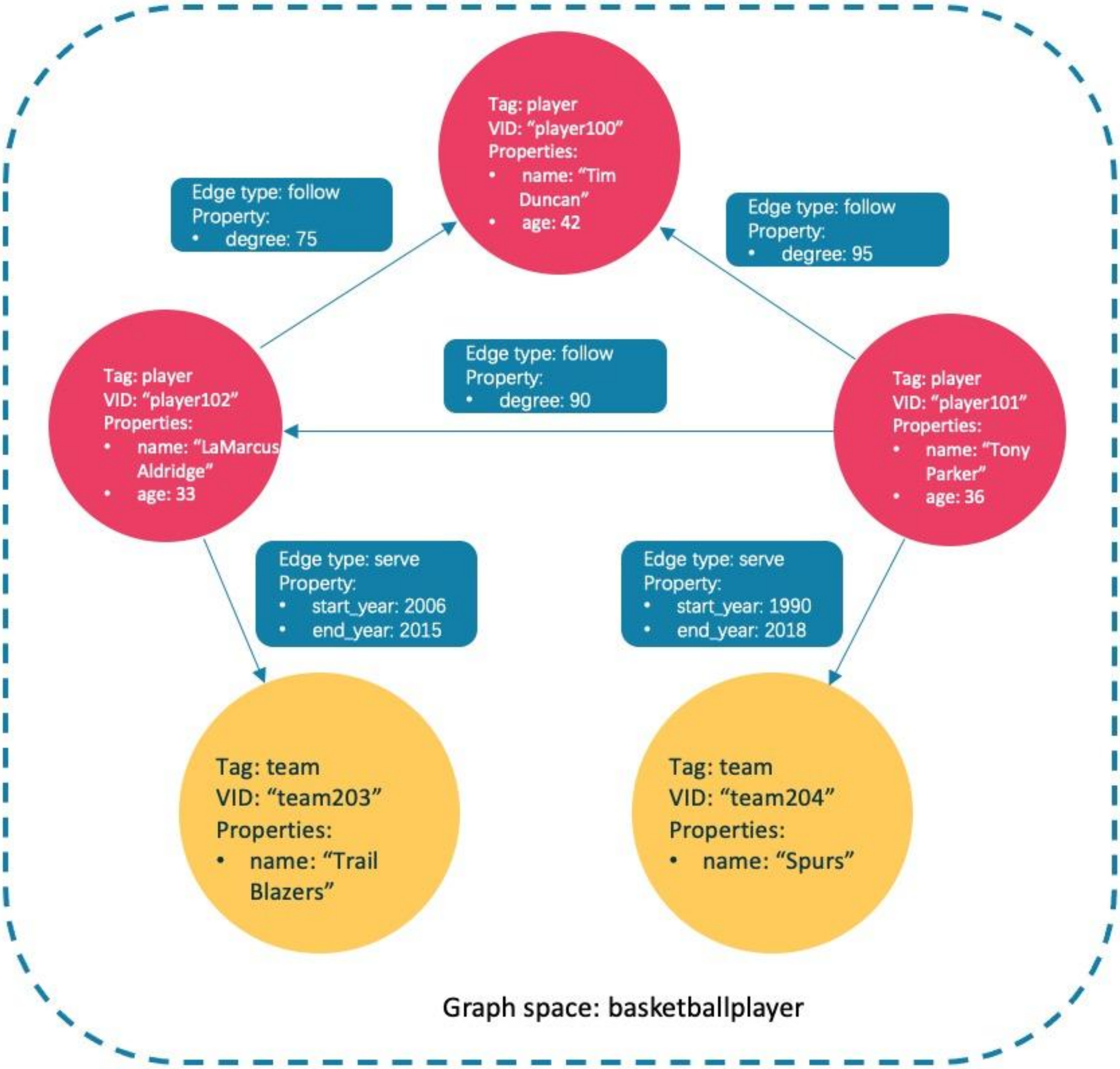


To insert data into a graph space, define a schema for the graph database. NebulaGraph schema is based on the following components.

Schema component	Description
Vertex	Represents an entity in the real world. A vertex can have zero to multiple tags.
Tag	The type of the same group of vertices. It defines a set of properties that describes the types of vertices.
Edge	Represents a **directed** relationship between two vertices.
Edge type	The type of an edge. It defines a group of properties that describes the types of edges.

For more information, see Data modeling.

In this topic, we will use the following dataset to demonstrate basic CRUD operations.


Tag: player
VID: “player100”
Properties:
• name: “Tim Duncan”
• age: 42
Edge type: follow
Property:
• degree: 75
Edge type: follow
Property:
• degree: 95
Tag: player
VID: “player102”
Properties:
• name: “LaMarcus Aldridge”
• age: 33
Edge type: follow
Property:
• degree: 90
Tag: player
VID: “player101”
Properties:
• name: “Tony Parker”
• age: 36
Edge type: serve
Property:
• start_year: 2006
• end_year: 2015
Edge type: serve
Property:
• start_year: 1990
• end_year: 2018
Tag: team
VID: “team203”
Properties:
• name: “Trail Blazers”
Tag: team
VID: “team204”
Properties:
• name: “Spurs”
Graph space: basketballplayer

Async implementation of `CREATE` and `ALTER`

Caution

In NebulaGraph, the following `CREATE` or `ALTER` commands are implemented in an async way and take effect in the **next** heartbeat cycle. Otherwise, an error will be returned. To make sure the follow-up operations work as expected, Wait for two heartbeat cycles, i.e., 20 seconds.

- `CREATE SPACE`
- `CREATE TAG`
- `CREATE EDGE`
- `ALTER TAG`
- `ALTER EDGE`
- `CREATE TAG INDEX`
- `CREATE EDGE INDEX`

Note

The default heartbeat interval is 10 seconds. To change the heartbeat interval, modify the `heartbeat_interval_secs` parameter in the configuration files for all services.

3.6.2 Create and use a graph space

nGQL syntax

- Create a graph space:

```
CREATE SPACE [IF NOT EXISTS] <graph_space_name> (
[partition_num = <partition_number>,]
[replica_factor = <replica_number>,]
vid_type = {FIXED_STRING(<N>) | INT64}
)
[COMMENT = '<comment>'];
```

  For more information on parameters, see CREATE SPACE.

- List graph spaces and check if the creation is successful:

```
nebula> SHOW SPACES;
```

- Use a graph space:

```
USE <graph_space_name>;
```

Examples

1. Use the following statement to create a graph space named `basketballplayer`.

```
nebula> CREATE SPACE basketballplayer(partition_num=15, replica_factor=1, vid_type=fixed_string(30));
```

Note

If the system returns the error `[ERROR (-1005)]: Host not enough!`, check whether registered the Storage Service.

2. Check the partition distribution with `SHOW HOSTS` to make sure that the partitions are distributed in a balanced way.

```
nebula> SHOW HOSTS;
+-------------+-----------+-----------+--------------+-----------------------------------+------------------------+---------+
| Host        | Port      | Status    | Leader count | Leader distribution               | Partition distribution | Version |
+-------------+-----------+-----------+--------------+-----------------------------------+------------------------+---------+
| "storaged0" | 9779      | "ONLINE"  | 5            | "basketballplayer:5"              | "basketballplayer:5"   | "3.5.0"|
| "storaged1" | 9779      | "ONLINE"  | 5            | "basketballplayer:5"              | "basketballplayer:5"   | "3.5.0"|
| "storaged2" | 9779      | "ONLINE"  | 5            | "basketballplayer:5"              | "basketballplayer:5"   | "3.5.0"|
+-------------+-----------+-----------+----------+-------------+---------------------------------+-----------------------+---------+
```

If the **Leader distribution** is uneven, use `BALANCE LEADER` to redistribute the partitions. For more information, see BALANCE.

3. Use the `basketballplayer` graph space.

```
nebula[(none)]> USE basketballplayer;
```

You can use `SHOW SPACES` to check the graph space you created.

```
nebula> SHOW SPACES;
+--------------------+
| Name               |
+--------------------+
| "basketballplayer" |
+--------------------+
```

3.6.3 Create tags and edge types

nGQL syntax

```
CREATE {TAG | EDGE} [IF NOT EXISTS] {<tag_name> | <edge_type_name>}
    (
      <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']
      [{, <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']} ...]
    )
    [TTL_DURATION = <ttl_duration>]
    [TTL_COL = <prop_name>]
    [COMMENT = '<comment>'];
```

For more information on parameters, see CREATE TAG and CREATE EDGE.

Examples

Create tags `player` and `team`, and edge types `follow` and `serve`. Descriptions are as follows.

Component name	**Type**	**Property**
player	Tag	name (string), age (int)
team	Tag	name (string)
follow	Edge type	degree (int)
serve	Edge type	start_year (int), end_year (int)

```
nebula> CREATE TAG player(name string, age int);

nebula> CREATE TAG team(name string);

nebula> CREATE EDGE follow(degree int);

nebula> CREATE EDGE serve(start_year int, end_year int);
```

3.6.4 Insert vertices and edges

You can use the `INSERT` statement to insert vertices or edges based on existing tags or edge types.

nGQL syntax

- Insert vertices:

```
INSERT VERTEX [IF NOT EXISTS] [tag_props, [tag_props] ...]
VALUES <vid>: ([prop_value_list])

tag_props:
  tag_name ([prop_name_list])

prop_name_list:
   [prop_name [, prop_name] ...]

prop_value_list:
   [prop_value [, prop_value] ...]
```

`vid` is short for Vertex ID. A `vid` must be a unique string value in a graph space. For details, see INSERT VERTEX.

- Insert edges:

```
INSERT EDGE [IF NOT EXISTS] <edge_type> ( <prop_name_list> ) VALUES
<src_vid> -> <dst_vid>[@<rank>] : ( <prop_value_list> )
[, <src_vid> -> <dst_vid>[@<rank>] : ( <prop_value_list> ), ...];
<prop_name_list> ::=
[ <prop_name> [, <prop_name> ] ...]
<prop_value_list> ::=
[ <prop_value> [, <prop_value> ] ...]
```

For more information on parameters, see INSERT EDGE.

Examples

- Insert vertices representing basketball players and teams:

```
nebula> INSERT VERTEX player(name, age) VALUES "player100":("Tim Duncan", 42);

nebula> INSERT VERTEX player(name, age) VALUES "player101":("Tony Parker", 36);

nebula> INSERT VERTEX player(name, age) VALUES "player102":("LaMarcus Aldridge", 33);

nebula> INSERT VERTEX team(name) VALUES "team203":("Trail Blazers"), "team204":("Spurs");
```

- Insert edges representing the relations between basketball players and teams:

```
nebula> INSERT EDGE follow(degree) VALUES "player101" -> "player100":(95);

nebula> INSERT EDGE follow(degree) VALUES "player101" -> "player102":(90);

nebula> INSERT EDGE follow(degree) VALUES "player102" -> "player100":(75);

nebula> INSERT EDGE serve(start_year, end_year) VALUES "player101" -> "team204":(1999, 2018),"player102" -> "team203":(2006,  2015);
```

3.6.5 Read data

- The GO statement can traverse the database based on specific conditions. A `GO` traversal starts from one or more vertices, along one or more edges, and returns information in a form specified in the `YIELD` clause.
- The FETCH statement is used to get properties from vertices or edges.
- The LOOKUP statement is based on indexes. It is used together with the `WHERE` clause to search for the data that meet the specific conditions.
- The MATCH statement is the most commonly used statement for graph data querying. It can describe all kinds of graph patterns, but it relies on indexes to match data patterns in NebulaGraph. Therefore, its performance still needs optimization.

nGQL syntax

- `GO`

```
GO [[<M> TO] <N> {STEP|STEPS} ] FROM <vertex_list>
OVER <edge_type_list> [{REVERSELY | BIDIRECT}]
[ WHERE <conditions> ]
YIELD [DISTINCT] <return_list>
[{ SAMPLE <sample_list> | <limit_by_list_clause> }]
[| GROUP BY {<col_name> | expression> | <position>} YIELD <col_name>]
```

```
[| ORDER BY <expression> [{ASC | DESC}]]
[| LIMIT [<offset>,] <number_rows>];
```

- `FETCH`

- Fetch properties on tags:

```
FETCH PROP ON {<tag_name>[, tag_name ...] | *}
<vid> [, vid ...]
YIELD <return_list> [AS <alias>];
```

- Fetch properties on edges:

```
FETCH PROP ON <edge_type> <src_vid> -> <dst_vid>[@<rank>] [, <src_vid> -> <dst_vid> ...]
YIELD <output>;
```

- `LOOKUP`

```
LOOKUP ON {<vertex_tag> | <edge_type>}
[WHERE <expression> [AND <expression> ...]]
YIELD <return_list> [AS <alias>];
<return_list>
    <prop_name> [AS <col_alias>] [, <prop_name> [AS <prop_alias>] ...];
```

- `MATCH`

```
MATCH <pattern> [<clause_1>] RETURN <output> [<clause_2>];
```

Examples of `GO` statement

- Search for the players that the player with VID `player101` follows.

```
nebula> GO FROM "player101" OVER follow YIELD id($$);
+-------------+
| id($$)      |
+-------------+
| "player100" |
| "player102" |
```

```
| "player125" |
+-------------+
```

- Filter the players that the player with VID `player101` follows whose age is equal to or greater than 35. Rename the corresponding columns in the results with `Teammate` and `Age`.

```
nebula> GO FROM "player101" OVER follow WHERE properties($$).age >= 35 \
        YIELD properties($$).name AS Teammate, properties($$).age AS Age;
+-----------------+-----+
| Teammate        | Age |
+-----------------+-----+
| "Tim Duncan"    | 42  |
| "Manu Ginobili" | 41  |
+-----------------+-----+
```

| Clause/Sign | Description | |-------------+---| | `YIELD` | Specifies what values or results you want to return from the query. | | `$$` | Represents the target vertices. | | `\` | A line-breaker. |

- Search for the players that the player with VID `player101` follows. Then retrieve the teams of the players that the player with VID `player100` follows. To combine the two queries, use a pipe or a temporary variable.

- With a pipe:

```
nebula> GO FROM "player101" OVER follow YIELD dst(edge) AS id | \
        GO FROM $-.id OVER serve YIELD properties($$).name AS Team, \
        properties($^).name AS Player;
+-----------------+---------------------+
| Team            | Player              |
+-----------------+---------------------+
| "Spurs"         | "Tim Duncan"        |
| "Trail Blazers" | "LaMarcus Aldridge" |
| "Spurs"         | "LaMarcus Aldridge" |
| "Spurs"         | "Manu Ginobili"     |
+-----------------+---------------------+
```

Clause/Sign	Description
`$^`	Represents the source vertex of the edge.
`|`	A pipe symbol can combine multiple queries.
`$-`	Represents the outputs of the query before the pipe symbol.

- With a temporary variable:

Note

Once a composite statement is submitted to the server as a whole, the life cycle of the temporary variables in the statement ends.

```
nebula> $var = GO FROM "player101" OVER follow YIELD dst(edge) AS id; \
        GO FROM $var.id OVER serve YIELD properties($$).name AS Team, \
        properties($^).name AS Player;
+-----------------+---------------------+
| Team            | Player              |
+-----------------+---------------------+
| "Spurs"         | "Tim Duncan"        |
| "Trail Blazers" | "LaMarcus Aldridge" |
| "Spurs"         | "LaMarcus Aldridge" |
| "Spurs"         | "Manu Ginobili"     |
+-----------------+---------------------+
```

Example of `FETCH` statement

Use `FETCH`: Fetch the properties of the player with VID `player100`.

```
nebula> FETCH PROP ON player "player100" YIELD properties(vertex);
+-------------------------------+
| properties(VERTEX)            |
+-------------------------------+
| {age: 42, name: "Tim Duncan"} |
+-------------------------------+
```

Note

The examples of `LOOKUP` and `MATCH` statements are in indexes.

3.6.6 Update vertices and edges

Users can use the `UPDATE` or the `UPSERT` statements to update existing data.

`UPSERT` is the combination of `UPDATE` and `INSERT`. If you update a vertex or an edge with `UPSERT`, the database will insert a new vertex or edge if it does not exist.

Note

`UPSERT` operates serially in a partition-based order. Therefore, it is slower than `INSERT` OR `UPDATE`. And `UPSERT` has concurrency only between multiple partitions.

nGQL syntax

- `UPDATE` vertices:

```
UPDATE VERTEX <vid> SET <properties to be updated>
[WHEN <condition>] [YIELD <columns>];
```

- `UPDATE` edges:

```
UPDATE EDGE ON <edge_type> <source vid> -> <destination vid> [@rank]
SET <properties to be updated> [WHEN <condition>] [YIELD <columns to be output>];
```

- `UPSERT` vertices or edges:

```
UPSERT {VERTEX <vid> | EDGE <edge_type>} SET <update_columns>
[WHEN <condition>] [YIELD <columns>];
```

Examples

- `UPDATE` the `name` property of the vertex with VID `player100` and check the result with the `FETCH` statement.

```
nebula> UPDATE VERTEX "player100" SET player.name = "Tim";

nebula> FETCH PROP ON player "player100" YIELD properties(vertex);
+------------------------+
| properties(VERTEX)     |
+------------------------+
```

```
| {age: 42, name: "Tim"} |
+------------------------+
```

- `UPDATE` the `degree` property of an edge and check the result with the `FETCH` statement.

```
nebula> UPDATE EDGE ON follow "player101" -> "player100" SET degree = 96;

nebula> FETCH PROP ON follow "player101" -> "player100" YIELD properties(edge);
+------------------+
| properties(EDGE) |
+------------------+
| {degree: 96}     |
+------------------+
```

- Insert a vertex with VID `player111` and `UPSERT` it.

```
nebula> INSERT VERTEX player(name,age) VALUES "player111":("David West", 38);

nebula> UPSERT VERTEX "player111" SET player.name = "David", player.age = $^.player.age + 11 \
        WHEN $^.player.name == "David West" AND $^.player.age > 20 \
        YIELD $^.player.name AS Name, $^.player.age AS Age;
+---------+-----+
| Name    | Age |
+---------+-----+
| "David" | 49  |
+---------+-----+
```

3.6.7 Delete vertices and edges

nGQL syntax

- Delete vertices:

```
DELETE VERTEX <vid1>[, <vid2>...]
```

- Delete edges:

```
DELETE EDGE <edge_type> <src_vid> -> <dst_vid>[@<rank>]
[, <src_vid> -> <dst_vid>...]
```

Examples

- Delete vertices:

```
nebula> DELETE VERTEX "player111", "team203";
```

- Delete edges:

```
nebula> DELETE EDGE follow "player101" -> "team204";
```

3.6.8 About indexes

Users can add indexes to tags and edge types with the CREATE INDEX statement.

Must-read for using indexes

Both `MATCH` and `LOOKUP` statements depend on the indexes. But indexes can dramatically reduce the write performance. **DO NOT** use indexes in production environments unless you are fully aware of their influences on your service.

Users **MUST** rebuild indexes for pre-existing data. Otherwise, the pre-existing data cannot be indexed and therefore cannot be returned in `MATCH` or `LOOKUP` statements. For more information, see REBUILD INDEX.

nGQL syntax

- Create an index:

```
CREATE {TAG | EDGE} INDEX [IF NOT EXISTS] <index_name>
ON {<tag_name> | <edge_name>} ([<prop_name_list>]) [COMMENT = '<comment>'];
```

- Rebuild an index:

```
REBUILD {TAG | EDGE} INDEX <index_name>;
```

Note

Define the index length when creating an index for a variable-length property. In UTF-8 encoding, a non-ascii character occupies 3 bytes. You should set an appropriate index length according to the variable-length property. For example, the index should be 30 bytes for 10 non-ascii characters. For more information, see CREATE INDEX

Examples of `LOOKUP` and `MATCH` (index-based)

Make sure there is an index for `LOOKUP` or `MATCH` to use. If there is not, create an index first.

Find the information of the vertex with the tag `player` and its value of the `name` property is `Tony Parker`.

This example creates the index `player_index_1` on the `name` property.

```
nebula> CREATE TAG INDEX IF NOT EXISTS player_index_1 ON player(name(20));
```

This example rebuilds the index to make sure it takes effect on pre-existing data.

```
nebula> REBUILD TAG INDEX player_index_1
+------------+
| New Job Id |
+------------+
| 31         |
+------------+
```

This example uses the `LOOKUP` statement to retrieve the vertex property.

```
nebula> LOOKUP ON player WHERE player.name == "Tony Parker" \
        YIELD properties(vertex).name AS name, properties(vertex).age AS age;
+---------------+-----+
| name          | age |
+---------------+-----+
| "Tony Parker" | 36  |
+---------------+-----+
```

This example uses the `MATCH` statement to retrieve the vertex property.

```
nebula> MATCH (v:player{name:"Tony Parker"}) RETURN v;
+-----------------------------------------------------+
| v                                                   |
+-----------------------------------------------------+
| ("player101" :player{age: 36, name: "Tony Parker"}) |
+-----------------------------------------------------+
```

Last update: January 30, 2023

3.7 nGQL cheatsheet

3.7.1 Functions

- Math functions

Function	Description
double abs(double x)	Returns the absolute value of the argument.
double floor(double x)	Returns the largest integer value smaller than or equal to the argument. (Rounds down)
double ceil(double x)	Returns the smallest integer greater than or equal to the argument. (Rounds up)
double round(double x)	Returns the integer value nearest to the argument. Returns a number farther away from 0 if the argument is in the middle.
double sqrt(double x)	Returns the square root of the argument.
double cbrt(double x)	Returns the cubic root of the argument.
double hypot(double x, double y)	Returns the hypotenuse of a right-angled triangle.
double pow(double x, double y)	Returns the result of x^y.
double exp(double x)	Returns the result of e^x.
double exp2(double x)	Returns the result of 2^x.
double log(double x)	Returns the base-e logarithm of the argument.
double log2(double x)	Returns the base-2 logarithm of the argument.
double log10(double x)	Returns the base-10 logarithm of the argument.
double sin(double x)	Returns the sine of the argument.
double asin(double x)	Returns the inverse sine of the argument.
double cos(double x)	Returns the cosine of the argument.
double acos(double x)	Returns the inverse cosine of the argument.
double tan(double x)	Returns the tangent of the argument.
double atan(double x)	Returns the inverse tangent of the argument.
double rand()	Returns a random floating point number in the range from 0 (inclusive) to 1 (exclusive); i.e. [0,1).
int rand32(int min, int max)	Returns a random 32-bit integer in `[min, max)`. If you set only one argument, it is parsed as `max` and `min` is `0` by default. If you set no argument, the system returns a random signed 32-bit integer.
int rand64(int min, int max)	Returns a random 64-bit integer in `[min, max)`. If you set only one argument, it is parsed as `max` and `min` is `0` by default. If you set no argument, the system returns a random signed 64-bit integer.
bit_and()	Bitwise AND.
bit_or()	Bitwise OR.
bit_xor()	Bitwise XOR.
int size()	Returns the number of elements in a list or a map or the length of a string.
int range(int start, int end, int step)	Returns a list of integers from `[start,end]` in the specified steps. `step` is 1 by default.
int sign(double x)	Returns the signum of the given number. If the number is `0`, the system returns `0`. If the number is negative, the system returns `-1`. If the number is positive, the system returns `1`.

Function	Description
double e()	Returns the base of the natural logarithm, e (2.718281828459045).
double pi()	Returns the mathematical constant pi (3.141592653589793).
double radians()	Converts degrees to radians. `radians(180)` returns `3.141592653589793`.

- Aggregating functions

Function	Description
avg()	Returns the average value of the argument.
count()	Syntax: `count({expr | *})` . `count()` returns the number of rows (including NULL). `count(expr)` returns the number of non-NULL values that meet the expression. count() and size() are different.
max()	Returns the maximum value.
min()	Returns the minimum value.
collect()	The collect() function returns a list containing the values returned by an expression. Using this function aggregates data by merging multiple records or values into a single list.
std()	Returns the population standard deviation.
sum()	Returns the sum value.

- String functions

Function	Description
int strcasecmp(string a, string b)	Compares string a and b without case sensitivity. When a = b, the return
string lower(string a)	Returns the argument in lowercase.
string toLower(string a)	The same as `lower()`.
string upper(string a)	Returns the argument in uppercase.
string toUpper(string a)	The same as `upper()`.
int length(a)	Returns the length of the given string in bytes or the length of a path in hops.
string trim(string a)	Removes leading and trailing spaces.
string ltrim(string a)	Removes leading spaces.
string rtrim(string a)	Removes trailing spaces.
string left(string a, int count)	Returns a substring consisting of `count` characters from the left side of
string right(string a, int count)	Returns a substring consisting of `count` characters from the right side of
string lpad(string a, int size, string letters)	Left-pads string a with string `letters` and returns a
string rpad(string a, int size, string letters)	Right-pads string a with string `letters` and returns a
string substr(string a, int pos, int count)	Returns a substring extracting `count` characters starting from
string substring(string a, int pos, int count)	The same as `substr()`.
string reverse(string)	Returns a string in reverse order.
string replace(string a, string b, string c)	Replaces string b in string a with string c.
list split(string a, string b)	Splits string a at string b and returns a list of strings.
concat()	The `concat()` function requires at least two or more strings. All the parameters are concatenated into one string. Syntax: `concat(string1,string2,...)`
concat_ws()	The `concat_ws()` function connects two or more strings with a predefined separator.
extract()	`extract()` uses regular expression matching to retrieve a single substring or all substrings from a string.
json_extract()	The `json_extract()` function converts the specified JSON string to map.

- Data and time functions

Function	Description
int now()	Returns the current timestamp of the system.
timestamp timestamp()	Returns the current timestamp of the system.
date date()	Returns the current UTC date based on the current system.
time time()	Returns the current UTC time based on the current system.
datetime datetime()	Returns the current UTC date and time based on the current system.

- Schema-related functions

- For nGQL statements

Function	Description
id(vertex)	Returns the ID of a vertex. The data type of the result is the same as the vertex ID.
map properties(vertex)	Returns the properties of a vertex.
map properties(edge)	Returns the properties of an edge.
string type(edge)	Returns the edge type of an edge.
src(edge)	Returns the source vertex ID of an edge. The data type of the result is the same as the vertex ID.
dst(edge)	Returns the destination vertex ID of an edge. The data type of the result is the same as the vertex ID.
int rank(edge)	Returns the rank value of an edge.
vertex	Returns the information of vertices, including VIDs, tags, properties, and values.
edge	Returns the information of edges, including edge types, source vertices, destination vertices, ranks, properties, and values.
vertices	Returns the information of vertices in a subgraph. For more information, see GET SUBGRAPH.
edges	Returns the information of edges in a subgraph. For more information, see GET SUBGRAPH.
path	Returns the information of a path. For more information, see FIND PATH.

- For statements compatible with openCypher

Function	Description
id(<vertex>)	Returns the ID of a vertex. The data type of the result is the same as the vertex ID.
list tags(<vertex>)	Returns the Tag of a vertex, which serves the same purpose as labels().
list labels(<vertex>)	Returns the Tag of a vertex, which serves the same purpose as tags(). This function is used for compatibility with openCypher syntax.
map properties(<vertex_or_edge>)	Returns the properties of a vertex or an edge.
string type(<edge>)	Returns the edge type of an edge.
src(<edge>)	Returns the source vertex ID of an edge. The data type of the result is the same as the vertex ID.
dst(<edge>)	Returns the destination vertex ID of an edge. The data type of the result is the same as the vertex ID.
vertex startNode(<path>)	Visits an edge or a path and returns its source vertex ID.
string endNode(<path>)	Visits an edge or a path and returns its destination vertex ID.
int rank(<edge>)	Returns the rank value of an edge.

- List functions

Function	Description
keys(expr)	Returns a list containing the string representations for all the property names of vertices, edges, or maps.
labels(vertex)	Returns the list containing all the tags of a vertex.
nodes(path)	Returns the list containing all the vertices in a path.
range(start, end [, step])	Returns the list containing all the fixed-length steps in `[start,end]`. `step` is 1 by default.
relationships(path)	Returns the list containing all the relationships in a path.
reverse(list)	Returns the list reversing the order of all elements in the original list.
tail(list)	Returns all the elements of the original list, excluding the first one.
head(list)	Returns the first element of a list.
last(list)	Returns the last element of a list.
reduce()	The `reduce()` function applies an expression to each element in a list one by one, chains the result to the next iteration by taking it as the initial value, and returns the final result.

- Type conversion functions

Function	Description
bool toBoolean()	Converts a string value to a boolean value.
float toFloat()	Converts an integer or string value to a floating point number.
string toString()	Converts non-compound types of data, such as numbers, booleans, and so on, to strings.
int toInteger()	Converts a floating point or string value to an integer value.
set toSet()	Converts a list or set value to a set value.
int hash()	The `hash()` function returns the hash value of the argument. The argument can be a number, a string, a list, a boolean, null, or an expression that evaluates to a value of the preceding data types.

- Predicate functions

Predicate functions return `true` or `false`. They are most commonly used in `WHERE` clauses.

```
<predicate>(<variable> IN <list> WHERE <condition>)
```

Function	Description
exists()	Returns `true` if the specified property exists in the vertex, edge or map. Otherwise, returns `false`.
any()	Returns `true` if the specified predicate holds for at least one element in the given list. Otherwise, returns `false`.
all()	Returns `true` if the specified predicate holds for all elements in the given list. Otherwise, returns `false`.
none()	Returns `true` if the specified predicate holds for no element in the given list. Otherwise, returns `false`.
single()	Returns `true` if the specified predicate holds for exactly one of the elements in the given list. Otherwise, returns `false`.

- Conditional expressions functions

Function	Description
CASE	The `CASE` expression uses conditions to filter the result of an nGQL query statement. It is usually used in the `YIELD` and `RETURN` clauses. The `CASE` expression will traverse all the conditions. When the first condition is met, the `CASE` expression stops reading the conditions and returns the result. If no conditions are met, it returns the result in the `ELSE` clause. If there is no `ELSE` clause and no conditions are met, it returns `NULL`.
coalesce()	Returns the first not null value in all expressions.

3.7.2 General queries statements

- MATCH

```
MATCH <pattern> [<clause_1>] RETURN <output> [<clause_2>];
```

Pattern	Example	Description
Match vertices	`(v)`	You can use a user-defined variable in a pair of parentheses to represent a vertex in a pattern. For example: `(v)`.
Match tags	`MATCH (v:player) RETURN v`	You can specify a tag with `:<tag_name>` after the vertex in a pattern.
Match multiple tags	`MATCH (v:player:team) RETURN v`	To match vertices with multiple tags, use colons (:).

Match vertex properties	`MATCH (v:player{name:"Tim Duncan"}) RETURN v`
	
	 `MATCH (v) WITH v, properties(v) as props, keys(properties(v)) as kk WHERE [i in kk where props[i] == "Tim Duncan"] RETURN v`
		You can specify a vertex property with `{<prop_name>: <prop_value>}` after the tag in a pattern; or use a vertex property value to get vertices directly.

Match a VID.	`MATCH (v) WHERE id(v) == 'player101' RETURN v`	You can use the VID to match a vertex. The `id()` function can retrieve the VID of a vertex.
Match multiple VIDs.	`MATCH (v:player { name: 'Tim Duncan' })--(v2) WHERE id(v2) IN ["player101", "player102"] RETURN v2`	To match multiple VIDs, use `WHERE id(v) IN [vid_list]`.
Match connected vertices	`MATCH (v:player{name:"Tim Duncan"})--(v2) RETURN v2.player.name AS Name`	You can use the `--` symbol to represent edges of both directions and match vertices connected by these edges. You can add a `>` or `<` to the `--` symbol to specify the direction of an edge.
Match paths	`MATCH p=(v:player{name:"Tim Duncan"})-->(v2) RETURN p`	Connected vertices and edges form a path. You can use a user-defined variable to name a path as follows.
Match edges	`MATCH (v:player{name:"Tim Duncan"})-[e]-(v2) RETURN e` `MATCH ()<-[e]-() RETURN e`	Besides using `--`, `-->`, or `<--` to indicate a nameless edge, you can use a user-defined variable in a pair of square brackets to represent a named edge. For example: `-[e]-`.
Match an edge type	`MATCH ()-[e:follow]-() RETURN e`	Just like vertices, you can specify an edge type with `:<edge_type>` in a pattern. For example: `-[e:follow]-`.

Match edge type properties	`MATCH (v:player{name:"Tim Duncan"})-[e:follow{degree:95}]->(v2) RETURN e`
	
	 `MATCH ()-[e]->() WITH e, properties(e) as props, keys(properties(e)) as kk WHERE [i in kk where props[i] == 90] RETURN e`
		You can specify edge type properties with `{<prop_name>: <prop_value>}` in a pattern. For example: `[e:follow{likeness:95}]`; or use an edge type property value to get edges directly.

Match multiple edge types	`MATCH (v:player{name:"Tim Duncan"})-[e:follow | :serve]->(v2) RETURN e`	The `|` symbol can help matching multiple edge types. For example: `[e:follow|:serve]`. The English colon (:) before the first edge type cannot be omitted, but the English colon before the subsequent edge type can be omitted, such as `[e:follow|serve]`.
Match multiple edges	`MATCH (v:player{name:"Tim Duncan"})-[]->(v2)<-[e:serve]-(v3) RETURN v2, v3`	You can extend a pattern to match multiple edges in a path.
Match fixed-length paths	`MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*2]->(v2) RETURN DISTINCT v2 AS Friends`	You can use the `:<edge_type>*<hop>` pattern to match a fixed-length path. `hop` must be a non-negative integer. The data type of `e` is the list.
Match variable-length paths	`MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*1..3]->(v2) RETURN v2 AS Friends`	`minHop`: Optional. It represents the minimum length of the path. `minHop`: must be a non-negative integer. The default value is 1.

Pattern	Example	Description
		`minHop` and `maxHop` are optional and the default value is 1 and infinity respectively. The data type of `e` is the list.
Match variable-length paths with multiple edge types	`MATCH p=(v:player{name:"Tim Duncan"})-[e:follow | serve*2]->(v2) RETURN DISTINCT v2`	You can specify multiple edge types in a fixed-length or variable-length pattern. In this case, `hop`, `minHop`, and `maxHop` take effect on all edge types. The data type of `e` is the list.
Retrieve vertex or edge information	`MATCH (v:player{name:"Tim Duncan"}) RETURN v` `MATCH (v:player{name:"Tim Duncan"})-[e]->(v2) RETURN e`	Use `RETURN {<vertex_name> | <edge_name>}` to retrieve all the information of a vertex or an edge.
Retrieve VIDs	`MATCH (v:player{name:"Tim Duncan"}) RETURN id(v)`	Use the `id()` function to retrieve VIDs.
Retrieve tags	`MATCH (v:player{name:"Tim Duncan"}) RETURN labels(v)`	Use the `labels()` function to retrieve the list of tags on a vertex. To retrieve the nth element in the `labels(v)` list, use `labels(v)[n-1]`.
Retrieve a single property on a vertex or an edge	`MATCH (v:player{name:"Tim Duncan"}) RETURN v.player.age`	Use `RETURN {<vertex_name> | <edge_name>}.<property>` to retrieve a single property. Use `AS` to specify an alias for a property.
Retrieve all properties on a vertex or an edge	`MATCH p=(v:player{name:"Tim Duncan"})-[]->(v2) RETURN properties(v2)`	Use the `properties()` function to retrieve all properties on a vertex or an edge.
Retrieve edge types	`MATCH p=(v:player{name:"Tim Duncan"})-[e]->() RETURN DISTINCT type(e)`	Use the `type()` function to retrieve the matched edge types.
Retrieve paths	`MATCH p=(v:player{name:"Tim Duncan"})-[*3]->() RETURN p`	Use `RETURN <path_name>` to retrieve all the information of the matched paths.
Retrieve vertices in a path	`MATCH p=(v:player{name:"Tim Duncan"})-[]->(v2) RETURN nodes(p)`	Use the `nodes()` function to retrieve all vertices in a path.
Retrieve edges in a path	`MATCH p=(v:player{name:"Tim Duncan"})-[]->(v2) RETURN relationships(p)`	Use the `relationships()` function to retrieve all edges in a path.
Retrieve path length	`MATCH p=(v:player{name:"Tim Duncan"})-[*..2]->(v2) RETURN p AS Paths, length(p) AS Length`	Use the `length()` function to retrieve the length of a path.

- OPTIONAL MATCH

Pattern	Example	Description
Matches patterns against your graph database, just like `MATCH` does.	`MATCH (m)-[]->(n) WHERE id(m)=="player100" OPTIONAL MATCH (n)-[]->(l) RETURN id(m),id(n),id(l)`	If no matches are found, `OPTIONAL MATCH` will use a null for missing parts of the pattern.

- LOOKUP

```
LOOKUP ON {<vertex_tag> | <edge_type>}
[WHERE <expression> [AND <expression> ...]]
YIELD <return_list> [AS <alias>]
```

Pattern	Example	Description
Retrieve vertices	`LOOKUP ON player WHERE player.name == "Tony Parker" YIELD player.name AS name, player.age AS age`	The following example returns vertices whose `name` is `Tony Parker` and the tag is `player`.
Retrieve edges	`LOOKUP ON follow WHERE follow.degree == 90 YIELD follow.degree`	Returns edges whose `degree` is `90` and the edge type is `follow`.
List vertices with a tag	`LOOKUP ON player YIELD properties(vertex),id(vertex)`	Shows how to retrieve the VID of all vertices tagged with `player`.
List edges with an edge types	`LOOKUP ON like YIELD edge AS e`	Shows how to retrieve the source Vertex IDs, destination vertex IDs, and ranks of all edges of the `like` edge type.
Count the numbers of vertices or edges	`LOOKUP ON player YIELD id(vertex)| YIELD COUNT(*) AS Player_Count`	Shows how to count the number of vertices tagged with `player`.
Count the numbers of edges	`LOOKUP ON like YIELD id(vertex)| YIELD COUNT(*) AS Like_Count`	Shows how to count the number of edges of the `like` edge type.

- GO

```
GO [[<M> TO] <N> {STEP|STEPS} ] FROM <vertex_list>
OVER <edge_type_list> [{REVERSELY | BIDIRECT}]
[ WHERE <conditions> ]
YIELD [DISTINCT] <return_list>
[{SAMPLE <sample_list> | LIMIT <limit_list>}]
[| GROUP BY {col_name | expr | position} YIELD <col_name>]
[| ORDER BY <expression> [{ASC | DESC}]]
[| LIMIT [<offset_value>,] <number_rows>]
```

Example	Description
`GO FROM "player102" OVER serve YIELD dst(edge)`	Returns the teams that player 102 serves.
`GO 2 STEPS FROM "player102" OVER follow YIELD dst(edge)`	Returns the friends of player 102 with 2 hops.
`GO FROM "player100", "player102" OVER serve WHERE properties(edge).start_year > 1995 YIELD DISTINCT properties($$).name AS team_name, properties(edge).start_year AS start_year, properties($^).name AS player_name`	Adds a filter for the traversal.
`GO FROM "player100" OVER follow, serve YIELD properties(edge).degree, properties(edge).start_year`	The following example traverses along with multiple edge types. If there is no value for a property, the output is `NULL`.
`GO FROM "player100" OVER follow REVERSELY YIELD src(edge) AS destination`	The following example returns the neighbor vertices in the incoming direction of player 100.
`GO FROM "player100" OVER follow REVERSELY YIELD src(edge) AS id | GO FROM $-.id OVER serve WHERE properties($^).age > 20 YIELD properties($^).name AS FriendOf, properties($$).name AS Team`	The following example retrieves the friends of player 100 and the teams that they serve.
`GO FROM "player102" OVER follow YIELD dst(edge) AS both`	The following example returns all the neighbor vertices of player 102.
`GO 2 STEPS FROM "player100" OVER follow YIELD src(edge) AS src, dst(edge) AS dst, properties($$).age AS age | GROUP BY $-.dst YIELD $-.dst AS dst, collect_set($-.src) AS src, collect($-.age) AS age`	The following example the outputs according to age.

- FETCH

- Fetch vertex properties

```
FETCH PROP ON {<tag_name>[, tag_name ...] | *}
<vid> [, vid ...]
YIELD <return_list> [AS <alias>]
```

Example	Description
`FETCH PROP ON player "player100" YIELD properties(vertex)`	Specify a tag in the `FETCH` statement to fetch the vertex properties by that tag.
`FETCH PROP ON player "player100" YIELD player.name AS name`	Use a `YIELD` clause to specify the properties to be returned.
`FETCH PROP ON player "player101", "player102", "player103" YIELD properties(vertex)`	Specify multiple VIDs (vertex IDs) to fetch properties of multiple vertices. Separate the VIDs with commas.
`FETCH PROP ON player, t1 "player100", "player103" YIELD properties(vertex)`	Specify multiple tags in the `FETCH` statement to fetch the vertex properties by the tags. Separate the tags with commas.
`FETCH PROP ON * "player100", "player106", "team200" YIELD properties(vertex)`	Set an asterisk symbol `*` to fetch properties by all tags in the current graph space.

- Fetch edge properties

```
FETCH PROP ON <edge_type> <src_vid> -> <dst_vid>[@<rank>] [, <src_vid> -> <dst_vid> ...]
YIELD <output>;
```

Example	Description
`FETCH PROP ON serve "player100" -> "team204" YIELD properties(edge)`	The following statement fetches all the properties of the `serve` edge that connects vertex `"player100"` and vertex `"team204"`.
`FETCH PROP ON serve "player100" -> "team204" YIELD serve.start_year`	Use a `YIELD` clause to fetch specific properties of an edge.
`FETCH PROP ON serve "player100" -> "team204", "player133" -> "team202" YIELD properties(edge)`	Specify multiple edge patterns (`<src_vid> -> <dst_vid>[@<rank>]`) to fetch properties of multiple edges. Separate the edge patterns with commas.
`FETCH PROP ON serve "player100" -> "team204"@1 YIELD properties(edge)`	To fetch on an edge whose rank is not 0, set its rank in the FETCH statement.
`GO FROM "player101" OVER follow YIELD follow._src AS s, follow._dst AS d | FETCH PROP ON follow $-.s -> $-.d YIELD follow.degree`	The following statement returns the `degree` values of the `follow` edges that start from vertex `"player101"`.
`$var = GO FROM "player101" OVER follow YIELD follow._src AS s, follow._dst AS d; FETCH PROP ON follow $var.s -> $var.d YIELD follow.degree`	You can use user-defined variables to construct similar queries.

- SHOW

Statement	Syntax	Example	Description
SHOW CHARSET	`SHOW CHARSET`	`SHOW CHARSET`	Shows the available character sets.
SHOW COLLATION	`SHOW COLLATION`	`SHOW COLLATION`	Shows the collations supported by NebulaGraph.
SHOW CREATE SPACE	`SHOW CREATE SPACE <space_name>`	`SHOW CREATE SPACE basketballplayer`	Shows the creating statement of the specified graph space.
SHOW CREATE TAG/EDGE	`SHOW CREATE {TAG <tag_name> | EDGE <edge_name>}`	`SHOW CREATE TAG player`	Shows the basic information of the specified tag.
SHOW HOSTS	`SHOW HOSTS [GRAPH | STORAGE | META]`	`SHOW HOSTS` `SHOW HOSTS GRAPH`	Shows the host and version information of Graph Service, Storage Service, and Meta Service.
SHOW INDEX STATUS	`SHOW {TAG | EDGE} INDEX STATUS`	`SHOW TAG INDEX STATUS`	Shows the status of jobs that rebuild native indexes, which helps check whether a native index is successfully rebuilt or not.
SHOW INDEXES	`SHOW {TAG | EDGE} INDEXES`	`SHOW TAG INDEXES`	Shows the names of existing native indexes.
SHOW PARTS	`SHOW PARTS [<part_id>]`	`SHOW PARTS`	Shows the information of a specified partition or all partitions in a graph space.
SHOW ROLES	`SHOW ROLES IN <space_name>`	`SHOW ROLES in basketballplayer`	Shows the roles that are assigned to a user account.
SHOW SNAPSHOTS	`SHOW SNAPSHOTS`	`SHOW SNAPSHOTS`	Shows the information of all the snapshots.
SHOW SPACES	`SHOW SPACES`	`SHOW SPACES`	Shows existing graph spaces in NebulaGraph.
SHOW STATS	`SHOW STATS`	`SHOW STATS`	Shows the statistics of the graph space collected by the latest `STATS` job.
SHOW TAGS/ EDGES	`SHOW TAGS | EDGES`	`SHOW TAGS` , `SHOW EDGES`	Shows all the tags in the current graph space.
SHOW USERS	`SHOW USERS`	`SHOW USERS`	Shows the user information.
SHOW SESSIONS	`SHOW SESSIONS`	`SHOW SESSIONS`	Shows the information of all the sessions.
SHOW SESSIONS	`SHOW SESSION <Session_Id>`	`SHOW SESSION 1623304491050858`	Shows a specified session with its ID.
SHOW QUERIES	`SHOW [ALL] QUERIES`	`SHOW QUERIES`	Shows the information of working queries in the current session.
SHOW META LEADER	`SHOW META LEADER`	`SHOW META LEADER`	Shows the information of the leader in the current Meta cluster.

3.7.3 Clauses and options

Clause	Syntax	Example	Description
GROUP BY	`GROUP BY <var> YIELD <var>, <aggregation_function(var)>`	`GO FROM "player100" OVER follow BIDIRECT YIELD $$.player.name as Name | GROUP BY $-.Name YIELD $-.Name as Player, count(*) AS Name_Count`	Finds all the vertices connected directly to vertex `"player100"`, groups the result set by player names, and counts how many times the name shows up in the result set.
LIMIT	`YIELD <var> [| LIMIT [<offset_value>,] <number_rows>]`	`GO FROM "player100" OVER follow REVERSELY YIELD $$.player.name AS Friend, $$.player.age AS Age | ORDER BY $-.Age, $-.Friend | LIMIT 1, 3`	Returns the 3 rows of data starting from the second row of the sorted output.
SKIP	`RETURN <var> [SKIP <offset>] [LIMIT <number_rows>]`	`MATCH (v:player{name:"Tim Duncan"}) --> (v2) RETURN v2.player.name AS Name, v2.player.age AS Age ORDER BY Age DESC SKIP 1`	`SKIP` can be used alone to set the offset and return the data after the specified position.
SAMPLE	`<go_statement> SAMPLE <sample_list>;`	`GO 3 STEPS FROM "player100" OVER * YIELD properties($$).name AS NAME, properties($$).age AS Age SAMPLE [1,2,3];`	Takes samples evenly in the result set and returns the specified amount of data.
ORDER BY	`<YIELD clause> ORDER BY <expression> [ASC | DESC] [, <expression> [ASC | DESC] ...]`	`FETCH PROP ON player "player100", "player101", "player102", "player103" YIELD player.age AS age, player.name AS name | ORDER BY $-.age ASC, $-.name DESC`	The `ORDER BY` clause specifies the order of the rows in the output.
RETURN	`RETURN {<vertex_name>|<edge_name>|<vertex_name>.<property>|<edge_name>.<property>|...}`	`MATCH (v:player) RETURN v.player.name, v.player.age LIMIT 3`	Returns the first three rows with values of the vertex properties `name` and `age`.
TTL	`CREATE TAG <tag_name>(<property_name_1> <property_value_1>, <property_name_2> <property_value_2>, ...) ttl_duration= <value_int>, ttl_col = <property_name>`	`CREATE TAG t2(a int, b int, c string) ttl_duration= 100, ttl_col = "a"`	Create a tag and set the TTL options.
WHERE	`WHERE {<vertex|edge_alias>.<property_name> {>|==|<|...} <value>...}`	`MATCH (v:player) WHERE v.player.name == "Tim Duncan" XOR (v.player.age < 30 AND v.player.name == "Yao Ming") OR NOT (v.player.name == "Yao Ming" OR v.player.name == "Tim Duncan") RETURN v.player.name, v.player.age`	The `WHERE` clause filters the output by conditions. The `WHERE` clause usually works in Native nGQL `GO` and `LOOKUP` statements, and OpenCypher `MATCH` and `WITH` statements.
YIELD	`YIELD [DISTINCT] <col> [AS <alias>] [, <col> [AS <alias>] ...] [WHERE <conditions>];`	`GO FROM "player100" OVER follow YIELD dst(edge) AS ID | FETCH PROP ON player $-.ID YIELD player.age AS Age \| YIELD AVG($-.Age) as Avg_age, count(*)as Num_friends`	Finds the players that "player100" follows and calculates their average age.
WITH	`MATCH $expressions WITH {nodes()|labels()|...}`	`MATCH p=(v:player{name:"Tim Duncan"})--() WITH nodes(p) AS n UNWIND n AS n1 RETURN DISTINCT n1`	The `WITH` clause can retrieve the output from a query part, process it, and pass it to the next query part as the input.
UNWIND	`UNWIND <list> AS <alias> <RETURN clause>`	`UNWIND [1,2,3] AS n RETURN n`	Splits a list into rows.

3.7.4 Space statements

Statement	Syntax	Example	Description
CREATE SPACE	`CREATE SPACE [IF NOT EXISTS] <graph_space_name> ( [partition_num = <partition_number>,] [replica_factor = <replica_number>,] vid_type = {FIXED_STRING(<N>) | INT[64]} ) [COMMENT = '<comment>']`	`CREATE SPACE my_space_1 (vid_type=FIXED_STRING(30))`	Creates a graph space with
CREATE SPACE	`CREATE SPACE <new_graph_space_name> AS <old_graph_space_name>`	`CREATE SPACE my_space_4 as my_space_3`	Clone a graph. space.
USE	`USE <graph_space_name>`	`USE space1`	Specifies a graph space as the current working graph space for subsequent queries.
SHOW SPACES	`SHOW SPACES`	`SHOW SPACES`	Lists all the graph spaces in the NebulaGraph examples.
DESCRIBE SPACE	`DESC[RIBE] SPACE <graph_space_name>`	`DESCRIBE SPACE basketballplayer`	Returns the information about the specified graph space.
CLEAR SPACE	`CLEAR SPACE [IF EXISTS] <graph_space_name>`	Deletes the vertices and edges in a graph space, but does not delete the graph space itself and the schema information.	
DROP SPACE	`DROP SPACE [IF EXISTS] <graph_space_name>`	`DROP SPACE basketballplayer`	Deletes everything in the specified graph space.

3.7.5 TAG statements

Statement	Syntax	Example	Description
CREATE TAG	`CREATE TAG [IF NOT EXISTS] <tag_name> (<prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>'] [{, <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']} ...]) [TTL_DURATION = <ttl_duration>] [TTL_COL = <prop_name>] [COMMENT = '<comment>']`	`CREATE TAG woman(name string, age int, married bool, salary double, create_time timestamp) TTL_DURATION = 100, TTL_COL = "create_time"`	Creates a tag with the given name in a graph space.
DROP TAG	`DROP TAG [IF EXISTS] <tag_name>`	`DROP TAG test;`	Drops a tag with the given name in the current working graph space.
ALTER TAG	`ALTER TAG <tag_name> <alter_definition> [, alter_definition] ...] [ttl_definition [, ttl_definition] ... ] [COMMENT = '<comment>']`	`ALTER TAG t1 ADD (p3 int, p4 string)`	Alters the structure of a tag with the given name in a graph space. You can add or drop properties, and change the data type of an existing property. You can also set a TTL (Time-To-Live) on a property, or change its TTL duration.
SHOW TAGS	`SHOW TAGS`	`SHOW TAGS`	Shows the name of all tags in the current graph space.
DESCRIBE TAG	`DESC[RIBE] TAG <tag_name>`	`DESCRIBE TAG player`	Returns the information about a tag with the given name in a graph space, such as field names, data type, and so on.
DELETE TAG	`DELETE TAG <tag_name_list> FROM <VID>`	`DELETE TAG test1 FROM "test"`	Deletes a tag with the given name on a specified vertex.

3.7.6 Edge type statements

Statement	Syntax	Example	Description
CREATE EDGE	`CREATE EDGE [IF NOT EXISTS] <edge_type_name> (<prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>'] [{, <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']} ...]) [TTL_DURATION = <ttl_duration>] [TTL_COL = <prop_name>] [COMMENT = '<comment>']`	`CREATE EDGE e1(p1 string, p2 int, p3 timestamp) TTL_DURATION = 100, TTL_COL = "p2"`	Creates an edge type with the given name in a graph space.
DROP EDGE	`DROP EDGE [IF EXISTS] <edge_type_name>`	`DROP EDGE e1`	Drops an edge type with the given name in a graph space.
ALTER EDGE	`ALTER EDGE <edge_type_name> <alter_definition> [, alter_definition] ...] [ttl_definition [, ttl_definition] ... ] [COMMENT = '<comment>']`	`ALTER EDGE e1 ADD (p3 int, p4 string)`	Alters the structure of an edge type with the given name in a graph space.
SHOW EDGES	`SHOW EDGES`	`SHOW EDGES`	Shows all edge types in the current graph space.
DESCRIBE EDGE	`DESC[RIBE] EDGE <edge_type_name>`	`DESCRIBE EDGE follow`	Returns the information about an edge type with the given name in a graph space, such as field names, data type, and so on.

3.7.7 Vertex statements

Statement	Syntax	Example	Description
INSERT VERTEX	`INSERT VERTEX [IF NOT EXISTS] [tag_props, [tag_props] ...] VALUES <vid>: ([prop_value_list])`	`INSERT VERTEX t2 (name, age) VALUES "13":("n3", 12), "14":("n4", 8)`	Inserts one or more vertices into a graph space in NebulaGraph.
DELETE VERTEX	`DELETE VERTEX <vid> [, <vid> ...]`	`DELETE VERTEX "team1"`	Deletes vertices and the related incoming and outgoing edges of the vertices.
UPDATE VERTEX	`UPDATE VERTEX ON <tag_name> <vid> SET <update_prop> [WHEN <condition>] [YIELD <output>]`	`UPDATE VERTEX ON player "player101" SET age = age + 2`	Updates properties on tags of a vertex.
UPSERT VERTEX	`UPSERT VERTEX ON <tag> <vid> SET <update_prop> [WHEN <condition>] [YIELD <output>]`	`UPSERT VERTEX ON player "player667" SET age = 31`	The `UPSERT` statement is a combination of `UPDATE` and `INSERT`. You can use `UPSERT VERTEX` to update the properties of a vertex if it exists or insert a new vertex if it does not exist.

3.7.8 Edge statements

Statement	Syntax	Example	Description
INSERT EDGE	`INSERT EDGE [IF NOT EXISTS] <edge_type> ( <prop_name_list> ) VALUES <src_vid> -> <dst_vid>[@<rank>] : ( <prop_value_list> ) [, <src_vid> -> <dst_vid>[@<rank>] : ( <prop_value_list> ), ...]`	`INSERT EDGE e2 (name, age) VALUES "11"->"13":("n1", 1)`	Inserts an edge or multiple edges into a graph space from a source vertex (given by src_vid) to a destination vertex (given by dst_vid) with a specific rank in NebulaGraph.
DELETE EDGE	`DELETE EDGE <edge_type> <src_vid> -> <dst_vid>[@<rank>] [, <src_vid> -> <dst_vid>[@<rank>] ...]`	`DELETE EDGE serve "player100" -> "team204"@0`	Deletes one edge or multiple edges at a time.
UPDATE EDGE	`UPDATE EDGE ON <edge_type> <src_vid> -> <dst_vid> [@<rank>] SET <update_prop> [WHEN <condition>] [YIELD <output>]`	`UPDATE EDGE ON serve "player100" -> "team204"@0 SET start_year = start_year + 1`	Updates properties on an edge.
UPSERT EDGE	`UPSERT EDGE ON <edge_type> <src_vid> -> <dst_vid> [@rank] SET <update_prop> [WHEN <condition>] [YIELD <properties>]`	`UPSERT EDGE on serve "player666" -> "team200"@0 SET end_year = 2021`	The `UPSERT` statement is a combination of `UPDATE` and `INSERT`. You can use `UPSERT EDGE` to update the properties of an edge if it exists or insert a new edge if it does not exist.

3.7.9 Index

- Native index

  You can use native indexes together with `LOOKUP` and `MATCH` statements.

Statement	Syntax	Example	Description
CREATE INDEX	`CREATE {TAG | EDGE} INDEX [IF NOT EXISTS] <index_name> ON {<tag_name> | <edge_name>} ([<prop_name_list>]) [COMMENT = '<comment>']`	`CREATE TAG INDEX player_index on player()`	Add native indexes for the existing tags, edge types, or properties.
SHOW CREATE INDEX	`SHOW CREATE {TAG | EDGE} INDEX <index_name>`	`show create tag index index_2`	Shows the statement used when creating a tag or an edge type. It contains detailed information about the index, such as its associated properties.
SHOW INDEXES	`SHOW {TAG | EDGE} INDEXES`	`SHOW TAG INDEXES`	Shows the defined tag or edge type indexes names in the current graph space.
DESCRIBE INDEX	`DESCRIBE {TAG | EDGE} INDEX <index_name>`	`DESCRIBE TAG INDEX player_index_0`	Gets the information about the index with a given name, including the property name (Field) and the property type (Type) of the index.
REBUILD INDEX	`REBUILD {TAG | EDGE} INDEX [<index_name_list>]`	`REBUILD TAG INDEX single_person_index`	Rebuilds the created tag or edge type index. If data is updated or inserted before the creation of the index, you must rebuild the indexes **manually** to make sure that the indexes contain the previously added data.
SHOW INDEX STATUS	`SHOW {TAG | EDGE} INDEX STATUS`	`SHOW TAG INDEX STATUS`	Returns the name of the created tag or edge type index and its status.
DROP INDEX	`DROP {TAG | EDGE} INDEX [IF EXISTS] <index_name>`	`DROP TAG INDEX player_index_0`	Removes an existing index from the current graph space.

- Full-text index

Syntax	Example	Description
`SIGN IN TEXT SERVICE [(<elastic_ip:port> [,<username>, <password>]), (<elastic_ip:port>), ...]`	`SIGN IN TEXT SERVICE (127.0.0.1:9200)`	The full-text indexes is implemented based on Elasticsearch. After deploying an Elasticsearch cluster, you can use the `SIGN IN` statement to log in to the Elasticsearch client.
`SHOW TEXT SEARCH CLIENTS`	`SHOW TEXT SEARCH CLIENTS`	Shows text search clients.
`SIGN OUT TEXT SERVICE`	`SIGN OUT TEXT SERVICE`	Signs out to the text search clients.
`CREATE FULLTEXT {TAG | EDGE} INDEX <index_name> ON {<tag_name> | <edge_name>} ([<prop_name_list>])`	`CREATE FULLTEXT TAG INDEX nebula_index_1 ON player(name)`	Creates full-text indexes.
`SHOW FULLTEXT INDEXES`	`SHOW FULLTEXT INDEXES`	Show full-text indexes.
`REBUILD FULLTEXT INDEX`	`REBUILD FULLTEXT INDEX`	Rebuild full-text indexes.
`DROP FULLTEXT INDEX <index_name>`	`DROP FULLTEXT INDEX nebula_index_1`	Drop full-text indexes.
`LOOKUP ON {<tag> | <edge_type>} WHERE <expression> [YIELD <return_list>]`	`LOOKUP ON player WHERE FUZZY(player.name, "Tim Dunncan", AUTO, OR) YIELD player.name`	Use query options.

3.7.10 Subgraph and path statements

Type	Syntax	Example	Description
GET SUBGRAPH	`GET SUBGRAPH [WITH PROP] [<step_count> {STEP|STEPS}] FROM {<vid>, <vid>...} [{IN | OUT | BOTH} <edge_type>, <edge_type>...] YIELD [VERTICES AS <vertex_alias>] [,EDGES AS <edge_alias>]`	`GET SUBGRAPH 1 STEPS FROM "player100" YIELD VERTICES AS nodes, EDGES AS relationships`	Retrieves information of vertices and edges reachable from the source vertices of the specified edge types and returns information of the subgraph.
FIND PATH	`FIND { SHORTEST | ALL | NOLOOP } PATH [WITH PROP] FROM <vertex_id_list> TO <vertex_id_list> OVER <edge_type_list> [REVERSELY | BIDIRECT] [<WHERE clause>] [UPTO <N> {STEP|STEPS}] YIELD path as <alias> [| ORDER BY $-.path] [| LIMIT <M>]`	`FIND SHORTEST PATH FROM "player102" TO "team204" OVER * YIELD path as p`	Finds the paths between the selected source vertices and destination vertices. A returned path is like `(<vertex_id>)-[:<edge_type_name>@<rank>]->(<vertex_id)`.

3.7.11 Query tuning statements

Type	Syntax	Example	Description
EXPLAIN	`EXPLAIN [format="row" | "dot"] <your_nGQL_statement>`	`EXPLAIN format="row" SHOW TAGS` `EXPLAIN format="dot" SHOW TAGS`	Helps output the execution plan of an nGQL statement without executing the statement.
PROFILE	`PROFILE [format="row" | "dot"] <your_nGQL_statement>`	`PROFILE format="row" SHOW TAGS` `EXPLAIN format="dot" SHOW TAGS`	Executes the statement, then outputs the execution plan as well as the execution profile.

3.7.12 Operation and maintenance statements

- SUBMIT JOB BALANCE

Syntax	Description
`BALANCE LEADER`	Starts a job to balance the distribution of all the storage leaders in graph spaces. It returns the job ID.

- Job statements

Syntax	Description
`SUBMIT JOB COMPACT`	Triggers the long-term RocksDB `compact` operation.
`SUBMIT JOB FLUSH`	Writes the RocksDB memfile in the memory to the hard disk.
`SUBMIT JOB STATS`	Starts a job that makes the statistics of the current graph space. Once this job succeeds, you can use the `SHOW STATS` statement to list the statistics.
`SHOW JOB <job_id>`	Shows the information about a specific job and all its tasks in the current graph space. The Meta Service parses a `SUBMIT JOB` request into multiple tasks and assigns them to the nebula-storaged processes.
`SHOW JOBS`	Lists all the unexpired jobs in the current graph space.
`STOP JOB`	Stops jobs that are not finished in the current graph space.
`RECOVER JOB`	Re-executes the failed jobs in the current graph space and returns the number of recovered jobs.

- Kill queries

Syntax	Example	Description
`KILL QUERY (session=<session_id>, plan=<plan_id>)`	`KILL QUERY(SESSION=1625553545984255,PLAN=163)`	Terminates the query being executed, and is often used to terminate slow queries.

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4. nGQL guide

4.1 nGQL overview

4.1.1 NebulaGraph Query Language (nGQL)

This topic gives an introduction to the query language of NebulaGraph, nGQL.

What is nGQL

nGQL is a declarative graph query language for NebulaGraph. It allows expressive and efficient graph patterns. nGQL is designed for both developers and operations professionals. nGQL is an SQL-like query language, so it's easy to learn.

nGQL is a project in progress. New features and optimizations are done steadily. There can be differences between syntax and implementation. Submit an issue to inform the NebulaGraph team if you find a new issue of this type. NebulaGraph 3.0 or later releases will support openCypher 9.

What can nGQL do

- Supports graph traversals
- Supports pattern match
- Supports aggregation
- Supports graph mutation
- Supports access control
- Supports composite queries
- Supports index
- Supports most openCypher 9 graph query syntax (but mutations and controls syntax are not supported)

Example data Basketballplayer

Users can download the example data Basketballplayer in NebulaGraph. After downloading the example data, you can import it to NebulaGraph by using the `-f` option in NebulaGraph Console.

Note

Ensure that you have executed the `ADD HOSTS` command to add the Storage service to your NebulaGraph cluster before importing the example data. For more information, see Manage Storage hosts.

Placeholder identifiers and values

Refer to the following standards in nGQL:

- (Draft) ISO/IEC JTC1 N14279 SC 32 - Database_Languages - GQL
- (Draft) ISO/IEC JTC1 SC32 N3228 - SQL_Property_Graph_Queries - SQLPGQ
- OpenCypher 9

In template code, any token that is not a keyword, a literal value, or punctuation is a placeholder identifier or a placeholder value.

For details of the symbols in nGQL syntax, see the following table:

Token	Meaning
< >	name of a syntactic element
:	formula that defines an element
[ ]	optional elements
{ }	explicitly specified elements
|	complete alternative elements
...	may be repeated any number of times

For example, create vertices in nGQL syntax:

```
INSERT VERTEX [IF NOT EXISTS] [tag_props, [tag_props] ...]
VALUES <vid>: ([prop_value_list])
tag_props:
  tag_name ([prop_name_list])
prop_name_list:
   [prop_name [, prop_name] ...]
prop_value_list:
   [prop_value [, prop_value] ...]
```

Example statement:

```
nebula> CREATE TAG IF NOT EXISTS player(name string, age int);
```

About openCypher compatibility

NATIVE NGQL AND OPENCYPHER

Native nGQL is the part of a graph query language designed and implemented by NebulaGraph. OpenCypher is a graph query language maintained by openCypher Implementers Group.

The latest release is openCypher 9. The compatible parts of openCypher in nGQL are called openCypher compatible sentences (short as openCypher).

Note

`nGQL` = `native nGQL` + `openCypher compatible sentences`

IS NGQL COMPATIBLE WITH OPENCYPHER 9 COMPLETELY?

NO.

Compatibility with openCypher

nGQL is designed to be compatible with part of DQL (match, optional match, with, etc.).

- It is not planned to be compatible with any DDL, DML, or DCL.
- It is not planned to be compatible with the Bolt Protocol.
- It is not planned to be compatible with APOC and GDS.

Users can search in this manual with the keyword `compatibility` to find major compatibility issues.

Multiple known incompatible items are listed in NebulaGraph Issues. Submit an issue with the `incompatible` tag if you find a new issue of this type.

WHAT ARE THE MAJOR DIFFERENCES BETWEEN NGQL AND OPENCYPHER 9?

The following are some major differences (by design incompatible) between nGQL and openCypher.

Category	openCypher 9	nGQL
Schema	Optional Schema	Strong Schema
Equality operator	`=`	`==`
Math exponentiation	`^`	`^` is not supported. Use pow(x, y) instead.
Edge rank	No such concept.	edge rank (reference by @)
Statement	-	All DMLs (`CREATE`, `MERGE`, etc) of openCypher 9.
Label and tag	A label is used for searching a vertex, namely an index of vertex.	A tag defines the type of a vertex and its corresponding properties. It cannot be used as an index.
Pre-compiling and parameterized queries	Support	Parameterized queries are supported, but precompiling is not.

Compatibility

OpenCypher 9 and Cypher have some differences in grammar and licence. For example,

1. Cypher requires that **All Cypher statements are explicitly run within a transaction**. While openCypher has no such requirement. And nGQL does not support transactions.
2. Cypher has a variety of constraints, including Unique node property constraints, Node property existence constraints, Relationship property existence constraints, and Node key constraints. While OpenCypher has no such constraints. As a strong schema system, most of the constraints mentioned above can be solved through schema definitions (including NOT NULL) in nGQL. The only function that cannot be supported is the UNIQUE constraint.
3. Cypher has APoC, while openCypher 9 does not have APoC. Cypher has Blot protocol support requirements, while openCypher 9 does not.

WHERE CAN I FIND MORE NGQL EXAMPLES?

Users can find more than 2500 nGQL examples in the features directory on the NebulaGraph GitHub page.

The `features` directory consists of `.feature` files. Each file records scenarios that you can use as nGQL examples. Here is an example:

```
Feature: Basic match

  Background:
    Given a graph with space named "basketballplayer"

  Scenario: Single node
    When executing query:
      """
      MATCH (v:player {name: "Yao Ming"}) RETURN v;
      """
    Then the result should be, in any order, with relax comparison:
      | v                                                |
      | ("player133" :player{age: 38, name: "Yao Ming"}) |

  Scenario: One step
    When executing query:
      """
      MATCH (v1:player{name: "LeBron James"}) -[r]-> (v2)
      RETURN type(r) AS Type, v2.player.name AS Name
      """
    Then the result should be, in any order:

      | Type     | Name        |
      | "follow" | "Ray Allen" |
      | "serve"  | "Lakers"    |
      | "serve"  | "Heat"      |
      | "serve"  | "Cavaliers" |

Feature:  Comparison of where clause
```

```
Background:
  Given a graph with space named "basketballplayer"

  Scenario: push edge props filter down
    When profiling query:
      """
      GO FROM "player100" OVER follow
      WHERE properties(edge).degree IN [v IN [95,99] WHERE v > 0]
      YIELD dst(edge), properties(edge).degree
      """
    Then the result should be, in any order:
      | follow._dst | follow.degree |
      | "player101" | 95            |
      | "player125" | 95            |
    And the execution plan should be:
      | id | name         | dependencies | operator info                                                |
      | 0  | Project      | 1            |                                                              |
      | 1  | GetNeighbors | 2            | {"filter": "(properties(edge).degree IN [v IN [95,99] WHERE (v>0)])"} |
      | 2  | Start        |              |                                                              |
```

The keywords in the preceding example are described as follows.

Keyword	Description
`Feature`	Describes the topic of the current `.feature` file.
`Background`	Describes the background information of the current `.feature` file.
`Given`	Describes the prerequisites of running the test statements in the current `.feature` file.
`Scenario`	Describes the scenarios. If there is the `@skip` before one `Scenario`, this scenario may not work and do not use it as a working example in a production environment.
`When`	Describes the nGQL statement to be executed. It can be a `executing query` or `profiling query`.
`Then`	Describes the expected return results of running the statement in the `When` clause. If the return results in your environment do not match the results described in the `.feature` file, submit an issue to inform the NebulaGraph team.
`And`	Describes the side effects of running the statement in the `When` clause.
`@skip`	This test case will be skipped. Commonly, the to-be-tested code is not ready.

Welcome to add more tck case and return automatically to the using statements in CI/CD.

DOES IT SUPPORT TINKERPOP GREMLIN?

No. And no plan to support that.

DOES NEBULAGRAPH SUPPORT W3C RDF (SPARQL) OR GRAPHQL?

No. And no plan to support that.

The data model of NebulaGraph is the property graph. And as a strong schema system, NebulaGraph does not support RDF.

NebulaGraph Query Language does not support `SPARQL` nor `GraphQL`.

Last update: August 29, 2022

4.1.2 Patterns

Patterns and graph pattern matching are the very heart of a graph query language. This topic will describe the patterns in NebulaGraph, some of which have not yet been implemented.

Patterns for vertices

A vertex is described using a pair of parentheses and is typically given a name. For example:

```
(a)
```

This simple pattern describes a single vertex and names that vertex using the variable `a`.

Patterns for related vertices

A more powerful construct is a pattern that describes multiple vertices and edges between them. Patterns describe an edge by employing an arrow between two vertices. For example:

```
(a)-[]->(b)
```

This pattern describes a very simple data structure: two vertices and a single edge from one to the other. In this example, the two vertices are named as `a` and `b` respectively and the edge is `directed`: it goes from `a` to `b`.

This manner of describing vertices and edges can be extended to cover an arbitrary number of vertices and the edges between them, for example:

```
(a)-[]->(b)<-[]-(c)
```

Such a series of connected vertices and edges is called a `path`.

Note that the naming of the vertices in these patterns is only necessary when one needs to refer to the same vertex again, either later in the pattern or elsewhere in the query. If not, the name may be omitted as follows:

```
(a)-[]->()<-[]-(c)
```

Patterns for tags

Note

The concept of `tag` in nGQL has a few differences from that of `label` in openCypher. For example, users must create a `tag` before using it. And a `tag` also defines the type of properties.

In addition to simply describing the vertices in the graphs, patterns can also describe the tags of the vertices. For example:

```
(a:User)-[]->(b)
```

Patterns can also describe a vertex that has multiple tags. For example:

```
(a:User:Admin)-[]->(b)
```

Patterns for properties

Vertices and edges are the fundamental elements in a graph. In nGQL, properties are added to them for richer models.

In the patterns, the properties can be expressed as follows: some key-value pairs are enclosed in curly brackets and separated by commas, and the tag or edge type to which a property belongs must be specified.

For example, a vertex with two properties will be like:

```
(a:player{name: "Tim Duncan", age: 42})
```

One of the edges that connect to this vertex can be like:

```
(a)-[e:follow{degree: 95}]->(b)
```

Patterns for edges

The simplest way to describe an edge is by using the arrow between two vertices, as in the previous examples.

Users can describe an edge and its direction using the following statement. If users do not care about its direction, the arrowhead can be omitted. For example:

```
(a)-[]-(b)
```

Like vertices, edges can also be named. A pair of square brackets will be used to separate the arrow and the variable will be placed between them. For example:

```
(a)-[r]->(b)
```

Like the tags on vertices, edges can also have types. To describe an edge with a specific type, use the pattern as follows:

```
(a)-[r:REL_TYPE]->(b)
```

An edge can only have one edge type. But if we'd like to describe some data such that the edge could have a set of types, then they can all be listed in the pattern, separating them with the pipe symbol `|` like this:

```
(a)-[r:TYPE1|TYPE2]->(b)
```

Like vertices, the name of an edge can be omitted. For example:

```
(a)-[:REL_TYPE]->(b)
```

Variable-length pattern

Rather than describing a long path using a sequence of many vertex and edge descriptions in a pattern, many edges (and the intermediate vertices) can be described by specifying a length in the edge description of a pattern. For example:

```
(a)-[*2]->(b)
```

The following pattern describes a graph of three vertices and two edges, all in one path (a path of length 2). It is equivalent to:

```
(a)-[]->()-[]->(b)
```

The range of lengths can also be specified. Such edge patterns are called `variable-length edges`. For example:

```
(a)-[*3..5]->(b)
```

The preceding example defines a path with a minimum length of 3 and a maximum length of 5.

It describes a graph of either 4 vertices and 3 edges, 5 vertices and 4 edges, or 6 vertices and 5 edges, all connected in a single path.

The lower bound can be omitted. For example, to describe paths of length 5 or less, use:

```
(a)-[*..5]->(b)
```

Note

The upper bound must be specified. The following are **NOT** accepted.

```
(a)-[*3..]->(b)
(a)-[*]->(b)
```

Assigning to path variables

As described above, a series of connected vertices and edges is called a `path`. nGQL allows paths to be named using variables. For example:

```
p = (a)-[*3..5]->(b)
```

Users can do this in the `MATCH` statement.

Last update: February 3, 2023

4.1.3 Comments

This topic will describe the comments in nGQL.

Legacy version compatibility

- In NebulaGraph 1.x, there are four comment styles: `#`, `--`, `//`, `/* */`.
- Since NebulaGraph 2.x, `--` cannot be used as comments.

Examples

```
nebula> # Do nothing in this line
nebula> RETURN 1+1;     # This comment continues to the end of this line.
nebula> RETURN 1+1;     // This comment continues to the end of this line.
nebula> RETURN 1 /* This is an in-line comment. */ + 1 == 2;
nebula> RETURN 11 +            \
/* Multi-line comment.       \
Use a backslash as a line break.   \
*/ 12;
```

In nGQL statement, the backslash `\` in a line indicates a line break.

OpenCypher compatibility

- In nGQL, you must add a `\` at the end of every line, even in multi-line comments `/* */`.
- In openCypher, there is no need to use a `\` as a line break.

```
/* openCypher style:
The following comment
spans more than
one line */
MATCH (n:label)
RETURN n;
```

```
/* nGQL style:  \
The following comment       \
spans more than     \
one line */       \
MATCH (n:tag) \
RETURN n;
```

Last update: August 11, 2022

4.1.4 Identifier case sensitivity

Identifiers are Case-Sensitive

The following statements will not work because they refer to two different spaces, i.e. `my_space` and `MY_SPACE`.

```
nebula> CREATE SPACE IF NOT EXISTS my_space (vid_type=FIXED_STRING(30));
nebula> use MY_SPACE;
[ERROR (-1005)]: SpaceNotFound:
```

Keywords and Reserved Words are Case-Insensitive

The following statements are equivalent since `show` and `spaces` are keywords.

```
nebula> show spaces;
nebula> SHOW SPACES;
nebula> SHOW spaces;
nebula> show SPACES;
```

Functions are Case-Insensitive

Functions are case-insensitive. For example, `count()`, `COUNT()`, and `couNT()` are equivalent.

```
nebula> WITH [NULL, 1, 1, 2, 2] As a \
        UNWIND a AS b \
        RETURN count(b), COUNT(*), couNT(DISTINCT b);
+----------+----------+-------------------+
| count(b) | COUNT(*) | couNT(distinct b) |
+----------+----------+-------------------+
| 4        | 5        | 2                 |
+----------+----------+-------------------+
```

Last update: May 13, 2022

4.1.5 Keywords

Keywords have significance in nGQL. It can be classified into reserved keywords and non-reserved keywords. It is not recommend to use keywords in schema.

If you must use keywords in schema:

- Non-reserved keywords can be used as identifiers without quotes if they are all in lowercase. However, if a non-reserved keyword contains any uppercase letters when used as an identifier, it must be enclosed in backticks (`), for example, `Comment`.
- To use special characters or reserved keywords as identifiers, quote them with backticks such as `AND`.

Note

Keywords are case-insensitive.

```
nebula> CREATE TAG TAG(name string);
[ERROR (-1004)]: SyntaxError: syntax error near `TAG'

nebula> CREATE TAG `TAG` (name string);
Execution succeeded

nebula> CREATE TAG SPACE(name string);
Execution succeeded

nebula> CREATE TAG 中文(简体 string);
Execution succeeded

nebula> CREATE TAG `￥%special characters&*+-*/` (`q~！（）=  wer` string);
Execution succeeded
```

Reserved keywords

```
ACROSS
ADD
ALTER
AND
AS
ASC
ASCENDING
BALANCE
BOOL
BY
CASE
CHANGE
COMPACT
CREATE
DATE
DATETIME
DELETE
DESC
DESCENDING
DESCRIBE
DISTINCT
DOUBLE
DOWNLOAD
DROP
DURATION
EDGE
EDGES
EXISTS
EXPLAIN
FETCH
FIND
FIXED_STRING
FLOAT
FLUSH
FORMAT
FROM
GET
GO
GRANT
IF
IGNORE_EXISTED_INDEX
IN
INDEX
INDEXES
```

```
INGEST
INSERT
INT
INT16
INT32
INT64
INT8
INTERSECT
IS
LIMIT
LIST
LOOKUP
MAP
MATCH
MINUS
NO
NOT
NOT_IN
NULL
OF
OFFSET
ON
OR
ORDER
OVER
OVERWRITE
PROFILE
PROP
REBUILD
RECOVER
REMOVE
RESTART
RETURN
REVERSELY
REVOKE
SET
SHOW
STEP
STEPS
STOP
STRING
SUBMIT
TAG
TAGS
TIME
TIMESTAMP
TO
UNION
UPDATE
UPSERT
UPTO
USE
VERTEX
VERTICES
WHEN
WHERE
WITH
XOR
YIELD
```

Non-reserved keywords

```
ACCOUNT
ADMIN
ALL
ANY
ATOMIC_EDGE
AUTO
BIDIRECT
BOTH
CHARSET
CLIENTS
COLLATE
COLLATION
COMMENT
CONFIGS
CONTAINS
DATA
DBA
DEFAULT
ELASTICSEARCH
ELSE
END
ENDS
ENDS_WITH
FORCE
FULLTEXT
FUZZY
GOD
GRAPH
GROUP
```

```
GROUPS
GUEST
HDFS
HOST
HOSTS
INTO
IS_EMPTY
IS_NOT_EMPTY
IS_NOT_NULL
IS_NULL
JOB
JOBS
KILL
LEADER
LISTENER
META
NOLOOP
NONE
NOT_CONTAINS
NOT_ENDS_WITH
NOT_STARTS_WITH
OPTIONAL
OUT
PART
PARTITION_NUM
PARTS
PASSWORD
PATH
PLAN
PREFIX
QUERIES
QUERY
REDUCE
REGEXP
REPLICA_FACTOR
RESET
ROLE
ROLES
SAMPLE
SEARCH
SERVICE
SESSION
SESSIONS
SHORTEST
SIGN
SINGLE
SKIP
SNAPSHOT
SNAPSHOTS
SPACE
SPACES
STARTS
STARTS_WITH
STATS
STATUS
STORAGE
SUBGRAPH
TEXT
TEXT_SEARCH
THEN
TOP
TTL_COL
TTL_DURATION
UNWIND
USER
USERS
UUID
VALUE
VALUES
VID_TYPE
WILDCARD
ZONE
ZONES
FALSE
TRUE
```

Last update: March 27, 2023

4.1.6 nGQL style guide

nGQL does not have strict formatting requirements, but creating nGQL statements according to an appropriate and uniform style can improve readability and avoid ambiguity. Using the same nGQL style in the same organization or project helps reduce maintenance costs and avoid problems caused by format confusion or misunderstanding. This topic will provide a style guide for writing nGQL statements.

Compatibility

The styles of nGQL and Cypher Style Guide are different.

Newline

1. Start a new line to write a clause.

   Not recommended:

   ```
   GO FROM "player100" OVER follow REVERSELY YIELD src(edge) AS id;
   ```

   Recommended:

   ```
   GO FROM "player100" \
   OVER follow REVERSELY \
   YIELD src(edge) AS id;
   ```

2. Start a new line to write different statements in a composite statement.

   Not recommended:

   ```
   GO FROM "player100" OVER follow REVERSELY YIELD src(edge) AS id | GO FROM $-.id \
   OVER serve WHERE properties($^).age > 20 YIELD properties($^).name AS FriendOf, properties($$).name AS Team;
   ```

   Recommended:

   ```
   GO FROM "player100" \
   OVER follow REVERSELY \
   YIELD src(edge) AS id | \
   GO FROM $-.id OVER serve \
   WHERE properties($^).age > 20 \
   YIELD properties($^).name AS FriendOf, properties($$).name AS Team;
   ```

3. If the clause exceeds 80 characters, start a new line at the appropriate place.

   Not recommended:

   ```
   MATCH (v:player{name:"Tim Duncan"})-[e]->(v2) \
   WHERE (v2.player.name STARTS WITH "Y" AND v2.player.age > 35 AND v2.player.age < v.player.age) OR (v2.player.name STARTS WITH "T" AND v2.player.age < 45 AND v2.player.age > v.player.age) \
   RETURN v2;
   ```

   Recommended:

   ```
   MATCH (v:player{name:"Tim Duncan"})-[e]->(v2) \
   WHERE (v2.player.name STARTS WITH "Y" AND v2.player.age > 35 AND v2.player.age < v.player.age) \
   OR (v2.player.name STARTS WITH "T" AND v2.player.age < 45 AND v2.player.age > v.player.age) \
   RETURN v2;
   ```

Note

If needed, you can also start a new line for better understanding, even if the clause does not exceed 80 characters.

Identifier naming

In nGQL statements, characters other than keywords, punctuation marks, and blanks are all identifiers. Recommended methods to name the identifiers are as follows.

1. Use singular nouns to name tags, and use the base form of verbs or verb phrases to form Edge types.

   Not recommended:

   ```
   MATCH p=(v:players)-[e:are_following]-(v2) \
   RETURN nodes(p);
   ```

   Recommended:

   ```
   MATCH p=(v:player)-[e:follow]-(v2) \
   RETURN nodes(p);
   ```

2. Use the snake case to name identifiers, and connect words with underscores (_) with all the letters lowercase.

   Not recommended:

   ```
   MATCH (v:basketballTeam) \
   RETURN v;
   ```

   Recommended:

   ```
   MATCH (v:basketball_team) \
   RETURN v;
   ```

3. Use uppercase keywords and lowercase variables.

   Not recommended:

   ```
   match (V:player) return V limit 5;
   ```

   Recommended:

   ```
   MATCH (v:player) RETURN v LIMIT 5;
   ```

Pattern

1. Start a new line on the right side of the arrow indicating an edge when writing patterns.

   Not recommended:

   ```
   MATCH (v:player{name: "Tim Duncan", age: 42}) \
   -[e:follow]->()-[e:serve]->()<--(v2) \
   RETURN v, e, v2;
   ```

   Recommended:

   ```
   MATCH (v:player{name: "Tim Duncan", age: 42})-[e:follow]-> \
   ()-[e:serve]->()<--(v2) \
   RETURN v, e, v2;
   ```

2. Anonymize the vertices and edges that do not need to be queried.

   Not recommended:

   ```
   MATCH (v:player)-[e:follow]->(v2) \
   RETURN v;
   ```

   Recommended:

   ```
   MATCH (v:player)-[:follow]->() \
   RETURN v;
   ```

3. Place named vertices in front of anonymous vertices.

   Not recommended:

```
MATCH ()-[:follow]->(v) \
RETURN v;
```

Recommended:

```
MATCH (v)<-[:follow]-() \
RETURN v;
```

String

The strings should be surrounded by double quotes.

Not recommended:

```
RETURN 'Hello Nebula!';
```

Recommended:

```
RETURN "Hello Nebula!\"123\"";
```

Note

When single or double quotes need to be nested in a string, use a backslash () to escape. For example:

```
RETURN "\"NebulaGraph is amazing,\" the user says.";
```

Statement termination

1. End the nGQL statements with an English semicolon (;).

   Not recommended:

   ```
   FETCH PROP ON player "player100" YIELD properties(vertex)
   ```

   Recommended:

   ```
   FETCH PROP ON player "player100" YIELD properties(vertex);
   ```

2. Use a pipe (|) to separate a composite statement, and end the statement with an English semicolon at the end of the last line. Using an English semicolon before a pipe will cause the statement to fail.

   Not supported:

   ```
   GO FROM "player100" \
   OVER follow \
   YIELD dst(edge) AS id; | \
   GO FROM $-.id \
   OVER serve \
   YIELD properties($$).name AS Team, properties($^).name AS Player;
   ```

   Supported:

   ```
   GO FROM "player100" \
   OVER follow \
   YIELD dst(edge) AS id | \
   GO FROM $-.id \
   OVER serve \
   YIELD properties($$).name AS Team, properties($^).name AS Player;
   ```

3. In a composite statement that contains user-defined variables, use an English semicolon to end the statements that define the variables. If you do not follow the rules to add a semicolon or use a pipe to end the composite statement, the execution will fail.

   Not supported:

   ```
   $var = GO FROM "player100" \
   OVER follow \
   YIELD follow._dst AS id \
   GO FROM $var.id \
   ```

```
OVER serve \
YIELD $$.team.name AS Team, $^.player.name AS Player;
```

Not supported:

```
$var = GO FROM "player100" \
OVER follow \
YIELD follow._dst AS id | \
GO FROM $var.id \
OVER serve \
YIELD $$.team.name AS Team, $^.player.name AS Player;
```

Supported:

```
$var = GO FROM "player100" \
OVER follow \
YIELD follow._dst AS id; \
GO FROM $var.id \
OVER serve \
YIELD $$.team.name AS Team, $^.player.name AS Player;
```

Last update: February 2, 2023

4.2 Data types

4.2.1 Numeric types

nGQL supports both integer and floating-point number.

Integer

Signed 64-bit integer (INT64), 32-bit integer (INT32), 16-bit integer (INT16), and 8-bit integer (INT8) are supported.

Type	Declared keywords	Range
INT64	`INT64` or `INT`	-9,223,372,036,854,775,808 ~ 9,223,372,036,854,775,807
INT32	`INT32`	-2,147,483,648 ~ 2,147,483,647
INT16	`INT16`	-32,768 ~ 32,767
INT8	`INT8`	-128 ~ 127

Floating-point number

Both single-precision floating-point format (FLOAT) and double-precision floating-point format (DOUBLE) are supported.

Type	Declared keywords	Range	Precision
FLOAT	`FLOAT`	3.4E +/- 38	6~7 bits
DOUBLE	`DOUBLE`	1.7E +/- 308	15~16 bits

Scientific notation is also supported, such as `1e2`, `1.1e2`, `.3e4`, `1.e4`, and `-1234E-10`.

Note

The data type of DECIMAL in MySQL is not supported.

Reading and writing of data values

When writing and reading different types of data, nGQL complies with the following rules:

Data type	Set as VID	Set as property	Resulted data type
INT64	Supported	Supported	INT64
INT32	Not supported	Supported	INT64
INT16	Not supported	Supported	INT64
INT8	Not supported	Supported	INT64
FLOAT	Not supported	Supported	DOUBLE
DOUBLE	Not supported	Supported	DOUBLE

For example, nGQL does not support setting VID as INT8, but supports setting a certain property type of TAG or Edge type as INT8. When using the nGQL statement to read the property of INT8, the resulted type is INT64.

- Multiple formats are supported:
- Decimal, such as `123456`.
- Hexadecimal, such as `0x1e240`.
- Octal, such as `0361100`.

  However, NebulaGraph will parse the written non-decimal value into a decimal value and save it. The value read is decimal.

  For example, the type of the property `score` is `INT`. The value of `0xb` is assigned to it through the INSERT statement. If querying the property value with statements such as FETCH, you will get the result `11`, which is the decimal result of the hexadecimal `0xb`.

- Round a FLOAT/DOUBLE value when inserting it to an INT column.

Last update: August 11, 2022

4.2.2 Boolean

A boolean data type is declared with the `bool` keyword and can only take the values `true` or `false`.

nGQL supports using boolean in the following ways:

- Define the data type of the property value as a boolean.
- Use boolean as judgment conditions in the `WHERE` clause.

Last update: August 23, 2021

4.2.3 String

Fixed-length strings and variable-length strings are supported.

Declaration and literal representation

The string type is declared with the keywords of:

- `STRING` : Variable-length strings.
- `FIXED_STRING(<length>)` : Fixed-length strings. `<length>` is the length of the string, such as `FIXED_STRING(32)` .

A string type is used to store a sequence of characters (text). The literal constant is a sequence of characters of any length surrounded by double or single quotes. For example, `"Hello, Cooper"` or `'Hello, Cooper'` .

String reading and writing

Nebula Graph supports using string types in the following ways:

- Define the data type of VID as a fixed-length string.
- Set the variable-length string as the Schema name, including the names of the graph space, tag, edge type, and property.
- Define the data type of the property as a fixed-length or variable-length string.

For example:

- Define the data type of the property as a fixed-length string

```
nebula> CREATE TAG IF NOT EXISTS t1 (p1 FIXED_STRING(10));
```

- Define the data type of the property as a variable-length string

```
nebula> CREATE TAG IF NOT EXISTS t2 (p2 STRING);
```

When the fixed-length string you try to write exceeds the length limit:

- If the fixed-length string is a property, the writing will succeed, and NebulaGraph will truncate the string and only store the part that meets the length limit.
- If the fixed-length string is a VID, the writing will fail and NebulaGraph will return an error.

Escape characters

Line breaks are not allowed in a string. Escape characters are supported within strings, for example:

- `"\n\t\r\b\f"`
- `"\110ello world"`

OpenCypher compatibility

There are some tiny differences between openCypher and Cypher, as well as nGQL. The following is what openCypher requires. Single quotes cannot be converted to double quotes.

```
# File: Literals.feature
Feature: Literals

Background:
    Given any graph
 Scenario: Return a single-quoted string
    When executing query:
      """
      RETURN '' AS literal
      """
```

```
    Then the result should be, in any order:
      | literal |
      | ''      |    # Note: it should return single-quotes as openCypher required.
    And no side effects
```

While Cypher accepts both single quotes and double quotes as the return results. nGQL follows the Cypher way.

```
nebula > YIELD '' AS quote1, "" AS quote2, "'" AS quote3, '"' AS quote4
+--------+--------+--------+--------+
| quote1 | quote2 | quote3 | quote4 |
+--------+--------+--------+--------+
| ""     | ""     | "'"    | """    |
+--------+--------+--------+--------+
```

Last update: August 11, 2022

4.2.4 Date and time types

This topic will describe the `DATE`, `TIME`, `DATETIME`, `TIMESTAMP`, and `DURATION` types.

Precautions

- While inserting time-type property values with `DATE`, `TIME`, and `DATETIME`, NebulaGraph transforms them to a UTC time according to the timezone specified with the `timezone_name` parameter in the configuration files.

    Note

    To change the timezone, modify the `timezone_name` value in the configuration files of all NebulaGraph services.

- `date()`, `time()`, and `datetime()` can convert a time-type property with a specified timezone. For example, `datetime("2017-03-04 22:30:40.003000+08:00")` or `datetime("2017-03-04T22:30:40.003000[Asia/Shanghai]")`.
- `date()`, `time()`, `datetime()`, and `timestamp()` all accept empty parameters to return the current date, time, and datetime.
- `date()`, `time()`, and `datetime()` all accept the property name to return a specific property value of itself. For example, `date().month` returns the current month, while `time("02:59:40").minute` returns the minutes of the importing time.

OpenCypher Compatibility

In nGQL:

- Year, month, day, hour, minute, second, millisecond, and microsecond are supported, while the nanosecond is not supported.
- `localdatetime()` is not supported.
- Most string time formats are not supported. The exceptions are `YYYY-MM-DDThh:mm:ss` and `YYYY-MM-DD hh:mm:ss`.
- The single-digit string time format is supported. For example, `time("1:1:1")`.

DATE

The `DATE` type is used for values with a date part but no time part. Nebula Graph retrieves and displays `DATE` values in the `YYYY-MM-DD` format. The supported range is `-32768-01-01` to `32767-12-31`.

The properties of `date()` include `year`, `month`, and `day`.

TIME

The `TIME` type is used for values with a time part but no date part. Nebula Graph retrieves and displays `TIME` values in `hh:mm:ss.msmsmsususus` format. The supported range is `00:00:00.000000` to `23:59:59.999999`.

The properties of `time()` include `hour`, `minute`, and `second`.

DATETIME

The `DATETIME` type is used for values that contain both date and time parts. Nebula Graph retrieves and displays `DATETIME` values in `YYYY-MM-DDThh:mm:ss.msmsmsususus` format. The supported range is `-32768-01-01T00:00:00.000000` to `32767-12-31T23:59:59.999999`.

- The properties of `datetime()` include `year`, `month`, `day`, `hour`, `minute`, and `second`.
- `datetime()` can convert `TIMESTAMP` to `DATETIME`. The value range of `TIMESTAMP` is `0~9223372036`.
- `datetime()` supports an `int` argument. The `int` argument specifies a timestamp.

```
# To get the current date and time.
nebula> RETURN datetime();
+----------------------------+
| datetime()                 |
+----------------------------+
| 2022-08-29T06:37:08.933000 |
+----------------------------+

# To get the current hour.
nebula> RETURN datetime().hour;
+-----------------+
| datetime().hour |
+-----------------+
| 6               |
+-----------------+

# To get date time from a given timestamp.
nebula> RETURN datetime(timestamp(1625469277));
+---------------------------------+
| datetime(timestamp(1625469277)) |
+---------------------------------+
| 2021-07-05T07:14:37.000000      |
+---------------------------------+

nebula> RETURN datetime(1625469277);
+----------------------------+
| datetime(1625469277)       |
+----------------------------+
| 2021-07-05T07:14:37.000000 |
+----------------------------+
```

TIMESTAMP

The `TIMESTAMP` data type is used for values that contain both date and time parts. It has a range of `1970-01-01T00:00:01` UTC to `2262-04-11T23:47:16` UTC.

`TIMESTAMP` has the following features:

- Stored and displayed in the form of a timestamp, such as `1615974839`, which means `2021-03-17T17:53:59`.
- Supported `TIMESTAMP` querying methods: timestamp and `timestamp()` function.
- Supported `TIMESTAMP` inserting methods: timestamp, `timestamp()` function, and `now()` function.
- `timestamp()` function accepts empty arguments to get the current timestamp. It can pass an integer arguments to identify the integer as a timestamp and the range of passed integer is: `0~9223372036` 。
- `timestamp()` function can convert `DATETIME` to `TIMESTAMP`, and the data type of `DATETIME` should be a `string`.
- The underlying storage data type is **int64**.

```
# To get the current timestamp.
nebula> RETURN timestamp();
+-------------+
| timestamp() |
+-------------+
| 1625469277  |
+-------------+

# To get a timestamp from given date and time.
nebula> RETURN timestamp("2022-01-05T06:18:43");
+----------------------------------+
| timestamp("2022-01-05T06:18:43") |
+----------------------------------+
| 1641363523                       |
+----------------------------------+

# To get a timestamp using datetime().
nebula> RETURN timestamp(datetime("2022-08-29T07:53:10.939000"));
+---------------------------------------------------+
| timestamp(datetime("2022-08-29T07:53:10.939000")) |
+---------------------------------------------------+
| 1661759590                                        |
+---------------------------------------------------+
```

Note

The date and time format string passed into `timestamp()` cannot include any millisecond and microsecond, but the date and time format string passed into `timestamp(datetime())` can include a millisecond and a microsecond.

DURATION

The `DURATION` data type is used to indicate a period of time. Map data that are freely combined by `years`, `months`, `days`, `hours`, `minutes`, and `seconds` indicates the `DURATION`.

`DURATION` has the following features:

- Creating indexes for `DURATION` is not supported.
- `DURATION` can be used to calculate the specified time.

Examples

1. Create a tag named `date1` with three properties: `DATE`, `TIME`, and `DATETIME`.

```
nebula> CREATE TAG IF NOT EXISTS date1(p1 date, p2 time, p3 datetime);
```

2. Insert a vertex named `test1`.

```
nebula> INSERT VERTEX date1(p1, p2, p3) VALUES "test1":(date("2021-03-17"), time("17:53:59"), datetime("2017-03-04T22:30:40.003000[Asia/Shanghai]"));
```

3. Query whether the value of property `p1` on the `test1` tag is `2021-03-17`.

```
nebula> MATCH (v:date1)  RETURN v.date1.p1 == date("2021-03-17");
+----------------------------------+
| (v.date1.p1==date("2021-03-17")) |
+----------------------------------+
| true                             |
+----------------------------------+
```

4. Return the content of the property `p1` on `test1`.

```
nebula> CREATE TAG INDEX IF NOT EXISTS date1_index ON date1(p1);
nebula> REBUILD TAG INDEX date1_index;
nebula> MATCH (v:date1) RETURN v.date1.p1;
+------------------+
| v.date1.p1.month |
+------------------+
| 3                |
+------------------+
```

5. Search for vertices with `p3` property values less than `2023-01-01T00:00:00.000000`, and return the `p3` values.

```
nebula> MATCH (v:date1)  \
WHERE v.date1.p3 < datetime("2023-01-01T00:00:00.000000") \
RETURN v.date1.p3;
+----------------------------+
| v.date1.p3                 |
+----------------------------+
| 2017-03-04T14:30:40.003000 |
+----------------------------+
```

6. Create a tag named `school` with the property of `TIMESTAMP`.

```
nebula> CREATE TAG IF NOT EXISTS school(name string , found_time timestamp);
```

7. Insert a vertex named `DUT` with a found-time timestamp of `"1988-03-01T08:00:00"`.

```
# Insert as a timestamp. The corresponding timestamp of 1988-03-01T08:00:00 is 573177600, or 573206400 UTC.
nebula> INSERT VERTEX school(name, found_time) VALUES "DUT":("DUT", 573206400);

# Insert in the form of date and time.
nebula> INSERT VERTEX school(name, found_time) VALUES "DUT":("DUT", timestamp("1988-03-01T08:00:00"));
```

8. Insert a vertex named `dut` and store time with `now()` or `timestamp()` functions.

```
# Use now() function to store time
nebula> INSERT VERTEX school(name, found_time) VALUES "dut":("dut", now());

# Use timestamp() function to store time
nebula> INSERT VERTEX school(name, found_time) VALUES "dut":("dut", timestamp());
```

You can also use `WITH` statement to set a specific date and time, or to perform calculations. For example:

```
nebula> WITH time({hour: 12, minute: 31, second: 14, millisecond:111, microsecond: 222}) AS d RETURN d;
+-----------------+
| d               |
+-----------------+
| 12:31:14.111222 |
+-----------------+

nebula> WITH date({year: 1984, month: 10, day: 11}) AS x RETURN x + 1;
+------------+
| (x+1)      |
+------------+
| 1984-10-12 |
+------------+

nebula> WITH date('1984-10-11') as x, duration({years: 12, days: 14, hours: 99, minutes: 12}) as d \
        RETURN x + d AS sum, x - d AS diff;
+------------+------------+
| sum        | diff       |
+------------+------------+
| 1996-10-29 | 1972-09-23 |
+------------+------------+
```

Last update: January 17, 2023

4.2.5 NULL

You can set the properties for vertices or edges to `NULL`. Also, you can set the `NOT NULL` constraint to make sure that the property values are `NOT NULL`. If not specified, the property is set to `NULL` by default.

Logical operations with NULL

Here is the truth table for `AND`, `OR`, `XOR`, and `NOT`.

a	b	a AND b	a OR b	a XOR b	NOT a
false	false	false	false	false	true
false	null	false	null	null	true
false	true	false	true	true	true
true	false	false	true	true	false
true	null	null	true	null	false
true	true	true	true	false	false
null	false	false	null	null	null
null	null	null	null	null	null
null	true	null	true	null	null

OpenCypher compatibility

The comparisons and operations about NULL are different from openCypher. There may be changes later.

COMPARISONS WITH NULL

The comparison operations with NULL are incompatible with openCypher.

OPERATIONS AND RETURN WITH NULL

The NULL operations and RETURN with NULL are incompatible with openCypher.

Examples

USE NOT NULL

Create a tag named `player`. Specify the property `name` as `NOT NULL`.

```
nebula> CREATE TAG IF NOT EXISTS player(name string NOT NULL, age int);
```

Use `SHOW` to create tag statements. The property `name` is `NOT NULL`. The property `age` is `NULL` by default.

```
nebula> SHOW CREATE TAG player;
+-----------+-----------------------------------+
| Tag       | Create Tag                        |
+-----------+-----------------------------------+
| "student" | "CREATE TAG `player` (            |
|           |  `name` string NOT NULL,          |
|           |  `age` int64 NULL                 |
|           | ) ttl_duration = 0, ttl_col = """ |
+-----------+-----------------------------------+
```

Insert the vertex `Kobe`. The property `age` can be `NULL`.

```
nebula> INSERT VERTEX player(name, age) VALUES "Kobe":("Kobe",null);
```

USE NOT NULL AND SET THE DEFAULT

Create a tag named `player`. Specify the property `age` as `NOT NULL`. The default value is `18`.

```
nebula> CREATE TAG IF NOT EXISTS player(name string, age int NOT NULL DEFAULT 18);
```

Insert the vertex `Kobe`. Specify the property `name` only.

```
nebula> INSERT VERTEX player(name) VALUES "Kobe":("Kobe");
```

Query the vertex `Kobe`. The property `age` is `18` by default.

```
nebula> FETCH PROP ON player "Kobe" YIELD properties(vertex);
+--------------------------+
| properties(VERTEX)       |
+--------------------------+
| {age: 18, name: "Kobe"}  |
+--------------------------+
```

Last update: December 8, 2021

4.2.6 Lists

The list is a composite data type. A list is a sequence of values. Individual elements in a list can be accessed by their positions.

A list starts with a left square bracket `[` and ends with a right square bracket `]`. A list contains zero, one, or more expressions. List elements are separated from each other with commas (`,`). Whitespace around elements is ignored in the list, thus line breaks, tab stops, and blanks can be used for formatting.

OpenCypher compatibility

A composite data type (i.e. set, map, and list) **CANNOT** be stored as properties of vertices or edges.

List operations

You can use the preset list function to operate the list, or use the index to filter the elements in the list.

INDEX SYNTAX

```
[M]
[M..N]
[M..]
[..N]
```

The index of nGQL supports queries from front to back, starting from 0. 0 means the first element, 1 means the second element, and so on. It also supports queries from back to front, starting from -1. -1 means the last element, -2 means the penultimate element, and so on.

- [M]: represents the element whose index is M.
- [M..N]: represents the elements whose indexes are `greater or equal to M but smaller than N`. Return empty when `N` is 0.
- [M..]: represents the elements whose indexes are `greater or equal to M`.
- [..N]: represents the elements whose indexes are `smaller than N`. Return empty when `N` is 0.

Note

- Return empty if the index is out of bounds, while return normally if the index is within the bound.
- Return empty if `M ≥ N`.
- When querying a single element, if `M` is null, return `BAD_TYPE`. When conducting a range query, if `M` or `N` is null, return `null`.

Examples

```
# The following query returns the list [1,2,3].
nebula> RETURN list[1, 2, 3] AS a;
+-----------+
| a         |
+-----------+
| [1, 2, 3] |
+-----------+

# The following query returns the element whose index is 3 in the list [1,2,3,4,5]. In a list, the index starts from 0, and thus the return element is 4.
nebula> RETURN range(1,5)[3];
+---------------+
| range(1,5)[3] |
+---------------+
| 4             |
+---------------+

# The following query returns the element whose index is -2 in the list [1,2,3,4,5]. The index of the last element in a list is -1, and thus the return element is 4.
nebula> RETURN range(1,5)[-2];
+------------------+
| range(1,5)[-(2)] |
+------------------+
| 4                |
+------------------+

# The following query returns the elements whose indexes are from 0 to 3 (not including 3) in the list [1,2,3,4,5].
nebula> RETURN range(1,5)[0..3];
```

```
+------------------+
| range(1,5)[0..3] |
+------------------+
| [1, 2, 3]        |
+------------------+

# The following query returns the elements whose indexes are greater than 2 in the list [1,2,3,4,5].
nebula> RETURN range(1,5)[3..] AS a;
+--------+
| a      |
+--------+
| [4, 5] |
+--------+

# The following query returns the elements whose indexes are smaller than 3.
nebula> WITH list[1, 2, 3, 4, 5] AS a \
        RETURN a[..3] AS r;
+-----------+
| r         |
+-----------+
| [1, 2, 3] |
+-----------+

# The following query filters the elements whose indexes are greater than 2 in the list [1,2,3,4,5], calculate them respectively, and returns them.
nebula> RETURN [n IN range(1,5) WHERE n > 2 | n + 10] AS a;
+--------------+
| a            |
+--------------+
| [13, 14, 15] |
+--------------+

# The following query returns the elements from the first to the penultimate (inclusive) in the list [1, 2, 3].
nebula> YIELD list[1, 2, 3][0..-1] AS a;
+--------+
| a      |
+--------+
| [1, 2] |
+--------+

# The following query returns the elements from the first (exclusive) to the third backward in the list [1, 2, 3, 4, 5].
nebula> YIELD list[1, 2, 3, 4, 5][-3..-1] AS a;
+--------+
| a      |
+--------+
| [3, 4] |
+--------+

# The following query sets the variables and returns the elements whose indexes are 1 and 2.
nebula> $var = YIELD 1 AS f, 3 AS t; \
        YIELD list[1, 2, 3][$var.f..$var.t] AS a;
+--------+
| a      |
+--------+
| [2, 3] |
+--------+

# The following query returns empty because the index is out of bound. It will return normally when the index is within the bound.
nebula> RETURN list[1, 2, 3, 4, 5] [0..10] AS a;
+-----------------+
| a               |
+-----------------+
| [1, 2, 3, 4, 5] |
+-----------------+

nebula> RETURN list[1, 2, 3] [-5..5] AS a;
+-----------+
| a         |
+-----------+
| [1, 2, 3] |
+-----------+

# The following query returns empty because there is a [0..0].
nebula> RETURN list[1, 2, 3, 4, 5] [0..0] AS a;
+----+
| a  |
+----+
| [] |
+----+

# The following query returns empty because of M ≥ N.
nebula> RETURN list[1, 2, 3, 4, 5] [3..1] AS a;
+----+
| a  |
+----+
| [] |
+----+

# When conduct a range query, if `M` or `N` is null, return `null`.
nebula> WITH list[1,2,3] AS a \
        RETURN a[0..null] as r;
+----------+
| r        |
+----------+
| __NULL__ |
```

```
+----------+

# The following query calculates the elements in the list [1,2,3,4,5] respectively and returns them without the list head.
nebula> RETURN tail([n IN range(1, 5) | 2 * n - 10]) AS a;
+-----------------+
| a               |
+-----------------+
| [-6, -4, -2, 0] |
+-----------------+

# The following query takes the elements in the list [1,2,3] as true and return.
nebula> RETURN [n IN range(1, 3) WHERE true | n] AS r;
+-----------+
| r         |
+-----------+
| [1, 2, 3] |
+-----------+

# The following query returns the length of the list [1,2,3].
nebula> RETURN size(list[1,2,3]);
+-------------------+
| size(list[1,2,3]) |
+-------------------+
| 3                 |
+-------------------+

# The following query calculates the elements in the list [92,90] and runs a conditional judgment in a where clause.
nebula> GO FROM "player100" OVER follow WHERE properties(edge).degree NOT IN [x IN [92, 90] | x + $$.player.age] \
        YIELD dst(edge) AS id, properties(edge).degree AS degree;
+-------------+--------+
| id          | degree |
+-------------+--------+
| "player101" | 95     |
| "player102" | 90     |
+-------------+--------+

# The following query takes the query result of the MATCH statement as the elements in a list. Then it calculates and returns them.
nebula> MATCH p = (n:player{name:"Tim Duncan"})-[:follow]->(m) \
        RETURN [n IN nodes(p) | n.player.age + 100] AS r;
+------------+
| r          |
+------------+
| [142, 136] |
| [142, 141] |
+------------+
```

OpenCypher compatibility

- In openCypher, return `null` when querying a single out-of-bound element. However, in nGQL, return `OUT_OF_RANGE` when querying a single out-of-bound element.

```
nebula> RETURN range(0,5)[-12];
+-------------------+
| range(0,5)[-(12)] |
+-------------------+
| OUT_OF_RANGE      |
+-------------------+
```

- A composite data type (i.e., set, map, and list) **CAN NOT** be stored as properties for vertices or edges.

  It is recommended to modify the graph modeling method. The composite data type should be modeled as an adjacent edge of a vertex, rather than its property. Each adjacent edge can be dynamically added or deleted. The rank values of the adjacent edges can be used for sequencing.

- Patterns are not supported in the list. For example, `[(src)-[]->(m) | m.name]`.

Last update: April 25, 2023

4.2.7 Sets

The set is a composite data type. A set is a set of values. Unlike a List, values in a set are unordered and each value must be unique.

A set starts with a left curly bracket `{` and ends with a right curly bracket `}`. A set contains zero, one, or more expressions. Set elements are separated from each other with commas (`,`). Whitespace around elements is ignored in the set, thus line breaks, tab stops, and blanks can be used for formatting.

OpenCypher compatibility

- A composite data type (i.e. set, map, and list) **CANNOT** be stored as properties of vertices or edges.
- A set is not a data type in openCypher, but in nGQL, users can use the set.

Examples

```
# The following query returns the set {1,2,3}.
nebula> RETURN set{1, 2, 3} AS a;
+-----------+
| a         |
+-----------+
| {3, 2, 1} |
+-----------+

# The following query returns the set {1,2}, Because the set does not allow repeating elements, and the order is unordered.
nebula> RETURN set{1, 2, 1} AS a;
+--------+
| a      |
+--------+
| {2, 1} |
+--------+

# The following query checks whether the set has the specified element 1.
nebula> RETURN 1 IN set{1, 2} AS a;
+------+
| a    |
+------+
| true |
+------+

# The following query counts the number of elements in the set.
nebula> YIELD size(set{1, 2, 1}) AS a;
+---+
| a |
+---+
| 2 |
+---+

# The following query returns a set of target vertex property values.
nebula> GO FROM "player100" OVER follow \
        YIELD set{properties($$).name,properties($$).age} as a;
+-----------------------+
| a                     |
+-----------------------+
| {36, "Tony Parker"}   |
| {41, "Manu Ginobili"} |
+-----------------------+
```

Last update: January 13, 2022

4.2.8 Maps

The map is a composite data type. Maps are unordered collections of key-value pairs. In maps, the key is a string. The value can have any data type. You can get the map element by using `map['key']`.

A map starts with a left curly bracket `{` and ends with a right curly bracket `}`. A map contains zero, one, or more key-value pairs. Map elements are separated from each other with commas (`,`). Whitespace around elements is ignored in the map, thus line breaks, tab stops, and blanks can be used for formatting.

OpenCypher compatibility

- A composite data type (i.e. set, map, and list) **CANNOT** be stored as properties of vertices or edges.
- Map projection is not supported.

Examples

```
# The following query returns the simple map.
nebula> YIELD map{key1: 'Value1', Key2: 'Value2'} as a;
+----------------------------------+
| a                                |
+----------------------------------+
| {Key2: "Value2", key1: "Value1"} |
+----------------------------------+

# The following query returns the list type map.
nebula> YIELD map{listKey: [{inner: 'Map1'}, {inner: 'Map2'}]} as a;
+-----------------------------------------------+
| a                                             |
+-----------------------------------------------+
| {listKey: [{inner: "Map1"}, {inner: "Map2"}]} |
+-----------------------------------------------+

# The following query returns the hybrid type map.
nebula> RETURN map{a: LIST[1,2], b: SET{1,2,1}, c: "hee"} as a;
+----------------------------------+
| a                                |
+----------------------------------+
| {a: [1, 2], b: {2, 1}, c: "hee"} |
+----------------------------------+

# The following query returns the specified element in a map.
nebula> RETURN map{a: LIST[1,2], b: SET{1,2,1}, c: "hee"}["b"] AS b;
+--------+
| b      |
+--------+
| {2, 1} |
+--------+

# The following query checks whether the map has the specified key, not support checks whether the map has the specified value yet.
nebula> RETURN "a" IN MAP{a:1, b:2} AS a;
+------+
| a    |
+------+
| true |
+------+
```

Last update: January 13, 2022

4.2.9 Type Conversion/Type coercions

Converting an expression of a given type to another type is known as type conversion.

NebulaGraph supports converting expressions explicit to other types. For details, see Type conversion functions.

Examples

```
nebula> UNWIND [true, false, 'true', 'false', NULL] AS b \
        RETURN toBoolean(b) AS b;
+----------+
| b        |
+----------+
| true     |
| false    |
| true     |
| false    |
| __NULL__ |
+----------+

nebula> RETURN toFloat(1), toFloat('1.3'), toFloat('1e3'), toFloat('not a number');
+------------+----------------+----------------+-------------------------+
| toFloat(1) | toFloat("1.3") | toFloat("1e3") | toFloat("not a number") |
+------------+----------------+----------------+-------------------------+
| 1.0        | 1.3            | 1000.0         | __NULL__                |
+------------+----------------+----------------+-------------------------+
```

Last update: August 11, 2022

4.2.10 Geography

Geography is a data type composed of latitude and longitude that represents geospatial information. NebulaGraph currently supports Point, LineString, and Polygon in Simple Features and some functions in SQL-MM 3, such as part of the core geo parsing, construction, formatting, conversion, predicates, and dimensions.

Type description

A point is the basic data type of geography, which is determined by a latitude and a longitude. For example, `"POINT(3 8)"` means that the longitude is `3°` and the latitude is `8°`. Multiple points can form a linestring or a polygon.

Note

You cannot directly insert geographic data of the following types, such as `INSERT VERTEX any_shape(geo) VALUES "1":("POINT(1 1)")`. Instead, you need to use a geography function to specify the data type before inserting, such as `INSERT VERTEX any_shape(geo) VALUES "1":(ST_GeogFromText("POINT(1 1)"));`.

Shape	Example	Description
Point	`"POINT(3 8)"`	Specifies the data type as a point.
LineString	`"LINESTRING(3 8, 4.7 73.23)"`	Specifies the data type as a linestring.
Polygon	`"POLYGON((0 1, 1 2, 2 3, 0 1))"`	Specifies the data type as a polygon.

Examples

```
//Create a Tag to allow storing any geography data type.
nebula> CREATE TAG IF NOT EXISTS any_shape(geo geography);

//Create a Tag to allow storing a point only.
nebula> CREATE TAG IF NOT EXISTS only_point(geo geography(point));

//Create a Tag to allow storing a linestring only.
nebula> CREATE TAG IF NOT EXISTS only_linestring(geo geography(linestring));

//Create a Tag to allow storing a polygon only.
nebula> CREATE TAG IF NOT EXISTS only_polygon(geo geography(polygon));

//Create an Edge type to allow storing any geography data type.
nebula> CREATE EDGE IF NOT EXISTS any_shape_edge(geo geography);

//Create a vertex to store the geography of a polygon.
nebula> INSERT VERTEX any_shape(geo) VALUES "103":(ST_GeogFromText("POLYGON((0 1, 1 2, 2 3, 0 1))"));

//Create an edge to store the geography of a polygon.
nebula> INSERT EDGE any_shape_edge(geo) VALUES "201"->"302":(ST_GeogFromText("POLYGON((0 1, 1 2, 2 3, 0 1))"));

//Query the geography of Vertex 103.
nebula> FETCH PROP ON any_shape "103" YIELD ST_ASText(any_shape.geo);
+---------------------------------+
| ST_ASText(any_shape.geo)        |
+---------------------------------+
| "POLYGON((0 1, 1 2, 2 3, 0 1))" |
+---------------------------------+

//Query the geography of the edge which traverses from Vertex 201 to Vertex 302.
nebula> FETCH PROP ON any_shape_edge "201"->"302" YIELD ST_ASText(any_shape_edge.geo);
+---------------------------------+
| ST_ASText(any_shape_edge.geo)   |
+---------------------------------+
| "POLYGON((0 1, 1 2, 2 3, 0 1))" |
+---------------------------------+

//Create an index for the geography of the Tag any_shape and run LOOKUP.
nebula> CREATE TAG INDEX IF NOT EXISTS any_shape_geo_index ON any_shape(geo);
nebula> REBUILD TAG INDEX any_shape_geo_index;
nebula> LOOKUP ON any_shape YIELD ST_ASText(any_shape.geo);
+---------------------------------+
| ST_ASText(any_shape.geo)        |
+---------------------------------+
| "POLYGON((0 1, 1 2, 2 3, 0 1))" |
+---------------------------------+
```

When creating an index for geography properties, you can specify the parameters for the index.

Parameter	Default value	Description
`s2_max_level`	`30`	The maximum level of S2 cell used in the covering. Allowed values: `1`~`30`. Setting it to less than the default means that NebulaGraph will be forced to generate coverings using larger cells.
`s2_max_cells`	`8`	The maximum number of S2 cells used in the covering. Provides a limit on how much work is done exploring the possible coverings. Allowed values: `1`~`30`. You may want to use higher values for odd-shaped regions such as skinny rectangles.

Note

Specifying the above two parameters does not affect the Point type of property. The `s2_max_level` value of the Point type is forced to be `30`.

```
nebula> CREATE TAG INDEX IF NOT EXISTS any_shape_geo_index ON any_shape(geo) with (s2_max_level=30, s2_max_cells=8);
```

Last update: April 25, 2023

4.3 Variables and composite queries

4.3.1 Composite queries (clause structure)

Composite queries put data from different queries together. They then use filters, group-bys, or sorting before returning the combined return results.

Nebula Graph supports three methods to run composite queries (or sub-queries):

- (openCypher) Clauses are chained together, and they feed intermediate result sets between each other.
- (Native nGQL) More than one query can be batched together, separated by semicolons (;). The result of the last query is returned as the result of the batch.
- (Native nGQL) Queries can be piped together by using the pipe (`|`). The result of the previous query can be used as the input of the next query.

OpenCypher compatibility

In a composite query, **do not** put together openCypher and native nGQL clauses in one statement. For example, this statement is undefined: `MATCH ... | GO ... | YIELD ...`.

- If you are in the openCypher way (`MATCH`, `RETURN`, `WITH`, etc), do not introduce any pipe or semicolons to combine the sub-clauses.
- If you are in the native nGQL way (`FETCH`, `GO`, `LOOKUP`, etc), you must use pipe or semicolons to combine the sub-clauses.

Composite queries are not `transactional` queries (as in SQL/Cypher)

For example, a query is composed of three sub-queries: `A B C`, `A | B | C` or `A; B; C`. In that A is a read operation, B is a computation operation, and C is a write operation. If any part fails in the execution, the whole result will be undefined. There is no rollback. What is written depends on the query executor.

Note

OpenCypher has no requirement of `transaction`.

Examples

- OpenCypher compatibility statement

```
# Connect multiple queries with clauses.
nebula> MATCH p=(v:player{name:"Tim Duncan"})--() \
        WITH nodes(p) AS n \
```

```
        UNWIND n AS n1 \
        RETURN DISTINCT n1;
```

- Native nGQL (Semicolon queries)

```
# Only return edges.
nebula> SHOW TAGS; SHOW EDGES;

# Insert multiple vertices.
nebula> INSERT VERTEX player(name, age) VALUES "player100":("Tim Duncan", 42); \
        INSERT VERTEX player(name, age) VALUES "player101":("Tony Parker", 36); \
        INSERT VERTEX player(name, age) VALUES "player102":("LaMarcus Aldridge", 33);
```

- Native nGQL (Pipe queries)

```
# Connect multiple queries with pipes.
nebula> GO FROM "player100" OVER follow YIELD dst(edge) AS id | \
        GO FROM $-.id OVER serve YIELD properties($$).name AS Team, \
        properties($^).name AS Player;
+-----------+-----------------+
| Team      | Player          |
+-----------+-----------------+
| "Spurs"   | "Tony Parker"   |
| "Hornets" | "Tony Parker"   |
| "Spurs"   | "Manu Ginobili" |
+-----------+-----------------+
```

Last update: August 29, 2022

4.3.2 User-defined variables

User-defined variables allow passing the result of one statement to another.

OpenCypher compatibility

In openCypher, when you refer to the vertex, edge, or path of a variable, you need to name it first. For example:

```
nebula> MATCH (v:player{name:"Tim Duncan"}) RETURN v;
+----------------------------------------------------+
| v                                                  |
+----------------------------------------------------+
| ("player100" :player{name: "Tim Duncan", age: 42}) |
+----------------------------------------------------+
```

The user-defined variable in the preceding query is `v`.

Caution

In a pattern of a MATCH statement, you cannot use the same edge variable repeatedly. For example, `e` cannot be written in the pattern `p=(v1)-[e*2..2]->(v2)-[e*2..2]->(v3)`.

Native nGQL

User-defined variables are written as `$var_name`. The `var_name` consists of letters, numbers, or underline characters. Any other characters are not permitted.

The user-defined variables are valid only at the current execution (namely, in this composite query). When the execution ends, the user-defined variables will be automatically expired. The user-defined variables in one statement **CANNOT** be used in any other clients, executions, or sessions.

You can use user-defined variables in composite queries. Details about composite queries, see Composite queries.

Note

- User-defined variables are case-sensitive.
- To define a user-defined variable in a compound statement, end the statement with a semicolon (;). For details, please refer to the nGQL Style Guide.

Example

```
nebula> $var = GO FROM "player100" OVER follow YIELD dst(edge) AS id; \
        GO FROM $var.id OVER serve YIELD properties($$).name AS Team, \
        properties($^).name AS Player;
+-----------+-----------------+
| Team      | Player          |
+-----------+-----------------+
| "Spurs"   | "Tony Parker"   |
| "Hornets" | "Tony Parker"   |
| "Spurs"   | "Manu Ginobili" |
+-----------+-----------------+
```

Last update: March 13, 2023

4.3.3 Property reference

You can refer to the properties of a vertex or an edge in `WHERE` and `YIELD` syntax.

Note

This function applies to native nGQL only.

Property reference for vertex

FOR SOURCE VERTEX

```
$^.<tag_name>.<prop_name>
```

Parameter	Description
`$^`	is used to get the property of the source vertex.
`tag_name`	is the tag name of the vertex.
`prop_name`	specifies the property name.

FOR DESTINATION VERTEX

```
$$.<tag_name>.<prop_name>
```

Parameter	Description
`$$`	is used to get the property of the destination vertex.
`tag_name`	is the tag name of the vertex.
`prop_name`	specifies the property name.

Property reference for edge

FOR USER-DEFINED EDGE PROPERTY

```
<edge_type>.<prop_name>
```

Parameter	Description
`edge_type`	is the edge type of the edge.
`prop_name`	specifies the property name of the edge type.

FOR BUILT-IN PROPERTIES

Apart from the user-defined edge property, there are four built-in properties in each edge:

Parameter	Description
`_src`	source vertex ID of the edge
`_dst`	destination vertex ID of the edge
`_type`	edge type
`_rank`	the rank value for the edge

Examples

The following query returns the `name` property of the `player` tag on the source vertex and the `age` property of the `player` tag on the destination vertex.

```
nebula> GO FROM "player100" OVER follow YIELD $^.player.name AS startName, $$.player.age AS endAge;
+--------------+--------+
| startName    | endAge |
+--------------+--------+
| "Tim Duncan" | 36     |
| "Tim Duncan" | 41     |
+--------------+--------+
```

The following query returns the `degree` property of the edge type `follow`.

```
nebula> GO FROM "player100" OVER follow YIELD follow.degree;
+---------------+
| follow.degree |
+---------------+
| 95            |
+---------------+
```

The following query returns the source vertex, the destination vertex, the edge type, and the edge rank value of the edge type `follow`.

```
nebula> GO FROM "player100" OVER follow YIELD follow._src, follow._dst, follow._type, follow._rank;
+-------------+-------------+--------------+--------------+
| follow._src | follow._dst | follow._type | follow._rank |
+-------------+-------------+--------------+--------------+
| "player100" | "player101" | 17           | 0            |
| "player100" | "player125" | 17           | 0            |
+-------------+-------------+--------------+--------------+
```

Legacy version compatibility

NebulaGraph 2.6.0 and later versions support the new Schema-related functions. Similar statements as the above examples are written as follows in 3.5.0.

```
GO FROM "player100" OVER follow YIELD properties($^).name AS startName, properties($$).age AS endAge;
GO FROM "player100" OVER follow YIELD properties(edge).degree;
GO FROM "player100" OVER follow YIELD src(edge), dst(edge), type(edge), rank(edge);
```

In 3.5.0, NebulaGraph is still compatible with the old syntax.

Last update: December 21, 2022

4.4 Operators

4.4.1 Comparison operators

NebulaGraph supports the following comparison operators.

Name	Description
`=`	Assigns a value
`+`	Addition operator
`-`	Minus operator
`*`	Multiplication operator
`/`	Division operator
`==`	Equal operator
`!=`, `<>`	Not equal operator
`>`	Greater than operator
`>=`	Greater than or equal operator
`<`	Less than operator
`<=`	Less than or equal operator
`%`	Modulo operator
`-`	Changes the sign of the argument
`IS NULL`	NULL check
`IS NOT NULL`	Not NULL check
`IS EMPTY`	EMPTY check
`IS NOT EMPTY`	Not EMPTY check

The result of the comparison operation is `true` or `false`.

Note

- Comparability between values of different types is often undefined. The result could be `NULL` or others.
- `EMPTY` is currently used only for checking, and does not support functions or operations such as `GROUP BY`, `count()`, `sum()`, `max()`, `hash()`, `collect()`, `+` or `*`.

OpenCypher compatibility

openCypher does not have `EMPTY`. Thus `EMPTY` is not supported in MATCH statements.

Examples

`==`

String comparisons are case-sensitive. Values of different types are not equal.

Note

The equal operator is `==` in nGQL, while in openCypher it is `=`.

```
nebula> RETURN 'A' == 'a', toUpper('A') == toUpper('a'), toLower('A') == toLower('a');
+------------+------------------------------+------------------------------+
| ("A"=="a") | (toUpper("A")==toUpper("a")) | (toLower("A")==toLower("a")) |
+------------+------------------------------+------------------------------+
| false      | true                         | true                         |
+------------+------------------------------+------------------------------+

nebula> RETURN '2' == 2, toInteger('2') == 2;
+----------+---------------------+
| ("2"==2) | (toInteger("2")==2) |
+----------+---------------------+
| false    | true                |
+----------+---------------------+
```

`>`

```
nebula> RETURN 3 > 2;
+-------+
| (3>2) |
+-------+
| true  |
+-------+

nebula> WITH 4 AS one, 3 AS two \
        RETURN one > two AS result;
+--------+
| result |
+--------+
| true   |
+--------+
```

`>=`

```
nebula> RETURN 2 >= "2", 2 >= 2;
+----------+--------+
| (2>="2") | (2>=2) |
+----------+--------+
| __NULL__ | true   |
+----------+--------+
```

`<`

```
nebula> YIELD 2.0 < 1.9;
+---------+
| (2<1.9) |
+---------+
| false   |
+---------+
```

`<=`

```
nebula> YIELD 0.11 <= 0.11;
+--------------+
| (0.11<=0.11) |
+--------------+
| true         |
+--------------+
```

`!=`

```
nebula> YIELD 1 != '1';
+----------+
| (1!="1") |
+----------+
| true     |
+----------+
```

`IS [NOT] NULL`

```
nebula> RETURN null IS NULL AS value1, null == null AS value2, null != null AS value3;
+--------+----------+----------+
| value1 | value2   | value3   |
+--------+----------+----------+
| true   | __NULL__ | __NULL__ |
+--------+----------+----------+
```

```
nebula> RETURN length(NULL), size(NULL), count(NULL), NULL IS NULL, NULL IS NOT NULL, sin(NULL), NULL + NULL, [1, NULL] IS NULL;
+--------------+------------+-------------+--------------+------------------+-----------+-------------+------------------+
| length(NULL) | size(NULL) | count(NULL) | NULL IS NULL | NULL IS NOT NULL | sin(NULL) | (NULL+NULL) | [1,NULL] IS NULL |
+--------------+------------+-------------+--------------+------------------+-----------+-------------+------------------+
| __NULL__     | __NULL__   | 0           | true         | false            | __NULL__  | __NULL__    | false            |
+--------------+------------+-------------+--------------+------------------+-----------+-------------+------------------+

nebula> WITH {name: null} AS `map` \
        RETURN `map`.name IS NOT NULL;
+----------------------+
| map.name IS NOT NULL |
+----------------------+
| false                |
+----------------------+

nebula> WITH {name: 'Mats', name2: 'Pontus'} AS map1, \
        {name: null} AS map2, {notName: 0, notName2: null } AS map3 \
        RETURN map1.name IS NULL, map2.name IS NOT NULL, map3.name IS NULL;
+-------------------+-----------------------+-------------------+
| map1.name IS NULL | map2.name IS NOT NULL | map3.name IS NULL |
+-------------------+-----------------------+-------------------+
| false             | false                 | true              |
+-------------------+-----------------------+-------------------+

nebula> MATCH (n:player) \
        RETURN n.player.age IS NULL, n.player.name IS NOT NULL, n.player.empty IS NULL;
+----------------------+---------------------------+------------------------+
| n.player.age IS NULL | n.player.name IS NOT NULL | n.player.empty IS NULL |
+----------------------+---------------------------+------------------------+
| false                | true                      | true                   |
| false                | true                      | true                   |
...
```

IS [NOT] EMPTY

```
nebula> RETURN null IS EMPTY;
+---------------+
| NULL IS EMPTY |
+---------------+
| false         |
+---------------+

nebula> RETURN "a" IS NOT EMPTY;
+------------------+
| "a" IS NOT EMPTY |
+------------------+
| true             |
+------------------+

nebula> GO FROM "player100" OVER * WHERE properties($$).name IS NOT EMPTY YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
| "team204"   |
| "player101" |
| "player125" |
+-------------+
```

Last update: August 11, 2022

4.4.2 Boolean operators

NebulaGraph supports the following boolean operators.

Name	Description
AND	Logical AND
NOT	Logical NOT
OR	Logical OR
XOR	Logical XOR

For the precedence of the operators, refer to Operator Precedence.

For the logical operations with `NULL`, refer to NULL.

Legacy version compatibility

- Non-zero numbers cannot be converted to boolean values.

Last update: August 11, 2022

4.4.3 Pipe operators

Multiple queries can be combined using pipe operators in nGQL.

OpenCypher compatibility

Pipe operators apply to native nGQL only.

Syntax

One major difference between nGQL and SQL is how sub-queries are composed.

- In SQL, sub-queries are nested in the query statements.
- In nGQL, the shell style `PIPE (|)` is introduced into the sub-queries.

Examples

```
nebula> GO FROM "player100" OVER follow \
        YIELD dst(edge) AS dstid, properties($$).name AS Name | \
        GO FROM $-.dstid OVER follow YIELD dst(edge);

+-------------+
| dst(EDGE)   |
+-------------+
| "player100" |
| "player102" |
| "player125" |
| "player100" |
+-------------+
```

Users must define aliases in the `YIELD` clause for the reference operator `$-` to use, just like `$-.dstid` in the preceding example.

Performance tips

In NebulaGraph, pipes will affect the performance. Take `A | B` as an example, the effects are as follows:

1. Pipe operators operate synchronously. That is, the data can enter the pipe clause as a whole after the execution of clause `A` before the pipe operator is completed.
2. Pipe operators need to be serialized and deserialized, which is executed in a single thread.
3. If `A` sends a large amount of data to `|`, the entire query request may be very slow. You can try to split this statement.

a. Send `A` from the application,

b. Split the return results on the application,

c. Send to multiple graphd processes concurrently,

d. Every graphd process executes part of B.

This is usually much faster than executing a complete `A | B` with a single graphd process.

Last update: March 13, 2023

4.4.4 Reference operators

NGQL provides reference operators to represent a property in a `WHERE` or `YIELD` clause, or the output of the statement before the pipe operator in a composite query.

OpenCypher compatibility

Reference operators apply to native nGQL only.

Reference operator List

Reference operator	Description
`$^`	Refers to a source vertex property. For more information, see Property reference.
`$$`	Refers to a destination vertex property. For more information, see Property reference.
`$-`	Refers to the output of the statement before the pipe operator in a composite query. For more information, see Pipe.

Examples

```
# The following example returns the age of the source vertex and the destination vertex.
nebula> GO FROM "player100" OVER follow YIELD properties($^).age AS SrcAge, properties($$).age AS DestAge;
+--------+---------+
| SrcAge | DestAge |
+--------+---------+
| 42     | 36      |
| 42     | 41      |
+--------+---------+

# The following example returns the name and team of the players that player100 follows.
nebula> GO FROM "player100" OVER follow \
        YIELD dst(edge) AS id | \
        GO FROM $-.id OVER serve \
        YIELD $^.player.name AS Player, properties($$).name AS Team;
+-----------------+-----------+
| Player          | Team      |
+-----------------+-----------+
| "Tony Parker"   | "Spurs"   |
| "Tony Parker"   | "Hornets" |
| "Manu Ginobili" | "Spurs"   |
+-----------------+-----------+
```

Last update: December 1, 2021

4.4.5 Set operators

This topic will describe the set operators, including `UNION`, `UNION ALL`, `INTERSECT`, and `MINUS`. To combine multiple queries, use these set operators.

All set operators have equal precedence. If a nGQL statement contains multiple set operators, NebulaGraph will evaluate them from left to right unless parentheses explicitly specify another order.

Caution

The names and order of the variables defined in the query statements before and after the set operator must be consistent. For example, the names and order of `a,b,c` in `RETURN a,b,c UNION RETURN a,b,c` need to be consistent.

UNION, UNION DISTINCT, and UNION ALL

```
<left> UNION [DISTINCT | ALL] <right> [ UNION [DISTINCT | ALL] <right> ...]
```

- Operator `UNION DISTINCT` (or by short `UNION`) returns the union of two sets A and B without duplicated elements.
- Operator `UNION ALL` returns the union of two sets A and B with duplicated elements.
- The `<left>` and `<right>` must have the same number of columns and data types. Different data types are converted according to the Type Conversion.

EXAMPLES

```
# The following statement returns the union of two query results without duplicated elements.
nebula> GO FROM "player102" OVER follow YIELD dst(edge) \
        UNION \
        GO FROM "player100" OVER follow YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
| "player100" |
| "player101" |
| "player125" |
+-------------+

nebula> MATCH (v:player) \
        WITH v.player.name AS v \
        RETURN n ORDER BY n LIMIT 3 \
        UNION \
        UNWIND ["Tony Parker", "Ben Simmons"] AS n \
        RETURN n;
+---------------------+
| n                   |
+---------------------+
| "Amar'e Stoudemire" |
| "Aron Baynes"       |
| "Ben Simmons"       |
| "Tony Parker"       |
+---------------------+

# The following statement returns the union of two query results with duplicated elements.
nebula> GO FROM "player102" OVER follow YIELD dst(edge) \
        UNION ALL \
        GO FROM "player100" OVER follow YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
| "player100" |
| "player101" |
| "player101" |
| "player125" |
+-------------+

nebula> MATCH (v:player) \
        WITH v.player.name AS n \
        RETURN n ORDER BY n LIMIT 3 \
        UNION ALL \
        UNWIND ["Tony Parker", "Ben Simmons"] AS n \
        RETURN n;
+---------------------+
| n                   |
+---------------------+
| "Amar'e Stoudemire" |
| "Aron Baynes"       |
```

```
| "Ben Simmons"       |
| "Tony Parker"       |
| "Ben Simmons"       |
+---------------------+

# UNION can also work with the YIELD statement. The DISTINCT keyword will check duplication by all the columns for every line, and remove duplicated lines if every column is the same.
nebula> GO FROM "player102" OVER follow \
        YIELD dst(edge) AS id, properties(edge).degree AS Degree, properties($$).age AS Age \
        UNION /* DISTINCT */ \
        GO FROM "player100" OVER follow \
        YIELD dst(edge) AS id, properties(edge).degree AS Degree, properties($$).age AS Age;
+-------------+--------+-----+
| id          | Degree | Age |
+-------------+--------+-----+
| "player100" | 75     | 42  |
| "player101" | 75     | 36  |
| "player101" | 95     | 36  |
| "player125" | 95     | 41  |
+-------------+--------+-----+
```

INTERSECT

```
<left> INTERSECT <right>
```

- Operator `INTERSECT` returns the intersection of two sets A and B (denoted by A ⋂ B).
- Similar to `UNION`, the `left` and `right` must have the same number of columns and data types. Different data types are converted according to the Type Conversion.

EXAMPLE

```
# The following statement returns the intersection of two query results.
nebula> GO FROM "player102" OVER follow \
        YIELD dst(edge) AS id, properties(edge).degree AS Degree, properties($$).age AS Age \
        INTERSECT \
        GO FROM "player100" OVER follow \
        YIELD dst(edge) AS id, properties(edge).degree AS Degree, properties($$).age AS Age;
+----+--------+-----+
| id | Degree | Age |
+----+--------+-----+
+----+--------+-----+

nebula> MATCH (v:player)-[e:follow]->(v2) \
        WHERE id(v) == "player102" \
        RETURN id(v2) As id, e.degree As Degree, v2.player.age AS Age \
        INTERSECT \
        MATCH (v:player)-[e:follow]->(v2) \
        WHERE id(v) == "player100" \
        RETURN id(v2) As id, e.degree As Degree, v2.player.age AS Age;
+----+--------+-----+
| id | Degree | Age |
+----+--------+-----+
+----+--------+-----+

nebula> UNWIND [1,2] AS a RETURN a \
        INTERSECT \
        UNWIND [1,2,3,4] AS a \
        RETURN a;
+---+
| a |
+---+
| 1 |
| 2 |
+---+
```

MINUS

```
<left> MINUS <right>
```

Operator `MINUS` returns the subtraction (or difference) of two sets A and B (denoted by `A-B`). Always pay attention to the order of `left` and `right`. The set `A-B` consists of elements that are in A but not in B.

EXAMPLE

```
# The following statement returns the elements in the first query result but not in the second query result.
nebula> GO FROM "player100" OVER follow YIELD dst(edge) \
        MINUS \
        GO FROM "player102" OVER follow YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
```

```
| "player125" |
+-------------+

nebula> GO FROM "player102" OVER follow YIELD dst(edge) AS id\
        MINUS \
        GO FROM "player100" OVER follow YIELD dst(edge) AS id;
+-------------+
| id          |
+-------------+
| "player100" |
+-------------+

nebula> MATCH (v:player)-[e:follow]->(v2) \
        WHERE id(v) =="player102" \
        RETURN id(v2) AS id\
        MINUS \
        MATCH (v:player)-[e:follow]->(v2) \
        WHERE id(v) =="player100" \
        RETURN id(v2) AS id;
+-------------+
| id          |
+-------------+
| "player100" |
+-------------+

nebula> UNWIND [1,2,3] AS a RETURN a \
        MINUS \
        WITH 4 AS a \
        RETURN a;
+---+
| a |
+---+
| 1 |
| 2 |
| 3 |
+---+
```

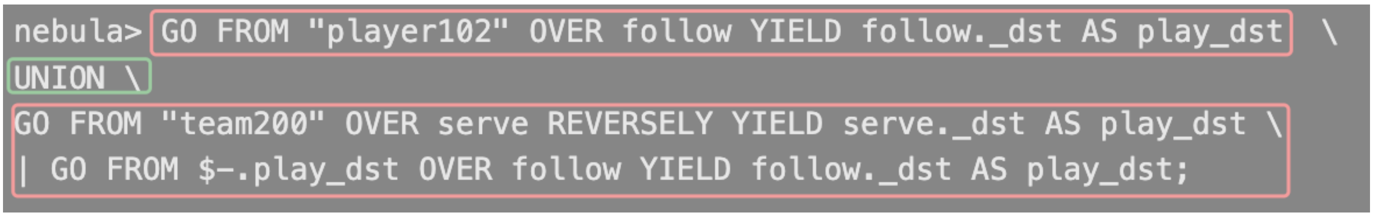
Precedence of the set operators and pipe operators

Please note that when a query contains a pipe `|` and a set operator, the pipe takes precedence. Refer to Pipe for details. The query `GO FROM 1 UNION GO FROM 2 | GO FROM 3` is the same as the query `GO FROM 1 UNION (GO FROM 2 | GO FROM 3)`.

EXAMPLES

```
nebula> GO FROM "player102" OVER follow \
        YIELD dst(edge) AS play_dst  \
        UNION \
        GO FROM "team200" OVER serve REVERSELY \
        YIELD src(edge) AS play_src \
        | GO FROM $-.play_src OVER follow YIELD dst(edge) AS play_dst;

+-------------+
| play_dst    |
+-------------+
| "player100" |
| "player101" |
| "player117" |
| "player105" |
+-------------+
```



The above query executes the statements in the red bar first and then executes the statement in the green box.

The parentheses can change the execution priority. For example:

```
nebula> (GO FROM "player102" OVER follow \
        YIELD dst(edge) AS play_dst  \
        UNION \
        GO FROM "team200" OVER serve REVERSELY \
        YIELD src(edge) AS play_dst) \
        | GO FROM $-.play_dst OVER follow YIELD dst(edge) AS play_dst;
```

In the above query, the statements within the parentheses take precedence. That is, the `UNION` operation will be executed first, and its output will be executed as the input of the next operation with pipes.

Last update: February 3, 2023

4.4.6 String operators

You can use the following string operators for concatenating, querying, and matching.

Name	Description
+	Concatenates strings.
CONTAINS	Performs searchings in strings.
(NOT) IN	Checks whether a value is within a set of values.
(NOT) STARTS WITH	Performs matchings at the beginning of a string.
(NOT) ENDS WITH	Performs matchings at the end of a string.
Regular expressions	Perform string matchings using regular expressions.

Note

All the string searchings or matchings are case-sensitive.

Examples

`+`

```
nebula> RETURN 'a' + 'b';
+-----------+
| ("a"+"b") |
+-----------+
| "ab"      |
+-----------+
nebula> UNWIND 'a' AS a UNWIND 'b' AS b RETURN a + b;
+-------+
| (a+b) |
+-------+
| "ab"  |
+-------+
```

`CONTAINS`

The `CONTAINS` operator requires string types on both left and right sides.

```
nebula> MATCH (s:player)-[e:serve]->(t:team) WHERE id(s) == "player101" \
        AND t.team.name CONTAINS "ets" RETURN s.player.name, e.start_year, e.end_year, t.team.name;
+---------------+--------------+------------+-------------+
| s.player.name | e.start_year | e.end_year | t.team.name |
+---------------+--------------+------------+-------------+
| "Tony Parker" | 2018         | 2019       | "Hornets"   |
+---------------+--------------+------------+-------------+

nebula> GO FROM "player101" OVER serve WHERE (STRING)properties(edge).start_year CONTAINS "19" AND \
        properties($^).name CONTAINS "ny" \
        YIELD properties($^).name, properties(edge).start_year, properties(edge).end_year, properties($$).name;
+---------------------+----------------------------+--------------------------+---------------------+
| properties($^).name | properties(EDGE).start_year | properties(EDGE).end_year | properties($$).name |
+---------------------+----------------------------+--------------------------+---------------------+
| "Tony Parker"       | 1999                       | 2018                     | "Spurs"             |
+---------------------+----------------------------+--------------------------+---------------------+

nebula> GO FROM "player101" OVER serve WHERE !(properties($$).name CONTAINS "ets") \
        YIELD properties($^).name, properties(edge).start_year, properties(edge).end_year, properties($$).name;
+---------------------+----------------------------+--------------------------+---------------------+
| properties($^).name | properties(EDGE).start_year | properties(EDGE).end_year | properties($$).name |
+---------------------+----------------------------+--------------------------+---------------------+
| "Tony Parker"       | 1999                       | 2018                     | "Spurs"             |
+---------------------+----------------------------+--------------------------+---------------------+
```

`(NOT) IN`

```
nebula> RETURN  1 IN [1,2,3], "Yao" NOT IN ["Yi", "Tim", "Kobe"], NULL IN ["Yi", "Tim", "Kobe"];
+----------------+------------------------------------+-------------------------------+
| (1 IN [1,2,3]) | ("Yao" NOT IN ["Yi","Tim","Kobe"]) | (NULL IN ["Yi","Tim","Kobe"]) |
+----------------+------------------------------------+-------------------------------+
```

```
| true          | true                              | __NULL__                     |
+---------------+-----------------------------------+------------------------------+
```

`(NOT) STARTS WITH`

```
nebula> RETURN 'apple' STARTS WITH 'app', 'apple' STARTS WITH 'a', 'apple' STARTS WITH toUpper('a');
+-----------------------------+---------------------------+------------------------------------+
| ("apple" STARTS WITH "app") | ("apple" STARTS WITH "a") | ("apple" STARTS WITH toUpper("a")) |
+-----------------------------+---------------------------+------------------------------------+
| true                        | true                      | false                              |
+-----------------------------+---------------------------+------------------------------------+

nebula> RETURN 'apple' STARTS WITH 'b','apple' NOT STARTS WITH 'app';
+---------------------------+---------------------------------+
| ("apple" STARTS WITH "b") | ("apple" NOT STARTS WITH "app") |
+---------------------------+---------------------------------+
| false                     | false                           |
+---------------------------+---------------------------------+
```

`(NOT) ENDS WITH`

```
nebula> RETURN 'apple' ENDS WITH 'app', 'apple' ENDS WITH 'e', 'apple' ENDS WITH 'E', 'apple' ENDS WITH 'b';
+---------------------------+-------------------------+-------------------------+-------------------------+
| ("apple" ENDS WITH "app") | ("apple" ENDS WITH "e") | ("apple" ENDS WITH "E") | ("apple" ENDS WITH "b") |
+---------------------------+-------------------------+-------------------------+-------------------------+
| false                     | true                    | false                   | false                   |
+---------------------------+-------------------------+-------------------------+-------------------------+
```

REGULAR EXPRESSIONS

Note

Regular expressions cannot work with native nGQL statements (`GO`, `FETCH`, `LOOKUP`, etc.). Use it in openCypher only (`MATCH`, `WHERE`, etc.).

NebulaGraph supports filtering by using regular expressions. The regular expression syntax is inherited from `std::regex`. You can match on regular expressions by using `=~ 'regexp'`. For example:

```
nebula> RETURN "384748.39" =~ "\\d+(\\.\\d{2})?";
+--------------------------------+
| ("384748.39"=~"\d+(\.\d{2})?") |
+--------------------------------+
| true                           |
+--------------------------------+

nebula> MATCH (v:player) WHERE v.player.name =~ 'Tony.*' RETURN v.player.name;
+---------------+
| v.player.name |
+---------------+
| "Tony Parker" |
+---------------+
```

Last update: August 11, 2022

4.4.7 List operators

NebulaGraph supports the following list operators:

List operator	Description
+	Concatenates lists.
IN	Checks if an element exists in a list.
[]	Accesses an element(s) in a list using the index operator.

Examples

```
nebula> YIELD [1,2,3,4,5]+[6,7] AS myList;
+-----------------------+
| myList                |
+-----------------------+
| [1, 2, 3, 4, 5, 6, 7] |
+-----------------------+

nebula> RETURN size([NULL, 1, 2]);
+------------------+
| size([NULL,1,2]) |
+------------------+
| 3                |
+------------------+

nebula> RETURN NULL IN [NULL, 1];
+--------------------+
| (NULL IN [NULL,1]) |
+--------------------+
| __NULL__           |
+--------------------+

nebula> WITH [2, 3, 4, 5] AS numberlist \
    UNWIND numberlist AS number \
    WITH number \
    WHERE number IN [2, 3, 8] \
    RETURN number;
+--------+
| number |
+--------+
| 2      |
| 3      |
+--------+

nebula> WITH ['Anne', 'John', 'Bill', 'Diane', 'Eve'] AS names RETURN names[1] AS result;
+--------+
| result |
+--------+
| "John" |
+--------+
```

Last update: August 11, 2022

4.4.8 Operator precedence

The following list shows the precedence of nGQL operators in descending order. Operators that are shown together on a line have the same precedence.

- `-` (negative number)
- `!` , `NOT`
- `*` , `/` , `%`
- `-` , `+`
- `==` , `>=` , `>` , `<=` , `<` , `<>` , `!=`
- `AND`
- `OR` , `XOR`
- `=` (assignment)

For operators that occur at the same precedence level within an expression, evaluation proceeds left to right, with the exception that assignments evaluate right to left.

The precedence of operators determines the order of evaluation of terms in an expression. To modify this order and group terms explicitly, use parentheses.

Examples

```
nebula> RETURN 2+3*5;
+-----------+
| (2+(3*5)) |
+-----------+
| 17        |
+-----------+

nebula> RETURN (2+3)*5;
+-----------+
| ((2+3)*5) |
+-----------+
| 25        |
+-----------+
```

OpenCypher compatibility

In openCypher, comparisons can be chained arbitrarily, e.g., `x < y <= z` is equivalent to `x < y AND y <= z` in openCypher.

But in nGQL, `x < y <= z` is equivalent to `(x < y) <= z` . The result of `(x < y)` is a boolean. Compare it with an integer `z` , and you will get the final result `NULL` .

Last update: September 6, 2021

4.5 Functions and expressions

4.5.1 Built-in math functions

This topic describes the built-in math functions supported by NebulaGraph.

abs()

abs() returns the absolute value of the argument.

Syntax: `abs(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN abs(-10);
+------------+
| abs(-(10)) |
+------------+
| 10         |
+------------+
nebula> RETURN abs(5-6);
+------------+
| abs((5-6)) |
+------------+
| 1          |
+------------+
```

floor()

floor() returns the largest integer value smaller than or equal to the argument.(Rounds down)

Syntax: `floor(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN floor(9.9);
+------------+
| floor(9.9) |
+------------+
| 9.0        |
+------------+
```

ceil()

ceil() returns the smallest integer greater than or equal to the argument.(Rounds up)

Syntax: `ceil(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN ceil(9.1);
+-----------+
| ceil(9.1) |
+-----------+
```

```
| 10.0      |
+-----------+
```

round()

round() returns the rounded value of the specified number. Pay attention to the floating-point precision when using this function.

Syntax: `round(<expression>, <digit>)`

- `expression` : An expression of which the result type is double.
- `digit` : Decimal digits. If `digit` is less than 0, round at the left of the decimal point.
- Result type: Double

Example:

```
nebula> RETURN round(314.15926, 2);
+--------------------+
| round(314.15926,2) |
+--------------------+
| 314.16             |
+--------------------+
nebula> RETURN round(314.15926, -1);
+-----------------------+
| round(314.15926,-(1)) |
+-----------------------+
| 310.0                 |
+-----------------------+
```

sqrt()

sqrt() returns the square root of the argument.

Syntax: `sqrt(<expression>)`

- `expression` : An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN sqrt(9);
+---------+
| sqrt(9) |
+---------+
| 3.0     |
+---------+
```

cbrt()

cbrt() returns the cubic root of the argument.

Syntax: `cbrt(<expression>)`

- `expression` : An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN cbrt(8);
+---------+
| cbrt(8) |
+---------+
| 2.0     |
+---------+
```

hypot()

hypot() returns the hypotenuse of a right-angled triangle.

Syntax: `hypot(<expression_x>,<expression_y>)`

- `expression_x`, `expression_y`: An expression of which the result type is double. They represent the side lengths x and y of a right triangle.
- Result type: Double

Example:

```
nebula> RETURN hypot(3,2*2);
+----------------+
| hypot(3,(2*2)) |
+----------------+
| 5.0            |
+----------------+
```

pow()

pow() returns the result of x^y.

Syntax: `pow(<expression_x>,<expression_y>,)`

- `expression_x`: An expression of which the result type is double. It represents the base `x`.
- `expression_y`: An expression of which the result type is double. It represents the exponential `y`.
- Result type: Double

Example:

```
nebula> RETURN pow(3,3);
+----------+
| pow(3,3) |
+----------+
| 27       |
+----------+
```

exp()

exp() returns the result of e^x.

Syntax: `exp(<expression>)`

- `expression`: An expression of which the result type is double. It represents the exponential `x`.
- Result type: Double

Example:

```
nebula> RETURN exp(2);
+------------------+
| exp(2)           |
+------------------+
| 7.38905609893065 |
+------------------+
```

exp2()

exp2() returns the result of 2^x.

Syntax: `exp2(<expression>)`

- `expression`: An expression of which the result type is double. It represents the exponential `x`.
- Result type: Double

Example:

```
nebula> RETURN exp2(3);
+---------+
| exp2(3) |
+---------+
| 8.0     |
+---------+
```

log()

log() returns the base-e logarithm of the argument. ($log_{e}{N}$)

Syntax: `log(<expression>)`

- `expression`: An expression of which the result type is double. It represents the antilogarithm `N`.
- Result type: Double

Example:

```
nebula> RETURN log(8);
+--------------------+
| log(8)             |
+--------------------+
| 2.0794415416798357 |
+--------------------+
```

log2()

log2() returns the base-2 logarithm of the argument. ($log_{2}{N}$)

Syntax: `log2(<expression>)`

- `expression`: An expression of which the result type is double. It represents the antilogarithm `N`.
- Result type: Double

Example:

```
nebula> RETURN log2(8);
+---------+
| log2(8) |
+---------+
| 3.0     |
+---------+
```

log10()

log10() returns the base-10 logarithm of the argument. ($log_{10}{N}$)

Syntax: `log10(<expression>)`

- `expression`: An expression of which the result type is double. It represents the antilogarithm `N`.
- Result type: Double

Example:

```
nebula> RETURN log10(100);
+------------+
| log10(100) |
+------------+
| 2.0        |
+------------+
```

sin()

sin() returns the sine of the argument. Users can convert angles to radians using the function `radians()`.

Syntax: `sin(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN sin(3);
+--------------------+
| sin(3)             |
+--------------------+
| 0.1411200080598672 |
+--------------------+
```

asin()

asin() returns the inverse sine of the argument. Users can convert angles to radians using the function `radians()`.

Syntax: `asin(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN asin(0.5);
+--------------------+
| asin(0.5)          |
+--------------------+
| 0.5235987755982989 |
+--------------------+
```

cos()

cos() returns the cosine of the argument. Users can convert angles to radians using the function `radians()`.

Syntax: `cos(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN cos(0.5);
+--------------------+
| cos(0.5)           |
+--------------------+
| 0.8775825618903728 |
+--------------------+
```

acos()

acos() returns the inverse cosine of the argument. Users can convert angles to radians using the function `radians()`.

Syntax: `acos(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN acos(0.5);
+--------------------+
| acos(0.5)          |
+--------------------+
```

```
| 1.0471975511965979 |
+--------------------+
```

tan()

tan() returns the tangent of the argument. Users can convert angles to radians using the function `radians()`.

Syntax: `tan(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN tan(0.5);
+--------------------+
| tan(0.5)           |
+--------------------+
| 0.5463024898437905 |
+--------------------+
```

atan()

atan() returns the inverse tangent of the argument. Users can convert angles to radians using the function `radians()`.

Syntax: `atan(<expression>)`

- `expression`: An expression of which the result type is double.
- Result type: Double

Example:

```
nebula> RETURN atan(0.5);
+--------------------+
| atan(0.5)          |
+--------------------+
| 0.4636476090008061 |
+--------------------+
```

rand()

rand() returns a random floating point number in the range from 0 (inclusive) to 1 (exclusive); i.e.[0,1).

Syntax: `rand()`

- Result type: Double

Example:

```
nebula> RETURN rand();
+--------------------+
| rand()             |
+--------------------+
| 0.6545837172298736 |
+--------------------+
```

rand32()

rand32() returns a random 32-bit integer in `[min, max)`.

Syntax: `rand32(<expression_min>,<expression_max>)`

- `expression_min`: An expression of which the result type is int. It represents the minimum `min`.
- `expression_max`: An expression of which the result type is int. It represents the maximum `max`.
- Result type: Int
- If you set only one argument, it is parsed as `max` and `min` is `0` by default. If you set no argument, the system returns a random signed 32-bit integer.

Example:

```
nebula> RETURN rand32(1,100);
+---------------+
| rand32(1,100) |
+---------------+
| 63            |
+---------------+
```

rand64()

rand64() returns a random 64-bit integer in `[min, max)`.

Syntax: `rand64(<expression_min>,<expression_max>)`

- `expression_min`: An expression of which the result type is int. It represents the minimum `min`.
- `expression_max`: An expression of which the result type is int. It represents the maximum `max`.
- Result type: Int
- If you set only one argument, it is parsed as `max` and `min` is `0` by default. If you set no argument, the system returns a random signed 64-bit integer.

Example:

```
nebula> RETURN rand64(1,100);
+---------------+
| rand64(1,100) |
+---------------+
| 34            |
+---------------+
```

bit_and()

bit_and() returns the result of bitwise AND.

Syntax: `bit_and(<expression_1>,<expression_2>)`

- `expression_1`, `expression_2`: An expression of which the result type is int.
- Result type: Int

Example:

```
nebula> RETURN bit_and(5,6);
+--------------+
| bit_and(5,6) |
+--------------+
| 4            |
+--------------+
```

bit_or()

bit_or() returns the result of bitwise OR.

Syntax: `bit_or(<expression_1>,<expression_2>)`

- `expression_1`, `expression_2`: An expression of which the result type is int.

- Result type: Int

Example:

```
nebula> RETURN bit_or(5,6);
+-------------+
| bit_or(5,6) |
+-------------+
| 7           |
+-------------+
```

bit_xor()

bit_xor() returns the result of bitwise XOR.

Syntax: `bit_xor(<expression_1>,<expression_2>)`

- `expression_1`, `expression_2`: An expression of which the result type is int.

- Result type: Int

Example:

```
nebula> RETURN bit_xor(5,6);
+--------------+
| bit_xor(5,6) |
+--------------+
| 3            |
+--------------+
```

size()

size() returns the number of elements in a list or a map, or the length of a string.

Syntax: `size({<expression>|<string>})`

- `expression`: An expression for a list or map.
- `string`: A specified string.

- Result type: Int

Example:

```
nebula> RETURN size([1,2,3,4]);
+-----------------+
| size([1,2,3,4]) |
+-----------------+
| 4               |
+-----------------+
```

```
nebula> RETURN size("basketballplayer") as size;
+------+
| size |
+------+
| 16   |
+------+
```

range()

range() returns a list of integers from `[start,end]` in the specified steps.

Syntax: `range(<expression_start>,<expression_end>[,<expression_step>])`

- `expression_start` : An expression of which the result type is int. It represents the starting value `start` .
- `expression_end` : An expression of which the result type is int. It represents the end value `end` .
- `expression_step` : An expression of which the result type is int. It represents the step size `step` , `step` is 1 by default.
- Result type: List

Example:

```
nebula> RETURN range(1,3*3,2);
+------------------+
| range(1,(3*3),2) |
+------------------+
| [1, 3, 5, 7, 9]  |
+------------------+
```

sign()

sign() returns the signum of the given number. If the number is `0` , the system returns `0` . If the number is negative, the system returns `-1` . If the number is positive, the system returns `1` .

Syntax: `sign(<expression>)`

- `expression` : An expression of which the result type is double.
- Result type: Int

Example:

```
nebula> RETURN sign(10);
+----------+
| sign(10) |
+----------+
| 1        |
+----------+
```

e()

e() returns the base of the natural logarithm, e (2.718281828459045).

Syntax: `e()`

- Result type: Double

Example:

```
nebula> RETURN e();
+-------------------+
| e()               |
+-------------------+
| 2.718281828459045 |
+-------------------+
```

pi()

pi() returns the mathematical constant pi (3.141592653589793).

Syntax: `pi()`

- Result type: Double

Example:

```
nebula> RETURN pi();
+-------------------+
| pi()              |
+-------------------+
```

```
| 3.141592653589793 |
+-------------------+
```

radians()

radians() converts angles to radians.

Syntax: `radians(<angle>)`

- Result type: Double

Example:

```
nebula> RETURN radians(180);
+-------------------+
| radians(180)      |
+-------------------+
| 3.141592653589793 |
+-------------------+
```

Last update: December 21, 2022

4.5.2 Aggregating functions

This topic describes the aggregating functions supported by NebulaGraph.

avg()

avg() returns the average value of the argument.

Syntax: `avg(<expression>)`

- Result type: Double

Example:

```
nebula> MATCH (v:player) RETURN avg(v.player.age);
+--------------------+
| avg(v.player.age)  |
+--------------------+
| 33.294117647058826 |
+--------------------+
```

count()

count() returns the number of records.

- (Native nGQL) You can use `count()` and `GROUP BY` together to group and count the number of parameters. Use `YIELD` to return.
- (OpenCypher style) You can use `count()` and `RETURN`. `GROUP BY` is not necessary.

Syntax: `count({<expression> | *})`

- count(*) returns the number of rows (including NULL).
- Result type: Int

Example:

```
nebula> WITH [NULL, 1, 1, 2, 2] As a UNWIND a AS b \
        RETURN count(b), count(*), count(DISTINCT b);
+----------+----------+-------------------+
| count(b) | count(*) | count(distinct b) |
+----------+----------+-------------------+
| 4        | 5        | 2                 |
+----------+----------+-------------------+
```

```
# The statement in the following example searches for the people whom `player101` follows and people who follow `player101`, i.e. a bidirectional query.
# Group and count the number of parameters.
nebula> GO FROM "player101" OVER follow BIDIRECT \
        YIELD properties($$).name AS Name \
        | GROUP BY $-.Name YIELD $-.Name, count(*);
+---------------------+----------+
| $-.Name             | count(*) |
+---------------------+----------+
| "LaMarcus Aldridge" | 2        |
| "Tim Duncan"        | 2        |
| "Marco Belinelli"   | 1        |
| "Manu Ginobili"     | 1        |
| "Boris Diaw"        | 1        |
| "Dejounte Murray"   | 1        |
+---------------------+----------+

# Count the number of parameters.
nebula> MATCH (v1:player)-[:follow]-(v2:player) \
        WHERE id(v1)== "player101" \
        RETURN v2.player.name AS Name, count(*) as cnt ORDER BY cnt DESC;
+---------------------+-----+
| Name                | cnt |
+---------------------+-----+
| "LaMarcus Aldridge" | 2   |
| "Tim Duncan"        | 2   |
| "Boris Diaw"        | 1   |
| "Manu Ginobili"     | 1   |
| "Dejounte Murray"   | 1   |
| "Marco Belinelli"   | 1   |
+---------------------+-----+
```

The preceding example retrieves two columns:

- `$-.Name` : the names of the people.
- `count(*)` : how many times the names show up.

Because there are no duplicate names in the `basketballplayer` dataset, the number `2` in the column `count(*)` shows that the person in that row and `player101` have followed each other.

```
# a: The statement in the following example retrieves the age distribution of the players in the dataset.
nebula> LOOKUP ON player \
        YIELD player.age As playerage \
        | GROUP BY $-.playerage \
        YIELD $-.playerage as age, count(*) AS number \
        | ORDER BY $-.number DESC, $-.age DESC;
+-----+--------+
| age | number |
+-----+--------+
| 34  | 4      |
| 33  | 4      |
| 30  | 4      |
| 29  | 4      |
| 38  | 3      |
+-----+--------+
...
# b: The statement in the following example retrieves the age distribution of the players in the dataset.
nebula> MATCH (n:player) \
        RETURN n.player.age as age, count(*) as number \
        ORDER BY number DESC, age DESC;
+-----+--------+
| age | number |
+-----+--------+
| 34  | 4      |
| 33  | 4      |
| 30  | 4      |
| 29  | 4      |
| 38  | 3      |
+-----+--------+
...
```

```
# The statement in the following example counts the number of edges that Tim Duncan relates.
nebula> MATCH (v:player{name:"Tim Duncan"}) -[e]- (v2) \
        RETURN count(e);
+----------+
| count(e) |
+----------+
| 13       |
+----------+

# The statement in the following example counts the number of edges that Tim Duncan relates and returns two columns (no DISTINCT and DISTINCT) in multi-hop queries.
nebula> MATCH (n:player {name : "Tim Duncan"})-[]->(friend:player)-[]->(fof:player) \
        RETURN count(fof), count(DISTINCT fof);
+------------+---------------------+
| count(fof) | count(distinct fof) |
+------------+---------------------+
| 4          | 3                   |
+------------+---------------------+
```

max()

max() returns the maximum value.

Syntax: `max(<expression>)`

- Result type: Same as the original argument.

Example:

```
nebula> MATCH (v:player) RETURN max(v.player.age);
+-------------------+
| max(v.player.age) |
+-------------------+
| 47                |
+-------------------+
```

min()

min() returns the minimum value.

Syntax: `min(<expression>)`

- Result type: Same as the original argument.

Example:

```
nebula> MATCH (v:player) RETURN min(v.player.age);
+-------------------+
| min(v.player.age) |
+-------------------+
| 20                |
+-------------------+
```

collect()

collect() returns a list containing the values returned by an expression. Using this function aggregates data by merging multiple records or values into a single list.

Syntax: `collect(<expression>)`

- Result type: List

Example:

```
nebula> UNWIND [1, 2, 1] AS a \
        RETURN a;
+---+
| a |
+---+
| 1 |
| 2 |
| 1 |
+---+

nebula> UNWIND [1, 2, 1] AS a \
        RETURN collect(a);
+------------+
| collect(a) |
+------------+
| [1, 2, 1]  |
+------------+

nebula> UNWIND [1, 2, 1] AS a \
        RETURN a, collect(a), size(collect(a));
+---+------------+------------------+
| a | collect(a) | size(collect(a)) |
+---+------------+------------------+
| 2 | [2]        | 1                |
| 1 | [1, 1]     | 2                |
+---+------------+------------------+

# The following examples sort the results in descending order, limit output rows to 3, and collect the output into a list.
nebula> UNWIND ["c", "b", "a", "d" ] AS p \
        WITH p AS q \
        ORDER BY q DESC LIMIT 3 \
        RETURN collect(q);
+-----------------+
| collect(q)      |
+-----------------+
| ["d", "c", "b"] |
+-----------------+

nebula> WITH [1, 1, 2, 2] AS coll \
        UNWIND coll AS x \
        WITH DISTINCT x \
        RETURN collect(x) AS ss;
+--------+
| ss     |
+--------+
| [1, 2] |
+--------+

nebula> MATCH (n:player) \
        RETURN collect(n.player.age);
+---------------------------------------------------------------+
| collect(n.player.age)                                         |
+---------------------------------------------------------------+
| [32, 32, 34, 29, 41, 40, 33, 25, 40, 37, ...
...

# The following example aggregates all the players' names by their ages.
nebula> MATCH (n:player) \
        RETURN n.player.age AS age, collect(n.player.name);
+-----+--------------------------------------------------------------------------+
| age | collect(n.player.name)                                                   |
```

```
+-----+---------------------------------------------------------------------------+
| 24  | ["Giannis Antetokounmpo"]                                                 |
| 20  | ["Luka Doncic"]                                                           |
| 25  | ["Joel Embiid", "Kyle Anderson"]                                          |
+-----+---------------------------------------------------------------------------+
...

nebula> GO FROM "player100" OVER serve \
        YIELD properties($$).name AS name \
        | GROUP BY $-.name \
        YIELD collect($-.name) AS name;
+-----------+
| name      |
+-----------+
| ["Spurs"] |
+-----------+

nebula> LOOKUP ON player \
        YIELD player.age As playerage \
        | GROUP BY $-.playerage \
        YIELD collect($-.playerage) AS playerage;
+------------------+
| playerage        |
+------------------+
| [22]             |
| [47]             |
| [43]             |
| [25, 25]         |
+------------------+
...
```

std()

std() returns the population standard deviation.

Syntax: `std(<expression>)`

- Result type: Double

Example:

```
nebula> MATCH (v:player) RETURN std(v.player.age);
+-------------------+
| std(v.player.age) |
+-------------------+
| 6.423895701687502 |
+-------------------+
```

sum()

sum() returns the sum value.

Syntax: `sum(<expression>)`

- Result type: Same as the original argument.

Example:

```
nebula> MATCH (v:player) RETURN sum(v.player.age);
+-------------------+
| sum(v.player.age) |
+-------------------+
| 1698              |
+-------------------+
```

Aggregating example

```
nebula>  GO FROM "player100" OVER follow YIELD dst(edge) AS dst, properties($$).age AS age \
         | GROUP BY $-.dst \
         YIELD \
         $-.dst AS dst, \
         toInteger((sum($-.age)/count($-.age)))+avg(distinct $-.age+1)+1 AS statistics;
+-------------+------------+
| dst         | statistics |
+-------------+------------+
| "player125" | 84.0       |
| "player101" | 74.0       |
+-------------+------------+
```

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4.5.3 Built-in string functions

This topic describes the built-in string functions supported by NebulaGraph.

Precautions

- A string type is used to store a sequence of characters (text). The literal constant is a sequence of characters of any length surrounded by double or single quotes.
- Like SQL, the position index of nGQL starts from `1`, while in C language it starts from `0`.

strcasecmp()

strcasecmp() compares string a and b without case sensitivity.

Syntax: `strcasecmp(<string_a>,<string_b>)`

- `string_a`, `string_b`: Strings to compare.
- Result type: Int
- When `string_a = string_b`, the return value is `0`. When `string_a > string_b`, the return value is greater than `0`. When `string_a < string_b`, the return value is less than `0`.

Example:

```
nebula> RETURN strcasecmp("a","aa");
+----------------------+
| strcasecmp("a","aa") |
+----------------------+
| -97                  |
+----------------------+
```

lower() and toLower()

lower() and toLower() can both returns the argument in lowercase.

Syntax: `lower(<string>)`, `toLower(<string>)`

- `string`: A specified string.
- Result type: String

Example:

```
nebula> RETURN lower("Basketball_Player");
+----------------------------+
| lower("Basketball_Player") |
+----------------------------+
| "basketball_player"        |
+----------------------------+
```

upper() and toUpper()

upper() and toUpper() can both returns the argument in uppercase.

Syntax: `upper(<string>)`, `toUpper(<string>)`

- `string`: A specified string.
- Result type: String

Example:

```
nebula> RETURN upper("Basketball_Player");
+----------------------------+
| upper("Basketball_Player") |
+----------------------------+
| "BASKETBALL_PLAYER"        |
+----------------------------+
```

length()

length() returns the length of the given string in bytes.

Syntax: `length({<string>|<path>})`

- `string`: A specified string.
- `path`: A specified path represented by a variable.
- Result type: Int

Example:

```
nebula> RETURN length("basketball");
+----------------------+
| length("basketball") |
+----------------------+
| 10                   |
+----------------------+
```

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-->(v2) return length(p);
+-----------+
| length(p) |
+-----------+
| 1         |
| 1         |
| 1         |
+-----------+
```

trim()

trim() removes the spaces at the leading and trailing of the string.

Syntax: `trim(<string>)`

- `string`: A specified string.
- Result type: String

Example:

```
nebula> RETURN trim(" basketball player ");
+-----------------------------+
| trim(" basketball player ") |
+-----------------------------+
| "basketball player"         |
+-----------------------------+
```

ltrim()

ltrim() removes the spaces at the leading of the string.

Syntax: `ltrim(<string>)`

- `string`: A specified string.
- Result type: String

Example:

```
nebula> RETURN ltrim(" basketball player ");
+------------------------------+
| ltrim(" basketball player ") |
+------------------------------+
```

```
| "basketball player "         |
+------------------------------+
```

rtrim()

rtrim() removes the spaces at the trailing of the string.

Syntax: `rtrim(<string>)`

- `string` : A specified string.
- Result type: String

Example:

```
nebula> RETURN rtrim(" basketball player ");
+------------------------------+
| rtrim(" basketball player ") |
+------------------------------+
| " basketball player"         |
+------------------------------+
```

left()

left() returns a substring consisting of several characters from the leading of a string.

Syntax: `left(<string>,<count>)`

- `string` : A specified string.
- `count` : The number of characters from the leading of the string. If the string is shorter than `count`, the system returns the string itself.
- Result type: String

Example:

```
nebula> RETURN left("basketball_player",6);
+-----------------------------+
| left("basketball_player",6) |
+-----------------------------+
| "basket"                    |
+-----------------------------+
```

right()

right() returns a substring consisting of several characters from the trailing of a string.

Syntax: `right(<string>,<count>)`

- `string` : A specified string.
- `count` : The number of characters from the trailing of the string. If the string is shorter than `count`, the system returns the string itself.
- Result type: String

Example:

```
nebula> RETURN right("basketball_player",6);
+------------------------------+
| right("basketball_player",6) |
+------------------------------+
| "player"                     |
+------------------------------+
```

lpad()

lpad() pads a specified string from the left-side to the specified length and returns the result string.

Syntax: `lpad(<string>,<count>,<letters>)`

- `string` : A specified string.
- `count` : The length of the string after it has been left-padded. If the length is less than that of `string`, only the length of `string` characters **from front to back** will be returned.
- `letters` : A string to be padding from the leading.
- Result type: String

Example:

```
nebula> RETURN lpad("abcd",10,"b");
+---------------------+
| lpad("abcd",10,"b") |
+---------------------+
| "bbbbbbabcd"        |
+---------------------+
nebula> RETURN lpad("abcd",3,"b");
+--------------------+
| lpad("abcd",3,"b") |
+--------------------+
| "abc"              |
+--------------------+
```

rpad()

rpad() pads a specified string from the right-side to the specified length and returns the result string.

Syntax: `rpad(<string>,<count>,<letters>)`

- `string` : A specified string.
- `count` : The length of the string after it has been right-padded. If the length is less than that of `string`, only the length of `string` characters **from front to back** will be returned.
- `letters` : A string to be padding from the trailing.
- Result type: String

Example:

```
nebula> RETURN rpad("abcd",10,"b");
+---------------------+
| rpad("abcd",10,"b") |
+---------------------+
| "abcdbbbbbb"        |
+---------------------+
nebula> RETURN rpad("abcd",3,"b");
+--------------------+
| rpad("abcd",3,"b") |
+--------------------+
| "abc"              |
+--------------------+
```

substr() and substring()

substr() and substring() return a substring extracting `count` characters starting from the specified position `pos` of a specified string.

Syntax: `substr(<string>,<pos>,<count>)` , `substring(<string>,<pos>,<count>)`

- `string` : A specified string.
- `pos` : The position of starting extract (character index). Data type is int.
- `count` : The number of characters extracted from the start position onwards.
- Result type: String

EXPLANATIONS FOR THE RETURN OF `SUBSTR()` AND `SUBSTRING()`

- If `pos` is 0, it extracts from the specified string leading (including the first character).
- If `pos` is greater than the maximum string index, an empty string is returned.
- If `pos` is a negative number, `BAD_DATA` is returned.
- If `count` is omitted, the function returns the substring starting at the position given by `pos` and extending to the end of the string.
- If `count` is 0, an empty string is returned.
- Using `NULL` as any of the argument of `substr()` will cause an issue.

openCypher compatibility

In openCypher, if `a` is `null`, `null` is returned.

Example:

```
nebula> RETURN substr("abcdefg",2,4);
+-----------------------+
| substr("abcdefg",2,4) |
+-----------------------+
| "cdef"                |
+-----------------------+
nebula> RETURN substr("abcdefg",0,4);
+-----------------------+
| substr("abcdefg",0,4) |
+-----------------------+
| "abcd"                |
+-----------------------+
nebula> RETURN substr("abcdefg",2);
+---------------------+
| substr("abcdefg",2) |
+---------------------+
| "cdefg"             |
+---------------------+
```

reverse()

reverse() returns a string in reverse order.

Syntax: `reverse(<string>)`

- `string` : A specified string.
- Result type: String

Example:

```
nebula> RETURN reverse("abcdefg");
+--------------------+
| reverse("abcdefg") |
+--------------------+
| "gfedcba"          |
+--------------------+
```

replace()

replace() replaces string a in a specified string with string b.

Syntax: `replace(<string>,<substr_a>,<string_b>)`

- `string` : A specified string.
- `substr_a` : String a.
- `string_b` : String b.
- Result type: String

Example:

```
nebula> RETURN replace("abcdefg","cd","AAAAA");
+---------------------------------+
| replace("abcdefg","cd","AAAAA") |
+---------------------------------+
| "abAAAAAefg"                    |
+---------------------------------+
```

split()

split() splits a specified string at string b and returns a list of strings.

Syntax: `split(<string>,<substr>)`

- `string` : A specified string.
- `substr` : String b.
- Result type: List

Example:

```
nebula> RETURN split("basketballplayer","a");
+-------------------------------+
| split("basketballplayer","a") |
+-------------------------------+
| ["b", "sketb", "llpl", "yer"] |
+-------------------------------+
```

concat()

concat() returns strings concatenated by all strings.

Syntax: `concat(<string1>,<string2>,...)`

- The function requires at least two or more strings. If there is only one string, the string itself is returned.
- If any one of the strings is `NULL`, `NULL` is returned.
- Result type: String

Example:

```
//This example concatenates 1, 2, and 3.
nebula> RETURN concat("1","2","3") AS r;
+-------+
| r     |
+-------+
| "123" |
+-------+

//In this example, one of the string is NULL.
nebula> RETURN concat("1","2",NULL) AS r;
+----------+
| r        |
+----------+
| __NULL__ |
+----------+
```

```
nebula> GO FROM "player100" over follow \
        YIELD concat(src(edge), properties($^).age, properties($$).name, properties(edge).degree) AS A;
+------------------------------+
| A                            |
+------------------------------+
| "player10042Tony Parker95"   |
| "player10042Manu Ginobili95" |
+------------------------------+
```

concat_ws()

concat_ws() returns strings concatenated by all strings that are delimited with a separator.

Syntax: `concat_ws(<separator>,<string1>,<string2>,... )`

- The function requires at least two or more strings.
- If the separator is `NULL`, the `concat_ws()` function returns `NULL`.
- If the separator is not `NULL` and there is only one string, the string itself is returned.
- If there is a `NULL` in the strings, `NULL` is ignored during the concatenation.

Example:

```
//This example concatenates a, b, and c with the separator +.
nebula> RETURN concat_ws("+","a","b","c") AS r;
+---------+
| r       |
+---------+
| "a+b+c" |
+---------+

//In this example, the separator is NULL.
neubla> RETURN concat_ws(NULL,"a","b","c") AS r;
+----------+
| r        |
+----------+
| __NULL__ |
+----------+

//In this example, the separator is + and there is a NULL in the strings.
nebula> RETURN concat_ws("+","a",NULL,"b","c") AS r;
+---------+
| r       |
+---------+
| "a+b+c" |
+---------+

//In this example, the separator is + and there is only one string.
nebula> RETURN concat_ws("+","a") AS r;
+-----+
| r   |
+-----+
| "a" |
+-----+
nebula> GO FROM "player100" over follow \
        YIELD concat_ws(" ",src(edge), properties($^).age, properties($$).name, properties(edge).degree) AS A;
+---------------------------------+
| A                               |
+---------------------------------+
| "player100 42 Tony Parker 95"   |
| "player100 42 Manu Ginobili 95" |
+---------------------------------+
```

extract()

extract() uses regular expression matching to retrieve a single substring or all substrings from a string.

Syntax: `extract(<string>,"<regular_expression>")`

- `string`: A specified string
- `regular_expression`: A regular expression
- Result type: List

Example:

```
nebula> MATCH (a:player)-[b:serve]-(c:team{name: "Lakers"}) \
        WHERE a.player.age > 45 \
        RETURN extract(a.player.name, "\\w+") AS result;
+----------------------------+
| result                     |
+----------------------------+
| ["Shaquille", "O", "Neal"] |
+----------------------------+

nebula> MATCH (a:player)-[b:serve]-(c:team{name: "Lakers"}) \
        WHERE a.player.age > 45 \
        RETURN extract(a.player.name, "hello") AS result;
+--------+
| result |
+--------+
| []     |
+--------+
```

json_extract()

json_extract() converts the specified JSON string to a map.

Syntax: `extract(<string>)`

- `string` :A specified string, must be JSON string.
- Result type: Map

Caution

- Only Bool, Double, Int, String value and NULL are supported.
- Only depth-1 nested Map is supported now. If nested Map depth is greater than 1, the nested item is left as an empty Map().

Example:

```
nebula> YIELD json_extract('{"a": 1, "b": {}, "c": {"d": true}}') AS result;
+-----------------------------+
| result                      |
+-----------------------------+
| {a: 1, b: {}, c: {d: true}} |
+-----------------------------+
```

Last update: December 21, 2022

4.5.4 Built-in date and time functions

NebulaGraph supports the following built-in date and time functions:

Function	Description
int now()	Returns the current timestamp of the system.
timestamp timestamp()	Returns the current timestamp of the system.
date date()	Returns the current UTC date based on the current system.
time time()	Returns the current UTC time based on the current system.
datetime datetime()	Returns the current UTC date and time based on the current system.
map duration()	Returns the period of time. It can be used to calculate the specified time.

For more information, see Date and time types.

Examples

```
nebula>  RETURN now(), timestamp(), date(), time(), datetime();
+------------+-------------+------------+-----------------+----------------------------+
| now()      | timestamp() | date()     | time()          | datetime()                 |
+------------+-------------+------------+-----------------+----------------------------+
| 1640057560 | 1640057560  | 2021-12-21 | 03:32:40.351000 | 2021-12-21T03:32:40.351000 |
+------------+-------------+------------+-----------------+----------------------------+
```

Last update: December 21, 2022

4.5.5 Schema-related functions

This topic describes the schema-related functions supported by NebulaGraph. There are two types of schema-related functions, one for native nGQL statements and the other for openCypher-compatible statements.

For nGQL statements

The following functions are available in `YIELD` and `WHERE` clauses of nGQL statements.

Note

Since vertex, edge, vertices, edges, and path are keywords, you need to use `AS <alias>` to set the alias, such as `GO FROM "player100" OVER follow YIELD edge AS e;`.

ID(VERTEX)

id(vertex) returns the ID of a vertex.

Syntax: `id(vertex)`

- Result type: Same as the vertex ID.

Example:

```
nebula> LOOKUP ON player WHERE player.age  > 45 YIELD id(vertex);
+-------------+
| id(VERTEX)  |
+-------------+
| "player144" |
| "player140" |
+-------------+
```

PROPERTIES(VERTEX)

properties(vertex) returns the properties of a vertex.

Syntax: `properties(vertex)`

- Result type: Map

Example:

```
nebula> LOOKUP ON player WHERE player.age  > 45 \
        YIELD properties(vertex);
+-------------------------------------+
| properties(VERTEX)                  |
+-------------------------------------+
| {age: 47, name: "Shaquille O'Neal"} |
| {age: 46, name: "Grant Hill"}       |
+-------------------------------------+
```

You can also use the property reference symbols (`$^` and `$$`) instead of the `vertex` field in the `properties()` function to get all properties of a vertex.

- `$^` represents the data of the starting vertex at the beginning of exploration. For example, in `GO FROM "player100" OVER follow reversely YIELD properties($^)`, `$^` refers to the vertex `player100`.

- `$$` represents the data of the end vertex at the end of exploration.

`properties($^)` and `properties($$)` are generally used in `GO` statements. For more information, see Property reference.

Caution

You can use `properties().<property_name>` to get a specific property of a vertex. However, it is not recommended to use this method to obtain specific properties because the `properties()` function returns all properties, which can decrease query performance.

PROPERTIES(EDGE)

properties(edge) returns the properties of an edge.

Syntax: `properties(edge)`

- Result type: Map

Example:

```
nebula> GO FROM "player100" OVER follow \
        YIELD properties(edge);
+------------------+
| properties(EDGE) |
+------------------+
| {degree: 95}     |
| {degree: 95}     |
+------------------+
```

Caution

You can use `properties(edge).<property_name>` to get a specific property of an edge. However, it is not recommended to use this method to obtain specific properties because the `properties(edge)` function returns all properties, which can decrease query performance.

TYPE(EDGE)

type(edge) returns the edge type of an edge.

Syntax: `type(edge)`

- Result type: String

Example:

```
nebula> GO FROM "player100" OVER follow \
        YIELD src(edge), dst(edge), type(edge), rank(edge);
+-------------+-------------+------------+------------+
| src(EDGE)   | dst(EDGE)   | type(EDGE) | rank(EDGE) |
+-------------+-------------+------------+------------+
| "player100" | "player101" | "follow"   | 0          |
| "player100" | "player125" | "follow"   | 0          |
+-------------+-------------+------------+------------+
```

SRC(EDGE)

src(edge) returns the source vertex ID of an edge.

Syntax: `src(edge)`

- Result type: Same as the vertex ID.

Example:

```
nebula> GO FROM "player100" OVER follow \
        YIELD src(edge), dst(edge);
+-------------+-------------+
| src(EDGE)   | dst(EDGE)   |
+-------------+-------------+
| "player100" | "player101" |
| "player100" | "player125" |
+-------------+-------------+
```

Note

The semantics of the query for the starting vertex with src(edge) and properties(`$^`) are different. src(edge) indicates the starting vertex ID of the edge in the graph database, while properties(`$^`) indicates the data of the starting vertex where you start to expand the graph, such as the data of the starting vertex `player100` in the above GO statement.

DST(EDGE)

dst(edge) returns the destination vertex ID of an edge.

Syntax: `dst(edge)`

- Result type: Same as the vertex ID.

Example:

```
nebula> GO FROM "player100" OVER follow \
        YIELD src(edge), dst(edge);
+-------------+-------------+
| src(EDGE)   | dst(EDGE)   |
+-------------+-------------+
| "player100" | "player101" |
| "player100" | "player125" |
+-------------+-------------+
```

Note

dst(edge) indicates the destination vertex ID of the edge in the graph database.

RANK(EDGE)

rank(edge) returns the rank value of an edge.

Syntax: `rank(edge)`

- Result type: Int

Example:

```
nebula> GO FROM "player100" OVER follow \
        YIELD src(edge), dst(edge), rank(edge);
+-------------+-------------+------------+
| src(EDGE)   | dst(EDGE)   | rank(EDGE) |
+-------------+-------------+------------+
| "player100" | "player101" | 0          |
| "player100" | "player125" | 0          |
+-------------+-------------+------------+
```

VERTEX

vertex returns the information of vertices, including VIDs, tags, properties, and values. You need to use `AS <alias>` to set the alias.

Syntax: `vertex`

Example:

```
nebula> LOOKUP ON player WHERE player.age > 45 YIELD vertex AS v;
+----------------------------------------------------------+
| v                                                        |
+----------------------------------------------------------+
| ("player144" :player{age: 47, name: "Shaquille O'Neal"}) |
| ("player140" :player{age: 46, name: "Grant Hill"})       |
+----------------------------------------------------------+
```

EDGE

edge returns the information of edges, including edge types, source vertices, destination vertices, ranks, properties, and values. You need to use `AS <alias>` to set the alias.

Syntax: `edge`

Example:

```
nebula> GO FROM "player100" OVER follow YIELD edge AS e;
+----------------------------------------------------+
| e                                                  |
+----------------------------------------------------+
| [:follow "player100"->"player101" @0 {degree: 95}] |
| [:follow "player100"->"player125" @0 {degree: 95}] |
+----------------------------------------------------+
```

VERTICES

vertices returns the information of vertices in a subgraph. For more information, see GET SUBGRAPH.

EDGES

edges returns the information of edges in a subgraph. For more information, see GET SUBGRAPH.

PATH

path returns the information of a path. For more information, see FIND PATH.

For statements compatible with openCypher

The following functions are available in `RETURN` and `WHERE` clauses of openCypher-compatible statements.

ID()

id() returns the ID of a vertex.

Syntax: `id(<vertex>)`

- Result type: Same as the vertex ID.

Example:

```
nebula> MATCH (v:player) RETURN id(v);
+-------------+
| id(v)       |
+-------------+
| "player129" |
| "player115" |
| "player106" |
| "player102" |
...
```

TAGS() AND LABELS()

tags() and labels() return the Tag of a vertex.

Syntax: `tags(<vertex>)`, `labels(<vertex>)`

- Result type: List

Example:

```
nebula> MATCH (v) WHERE id(v) == "player100" \
        RETURN tags(v);
+------------+
| tags(v)    |
+------------+
| ["player"] |
+------------+
```

PROPERTIES()

properties() returns the properties of a vertex or an edge.

Syntax: `properties(<vertex_or_edge>)`

- Result type: Map

Example:

```
nebula> MATCH (v:player)-[e:follow]-() RETURN properties(v),properties(e);
+---------------------------------------+---------------+
| properties(v)                         | properties(e) |
+---------------------------------------+---------------+
| {age: 31, name: "Stephen Curry"}      | {degree: 90}  |
| {age: 47, name: "Shaquille O'Neal"}   | {degree: 100} |
| {age: 34, name: "LeBron James"}       | {degree: 13}  |
...
```

TYPE()

type() returns the edge type of an edge.

Syntax: `type(<edge>)`

- Result type: String

Example:

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->() \
        RETURN type(e);
+----------+
| type(e)  |
+----------+
| "serve"  |
| "follow" |
| "follow" |
+----------+
```

SRC()

src() returns the source vertex ID of an edge.

Syntax: `src(<edge>)`

- Result type: Same as the vertex ID.

Example:

```
nebula> MATCH ()-[e]->(v:player{name:"Tim Duncan"}) \
        RETURN src(e);
+-------------+
| src(e)      |
+-------------+
| "player125" |
| "player113" |
| "player102" |
...
```

DST()

dst() returns the destination vertex ID of an edge.

Syntax: `dst(<edge>)`

- Result type: Same as the vertex ID.

Example:

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->() \
        RETURN dst(e);
+-------------+
| dst(e)      |
+-------------+
| "team204"   |
| "player101" |
| "player125" |
+-------------+
```

STARTNODE()

startNode() visits a path and returns its information of source vertex ID, including VIDs, tags, properties, and values.

Syntax: `startNode(<path>)`

Example:

```
nebula> MATCH p = (a :player {name : "Tim Duncan"})-[r:serve]-(t) \
        RETURN startNode(p);
+----------------------------------------------------+
| startNode(p)                                       |
+----------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------+
```

ENDNODE()

endNode() visits a path and returns its information of destination vertex ID, including VIDs, tags, properties, and values.

Syntax: `endNode(<path>)`

Example:

```
nebula> MATCH p = (a :player {name : "Tim Duncan"})-[r:serve]-(t) \
        RETURN endNode(p);
+----------------------------------+
| endNode(p)                       |
+----------------------------------+
| ("team204" :team{name: "Spurs"}) |
+----------------------------------+
```

RANK()

rank() returns the rank value of an edge.

Syntax: `rank(<edge>)`

- Result type: Int

Example:

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->() \
        RETURN rank(e);
+---------+
| rank(e) |
+---------+
| 0       |
| 0       |
| 0       |
+---------+
```

Last update: March 13, 2023

4.5.6 List functions

This topic describes the list functions supported by NebulaGraph. Some of the functions have different syntax in native nGQL statements and openCypher-compatible statements.

Precautions

Like SQL, the position index in nGQL starts from `1`, while in the C language it starts from `0`.

General

RANGE()

range() returns the list containing all the fixed-length steps in `[start,end]`.

Syntax: `range(start, end [, step])`

- `step`: Optional parameters. `step` is 1 by default.
- Result type: List

Example:

```
nebula> RETURN range(1,9,2);
+-----------------+
| range(1,9,2)    |
+-----------------+
| [1, 3, 5, 7, 9] |
+-----------------+
```

REVERSE()

reverse() returns the list reversing the order of all elements in the original list.

Syntax: `reverse(<list>)`

- Result type: List

Example:

```
nebula> WITH [NULL, 4923, 'abc', 521, 487] AS ids \
        RETURN reverse(ids);
+-----------------------------------+
| reverse(ids)                      |
+-----------------------------------+
| [487, 521, "abc", 4923, __NULL__] |
+-----------------------------------+
```

TAIL()

tail() returns all the elements of the original list, excluding the first one.

Syntax: `tail(<list>)`

- Result type: List

Example:

```
nebula> WITH [NULL, 4923, 'abc', 521, 487] AS ids \
        RETURN tail(ids);
+-------------------------+
| tail(ids)               |
+-------------------------+
| [4923, "abc", 521, 487] |
+-------------------------+
```

HEAD()

head() returns the first element of a list.

Syntax: `head(<list>)`

- Result type: Same as the element in the original list.

Example:

```
nebula> WITH [NULL, 4923, 'abc', 521, 487] AS ids \
        RETURN head(ids);
+-----------+
| head(ids) |
+-----------+
| __NULL__  |
+-----------+
```

LAST()

last() returns the last element of a list.

Syntax: `last(<list>)`

- Result type: Same as the element in the original list.

Example:

```
nebula> WITH [NULL, 4923, 'abc', 521, 487] AS ids \
        RETURN last(ids);
+-----------+
| last(ids) |
+-----------+
| 487       |
+-----------+
```

REDUCE()

reduce() applies an expression to each element in a list one by one, chains the result to the next iteration by taking it as the initial value, and returns the final result. This function iterates each element `e` in the given list, runs the expression on `e`, accumulates the result with the initial value, and store the new result in the accumulator as the initial value of the next iteration. It works like the fold or reduce method in functional languages such as Lisp and Scala.

openCypher compatibility

In openCypher, the `reduce()` function is not defined. nGQL will implement the `reduce()` function in the Cypher way.

Syntax: `reduce(<accumulator> = <initial>, <variable> IN <list> | <expression>)`

- `accumulator`: A variable that will hold the accumulated results as the list is iterated.
- `initial`: An expression that runs once to give an initial value to the `accumulator`.
- `variable`: A variable in the list that will be applied to the expression successively.
- `list`: A list or a list of expressions.
- `expression`: This expression will be run on each element in the list once and store the result value in the `accumulator`.
- Result type: Depends on the parameters provided, along with the semantics of the expression.

Example:

```
nebula> RETURN reduce(totalNum = -4 * 5, n IN [1, 2] | totalNum + n * 2) AS r;
+-----+
| r   |
+-----+
| -14 |
+-----+

nebula> MATCH p = (n:player{name:"LeBron James"})<-[:follow]-(m) \
        RETURN  nodes(p)[0].player.age AS src1,  nodes(p)[1].player.age AS dst2,  \
        reduce(totalAge = 100, n IN nodes(p) | totalAge + n.player.age) AS sum;
+------+------+-----+
| src1 | dst2 | sum |
+------+------+-----+
```

```
| 34   | 31   | 165 |
| 34   | 29   | 163 |
| 34   | 33   | 167 |
| 34   | 26   | 160 |
| 34   | 34   | 168 |
| 34   | 37   | 171 |
+------+------+-----+

nebula> LOOKUP ON player WHERE player.name == "Tony Parker" YIELD id(vertex) AS VertexID \
        |  GO FROM $-.VertexID over follow \
        WHERE properties(edge).degree != reduce(totalNum = 5, n IN range(1, 3) | properties($$).age + totalNum + n) \
        YIELD properties($$).name AS id, properties($$).age AS age, properties(edge).degree AS degree;
+---------------------+-----+--------+
| id                  | age | degree |
+---------------------+-----+--------+
| "Tim Duncan"        | 42  | 95     |
| "LaMarcus Aldridge" | 33  | 90     |
| "Manu Ginobili"     | 41  | 95     |
+---------------------+-----+--------+
```

For nGQL statements

KEYS()

keys() returns a list containing the string representations for all the property names of vertices or edges.

Syntax: `keys({vertex | edge})`

- Result type: List

Example:

```
nebula> LOOKUP ON player \
        WHERE player.age  > 45 \
        YIELD keys(vertex);
+-----------------+
| keys(VERTEX)    |
+-----------------+
| ["age", "name"] |
| ["age", "name"] |
+-----------------+
```

LABELS()

labels() returns the list containing all the tags of a vertex.

Syntax: `labels(verte)`

- Result type: List

Example:

```
nebula> FETCH PROP ON * "player101", "player102", "team204" \
        YIELD labels(vertex);
+----------------+
| labels(VERTEX) |
+----------------+
| ["player"]     |
| ["player"]     |
| ["team"]       |
+----------------+
```

For statements compatible with openCypher

KEYS()

keys() returns a list containing the string representations for all the property names of vertices, edges, or maps.

Syntax: `keys(<vertex_or_edge>)`

- Result type: List

Example:

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->() \
        RETURN keys(e);
+----------------------------+
```

```
| keys(e)                    |
+----------------------------+
| ["end_year", "start_year"] |
| ["degree"]                 |
| ["degree"]                 |
+----------------------------+
```

LABELS()

labels() returns the list containing all the tags of a vertex.

Syntax: `labels(<vertex>)`

- Result type: List

Example:

```
nebula> MATCH (v)-[e:serve]->() \
        WHERE id(v)=="player100" \
        RETURN labels(v);
+------------+
| labels(v)  |
+------------+
| ["player"] |
+------------+
```

NODES()

nodes() returns the list containing all the vertices in a path.

Syntax: `nodes(<path>)`

- Result type: List

Example:

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-->(v2) \
        RETURN nodes(p);
+-------------------------------------------------------------------------------------------------------------+
| nodes(p)                                                                                                    |
+-------------------------------------------------------------------------------------------------------------+
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("team204" :team{name: "Spurs"})]                      |
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("player101" :player{age: 36, name: "Tony Parker"})]   |
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("player125" :player{age: 41, name: "Manu Ginobili"})] |
+-------------------------------------------------------------------------------------------------------------+
```

RELATIONSHIPS()

relationships() returns the list containing all the relationships in a path.

Syntax: `relationships(<path>)`

- Result type: List

Example:

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-->(v2) \
        RETURN relationships(p);
+-------------------------------------------------------------------------+
| relationships(p)                                                        |
+-------------------------------------------------------------------------+
| [[:serve "player100"->"team204" @0 {end_year: 2016, start_year: 1997}]] |
| [[:follow "player100"->"player101" @0 {degree: 95}]]                    |
| [[:follow "player100"->"player125" @0 {degree: 95}]]                    |
+-------------------------------------------------------------------------+
```

Last update: February 3, 2023

4.5.7 Type conversion functions

This topic describes the type conversion functions supported by NebulaGraph.

toBoolean()

toBoolean() converts a string value to a boolean value.

Syntax: `toBoolean(<value>)`

- Result type: Bool

Example:

```
nebula> UNWIND [true, false, 'true', 'false', NULL] AS b \
        RETURN toBoolean(b) AS b;
+----------+
| b        |
+----------+
| true     |
| false    |
| true     |
| false    |
| __NULL__ |
+----------+
```

toFloat()

toFloat() converts an integer or string value to a floating point number.

Syntax: `toFloat(<value>)`

- Result type: Float

Example:

```
nebula> RETURN toFloat(1), toFloat('1.3'), toFloat('1e3'), toFloat('not a number');
+------------+----------------+----------------+-------------------------+
| toFloat(1) | toFloat("1.3") | toFloat("1e3") | toFloat("not a number") |
+------------+----------------+----------------+-------------------------+
| 1.0        | 1.3            | 1000.0         | __NULL__                |
+------------+----------------+----------------+-------------------------+
```

toString()

toString() converts non-compound types of data, such as numbers, booleans, and so on, to strings.

Syntax: `toString(<value>)`

- Result type: String

Example:

```
nebula> RETURN toString(9669) AS int2str, toString(null) AS null2str;
+---------+----------+
| int2str | null2str |
+---------+----------+
| "9669"  | __NULL__ |
+---------+----------+
```

toInteger()

toInteger() converts a floating point or string value to an integer value.

Syntax: `toInteger(<value>)`

- Result type: Int

Example:

```
nebula> RETURN toInteger(1), toInteger('1'), toInteger('1e3'), toInteger('not a number');
+--------------+----------------+------------------+--------------------------+
| toInteger(1) | toInteger("1") | toInteger("1e3") | toInteger("not a number") |
+--------------+----------------+------------------+--------------------------+
| 1            | 1              | 1000             | __NULL__                 |
+--------------+----------------+------------------+--------------------------+
```

toSet()

toSet() converts a list or set value to a set value.

Syntax: `toSet(<value>)`

- Result type: Set

Example:

```
nebula> RETURN toSet(list[1,2,3,1,2]) AS list2set;
+-----------+
| list2set  |
+-----------+
| {3, 1, 2} |
+-----------+
```

hash()

hash() returns the hash value of the argument. The argument can be a number, a string, a list, a boolean, null, or an expression that evaluates to a value of the preceding data types.

The source code of the `hash()` function (MurmurHash2), seed (`0xc70f6907UL`), and other parameters can be found in `MurmurHash2.h`.

For Java, the hash function operates as follows.

```
MurmurHash2.hash64("to_be_hashed".getBytes(),"to_be_hashed".getBytes().length, 0xc70f6907)
```

Syntax: `hash(<string>)`

- Result type: Int

Example:

```
nebula> RETURN hash("abcde");
+--------------------+
| hash("abcde")      |
+--------------------+
| 811036730794841393 |
+--------------------+
nebula> YIELD hash([1,2,3]);
+----------------+
| hash([1,2,3])  |
+----------------+
| 11093822460243 |
+----------------+
nebula> YIELD hash(NULL);
+------------+
| hash(NULL) |
+------------+
| -1         |
+------------+
nebula> YIELD hash(toLower("HELLO NEBULA"));
+-------------------------------+
| hash(toLower("HELLO NEBULA")) |
+-------------------------------+
| -8481157362655072082          |
+-------------------------------+
```

Last update: December 21, 2022

4.5.8 Conditional expressions

This topic describes the conditional functions supported by NebulaGraph.

CASE

The `CASE` expression uses conditions to filter the parameters. nGQL provides two forms of `CASE` expressions just like openCypher: the simple form and the generic form.

The `CASE` expression will traverse all the conditions. When the first condition is met, the `CASE` expression stops reading the conditions and returns the result. If no conditions are met, it returns the result in the `ELSE` clause. If there is no `ELSE` clause and no conditions are met, it returns `NULL`.

THE SIMPLE FORM OF CASE EXPRESSIONS

- Syntax

```
CASE <comparer>
WHEN <value> THEN <result>
[WHEN ...]
[ELSE <default>]
END
```

Caution

Always remember to end the `CASE` expression with an `END`.

Parameter	Description
`comparer`	A value or a valid expression that outputs a value. This value is used to compare with the `value`.
`value`	It will be compared with the `comparer`. If the `value` matches the `comparer`, then this condition is met.
`result`	The `result` is returned by the `CASE` expression if the `value` matches the `comparer`.
`default`	The `default` is returned by the `CASE` expression if no conditions are met.

- Examples

```
nebula> RETURN \
        CASE 2+3 \
        WHEN 4 THEN 0 \
        WHEN 5 THEN 1 \
        ELSE -1 \
        END \
        AS result;
+--------+
| result |
+--------+
| 1      |
+--------+
```

```
nebula> GO FROM "player100" OVER follow \
        YIELD properties($$).name AS Name, \
        CASE properties($$).age > 35 \
        WHEN true THEN "Yes" \
        WHEN false THEN "No" \
        ELSE "Nah" \
        END \
        AS Age_above_35;
+-----------------+--------------+
| Name            | Age_above_35 |
+-----------------+--------------+
| "Tony Parker"   | "Yes"        |
| "Manu Ginobili" | "Yes"        |
+-----------------+--------------+
```

THE GENERIC FORM OF CASE EXPRESSIONS

- Syntax

```
CASE
WHEN <condition> THEN <result>
[WHEN ...]
[ELSE <default>]
END
```

Parameter	Description
`condition`	If the `condition` is evaluated as true, the `result` is returned by the `CASE` expression.
`result`	The `result` is returned by the `CASE` expression if the `condition` is evaluated as true.
`default`	The `default` is returned by the `CASE` expression if no conditions are met.

- Examples

```
nebula> YIELD \
        CASE WHEN 4 > 5 THEN 0 \
        WHEN 3+4==7 THEN 1 \
        ELSE 2 \
        END \
        AS result;
+--------+
| result |
+--------+
| 1      |
+--------+
```

```
nebula> MATCH (v:player) WHERE v.player.age > 30 \
        RETURN v.player.name AS Name,  \
        CASE \
        WHEN v.player.name STARTS WITH "T" THEN "Yes" \
        ELSE "No" \
        END \
        AS Starts_with_T;
+---------------------+---------------+
| Name                | Starts_with_T |
+---------------------+---------------+
| "Tim Duncan"        | "Yes"         |
| "LaMarcus Aldridge" | "No"          |
| "Tony Parker"       | "Yes"         |
+---------------------+---------------+
```

DIFFERENCES BETWEEN THE SIMPLE FORM AND THE GENERIC FORM

To avoid the misuse of the simple form and the generic form, it is important to understand their differences. The following example can help explain them.

```
nebula> GO FROM "player100" OVER follow \
        YIELD properties($$).name AS Name, properties($$).age AS Age, \
        CASE properties($$).age \
        WHEN properties($$).age > 35 THEN "Yes" \
        ELSE "No" \
        END \
        AS Age_above_35;
+-----------------+-----+--------------+
| Name            | Age | Age_above_35 |
+-----------------+-----+--------------+
| "Tony Parker"   | 36  | "No"         |
| "Manu Ginobili" | 41  | "No"         |
+-----------------+-----+--------------+
```

The preceding `GO` query is intended to output `Yes` when the player's age is above 35. However, in this example, when the player's age is 36, the actual output is not as expected: It is `No` instead of `Yes`.

This is because the query uses the `CASE` expression in the simple form, and a comparison between the values of `$$.player.age` and `$$.player.age > 35` is made. When the player age is 36:

- The value of `$$.player.age` is `36`. It is an integer.
- `$$.player.age > 35` is evaluated to be `true`. It is a boolean.

The values of `$$.player.age` and `$$.player.age > 35` do not match. Therefore, the condition is not met and `No` is returned.

coalesce()

coalesce() returns the first not null value in all expressions.

Syntax: `coalesce(<expression_1>[,<expression_2>...])`

- Result type: Same as the original element.

Example:

```
nebula> RETURN coalesce(null,[1,2,3]) as result;
+-----------+
| result    |
+-----------+
| [1, 2, 3] |
+-----------+
nebula> RETURN coalesce(null) as result;
+----------+
| result   |
+----------+
| __NULL__ |
+----------+
```

Last update: September 23, 2022

4.5.9 Predicate functions

Predicate functions return `true` or `false`. They are most commonly used in `WHERE` clauses.

NebulaGraph supports the following predicate functions:

Functions	Description
exists()	Returns `true` if the specified property exists in the vertex, edge or map. Otherwise, returns `false`.
any()	Returns `true` if the specified predicate holds for at least one element in the given list. Otherwise, returns `false`.
all()	Returns `true` if the specified predicate holds for all elements in the given list. Otherwise, returns `false`.
none()	Returns `true` if the specified predicate holds for no element in the given list. Otherwise, returns `false`.
single()	Returns `true` if the specified predicate holds for exactly one of the elements in the given list. Otherwise, returns `false`.

Note

NULL is returned if the list is NULL or all of its elements are NULL.

Compatibility

In openCypher, only function `exists()` is defined and specified. The other functions are implement-dependent.

Syntax

```
<predicate>(<variable> IN <list> WHERE <condition>)
```

Examples

```
nebula> RETURN any(n IN [1, 2, 3, 4, 5, NULL] \
        WHERE n > 2) AS r;
+------+
| r    |
+------+
| true |
+------+

nebula> RETURN single(n IN range(1, 5) \
        WHERE n == 3) AS r;
+------+
| r    |
+------+
| true |
+------+

nebula> RETURN none(n IN range(1, 3) \
        WHERE n == 0) AS r;
+------+
| r    |
+------+
| true |
+------+

nebula> WITH [1, 2, 3, 4, 5, NULL] AS a \
        RETURN any(n IN a WHERE n > 2);
+-------------------------+
| any(n IN a WHERE (n>2)) |
+-------------------------+
| true                    |
+-------------------------+

nebula> MATCH p = (n:player{name:"LeBron James"})<-[:follow]-(m) \
        RETURN nodes(p)[0].player.name AS n1, nodes(p)[1].player.name AS n2, \
        all(n IN nodes(p) WHERE n.player.name NOT STARTS WITH "D") AS b;
+----------------+-------------------+-------+
```

```
| n1             | n2                | b     |
+----------------+-------------------+-------+
| "LeBron James" | "Danny Green"     | false |
| "LeBron James" | "Dejounte Murray" | false |
| "LeBron James" | "Chris Paul"      | true  |
| "LeBron James" | "Kyrie Irving"    | true  |
| "LeBron James" | "Carmelo Anthony" | true  |
| "LeBron James" | "Dwyane Wade"     | false |
+----------------+-------------------+-------+

nebula> MATCH p = (n:player{name:"LeBron James"})-[:follow]->(m) \
        RETURN single(n IN nodes(p) WHERE n.player.age > 40) AS b;
+------+
| b    |
+------+
| true |
+------+

nebula> MATCH (n:player) \
        RETURN exists(n.player.id), n IS NOT NULL;
+---------------------+---------------+
| exists(n.player.id) | n IS NOT NULL |
+---------------------+---------------+
| false               | true          |
...

nebula> MATCH (n:player) \
        WHERE exists(n['name']) RETURN n;
+---------------------------------------------------------------------------------------------------------------+
| n                                                                                                             |
+---------------------------------------------------------------------------------------------------------------+
| ("Grant Hill" :player{age: 46, name: "Grant Hill"})                                                           |
| ("Marc Gasol" :player{age: 34, name: "Marc Gasol"})                                                           |
+---------------------------------------------------------------------------------------------------------------+
...
```

Last update: February 3, 2023

4.5.10 Geography functions

Geography functions are used to generate or perform operations on the value of the geography data type.

For descriptions of the geography data types, see Geography.

Descriptions

Function	Return Type	Description
ST_Point(longitude, latitude)	`GEOGRAPHY`	Creates the geography that contains a point.
ST_GeogFromText(wkt_string)	`GEOGRAPHY`	Returns the geography corresponding to the input WKT string.
ST_ASText(geography)	`STRING`	Returns the WKT string of the input geography.
ST_Centroid(geography)	`GEOGRAPHY`	Returns the centroid of the input geography in the form of the single point geography.
ST_ISValid(geography)	`BOOL`	Returns whether the input geography is valid.
ST_Intersects(geography_1, geography_2)	`BOOL`	Returns whether geography_1 and geography_2 have intersections.
ST_Covers(geography_1, geography_2)	`BOOL`	Returns whether geography_1 completely contains geography_2. If there is no point outside geography_1 in geography_2, return True.
ST_CoveredBy(geography_1, geography_2)	`BOOL`	Returns whether geography_2 completely contains geography_1.If there is no point outside geography_2 in geography_1, return True.
ST_DWithin(geography_1, geography_2, distance)	`BOOL`	If the distance between one point (at least) in geography_1 and one point in geography_2 is less than or equal to the distance specified by the distance parameter (measured by meters), return True.
ST_Distance(geography_1, geography_2)	`FLOAT`	Returns the smallest possible distance (measured by meters) between two non-empty geographies.
S2_CellIdFromPoint(point_geography)	`INT`	Returns the S2 Cell ID that covers the point geography.
S2_CoveringCellIds(geography)	`ARRAY<INT64>`	Returns an array of S2 Cell IDs that cover the input geography.

Examples

```
nebula> RETURN ST_ASText(ST_Point(1,1));
+--------------------------+
| ST_ASText(ST_Point(1,1)) |
+--------------------------+
| "POINT(1 1)"             |
+--------------------------+

nebula> RETURN ST_ASText(ST_GeogFromText("POINT(3 8)"));
+------------------------------------------+
| ST_ASText(ST_GeogFromText("POINT(3 8)")) |
+------------------------------------------+
| "POINT(3 8)"                             |
+------------------------------------------+

nebula> RETURN ST_ASTEXT(ST_Centroid(ST_GeogFromText("LineString(0 1,1 0)")));
+----------------------------------------------------------------+
| ST_ASTEXT(ST_Centroid(ST_GeogFromText("LineString(0 1,1 0)"))) |
+----------------------------------------------------------------+
| "POINT(0.5000380800773782 0.5000190382261059)"                 |
+----------------------------------------------------------------+
```

```
nebula> RETURN ST_ISValid(ST_GeogFromText("POINT(3 8)"));
+--------------------------------------------+
| ST_ISValid(ST_GeogFromText("POINT(3 8)")) |
+--------------------------------------------+
| true                                       |
+--------------------------------------------+

nebula> RETURN ST_Intersects(ST_GeogFromText("LineString(0 1,1 0)"),ST_GeogFromText("LineString(0 0,1 1)"));
+----------------------------------------------------------------------------------------------+
| ST_Intersects(ST_GeogFromText("LineString(0 1,1 0)"),ST_GeogFromText("LineString(0 0,1 1)")) |
+----------------------------------------------------------------------------------------------+
| true                                                                                         |
+----------------------------------------------------------------------------------------------+

nebula> RETURN ST_Covers(ST_GeogFromText("POLYGON((0 0,10 0,10 10,0 10,0 0))"),ST_Point(1,2));
+--------------------------------------------------------------------------------+
| ST_Covers(ST_GeogFromText("POLYGON((0 0,10 0,10 10,0 10,0 0))"),ST_Point(1,2)) |
+--------------------------------------------------------------------------------+
| true                                                                           |
+--------------------------------------------------------------------------------+

nebula> RETURN ST_CoveredBy(ST_Point(1,2),ST_GeogFromText("POLYGON((0 0,10 0,10 10,0 10,0 0))"));
+-----------------------------------------------------------------------------------+
| ST_CoveredBy(ST_Point(1,2),ST_GeogFromText("POLYGON((0 0,10 0,10 10,0 10,0 0))")) |
+-----------------------------------------------------------------------------------+
| true                                                                              |
+-----------------------------------------------------------------------------------+

nebula> RETURN ST_dwithin(ST_GeogFromText("Point(0 0)"),ST_GeogFromText("Point(10 10)"),20000000000.0);
+---------------------------------------------------------------------------------------+
| ST_dwithin(ST_GeogFromText("Point(0 0)"),ST_GeogFromText("Point(10 10)"),20000000000) |
+---------------------------------------------------------------------------------------+
| true                                                                                  |
+---------------------------------------------------------------------------------------+

nebula> RETURN ST_Distance(ST_GeogFromText("Point(0 0)"),ST_GeogFromText("Point(10 10)"));
+----------------------------------------------------------------------------+
| ST_Distance(ST_GeogFromText("Point(0 0)"),ST_GeogFromText("Point(10 10)")) |
+----------------------------------------------------------------------------+
| 1.5685230187677438e+06                                                     |
+----------------------------------------------------------------------------+

nebula> RETURN S2_CellIdFromPoint(ST_GeogFromText("Point(1 1)"));
+---------------------------------------------------+
| S2_CellIdFromPoint(ST_GeogFromText("Point(1 1)")) |
+---------------------------------------------------+
| 1153277837650709461                               |
+---------------------------------------------------+

nebula> RETURN S2_CoveringCellIds(ST_GeogFromText("POLYGON((0 1, 1 2, 2 3, 0 1))"));
+------------------------------------------------------------------------------------------------------------------------------------------------------------------+
| S2_CoveringCellIds(ST_GeogFromText("POLYGON((0 1, 1 2, 2 3, 0 1))"))                                                                                             |
+------------------------------------------------------------------------------------------------------------------------------------------------------------------+
| [1152391494368201343, 1153466862374223872, 1153554823304445952, 1153836298281156608, 1153959443583467520, 1154240918560178176, 1160503736791990272, 1160591697722212352] |
+------------------------------------------------------------------------------------------------------------------------------------------------------------------+
```

Last update: May 13, 2022

4.5.11 User-defined functions

OpenCypher compatibility

User-defined functions (UDF) and storage processes are not yet supported nor designed in NebulaGraph 3.5.0.

Last update: August 11, 2022

4.6 General queries statements

4.6.1 MATCH

The `MATCH` statement provides pattern-based search functionality, allowing you to retrieve data that matches one or more patterns in NebulaGraph. By defining one or more patterns, you can search for data that matches the patterns in NebulaGraph. Once the matching data is retrieved, you can use the `RETURN` clause to return it as a result.

The examples in this topic use the basketballplayer dataset as the sample dataset.

Syntax

The syntax of `MATCH` is relatively more flexible compared with that of other query statements such as `GO` or `LOOKUP`. The path type of the `MATCH` statement is `trail`. That is, only vertices can be repeatedly visited in the graph traversal. Edges cannot be repeatedly visited. For details, see path. But generally, it can be summarized as follows.

```
MATCH <pattern> [<clause_1>] RETURN <output> [<clause_2>];
```

- `pattern`: The `MATCH` statement supports matching one or multiple patterns. Multiple patterns are separated by commas (,). For example: `(a)-[]->(b),(c)-[]->(d)`. For the detailed description of patterns, see Patterns.
- `clause_1`: The `WHERE`, `WITH`, `UNWIND`, and `OPTIONAL MATCH` clauses are supported, and the `MATCH` clause can also be used.
- `output`: Define the list name for the output results to be returned. You can use `AS` to set an alias for the list.
- `clause_2`: The `ORDER BY` and `LIMIT` clauses are supported.

Legacy version compatibility

- Starting from version 3.5.0, the `MATCH` statement supports full table scans. It can traverse vertices or edges in the graph without using any indexes or filter conditions. In previous versions, the `MATCH` statement required an index for certain queries or needed to use `LIMIT` to restrict the number of output results.
- Starting from NebulaGraph version 3.0.0, in order to distinguish the properties of different tags, you need to specify a tag name when querying properties. The original statement `RETURN <variable_name>.<property_name>` is changed to `RETURN <variable_name>.<tag_name>.<property_name>`.

Notes

- Avoid full table scans, as they may result in decreased query performance, and if there is insufficient memory during a full table scan, the query may fail, and the system will report an error. It is recommended to use queries with filter conditions or specifying tags and edge types, such as `v:player` and `v.player.name` in the statement `MATCH (v:player) RETURN v.player.name AS Name`.
- You can create an index for a tag, edge type, or a specific property of a tag or edge type to improve query performance. For example, you can create an index for the `player` tag or the name property of the `player` tag. For more information about the usage and considerations for indexes, see Must-read for using indexes.
- The `MATCH` statement cannot query dangling edges.

Using patterns in MATCH statements

MATCH VERTICES

You can use a user-defined variable in a pair of parentheses to represent a vertex in a pattern. For example: `(v)`.

```
nebula> MATCH (v) \
        RETURN v \
        LIMIT 3;
+-----------------------------------------------------------+
| v                                                         |
```

```
+-----------------------------------------------------------+
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) |
| ("player106" :player{age: 25, name: "Kyle Anderson"})     |
| ("player115" :player{age: 40, name: "Kobe Bryant"})       |
+-----------------------------------------------------------+
```

MATCH TAGS

Legacy version compatibility

- In NebulaGraph versions earlier than 3.0.0, the prerequisite for matching a tag is that the tag itself has an index or a certain property of the tag has an index.
- Starting from NebulaGraph 3.0.0, you can match tags without creating an index, but you need to use `LIMIT` to restrict the number of output results.
- Starting from NebulaGraph 3.5.0, the `MATCH` statement supports full table scans. There is no need to create an index for a tag or a specific property of a tag, nor use `LIMIT` to restrict the number of output results in order to execute the `MATCH` statement.

You can specify a tag with `:<tag_name>` after the vertex in a pattern.

```
nebula> MATCH (v:player) \
        RETURN v;
+---------------------------------------------------------------+
| v                                                             |
+---------------------------------------------------------------+
| ("player105" :player{age: 31, name: "Danny Green"})           |
| ("player109" :player{age: 34, name: "Tiago Splitter"})        |
| ("player111" :player{age: 38, name: "David West"})            |
...
```

To match vertices with multiple tags, use colons (:).

```
nebula> CREATE TAG actor (name string, age int);
nebula> INSERT VERTEX actor(name, age) VALUES "player100":("Tim Duncan", 42);
nebula> MATCH (v:player:actor) \
        RETURN v \
+----------------------------------------------------------------------------------------+
| v                                                                                      |
+----------------------------------------------------------------------------------------+
| ("player100" :actor{age: 42, name: "Tim Duncan"} :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------------------------------------------+
```

MATCH VERTEX PROPERTIES

Note

The prerequisite for matching a vertex property is that the tag itself has an index of the corresponding property. Otherwise, you cannot execute the `MATCH` statement to match the property.

You can specify a vertex property with `{<prop_name>: <prop_value>}` after the tag in a pattern.

```
# The following example uses the name property to match a vertex.
nebula> MATCH (v:player{name:"Tim Duncan"}) \
        RETURN v;
+----------------------------------------------------+
| v                                                  |
+----------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------+
```

The `WHERE` clause can do the same thing:

```
nebula> MATCH (v:player) \
        WHERE v.player.name == "Tim Duncan" \
        RETURN v;
+----------------------------------------------------+
| v                                                  |
+----------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------+
```

OpenCypher compatibility

In openCypher 9, `=` is the equality operator. However, in nGQL, `==` is the equality operator and `=` is the assignment operator (as in C++ or Java).

Use the `WHERE` clause to directly get all the vertices with the vertex property value Tim Duncan.

```
nebula> MATCH (v) \
        WITH v, properties(v) as props, keys(properties(v)) as kk \
        WHERE [i in kk where props[i] == "Tim Duncan"] \
        RETURN v;
+----------------------------------------------------+
| v                                                  |
+----------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------+
```

MATCH VIDS

You can use the VID to match a vertex. The `id()` function can retrieve the VID of a vertex.

```
nebula> MATCH (v) \
        WHERE id(v) == 'player101' \
        RETURN v;
+-----------------------------------------------------+
| v                                                   |
+-----------------------------------------------------+
| ("player101" :player{age: 36, name: "Tony Parker"}) |
+-----------------------------------------------------+
```

To match multiple VIDs, use `WHERE id(v) IN [vid_list]` or `WHERE id(v) IN {vid_list}`.

```
nebula> MATCH (v:player { name: 'Tim Duncan' })--(v2) \
        WHERE id(v2) IN ["player101", "player102"] \
        RETURN v2;
+-----------------------------------------------------------+
| v2                                                        |
+-----------------------------------------------------------+
| ("player101" :player{age: 36, name: "Tony Parker"})       |
| ("player101" :player{age: 36, name: "Tony Parker"})       |
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) |
+-----------------------------------------------------------+

nebula> MATCH (v) WHERE id(v) IN {"player100", "player101"} \
        RETURN v.player.name AS name;
+---------------+
| name          |
+---------------+
| "Tony Parker" |
| "Tim Duncan"  |
+---------------+
```

MATCH CONNECTED VERTICES

You can use the `--` symbol to represent edges of both directions and match vertices connected by these edges.

Legacy version compatibility

In nGQL 1.x, the `--` symbol is used for inline comments. Starting from nGQL 2.x, the `--` symbol represents an incoming or outgoing edge.

```
nebula> MATCH (v:player{name:"Tim Duncan"})--(v2) \
        RETURN v2.player.name AS Name;
+---------------------+
| Name                |
+---------------------+
| "Manu Ginobili"     |
| "Manu Ginobili"     |
| "Tiago Splitter"    |
...
```

You can add a `>` or `<` to the `--` symbol to specify the direction of an edge.

In the following example, `-->` represents an edge that starts from `v` and points to `v2`. To `v`, this is an outgoing edge, and to `v2` this is an incoming edge.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-->(v2:player) \
        RETURN v2.player.name AS Name;
+-----------------+
| Name            |
+-----------------+
| "Manu Ginobili" |
| "Tony Parker"   |
+-----------------+
```

To query the properties of the target vertices, use the `CASE` expression.

```
nebula> MATCH (v:player{name:"Tim Duncan"})--(v2) \
        RETURN \
        CASE WHEN v2.team.name IS NOT NULL \
        THEN v2.team.name  \
        WHEN v2.player.name IS NOT NULL \
        THEN v2.player.name END AS Name;
+---------------------+
| Name                |
+---------------------+
| "Manu Ginobili"     |
| "Manu Ginobili"     |
| "Spurs"             |
| "Dejounte Murray"   |
...
```

To extend the pattern, you can add more vertices and edges.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-->(v2)<--(v3) \
        RETURN v3.player.name AS Name;
+---------------------+
| Name                |
+---------------------+
| "Dejounte Murray"   |
| "LaMarcus Aldridge" |
| "Marco Belinelli"   |
...
```

If you do not need to refer to a vertex, you can omit the variable representing it in the parentheses.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-->()<--(v3) \
        RETURN v3.player.name AS Name;
+---------------------+
| Name                |
+---------------------+
| "Dejounte Murray"   |
| "LaMarcus Aldridge" |
| "Marco Belinelli"   |
...
```

MATCH PATHS

Connected vertices and edges form a path. You can use a user-defined variable to name a path as follows.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-->(v2) \
        RETURN p;
+--------------------------------------------------------------------------------------------------------------------------------------+
| p                                                                                                                                    |
+--------------------------------------------------------------------------------------------------------------------------------------+
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:serve@0 {end_year: 2016, start_year: 1997}]->("team204" :team{name: "Spurs"})> |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})>   |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41, name: "Manu Ginobili"})> |
+--------------------------------------------------------------------------------------------------------------------------------------+
```

openCypher compatibility

In nGQL, the `@` symbol represents the rank of an edge, but openCypher has no such concept.

MATCH EDGES

```
nebula> MATCH ()<-[e]-() \
        RETURN e \
        LIMIT 3;
+----------------------------------------------------+
| e                                                  |
```

```
+---------------------------------------------------+
| [:follow "player101"->"player102" @0 {degree: 90}] |
| [:follow "player103"->"player102" @0 {degree: 70}] |
| [:follow "player135"->"player102" @0 {degree: 80}] |
+---------------------------------------------------+
```

MATCH EDGE TYPES

Just like vertices, you can specify edge types with `:<edge_type>` in a pattern. For example: `-[e:follow]-`.

OpenCypher compatibility

- In NebulaGraph versions earlier than 3.0.0, the prerequisite for matching a edge type is that the edge type itself has an index or a certain property of the edge type has an index.
- Starting from version 3.0.0, there is no need to create an index for matching a edge type, but you need to use `LIMIT` to limit the number of output results and you must specify the direction of the edge.
- Starting from NebulaGraph 3.5.0, you can use the `MATCH` statement to match edges without creating an index for edge type or using `LIMIT` to restrict the number of output results.

```
nebula> MATCH ()-[e:follow]->() \
        RETURN e;
+---------------------------------------------------+
| e                                                 |
+---------------------------------------------------+
| [:follow "player102"->"player100" @0 {degree: 75}] |
| [:follow "player102"->"player101" @0 {degree: 75}] |
| [:follow "player129"->"player116" @0 {degree: 90}] |
...
```

MATCH EDGE TYPE PROPERTIES

Note

The prerequisite for matching an edge type property is that the edge type itself has an index of the corresponding property. Otherwise, you cannot execute the `MATCH` statement to match the property.

You can specify edge type properties with `{<prop_name>: <prop_value>}` in a pattern. For example: `[e:follow{likeness:95}]`.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e:follow{degree:95}]->(v2) \
        RETURN e;
+--------------------------------------------------------+
| e                                                      |
+--------------------------------------------------------+
| [:follow "player100"->"player101" @0 {degree: 95}]     |
| [:follow "player100"->"player125" @0 {degree: 95}]     |
+--------------------------------------------------------+
```

Use the `WHERE` clause to directly get all the edges with the edge property value 90.

```
nebula> MATCH ()-[e]->() \
        WITH e, properties(e) as props, keys(properties(e)) as kk \
        WHERE [i in kk where props[i] == 90] \
        RETURN e;
+---------------------------------------------------+
| e                                                 |
+---------------------------------------------------+
| [:follow "player125"->"player100" @0 {degree: 90}] |
| [:follow "player140"->"player114" @0 {degree: 90}] |
| [:follow "player133"->"player144" @0 {degree: 90}] |
| [:follow "player133"->"player114" @0 {degree: 90}] |
...
+---------------------------------------------------+
```

MATCH MULTIPLE EDGE TYPES

The `|` symbol can help matching multiple edge types. For example: `[e:follow|:serve]`. The English colon (:) before the first edge type cannot be omitted, but the English colon before the subsequent edge type can be omitted, such as `[e:follow|serve]`.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e:follow|:serve]->(v2) \
        RETURN e;
```

```
+------------------------------------------------------------------------+
| e                                                                      |
+------------------------------------------------------------------------+
| [:follow "player100"->"player101" @0 {degree: 95}]                     |
| [:follow "player100"->"player125" @0 {degree: 95}]                     |
| [:serve "player100"->"team204" @0 {end_year: 2016, start_year: 1997}]  |
+------------------------------------------------------------------------+
```

MATCH MULTIPLE EDGES

You can extend a pattern to match multiple edges in a path.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[]->(v2)<-[e:serve]-(v3) \
        RETURN v2, v3;
+---------------------------------+-----------------------------------------------------------+
| v2                              | v3                                                        |
+---------------------------------+-----------------------------------------------------------+
| ("team204" :team{name: "Spurs"}) | ("player104" :player{age: 32, name: "Marco Belinelli"})   |
| ("team204" :team{name: "Spurs"}) | ("player101" :player{age: 36, name: "Tony Parker"})       |
| ("team204" :team{name: "Spurs"}) | ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) |
...
```

MATCH FIXED-LENGTH PATHS

You can use the `:<edge_type>*<hop>` pattern to match a fixed-length path. `hop` must be a non-negative integer.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*2]->(v2) \
        RETURN DISTINCT v2 AS Friends;
+-----------------------------------------------------------+
| Friends                                                   |
+-----------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"})        |
| ("player125" :player{age: 41, name: "Manu Ginobili"})     |
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) |
+-----------------------------------------------------------+
```

If `hop` is 0, the pattern will match the source vertex of the path.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) -[*0]-> (v2) \
        RETURN v2;
+----------------------------------------------------+
| v2                                                 |
+----------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------+
```

Note

When you conditionally filter on multi-hop edges, such as `-[e:follow*2]->`, note that the `e` is a list of edges instead of a single edge.

For example, the following statement is correct from the syntax point of view which may not get your expected query result, because the `e` is a list without the `.degree` property.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*2]->(v2) \
        WHERE e.degree > 1 \
        RETURN DISTINCT v2 AS Friends;
```

The correct statement is as follows:

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*2]->(v2) \
        WHERE ALL(e_ in e WHERE e_.degree > 0) \
        RETURN DISTINCT v2 AS Friends;
```

Further, the following statement is for filtering the properties of the first-hop edge in multi-hop edges:

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*2]->(v2) \
        WHERE e[0].degree > 98 \
        RETURN DISTINCT v2 AS Friends;
```

MATCH VARIABLE-LENGTH PATHS

You can use the `:<edge_type>*[minHop..maxHop]` pattern to match variable-length paths. `minHop` and `maxHop` are optional and default to 1 and infinity respectively.

Note

When setting bounds, at least one of `minHop` and `maxHop` exists.

Caution

If `maxHop` is not set, it may cause the Graph service to OOM, execute this command with caution.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*]->(v2) \
        RETURN v2 AS Friends;
+-----------------------------------------------------------+
| Friends                                                   |
+-----------------------------------------------------------+
| ("player125" :player{age: 41, name: "Manu Ginobili"})     |
| ("player101" :player{age: 36, name: "Tony Parker"})       |
...

nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*1..3]->(v2) \
        RETURN v2 AS Friends;
+-----------------------------------------------------------+
| Friends                                                   |
+-----------------------------------------------------------+
| ("player101" :player{age: 36, name: "Tony Parker"})       |
| ("player125" :player{age: 41, name: "Manu Ginobili"})     |
| ("player100" :player{age: 42, name: "Tim Duncan"})        |
...

nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*1..]->(v2) \
        RETURN v2 AS Friends;
+-----------------------------------------------------------+
| Friends                                                   |
+-----------------------------------------------------------+
| ("player125" :player{age: 41, name: "Manu Ginobili"})     |
| ("player101" :player{age: 36, name: "Tony Parker"})       |
| ("player100" :player{age: 42, name: "Tim Duncan"})        |
...
```

You can use the `DISTINCT` keyword to aggregate duplicate results.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*1..3]->(v2:player) \
        RETURN DISTINCT v2 AS Friends, count(v2);
+-----------------------------------------------------------+-----------+
| Friends                                                   | count(v2) |
+-----------------------------------------------------------+-----------+
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) | 1         |
| ("player100" :player{age: 42, name: "Tim Duncan"})        | 4         |
| ("player101" :player{age: 36, name: "Tony Parker"})       | 3         |
| ("player125" :player{age: 41, name: "Manu Ginobili"})     | 3         |
+-----------------------------------------------------------+-----------+
```

If `minHop` is `0`, the pattern will match the source vertex of the path. Compared to the preceding statement, the following example uses `0` as the `minHop`. So in the following result set, `"Tim Duncan"` is counted one more time than it is in the preceding result set because it is the source vertex.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow*0..3]->(v2:player) \
        RETURN DISTINCT v2 AS Friends, count(v2);
+-----------------------------------------------------------+-----------+
| Friends                                                   | count(v2) |
+-----------------------------------------------------------+-----------+
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) | 1         |
| ("player100" :player{age: 42, name: "Tim Duncan"})        | 5         |
| ("player125" :player{age: 41, name: "Manu Ginobili"})     | 3         |
| ("player101" :player{age: 36, name: "Tony Parker"})       | 3         |
+-----------------------------------------------------------+-----------+
```

Note

When using the variable `e` to match fixed-length or variable-length paths in a pattern, such as `-[e:follow*0..3]->`, it is not supported to reference `e` in other patterns. For example, the following statement is not supported.

```
nebula> MATCH (v:player)-[e:like*1..3]->(n) \
        WHERE (n)-[e*1..4]->(:player) \
        RETURN v;
```

MATCH VARIABLE-LENGTH PATHS WITH MULTIPLE EDGE TYPES

You can specify multiple edge types in a fixed-length or variable-length pattern. In this case, `hop`, `minHop`, and `maxHop` take effect on all edge types.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e:follow|serve*2]->(v2) \
        RETURN DISTINCT v2;
+-----------------------------------------------------------+
| v2                                                        |
+-----------------------------------------------------------+
| ("team204" :team{name: "Spurs"})                          |
| ("player100" :player{age: 42, name: "Tim Duncan"})        |
| ("team215" :team{name: "Hornets"})                        |
| ("player125" :player{age: 41, name: "Manu Ginobili"})     |
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) |
+-----------------------------------------------------------+
```

MATCH MULTIPLE PATTERNS

You can separate multiple patterns with commas (,).

```
nebula> CREATE TAG INDEX IF NOT EXISTS team_index ON team(name(20));
nebula> REBUILD TAG INDEX team_index;
nebula> MATCH (v1:player{name:"Tim Duncan"}), (v2:team{name:"Spurs"}) \
        RETURN v1,v2;
+----------------------------------------------------+----------------------------------+
| v1                                                 | v2                               |
+----------------------------------------------------+----------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) | ("team204" :team{name: "Spurs"}) |
+----------------------------------------------------+----------------------------------+
```

MATCH SHORTEST PATHS

The `allShortestPaths` function can be used to find all shortest paths between two vertices.

```
nebula> MATCH p = allShortestPaths((a:player{name:"Tim Duncan"})-[e*..5]-(b:player{name:"Tony Parker"})) \
        RETURN p;
+------------------------------------------------------------------------------------------------------------------------------------+
| p                                                                                                                                  |
+------------------------------------------------------------------------------------------------------------------------------------+
| <("player100" :player{age: 42, name: "Tim Duncan"})<-[:follow@0 {degree: 95}]-("player101" :player{age: 36, name: "Tony Parker"})> |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})> |
+------------------------------------------------------------------------------------------------------------------------------------+
```

The `shortestPath` function can be used to find a single shortest path between two vertices.

```
nebula> MATCH p = shortestPath((a:player{name:"Tim Duncan"})-[e*..5]-(b:player{name:"Tony Parker"})) \
        RETURN p;
+------------------------------------------------------------------------------------------------------------------------------------+
| p                                                                                                                                  |
+------------------------------------------------------------------------------------------------------------------------------------+
| <("player100" :player{age: 42, name: "Tim Duncan"})<-[:follow@0 {degree: 95}]-("player101" :player{age: 36, name: "Tony Parker"})> |
+------------------------------------------------------------------------------------------------------------------------------------+
```

Retrieve with multiple match

Multiple `MATCH` can be used when different patterns have different filtering criteria and return the rows that exactly match the pattern.

```
nebula> MATCH (m)-[]->(n) WHERE id(m)=="player100" \
        MATCH (n)-[]->(l) WHERE id(n)=="player125" \
        RETURN id(m),id(n),id(l);
+-------------+-------------+-------------+
| id(m)       | id(n)       | id(l)       |
+-------------+-------------+-------------+
| "player100" | "player125" | "team204"   |
| "player100" | "player125" | "player100" |
+-------------+-------------+-------------+
```

Retrieve with optional match

See OPTIONAL MATCH.

Performance

In NebulaGraph, the performance and resource usage of the `MATCH` statement have been optimized. But we still recommend to use `GO`, `LOOKUP`, `|`, and `FETCH` instead of `MATCH` when high performance is required.

Last update: April 25, 2023

4.6.2 OPTIONAL MATCH

Caution

The feature is still in beta. It will continue to be optimized.

The `OPTIONAL MATCH` clause is used to search for the pattern described in it. `OPTIONAL MATCH` matches patterns against your graph database, just like `MATCH` does. The difference is that if no matches are found, `OPTIONAL MATCH` will use a null for missing parts of the pattern.

OpenCypher Compatibility

This topic applies to the openCypher syntax in nGQL only.

Limitations

The `WHERE` clause cannot be used in an `OPTIONAL MATCH` clause.

Example

The example of the use of `OPTIONAL MATCH` in the `MATCH` statement is as follows:

```
nebula> MATCH (m)-[]->(n) WHERE id(m)=="player100" \
        OPTIONAL MATCH (n)-[]->(l) \
        RETURN id(m),id(n),id(l);
+-------------+-------------+-------------+
| id(m)       | id(n)       | id(l)       |
+-------------+-------------+-------------+
| "player100" | "team204"   | __NULL__    |
| "player100" | "player101" | "team204"   |
| "player100" | "player101" | "team215"   |
| "player100" | "player101" | "player100" |
| "player100" | "player101" | "player102" |
| "player100" | "player101" | "player125" |
| "player100" | "player125" | "team204"   |
| "player100" | "player125" | "player100" |
+-------------+-------------+-------------+
```

Using multiple `MATCH` instead of `OPTIONAL MATCH` returns rows that match the pattern exactly. The example is as follows:

```
nebula> MATCH (m)-[]->(n) WHERE id(m)=="player100" \
        MATCH (n)-[]->(l) \
        RETURN id(m),id(n),id(l);
+-------------+-------------+-------------+
| id(m)       | id(n)       | id(l)       |
+-------------+-------------+-------------+
| "player100" | "player101" | "team204"   |
| "player100" | "player101" | "team215"   |
| "player100" | "player101" | "player100" |
| "player100" | "player101" | "player102" |
| "player100" | "player101" | "player125" |
| "player100" | "player125" | "team204"   |
| "player100" | "player125" | "player100" |
+-------------+-------------+-------------+
```

Last update: February 3, 2023

4.6.3 LOOKUP

The `LOOKUP` statement traverses data based on indexes. You can use `LOOKUP` for the following purposes:

- Search for the specific data based on conditions defined by the `WHERE` clause.
- List vertices with a tag: retrieve the VID of all vertices with a tag.
- List edges with an edge type: retrieve the source vertex IDs, destination vertex IDs, and ranks of all edges with an edge type.
- Count the number of vertices or edges with a tag or an edge type.

OpenCypher compatibility

This topic applies to native nGQL only.

Precautions

- Correct use of indexes can speed up queries, but indexes can dramatically reduce the write performance. The performance can be greatly reduced. **DO NOT** use indexes in production environments unless you are fully aware of their influences on your service.

- If the specified property is not indexed when using the `LOOKUP` statement, NebulaGraph randomly selects one of the available indexes.

  For example, the tag `player` has two properties, `name` and `age`. Both the tag `player` itself and the property `name` have indexes, but the property `age` has no indexes. When running `LOOKUP ON player WHERE player.age == 36 YIELD player.name;`, NebulaGraph randomly uses one of the indexes of the tag `player` and the property `name`. You can use the `EXPLAIN` statement to check the selected index.

  > **Legacy version compatibility**
  >
  > Before the release 2.5.0, if the specified property is not indexed when using the `LOOKUP` statement, NebulaGraph reports an error and does not use other indexes.

Prerequisites

Before using the `LOOKUP` statement, make sure that at least one index is created. If there are already related vertices, edges, or properties before an index is created, the user must rebuild the index after creating the index to make it valid.

Syntax

```
LOOKUP ON {<vertex_tag> | <edge_type>}
[WHERE <expression> [AND <expression> ...]]
YIELD [DISTINCT] <return_list> [AS <alias>];

<return_list>
    <prop_name> [AS <col_alias>] [, <prop_name> [AS <prop_alias>] ...];
```

- `WHERE <expression>`: filters data with specified conditions. Both `AND` and `OR` are supported between different expressions. For more information, see WHERE.
- `YIELD`: Define the output to be returned. For details, see `YIELD`.
- `DISTINCT`: Aggregate the output results and return the de-duplicated result set.
- `AS`: Set an alias.

Limitations of using `WHERE` in `LOOKUP`

The `WHERE` clause in a `LOOKUP` statement does not support the following operations:

- `$-` and `$^`.
- Filter `rank()`.
- In relational expressions, operators are not supported to have field names on both sides, such as `tagName.prop1> tagName.prop2`.
- Nested AliasProp expressions in operation expressions and function expressions are not supported.
- The `XOR` operation is not supported.
- String operations other than `STARTS WITH` are not supported.
- Graph patterns.

Retrieve vertices

The following example returns vertices whose `name` is `Tony Parker` and the tag is `player`.

```
nebula> CREATE TAG INDEX IF NOT EXISTS index_player ON player(name(30), age);

nebula> REBUILD TAG INDEX index_player;
+------------+
| New Job Id |
+------------+
| 15         |
+------------+

nebula> LOOKUP ON player \
        WHERE player.name == "Tony Parker" \
        YIELD id(vertex);
+---------------+
| id(VERTEX)    |
+---------------+
| "player101"   |
+---------------+

nebula> LOOKUP ON player \
        WHERE player.name == "Tony Parker" \
        YIELD properties(vertex).name AS name, properties(vertex).age AS age;
+---------------+-----+
| name          | age |
+---------------+-----+
| "Tony Parker" | 36  |
+---------------+-----+

nebula> LOOKUP ON player \
        WHERE player.age  > 45 \
        YIELD id(vertex);
+-------------+
| id(VERTEX)  |
+-------------+
| "player144" |
| "player140" |
+-------------+

nebula> LOOKUP ON player \
        WHERE player.name STARTS WITH "B" \
        AND player.age IN [22,30] \
        YIELD properties(vertex).name, properties(vertex).age;
+-------------------------+------------------------+
| properties(VERTEX).name | properties(VERTEX).age |
+-------------------------+------------------------+
| "Ben Simmons"           | 22                     |
| "Blake Griffin"         | 30                     |
+-------------------------+------------------------+

nebula> LOOKUP ON player \
        WHERE player.name == "Kobe Bryant"\
        YIELD id(vertex) AS VertexID, properties(vertex).name AS name |\
        GO FROM $-.VertexID OVER serve \
        YIELD $-.name, properties(edge).start_year, properties(edge).end_year, properties($$).name;
+---------------+-----------------------------+---------------------------+---------------------+
| $-.name       | properties(EDGE).start_year | properties(EDGE).end_year | properties($$).name |
+---------------+-----------------------------+---------------------------+---------------------+
| "Kobe Bryant" | 1996                        | 2016                      | "Lakers"            |
+---------------+-----------------------------+---------------------------+---------------------+
```

Retrieve edges

The following example returns edges whose `degree` is `90` and the edge type is `follow`.

```
nebula> CREATE EDGE INDEX IF NOT EXISTS index_follow ON follow(degree);

nebula> REBUILD EDGE INDEX index_follow;
+------------+
| New Job Id |
+------------+
| 62         |
+------------+

nebula> LOOKUP ON follow \
        WHERE follow.degree == 90 YIELD edge AS e;
+----------------------------------------------------+
| e                                                  |
+----------------------------------------------------+
| [:follow "player109"->"player125" @0 {degree: 90}] |
| [:follow "player118"->"player120" @0 {degree: 90}] |
| [:follow "player118"->"player131" @0 {degree: 90}] |
...

nebula> LOOKUP ON follow \
        WHERE follow.degree == 90 \
        YIELD properties(edge).degree;
+-------------+-------------+---------+-------------------------+
| SrcVID      | DstVID      | Ranking | properties(EDGE).degree |
+-------------+-------------+---------+-------------------------+
| "player150" | "player143" | 0       | 90                      |
| "player150" | "player137" | 0       | 90                      |
| "player148" | "player136" | 0       | 90                      |
...

nebula> LOOKUP ON follow \
        WHERE follow.degree == 60 \
        YIELD dst(edge) AS DstVID, properties(edge).degree AS Degree |\
        GO FROM $-.DstVID OVER serve \
        YIELD $-.DstVID, properties(edge).start_year, properties(edge).end_year, properties($$).name;
+-------------+-----------------------------+---------------------------+---------------------+
| $-.DstVID   | properties(EDGE).start_year | properties(EDGE).end_year | properties($$).name |
+-------------+-----------------------------+---------------------------+---------------------+
| "player105" | 2010                        | 2018                      | "Spurs"             |
| "player105" | 2009                        | 2010                      | "Cavaliers"         |
| "player105" | 2018                        | 2019                      | "Raptors"           |
+-------------+-----------------------------+---------------------------+---------------------+
```

List vertices or edges with a tag or an edge type

To list vertices or edges with a tag or an edge type, at least one index must exist on the tag, the edge type, or its property.

For example, if there is a `player` tag with a `name` property and an `age` property, to retrieve the VID of all vertices tagged with `player`, there has to be an index on the `player` tag itself, the `name` property, or the `age` property.

- The following example shows how to retrieve the VID of all vertices tagged with `player`.

```
nebula> CREATE TAG IF NOT EXISTS player(name string,age int);

nebula> CREATE TAG INDEX IF NOT EXISTS player_index on player();

nebula> REBUILD TAG INDEX player_index;
+------------+
| New Job Id |
+------------+
| 66         |
+------------+

nebula> INSERT VERTEX player(name,age) \
        VALUES "player100":("Tim Duncan", 42), "player101":("Tony Parker", 36);

The following statement retrieves the VID of all vertices with the tag `player`. It is similar to `MATCH (n:player) RETURN id(n) /*, n */`.

nebula> LOOKUP ON player YIELD id(vertex);
+-------------+
| id(VERTEX)  |
+-------------+
| "player100" |
| "player101" |
...
```

- The following example shows how to retrieve the source Vertex IDs, destination vertex IDs, and ranks of all edges of the `follow` edge type.

```
nebula> CREATE EDGE IF NOT EXISTS follow(degree int);

nebula> CREATE EDGE INDEX IF NOT EXISTS follow_index on follow();

nebula> REBUILD EDGE INDEX follow_index;
+------------+
| New Job Id |
+------------+
| 88         |
+------------+

nebula> INSERT EDGE follow(degree) \
        VALUES "player100"->"player101":(95);

The following statement retrieves all edges with the edge type `follow`. It is similar to `MATCH (s)-[e:follow]->(d) RETURN id(s), rank(e), id(d) /*, type(e) */`.

nebula)> LOOKUP ON follow YIELD edge AS e;
+-----------------------------------------------------+
| e                                                   |
+-----------------------------------------------------+
| [:follow "player105"->"player100" @0 {degree: 70}]  |
| [:follow "player105"->"player116" @0 {degree: 80}]  |
| [:follow "player109"->"player100" @0 {degree: 80}]  |
...
```

Count the numbers of vertices or edges

The following example shows how to count the number of vertices tagged with `player` and edges of the `follow` edge type.

```
nebula> LOOKUP ON player YIELD id(vertex)|\
        YIELD COUNT(*) AS Player_Number;
+---------------+
| Player_Number |
+---------------+
| 51            |
+---------------+

nebula> LOOKUP ON follow YIELD edge AS e| \
        YIELD COUNT(*) AS Follow_Number;
+---------------+
| Follow_Number |
+---------------+
| 81            |
+---------------+
```

Note

You can also use `SHOW STATS` to count the numbers of vertices or edges.

Last update: April 25, 2023

4.6.4 GO

`GO` traverses in a graph with specified filters and returns results.

OpenCypher compatibility

This topic applies to native nGQL only.

Syntax

```
GO [[<M> TO] <N> {STEP|STEPS}] FROM <vertex_list>
OVER <edge_type_list> [{REVERSELY | BIDIRECT}]
[ WHERE <conditions> ]
YIELD [DISTINCT] <return_list>
[{SAMPLE <sample_list> | <limit_by_list_clause>}]
[| GROUP BY {col_name | expr | position} YIELD <col_name>]
[| ORDER BY <expression> [{ASC | DESC}]]
[| LIMIT [<offset>,] <number_rows>];

<vertex_list> ::=
    <vid> [, <vid> ...]

<edge_type_list> ::=
   edge_type [, edge_type ...]
   | *
```

```
<return_list> ::=
    <col_name> [AS <col_alias>] [, <col_name> [AS <col_alias>] ...]
```

- `<N> {STEP|STEPS}`: specifies the hop number. If not specified, the default value for `N` is `one`. When `N` is `zero`, NebulaGraph does not traverse any edges and returns nothing.

  Note

  The path type of the `GO` statement is `walk`, which means both vertices and edges can be repeatedly visited in graph traversal. For more information, see Path.

- `M TO N {STEP|STEPS}`: traverses `from M to N` hops. When `M` is `zero`, the output is the same as that of `M` is `one`. That is, the output of `GO 0 TO 2` and `GO 1 TO 2` are the same.
- `<vertex_list>`: represents a list of vertex IDs separated by commas, or a special place holder `$-.id`. For more information, see Pipe.
- `<edge_type_list>`: represents a list of edge types which the traversal can go through.
- `REVERSELY | BIDIRECT`: defines the direction of the query. By default, the `GO` statement searches for outgoing edges of `<vertex_list>`. If `REVERSELY` is set, `GO` searches for incoming edges. If `BIDIRECT` is set, `GO` searches for edges of both directions.
- `WHERE <expression>`: specifies the traversal filters. You can use the `WHERE` clause for the source vertices, the edges, and the destination vertices. You can use it together with `AND`, `OR`, `NOT`, and `XOR`. For more information, see WHERE.

  Note

  - There are some restrictions for the `WHERE` clause when you traverse along with multiple edge types. For example, `WHERE edge1.prop1 > edge2.prop2` is not supported.
  - The GO statement is executed by traversing all the vertices and then filtering according to the filter condition.

- `YIELD [DISTINCT] <return_list>`: defines the output to be returned. It is recommended to use the Schema-related functions to fill in `<return_list>`. `src(edge)`, `dst(edge)`, `type(edge) )`, `rank(edge)`, etc., are currently supported, while nested functions are not. For more information, see YIELD.
- `SAMPLE <sample_list>`: takes samples from the result set. For more information, see SAMPLE.
- `<limit_by_list_clause>`: limits the number of outputs during the traversal process. For more information, see LIMIT.
- `GROUP BY`: groups the output into subgroups based on the value of the specified property. For more information, see GROUP BY. After grouping, you need to use `YIELD` again to define the output that needs to be returned.
- `ORDER BY`: sorts outputs with specified orders. For more information, see ORDER BY.

  Note

  When the sorting method is not specified, the output orders can be different for the same query.

- `LIMIT [<offset>,] <number_rows>]`: limits the number of rows of the output. For more information, see LIMIT.

Examples

```
# The following example returns the teams that player 102 serves.
nebula> GO FROM "player102" OVER serve YIELD dst(edge);
+-----------+
| dst(EDGE) |
+-----------+
| "team203" |
```

```
| "team204" |
+-----------+
```

```
# The following example returns the friends of player 102 with 2 hops.
nebula> GO 2 STEPS FROM "player102" OVER follow YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
| "player101" |
| "player125" |
| "player100" |
| "player102" |
| "player125" |
+-------------+
```

```
# The following example adds a filter for the traversal.
nebula> GO FROM "player100", "player102" OVER serve \
        WHERE properties(edge).start_year > 1995 \
        YIELD DISTINCT properties($$).name AS team_name, properties(edge).start_year AS start_year, properties($^).name AS player_name;

+-----------------+------------+---------------------+
| team_name       | start_year | player_name         |
+-----------------+------------+---------------------+
| "Spurs"         | 1997       | "Tim Duncan"        |
| "Trail Blazers" | 2006       | "LaMarcus Aldridge" |
| "Spurs"         | 2015       | "LaMarcus Aldridge" |
+-----------------+------------+---------------------+
```

```
# The following example traverses along with multiple edge types. If there is no value for a property, the output is `NULL`.
nebula> GO FROM "player100" OVER follow, serve \
        YIELD properties(edge).degree, properties(edge).start_year;
+-------------------------+-----------------------------+
| properties(EDGE).degree | properties(EDGE).start_year |
+-------------------------+-----------------------------+
| 95                      | __NULL__                    |
| 95                      | __NULL__                    |
| __NULL__                | 1997                        |
+-------------------------+-----------------------------+
```

```
# The following example returns the neighbor vertices in the incoming direction of player 100.
nebula> GO FROM "player100" OVER follow REVERSELY \
        YIELD src(edge) AS destination;
+-------------+
| destination |
+-------------+
| "player101" |
| "player102" |
...

# This MATCH query shares the same semantics with the preceding GO query.
nebula> MATCH (v)<-[e:follow]- (v2) WHERE id(v) == 'player100' \
        RETURN id(v2) AS destination;
+-------------+
| destination |
+-------------+
| "player101" |
| "player102" |
+-------------+
...
```

```
# The following example retrieves the friends of player 100 and the teams that they serve.
nebula> GO FROM "player100" OVER follow REVERSELY \
        YIELD src(edge) AS id | \
        GO FROM $-.id OVER serve \
        WHERE properties($^).age > 20 \
        YIELD properties($^).name AS FriendOf, properties($$).name AS Team;
+---------------------+-----------------+
| FriendOf            | Team            |
+---------------------+-----------------+
| "Boris Diaw"        | "Spurs"         |
| "Boris Diaw"        | "Jazz"          |
| "Boris Diaw"        | "Suns"          |
...

# This MATCH query shares the same semantics with the preceding GO query.
nebula> MATCH (v)<-[e:follow]- (v2)-[e2:serve]->(v3)  \
        WHERE id(v) == 'player100' \
        RETURN v2.player.name AS FriendOf, v3.team.name AS Team;
+---------------------+-----------------+
| FriendOf            | Team            |
+---------------------+-----------------+
| "Boris Diaw"        | "Spurs"         |
| "Boris Diaw"        | "Jazz"          |
| "Boris Diaw"        | "Suns"          |
...
```

```
# The following example retrieves the friends of player 100 within 1 or 2 hops.
nebula> GO 1 TO 2 STEPS FROM "player100" OVER follow \
        YIELD dst(edge) AS destination;
```

```
+-------------+
| destination |
+-------------+
| "player101" |
| "player125" |
...

# This MATCH query shares the same semantics with the preceding GO query.
nebula> MATCH (v) -[e:follow*1..2]->(v2) \
        WHERE id(v) == "player100" \
        RETURN id(v2) AS destination;
+-------------+
| destination |
+-------------+
| "player100" |
| "player102" |
...
```

```
# The following example the outputs according to age.
nebula> GO 2 STEPS FROM "player100" OVER follow \
        YIELD src(edge) AS src, dst(edge) AS dst, properties($$).age AS age \
        | GROUP BY $-.dst \
        YIELD $-.dst AS dst, collect_set($-.src) AS src, collect($-.age) AS age;
+-------------+----------------------------+----------+
| dst         | src                        | age      |
+-------------+----------------------------+----------+
| "player125" | ["player101"]              | [41]     |
| "player100" | ["player125", "player101"] | [42, 42] |
| "player102" | ["player101"]              | [33]     |
+-------------+----------------------------+----------+
```

```
# The following example groups the outputs and restricts the number of rows of the outputs.
nebula> $a = GO FROM "player100" OVER follow YIELD src(edge) AS src, dst(edge) AS dst; \
        GO 2 STEPS FROM $a.dst OVER follow \
        YIELD $a.src AS src, $a.dst, src(edge), dst(edge) \
        | ORDER BY $-.src | OFFSET 1 LIMIT 2;
+-------------+-------------+-------------+-------------+
| src         | $a.dst      | follow._src | follow._dst |
+-------------+-------------+-------------+-------------+
| "player100" | "player125" | "player100" | "player101" |
| "player100" | "player101" | "player100" | "player125" |
+-------------+-------------+-------------+-------------+
```

```
# The following example determines if $$.player.name IS NOT EMPTY.
nebula> GO FROM "player100" OVER follow WHERE properties($$).name IS NOT EMPTY YIELD dst(edge);
+-------------+
| follow._dst |
+-------------+
| "player125" |
| "player101" |
+-------------+
```

Last update: January 17, 2023

4.6.5 FETCH

The `FETCH` statement retrieves the properties of the specified vertices or edges.

OpenCypher Compatibility

This topic applies to native nGQL only.

Fetch vertex properties

SYNTAX

```
FETCH PROP ON {<tag_name>[, tag_name ...] | *}
<vid> [, vid ...]
YIELD [DISTINCT] <return_list> [AS <alias>];
```

Parameter	Description
`tag_name`	The name of the tag.
`*`	Represents all the tags in the current graph space.
`vid`	The vertex ID.
`YIELD`	Define the output to be returned. For details, see `YIELD`.
`AS`	Set an alias.

FETCH VERTEX PROPERTIES BY ONE TAG

Specify a tag in the `FETCH` statement to fetch the vertex properties by that tag.

```
nebula> FETCH PROP ON player "player100" YIELD properties(vertex);
+-------------------------------+
| properties(VERTEX)            |
+-------------------------------+
| {age: 42, name: "Tim Duncan"} |
+-------------------------------+
```

FETCH SPECIFIC PROPERTIES OF A VERTEX

Use a `YIELD` clause to specify the properties to be returned.

```
nebula> FETCH PROP ON player "player100" \
        YIELD properties(vertex).name AS name;
+--------------+
| name         |
+--------------+
| "Tim Duncan" |
+--------------+
```

FETCH PROPERTIES OF MULTIPLE VERTICES

Specify multiple VIDs (vertex IDs) to fetch properties of multiple vertices. Separate the VIDs with commas.

```
nebula> FETCH PROP ON player "player101", "player102", "player103" YIELD properties(vertex);
+--------------------------------------+
| properties(VERTEX)                   |
+--------------------------------------+
| {age: 33, name: "LaMarcus Aldridge"} |
| {age: 36, name: "Tony Parker"}       |
| {age: 32, name: "Rudy Gay"}          |
+--------------------------------------+
```

FETCH VERTEX PROPERTIES BY MULTIPLE TAGS

Specify multiple tags in the `FETCH` statement to fetch the vertex properties by the tags. Separate the tags with commas.

```
# The following example creates a new tag t1.
nebula> CREATE TAG IF NOT EXISTS t1(a string, b int);
```

```
# The following example attaches t1 to the vertex "player100".
nebula> INSERT VERTEX t1(a, b) VALUES "player100":("Hello", 100);

# The following example fetches the properties of vertex "player100" by the tags player and t1.
nebula> FETCH PROP ON player, t1 "player100" YIELD vertex AS v;
+----------------------------------------------------------------------------+
| v                                                                          |
+----------------------------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"} :t1{a: "Hello", b: 100}) |
+----------------------------------------------------------------------------+
```

You can combine multiple tags with multiple VIDs in a `FETCH` statement.

```
nebula> FETCH PROP ON player, t1 "player100", "player103" YIELD vertex AS v;
+----------------------------------------------------------------------------+
| v                                                                          |
+----------------------------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"} :t1{a: "Hello", b: 100}) |
| ("player103" :player{age: 32, name: "Rudy Gay"})                           |
+----------------------------------------------------------------------------+
```

FETCH VERTEX PROPERTIES BY ALL TAGS

Set an asterisk symbol `*` to fetch properties by all tags in the current graph space.

```
nebula> FETCH PROP ON * "player100", "player106", "team200" YIELD vertex AS v;
+----------------------------------------------------------------------------+
| v                                                                          |
+----------------------------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"} :t1{a: "Hello", b: 100}) |
| ("player106" :player{age: 25, name: "Kyle Anderson"})                      |
| ("team200" :team{name: "Warriors"})                                        |
+----------------------------------------------------------------------------+
```

Fetch edge properties

SYNTAX

```
FETCH PROP ON <edge_type> <src_vid> -> <dst_vid>[@<rank>] [, <src_vid> -> <dst_vid> ...]
YIELD <output>;
```

Parameter	Description
`edge_type`	The name of the edge type.
`src_vid`	The VID of the source vertex. It specifies the start of an edge.
`dst_vid`	The VID of the destination vertex. It specifies the end of an edge.
`rank`	The rank of the edge. It is optional and defaults to `0`. It distinguishes an edge from other edges with the same edge type, source vertex, destination vertex, and rank.
`YIELD`	Define the output to be returned. For details, see `YIELD`.

FETCH ALL PROPERTIES OF AN EDGE

The following statement fetches all the properties of the `serve` edge that connects vertex `"player100"` and vertex `"team204"`.

```
nebula> FETCH PROP ON serve "player100" -> "team204" YIELD properties(edge);
+------------------------------------+
| properties(EDGE)                   |
+------------------------------------+
| {end_year: 2016, start_year: 1997} |
+------------------------------------+
```

FETCH SPECIFIC PROPERTIES OF AN EDGE

Use a `YIELD` clause to fetch specific properties of an edge.

```
nebula> FETCH PROP ON serve "player100" -> "team204"    \
        YIELD properties(edge).start_year;
+-----------------------------+
| properties(EDGE).start_year |
+-----------------------------+
| 1997                        |
+-----------------------------+
```

FETCH PROPERTIES OF MULTIPLE EDGES

Specify multiple edge patterns (`<src_vid> -> <dst_vid>[@<rank>]`) to fetch properties of multiple edges. Separate the edge patterns with commas.

```
nebula> FETCH PROP ON serve "player100" -> "team204", "player133" -> "team202" YIELD edge AS e;
+-----------------------------------------------------------------------+
| e                                                                     |
+-----------------------------------------------------------------------+
| [:serve "player100"->"team204" @0 {end_year: 2016, start_year: 1997}] |
| [:serve "player133"->"team202" @0 {end_year: 2011, start_year: 2002}] |
+-----------------------------------------------------------------------+
```

Fetch properties based on edge rank

If there are multiple edges with the same edge type, source vertex, and destination vertex, you can specify the rank to fetch the properties on the correct edge.

```
# The following example inserts edges with different ranks and property values.
nebula> insert edge serve(start_year,end_year) \
        values "player100"->"team204"@1:(1998, 2017);

nebula> insert edge serve(start_year,end_year) \
        values "player100"->"team204"@2:(1990, 2018);

# By default, the FETCH statement returns the edge whose rank is 0.
nebula> FETCH PROP ON serve "player100" -> "team204" YIELD edge AS e;
+-----------------------------------------------------------------------+
| e                                                                     |
+-----------------------------------------------------------------------+
| [:serve "player100"->"team204" @0 {end_year: 2016, start_year: 1997}] |
+-----------------------------------------------------------------------+

# To fetch on an edge whose rank is not 0, set its rank in the FETCH statement.
nebula> FETCH PROP ON serve "player100" -> "team204"@1 YIELD edge AS e;
+-----------------------------------------------------------------------+
| e                                                                     |
+-----------------------------------------------------------------------+
| [:serve "player100"->"team204" @1 {end_year: 2017, start_year: 1998}] |
+-----------------------------------------------------------------------+
```

Use FETCH in composite queries

A common way to use `FETCH` is to combine it with native nGQL such as `GO`.

The following statement returns the `degree` values of the `follow` edges that start from vertex `"player101"`.

```
nebula> GO FROM "player101" OVER follow \
        YIELD src(edge) AS s, dst(edge) AS d \
        | FETCH PROP ON follow $-.s -> $-.d \
        YIELD properties(edge).degree;
+-------------------------+
| properties(EDGE).degree |
+-------------------------+
| 95                      |
| 90                      |
| 95                      |
+-------------------------+
```

Or you can use user-defined variables to construct similar queries.

```
nebula> $var = GO FROM "player101" OVER follow \
        YIELD src(edge) AS s, dst(edge) AS d; \
        FETCH PROP ON follow $var.s -> $var.d \
        YIELD properties(edge).degree;
+-------------------------+
| properties(EDGE).degree |
+-------------------------+
| 95                      |
| 90                      |
| 95                      |
+-------------------------+
```

For more information about composite queries, see Composite queries (clause structure).

Last update: February 7, 2023

4.6.6 SHOW

SHOW CHARSET

The `SHOW CHARSET` statement shows the available character sets.

Currently available types are `utf8` and `utf8mb4`. The default charset type is `utf8`. NebulaGraph extends the `uft8` to support four-byte characters. Therefore `utf8` and `utf8mb4` are equivalent.

SYNTAX

```
SHOW CHARSET;
```

EXAMPLE

```
nebula> SHOW CHARSET;
+---------+-----------------+-------------------+--------+
| Charset | Description     | Default collation | Maxlen |
+---------+-----------------+-------------------+--------+
| "utf8"  | "UTF-8 Unicode" | "utf8_bin"        | 4      |
+---------+-----------------+-------------------+--------+
```

Parameter	Description
`Charset`	The name of the character set.
`Description`	The description of the character set.
`Default collation`	The default collation of the character set.
`Maxlen`	The maximum number of bytes required to store one character.

Last update: August 11, 2022

SHOW COLLATION

The `SHOW COLLATION` statement shows the collations supported by NebulaGraph.

Currently available types are: `utf8_bin` and `utf8mb4_bin`.

- When the character set is `utf8`, the default collate is `utf8_bin`.
- When the character set is `utf8mb4`, the default collate is `utf8mb4_bin`.

SYNTAX

```
SHOW COLLATION;
```

EXAMPLE

```
nebula> SHOW COLLATION;
+------------+---------+
| Collation  | Charset |
+------------+---------+
| "utf8_bin" | "utf8"  |
+------------+---------+
```

Parameter	Description
`Collation`	The name of the collation.
`Charset`	The name of the character set with which the collation is associated.

Last update: December 21, 2022

SHOW CREATE SPACE

The `SHOW CREATE SPACE` statement shows the creating statement of the specified graph space.

For details about the graph space information, see CREATE SPACE.

SYNTAX

```
SHOW CREATE SPACE <space_name>;
```

EXAMPLE

```
nebula> SHOW CREATE SPACE basketballplayer;
+--------------------+---------------------------------------------------------------------------------------------------------------------------------------------+
| Space              | Create Space                                                                                                                                |
+--------------------+---------------------------------------------------------------------------------------------------------------------------------------------+
| "basketballplayer" | "CREATE SPACE `basketballplayer` (partition_num = 10, replica_factor = 1, charset = utf8, collate = utf8_bin, vid_type = FIXED_STRING(32))" |
+--------------------+---------------------------------------------------------------------------------------------------------------------------------------------+
```

Last update: February 3, 2023

SHOW CREATE TAG/EDGE

The `SHOW CREATE TAG` statement shows the basic information of the specified tag. For details about the tag, see CREATE TAG.

The `SHOW CREATE EDGE` statement shows the basic information of the specified edge type. For details about the edge type, see CREATE EDGE.

SYNTAX

```
SHOW CREATE {TAG <tag_name> | EDGE <edge_name>};
```

EXAMPLES

```
nebula> SHOW CREATE TAG player;
+----------+----------------------------------+
| Tag      | Create Tag                       |
+----------+----------------------------------+
| "player" | "CREATE TAG `player` (           |
|          |  `name` string NULL,             |
|          |  `age` int64 NULL                |
|          | ) ttl_duration = 0, ttl_col = "" |
+----------+----------------------------------+

nebula> SHOW CREATE EDGE follow;
+----------+----------------------------------+
| Edge     | Create Edge                      |
+----------+----------------------------------+
| "follow" | "CREATE EDGE `follow` (          |
|          |  `degree` int64 NULL             |
|          | ) ttl_duration = 0, ttl_col = "" |
+----------+----------------------------------+
```

Last update: December 1, 2021

SHOW HOSTS

The `SHOW HOSTS` statement shows the cluster information, including the port, status, leader, partition, and version information. You can also add the service type in the statement to view the information of the specific service.

SYNTAX

```
SHOW HOSTS [GRAPH | STORAGE | META];
```

Note

For a NebulaGraph cluster installed with the source code, the version of the cluster will not be displayed in the output after executing the command `SHOW HOSTS (GRAPH | STORAGE | META)` with the service name.

EXAMPLES

```
nebula> SHOW HOSTS;
+-------------+-------+----------+--------------+----------------------------------+------------------------------+---------+
| Host        | Port  | Status   | Leader count | Leader distribution              | Partition distribution       | Version |
+-------------+-------+----------+--------------+----------------------------------+------------------------------+---------+
| "storaged0" | 9779  | "ONLINE" | 8            | "docs:5, basketballplayer:3"     | "docs:5, basketballplayer:3" | "3.5.0" |
| "storaged1" | 9779  | "ONLINE" | 9            | "basketballplayer:4, docs:5"     | "docs:5, basketballplayer:4" | "3.5.0" |
| "storaged2" | 9779  | "ONLINE" | 8            | "basketballplayer:3, docs:5"     | "docs:5, basketballplayer:3" | "3.5.0" |
+-------------+-------+----------+--------------+----------------------------------+------------------------------+---------+

nebula> SHOW HOSTS GRAPH;
+-----------+------+----------+---------+--------------+---------+
| Host      | Port | Status   | Role    | Git Info Sha | Version |
+-----------+------+----------+---------+--------------+---------+
| "graphd"  | 9669 | "ONLINE" | "GRAPH" | "3ba41bd"    | "3.5.0" |
| "graphd1" | 9669 | "ONLINE" | "GRAPH" | "3ba41bd"    | "3.5.0" |
| "graphd2" | 9669 | "ONLINE" | "GRAPH" | "3ba41bd"    | "3.5.0" |
+-----------+------+----------+---------+--------------+---------+

nebula> SHOW HOSTS STORAGE;
+-------------+------+----------+-----------+--------------+---------+
| Host        | Port | Status   | Role      | Git Info Sha | Version |
+-------------+------+----------+-----------+--------------+---------+
| "storaged0" | 9779 | "ONLINE" | "STORAGE" | "3ba41bd"    | "3.5.0" |
| "storaged1" | 9779 | "ONLINE" | "STORAGE" | "3ba41bd"    | "3.5.0" |
| "storaged2" | 9779 | "ONLINE" | "STORAGE" | "3ba41bd"    | "3.5.0" |
+-------------+------+----------+-----------+--------------+---------+

nebula> SHOW HOSTS META;
+----------+------+----------+--------+--------------+---------+
| Host     | Port | Status   | Role   | Git Info Sha | Version |
+----------+------+----------+--------+--------------+---------+
| "metad2" | 9559 | "ONLINE" | "META" | "3ba41bd"    | "3.5.0" |
| "metad0" | 9559 | "ONLINE" | "META" | "3ba41bd"    | "3.5.0" |
| "metad1" | 9559 | "ONLINE" | "META" | "3ba41bd"    | "3.5.0" |
+----------+------+----------+--------+--------------+---------+
```

Last update: January 30, 2023

SHOW INDEX STATUS

The `SHOW INDEX STATUS` statement shows the status of jobs that rebuild native indexes, which helps check whether a native index is successfully rebuilt or not.

SYNTAX

```
SHOW {TAG | EDGE} INDEX STATUS;
```

EXAMPLES

```
nebula> SHOW TAG INDEX STATUS;
+------------------------------------+--------------+
| Name                               | Index Status |
+------------------------------------+--------------+
| "date1_index"                      | "FINISHED"   |
| "basketballplayer_all_tag_indexes" | "FINISHED"   |
| "any_shape_geo_index"              | "FINISHED"   |
+------------------------------------+--------------+

nebula> SHOW EDGE INDEX STATUS;
+----------------+--------------+
| Name           | Index Status |
+----------------+--------------+
| "follow_index" | "FINISHED"   |
+----------------+--------------+
```

RELATED TOPICS

- Job manager and the JOB statements
- REBUILD NATIVE INDEX

Last update: March 23, 2022

SHOW INDEXES

The `SHOW INDEXES` statement shows the names of existing native indexes.

SYNTAX

```
SHOW {TAG | EDGE} INDEXES;
```

EXAMPLES

```
nebula> SHOW TAG INDEXES;
+------------------+----------+----------+
| Index Name       | By Tag   | Columns  |
+------------------+----------+----------+
| "player_index_0" | "player" | []       |
| "player_index_1" | "player" | ["name"] |
+------------------+----------+----------+

nebula> SHOW EDGE INDEXES;
+----------------+----------+---------+
| Index Name     | By Edge  | Columns |
+----------------+----------+---------+
| "follow_index" | "follow" | []      |
+----------------+----------+---------+
```

Legacy version compatibility

In NebulaGraph 2.x, `SHOW TAG/EDGE INDEXES` only returns `Names`.

Last update: September 21, 2022

SHOW PARTS

The `SHOW PARTS` statement shows the information of a specified partition or all partitions in a graph space.

SYNTAX

```
SHOW PARTS [<part_id>];
```

EXAMPLES

```
nebula> SHOW PARTS;
+--------------+--------------------+--------------------+-------+
| Partition ID | Leader             | Peers              | Losts |
+--------------+--------------------+--------------------+-------+
| 1            | "192.168.2.1:9779" | "192.168.2.1:9779" | ""    |
| 2            | "192.168.2.2:9779" | "192.168.2.2:9779" | ""    |
| 3            | "192.168.2.3:9779" | "192.168.2.3:9779" | ""    |
| 4            | "192.168.2.1:9779" | "192.168.2.1:9779" | ""    |
| 5            | "192.168.2.2:9779" | "192.168.2.2:9779" | ""    |
| 6            | "192.168.2.3:9779" | "192.168.2.3:9779" | ""    |
| 7            | "192.168.2.1:9779" | "192.168.2.1:9779" | ""    |
| 8            | "192.168.2.2:9779" | "192.168.2.2:9779" | ""    |
| 9            | "192.168.2.3:9779" | "192.168.2.3:9779" | ""    |
| 10           | "192.168.2.1:9779" | "192.168.2.1:9779" | ""    |
+--------------+--------------------+--------------------+-------+

nebula> SHOW PARTS 1;
+--------------+--------------------+--------------------+-------+
| Partition ID | Leader             | Peers              | Losts |
+--------------+--------------------+--------------------+-------+
| 1            | "192.168.2.1:9779" | "192.168.2.1:9779" | ""    |
+--------------+--------------------+--------------------+-------+
```

The descriptions are as follows.

Parameter	Description
`Partition ID`	The ID of the partition.
`Leader`	The IP address and the port of the leader.
`Peers`	The IP addresses and the ports of all the replicas.
`Losts`	The IP addresses and the ports of replicas at fault.

Last update: October 27, 2021

SHOW ROLES

The `SHOW ROLES` statement shows the roles that are assigned to a user account.

The return message differs according to the role of the user who is running this statement:

- If the user is a `GOD` or `ADMIN` and is granted access to the specified graph space, NebulaGraph shows all roles in this graph space except for `GOD`.
- If the user is a `DBA`, `USER`, or `GUEST` and is granted access to the specified graph space, NebulaGraph shows the user's own role in this graph space.
- If the user does not have access to the specified graph space, NebulaGraph returns `PermissionError`.

For more information about roles, see Roles and privileges.

SYNTAX

```
SHOW ROLES IN <space_name>;
```

EXAMPLE

```
nebula> SHOW ROLES in basketballplayer;
+---------+-----------+
| Account | Role Type |
+---------+-----------+
| "user1" | "ADMIN"   |
+---------+-----------+
```

Last update: August 11, 2022

SHOW SNAPSHOTS

The `SHOW SNAPSHOTS` statement shows the information of all the snapshots.

For how to create a snapshot and backup data, see Snapshot.

ROLE REQUIREMENT

Only the `root` user who has the `GOD` role can use the `SHOW SNAPSHOTS` statement.

SYNTAX

```
SHOW SNAPSHOTS;
```

EXAMPLE

```
nebula> SHOW SNAPSHOTS;
+--------------------------------+---------+-----------------------------------------------------+
| Name                           | Status  | Hosts                                               |
+--------------------------------+---------+-----------------------------------------------------+
| "SNAPSHOT_2020_12_16_11_13_55" | "VALID" | "storaged0:9779, storaged1:9779, storaged2:9779"    |
| "SNAPSHOT_2020_12_16_11_14_10" | "VALID" | "storaged0:9779, storaged1:9779, storaged2:9779"    |
+--------------------------------+---------+-----------------------------------------------------+
```

Last update: March 23, 2022

SHOW SPACES

The `SHOW SPACES` statement shows existing graph spaces in NebulaGraph.

For how to create a graph space, see CREATE SPACE.

SYNTAX

```
SHOW SPACES;
```

EXAMPLE

```
nebula> SHOW SPACES;
+--------------------+
| Name               |
+--------------------+
| "docs"             |
| "basketballplayer" |
+--------------------+
```

Last update: August 11, 2022

SHOW STATS

The `SHOW STATS` statement shows the statistics of the graph space collected by the latest `SUBMIT JOB STATS` job.

The statistics include the following information:

- The number of vertices in the graph space
- The number of edges in the graph space
- The number of vertices of each tag
- The number of edges of each edge type

Warning

The data returned by `SHOW STATS` is not real-time. The returned data is collected by the latest SUBMIT JOB STATS job and may include TTL-expired data. The expired data will be deleted and not included in the statistics the next time the Compaction operation is performed.

PREREQUISITES

You have to run the `SUBMIT JOB STATS` statement in the graph space where you want to collect statistics. For more information, see SUBMIT JOB STATS.

Caution

The result of the `SHOW STATS` statement is based on the last executed `SUBMIT JOB STATS` statement. If you want to update the result, run `SUBMIT JOB STATS` again. Otherwise the statistics will be wrong.

SYNTAX

```
SHOW STATS;
```

EXAMPLES

```
# Choose a graph space.
nebula> USE basketballplayer;

# Start SUBMIT JOB STATS.
nebula> SUBMIT JOB STATS;
+------------+
| New Job Id |
+------------+
| 98         |
+------------+

# Make sure the job executes successfully.
nebula> SHOW JOB 98;
+----------------+---------------+------------+----------------------------+----------------------------+-------------+
| Job Id(TaskId) | Command(Dest) | Status     | Start Time                 | Stop Time                  | Error Code  |
+----------------+---------------+------------+----------------------------+----------------------------+-------------+
| 98             | "STATS"       | "FINISHED" | 2021-11-01T09:33:21.000000 | 2021-11-01T09:33:21.000000 | "SUCCEEDED" |
| 0              | "storaged2"   | "FINISHED" | 2021-11-01T09:33:21.000000 | 2021-11-01T09:33:21.000000 | "SUCCEEDED" |
| 1              | "storaged0"   | "FINISHED" | 2021-11-01T09:33:21.000000 | 2021-11-01T09:33:21.000000 | "SUCCEEDED" |
| 2              | "storaged1"   | "FINISHED" | 2021-11-01T09:33:21.000000 | 2021-11-01T09:33:21.000000 | "SUCCEEDED" |
| "Total:3"      | "Succeeded:3" | "Failed:0" | "In Progress:0"            | ""                         | ""          |
+----------------+---------------+------------+----------------------------+----------------------------+-------------+

# Show the statistics of the graph space.
nebula> SHOW STATS;
+---------+------------+-------+
| Type    | Name       | Count |
+---------+------------+-------+
| "Tag"   | "player"   | 51    |
| "Tag"   | "team"     | 30    |
| "Edge"  | "follow"   | 81    |
| "Edge"  | "serve"    | 152   |
| "Space" | "vertices" | 81    |
| "Space" | "edges"    | 233   |
+---------+------------+-------+
```

Last update: October 20, 2022

SHOW TAGS/EDGES

The `SHOW TAGS` statement shows all the tags in the current graph space.

The `SHOW EDGES` statement shows all the edge types in the current graph space.

SYNTAX

```
SHOW {TAGS | EDGES};
```

EXAMPLES

```
nebula> SHOW TAGS;
+----------+
| Name     |
+----------+
| "player" |
| "star"   |
| "team"   |
+----------+

nebula> SHOW EDGES;
+----------+
| Name     |
+----------+
| "follow" |
| "serve"  |
+----------+
```

Last update: December 1, 2021

SHOW USERS

The `SHOW USERS` statement shows the user information.

ROLE REQUIREMENT

Only the `root` user who has the `GOD` role can use the `SHOW USERS` statement.

SYNTAX

```
SHOW USERS;
```

EXAMPLE

```
nebula> SHOW USERS;
+---------+-----------------+
| Account | IP Whitelist    |
+---------+-----------------+
| "root"  | ""              |
| "user1" | ""              |
| "user2" | "192.168.10.10" |
+---------+-----------------+
```

Last update: March 17, 2022

SHOW SESSIONS

When a user logs in to the database, a corresponding session will be created and users can query for session information.

The `SHOW SESSIONS` statement shows the information of all the sessions. It can also show a specified session with its ID.

PRECAUTIONS

- The client will call the API `release` to release the session and clear the session information when you run `exit` after the operation ends. If you exit the database in an unexpected way and the session timeout duration is not set via `session_idle_timeout_secs` in nebula-graphd.conf, the session will not be released automatically. For those sessions that are not automatically released, you need to delete them manually. For details, see KILL SESSIONS.
- `SHOW SESSIONS` queries the session information of all the Graph services.
- `SHOW LOCAL SESSIONS` queries the session information of the currently connected Graph service and does not query the session information of other Graph services.
- `SHOW SESSION <Session_Id>` queries the session information with a specific session id.

SYNTAX

```
SHOW [LOCAL] SESSIONS;
SHOW SESSION <Session_Id>;
```

EXAMPLES

```
nebula> SHOW SESSIONS;
+------------------+----------+--------------------+----------------------------+----------------------------+------------------+----------+-------------------+
| SessionId        | UserName | SpaceName          | CreateTime                 | UpdateTime                 | GraphAddr        | Timezone | ClientIp          |
+------------------+----------+--------------------+----------------------------+----------------------------+------------------+----------+-------------------+
| 1651220858102296 | "root"   | "basketballplayer" | 2022-04-29T08:27:38.102296 | 2022-04-29T08:50:46.282921 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
| 1651199330300991 | "root"   | "basketballplayer" | 2022-04-29T02:28:50.300991 | 2022-04-29T08:16:28.339038 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
| 1651112899847744 | "root"   | "basketballplayer" | 2022-04-28T02:28:19.847744 | 2022-04-28T08:17:44.470210 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
| 1651041092662100 | "root"   | "basketballplayer" | 2022-04-27T06:31:32.662100 | 2022-04-27T07:01:25.200978 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
| 1650959429593975 | "root"   | "basketballplayer" | 2022-04-26T07:50:29.593975 | 2022-04-26T07:51:47.184810 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
| 1650958897679595 | "root"   | ""                 | 2022-04-26T07:41:37.679595 | 2022-04-26T07:41:37.683802 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
+------------------+----------+--------------------+----------------------------+----------------------------+------------------+----------+-------------------+

nebula> SHOW SESSION 1635254859271703;
+------------------+----------+--------------------+----------------------------+----------------------------+------------------+----------+-------------------+
| SessionId        | UserName | SpaceName          | CreateTime                 | UpdateTime                 | GraphAddr        | Timezone | ClientIp          |
+------------------+----------+--------------------+----------------------------+----------------------------+------------------+----------+-------------------+
| 1651220858102296 | "root"   | "basketballplayer" | 2022-04-29T08:27:38.102296 | 2022-04-29T08:50:54.254384 | "127.0.0.1:9669" | 0        | "127.0.0.1" |
+------------------+----------+--------------------+----------------------------+----------------------------+------------------+----------+-------------------+
```

Parameter	Description
`SessionId`	The session ID, namely the identifier of a session.
`UserName`	The username in a session.
`SpaceName`	The name of the graph space that the user uses currently. It is null (`""`) when you first log in because there is no specified graph space.
`CreateTime`	The time when the session is created, namely the time when the user logs in. The time zone is specified by `timezone_name` in the configuration file.
`UpdateTime`	The system will update the time when there is an operation. The time zone is specified by `timezone_name` in the configuration file.
`GraphAddr`	The IP address and port of the Graph server that hosts the session.
`Timezone`	A reserved parameter that has no specified meaning for now.
`ClientIp`	The IP address of the client.

Last update: March 27, 2023

SHOW QUERIES

The `SHOW QUERIES` statement shows the information of working queries in the current session.

Note

To terminate queries, see Kill Query.

PRECAUTIONS

- The `SHOW LOCAL QUERIES` statement gets the status of queries in the current session from the local cache with almost no latency.
- The `SHOW QUERIES` statement gets the information of queries in all the sessions from the Meta Service. The information will be synchronized to the Meta Service according to the interval defined by `session_reclaim_interval_secs`. Therefore the information that you get from the client may belong to the last synchronization interval.

SYNTAX

```
SHOW [LOCAL] QUERIES;
```

EXAMPLES

```
nebula> SHOW LOCAL QUERIES;
+------------------+-----------------+--------+----------------------+----------------------------+----------------+-----------+-----------------------+
| SessionID        | ExecutionPlanID | User   | Host                 | StartTime                  | DurationInUSec | Status    | Query                 |
+------------------+-----------------+--------+----------------------+----------------------------+----------------+-----------+-----------------------+
| 1625463842921750 | 46              | "root" | ""192.168.x.x":9669" | 2021-07-05T05:44:19.502903 | 0              | "RUNNING" | "SHOW LOCAL QUERIES;" |
+------------------+-----------------+--------+----------------------+----------------------------+----------------+-----------+-----------------------+

nebula> SHOW QUERIES;
+------------------+-----------------+---------+----------------------+----------------------------+----------------+-----------+---------------------------------------------------------+
| SessionID        | ExecutionPlanID | User    | Host                 | StartTime                  | DurationInUSec | Status    | Query                                                   |
+------------------+-----------------+---------+----------------------+----------------------------+----------------+-----------+---------------------------------------------------------+
| 1625456037718757 | 54              | "user1" | ""192.168.x.x":9669" | 2021-07-05T05:51:08.691318 | 1504502        | "RUNNING" | "MATCH p=(v:player)-[*1..4]-(v2) RETURN v2 AS Friends;" |
+------------------+-----------------+---------+----------------------+----------------------------+----------------+-----------+---------------------------------------------------------+

# The following statement returns the top 10 queries that have the longest duration.
nebula> SHOW QUERIES | ORDER BY $-.DurationInUSec DESC | LIMIT 10;
+------------------+-----------------+---------+----------------------+----------------------------+----------------+-----------+-------------------------------------------------------+
| SessionID        | ExecutionPlanID | User    | Host                 | StartTime                  | DurationInUSec | Status    | Query                                                 |
+------------------+-----------------+---------+----------------------+----------------------------+----------------+-----------+-------------------------------------------------------+
| 1625471375320831 | 98              | "user2" | ""192.168.x.x":9669" | 2021-07-05T07:50:24.461779 | 2608176        | "RUNNING" | "MATCH (v:player)-[*1..4]-(v2) RETURN v2 AS Friends;" |
| 1625456037718757 | 99              | "user1" | ""192.168.x.x":9669" | 2021-07-05T07:50:24.910616 | 2159333        | "RUNNING" | "MATCH (v:player)-[*1..4]-(v2) RETURN v2 AS Friends;" |
+------------------+-----------------+---------+----------------------+----------------------------+----------------+-----------+-------------------------------------------------------+
```

The descriptions are as follows.

Parameter	Description
`SessionID`	The session ID.
`ExecutionPlanID`	The ID of the execution plan.
`User`	The username that executes the query.
`Host`	The IP address and port of the Graph server that hosts the session.
`StartTime`	The time when the query starts.
`DurationInUSec`	The duration of the query. The unit is microsecond.
`Status`	The current status of the query.
`Query`	The query statement.

Last update: May 13, 2022

SHOW META LEADER

The `SHOW META LEADER` statement shows the information of the leader in the current Meta cluster.

For more information about the Meta service, see Meta service.

SYNTAX

```
SHOW META LEADER;
```

EXAMPLE

```
nebula> SHOW META LEADER;
+------------------+---------------------------+
| Meta Leader      | secs from last heart beat |
+------------------+---------------------------+
| "127.0.0.1:9559" | 3                         |
+------------------+---------------------------+
```

Parameter	Description
`Meta Leader`	Shows the information of the leader in the Meta cluster, including the IP address and port of the server where the leader is located.
`secs from last heart beat`	Indicates the time interval since the last heartbeat. This parameter is measured in seconds.

Last update: October 27, 2021

4.7 Clauses and options

4.7.1 GROUP BY

The `GROUP BY` clause can be used to aggregate data.

OpenCypher Compatibility

This topic applies to native nGQL only.

You can also use the count() function to aggregate data.

```
nebula>  MATCH (v:player)<-[:follow]-(:player) RETURN v.player.name AS Name, count(*) as cnt ORDER BY cnt DESC;
+----------------------+-----+
| Name                 | cnt |
+----------------------+-----+
| "Tim Duncan"         | 10  |
| "LeBron James"       | 6   |
| "Tony Parker"        | 5   |
| "Chris Paul"         | 4   |
| "Manu Ginobili"      | 4   |
+----------------------+-----+
...
```

Syntax

The `GROUP BY` clause groups the rows with the same value. Then operations such as counting, sorting, and calculation can be applied.

The `GROUP BY` clause works after the pipe symbol (|) and before a `YIELD` clause.

```
| GROUP BY <var> YIELD <var>, <aggregation_function(var)>
```

The `aggregation_function()` function supports `avg()`, `sum()`, `max()`, `min()`, `count()`, `collect()`, and `std()`.

Examples

The following statement finds all the vertices connected directly to vertex `"player100"`, groups the result set by player names, and counts how many times the name shows up in the result set.

```
nebula> GO FROM "player100" OVER follow BIDIRECT \
        YIELD properties($$).name as Name \
        | GROUP BY $-.Name \
        YIELD $-.Name as Player, count(*) AS Name_Count;
+---------------------+------------+
| Player              | Name_Count |
+---------------------+------------+
| "Shaquille O'Neal"  | 1          |
| "Tiago Splitter"    | 1          |
| "Manu Ginobili"     | 2          |
| "Boris Diaw"        | 1          |
| "LaMarcus Aldridge" | 1          |
| "Tony Parker"       | 2          |
| "Marco Belinelli"   | 1          |
| "Dejounte Murray"   | 1          |
| "Danny Green"       | 1          |
| "Aron Baynes"       | 1          |
+---------------------+------------+
```

The following statement finds all the vertices connected directly to vertex `"player100"`, groups the result set by source vertices, and returns the sum of degree values.

```
nebula> GO FROM "player100" OVER follow \
        YIELD src(edge) AS player, properties(edge).degree AS degree \
        | GROUP BY $-.player \
        YIELD sum($-.degree);
+----------------+
| sum($-.degree) |
+----------------+
```

```
| 190           |
+---------------+
```

For more information about the `sum()` function, see Built-in math functions.

Implicit GROUP BY

The usage of `GROUP BY` in the above nGQL statements that explicitly write `GROUP BY` and act as grouping fields is called explicit `GROUP BY`, while in openCypher, the `GROUP BY` is implicit, i.e., `GROUP BY` groups fields without explicitly writing `GROUP BY`. The explicit `GROUP BY` in nGQL is the same as the implicit `GROUP BY` in openCypher, and nGQL also supports the implicit `GROUP BY`. For the implicit usage of `GROUP BY`, see how-to-make-group-by-in-a-cypher-query.

For example, to look up the players over 34 years old with the same length of service, you can use the following statement:

```
nebula> LOOKUP ON player WHERE player.age > 34 YIELD id(vertex) AS v | \
        GO FROM $-.v OVER serve YIELD serve.start_year AS start_year, serve.end_year AS end_year | \
        YIELD $-.start_year, $-.end_year, count(*) AS count | \
        ORDER BY $-.count DESC | LIMIT 5;
+---------------+-------------+-------+
| $-.start_year | $-.end_year | count |
+---------------+-------------+-------+
| 2018          | 2019        | 3     |
| 1998          | 2004        | 2     |
| 2012          | 2013        | 2     |
| 2007          | 2012        | 2     |
| 2010          | 2011        | 2     |
+---------------+-------------+-------+
```

Last update: December 21, 2022

4.7.2 LIMIT AND SKIP

The `LIMIT` clause constrains the number of rows in the output. The usage of `LIMIT` in native nGQL statements and openCypher compatible statements is different.

- Native nGQL: Generally, a pipe `|` needs to be used before the `LIMIT` clause. The offset parameter can be set or omitted directly after the `LIMIT` statement.
- OpenCypher compatible statements: No pipes are permitted before the `LIMIT` clause. And you can use `SKIP` to indicate an offset.

Note

When using `LIMIT` in either syntax above, it is important to use an `ORDER BY` clause that constrains the output into a unique order. Otherwise, you will get an unpredictable subset of the output.

LIMIT in native nGQL statements

In native nGQL, `LIMIT` has general syntax and exclusive syntax in `GO` statements.

GENERAL LIMIT SYNTAX IN NATIVE NGQL STATEMENTS

In native nGQL, the general `LIMIT` syntax works the same as in `SQL`. The `LIMIT` clause accepts one or two parameters. The values of both parameters must be non-negative integers and be used after a pipe. The syntax and description are as follows:

```
... | LIMIT [<offset>,] <number_rows>;
```

Parameter	Description
`offset`	The offset value. It defines the row from which to start returning. The offset starts from `0`. The default value is `0`, which returns from the first row.
`number_rows`	It constrains the total number of returned rows.

For example:

```
# The following example returns the top 3 rows of data from the result.
nebula> LOOKUP ON player YIELD id(vertex)|\
        LIMIT 3;
+-------------+
| id(VERTEX)  |
+-------------+
| "player100" |
| "player101" |
| "player102" |
+-------------+

# The following example returns the 3 rows of data starting from the second row of the sorted output.
nebula> GO FROM "player100" OVER follow REVERSELY \
        YIELD properties($$).name AS Friend, properties($$).age AS Age \
        | ORDER BY $-.Age, $-.Friend \
        | LIMIT 1, 3;
+-------------------+-----+
| Friend            | Age |
+-------------------+-----+
| "Danny Green"     | 31  |
| "Aron Baynes"     | 32  |
| "Marco Belinelli" | 32  |
+-------------------+-----+
```

LIMIT IN GO STATEMENTS

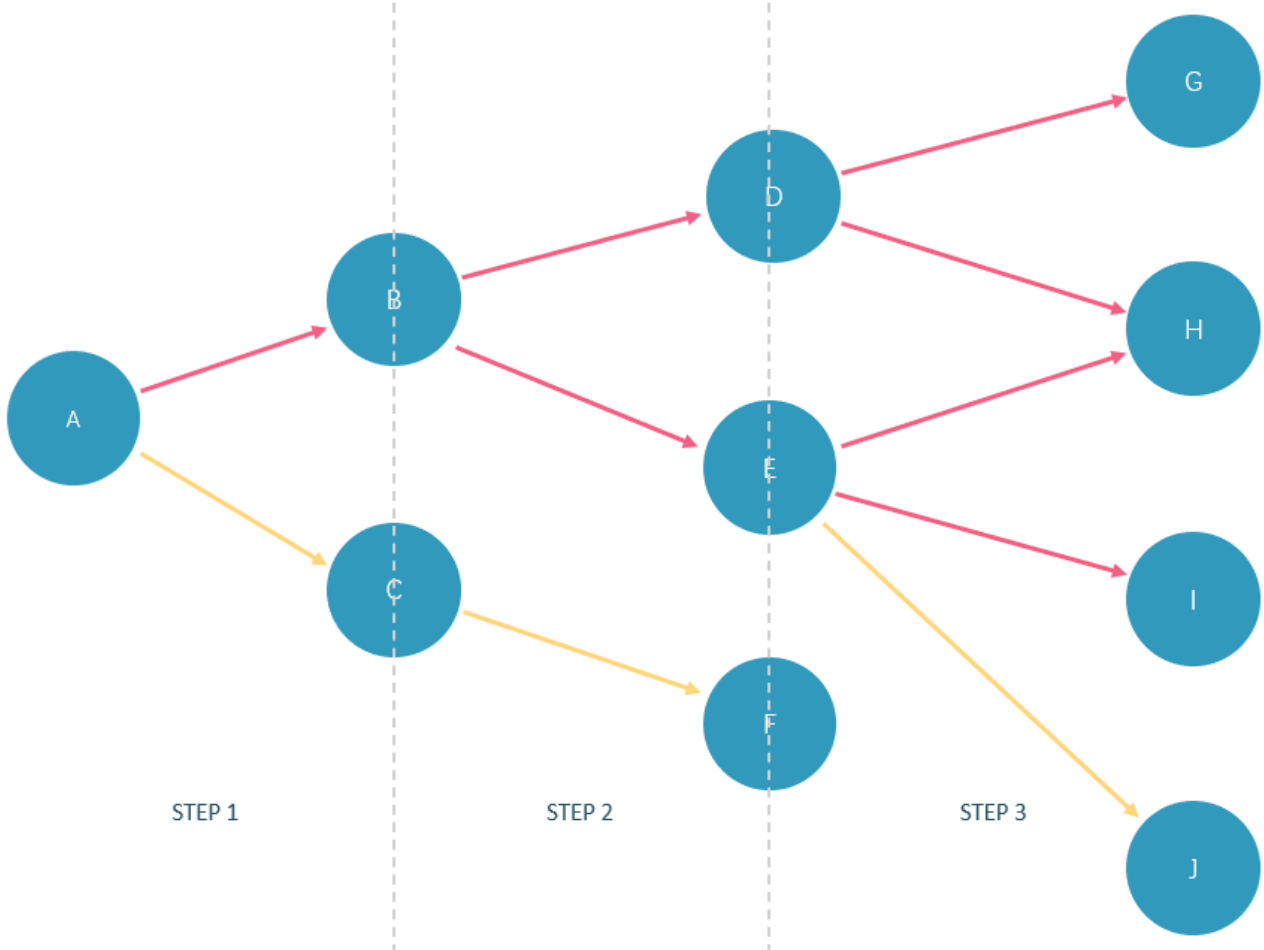
In addition to the general syntax in the native nGQL, the `LIMIT` in the `GO` statement also supports limiting the number of output results based on edges.

Syntax:

```
<go_statement> LIMIT <limit_list>;
```

`limit_list` is a list. Elements in the list must be natural numbers, and the number of elements must be the same as the maximum number of `STEPS` in the `GO` statement. The following takes `GO 1 TO 3 STEPS FROM "A" OVER * LIMIT <limit_list>` as an example to introduce this usage of `LIMIT` in detail.

- The list `limit_list` must contain 3 natural numbers, such as `GO 1 TO 3 STEPS FROM "A" OVER * LIMIT [1,2,4]` .
- `1` in `LIMIT [1,2,4]` means that the system automatically selects 1 edge to continue traversal in the first step. `2` means to select 2 edges to continue traversal in the second step. `4` indicates that 4 edges are selected to continue traversal in the third step.
- Because `GO 1 TO 3 STEPS` means to return all the traversal results from the first to third steps, all the red edges and their source and destination vertices in the figure below will be matched by this `GO` statement. And the yellow edges represent there is no path selected when the GO statement traverses. If it is not `GO 1 TO 3 STEPS` but `GO 3 STEPS`, it will only match the red edges of the third step and the vertices at both ends.



In the basketballplayer dataset, the example is as follows:

```
nebula> GO 3 STEPS FROM "player100" \
        OVER * \
        YIELD properties($$).name AS NAME, properties($$).age AS Age \
        LIMIT [3,3,3];
+-----------------+----------+
| NAME            | Age      |
+-----------------+----------+
| "Tony Parker"   | 36       |
| "Manu Ginobili" | 41       |
| "Spurs"         | __NULL__ |
+-----------------+----------+

nebula> GO 3 STEPS FROM "player102" OVER * BIDIRECT\
        YIELD dst(edge) \
        LIMIT [rand32(5),rand32(5),rand32(5)];
+-------------+
| dst(EDGE)   |
+-------------+
```

```
| "player100" |
| "player100" |
+-------------+
```

LIMIT in openCypher compatible statements

In openCypher compatible statements such as `MATCH`, there is no need to use a pipe when `LIMIT` is used. The syntax and description are as follows:

```
... [SKIP <offset>] [LIMIT <number_rows>];
```

Parameter	Description
`offset`	The offset value. It defines the row from which to start returning. The offset starts from `0`. The default value is `0`, which returns from the first row.
`number_rows`	It constrains the total number of returned rows.

Both `offset` and `number_rows` accept expressions, but the result of the expression must be a non-negative integer.

Note

Fraction expressions composed of two integers are automatically floored to integers. For example, `8/6` is floored to 1.

EXAMPLES OF LIMIT

`LIMIT` can be used alone to return a specified number of results.

```
nebula> MATCH (v:player) RETURN v.player.name AS Name, v.player.age AS Age \
        ORDER BY Age LIMIT 5;
+-------------------------+-----+
| Name                    | Age |
+-------------------------+-----+
| "Luka Doncic"           | 20  |
| "Ben Simmons"           | 22  |
| "Kristaps Porzingis"    | 23  |
| "Giannis Antetokounmpo" | 24  |
| "Kyle Anderson"         | 25  |
+-------------------------+-----+
```

EXAMPLES OF SKIP

`SKIP` can be used alone to set the offset and return the data after the specified position.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) --> (v2) \
        RETURN v2.player.name AS Name, v2.player.age AS Age \
        ORDER BY Age DESC SKIP 1;
+-----------------+-----+
| Name            | Age |
+-----------------+-----+
| "Manu Ginobili" | 41  |
| "Tony Parker"   | 36  |
+-----------------+-----+

nebula> MATCH (v:player{name:"Tim Duncan"}) --> (v2) \
        RETURN v2.player.name AS Name, v2.player.age AS Age \
        ORDER BY Age DESC SKIP 1+1;
+---------------+-----+
| Name          | Age |
+---------------+-----+
| "Tony Parker" | 36  |
+---------------+-----+
```

EXAMPLE OF SKIP AND LIMIT

`SKIP` and `LIMIT` can be used together to return the specified amount of data starting from the specified position.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) --> (v2) \
        RETURN v2.player.name AS Name, v2.player.age AS Age \
        ORDER BY Age DESC SKIP 1 LIMIT 1;
+-----------------+-----+
| Name            | Age |
+-----------------+-----+
```

```
| "Manu Ginobili" | 41  |
+-----------------+-----+
```

Last update: January 17, 2023

4.7.3 SAMPLE

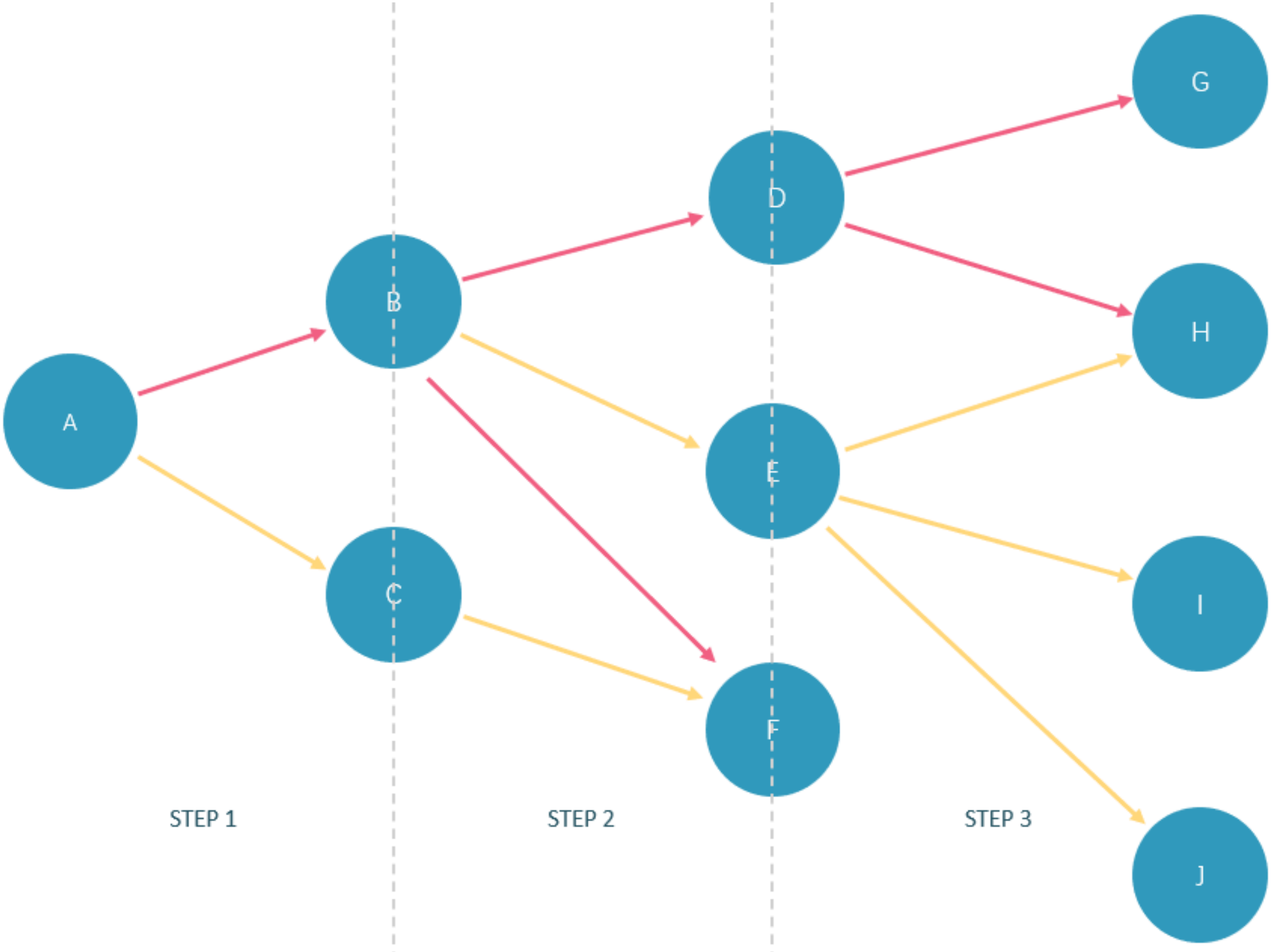
The `SAMPLE` clause takes samples evenly in the result set and returns the specified amount of data.

`SAMPLE` can be used in `GO` statements only. The syntax is as follows:

```
<go_statement> SAMPLE <sample_list>;
```

`sample_list` is a list. Elements in the list must be natural numbers, and the number of elements must be the same as the maximum number of `STEPS` in the `GO` statement. The following takes `GO 1 TO 3 STEPS FROM "A" OVER * SAMPLE <sample_list>` as an example to introduce this usage of `SAMPLE` in detail.

- The list `sample_list` must contain 3 natural numbers, such as `GO 1 TO 3 STEPS FROM "A" OVER * SAMPLE [1,2,4]`.
- `1` in `SAMPLE [1,2,4]` means that the system automatically selects 1 edge to continue traversal in the first step. `2` means to select 2 edges to continue traversal in the second step. `4` indicates that 4 edges are selected to continue traversal in the third step. If there is no matched edge in a certain step or the number of matched edges is less than the specified number, the actual number will be returned.
- Because `GO 1 TO 3 STEPS` means to return all the traversal results from the first to third steps, all the red edges and their source and destination vertices in the figure below will be matched by this `GO` statement. And the yellow edges represent there is no path selected when the GO statement traverses. If it is not `GO 1 TO 3 STEPS` but `GO 3 STEPS`, it will only match the red edges of the third step and the vertices at both ends.



In the basketballplayer dataset, the example is as follows:

```
nebula> GO 3 STEPS FROM "player100" \
        OVER * \
```

```
        YIELD properties($$).name AS NAME, properties($$).age AS Age \
        SAMPLE [1,2,3];
+-----------------+----------+
| NAME            | Age      |
+-----------------+----------+
| "Tony Parker"   | 36       |
| "Manu Ginobili" | 41       |
| "Spurs"         | __NULL__ |
+-----------------+----------+

nebula> GO 1 TO 3 STEPS FROM "player100" \
        OVER * \
        YIELD properties($$).name AS NAME, properties($$).age AS Age \
        SAMPLE [2,2,2];
+-----------------+----------+
| NAME            | Age      |
+-----------------+----------+
| "Manu Ginobili" | 41       |
| "Spurs"         | __NULL__ |
| "Tim Duncan"    | 42       |
| "Spurs"         | __NULL__ |
| "Manu Ginobili" | 41       |
| "Spurs"         | __NULL__ |
+-----------------+----------+
```

Last update: January 17, 2023

4.7.4 ORDER BY

The `ORDER BY` clause specifies the order of the rows in the output.

- Native nGQL: You must use a pipe (`|`) and an `ORDER BY` clause after `YIELD` clause.
- OpenCypher style: No pipes are permitted. The `ORDER BY` clause follows a `RETURN` clause.

There are two order options:

- `ASC`: Ascending. `ASC` is the default order.
- `DESC`: Descending.

Native nGQL Syntax

```
<YIELD clause>
| ORDER BY <expression> [ASC | DESC] [, <expression> [ASC | DESC] ...];
```

Compatibility

In the native nGQL syntax, `$-.` must be used after `ORDER BY`. But it is not required in releases prior to 2.5.0.

EXAMPLES

```
nebula> FETCH PROP ON player "player100", "player101", "player102", "player103" \
        YIELD player.age AS age, player.name AS name \
        | ORDER BY $-.age ASC, $-.name DESC;
+-----+---------------------+
| age | name                |
+-----+---------------------+
| 32  | "Rudy Gay"          |
| 33  | "LaMarcus Aldridge" |
| 36  | "Tony Parker"       |
| 42  | "Tim Duncan"        |
+-----+---------------------+

nebula> $var = GO FROM "player100" OVER follow \
        YIELD dst(edge) AS dst; \
        ORDER BY $var.dst DESC;
+-------------+
| dst         |
+-------------+
| "player125" |
| "player101" |
+-------------+
```

OpenCypher Syntax

```
<RETURN clause>
ORDER BY <expression> [ASC | DESC] [, <expression> [ASC | DESC] ...];
```

EXAMPLES

```
nebula> MATCH (v:player) RETURN v.player.name AS Name, v.player.age AS Age  \
        ORDER BY Name DESC;
+-----------------+-----+
| Name            | Age |
+-----------------+-----+
| "Yao Ming"      | 38  |
| "Vince Carter"  | 42  |
| "Tracy McGrady" | 39  |
| "Tony Parker"   | 36  |
| "Tim Duncan"    | 42  |
+-----------------+-----+
...

# In the following example, nGQL sorts the rows by age first. If multiple people are of the same age, nGQL will then sort them by name.
nebula> MATCH (v:player) RETURN v.player.age AS Age, v.player.name AS Name  \
        ORDER BY Age DESC, Name ASC;
+-----+-------------------+
| Age | Name              |
+-----+-------------------+
| 47  | "Shaquille O'Neal" |
```

```
| 46  | "Grant Hill"      |
| 45  | "Jason Kidd"      |
| 45  | "Steve Nash"      |
+-----+-------------------+
...
```

Order of NULL values

nGQL lists NULL values at the end of the output for ascending sorting, and at the start for descending sorting.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) --> (v2) \
        RETURN v2.player.name AS Name, v2.player.age AS Age  \
        ORDER BY Age;
+-----------------+----------+
| Name            | Age      |
+-----------------+----------+
| "Tony Parker"   | 36       |
| "Manu Ginobili" | 41       |
| __NULL__        | __NULL__ |
+-----------------+----------+

nebula> MATCH (v:player{name:"Tim Duncan"}) --> (v2) \
        RETURN v2.player.name AS Name, v2.player.age AS Age  \
        ORDER BY Age DESC;
+-----------------+----------+
| Name            | Age      |
+-----------------+----------+
| __NULL__        | __NULL__ |
| "Manu Ginobili" | 41       |
| "Tony Parker"   | 36       |
+-----------------+----------+
```

Last update: March 27, 2023

4.7.5 RETURN

The `RETURN` clause defines the output of an nGQL query. To return multiple fields, separate them with commas.

`RETURN` can lead a clause or a statement:

- A `RETURN` clause can work in openCypher statements in nGQL, such as `MATCH` or `UNWIND`.
- A `RETURN` statement can work independently to output the result of an expression.

OpenCypher compatibility

This topic applies to the openCypher syntax in nGQL only. For native nGQL, use `YIELD`.

`RETURN` does not support the following openCypher features yet.

- Return variables with uncommon characters, for example:

```
MATCH (`non-english_characters`:player) \
RETURN `non-english_characters`;
```

- Set a pattern in the `RETURN` clause and return all elements that this pattern matches, for example:

```
MATCH (v:player) \
RETURN (v)-[e]->(v2);
```

Map order description

When `RETURN` returns the map data structure, the order of key-value pairs is undefined.

```
nebula> RETURN {age: 32, name: "Marco Belinelli"};
+------------------------------------+
| {age:32,name:"Marco Belinelli"}    |
+------------------------------------+
| {age: 32, name: "Marco Belinelli"} |
+------------------------------------+

nebula> RETURN {zage: 32, name: "Marco Belinelli"};
+-------------------------------------+
| {zage:32,name:"Marco Belinelli"}    |
+-------------------------------------+
| {name: "Marco Belinelli", zage: 32} |
+-------------------------------------+
```

Return vertices or edges

Use the `RETURN {<vertex_name> | <edge_name>}` to return vertices and edges all information.

```
// Return vertices
nebula> MATCH (v:player) \
        RETURN v;
+---------------------------------------------------------------+
| v                                                             |
+---------------------------------------------------------------+
| ("player104" :player{age: 32, name: "Marco Belinelli"})       |
| ("player107" :player{age: 32, name: "Aron Baynes"})           |
| ("player116" :player{age: 34, name: "LeBron James"})          |
| ("player120" :player{age: 29, name: "James Harden"})          |
| ("player125" :player{age: 41, name: "Manu Ginobili"})         |
+---------------------------------------------------------------+
...

// Return edges
nebula> MATCH (v:player)-[e]->() \
        RETURN e;
+------------------------------------------------------------------------------+
| e                                                                            |
+------------------------------------------------------------------------------+
| [:follow "player104"->"player100" @0 {degree: 55}]                           |
| [:follow "player104"->"player101" @0 {degree: 50}]                           |
| [:follow "player104"->"player105" @0 {degree: 60}]                           |
| [:serve "player104"->"team200" @0 {end_year: 2009, start_year: 2007}]        |
```

```
| [:serve "player104"->"team208" @0 {end_year: 2016, start_year: 2015}]       |
+-----------------------------------------------------------------------------+
...
```

Return VIDs

Use the `id()` function to retrieve VIDs.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) \
        RETURN id(v);
+-------------+
| id(v)       |
+-------------+
| "player100" |
+-------------+
```

Return Tag

Use the `labels()` function to return the list of tags on a vertex.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) \
        RETURN labels(v);
+------------+
| labels(v)  |
+------------+
| ["player"] |
+------------+
```

To retrieve the nth element in the `labels(v)` list, use `labels(v)[n-1]`. The following example shows how to use `labels(v)[0]` to return the first tag in the list.

```
nebula> MATCH (v:player{name:"Tim Duncan"}) \
        RETURN labels(v)[0];
+--------------+
| labels(v)[0] |
+--------------+
| "player"     |
+--------------+
```

Return properties

To return a vertex or edge property, use the `{<vertex_name>|<edge_name>}.<property>` syntax.

```
nebula> MATCH (v:player) \
        RETURN v.player.name, v.player.age \
        LIMIT 3;
+------------------+--------------+
| v.player.name    | v.player.age |
+------------------+--------------+
| "Danny Green"    | 31           |
| "Tiago Splitter" | 34           |
| "David West"     | 38           |
+------------------+--------------+
```

Use the syntax `<vertex_name>.<tag_name>.<property_name>` to return the property of a vertex; use the syntax `<edge_name>.<property_name>` to return the property of an edge.

```
// Return the property of a vertex
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[]->(v2) \
        RETURN properties(v2);
+----------------------------------+
| properties(v2)                   |
+----------------------------------+
| {name: "Spurs"}                  |
| {age: 36, name: "Tony Parker"}   |
| {age: 41, name: "Manu Ginobili"} |
+----------------------------------+
```

```
// Return the property of an edge
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->() \
        RETURN e.start_year, e.degree \
+--------------+----------+
| e.start_year | e.degree |
+--------------+----------+
| __NULL__     | 95       |
| __NULL__     | 95       |
```

```
| 1997         | __NULL__ |
+--------------+----------+
```

Return edge type

Use the `type()` function to return the matched edge types.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[e]->() \
        RETURN DISTINCT type(e);
+----------+
| type(e)  |
+----------+
| "serve"  |
| "follow" |
+----------+
```

Return paths

Use `RETURN <path_name>` to return all the information of the matched paths.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[*3]->() \
        RETURN p;
+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
|
p
|
+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:follow@0 {degree: 90}]->("player102" :player{age: 33, 
name: "LaMarcus Aldridge"})-[:serve@0 {end_year: 2019, start_year: 2015}]->("team204" :team{name: "Spurs"})>        |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:follow@0 {degree: 90}]->("player102" :player{age: 33, 
name: "LaMarcus Aldridge"})-[:serve@0 {end_year: 2015, start_year: 2006}]->("team203" :team{name: "Trail Blazers"})> |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:follow@0 {degree: 90}]->("player102" :player{age: 33, 
name: "LaMarcus Aldridge"})-[:follow@0 {degree: 75}]->("player101" :player{age: 36, name: "Tony Parker"})>          |
+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
...
```

RETURN VERTICES IN A PATH

Use the `nodes()` function to return all vertices in a path.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[]->(v2) \
        RETURN nodes(p);
+-------------------------------------------------------------------------------------------------------------+
| nodes(p)                                                                                                    |
+-------------------------------------------------------------------------------------------------------------+
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("team204" :team{name: "Spurs"})]                      |
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("player101" :player{age: 36, name: "Tony Parker"})]   |
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("player125" :player{age: 41, name: "Manu Ginobili"})] |
+-------------------------------------------------------------------------------------------------------------+
```

RETURN EDGES IN A PATH

Use the `relationships()` function to return all edges in a path.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[]->(v2) \
        RETURN relationships(p);
+-------------------------------------------------------------------------+
| relationships(p)                                                        |
+-------------------------------------------------------------------------+
| [[:serve "player100"->"team204" @0 {end_year: 2016, start_year: 1997}]] |
| [[:follow "player100"->"player101" @0 {degree: 95}]]                    |
| [[:follow "player100"->"player125" @0 {degree: 95}]]                    |
+-------------------------------------------------------------------------+
```

RETURN PATH LENGTH

Use the `length()` function to return the length of a path.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})-[*..2]->(v2) \
        RETURN p AS Paths, length(p) AS Length;
+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+--------+
|
Paths
| Length |
+-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+--------+
```

```
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:serve@0 {end_year: 2016, start_year: 1997}]->("team204" :team{name: 
"Spurs"})>                                                                                         | 1      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony 
Parker"})>                                                                                           | 1      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41, name: "Manu 
Ginobili"})>                                                                                         | 1      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:serve@0 {end_year: 2018, start_year: 1999}]-
>("team204" :team{name: "Spurs"})>     | 2      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:serve@0 {end_year: 2019, start_year: 2018}]-
>("team215" :team{name: "Hornets"})>   | 2      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:follow@0 {degree: 95}]->("player100" :player{age: 42, 
name: "Tim Duncan"})>        | 2      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:follow@0 {degree: 90}]->("player102" :player{age: 33, 
name: "LaMarcus Aldridge"})> | 2      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41, 
name: "Manu Ginobili"})>     | 2      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41, name: "Manu Ginobili"})-[:serve@0 {end_year: 2018, start_year: 2002}]-
>("team204" :team{name: "Spurs"})>   | 2      |
| <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41, name: "Manu Ginobili"})-[:follow@0 {degree: 90}]->("player100" :player{age: 42, 
name: "Tim Duncan"})>      | 2      |
+------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+--------+
```

Return all elements

To return all the elements that this pattern matches, use an asterisk (*).

```
nebula> MATCH (v:player{name:"Tim Duncan"}) \
        RETURN *;
+----------------------------------------------------+
| v                                                  |
+----------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) |
+----------------------------------------------------+

nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->(v2) \
        RETURN *;
+----------------------------------------------------+-----------------------------------------------------------------------+-------------------------------------------------------+
| v                                                  | e                                                                     | v2                                                    |
+----------------------------------------------------+-----------------------------------------------------------------------+-------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) | [:follow "player100"->"player101" @0 {degree: 95}]                    | ("player101" :player{age: 36, name: "Tony Parker"})   |
| ("player100" :player{age: 42, name: "Tim Duncan"}) | [:follow "player100"->"player125" @0 {degree: 95}]                    | ("player125" :player{age: 41, name: "Manu Ginobili"}) |
| ("player100" :player{age: 42, name: "Tim Duncan"}) | [:serve "player100"->"team204" @0 {end_year: 2016, start_year: 1997}] | ("team204" :team{name: "Spurs"})                      |
+----------------------------------------------------+-----------------------------------------------------------------------+-------------------------------------------------------+
```

Rename a field

Use the `AS <alias>` syntax to rename a field in the output.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[:serve]->(v2) \
        RETURN v2.team.name AS Team;
+---------+
| Team    |
+---------+
| "Spurs" |
+---------+

nebula> RETURN "Amber" AS Name;
+---------+
| Name    |
+---------+
| "Amber" |
+---------+
```

Return a non-existing property

If a property matched does not exist, `NULL` is returned.

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->(v2) \
        RETURN v2.player.name, type(e), v2.player.age;
+-----------------+----------+---------------+
| v2.player.name  | type(e)  | v2.player.age |
+-----------------+----------+---------------+
| "Manu Ginobili" | "follow" | 41            |
| __NULL__        | "serve"  | __NULL__      |
| "Tony Parker"   | "follow" | 36            |
+-----------------+----------+---------------+
```

Return expression results

To return the results of expressions such as literals, functions, or predicates, set them in a `RETURN` clause.

```
nebula> MATCH (v:player{name:"Tony Parker"})-->(v2:player) \
        RETURN DISTINCT v2.player.name, "Hello"+" graphs!", v2.player.age > 35;
+---------------------+----------------------+--------------------+
| v2.player.name      | ("Hello"+" graphs!") | (v2.player.age>35) |
+---------------------+----------------------+--------------------+
| "LaMarcus Aldridge" | "Hello graphs!"      | false              |
| "Tim Duncan"        | "Hello graphs!"      | true               |
| "Manu Ginobili"     | "Hello graphs!"      | true               |
+---------------------+----------------------+--------------------+

nebula> RETURN 1+1;
+-------+
| (1+1) |
+-------+
| 2     |
+-------+

nebula> RETURN 1- -1;
+----------+
| (1--(1)) |
+----------+
| 2        |
+----------+

nebula> RETURN 3 > 1;
+-------+
| (3>1) |
+-------+
| true  |
+-------+

nebula> RETURN 1+1, rand32(1, 5);
+-------+-------------+
| (1+1) | rand32(1,5) |
+-------+-------------+
| 2     | 1           |
+-------+-------------+
```

Return unique fields

Use `DISTINCT` to remove duplicate fields in the result set.

```
# Before using DISTINCT.
nebula> MATCH (v:player{name:"Tony Parker"})--(v2:player) \
        RETURN v2.player.name, v2.player.age;
+---------------------+---------------+
| v2.player.name      | v2.player.age |
+---------------------+---------------+
| "Manu Ginobili"     | 41            |
| "Boris Diaw"        | 36            |
| "Marco Belinelli"   | 32            |
| "Dejounte Murray"   | 29            |
| "Tim Duncan"        | 42            |
| "Tim Duncan"        | 42            |
| "LaMarcus Aldridge" | 33            |
| "LaMarcus Aldridge" | 33            |
+---------------------+---------------+

# After using DISTINCT.
nebula> MATCH (v:player{name:"Tony Parker"})--(v2:player) \
        RETURN DISTINCT v2.player.name, v2.player.age;
+---------------------+---------------+
| v2.player.name      | v2.player.age |
+---------------------+---------------+
| "Manu Ginobili"     | 41            |
| "Boris Diaw"        | 36            |
| "Marco Belinelli"   | 32            |
| "Dejounte Murray"   | 29            |
| "Tim Duncan"        | 42            |
| "LaMarcus Aldridge" | 33            |
+---------------------+---------------+
```

Last update: April 25, 2023

4.7.6 TTL

TTL (Time To Live) specifies a timeout for a property. Once timed out, the property expires.

OpenCypher Compatibility

This topic applies to native nGQL only.

Precautions

- You CANNOT modify a property schema with TTL options on it.

- TTL options and indexes have coexistence issues.
- TTL options and indexes CANNOT coexist on a tag or an edge type. If there is an index on a property, you cannot set TTL options on other properties.
- If there are TTL options on a tag, an edge type, or a property, you can still add an index on them.

TTL options

The native nGQL TTL feature has the following options.

Option	Description
`ttl_col`	Specifies the property to set a timeout on. The data type of the property must be `int` or `timestamp`.
`ttl_duration`	Specifies the timeout adds-on value in seconds. The value must be a non-negative int64 number. A property expires if the sum of its value and the `ttl_duration` value is smaller than the current timestamp. If the `ttl_duration` value is `0`, the property never expires. You can set `ttl_use_ms` to `true` in the configuration file `nebula-storaged.conf` (default path: `/usr/local/nightly/etc/`) to set the default unit to milliseconds.

Caution

- Before setting `ttl_use_ms` to `true`, make sure that no TTL has been set for any property, as shortening the expiration time may cause data to be erroneously deleted.

- After setting `ttl_use_ms` to `true`, which sets the default TTL unit to milliseconds, the data type of the property specified by `ttl_col` must be `int`, and the property value needs to be manually converted to milliseconds. For example, when setting `ttl_col` to `a`, you need to convert the value of `a` to milliseconds, such as when the value of `a` is `now()`, you need to set the value of `a` to `now() * 1000`.

Data expiration and deletion

Caution

- When the TTL options are set for a property of a tag or an edge type and the property's value is `NULL`, the property never expires.
- If a property with a default value of `now()` is added to a tag or an edge type and the TTL options are set for the property, the history data related to the tag or the edge type will never expire because the value of that property for the history data is the current timestamp.

VERTEX PROPERTY EXPIRATION

Vertex property expiration has the following impact.

- If a vertex has only one tag, once a property of the vertex expires, the vertex expires.
- If a vertex has multiple tags, once a property of the vertex expires, properties bound to the same tag with the expired property also expire, but the vertex does not expire and other properties of it remain untouched.

EDGE PROPERTY EXPIRATION

Since an edge can have only one edge type, once an edge property expires, the edge expires.

DATA DELETION

The expired data are still stored on the disk, but queries will filter them out.

NebulaGraph automatically deletes the expired data and reclaims the disk space during the next compaction.

Note

If TTL is disabled, the corresponding data deleted after the last compaction can be queried again.

Use TTL options

You must use the TTL options together to set a valid timeout on a property.

SET A TIMEOUT IF A TAG OR AN EDGE TYPE EXISTS

If a tag or an edge type is already created, to set a timeout on a property bound to the tag or edge type, use `ALTER` to update the tag or edge type.

```
# Create a tag.
nebula> CREATE TAG IF NOT EXISTS t1 (a timestamp);

# Use ALTER to update the tag and set the TTL options.
nebula> ALTER TAG t1 TTL_COL = "a", TTL_DURATION = 5;

# Insert a vertex with tag t1. The vertex expires 5 seconds after the insertion.
nebula> INSERT VERTEX t1(a) VALUES "101":(now());
```

SET A TIMEOUT WHEN CREATING A TAG OR AN EDGE TYPE

Use TTL options in the `CREATE` statement to set a timeout when creating a tag or an edge type. For more information, see CREATE TAG and CREATE EDGE.

```
# Create a tag and set the TTL options.
nebula> CREATE TAG IF NOT EXISTS t2(a int, b int, c string) TTL_DURATION= 100, TTL_COL = "a";

# Insert a vertex with tag t2. The timeout timestamp is 1648197238 (1648197138 + 100).
nebula> INSERT VERTEX t2(a, b, c) VALUES "102":(1648197138, 30, "Hello");
```

Remove a timeout

To disable TTL and remove the timeout on a property, you can use the following approaches.

- Drop the property with the timeout.

```
nebula> ALTER TAG t1 DROP (a);
```

- Set `ttl_col` to an empty string.

```
nebula> ALTER TAG t1 TTL_COL = "";
```

- Set `ttl_duration` to `0`. This operation keeps the TTL options and prevents the property from expiring and the property schema from being modified.

```
nebula> ALTER TAG t1 TTL_DURATION = 0;
```

Last update: April 25, 2023

4.7.7 WHERE

The `WHERE` clause filters the output by conditions.

The `WHERE` clause usually works in the following queries:

- Native nGQL: such as `GO` and `LOOKUP`.
- OpenCypher syntax: such as `MATCH` and `WITH`.

OpenCypher compatibility

Filtering on edge rank is a native nGQL feature. To retrieve the rank value in openCypher statements, use the rank() function, such as `MATCH (:player)-[e:follow]->() RETURN rank(e);`.

Basic usage

Note

In the following examples, `$$` and `$^` are reference operators. For more information, see Operators.

DEFINE CONDITIONS WITH BOOLEAN OPERATORS

Use the boolean operators `NOT`, `AND`, `OR`, and `XOR` to define conditions in `WHERE` clauses. For the precedence of the operators, see Precedence.

```
nebula> MATCH (v:player) \
        WHERE v.player.name == "Tim Duncan" \
        XOR (v.player.age < 30 AND v.player.name == "Yao Ming") \
        OR NOT (v.player.name == "Yao Ming" OR v.player.name == "Tim Duncan") \
        RETURN v.player.name, v.player.age;
+-------------------------+--------------+
| v.player.name           | v.player.age |
+-------------------------+--------------+
| "Danny Green"           | 31           |
| "Tiago Splitter"        | 34           |
| "David West"            | 38           |
...
```

```
nebula> GO FROM "player100" \
        OVER follow \
        WHERE properties(edge).degree > 90 \
        OR properties($$).age != 33 \
        AND properties($$).name != "Tony Parker" \
        YIELD properties($$);
+----------------------------------+
| properties($$)                   |
+----------------------------------+
| {age: 41, name: "Manu Ginobili"} |
+----------------------------------+
```

FILTER ON PROPERTIES

Use vertex or edge properties to define conditions in `WHERE` clauses.

- Filter on a vertex property:

```
nebula> MATCH (v:player)-[e]->(v2) \
        WHERE v2.player.age < 25 \
        RETURN v2.player.name, v2.player.age;
+----------------------+---------------+
| v2.player.name       | v2.player.age |
+----------------------+---------------+
| "Ben Simmons"        | 22            |
| "Luka Doncic"        | 20            |
| "Kristaps Porzingis" | 23            |
+----------------------+---------------+
```

```
nebula> GO FROM "player100" OVER follow \
        WHERE $^.player.age >= 42 \
        YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
+-------------+
| "player101" |
| "player125" |
+-------------+
```

- Filter on an edge property:

```
nebula> MATCH (v:player)-[e]->() \
        WHERE e.start_year < 2000 \
        RETURN DISTINCT v.player.name, v.player.age;
+--------------------+--------------+
| v.player.name      | v.player.age |
+--------------------+--------------+
| "Tony Parker"      | 36           |
| "Tim Duncan"       | 42           |
| "Grant Hill"       | 46           |
...
```

```
nebula> GO FROM "player100" OVER follow \
        WHERE follow.degree > 90 \
        YIELD dst(edge);
+-------------+
| dst(EDGE)   |
+-------------+
| "player101" |
| "player125" |
+-------------+
```

FILTER ON DYNAMICALLY-CALCULATED PROPERTIES

```
nebula> MATCH (v:player) \
        WHERE v[toLower("AGE")] < 21 \
        RETURN v.player.name, v.player.age;
+---------------+-------+
| v.name        | v.age |
+---------------+-------+
| "Luka Doncic" | 20    |
+---------------+-------+
```

FILTER ON EXISTING PROPERTIES

```
nebula> MATCH (v:player) \
        WHERE exists(v.player.age) \
        RETURN v.player.name, v.player.age;
+-------------------------+--------------+
| v.player.name           | v.player.age |
+-------------------------+--------------+
| "Danny Green"           | 31           |
| "Tiago Splitter"        | 34           |
| "David West"            | 38           |
...
```

FILTER ON EDGE RANK

In nGQL, if a group of edges has the same source vertex, destination vertex, and properties, the only thing that distinguishes them is the rank. Use rank conditions in `WHERE` clauses to filter such edges.

```
# The following example creates test data.
nebula> CREATE SPACE IF NOT EXISTS test (vid_type=FIXED_STRING(30));
nebula> USE test;
nebula> CREATE EDGE IF NOT EXISTS e1(p1 int);
nebula> CREATE TAG IF NOT EXISTS person(p1 int);
nebula> INSERT VERTEX person(p1) VALUES "1":(1);
nebula> INSERT VERTEX person(p1) VALUES "2":(2);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@0:(10);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@1:(11);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@2:(12);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@3:(13);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@4:(14);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@5:(15);
nebula> INSERT EDGE e1(p1) VALUES "1"->"2"@6:(16);

# The following example use rank to filter edges and retrieves edges with a rank greater than 2.
nebula> GO FROM "1" \
        OVER e1 \
        WHERE rank(edge) > 2 \
        YIELD src(edge), dst(edge), rank(edge) AS Rank, properties(edge).p1 | \
        ORDER BY $-.Rank DESC;
+-----------+-----------+------+---------------------+
| src(EDGE) | dst(EDGE) | Rank | properties(EDGE).p1 |
+-----------+-----------+------+---------------------+
| "1"       | "2"       | 6    | 16                  |
| "1"       | "2"       | 5    | 15                  |
| "1"       | "2"       | 4    | 14                  |
| "1"       | "2"       | 3    | 13                  |
+-----------+-----------+------+---------------------+

# Filter edges by rank. Find follow edges with rank equal to 0.
nebula> MATCH (v)-[e:follow]->() \
         WHERE rank(e)==0 \
         RETURN *;
+------------------------------------------------------------+-----------------------------------------------------+
| v                                                          | e                                                   |
+------------------------------------------------------------+-----------------------------------------------------+
| ("player142" :player{age: 29, name: "Klay Thompson"})      | [:follow "player142"->"player117" @0 {degree: 90}]  |
| ("player139" :player{age: 34, name: "Marc Gasol"})         | [:follow "player139"->"player138" @0 {degree: 99}]  |
| ("player108" :player{age: 36, name: "Boris Diaw"})         | [:follow "player108"->"player100" @0 {degree: 80}]  |
| ("player108" :player{age: 36, name: "Boris Diaw"})         | [:follow "player108"->"player101" @0 {degree: 80}]  |
...
```

FILTER ON PATTERN

```
nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->(t) \
        WHERE (v)-[e]->(t:team) \
        RETURN (v)-->();
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
| (v)-->() = (v)--
>()
|
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
| [<("player100" :player{age: 42, name: "Tim Duncan"})-[:serve@0 {end_year: 2016, start_year: 1997}]->("team204" :team{name: "Spurs"})>, <("player100" :player{age: 42, name: "Tim Duncan"})-
[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})>, <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41,
name: "Manu Ginobili"})>] |
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+

nebula> MATCH (v:player{name:"Tim Duncan"})-[e]->(t) \
        WHERE NOT (v)-[e]->(t:team) \
        RETURN (v)-->();
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
| (v)-->() = (v)--
>()
|
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
| [<("player100" :player{age: 42, name: "Tim Duncan"})-[:serve@0 {end_year: 2016, start_year: 1997}]->("team204" :team{name: "Spurs"})>, <("player100" :player{age: 42, name: "Tim Duncan"})-
[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})>, <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41,
name: "Manu Ginobili"})>] |
| [<("player100" :player{age: 42, name: "Tim Duncan"})-[:serve@0 {end_year: 2016, start_year: 1997}]->("team204" :team{name: "Spurs"})>, <("player100" :player{age: 42, name: "Tim Duncan"})-
[:follow@0 {degree: 95}]->("player101" :player{age: 36, name: "Tony Parker"})>, <("player100" :player{age: 42, name: "Tim Duncan"})-[:follow@0 {degree: 95}]->("player125" :player{age: 41,
name: "Manu Ginobili"})>] |
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
+
```

Filter on strings

Use `STARTS WITH`, `ENDS WITH`, or `CONTAINS` in `WHERE` clauses to match a specific part of a string. String matching is case-sensitive.

`STARTS WITH`

`STARTS WITH` will match the beginning of a string.

The following example uses `STARTS WITH "T"` to retrieve the information of players whose name starts with `T`.

```
nebula> MATCH (v:player) \
        WHERE v.player.name STARTS WITH "T" \
        RETURN v.player.name, v.player.age;
+------------------+--------------+
| v.player.name    | v.player.age |
+------------------+--------------+
| "Tony Parker"    | 36           |
| "Tiago Splitter" | 34           |
| "Tim Duncan"     | 42           |
| "Tracy McGrady"  | 39           |
+------------------+--------------+
```

If you use `STARTS WITH "t"` in the preceding statement, an empty set is returned because no name in the dataset starts with the lowercase `t`.

```
nebula> MATCH (v:player) \
        WHERE v.player.name STARTS WITH "t" \
        RETURN v.player.name, v.player.age;
+---------------+--------------+
| v.player.name | v.player.age |
+---------------+--------------+
+---------------+--------------+
Empty set (time spent 5080/6474 us)
```

`ENDS WITH`

`ENDS WITH` will match the ending of a string.

The following example uses `ENDS WITH "r"` to retrieve the information of players whose name ends with `r`.

```
nebula> MATCH (v:player) \
        WHERE v.player.name ENDS WITH "r" \
        RETURN v.player.name, v.player.age;
+------------------+--------------+
| v.player.name    | v.player.age |
+------------------+--------------+
| "Tony Parker"    | 36           |
| "Tiago Splitter" | 34           |
| "Vince Carter"   | 42           |
+------------------+--------------+
```

`CONTAINS`

`CONTAINS` will match a certain part of a string.

The following example uses `CONTAINS "Pa"` to match the information of players whose name contains `Pa`.

```
nebula> MATCH (v:player) \
        WHERE v.player.name CONTAINS "Pa" \
        RETURN v.player.name, v.player.age;
+---------------+--------------+
| v.player.name | v.player.age |
+---------------+--------------+
| "Paul George" | 28           |
| "Tony Parker" | 36           |
| "Paul Gasol"  | 38           |
| "Chris Paul"  | 33           |
+---------------+--------------+
```

NEGATIVE STRING MATCHING

You can use the boolean operator `NOT` to negate a string matching condition.

```
nebula> MATCH (v:player) \
        WHERE NOT v.player.name ENDS WITH "R" \
        RETURN v.player.name, v.player.age;
+-------------------------+--------------+
| v.player.name           | v.player.age |
+-------------------------+--------------+
| "Danny Green"           | 31           |
| "Tiago Splitter"        | 34           |
| "David West"            | 38           |
| "Russell Westbrook"     | 30           |
...
```

Filter on lists

MATCH VALUES IN A LIST

Use the `IN` operator to check if a value is in a specific list.

```
nebula> MATCH (v:player) \
        WHERE v.player.age IN range(20,25) \
        RETURN v.player.name, v.player.age;
+-------------------------+--------------+
| v.player.name           | v.player.age |
+-------------------------+--------------+
| "Ben Simmons"           | 22           |
| "Giannis Antetokounmpo" | 24           |
| "Kyle Anderson"         | 25           |
| "Joel Embiid"           | 25           |
| "Kristaps Porzingis"    | 23           |
| "Luka Doncic"           | 20           |
+-------------------------+--------------+

nebula> LOOKUP ON player \
        WHERE player.age IN [25,28]  \
        YIELD properties(vertex).name, properties(vertex).age;
+-------------------------+------------------------+
| properties(VERTEX).name | properties(VERTEX).age |
+-------------------------+------------------------+
| "Kyle Anderson"         | 25                     |
| "Damian Lillard"        | 28                     |
| "Joel Embiid"           | 25                     |
| "Paul George"           | 28                     |
| "Ricky Rubio"           | 28                     |
+-------------------------+------------------------+
```

MATCH VALUES NOT IN A LIST

Use `NOT` before `IN` to rule out the values in a list.

```
nebula> MATCH (v:player) \
        WHERE v.player.age NOT IN range(20,25) \
        RETURN v.player.name AS Name, v.player.age AS Age \
        ORDER BY Age;
+---------------------+-----+
| Name                | Age |
+---------------------+-----+
| "Kyrie Irving"      | 26  |
| "Cory Joseph"       | 27  |
| "Damian Lillard"    | 28  |
| "Paul George"       | 28  |
| "Ricky Rubio"       | 28  |
+---------------------+-----+
...
```

Last update: February 7, 2023

4.7.8 YIELD

`YIELD` defines the output of an nGQL query.

`YIELD` can lead a clause or a statement:

- A `YIELD` clause works in nGQL statements such as `GO`, `FETCH`, or `LOOKUP` and must be defined to return the result.
- A `YIELD` statement works in a composite query or independently.

OpenCypher compatibility

This topic applies to native nGQL only. For the openCypher syntax, use `RETURN`.

`YIELD` has different functions in openCypher and nGQL.

- In openCypher, `YIELD` is used in the `CALL[…YIELD]` clause to specify the output of the procedure call.

  Note

  NGQL does not support `CALL[…YIELD]` yet.

- In nGQL, `YIELD` works like `RETURN` in openCypher.

Note

In the following examples, `$$` and `$-` are reference operators. For more information, see Operators.

YIELD clauses

SYNTAX

```
YIELD [DISTINCT] <col> [AS <alias>] [, <col> [AS <alias>] ...];
```

Parameter	Description
`DISTINCT`	Aggregates the output and makes the statement return a distinct result set.
`col`	A field to be returned. If no alias is set, `col` will be a column name in the output.
`alias`	An alias for `col`. It is set after the keyword `AS` and will be a column name in the output.

USE A YIELD CLAUSE IN A STATEMENT

- Use `YIELD` with `GO`:

```
nebula> GO FROM "player100" OVER follow \
        YIELD properties($$).name AS Friend, properties($$).age AS Age;
+-----------------+-----+
| Friend          | Age |
+-----------------+-----+
| "Tony Parker"   | 36  |
```

```
| "Manu Ginobili" | 41  |
+-----------------+-----+
```

- Use `YIELD` with `FETCH`:

```
nebula> FETCH PROP ON player "player100" \
        YIELD properties(vertex).name;
+-------------------------+
| properties(VERTEX).name |
+-------------------------+
| "Tim Duncan"            |
+-------------------------+
```

- Use `YIELD` with `LOOKUP`:

```
nebula> LOOKUP ON player WHERE player.name == "Tony Parker" \
        YIELD properties(vertex).name, properties(vertex).age;
+-------------------------+------------------------+
| properties(VERTEX).name | properties(VERTEX).age |
+-------------------------+------------------------+
| "Tony Parker"           | 36                     |
+-------------------------+------------------------+
```

YIELD statements

SYNTAX

```
YIELD [DISTINCT] <col> [AS <alias>] [, <col> [AS <alias>] ...]
[WHERE <conditions>];
```

Parameter	Description
`DISTINCT`	Aggregates the output and makes the statement return a distinct result set.
`col`	A field to be returned. If no alias is set, `col` will be a column name in the output.
`alias`	An alias for `col`. It is set after the keyword `AS` and will be a column name in the output.
`conditions`	Conditions set in a `WHERE` clause to filter the output. For more information, see `WHERE`.

USE A YIELD STATEMENT IN A COMPOSITE QUERY

In a composite query, a `YIELD` statement accepts, filters, and modifies the result set of the preceding statement, and then outputs it.

The following query finds the players that "player100" follows and calculates their average age.

```
nebula> GO FROM "player100" OVER follow \
        YIELD dst(edge) AS ID \
        | FETCH PROP ON player $-.ID \
        YIELD properties(vertex).age AS Age \
        | YIELD AVG($-.Age) as Avg_age, count(*)as Num_friends;
+---------+-------------+
| Avg_age | Num_friends |
+---------+-------------+
| 38.5    | 2           |
+---------+-------------+
```

The following query finds the players that "player101" follows with the follow degrees greater than 90.

```
nebula> $var1 = GO FROM "player101" OVER follow \
        YIELD properties(edge).degree AS Degree, dst(edge) as ID; \
        YIELD $var1.ID AS ID WHERE $var1.Degree > 90;
+-------------+
| ID          |
+-------------+
| "player100" |
| "player125" |
+-------------+
```

The following query finds the vertices in the player that are older than 30 and younger than 32, and returns the de-duplicate results.

```
nebula> LOOKUP ON player  \
        WHERE player.age < 32 and player.age >30  \
        YIELD DISTINCT properties(vertex).age as v;
+--------+
| v      |
+--------+
| 31     |
+--------+
```

USE A STANDALONE YIELD STATEMENT

A `YIELD` statement can calculate a valid expression and output the result.

```
nebula> YIELD rand32(1, 6);
+-------------+
| rand32(1,6) |
+-------------+
| 3           |
+-------------+

nebula> YIELD "Hel" + "\tlo" AS string1, ", World!" AS string2;
+-------------+------------+
| string1     | string2    |
+-------------+------------+
| "Hel    lo" | ", World!" |
+-------------+------------+

nebula> YIELD hash("Tim") % 100;
+-----------------+
| (hash(Tim)%100) |
+-----------------+
| 42              |
+-----------------+

nebula> YIELD \
      CASE 2+3 \
      WHEN 4 THEN 0 \
      WHEN 5 THEN 1 \
      ELSE -1 \
      END \
      AS result;
+--------+
| result |
+--------+
| 1      |
+--------+

nebula> YIELD 1- -1;
+----------+
| (1--(1)) |
+----------+
| 2        |
+----------+
```

Last update: April 25, 2023

4.7.9 WITH

The `WITH` clause can retrieve the output from a query part, process it, and pass it to the next query part as the input.

OpenCypher compatibility

This topic applies to openCypher syntax only.

Note

`WITH` has a similar function with the Pipe symbol in native nGQL, but they work in different ways. DO NOT use pipe symbols in the openCypher syntax or use `WITH` in native nGQL statements.

Combine statements and form a composite query

Use a `WITH` clause to combine statements and transfer the output of a statement as the input of another statement.

EXAMPLE 1

The following statement:

1. Matches a path.
2. Outputs all the vertices on the path to a list with the `nodes()` function.
3. Unwinds the list into rows.
4. Removes duplicated vertices and returns a set of distinct vertices.

```
nebula> MATCH p=(v:player{name:"Tim Duncan"})--() \
        WITH nodes(p) AS n \
        UNWIND n AS n1 \
        RETURN DISTINCT n1;
+-----------------------------------------------------------+
| n1                                                        |
+-----------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"})        |
| ("player101" :player{age: 36, name: "Tony Parker"})       |
| ("team204" :team{name: "Spurs"})                          |
| ("player102" :player{age: 33, name: "LaMarcus Aldridge"}) |
| ("player125" :player{age: 41, name: "Manu Ginobili"})     |
| ("player104" :player{age: 32, name: "Marco Belinelli"})   |
| ("player144" :player{age: 47, name: "Shaquille O'Neal"})  |
| ("player105" :player{age: 31, name: "Danny Green"})       |
| ("player113" :player{age: 29, name: "Dejounte Murray"})   |
| ("player107" :player{age: 32, name: "Aron Baynes"})       |
| ("player109" :player{age: 34, name: "Tiago Splitter"})    |
| ("player108" :player{age: 36, name: "Boris Diaw"})        |
+-----------------------------------------------------------+
```

EXAMPLE 2

The following statement:

1. Matches the vertex with the VID `player100`.
2. Outputs all the tags of the vertex into a list with the `labels()` function.
3. Unwinds the list into rows.
4. Returns the output.

```
nebula> MATCH (v) \
        WHERE id(v)=="player100" \
        WITH labels(v) AS tags_unf \
        UNWIND tags_unf AS tags_f \
        RETURN tags_f;
+----------+
| tags_f   |
+----------+
| "player" |
+----------+
```

Filter composite queries

`WITH` can work as a filter in the middle of a composite query.

```
nebula> MATCH (v:player)-->(v2:player) \
        WITH DISTINCT v2 AS v2, v2.player.age AS Age \
        ORDER BY Age \
        WHERE Age<25 \
        RETURN v2.player.name AS Name, Age;
+----------------------+-----+
| Name                 | Age |
+----------------------+-----+
| "Luka Doncic"        | 20  |
| "Ben Simmons"        | 22  |
| "Kristaps Porzingis" | 23  |
+----------------------+-----+
```

Process the output before using collect()

Use a `WITH` clause to sort and limit the output before using `collect()` to transform the output into a list.

```
nebula> MATCH (v:player) \
        WITH v.player.name AS Name \
        ORDER BY Name DESC \
        LIMIT 3 \
        RETURN collect(Name);
+-----------------------------------------------+
| collect(Name)                                 |
+-----------------------------------------------+
| ["Yao Ming", "Vince Carter", "Tracy McGrady"] |
+-----------------------------------------------+
```

Use with RETURN

Set an alias using a `WITH` clause, and then output the result through a `RETURN` clause.

```
nebula> WITH [1, 2, 3] AS `list` RETURN 3 IN `list` AS r;
+------+
| r    |
+------+
| true |
+------+

nebula> WITH 4 AS one, 3 AS two RETURN one > two AS result;
+--------+
| result |
+--------+
| true   |
+--------+
```

Last update: May 13, 2022

4.7.10 UNWIND

`UNWIND` transform a list into a sequence of rows.

`UNWIND` can be used as an individual statement or as a clause within a statement.

UNWIND statement

SYNTAX

```
UNWIND <list> AS <alias> <RETURN clause>;
```

EXAMPLES

- To transform a list.

```
nebula> UNWIND [1,2,3] AS n RETURN n;
+---+
| n |
+---+
| 1 |
| 2 |
| 3 |
+---+
```

UNWIND clause

SYNTAX

- The `UNWIND` clause in native nGQL statements.

> **Note**
>
> To use a `UNWIND` clause in a native nGQL statement, use it after the `|` operator and use the `$-` prefix for variables. If you use a statement or clause after the `UNWIND` clause, use the `|` operator and use the `$-` prefix for variables.

```
<statement> | UNWIND $-.<var> AS <alias> <|> <clause>;
```

- The `UNWIND` clause in openCypher statements.

```
<statement> UNWIND <list> AS <alias> <RETURN clause>;
```

EXAMPLES

- To transform a list of duplicates into a unique set of rows using `WITH DISTINCT` in a `UNWIND` clause.

> **Note**
>
> `WITH DISTINCT` is not available in native nGQL statements.

```
// Transform the list `[1,1,2,2,3,3]` into a unique set of rows, sort the rows, and then transform the rows into a list of unique values.

nebula> WITH [1,1,2,2,3,3] AS n \
        UNWIND n AS r \
        WITH DISTINCT r AS r \
        ORDER BY r \
        RETURN collect(r);
+------------+
| collect(r) |
+------------+
```

```
| [1, 2, 3]  |
+-----------+
```

- To use an `UNWIND` clause in a `MATCH` statement.

```
// Get a list of the vertices in the matched path, transform the list into a unique set of rows, and then transform the rows into a list.

nebula> MATCH p=(v:player{name:"Tim Duncan"})--(v2) \
        WITH nodes(p) AS n \
        UNWIND n AS r \
        WITH DISTINCT r AS r \
        RETURN collect(r);
+----------------------------------------------------------------------------------------------------------------------+
| collect(r)                                                                                                           |
+----------------------------------------------------------------------------------------------------------------------+
| [("player100" :player{age: 42, name: "Tim Duncan"}), ("player101" :player{age: 36, name: "Tony Parker"}),            |
|("team204" :team{name: "Spurs"}), ("player102" :player{age: 33, name: "LaMarcus Aldridge"}),                          |
|("player125" :player{age: 41, name: "Manu Ginobili"}), ("player104" :player{age: 32, name: "Marco Belinelli"}),       |
|("player144" :player{age: 47, name: "Shaquile O'Neal"}), ("player105" :player{age: 31, name: "Danny Green"}),         |
|("player113" :player{age: 29, name: "Dejounte Murray"}), ("player107" :player{age: 32, name: "Aron Baynes"}),        |
|("player109" :player{age: 34, name: "Tiago Splitter"}), ("player108" :player{age: 36, name: "Boris Diaw"})]          |
+----------------------------------------------------------------------------------------------------------------------+
```

- To use an `UNWIND` clause in a `GO` statement.

```
// Query the vertices in a list for the corresponding edges with a specified statement.

nebula> YIELD ['player101', 'player100'] AS a | UNWIND $-.a AS  b | GO FROM $-.b OVER follow YIELD edge AS e;
+----------------------------------------------------+
| e                                                  |
+----------------------------------------------------+
| [:follow "player101"->"player100" @0 {degree: 95}] |
| [:follow "player101"->"player102" @0 {degree: 90}] |
| [:follow "player101"->"player125" @0 {degree: 95}] |
| [:follow "player100"->"player101" @0 {degree: 95}] |
| [:follow "player100"->"player125" @0 {degree: 95}] |
+----------------------------------------------------+
```

- To use an `UNWIND` clause in a `LOOKUP` statement.

```
// Find all the properties of players whose age is greater than 46, get a list of unique properties, and then transform the list into rows.

nebula> LOOKUP ON player \
        WHERE player.age > 46 \
        YIELD DISTINCT keys(vertex) as p | UNWIND $-.p as a | YIELD $-.a AS a;
+--------+
| a      |
+--------+
| "age"  |
| "name" |
+--------+
```

- To use an `UNWIND` clause in a `FETCH` statement.

```
// Query player101 for all tags related to player101, get a list of the tags and then transform the list into rows.

nebula> CREATE TAG hero(like string, height int);
        INSERT VERTEX hero(like, height) VALUES "player101":("deep", 182);
        FETCH PROP ON * "player101" \
        YIELD tags(vertex) as t | UNWIND $-.t as a | YIELD $-.a AS a;
+----------+
| a        |
+----------+
| "hero"   |
| "player" |
+----------+
```

- To use an `UNWIND` clause in a `GET SUBGRAPH` statement.

```
// Get the subgraph including outgoing and incoming serve edges within 0~2 hops from/to player100, and transform the result into rows.

nebula> GET SUBGRAPH 2 STEPS FROM "player100" BOTH serve \
        YIELD edges as e | UNWIND $-.e as a | YIELD $-.a AS a;
+----------------------------------------------+
| a                                            |
+----------------------------------------------+
| [:serve "player100"->"team204" @0 {}]        |
| [:serve "player101"->"team204" @0 {}]        |
| [:serve "player102"->"team204" @0 {}]        |
| [:serve "player103"->"team204" @0 {}]        |
| [:serve "player105"->"team204" @0 {}]        |
| [:serve "player106"->"team204" @0 {}]        |
| [:serve "player107"->"team204" @0 {}]        |
| [:serve "player108"->"team204" @0 {}]        |
| [:serve "player109"->"team204" @0 {}]        |
| [:serve "player110"->"team204" @0 {}]        |
| [:serve "player111"->"team204" @0 {}]        |
| [:serve "player112"->"team204" @0 {}]        |
| [:serve "player113"->"team204" @0 {}]        |
| [:serve "player114"->"team204" @0 {}]        |
| [:serve "player125"->"team204" @0 {}]        |
| [:serve "player138"->"team204" @0 {}]        |
| [:serve "player104"->"team204" @20132015 {}] |
| [:serve "player104"->"team204" @20182019 {}] |
+----------------------------------------------+
```

- To use an `UNWIND` clause in a `FIND PATH` statement.

```
// Find all the vertices in the shortest path from player101 to team204 along the serve edge, and transform the result into rows.

nebula> FIND SHORTEST PATH FROM "player101" TO "team204" OVER serve \
        YIELD path as p | YIELD nodes($-.p) AS nodes | UNWIND $-.nodes AS a | YIELD $-.a AS a;
+---------------+
| a             |
+---------------+
| ("player101") |
| ("team204")   |
+---------------+
```

Last update: September 7, 2022

4.8 Space statements

4.8.1 CREATE SPACE

Graph spaces are used to store data in a physically isolated way in NebulaGraph, which is similar to the database concept in MySQL. The `CREATE SPACE` statement can create a new graph space or clone the schema of an existing graph space.

Prerequisites

Only the God role can use the `CREATE SPACE` statement. For more information, see AUTHENTICATION.

Syntax

CREATE GRAPH SPACES

```
CREATE SPACE [IF NOT EXISTS] <graph_space_name> (
    [partition_num = <partition_number>,]
    [replica_factor = <replica_number>,]
    vid_type = {FIXED_STRING(<N>) | INT[64]}
    )
    [COMMENT = '<comment>'];
```

Parameter	Description
`IF NOT EXISTS`	Detects if the related graph space exists. If it does not exist, a new one will be created. The graph space existence detection here only compares the graph space name (excluding properties).
`<graph_space_name>`	1. Uniquely identifies a graph space in a NebulaGraph instance. 2. Space names cannot be modified after they are set. 3. Space names cannot start with a number; they support 1-4 byte UTF-8 encoded characters, including English letters (case sensitive), numbers, Chinese characters, etc., but do not include special characters other than underscores. To use special characters, reserved keywords or starting with a number, quote them with backticks (`) and cannot use periods ( `.` ). For more information, see Keywords and reserved words. **Note**: If you name a space in Chinese and encounter a `SyntaxError`, you need to quote the Chinese characters with backticks (`).
`partition_num`	Specifies the number of partitions in each replica. The suggested value is 20 times (2 times for HDD) the number of the hard disks in the cluster. For example, if you have three hard disks in the cluster, we recommend that you set 60 partitions. The default value is 100.
`replica_factor`	Specifies the number of replicas in the cluster. The suggested number is 3 in a production environment and 1 in a test environment. The replica number must be an **odd number** for the need of quorum-based voting. The default value is 1.
`vid_type`	A required parameter. Specifies the VID type in a graph space. Available values are `FIXED_STRING(N)` and `INT64`. `INT` equals to `INT64`. `` `FIXED_STRING(<N>) `` specifies the VID as a string, while `INT64` specifies it as an integer. `N` represents the maximum length of the VIDs. If you set a VID that is longer than `N` bytes, NebulaGraph throws an error. Note, for UTF-8 chars, the length may vary in different cases, i.e. a UTF-8 Chinese char is 3 byte, this means 11 Chinese chars(length-33) will exeed a FIXED_STRING(32) vid defination.
`COMMENT`	The remarks of the graph space. The maximum length is 256 bytes. By default, there is no comments on a space.

Caution

- If the replica number is set to one, you will not be able to load balance or scale out the NebulaGraph Storage Service with the SUBMIT JOB BALANCE statement.

- Restrictions on VID type change and VID length:
- For NebulaGraph v1.x, the type of VIDs can only be `INT64`, and the String type is not allowed. For NebulaGraph v2.x, both `INT64` and `FIXED_STRING(<N>)` VID types are allowed. You must specify the VID type when creating a graph space, and use the same VID type in `INSERT` statements, otherwise, an error message `Wrong vertex id type: 1001` occurs.
- The length of the VID should not be longer than `N` characters. If it exceeds `N`, NebulaGraph throws `The VID must be a 64-bit integer or a string fitting space vertex id length limit.`.

- If the `Host not enough!` error appears, the immediate cause is that the number of online storage hosts is less than the value of `replica_factor` specified when creating a graph space. In this case, you can use the `SHOW HOSTS` command to see if the following situations occur:
- For the case where there is only one storage host in a cluster, the value of `replica_factor` can only be specified to `1`. Or create a graph space after storage hosts are scaled out.
- A new storage host is found, but `ADD HOSTS` is not executed to activate it. In this case, run `SHOW HOSTS` to locate the new storage host information and then run `ADD HOSTS` to activate it. A graph space can be created after there are enough storage hosts.
- For offline storage hosts after running `SHOW HOSTS`, troubleshooting is needed.

Legacy version compatibility

For NebulaGraph v2.x before v2.5.0, `vid_type` is optional and defaults to `FIXED_STRING(8)`.

Note

`graph_space_name`, `partition_num`, `replica_factor`, `vid_type`, and `comment` cannot be modified once set. To modify them, drop the current working graph space with `DROP SPACE` and create a new one with `CREATE SPACE`.

CLONE GRAPH SPACES

```
CREATE SPACE [IF NOT EXISTS] <new_graph_space_name> AS <old_graph_space_name>;
```

Parameter	Description
`IF NOT EXISTS`	Detects if the new graph space exists. If it does not exist, the new one will be created. The graph space existence detection here only compares the graph space name (excluding properties).
`<new_graph_space_name>`	The name of the graph space that is newly created. The name of the graph space starts with a letter, supports 1 to 4 bytes UTF-8 encoded characters, such as English letters (case-sensitive), digits, and Chinese characters, but does not support special characters except underscores. For more information, see Keywords and reserved words. When a new graph space is created, the schema of the old graph space `<old_graph_space_name>` will be cloned, including its parameters (the number of partitions and replicas, etc.), Tag, Edge type and native indexes.
`<old_graph_space_name>`	The name of the graph space that already exists.

Examples

```
# The following example creates a graph space with a specified VID type and the maximum length. Other fields still use the default values.
nebula> CREATE SPACE IF NOT EXISTS my_space_1 (vid_type=FIXED_STRING(30));

# The following example creates a graph space with a specified partition number, replica number, and VID type.
nebula> CREATE SPACE IF NOT EXISTS my_space_2 (partition_num=15, replica_factor=1, vid_type=FIXED_STRING(30));

#  The following example creates a graph space with a specified partition number, replica number, and VID type, and adds a comment on it.
nebula> CREATE SPACE IF NOT EXISTS my_space_3 (partition_num=15, replica_factor=1, vid_type=FIXED_STRING(30)) comment="Test the graph space";
```

```
# Clone a graph space.
nebula> CREATE SPACE IF NOT EXISTS my_space_4 as my_space_3;
nebula> SHOW CREATE SPACE my_space_4;
+--------------+-----------------------------------------------------------------------------------------------------------------------------------------------+
| Space        | Create Space                                                                                                                                  |
+--------------+-----------------------------------------------------------------------------------------------------------------------------------------------+
| "my_space_4" | "CREATE SPACE `my_space_4` (partition_num = 15, replica_factor = 1, charset = utf8, collate = utf8_bin, vid_type = FIXED_STRING(30)) comment = '测试图空间'" |
+--------------+-----------------------------------------------------------------------------------------------------------------------------------------------+
```

Implementation of the operation

Caution

Trying to use a newly created graph space may fail because the creation is implemented asynchronously. To make sure the follow-up operations work as expected, Wait for two heartbeat cycles, i.e., 20 seconds. To change the heartbeat interval, modify the `heartbeat_interval_secs` parameter in the configuration files for all services. If the heartbeat interval is too short (i.e., less than 5 seconds), disconnection between peers may happen because of the misjudgment of machines in the distributed system.

Check partition distribution

On some large clusters, the partition distribution is possibly unbalanced because of the different startup times. You can run the following command to do a check of the machine distribution.

```
nebula> SHOW HOSTS;
+-------------+------+----------+--------------+--------------------------------+--------------------------------+---------+
| Host        | Port | Status   | Leader count | Leader distribution            | Partition distribution         | Version |
+-------------+------+----------+--------------+--------------------------------+--------------------------------+---------+
| "storaged0" | 9779 | "ONLINE" | 8            | "basketballplayer:3, test:5"   | "basketballplayer:10, test:10" | "3.5.0" |
| "storaged1" | 9779 | "ONLINE" | 9            | "basketballplayer:4, test:5"   | "basketballplayer:10, test:10" | "3.5.0" |
| "storaged2" | 9779 | "ONLINE" | 3            | "basketballplayer:3"           | "basketballplayer:10, test:10" | "3.5.0" |
+-------------+------+----------+--------------+--------------------------------+--------------------------------+---------+
```

To balance the request loads, use the following command.

```
nebula> BALANCE LEADER;
nebula> SHOW HOSTS;
+-------------+------+----------+--------------+--------------------------------+--------------------------------+---------+
| Host        | Port | HTTP port | Status   | Leader count | Leader distribution            | Partition distribution         | Version |
+-------------+------+-----------+----------+--------------+--------------------------------+--------------------------------+---------+
| "storaged0" | 9779 | "ONLINE" | 7            | "basketballplayer:3, test:4"   | "basketballplayer:10, test:10" | "3.5.0" |
| "storaged1" | 9779 | "ONLINE" | 7            | "basketballplayer:4, test:3"   | "basketballplayer:10, test:10" | "3.5.0" |
| "storaged2" | 9779 | "ONLINE" | 6            | "basketballplayer:3, test:3"   | "basketballplayer:10, test:10" | "3.5.0" |
+-------------+------+----------+--------------+--------------------------------+--------------------------------+---------+
```

Last update: May 29, 2023

4.8.2 USE

`USE` specifies a graph space as the current working graph space for subsequent queries.

Prerequisites

Running the `USE` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

```
USE <graph_space_name>;
```

Examples

```
# The following example creates two sample spaces.
nebula> CREATE SPACE IF NOT EXISTS space1 (vid_type=FIXED_STRING(30));
nebula> CREATE SPACE IF NOT EXISTS space2 (vid_type=FIXED_STRING(30));

# The following example specifies space1 as the current working graph space.
nebula> USE space1;

# The following example specifies space2 as the current working graph space. Hereafter, you cannot read any data from space1, because these vertices and edges being traversed have no relevance with space1.
nebula> USE space2;
```

Caution

You cannot use two graph spaces in one statement.

Different from Fabric Cypher, graph spaces in NebulaGraph are fully isolated from each other. Making a graph space as the working graph space prevents you from accessing other spaces. The only way to traverse in a new graph space is to switch by the `USE` statement. In Fabric Cypher, you can use two graph spaces in one statement (using the `USE + CALL` syntax). But in NebulaGraph, you can only use one graph space in one statement.

Last update: August 11, 2022

4.8.3 SHOW SPACES

`SHOW SPACES` lists all the graph spaces in the NebulaGraph examples.

Syntax

```
SHOW SPACES;
```

Example

```
nebula> SHOW SPACES;
+--------------------+
| Name               |
+--------------------+
| "cba"              |
| "basketballplayer" |
+--------------------+
```

To create graph spaces, see CREATE SPACE.

Last update: August 11, 2022

4.8.4 DESCRIBE SPACE

`DESCRIBE SPACE` returns the information about the specified graph space.

Syntax

You can use `DESC` instead of `DESCRIBE` for short.

```
DESC[RIBE] SPACE <graph_space_name>;
```

The `DESCRIBE SPACE` statement is different from the `SHOW SPACES` statement. For details about `SHOW SPACES`, see SHOW SPACES.

Example

```
nebula> DESCRIBE SPACE basketballplayer;
+----+--------------------+------------------+----------------+---------+------------+--------------------+---------+
| ID | Name               | Partition Number | Replica Factor | Charset | Collate    | Vid Type           | Comment |
+----+--------------------+------------------+----------------+---------+------------+--------------------+---------+
| 1  | "basketballplayer" | 10               | 1              | "utf8"  | "utf8_bin" | "FIXED_STRING(32)" |         |
+----+--------------------+------------------+----------------+---------+------------+--------------------+---------+
```

Last update: May 13, 2022

4.8.5 CLEAR SPACE

`CLEAR SPACE` deletes the vertices and edges in a graph space, but does not delete the graph space itself and the schema information.

Note

It is recommended to execute `SUBMIT JOB COMPACT` immediately after executing the `CLEAR SPACE` operation improve the query performance. Note that the COMPACT operation may affect query performance, and it is recommended to perform this operation during low business hours (e.g., early morning).

Permission requirements

Only the God role has the permission to run `CLEAR SPACE`.

Caution

- Once cleared, the data **CANNOT be recovered**. Use `CLEAR SPACE` with caution.
- `CLEAR SPACE` is not an atomic operation. If an error occurs, re-run `CLEAR SPACE` to avoid data remaining.
- The larger the amount of data in the graph space, the longer it takes to clear it. If the execution fails due to client connection timeout, increase the value of the `storage_client_timeout_ms` parameter in the Graph Service configuration.
- During the execution of `CLEAR SPACE`, writing data into the graph space is not automatically prohibited. Such write operations can result in incomplete data clearing, and the residual data can be damaged.

Note

The NebulaGraph Community Edition does not support blocking data writing while allowing `CLEAR SPACE`.

Syntax

```
CLEAR SPACE [IF EXISTS] <space_name>;
```

Parameter/ Option	Description
`IF EXISTS`	Check whether the graph space to be cleared exists. If it exists, continue to clear it. If it does not exist, the execution finishes, and a message indicating that the execution succeeded is displayed. If `IF EXISTS` is not set and the graph space does not exist, the `CLEAR SPACE` statement fails to execute, and an error occurs.
`space_name`	The name of the space to be cleared.

Example:

```
CLEAR SPACE basketballplayer;
```

Data reserved

`CLEAR SPACE` does not delete the following data in a graph space:

- Tag information.
- Edge type information.
- The metadata of native indexes and full-text indexes.

The following example shows what `CLEAR SPACE` deletes and reserves.

```
# Enter the graph space basketballplayer.
nebula [(none)]> use basketballplayer;
Execution succeeded

# List tags and Edge types.
nebula[basketballplayer]> SHOW TAGS;
+----------+
| Name     |
+----------+
| "player" |
| "team"   |
+----------+
Got 2 rows

nebula[basketballplayer]> SHOW EDGES;
+----------+
| Name     |
+----------+
| "follow" |
| "serve"  |
+----------+
Got 2 rows

# Submit a job to make statistics of the graph space.
nebula[basketballplayer]> SUBMIT JOB STATS;
+------------+
| New Job Id |
+------------+
| 4          |
+------------+
Got 1 rows

# Check the statistics.
nebula[basketballplayer]> SHOW STATS;
+---------+------------+-------+
| Type    | Name       | Count |
+---------+------------+-------+
| "Tag"   | "player"   | 51    |
| "Tag"   | "team"     | 30    |
| "Edge"  | "follow"   | 81    |
| "Edge"  | "serve"    | 152   |
| "Space" | "vertices" | 81    |
| "Space" | "edges"    | 233   |
+---------+------------+-------+
Got 6 rows

# List tag indexes.
nebula[basketballplayer]> SHOW TAG INDEXES;
+------------------+----------+----------+
| Index Name       | By Tag   | Columns  |
+------------------+----------+----------+
| "player_index_0" | "player" | []       |
| "player_index_1" | "player" | ["name"] |
+------------------+----------+----------+
Got 2 rows

# ----------------------- Dividing line for CLEAR SPACE -----------------------
# Run CLEAR SPACE to clear the graph space basketballplayer.
nebula[basketballplayer]> CLEAR SPACE basketballplayer;
Execution succeeded

# Update the statistics.
nebula[basketballplayer]> SUBMIT JOB STATS;
+------------+
| New Job Id |
+------------+
| 5          |
+------------+
Got 1 rows

# Check the statistics. The tags and edge types still exist, but all the vertices and edges are gone.
nebula[basketballplayer]> SHOW STATS;
+---------+------------+-------+
| Type    | Name       | Count |
+---------+------------+-------+
| "Tag"   | "player"   | 0     |
| "Tag"   | "team"     | 0     |
| "Edge"  | "follow"   | 0     |
| "Edge"  | "serve"    | 0     |
| "Space" | "vertices" | 0     |
| "Space" | "edges"    | 0     |
+---------+------------+-------+
Got 6 rows

# Try to list the tag indexes. They still exist.
nebula[basketballplayer]> SHOW TAG INDEXES;
+------------------+----------+----------+
| Index Name       | By Tag   | Columns  |
+------------------+----------+----------+
| "player_index_0" | "player" | []       |
| "player_index_1" | "player" | ["name"] |
```

```
+------------------+----------+----------+
Got 2 rows (time spent 523/978 us)
```

Last update: December 23, 2022

4.8.6 DROP SPACE

`DROP SPACE` deletes the specified graph space and everything in it.

Note

`DROP SPACE` can only delete the specified logic graph space while retain all the data on the hard disk by modifying the value of `auto_remove_invalid_space` to `false` in the Storage service configuration file. For more information, see Storage configuration.

Warning

After you execute `DROP SPACE`, even if the snapshot contains data of the graph space, the data of the graph space cannot be recovered. But if the value of `auto_remove_invalid_space` is set to `false`, contact the sales team to recover the data of the graph space.

Prerequisites

Only the God role can use the `DROP SPACE` statement. For more information, see AUTHENTICATION.

Syntax

```
DROP SPACE [IF EXISTS] <graph_space_name>;
```

You can use the `IF EXISTS` keywords when dropping spaces. These keywords automatically detect if the related graph space exists. If it exists, it will be deleted. Otherwise, no graph space will be deleted.

Legacy version compatibility

In NebulaGraph versions earlier than 3.1.0, the `DROP SPACE` statement does not remove all the files and directories from the disk by default.

Caution

BE CAUTIOUS about running the `DROP SPACE` statement.

FAQ

Q: Why is my disk space not freed after executing the 'DROP SPACE' statement and deleting a graph space?

A: For NebulaGraph version earlier than 3.1.0, `DROP SPACE` can only delete the specified logic graph space and does not delete the files and directories on the disk. To delete the files and directories on the disk, manually delete the corresponding file path. The file path is located in `<nebula_graph_install_path>/data/storage/nebula/<space_id>`. The `<space_id>` can be viewed via `DESCRIBE SPACE {space_name}`.

Last update: January 11, 2023

4.9 Tag statements

4.9.1 CREATE TAG

`CREATE TAG` creates a tag with the given name in a graph space.

OpenCypher compatibility

Tags in nGQL are similar to labels in openCypher. But they are also quite different. For example, the ways to create them are different.

- In openCypher, labels are created together with vertices in `CREATE` statements.
- In nGQL, tags are created separately using `CREATE TAG` statements. Tags in nGQL are more like tables in MySQL.

Prerequisites

Running the `CREATE TAG` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

To create a tag in a specific graph space, you must specify the current working space with the `USE` statement.

```
CREATE TAG [IF NOT EXISTS] <tag_name>
    (
      <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']
      [{, <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']} ...]
    )
    [TTL_DURATION = <ttl_duration>]
```

```
[TTL_COL = <prop_name>]
[COMMENT = '<comment>'];
```

Parameter	Description
`IF NOT EXISTS`	Detects if the tag that you want to create exists. If it does not exist, a new one will be created. The tag existence detection here only compares the tag names (excluding properties).
`<tag_name>`	1. Each tag name in the graph space must be **unique**. 2. Tag names cannot be modified after they are set. 3. Tag names cannot start with a number; they support 1-4 byte UTF-8 encoded characters, including English letters (case sensitive), numbers, Chinese characters, etc., but do not support special characters other than underscores. To use special characters, reserved keywords, or start with a number in a tag name, enclose them in backticks (\`), and do not use periods ( `.` ) in a tag name. For more information, see Keywords and reserved words. **Note**: If you name a tag in Chinese and encounter a `SyntaxError`, you need to quote the Chinese characters with backticks (\`).
`<prop_name>`	The name of the property. It must be unique for each tag. The rules for permitted property names are the same as those for tag names.
`<data_type>`	Shows the data type of each property. For a full description of the property data types, see Data types and Boolean.
`NULL | NOT NULL`	Specifies if the property supports `NULL | NOT NULL`. The default value is `NULL`. `DEFAULT` must be specified if `NOT NULL` is set.
`DEFAULT`	Specifies a default value for a property. The default value can be a literal value or an expression supported by NebulaGraph. If no value is specified, the default value is used when inserting a new vertex.
`COMMENT`	The remarks of a certain property or the tag itself. The maximum length is 256 bytes. By default, there will be no comments on a tag.
`TTL_DURATION`	Specifies the life cycle for the property. The property that exceeds the specified TTL expires. The expiration threshold is the `TTL_COL` value plus the `TTL_DURATION`. The default value of `TTL_DURATION` is `0`. It means the data never expires.
`TTL_COL`	Specifies the property to set a timeout on. The data type of the property must be `int` or `timestamp`. A tag can only specify one field as `TTL_COL`. For more information on TTL, see TTL options.

EXAMPLES

```
nebula> CREATE TAG IF NOT EXISTS player(name string, age int);

# The following example creates a tag with no properties.
nebula> CREATE TAG IF NOT EXISTS no_property();

# The following example creates a tag with a default value.
nebula> CREATE TAG IF NOT EXISTS player_with_default(name string, age int DEFAULT 20);

# In the following example, the TTL of the create_time field is set to be 100 seconds.
nebula> CREATE TAG IF NOT EXISTS woman(name string, age int, \
        married bool, salary double, create_time timestamp) \
        TTL_DURATION = 100, TTL_COL = "create_time";
```

Implementation of the operation

Trying to use a newly created tag may fail because the creation of the tag is implemented asynchronously. To make sure the follow-up operations work as expected, Wait for two heartbeat cycles, i.e., 20 seconds.

To change the heartbeat interval, modify the `heartbeat_interval_secs` parameter in the configuration files for all services.

Last update: April 25, 2023

4.9.2 DROP TAG

`DROP TAG` drops a tag with the given name in the current working graph space.

A vertex can have one or more tags.

- If a vertex has only one tag, the vertex **CANNOT** be accessed after you drop it. The vertex will be dropped in the next compaction. But its edges are available, this operation will result in dangling edges.
- If a vertex has multiple tags, the vertex is still accessible after you drop one of them. But all the properties defined by this dropped tag **CANNOT** be accessed.

This operation only deletes the Schema data. All the files or directories in the disk will not be deleted directly until the next compaction.

Compatibility

In NebulaGraph 3.5.0, inserting vertex without tag is not supported by default. If you want to use the vertex without tags, add `--graph_use_vertex_key=true` to the configuration files (`nebula-graphd.conf`) of all Graph services in the cluster, and add `--use_vertex_key=true` to the configuration files (`nebula-storaged.conf`) of all Storage services in the cluster.

Prerequisites

- Running the `DROP TAG` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.
- Before you drop a tag, make sure that the tag does not have any indexes. Otherwise, the conflict error (`[ERROR (-1005)]: Conflict!`) will be returned when you run the `DROP TAG` statement. To drop an index, see DROP INDEX.

Syntax

```
DROP TAG [IF EXISTS] <tag_name>;
```

- `IF NOT EXISTS` : Detects if the tag that you want to drop exists. Only when it exists will it be dropped.
- `tag_name` : Specifies the tag name that you want to drop. You can drop only one tag in one statement.

Example

```
nebula> CREATE TAG IF NOT EXISTS test(p1 string, p2 int);
nebula> DROP TAG test;
```

Last update: October 31, 2022

4.9.3 ALTER TAG

`ALTER TAG` alters the structure of a tag with the given name in a graph space. You can add or drop properties, and change the data type of an existing property. You can also set a TTL (Time-To-Live) on a property, or change its TTL duration.

Notes

- Running the `ALTER TAG` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.
- Before you alter properties for a tag, make sure that the properties are not indexed. If the properties contain any indexes, the conflict error `[ERROR (-1005)]: Conflict!` will occur when you `ALTER TAG`. For more information on dropping an index, see DROP INDEX.
- The property name must be unique in a tag. If you add a property with the same name as an existing property or a dropped property, the operation fails.

Syntax

```
ALTER TAG <tag_name>
    <alter_definition> [[, alter_definition] ...]
    [ttl_definition [, ttl_definition] ... ]
    [COMMENT '<comment>'];

alter_definition:
| ADD    (prop_name data_type [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>'])
| DROP   (prop_name)
| CHANGE (prop_name data_type [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>'])

ttl_definition:
    TTL_DURATION = ttl_duration, TTL_COL = prop_name
```

- `tag_name`: Specifies the tag name that you want to alter. You can alter only one tag in one statement. Before you alter a tag, make sure that the tag exists in the current working graph space. If the tag does not exist, an error will occur when you alter it.
- Multiple `ADD`, `DROP`, and `CHANGE` clauses are permitted in a single `ALTER TAG` statement, separated by commas.
- When a property value is set to `NOT NULL` using `ADD` or `CHANGE`, a default value must be specified for the property, that is, the value of `DEFAULT` must be specified.
- When using `CHANGE` to modify the data type of a property:
- Only the length of a `FIXED_STRING` or an `INT` can be increased. The length of a `STRING` or an `INT` cannot be decreased.
- Only the data type conversions from FIXED_STRING to STRING and from FLOAT to DOUBLE are allowed.

Examples

```
nebula> CREATE TAG IF NOT EXISTS t1 (p1 string, p2 int);
nebula> ALTER TAG t1 ADD (p3 int32, fixed_string(10));
nebula> ALTER TAG t1 TTL_DURATION = 2, TTL_COL = "p2";
nebula> ALTER TAG t1 COMMENT = 'test1';
nebula> ALTER TAG t1 ADD (p5 double NOT NULL DEFAULT 0.4 COMMENT 'p5') COMMENT='test2';
// Change the data type of p3 in the TAG t1 from INT32 to INT64, and that of p4 from FIXED_STRING(10) to STRING.
nebula> ALTER TAG t1 CHANGE (p3 int64, p4 string);
[ERROR(-1005)]: Unsupported!
```

Implementation of the operation

Trying to use a newly altered tag may fail because the alteration of the tag is implemented asynchronously. To make sure the follow-up operations work as expected, Wait for two heartbeat cycles, i.e., 20 seconds.

To change the heartbeat interval, modify the `heartbeat_interval_secs` parameter in the configuration files for all services.

Last update: March 27, 2023

4.9.4 SHOW TAGS

The `SHOW TAGS` statement shows the name of all tags in the current graph space.

You do not need any privileges for the graph space to run the `SHOW TAGS` statement. But the returned results are different based on role privileges.

Syntax

```
SHOW TAGS;
```

Examples

```
nebula> SHOW TAGS;
+----------+
| Name     |
+----------+
| "player" |
| "team"   |
+----------+
```

Last update: October 27, 2021

4.9.5 DESCRIBE TAG

`DESCRIBE TAG` returns the information about a tag with the given name in a graph space, such as field names, data type, and so on.

Prerequisite

Running the `DESCRIBE TAG` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

```
DESC[RIBE] TAG <tag_name>;
```

You can use `DESC` instead of `DESCRIBE` for short.

Example

```
nebula> DESCRIBE TAG player;
+--------+----------+-------+---------+---------+
| Field  | Type     | Null  | Default | Comment |
+--------+----------+-------+---------+---------+
| "name" | "string" | "YES" |         |         |
| "age"  | "int64"  | "YES" |         |         |
+--------+----------+-------+---------+---------+
```

Last update: August 11, 2022

4.9.6 DELETE TAG

`DELETE TAG` deletes a tag with the given name on a specified vertex.

Prerequisites

Running the `DELETE TAG` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

```
DELETE TAG <tag_name_list> FROM <VID>;
```

- `tag_name_list` : Specifies the name of the tag. Multiple tags are separated with commas (,). `*` means all tags.
- `VID` : Specifies the VID of the tag to delete.

Example

```
nebula> CREATE TAG IF NOT EXISTS test1(p1 string, p2 int);
nebula> CREATE TAG IF NOT EXISTS test2(p3 string, p4 int);
nebula> INSERT VERTEX test1(p1, p2),test2(p3, p4) VALUES "test":("123", 1, "456", 2);
nebula> FETCH PROP ON * "test" YIELD vertex AS v;
+------------------------------------------------------------+
| v                                                          |
+------------------------------------------------------------+
| ("test" :test1{p1: "123", p2: 1} :test2{p3: "456", p4: 2}) |
+------------------------------------------------------------+
nebula> DELETE TAG test1 FROM "test";
nebula> FETCH PROP ON * "test" YIELD vertex AS v;
+-----------------------------------+
| v                                 |
+-----------------------------------+
| ("test" :test2{p3: "456", p4: 2}) |
+-----------------------------------+
nebula> DELETE TAG * FROM "test";
nebula> FETCH PROP ON * "test" YIELD vertex AS v;
+---+
| v |
+---+
+---+
```

Compatibility

- In openCypher, you can use the statement `REMOVE v:LABEL` to delete the tag `LABEL` of the vertex `v` .
- `DELETE TAG` and `DROP TAG` have the same semantics but different syntax. In nGQL, use `DELETE TAG` .

Last update: August 11, 2022

4.9.7 Add and delete tags

OpenCypher has the features of `SET label` and `REMOVE label` to speed up the process of querying or labeling.

NebulaGraph achieves the same operations by creating and inserting tags to an existing vertex, which can quickly query vertices based on the tag name. Users can also run `DELETE TAG` to delete some vertices that are no longer needed.

Examples

For example, in the `basketballplayer` data set, some basketball players are also team shareholders. Users can create an index for the shareholder tag `shareholder` for quick search. If the player is no longer a shareholder, users can delete the shareholder tag of the corresponding player by `DELETE TAG`.

```
//This example creates the shareholder tag and index.
nebula> CREATE TAG IF NOT EXISTS shareholder();
nebula> CREATE TAG INDEX IF NOT EXISTS shareholder_tag on shareholder();

//This example adds a tag on the vertex.
nebula> INSERT VERTEX shareholder() VALUES "player100":();
nebula> INSERT VERTEX shareholder() VALUES "player101":();

//This example queries all the shareholders.
nebula> MATCH (v:shareholder) RETURN v;
+---------------------------------------------------------------------+
| v                                                                   |
+---------------------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"} :shareholder{})  |
| ("player101" :player{age: 36, name: "Tony Parker"} :shareholder{}) |
+---------------------------------------------------------------------+

nebula> LOOKUP ON shareholder YIELD id(vertex);
+-------------+
| id(VERTEX)  |
+-------------+
| "player100" |
| "player101" |
+-------------+

//In this example, the "player100" is no longer a shareholder.
nebula> DELETE TAG shareholder FROM "player100";
nebula> LOOKUP ON shareholder YIELD id(vertex);
+-------------+
| id(VERTEX)  |
+-------------+
| "player101" |
+-------------+
```

Note

If the index is created after inserting the test data, use the `REBUILD TAG INDEX <index_name_list>;` statement to rebuild the index.

Last update: August 11, 2022

4.10 Edge type statements

4.10.1 CREATE EDGE

`CREATE EDGE` creates an edge type with the given name in a graph space.

OpenCypher compatibility

Edge types in nGQL are similar to relationship types in openCypher. But they are also quite different. For example, the ways to create them are different.

- In openCypher, relationship types are created together with vertices in `CREATE` statements.
- In nGQL, edge types are created separately using `CREATE EDGE` statements. Edge types in nGQL are more like tables in MySQL.

Prerequisites

Running the `CREATE EDGE` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

To create an edge type in a specific graph space, you must specify the current working space with the `USE` statement.

```
CREATE EDGE [IF NOT EXISTS] <edge_type_name>
    (
      <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']
      [{, <prop_name> <data_type> [NULL | NOT NULL] [DEFAULT <default_value>] [COMMENT '<comment>']} ...]
    )
    [TTL_DURATION = <ttl_duration>]
```

```
[TTL_COL = <prop_name>]
[COMMENT = '<comment>'];
```

Parameter	Description
`IF NOT EXISTS`	Detects if the edge type that you want to create exists. If it does not exist, a new one will be created. The edge type existence detection here only compares the edge type names (excluding properties).
`<edge_type_name>`	1. The edge type name must be **unique** in a graph space. 2. Once the edge type name is set, it can not be altered. 3. Edge type names cannot start with a number; they support 1-4 byte UTF-8 encoded characters, including English letters (case sensitive), numbers, Chinese characters, etc., but do not include special characters other than underscores. To use special characters, reserved keywords or starting with a number, quote them with backticks (\`) and cannot use periods ( `.` ). For more information, see Keywords and reserved words. **Note**: If you name an edge type in Chinese and encounter a `SyntaxError`, you need to quote the Chinese characters with backticks (\`).
`<prop_name>`	The name of the property. It must be unique for each edge type. The rules for permitted property names are the same as those for edge type names.
`<data_type>`	Shows the data type of each property. For a full description of the property data types, see Data types and Boolean.
`NULL | NOT NULL`	Specifies if the property supports `NULL | NOT NULL`. The default value is `NULL`. `DEFAULT` must be specified if `NOT NULL` is set.
`DEFAULT`	Specifies a default value for a property. The default value can be a literal value or an expression supported by NebulaGraph. If no value is specified, the default value is used when inserting a new edge.
`COMMENT`	The remarks of a certain property or the edge type itself. The maximum length is 256 bytes. By default, there will be no comments on an edge type.
`TTL_DURATION`	Specifies the life cycle for the property. The property that exceeds the specified TTL expires. The expiration threshold is the `TTL_COL` value plus the `TTL_DURATION`. The default value of `TTL_DURATION` is `0`. It means the data never expires.
`TTL_COL`	Specifies the property to set a timeout on. The data type of the property must be `int` or `timestamp`. An edge type can only specify one field as `TTL_COL`. For more information on TTL, see TTL options.

EXAMPLES

```
nebula> CREATE EDGE IF NOT EXISTS follow(degree int);

# The following example creates an edge type with no properties.
nebula> CREATE EDGE IF NOT EXISTS no_property();

# The following example creates an edge type with a default value.
nebula> CREATE EDGE IF NOT EXISTS follow_with_default(degree int DEFAULT 20);

# In the following example, the TTL of the p2 field is set to be 100 seconds.
nebula> CREATE EDGE IF NOT EXISTS e1(p1 string, p2 int, p3 timestamp) \
        TTL_DURATION = 100, TTL_COL = "p2";
```

Last update: April 25, 2023

4.10.2 DROP EDGE

`DROP EDGE` drops an edge type with the given name in a graph space.

An edge can have only one edge type. After you drop it, the edge **CANNOT** be accessed. The edge will be deleted in the next compaction.

This operation only deletes the Schema data. All the files or directories in the disk will not be deleted directly until the next compaction.

Prerequisites

- Running the `DROP EDGE` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.
- Before you drop an edge type, make sure that the edge type does not have any indexes. Otherwise, the conflict error (`[ERROR (-1005)]: Conflict!`) will be returned. To drop an index, see DROP INDEX.

Syntax

```
DROP EDGE [IF EXISTS] <edge_type_name>
```

- `IF NOT EXISTS`: Detects if the edge type that you want to drop exists. Only when it exists will it be dropped.
- `edge_type_name`: Specifies the edge type name that you want to drop. You can drop only one edge type in one statement.

Example

```
nebula> CREATE EDGE IF NOT EXISTS e1(p1 string, p2 int);
nebula> DROP EDGE e1;
```

Last update: August 11, 2022

4.10.3 ALTER EDGE

`ALTER EDGE` alters the structure of an edge type with the given name in a graph space. You can add or drop properties, and change the data type of an existing property. You can also set a TTL (Time-To-Live) on a property, or change its TTL duration.

Notes

- Running the `ALTER EDGE` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.
- Before you alter properties for an edge type, make sure that the properties are not indexed. If the properties contain any indexes, the conflict error `[ERROR (-1005)]: Conflict!` will occur when you `ALTER EDGE`. For more information on dropping an index, see DROP INDEX.
- The property name must be unique in an edge type. If you add a property with the same name as an existing property or a dropped property, the operation fails.
- Only the length of a `FIXED_STRING` or an `INT` can be increased.
- Only the data type conversions from FIXED_STRING to STRING and from FLOAT to DOUBLE are allowed.

Syntax

```
ALTER EDGE <edge_type_name>
    <alter_definition> [, alter_definition] ...]
    [ttl_definition [, ttl_definition] ... ]
    [COMMENT = '<comment>'];

alter_definition:
| ADD    (prop_name data_type)
| DROP   (prop_name)
| CHANGE (prop_name data_type)

ttl_definition:
    TTL_DURATION = ttl_duration, TTL_COL = prop_name
```

- `edge_type_name`: Specifies the edge type name that you want to alter. You can alter only one edge type in one statement. Before you alter an edge type, make sure that the edge type exists in the graph space. If the edge type does not exist, an error occurs when you alter it.
- Multiple `ADD`, `DROP`, and `CHANGE` clauses are permitted in a single `ALTER EDGE` statement, separated by commas.
- When a property value is set to `NOT NULL` using `ADD` or `CHANGE`, a default value must be specified for the property, that is, the value of `DEFAULT` must be specified.

Example

```
nebula> CREATE EDGE IF NOT EXISTS e1(p1 string, p2 int);
nebula> ALTER EDGE e1 ADD (p3 int, p4 string);
nebula> ALTER EDGE e1 TTL_DURATION = 2, TTL_COL = "p2";
nebula> ALTER EDGE e1 COMMENT = 'edge1';
```

Implementation of the operation

Trying to use a newly altered edge type may fail because the alteration of the edge type is implemented asynchronously. To make sure the follow-up operations work as expected, Wait for two heartbeat cycles, i.e., 20 seconds.

To change the heartbeat interval, modify the `heartbeat_interval_secs` parameter in the configuration files for all services.

Last update: February 7, 2023

4.10.4 SHOW EDGES

`SHOW EDGES` shows all edge types in the current graph space.

You do not need any privileges for the graph space to run the `SHOW EDGES` statement. But the returned results are different based on role privileges.

Syntax

```
SHOW EDGES;
```

Example

```
nebula> SHOW EDGES;
+----------+
| Name     |
+----------+
| "follow" |
| "serve"  |
+----------+
```

Last update: October 27, 2021

4.10.5 DESCRIBE EDGE

`DESCRIBE EDGE` returns the information about an edge type with the given name in a graph space, such as field names, data type, and so on.

Prerequisites

Running the `DESCRIBE EDGE` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

```
DESC[RIBE] EDGE <edge_type_name>
```

You can use `DESC` instead of `DESCRIBE` for short.

Example

```
nebula> DESCRIBE EDGE follow;
+----------+---------+-------+---------+---------+
| Field    | Type    | Null  | Default | Comment |
+----------+---------+-------+---------+---------+
| "degree" | "int64" | "YES" |         |         |
+----------+---------+-------+---------+---------+
```

Last update: August 11, 2022

4.11 Vertex statements

4.11.1 INSERT VERTEX

The `INSERT VERTEX` statement inserts one or more vertices into a graph space in NebulaGraph.

Prerequisites

Running the `INSERT VERTEX` statement requires some privileges for the graph space. Otherwise, NebulaGraph throws an error.

Syntax

```
INSERT VERTEX [IF NOT EXISTS] [tag_props, [tag_props] ...]
VALUES VID: ([prop_value_list])

tag_props:
  tag_name ([prop_name_list])

prop_name_list:
   [prop_name [, prop_name] ...]

prop_value_list:
   [prop_value [, prop_value] ...]
```

- `IF NOT EXISTS` detects if the VID that you want to insert exists. If it does not exist, a new one will be inserted.

Note

- `IF NOT EXISTS` only compares the names of the VID and the tag (excluding properties).
- `IF NOT EXISTS` will read to check whether the data exists, which will have a significant impact on performance.

- `tag_name` denotes the tag (vertex type), which must be created before `INSERT VERTEX`. For more information, see CREATE TAG.

Caution

NebulaGraph 3.5.0 supports inserting vertices without tags.

Compatibility

In NebulaGraph 3.5.0, inserting vertex without tag is not supported by default. If you want to use the vertex without tags, add `--graph_use_vertex_key=true` to the configuration files (`nebula-graphd.conf`) of all Graph services in the cluster, add `--use_vertex_key=true` to the configuration files (`nebula-storaged.conf`) of all Storage services in the cluster. An example of a command to insert a vertex without tag is `INSERT VERTEX VALUES "1":();` .

- `prop_name_list` contains the names of the properties on the tag.
- `VID` is the vertex ID. In NebulaGraph 2.0, string and integer VID types are supported. The VID type is set when a graph space is created. For more information, see CREATE SPACE.
- `prop_value_list` must provide the property values according to the `prop_name_list`. When the `NOT NULL` constraint is set for a given property, an error is returned if no property is given. When the default value for a property is `NULL`, you can omit to specify the property value. For details, see CREATE TAG.

Caution

`INSERT VERTEX` and `CREATE` have different semantics.

- The semantics of `INSERT VERTEX` is closer to that of INSERT in NoSQL (key-value), or `UPSERT` (`UPDATE` or `INSERT`) in SQL.
- When two INSERT statements (neither uses `IF NOT EXISTS`) with the same `VID` and `TAG` are operated at the same time, the latter INSERT will overwrite the former.
- When two INSERT statements with the same `VID` but different `TAGS` are operated at the same time, the operation of different tags will not overwrite each other.

Examples are as follows.

Examples

```
# Insert a vertex without tag.
nebula> INSERT VERTEX VALUES "1":();

# The following examples create tag t1 with no property and inserts vertex "10" with no property.
nebula> CREATE TAG IF NOT EXISTS t1();
nebula> INSERT VERTEX t1() VALUES "10":();
```

```
nebula> CREATE TAG IF NOT EXISTS t2 (name string, age int);
nebula> INSERT VERTEX t2 (name, age) VALUES "11":("n1", 12);

#  In the following example, the insertion fails because "a13" is not int.
nebula> INSERT VERTEX t2 (name, age) VALUES "12":("n1", "a13");

# The following example inserts two vertices at one time.
nebula> INSERT VERTEX t2 (name, age) VALUES "13":("n3", 12), "14":("n4", 8);
```

```
nebula> CREATE TAG IF NOT EXISTS t3(p1 int);
nebula> CREATE TAG IF NOT EXISTS t4(p2 string);

# The following example inserts vertex "21" with two tags.
nebula> INSERT VERTEX t3 (p1), t4(p2) VALUES "21": (321, "hello");
```

A vertex can be inserted/written with new values multiple times. Only the last written values can be read.

```
# The following examples insert vertex "11" with new values for multiple times.
nebula> INSERT VERTEX t2 (name, age) VALUES "11":("n2", 13);
nebula> INSERT VERTEX t2 (name, age) VALUES "11":("n3", 14);
nebula> INSERT VERTEX t2 (name, age) VALUES "11":("n4", 15);
nebula> FETCH PROP ON t2 "11" YIELD properties(vertex);
+-----------------------+
| properties(VERTEX)    |
+-----------------------+
| {age: 15, name: "n4"} |
+-----------------------+
```

```
nebula> CREATE TAG IF NOT EXISTS t5(p1 fixed_string(5) NOT NULL, p2 int, p3 int DEFAULT NULL);
nebula> INSERT VERTEX t5(p1, p2, p3) VALUES "001":("Abe", 2, 3);

# In the following example, the insertion fails because the value of p1 cannot be NULL.
nebula> INSERT VERTEX t5(p1, p2, p3) VALUES "002":(NULL, 4, 5);
[ERROR (-1009)]: SemanticError: No schema found for `t5'

# In the following example, the value of p3 is the default NULL.
nebula> INSERT VERTEX t5(p1, p2) VALUES "003":("cd", 5);
nebula> FETCH PROP ON t5 "003" YIELD properties(vertex);
+---------------------------------+
| properties(VERTEX)              |
+---------------------------------+
| {p1: "cd", p2: 5, p3: __NULL__} |
+---------------------------------+

# In the following example, the allowed maximum length of p1 is 5.
nebula> INSERT VERTEX t5(p1, p2) VALUES "004":("shalalalala", 4);
nebula> FETCH PROP on t5 "004" YIELD properties(vertex);
+------------------------------------+
| properties(VERTEX)                 |
+------------------------------------+
| {p1: "shala", p2: 4, p3: __NULL__} |
+------------------------------------+
```

If you insert a vertex that already exists with `IF NOT EXISTS`, there will be no modification.

```
# The following example inserts vertex "1".
nebula> INSERT VERTEX t2 (name, age) VALUES "1":("n2", 13);
# Modify vertex "1" with IF NOT EXISTS. But there will be no modification as vertex "1" already exists.
nebula> INSERT VERTEX IF NOT EXISTS t2 (name, age) VALUES "1":("n3", 14);
nebula> FETCH PROP ON t2 "1" YIELD properties(vertex);
+-----------------------+
| properties(VERTEX)    |
+-----------------------+
| {age: 13, name: "n2"} |
+-----------------------+
```

Last update: October 31, 2022

4.11.2 DELETE VERTEX

By default, the `DELETE VERTEX` statement deletes vertices but the incoming and outgoing edges of the vertices.

Compatibility

- NebulaGraph 2.x deletes vertices and their incoming and outgoing edges.
- NebulaGraph 3.5.0 only deletes the vertices, and does not delete the related outgoing and incoming edges of the vertices. At this time, there will be dangling edges by default.

The `DELETE VERTEX` statement deletes one vertex or multiple vertices at a time. You can use `DELETE VERTEX` together with pipes. For more information about pipe, see Pipe operator.

Note

- `DELETE VERTEX` deletes vertices directly.
- `DELETE TAG` deletes a tag with the given name on a specified vertex.

Syntax

```
DELETE VERTEX <vid> [, <vid> ...] [WITH EDGE];
```

- WITH EDGE: deletes vertices and the related incoming and outgoing edges of the vertices.

Examples

This query deletes the vertex whose ID is "team1".

```
# Delete the vertex whose VID is `team1` but the related incoming and outgoing edges are not deleted.
nebula> DELETE VERTEX "team1";

# Delete the vertex whose VID is `team1` and the related incoming and outgoing edges.
nebula> DELETE VERTEX "team1" WITH EDGE;
```

This query shows that you can use `DELETE VERTEX` together with pipe to delete vertices.

```
nebula> GO FROM "player100" OVER serve WHERE properties(edge).start_year == "2021" YIELD dst(edge) AS id | DELETE VERTEX $-.id;
```

Process of deleting vertices

Once NebulaGraph deletes the vertices, all edges (incoming and outgoing edges) of the target vertex will become dangling edges. When NebulaGraph deletes the vertices `WITH EDGE`, NebulaGraph traverses the incoming and outgoing edges related to the vertices and deletes them all. Then NebulaGraph deletes the vertices.

Caution

- Atomic deletion is not supported during the entire process for now. Please retry when a failure occurs to avoid partial deletion, which will cause pendent edges.
- Deleting a supernode takes a lot of time. To avoid connection timeout before the deletion is complete, you can modify the parameter `--storage_client_timeout_ms` in `nebula-graphd.conf` to extend the timeout period.

Last update: August 11, 2022

4.11.3 UPDATE VERTEX

The `UPDATE VERTEX` statement updates properties on tags of a vertex.

In NebulaGraph, `UPDATE VERTEX` supports compare-and-set (CAS).

Note

An `UPDATE VERTEX` statement can only update properties on **ONE TAG** of a vertex.

Syntax

```
UPDATE VERTEX ON <tag_name> <vid>
SET <update_prop>
[WHEN <condition>]
[YIELD <output>]
```

Parameter	Required	Description	Example
`ON <tag_name>`	Yes	Specifies the tag of the vertex. The properties to be updated must be on this tag.	`ON player`
`<vid>`	Yes	Specifies the ID of the vertex to be updated.	`"player100"`
`SET <update_prop>`	Yes	Specifies the properties to be updated and how they will be updated.	`SET age = age +1`
`WHEN <condition>`	No	Specifies the filter conditions. If `<condition>` evaluates to `false`, the `SET` clause will not take effect.	`WHEN name == "Tim"`
`YIELD <output>`	No	Specifies the output format of the statement.	`YIELD name AS Name`

Example

```
// This query checks the properties of vertex "player101".
nebula> FETCH PROP ON player "player101" YIELD properties(vertex);
+--------------------------------+
| properties(VERTEX)             |
+--------------------------------+
| {age: 36, name: "Tony Parker"} |
+--------------------------------+

// This query updates the age property and returns name and the new age.
nebula> UPDATE VERTEX ON player "player101" \
        SET age = age + 2 \
        WHEN name == "Tony Parker" \
        YIELD name AS Name, age AS Age;
+---------------+-----+
| Name          | Age |
+---------------+-----+
| "Tony Parker" | 38  |
+---------------+-----+
```

Last update: August 11, 2022

4.11.4 UPSERT VERTEX

The `UPSERT` statement is a combination of `UPDATE` and `INSERT`. You can use `UPSERT VERTEX` to update the properties of a vertex if it exists or insert a new vertex if it does not exist.

Note

An `UPSERT VERTEX` statement can only update the properties on **ONE TAG** of a vertex.

The performance of `UPSERT` is much lower than that of `INSERT` because `UPSERT` is a read-modify-write serialization operation at the partition level.

Danger

Don't use `UPSERT` for scenarios with highly concurrent writes. You can use `UPDATE` or `INSERT` instead.

Syntax

```
UPSERT VERTEX ON <tag> <vid>
SET <update_prop>
[WHEN <condition>]
[YIELD <output>]
```

Parameter	Required	Description	Example
`ON <tag>`	Yes	Specifies the tag of the vertex. The properties to be updated must be on this tag.	`ON player`
`<vid>`	Yes	Specifies the ID of the vertex to be updated or inserted.	`"player100"`
`SET <update_prop>`	Yes	Specifies the properties to be updated and how they will be updated.	`SET age = age +1`
`WHEN <condition>`	No	Specifies the filter conditions.	`WHEN name == "Tim"`
`YIELD <output>`	No	Specifies the output format of the statement.	`YIELD name AS Name`

Insert a vertex if it does not exist

If a vertex does not exist, it is created no matter the conditions in the `WHEN` clause are met or not, and the `SET` clause always takes effect. The property values of the new vertex depend on:

- How the `SET` clause is defined.
- Whether the property has a default value.

For example, if:

- The vertex to be inserted will have properties `name` and `age` based on the tag `player`.
- The `SET` clause specifies that `age = 30`.

Then the property values in different cases are listed as follows:

Are `WHEN` conditions met	If properties have default values	Value of `name`	Value of `age`
Yes	Yes	The default value	`30`
Yes	No	`NULL`	`30`
No	Yes	The default value	`30`
No	No	`NULL`	`30`

Here are some examples:

```
// This query checks if the following three vertices exist. The result "Empty set" indicates that the vertices do not exist.
nebula> FETCH PROP ON * "player666", "player667", "player668" YIELD properties(vertex);
+--------------------+
| properties(VERTEX) |
+--------------------+
+--------------------+
Empty set

nebula> UPSERT VERTEX ON player "player666" \
        SET age = 30 \
        WHEN name == "Joe" \
        YIELD name AS Name, age AS Age;
+----------+----------+
| Name     | Age      |
+----------+----------+
| __NULL__ | 30       |
+----------+----------+

nebula> UPSERT VERTEX ON player "player666" \
        SET age = 31 \
        WHEN name == "Joe" \
        YIELD name AS Name, age AS Age;
+----------+-----+
| Name     | Age |
+----------+-----+
| __NULL__ | 30  |
+----------+-----+

nebula> UPSERT VERTEX ON player "player667" \
        SET age = 31 \
        YIELD name AS Name, age AS Age;
+----------+-----+
| Name     | Age |
+----------+-----+
| __NULL__ | 31  |
+----------+-----+

nebula> UPSERT VERTEX ON player "player668" \
        SET name = "Amber", age = age + 1 \
        YIELD name AS Name, age AS Age;
+---------+----------+
| Name    | Age      |
+---------+----------+
| "Amber" | __NULL__ |
+---------+----------+
```

In the last query of the preceding examples, since `age` has no default value, when the vertex is created, `age` is `NULL`, and `age = age + 1` does not take effect. But if `age` has a default value, `age = age + 1` will take effect. For example:

```
nebula> CREATE TAG IF NOT EXISTS player_with_default(name string, age int DEFAULT 20);
Execution succeeded

nebula> UPSERT VERTEX ON player_with_default "player101" \
        SET age = age + 1 \
        YIELD name AS Name, age AS Age;

+----------+-----+
| Name     | Age |
+----------+-----+
| __NULL__ | 21  |
+----------+-----+
```

Update a vertex if it exists

If the vertex exists and the `WHEN` conditions are met, the vertex is updated.

```
nebula> FETCH PROP ON player "player101" YIELD properties(vertex);
+--------------------------------+
```

```
| properties(VERTEX)             |
+--------------------------------+
| {age: 36, name: "Tony Parker"} |
+--------------------------------+

nebula> UPSERT VERTEX ON player "player101" \
        SET age = age + 2 \
        WHEN name == "Tony Parker" \
        YIELD name AS Name, age AS Age;
+---------------+-----+
| Name          | Age |
+---------------+-----+
| "Tony Parker" | 38  |
+---------------+-----+
```

If the vertex exists and the `WHEN` conditions are not met, the update does not take effect.

```
nebula> FETCH PROP ON player "player101" YIELD properties(vertex);
+--------------------------------+
| properties(VERTEX)             |
+--------------------------------+
| {age: 38, name: "Tony Parker"} |
+--------------------------------+

nebula> UPSERT VERTEX ON player "player101" \
        SET age = age + 2 \
        WHEN name == "Someone else" \
        YIELD name AS Name, age AS Age;
+---------------+-----+
| Name          | Age |
+---------------+-----+
| "Tony Parker" | 38  |
+---------------+-----+
```

Last update: March 8, 2022

4.12 Edge statements

4.12.1 INSERT EDGE

The `INSERT EDGE` statement inserts an edge or multiple edges into a graph space from a source vertex (given by src_vid) to a destination vertex (given by dst_vid) with a specific rank in NebulaGraph.

When inserting an edge that already exists, `INSERT EDGE` **overrides** the edge.

Syntax

```
INSERT EDGE [IF NOT EXISTS] <edge_type> ( <prop_name_list> ) VALUES
<src_vid> -> <dst_vid>[@<rank>] : ( <prop_value_list> )
[, <src_vid> -> <dst_vid>[@<rank>] : ( <prop_value_list> ), ...];

<prop_name_list> ::=
  [ <prop_name> [, <prop_name> ] ...]

<prop_value_list> ::=
  [ <prop_value> [, <prop_value> ] ...]
```

- `IF NOT EXISTS` detects if the edge that you want to insert exists. If it does not exist, a new one will be inserted.

Note

- `IF NOT EXISTS` only detects whether exist and does not detect whether the property values overlap.
- `IF NOT EXISTS` will read to check whether the data exists, which will have a significant impact on performance.

- `<edge_type>` denotes the edge type, which must be created before `INSERT EDGE`. Only one edge type can be specified in this statement.
- `<prop_name_list>` is the property name list in the given `<edge_type>`.
- `src_vid` is the VID of the source vertex. It specifies the start of an edge.
- `dst_vid` is the VID of the destination vertex. It specifies the end of an edge.
- `rank` is optional. It specifies the edge rank of the same edge type. The data type is `int`. If not specified, the default value is `0`. You can insert many edges with the same edge type, source vertex, and destination vertex by using different rank values.

OpenCypher compatibility

OpenCypher has no such concept as rank.

- `<prop_value_list>` must provide the value list according to `<prop_name_list>`. If the property values do not match the data type in the edge type, an error is returned. When the `NOT NULL` constraint is set for a given property, an error is returned if no property is given. When the default value for a property is `NULL`, you can omit to specify the property value. For details, see CREATE EDGE.

Examples

```
# The following example creates edge type e1 with no property and inserts an edge from vertex "10" to vertex "11" with no property.
nebula> CREATE EDGE IF NOT EXISTS e1();
nebula> INSERT EDGE e1 () VALUES "10"->"11":();

# The following example inserts an edge from vertex "10" to vertex "11" with no property. The edge rank is 1.
nebula> INSERT EDGE e1 () VALUES "10"->"11"@1:();
```

```
nebula> CREATE EDGE IF NOT EXISTS e2 (name string, age int);
nebula> INSERT EDGE e2 (name, age) VALUES "11"->"13":("n1", 1);

# The following example creates edge type e2 with two properties.
nebula> INSERT EDGE e2 (name, age) VALUES \
        "12"->"13":("n1", 1), "13"->"14":("n2", 2);

# In the following example, the insertion fails because "a13" is not int.
nebula> INSERT EDGE e2 (name, age) VALUES "11"->"13":("n1", "a13");
```

An edge can be inserted/written with property values multiple times. Only the last written values can be read.

```
The following examples insert edge e2 with the new values for multiple times.
nebula> INSERT EDGE e2 (name, age) VALUES "11"->"13":("n1", 12);
nebula> INSERT EDGE e2 (name, age) VALUES "11"->"13":("n1", 13);
nebula> INSERT EDGE e2 (name, age) VALUES "11"->"13":("n1", 14);
nebula> FETCH PROP ON e2 "11"->"13" YIELD edge AS e;
+-------------------------------------------+
| e                                         |
+-------------------------------------------+
| [:e2 "11"->"13" @0 {age: 14, name: "n1"}] |
+-------------------------------------------+
```

If you insert an edge that already exists with `IF NOT EXISTS`, there will be no modification.

```
# The following example inserts edge e2 from vertex "14" to vertex "15".
nebula> INSERT EDGE e2 (name, age) VALUES "14"->"15"@1:("n1", 12);
# The following example alters the edge with IF NOT EXISTS. But there will be no alteration because edge e2 already exists.
nebula> INSERT EDGE IF NOT EXISTS e2 (name, age) VALUES "14"->"15"@1:("n2", 13);
nebula> FETCH PROP ON e2 "14"->"15"@1 YIELD edge AS e;
+-------------------------------------------+
| e                                         |
+-------------------------------------------+
| [:e2 "14"->"15" @1 {age: 12, name: "n1"}] |
+-------------------------------------------+
```

Note

- NebulaGraph 3.5.0 allows dangling edges. Therefore, you can write the edge before the source vertex or the destination vertex exists. At this time, you can get the (not written) vertex VID through `<edgetype>._src` or `<edgetype>._dst` (which is not recommended).
- Atomic operation is not guaranteed during the entire process for now. If it fails, please try again. Otherwise, partial writing will occur. At this time, the behavior of reading the data is undefined. For example, if multiple machines are involved in the write operation, only one of the forward and reverse edges of a single edge is written successfully, or only part of the edge is written successfully when multiple edges are inserted. In this case, an error will be returned, so please execute the command again.
- Concurrently writing the same edge will cause an `edge conflict` error, so please try again later.
- The inserting speed of an edge is about half that of a vertex. Because in the storaged process, the insertion of an edge involves two tasks, while the insertion of a vertex involves only one task.

Last update: March 27, 2023

4.12.2 DELETE EDGE

The `DELETE EDGE` statement deletes one edge or multiple edges at a time. You can use `DELETE EDGE` together with pipe operators. For more information, see PIPE OPERATORS.

To delete all the outgoing edges for a vertex, please delete the vertex. For more information, see DELETE VERTEX.

Syntax

```
DELETE EDGE <edge_type> <src_vid> -> <dst_vid>[@<rank>] [, <src_vid> -> <dst_vid>[@<rank>] ...]
```

Caution

If no rank is specified, NebulaGraph only deletes the edge with rank 0. Delete edges with all ranks, as shown in the following example.

Examples

```
nebula> DELETE EDGE serve "player100" -> "team204"@0;
```

The following example shows that you can use `DELETE EDGE` together with pipe operators to delete edges that meet the conditions.

```
nebula> GO FROM "player100" OVER follow \
        WHERE dst(edge) == "player101" \
        YIELD src(edge) AS src, dst(edge) AS dst, rank(edge) AS rank \
        | DELETE EDGE follow $-.src->$-.dst @ $-.rank;
```

Last update: February 7, 2023

4.12.3 UPDATE EDGE

The `UPDATE EDGE` statement updates properties on an edge.

In NebulaGraph, `UPDATE EDGE` supports compare-and-swap (CAS).

Syntax

```
UPDATE EDGE ON <edge_type>
<src_vid> -> <dst_vid> [@<rank>]
SET <update_prop>
[WHEN <condition>]
[YIELD <output>]
```

Parameter	Required	Description	Example
`ON <edge_type>`	Yes	Specifies the edge type. The properties to be updated must be on this edge type.	`ON serve`
`<src_vid>`	Yes	Specifies the source vertex ID of the edge.	`"player100"`
`<dst_vid>`	Yes	Specifies the destination vertex ID of the edge.	`"team204"`
`<rank>`	No	Specifies the rank of the edge. The data type is `int`.	`10`
`SET <update_prop>`	Yes	Specifies the properties to be updated and how they will be updated.	`SET start_year = start_year +1`
`WHEN <condition>`	No	Specifies the filter conditions. If `<condition>` evaluates to `false`, the `SET` clause does not take effect.	`WHEN end_year < 2010`
`YIELD <output>`	No	Specifies the output format of the statement.	`YIELD start_year AS Start_Year`

Example

The following example checks the properties of the edge with the GO statement.

```
nebula> GO FROM "player100" \
        OVER serve \
        YIELD properties(edge).start_year, properties(edge).end_year;
+-----------------------------+---------------------------+
| properties(EDGE).start_year | properties(EDGE).end_year |
+-----------------------------+---------------------------+
| 1997                        | 2016                      |
+-----------------------------+---------------------------+
```

The following example updates the `start_year` property and returns the `end_year` and the new `start_year`.

```
nebula> UPDATE EDGE on serve "player100" -> "team204"@0 \
        SET start_year = start_year + 1 \
        WHEN end_year > 2010 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| 1998       | 2016     |
+------------+----------+
```

Last update: March 27, 2023

4.12.4 UPSERT EDGE

The `UPSERT` statement is a combination of `UPDATE` and `INSERT`. You can use `UPSERT EDGE` to update the properties of an edge if it exists or insert a new edge if it does not exist.

The performance of `UPSERT` is much lower than that of `INSERT` because `UPSERT` is a read-modify-write serialization operation at the partition level.

Danger

Do not use `UPSERT` for scenarios with highly concurrent writes. You can use `UPDATE` or `INSERT` instead.

Syntax

```
UPSERT EDGE ON <edge_type>
<src_vid> -> <dst_vid> [@rank]
SET <update_prop>
[WHEN <condition>]
[YIELD <properties>]
```

Parameter	Required	Description	Example
`ON <edge_type>`	Yes	Specifies the edge type. The properties to be updated must be on this edge type.	`ON serve`
`<src_vid>`	Yes	Specifies the source vertex ID of the edge.	`"player100"`
`<dst_vid>`	Yes	Specifies the destination vertex ID of the edge.	`"team204"`
`<rank>`	No	Specifies the rank of the edge.	`10`
`SET <update_prop>`	Yes	Specifies the properties to be updated and how they will be updated.	`SET start_year = start_year +1`
`WHEN <condition>`	No	Specifies the filter conditions.	`WHEN end_year < 2010`
`YIELD <output>`	No	Specifies the output format of the statement.	`YIELD start_year AS Start_Year`

Insert an edge if it does not exist

If an edge does not exist, it is created no matter the conditions in the `WHEN` clause are met or not, and the `SET` clause takes effect. The property values of the new edge depend on:

- How the `SET` clause is defined.
- Whether the property has a default value.

For example, if:

- The edge to be inserted will have properties `start_year` and `end_year` based on the edge type `serve`.
- The `SET` clause specifies that `end_year = 2021`.

Then the property values in different cases are listed as follows:

Are `WHEN` conditions met	If properties have default values	Value of `start_year`	Value of `end_year`
Yes	Yes	The default value	`2021`
Yes	No	`NULL`	`2021`
No	Yes	The default value	`2021`
No	No	`NULL`	`2021`

Here are some examples:

```
// This example checks if the following three vertices have any outgoing serve edge. The result "Empty set" indicates that such an edge does not exist.
nebula> GO FROM "player666", "player667", "player668" \
        OVER serve \
        YIELD properties(edge).start_year, properties(edge).end_year;
+-----------------------------+---------------------------+
| properties(EDGE).start_year | properties(EDGE).end_year |
+-----------------------------+---------------------------+
+-----------------------------+---------------------------+
Empty set

nebula> UPSERT EDGE on serve \
        "player666" -> "team200"@0 \
        SET end_year = 2021 \
        WHEN end_year == 2010 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| __NULL__   | 2021     |
+------------+----------+

nebula> UPSERT EDGE on serve \
        "player666" -> "team200"@0 \
        SET end_year = 2022 \
        WHEN end_year == 2010 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| __NULL__   | 2021     |
+------------+----------+

nebula> UPSERT EDGE on serve \
        "player667" -> "team200"@0 \
        SET end_year = 2022 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| __NULL__   | 2022     |
+------------+----------+

nebula> UPSERT EDGE on serve \
        "player668" -> "team200"@0 \
        SET start_year = 2000, end_year = end_year + 1 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| 2000       | __NULL__ |
+------------+----------+
```

In the last query of the preceding example, since `end_year` has no default value, when the edge is created, `end_year` is `NULL`, and `end_year = end_year + 1` does not take effect. But if `end_year` has a default value, `end_year = end_year + 1` will take effect. For example:

```
nebula> CREATE EDGE IF NOT EXISTS serve_with_default(start_year int, end_year int DEFAULT 2010);
Execution succeeded

nebula> UPSERT EDGE on serve_with_default \
        "player668" -> "team200" \
        SET end_year = end_year + 1 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| __NULL__   | 2011     |
+------------+----------+
```

Update an edge if it exists

If the edge exists and the `WHEN` conditions are met, the edge is updated.

```
nebula> MATCH (v:player{name:"Ben Simmons"})-[e:serve]-(v2) \
        RETURN e;
+-----------------------------------------------------------------------+
| e                                                                     |
+-----------------------------------------------------------------------+
| [:serve "player149"->"team219" @0 {end_year: 2019, start_year: 2016}] |
+-----------------------------------------------------------------------+

nebula> UPSERT EDGE on serve \
        "player149" -> "team219" \
        SET end_year = end_year + 1 \
        WHEN start_year == 2016 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| 2016       | 2020     |
+------------+----------+
```

If the edge exists and the `WHEN` conditions are not met, the update does not take effect.

```
nebula> MATCH (v:player{name:"Ben Simmons"})-[e:serve]-(v2) \
        RETURN e;
+-----------------------------------------------------------------------+
| e                                                                     |
+-----------------------------------------------------------------------+
| [:serve "player149"->"team219" @0 {end_year: 2020, start_year: 2016}] |
+-----------------------------------------------------------------------+


nebula> UPSERT EDGE on serve \
        "player149" -> "team219" \
        SET end_year = end_year + 1 \
        WHEN start_year != 2016 \
        YIELD start_year, end_year;
+------------+----------+
| start_year | end_year |
+------------+----------+
| 2016       | 2020     |
+------------+----------+
```

Last update: March 8, 2022

4.13 Native index statements

4.13.1 Index overview

Indexes are built to fast process graph queries. Nebula Graph supports two kinds of indexes: native indexes and full-text indexes. This topic introduces the index types and helps choose the right index.

Usage Instructions

- Indexes can improve query performance but may reduce write performance.
- An index is a prerequisite for locating data when executing a `LOOKUP` statement. If there is no index, an error will be reported when executing the `LOOKUP` statement.
- When using an index, NebulaGraph will automatically select the most optimal index.
- Indexes with high selectivity, that is, when the ratio of the number of records with unique values in the index column to the total number of records is high (for example, the ratio for `ID numbers` is `1`), can significantly improve query performance. For indexes with low selectivity (such as `country`), query performance might not experience a substantial improvement.

Native indexes

Native indexes allow querying data based on a given property. Features are as follows.

- There are two kinds of native indexes: tag index and edge type index.
- Native indexes must be updated manually. You can use the `REBUILD INDEX` statement to update native indexes.
- Native indexes support indexing multiple properties on a tag or an edge type (composite indexes), but do not support indexing across multiple tags or edge types.

OPERATIONS ON NATIVE INDEXES

- CREATE INDEX
- SHOW CREATE INDEX
- SHOW INDEXES
- DESCRIBE INDEX
- REBUILD INDEX
- SHOW INDEX STATUS
- DROP INDEX
- LOOKUP
- MATCH

Full-text indexes

Full-text indexes are used to do prefix, wildcard, regexp, and fuzzy search on a string property. Features are as follows.

- Full-text indexes allow indexing just one property.
- Full-text indexes do not support logical operations such as `AND`, `OR`, and `NOT`.

Note

To do complete string matches, use native indexes.

Null values

Indexes do not support indexing null values.

Range queries

In addition to querying single results from native indexes, you can also do range queries. Not all the native indexes support range queries. You can only do range searches for numeric, date, and time type properties.

Last update: April 25, 2023

4.13.2 CREATE INDEX

Prerequisites

Before you create an index, make sure that the relative tag or edge type is created. For how to create tags or edge types, see CREATE TAG and CREATE EDGE.

For how to create full-text indexes, see Deploy full-text index.

Must-read for using indexes

The concept and using restrictions of indexes are comparatively complex. Before you use indexes, you must read the following sections carefully.

You can use `CREATE INDEX` to add native indexes for the existing tags, edge types, or properties. They are usually called as tag indexes, edge type indexes, and property indexes.

- Tag indexes and edge type indexes apply to queries related to the tag and the edge type, but do not apply to queries that are based on certain properties on the tag. For example, you can use `LOOKUP` to retrieve all the vertices with the tag `player`.
- Property indexes apply to property-based queries. For example, you can use the `age` property to retrieve the VID of all vertices that meet `age == 19`.

If a property index `i_TA` is created for the property `A` of the tag `T` and `i_T` for the tag `T`, the indexes can be replaced as follows (the same for edge type indexes):

- The query engine can use `i_TA` to replace `i_T`.
- In the `MATCH` and `LOOKUP` statements, `i_T` may replace `i_TA` for querying properties.

> **Legacy version compatibility**
>
> In previous releases, the tag or edge type index in the `LOOKUP` statement cannot replace the property index for property queries.

Although the same results can be obtained by using alternative indexes for queries, the query performance varies according to the selected index.

> **Caution**
>
> Indexes can dramatically reduce the write performance. The performance can be greatly reduced. **DO NOT** use indexes in production environments unless you are fully aware of their influences on your service.
>
> Indexes cannot make queries faster. It can only locate a vertex or an edge according to properties or count the number of vertices or edges.
>
> Long indexes decrease the scan performance of the Storage Service and use more memory. We suggest that you set the indexing length the same as that of the longest string to be indexed. The longest index length is 256 bytes.

Steps

If you must use indexes, we suggest that you:

1. Import the data into NebulaGraph.
2. Create indexes.
3. Rebuild indexes.
4. After the index is created and the data is imported, you can use LOOKUP or MATCH to retrieve the data. You do not need to specify which indexes to use in a query, NebulaGraph figures that out by itself.

Note

If you create an index before importing the data, the importing speed will be extremely slow due to the reduction in the write performance.

Keep `--disable_auto_compaction = false` during daily incremental writing.

The newly created index will not take effect immediately. Trying to use a newly created index (such as `LOOKUP` or `REBUILD INDEX`) may fail and return `can't find xxx in the space` because the creation is implemented asynchronously. To make sure the follow-up operations work as expected, Wait for two heartbeat cycles, i.e., 20 seconds. To change the heartbeat interval, modify the `heartbeat_interval_secs` in the configuration files for all services.

Danger

After creating a new index, or dropping the old index and creating a new one with the same name again, you must `REBUILD INDEX`. Otherwise, these data cannot be returned in the `MATCH` and `LOOKUP` statements.

Syntax

```
CREATE {TAG | EDGE} INDEX [IF NOT EXISTS] <index_name> ON {<tag_name> | <edge_name>} ([<prop_name_list>]) [COMMENT '<comment>'];
```

Parameter	Description
`TAG | EDGE`	Specifies the index type that you want to create.
`IF NOT EXISTS`	Detects if the index that you want to create exists. If it does not exist, a new one will be created.
`<index_name>`	The name of the index. It must be unique in a graph space. A recommended way of naming is `i_tagName_propName`. Index names cannot start with a number. They supports 1 to 4 bytes UTF-8 encoded characters, such as English letters (case-sensitive), numbers, and Chinese characters, but does not support special characters except underscores. To use special characters, reserved keywords, or starting with a number, quote them with backticks. For more information, see Keywords and reserved words. **Note**: If you name an index in Chinese and encounter a `SyntaxError`, you need to quote the Chinese characters with backticks (`).
`<tag_name> | <edge_name>`	Specifies the name of the tag or edge associated with the index.
`<prop_name_list>`	To index a **variable-length** string property, you must use `prop_name(length)` to specify the index length. To index a tag or an edge type, ignore the `prop_name_list`.
`COMMENT`	The remarks of the index. The maximum length is 256 bytes. By default, there will be no comments on an index.

Create tag/edge type indexes

```
nebula> CREATE TAG INDEX IF NOT EXISTS player_index on player();
```

```
nebula> CREATE EDGE INDEX IF NOT EXISTS follow_index on follow();
```

After indexing a tag or an edge type, you can use the `LOOKUP` statement to retrieve the VID of all vertices `with the tag`, or `the source vertex ID, destination vertex ID, and ranks` of `all edges with the edge type`. For more information, see LOOKUP.

Create single-property indexes

```
nebula> CREATE TAG INDEX IF NOT EXISTS player_index_0 on player(name(10));
```

The preceding example creates an index for the `name` property on all vertices carrying the `player` tag. This example creates an index using the first 10 characters of the `name` property.

```
# To index a variable-length string property, you need to specify the index length.
nebula> CREATE TAG IF NOT EXISTS var_string(p1 string);
nebula> CREATE TAG INDEX IF NOT EXISTS var ON var_string(p1(10));

# To index a fixed-length string property, you do not need to specify the index length.
nebula> CREATE TAG IF NOT EXISTS fix_string(p1 FIXED_STRING(10));
nebula> CREATE TAG INDEX IF NOT EXISTS fix ON fix_string(p1);
```

```
nebula> CREATE EDGE INDEX IF NOT EXISTS follow_index_0 on follow(degree);
```

Create composite property indexes

An index on multiple properties on a tag (or an edge type) is called a composite property index.

```
nebula> CREATE TAG INDEX IF NOT EXISTS player_index_1 on player(name(10), age);
```

Caution

Creating composite property indexes across multiple tags or edge types is not supported.

Note

NebulaGraph follows the left matching principle to select indexes.

Last update: April 25, 2023

4.13.3 SHOW INDEXES

`SHOW INDEXES` shows the defined tag or edge type indexes names in the current graph space.

Syntax

```
SHOW {TAG | EDGE} INDEXES
```

Examples

```
nebula> SHOW TAG INDEXES;
+------------------+--------------+-----------------+
| Index Name       | By Tag       | Columns         |
+------------------+--------------+-----------------+
| "fix"            | "fix_string" | ["p1"]          |
| "player_index_0" | "player"     | ["name"]        |
| "player_index_1" | "player"     | ["name", "age"] |
| "var"            | "var_string" | ["p1"]          |
+------------------+--------------+-----------------+

nebula> SHOW EDGE INDEXES;
+----------------+----------+---------+
| Index Name     | By Edge  | Columns |
| "follow_index" | "follow" | []      |
+----------------+----------+---------+
```

Legacy version compatibility

In NebulaGraph 2.x, the `SHOW TAG/EDGE INDEXES` statement only returns `Names`.

Last update: August 11, 2022

4.13.4 SHOW CREATE INDEX

`SHOW CREATE INDEX` shows the statement used when creating a tag or an edge type. It contains detailed information about the index, such as its associated properties.

Syntax

```
SHOW CREATE {TAG | EDGE} INDEX <index_name>;
```

Examples

You can run `SHOW TAG INDEXES` to list all tag indexes, and then use `SHOW CREATE TAG INDEX` to show the information about the creation of the specified index.

```
nebula> SHOW TAG INDEXES;
+------------------+----------+----------+
| Index Name       | By Tag   | Columns  |
+------------------+----------+----------+
| "player_index_0" | "player" | []       |
| "player_index_1" | "player" | ["name"] |
+------------------+----------+----------+

nebula> SHOW CREATE TAG INDEX player_index_1;
+------------------+--------------------------------------------------+
| Tag Index Name   | Create Tag Index                                 |
+------------------+--------------------------------------------------+
| "player_index_1" | "CREATE TAG INDEX `player_index_1` ON `player` ( |
|                  |  `name`(20)                                      |
|                  | )"                                               |
+------------------+--------------------------------------------------+
```

Edge indexes can be queried through a similar approach.

```
nebula> SHOW EDGE INDEXES;
+----------------+----------+---------+
| Index Name     | By Edge  | Columns |
+----------------+----------+---------+
| "follow_index" | "follow" | []      |
+----------------+----------+---------+

nebula> SHOW CREATE EDGE INDEX follow_index;
+-----------------+-------------------------------------------------+
| Edge Index Name | Create Edge Index                               |
+-----------------+-------------------------------------------------+
| "follow_index"  | "CREATE EDGE INDEX `follow_index` ON `follow` ( |
|                 | )"                                              |
+-----------------+-------------------------------------------------+
```

Last update: May 13, 2022

4.13.5 DESCRIBE INDEX

`DESCRIBE INDEX` can get the information about the index with a given name, including the property name (Field) and the property type (Type) of the index.

Syntax

```
DESCRIBE {TAG | EDGE} INDEX <index_name>;
```

Examples

```
nebula> DESCRIBE TAG INDEX player_index_0;
+--------+--------------------+
| Field  | Type               |
+--------+--------------------+
| "name" | "fixed_string(30)" |
+--------+--------------------+

nebula> DESCRIBE TAG INDEX player_index_1;
+--------+--------------------+
| Field  | Type               |
+--------+--------------------+
| "name" | "fixed_string(10)" |
| "age"  | "int64"            |
+--------+--------------------+
```

Last update: October 27, 2021

4.13.6 REBUILD INDEX

Danger

- If data is updated or inserted before the creation of the index, you must rebuild the indexes **manually** to make sure that the indexes contain the previously added data. Otherwise, you cannot use `LOOKUP` and `MATCH` to query the data based on the index. If the index is created before any data insertion, there is no need to rebuild the index.
- When the rebuild of an index is incomplete, queries that rely on the index can use only part of the index and therefore cannot obtain accurate results.

You can use `REBUILD INDEX` to rebuild the created tag or edge type index. For details on how to create an index, see CREATE INDEX.

Performance

The speed of rebuilding indexes can be optimized by modifying the `rebuild_index_part_rate_limit` and `snapshot_batch_size` parameters in the configuration file. In addition, greater parameter values may result in higher memory and network usage, see Storage Service configurations for details.

Syntax

```
REBUILD {TAG | EDGE} INDEX [<index_name_list>];

<index_name_list>::=
    [index_name [, index_name] ...]
```

- Multiple indexes are permitted in a single `REBUILD` statement, separated by commas. When the index name is not specified, all tag or edge indexes are rebuilt.
- After the rebuilding is complete, you can use the `SHOW {TAG | EDGE} INDEX STATUS` command to check if the index is successfully rebuilt. For details on index status, see SHOW INDEX STATUS.

Examples

```
nebula> CREATE TAG IF NOT EXISTS person(name string, age int, gender string, email string);
nebula> CREATE TAG INDEX IF NOT EXISTS single_person_index ON person(name(10));

# The following example rebuilds an index and returns the job ID.
nebula> REBUILD TAG INDEX single_person_index;
+------------+
| New Job Id |
+------------+
| 31         |
+------------+

# The following example checks the index status.
nebula> SHOW TAG INDEX STATUS;
+----------------------+--------------+
| Name                 | Index Status |
+----------------------+--------------+
| "single_person_index" | "FINISHED"   |
+----------------------+--------------+

# You can also use "SHOW JOB <job_id>" to check if the rebuilding process is complete.
nebula> SHOW JOB 31;
+----------------+---------------------+------------+-------------------------+-------------------------+-------------+
| Job Id(TaskId) | Command(Dest)       | Status     | Start Time              | Stop Time               | Error Code  |
+----------------+---------------------+------------+-------------------------+-------------------------+-------------+
| 31             | "REBUILD_TAG_INDEX" | "FINISHED" | 2021-07-07T09:04:24.000 | 2021-07-07T09:04:24.000 | "SUCCEEDED" |
| 0              | "storaged1"         | "FINISHED" | 2021-07-07T09:04:24.000 | 2021-07-07T09:04:28.000 | "SUCCEEDED" |
| 1              | "storaged2"         | "FINISHED" | 2021-07-07T09:04:24.000 | 2021-07-07T09:04:28.000 | "SUCCEEDED" |
| 2              | "storaged0"         | "FINISHED" | 2021-07-07T09:04:24.000 | 2021-07-07T09:04:28.000 | "SUCCEEDED" |
| "Total:3"      | "Succeeded:3"       | "Failed:0" | "In Progress:0"         | ""                      | ""          |
+----------------+---------------------+------------+-------------------------+-------------------------+-------------+
```

NebulaGraph creates a job to rebuild the index. The job ID is displayed in the preceding return message. To check if the rebuilding process is complete, use the `SHOW JOB <job_id>` statement. For more information, see SHOW JOB.

Last update: October 20, 2022

4.13.7 SHOW INDEX STATUS

`SHOW INDEX STATUS` returns the name of the created tag or edge type index and its status of job.

The index status includes:

- `QUEUE`: The job is in a queue.
- `RUNNING`: The job is running.
- `FINISHED`: The job is finished.
- `FAILED`: The job has failed.
- `STOPPED`: The job has stopped.
- `INVALID`: The job is invalid.

Note

For details on how to create an index, see CREATE INDEX.

Syntax

```
SHOW {TAG | EDGE} INDEX STATUS;
```

Example

```
nebula> SHOW TAG INDEX STATUS;
+----------------------+--------------+
| Name                 | Index Status |
+----------------------+--------------+
| "player_index_0"     | "FINISHED"   |
| "player_index_1"     | "FINISHED"   |
+----------------------+--------------+
```

Last update: January 14, 2022

4.13.8 DROP INDEX

`DROP INDEX` removes an existing index from the current graph space.

Prerequisite

Running the `DROP INDEX` statement requires some privileges of `DROP TAG INDEX` and `DROP EDGE INDEX` in the given graph space. Otherwise, NebulaGraph throws an error.

Syntax

```
DROP {TAG | EDGE} INDEX [IF EXISTS] <index_name>;
```

`IF EXISTS`: Detects whether the index that you want to drop exists. If it exists, it will be dropped.

Example

```
nebula> DROP TAG INDEX player_index_0;
```

Last update: January 11, 2023

4.14 Full-text index statements

4.14.1 Full-text index restrictions

Caution

This topic introduces the restrictions for full-text indexes. Please read the restrictions very carefully before using the full-text indexes.

For now, full-text search has the following limitations:

- Currently, full-text search supports `LOOKUP` statements only.
- The full-text index name must starts with `nebula_` and can contain only numbers, lowercase letters, underscores, and strings no longer than 256 bytes.
- If there is a full-text index on the tag/edge type, the tag/edge type cannot be deleted or modified.
- The type of properties must be `STRING` or `FIXED_STRING`.
- Full-text index can not be applied to search multiple tags/edge types.
- Sorting for the returned results of the full-text search is not supported. Data is returned in the order of data insertion.
- Full-text index can not search properties with value `NULL`.
- Altering Elasticsearch indexes is not supported at this time.
- The pipe operator is not supported.
- `WHERE` clauses supports full-text search only working on single terms.
- Make sure that you start the Elasticsearch cluster and Nebula Graph at the same time. If not, the data writing on the Elasticsearch cluster can be incomplete.
- It may take a while for Elasticsearch to create indexes. If Nebula Graph warns no index is found, wait for the index to take effect (however, the waiting time is unknown and there is no code to check).
- NebulaGraph clusters deployed with K8s do not support the full-text search feature.

Last update: February 7, 2023

4.14.2 Deploy full-text index

Nebula Graph full-text indexes are powered by Elasticsearch. This means that you can use Elasticsearch full-text query language to retrieve what you want. Full-text indexes are managed through built-in procedures. They can be created only for variable `STRING` and `FIXED_STRING` properties when the listener cluster and the Elasticsearch cluster are deployed.

Precaution

Before you start using the full-text index, please make sure that you know the restrictions.

Deploy Elasticsearch cluster

To deploy an Elasticsearch cluster, see Kubernetes Elasticsearch deployment or Elasticsearch installation.

Compatibility

For NebulaGraph 3.4 and later versions, no additional templates need to be created.

Caution

The full-text index name must starts with `nebula_`.

You can configure the Elasticsearch to meet your business needs. To customize the Elasticsearch, see Elasticsearch Document.

Sign in to the text search clients

When the Elasticsearch cluster is deployed, use the `SIGN IN` statement to sign in to the Elasticsearch clients. Multiple `elastic_ip:port` pairs are separated with commas. You must use the IPs and the port number in the configuration file for the Elasticsearch.

SYNTAX

```
SIGN IN TEXT SERVICE (<elastic_ip:port>, {HTTP | HTTPS} [,"<username>", "<password>"]) [, (<elastic_ip:port>, ...)];
```

EXAMPLE

```
nebula> SIGN IN TEXT SERVICE (127.0.0.1:9200, HTTP);
```

Note

Elasticsearch does not have a username or password by default. If you configured a username and password, you need to specify them in the `SIGN IN` statement.

Caution

The Elasticsearch client can only be logged in once, and if there are changes, you need to `SIGN OUT` and then `SIGN IN` again, and the client takes effect globally, and multiple graph spaces share the same Elasticsearch client.

Show text search clients

The `SHOW TEXT SEARCH CLIENTS` statement can list the text search clients.

SYNTAX

```
SHOW TEXT SEARCH CLIENTS;
```

EXAMPLE

```
nebula> SHOW TEXT SEARCH CLIENTS;
+-------------+------+
| Host        | Port |
+-------------+------+
| "127.0.0.1" | 9200 |
| "127.0.0.1" | 9200 |
| "127.0.0.1" | 9200 |
+-------------+------+
```

Sign out to the text search clients

The `SIGN OUT TEXT SERVICE` statement can sign out all the text search clients.

SYNTAX

```
SIGN OUT TEXT SERVICE;
```

EXAMPLE

```
nebula> SIGN OUT TEXT SERVICE;
```

Last update: February 7, 2023

4.14.3 Deploy Raft Listener for NebulaGraph Storage service

Full-text index data is written to the Elasticsearch cluster asynchronously. The Raft Listener (Listener for short) is a separate process that fetches data from the Storage Service and writes them into the Elasticsearch cluster.

Prerequisites

- You have read and fully understood the restrictions for using full-text indexes.
- You have deployed a NebulaGraph cluster.
- You have deploy a Elasticsearch cluster.
- You have prepared at least one extra Storage Server. To use the full-text search, you must run one or more Storage Server as the Raft Listener.

Precautions

- The Storage Service that you want to run as the Listener must have the same or later release with all the other Nebula Graph services in the cluster.
- For now, you can only add all Listeners to a graph space once and for all. Trying to add a new Listener to a graph space that already has a Listener will fail. To add all Listeners, set them in one statement.

Deployment process

STEP 1: INSTALL THE STORAGE SERVICE

The Listener process and the storaged process use the same binary file. However, their configuration files and using ports are different. You can install NebulaGraph on all servers that need to deploy a Listener, but only the Storage service can be used. For details, see Install NebulaGraph by RPM or DEB Package.

STEP 2: PREPARE THE CONFIGURATION FILE FOR THE LISTENER

You have to prepare a corresponding configuration file on the machine that you want to deploy a Listener. The file must be named as `nebula-storaged-listener.conf` and stored in the `etc` directory. A template is provided for your reference. Note that the file suffix `.production` should be removed.

Most configurations are the same as the configurations of Storage Service. This topic only introduces the differences.

Name	Default value	Description
`daemonize`	`true`	When set to `true`, the process is a daemon process.
`pid_file`	`pids/nebula-metad-listener.pid`	The file that records the process ID.
`meta_server_addrs`	-	IP addresses and ports of all Meta services. Multiple Meta services are separated by commas.
`local_ip`	-	The local IP address of the Listener service.
`port`	-	The listening port of the RPC daemon of the Listener service.
`heartbeat_interval_secs`	`10`	The heartbeat interval of the Meta service. The unit is second (s).
`listener_path`	`data/listener`	The WAL directory of the Listener. Only one directory is allowed.
`data_path`	`data`	For compatibility reasons, this parameter can be ignored. Fill in the default value `data`.
`part_man_type`	`memory`	The type of the part manager. Optional values are `memory` and `meta`.
`rocksdb_batch_size`	`4096`	The default reserved bytes for batch operations.
`rocksdb_block_cache`	`4`	The default block cache size of BlockBasedTable. The unit is Megabyte (MB).
`engine_type`	`rocksdb`	The type of the Storage engine, such as `rocksdb`, `memory`, etc.
`part_type`	`simple`	The type of the part, such as `simple`, `consensus`, etc.

Note

Use real IP addresses in the configuration file instead of domain names or loopback IP addresses such as `127.0.0.1`.

STEP 3: START LISTENERS

Run the following command to start the Listener.

```
./bin/nebula-storaged --flagfile <listener_config_path>/nebula-storaged-listener.conf
```

`${listener_config_path}` is the path where you store the Listener configuration file.

STEP 4: ADD LISTENERS TO NEBULAGRAPH

Connect to NebulaGraph and run `USE <space>` to enter the graph space that you want to create full-text indexes for. Then run the following statement to add a Listener into NebulaGraph.

```
ADD LISTENER ELASTICSEARCH <listener_ip:port> [,<listener_ip:port>, ...]
```

Warning

You must use real IPs for a Listener.

Add all Listeners in one statement completely.

```
nebula> ADD LISTENER ELASTICSEARCH 192.168.8.5:9789,192.168.8.6:9789;
```

Show Listeners

Run the `SHOW LISTENER` statement to list all Listeners.

EXAMPLE

```
nebula> SHOW LISTENER;
+--------+-----------------+-----------------------+----------+
| PartId | Type            | Host                  | Status   |
+--------+-----------------+-----------------------+----------+
| 1      | "ELASTICSEARCH" | "[192.168.8.5:46780]" | "ONLINE" |
| 2      | "ELASTICSEARCH" | "[192.168.8.5:46780]" | "ONLINE" |
| 3      | "ELASTICSEARCH" | "[192.168.8.5:46780]" | "ONLINE" |
+--------+-----------------+-----------------------+----------+
```

Remove Listeners

Run the `REMOVE LISTENER ELASTICSEARCH` statement to remove all Listeners in a graph space.

EXAMPLE

```
nebula> REMOVE LISTENER ELASTICSEARCH;
```

Last update: February 7, 2023

4.14.4 Full-text indexes

Full-text indexes are used to do prefix, wildcard, regexp, and fuzzy search on a string property.

You can use the `WHERE` clause to specify the search strings in `LOOKUP` statements.

Prerequisite

Before using the full-text index, make sure that you have deployed a Elasticsearch cluster and a Listener cluster. For more information, see Deploy Elasticsearch and Deploy Listener.

Precaution

Before using the full-text index, make sure that you know the restrictions.

Natural language full-text search

A natural language search interprets the search string as a phrase in natural human language. The search is case-sensitive and by default prefixes the string with a match. For example, there are three vertices with the tag `player`. The tag `player` contains the property `name`. The `name` of these three vertices are `Kevin Durant`, `Tim Duncan`, and `David Beckham`. Now that the full-text index of `player.name` is established, only `David Beckham` will be queried when using the prefix search statement `LOOKUP ON player WHERE PREFIX(player.name,"D");`.

Syntax

CREATE FULL-TEXT INDEXES

```
CREATE FULLTEXT {TAG | EDGE} INDEX <index_name> ON {<tag_name> | <edge_name>} ([<prop_name>]);
```

SHOW FULL-TEXT INDEXES

```
SHOW FULLTEXT INDEXES;
```

REBUILD FULL-TEXT INDEXES

```
REBUILD FULLTEXT INDEX;
```

Caution

When there is a large amount of data, rebuilding full-text index is slow, you can modify `snapshot_send_files=false` in the configuration file of Storage service(`nebula-storaged.conf`).

DROP FULL-TEXT INDEXES

```
DROP FULLTEXT INDEX <index_name>;
```

USE QUERY OPTIONS

```
LOOKUP ON {<tag> | <edge_type>} WHERE <expression> [YIELD <return_list>];

<expression> ::=
    PREFIX | WILDCARD | REGEXP | FUZZY
```

```
<return_list>
    <prop_name> [AS <prop_alias>] [, <prop_name> [AS <prop_alias>] ...]
```

- PREFIX(schema_name.prop_name, prefix_string, row_limit, timeout)
- WILDCARD(schema_name.prop_name, wildcard_string, row_limit, timeout)
- REGEXP(schema_name.prop_name, regexp_string, row_limit, timeout)
- FUZZY(schema_name.prop_name, fuzzy_string, fuzziness, operator, row_limit, timeout)
- `fuzziness` (optional): Maximum edit distance allowed for matching. The default value is `AUTO`. For other valid values and more information, see Elasticsearch document.
- `operator` (optional): Boolean logic used to interpret the text. Valid values are `OR` (default) and `AND`.
- `row_limit` (optional): Specifies the number of rows to return. The default value is `100`.
- `timeout` (optional): Specifies the timeout time. The default value is `200ms`.

Examples

```
// This example creates the graph space.
nebula> CREATE SPACE IF NOT EXISTS basketballplayer (partition_num=3,replica_factor=1, vid_type=fixed_string(30));

// This example signs in the text service.
nebula> SIGN IN TEXT SERVICE (127.0.0.1:9200, HTTP);

// This example checks the text service status.
nebula> SHOW TEXT SEARCH CLIENTS;

// This example switches the graph space.
nebula> USE basketballplayer;

// This example adds the listener to the NebulaGraph cluster.
nebula> ADD LISTENER ELASTICSEARCH 192.168.8.5:9789;

// This example checks the listener status. When the status is `Online`, the listener is ready.
nebula> SHOW LISTENER;

// This example creates the tag.
nebula> CREATE TAG IF NOT EXISTS player(name string, age int);

// This example creates the full-text index. The index name starts with "nebula_".
nebula> CREATE FULLTEXT TAG INDEX nebula_index_1 ON player(name);

// This example rebuilds the full-text index.
nebula> REBUILD FULLTEXT INDEX;

// This example shows the full-text index.
nebula> SHOW FULLTEXT INDEXES;
+------------------+-------------+-------------+--------+
| Name             | Schema Type | Schema Name | Fields |
+------------------+-------------+-------------+--------+
| "nebula_index_1" | "Tag"       | "player"    | "name" |
+------------------+-------------+-------------+--------+

// This example inserts the test data.
nebula> INSERT VERTEX player(name, age) VALUES \
  "Russell Westbrook": ("Russell Westbrook", 30), \
  "Chris Paul": ("Chris Paul", 33),\
  "Boris Diaw": ("Boris Diaw", 36),\
  "David West": ("David West", 38),\
  "Danny Green": ("Danny Green", 31),\
  "Tim Duncan": ("Tim Duncan", 42),\
  "James Harden": ("James Harden", 29),\
  "Tony Parker": ("Tony Parker", 36),\
  "Aron Baynes": ("Aron Baynes", 32),\
  "Ben Simmons": ("Ben Simmons", 22),\
  "Blake Griffin": ("Blake Griffin", 30);

// These examples run test queries.
nebula> LOOKUP ON player WHERE PREFIX(player.name, "B") YIELD id(vertex);
+-----------------+
| id(VERTEX)      |
+-----------------+
| "Boris Diaw"    |
| "Ben Simmons"   |
| "Blake Griffin" |
+-----------------+

nebula> LOOKUP ON player WHERE WILDCARD(player.name, "*ri*") YIELD player.name, player.age;
+-----------------+-----+
| name            | age |
+-----------------+-----+
```

```
| "Chris Paul"    | 33  |
| "Boris Diaw"    | 36  |
| "Blake Griffin" | 30  |
+-----------------+-----+

nebula> LOOKUP ON player WHERE WILDCARD(player.name, "*ri*") YIELD player.name, player.age | YIELD count(*);
+----------+
| count(*) |
+----------+
| 3        |
+----------+

nebula> LOOKUP ON player WHERE REGEXP(player.name, "R.*") YIELD player.name, player.age;
+---------------------+-----+
| name                | age |
+---------------------+-----+
| "Russell Westbrook" | 30  |
+---------------------+-----+

nebula> LOOKUP ON player WHERE REGEXP(player.name, ".*") YIELD id(vertex);
+---------------------+
| id(VERTEX)          |
+---------------------+
| "Danny Green"       |
| "David West"        |
...

nebula> LOOKUP ON player WHERE FUZZY(player.name, "Tim Dunncan", AUTO, OR) YIELD player.name;
+--------------+
| name         |
+--------------+
| "Tim Duncan" |
+--------------+

// This example drops the full-text index.
nebula> DROP FULLTEXT INDEX nebula_index_1;
```

Last update: May 6, 2023

4.15 Subgraph and path

4.15.1 GET SUBGRAPH

The `GET SUBGRAPH` statement returns a subgraph that is generated by traversing a graph starting from a specified vertex. `GET SUBGRAPH` statements allow you to specify the number of steps and the type or direction of edges during the traversal.

Syntax

```
GET SUBGRAPH [WITH PROP] [<step_count> {STEP|STEPS}] FROM {<vid>, <vid>...}
[{IN | OUT | BOTH} <edge_type>, <edge_type>...]
[WHERE <expression> [AND <expression> ...]]
YIELD {[VERTICES AS <vertex_alias>] [,EDGES AS <edge_alias>]};
```

- `WITH PROP` shows the properties. If not specified, the properties will be hidden.
- `step_count` specifies the number of hops from the source vertices and returns the subgraph from 0 to `step_count` hops. It must be a non-negative integer. Its default value is 1.
- `vid` specifies the vertex IDs.
- `edge_type` specifies the edge type. You can use `IN`, `OUT`, and `BOTH` to specify the traversal direction of the edge type. The default is `BOTH`.
- `<WHERE clause>` specifies the filter conditions for the traversal, which can be used with the boolean operator `AND`.
- `YIELD` defines the output that needs to be returned. You can return only vertices or edges. A column alias must be set.

Note

The path type of `GET SUBGRAPH` is `trail`. Only vertices can be repeatedly visited in graph traversal. For more information, see Path.

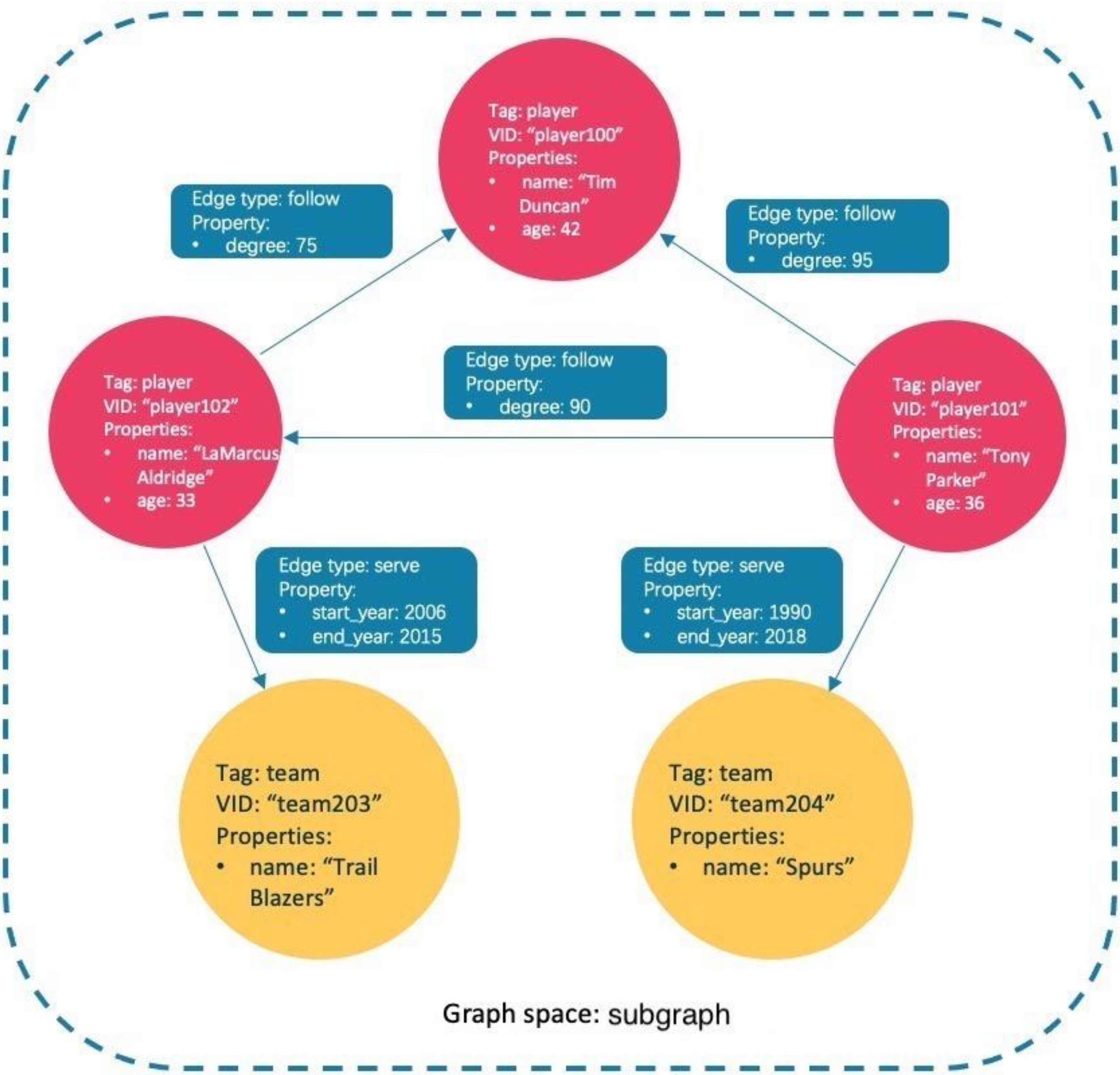
Limitations

While using the `WHERE` clause in a `GET SUBGRAPH` statement, note the following restrictions:

- **Only support** the `AND` operator.
- **Only support** filter destination vertex, the vertex format must be `$$.tagName.propName`.
- **Support** filter edge, the edge format must be `edge_type.propName`.
- **Support** math functions, aggregate functions, string functions, datetime functions, type conversion functions and general functions in list functions.
- **Not support** aggregate functions, schema-related functions, conditional expression, predicate functions, geography function and user-defined functions.

Examples

The following graph is used as the sample.



Insert the test data:

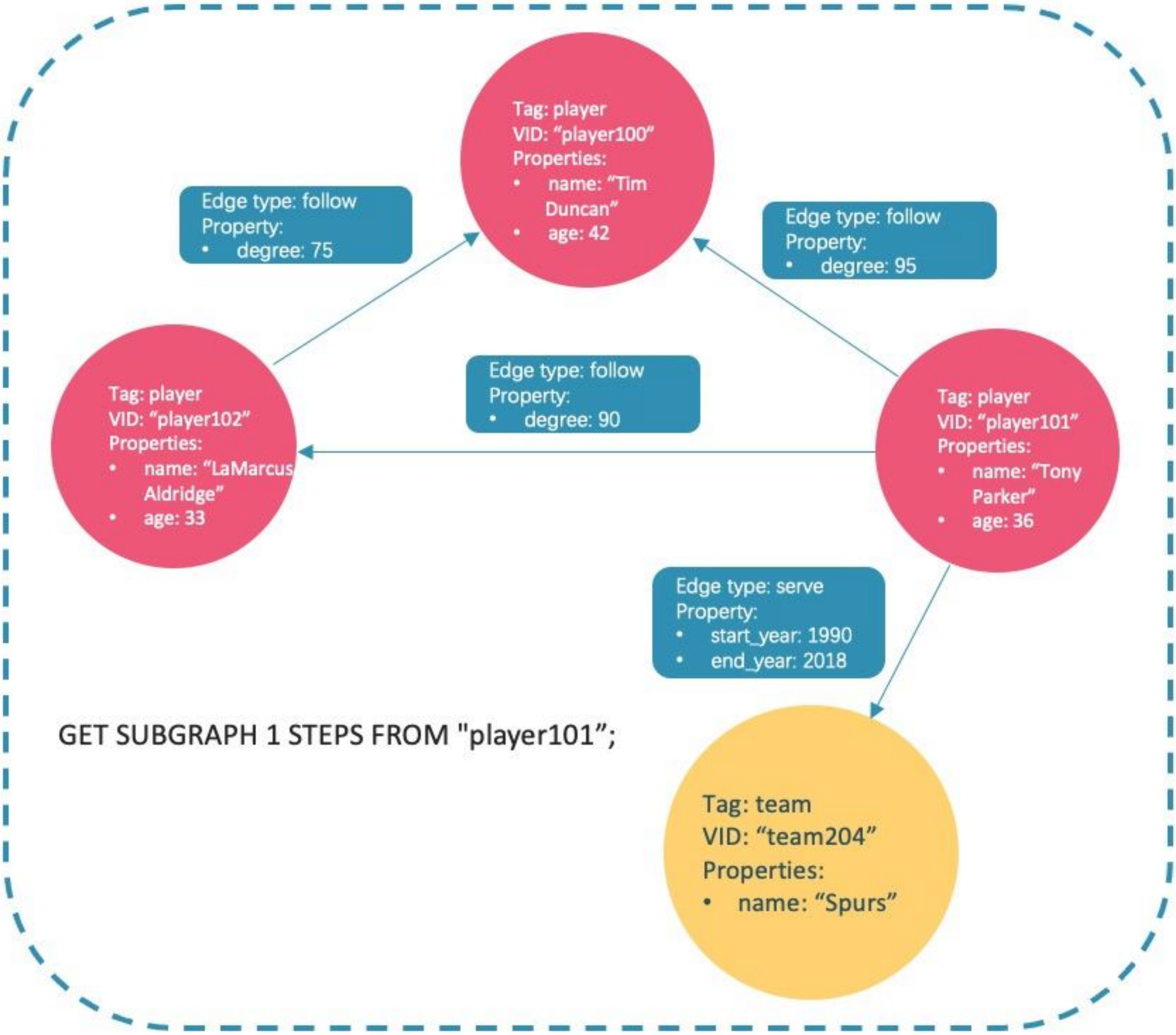
```
nebula> CREATE SPACE IF NOT EXISTS subgraph(partition_num=15, replica_factor=1, vid_type=fixed_string(30));
nebula> USE subgraph;
nebula> CREATE TAG IF NOT EXISTS player(name string, age int);
nebula> CREATE TAG IF NOT EXISTS team(name string);
nebula> CREATE EDGE IF NOT EXISTS follow(degree int);
nebula> CREATE EDGE IF NOT EXISTS serve(start_year int, end_year int);
nebula> INSERT VERTEX player(name, age) VALUES "player100":("Tim Duncan", 42);
nebula> INSERT VERTEX player(name, age) VALUES "player101":("Tony Parker", 36);
nebula> INSERT VERTEX player(name, age) VALUES "player102":("LaMarcus Aldridge", 33);
nebula> INSERT VERTEX team(name) VALUES "team203":("Trail Blazers"), "team204":("Spurs");
nebula> INSERT EDGE follow(degree) VALUES "player101" -> "player100":(95);
nebula> INSERT EDGE follow(degree) VALUES "player101" -> "player102":(90);
```

```
nebula> INSERT EDGE follow(degree) VALUES "player102" -> "player100":(75);
nebula> INSERT EDGE serve(start_year, end_year) VALUES "player101" -> "team204":(1999, 2018),"player102" -> "team203":(2006,  2015);
```

- This example goes one step from the vertex `player101` over all edge types and gets the subgraph.

```
nebula> GET SUBGRAPH 1 STEPS FROM "player101" YIELD VERTICES AS nodes, EDGES AS relationships;
+-------------------------------------------------------------------------
+-------------------------------------------------------------------------------------------------------------------------+
| nodes                                                                   |
relationships                                                                                                             |
+-------------------------------------------------------------------------
+-------------------------------------------------------------------------------------------------------------------------+
| [("player101" :player{})]                                               | [[:serve "player101"->"team204" @0 {}], [:follow "player101"->"player100" @0 {}], [:follow "player101"-
>"player102" @0 {}]] |
| [("team204" :team{}), ("player100" :player{}), ("player102" :player{})] | [[:follow "player102"->"player100" @0
{}]]                                                                                                    |
+-------------------------------------------------------------------------
+-------------------------------------------------------------------------------------------------------------------------+
```

The returned subgraph is as follows.



- This example goes one step from the vertex `player101` over incoming `follow` edges and gets the subgraph.

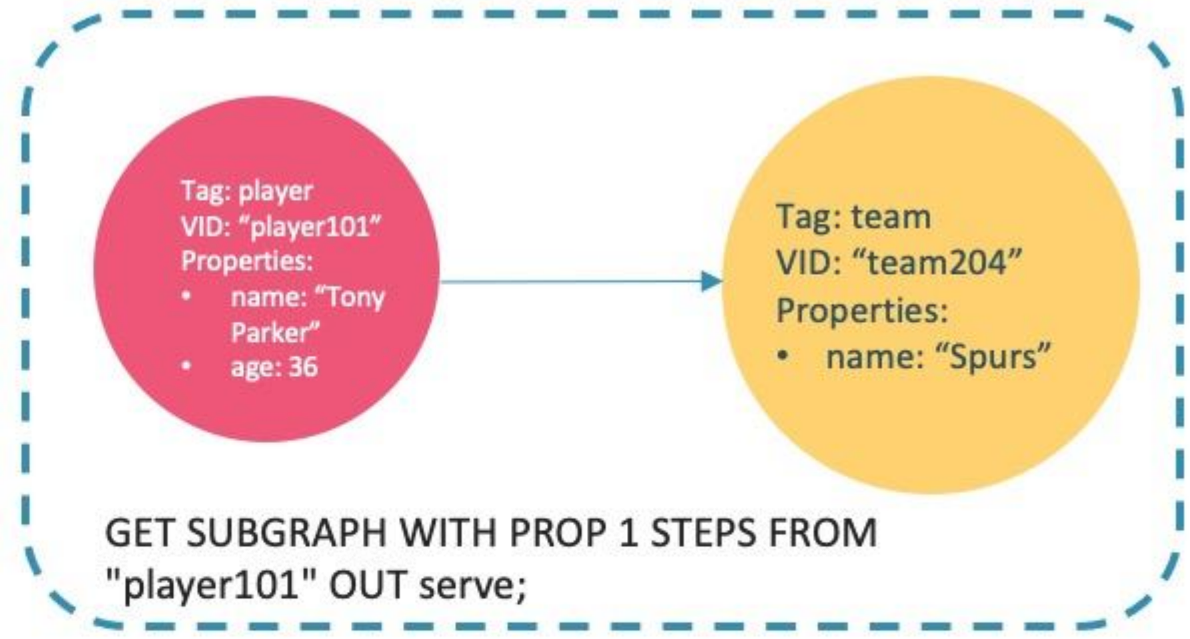
```
nebula> GET SUBGRAPH 1 STEPS FROM "player101" IN follow YIELD VERTICES AS nodes, EDGES AS relationships;
+---------------------------+---------------+
| nodes                     | relationships |
+---------------------------+---------------+
| [("player101" :player{})] | []            |
+---------------------------+---------------+
```

There is no incoming `follow` edge to `player101`, so only the vertex `player101` is returned.

- This example goes one step from the vertex `player101` over outgoing `serve` edges, gets the subgraph, and shows the property of the edge.

```
nebula> GET SUBGRAPH WITH PROP 1 STEPS FROM "player101" OUT serve YIELD VERTICES AS nodes, EDGES AS relationships;
+-------------------------------------------------------+-------------------------------------------------------------------------+
| nodes                                                 | relationships                                                           |
+-------------------------------------------------------+-------------------------------------------------------------------------+
| [("player101" :player{age: 36, name: "Tony Parker"})] | [[:serve "player101"->"team204" @0 {end_year: 2018, start_year: 1999}]] |
| [("team204" :team{name: "Spurs"})]                    | []                                                                      |
+-------------------------------------------------------+-------------------------------------------------------------------------+
```

The returned subgraph is as follows.



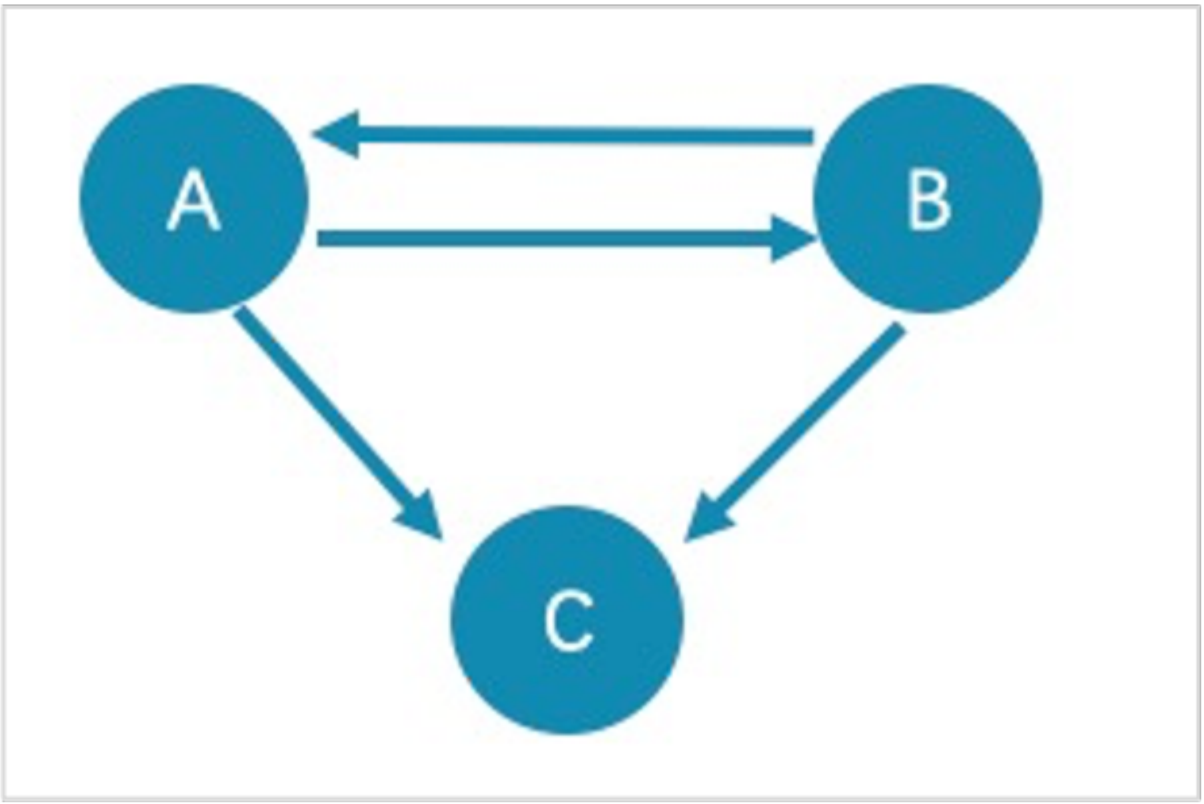
- This example goes two steps from the vertex `player101` over `follow` edges, filters by degree > 90 and age > 30, and shows the properties of edges.

```
nebula> GET SUBGRAPH WITH PROP 2 STEPS FROM "player101" \
    WHERE follow.degree > 90 AND $$.player.age > 30 \
    YIELD VERTICES AS nodes, EDGES AS relationships;
+-------------------------------------------------------+------------------------------------------------------+
| nodes                                                 | relationships                                        |
+-------------------------------------------------------+------------------------------------------------------+
| [("player101" :player{age: 36, name: "Tony Parker"})] | [[:follow "player101"->"player100" @0 {degree: 95}]] |
| [("player100" :player{age: 42, name: "Tim Duncan"})]  | []                                                   |
+-------------------------------------------------------+------------------------------------------------------+
```

FAQ

WHY IS THE NUMBER OF HOPS IN THE RETURNED RESULT GREATER THAN `STEP_COUNT`?

To show the completeness of the subgraph, an additional hop is made on all vertices that meet the conditions. The following graph is used as the sample.



- The returned paths of `GET SUBGRAPH 1 STEPS FROM "A";` are `A->B`, `B->A`, and `A->C`. To show the completeness of the subgraph, an additional hop is made on all vertices that meet the conditions, namely `B->C`.
- The returned path of `GET SUBGRAPH 1 STEPS FROM "A" IN follow;` is `B->A`. To show the completeness of the subgraph, an additional hop is made on all vertices that meet the conditions, namely `A->B`.

If you only query paths or vertices that meet the conditions, we suggest you use MATCH or GO. The example is as follows.

```
nebula> MATCH p= (v:player) -- (v2) WHERE id(v)=="A" RETURN p;
nebula> GO 1 STEPS FROM "A" OVER follow YIELD src(edge),dst(edge);
```

WHY IS THE NUMBER OF HOPS IN THE RETURNED RESULT LOWER THAN `STEP_COUNT`?

The query stops when there is not enough subgraph data and will not return the null value.

```
nebula> GET SUBGRAPH 100 STEPS FROM "player101" OUT follow YIELD VERTICES AS nodes, EDGES AS relationships;
+----------------------------------------------------+-----------------------------------------------------------------------------------------+
| nodes                                              | relationships                                                                           |
+----------------------------------------------------+-----------------------------------------------------------------------------------------+
| [("player101" :player{})]                          | [[:follow "player101"->"player100" @0 {}], [:follow "player101"->"player102" @0 {}]] |
| [("player100" :player{}), ("player102" :player{})] | [[:follow "player102"->"player100" @0 {}]]                                              |
+----------------------------------------------------+-----------------------------------------------------------------------------------------+
```

Last update: March 13, 2023

4.15.2 FIND PATH

The `FIND PATH` statement finds the paths between the selected source vertices and destination vertices.

Note

To improve the query performance with the `FIND PATH` statement, you can add the `num_operator_threads` parameter in the `nebula-graphd.conf` configuration file. The value range of the `num_operator_threads` parameter is [2, 10] and make sure that the value is not greater than the number of CPU cores of the machine where the `graphd` service is deployed. It is recommended to set the value to the number of CPU cores of the machine where the `graphd` service is deployed. For more information about the `nebula-graphd.conf` configuration file, see nebula-graphd.conf.

Syntax

```
FIND { SHORTEST | ALL | NOLOOP } PATH [WITH PROP] FROM <vertex_id_list> TO <vertex_id_list>
OVER <edge_type_list> [REVERSELY | BIDIRECT]
[<WHERE clause>] [UPTO <N> {STEP|STEPS}]
YIELD path as <alias>
[| ORDER BY $-.path] [| LIMIT <M>];

<vertex_id_list> ::=
    [vertex_id [, vertex_id] ...]
```

- `SHORTEST` finds the shortest path.
- `ALL` finds all the paths.
- `NOLOOP` finds the paths without circles.
- `WITH PROP` shows properties of vertices and edges. If not specified, properties will be hidden.
- `<vertex_id_list>` is a list of vertex IDs separated with commas (,). It supports `$-` and `$var`.
- `<edge_type_list>` is a list of edge types separated with commas (,). `*` is all edge types.
- `REVERSELY | BIDIRECT` specifies the direction. `REVERSELY` is reverse graph traversal while `BIDIRECT` is bidirectional graph traversal.
- `<WHERE clause>` filters properties of edges.
- `<N>` is the maximum hop number of the path. The default value is `5`.
- `<M>` specifies the maximum number of rows to return.

Note

The path type of `FIND PATH` is `trail`. Only vertices can be repeatedly visited in graph traversal. For more information, see Path.

Limitations

- When a list of source and/or destination vertex IDs are specified, the paths between any source vertices and the destination vertices will be returned.
- There can be cycles when searching all paths.
- `FIND PATH` only supports filtering properties of edges with `WHERE` clauses. Filtering properties of vertices and functions are not supported for now.
- `FIND PATH` is a single-thread procedure, so it uses much memory.

Examples

A returned path is like `(<vertex_id>)-[:<edge_type_name>@<rank>]->(<vertex_id)` .

```
nebula> FIND SHORTEST PATH FROM "player102" TO "team204" OVER * YIELD path AS p;
+--------------------------------------------+
| p                                          |
+--------------------------------------------+
| <("player102")-[:serve@0 {}]->("team204")> |
+--------------------------------------------+
```

```
nebula> FIND SHORTEST PATH WITH PROP FROM "team204" TO "player100" OVER * REVERSELY YIELD path AS p;
+--------------------------------------------------------------------------------------------------------------------------------------+
| p                                                                                                                                    |
+--------------------------------------------------------------------------------------------------------------------------------------+
| <("team204" :team{name: "Spurs"})<-[:serve@0 {end_year: 2016, start_year: 1997}]-("player100" :player{age: 42, name: "Tim Duncan"})> |
+--------------------------------------------------------------------------------------------------------------------------------------+
```

```
nebula> FIND ALL PATH FROM "player100" TO "team204" OVER * WHERE follow.degree is EMPTY or follow.degree >=0 YIELD path AS p;
+------------------------------------------------------------------------------+
| p                                                                            |
+------------------------------------------------------------------------------+
| <("player100")-[:serve@0 {}]->("team204")>                                   |
| <("player100")-[:follow@0 {}]->("player125")-[:serve@0 {}]->("team204")>     |
| <("player100")-[:follow@0 {}]->("player101")-[:serve@0 {}]->("team204")>     |
|...                                                                           |
+------------------------------------------------------------------------------+
```

```
nebula> FIND NOLOOP PATH FROM "player100" TO "team204" OVER * YIELD path AS p;
+--------------------------------------------------------------------------------------------------------+
| p                                                                                                      |
+--------------------------------------------------------------------------------------------------------+
| <("player100")-[:serve@0 {}]->("team204")>                                                             |
| <("player100")-[:follow@0 {}]->("player125")-[:serve@0 {}]->("team204")>                               |
| <("player100")-[:follow@0 {}]->("player101")-[:serve@0 {}]->("team204")>                               |
| <("player100")-[:follow@0 {}]->("player101")-[:follow@0 {}]->("player125")-[:serve@0 {}]->("team204")> |
| <("player100")-[:follow@0 {}]->("player101")-[:follow@0 {}]->("player102")-[:serve@0 {}]->("team204")> |
+--------------------------------------------------------------------------------------------------------+
```

FAQ

DOES IT SUPPORT THE WHERE CLAUSE TO ACHIEVE CONDITIONAL FILTERING DURING GRAPH TRAVERSAL?

`FIND PATH` only supports filtering properties of edges with `WHERE` clauses, such as `WHERE follow.degree is EMPTY or follow.degree >=0` .

Filtering properties of vertices is not supported for now.

Last update: January 5, 2023

4.16 Query tuning and terminating statements

4.16.1 EXPLAIN and PROFILE

`EXPLAIN` helps output the execution plan of an nGQL statement without executing the statement.

`PROFILE` executes the statement, then outputs the execution plan as well as the execution profile. You can optimize the queries for better performance according to the execution plan and profile.

Execution Plan

The execution plan is determined by the execution planner in the NebulaGraph query engine.

The execution planner processes the parsed nGQL statements into `actions`. An `action` is the smallest unit that can be executed. A typical `action` fetches all neighbors of a given vertex, gets the properties of an edge, and filters vertices or edges based on the given conditions. Each `action` is assigned to an `operator` that performs the action.

For example, a `SHOW TAGS` statement is processed into two `actions` and assigned to a `Start operator` and a `ShowTags operator`, while a more complex `GO` statement may be processed into more than 10 `actions` and assigned to 10 operators.

Syntax

- `EXPLAIN`

```
EXPLAIN [format= {"row" | "dot" | "tck"}] <your_nGQL_statement>;
```

- `PROFILE`

```
PROFILE [format= {"row" | "dot" | "tck"}] <your_nGQL_statement>;
```

Output formats

The output of an `EXPLAIN` or a `PROFILE` statement has three formats, the default `row` format, the `dot` format, and the `tck` format. You can use the `format` option to modify the output format. Omitting the `format` option indicates using the default `row` format.

The `row` format

The `row` format outputs the return message in a table as follows.

- `EXPLAIN`

```
nebula> EXPLAIN format="row" SHOW TAGS;
Execution succeeded (time spent 327/892 us)

Execution Plan

-----+----------+--------------+----------------+----------------------------------------------------------------------
| id | name     | dependencies | profiling data | operator info                                                       |
-----+----------+--------------+----------------+----------------------------------------------------------------------
|  1 | ShowTags | 0            |                | outputVar: [{"colNames":[],"name":"__ShowTags_1","type":"DATASET"}] |
|    |          |              |                | inputVar:                                                           |
-----+----------+--------------+----------------+----------------------------------------------------------------------
|  0 | Start    |              |                | outputVar: [{"colNames":[],"name":"__Start_0","type":"DATASET"}]    |
-----+----------+--------------+----------------+----------------------------------------------------------------------
```

- `PROFILE`

```
nebula> PROFILE format="row" SHOW TAGS;
+--------+
| Name   |
+--------+
| player |
+--------+
| team   |
+--------+
Got 2 rows (time spent 2038/2728 us)

Execution Plan

-----+----------+--------------+----------------------------------------------------+----------------------------------------------------------------------
| id | name     | dependencies | profiling data                                     | operator info                                                       |
-----+----------+--------------+----------------------------------------------------+----------------------------------------------------------------------
|  1 | ShowTags | 0            | ver: 0, rows: 1, execTime: 42us, totalTime: 1177us | outputVar: [{"colNames":[],"name":"__ShowTags_1","type":"DATASET"}] |
|    |          |              |                                                    | inputVar:                                                           |
-----+----------+--------------+----------------------------------------------------+----------------------------------------------------------------------
|  0 | Start    |              | ver: 0, rows: 0, execTime: 1us, totalTime: 57us    | outputVar: [{"colNames":[],"name":"__Start_0","type":"DATASET"}]    |
-----+----------+--------------+----------------------------------------------------+----------------------------------------------------------------------
```

The descriptions are as follows.

Parameter	Description
`id`	The ID of the `operator`.
`name`	The name of the `operator`.
`dependencies`	The ID of the `operator` that the current `operator` depends on.
`profiling data`	The content of the execution profile. `ver` is the version of the `operator`. `rows` shows the number of rows to be output by the `operator`. `execTime` shows the execution time of `action`. `totalTime` is the sum of the execution time, the system scheduling time, and the queueing time.
`operator info`	The detailed information of the `operator`.

The `dot` format

You can use the `format="dot"` option to output the return message in the `dot` language, and then use Graphviz to generate a graph of the plan.

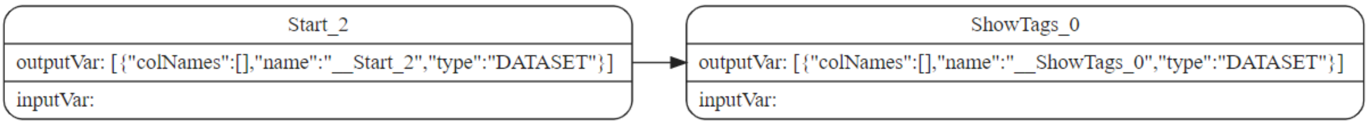
Note

Graphviz is open source graph visualization software. Graphviz provides an online tool for previewing DOT language files and exporting them to other formats such as SVG or JSON. For more information, see Graphviz Online.

```
nebula> EXPLAIN format="dot" SHOW TAGS;
Execution succeeded (time spent 161/665 us)
Execution Plan
-------------------------------------------------------------------------------------------------------------------------------------------  -------------
```

```
  plan
-----------------------------------------------------------------------------------------------------------------------------------------   -------------
  digraph exec_plan {
      rankdir=LR;
      "ShowTags_0"[label="ShowTags_0|outputVar: \[\{\"colNames\":\[\],\"name\":\"__ShowTags_0\",\"type\":\"DATASET\"\}\]\l|inputVar:\l",   shape=Mrecord];
      "Start_2"->"ShowTags_0";
      "Start_2"[label="Start_2|outputVar: \[\{\"colNames\":\[\],\"name\":\"__Start_2\",\"type\":\"DATASET\"\}\]\l|inputVar: \l",   shape=Mrecord];
  }
-----------------------------------------------------------------------------------------------------------------------------------------   -------------
```

The Graphviz graph transformed from the above DOT statement is as follows.



The `tck` format

The tck format is similar to a table, but without borders and dividing lines between rows. You can use the results as test cases for unit testing. For information on tck format test cases, see TCK cases.

- `EXPLAIN`

```
nebula> EXPLAIN format="tck" FETCH PROP ON player "player_1","player_2","player_3" YIELD properties(vertex).name as name, properties(vertex).age as age;
Execution succeeded (time spent 261µs/613.718µs)
Execution Plan (optimize time 28 us)
| id | name        | dependencies | profiling data | operator info |
|  2 | Project     | 1            |                |               |
|  1 | GetVertices | 0            |                |               |
|  0 | Start       |              |                |               |

Wed, 22 Mar 2023 23:15:52 CST
```

- `PROFILE`

```
nebula> PROFILE format="tck" FETCH PROP ON player "player_1","player_2","player_3" YIELD properties(vertex).name as name, properties(vertex).age as age;
| name        | age |
| "Piter Park" | 24  |
| "aaa"       | 24  |
| "ccc"       | 24  |
Got 3 rows (time spent 1.474ms/2.19677ms)
Execution Plan (optimize time 41 us)
| id | name        | dependencies | profiling data                                                                                                        | operator info |
|  2 | Project     | 1            | {"rows":3,"version":0}                                                                                                |               |
|  1 | GetVertices | 0            | {"resp[0]":{"exec":"232(us)","host":"127.0.0.1:9779","total":"758(us)"},"rows":3,"total_rpc":"875(us)","version":0} |               |
|  0 | Start       |              | {"rows":0,"version":0}                                                                                                |               |
Wed, 22 Mar 2023 23:16:13 CST
```

Last update: March 31, 2023

4.16.2 Kill queries

`KILL QUERY` can terminate the query being executed, and is often used to terminate slow queries.

Note

Users with the God role can kill any query. Other roles can only kill their own queries.

Syntax

```
KILL QUERY (session=<session_id>, plan=<plan_id>);
```

- `session_id`: The ID of the session.
- `plan_id`: The ID of the execution plan.

The ID of the session and the ID of the execution plan can uniquely determine a query. Both can be obtained through the SHOW QUERIES statement.

Examples

This example executes `KILL QUERY` in one session to terminate the query in another session.

```
nebula> KILL QUERY(SESSION=1625553545984255,PLAN=163);
```

The query will be terminated and the following information will be returned.

```
[ERROR (-1005)]: ExecutionPlanId[1001] does not exist in current Session.
```

Last update: May 13, 2022

4.16.3 Kill sessions

The `KILL SESSION` command is to terminate running sessions.

Note

- Only the NebulaGraph `root` user can terminate sessions.
- After executing the `KILL SESSION` command, all Graph services synchronize the latest session information after `2* session_reclaim_interval_secs` seconds (`120` seconds by default).

Syntax

You can run the `KILL SESSION` command to terminate one or multiple sessions. The syntax is as follows:

- To terminate one session

```
KILL {SESSION|SESSIONS} <SessionId>
```

- `{SESSION|SESSIONS}`: `SESSION` or `SESSIONS`, both are supported.
- `<SessionId>`: Specifies the ID of one session. You can run the SHOW SESSIONS command to view the IDs of sessions.

- To terminate multiple sessions

```
SHOW SESSIONS
| YIELD $-.SessionId AS sid [WHERE <filter_clause>]
| KILL {SESSION|SESSIONS} $-.sid
```

Note

The `KILL SESSION` command supports the pipeline operation, combining the `SHOW SESSIONS` command with the `KILL SESSION` command to terminate multiple sessions.

- `[WHERE <filter_clause>]`:
- Optional, the `WHERE` clause is used to filter sessions. `<filter_expression>` specifies a session filtering expression, for example, `WHERE $-.CreateTime < datetime("2022-12-14T18:00:00")`. If the `WHERE` clause is not specified, all sessions are terminated.
- Filtering conditions in a `WHERE` clause include: `SessionId`, `UserName`, `SpaceName`, `CreateTime`, `UpdateTime`, `GraphAddr`, `Timezone`, and `ClientIp`. You can run the SHOW SESSIONS command to view descriptions of these conditions.
- `{SESSION|SESSIONS}`: `SESSION` or `SESSIONS`, both are supported.

Caution

Please use filtering conditions with caution to avoid deleting sessions by mistake.

Examples

- To terminate one session

```
nebula> KILL SESSION 1672887983842984
```

- To terminate multiple sessions
- Terminate all sessions whose creation time is less than `2023-01-05T18:00:00`.

```
nebula> SHOW SESSIONS | YIELD $-.SessionId AS sid WHERE $-.CreateTime < datetime("2023-01-05T18:00:00") | KILL SESSIONS $-.sid
```

- Terminates the two sessions with the earliest creation times.

```
nebula> SHOW SESSIONS | YIELD $-.SessionId AS sid, $-.CreateTime as CreateTime | ORDER BY $-.CreateTime ASC | LIMIT 2 | KILL SESSIONS $-.sid
```

- Terminates all sessions created by the username `session_user1`.

```
nebula> SHOW SESSIONS | YIELD $-.SessionId as sid WHERE $-.UserName == "session_user1" | KILL SESSIONS $-.sid
```

- Terminate all sessions.

```
nebula> SHOW SESSIONS | YIELD $-.SessionId as sid | KILL SESSION $-.sid

// Or
nebula> SHOW SESSIONS | KILL SESSIONS $-.SessionId
```

Caution

When you terminate all sessions, the current session is terminated. Please use it with caution.

Last update: February 3, 2023

4.17 Job manager and the JOB statements

The long-term tasks run by the Storage Service are called jobs, such as `COMPACT`, `FLUSH`, and `STATS`. These jobs can be time-consuming if the data amount in the graph space is large. The job manager helps you run, show, stop, and recover jobs.

Note

All job management commands can be executed only after selecting a graph space.

4.17.1 SUBMIT JOB COMPACT

The `SUBMIT JOB COMPACT` statement triggers the long-term RocksDB `compact` operation in the current graph space.

For more information about `compact` configuration, see Storage Service configuration.

For example:

```
nebula> SUBMIT JOB COMPACT;
+------------+
| New Job Id |
+------------+
| 40         |
+------------+
```

4.17.2 SUBMIT JOB FLUSH

The `SUBMIT JOB FLUSH` statement writes the RocksDB memfile in the memory to the hard disk in the current graph space.

For example:

```
nebula> SUBMIT JOB FLUSH;
+------------+
| New Job Id |
+------------+
| 96         |
+------------+
```

4.17.3 SUBMIT JOB STATS

The `SUBMIT JOB STATS` statement starts a job that makes the statistics of the current graph space. Once this job succeeds, you can use the `SHOW STATS` statement to list the statistics. For more information, see SHOW STATS.

Note

If the data stored in the graph space changes, in order to get the latest statistics, you have to run `SUBMIT JOB STATS` again.

For example:

```
nebula> SUBMIT JOB STATS;
+------------+
| New Job Id |
+------------+
| 9          |
+------------+
```

4.17.4 SUBMIT JOB DOWNLOAD/INGEST

The `SUBMIT JOB DOWNLOAD HDFS` and `SUBMIT JOB INGEST` commands are used to import the SST file into NebulaGraph. For detail, see Import data from SST files.

The `SUBMIT JOB DOWNLOAD HDFS` command will download the SST file on the specified HDFS.

The `SUBMIT JOB INGEST` command will import the downloaded SST file into NebulaGraph.

For example:

```
nebula> SUBMIT JOB DOWNLOAD HDFS "hdfs://192.168.10.100:9000/sst";
+------------+
| New Job Id |
+------------+
| 10         |
+------------+
nebula> SUBMIT JOB INGEST;
+------------+
| New Job Id |
+------------+
| 11         |
+------------+
```

4.17.5 SHOW JOB

The Meta Service parses a `SUBMIT JOB` request into multiple tasks and assigns them to the nebula-storaged processes. The `SHOW JOB <job_id>` statement shows the information about a specific job and all its tasks in the current graph space.

`job_id` is returned when you run the `SUBMIT JOB` statement.

For example:

```
nebula> SHOW JOB 9;
+----------------+-----------------+------------+----------------------------+----------------------------+-------------+
| Job Id(TaskId) | Command(Dest)   | Status     | Start Time                 | Stop Time                  | Error Code  |
+----------------+-----------------+------------+----------------------------+----------------------------+-------------+
| 8              | "STATS"         | "FINISHED" | 2022-10-18T08:14:45.000000 | 2022-10-18T08:14:45.000000 | "SUCCEEDED" |
| 0              | "192.168.8.129" | "FINISHED" | 2022-10-18T08:14:45.000000 | 2022-10-18T08:15:13.000000 | "SUCCEEDED" |
| "Total:1"      | "Succeeded:1"   | "Failed:0" | "In Progress:0"            | ""                         | ""          |
+----------------+-----------------+------------+----------------------------+----------------------------+-------------+
```

The descriptions are as follows.

Parameter	Description
`Job Id(TaskId)`	The first row shows the job ID and the other rows show the task IDs and the last row shows the total number of job-related tasks.
`Command(Dest)`	The first row shows the command executed and the other rows show on which storaged processes the task is running. The last row shows the number of successful tasks related to the job.
`Status`	Shows the status of the job or task. The last row shows the number of failed tasks related to the job. For more information, see Job status.
`Start Time`	Shows a timestamp indicating the time when the job or task enters the `RUNNING` phase. The last row shows the number of ongoing tasks related to the job.
`Stop Time`	Shows a timestamp indicating the time when the job or task gets `FINISHED`, `FAILED`, or `STOPPED`.
`Error Code`	The error code of job.

Job status

The descriptions are as follows.

Status	Description
QUEUE	The job or task is waiting in a queue. The `Start Time` is empty in this phase.
RUNNING	The job or task is running. The `Start Time` shows the beginning time of this phase.
FINISHED	The job or task is successfully finished. The `Stop Time` shows the time when the job or task enters this phase.
FAILED	The job or task has failed. The `Stop Time` shows the time when the job or task enters this phase.
STOPPED	The job or task is stopped without running. The `Stop Time` shows the time when the job or task enters this phase.
REMOVED	The job or task is removed.

The description of switching the status is described as follows.

```
Queue -- running -- finished -- removed
     \          \                /
      \          \ -- failed -- /
       \          \            /
        \ ---------- stopped -/
```

4.17.6 SHOW JOBS

The `SHOW JOBS` statement lists all the unexpired jobs in the current graph space.

The default job expiration interval is one week. You can change it by modifying the `job_expired_secs` parameter of the Meta Service. For how to modify `job_expired_secs`, see Meta Service configuration.

For example:

```
nebula> SHOW JOBS;
+--------+---------------------+------------+----------------------------+----------------------------+
| Job Id | Command             | Status     | Start Time                 | Stop Time                  |
+--------+---------------------+------------+----------------------------+----------------------------+
| 34     | "STATS"             | "FINISHED" | 2021-11-01T03:32:27.000000 | 2021-11-01T03:32:27.000000 |
| 33     | "FLUSH"             | "FINISHED" | 2021-11-01T03:32:15.000000 | 2021-11-01T03:32:15.000000 |
| 32     | "COMPACT"           | "FINISHED" | 2021-11-01T03:32:06.000000 | 2021-11-01T03:32:06.000000 |
| 31     | "REBUILD_TAG_INDEX" | "FINISHED" | 2021-10-29T05:39:16.000000 | 2021-10-29T05:39:17.000000 |
| 10     | "COMPACT"           | "FINISHED" | 2021-10-26T02:27:05.000000 | 2021-10-26T02:27:05.000000 |
+--------+---------------------+------------+----------------------------+----------------------------+
```

4.17.7 STOP JOB

The `STOP JOB <job_id>` statement stops jobs that are not finished in the current graph space.

For example:

```
nebula> STOP JOB 22;
+---------------+
| Result        |
+---------------+
| "Job stopped" |
+---------------+
```

4.17.8 RECOVER JOB

The `RECOVER JOB [<job_id>]` statement re-executes the jobs that status is `FAILED` or `STOPPED` in the current graph space and returns the number of recovered jobs. If `<job_id>` is not specified, re-execution is performed from the earliest job and the number of jobs that have been recovered is returned.

For example:

```
nebula> RECOVER JOB;
+-------------------+
| Recovered job num |
+-------------------+
| 5 job recovered   |
+-------------------+
```

4.17.9 FAQ

How to troubleshoot job problems?

The `SUBMIT JOB` operations use the HTTP port. Please check if the HTTP ports on the machines where the Storage Service is running are working well. You can use the following command to debug.

```
curl "http://{storaged-ip}:19779/admin?space={space_name}&op=compact"
```

Last update: May 29, 2023

5. Deployment and installation

5.1 Prepare resources for compiling, installing, and running NebulaGraph

This topic describes the requirements and suggestions for compiling and installing NebulaGraph, as well as how to estimate the resource you need to reserve for running a NebulaGraph cluster.

Enterpriseonly

In addition to installing NebulaGraph with the source code, the Dashboard Enterprise Edition tool is a better and convenient choice for installing Community and Enterprise Edition NebulaGraph. For details, see Deploy Dashboard.

5.1.1 About storage devices

NebulaGraph is designed and implemented for NVMe SSD. All default parameters are optimized for the SSD devices and require extremely high IOPS and low latency.

- Due to the poor IOPS capability and long random seek latency, HDD is not recommended. Users may encounter many problems when using HDD.
- Do not use remote storage devices, such as NAS or SAN. Do not connect an external virtual hard disk based on HDFS or Ceph.
- Do not use RAID.
- Use local SSD devices, or AWS Provisioned IOPS SSD equivalence.

5.1.2 About CPU architecture

Note

Starting with 3.0.2, you can run containerized NebulaGraph databases on Docker Desktop for ARM macOS or on ARM Linux servers.

5.1.3 Requirements for compiling the source code

Hardware requirements for compiling NebulaGraph

Item	Requirement
CPU architecture	x86_64
Memory	4 GB
Disk	10 GB, SSD

Supported operating systems for compiling NebulaGraph

For now, we can only compile NebulaGraph in the Linux system. We recommend that you use any Linux system with kernel version `4.15` or above.

Note

To install NebulaGraph on Linux systems with kernel version lower than required, use RPM/DEB packages or TAR files.

Software requirements for compiling NebulaGraph

You must have the correct version of the software listed below to compile NebulaGraph. If they are not as required or you are not sure, follow the steps in Prepare software for compiling NebulaGraph to get them ready.

Software	Version	Note
glibc	2.17 or above	You can run `ldd --version` to check the glibc version.
make	Any stable version	-
m4	Any stable version	-
git	Any stable version	-
wget	Any stable version	-
unzip	Any stable version	-
xz	Any stable version	-
readline-devel	Any stable version	-
ncurses-devel	Any stable version	-
zlib-devel	Any stable version	-
g++	8.5.0 or above	You can run `gcc -v` to check the gcc version.
cmake	3.14.0 or above	You can run `cmake --version` to check the cmake version.
curl	Any stable version	-
redhat-lsb-core	Any stable version	-
libstdc++-static	Any stable version	Only needed in CentOS 8+, RedHat 8+, and Fedora systems.
libasan	Any stable version	Only needed in CentOS 8+, RedHat 8+, and Fedora systems.
bzip2	Any stable version	-

Other third-party software will be automatically downloaded and installed to the `build` directory at the configure (cmake) stage.

Prepare software for compiling NebulaGraph

If part of the dependencies are missing or the versions does not meet the requirements, manually install them with the following steps. You can skip unnecessary dependencies or steps according to your needs.

1. Install dependencies.

- For CentOS, RedHat, and Fedora users, run the following commands.

```
$ yum update
$ yum install -y make \
                 m4 \
                 git \
                 wget \
                 unzip \
                 xz \
                 readline-devel \
                 ncurses-devel \
                 zlib-devel \
                 gcc \
                 gcc-c++ \
                 cmake \
                 curl \
                 redhat-lsb-core \
                 bzip2
  // For CentOS 8+, RedHat 8+, and Fedora, install libstdc++-static and libasan as well
$ yum install -y libstdc++-static libasan
```

- For Debian and Ubuntu users, run the following commands.

```
$ apt-get update
$ apt-get install -y make \
                     m4 \
                     git \
                     wget \
                     unzip \
                     xz-utils \
                     curl \
                     lsb-core \
                     build-essential \
                     libreadline-dev \
                     ncurses-dev \
                     cmake \
                     bzip2
```

2. Check if the GCC and cmake on your host are in the right version. See Software requirements for compiling NebulaGraph for the required versions.

```
$ g++ --version
$ cmake --version
```

If your GCC and CMake are in the right versions, then you are all set and you can ignore the subsequent steps. If they are not, select and perform the needed steps as follows.

3. If the CMake version is incorrect, visit the CMake official website to install the required version.

4. If the G++ version is incorrect, visit the G++ official website or follow the instructions below to to install the required version.

- For CentOS users, run:

```
yum install centos-release-scl
yum install devtoolset-11
scl enable devtoolset-11 'bash'
```

- For Ubuntu users, run:

```
add-apt-repository ppa:ubuntu-toolchain-r/test
apt install gcc-11 g++-11
```

5.1.4 Requirements and suggestions for installing NebulaGraph in test environments

Hardware requirements for test environments

Item	Requirement
CPU architecture	x86_64
Number of CPU core	4
Memory	8 GB
Disk	100 GB, SSD

Supported operating systems for test environments

For now, we can only install NebulaGraph in the Linux system. To install NebulaGraph in a test environment, we recommend that you use any Linux system with kernel version `3.9` or above.

Suggested service architecture for test environments

Process	Suggested number
metad (the metadata service process)	1
storaged (the storage service process)	1 or more
graphd (the query engine service process)	1 or more

For example, for a single-machine test environment, you can deploy 1 metad, 1 storaged, and 1 graphd processes in the machine.

For a more common test environment, such as a cluster of 3 machines (named as A, B, and C), you can deploy NebulaGraph as follows:

Machine name	Number of metad	Number of storaged	Number of graphd
A	1	1	1
B	None	1	1
C	None	1	1

5.1.5 Requirements and suggestions for installing NebulaGraph in production environments

Hardware requirements for production environments

Item	Requirement
CPU architecture	x86_64
Number of CPU core	48
Memory	256 GB
Disk	2 * 1.6 TB, NVMe SSD

Supported operating systems for production environments

For now, we can only install NebulaGraph in the Linux system. To install NebulaGraph in a production environment, we recommend that you use any Linux system with kernel version 3.9 or above.

Users can adjust some of the kernel parameters to better accommodate the need for running NebulaGraph. For more information, see kernel configuration.

Suggested service architecture for production environments

Danger

DO NOT deploy a single cluster across IDCs (The Enterprise Edtion supports data synchronization between clusters across IDCs).

Process	Suggested number
metad (the metadata service process)	3
storaged (the storage service process)	3 or more
graphd (the query engine service process)	3 or more

Each metad process automatically creates and maintains a replica of the metadata. Usually, you need to deploy three metad processes and only three.

The number of storaged processes does not affect the number of graph space replicas.

Users can deploy multiple processes on a single machine. For example, on a cluster of 5 machines (named as A, B, C, D, and E), you can deploy NebulaGraph as follows:

Machine name	Number of metad	Number of storaged	Number of graphd
A	1	1	1
B	1	1	1
C	1	1	1
D	None	1	1
E	None	1	1

5.1.6 Capacity requirements for running a NebulaGraph cluster

Users can estimate the memory, disk space, and partition number needed for a NebulaGraph cluster of 3 replicas as follows.

Resource	Unit	How to estimate	Description
Disk space for a cluster	Bytes	`the_sum_of_edge_number_and_vertex_number` * `average_bytes_of_properties` * 7.5 * 120%	For more information, see Edge partitioning and storage amplification.
Memory for a cluster	Bytes	[`the_sum_of_edge_number_and_vertex_number` * 16 + `the_number_of_RocksDB_instances` * (`write_buffer_size` * `max_write_buffer_number`) + `rocksdb_block_cache`] * 120%	`write_buffer_size` and `max_write_buffer_number` are RocksDB parameters. For more information, see MemTable. For details about `rocksdb_block_cache`, see Memory usage in RocksDB.
Number of partitions for a graph space	-	`the_number_of_disks_in_the_cluster` * `disk_partition_num_multiplier`	`disk_partition_num_multiplier` is an integer between 2 and 20 (both including). Its value depends on the disk performance. Use 20 for SSD and 2 for HDD.

- Question 1: Why do I need to multiply by 7.5 in the disk space estimation formula?

  Answer: On one hand, the data in one single replica takes up about 2.5 times more space than that of the original data file (csv) according to test values. On the other hand, indexes take up additional space. Each indexed vertex or edge takes up 16 bytes of memory. The hard disk space occupied by the index can be empirically estimated as the total number of indexed vertices or edges * 50 bytes.

- Question 2: Why do we multiply the disk space and memory by 120%?

  Answer: The extra 20% is for buffer.

- Question 3: How to get the number of RocksDB instances?

  Answer: Each graph space corresponds to one RocksDB instance and each directory in the `--data_path` item in the `etc/nebula-storaged.conf` file corresponds to one RocksDB instance. That is, the number of RocksDB instances = the number of directories * the number of graph spaces.

Note

Users can decrease the memory size occupied by the bloom filter by adding `--enable_partitioned_index_filter=true` in `etc/nebula-storaged.conf`. But it may decrease the read performance in some random-seek cases.

Caution

Each RocksDB instance takes up about 70M of disk space even when no data has been written yet. One partition corresponds to one RocksDB instance, and when the partition setting is very large, for example, 100, the graph space takes up a lot of disk space after it is created.

Last update: February 7, 2023

5.2 Compile and install Nebula Graph

5.2.1 Install NebulaGraph by compiling the source code

Installing NebulaGraph from the source code allows you to customize the compiling and installation settings and test the latest features.

Prerequisites

- Users have to prepare correct resources described in Prepare resources for compiling, installing, and running NebulaGraph.

  Note

  Compilation of NebulaGraph offline is not currently supported.

- The host to be installed with NebulaGraph has access to the Internet.

Installation steps

1. Use Git to clone the source code of NebulaGraph to the host.

- [Recommended] To install NebulaGraph 3.5.0, run the following command.

```
$ git clone --branch release-3.5 https://github.com/vesoft-inc/nebula.git
```

- To install the latest developing release, run the following command to clone the source code from the master branch.

```
$ git clone https://github.com/vesoft-inc/nebula.git
```

2. Go to the `nebula/third-party` directory, and run the `install-third-party.sh` script to install the third-party libraries.

```
$ cd nebula/third-party
$ ./install-third-party.sh
```

3. Go back to the `nebula` directory, create a directory named `build`, and enter the directory.

```
$ cd ..
$ mkdir build && cd build
```

4. Generate Makefile with CMake.

   Note

   The installation path is `/usr/local/nebula` by default. To customize it, add the `-DCMAKE_INSTALL_PREFIX=<installation_path>` CMake variable in the following command.

   For more information about CMake variables, see CMake variables.

```
$ cmake -DCMAKE_INSTALL_PREFIX=/usr/local/nebula -DENABLE_TESTING=OFF -DCMAKE_BUILD_TYPE=Release ..
```

5. Compile NebulaGraph.

   Note

   Check Prepare resources for compiling, installing, and running NebulaGraph.

To speed up the compiling, use the `-j` option to set a concurrent number `N`. It should be $\min(\text{CPU core number}, \frac{\text{the\_memory\_size(GB)}}{2})$.

```
$ make -j{N} # E.g., make -j2
```

6. Install NebulaGraph.

```
$ sudo make install
```

7. The configuration files in the `etc/` directory (`/usr/local/nebula/etc` by default) are references. Users can create their own configuration files accordingly. If you want to use the scripts in the `script` directory to start, stop, restart, and kill the service, and check the service status, the configuration files have to be named as `nebula-graph.conf`, `nebula-metad.conf`, and `nebula-storaged.conf`.

Update the master branch

The source code of the master branch changes frequently. If the corresponding NebulaGraph release is installed, update it in the following steps.

1. In the `nebula` directory, run `git pull upstream master` to update the source code.
2. In the `nebula/build` directory, run `make -j{N}` and `make install` again.

Next to do

- Manage NebulaGraph services

CMake variables

USAGE OF CMAKE VARIABLES

```
$ cmake -D<variable>=<value> ...
```

The following CMake variables can be used at the configure (cmake) stage to adjust the compiling settings.

CMAKE_INSTALL_PREFIX

`CMAKE_INSTALL_PREFIX` specifies the path where the service modules, scripts, configuration files are installed. The default path is `/usr/local/nebula`.

ENABLE_WERROR

`ENABLE_WERROR` is `ON` by default and it makes all warnings into errors. You can set it to `OFF` if needed.

ENABLE_TESTING

`ENABLE_TESTING` is `ON` by default and unit tests are built with the NebulaGraph services. If you just need the service modules, set it to `OFF`.

ENABLE_ASAN

`ENABLE_ASAN` is `OFF` by default and the building of ASan (AddressSanitizer), a memory error detector, is disabled. To enable it, set `ENABLE_ASAN` to `ON`. This variable is intended for NebulaGraph developers.

CMAKE_BUILD_TYPE

NebulaGraph supports the following building types of `MAKE_BUILD_TYPE`:

- `Debug`

  The default value of `CMAKE_BUILD_TYPE`. It indicates building NebulaGraph with the debug info but not the optimization options.

- `Release`

  It indicates building NebulaGraph with the optimization options but not the debug info.

- `RelWithDebInfo`

  It indicates building NebulaGraph with the optimization options and the debug info.

- `MinSizeRel`

  It indicates building NebulaGraph with the optimization options for controlling the code size but not the debug info.

ENABLE_INCLUDE_WHAT_YOU_USE

`ENABLE_INCLUDE_WHAT_YOU_USE` is `OFF` by default. When set to `ON` and include-what-you-use is installed on the system, the system reports redundant headers contained in the project source code during makefile generation.

NEBULA_USE_LINKER

Specifies the program linker on the system. The available values are:

- `bfd`, the default value, indicates that ld.bfd is applied as the linker.
- `lld`, indicates that ld.lld, if installed on the system, is applied as the linker.
- `gold`, indicates that ld.gold, if installed on the system, is applied as the linker.

CMAKE_C_COMPILER/CMAKE_CXX_COMPILER

Usually, CMake locates and uses a C/C++ compiler installed in the host automatically. But if your compiler is not installed at the standard path, or if you want to use a different one, run the command as follows to specify the installation path of the target compiler:

```
$ cmake -DCMAKE_C_COMPILER=<path_to_gcc/bin/gcc> -DCMAKE_CXX_COMPILER=<path_to_gcc/bin/g++> ..
$ cmake -DCMAKE_C_COMPILER=<path_to_clang/bin/clang> -DCMAKE_CXX_COMPILER=<path_to_clang/bin/clang++> ..
```

ENABLE_CCACHE

`ENABLE_CCACHE` is `ON` by default and Ccache (compiler cache) is used to speed up the compiling of NebulaGraph.

To disable `ccache`, setting `ENABLE_CCACHE` to `OFF` is not enough. On some platforms, the `ccache` installation hooks up or precedes the compiler. In such a case, you have to set an environment variable `export CCACHE_DISABLE=true` or add a line `disable=true` in `~/.ccache/ccache.conf` as well. For more information, see the ccache official documentation.

NEBULA_THIRDPARTY_ROOT

`NEBULA_THIRDPARTY_ROOT` specifies the path where the third party software is installed. By default it is `/opt/vesoft/third-party`.

Examine problems

If the compiling fails, we suggest you:

1. Check whether the operating system release meets the requirements and whether the memory and hard disk space are sufficient.
2. Check whether the third-party is installed correctly.
3. Use `make -j1` to reduce the compiling concurrency.

Last update: April 25, 2023

5.2.2 Install NebulaGraph with RPM or DEB package

RPM and DEB are common package formats on Linux systems. This topic shows how to quickly install NebulaGraph with the RPM or DEB package.

Note

The console is not complied or packaged with NebulaGraph server binaries. You can install nebula-console by yourself.

Prerequisites

Wget installed.

Download the package from cloud service

Note

NebulaGraph is currently only supported for installation on Linux systems, and only CentOS 7.x, CentOS 8.x, Ubuntu 16.04, Ubuntu 18.04, and Ubuntu 20.04 operating systems are supported.

- Download the released version.

  URL:

```
//Centos 6
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.el6.x86_64.rpm

//Centos 7
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.el7.x86_64.rpm

//Centos 8
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.el8.x86_64.rpm

//Ubuntu 1604
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.ubuntu1604.amd64.deb

//Ubuntu 1804
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.ubuntu1804.amd64.deb

//Ubuntu 2004
https://oss-cdn.nebula-graph.io/package/<release_version>/nebula-graph-<release_version>.ubuntu2004.amd64.deb
```

  For example, download the release package `3.5.0` for `Centos 7.5`:

```
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.el7.x86_64.rpm
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.el7.x86_64.rpm.sha256sum.txt
```

  Download the release package `3.5.0` for `Ubuntu 1804`:

```
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.ubuntu1804.amd64.deb
wget https://oss-cdn.nebula-graph.io/package/3.5.0/nebula-graph-3.5.0.ubuntu1804.amd64.deb.sha256sum.txt
```

- Download the nightly version.

Danger

- Nightly versions are usually used to test new features. Do not use it in a production environment.
- Nightly versions may not be built successfully every night. And the names may change from day to day.

URL:

```
//Centos 6
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.el6.x86_64.rpm

//Centos 7
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.el7.x86_64.rpm

//Centos 8
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.el8.x86_64.rpm

//Ubuntu 1604
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.ubuntu1604.amd64.deb

//Ubuntu 1804
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.ubuntu1804.amd64.deb

//Ubuntu 2004
https://oss-cdn.nebula-graph.io/package/nightly/<yyyy.mm.dd>/nebula-graph-<yyyy.mm.dd>-nightly.ubuntu2004.amd64.deb
```

For example, download the `Centos 7.5` package developed and built in `2021.11.28`:

```
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.el7.x86_64.rpm
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.el7.x86_64.rpm.sha256sum.txt
```

For example, download the `Ubuntu 1804` package developed and built in `2021.11.28`:

```
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.ubuntu1804.amd64.deb
wget https://oss-cdn.nebula-graph.io/package/nightly/2021.11.28/nebula-graph-2021.11.28-nightly.ubuntu1804.amd64.deb.sha256sum.txt
```

Install NebulaGraph

- Use the following syntax to install with an RPM package.

```
$ sudo rpm -ivh --prefix=<installation_path> <package_name>
```

The option `--prefix` indicates the installation path. The default path is `/usr/local/nebula/`.

For example, to install an RPM package in the default path for the 3.5.0 version, run the following command.

```
sudo rpm -ivh nebula-graph-3.5.0.el7.x86_64.rpm
```

- Use the following syntax to install with a DEB package.

```
$ sudo dpkg -i <package_name>
```

Note

Customizing the installation path is not supported when installing NebulaGraph with a DEB package. The default installation path is `/usr/local/nebula/`.

For example, to install a DEB package for the 3.5.0 version, run the following command.

```
sudo dpkg -i nebula-graph-3.5.0.ubuntu1804.amd64.deb
```

Note

The default installation path is `/usr/local/nebula/`.

Next to do

- Start NebulaGraph
- Connect to NebulaGraph

Last update: August 11, 2022

5.2.3 Install NebulaGraph graph with the tar.gz file

You can install NebulaGraph by downloading the tar.gz file.

Note

- NebulaGraph provides installing with the tar.gz file starting from version 2.6.0.
- NebulaGraph is currently only supported for installation on Linux systems, and only CentOS 7.x, CentOS 8.x, Ubuntu 16.04, Ubuntu 18.04, and Ubuntu 20.04 operating systems are supported.

Installation steps

1. Download the NebulaGraph tar.gz file using the following address.

   Before downloading, you need to replace `<release_version>` with the version you want to download.

```
//Centos 7
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.el7.x86_64.tar.gz
//Checksum
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.el7.x86_64.tar.gz.sha256sum.txt

//Centos 8
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.el8.x86_64.tar.gz
//Checksum
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.el8.x86_64.tar.gz.sha256sum.txt

//Ubuntu 1604
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.ubuntu1604.amd64.tar.gz
//Checksum
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.ubuntu1604.amd64.tar.gz.sha256sum.txt

//Ubuntu 1804
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.ubuntu1804.amd64.tar.gz
//Checksum
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.ubuntu1804.amd64.tar.gz.sha256sum.txt

//Ubuntu 2004
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.ubuntu2004.amd64.tar.gz
//Checksum
https://oss-cdn.nebula-graph.com.cn/package/<release_version>/nebula-graph-<release_version>.ubuntu2004.amd64.tar.gz.sha256sum.txt
```

   For example, to download the NebulaGraph release-3.5 tar.gz file for `CentOS 7.5`, run the following command:

```
wget https://oss-cdn.nebula-graph.com.cn/package/3.5.0/nebula-graph-3.5.0.el7.x86_64.tar.gz
```

2. Decompress the tar.gz file to the NebulaGraph installation directory.

```
tar -xvzf <tar.gz_file_name> -C <install_path>
```

- `tar.gz_file_name` specifies the name of the tar.gz file.
- `install_path` specifies the installation path.

   For example:

```
tar -xvzf nebula-graph-3.5.0.el7.x86_64.tar.gz -C /home/joe/nebula/install
```

3. Modify the name of the configuration file.

   Enter the decompressed directory, rename the files `nebula-graphd.conf.default`, `nebula-metad.conf.default`, and `nebula-storaged.conf.default` in the subdirectory `etc`, and delete `.default` to apply the default configuration of NebulaGraph. To modify the configuration, see Configurations.

So far, you have installed NebulaGraph successfully.

Next to do

- Manage NebulaGraph services

Last update: December 21, 2022

5.2.4 Deploy NebulaGraph with Docker Compose

Using Docker Compose can quickly deploy NebulaGraph services based on the prepared configuration file. It is only recommended to use this method when testing functions of NebulaGraph.

Prerequisites

- You have installed the following applications on your host.

Application	Recommended version	Official installation reference
Docker	Latest	Install Docker Engine
Docker Compose	Latest	Install Docker Compose
Git	Latest	Download Git

- If you are deploying NebulaGraph as a non-root user, grant the user with Docker-related privileges. For detailed instructions, see Manage Docker as a non-root user.
- You have started the Docker service on your host.
- If you have already deployed another version of NebulaGraph with Docker Compose on your host, to avoid compatibility issues, you need to delete the `nebula-docker-compose/data` directory.

Deploy NebulaGraph

1. Clone the `3.5.0` branch of the `nebula-docker-compose` repository to your host with Git.

   Danger

   The `master` branch contains the untested code for the latest NebulaGraph development release. **DO NOT** use this release in a production environment.

   ```
   $ git clone -b release-3.5 https://github.com/vesoft-inc/nebula-docker-compose.git
   ```

   Note

   The `x.y` version of Docker Compose aligns to the `x.y` version of NebulaGraph. For the NebulaGraph `z` version, Docker Compose does not publish the corresponding `z` version, but pulls the `z` version of the NebulaGraph image.

2. Go to the `nebula-docker-compose` directory.

   ```
   $ cd nebula-docker-compose/
   ```

3. Run the following command to start all the NebulaGraph services.

   Note

   - Update the NebulaGraph images and NebulaGraph Console images first if they are out of date.
   - The return result after executing the command varies depending on the installation directory.

   ```
   [nebula-docker-compose]$ docker-compose up -d
   Creating nebuladockercompose_metad0_1 ... done
   Creating nebuladockercompose_metad2_1 ... done
   Creating nebuladockercompose_metad1_1 ... done
   Creating nebuladockercompose_graphd2_1   ... done
   Creating nebuladockercompose_graphd_1    ... done
   ```

```
Creating nebuladockercompose_graphd1_1   ... done
Creating nebuladockercompose_storaged0_1 ... done
Creating nebuladockercompose_storaged2_1 ... done
Creating nebuladockercompose_storaged1_1 ... done
```

Compatibility

Starting from NebulaGraph version 3.1.0, nebula-docker-compose automatically starts a NebulaGraph Console docker container and adds the storage host to the cluster (i.e. `ADD HOSTS` command).

Note

For more information of the preceding services, see NebulaGraph architecture.

Connect to NebulaGraph

There are two ways to connect to NebulaGraph:

- Connected with Nebula Console outside the container. Because the external mapping port for the Graph service is also fixed as `9669` in the container's configuration file, you can connect directly through the default port. For details, see Connect to NebulaGraph.
- Log into the container installed NebulaGraph Console, then connect to the Graph service. This section describes this approach.

1. Run the following command to view the name of NebulaGraph Console docker container.

```
$ docker-compose ps
          Name                        Command             State                Ports
--------------------------------------------------------------------------------------------
nebuladockercompose_console_1     sh -c sleep 3 &&         Up
                                  nebula-co ...
......
```

2. Run the following command to enter the NebulaGraph Console docker container.

```
docker exec -it nebuladockercompose_console_1 /bin/sh
/ #
```

3. Connect to NebulaGraph with NebulaGraph Console.

```
/ # ./usr/local/bin/nebula-console -u <user_name> -p <password> --address=graphd --port=9669
```

Note

By default, the authentication is off, you can only log in with an existing username (the default is `root`) and any password. To turn it on, see Enable authentication.

4. Run the following commands to view the cluster state.

```
nebula> SHOW HOSTS;
+-------------+------+----------+--------------+---------------------+------------------------+---------+
| Host        | Port | Status   | Leader count | Leader distribution  | Partition distribution | Version |
+-------------+------+----------+--------------+---------------------+------------------------+---------+
| "storaged0" | 9779 | "ONLINE" | 0            | "No valid partition" | "No valid partition"   | "3.5.0" |
| "storaged1" | 9779 | "ONLINE" | 0            | "No valid partition" | "No valid partition"   | "3.5.0" |
| "storaged2" | 9779 | "ONLINE" | 0            | "No valid partition" | "No valid partition"   | "3.5.0" |
+-------------+------+----------+--------------+---------------------+------------------------+---------+
```

Run `exit` twice to switch back to your terminal (shell).

Check the NebulaGraph service status and ports

Run `docker-compose ps` to list all the services of NebulaGraph and their status and ports.

Note

NebulaGraph provides services to the clients through port `9669` by default. To use other ports, modify the `docker-compose.yaml` file in the `nebula-docker-compose` directory and restart the NebulaGraph services.

```
$ docker-compose ps
nebuladockercompose_console_1     sh -c sleep 3 &&               Up
                                  nebula-co ...
nebuladockercompose_graphd1_1     /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49174->19669/tcp,:::49174->19669/tcp, 0.0.0.0:49171->19670/tcp,:::49171->19670/tcp, 0.0.0.0:49177->9669/
tcp,:::49177->9669/tcp
nebuladockercompose_graphd2_1     /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49175->19669/tcp,:::49175->19669/tcp, 0.0.0.0:49172->19670/tcp,:::49172->19670/tcp, 0.0.0.0:49178->9669/
tcp,:::49178->9669/tcp
nebuladockercompose_graphd_1      /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49180->19669/tcp,:::49180->19669/tcp, 0.0.0.0:49179->19670/tcp,:::49179->19670/tcp, 0.0.0.0:9669->9669/
tcp,:::9669->9669/tcp
nebuladockercompose_metad0_1      /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49157->19559/tcp,:::49157->19559/tcp, 0.0.0.0:49154->19560/tcp,:::49154->19560/tcp, 0.0.0.0:49160->9559/
tcp,:::49160->9559/tcp, 9560/tcp
nebuladockercompose_metad1_1      /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49156->19559/tcp,:::49156->19559/tcp, 0.0.0.0:49153->19560/tcp,:::49153->19560/tcp, 0.0.0.0:49159->9559/
tcp,:::49159->9559/tcp, 9560/tcp
nebuladockercompose_metad2_1      /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49158->19559/tcp,:::49158->19559/tcp, 0.0.0.0:49155->19560/tcp,:::49155->19560/tcp, 0.0.0.0:49161->9559/
tcp,:::49161->9559/tcp, 9560/tcp
nebuladockercompose_storaged0_1   /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49166->19779/tcp,:::49166->19779/tcp, 0.0.0.0:49163->19780/tcp,:::49163->19780/tcp, 9777/tcp, 9778/tcp, 0.
0.0.0:49169->9779/tcp,:::49169->9779/tcp, 9780/tcp
nebuladockercompose_storaged1_1   /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49165->19779/tcp,:::49165->19779/tcp, 0.0.0.0:49162->19780/tcp,:::49162->19780/tcp, 9777/tcp, 9778/tcp, 0.
0.0.0:49168->9779/tcp,:::49168->9779/tcp, 9780/tcp
nebuladockercompose_storaged2_1   /usr/local/nebula/bin/nebu ...   Up      0.0.0.0:49167->19779/tcp,:::49167->19779/tcp, 0.0.0.0:49164->19780/tcp,:::49164->19780/tcp, 9777/tcp, 9778/tcp, 0.
0.0.0:49170->9779/tcp,:::49170->9779/tcp, 9780/tcp
```

If the service is abnormal, you can first confirm the abnormal container name (such as `nebuladockercompose_graphd2_1`).

Then you can execute `docker ps` to view the corresponding `CONTAINER ID` (such as `2a6c56c405f5`).

```
[nebula-docker-compose]$ docker ps
CONTAINER ID   IMAGE                               COMMAND                  CREATED          STATUS
PORTS                                                                                                   NAMES
2a6c56c405f5   vesoft/nebula-graphd:nightly     "/usr/local/nebula/b..."   36 minutes ago   Up 36 minutes (healthy)   0.0.0.0:49230->9669/tcp, 0.0.0.0:49229->19669/tcp, 0.0.0.0:49228->19670/
tcp                                nebuladockercompose_graphd2_1
7042e0a8e83d   vesoft/nebula-storaged:nightly   "./bin/nebula-storag..."   36 minutes ago   Up 36 minutes (healthy)   9777-9778/tcp, 9780/tcp, 0.0.0.0:49227->9779/tcp, 0.0.0.0:49226->19779/
tcp, 0.0.0.0:49225->19780/tcp   nebuladockercompose_storaged2_1
18e3ea63ad65   vesoft/nebula-storaged:nightly   "./bin/nebula-storag..."   36 minutes ago   Up 36 minutes (healthy)   9777-9778/tcp, 9780/tcp, 0.0.0.0:49219->9779/tcp, 0.0.0.0:49218->19779/
tcp, 0.0.0.0:49217->19780/tcp   nebuladockercompose_storaged0_1
4dcabfe8677a   vesoft/nebula-graphd:nightly     "/usr/local/nebula/b..."   36 minutes ago   Up 36 minutes (healthy)   0.0.0.0:49224->9669/tcp, 0.0.0.0:49223->19669/tcp, 0.0.0.0:49222->19670/
tcp                                nebuladockercompose_graphd1_1
a74054c6ae25   vesoft/nebula-graphd:nightly     "/usr/local/nebula/b..."   36 minutes ago   Up 36 minutes (healthy)   0.0.0.0:9669->9669/tcp, 0.0.0.0:49221->19669/tcp, 0.0.0.0:49220->19670/
tcp                                nebuladockercompose_graphd_1
880025a3858c   vesoft/nebula-storaged:nightly   "./bin/nebula-storag..."   36 minutes ago   Up 36 minutes (healthy)   9777-9778/tcp, 9780/tcp, 0.0.0.0:49216->9779/tcp, 0.0.0.0:49215->19779/
tcp, 0.0.0.0:49214->19780/tcp   nebuladockercompose_storaged1_1
45736a32a23a   vesoft/nebula-metad:nightly      "./bin/nebula-metad ..."   36 minutes ago   Up 36 minutes (healthy)   9560/tcp, 0.0.0.0:49213->9559/tcp, 0.0.0.0:49212->19559/tcp, 0.
0.0.0:49211->19560/tcp                     nebuladockercompose_metad0_1
3b2c90eb073e   vesoft/nebula-metad:nightly      "./bin/nebula-metad ..."   36 minutes ago   Up 36 minutes (healthy)   9560/tcp, 0.0.0.0:49207->9559/tcp, 0.0.0.0:49206->19559/tcp, 0.
0.0.0:49205->19560/tcp                     nebuladockercompose_metad2_1
7bb31b7a5b3f   vesoft/nebula-metad:nightly      "./bin/nebula-metad ..."   36 minutes ago   Up 36 minutes (healthy)   9560/tcp, 0.0.0.0:49210->9559/tcp, 0.0.0.0:49209->19559/tcp, 0.
0.0.0:49208->19560/tcp                     nebuladockercompose_metad1_1
```

Use the `CONTAINER ID` to log in the container and troubleshoot.

```
nebula-docker-compose]$ docker exec -it 2a6c56c405f5 bash
[root@2a6c56c405f5 nebula]#
```

Check the service data and logs

All the data and logs of NebulaGraph are stored persistently in the `nebula-docker-compose/data` and `nebula-docker-compose/logs` directories.

The structure of the directories is as follows:

```
nebula-docker-compose/
  |-- docker-compose.yaml
  ├── data
  │     ├── meta0
  │     ├── meta1
  │     ├── meta2
  │     ├── storage0
  │     ├── storage1
  │     └── storage2
  └── logs
       ├── graph
       ├── graph1
       ├── graph2
       ├── meta0
       ├── meta1
       ├── meta2
```

```
    ├── storage0
    ├── storage1
    └── storage2
```

Stop the NebulaGraph services

You can run the following command to stop the NebulaGraph services:

```
$ docker-compose down
```

The following information indicates you have successfully stopped the NebulaGraph services:

```
Stopping nebuladockercompose_console_1   ... done
Stopping nebuladockercompose_graphd1_1   ... done
Stopping nebuladockercompose_graphd_1    ... done
Stopping nebuladockercompose_graphd2_1   ... done
Stopping nebuladockercompose_storaged1_1 ... done
Stopping nebuladockercompose_storaged0_1 ... done
Stopping nebuladockercompose_storaged2_1 ... done
Stopping nebuladockercompose_metad2_1    ... done
Stopping nebuladockercompose_metad0_1    ... done
Stopping nebuladockercompose_metad1_1    ... done
Removing nebuladockercompose_console_1   ... done
Removing nebuladockercompose_graphd1_1   ... done
Removing nebuladockercompose_graphd_1    ... done
Removing nebuladockercompose_graphd2_1   ... done
Removing nebuladockercompose_storaged1_1 ... done
Removing nebuladockercompose_storaged0_1 ... done
Removing nebuladockercompose_storaged2_1 ... done
Removing nebuladockercompose_metad2_1    ... done
Removing nebuladockercompose_metad0_1    ... done
Removing nebuladockercompose_metad1_1    ... done
Removing network nebuladockercompose_nebula-net
```

Danger

The parameter `-v` in the command `docker-compose down -v` will **delete** all your local NebulaGraph storage data. Try this command if you are using the nightly release and having some compatibility issues.

Modify configurations

The configuration file of NebulaGraph deployed by Docker Compose is `nebula-docker-compose/docker-compose.yaml`. To make the new configuration take effect, modify the configuration in this file and restart the service.

For more instructions, see Configurations.

FAQ

HOW TO FIX THE DOCKER MAPPING TO EXTERNAL PORTS?

To set the `ports` of corresponding services as fixed mapping, modify the `docker-compose.yaml` in the `nebula-docker-compose` directory. For example:

```
graphd:
    image: vesoft/nebula-graphd:release-3.5
    ...
    ports:
      - 9669:9669
      - 19669
      - 19670
```

`9669:9669` indicates the internal port 9669 is uniformly mapped to external ports, while `19669` indicates the internal port 19669 is randomly mapped to external ports.

HOW TO UPGRADE OR UPDATE THE DOCKER IMAGES OF NEBULAGRAPH SERVICES

1. In the `nebula-docker-compose/docker-compose.yaml` file, change all the `image` values to the required image version.
2. In the `nebula-docker-compose` directory, run `docker-compose pull` to update the images of the Graph Service, Storage Service, Meta Service, and NebulaGraph Console.

3. Run `docker-compose up -d` to start the NebulaGraph services again.
4. After connecting to NebulaGraph with NebulaGraph Console, run `SHOW HOSTS GRAPH`, `SHOW HOSTS STORAGE`, or `SHOW HOSTS META` to check the version of the responding service respectively.

`ERROR: TOOMANYREQUESTS` WHEN `DOCKER-COMPOSE PULL`

You may meet the following error.

`ERROR: toomanyrequests: You have reached your pull rate limit. You may increase the limit by authenticating and upgrading: https://www.docker.com/increase-rate-limit`.

You have met the rate limit of Docker Hub. Learn more on Understanding Docker Hub Rate Limiting.

HOW TO UPDATE THE NEBULAGRAPH CONSOLE CLIENT

The command `docker-compose pull` updates both the NebulaGraph services and the NebulaGraph Console.

Related documents

- Install and deploy NebulaGraph with the source code
- Install NebulaGraph by RPM or DEB
- Connect to NebulaGraph

Last update: March 27, 2023

5.2.5 Deploy a NebulaGraph cluster with RPM/DEB package on multiple servers

For now, NebulaGraph does not provide an official deployment tool. Users can deploy a NebulaGraph cluster with RPM or DEB package manually. This topic provides an example of deploying a NebulaGraph cluster on multiple servers (machines).

Deployment

Machine name	IP address	Number of graphd	Number of storaged	Number of metad
A	192.168.10.111	1	1	1
B	192.168.10.112	1	1	1
C	192.168.10.113	1	1	1
D	192.168.10.114	1	1	None
E	192.168.10.115	1	1	None

Prerequisites

- Prepare 5 machines for deploying the cluster.
- Use the NTP service to synchronize time in the cluster.

Manual deployment process

INSTALL NEBULAGRAPH

Install NebulaGraph on each machine in the cluster. Available approaches of installation are as follows.

- Install NebulaGraph with RPM or DEB package
- Install NebulaGraph by compiling the source code

MODIFY THE CONFIGURATIONS

To deploy NebulaGraph according to your requirements, you have to modify the configuration files.

All the configuration files for NebulaGraph, including `nebula-graphd.conf`, `nebula-metad.conf`, and `nebula-storaged.conf`, are stored in the `etc` directory in the installation path. You only need to modify the configuration for the corresponding service on the machines. The configurations that need to be modified for each machine are as follows.

Machine name	The configuration to be modified
A	`nebula-graphd.conf`, `nebula-storaged.conf`, `nebula-metad.conf`
B	`nebula-graphd.conf`, `nebula-storaged.conf`, `nebula-metad.conf`
C	`nebula-graphd.conf`, `nebula-storaged.conf`, `nebula-metad.conf`
D	`nebula-graphd.conf`, `nebula-storaged.conf`
E	`nebula-graphd.conf`, `nebula-storaged.conf`

Users can refer to the content of the following configurations, which only show part of the cluster settings. The hidden content uses the default setting so that users can better understand the relationship between the servers in the NebulaGraph cluster.

Note

The main configuration to be modified is `meta_server_addrs`. All configurations need to fill in the IP addresses and ports of all Meta services. At the same time, `local_ip` needs to be modified as the network IP address of the machine itself. For detailed descriptions of the configuration parameters, see:

- Meta Service configurations
- Graph Service configurations
- Storage Service configurations

- Deploy machine A
- `nebula-graphd.conf`

```
########## networking ##########
# Comma separated Meta Server Addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-graphd process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.111
# Network device to listen on
--listen_netdev=any
# Port to listen on
--port=9669
```

- `nebula-storaged.conf`

```
########## networking ##########
# Comma separated Meta server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-storaged process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.111
# Storage daemon listening port
--port=9779
```

- `nebula-metad.conf`

```
########## networking ##########
# Comma separated Meta Server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-metad process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.111
# Meta daemon listening port
--port=9559
```

- Deploy machine B

- `nebula-graphd.conf`

```
########## networking ##########
# Comma separated Meta Server Addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-graphd process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.112
# Network device to listen on
--listen_netdev=any
# Port to listen on
--port=9669
```

- `nebula-storaged.conf`

```
########## networking ##########
# Comma separated Meta server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-storaged process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.112
# Storage daemon listening port
--port=9779
```

- `nebula-metad.conf`

```
########## networking ##########
# Comma separated Meta Server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-metad process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.112
# Meta daemon listening port
--port=9559
```

- Deploy machine C

- `nebula-graphd.conf`

```
########## networking ##########
# Comma separated Meta Server Addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-graphd process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.113
# Network device to listen on
--listen_netdev=any
# Port to listen on
--port=9669
```

- `nebula-storaged.conf`

```
########## networking ##########
# Comma separated Meta server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-storaged process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.113
# Storage daemon listening port
--port=9779
```

- `nebula-metad.conf`

```
########## networking ##########
# Comma separated Meta Server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-metad process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.113
# Meta daemon listening port
--port=9559
```

- Deploy machine D

- `nebula-graphd.conf`

```
########## networking ##########
# Comma separated Meta Server Addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-graphd process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.114
# Network device to listen on
--listen_netdev=any
# Port to listen on
--port=9669
```

- `nebula-storaged.conf`

```
########## networking ##########
# Comma separated Meta server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-storaged process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.114
# Storage daemon listening port
--port=9779
```

- Deploy machine E

- `nebula-graphd.conf`

```
########## networking ##########
# Comma separated Meta Server Addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-graphd process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.115
# Network device to listen on
--listen_netdev=any
# Port to listen on
--port=9669
```

- `nebula-storaged.conf`

```
########## networking ##########
# Comma separated Meta server addresses
--meta_server_addrs=192.168.10.111:9559,192.168.10.112:9559,192.168.10.113:9559
# Local IP used to identify the nebula-storaged process.
# Change it to an address other than loopback if the service is distributed or
# will be accessed remotely.
--local_ip=192.168.10.115
# Storage daemon listening port
--port=9779
```

START THE CLUSTER

Start the corresponding service on **each machine**. Descriptions are as follows.

Machine name	The process to be started
A	graphd, storaged, metad
B	graphd, storaged, metad
C	graphd, storaged, metad
D	graphd, storaged
E	graphd, storaged

The command to start the NebulaGraph services is as follows.

```
sudo /usr/local/nebula/scripts/nebula.service start <metad|graphd|storaged|all>
```

Note

- Make sure all the processes of services on each machine are started. Otherwise, you will fail to start NebulaGraph.
- When the graphd process, the storaged process, and the metad process are all started, you can use `all` instead.
- `/usr/local/nebula` is the default installation path for NebulaGraph. Use the actual path if you have customized the path. For more information about how to start and stop the services, see Manage NebulaGraph services.

CHECK THE CLUSTER STATUS

Install the native CLI client NebulaGraph Console, then connect to any machine that has started the graphd process, run `ADD HOSTS` command to add storage hosts, and run `SHOW HOSTS` to check the cluster status. For example:

```
$ ./nebula-console --addr 192.168.10.111 --port 9669 -u root -p nebula

2021/05/25 01:41:19 [INFO] connection pool is initialized successfully
Welcome to NebulaGraph!

> ADD HOSTS 192.168.10.111:9779, 192.168.10.112:9779, 192.168.10.113:9779, 192.168.10.114:9779, 192.168.10.115:9779;
> SHOW HOSTS;
+------------------+------+----------+--------------+----------------------+------------------------+---------+
| Host             | Port | Status   | Leader count | Leader distribution  | Partition distribution | Version |
```

```
+------------------+------+----------+-------------+---------------------+-----------------------+---------+
| "192.168.10.111" | 9779 | "ONLINE" | 0           | "No valid partition" | "No valid partition"   | "3.5.0" |
| "192.168.10.112" | 9779 | "ONLINE" | 0           | "No valid partition" | "No valid partition"   | "3.5.0" |
| "192.168.10.113" | 9779 | "ONLINE" | 0           | "No valid partition" | "No valid partition"   | "3.5.0" |
| "192.168.10.114" | 9779 | "ONLINE" | 0           | "No valid partition" | "No valid partition"   | "3.5.0" |
| "192.168.10.115" | 9779 | "ONLINE" | 0           | "No valid partition" | "No valid partition"   | "3.5.0" |
+------------------+------+----------+----------+-------------+---------------------+-----------------------+---------+
```

Last update: January 30, 2023

5.2.6 Install NebulaGraph with ecosystem tools

You can install the Enterprise Edition and Community Edition of NebulaGraph with the following ecosystem tools:

- NebulaGraph Operator

Installation details

- To install NebulaGraph with **NebulaGraph Operator**, see Deploy NebulaGraph clusters with Kubectl or Deploy NebulaGraph clusters with Helm.

Last update: August 11, 2022

5.3 Standalone NebulaGraph

Standalone NebulaGraph merges the Meta, Storage, and Graph services into a single process deployed on a single machine. This topic introduces scenarios, deployment steps, etc. of standalone NebulaGraph.

Danger

Do not use standalone NebulaGraph in production environments.

5.3.1 Background

The traditional NebulaGraph consists of three services, each service having executable binary files and the corresponding process. Processes communicate with each other by RPC. In standalone NebulaGraph, the three processes corresponding to the three services are combined into one process. For more information about NebulaGraph, see Architecture overview.

5.3.2 Scenarios

Small data sizes and low availability requirements. For example, test environments that are limited by the number of machines, scenarios that are only used to verify functionality.

5.3.3 Limitations

- Single service instance per machine.
- High availability and reliability not supported.

5.3.4 Resource requirements

For information about the resource requirements for standalone NebulaGraph, see Software requirements for compiling NebulaGraph.

5.3.5 Steps

Currently, you can only install standalone NebulaGraph with the source code. The steps are similar to those of the multi-process NebulaGraph. You only need to modify the step **Generate Makefile with CMake** by adding `-DENABLE_STANDALONE_VERSION=on` to the command. For example:

```
cmake -DCMAKE_INSTALL_PREFIX=/usr/local/nebula -DENABLE_TESTING=OFF -DENABLE_STANDALONE_VERSION=on -DCMAKE_BUILD_TYPE=Release ..
```

For more information about installation details, see Install NebulaGraph by compiling the source code.

After installing standalone NebulaGraph, see the topic connect to Service to connect to NebulaGraph databases.

5.3.6 Configuration file

The path to the configuration file for standalone NebulaGraph is `/usr/local/nebula/etc` by default.

You can run `sudo cat nebula-standalone.conf.default` to see the file content. The parameters and the corresponding descriptions in the file are generally the same as the configurations for multi-process NebulaGraph except for the following parameters.

Parameter	Predefined value	Description
`meta_port`	`9559`	The port number of the Meta service.
`storage_port`	`9779`	The port number of the Storage Service.
`meta_data_path`	`data/meta`	The path to Meta data.

You can run commands to check configurable parameters and the corresponding descriptions. For details, see Configurations.

Last update: August 11, 2022

5.4 Manage NebulaGraph Service

NebulaGraph supports managing services with scripts.

5.4.1 Manage services with script

You can use the `nebula.service` script to start, stop, restart, terminate, and check the NebulaGraph services.

Note

`nebula.service` is stored in the `/usr/local/nebula/scripts` directory by default. If you have customized the path, use the actual path in your environment.

Syntax

```
$ sudo /usr/local/nebula/scripts/nebula.service
[-v] [-c <config_file_path>]
<start | stop | restart | kill | status>
<metad | graphd | storaged | all>
```

Parameter	Description
`-v`	Display detailed debugging information.
`-c`	Specify the configuration file path. The default path is `/usr/local/nebula/etc/`.
`start`	Start the target services.
`stop`	Stop the target services.
`restart`	Restart the target services.
`kill`	Terminate the target services.
`status`	Check the status of the target services.
`metad`	Set the Meta Service as the target service.
`graphd`	Set the Graph Service as the target service.
`storaged`	Set the Storage Service as the target service.
`all`	Set all the NebulaGraph services as the target services.

5.4.2 Start NebulaGraph

Run the following command to start NebulaGraph.

```
$ sudo /usr/local/nebula/scripts/nebula.service start all
[INFO] Starting nebula-metad...
[INFO] Done
[INFO] Starting nebula-graphd...
[INFO] Done
[INFO] Starting nebula-storaged...
[INFO] Done
```

5.4.3 Check the service status

Run the following command to check the service status of NebulaGraph.

```
$ sudo /usr/local/nebula/scripts/nebula.service status all
```

- NebulaGraph is running normally if the following information is returned.

```
INFO] nebula-metad(33fd35e): Running as 29020, Listening on 9559
[INFO] nebula-graphd(33fd35e): Running as 29095, Listening on 9669
[WARN] nebula-storaged after v3.0.0 will not start service until it is added to cluster.
[WARN] See Manage Storage hosts:ADD HOSTS in https://docs.nebula-graph.io/
[INFO] nebula-storaged(33fd35e): Running as 29147, Listening on 9779
```

Note

After starting NebulaGraph, the port of the `nebula-storaged` process is shown in red. Because the `nebula-storaged` process waits for the `nebula-metad` to add the current Storage service during the startup process. The Storage works after it receives the ready signal. Starting from NebulaGraph 3.0.0, the Meta service cannot directly read or write data in the Storage service that you add in the configuration file. The configuration file only registers the Storage service to the Meta service. You must run the `ADD HOSTS` command to enable the Meta to read and write data in the Storage service. For more information, see Manage Storage hosts.

- If the returned result is similar to the following one, there is a problem. You may also go to the NebulaGraph community for help.

```
[INFO] nebula-metad: Running as 25600, Listening on 9559
[INFO] nebula-graphd: Exited
[INFO] nebula-storaged: Running as 25646, Listening on 9779
```

The NebulaGraph services consist of the Meta Service, Graph Service, and Storage Service. The configuration files for all three services are stored in the `/usr/local/nebula/etc/` directory by default. You can check the configuration files according to the returned result to troubleshoot problems.

5.4.4 Next to do

Connect to NebulaGraph

Last update: August 11, 2022

5.5 Connect to NebulaGraph

This topic provides basic instruction on how to use the native CLI client NebulaGraph Console to connect to NebulaGraph.

Caution

When connecting to NebulaGraph for the first time, you must register the Storage Service before querying data.

NebulaGraph supports multiple types of clients, including a CLI client, a GUI client, and clients developed in popular programming languages. For more information, see the client list.

5.5.1 Prerequisites

- You have started NebulaGraph services.
- The machine on which you plan to run NebulaGraph Console has network access to the Graph Service of NebulaGraph.
- The NebulaGraph Console version is compatible with the NebulaGraph version.

  Note

  NebulaGraph Console and NebulaGraph of the same version number are the most compatible. There may be compatibility issues when connecting to NebulaGraph with a different version of NebulaGraph Console. The error message `incompatible version between client and server` is displayed when there is such an issue.

Steps

1. On the NebulaGraph Console releases page, select a NebulaGraph Console version and click **Assets**.

   Note

   It is recommended to select the **latest** version.

2. In the **Assets** area, find the correct binary file for the machine where you want to run NebulaGraph Console and download the file to the machine.
3. (Optional) Rename the binary file to `nebula-console` for convenience.

   Note

   For Windows, rename the file to `nebula-console.exe`.

4. On the machine to run NebulaGraph Console, grant the execute permission of the nebula-console binary file to the user.

   Note

   For Windows, skip this step.

```
$ chmod 111 nebula-console
```

5. In the command line interface, change the working directory to the one where the nebula-console binary file is stored.

6. Run the following command to connect to NebulaGraph.

- For Linux or macOS:

```
$ ./nebula-console -addr <ip> -port <port> -u <username> -p <password>
[-t 120] [-e "nGQL_statement" | -f filename.nGQL]
```

- For Windows:

```
> nebula-console.exe -addr <ip> -port <port> -u <username> -p <password>
[-t 120] [-e "nGQL_statement" | -f filename.nGQL]
```

Parameter descriptions are as follows:

Parameter	**Description**
`-h/-help`	Shows the help menu.
`-addr/-address`	Sets the IP address of the Graph service. The default address is 127.0.0.1.
`-P/-port`	Sets the port number of the graphd service. The default port number is 9669.
`-u/-user`	Sets the username of your NebulaGraph account. Before enabling authentication, you can use any existing username. The default username is `root`.
`-p/-password`	Sets the password of your NebulaGraph account. Before enabling authentication, you can use any characters as the password.
`-t/-timeout`	Sets an integer-type timeout threshold of the connection. The unit is millisecond. The default value is 120.
`-e/-eval`	Sets a string-type nGQL statement. The nGQL statement is executed once the connection succeeds. The connection stops after the result is returned.
`-f/-file`	Sets the path of an nGQL file. The nGQL statements in the file are executed once the connection succeeds. The result will be returned and the connection stops then.
`-enable_ssl`	Enables SSL encryption when connecting to NebulaGraph.
`-ssl_root_ca_path`	Sets the storage path of the certification authority file.
`-ssl_cert_path`	Sets the storage path of the certificate file.
`-ssl_private_key_path`	Sets the storage path of the private key file.

For information on more parameters, see the project repository.

Last update: August 11, 2022

5.6 Manage Storage hosts

Starting from NebulaGraph 3.0.0, setting Storage hosts in the configuration files only registers the hosts on the Meta side, but does not add them into the cluster. You must run the `ADD HOSTS` statement to add the Storage hosts.

Note

NebulaGraph Cloud clusters add Storage hosts automatically. Cloud users do not need to manually run `ADD HOSTS`.

5.6.1 Add Storage hosts

Add the Storage hosts to a NebulaGraph cluster.

```
ADD HOSTS <ip>:<port> [,<ip>:<port> ...];
ADD HOSTS "<hostname>":<port> [,"<hostname>":<port> ...];
```

Note

- To make sure the follow-up operations work as expected, wait for two heartbeat cycles, i.e., 20 seconds, and then run `SHOW HOSTS` to check whether the host is online.
- Make sure that the IP address and port number are the same as those in the configuration file. For example, the default IP address and port number in standalone deployment are `127.0.0.1:9779`.
- When using a domain name, enclose it in quotation marks, for example, `ADD HOSTS "foo-bar":9779`.
- Ensure that the storage host to be added is not used by any other cluster, otherwise, the storage adding operation will fail.

5.6.2 Drop Storage hosts

Delete the Storage hosts from cluster.

Note

You can not delete an in-use Storage host directly. Delete the associated graph space before deleting the Storage host.

```
DROP HOSTS <ip>:<port> [,<ip>:<port> ...];
DROP HOSTS "<hostname>":<port> [,"<hostname>":<port> ...];
```

Last update: August 12, 2022

5.7 Upgrade

5.7.1 Upgrade NebulaGraph to 3.5.0

This topic describes how to upgrade NebulaGraph from version 2.x and 3.x to 3.5.0, taking upgrading from version 2.6.1 to 3.5.0 as an example.

Applicable source versions

This topic applies to upgrading NebulaGraph from 2.5.0 and later 2.x, and 3.x versions to 3.5.0. It does not apply to historical versions earlier than 2.5.0, including the 1.x versions.

To upgrade NebulaGraph from historical versions to 3.5.0:

1. Upgrade it to the latest 2.5 version according to the docs of that version.
2. Follow this topic to upgrade it to 3.5.0.

Caution

To upgrade NebulaGraph from versions earlier than 2.0.0 (including the 1.x versions) to 3.5.0, you need to find the `date_time_zonespec.csv` in the `share/resources` directory of 3.5.0 files, and then copy it to the same directory in the NebulaGraph installation path.

Limitations

- Rolling Upgrade is not supported. You must stop all the NebulaGraph services before the upgrade.
- There is no upgrade script. You have to manually upgrade each server in the cluster.
- This topic does not apply to scenarios where NebulaGraph is deployed with Docker, including Docker Swarm, Docker Compose, and K8s.
- You must upgrade the old NebulaGraph services on the same machines they are deployed. **DO NOT** change the IP addresses, configuration files of the machines, and **DO NOT** change the cluster topology.
- Known issues that could cause data loss are listed on GitHub known issues. The issues are all related to altering schema or default values.
- **DO NOT** use soft links to switch the data directories.
- You must have the sudo privileges to complete the steps in this topic.

Upgrade influences

- Client compatibility

After the upgrade, you will not be able to connect to NebulaGraph from old clients. You will need to upgrade all clients to a version compatible with NebulaGraph 3.5.0.

- Configuration changes

  A few configuration parameters have been changed. For more information, see the release notes and configuration docs.

- nGQL compatibility

  The nGQL syntax is partially incompatible:

- Disable the `YIELD` clause to return custom variables.
- The `YIELD` clause is required in the `FETCH`, `GO`, `LOOKUP`, `FIND PATH` and `GET SUBGRAPH` statements.
- It is required to specify a tag to query properties of a vertex in a `MATCH` statement. For example, from `return v.name` to `return v.player.name`.

- Full-text indexes

  Before upgrading a NebulaGraph cluster with full-text indexes deployed, you must manually delete the full-text indexes in Elasticsearch, and then run the `SIGN IN` command to log into ES and recreate the indexes after the upgrade is complete. To manually delete the full-text indexes in Elasticsearch, you can use the curl command `curl -XDELETE -u <es_username>:<es_password> '<es_access_ip>:<port>/<fullindex_name>'`, for example, `curl -XDELETE -u elastic:elastic 'http://192.168.8.xxx:9200/nebula_index_2534'`. If no username and password are set for Elasticsearch, you can omit the `-u <es_username>:<es_password>` part.

Caution

There may be other undiscovered influences. Before the upgrade, we recommend that you read the release notes and user manual carefully, and keep an eye on the posts on the forum and issues on Github.

Preparations before the upgrade

- Download the package of NebulaGraph 3.5.0 according to your operating system and system architecture. You need the binary files during the upgrade. Find the package on the download page.

  Note

  You can also get the new binaries from the source code or the RPM/DEB package.

- Locate the data files based on the value of the `data_path` parameters in the Storage and Meta configurations, and backup the data files. The default paths are `nebula/data/storage` and `nebula/data/meta`.

  Danger

  The old data will not be automatically backed up during the upgrade. You must manually back up the data to avoid data loss.

- Backup the configuration files.

- Collect the statistics of all graph spaces before the upgrade. After the upgrade, you can collect again and compare the results to make sure that no data is lost. To collect the statistics:

a. Run `SUBMIT JOB STATS`.

b. Run `SHOW JOBS` and record the result.

Upgrade steps

1. Stop all NebulaGraph services.

```
<nebula_install_path>/scripts/nebula.service stop all
```

`nebula_install_path` indicates the installation path of NebulaGraph.

The storaged progress needs around 1 minute to flush data. You can run `nebula.service status all` to check if all services are stopped. For more information about starting and stopping services, see Manage services.

Note

If the services are not fully stopped in 20 minutes, stop upgrading and ask for help on the forum or Github.

Caution

Starting from version 3.0.0, it is possible to insert vertices without tags. If you need to keep vertices without tags, add `--graph_use_vertex_key=true` in the configuration file (`nebula-graphd.conf`) of all Graph services within the cluster; and add `--use_vertex_key=true` in the configuration file (`nebula-storaged.conf`) of all Storage services."

2. In the target path where you unpacked the package, use the binaries in the `bin` directory to replace the old binaries in the `bin` directory in the NebulaGraph installation path.

Note

Update the binary of the corresponding service on each NebulaGraph server.

3. Modify the following parameters in all Graph configuration files to accommodate the value range of the new version. If the parameter values are within the specified range, skip this step.

- Set a value in [1,604800] for `session_idle_timeout_secs`. The recommended value is 28800.
- Set a value in [1,604800] for `client_idle_timeout_secs`. The recommended value is 28800.

The default values of these parameters in the 2.x versions are not within the range of the new version. If you do not change the default values, the upgrade will fail. For detailed parameter description, see Graph Service Configuration.

4. Start all Meta services.

```
<nebula_install_path>/scripts/nebula-metad.service start
```

Once started, the Meta services take several seconds to elect a leader.

To verify that Meta services are all started, you can start any Graph server, connect to it through NebulaGraph Console, and run `SHOW HOSTS meta` and `SHOW META LEADER`. If the status of Meta services are correctly returned, the services are successfully started.

Note

If the operation fails, stop the upgrade and ask for help on the forum or GitHub.

5. Start all the Graph and Storage services.

Note

If the operation fails, stop the upgrade and ask for help on the forum or GitHub.

6. Connect to the new version of NebulaGraph to verify that services are available and data are complete. For how to connect, see Connect to NebulaGraph.

Currently, there is no official way to check whether the upgrade is successful. You can run the following reference statements to test the upgrade:

```
nebula> SHOW HOSTS;
nebula> SHOW HOSTS storage;
nebula> SHOW SPACES;
nebula> USE <space_name>
nebula> SHOW PARTS;
nebula> SUBMIT JOB STATS;
nebula> SHOW STATS;
nebula> MATCH (v) RETURN v LIMIT 5;
```

You can also test against new features in version 3.5.0.

Upgrade failure and rollback

If the upgrade fails, stop all NebulaGraph services of the new version, recover the old configuration files and binaries, and start the services of the old version.

All NebulaGraph clients in use must be switched to the old version.

FAQ

CAN I WRITE THROUGH THE CLIENT DURING THE UPGRADE?

A: No. You must stop all NebulaGraph services during the upgrade.

THE `SPACE 0 NOT FOUND` WARNING MESSAGE DURING THE UPGRADE PROCESS

When the `Space 0 not found` warning message appears during the upgrade process, you can ignore it. The space `0` is used to store meta information about the Storage service and does not contain user data, so it will not affect the upgrade.

HOW TO UPGRADE IF A MACHINE HAS ONLY THE GRAPH SERVICE, BUT NOT THE STORAGE SERVICE?

A: You only need to update the configuration files and binaries of the Graph Service.

HOW TO RESOLVE THE ERROR `PERMISSION DENIED`?

A: Try again with the sudo privileges.

IS THERE ANY CHANGE IN GFLAGS?

A: Yes. For more information, see the release notes and configuration docs.

IS THERE A TOOL OR SOLUTION FOR VERIFYING DATA CONSISTENCY AFTER THE UPGRADE?

A: No. But if you only want to check the number of vertices and edges, run `SUBMIT JOB STATS` and `SHOW STATS` after the upgrade, and compare the result with the result that you recorded before the upgrade.

HOW TO SOLVE THE ISSUE THAT STORAGE IS `OFFLINE` AND `LEADER COUNT` IS `0`?

A: Run the following statement to add the Storage hosts into the cluster manually.

```
ADD HOSTS <ip>:<port>[, <ip>:<port> ...];
```

For example:

```
ADD HOSTS 192.168.10.100:9779, 192.168.10.101:9779, 192.168.10.102:9779;
```

If the issue persists, ask for help on the forum or GitHub.

WHY THE JOB TYPE CHANGED AFTER THE UPGRADE, BUT JOB ID REMAINS THE SAME?

A: `SHOW JOBS` depends on an internal ID to identify job types, but in NebulaGraph 2.5.0 the internal ID changed in this pull request, so this issue happens after upgrading from a version earlier than 2.5.0.

Last update: March 27, 2023

5.7.2 Upgrade NebulaGraph Enterprise Edition from version 3.x to 3.5.0

This topic takes the enterprise edition of NebulaGraph v3.1.0 as an example and describes how to upgrade to v3.5.0.

Notes

- This upgrade is only applicable for upgrading the enterprise edition of NebulaGraph v3.x (x < 4) to v3.5.0. For upgrading from version 3.4.0 and above to 3.5.0, you can directly replace the binary files for upgrade. For more information, see Upgrade NebulaGraph to 3.5.0 . !!! note

```
  If your version is below 3.0.0, please upgrade to enterprise edition 3.1.0 before upgrading to v3.5.0. For details, see [Upgrade NebulaGraph Enterprise Edition 2.x to 3.1.0](https://docs.nebula-graph.io/3.1.0/4.deployment-and-installation/3.upgrade-nebula-graph/upgrade-nebula-graph-to-latest/).
```

- The IP address of the machine performing the upgrade operation must be the same as the original machine.
- The remaining disk space on the machine must be at least 1.5 times the size of the original data directory.
- Before upgrading a NebulaGraph cluster with full-text indexes deployed, you must manually delete the full-text indexes in Elasticsearch, and then run the `SIGN IN` command to log into ES and recreate the indexes after the upgrade is complete.

  Note

  To manually delete the full-text indexes in Elasticsearch, you can use the curl command `curl -XDELETE -u <es_username>:<es_password> '<es_access_ip>:<port>/<fullindex_name>'`, for example, `curl -XDELETE -u elastic:elastic 'http://192.168.8.223:9200/nebula_index_2534'`. If no username and password are set for Elasticsearch, you can omit the `-u <es_username>:<es_password>` part.

Steps

1. Contact us to obtain the installation package of the enterprise edition of NebulaGraph v3.5.0 and install it.

   Note

   The upgrade steps are the same for different installation packages. This article uses the RPM package and the installation directory `/usr/local/nebulagraph-ent-3.4` as an example. See Install with RPM packages for specific operations.

   Caution

   Please ensure that the number of storage paths set for the `--data_path` parameter in the Meta and Storage service configuration files of the 3.5.0 cluster is the same as that for the `--data_path` parameter in the configuration files of the 3.x cluster. Otherwise, the upgraded cluster will not start.

2. Stop the enterprise edition of v3.x services. For details see Manage NebulaGraph services.

   Run the `nebula.service status all` command to confirm that all services have been stopped after running the command.

3. In the installation directory of the Enterprise Edition NebulaGraph v3.5.0, run the following commands to upgrade the Storage and Meta services.

- Upgrade the Storage service:

  Syntax:

```
sudo ./bin/db_upgrader  --max_concurrent_parts=<num> --src_db_path=<source_storage_data_path> --dst_db_path=<destination_storage_data_path>
```

Parameter	Description
`--max_concurrent_parts`	Specify the number of partitions to upgrade simultaneously, with the default value being 1. It is recommended to increase the value appropriately based on disk performance.
`--src_db_path`	Specify the absolute path to the source data directory. The following takes the source data directory `/usr/local/nebula-ent-3.1.0/data/storage` as an example.
`--dst_db_path`	Specify the absolute path to the target data directory. The example target data directory is `/usr/local/nebula-ent-3.4/data/storage`.

  Example:

```
sudo ./bin/db_upgrader --max_concurrent_parts=20 --src_db_path=/usr/local/nebula-ent-3.1.0/data/storage --dst_db_path=/usr/local/nebula-ent-3.4/data/storage
```

  If there are multiple source data directories, specify each source data directory and target data directory and run the corresponding command. For example, there are two source data directories `/usr/local/nebula-ent-3.1.0/data/storage` and `/usr/local/nebula-ent-3.1.0/data2/storage`, run the following commands:

```
sudo ./bin/db_upgrader --src_db_path=/usr/local/nebula-ent-3.1.0/data/storage --dst_db_path=/usr/local/nebula-ent-3.4/data/storage

sudo ./bin/db_upgrader --src_db_path=/usr/local/nebula-ent-3.1.0/data2/storage --dst_db_path=/usr/local/nebula-ent-3.4/data2/storage
```

- Upgrade the Meta service:

  Syntax:

```
sudo ./bin/meta_upgrader --src_meta_path=<source_meta_data_path> --dst_meta_path=<destination_meta_data_path>
```

Parameter	Description
`--src_meta_path`	Specify the absolute path to the source meta data directory. The following takes the source data directory `/usr/local/nebula-ent-3.1.0/data/meta` as an example.
`--dst_meta_path`	Specify the absolute path to the target meta data directory. The example target data directory is `/usr/local/nebula-ent-3.4/data/meta`.

  Example:

```
sudo ./bin/meta_upgrader --src_meta_path=/usr/local/nebula-ent-3.1.0/data/meta --dst_meta_path=/usr/local/nebula-ent-3.4/data/meta
```

  If there are multiple source meta data directories, specify each source meta data directory and target meta data directory and run the corresponding command.

  After the upgrade, a `data` directory will be generated in the v3.5.0 installation directory, containing the upgraded data files.

4. Upload the license file to the `share/resources` directory under the v3.5.0 installation directory.
5. Start and connect to the NebulaGraph v3.5.0 enterprise edition service and verify that the data is correct. The following commands can be used as reference:

```
nebula> SHOW HOSTS;
nebula> SHOW HOSTS storage;
nebula> SHOW SPACES;
nebula> USE <space_name>
nebula> SHOW PARTS;
nebula> SUBMIT JOB STATS;
nebula> SHOW STATS;
nebula> MATCH (v) RETURN v LIMIT 5;
```

Docker Compose Deployment

Caution

For NebulaGraph deployed using Docker Compose, it is recommended to redeploy the new version and import data.

Last update: March 27, 2023

5.8 Uninstall NebulaGraph

This topic describes how to uninstall NebulaGraph.

Caution

Before re-installing NebulaGraph on a machine, follow this topic to completely uninstall the old NebulaGraph, in case the remaining data interferes with the new services, including inconsistencies between Meta services.

5.8.1 Prerequisite

The NebulaGraph services should be stopped before the uninstallation. For more information, see Manage NebulaGraph services.

5.8.2 Step 1: Delete data files of the Storage and Meta Services

If you have modified the `data_path` in the configuration files for the Meta Service and Storage Service, the directories where NebulaGraph stores data may not be in the installation path of NebulaGraph. Check the configuration files to confirm the data paths, and then manually delete the directories to clear all data.

Note

For a NebulaGraph cluster, delete the data files of all Storage and Meta servers.

1. Check the Storage Service disk settings. For example:

```
########## Disk ##########
# Root data path. Split by comma. e.g. --data_path=/disk1/path1/,/disk2/path2/
# One path per Rocksdb instance.
--data_path=/nebula/data/storage
```

2. Check the Metad Service configurations and find the corresponding metadata directories.
3. Delete the data and the directories found in step 2.

5.8.3 Step 2: Delete the installation directories

Note

Delete all installation directories, including the `cluster.id` file in them.

The default installation path is `/usr/local/nebula`, which is specified by `--prefix` while installing NebulaGraph.

Uninstall NebulaGraph deployed with source code

Find the installation directories of NebulaGraph, and delete them all.

Uninstall NebulaGraph deployed with RPM packages

1. Run the following command to get the NebulaGraph version.

```
$ rpm -qa | grep "nebula"
```

The return message is as follows.

```
nebula-graph-3.5.0-1.x86_64
```

2. Run the following command to uninstall NebulaGraph.

```
sudo rpm -e <nebula_version>
```

For example:

```
sudo rpm -e nebula-graph-3.5.0-1.x86_64
```

3. Delete the installation directories.

Uninstall NebulaGraph deployed with DEB packages

1. Run the following command to get the NebulaGraph version.

```
$ dpkg -l | grep "nebula"
```

The return message is as follows.

```
ii  nebula-graph  3.5.0  amd64     NebulaGraph Package built using CMake
```

2. Run the following command to uninstall NebulaGraph.

```
sudo dpkg -r <nebula_version>
```

For example:

```
sudo dpkg -r nebula-graph
```

3. Delete the installation directories.

Uninstall NebulaGraph deployed with Docker Compose

1. In the `nebula-docker-compose` directory, run the following command to stop the NebulaGraph services.

```
docker-compose down -v
```

2. Delete the `nebula-docker-compose` directory.

Last update: August 11, 2022

6. Configurations and logs

6.1 Configurations

6.1.1 Configurations

NebulaGraph builds the configurations based on the gflags repository. Most configurations are flags. When the NebulaGraph service starts, it will get the configuration information from Configuration files by default. Configurations that are not in the file apply the default values.

Note

- Because there are many configurations and they may change as NebulaGraph develops, this topic will not introduce all configurations. To get detailed descriptions of configurations, follow the instructions below.
- It is not recommended to modify the configurations that are not introduced in this topic, unless you are familiar with the source code and fully understand the function of configurations.

Legacy version compatibility

In the topic of 1.x, we provide a method of using the `CONFIGS` command to modify the configurations in the cache. However, using this method in a production environment can easily cause inconsistencies of configurations between clusters and the local. Therefore, this method will no longer be introduced starting with version 2.x.

Get the configuration list and descriptions

Use the following command to get all the configuration information of the service corresponding to the binary file:

```
<binary> --help
```

For example:

```
# Get the help information from Meta
$ /usr/local/nebula/bin/nebula-metad  --help

# Get the help information from Graph
$ /usr/local/nebula/bin/nebula-graphd --help

# Get the help information from Storage
$ /usr/local/nebula/bin/nebula-storaged --help
```

The above examples use the default storage path `/usr/local/nebula/bin/`. If you modify the installation path of NebulaGraph, use the actual path to query the configurations.

Get configurations

Use the `curl` command to get the value of the running configurations.

For example:

```
# Get the running configurations from Meta
curl 127.0.0.1:19559/flags

# Get the running configurations from Graph
curl 127.0.0.1:19669/flags

# Get the running configurations from Storage
curl 127.0.0.1:19779/flags
```

Note

In an actual environment, use the real host IP address instead of `127.0.0.1` in the above example.

Configuration files

CONFIGURATION FILES FOR CLUSTERS INSTALLED FROM SOURCE, WITH AN RPM/DEB PACKAGE, OR A TAR PACKAGE

NebulaGraph provides two initial configuration files for each service, `<service_name>.conf.default` and `<service_name>.conf.production`. You can use them in different scenarios conveniently. For clusters installed from source and with a RPM/DEB package, the default path is `/usr/local/nebula/etc/`. For clusters installed with a TAR package, the path is `<install_path>/<tar_package_directory>/etc`.

The configuration values in the initial configuration file are for reference only and can be adjusted according to actual needs. To use the initial configuration file, choose one of the above two files and delete the suffix `.default` or `.production` to make it valid.

Caution

To ensure the availability of services, the configurations of the same service must be consistent, except for the local IP address `local_ip`. For example, three Storage servers are deployed in one NebulaGraph cluster. The configurations of the three Storage servers need to be the same, except for the IP address.

The initial configuration files corresponding to each service are as follows.

NebulaGraph service	Initial configuration file	Description
Meta	`nebula-metad.conf.default` and `nebula-metad.conf.production`	Meta service configuration
Graph	`nebula-graphd.conf.default` and `nebula-graphd.conf.production`	Graph service configuration
Storage	`nebula-storaged.conf.default` and `nebula-storaged.conf.production`	Storage service configuration

Each initial configuration file of all services contains `local_config`. The default value is `true`, which means that the NebulaGraph service will get configurations from its configuration files and start it.

Caution

It is not recommended to modify the value of `local_config` to `false`. If modified, the NebulaGraph service will first read the cached configurations, which may cause configuration inconsistencies between clusters and cause unknown risks.

CONFIGURATION FILES FOR CLUSTERS INSTALLED WITH DOCKER COMPOSE

For clusters installed with Docker Compose, the configuration file's default installation path of the cluster is `<install_path>/nebula-docker-compose/docker-compose.yaml`. The parameters in the `command` field of the file are the launch parameters for each service.

CONFIGURATION FILES FOR CLUSTERS INSTALLED WITH NEBULAGRAPH OPERATOR

For clusters installed with Kubectl through NebulaGraph Operator, the configuration file's path is the path of the cluster YAML file. You can modify the configuration of each service through the `spec.{graphd|storaged|metad}.config` parameter.

Note

The services cannot be configured for clusters installed with Helm.

Modify configurations

You can modify the configurations of NebulaGraph in the configuration file or use commands to dynamically modify configurations.

Caution

Using both methods to modify the configuration can cause the configuration information to be managed inconsistently, which may result in confusion. It is recommended to only use the configuration file to manage the configuration, or to make the same modifications to the configuration file after dynamically updating the configuration through commands to ensure consistency.

MODIFYING CONFIGURATIONS IN THE CONFIGURATION FILE

By default, each NebulaGraph service gets configured from its configuration files. You can modify configurations and make them valid according to the following steps:

- For clusters installed from source, with a RPM/DEB, or a TAR package

a. Use a text editor to modify the configuration files of the target service and save the modification.

b. Choose an appropriate time to restart **all** NebulaGraph services to make the modifications valid.

- For clusters installed with Docker Compose

a. In the `<install_path>/nebula-docker-compose/docker-compose.yaml` file, modify the configurations of the target service.

b. In the `nebula-docker-compose` directory, run the command `docker-compose up -d` to restart the service involving configuration modifications.

- For clusters installed with Kubectl

  For details, see Customize configuration parameters for a NebulaGraph cluster.

DYNAMICALLY MODIFYING CONFIGURATIONS USING COMMAND

You can dynamically modify the configuration of NebulaGraph by using the curl command. For example, to modify the `wal_ttl` parameter of the Storage service to `600`, use the following command:

```
curl -X PUT -H "Content-Type: application/json" -d'{"wal_ttl":"600"}' -s "http://192.168.15.6:19779/flags"
```

In this command, `{"wal_ttl":"600"}` specifies the configuration parameter and its value to be modified, and `192.168.15.6:19779` specifies the IP address and HTTP port number of the Storage service.

Caution

- The functionality of dynamically modifying configurations is only applicable to prototype verification and testing environments. It is not recommended to use this feature in production environments. This is because when the `local_config` value is set to `true`, the dynamically modified configuration is not persisted, and the configuration will be restored to the initial configuration after the service is restarted.
- Only **part of** the configuration parameters can be dynamically modified. For the specific list of parameters that can be modified, see the description of **Whether supports runtime dynamic modifications** in the respective service configuration.

Last update: March 13, 2023

6.1.2 Meta Service configuration

NebulaGraph provides two initial configuration files for the Meta Service, `nebula-metad.conf.default` and `nebula-metad.conf.production`. Users can use them in different scenarios conveniently. The default file path is `/usr/local/nebula/etc/`.

Caution

- It is not recommended to modify the value of `local_config` to `false`. If modified, the NebulaGraph service will first read the cached configurations, which may cause configuration inconsistencies between clusters and cause unknown risks.
- It is not recommended to modify the configurations that are not introduced in this topic, unless you are familiar with the source code and fully understand the function of configurations.

How to use the configuration files

To use the initial configuration file, choose one of the above two files and delete the suffix `.default` or `.production` from the initial configuration file for the Meta Service to apply the configurations defined in it.

About parameter values

If a parameter is not set in the configuration file, NebulaGraph uses the default value. Not all parameters are predefined. And the predefined parameters in the two initial configuration files are different. This topic uses the parameters in `nebula-metad.conf.default`.

Caution

Some parameter values in the configuration file can be dynamically modified during runtime. We label these parameters as **Yes** that supports runtime dynamic modification in this article. When the `local_config` value is set to `true`, the dynamically modified configuration is not persisted, and the configuration will be restored to the initial configuration after the service is restarted. For more information, see Modify configurations.

For all parameters and their current values, see Configurations.

Basics configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`daemonize`	`true`	When set to `true`, the process is a daemon process.	No
`pid_file`	`pids/nebula-metad.pid`	The file that records the process ID.	No
`timezone_name`	-	Specifies the NebulaGraph time zone. This parameter is not predefined in the initial configuration files. You can manually set it if you need it. The system default value is `UTC+00:00:00`. For the format of the parameter value, see Specifying the Time Zone with TZ. For example, `--timezone_name=UTC+08:00` represents the GMT+8 time zone.	No

Note

- While inserting property values of time types, NebulaGraph transforms time types (except TIMESTAMP) to the corresponding UTC according to the time zone specified by `timezone_name`. The time-type values returned by nGQL queries are all UTC time.
- `timezone_name` is only used to transform the data stored in NebulaGraph. Other time-related data of the NebulaGraph processes still uses the default time zone of the host, such as the log printing time.

Logging configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`log_dir`	`logs`	The directory that stores the Meta Service log. It is recommended to put logs on a different hard disk from the data.	No
`minloglevel`	`0`	Specifies the minimum level of the log. That is, log messages at or above this level. Optional values are `0` (INFO), `1` (WARNING), `2` (ERROR), `3` (FATAL). It is recommended to set it to `0` during debugging and `1` in a production environment. If it is set to `4`, NebulaGraph will not print any logs.	Yes
`v`	`0`	Specifies the detailed level of VLOG. That is, log all VLOG messages less or equal to the level. Optional values are `0`, `1`, `2`, `3`, `4`, `5`. The VLOG macro provided by glog allows users to define their own numeric logging levels and control verbose messages that are logged with the parameter `v`. For details, see Verbose Logging.	Yes
`logbufsecs`	`0`	Specifies the maximum time to buffer the logs. If there is a timeout, it will output the buffered log to the log file. `0` means real-time output. This configuration is measured in seconds.	No
`redirect_stdout`	`true`	When set to `true`, the process redirects the `stdout` and `stderr` to separate output files.	No
`stdout_log_file`	`metad-stdout.log`	Specifies the filename for the `stdout` log.	No
`stderr_log_file`	`metad-stderr.log`	Specifies the filename for the `stderr` log.	No
`stderrthreshold`	`3`	Specifies the `minloglevel` to be copied to the `stderr` log.	No
`timestamp_in_logfile_name`	`true`	Specifies if the log file name contains a timestamp. `true` indicates yes, `false` indicates no.	No

Networking configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`meta_server_addrs`	`127.0.0.1:9559`	Specifies the IP addresses and ports of all Meta Services. Multiple addresses are separated with commas.	No
`local_ip`	`127.0.0.1`	Specifies the local IP for the Meta Service. The local IP address is used to identify the nebula-metad process. If it is a distributed cluster or requires remote access, modify it to the corresponding address.	No
`port`	`9559`	Specifies RPC daemon listening port of the Meta service. The external port for the Meta Service is predefined to `9559`. The internal port is predefined to `port + 1`, i.e., `9560`. Nebula Graph uses the internal port for multi-replica interactions.	No
`ws_ip`	`0.0.0.0`	Specifies the IP address for the HTTP service.	No
`ws_http_port`	`19559`	Specifies the port for the HTTP service.	No
`ws_storage_http_port`	`19779`	Specifies the Storage service listening port used by the HTTP protocol. It must be consistent with the `ws_http_port` in the Storage service configuration file. This parameter only applies to standalone NebulaGraph.	No
`heartbeat_interval_secs`	`10`	Specifies the default heartbeat interval. Make sure the `heartbeat_interval_secs` values for all services are the same, otherwise NebulaGraph **CANNOT** work normally. This configuration is measured in seconds.	Yes

Caution

The real IP address must be used in the configuration file. Otherwise, `127.0.0.1/0.0.0.0` cannot be parsed correctly in some cases.

Storage configurations

Name	Predefined Value	Description	Whether supports runtime dynamic modifications
`data_path`	`data/meta`	The storage path for Meta data.	No

Misc configurations

Name	Predefined Value	Description	Whether supports runtime dynamic modifications
`default_parts_num`	`100`	Specifies the default partition number when creating a new graph space.	No
`default_replica_factor`	`1`	Specifies the default replica number when creating a new graph space.	No

RocksDB options configurations

Name	Predefined Value	Description	Whether supports runtime dynamic modifications
`rocksdb_wal_sync`	`true`	Enables or disables RocksDB WAL synchronization. Available values are `true` (enable) and `false` (disable).	No

Last update: March 13, 2023

6.1.3 Graph Service configuration

NebulaGraph provides two initial configuration files for the Graph Service, `nebula-graphd.conf.default` and `nebula-graphd.conf.production`. Users can use them in different scenarios conveniently. The default file path is `/usr/local/nebula/etc/`.

Caution

- It is not recommended to modify the value of `local_config` to `false`. If modified, the NebulaGraph service will first read the cached configurations, which may cause configuration inconsistencies between clusters and cause unknown risks.
- It is not recommended to modify the configurations that are not introduced in this topic, unless you are familiar with the source code and fully understand the function of configurations.

How to use the configuration files

To use the initial configuration file, choose one of the above two files and delete the suffix `.default` or `.production` from the initial configuration file for the Meta Service to apply the configurations defined in it.

About parameter values

If a parameter is not set in the configuration file, NebulaGraph uses the default value. Not all parameters are predefined. And the predefined parameters in the two initial configuration files are different. This topic uses the parameters in `nebula-metad.conf.default`.

Caution

Some parameter values in the configuration file can be dynamically modified during runtime. We label these parameters as **Yes** that supports runtime dynamic modification in this article. When the `local_config` value is set to `true`, the dynamically modified configuration is not persisted, and the configuration will be restored to the initial configuration after the service is restarted. For more information, see Modify configurations.

For all parameters and their current values, see Configurations.

Basics configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`daemonize`	`true`	When set to `true`, the process is a daemon process.	No
`pid_file`	`pids/nebula-graphd.pid`	The file that records the process ID.	No
`enable_optimizer`	`true`	When set to `true`, the optimizer is enabled.	No
`timezone_name`	-	Specifies the NebulaGraph time zone. This parameter is not predefined in the initial configuration files. The system default value is `UTC+00:00:00`. For the format of the parameter value, see Specifying the Time Zone with TZ. For example, `--timezone_name=UTC+08:00` represents the GMT+8 time zone.	No
`local_config`	`true`	When set to `true`, the process gets configurations from the configuration files.	No

Note

- While inserting property values of time types, NebulaGraph transforms time types (except TIMESTAMP) to the corresponding UTC according to the time zone specified by `timezone_name`. The time-type values returned by nGQL queries are all UTC time.
- `timezone_name` is only used to transform the data stored in NebulaGraph. Other time-related data of the NebulaGraph processes still uses the default time zone of the host, such as the log printing time.

Logging configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`log_dir`	`logs`	The directory that stores the Meta Service log. It is recommended to put logs on a different hard disk from the data.	No
`minloglevel`	`0`	Specifies the minimum level of the log. That is, log messages at or above this level. Optional values are `0` (INFO), `1` (WARNING), `2` (ERROR), `3` (FATAL). It is recommended to set it to `0` during debugging and `1` in a production environment. If it is set to `4`, NebulaGraph will not print any logs.	Yes
`v`	`0`	Specifies the detailed level of VLOG. That is, log all VLOG messages less or equal to the level. Optional values are `0`, `1`, `2`, `3`, `4`, `5`. The VLOG macro provided by glog allows users to define their own numeric logging levels and control verbose messages that are logged with the parameter `v`. For details, see Verbose Logging.	Yes
`logbufsecs`	`0`	Specifies the maximum time to buffer the logs. If there is a timeout, it will output the buffered log to the log file. `0` means real-time output. This configuration is measured in seconds.	No
`redirect_stdout`	`true`	When set to `true`, the process redirects the `stdout` and `stderr` to separate output files.	No
`stdout_log_file`	`graphd-stdout.log`	Specifies the filename for the `stdout` log.	No
`stderr_log_file`	`graphd-stderr.log`	Specifies the filename for the `stderr` log.	No
`stderrthreshold`	`3`	Specifies the `minloglevel` to be copied to the `stderr` log.	No
`timestamp_in_logfile_name`	`true`	Specifies if the log file name contains a timestamp. `true` indicates yes, `false` indicates no.	No

Query configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`accept_partial_success`	`false`	When set to `false`, the process treats partial success as an error. This configuration only applies to read-only requests. Write requests always treat partial success as an error.	Yes
`session_reclaim_interval_secs`	`60`	Specifies the interval that the Session information is sent to the Meta service. This configuration is measured in seconds.	Yes
`max_allowed_query_size`	`4194304`	Specifies the maximum length of queries. Unit: bytes. The default value is `4194304`, namely 4MB.	Yes

Networking configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`meta_server_addrs`	`127.0.0.1:9559`	Specifies the IP addresses and ports of all Meta Services. Multiple addresses are separated with commas.	No
`local_ip`	`127.0.0.1`	Specifies the local IP for the Graph Service. The local IP address is used to identify the nebula-graphd process. If it is a distributed cluster or requires remote access, modify it to the corresponding address.	No
`listen_netdev`	`any`	Specifies the listening network device.	No
`port`	`9669`	Specifies RPC daemon listening port of the Graph service.	No
`reuse_port`	`false`	When set to `false`, the `SO_REUSEPORT` is closed.	No
`listen_backlog`	`1024`	Specifies the maximum length of the connection queue for socket monitoring. This configuration must be modified together with the `net.core.somaxconn`.	No
`client_idle_timeout_secs`	`28800`	Specifies the time to expire an idle connection. The value ranges from 1 to 604800. The default is 8 hours. This configuration is measured in seconds.	No
`session_idle_timeout_secs`	`28800`	Specifies the time to expire an idle session. The value ranges from 1 to 604800. The default is 8 hours. This configuration is measured in seconds.	No
`num_accept_threads`	`1`	Specifies the number of threads that accept incoming connections.	No
`num_netio_threads`	`0`	Specifies the number of networking IO threads. `0` is the number of CPU cores.	No
`num_max_connections`	`0`	Max active connections for all networking threads. 0 means no limit. Max connections for each networking thread = num_max_connections / num_netio_threads	No
`num_worker_threads`	`0`	Specifies the number of threads that execute queries. `0` is the number of CPU cores.	No
`ws_ip`	`0.0.0.0`	Specifies the IP address for the HTTP service.	No
`ws_http_port`	`19669`	Specifies the port for the HTTP service.	No
`heartbeat_interval_secs`	`10`	Specifies the default heartbeat interval. Make sure the `heartbeat_interval_secs` values for all services are the same, otherwise NebulaGraph **CANNOT** work normally. This configuration is measured in seconds.	Yes
`storage_client_timeout_ms`	-	Specifies the RPC connection timeout threshold between the Graph Service and the Storage Service. This parameter is not predefined in the initial configuration files. You can manually set it if you need it. The system default value is `60000` ms.	No
`enable_record_slow_query`	`true`		No

Name	Predefined value	Description	Whether supports runtime dynamic modifications
		Whether to record slow queries. Only available in NebulaGraph Enterprise Edition.	
`slow_query_limit`	`100`	The maximum number of slow queries that can be recorded. Only available in NebulaGraph Enterprise Edition.	No
`slow_query_threshold_us`	`200000`	When the execution time of a query exceeds the value, the query is called a slow query. Unit: Microsecond.	No
`ws_meta_http_port`	`19559`	Specifies the Meta service listening port used by the HTTP protocol. It must be consistent with the `ws_http_port` in the Meta service configuration file.	No

Caution

The real IP address must be used in the configuration file. Otherwise, `127.0.0.1/0.0.0.0` cannot be parsed correctly in some cases.

Charset and collate configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`default_charset`	`utf8`	Specifies the default charset when creating a new graph space.	No
`default_collate`	`utf8_bin`	Specifies the default collate when creating a new graph space.	No

Authorization configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`enable_authorize`	`false`	When set to `false`, the system authentication is not enabled. For more information, see Authentication.	No
`auth_type`	`password`	Specifies the login method. Available values are `password`, `ldap`, and `cloud`.	No

Memory configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`system_memory_high_watermark_ratio`	`0.8`	Specifies the trigger threshold of the high-level memory alarm mechanism. If the system memory usage is higher than this value, an alarm mechanism will be triggered, and NebulaGraph will stop querying. This parameter is not predefined in the initial configuration files.	Yes

Metrics configurations

| Name | Predefined value | Description |Whether supports runtime dynamic modifications| | - | - | - | | `enable_space_level_metrics` | `false` | Enable or disable space-level metrics. Such metric names contain the name of the graph space that it monitors, for example, `query_latency_us{space=basketballplayer}.avg.3600`. You can view the supported metrics with the `curl` command. For more information, see Query NebulaGraph metrics. | No|

Session configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`max_sessions_per_ip_per_user`	`300`	The maximum number of active sessions that can be created from a single IP adddress for a single user.	No

Experimental configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`enable_experimental_feature`	`false`	Specifies the experimental feature. Optional values are `true` and `false`.	No
`enable_data_balance`	`true`	Whether to enable the BALANCE DATA feature. Only works when `enable_experimental_feature` is `true`.	No

Memory tracker configurations

Name	Predefined value	Description	Whether supports runtime dynamic modifications
`memory_tracker_limit_ratio`	`0.8`	The percentage of free memory. When the free memory is lower than this value, NebulaGraph stops accepting queries. Calculated as follows: `Free memory / (Total memory - Reserved memory)` **Note**: For clusters with a mixed-used environment, the value of `memory_tracker_limit_ratio` should be set to a **lower** value. For example, when Graphd is expected to occupy only 50% of memory, the value can be set to less than `0.5`.	Yes
`memory_tracker_untracked_reserved_memory_mb`	`50`	The reserved memory that is not tracked by the memory tracker. Unit: MB.	Yes
`memory_tracker_detail_log`	`false`	Whether to enable the memory tracker log. When the value is `true`, the memory tracker log is generated.	Yes
`memory_tracker_detail_log_interval_ms`	`60000`	The time interval for generating the memory tracker log. Unit: Millisecond. `memory_tracker_detail_log` is `true` when this parameter takes effect.	Yes
`memory_purge_enabled`	`true`	Whether to enable the memory purge feature. When the value is `true`, the memory purge feature is enabled.	Yes
`memory_purge_interval_seconds`	`10`	The time interval for the memory purge feature to purge memory. Unit: Second. This parameter only takes effect if `memory_purge_enabled` is set to true.	Yes

Last update: April 25, 2023

6.1.4 *Macro Rendering Error*

File: `5.configurations-and-logs/1.configurations/4.storage-config.md`

UndefinedError: 'comm' is undefined

```
Traceback (most recent call last):
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/mkdocs_macros/plugin.py", line 523, in render
    return md_template.render(**page_variables)
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/jinja2/environment.py", line 1301, in render
    self.environment.handle_exception()
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/jinja2/environment.py", line 936, in handle_exception
    raise rewrite_traceback_stack(source=source)
  File "<template>", line 83, in top-level template code
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/jinja2/environment.py", line 485, in getattr
    return getattr(obj, attribute)
jinja2.exceptions.UndefinedError: 'comm' is undefined
```

Last update: April 25, 2023

6.1.5 Kernel configurations

This topic introduces the Kernel configurations in Nebula Graph.

Resource control

ULIMIT PRECAUTIONS

The `ulimit` command specifies the resource threshold for the current shell session. The precautions are as follows:

- The changes made by `ulimit` only take effect for the current session or child process.
- The resource threshold (soft threshold) cannot exceed the hard threshold.
- Common users cannot use commands to adjust the hard threshold, even with `sudo`.
- To modify the system level or adjust the hard threshold, edit the file `/etc/security/limits.conf`. This method requires re-login to take effect.

ULIMIT -C

`ulimit -c` limits the size of the core dumps. We recommend that you set it to `unlimited`. The command is:

```
ulimit -c unlimited
```

ULIMIT -N

`ulimit -n` limits the number of open files. We recommend that you set it to more than 100,000. For example:

```
ulimit -n 130000
```

Memory

VM.SWAPPINESS

`vm.swappiness` specifies the percentage of the available memory before starting swap. The greater the value, the more likely the swap occurs. We recommend that you set it to 0. When set to 0, the page cache is removed first. Note that when `vm.swappiness` is 0, it does not mean that there is no swap.

VM.MIN_FREE_KBYTES

`vm.min_free_kbytes` specifies the minimum number of kilobytes available kept by Linux VM. If you have a large system memory, we recommend that you increase this value. For example, if your physical memory 128GB, set it to 5GB. If the value is not big enough, the system cannot apply for enough continuous physical memory.

VM.MAX_MAP_COUNT

`vm.max_map_count` limits the maximum number of vma (virtual memory area) for a process. The default value is `65530`. It is enough for most applications. If your memory application fails because the memory consumption is large, increase the `vm.max_map_count` value.

VM.DIRTY_*

These values control the dirty data cache for the system. For write-intensive scenarios, you can make adjustments based on your needs (throughput priority or delay priority). We recommend that you use the system default value.

TRANSPARENT HUGE PAGE

For better delay performance, you must run the following commands to disable the transparent huge pages (THP).

```
root# echo never > /sys/kernel/mm/transparent_hugepage/enabled
root# echo never > /sys/kernel/mm/transparent_hugepage/defrag
root# swapoff -a && swapon -a
```

To prevent THP from being enabled again after the system restarts, you can modify the GRUB configuration file or `/etc/rc.local` to disable THP automatically upon system startup.

Networking

NET.IPV4.TCP_SLOW_START_AFTER_IDLE

The default value of `net.ipv4.tcp_slow_start_after_idle` is `1`. If set, the congestion window is timed out after an idle period. We recommend that you set it to `0`, especially for long fat scenarios (high latency and large bandwidth).

NET.CORE.SOMAXCONN

`net.core.somaxconn` specifies the maximum number of connection queues listened by the socket. The default value is `128`. For scenarios with a large number of burst connections, we recommend that you set it to greater than `1024`.

NET.IPV4.TCP_MAX_SYN_BACKLOG

`net.ipv4.tcp_max_syn_backlog` specifies the maximum number of TCP connections in the SYN_RECV (semi-connected) state. The setting rule for this parameter is the same as that of `net.core.somaxconn`.

NET.CORE.NETDEV_MAX_BACKLOG

`net.core.netdev_max_backlog` specifies the maximum number of packets. The default value is `1000`. We recommend that you increase it to greater than `10,000`, especially for 10G network adapters.

NET.IPV4.TCP_KEEPALIVE_*

These values keep parameters alive for TCP connections. For applications that use a 4-layer transparent load balancer, if the idle connection is disconnected unexpectedly, decrease the values of `tcp_keepalive_time` and `tcp_keepalive_intvl`.

NET.IPV4.TCP_RMEM/WMEM

`net.ipv4.tcp_wmem/rmem` specifies the minimum, default, and maximum size of the buffer pool sent/received by the TCP socket. For long fat links, we recommend that you increase the default value to `bandwidth (GB) * RTT (ms)`.

SCHEDULER

For SSD devices, we recommend that you set `scheduler` to `noop` or `none`. The path is `/sys/block/DEV_NAME/queue/scheduler`.

Other parameters

KERNEL.CORE_PATTERN

we recommend that you set it to `core` and set `kernel.core_uses_pid` to `1`.

Modify parameters

SYSCTL

- `sysctl <conf_name>`

  Checks the current parameter value.

- `sysctl -w <conf_name>=<value>`

  Modifies the parameter value. The modification takes effect immediately. The original value is restored after restarting.

- `sysctl -p [<file_path>]`

  Loads Linux parameter values from the specified configuration file. The default path is `/etc/sysctl.conf`.

PRLIMIT

The `prlimit` command gets and sets process resource limits. You can modify the hard threshold by using it and the `sudo` command. For example, `prlimit --nofile = 130000 --pid = $$` adjusts the maximum number of open files permitted by the current process to `14000`. And the modification takes effect immediately. Note that this command is only available in RedHat 7u or higher versions.

Last update: May 13, 2022

6.2 Log management

6.2.1 Runtime logs

Runtime logs are provided for DBAs and developers to locate faults when the system fails.

NebulaGraph uses glog to print runtime logs, uses gflags to control the severity level of the log, and provides an HTTP interface to dynamically change the log level at runtime to facilitate tracking.

Log directory

The default runtime log directory is `/usr/local/nebula/logs/`.

If the log directory is deleted while NebulaGraph is running, the log would not continue to be printed. However, this operation will not affect the services. To recover the logs, restart the services.

Parameter descriptions

- `minloglevel`: Specifies the minimum level of the log. That is, no logs below this level will be printed. Optional values are `0` (INFO), `1` (WARNING), `2` (ERROR), `3` (FATAL). It is recommended to set it to `0` during debugging and `1` in a production environment. If it is set to `4`, NebulaGraph will not print any logs.
- `v`: Specifies the detailed level of the log. The larger the value, the more detailed the log is. Optional values are `0`, `1`, `2`, `3`.

The default severity level for the metad, graphd, and storaged logs can be found in their respective configuration files. The default path is `/usr/local/nebula/etc/`.

Check the severity level

Check all the flag values (log values included) of the current gflags with the following command.

```
$ curl <ws_ip>:<ws_port>/flags
```

Parameter	Description
`ws_ip`	The IP address for the HTTP service, which can be found in the configuration files above. The default value is `127.0.0.1`.
`ws_port`	The port for the HTTP service, which can be found in the configuration files above. The default values are `19559` (Meta), `19669` (Graph), and `19779` (Storage) respectively.

Examples are as follows:

- Check the current `minloglevel` in the Meta service:

```
$ curl 127.0.0.1:19559/flags | grep 'minloglevel'
```

- Check the current `v` in the Storage service:

```
$ curl 127.0.0.1:19779/flags | grep -w 'v'
```

Change the severity level

Change the severity level of the log with the following command.

```
$ curl -X PUT -H "Content-Type: application/json" -d '{"<key>":<value>[,"<key>":<value>]}' "<ws_ip>:<ws_port>/flags"
```

Parameter	Description
`key`	The type of the log to be changed. For optional values, see Parameter descriptions.
`value`	The level of the log. For optional values, see Parameter descriptions.
`ws_ip`	The IP address for the HTTP service, which can be found in the configuration files above. The default value is `127.0.0.1`.
`ws_port`	The port for the HTTP service, which can be found in the configuration files above. The default values are `19559` (Meta), `19669` (Graph), and `19779` (Storage) respectively.

Examples are as follows:

```
$ curl -X PUT -H "Content-Type: application/json" -d '{"minloglevel":0,"v":3}' "127.0.0.1:19779/flags" # storaged
$ curl -X PUT -H "Content-Type: application/json" -d '{"minloglevel":0,"v":3}' "127.0.0.1:19669/flags" # graphd
$ curl -X PUT -H "Content-Type: application/json" -d '{"minloglevel":0,"v":3}' "127.0.0.1:19559/flags" # metad
```

If the log level is changed while NebulaGraph is running, it will be restored to the level set in the configuration file after restarting the service. To permanently modify it, see Configuration files.

RocksDB runtime logs

RocksDB runtime logs are usually used to debug RocksDB parameters and stored in `/usr/local/nebula/data/storage/nebula/$id/data/LOG`. `$id` is the ID of the example.

Last update: August 11, 2022

7. Monitor and metrics

7.1 Query NebulaGraph metrics

NebulaGraph supports querying the monitoring metrics through HTTP ports.

7.1.1 Metrics structure

Each metric of NebulaGraph consists of three fields: name, type, and time range. The fields are separated by periods, for example, `num_queries.sum.600`. Different NebulaGraph services (Graph, Storage, or Meta) support different metrics. The detailed description is as follows.

Field	Example	Description
Metric name	`num_queries`	Indicates the function of the metric.
Metric type	`sum`	Indicates how the metrics are collected. Supported types are SUM, AVG, RATE, and the P-th sample quantiles such as P75, P95, P99, and P99.9.
Time range	`600`	The time range in seconds for the metric collection. Supported values are 5, 60, 600, and 3600, representing the last 5 seconds, 1 minute, 10 minutes, and 1 hour.

7.1.2 Query metrics over HTTP

Syntax

```
curl -G "http://<ip>:<port>/stats?stats=<metric_name_list> [&format=json]"
```

Parameter	Description
`ip`	The IP address of the server. You can find it in the configuration file in the installation directory.
`port`	The HTTP port of the server. You can find it in the configuration file in the installation directory. The default ports are 19559 (Meta), 19669 (Graph), and 19779 (Storage).
`metric_name_list`	The metrics names. Multiple metrics are separated by commas (,).
`&format=json`	Optional. Returns the result in the JSON format.

Note

If NebulaGraph is deployed with Docker Compose, run `docker-compose ps` to check the ports that are mapped from the service ports inside of the container and then query through them.

Query a single metric

Query the query number in the last 10 minutes in the Graph Service.

```
$ curl -G "http://192.168.8.40:19669/stats?stats=num_queries.sum.600"
num_queries.sum.600=400
```

Query multiple metrics

Query the following metrics together:

- The average heartbeat latency in the last 1 minute.
- The average latency of the slowest 1% heartbeats, i.e., the P99 heartbeats, in the last 10 minutes.

```
$ curl -G "http://192.168.8.40:19559/stats?stats=heartbeat_latency_us.avg.60,heartbeat_latency_us.p99.600"
heartbeat_latency_us.avg.60=281
heartbeat_latency_us.p99.600=985
```

Return a JSON result.

Query the number of new vertices in the Storage Service in the last 10 minutes and return the result in the JSON format.

```
$ curl -G "http://192.168.8.40:19779/stats?stats=num_add_vertices.sum.600&format=json"
[{"value":1,"name":"num_add_vertices.sum.600"}]
```

Query all metrics in a service.

If no metric is specified in the query, NebulaGraph returns all metrics in the service.

```
$ curl -G "http://192.168.8.40:19559/stats"
heartbeat_latency_us.avg.5=304
heartbeat_latency_us.avg.60=308
heartbeat_latency_us.avg.600=299
heartbeat_latency_us.avg.3600=285
heartbeat_latency_us.p75.5=652
heartbeat_latency_us.p75.60=669
heartbeat_latency_us.p75.600=651
heartbeat_latency_us.p75.3600=642
heartbeat_latency_us.p95.5=930
heartbeat_latency_us.p95.60=963
heartbeat_latency_us.p95.600=933
heartbeat_latency_us.p95.3600=929
heartbeat_latency_us.p99.5=986
heartbeat_latency_us.p99.60=1409
heartbeat_latency_us.p99.600=989
heartbeat_latency_us.p99.3600=986
num_heartbeats.rate.5=0
num_heartbeats.rate.60=0
num_heartbeats.rate.600=0
num_heartbeats.rate.3600=0
num_heartbeats.sum.5=2
num_heartbeats.sum.60=40
num_heartbeats.sum.600=394
num_heartbeats.sum.3600=2364
...
```

Space-level metrics

The Graph service supports a set of space-level metrics that record the information of different graph spaces separately.

Space-level metrics can be queried only by querying all metrics. For example, run `curl -G "http://192.168.8.40:19559/stats"` to show all metrics. The returned result contains the graph space name in the form of '{space=space_name}', such as `num_active_queries{space=basketballplayer}.sum.5=0` .

Caution

To enable space-level metrics, set the value of `enable_space_level_metrics` to `true` in the Graph service configuration file before starting NebulaGraph. For details about how to modify the configuration, see Configuration Management.

7.1.3 Metric description

Graph

Parameter	Description
`num_active_queries`	The number of changes in the number of active queries. Formula: The number of started queries minus the number of finished queries within a specified time.
`num_active_sessions`	The number of changes in the number of active sessions. Formula: The number of logged in sessions minus the number of logged out sessions within a specified time. For example, when querying `num_active_sessions.sum.5`, if there were 10 sessions logged in and 30 sessions logged out in the last 5 seconds, the value of this metric is `-20` (10-30).
`num_aggregate_executors`	The number of executions for the Aggregation operator.
`num_auth_failed_sessions_bad_username_password`	The number of sessions where authentication failed due to incorrect username and password.
`num_auth_failed_sessions_out_of_max_allowed`	The number of sessions that failed to authenticate logins because the value of the parameter `FLAG_OUT_OF_MAX_ALLOWED_CONNECTIONS` was exceeded.
`num_auth_failed_sessions`	The number of sessions in which login authentication failed.
`num_indexscan_executors`	The number of executions for index scan operators.
`num_killed_queries`	The number of killed queries.
`num_opened_sessions`	The number of sessions connected to the server.
`num_queries`	The number of queries.
`num_query_errors_leader_changes`	The number of the raft leader changes due to query errors.
`num_query_errors`	The number of query errors.
`num_reclaimed_expired_sessions`	The number of expired sessions actively reclaimed by the server.
`num_rpc_sent_to_metad_failed`	The number of failed RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_metad`	The number of RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_storaged_failed`	The number of failed RPC requests that the Graphd service sent to the Storaged service.
`num_rpc_sent_to_storaged`	The number of RPC requests that the Graphd service sent to the Storaged service.
`num_sentences`	The number of statements received by the Graphd service.
`num_slow_queries`	The number of slow queries.
`num_sort_executors`	The number of executions for the Sort operator.
`optimizer_latency_us`	The latency of executing optimizer statements.
`query_latency_us`	The latency of queries.
`slow_query_latency_us`	The latency of slow queries.
`num_queries_hit_memory_watermark`	The number of queries reached the memory watermark.

Meta

Parameter	Description
`commit_log_latency_us`	The latency of committing logs in Raft.
`commit_snapshot_latency_us`	The latency of committing snapshots in Raft.
`heartbeat_latency_us`	The latency of heartbeats.
`num_heartbeats`	The number of heartbeats.
`num_raft_votes`	The number of votes in Raft.
`transfer_leader_latency_us`	The latency of transferring the raft leader.
`num_agent_heartbeats`	The number of heartbeats for the AgentHBProcessor.
`agent_heartbeat_latency_us`	The latency of the AgentHBProcessor.
`replicate_log_latency_us`	The latency of replicating the log record to most nodes by Raft.
`num_send_snapshot`	The number of times that Raft sends snapshots to other nodes.
`append_log_latency_us`	The latency of replicating the log record to a single node by Raft.
`append_wal_latency_us`	The Raft write latency for a single WAL.
`num_grant_votes`	The number of times that Raft votes for other nodes.
`num_start_elect`	The number of times that Raft starts an election.

Storage

Parameter	Description
`add_edges_latency_us`	The latency of adding edges.
`add_vertices_latency_us`	The latency of adding vertices.
`commit_log_latency_us`	The latency of committing logs in Raft.
`commit_snapshot_latency_us`	The latency of committing snapshots in Raft.
`delete_edges_latency_us`	The latency of deleting edges.
`delete_vertices_latency_us`	The latency of deleting vertices.
`get_neighbors_latency_us`	The latency of querying neighbor vertices.
`get_dst_by_src_latency_us`	The latency of querying the destination vertex by the source vertex.
`num_get_prop`	The number of executions for the GetPropProcessor.
`num_get_neighbors_errors`	The number of execution errors for the GetNeighborsProcessor.
`num_get_dst_by_src_errors`	The number of execution errors for the GetDstBySrcProcessor.
`get_prop_latency_us`	The latency of executions for the GetPropProcessor.
`num_edges_deleted`	The number of deleted edges.
`num_edges_inserted`	The number of inserted edges.
`num_raft_votes`	The number of votes in Raft.
`num_rpc_sent_to_metad_failed`	The number of failed RPC requests that the Storage service sent to the Meta service.
`num_rpc_sent_to_metad`	The number of RPC requests that the Storaged service sent to the Metad service.
`num_tags_deleted`	The number of deleted tags.
`num_vertices_deleted`	The number of deleted vertices.
`num_vertices_inserted`	The number of inserted vertices.
`transfer_leader_latency_us`	The latency of transferring the raft leader.
`lookup_latency_us`	The latency of executions for the LookupProcessor.
`num_lookup_errors`	The number of execution errors for the LookupProcessor.
`num_scan_vertex`	The number of executions for the ScanVertexProcessor.
`num_scan_vertex_errors`	The number of execution errors for the ScanVertexProcessor.
`update_edge_latency_us`	The latency of executions for the UpdateEdgeProcessor.
`num_update_vertex`	The number of executions for the UpdateVertexProcessor.
`num_update_vertex_errors`	The number of execution errors for the UpdateVertexProcessor.
`kv_get_latency_us`	The latency of executions for the Getprocessor.
`kv_put_latency_us`	The latency of executions for the PutProcessor.
`kv_remove_latency_us`	The latency of executions for the RemoveProcessor.
`num_kv_get_errors`	The number of execution errors for the GetProcessor.
`num_kv_get`	The number of executions for the GetProcessor.
`num_kv_put_errors`	The number of execution errors for the PutProcessor.
`num_kv_put`	The number of executions for the PutProcessor.

Parameter	Description
`num_kv_remove_errors`	The number of execution errors for the RemoveProcessor.
`num_kv_remove`	The number of executions for the RemoveProcessor.
`forward_tranx_latency_us`	The latency of transmission.
`scan_edge_latency_us`	The latency of executions for the ScanEdgeProcessor.
`num_scan_edge_errors`	The number of execution errors for the ScanEdgeProcessor.
`num_scan_edge`	The number of executions for the ScanEdgeProcessor.
`scan_vertex_latency_us`	The latency of executions for the ScanVertexProcessor.
`num_add_edges`	The number of times that edges are added.
`num_add_edges_errors`	The number of errors when adding edges.
`num_add_vertices`	The number of times that vertices are added.
`num_start_elect`	The number of times that Raft starts an election.
`num_add_vertices_errors`	The number of errors when adding vertices.
`num_delete_vertices_errors`	The number of errors when deleting vertices.
`append_log_latency_us`	The latency of replicating the log record to a single node by Raft.
`num_grant_votes`	The number of times that Raft votes for other nodes.
`replicate_log_latency_us`	The latency of replicating the log record to most nodes by Raft.
`num_delete_tags`	The number of times that tags are deleted.
`num_delete_tags_errors`	The number of errors when deleting tags.
`num_delete_edges`	The number of edge deletions.
`num_delete_edges_errors`	The number of errors when deleting edges
`num_send_snapshot`	The number of times that snapshots are sent.
`update_vertex_latency_us`	The latency of executions for the UpdateVertexProcessor.
`append_wal_latency_us`	The Raft write latency for a single WAL.
`num_update_edge`	The number of executions for the UpdateEdgeProcessor.
`delete_tags_latency_us`	The latency of deleting tags.
`num_update_edge_errors`	The number of execution errors for the UpdateEdgeProcessor.
`num_get_neighbors`	The number of executions for the GetNeighborsProcessor.
`num_get_dst_by_src`	The number of executions for the GetDstBySrcProcessor.
`num_get_prop_errors`	The number of execution errors for the GetPropProcessor.
`num_delete_vertices`	The number of times that vertices are deleted.
`num_lookup`	The number of executions for the LookupProcessor.
`num_sync_data`	The number of times the Storage service synchronizes data from the Drainer.
`num_sync_data_errors`	The number of errors that occur when the Storage service synchronizes data from the Drainer.
`sync_data_latency_us`	The latency of the Storage service synchronizing data from the Drainer.

Graph space

> **Note**
>
> Space-level metrics are created dynamically, so that only when the behavior is triggered in the graph space, the corresponding metric is created and can be queried by the user.

Parameter	Description
`num_active_queries`	The number of queries currently being executed.
`num_queries`	The number of queries.
`num_sentences`	The number of statements received by the Graphd service.
`optimizer_latency_us`	The latency of executing optimizer statements.
`query_latency_us`	The latency of queries.
`num_slow_queries`	The number of slow queries.
`num_query_errors`	The number of query errors.
`num_query_errors_leader_changes`	The number of raft leader changes due to query errors.
`num_killed_queries`	The number of killed queries.
`num_aggregate_executors`	The number of executions for the Aggregation operator.
`num_sort_executors`	The number of executions for the Sort operator.
`num_indexscan_executors`	The number of executions for index scan operators.
`num_auth_failed_sessions_bad_username_password`	The number of sessions where authentication failed due to incorrect username and password.
`num_auth_failed_sessions`	The number of sessions in which login authentication failed.
`num_opened_sessions`	The number of sessions connected to the server.
`num_queries_hit_memory_watermark`	The number of queries reached the memory watermark.
`num_reclaimed_expired_sessions`	The number of expired sessions actively reclaimed by the server.
`num_rpc_sent_to_metad_failed`	The number of failed RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_metad`	The number of RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_storaged_failed`	The number of failed RPC requests that the Graphd service sent to the Storaged service.
`num_rpc_sent_to_storaged`	The number of RPC requests that the Graphd service sent to the Storaged service.
`slow_query_latency_us`	The latency of slow queries.

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7.2 RocksDB statistics

NebulaGraph uses RocksDB as the underlying storage. This topic describes how to collect and show the RocksDB statistics of NebulaGraph.

7.2.1 Enable RocksDB

By default, the function of RocksDB statistics is disabled. To enable RocksDB statistics, you need to:

1. Modify the `--enable_rocksdb_statistics` parameter as `true` in the `nebula-storaged.conf` file. The default path of the configuration file is `/use/local/nebula/etc`.
2. Restart the service to make the modification valid.

7.2.2 Get RocksDB statistics

Users can use the built-in HTTP service in the storage service to get the following types of statistics. Results in the JSON format are supported.

- All RocksDB statistics.
- Specified RocksDB statistics.

7.2.3 Examples

Use the following command to get all RocksDB statistics:

```
curl -L "http://${storage_ip}:${port}/rocksdb_stats"
```

For example:

```
curl -L "http://172.28.2.1:19779/rocksdb_stats"

rocksdb.blobdb.blob.file.bytes.read=0
rocksdb.blobdb.blob.file.bytes.written=0
rocksdb.blobdb.blob.file.bytes.synced=0
...
```

Use the following command to get specified RocksDB statistics:

```
curl -L "http://${storage_ip}:${port}/rocksdb_stats?stats=${stats_name}"
```

For example, use the following command to get the information of `rocksdb.bytes.read` and `rocksdb.block.cache.add`.

```
curl -L "http://172.28.2.1:19779/rocksdb_stats?stats=rocksdb.bytes.read,rocksdb.block.cache.add"

rocksdb.block.cache.add=14
rocksdb.bytes.read=1632
```

Use the following command to get specified RocksDB statistics in the JSON format:

```
curl -L "http://${storage_ip}:${port}/rocksdb_stats?stats=${stats_name}&format=json"
```

For example, use the following command to get the information of `rocksdb.bytes.read` and `rocksdb.block.cache.add` and return the results in the JSON format.

```
curl -L "http://172.28.2.1:19779/rocksdb_stats?stats=rocksdb.bytes.read,rocksdb.block.cache.add&format=json"

[
  {
    "rocksdb.block.cache.add": 1
  },
  {
    "rocksdb.bytes.read": 160
```

```
  }
]
```

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8. Data security

8.1 Authentication and authorization

8.1.1 Authentication

NebulaGraph replies on local authentication or LDAP authentication to implement access control.

NebulaGraph creates a session when a client connects to it. The session stores information about the connection, including the user information. If the authentication system is enabled, the session will be mapped to corresponding users.

Note

By default, the authentication is disabled and NebulaGraph allows connections with the username `root` and any password.

NebulaGraph supports local authentication and LDAP authentication.

Local authentication

Local authentication indicates that usernames and passwords are stored locally on the server, with the passwords encrypted. Users will be authenticated when trying to visit NebulaGraph.

ENABLE LOCAL AUTHENTICATION

1. Modify the `nebula-graphd.conf` file (`/usr/local/nebula/etc/` is the default path) to set the following parameters:

- `--enable_authorize` : Set its value to `true` to enable authentication.

Note

- By default, the authentication is disabled and NebulaGraph allows connections with the username `root` and any password.
- You can use the username `root` and password `nebula` to log into NebulaGraph after enabling local authentication. This account has the build-in God role. For more information about roles, see Roles and privileges.

- `--failed_login_attempts` : This parameter is optional, and you need to add this parameter manually. Specify the attempts of continuously entering incorrect passwords for a single Graph service. When the number exceeds the limitation, your account will be locked. For multiple Graph services, the allowed attempts are `number of services * failed_login_attempts` .
- `--password_lock_time_in_secs` : This parameter is optional, and you need to add this parameter manually. Specify the time how long your account is locked after multiple incorrect password entries are entered. Unit: second.

2. Restart the NebulaGraph services. For how to restart, see Manage NebulaGraph services.

Last update: November 2, 2022

8.1.2 User management

User management is an indispensable part of NebulaGraph access control. This topic describes how to manage users and roles.

After enabling authentication, only valid users can connect to NebulaGraph and access the resources according to the user roles.

Note

- By default, the authentication is disabled. NebulaGraph allows connections with the username `root` and any password.
- Once the role of a user is modified, the user has to re-login to make the new role takes effect.

CREATE USER

The `root` user with the **GOD** role can run `CREATE USER` to create a new user.

- Syntax

```
CREATE USER [IF NOT EXISTS] <user_name> [WITH PASSWORD '<password>'];
```

- `IF NOT EXISTS`: Detects if the user name exists. The user will be created only if the user name does not exist.
- `user_name`: Sets the name of the user.
- `password`: Sets the password of the user. The default password is the empty string (`''`).

- Example

```
nebula> CREATE USER user1 WITH PASSWORD 'nebula';
nebula> SHOW USERS;
+---------+-------------------------------+
| Account | IP Whitelist                  |
+---------+-------------------------------+
| "root"  | ""                            |
| "user1" | ""                            |
+---------+-------------------------------+
```

GRANT ROLE

Users with the **GOD** role or the **ADMIN** role can run `GRANT ROLE` to assign a built-in role in a graph space to a user. For more information about NebulaGraph built-in roles, see Roles and privileges.

- Syntax

```
GRANT ROLE <role_type> ON <space_name> TO <user_name>;
```

- Example

```
nebula> GRANT ROLE USER ON basketballplayer TO user1;
```

REVOKE ROLE

Users with the **GOD** role or the **ADMIN** role can run `REVOKE ROLE` to revoke the built-in role of a user in a graph space. For more information about NebulaGraph built-in roles, see Roles and privileges.

- Syntax

```
REVOKE ROLE <role_type> ON <space_name> FROM <user_name>;
```

- Example

```
nebula> REVOKE ROLE USER ON basketballplayer FROM user1;
```

DESCRIBE USER

Users can run `DESCRIBE USER` to list the roles for a specified user.

- Syntax

```
DESCRIBE USER <user_name>;
DESC USER <user_name>;
```

- Example

```
nebula> DESCRIBE USER user1;
+---------+--------------------+
| role    | space              |
+---------+--------------------+
| "ADMIN" | "basketballplayer" |
+---------+--------------------+
```

SHOW ROLES

Users can run `SHOW ROLES` to list the roles in a graph space.

- Syntax

```
SHOW ROLES IN <space_name>;
```

- Example

```
nebula> SHOW ROLES IN basketballplayer;
+---------+-----------+
| Account | Role Type |
+---------+-----------+
| "user1" | "ADMIN"   |
+---------+-----------+
```

CHANGE PASSWORD

Users can run `CHANGE PASSWORD` to set a new password for a user. The old password is needed when setting a new one.

- Syntax

```
CHANGE PASSWORD <user_name> FROM '<old_password>' TO '<new_password>';
```

- Example

```
nebula> CHANGE PASSWORD user1 FROM 'nebula' TO 'nebula123';
```

ALTER USER

The `root` user with the **GOD** role can run `ALTER USER` to set a new password. The old password is not needed when altering the user.

- Syntax

```
ALTER USER <user_name> WITH PASSWORD '<password>';
```

- Example

```
nebula> ALTER USER user2 WITH PASSWORD 'nebula';
```

DROP USER

The `root` user with the **GOD** role can run `DROP USER` to remove a user.

Note

Removing a user does not close the current session of the user, and the user role still takes effect in the session until the session is closed.

- Syntax

```
DROP USER [IF EXISTS] <user_name>;
```

- Example

```
nebula> DROP USER user1;
```

SHOW USERS

The `root` user with the **GOD** role can run `SHOW USERS` to list all the users.

- Syntax

```
SHOW USERS;
```

- Example

```
nebula> SHOW USERS;
+---------+-----------------+
| Account | IP Whitelist    |
+---------+-----------------+
| "root"  | ""              |
| "user1" | ""              |
| "user2" | "192.168.10.10" |
+---------+-----------------+
```

Last update: May 30, 2023

8.1.3 Roles and privileges

A role is a collection of privileges. You can assign a role to a user for access control.

Built-in roles

NebulaGraph does not support custom roles, but it has multiple built-in roles:

- GOD
- GOD is the original role with **all privileges** not limited to graph spaces. It is similar to `root` in Linux and `administrator` in Windows.
- When the Meta Service is initialized, the one and only GOD role user `root` is automatically created with the password `nebula`.

> **Caution**
>
> Modify the password for `root` timely for security.

- When the `--enable_authorize` parameter in the `nebula-graphd.conf` file (the default directory is `/usr/local/nebula/etc/`) is set to `true`:
- One cluster can only have one user with the GOD role. This user can manage all graph spaces in a cluster.
- Manual authorization of the God role is not supported. Only the `root` user with the default God role can be used.

- ADMIN
- An ADMIN role can **read and write** both the Schema and the data in a specific graph space.
- An ADMIN role of a graph space can grant DBA, USER, and GUEST roles in the graph space to other users.

> **Note**
>
> Only roles lower than ADMIN can be authorized to other users.

- DBA
- A DBA role can **read and write** both the Schema and the data in a specific graph space.
- A DBA role of a graph space CANNOT grant roles to other users.

- USER
- A USER role can **read and write** data in a specific graph space.
- The Schema information is **read-only** to the USER roles in a graph space.

- GUEST
- A GUEST role can **only read** the Schema and the data in a specific graph space.

> **Note**

- NebulaGraph does not support custom roles. Users can only use the default built-in roles.
- A user can have only one role in a graph space. For authenticated users, see User management.

Role privileges and allowed nGQL

The privileges of roles and the nGQL statements that each role can use are listed as follows.

Privilege	God	Admin	DBA	User	Guest	Basic	Allowed nGQL
Read space	Y	Y	Y	Y	Y	Y	`USE`, `DESCRIBE SPACE`
Read schema	Y	Y	Y	Y	Y	Y	`DESCRIBE TAG`, `DESCRIBE EDGE`, `DESCRIBE TAG INDEX`, `DESCRIBE EDGE INDEX`
Write schema	Y	Y	Y		Y		`CREATE TAG`, `ALTER TAG`, `CREATE EDGE`, `ALTER EDGE`, `DROP TAG`, `DELETE TAG`, `DROP EDGE`, `CREATE TAG INDEX`, `CREATE EDGE INDEX`, `DROP TAG INDEX`, `DROP EDGE INDEX`
Write user	Y						`CREATE USER`, `DROP USER`, `ALTER USER`
Write role	Y	Y					`GRANT`, `REVOKE`
Read data	Y	Y	Y	Y	Y	C	`GO`, `SET`, `PIPE`, `MATCH`, `ASSIGNMENT`, `LOOKUP`, `YIELD`, `ORDER BY`, `FETCH VERTICES`, `Find`, `FETCH EDGES`, `FIND PATH`, `LIMIT`, `GROUP BY`, `RETURN`
Write data	Y	Y	Y	Y		C	`INSERT VERTEX`, `UPDATE VERTEX`, `INSERT EDGE`, `UPDATE EDGE`, `DELETE VERTEX`, `DELETE EDGES`, `DELETE TAG`
Show operations	Y	Y	Y	Y	Y	Y	`SHOW`, `CHANGE PASSWORD`
Job	Y	Y	Y	Y			`SUBMIT JOB COMPACT`, `SUBMIT JOB FLUSH`, `SUBMIT JOB STATS`, `STOP JOB`, `RECOVER JOB`, `BUILD TAG INDEX`, `BUILD EDGE INDEX`, `INGEST`, `DOWNLOAD`
Write space	Y						`CREATE SPACE`, `DROP SPACE`, `CREATE SNAPSHOT`, `DROP SNAPSHOT`, `BALANCE`, `CONFIG`

Enterpriseonly

Only the Enterprise Edition supports fine-grain (Tag/Edge type level) permission management based on Basic roles.

Caution

- The results of `SHOW` operations are limited to the role of a user. For example, all users can run `SHOW SPACES`, but the results only include the graph spaces that the users have privileges.
- Only the GOD role can run `SHOW USERS` and `SHOW SNAPSHOTS`.

Last update: February 7, 2023

8.2 SSL encryption

NebulaGraph supports data transmission with SSL encryption between clients, the Graph service, the Meta service, and the Storage service. This topic describes how to enable SSL encryption.

8.2.1 Precaution

Enabling SSL encryption will slightly affect the performance, such as causing operation latency.

8.2.2 Parameters

Parameter	Default value	Description
`cert_path`	-	The path to the PEM certification.
`key_path`	-	The path to the key certification.
`password_path`	-	The path to the password file certification.
`ca_path`	-	The path to the trusted CA file.
`enable_ssl`	`false`	Whether to enable SSL encryption.
`enable_graph_ssl`	`false`	Whether to enable SSL encryption in the Graph service only.
`enable_meta_ssl`	`false`	Whether to enable SSL encryption in the Meta service only.

8.2.3 Certificate modes

To use SSL encryption, SSL certificates are required. NebulaGraph supports two certificate modes.

- Self-signed certificate mode

  In this mode, users need to make the signed certificate by themselves and set `cert_path`, `key_path`, and `password_path` in the corresponding file according to encryption policies.

- CA-signed certificate mode

  In this mode, users need to apply for the signed certificate from a certificate authority and set `cert_path`, `key_path`, and `password_path` in the corresponding file according to encryption policies.

8.2.4 Encryption policies

NebulaGraph supports three encryption policies. For details, see Usage explanation.

- Encrypt the data transmission between clients, the Graph service, the Meta service, and the Storage service.

  Add `enable_ssl = true` to the configuration files of `nebula-graphd.conf`, `nebula-metad.conf`, and `nebula-storaged.conf`.

- Encrypt the data transmission between clients and the Graph service.

  This policy applies to the case that the clusters are set in the same server room. Only the port of the Graph service is open to the outside because other services can communicate over the internal network without encryption. Add `enable_graph_ssl = true` to the configuration file of `nebula-graphd.conf`.

- Encrypt the data transmission related to the Meta service in the cluster.

  This policy applies to transporting classified information to the Meta service. Add `enable_meta_ssl = true` to the configuration files of `nebula-graphd.conf`, `nebula-metad.conf`, and `nebula-storaged.conf`.

8.2.5 Steps

1. Ensure the certificate mode and the encryption policy.
2. Add the certificate configuration and the policy configuration in corresponding files.

   For example, the three configuration files need to be set as follows when using a self-signed certificate and encrypt data transmission between clients, the Graph service, the Meta service, and the Storage service.

   ```
   --cert_path=xxxxxx
   --key_path=xxxxx
   --password_path=xxxxxx
   --enable_ssl=true
   ```

3. Set the SSL and the trusted CA in clients. For code examples, see nebula-test-run.py.

Last update: August 11, 2022

9. Backup & Restore

9.1 NebulaGraph BR (Community Edition)

9.1.1 What is Backup & Restore

Backup & Restore (BR for short) is a Command-Line Interface (CLI) tool to back up data of graph spaces of NebulaGraph and to restore data from the backup files.

Features

The BR has the following features. It supports:

- Backing up and restoring data in a one-click operation.
- Restoring data in the following backup file types:
- Local Disk (SSD or HDD). It is recommend to use local disk in test environment only.
- Amazon S3 compatible interface, such as Alibaba Cloud OSS, MinIO,Ceph RGW, etc.
- Backing up and restoring the entire NebulaGraph cluster.
- Backing up data of specified graph spaces (experimental).

Limitations

- Supports NebulaGraph v3.x only.
- Supports full backup, but not incremental backup.
- Currently, NebulaGraph Listener and full-text indexes do not support backup.
- If you back up data to the local disk, the backup files will be saved in the local path of each server. You can also mount the NFS on your host to restore the backup data to a different host.
- During the backup process, both DDL and DML statements in the specified graph spaces are blocked. We recommend that you do the operation within the low peak period of the business, for example, from 2:00 AM to 5:00 AM.
- The backup graph space can be restored to the original cluster only. Cross clusters restoration is not supported. Make sure the number of hosts in the cluster is not changed. Restoring a specified graph space will delete all other graph spaces in the cluster.
- Restoration requires that the number of the storage servers in the original cluster is the same as that of the storage servers in the target cluster and storage server IPs must be the same. Restoring the specified space will clear all the remaining spaces in the cluster.
- During the restoration process, there is a time when NebulaGraph stops running.
- Using BR in a container-based NebulaGraph cluster is not supported.

How to use BR

To use the BR, follow these steps:

1. Install BR.
2. Use BR to back up data.
3. Use BR to restore data from backup files.

Last update: March 13, 2023

9.1.2 Install BR

This topic introduces the installation of BR in bare-metal deployment scenarios.

Notes

To use the BR (Enterprise Edition) tool, you need to install the NebulaGraph Agent service, which is taken as a daemon for each machine in the cluster that starts and stops the NebulaGraph service, and uploads and downloads backup files. The BR (Enterprise Edition) tool and the Agent plug-in are installed as described below.

Version compatibility

NebulaGraph	BR	Agent
3.3.0 ~ 3.4.1	3.3.0	0.2.0 ~ 3.4.0
3.0.x ~ 3.2.x	0.6.1	0.1.0 ~ 0.2.0

Install BR with a binary file

1. Install BR.

```
wget https://github.com/vesoft-inc/nebula-br/releases/download/v3.3.0/br-3.3.0-linux-amd64
```

2. Change the binary file name to `br`.

```
sudo mv br-3.3.0-linux-amd64 br
```

3. Grand execute permission to BR.

```
sudo chmod +x br
```

4. Run `./br version` to check BR version.

```
[nebula-br]$ ./br version
Nebula Backup And Restore Utility Tool,V-3.3.0
```

Install BR with the source code

Before compiling the BR, do a check of these:

- Go 1.14.x or a later version is installed.
- make is installed.

To compile the BR, follow these steps:

1. Clone the `nebula-br` repository to your machine.

```
git clone https://github.com/vesoft-inc/nebula-br.git
```

2. Change to the `br` directory.

```
cd nebula-br
```

3. Compile the BR.

```
make
```

Users can enter `bin/br version` on the command line. If the following results are returned, the BR is compiled successfully.

```
[nebula-br]$ bin/br version
NebulaGraph Backup And Restore Utility Tool,V-3.3.0
```

Install Agent

NebulaGraph Agent is installed as a binary file in each machine and serves the BR tool with the RPC protocol.

In **each machine**, follow these steps:

1. Install Agent.

```
wget https://github.com/vesoft-inc/nebula-agent/releases/download/v3.4.0/agent-3.4.0-linux-amd64
```

2. Rename the Agent file to `agent`.

```
sudo mv agent-3.4.0-linux-amd64 agent
```

3. Add execute permission to Agent.

```
sudo chmod +x agent
```

4. Start Agent.

Note

Before starting Agent, make sure that the Meta service has been started and Agent has read and write access to the corresponding NebulaGraph cluster directory and backup directory.

```
sudo nohup ./agent --agent="<agent_node_ip>:8888" --meta="<metad_node_ip>:9559" > nebula_agent.log 2>&1 &
```

- `--agent`: The IP address and port number of Agent.
- `--meta`: The IP address and access port of any Meta service in the cluster.
- `--ratelimit`: (Optional) Limits the speed of file uploads and downloads to prevent bandwidth from being filled up and making other services unavailable. Unit: Bytes.

For example:

```
sudo nohup ./agent --agent="192.168.8.129:8888" --meta="192.168.8.129:9559" --ratelimit=1048576 > nebula_agent.log 2>&1 &
```

Caution

The IP address format for `--agent` should be the same as that of Meta and Storage services set in the configuration files. That is, use the real IP addresses or use `127.0.0.1`. Otherwise Agent does not run.

5. Log into NebulaGraph and then run the following command to view the status of Agent.

```
nebula> SHOW HOSTS AGENT;
+-----------------+------+----------+---------+--------------+---------+
| Host            | Port | Status   | Role    | Git Info Sha | Version |
+-----------------+------+----------+---------+--------------+---------+
| "192.168.8.129" | 8888 | "ONLINE" | "AGENT" | "96646b8"    |         |
+-----------------+------+----------+---------+--------------+---------+
```

FAQ

THE ERROR `E_LIST_CLUSTER_NO_AGENT_FAILURE

If you encounter `E_LIST_CLUSTER_NO_AGENT_FAILURE` error, it may be due to the Agent service is not started or the Agent service is not registered to Meta service. First, execute `SHOW HOSTS AGENT` to check the status of the Agent service on all nodes in the cluster, when the status shows `OFFLINE`, it means the registration of Agent failed, then check whether the value of the `--meta` option in the command to start the Agent service is correct.

Last update: May 11, 2023

9.1.3 Use BR to back up data

After the BR is installed, you can back up data of the entire graph space. This topic introduces how to use the BR to back up data.

Prerequisites

To back up data with the BR, do a check of these:

- Install BR and Agent and run Agent on each host in the cluster.
- The NebulaGraph services are running.
- If you store the backup files locally, create a directory with the same absolute path on the meta servers, the storage servers, and the BR machine for the backup files and get the absolute path. Make sure the account has write privileges for this directory.

  Note

  In the production environment, we recommend that you mount Network File System (NFS) storage to the meta servers, the storage servers, and the BR machine for local backup, or use Amazon S3 or Alibaba Cloud OSS for remote backup. When you restore the data from local files, you must manually move these backup files to a specified directory, which causes redundant data and troubles. For more information, see Restore data from backup files.

Procedure

In the BR installation directory (the default path of the compiled BR is `./bin/br`), run the following command to perform a full backup for the entire cluster.

Note

Make sure that the local path where the backup file is stored exists.

```
$ ./br backup full --meta <ip_address> --storage <storage_path>
```

For example:

- Run the following command to perform a full backup for the entire cluster whose meta service address is `192.168.8.129:9559`, and save the backup file to `/home/nebula/backup/`.

  Caution

  If there are multiple metad addresses, you can use any one of them.

  Caution

  If you back up data to a local disk, only the data of the leader metad is backed up by default. So if there are multiple metad processes, you need to manually copy the directory of the leader metad (path `<storage_path>/meta`) and overwrite the corresponding directory of other follower meatd processes.

```
$ ./br backup full --meta "192.168.8.129:9559" --storage "local:///home/nebula/backup/"
```

- Run the following command to perform a full backup for the entire cluster whose meta service address is `192.168.8.129:9559`, and save the backup file to `backup` in the `br-test` bucket of the object storage service compatible with S3 protocol.

```
$ ./br backup full --meta "192.168.8.129:9559" --s3.endpoint "http://192.168.8.129:9000" --storage="s3://br-test/backup/" --s3.access_key=minioadmin --s3.secret_key=minioadmin --
s3.region=default
```

The parameters are as follows.

Parameter	Data type	Required	Default value	Description
`-h,-help`	-	No	None	Checks help for restoration.
`--debug`	-	No	None	Checks for more log information.
`--log`	string	No	`"br.log"`	Specifies detailed log path for restoration and backup.
`--meta`	string	Yes	None	The IP address and port of the meta service.
`--space`	string	Yes	None	(Experimental feature) Specifies the names of the spaces to be backed up. All spaces will be backed up if not specified. Multiple spaces can be specified, and format is `--spaces nba_01 --spaces nba_02`.
`--storage`	string	Yes	None	The target storage URL of BR backup data. The format is: \<Schema>://\<PATH>. Schema: Optional values are `local` and `s3`. When selecting s3, you need to fill in `s3.access_key`, `s3.endpoint`, `s3.region`, and `s3.secret_key`. PATH: The path of the storage location.
`--s3.access_key`	string	No	None	Sets AccessKey ID.
`--s3.endpoint`	string	No	None	Sets the S3 endpoint URL, please specify the HTTP or HTTPS scheme explicitly.
`--s3.region`	string	No	None	Sets the region or location to upload or download the backup.
`--s3.secret_key`	string	No	None	Sets SecretKey for AccessKey ID.

Next to do

After the backup files are generated, you can use the BR to restore them for NebulaGraph. For more information, see Use BR to restore data.

Last update: December 21, 2022

9.1.4 Use BR to restore data

If you use the BR to back up data, you can use it to restore the data to NebulaGraph. This topic introduces how to use the BR to restore data from backup files.

Caution

During the restoration process, the data on the target NebulaGraph cluster is removed and then is replaced with the data from the backup files. If necessary, back up the data on the target cluster.

Caution

The restoration process is performed OFFLINE.

Prerequisites

To restore data with the BR, do a check of these:

- Install BR and Agent and run Agent on each host in the cluster.
- Download nebula-agent and start the agent service in each cluster(including metad, storaged, graphd) host.
- No application is connected to the target NebulaGraph cluster.
- Make sure that the target and the source NebulaGraph clusters have the same topology, which means that they have exactly the same number of hosts. The number of data folders for each host is consistently distributed.

Procedures

In the BR installation directory (the default path of the compiled BR is `./br`), run the following command to perform a full backup for the entire cluster.

1. Users can use the following command to list the existing backup information:

```
$ ./br show --storage <storage_path>
```

For example, run the following command to list the backup information in the local `/home/nebula/backup` path.

```
$ ./br show --storage "local:///home/nebula/backup"
+----------------------------+---------------------+------------------------+-------------+------------+
|            NAME            |     CREATE TIME     |         SPACES         | FULL BACKUP | ALL SPACES |
+----------------------------+---------------------+------------------------+-------------+------------+
| BACKUP_2022_02_10_07_40_41 | 2022-02-10 07:40:41 | basketballplayer       | true        | true       |
| BACKUP_2022_02_11_08_26_43 | 2022-02-11 08:26:47 | basketballplayer,foesa | true        | true       |
+----------------------------+---------------------+------------------------+-------------+------------+
```

Or, you can run the following command to list the backup information stored in S3 URL `s3://192.168.8.129:9000/br-test/backup`.

```
$ ./br show --s3.endpoint "http://192.168.8.129:9000" --storage="s3://br-test/backup/" --s3.access_key=minioadmin --s3.secret_key=minioadmin --s3.region=default
```

Parameter	Data type	Required	Default value	Description
`-h,-help`	-	No	None	Checks help for restoration.
`-debug`	-	No	None	Checks for more log information.
`-log`	string	No	`"br.log"`	Specifies detailed log path for restoration and backup.
`--storage`	string	Yes	None	The target storage URL of BR backup data. The format is: <Schema>://<PATH>. Schema: Optional values are `local` and `s3`. When selecting s3, you need to fill in `s3.access_key`, `s3.endpoint`, `s3.region`, and `s3.secret_key`. PATH: The path of the storage location.
`--s3.access_key`	string	No	None	Sets AccessKey ID.
`--s3.endpoint`	string	No	None	Sets the S3 endpoint URL, please specify the HTTP or HTTPS scheme explicitly.
`--s3.region`	string	No	None	Sets the region or location to upload or download the backup.
`--s3.secret_key`	string	No	None	Sets SecretKey for AccessKey ID.

2. Run the following command to restore data.

```
$ ./br restore full --meta <ip_address> --storage <storage_path> --name <backup_name>
```

For example, run the following command to upload the backup files from the local `/home/nebula/backup/` to the cluster where the meta service's address is `192.168.8.129:9559`.

```
$ ./br restore full --meta "192.168.8.129:9559" --storage "local:///home/nebula/backup/" --name BACKUP_2021_12_08_18_38_08
```

Or, you can run the following command to upload the backup files from the S3 URL `s3://192.168.8.129:9000/br-test/backup`.

```
$ ./br restore full --meta "192.168.8.129:9559" --s3.endpoint "http://192.168.8.129:9000" --storage="s3://br-test/backup/" --s3.access_key=minioadmin --s3.secret_key=minioadmin --
s3.region="default" --name BACKUP_2021_12_08_18_38_08
```

If the following information is returned, the data is restored successfully.

```
Restore succeed.
```

Caution

If your new cluster hosts' IPs are not all the same as the backup cluster, after restoration, you should run `add hosts` to add the Storage host IPs in the new cluster one by one.

The parameters are as follows.

Parameter	Data type	Required	Default value	Description
`-h,-help`	-	No	None	Checks help for restoration.
`-debug`	-	No	None	Checks for more log information.
`-log`	string	No	`"br.log"`	Specifies detailed log path for restoration and backup.
`-meta`	string	Yes	None	The IP address and port of the meta service.
`-name`	string	Yes	None	The name of backup.
`--storage`	string	Yes	None	The target storage URL of BR backup data. The format is: \<Schema>://\<PATH>. Schema: Optional values are `local` and `s3`. When selecting s3, you need to fill in `s3.access_key`, `s3.endpoint`, `s3.region`, and `s3.secret_key`. PATH: The path of the storage location.
`--s3.access_key`	string	No	None	Sets AccessKey ID.
`--s3.endpoint`	string	No	None	Sets the S3 endpoint URL, please specify the HTTP or HTTPS scheme explicitly.
`--s3.region`	string	No	None	Sets the region or location to upload or download the backup.
`--s3.secret_key`	string	No	None	Sets SecretKey for AccessKey ID.

3. Run the following command to clean up temporary files if any error occurred during backup. It will clean the files in cluster and external storage. You could also use it to clean up old backups files in external storage.

```
$ ./br cleanup --meta <ip_address> --storage <storage_path> --name <backup_name>
```

The parameters are as follows.

Parameter	Data type	Required	Default value	Description
`-h,-help`	-	No	None	Checks help for restoration.
`-debug`	-	No	None	Checks for more log information.
`-log`	string	No	`"br.log"`	Specifies detailed log path for restoration and backup.
`-meta`	string	Yes	None	The IP address and port of the meta service.
`-name`	string	Yes	None	The name of backup.
`--storage`	string	Yes	None	The target storage URL of BR backup data. The format is: \<Schema>://\<PATH>. Schema: Optional values are `local` and `s3`. When selecting s3, you need to fill in `s3.access_key`, `s3.endpoint`, `s3.region`, and `s3.secret_key`. PATH: The path of the storage location.
`--s3.access_key`	string	No	None	Sets AccessKey ID.
`--s3.endpoint`	string	No	None	Sets the S3 endpoint URL, please specify the HTTP or HTTPS scheme explicitly.
`--s3.region`	string	No	None	Sets the region or location to upload or download the backup.
`--s3.secret_key`	string	No	None	Sets SecretKey for AccessKey ID.

Last update: December 21, 2022

9.2 Backup and restore data with snapshots

NebulaGraph supports using snapshots to back up and restore data. When data loss or misoperation occurs, the data will be restored through the snapshot.

9.2.1 Prerequisites

NebulaGraph authentication is disabled by default. In this case, all users can use the snapshot feature.

If authentication is enabled, only the GOD role user can use the snapshot feature. For more information about roles, see Roles and privileges.

9.2.2 Precautions

- To prevent data loss, create a snapshot as soon as the system structure changes, for example, after operations such as `ADD HOST`, `DROP HOST`, `CREATE SPACE`, `DROP SPACE`, and `BALANCE` are performed.
- NebulaGraph cannot automatically delete the invalid files created by a failed snapshot task. You have to manually delete them by using `DROP SNAPSHOT`.
- Customizing the storage path for snapshots is not supported for now. The default path is `/usr/local/nebula/data`.

9.2.3 Snapshot form and path

NebulaGraph snapshots are stored in the form of directories with names like `SNAPSHOT_2021_03_09_08_43_12`. The suffix `2021_03_09_08_43_12` is generated automatically based on the creation time (UTC).

When a snapshot is created, snapshot directories will be automatically created in the `checkpoints` directory on the leader Meta server and each Storage server.

To fast locate the path where the snapshots are stored, you can use the Linux command `find`. For example:

```
$ find |grep 'SNAPSHOT_2021_03_09_08_43_12'
./data/meta2/nebula/0/checkpoints/SNAPSHOT_2021_03_09_08_43_12
./data/meta2/nebula/0/checkpoints/SNAPSHOT_2021_03_09_08_43_12/data
./data/meta2/nebula/0/checkpoints/SNAPSHOT_2021_03_09_08_43_12/data/000081.sst
...
```

9.2.4 Create snapshots

Run `CREATE SNAPSHOT` to create a snapshot for all the graph spaces based on the current time for NebulaGraph. Creating a snapshot for a specific graph space is not supported yet.

Note

If the creation fails, delete the snapshot and try again.

```
nebula> CREATE SNAPSHOT;
```

9.2.5 View snapshots

To view all existing snapshots, run `SHOW SNAPSHOTS`.

```
nebula> SHOW SNAPSHOTS;
+--------------------------------+---------+------------------+
| Name                           | Status  | Hosts            |
+--------------------------------+---------+------------------+
| "SNAPSHOT_2021_03_09_08_43_12" | "VALID" | "127.0.0.1:9779" |
```

```
| "SNAPSHOT_2021_03_09_09_10_52" | "VALID" | "127.0.0.1:9779" |
+--------------------------------+---------+------------------+
```

The parameters in the return information are described as follows.

Parameter	Description
`Name`	The name of the snapshot directory. The prefix `SNAPSHOT` indicates that the file is a snapshot file, and the suffix indicates the time the snapshot was created (UTC).
`Status`	The status of the snapshot. `VALID` indicates that the creation succeeded, while `INVALID` indicates that it failed.
`Hosts`	IP addresses and ports of all Storage servers at the time the snapshot was created.

9.2.6 Delete snapshots

To delete a snapshot with the given name, run `DROP SNAPSHOT`.

```
DROP SNAPSHOT <snapshot_name>;
```

Example:

```
nebula> DROP SNAPSHOT SNAPSHOT_2021_03_09_08_43_12;
nebula> SHOW SNAPSHOTS;
+--------------------------------+---------+------------------+
| Name                           | Status  | Hosts            |
+--------------------------------+---------+------------------+
| "SNAPSHOT_2021_03_09_09_10_52" | "VALID" | "127.0.0.1:9779" |
+--------------------------------+---------+------------------+
```

9.2.7 Restore data with snapshots

Warning

When you restore data with snapshots, make sure that the graph spaces backed up in the snapshot have not been dropped. Otherwise, the data of the graph spaces cannot be restored.

Currently, there is no command to restore data with snapshots. You need to manually copy the snapshot file to the corresponding folder, or you can make it by using a shell script. The logic implements as follows:

1. After the snapshot is created, the `checkpoints` directory is generated in the installation directory of the leader Meta server and all Storage servers, and saves the created snapshot. Taking this topic as an example, when there are two graph spaces, the snapshots created are saved in `/usr/local/nebula/data/meta/nebula/0/checkpoints`, `/usr/local/nebula/data/storage/ nebula/3/checkpoints` and `/usr/local/nebula/data/storage/nebula/4/checkpoints`.

```
$ ls /usr/local/nebula/data/meta/nebula/0/checkpoints/
SNAPSHOT_2021_03_09_09_10_52
$ ls /usr/local/nebula/data/storage/nebula/3/checkpoints/
SNAPSHOT_2021_03_09_09_10_52
$ ls /usr/local/nebula/data/storage/nebula/4/checkpoints/
SNAPSHOT_2021_03_09_09_10_52
```

2. To restore the lost data through snapshots, you can take a snapshot at an appropriate time, copy the folders `data` and `wal` in the corresponding snapshot directory to its parent directory (at the same level with `checkpoints`) to overwrite the previous `data` and `wal`, and then restart the cluster.

Caution

The data and wal directories of all Meta servers should be overwritten at the same time. Otherwise, the new leader Meta server will use the latest Meta data after a cluster is restarted.

Last update: January 11, 2023

10. Synchronization & Migration

10.1 *Macro Rendering Error*

File: `synchronization-and-migration/2.balance-syntax.md`

UndefinedError: 'comm' is undefined

```
Traceback (most recent call last):
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/mkdocs_macros/plugin.py", line 523, in render
    return md_template.render(**page_variables)
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/jinja2/environment.py", line 1301, in render
    self.environment.handle_exception()
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/jinja2/environment.py", line 936, in handle_exception
    raise rewrite_traceback_stack(source=source)
  File "<template>", line 7, in top-level template code
  File "/opt/hostedtoolcache/Python/3.8.16/x64/lib/python3.8/site-packages/jinja2/environment.py", line 485, in getattr
    return getattr(obj, attribute)
jinja2.exceptions.UndefinedError: 'comm' is undefined
```

Last update: May 29, 2023

11. Practices

11.1 Compaction

This topic gives some information about compaction.

In NebulaGraph, `Compaction` is the most important background process and has an important effect on performance.

`Compaction` reads the data that is written on the hard disk, then re-organizes the data structure and the indexes, and then writes back to the hard disk. The read performance can increase by times after compaction. Thus, to get high read performance, trigger `compaction` (full `compaction`) manually when writing a large amount of data into Nebula Graph.

Note

Note that `compaction` leads to long-time hard disk IO. We suggest that users do compaction during off-peak hours (for example, early morning).

NebulaGraph has two types of `compaction`: automatic `compaction` and full `compaction`.

11.1.1 Automatic `compaction`

Automatic `compaction` is automatically triggered when the system reads data, writes data, or the system restarts. The read performance can increase in a short time. Automatic `compaction` is enabled by default. But once triggered during peak hours, it can cause unexpected IO occupancy that has an unwanted effect on the performance.

11.1.2 Full `compaction`

Full `compaction` enables large-scale background operations for a graph space such as merging files, deleting the data expired by TTL. This operation needs to be initiated manually. Use the following statements to enable full `compaction`:

Note

We recommend you to do the full compaction during off-peak hours because full compaction has a lot of IO operations.

```
nebula> USE <your_graph_space>;
nebula> SUBMIT JOB COMPACT;
```

The preceding statement returns the job ID. To show the `compaction` progress, use the following statement:

```
nebula> SHOW JOB <job_id>;
```

11.1.3 Operation suggestions

These are some operation suggestions to keep Nebula Graph performing well.

- After data import is done, run `SUBMIT JOB COMPACT`.
- Run `SUBMIT JOB COMPACT` periodically during off-peak hours (e.g. early morning).
- To control the write traffic limitation for `compactions`, set the following parameter in the `nebula-storaged.conf` configuration file.

Note

This parameter limits the rate of all writes including normal writes and compaction writes.

```
# Limit the write rate to 20MB/s.
--rocksdb_rate_limit=20 (in MB/s)
```

11.1.4 FAQ

"Where are the logs related to `Compaction` stored?"

By default, the logs are stored under the `LOG` file in the `/usr/local/nebula/data/storage/nebula/{1}/data/` directory, or similar to `LOG.old.1625797988509303`. You can find the following content.

```
** Compaction Stats [default] **
Level    Files   Size     Score Read(GB)  Rn(GB) Rnp1(GB) Write(GB) Wnew(GB) Moved(GB) W-Amp Rd(MB/s) Wr(MB/s) Comp(sec) CompMergeCPU(sec) Comp(cnt) Avg(sec) KeyIn KeyDrop
----------------------------------------------------------------------------------------------------------------------------------------------------------------------------
  L0      2/0    2.46 KB   0.5      0.0     0.0      0.0       0.0      0.0       0.0   1.0      0.0      0.0      0.53              0.51         2    0.264       0      0
 Sum      2/0    2.46 KB   0.0      0.0     0.0      0.0       0.0      0.0       0.0   1.0      0.0      0.0      0.53              0.51         2    0.264       0      0
 Int      0/0    0.00 KB   0.0      0.0     0.0      0.0       0.0      0.0       0.0   0.0      0.0      0.0      0.00              0.00         0    0.000       0      0
```

If the number of `L0` files is large, the read performance will be greatly affected and compaction can be triggered.

"Can I do full `compactions` for multiple graph spaces at the same time?"

Yes, you can. But the IO is much larger at this time and the efficiency may be affected.

"How much time does it take for full `compactions`?"

When `rocksdb_rate_limit` is set to `20`, you can estimate the full compaction time by dividing the hard disk usage by the `rocksdb_rate_limit`. If you do not set the `rocksdb_rate_limit` value, the empirical value is around 50 MB/s.

"Can I modify `--rocksdb_rate_limit` dynamically?"

No, you cannot.

"Can I stop a full `compaction` after it starts?"

No, you cannot. When you start a full compaction, you have to wait till it is done. This is the limitation of RocksDB.

Last update: September 7, 2022

11.2 Storage load balance

You can use the `SUBMIT JOB BALANCE` statement to balance the distribution of partitions and Raft leaders, or clear some Storage servers for easy maintenance. For details, see SUBMIT JOB BALANCE.

Danger

The `BALANCE` commands migrate data and balance the distribution of partitions by creating and executing a set of subtasks. **DO NOT** stop any machine in the cluster or change its IP address until all the subtasks finish. Otherwise, the follow-up subtasks fail.

11.2.1 Balance leader distribution

To balance the raft leaders, run `SUBMIT JOB BALANCE LEADER`.

Example

```
nebula> SUBMIT JOB BALANCE LEADER;
```

Run `SHOW HOSTS` to check the balance result.

```
nebula> SHOW HOSTS;
+------------------+------+----------+-------------+----------------------------------+------------------------+----------------------+
| Host             | Port | Status   | Leader count | Leader distribution              | Partition distribution | Version              |
+------------------+------+----------+-------------+----------------------------------+------------------------+----------------------+
| "192.168.10.101" | 9779 | "ONLINE" | 8           | "basketballplayer:3"             | "basketballplayer:8"   | "3.5.0" |
| "192.168.10.102" | 9779 | "ONLINE" | 3           | "basketballplayer:3"             | "basketballplayer:8"   | "3.5.0" |
| "192.168.10.103" | 9779 | "ONLINE" | 0           | "basketballplayer:2"             | "basketballplayer:7"   | "3.5.0" |
| "192.168.10.104" | 9779 | "ONLINE" | 0           | "basketballplayer:2"             | "basketballplayer:7"   | "3.5.0" |
| "192.168.10.105" | 9779 | "ONLINE" | 0           | "basketballplayer:2"             | "basketballplayer:7"   | "3.5.0" |
+------------------+------+----------+-------------+----------------------------------+------------------------+----------------------+
```

Caution

In NebulaGraph 3.5.0, switching leaders will cause a large number of short-term request errors (Storage Error `E_RPC_FAILURE`). For solutions, see FAQ.

Last update: May 29, 2023

11.3 Graph data modeling suggestions

This topic provides general suggestions for modeling data in NebulaGraph.

Note

The following suggestions may not apply to some special scenarios. In these cases, find help in the NebulaGraph community.

11.3.1 Model for performance

There is no perfect method to model in Nebula Graph. Graph modeling depends on the questions that you want to know from the data. Your data drives your graph model. Graph data modeling is intuitive and convenient. Create your data model based on your business model. Test your model and gradually optimize it to fit your business. To get better performance, you can change or re-design your model multiple times.

Design and evaluate the most important queries

Usually, various types of queries are validated in test scenarios to assess the overall capabilities of the system. However, in most production scenarios, there are not many types of frequently used queries. You can optimize the data model based on key queries selected according to the Pareto (80/20) principle.

Full-graph scanning avoidance

Graph traversal can be performed after one or more vertices/edges are located through property indexes or VIDs. But for some query patterns, such as subgraph and path query patterns, the source vertex or edge of the traversal cannot be located through property indexes or VIDs. These queries find all the subgraphs that satisfy the query pattern by scanning the whole graph space which will have poor query performance. NebulaGraph does not implement indexing for the graph structures of subgraphs or paths.

No predefined bonds between Tags and Edge types

Define the bonds between Tags and Edge types in the application, not NebulaGraph. There are no statements that could get the bonds between Tags and Edge types.

Tags/Edge types predefine a set of properties

While creating Tags or Edge types, you need to define a set of properties. Properties are part of the NebulaGraph Schema.

Control changes in the business model and the data model

Changes here refer to changes in business models and data models (meta-information), not changes in the data itself.

Some graph databases are designed to be Schema-free, so their data modeling, including the modeling of the graph topology and properties, can be very flexible. Properties can be re-modeled to graph topology, and vice versa. Such systems are often specifically optimized for graph topology access.

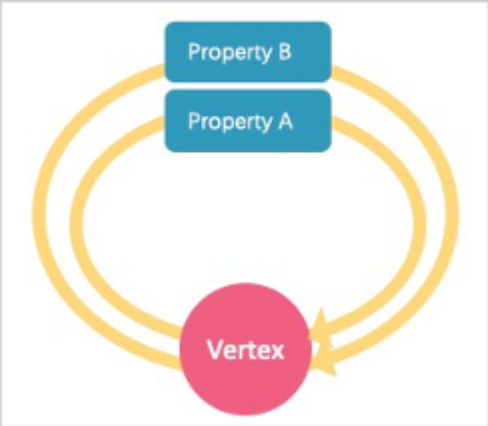
NebulaGraph 3.5.0 is a strong-Schema (row storage) system, which means that the business model should not change frequently. For example, the property Schema should not change. It is similar to avoiding `ALTER TABLE` in MySQL.

On the contrary, vertices and their edges can be added or deleted at low costs. Thus, the easy-to-change part of the business model should be transformed to vertices or edges, rather than properties.

For example, in a business model, people have relatively fixed properties such as age, gender, and name. But their contact, place of visit, trade account, and login device are often changing. The former is suitable for modeling as properties and the latter as vertices or edges.

Set temporary properties through self-loop edges

As a strong Schema system, NebulaGraph does not support List-type properties. And using `ALTER TAG` costs too much. If you need to add some temporary properties or List-type properties to a vertex, you can first create an edge type with the required properties, and then insert one or more edges that direct to the vertex itself. The figure is as follows.



To retrieve temporary properties of vertices, fetch from self-loop edges. For example:

```
//Create the edge type and insert the loop property.
nebula> CREATE EDGE IF NOT EXISTS temp(tmp int);
nebula> INSERT EDGE temp(tmp) VALUES "player100"->"player100"@1:(1);
nebula> INSERT EDGE temp(tmp) VALUES "player100"->"player100"@2:(2);
nebula> INSERT EDGE temp(tmp) VALUES "player100"->"player100"@3:(3);

//After the data is inserted, you can query the loop property by general query statements, for example:
nebula> GO FROM "player100" OVER temp YIELD properties(edge).tmp;
+----------------------+
| properties(EDGE).tmp |
+----------------------+
| 1                    |
| 2                    |
| 3                    |
+----------------------+

//If you want the results to be returned in the form of a List, you can use a function, for example:
nebula> MATCH (v1:player)-[e:temp]->() return collect(e.tmp);
+----------------+
| collect(e.tmp) |
+----------------+
| [1, 2, 3]      |
+----------------+
```

Operations on loops are not encapsulated with any syntactic sugars and you can use them just like those on normal edges.

About dangling edges

A dangling edge is an edge that only connects to a single vertex and only one part of the edge connects to the vertex.

In NebulaGraph 3.5.0, dangling edges may appear in the following two cases.

1. Insert edges with INSERT EDGE statement before the source vertex or the destination vertex exists.
2. Delete vertices with DELETE VERTEX statement and the `WITH EDGE` option is not used. At this time, the system does not delete the related outgoing and incoming edges of the vertices. There will be dangling edges by default.

Dangling edges may appear in NebulaGraph 3.5.0 as the design allow it to exist. And there is no MERGE statement like openCypher has. The existence of dangling edges depends entirely on the application level. You can use GO and LOOKUP statements to find a dangling edge, but cannot use the MATCH statement to find a dangling edge.

Examples:

```
// Insert an edge that connects two vertices which do not exist in the graph. The source vertex's ID is '11'. The destination vertex's ID is'13'.

nebula> CREATE EDGE IF NOT EXISTS e1 (name string, age int);
nebula> INSERT EDGE e1 (name, age) VALUES "11"->"13":("n1", 1);
```

```
// Query using the `GO` statement

nebula> GO FROM "11" over e1 YIELD properties(edge);
+----------------------+
| properties(EDGE)     |
+----------------------+
| {age: 1, name: "n1"} |
+----------------------+

// Query using the `LOOKUP` statement

nebula> LOOKUP ON e1 YIELD EDGE AS r;
+-------------------------------------------------------+
| r                                                     |
+-------------------------------------------------------+
| [:e2 "11"->"13" @0 {age: 1, name: "n1"}]              |
+-------------------------------------------------------+

// Query using the `MATCH` statement

nebula> MATCH ()-[e:e1]->() RETURN e;
+---+
| e |
+---+
+---+
Empty set (time spent 3153/3573 us)
```

Breadth-first traversal over depth-first traversal

- NebulaGraph has lower performance for depth-first traversal based on the Graph topology, and better performance for breadth-first traversal and obtaining properties. For example, if model A contains properties "name", "age", and "eye color", it is recommended to create a tag `person` and add properties `name`, `age`, and `eye_color` to it. If you create a tag `eye_color` and an edge type `has`, and then create an edge to represent the eye color owned by the person, the traversal performance will not be high.
- The performance of finding an edge by an edge property is close to that of finding a vertex by a vertex property. For some databases, it is recommended to re-model edge properties as those of the intermediate vertices. For example, model the pattern `(src)-[edge {P1, P2}]->(dst)` as `(src)-[edge1]->(i_node {P1, P2})-[edge2]->(dst)`. With NebulaGraph 3.5.0, you can use `(src)-[edge {P1, P2}]->(dst)` directly to decrease the depth of the traversal and increase the performance.

Edge directions

To query in the opposite direction of an edge, use the following syntax:

`(dst)<-[edge]-(src)` or `GO FROM dst REVERSELY`.

If you do not care about the directions or want to query against both directions, use the following syntax:

`(src)-[edge]-(dst)` or `GO FROM src BIDIRECT`.

Therefore, there is no need to insert the same edge redundantly in the reversed direction.

Set tag properties appropriately

Put a group of properties that are on the same level into the same tag. Different groups represent different concepts.

Use indexes correctly

Using property indexes helps find VIDs through properties, but can lead to great performance reduction. Only use an index when you need to find vertices or edges through their properties.

Design VIDs appropriately

See VID.

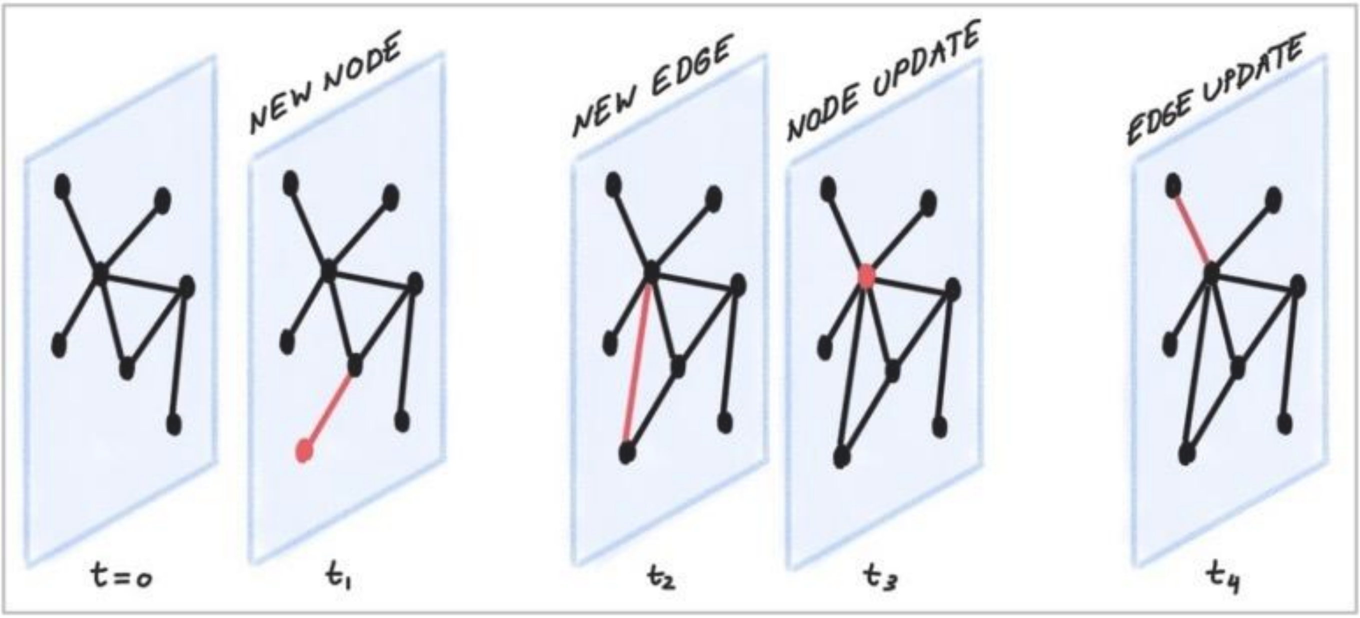
Long texts

Do not use long texts to create edge properties. Edge properties are stored twice and long texts lead to greater write amplification. For how edges properties are stored, see Storage architecture. It is recommended to store long texts in HBase or Elasticsearch and store its address in NebulaGraph.

11.3.2 Dynamic graphs (sequence graphs) are not supported

In some scenarios, graphs need to have the time information to describe how the structure of the entire graph changes over time.[1]

The Rank field on Edges in NebulaGraph 3.5.0 can be used to store time in int64, but no field on vertices can do this because if you store the time information as property values, it will be covered by new insertion. Thus NebulaGraph does not support sequence graphs.



11.3.3 Free graph data modeling tools

arrows.app

1. https://blog.twitter.com/engineering/en_us/topics/insights/2021/temporal-graph-networks ↩

Last update: April 25, 2023

11.4 System design suggestions

11.4.1 QPS or low-latency first

- NebulaGraph 3.5.0 is good at handling small requests with high concurrency. In such scenarios, the whole graph is huge, containing maybe trillions of vertices or edges, but the subgraphs accessed by each request are not large (containing millions of vertices or edges), and the latency of a single request is low. The concurrent number of such requests, i.e., the QPS, can be huge.

- On the other hand, in interactive analysis scenarios, the request concurrency is usually not high, but the subgraphs accessed by each request are large, with thousands of millions of vertices or edges. To lower the latency of big requests in such scenarios, you can split big requests into multiple small requests in the application, and concurrently send them to multiple graphd processes. This can decrease the memory used by each graphd process as well. Besides, you can use NebulaGraph Algorithm for such scenarios.

11.4.2 Data transmission and optimization

- Read/write balance. NebulaGraph fits into OLTP scenarios with balanced read/write, i.e., concurrent write and read. It is not suitable for OLAP scenarios that usually need to write once and read many times.
- Select different write methods. For large batches of data writing, use SST files. For small batches of data writing, use `INSERT`.
- Run `COMPACTION` and `BALANCE` jobs to optimize data format and storage distribution at the right time.
- NebulaGraph 3.5.0 does not support transactions and isolation in the relational database and is closer to NoSQL.

11.4.3 Query preheating and data preheating

Preheat on the application side:

- The Grapd process does not support pre-compiling queries and generating corresponding query plans, nor can it cache previous query results.
- The Storagd process does not support preheating data. Only the LSM-Tree and BloomFilter of RocksDB are loaded into memory at startup.
- Once accessed, vertices and edges are cached respectively in two types of LRU cache of the Storage Service.

Last update: August 11, 2022

11.5 Execution plan

NebulaGraph 3.5.0 applies rule-based execution plans. Users cannot change execution plans, pre-compile queries (and corresponding plan cache), or accelerate queries by specifying indexes.

To view the execution plan and executive summary, see EXPLAIN and PROFILE.

Last update: August 11, 2022

11.6 Processing super vertices

11.6.1 Principle introduction

In graph theory, a super vertex, also known as a dense vertex, is a vertex with an extremely high number of adjacent edges. The edges can be outgoing or incoming.

Super vertices are very common because of the power-law distribution. For example, popular leaders in social networks (Internet celebrities), top stocks in the stock market, Big Four in the banking system, hubs in transportation networks, websites with high clicking rates on the Internet, and best sellers in E-commerce.

In NebulaGraph 3.5.0, a `vertex` and its `properties` form a `key-value pair`, with its `VID` and other meta information as the `key`. Its `Out-Edge Key-Value` and `In-Edge Key-Value` are stored in the same partition in the form of LSM-trees in hard disks and caches.

Therefore, `directed traversals from this vertex` and `directed traversals ending at this vertex` both involve either `a large number of sequential IO scans` (ideally, after Compaction or a large number of `random IO` (frequent writes to `the vertex` and its `ingoing and outgoing edges`).

As a rule of thumb, a vertex is considered dense when the number of its edges exceeds 10,000. Some special cases require additional consideration.

Note

In NebulaGraph 3.5.0, there is not any data structure to store the out/in degree for each vertex. Therefore, there is no direct method to know whether it is a super vertex or not. You can try to use Spark to count the degrees periodically.

Indexes for duplicate properties

In a property graph, there is another class of cases similar to super vertices: **a property has a very high duplication rate**, i.e., many vertices with the same `tag` but different `VIDs` have identical property and property values.

Property indexes in NebulaGraph 3.5.0 are designed to reuse the functionality of RocksDB in the Storage Service, in which case indexes are modeled as `keys with the same prefix`. If the lookup of a property fails to hit the cache, it is processed as a random seek and a sequential prefix scan on the hard disk to find the corresponding VID. After that, the graph is usually traversed from this vertex, so that another random read and sequential scan for the corresponding key-value of this vertex will be triggered. The higher the duplication rate, the larger the scan range.

For more information about property indexes, see How indexing works in NebulaGraph.

Usually, special design and processing are required when the number of duplicate property values exceeds 10,000.

Suggested solutions

SOLUTIONS AT THE DATABASE END

1. Truncation: Only return a certain number (a threshold) of edges, and do not return other edges exceeding this threshold.
2. Compact: Reorganize the order of data in RocksDB to reduce random reads and increase sequential reads.

SOLUTIONS AT THE APPLICATION END

Break up some of the super vertices according to their business significance:

- Delete multiple edges and merge them into one.

  For example, in the transfer scenario `(Account_A)-[TRANSFER]->(Account_B)`, each transfer record is modeled as an edge between account A and account B, then there may be tens of thousands of transfer records between `(Account_A)` and `(Account_B)`.

  In such scenarios, merge obsolete transfer details on a daily, weekly, or monthly basis. That is, batch-delete old edges and replace them with a small number of edges representing `monthly total` and `times`. And keep the transfer details of the latest month.

- Split an edge into multiple edges of different types.

  For example, in the `(Airport)<-[DEPART]-(Flight)` scenario, the departure of each flight is modeled as an edge between a flight and an airport. Departures from a big airport might be enormous.

  According to different airlines, divide the `DEPART` edge type into finer edge types, such as `DEPART_CEAIR`, `DEPART_CSAIR`, etc. Specify the departing airline in queries (graph traversal).

- Split vertices.

  For example, in the loan network `(person)-[BORROW]->(bank)`, large bank A will have a very large number of loans and borrowers.

  In such scenarios, you can split the large vertex A into connected sub-vertices A1, A2, and A3.

  ```
  (Person1)-[BORROW]->(BankA1), (Person2)-[BORROW]->(BankA2), (Person2)-[BORROW]->(BankA3);
  (BankA1)-[BELONGS_TO]->(BankA), (BankA2)-[BELONGS_TO]->(BankA), (BankA3)-[BELONGS_TO]->(BankA).
  ```

  A1, A2, and A3 can either be three real branches of bank A, such as Beijing branch, Shanghai branch, and Zhejiang branch, or three virtual branches set up according to certain rules, such as `A1: 1-1000, A2: 1001-10000 and A3: 10000+` according to the number of loans. In this way, any operation on A is converted into three separate operations on A1, A2, and A3.

Last update: August 11, 2022

11.7 Enable AutoFDO for NebulaGraph

The AutoFDO can analyze the performance of an optimized program and use the program's performance information to guide the compiler to re-optimize the program. This document will help you to enable the AutoFDO for NebulaGraph.

More information about the AutoFDO, please refer AutoFDO Wiki.

11.7.1 Resource Preparations

Install Dependencies

- Install perf

```
sudo apt-get update
sudo apt-get install -y linux-tools-common \
linux-tools-generic \
linux-tools-`uname -r`
```

- Install autofdo tool

```
sudo apt-get update
sudo apt-get install -y autofdo
```

Or you can compile the ***autofdo tool*** from source.

NebulaGraph Binary with Debug Version

For how to build NebulaGraph from source, please refer to the official document: Install NebulaGraph by compiling the source code. In the configure step, replace `CMAKE_BUILD_TYPE=Release` with `CMAKE_BUILD_TYPE=RelWithDebInfo` as below:

```
$ cmake -DCMAKE_INSTALL_PREFIX=/usr/local/nebula -DENABLE_TESTING=OFF -DCMAKE_BUILD_TYPE=RelWithDebInfo ..
```

11.7.2 Prepare Test Data

In our test environment, we use NebulaGraph Bench to prepare the test data and collect the profile data by running the ***FindShortestPath***, ***Go1Step***, ***Go2Step***, ***Go3Step***, ***InsertPersonScenario*** 5 scenarios.

Note

You can use your ***TopN*** queries in your production environment to collect the profile data, the performance can gain more in your environment.

11.7.3 Prepare Profile Data

Collect Perf Data For AutoFdo Tool

1. After the test data preparation work done. Collect the perf data for different scenarios. Get the pid of `storaged`, `graphd`, `metad`.

```
$ nebula.service status all
[INFO] nebula-metad: Running as 305422, Listening on 9559
[INFO] nebula-graphd: Running as 305516, Listening on 9669
[INFO] nebula-storaged: Running as 305707, Listening on 9779
```

2. Start the ***perf record*** for *nebula-graphd* and *nebula-storaged*.

```
perf record -p 305516,305707 -b -e br_inst_retired.near_taken:pp -o ~/FindShortestPath.data
```

Note

Because the `nebula-metad` service contribution percent is small compared with `nebula-graphd` and `nebula-storaged` services. To reduce effort, we didn't collect the perf data for `nebula-metad` service.

3. Start the benchmark test for ***FindShortestPath*** scenario.

```
cd NebulaGraph-Bench
python3 run.py stress run -s benchmark -scenario find_path.FindShortestPath -a localhost:9669 --args='-u 100 -i 100000'
```

4. After the benchmark finished, end the ***perf record*** by ***Ctrl + c***.
5. Repeat above steps to collect corresponding profile data for the rest ***Go1Step***, ***Go2Step***, ***Go3Step*** and ***InsertPersonScenario*** scenarios.

Create Gcov File

```
create_gcov --binary=$NEBULA_HOME/bin/nebula-storaged \
--profile=~/FindShortestPath.data \
--gcov=~/FindShortestPath-storaged.gcov \
-gcov_version=1

create_gcov --binary=$NEBULA_HOME/bin/nebula-graphd \
--profile=~/FindShortestPath.data \
--gcov=~/FindShortestPath-graphd.gcov \
-gcov_version=1
```

Repeat for ***Go1Step***, ***Go2Step***, ***Go3Step*** and ***InsertPersonScenario*** scenarios.

Merge the Profile Data

```
profile_merger ~/FindShortestPath-graphd.gcov \
~/FindShortestPath-storaged.gcov \
~/go1step-storaged.gcov \
~/go1step-graphd.gcov \
~/go2step-storaged.gcov \
~/go2step-graphd.gcov \
~/go3step-storaged.gcov \
~/go3step-master-graphd.gcov \
~/InsertPersonScenario-storaged.gcov \
~/InsertPersonScenario-graphd.gcov
```

You will get a merged profile which is named `fbdata.afdo` after that.

11.7.4 Recompile GraphNebula Binary with the Merged Profile

Recompile the GraphNebula Binary by passing the profile with compile option `-fauto-profile`.

```
diff --git a/cmake/nebula/GeneralCompilerConfig.cmake b/cmake/nebula/GeneralCompilerConfig.cmake
@@ -20,6 +20,8 @@ add_compile_options(-Wshadow)
 add_compile_options(-Wnon-virtual-dtor)
 add_compile_options(-Woverloaded-virtual)
 add_compile_options(-Wignored-qualifiers)
+add_compile_options(-fauto-profile=~/fbdata.afdo)
```

Note

When you use multiple fbdata.afdo to compile multiple times, please remember to `make clean` before re-compile, baucase only change the fbdata.afdo will not trigger re-compile.

11.7.5 Performance Test Result

Hardware & Software Environment

Key	Value
CPU Processor#	2
Sockets	2
NUMA	2
CPU Type	Intel(R) Xeon(R) Platinum 8380 CPU @ 2.30GHz
Cores per Processor	40C80T
Cache	L1 data: 48KB L1 i: 32KB L2: 1.25MB per physical core L3: shared 60MB per processor
Memory	Micron DDR4 3200MT/s 16GB*16Micron DDR4 3200MT/s 16GB*16
SSD Disk	INTEL SSDPE2KE016T8
SSD R/W Sequential	3200 MB/s (read) / 2100 MB/s(write)
Nebula Version	master with commit id 51d84a4ed7d2a032a337e3b996c927e3bc5d1415
Kernel	4.18.0-408.el8.x86_64

Test Results

Scenario	Average Latency(LiB)	Default Binary	Optimized Binary with AutoFDO	P95 Latency (LiB)	Default Binary	Optimized Binary with AutoFDO
FindShortestPath	**1**	8072.52	7260.10	**1**	22102.00	19108.00
	2	8034.32	7218.59	**2**	22060.85	19006.00
	3	8079.27	7257.24	**3**	22147.00	19053.00
	4	8087.66	7221.39	**4**	22143.00	19050.00
	5	8044.77	7239.85	**5**	22181.00	19055.00
	STDDEVP	20.57	17.34	**STDDEVP**	41.41	32.36
	Mean	8063.71	7239.43	**Mean**	22126.77	19054.40
	STDDEVP/ Mean	0.26%	0.24%	**STDDEVP/ Mean**	0.19%	0.17%
	Opt/Default	100.00%	***10.22%***	**Opt/ Default**	100.00%	***13.89%***
Go1Step	**1**	422.53	418.37	**1**	838.00	850.00
	2	432.37	402.44	**2**	866.00	815.00
	3	437.45	407.98	**3**	874.00	836.00
	4	429.16	408.38	**4**	858.00	838.00
	5	446.38	411.32	**5**	901.00	837.00
	STDDEVP	8.02	5.20	**STDDEVP**	20.63	11.30
	Mean	433.58	409.70	**Mean**	867.40	835.20
	STDDEVP/ Mean	1.85%	1.27%	**STDDEVP/ Mean**	2.38%	1.35%
	Opt/Default	100.00%	***5.51%***	**Opt/ Default**	100.00%	***3.71%***
Go2Step	**1**	2989.93	2824.29	**1**	10202.00	9656.95
	2	2957.22	2834.55	**2**	10129.00	9632.40
	3	2962.74	2818.62	**3**	10168.40	9624.70
	4	2992.39	2817.27	**4**	10285.10	9647.50
	5	2934.85	2834.91	**5**	10025.00	9699.65
	STDDEVP	21.53	7.57	**STDDEVP**	85.62	26.25
	Mean	2967.43	2825.93	**Mean**	10161.90	9652.24
	STDDEVP/ Mean	0.73%	0.27%	**STDDEVP/ Mean**	0.84%	0.27%
	Opt/Default	100.00%	***4.77%***	**Opt/ Default**	100.00%	***5.02%***
Go3Step	**1**	93551.97	89406.96	**1**	371359.55	345433.50
	2	92418.43	89977.25	**2**	368868.00	352375.20
	3	92587.67	90339.25	**3**	365390.15	356198.55

Scenario	Average Latency(LiB)	Default Binary	Optimized Binary with AutoFDO	P95 Latency (LiB)	Default Binary	Optimized Binary with AutoFDO
	4	93371.64	92458.95	**4**	373578.15	365177.75
	5	94046.05	89943.44	**5**	373392.25	352576.00
	STDDEVP	609.07	1059.54	**STDDEVP**	3077.38	6437.52
	Mean	93195.15	90425.17	**Mean**	370517.62	354352.20
	STDDEVP/ Mean	0.65%	1.17%	**STDDEVP/ Mean**	0.83%	1.82%
	Opt/Default	100.00%	***2.97%***	**Opt/ Default**	100.00%	***4.36%***
InsertPerson	**1**	2022.86	1937.36	**1**	2689.00	2633.45
	2	1966.05	1935.41	**2**	2620.45	2555.00
	3	1985.25	1953.58	**3**	2546.00	2593.00
	4	2026.73	1887.28	**4**	2564.00	2394.00
	5	2007.55	1964.41	**5**	2676.00	2581.00
	STDDEVP	23.02	26.42	**STDDEVP**	57.45	82.62
	Mean	2001.69	1935.61	**Mean**	2619.09	2551.29
	STDDEVP/ Mean	1.15%	1.37%	**STDDEVP/ Mean**	2.19%	3.24%
	Opt/Default	100.00%	***3.30%***	**Opt/ Default**	100.00%	***2.59%***

Last update: March 13, 2023

11.8 Best practices

NebulaGraph is used in a variety of industries. This topic presents a few best practices for using NebulaGraph. For more best practices, see Blog.

11.8.1 Scenarios

- Use cases
- User review
- Performance

11.8.2 Kernel

- What is a graph database and what are its use cases - Definition, examples & trends
- NebulaGraph Source Code Explained: Variable-Length Pattern Matching
- Adding a Test Case for NebulaGraph
- BDD-Based Integration Testing Framework for NebulaGraph: Part I
- BDD-Based Integration Testing Framework for NebulaGraph: Part II
- Understanding Subgraph in NebulaGraph
- Full-Text Indexing in NebulaGraph

11.8.3 Ecosystem tool

- Validating Import Performance of NebulaGraph Importer
- Ecosystem Tools: NebulaGraph Dashboard for Monitoring
- Visualizing Graph Data with NebulaGraph Explorer

Last update: August 11, 2022

12. Client

12.1 Clients overview

NebulaGraph supports multiple types of clients for users to connect to and manage the NebulaGraph database.

- NebulaGraph Console: the native CLI client
- NebulaGraph CPP: the NebulaGraph client for C++
- NebulaGraph Java: the NebulaGraph client for Java
- NebulaGraph Python: the NebulaGraph client for Python
- NebulaGraph Go: the NebulaGraph client for Golang

Note

For now, only NebulaGraph Java is thread-safe.

Caution

The following clients can also be used to connect to and manage NebulaGraph, but there is no uptime guarantee.

- NebulaGraph PHP
- NebulaGraph Node
- NebulaGraph .net
- NebulaGraph JDBC
- NebulaGraph Carina（Python ORM）
- NORM (Golang ORM)
- Graph-Ocean (Java ORM)
- NebulaGraph Ngbatis (Java ORM in a MyBatis fashion)

Last update: September 23, 2022

12.2 NebulaGraph Console

NebulaGraph Console is a native CLI client for NebulaGraph. It can be used to connect a NebulaGraph cluster and execute queries. It also supports special commands to manage parameters, export query results, import test datasets, etc.

12.2.1 Obtain NebulaGraph Console

You can obtain NebulaGraph Console in the following ways:

- Download the binary file from the GitHub releases page.
- Compile the source code to obtain the binary file. For more information, see Install from source code.

12.2.2 NebulaGraph Console functions

Connect to NebulaGraph

To connect to NebulaGraph with the `nebula-console` file, use the following syntax:

```
<path_of_console> -addr <ip> -port <port> -u <username> -p <password>
```

`path_of_console` indicates the storage path of the NebulaGraph Console binary file.

Parameter descriptions are as follows:

Parameter	Description
`-h/-help`	Shows the help menu.
`-addr/-address`	Sets the IP address of the Graph service. The default address is 127.0.0.1.
`-P/-port`	Sets the port number of the graphd service. The default port number is 9669.
`-u/-user`	Sets the username of your NebulaGraph account. Before enabling authentication, you can use any existing username. The default username is `root`.
`-p/-password`	Sets the password of your NebulaGraph account. Before enabling authentication, you can use any characters as the password.
`-t/-timeout`	Sets an integer-type timeout threshold of the connection. The unit is millisecond. The default value is 120.
`-e/-eval`	Sets a string-type nGQL statement. The nGQL statement is executed once the connection succeeds. The connection stops after the result is returned.
`-f/-file`	Sets the path of an nGQL file. The nGQL statements in the file are executed once the connection succeeds. The result will be returned and the connection stops then.
`-enable_ssl`	Enables SSL encryption when connecting to NebulaGraph.
`-ssl_root_ca_path`	Sets the storage path of the certification authority file.
`-ssl_cert_path`	Sets the storage path of the certificate file.
`-ssl_private_key_path`	Sets the storage path of the private key file.

For information on more parameters, see the project repository.

For example, to connect to the Graph Service deployed on 192.168.10.8, run the following command:

```
./nebula-console -addr 192.168.10.8 -port 9669 -u root -p thisisapassword
```

Manage parameters

You can save parameters for parameterized queries.

Note

- Setting a parameter as a VID in a query is not supported.
- Parameters are not supported in `SAMPLE` clauses.
- Parameters are deleted when their sessions are released.

- The command to save a parameter is as follows:

```
nebula> :param <param_name> => <param_value>;
```

The example is as follows:

```
nebula> :param p1 => "Tim Duncan";
nebula> MATCH (v:player{name:$p1})-[:follow]->(n)  RETURN v,n;
+----------------------------------------------------+-------------------------------------------------------+
| v                                                  | n                                                     |
+----------------------------------------------------+-------------------------------------------------------+
| ("player100" :player{age: 42, name: "Tim Duncan"}) | ("player125" :player{age: 41, name: "Manu Ginobili"}) |
| ("player100" :player{age: 42, name: "Tim Duncan"}) | ("player101" :player{age: 36, name: "Tony Parker"})   |
+----------------------------------------------------+-------------------------------------------------------+
nebula> :param p2 => {"a":3,"b":false,"c":"Tim Duncan"};
nebula> RETURN $p2.b AS b;
+-------+
| b     |
+-------+
| false |
+-------+
```

- The command to view the saved parameters is as follows:

```
nebula> :params;
```

- The command to view the specified parameters is as follows:

```
nebula> :params <param_name>;
```

- The command to delete a specified parameter is as follows:

```
nebula> :param <param_name> =>;
```

Export query results

Export query results, which can be saved as a CSV file, DOT file, and a format of Profile or Explain.

Note

- The exported file is stored in the working directory, i.e., what the linux command `pwd` shows.
- This command only works for the next query statement.
- You can copy the contents of the DOT file and paste them in GraphvizOnline to generate a visualized execution plan.

- The command to export a csv file is as follows:

```
nebula> :CSV <file_name.csv>;
```

- The command to export a DOT file is as follows:

```
nebula> :dot <file_name.dot>
```

The example is as follows:

```
nebula> :dot a.dot
nebula> PROFILE FORMAT="dot" GO FROM "player100" OVER follow;
```

- The command to export a PROFILE or EXPLAIN format is as follows:

```
nebula> :profile <file_name>;
```

or

```
nebula> :explain <file_name>;
```

Note

The text file output by the above command is the preferred way to report issues in GitHub and execution plans in forums, and for graph query tuning because it has more information and is more readable than a screenshot or CSV file in Studio.

The example is as follows:

```
nebula> :profile profile.log
nebula> PROFILE GO FROM "player102" OVER serve YIELD dst(edge);
nebula> :profile profile.dot
nebula> PROFILE FORMAT="dot" GO FROM "player102" OVER serve YIELD dst(edge);
nebula> :explain explain.log
nebula> EXPLAIN GO FROM "player102" OVER serve YIELD dst(edge);
```

Import a testing dataset

The testing dataset is named `basketballplayer`. To view details about the schema and data, use the corresponding `SHOW` command.

The command to import a testing dataset is as follows:

```
nebula> :play basketballplayer
```

Run a command multiple times

To run a command multiple times, use the following command:

```
nebula> :repeat N
```

The example is as follows:

```
nebula> :repeat 3
nebula> GO FROM "player100" OVER follow YIELD dst(edge);
```

```
+-------------+
| dst(EDGE)   |
+-------------+
| "player101" |
| "player125" |
+-------------+
Got 2 rows (time spent 2602/3214 us)

Fri, 20 Aug 2021 06:36:05 UTC

+-------------+
| dst(EDGE)   |
+-------------+
| "player101" |
| "player125" |
+-------------+
Got 2 rows (time spent 583/849 us)

Fri, 20 Aug 2021 06:36:05 UTC

+-------------+
| dst(EDGE)   |
+-------------+
| "player101" |
| "player125" |
+-------------+
Got 2 rows (time spent 496/671 us)

Fri, 20 Aug 2021 06:36:05 UTC

Executed 3 times, (total time spent 3681/4734 us), (average time spent 1227/1578 us)
```

Sleep

This command will make NebulaGraph Console sleep for N seconds. The schema is altered in an async way and takes effect in the next heartbeat cycle. Therefore, this command is usually used when altering schema. The command is as follows:

```
nebula> :sleep N
```

Disconnect NebulaGraph Console from NebulaGraph

You can use `:EXIT` or `:QUIT` to disconnect from NebulaGraph. For convenience, NebulaGraph Console supports using these commands in lower case without the colon (":"), such as `quit`.

The example is as follows:

```
nebula> :QUIT

Bye root!
```

Last update: February 3, 2023

12.3 NebulaGraph CPP

NebulaGraph CPP is a C++ client for connecting to and managing the NebulaGraph database.

12.3.1 Limitations

You have installed C++ and GCC 4.8 or later versions.

12.3.2 Compatibility with NebulaGraph

NebulaGraph version	NebulaGraph CPP version
3.3.0	3.3.0
3.1.0 ~ 3.2.x	3.0.2
3.0.0	3.0.0
2.6.x	2.5.0
2.5.x	2.5.0
2.0.x	2.0.0

12.3.3 Install NebulaGraph CPP

This document describes how to install NebulaGraph CPP with the source code.

Prerequisites

- You have prepared the correct resources.
- You have installed C++ and GCC version is: {10.1.0 | 9.3.0 | 9.2.0 | 9.1.0 | 8.3.0 | 7.5.0 | 7.1.0}. For details, see the gcc_preset_versions parameter.

Steps

1. Clone the NebulaGraph CPP source code to the host.

- (Recommended) To install a specific version of NebulaGraph CPP, use the Git option `--branch` to specify the branch. For example, to install v3.4.0, run the following command:

```
$ git clone --branch release-3.4 https://github.com/vesoft-inc/nebula-cpp.git
```

- To install the daily development version, run the following command to download the source code from the `master` branch:

```
$ git clone https://github.com/vesoft-inc/nebula-cpp.git
```

2. Change the working directory to `nebula-cpp`.

```
$ cd nebula-cpp
```

3. Create a directory named `build` and change the working directory to it.

```
$ mkdir build && cd build
```

4. Generate the `makefile` file with CMake.

Note

The default installation path is `/usr/local/nebula`. To modify it, add the `-DCMAKE_INSTALL_PREFIX=<installation_path>` option while running the following command.

```
$ cmake -DCMAKE_BUILD_TYPE=Release ..
```

Note

If G++ does not support C++ 11, add the option `-DDISABLE_CXX11_ABI=ON`.

5. Compile NebulaGraph CPP.

   To speed up the compiling, use the `-j` option to set a concurrent number `N`. It should be $\min(\text{CPU core number}, \frac{\text{the\_memory\_size(GB)}}{2})$.

```
$ make -j{N}
```

6. Install NebulaGraph CPP.

```
$ sudo make install
```

7. Update the dynamic link library.

```
$ sudo ldconfig
```

12.3.4 Use NebulaGraph CPP

Compile the CPP file to an executable file, then you can use it. The following steps take using `SessionExample.cpp` for example.

1. Use the example code to create the `SessionExample.cpp` file.
2. Run the following command to compile the file.

```
$ LIBRARY_PATH=<library_folder_path>:$LIBRARY_PATH g++ -std=c++11 SessionExample.cpp -I<include_folder_path> -lnebula_graph_client -o session_example
```

- `library_folder_path`: The storage path of the NebulaGraph dynamic libraries. The default path is `/usr/local/nebula/lib64`.
- `include_folder_path`: The storage of the NebulaGraph header files. The default path is `/usr/local/nebula/include`.

For example:

```
$ LIBRARY_PATH=/usr/local/nebula/lib64:$LIBRARY_PATH g++ -std=c++11 SessionExample.cpp -I/usr/local/nebula/include -lnebula_graph_client -o session_example
```

12.3.5 Core of the example code

Nebula CPP clients provide both Session Pool and Connection Pool methods to connect to NebulaGraph. Using the Connection Pool method requires users to manage session instances by themselves.

- Session Pool

  For more details about all the code, see SessionPoolExample.

- Connection Pool

  For more details about all the code, see SessionExample.

Last update: October 31, 2022

12.4 NebulaGraph Java

NebulaGraph Java is a Java client for connecting to and managing the NebulaGraph database.

12.4.1 Prerequisites

You have installed Java 8.0 or later versions.

12.4.2 Compatibility with NebulaGraph

NebulaGraph version	NebulaGraph Java version
3.3.0	3.3.0
3.0.0 ~ 3.2.0	3.0.0
2.6.x	2.6.1
2.0.x	2.0.0
2.0.0-rc1	2.0.0-rc1

12.4.3 Download NebulaGraph Java

- (Recommended) To install a specific version of NebulaGraph Java, use the Git option `--branch` to specify the branch. For example, to install v3.5.0, run the following command:

```
$ git clone --branch release-3.5 https://github.com/vesoft-inc/nebula-java.git
```

- To install the daily development version, run the following command to download the source code from the `master` branch:

```
$ git clone https://github.com/vesoft-inc/nebula-java.git
```

12.4.4 Use NebulaGraph Java

Note

We recommend that each thread uses one session. If multiple threads use the same session, the performance will be reduced.

When importing a Maven project with tools such as IDEA, set the following dependency in `pom.xml`.

Note

`3.0.0-SNAPSHOT` indicates the daily development version that may have unknown issues. We recommend that you replace `3.0.0-SNAPSHOT` with a released version number to use a table version.

```
<dependency>
  <groupId>com.vesoft</groupId>
  <artifactId>client</artifactId>
  <version>3.0.0-SNAPSHOT</version>
</dependency>
```

If you cannot download the dependency for the daily development version, set the following content in `pom.xml`. Released versions have no such issue.

```xml
<repositories>
  <repository>
    <id>snapshots</id>
    <url>https://oss.sonatype.org/content/repositories/snapshots/</url>
  </repository>
</repositories>
```

If there is no Maven to manage the project, manually download the JAR file to install NebulaGraph Java.

Core of the example code

The NebulaGraph Java client provides both Connection Pool and Session Pool modes, using Connection Pool requires the user to manage session instances.

- Session Pool

  For all the code, see GraphSessionPoolExample.

- Connection Pool

  For all the code, see GraphClientExample.

Last update: October 31, 2022

12.5 NebulaGraph Python

NebulaGraph Python is a Python client for connecting to and managing the NebulaGraph database.

12.5.1 Prerequisites

You have installed Python 3.6 or later versions.

12.5.2 Compatibility with NebulaGraph

NebulaGraph version	NebulaGraph Python version
3.3.0	3.3.0
3.1.0 ~ 3.2.x	3.1.0
3.0.0 ~ 3.0.2	3.0.0
2.6.x	2.6.0
2.0.x	2.0.0
2.0.0-rc1	2.0.0rc1

12.5.3 Install NebulaGraph Python

Install NebulaGraph Python with pip

```
$ pip install nebula3-python==<version>
```

Install NebulaGraph Python from the source code

1. Clone the NebulaGraph Python source code to the host.

- (Recommended) To install a specific version of NebulaGraph Python, use the Git option `--branch` to specify the branch. For example, to install v3.4.0, run the following command:

```
$ git clone --branch release-3.4 https://github.com/vesoft-inc/nebula-python.git
```

- To install the daily development version, run the following command to download the source code from the `master` branch:

```
$ git clone https://github.com/vesoft-inc/nebula-python.git
```

2. Change the working directory to nebula-python.

```
$ cd nebula-python
```

3. Run the following command to install NebulaGraph Python.

```
$ pip install .
```

12.5.4 Core of the example code

NebulaGraph Python clients provides Connection Pool and Session Pool methods to connect to NebulaGraph. Using the Connection Pool method requires users to manage sessions by themselves.

- Session Pool

  For details about all the code, see SessinPoolExample.py.

  For limitations of using the Session Pool method, see Example of using session pool.

- Connection Pool

  For details about all the code, see Example.

Last update: October 31, 2022

12.6 NebulaGraph Go

NebulaGraph Go is a Golang client for connecting to and managing the NebulaGraph database.

12.6.1 Prerequisites

You have installed Golang 1.13 or later versions.

12.6.2 Compatibility with NebulaGraph

NebulaGraph version	NebulaGraph Go version
3.3.0	3.3.0
3.2.x	3.2.0
3.1.0	3.1.0
3.0.0 ~ 3.0.2	3.0.0
2.6.x	2.6.0
2.0.x	2.0.0-GA

12.6.3 Download NebulaGraph Go

- (Recommended) To install a specific version of NebulaGraph Go, use the Git option `--branch` to specify the branch. For example, to install v3.5.0, run the following command:

  ```
  $ git clone --branch release-3.5 https://github.com/vesoft-inc/nebula-go.git
  ```

- To install the daily development version, run the following command to download the source code from the `master` branch:

  ```
  $ git clone https://github.com/vesoft-inc/nebula-go.git
  ```

12.6.4 Install or update

Run the following command to install or update NebulaGraph Go:

```
$ go get -u -v github.com/vesoft-inc/nebula-go/v3@v3.5.0
```

12.6.5 Core of the example code

The NebulaGraph GO client provides both Connection Pool and Session Pool, using Connection Pool requires the user to manage the session instances.

- Session Pool

  For details about all the code, see session_pool_example.go.

  For limitations of using Session Pool, see Usage example.

- Connection Pool

  For all the code, see graph_client_basic_example and graph_client_goroutines_example.

Last update: October 31, 2022

13. NebulaGraph Studio

13.1 About NebulaGraph Studio

13.1.1 What is NebulaGraph Studio

NebulaGraph Studio (Studio in short) is a browser-based visualization tool to manage NebulaGraph. It provides you with a graphical user interface to manipulate graph schemas, import data, and run nGQL statements to retrieve data. With Studio, you can quickly become a graph exploration expert from scratch. You can view the latest source code in the NebulaGraph GitHub repository, see nebula-studio for details.

Note

You can also try some functions online in Studio.

Released versions

In addition to deploying Studio with RPM-based, DEB-based, or Tar-based package, or with Docker. You can also deploy Studio with Helm in the Kubernetes cluster. For more information, see Deploy Studio.

The functions of the above four deployment methods are the same and may be restricted when using Studio. For more information, see Limitations.

Features

Studio can easily manage NebulaGraph data, with the following functions:

- On the **Schema** page, you can use the graphical user interface to create the space, Tag, Edge Type, Index, and view the statistics on the graph. It helps you quickly get started with NebulaGraph.
- On the **Import** page, you can operate batch import of vertex and edge data with clicks, and view a real-time import log.
- On the **Console** page, you can run nGQL statements and read the results in a human-friendly way.

Scenarios

You can use Studio in one of these scenarios:

- You have a dataset, and you want to explore and analyze data in a visualized way. You can use Docker Compose to deploy NebulaGraph and then use Studio to explore or analyze data in a visualized way.
- You are a beginner of nGQL (NebulaGraph Query Language) and you prefer to use a GUI rather than a command-line interface (CLI) to learn the language.

Authentication

Authentication is not enabled in NebulaGraph by default. Users can log into Studio with the `root` account and any password.

When NebulaGraph enables authentication, users can only sign into Studio with the specified account. For more information, see Authentication.

Version compatibility

Note

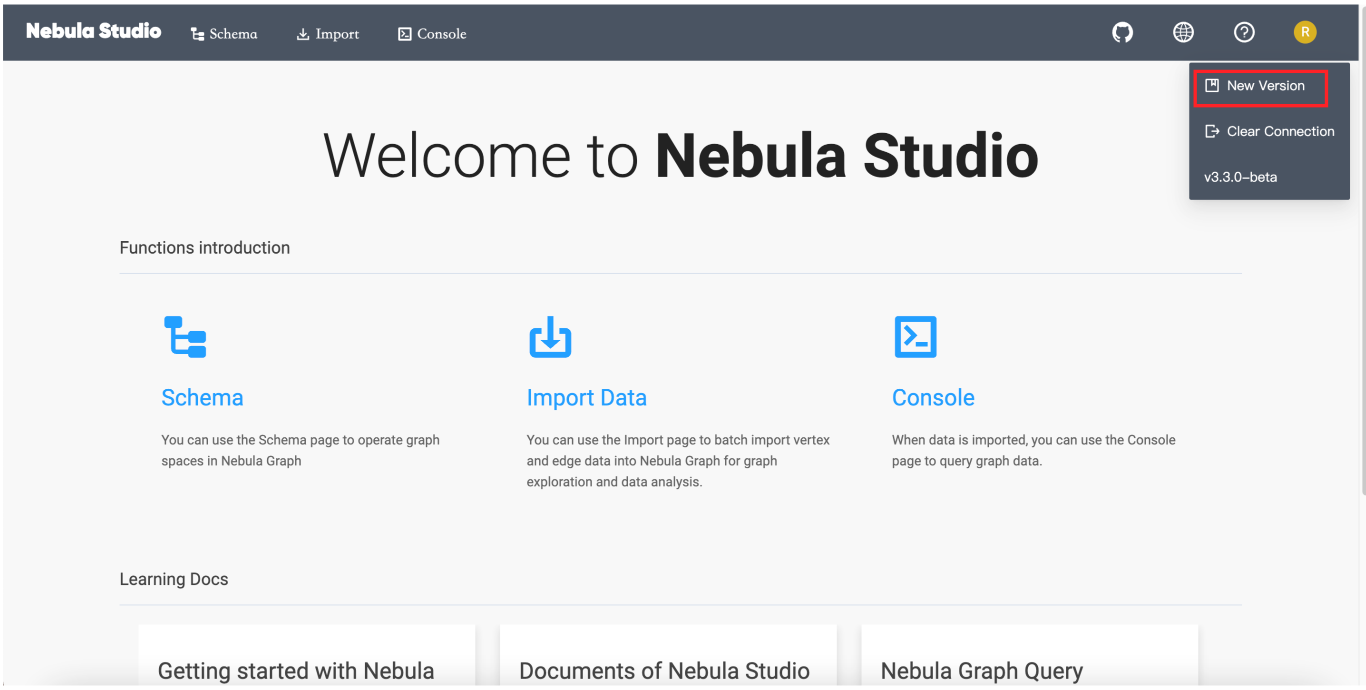
The Studio version is released independently of the NebulaGraph core. The correspondence between the versions of Studio and the NebulaGraph core, as shown in the table below.

NebulaGraph version	Studio version
3.5.0	3.7.0
3.4.0 ~ 3.4.1	3.7.0、3.6.0、3.5.1、3.5.0
3.3.0	3.5.1、3.5.0
3.0.0 ～ 3.2.0	3.4.1、3.4.0
3.1.0	3.3.2
3.0.0	3.2.x
2.6.x	3.1.x
2.6.x	3.1.x
2.0 & 2.0.1	2.x
1.x	1.x

Check updates

Studio is in development. Users can view the latest releases features through Changelog.

To view the Changelog, on the upper-right corner of the page, click the version and then **New version**.



Last update: May 19, 2023

13.1.2 Limitations

This topic introduces the limitations of Studio.

Architecture

For now, Studio v3.x supports x86_64 architecture only.

Upload data

Only CSV files without headers can be uploaded, but no limitations are applied to the size and store period for a single file. The maximum data volume depends on the storage capacity of your machine.

nGQL statements

On the **Console** page of Docker-based and RPM-based Studio v3.x, all the nGQL syntaxes except these are supported:

- `USE <space_name>`: You cannot run such a statement on the **Console** page to choose a graph space. As an alternative, you can click a graph space name in the drop-down list of **Current Graph Space**.
- You cannot use line breaks (\). As an alternative, you can use the Enter key to split a line.

Browser

We recommend that you use the latest version of Chrome to get access to Studio.

Last update: December 21, 2022

13.2 Deploy and connect

13.2.1 Deploy Studio

This topic describes how to deploy Studio locally by RPM, DEB, tar package and Docker.

RPM-based Studio

PREREQUISITES

Before you deploy RPM-based Studio, you must confirm that:

- The NebulaGraph services are deployed and started. For more information, see NebulaGraph Database Manual.
- The Linux distribution is CentOS, install `lsof`.
- Before the installation starts, the following ports are not occupied.

Port	Description
7001	Web service provided by Studio.

INSTALL

1. Select and download the RPM package according to your needs. It is recommended to select the latest version. Common links are as follows:

Installation package	Checksum	NebulaGraph version
nebula-graph-studio-3.7.0.x86_64.rpm	nebula-graph-studio-3.7.0.x86_64.rpm.sha256	3.5.0

2. Use `sudo rpm -i <rpm_name>` to install RPM package.

For example, install Studio 3.7.0, use the following command. The default installation path is `/usr/local/nebula-graph-studio`.

```
$ sudo rpm -i nebula-graph-studio-3.7.0.x86_64.rpm
```

You can also install it to the specified path using the following command:

```
$ sudo rpm -i nebula-graph-studio-3.7.0.x86_64.rpm --prefix=<path>
```

When the screen returns the following message, it means that the PRM-based Studio has been successfully started.

```
Start installing NebulaGraph Studio now...
NebulaGraph Studio has been installed.
NebulaGraph Studio started automatically.
```

3. When Studio is started, use `http://<ip address>:7001` to get access to Studio.

If you can see the **Config Server** page on the browser, Studio is started successfully.

UNINSTALL

You can uninstall Studio using the following command:

```
$ sudo rpm -e nebula-graph-studio-3.7.0.x86_64
```

If these lines are returned, PRM-based Studio has been uninstalled.

```
NebulaGraph Studio removed, bye~
```

EXCEPTION HANDLING

If the automatic start fails during the installation process or you want to manually start or stop the service, use the following command:

- Start the service manually

```
$ bash /usr/local/nebula-graph-studio/scripts/rpm/start.sh
```

- Stop the service manually

```
$ bash /usr/local/nebula-graph-studio/scripts/rpm/stop.sh
```

If you encounter an error `bind EADDRINUSE 0.0.0.0:7001` when starting the service, you can use the following command to check port 7001 usage.

```
$ lsof -i:7001
```

If the port is occupied and the process on that port cannot be terminated, you can use the following command to change Studio service port and restart the service.

```
//Open the configuration file
$ vi etc/studio-api.yam

//Change the port
Port: 7001 // Modify this port number and change it to any
```

```
//Restart service
$ systemctl restart nebula-graph-studio.service
```

DEB-based Studio

PREREQUISITES

Before you deploy DEB-based Studio, you must do a check of these:

- The NebulaGraph services are deployed and started. For more information, see NebulaGraph Database Manual.
- The Linux distribution is Ubuntu.
- Before the installation starts, the following ports are not occupied.

Port	Description
7001	Web service provided by Studio

- The path `/usr/lib/systemd/system` exists in the system. If not, create it manually.

INSTALL

1. Select and download the DEB package according to your needs. It is recommended to select the latest version. Common links are as follows:

Installation package	Checksum	NebulaGraph version
nebula-graph-studio-3.7.0.x86_64.deb	nebula-graph-studio-3.7.0.x86_64.deb.sha256	3.5.0

2. Use `sudo dpkg -i <deb_name>` to install DEB package.

   For example, install Studio 3.7.0, use the following command:

```
$ sudo dpkg -i nebula-graph-studio-3.7.0.x86_64.deb
```

3. When Studio is started, use `http://<ip address>:7001` to get access to Studio.

   If you can see the **Config Server** page on the browser, Studio is started successfully.

UNINSTALL

You can uninstall Studio using the following command:

```
$ sudo dpkg -r nebula-graph-studio
```

tar-based Studio

PREREQUISITES

Before you deploy tar-based Studio, you must do a check of these:

- The NebulaGraph services are deployed and started. For more information, see NebulaGraph Database Manual.
- Before the installation starts, the following ports are not occupied.

Port	Description
7001	Web service provided by Studio

INSTALL AND DEPLOY

1. Select and download the tar package according to your needs. It is recommended to select the latest version. Common links are as follows:

Installation package	Studio version
nebula-graph-studio-3.7.0.x86_64.tar.gz	3.7.0

2. Use `tar -xvf` to decompress the tar package.

```
$ tar -xvf nebula-graph-studio-3.7.0.x86_64.tar.gz
```

3. Deploy and start nebula-graph-studio.

```
$ cd nebula-graph-studio
$ ./server
```

4. When Studio is started, use `http://<ip address>:7001` to get access to Studio.

   If you can see the **Config Server** page on the browser, Studio is started successfully.

STOP SERVICE

You can use `kill pid` to stop the service:

```
$ kill $(lsof -t -i :7001) #stop nebula-graph-studio
```

Docker-based Studio

PREREQUISITES

Before you deploy Docker-based Studio, you must do a check of these:

- The NebulaGraph services are deployed and started. For more information, see NebulaGraph Database Manual.
- On the machine where Studio will run, Docker Compose is installed and started. For more information, see Docker Compose Documentation.
- Before the installation starts, the following ports are not occupied.

Port	Description
7001	Web service provided by Studio

PROCEDURE

To deploy and start Docker-based Studio, run the following commands. Here we use NebulaGraph v3.5.0 for demonstration:

1. Download the configuration files for the deployment.

Installation package	NebulaGraph version
nebula-graph-studio-3.7.0.tar.gz	3.5.0

2. Create the `nebula-graph-studio-3.7.0` directory and decompress the installation package to the directory.

```
$ mkdir nebula-graph-studio-3.7.0 -zxvf nebula-graph-studio-3.7.0.gz -C nebula-graph-studio-3.7.0
```

3. Change to the `nebula-graph-studio-3.7.0` directory.

```
$ cd nebula-graph-studio-3.7.0
```

4. Pull the Docker image of Studio.

```
$ docker-compose pull
```

5. Build and start Docker-based Studio. In this command, `-d` is to run the containers in the background.

```
$ docker-compose up -d
```

If these lines are returned, Docker-based Studio v3.x is deployed and started.

```
Creating docker_web_1      ... done
```

6. When Docker-based Studio is started, use `http://<ip address>:7001` to get access to Studio.

Note

Run `ifconfig` or `ipconfig` to get the IP address of the machine where Docker-based Studio is running. On the machine running Docker-based Studio, you can use `http://localhost:7001` to get access to Studio.

If you can see the **Config Server** page on the browser, Docker-based Studio is started successfully.

Helm-based Studio

This section describes how to deploy Studio with Helm.

PREREQUISITES

Before installing Studio, you need to install the following software and ensure the correct version of the software:

Software	Requirement
Kubernetes	>= 1.14
Helm	>= 3.2.0

INSTALL

1. Use Git to clone the source code of Studio to the host.

```
$ git clone https://github.com/vesoft-inc/nebula-studio.git
```

2. Make the `nebula-studio` directory the current working directory.

`bash`
`  $ cd nebula-studio`

3. Assume using release name:`my-studio`, installed Studio in Helm Chart.

```
$ helm upgrade --install my-studio --set service.type=NodePort --set service.port=30070deployment/helm
```

The configuration parameters of the Helm Chart are described below.

Parameter	Default value	Description
replicaCount	0	The number of replicas for Deployment.
image.nebulaStudio.name	vesoft/nebula-graph-studio	The image name of nebula-graph-studio.
image.nebulaStudio.version	v3.7.0	The image version of nebula-graph-studio.
service.type	ClusterIP	The service type, which should be one of `NodePort`, `ClusterIP`, and `LoadBalancer`.
service.port	7001	The expose port for nebula-graph-studio's web.
service.nodePort	32701	The proxy port for accessing nebula-studio outside kubernetes cluster.
resources.nebulaStudio	{}	The resource limits/requests for nebula-studio.
persistent.storageClassName	""	The name of storageClass. The default value will be used if not specified.
persistent.size	5Gi	The persistent volume size.

4. When Studio is started, use `http://<node_address>:30070/` to get access to Studio.

If you can see the **Config Server** page on the browser, Studio is started successfully.

UNINSTALL

```
$ helm uninstall my-studio
```

Next to do

On the **Config Server** page, connect Docker-based Studio to NebulaGraph. For more information, see Connect to NebulaGraph.

Last update: March 13, 2023

13.2.2 Connect to NebulaGraph

After successfully launching Studio, you need to configure to connect to NebulaGraph. This topic describes how Studio connects to the NebulaGraph database.

Prerequisites

Before connecting to the NebulaGraph database, you need to confirm the following information:

- The NebulaGraph services and Studio are started. For more information, see Deploy Studio.
- You have the local IP address and the port used by the Graph service of NebulaGraph. The default port is `9669`.
- You have a NebulaGraph account and its password.

Procedure

To connect Studio to NebulaGraph, follow these steps:

1. Type `http://<ip_address>:7001` in the address bar of your browser.

   The following login page shows that Studio is successfully connected to NebulaGraph.

2. On the **Config Server** page of Studio, configure these fields:

- **Graphd IP address**: Enter the IP address of the Graph service of NebulaGraph. For example, `192.168.10.100`.

> **Note**
>
> - When NebulaGraph and Studio are deployed on the same machine, you must enter the IP address of the machine, instead of `127.0.0.1` or `localhost`.
> - When connecting to a NebulaGraph database on a new tab, a new session will overwrite the sessions of the old TAB. If you need to log in to multiple NebulaGraph databases simultaneously, you can use a different browser or non-trace mode.

- **Port**: The port of the Graph service. The default port is `9669`.
- **Username** and **Password**: Fill in the log in account according to the authentication settings of NebulaGraph.
- If authentication is not enabled, you can use `root` and any password as the username and its password.
- If authentication is enabled and no account information has been created, you can only log in as GOD role and use `root` and `nebula` as the username and its password.
- If authentication is enabled and different users are created and assigned roles, users in different roles log in with their accounts and passwords.

3. After the configuration, click the **Connect** button.

> **Note**
>
> One session continues for up to 30 minutes. If you do not operate Studio within 30 minutes, the active session will time out and you must connect to NebulaGraph again.

A welcome page is displayed on the first login, showing the relevant functions according to the usage process, and the test datasets can be automatically downloaded and imported.

To visit the welcome page, click ?.

Next to do

When Studio is successfully connected to NebulaGraph, you can do these operations:

- Create a schema on the **Console** page or on the **Schema** page.
- Batch import data on the **Import** page.
- Execute nGQL statements on the **Console** page.
- Design the schema visually on the **Schema drafting** page.

> **Note**
>
> The permissions of an account determine the operations that can be performed. For details, see Roles and privileges.

LOG OUT

If you want to reset NebulaGraph, you can log out and reconfigure the database.

Click the user profile picture in the upper right corner, and choose **Log out**.

Last update: February 3, 2023

13.3 Quick start

13.3.1 Design a schema

To manipulate graph data in NebulaGraph with Studio, you must have a graph schema. This article introduces how to design a graph schema for NebulaGraph.

A graph schema for NebulaGraph must have these essential elements:

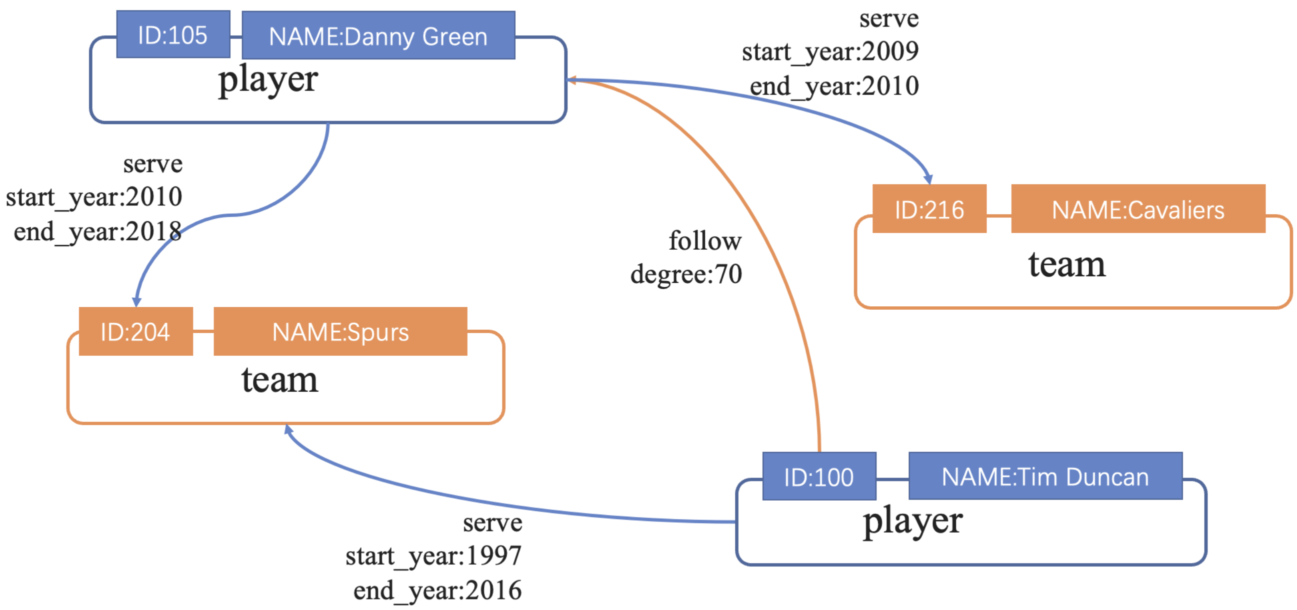
- Tags (namely vertex types) and their properties.
- Edge types and their properties.

In this article, you can install the sample data set basketballplayer and use it to explore a pre-designed schema.

This table gives all the essential elements of the schema.

Element	Name	Property name (Data type)	Description
Tag	**player**	- `name` (`string`) - `age` (`int`)	Represents the player.
Tag	**team**	- `name` (`string`)	Represents the team.
Edge type	**serve**	- `start_year` (`int`) - `end_year` (`int`)	Represent the players behavior. This behavior connects the player to the team, and the direction is from player to team.
Edge type	**follow**	- `degree` (`int`)	Represent the players behavior. This behavior connects the player to the player, and the direction is from a player to a player.

This figure shows the relationship (**serve/follow**) between a **player** and a **team**.



Last update: August 11, 2022

13.3.2 Create a schema

To batch import data into NebulaGraph, you must have a graph schema. You can create a schema on the **Console** page or on the **Schema** page of Studio.

Note

- Users can use nebula-console to create a schema. For more information, see NebulaGraph Manual and Get started with NebulaGraph.
- Users can use the Schema drafting function to design schema visually. For more information, see Schema drafting.

Prerequisites

To create a graph schema on Studio, you must do a check of these:

- Studio is connected to NebulaGraph.
- Your account has the privilege of GOD, ADMIN, or DBA.
- The schema is designed.
- A graph space is created.

Note

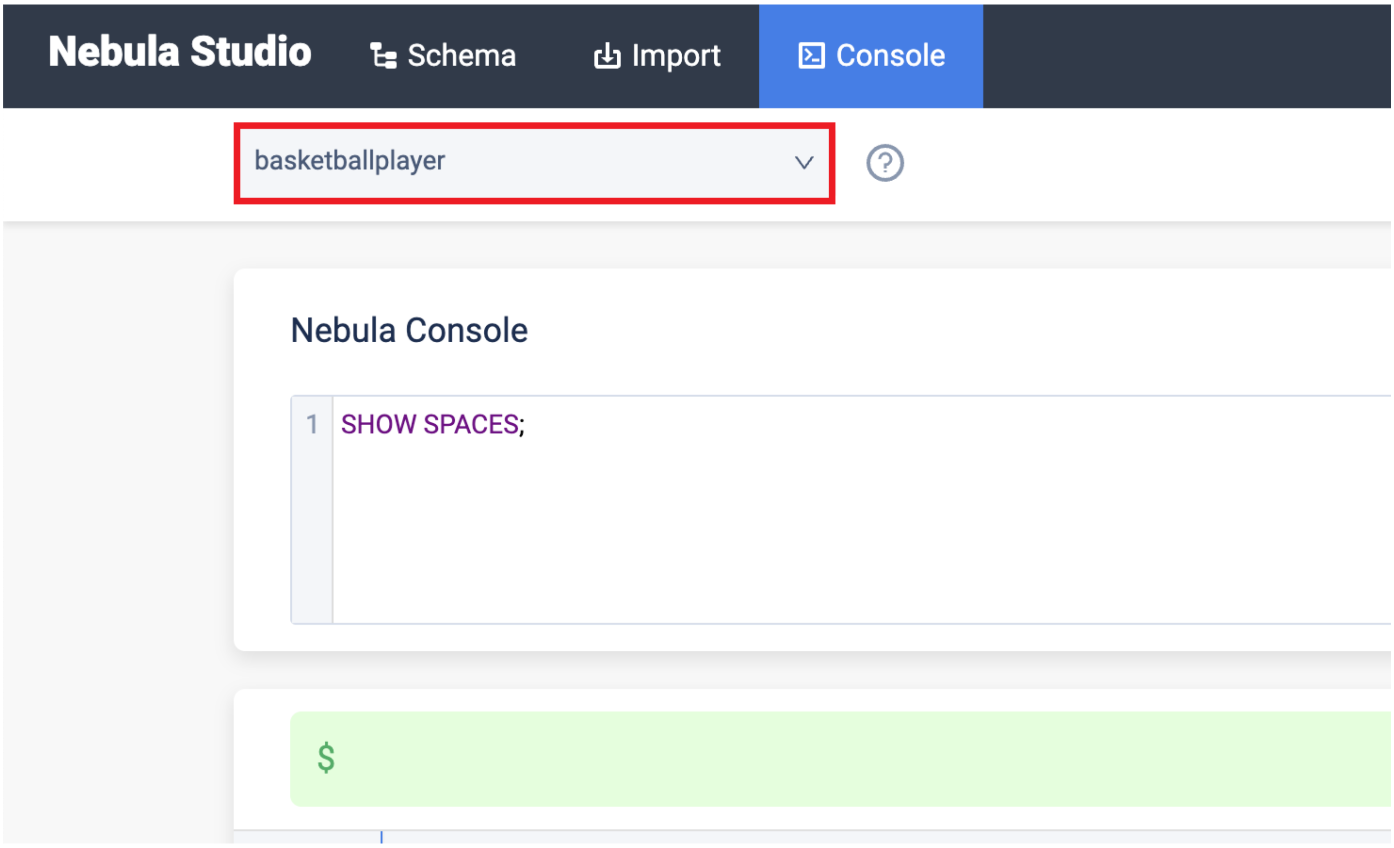
If no graph space exists and your account has the GOD privilege, you can create a graph space on the **Console** page. For more information, see CREATE SPACE.

Create a schema with Schema

1. Create tags. For more information, see Operate tags.
2. Create edge types. For more information, see Operate edge types.

Create a schema with Console

1. In the toolbar, click the **Console** tab.
2. In the **Current Graph Space** field, choose a graph space name. In this example, **basketballplayer** is used.



3. In the input box, enter these statements one by one and click the button **Run**.

```
// To create a tag named "player", with two property
nebula> CREATE TAG player(name string, age int);

// To create a tag named "team", with one property
nebula> CREATE TAG team(name string);

// To create an edge type named "follow", with one properties
nebula> CREATE EDGE follow(degree int);

// To create an edge type named "serve", with two properties
nebula> CREATE EDGE serve(start_year int, end_year int);
```

If the preceding statements are executed successfully, the schema is created. You can run the statements as follows to view the schema.

```
// To list all the tags in the current graph space
nebula> SHOW TAGS;

// To list all the edge types in the current graph space
nebula> SHOW EDGES;

// To view the definition of the tags and edge types
DESCRIBE TAG player;
DESCRIBE TAG team;
DESCRIBE EDGE follow;
DESCRIBE EDGE serve;
```

If the schema is created successfully, in the result window, you can see the definition of the tags and edge types.

Next to do

When a schema is created, you can import data.

Last update: October 28, 2022

13.3.3 Import data

After CSV files of data and a schema are created, you can use the **Import** page to batch import vertex and edge data into NebulaGraph for graph exploration and data analysis.

Prerequisites

To batch import data, do a check of these:

- Studio is connected to NebulaGraph.
- A schema is created.
- CSV files meet the demands of the Schema.
- Your account has privilege of GOD, ADMIN, DBA, or USER.

Procedure

Before importing data, you need to upload the file first and then create the import task.

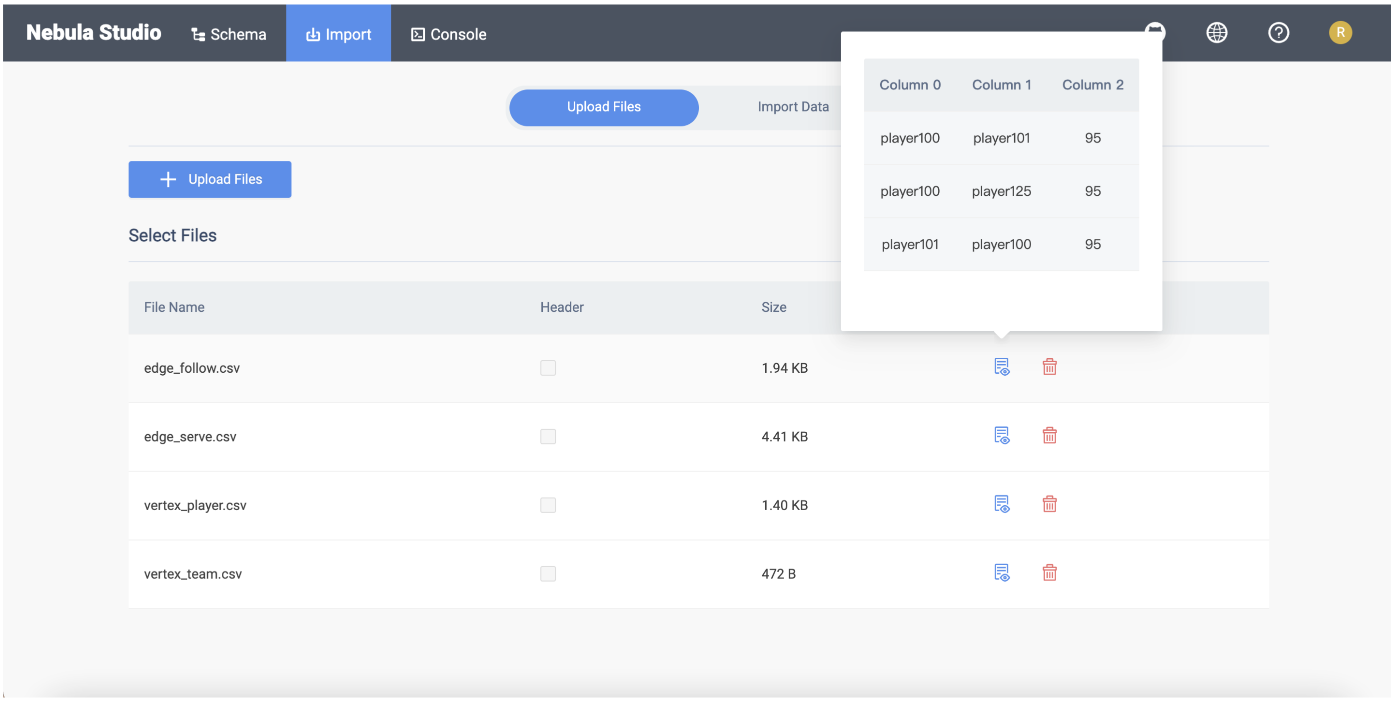
Upload files

To upload files, follow these steps:

1. In the toolbar, click the **Import** tab.
2. On the **Upload Files** page, click the **Upload Files** button and then choose CSV files. In this example, `edge_serve.csv`, `edge_follow.csv`, `vertex_player.csv`, and `vertex_team.csv` are chosen.

> **Note**
>
> You can choose multiple CSV files at the same time. The CSV file used in this article can be downloaded in the Design a schema.

3. After uploading, you can click the button in the **Operations** column to preview the file content, or click the button to delete the uploaded file.



Import Data

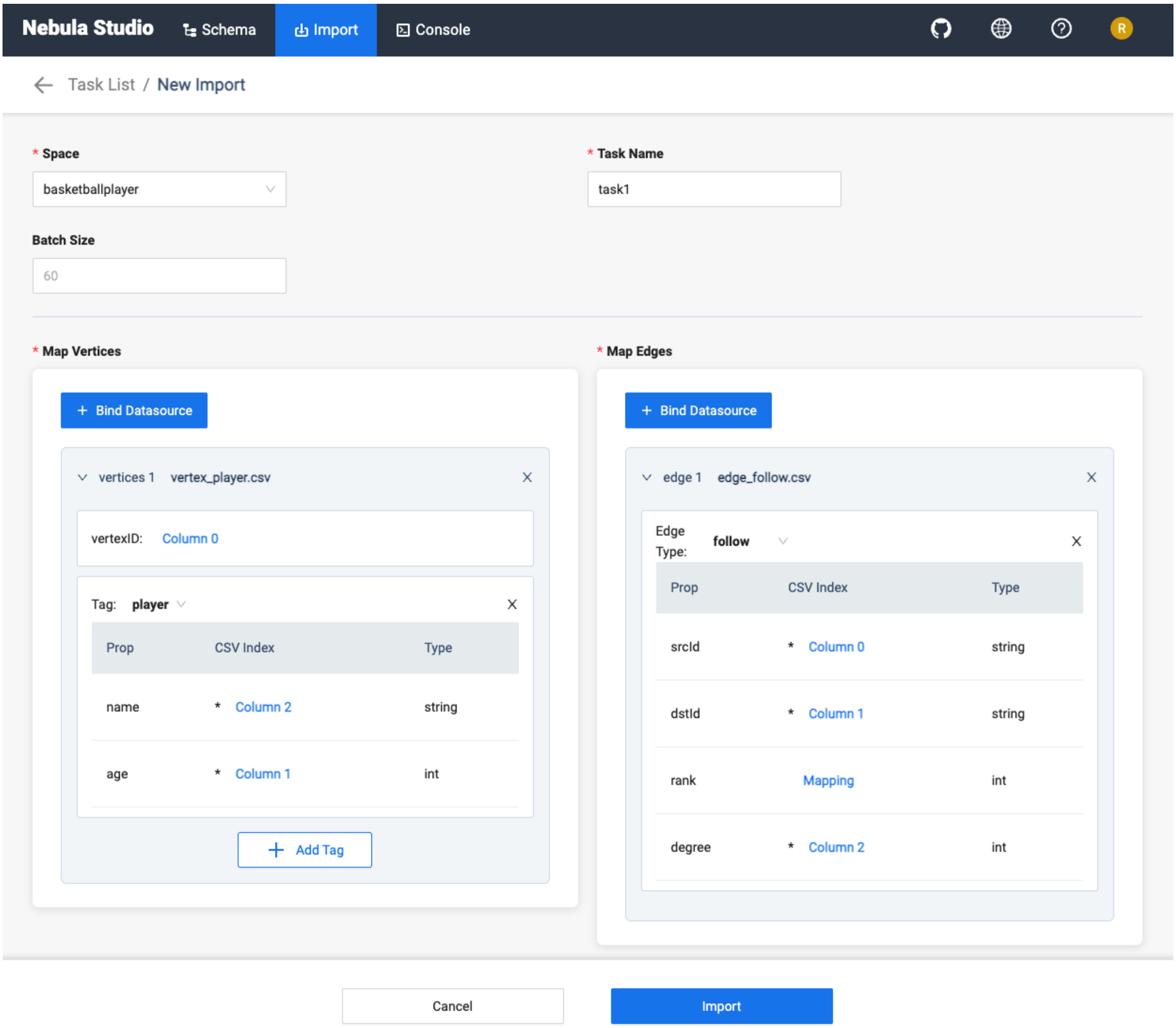
To batch import data, follow these steps:

1. In the toolbar, click the **Import** tab.
2. In **Import** tab, click the **Import Data**.
3. On the **Import Data** page, click **+ New Import** button to complete these operations:

Caution

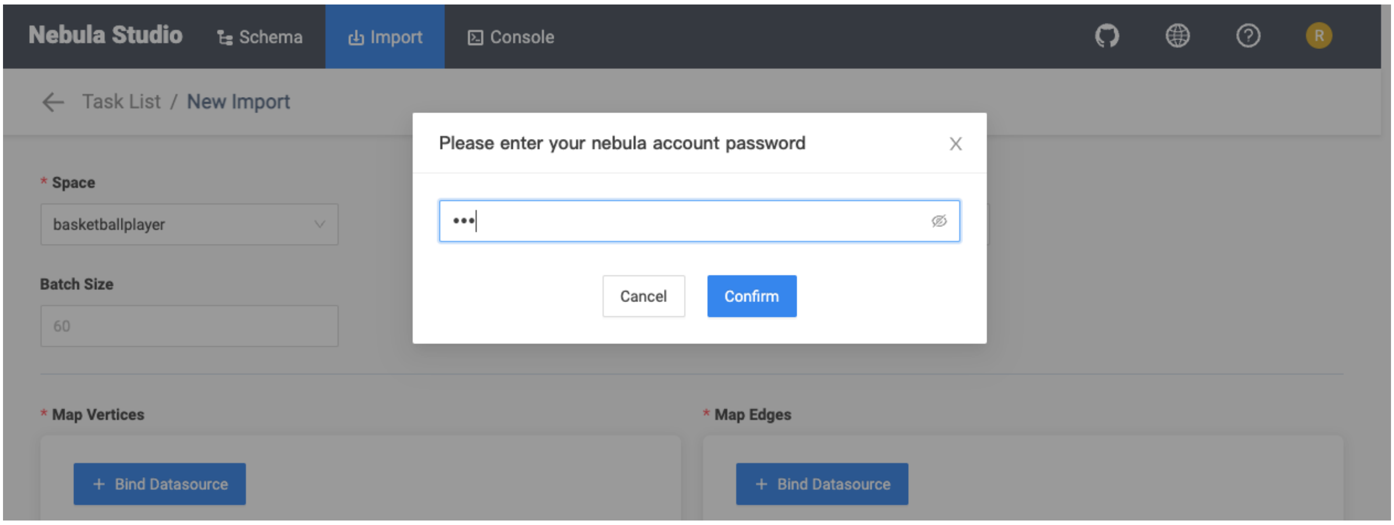
users can click **Import Template** to download the example configuration file `example.yaml`, and upload the configuration file after configuration. The configuration mode is similar to that of NebulaGraph Importer, but all file paths for configuration files in the template retain the filename only. And make sure all CSV data files are uploaded before importing the YAML file.

- Select a graph space.
- Fill in the task name.
- (Optional) Fill in the batch size.
- In the **Map Vertices** section, click the **+ Bind Datasource** button, select bind source file in the dialog box, and click the **Confirm** button, the `vertex_player.csv` file is chosen.
- In the **vertices 1** drop-down list, click **Select CSV Index**, and select the column where vertexID is located in the pop-up dialog box.
- Click the **+ Add Tag** button and click the icon on the right. In the displayed property list, bind the source data for the tag property. In this example, **player** is used for the `vertex_player.csv` file. For the **player** tag, choose **Column 1** for the age property, and choose **Column 2** for the name property.
- In the **Map Edges** section, click the **+ Bind Datasource** button, select bind source file in the dialog box, and click the **Confirm** button, the `edge_follow.csv` file is chosen.
- In the **vertices 1** drop-down list, click **Select Edge Type**. In this example, follow is chosen.
- Based on the edge type property, select the corresponding data column from the `edge_follow.csv` file. **srcId** and **dstId** are the VIDs of the source vertex and destination vertex of an edge. In this example, **srcId** must be set to the VIDs of the player and **dstId** must be set to the VIDs of another player. **Rank** is optional.

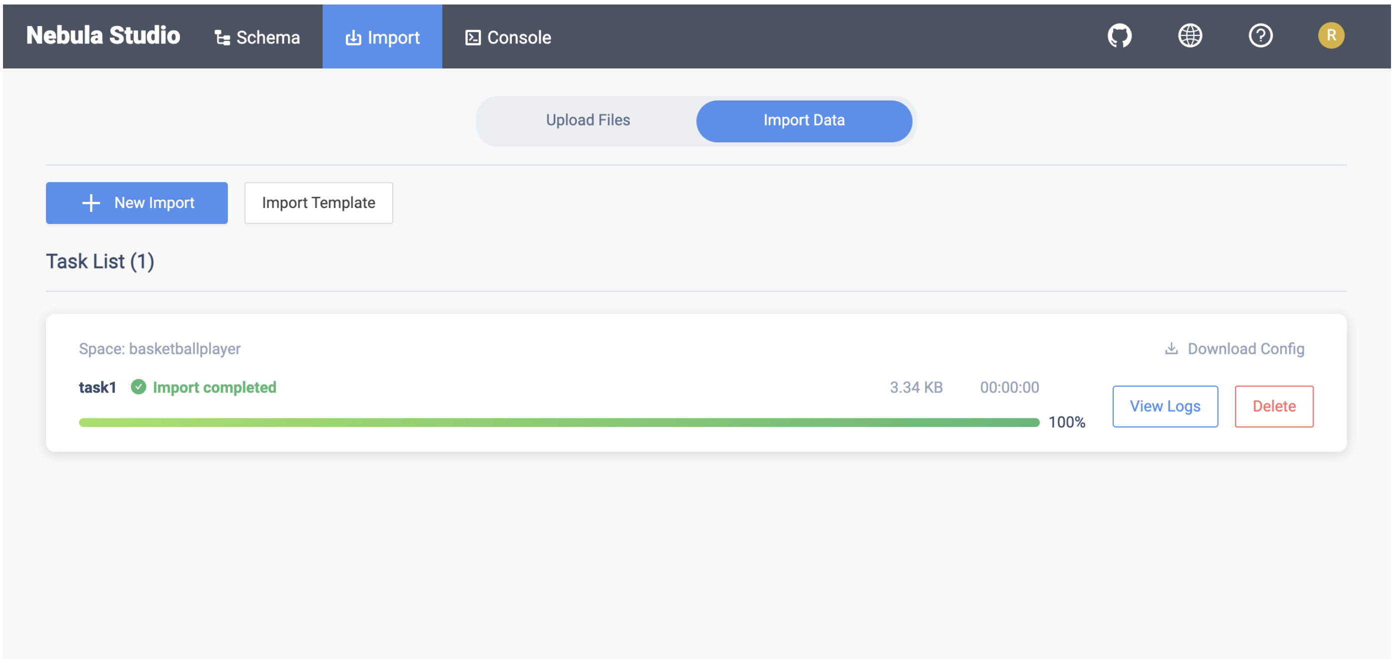


4. After completing the settings, click the **Import** button.

5. You need to enter the password of your NebulaGraph account before importing data.



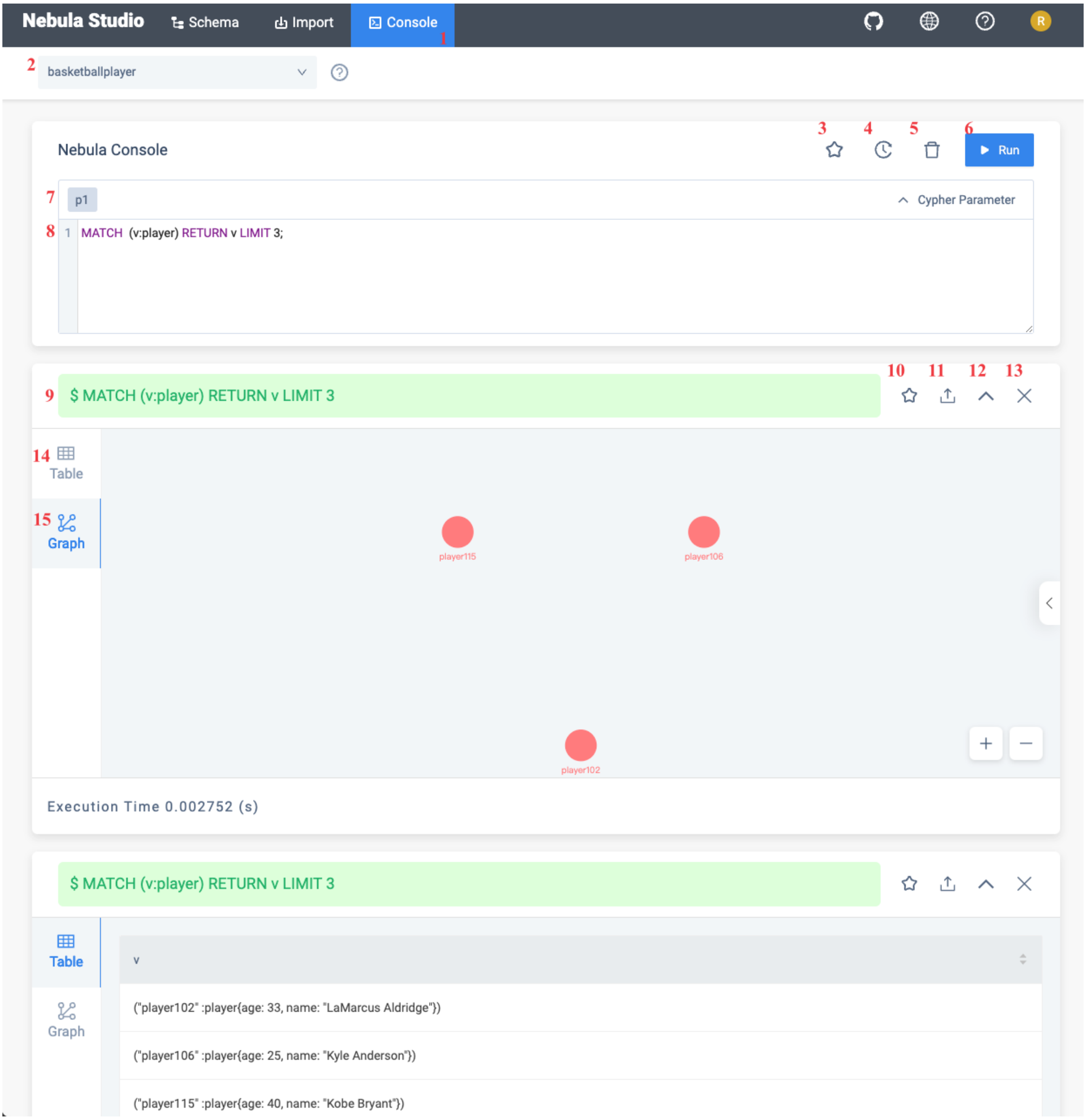
6. After importing data, you can view logs, download logs, download configuration files, and delete tasks on the **Import Data** tab.



Last update: August 11, 2022

13.3.4 Console

Studio console interface is shown as follows.



The following table lists various functions on the console interface.

number	function	descriptions
1	toolbar	Click the **Console** tab to enter the console page.
2	select a space	Select a space in the Current Graph Space list. **descriptions**: Studio does not support running the `USE <space_name>` statements directly in the input box.
3	favorites	Click the button to expand the favorites, click one of the statements, and the input box will automatically enter the statement.
4	history list	Click button representing the statement record. In the statement running record list, click one of the statements, and the statement will be automatically entered in the input box. The list provides the record of the last 15 statements.
5	clean input box	Click button to clear the content entered in the input box.
6	run	After inputting the nGQL statement in the input box, click button to indicate the operation to start running the statement.
7	custom parameters display	Click the button to expand the custom parameters for parameterized query. For details, see Manage parameters.
8	input box	After inputting the nGQL statements, click the button to run the statement. You can input multiple statements and run them at the same time by using the separator `;`, and also use the symbol `//` to add comments.
9	statement running status	After running the nGQL statement, the statement running status is displayed. If the statement runs successfully, the statement is displayed in green. If the statement fails, the statement is displayed in red.
10	add to favorites	Click the button to save the statement as a favorite, the button for the favorite statement is colored in yellow exhibit.
11	export CSV file or PNG file	After running the nGQL statement to return the result, when the result is in **Table** window, click the button to export as a CSV file. Switch to the **Graph** window and click the button to save the results as a CSV file or PNG image export.
12	expand/hide execution results	Click the button to hide the result or click button to expand the result.
13	close execution results	Click the button to close the result returned by this nGQL statement.
14	**Table** window	Display the result from running nGQL statement. If the statement returns results, the window displays the results in a table.
15	**Graph** window	Display the result from running nGQL statement. If the statement returns the complete vertex-edge result, the window displays the result as a graph . Click the button on the right to view the overview panel.

Last update: October 28, 2022

13.3.5 Use Schema

Operate graph spaces

When Studio is connected to NebulaGraph, you can create or delete a graph space. You can use the **Console** page or the **Schema** page to do these operations. This article only introduces how to use the **Schema** page to operate graph spaces in NebulaGraph.

PREREQUISITES

To operate a graph space on the **Schema** page of Studio, you must do a check of these:

- Studio is connected to NebulaGraph.
- Your account has the authority of GOD. It means that:
- If the authentication is enabled in NebulaGraph, you can use `root` and any password to sign in to Studio.
- If the authentication is disabled in NebulaGraph, you must use `root` and its password to sign in to Studio.

CREATE A GRAPH SPACE

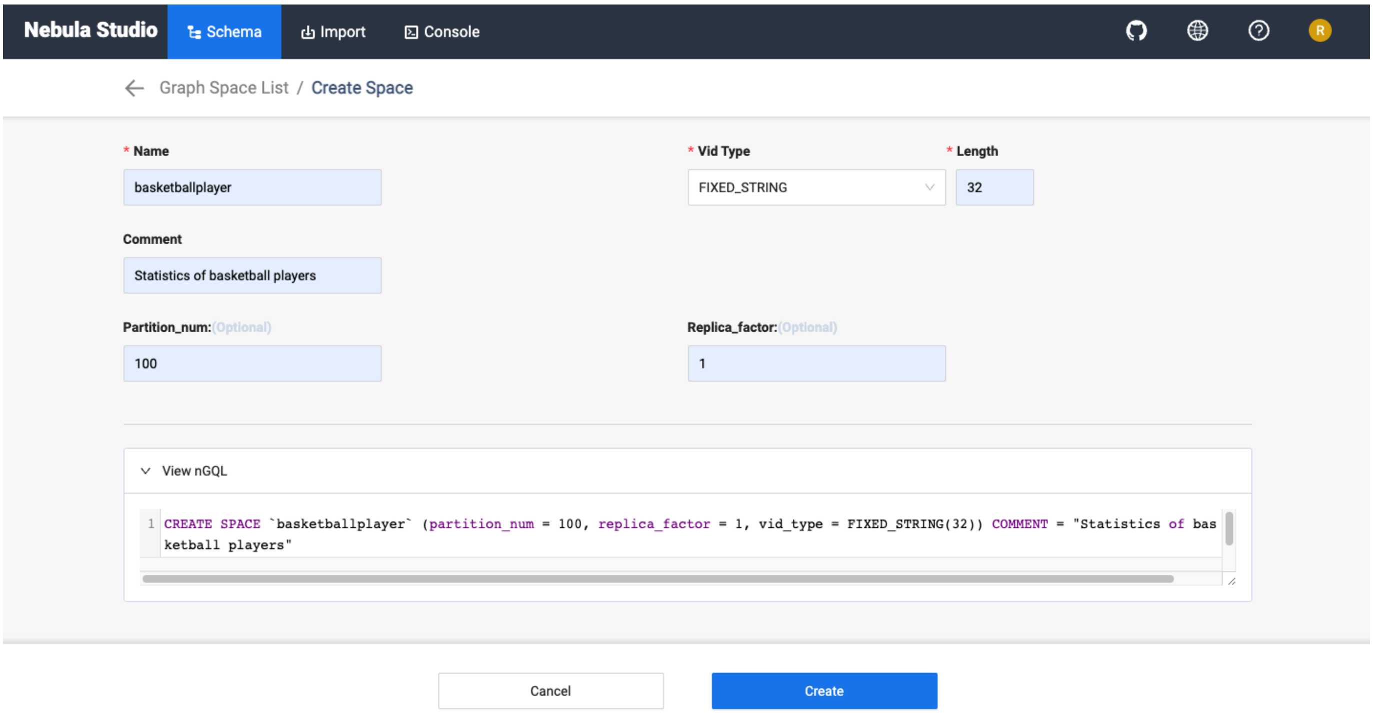
1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, click **Create Space**, do these settings:

- **Name**: Specify a name to the new graph space. In this example, `basketballplayer` is used. The name must be distinct in the database.
- **Vid Type**: The data types of VIDs are restricted to `FIXED_STRING(<N>)` or `INT64`. A graph space can only select one VID type. In this example, `FIXED_STRING(32)` is used. For more information, see VID.
- **Comment**: Enter the description for graph space. The maximum length is 256 bytes. By default, there will be no comments on a space. But in this example, `Statistics of basketball players` is used.
- **Optional Parameters**: Set the values of `partition_num` and `replica_factor` respectively. In this example, these parameters are set to `100` and `1` respectively. For more information, see `CREATE SPACE` syntax.

  In the **Equivalent to the following nGQL statement** panel, you can see the statement equivalent to the preceding settings.

```
CREATE SPACE basketballplayer (partition_num = 100, replica_factor = 1, vid_type = FIXED_STRING(32)) COMMENT = "Statistics of basketball players"
```

3. Confirm the settings and then click the **+ Create** button. If the graph space is created successfully, you can see it on the graph space list.

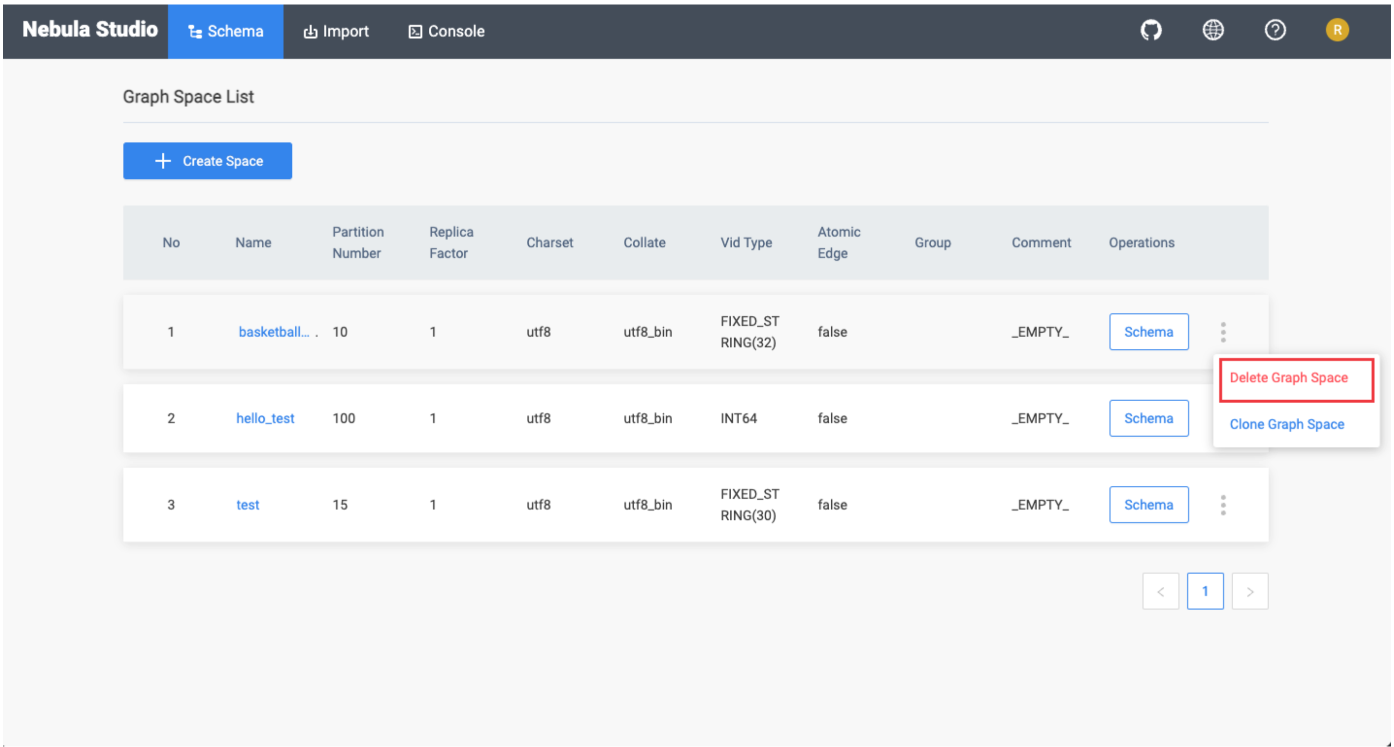

Nebula Studio
Schema
Import
Console
Graph Space List / Create Space
* Name
basketballplayer
* Vid Type
FIXED_STRING
* Length
32
Comment
Statistics of basketball players
Partition_num:(Optional)
100
Replica_factor:(Optional)
1
View nGQL
CREATE SPACE `basketballplayer` (partition_num = 100, replica_factor = 1, vid_type = FIXED_STRING(32)) COMMENT = "Statistics of basketball players"
Cancel
Create

DELETE A GRAPH SPACE

Danger

Deleting the space will delete all the data in it, and the deleted data cannot be restored if it is not backed up.

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List**, find the space you want to be deleted, and click **Delete Graph Space** in the **Operation** column.



3. On the dialog box, confirm the information and then click **OK**.

NEXT TO DO

After a graph space is created, you can create or edit a schema, including:

- Operate tags
- Operate edge types
- Operate indexes

Last update: August 11, 2022

Operate tags

After a graph space is created in NebulaGraph, you can create tags. With Studio, you can use the **Console** page or the **Schema** page to create, retrieve, update, or delete tags. This topic introduces how to use the **Schema** page to operate tags in a graph space only.

PREREQUISITES

To operate a tag on the **Schema** page of Studio, you must do a check of these:

- Studio is connected to NebulaGraph.
- A graph space is created.
- Your account has the authority of GOD, ADMIN, or DBA.

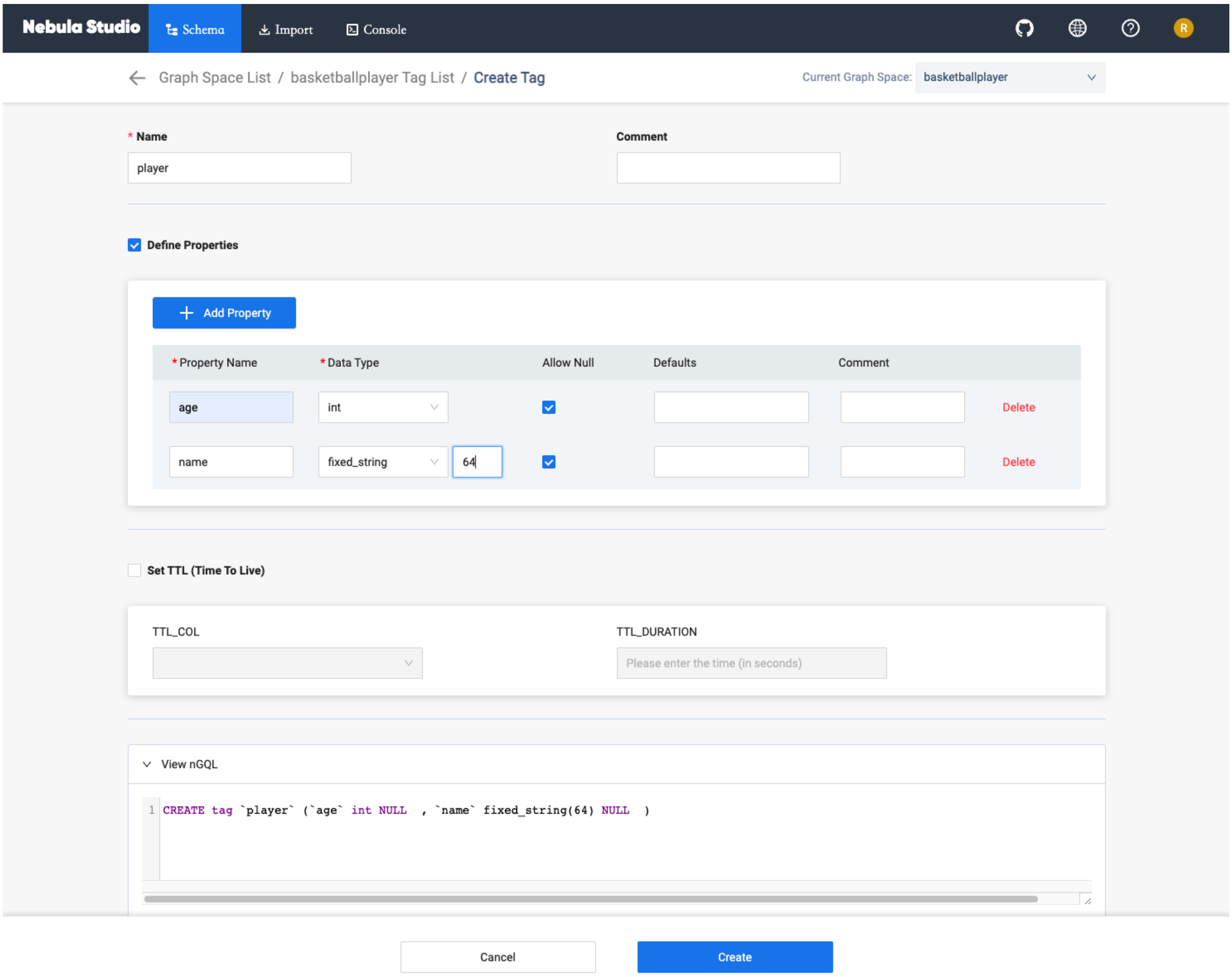
CREATE A TAG

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Tag** tab and click the **+ Create** button.
5. On the **Create** page, do these settings:

- **Name**: Specify an appropriate name for the tag. In this example, `course` is specified.
- **Comment** (Optional): Enter the description for tag.

- **Define Properties** (Optional): If necessary, click **+ Add Property** to do these settings:
- Enter a property name.
- Select a data type.
- Select whether to allow null values..
- (Optional) Enter the default value.
- (Optional) Enter the description.
- **Set TTL (Time To Live)** (Optional): If no index is set for the tag, you can set the TTL configuration: In the upper left corner of the **Set TTL** panel, click the check box to expand the panel, and configure `TTL_COL` and `TTL_ DURATION` (in seconds). For more information about both parameters, see TTL configuration.

6. When the preceding settings are completed, in the **Equivalent to the following nGQL statement** panel, you can see the nGQL statement equivalent to these settings.



7. Confirm the settings and then click the **+ Create** button.

   When the tag is created successfully, the **Define Properties** panel shows all its properties on the list.

EDIT A TAG

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Tag** tab, find a tag and then click the button  in the **Operations** column.

5. On the **Edit** page, do these operations:

- To edit a Comment: Click **Edit** on the right of `Comment`.
- To edit a property: On the **Define Properties** panel, find a property, click **Edit**, and then change the data type or the default value.
- To delete a property: On the **Define Properties** panel, find a property, click **Delete**.
- To add more properties: On the **Define Properties** panel, click the **Add Property** button to add a new property.
- To set the TTL configuration: In the upper left corner of the **Set TTL** panel, click the check box and then set TTL.
- To delete the TTL configuration: When the **Set TTL** panel is expanded, in the upper left corner of the panel, click the check box to delete the configuration.
- To edit the TTL configuration: On the **Set TTL** panel, click **Edit** and then change the configuration of `TTL_COL` and `TTL_DURATION` (in seconds).

Note

The problem of coexistence of TTL and index, see [TTL]((../../3.ngql-guide/8.clauses-and-options/ttl-options.md).

DELETE A TAG

Danger

Confirm the impact before deleting the tag. The deleted data cannot be restored if it is not backup.

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Tag** tab, find an tag and then click the button  in the **Operations** column.
5. Click **OK** to confirm delete a tag in the pop-up dialog box.

NEXT TO DO

After the tag is created, you can use the **Console** page to insert vertex data one by one manually or use the **Import** page to bulk import vertex data.

Last update: August 11, 2022

Operate edge types

After a graph space is created in NebulaGraph, you can create edge types. With Studio, you can choose to use the **Console** page or the **Schema** page to create, retrieve, update, or delete edge types. This topic introduces how to use the **Schema** page to operate edge types in a graph space only.

PREREQUISITES

To operate an edge type on the **Schema** page of Studio, you must do a check of these:

- Studio is connected to NebulaGraph.
- A graph space is created.
- Your account has the authority of GOD, ADMIN, or DBA.

CREATE AN EDGE TYPE

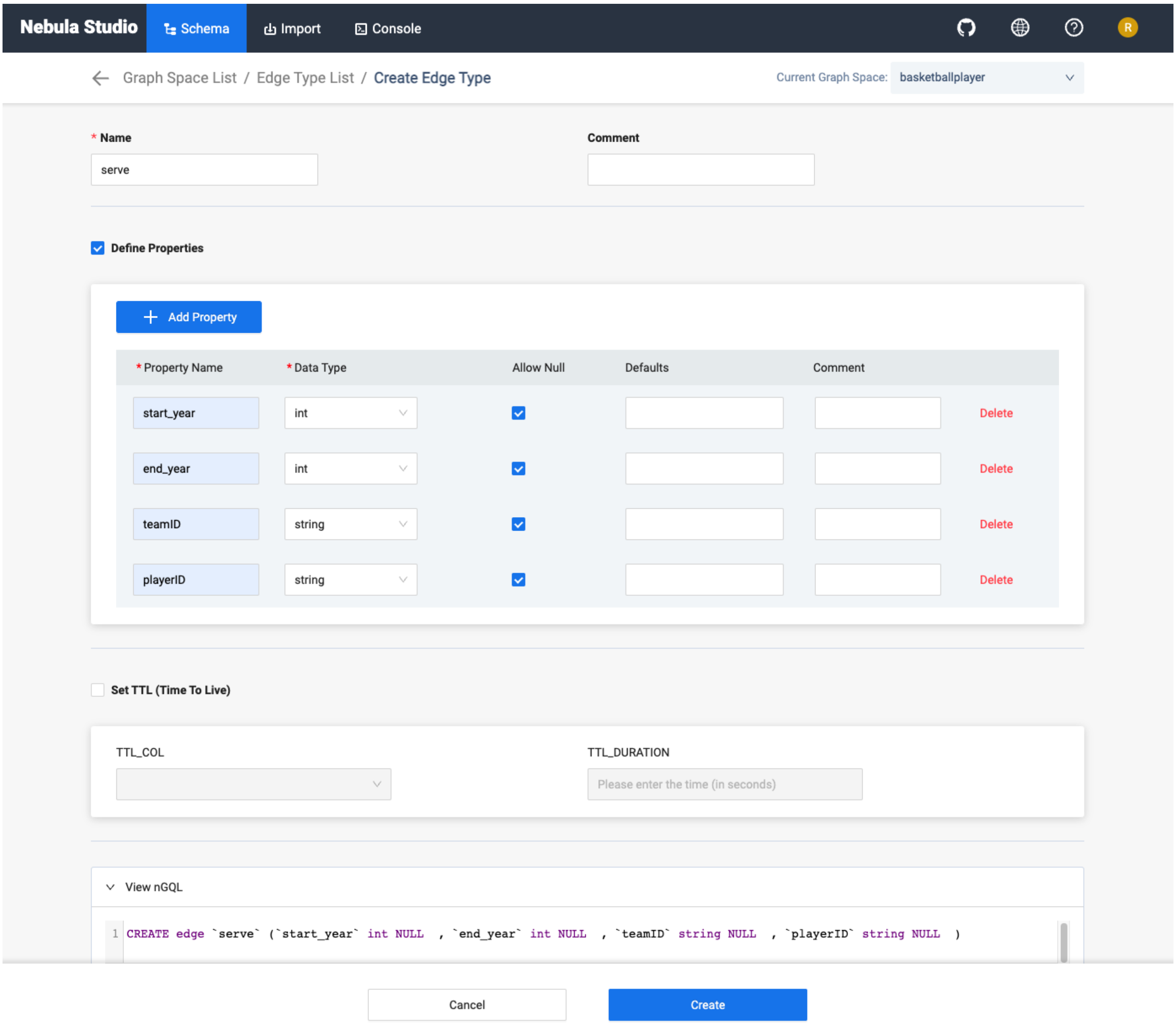
1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Edge Type** tab and click the **+ Create** button.
5. On the **Create Edge Type** page, do these settings:

- **Name**: Specify an appropriate name for the edge type. In this example, `serve` is used.
- **Comment** (Optional): Enter the description for edge type.

- **Define Properties** (Optional): If necessary, click **+ Add Property** to do these settings:
- Enter a property name.
- Select a data type.
- Select whether to allow null values..
- (Optional) Enter the default value.
- (Optional) Enter the description.

- **Set TTL (Time To Live)** (Optional): If no index is set for the edge type, you can set the TTL configuration: In the upper left corner of the **Set TTL** panel, click the check box to expand the panel, and configure `TTL_COL` and `TTL_ DURATION` (in seconds). For more information about both parameters, see TTL configuration.

6. When the preceding settings are completed, in the **Equivalent to the following nGQL statement** panel, you can see the nGQL statement equivalent to these settings.



7. Confirm the settings and then click the **+ Create** button.

   When the edge type is created successfully, the **Define Properties** panel shows all its properties on the list.

EDIT AN EDGE TYPE

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Edge Type** tab, find an edge type and then click the button  in the **Operations** column.

5. On the **Edit** page, do these operations:

- To edit a comment: Click **Edit** on the right of `Comment`.
- To edit a property: On the **Define Properties** panel, find a property, click **Edit**, and then change the data type or the default value.
- To delete a property: On the **Define Properties** panel, find a property, click **Delete**.
- To add more properties: On the **Define Properties** panel, click the **Add Property** button to add a new property.
- To set the TTL configuration: In the upper left corner of the **Set TTL** panel, click the check box and then set TTL.
- To delete the TTL configuration: When the **Set TTL** panel is expanded, in the upper left corner of the panel, click the check box to delete the configuration.
- To edit the TTL configuration: On the **Set TTL** panel, click **Edit** and then change the configuration of `TTL_COL` and `TTL_DURATION` (in seconds).

Note

For information about the coexistence problem of TTL and index, see [TTL]((../../3.ngql-guide/8.clauses-and-options/ttl-options.md).

DELETE AN EDGE TYPE

Danger

Confirm the impact before deleting the Edge type. The deleted data cannot be restored if it is not backup.

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Edge Type** tab, find an edge type and then click the button in the **Operations** column.
5. Click **OK** to confirm in the pop-up dialog box.

NEXT TO DO

After the edge type is created, you can use the **Console** page to insert edge data one by one manually or use the **Import** page to bulk import edge data.

Last update: August 11, 2022

Operate Indexes

You can create an index for a Tag and/or an Edge type. An index lets traversal start from vertices or edges with the same property and it can make a query more efficient. With Studio, you can use the **Console** page or the **Schema** page to create, retrieve, and delete indexes. This topic introduces how to use the **Schema** page to operate an index only.

> **Note**
>
> You can create an index when a Tag or an Edge Type is created. But an index can decrease the write speed during data import. We recommend that you import data firstly and then create and rebuild an index. For more information, see Index overview.

PREREQUISITES

To operate an index on the **Schema** page of Studio, you must do a check of these:

- Studio is connected to NebulaGraph.
- A graph Space, Tags, and Edge Types are created.
- Your account has the authority of GOD, ADMIN, or DBA.

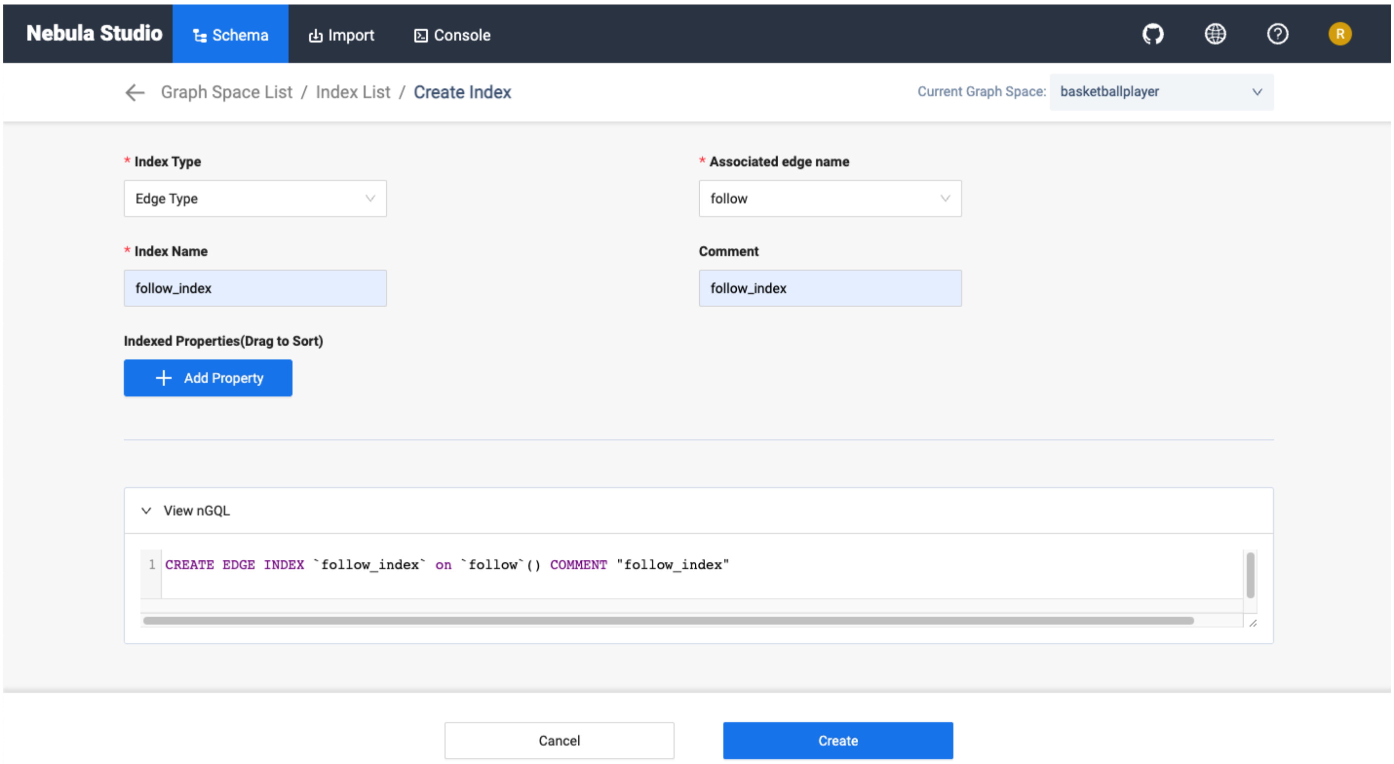
CREATE AN INDEX

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Index** tab and then click the **+ Create** button.
5. On the **Create** page, do these settings:

- **Index Type**: Choose to create an index for a tag or for an edge type. In this example, **Edge Type** is chosen.
- **Associated tag name**: Choose a tag name or an edge type name. In this example, **follow** is chosen.
- **Index Name**: Specify a name for the new index. In this example, **follow_index** is used.
- **Comment** (Optional): Enter the description for index.
- **Indexed Properties** (Optional): Click **Add property**, and then, in the dialog box, choose a property. If necessary, repeat this step to choose more properties. You can drag the properties to sort them. In this example, `degree` is chosen.

> **Note**
>
> The order of the indexed properties has an effect on the result of the `LOOKUP` statement. For more information, see nGQL Manual.

6. When the settings are done, the **Equivalent to the following nGQL statement** panel shows the statement equivalent to the settings.



7. Confirm the settings and then click the **+ Create** button. When an index is created, the index list shows the new index.

VIEW INDEXES

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Index** tab, in the upper left corner, choose an index type, **Tag** or **Edge Type**.
5. In the list, find an index and click its row. All its details are shown in the expanded row.

REBUILD INDEXES

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Index** tab, in the upper left corner, choose an index type, **Tag** or **Edge Type**.
5. Click the **Index** tab, find an index and then click the button **Rebuild** in the **Operations** column.

> **Note**
>
> For more Information, see REBUILD INDEX.

DELETE AN INDEX

To delete an index on **Schema**, follow these steps:

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. In the **Current Graph Space** field, confirm the name of the graph space. If necessary, you can choose another name to change the graph space.
4. Click the **Index** tab, find an index and then click the button in the **Operations** column.
5. Click **OK** to confirm in the pop-up dialog box.

Last update: August 11, 2022

View Schema

Users can visually view schemas in NebulaGraph Studio.

STEPS

1. In the toolbar, click the **Schema** tab.
2. In the **Graph Space List** page, find a graph space and then click its name or click **Schema** in the **Operations** column.
3. Click **View Schema** tab and click the **Get Schema** button.

OTHER OPERATIONS

In the **Graph Space List** page, find a graph space and then perform the following operations in the **Operations** column:

- View Schema DDL: Displays schema creation statements for the graph space, including graph spaces, tags, edge types, and indexes.
- Clone Graph Space: Clones the schema of the graph space to a new graph space.
- Delete Graph pace: Deletes the graph space, including the schema and all vertices and edges.

Last update: February 3, 2023

13.3.6 Schema drafting

Studio supports the schema drafting function. Users can design their schemas on the canvas to visually display the relationships between vertices and edges, and apply the schema to a specified graph space after the design is completed.

Features

- Design schema visually.
- Applies schema to a specified graph space.
- Export the schema as a PNG image.

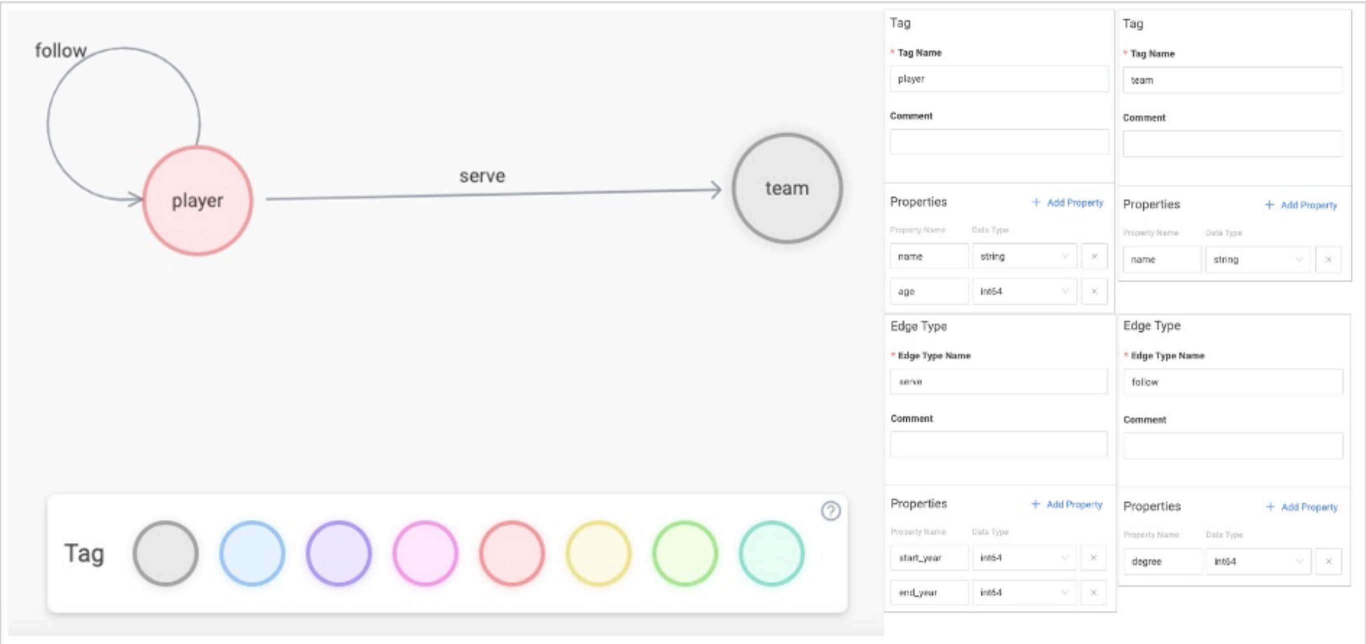
Entry

At the top navigation bar, click .

Design schema

The following steps take designing the schema of the `basketballplayer` dataset as an example to demonstrate how to use the schema drafting function.

1. At the upper left corner of the page, click **New**.
2. Create a tag by selecting the appropriate color tag under the canvas. You can hold down the left button and drag the tag into the canvas.
3. Click the tag. On the right side of the page, you need to fill in the name of the tag as `player`, and add two properties `name` and `age`.
4. Create a tag again. The name of the tag is `team`, and the property is `name`.
5. Connect from the anchor point of the tag `player` to the anchor point of the tag `team`. Click the generated edge, fill in the name of the edge type as `serve`, and add two properties `start_year` and `end_year`.
6. Connect from an anchor point of the tag `player` to another one of its own. Click the generated edge, fill in the name of the edge type as `follow`, and add a property `degree`.
7. After the design is complete, click at the top of the page to change the name of the draft, and then click at the top right corner to save the draft.



Apply schema

1. Select the draft that you want to import from the **Draft list** on the left side of the page, and then click **Apply to Space** at the upper right corner.
2. Import the schema to a new or existing space, and click **Confirm**.

Note

- For more information about the parameters for creating a graph space, see CREATE SPACE.
- If the same schema exists in the graph space, the import operation fails, and the system prompts you to modify the name or change the graph space.

Modify schema

Select the schema draft that you want to modify from the **Draft list** on the left side of the page. Click at the upper right corner after the modification.

Note

The graph space to which the schema has been applied will not be modified synchronously.

Delete schema

Select the schema draft that you want to delete from the **Draft list** on the left side of the page, click **X** at the upper right corner of the thumbnail, and confirm to delete it.

Export Schema

Click at the upper right corner to export the schema as a PNG image.

Last update: October 28, 2022

13.4 Troubleshooting

13.4.1 Connecting to the database error

Problem description

According to the connect Studio operation, it prompts **failed**.

Possible causes and solutions

You can troubleshoot the problem by following the steps below.

STEP1: CONFIRM THAT THE FORMAT OF THE HOST FIELD IS CORRECT

You must fill in the IP address (`graph_server_ip`) and port of the NebulaGraph database Graph service. If no changes are made, the port defaults to `9669`. Even if NebulaGraph and Studio are deployed on the current machine, you must use the local IP address instead of `127.0.0.1`, `localhost` or `0.0.0.0`.

STEP2: CONFIRM THAT THE USERNAME AND PASSWORD ARE CORRECT

If authentication is not enabled, you can use root and any password as the username and its password.

If authentication is enabled and different users are created and assigned roles, users in different roles log in with their accounts and passwords.

STEP3: CONFIRM THAT NEBULAGRAPH SERVICE IS NORMAL

Check NebulaGraph service status. Regarding the operation of viewing services:

- If you compile and deploy NebulaGraph on a Linux server, refer to the NebulaGraph service.
- If you use NebulaGraph deployed by Docker Compose and RPM, refer to the NebulaGraph service status and ports.

If the NebulaGraph service is normal, proceed to Step 4 to continue troubleshooting. Otherwise, please restart NebulaGraph service.

Note

If you used `docker-compose up -d` to satrt NebulaGraph before, you must run the `docker-compose down` to stop NebulaGraph.

STEP4: CONFIRM THE NETWORK CONNECTION OF THE GRAPH SERVICE IS NORMAL

Run a command (for example, telnet 9669) on the Studio machine to confirm whether NebulaGraph's Graph service network connection is normal.

If the connection fails, check according to the following steps:

- If Studio and NebulaGraph are on the same machine, check if the port is exposed.
- If Studio and NebulaGraph are not on the same machine, check the network configuration of the NebulaGraph server, such as firewall, gateway, and port.

If you cannot connect to the NebulaGraph service after troubleshooting with the above steps, please go to the NebulaGraph forum for consultation.

Last update: August 11, 2022

13.4.2 Cannot access to Studio

Problem description

I follow the document description and visit `127.0.0.1:7001` or `0.0.0.0:7001` after starting Studio, why can't I open the page?

Possible causes and solutions

You can troubleshoot the problem by following the steps below.

STEP1: CONFIRM SYSTEM ARCHITECTURE

It is necessary to confirm whether the machine where the Studio service is deployed is of x86_64 architecture. Currently, Studio only supports x86_64 architecture.

STEP2: CHECK IF THE STUDIO SERVICE STARTS NORMALLY

- For Studio deployed with RPM or DEB packages, use `systemctl status nebula-graph-studio` to see the running status.
- For Studio deployed with tar package, use `sudo lsof -i:7001` to check port status.
- For Studio deployed with docker, use `docker-compose ps` to see the running status. Run `docker-compose ps` to check if the service has started normally.

  If the service is normal, the return result is as follows. Among them, the `State` column should all be displayed as `Up`.

```
    Name                          Command               State              Ports
------------------------------------------------------------------------------------------------------
nebula-web-docker_client_1     ./nebula-go-api                  Up      0.0.0.0:32782->8080/tcp
nebula-web-docker_importer_1   nebula-importer --port=569 ...   Up      0.0.0.0:32783->5699/tcp
nebula-web-docker_nginx_1      /docker-entrypoint.sh ngin ...   Up      0.0.0.0:7001->7001/tcp, 80/tcp
nebula-web-docker_web_1        docker-entrypoint.sh npm r ...   Up      0.0.0.0:32784->7001/tcp
```

If the above result is not returned, stop Studio and restart it first. For details, refer to Deploy Studio.

!!! note

```
If you used `docker-compose up -d` to satrt NebulaGraph before, you must run the `docker-compose down` to stop NebulaGraph.
```

STEP3: CONFIRM ADDRESS

If Studio and the browser are on the same machine, users can use `localhost:7001`, `127.0.0.1:7001` or `0.0.0.0:7001` in the browser to access Studio.

If Studio and the browser are not on the same machine, you must enter `<studio_server_ip>:7001` in the browser. Among them, `studio_server_ip` refers to the IP address of the machine where the Studio service is deployed.

STEP4: CONFIRM NETWORK CONNECTION

Run `curl <studio_server_ip>:7001` -I to confirm if it is normal. If it returns `HTTP/1.1 200 OK`, it means that the network is connected normally.

If the connection is refused, check according to the following steps:

If the connection fails, check according to the following steps:

- If Studio and NebulaGraph are on the same machine, check if the port is exposed.
- If Studio and NebulaGraph are not on the same machine, check the network configuration of the NebulaGraph server, such as firewall, gateway, and port.

If you cannot connect to the NebulaGraph service after troubleshooting with the above steps, please go to the NebulaGraph forum for consultation.

Last update: August 11, 2022

13.4.3 FAQ

Why can't I use a function?

If you find that a function cannot be used, it is recommended to troubleshoot the problem according to the following steps:

1. Confirm that NebulaGraph is the latest version. If you use Docker Compose to deploy the NebulaGraph database, it is recommended to run `docker-compose pull && docker-compose up -d` to pull the latest Docker image and start the container.
2. Confirm that Studio is the latest version. For more information, refer to check updates.
3. Search the nebula forum, nebula and nebula-studio projects on the GitHub to confirm if there are already similar problems.
4. If none of the above steps solve the problem, you can submit a problem on the forum.

Last update: January 6, 2023

14. NebulaGraph Dashboard Community Edition

14.1 What is NebulaGraph Dashboard Community Edition

NebulaGraph Dashboard Community Edition (Dashboard for short) is a visualization tool that monitors the status of machines and services in NebulaGraph clusters.

Enterpriseonly

Dashboard Enterprise Edition adds features such as visual cluster creation, batch import of clusters, fast scaling, etc. For more information, see Pricing.

14.1.1 Features

Dashboard monitors:

- The status of all the machines in clusters, including CPU, memory, load, disk, and network.
- The information of all the services in clusters, including the IP addresses, versions, and monitoring metrics (such as the number of queries, the latency of queries, the latency of heartbeats, and so on).
- The information of clusters, including the information of services, partitions, configurations, and long-term tasks.
- Set how often the metrics page refreshes.

14.1.2 Scenarios

You can use Dashboard in one of the following scenarios:

- You want to monitor key metrics conveniently and quickly, and present multiple key information of the business to ensure the business operates normally.
- You want to monitor clusters from multiple dimensions (such as the time, aggregate rules, and metrics).
- After a failure occurs, you need to review it and confirm its occurrence time and unexpected phenomena.

14.1.3 Precautions

The monitoring data will be retained for 14 days by default, that is, only the monitoring data within the last 14 days can be queried.

Note

The monitoring service is supported by Prometheus. The update frequency and retention intervals can be modified. For details, see Prometheus.

14.1.4 Version compatibility

The version correspondence between NebulaGraph and Dashboard Community Edition is as follows.

NebulaGraph version	Dashboard version
3.5.0	3.5.0
3.4.0 ~ 3.4.1	3.5.0、3.4.0、3.2.0
3.3.0	3.2.0
2.5.0 ~ 3.2.0	3.1.0
2.5.x ~ 3.1.0	1.1.1
2.0.1~2.5.1	1.0.2
2.0.1~2.5.1	1.0.1

14.1.5 Release note

Release

Last update: May 19, 2023

14.2 Deploy Dashboard Community Edition

This topic will describe how to deploy NebulaGraph Dashboard in detail.

To download and compile the latest source code of Dashboard, follow the instructions on the nebula dashboard GitHub page.

14.2.1 Prerequisites

Before you deploy Dashboard, you must confirm that:

- The NebulaGraph services are deployed and started. For more information, see NebulaGraph Database Manual.

- Before the installation starts, the following ports are not occupied.
- 9200
- 9100
- 9090
- 8090
- 7003

- The node-exporter is installed on the machines to be monitored. For details on installation, see Prometheus document.

14.2.2 Steps

1. Download the tar packagenebula-dashboard-3.5.0.x86_64.tar.gz as needed.
2. Run `tar -xvf nebula-dashboard-3.5.0.x86_64.tar.gz` to decompress the installation package.
3. Modify the `config.yaml` file in `nebula-dashboard`.

The configuration file contains the configurations of four dependent services and configurations of clusters. The descriptions of the dependent services are as follows.

Service	Default port	Description
nebula-http-gateway	8090	Provides HTTP ports for cluster services to execute nGQL statements to interact with the NebulaGraph database.
nebula-stats-exporter	9200	Collects the performance metrics in the cluster, including the IP addresses, versions, and monitoring metrics (such as the number of queries, the latency of queries, the latency of heartbeats, and so on).
node-exporter	9100	Collects the source information of nodes in the cluster, including the CPU, memory, load, disk, and network.
prometheus	9090	The time series database that stores monitoring data.

The descriptions of the configuration file are as follows.

```
port: 7003   # Web service port.
gateway:
  ip: hostIP   # The IP of the machine where the Dashboard is deployed.
  port: 8090
  https: false  # Whether to enable HTTPS.
  runmode: dev  # Program running mode, including dev, test, and prod. It is used to distinguish between different running environments generally.
stats-exporter:
  ip: hostIP   # The IP of the machine where the Dashboard is deployed.
  nebulaPort: 9200
  https: false  # Whether to enable HTTPS.
node-exporter:
  - ip: nebulaHostIP_1 # The IP of the machine where the NebulaGraph is deployed.
    port: 9100
    https: false # Whether to enable HTTPS.
# - ip: nebulaHostIP_2
```

```
#   port: 9100
#   https: false
prometheus:
  ip: hostIP    # The IP of the machine where the Dashboard is deployed.
  prometheusPort: 9090
  https: false  # Whether to enable HTTPS.
  scrape_interval: 5s  # The interval for collecting the monitoring data, which is 1 minute by default.
  evaluation_interval: 5s  # The interval for running alert rules, which is 1 minute by default.
# Cluster node info
nebula-cluster:
  name: 'default' # Cluster name
  metad:
    - name: metad0
      endpointIP: nebulaMetadIP  # The IP of the machine where the Meta service is deployed.
      port: 9559
      endpointPort: 19559
  # - name: metad1
  #   endpointIP: nebulaMetadIP
  #   port: 9559
  #   endpointPort: 19559
  graphd:
    - name: graphd0
      endpointIP: nebulaGraphdIP  # The IP of the machine where the Graph service is deployed.
      port: 9669
      endpointPort: 19669
  # - name: graphd1
  #   endpointIP: nebulaGraphdIP
  #   port: 9669
  #   endpointPort: 19669
  storaged:
    - name: storaged0
      endpointIP: nebulaStoragedIP  # The IP of the machine where the Storage service is deployed.
      port: 9779
      endpointPort: 19779
  # - name: storaged1
  #   endpointIP: nebulaStoragedIP
  #   port: 9779
  #   endpointPort: 19779
```

4. Run `./dashboard.service start all` to start the services.

Deploy Dashboard with Docker Compose

If you are deploying Dashboard using docker, you should also modify the configuration file `config.yaml`, and then run `docker-compose up -d` to start the container.

Note

If you change the port number in `config.yaml`, the port number in `docker-compose.yaml` needs to be consistent as well.

Run `docker-compose stop` to stop the container.

14.2.3 Manage services in Dashboard

You can use the `dashboard.service` script to start, restart, stop, and check the Dashboard services.

```
sudo <dashboard_path>/dashboard.service
[-v] [-h]
<start|restart|stop|status>  <prometheus|webserver|exporter|gateway|all>
```

Parameter	Description
`dashboard_path`	Dashboard installation path.
`-v`	Display detailed debugging information.
`-h`	Display help information.
`start`	Start the target services.
`restart`	Restart the target services.
`stop`	Stop the target services.
`status`	Check the status of the target services.
`prometheus`	Set the prometheus service as the target service.
`webserver`	Set the webserver Service as the target service.
`exporter`	Set the exporter Service as the target service.
`gateway`	Set the gateway Service as the target service.
`all`	Set all the Dashboard services as the target services.

Note

To view the Dashboard version, run the command `./dashboard.service -version`.

14.2.4 Next to do

Connect to Dashboard

Last update: February 3, 2023

14.3 Connect Dashboard

After Dashboard is deployed, you can log in and use Dashboard on the browser.

14.3.1 Prerequisites

- The Dashboard services are started. For more information, see Deploy Dashboard.
- We recommend you to use the Chrome browser of the version above 89. Otherwise, there may be compatibility issues.

14.3.2 Procedures

1. Confirm the IP address of the machine where the Dashboard service is installed. Enter `<IP>:7003` in the browser to open the login page.
2. Enter the username and the passwords of the NebulaGraph database.

- If authentication is enabled, you can log in with the created accounts.
- If authentication is not enabled, you can only log in using `root` as the username and random characters as the password.

To enable authentication, see Authentication.

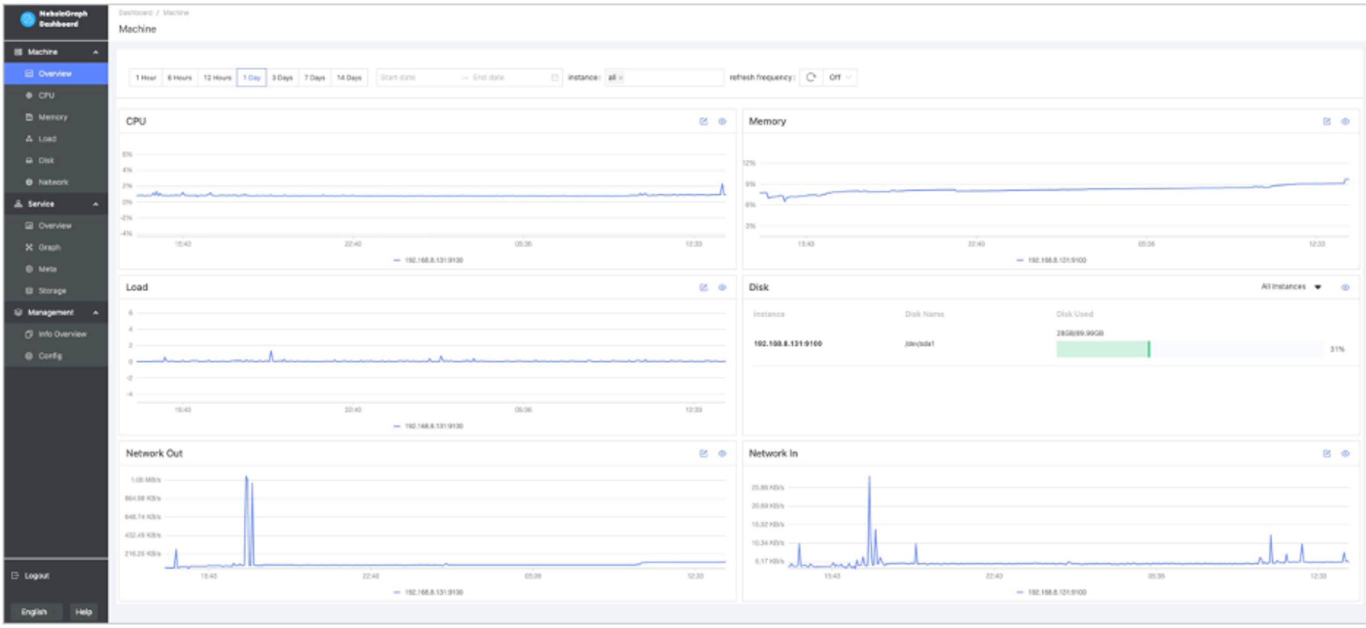
3. Select the NebulaGraph version to be used.
4. Click **Login**.

Last update: February 3, 2023

14.4 Dashboard

NebulaGraph Dashboard consists of three parts: Machine, Service, and Management. This topic will describe them in detail.

14.4.1 Overview

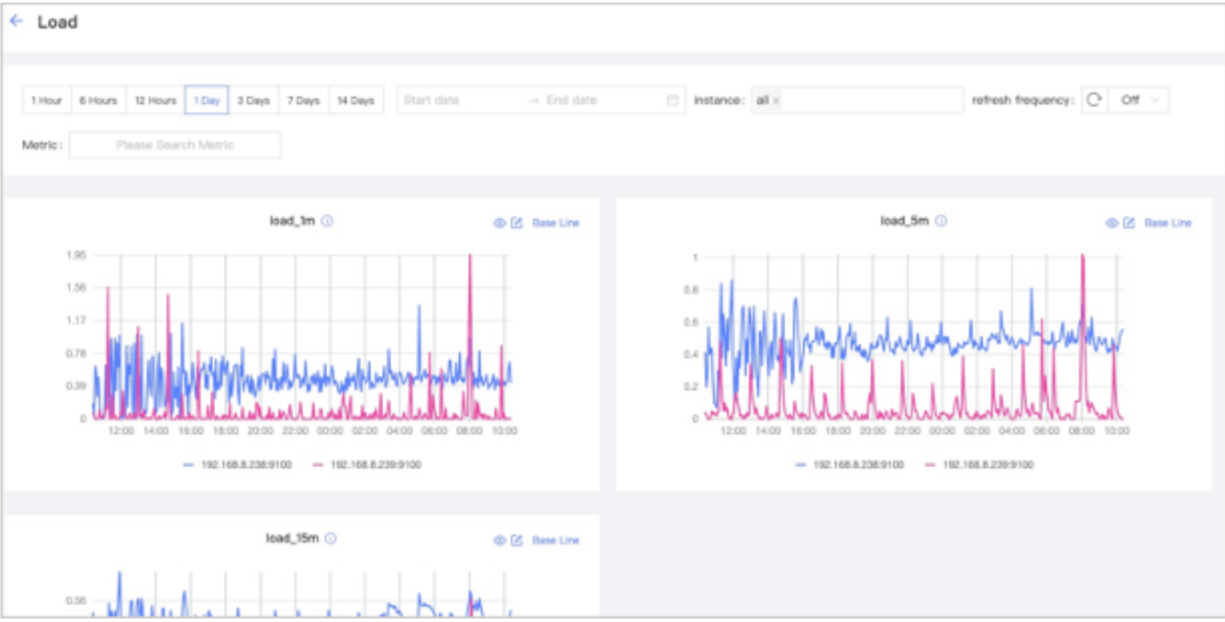


14.4.2 Machine

Click **Machine**->**Overview** to enter the machine overview page.

On this page, you can view the variation of CPU, Memory, Load, Disk, and Network In/Out quickly.

- By default, you can view the monitoring data for a maximum of 14 days. You can also select a time range or quickly select the latest 1 hour, 6 hours, 12 hours, 1 day, 3 days, 7 days, or 14 days.
- By default, you can view the monitoring data of all the instances in clusters. You can select the instances you want to view in the **instance** box.
- By default, the monitoring information page will not be updated automatically. You can set the update frequency of the monitoring information page globally or click the  button to update the page manually.
- To set a base line, click the  button.
- To view the detailed monitoring information, click the  button. In this example, select `Load` for details. The figure is as follows.



- You can set the monitoring time range, instance, update frequency and base line.
- You can search for or select the target metric. For details about monitoring metrics, see Metrics.
- You can temporarily hide nodes that you do not need to view.
- You can click the  button to view the detailed monitoring information.

14.4.3 Service

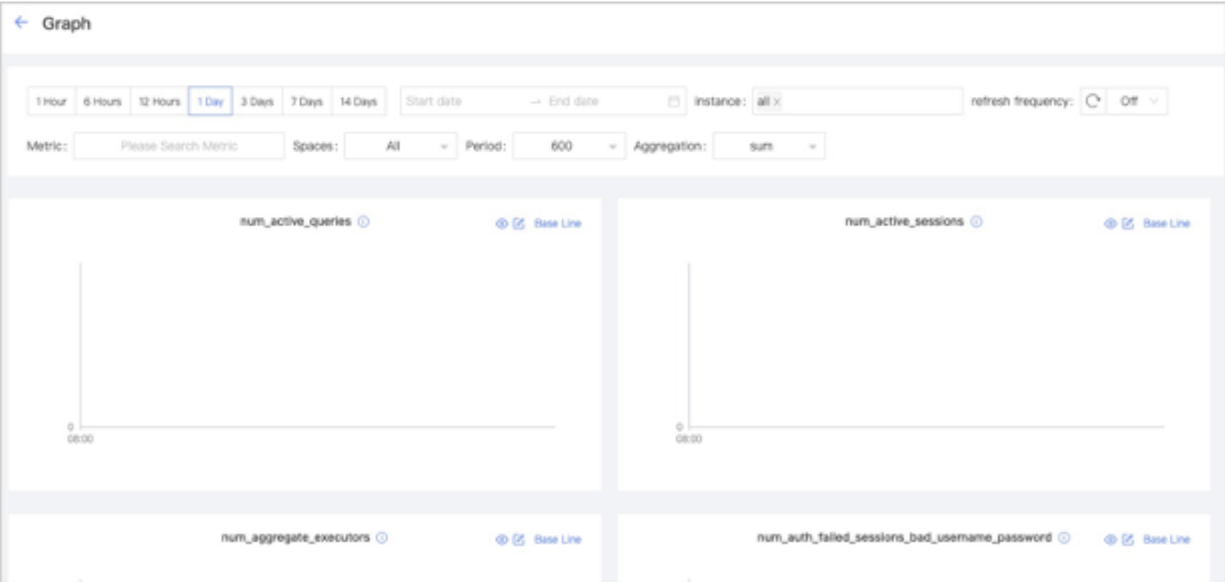
Click **Service**->**Overview** to enter the service overview page.

On this page, you can view the information of Graph, Meta, and Storage services quickly. In the upper right corner, the number of normal services and abnormal services will be displayed.

Note

In the **Service** page, only two monitoring metrics can be set for each service, which can be adjusted by clicking the **Set up** button.

- By default, you can view the monitoring data for a maximum of 14 days. You can also select a time range or quickly select the latest 1 hour, 6 hours, 12 hours, 1 day, 3 days, 7 days, or 14 days.
- By default, you can view the monitoring data of all the instances in clusters. You can select the instances you want to view in the **instance** box.
- By default, the monitoring information page will not be updated automatically. You can set the update frequency of the monitoring information page globally or click the button to update the page manually.
- You can view the status of all the services in a cluster.
- To view the detailed monitoring information, click the button. In this example, select `Graph` for details. The figure is as follows.



- You can set the monitoring time range, instance, update frequency, period, aggregation and base line.
- You can search for or select the target metric. For details of monitoring metrics, see Monitor parameter.
- You can temporarily hide nodes that you do not need to view.
- You can click the button to view the detailed monitoring information.
- The Graph service supports a set of space-level metrics. For more information, see the following section **Graph space**.

Graph space

Note

Before using graph space metrics, you need to set `enable_space_level_metrics` to `true` in the Graph service. For details, see [Graph Service configuration](../5.configurations-and-logs/1.configurations/3.graph-config.md).

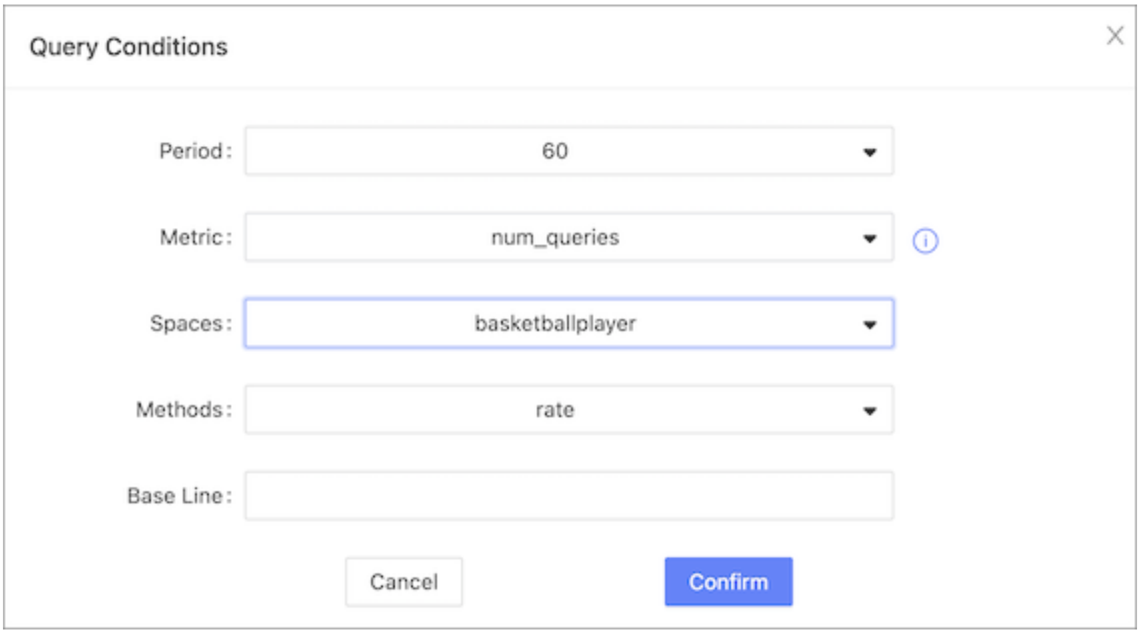
Space-level metric incompatibility

If a graph space name contains special characters, the corresponding metric data of that graph space may not be displayed.

The service monitoring page can also monitor graph space level metrics. **Only when the behavior of a graph space metric is triggered, you can specify the graph space to view information about the corresponding graph space metric**.

Space graph metrics record the information of different graph spaces separately. Currently, only the Graph service supports a set of space-level metrics.

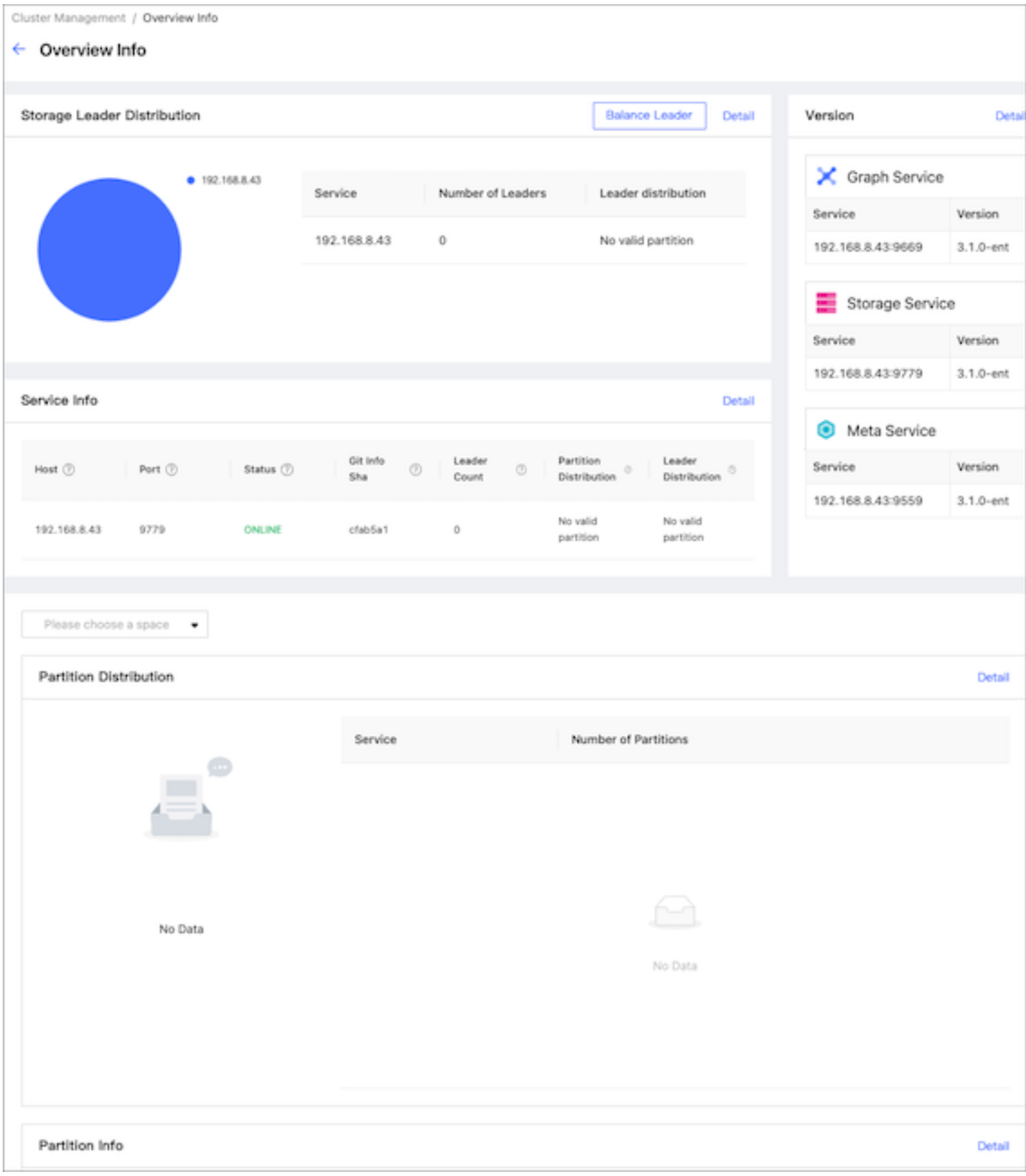
For information about the space graph metrics, see Graph space.



14.4.4 Management

Overview info

On the **Overview Info** page, you can see the information of the NebulaGraph cluster, including Storage leader distribution, Storage service details, versions and hosts information of each NebulaGraph service, and partition distribution and details.



STORAGE LEADER DISTRIBUTION

In this section, the number of Leaders and the Leader distribution will be shown.

- Click the **Balance Leader** button in the upper right corner to distribute Leaders evenly and quickly in the NebulaGraph cluster. For details about the Leader, see Storage Service.
- Click **Detail** in the upper right corner to view the details of the Leader distribution.

VERSION

In this section, the version and host information of each NebulaGraph service will be shown. Click **Detail** in the upper right corner to view the details of the version and host information.

SERVICE INFORMATION

In this section, the information on Storage services will be shown. The parameter description is as follows:

Parameter	Description
`Host`	The IP address of the host.
`Port`	The port of the host.
`Status`	The host status.
`Git Info Sha`	The commit ID of the current version.
`Leader Count`	The number of Leaders.
`Partition Distribution`	The distribution of partitions.
`Leader Distribution`	The distribution of Leaders.

Click **Detail** in the upper right corner to view the details of the Storage service information.

PARTITION DISTRIBUTION

Select the specified graph space in the upper left corner, you can view the distribution of partitions in the specified graph space. You can see the IP addresses and ports of all Storage services in the cluster, and the number of partitions in each Storage service.

Click **Detail** in the upper right corner to view more details.

PARTITION INFORMATION

In this section, the information on partitions will be shown. Before viewing the partition information, you need to select a graph space in the upper left corner. The parameter description is as follows:

Parameter	Description
`Partition ID`	The ID of the partition.
`Leader`	The IP address and port of the leader.
`Peers`	The IP addresses and ports of all the replicas.
`Losts`	The IP addresses and ports of faulty replicas.

Click **Detail** in the upper right corner to view details. You can also enter the partition ID into the input box in the upper right corner of the details page to filter the shown data.

Config

It shows the configuration of the NebulaGraph service. NebulaGraph Dashboard Community Edition does not support online modification of configurations for now.

14.4.5 Others

In the lower left corner of the page, you can:

- Sign out
- Switch between Chinese and English
- View the current Dashboard release
- View the user manual and forum
- Fold the sidebar

Last update: February 3, 2023

14.5 Metrics

This topic will describe the monitoring metrics in NebulaGraph Dashboard.

14.5.1 Machine

Note

- All the machine metrics listed below are for the Linux operating system.
- The default unit in **Disk** and **Network** is byte. The unit will change with the data magnitude as the page displays. For example, when the flow is less than 1 KB/s, the unit will be Bytes/s.
- For versions of Dashboard Community Edition greater than v1.0.2, the memory occupied by Buff and Cache will not be counted in the memory usage.

CPU

Parameter	Description
`cpu_utilization`	The percentage of used CPU.
`cpu_idle`	The percentage of idled CPU.
`cpu_wait`	The percentage of CPU waiting for IO operations.
`cpu_user`	The percentage of CPU used by users.
`cpu_system`	The percentage of CPU used by the system.

Memory

Parameter	Description
`memory_utilization`	The percentage of used memory.
`memory_used`	The memory space used (not including caches).
`memory_free`	The memory space available.

Load

Parameter	Description
`load_1m`	The average load of the system in the last 1 minute.
`load_5m`	The average load of the system in the last 5 minutes.
`load_15m`	The average load of the system in the last 15 minutes.

Disk

Parameter	Description
`disk_used_percentage`	The disk utilization percentage.
`disk_used`	The disk space used.
`disk_free`	The disk space available.
`disk_readbytes`	The number of bytes that the system reads in the disk per second.
`disk_writebytes`	The number of bytes that the system writes in the disk per second.
`disk_readiops`	The number of read queries that the disk receives per second.
`disk_writeiops`	The number of write queries that the disk receives per second.
`inode_utilization`	The percentage of used inode.

Network

Parameter	Description
`network_in_rate`	The number of bytes that the network card receives per second.
`network_out_rate`	The number of bytes that the network card sends out per second.
`network_in_errs`	The number of wrong bytes that the network card receives per second.
`network_out_errs`	The number of wrong bytes that the network card sends out per second.
`network_in_packets`	The number of data packages that the network card receives per second.
`network_out_packets`	The number of data packages that the network card sends out per second.

14.5.2 Service

Period

The period is the time range of counting metrics. It currently supports 5 seconds, 60 seconds, 600 seconds, and 3600 seconds, which respectively represent the last 5 seconds, the last 1 minute, the last 10 minutes, and the last 1 hour.

Metric methods

Parameter	Description
`rate`	The average rate of operations per second in a period.
`sum`	The sum of operations in the period.
`avg`	The average latency in the cycle.
`P75`	The 75th percentile latency.
`P95`	The 95th percentile latency.
`P99`	The 99th percentile latency.
`P999`	The 99.9th percentile latency.

Note

Dashboard collects the following metrics from the NebulaGraph core, but only shows the metrics that are important to it.

Graph

Parameter	Description
`num_active_queries`	The number of changes in the number of active queries. Formula: The number of started queries minus the number of finished queries within a specified time.
`num_active_sessions`	The number of changes in the number of active sessions. Formula: The number of logged in sessions minus the number of logged out sessions within a specified time. For example, when querying `num_active_sessions.sum.5`, if there were 10 sessions logged in and 30 sessions logged out in the last 5 seconds, the value of this metric is `-20` (10-30).
`num_aggregate_executors`	The number of executions for the Aggregation operator.
`num_auth_failed_sessions_bad_username_password`	The number of sessions where authentication failed due to incorrect username and password.
`num_auth_failed_sessions_out_of_max_allowed`	The number of sessions that failed to authenticate logins because the value of the parameter `FLAG_OUT_OF_MAX_ALLOWED_CONNECTIONS` was exceeded.
`num_auth_failed_sessions`	The number of sessions in which login authentication failed.
`num_indexscan_executors`	The number of executions for index scan operators.
`num_killed_queries`	The number of killed queries.
`num_opened_sessions`	The number of sessions connected to the server.
`num_queries`	The number of queries.
`num_query_errors_leader_changes`	The number of the raft leader changes due to query errors.
`num_query_errors`	The number of query errors.
`num_reclaimed_expired_sessions`	The number of expired sessions actively reclaimed by the server.
`num_rpc_sent_to_metad_failed`	The number of failed RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_metad`	The number of RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_storaged_failed`	The number of failed RPC requests that the Graphd service sent to the Storaged service.
`num_rpc_sent_to_storaged`	The number of RPC requests that the Graphd service sent to the Storaged service.
`num_sentences`	The number of statements received by the Graphd service.
`num_slow_queries`	The number of slow queries.
`num_sort_executors`	The number of executions for the Sort operator.
`optimizer_latency_us`	The latency of executing optimizer statements.
`query_latency_us`	The latency of queries.
`slow_query_latency_us`	The latency of slow queries.
`num_queries_hit_memory_watermark`	The number of queries reached the memory watermark.

Meta

Parameter	Description
`commit_log_latency_us`	The latency of committing logs in Raft.
`commit_snapshot_latency_us`	The latency of committing snapshots in Raft.
`heartbeat_latency_us`	The latency of heartbeats.
`num_heartbeats`	The number of heartbeats.
`num_raft_votes`	The number of votes in Raft.
`transfer_leader_latency_us`	The latency of transferring the raft leader.
`num_agent_heartbeats`	The number of heartbeats for the AgentHBProcessor.
`agent_heartbeat_latency_us`	The latency of the AgentHBProcessor.
`replicate_log_latency_us`	The latency of replicating the log record to most nodes by Raft.
`num_send_snapshot`	The number of times that Raft sends snapshots to other nodes.
`append_log_latency_us`	The latency of replicating the log record to a single node by Raft.
`append_wal_latency_us`	The Raft write latency for a single WAL.
`num_grant_votes`	The number of times that Raft votes for other nodes.
`num_start_elect`	The number of times that Raft starts an election.

Storage

Parameter	Description
`add_edges_latency_us`	The latency of adding edges.
`add_vertices_latency_us`	The latency of adding vertices.
`commit_log_latency_us`	The latency of committing logs in Raft.
`commit_snapshot_latency_us`	The latency of committing snapshots in Raft.
`delete_edges_latency_us`	The latency of deleting edges.
`delete_vertices_latency_us`	The latency of deleting vertices.
`get_neighbors_latency_us`	The latency of querying neighbor vertices.
`get_dst_by_src_latency_us`	The latency of querying the destination vertex by the source vertex.
`num_get_prop`	The number of executions for the GetPropProcessor.
`num_get_neighbors_errors`	The number of execution errors for the GetNeighborsProcessor.
`num_get_dst_by_src_errors`	The number of execution errors for the GetDstBySrcProcessor.
`get_prop_latency_us`	The latency of executions for the GetPropProcessor.
`num_edges_deleted`	The number of deleted edges.
`num_edges_inserted`	The number of inserted edges.
`num_raft_votes`	The number of votes in Raft.
`num_rpc_sent_to_metad_failed`	The number of failed RPC requests that the Storage service sent to the Meta service.
`num_rpc_sent_to_metad`	The number of RPC requests that the Storaged service sent to the Metad service.
`num_tags_deleted`	The number of deleted tags.
`num_vertices_deleted`	The number of deleted vertices.
`num_vertices_inserted`	The number of inserted vertices.
`transfer_leader_latency_us`	The latency of transferring the raft leader.
`lookup_latency_us`	The latency of executions for the LookupProcessor.
`num_lookup_errors`	The number of execution errors for the LookupProcessor.
`num_scan_vertex`	The number of executions for the ScanVertexProcessor.
`num_scan_vertex_errors`	The number of execution errors for the ScanVertexProcessor.
`update_edge_latency_us`	The latency of executions for the UpdateEdgeProcessor.
`num_update_vertex`	The number of executions for the UpdateVertexProcessor.
`num_update_vertex_errors`	The number of execution errors for the UpdateVertexProcessor.
`kv_get_latency_us`	The latency of executions for the Getprocessor.
`kv_put_latency_us`	The latency of executions for the PutProcessor.
`kv_remove_latency_us`	The latency of executions for the RemoveProcessor.
`num_kv_get_errors`	The number of execution errors for the GetProcessor.
`num_kv_get`	The number of executions for the GetProcessor.
`num_kv_put_errors`	The number of execution errors for the PutProcessor.
`num_kv_put`	The number of executions for the PutProcessor.

Parameter	Description
`num_kv_remove_errors`	The number of execution errors for the RemoveProcessor.
`num_kv_remove`	The number of executions for the RemoveProcessor.
`forward_tranx_latency_us`	The latency of transmission.
`scan_edge_latency_us`	The latency of executions for the ScanEdgeProcessor.
`num_scan_edge_errors`	The number of execution errors for the ScanEdgeProcessor.
`num_scan_edge`	The number of executions for the ScanEdgeProcessor.
`scan_vertex_latency_us`	The latency of executions for the ScanVertexProcessor.
`num_add_edges`	The number of times that edges are added.
`num_add_edges_errors`	The number of errors when adding edges.
`num_add_vertices`	The number of times that vertices are added.
`num_start_elect`	The number of times that Raft starts an election.
`num_add_vertices_errors`	The number of errors when adding vertices.
`num_delete_vertices_errors`	The number of errors when deleting vertices.
`append_log_latency_us`	The latency of replicating the log record to a single node by Raft.
`num_grant_votes`	The number of times that Raft votes for other nodes.
`replicate_log_latency_us`	The latency of replicating the log record to most nodes by Raft.
`num_delete_tags`	The number of times that tags are deleted.
`num_delete_tags_errors`	The number of errors when deleting tags.
`num_delete_edges`	The number of edge deletions.
`num_delete_edges_errors`	The number of errors when deleting edges
`num_send_snapshot`	The number of times that snapshots are sent.
`update_vertex_latency_us`	The latency of executions for the UpdateVertexProcessor.
`append_wal_latency_us`	The Raft write latency for a single WAL.
`num_update_edge`	The number of executions for the UpdateEdgeProcessor.
`delete_tags_latency_us`	The latency of deleting tags.
`num_update_edge_errors`	The number of execution errors for the UpdateEdgeProcessor.
`num_get_neighbors`	The number of executions for the GetNeighborsProcessor.
`num_get_dst_by_src`	The number of executions for the GetDstBySrcProcessor.
`num_get_prop_errors`	The number of execution errors for the GetPropProcessor.
`num_delete_vertices`	The number of times that vertices are deleted.
`num_lookup`	The number of executions for the LookupProcessor.
`num_sync_data`	The number of times the Storage service synchronizes data from the Drainer.
`num_sync_data_errors`	The number of errors that occur when the Storage service synchronizes data from the Drainer.
`sync_data_latency_us`	The latency of the Storage service synchronizing data from the Drainer.

Graph space

Note

Space-level metrics are created dynamically, so that only when the behavior is triggered in the graph space, the corresponding metric is created and can be queried by the user.

Parameter	Description
`num_active_queries`	The number of queries currently being executed.
`num_queries`	The number of queries.
`num_sentences`	The number of statements received by the Graphd service.
`optimizer_latency_us`	The latency of executing optimizer statements.
`query_latency_us`	The latency of queries.
`num_slow_queries`	The number of slow queries.
`num_query_errors`	The number of query errors.
`num_query_errors_leader_changes`	The number of raft leader changes due to query errors.
`num_killed_queries`	The number of killed queries.
`num_aggregate_executors`	The number of executions for the Aggregation operator.
`num_sort_executors`	The number of executions for the Sort operator.
`num_indexscan_executors`	The number of executions for index scan operators.
`num_auth_failed_sessions_bad_username_password`	The number of sessions where authentication failed due to incorrect username and password.
`num_auth_failed_sessions`	The number of sessions in which login authentication failed.
`num_opened_sessions`	The number of sessions connected to the server.
`num_queries_hit_memory_watermark`	The number of queries reached the memory watermark.
`num_reclaimed_expired_sessions`	The number of expired sessions actively reclaimed by the server.
`num_rpc_sent_to_metad_failed`	The number of failed RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_metad`	The number of RPC requests that the Graphd service sent to the Metad service.
`num_rpc_sent_to_storaged_failed`	The number of failed RPC requests that the Graphd service sent to the Storaged service.
`num_rpc_sent_to_storaged`	The number of RPC requests that the Graphd service sent to the Storaged service.
`slow_query_latency_us`	The latency of slow queries.

Last update: October 20, 2022

15. NebulaGraph Importer

15.1 NebulaGraph Importer

NebulaGraph Importer (Importer) is a standalone tool for importing data from CSV files into NebulaGraph. Importer can read and import CSV file data from multiple data sources.

15.1.1 Features

- Support multiple data sources, including local, S3, OSS, HDFS, FTP, and SFTP.
- Support importing data from CSV format files. A single file can contain multiple tags, multiple edge types or a mix of both.
- Support connecting to multiple Graph services simultaneously for importing and dynamic load balancing.
- Support reconnect or retry after failure.
- Support displaying statistics in multiple dimensions, including import time, import percentage, etc. Support for printing statistics in Console or logs.

15.1.2 Advantage

- Lightweight and fast: no complex environment can be used, fast data import.
- Flexible filtering: You can flexibly filter CSV data through configuration files.

15.1.3 Release note

Release

15.1.4 Prerequisites

Before using NebulaGraph Importer, make sure:

- NebulaGraph service has been deployed. There are currently three deployment modes:
- Deploy NebulaGraph with Docker Compose
- Install NebulaGraph with RPM or DEB package
- Install NebulaGraph by compiling the source code

- Schema is created in NebulaGraph, including space, Tag and Edge type, or set by parameter `manager.hooks.before.statements`.

15.1.5 Steps

Prepare the CSV file to be imported and configure the YAML file to use the tool to batch write data into NebulaGraph.

Note

For details about the YAML configuration file, see configuration file description at the end of topic.

Download binary package and run

1. Download the executable binary package.
2. Start the service.

```
$ ./<binary_package_name> --config <yaml_config_file_path>
```

Source code compile and run

Compiling the source code requires deploying a Golang environment. For details, see Build Go environment.

1. Clone repository.

```
$ git clone -b release-4.0 https://github.com/vesoft-inc/nebula-importer.git
```

Note

Use the correct branch. Different branches have different RPC protocols.

2. Access the directory `nebula-importer`.

```
$ cd nebula-importer
```

3. Compile the source code.

```
$ make build
```

4. Start the service.

```
$ ./bin/nebula-importer --config <yaml_config_file_path>
```

Run in Docker mode

Instead of installing the Go locale locally, you can use Docker to pull the image of the NebulaGraph Importer and mount the local configuration file and CSV data file into the container. The command is as follows:

```
$ docker pull vesoft/nebula-importer
$ docker run --rm -ti \
      --network=host \
      -v <config_file>:<config_file> \
      -v <data_dir>:<data_dir> \
      vesoft/nebula-importer:<version>
      --config <config_file>
```

- `<config_file>`: The absolute path to the YAML configuration file.
- `<csv_data_dir>`: The absolute path to the CSV data file. If the file is not local, ignore this parameter.
- `<version>`: NebulaGraph 3.x Please fill in 'v3'.

Note

A relative path is recommended. If you use a local absolute path, check that the path maps to the path in the Docker.

15.1.6 Configuration File Description

Various example configuration files are available within the Github of the NebulaGraph Importer. The configuration files are used to describe information about the files to be imported, {{ no such element: dict object['name'] }} server information, etc. The following section describes the fields within the configuration file in categories.

Note

If users download a binary package, create the configuration file manually.

Client configuration

Client configuration stores the configuration associated with the client's connection to the {{ no such element: dict object['name'] }}.

The example configuration is as follows:

```
client:
  version: v3
  address: "192.168.1.100:9669,192.168.1.101:9669"
  user: root
  password: nebula
  concurrencyPerAddress: 10
  reconnectInitialInterval: 1s
  retry: 3
  retryInitialInterval: 1s
```

Parameter	Default value	Required	Description
`client.version`	`v3`	Yes	Specifies the major version of the NebulaGraph. Currently only `v3` is supported.
`client.address`	`"127.0.0.1:9669"`	Yes	Specifies the address of the NebulaGraph. Multiple addresses are separated by commas.
`client.user`	`root`	No	NebulaGraph user name.
`client.password`	`nebula`	No	The password for the NebulaGraph user name.
`client.concurrencyPerAddress`	`10`	No	The number of concurrent client connections for a single graph service.
`client.retryInitialInterval`	`1s`	No	Reconnect interval time.
`client.retry`	`3`	No	The number of retries for failed execution of the nGQL statement.
`client.retryInitialInterval`	`1s`	No	Retry interval time.

Manager configuration

Manager configuration is a human-controlled configuration after connecting to the database.

The example configuration is as follows:

```
manager:
  spaceName: basic_string_examples
  batch: 128
  readerConcurrency: 50
  importerConcurrency: 512
  statsInterval: 10s
  hooks:
    before:
      - statements:
        - UPDATE CONFIGS storage:wal_ttl=3600;
        - UPDATE CONFIGS storage:rocksdb_column_family_options = { disable_auto_compactions = true };
      - statements:
        - |
            DROP SPACE IF EXISTS basic_int_examples;
            CREATE SPACE IF NOT EXISTS basic_int_examples(partition_num=5, replica_factor=1, vid_type=int);
            USE basic_int_examples;
        wait: 10s
    after:
      - statements:
          - |
```

```
        UPDATE CONFIGS storage:wal_ttl=86400;
        UPDATE CONFIGS storage:rocksdb_column_family_options = { disable_auto_compactions = false };
```

Parameter	Default value	Required	Description
`manager.spaceName`	-	Yes	Specifies the NebulaGraph space to import the data into. Do not support importing multiple map spaces at the same time.
`manager.batch`	`128`	No	The batch size for executing statements (global configuration).
Setting the batch size individually for a data source can using the parameter `sources.batch` below.			
`manager.readerConcurrency`	`50`	No	The number of concurrent reads of the data source by the reader.
`manager.importerConcurrency`	`512`	No	The number of concurrent nGQL statements generated to be executed, and then will call the client to execute these nGQL statements.
`manager.statsInterval`	`10s`	No	The time interval for printing statistical information
`manager.hooks.before.[].statements`	-	No	The command to execute in the graph space before importing.
`manager.hooks.before.[].wait`	-	No	The wait time after `statements` are executed.
`manager.hooks.after.[].statements`	-	No	The commands to execute in the graph space after importing.
`manager.hooks.after.[].wait`	-	No	The wait time after `statements` are executed.

Log configuration

Log configuration is the logging-related configuration.

The example configuration is as follows:

```
log:
  level: INFO
  console: true
  files:
   - logs/nebula-importer.log
```

Parameter	Default value	Required	Description
`log.level`	`INFO`	No	Specifies the log level. Optional values are `DEBUG`, `INFO`, `WARN`, `ERROR`, `PANIC`, `FATAL`.
`log.console`	`true`	No	Whether to print the logs to console synchronously when storing logs.
`log.files`	-	No	The log file path.

Source configuration

The Source configuration requires configuration of data source information, data processing methods, and Schema mapping.

The example configuration is as follows:

```yaml
sources:
  - path: ./person.csv  # Required. Specifies the path where the data files are stored. If a relative path is used, the path and current configuration file directory are spliced. Wildcard filename is also supported, for example: ./follower-*.csv, please make sure that all matching files with the same schema.
#  - s3: # AWS S3
#      endpoint: endpoint    # Optional. The endpoint of S3 service, can be omitted if using AWS S3.
#      region: us-east-1     # Required. The region of S3 service.
#      bucket: gdelt-open-data    # Required. The bucket of file in S3 service.
#      key: events/20190918.export.csv     # Required. The object key of file in S3 service.
#      accessKeyID: ""    # Optional. The access key of S3 service. If it is public data, no need to configure.
#      accessKeySecret: ""     # Optional. The secret key of S3 service. If it is public data, no need to configure.
#  - oss:
#      endpoint: https://oss-cn-hangzhou.aliyuncs.com    # Required. The endpoint of OSS service.
#      bucket: bucketName    # Required. The bucket of file in OSS service.
#      key: objectKey    # Required. The object key of file in OSS service.
#      accessKeyID: accessKey    # Required. The access key of OSS service.
#      accessKeySecret: secretKey    # Required. The secret key of OSS service.
#  - ftp:
#      host: 192.168.0.10    # Required. The host of FTP service.
#      port: 21    # Required. The port of FTP service.
#      user: user    # Required. The user of FTP service.
#      password: password    # Required. The password of FTP service.
#      path: "/events/20190918.export.csv"    # Required. The path of file in the FTP service.
#  - sftp:
#      host: 192.168.0.10    # Required. The host of SFTP service.
#      port: 22    # Required. The port of SFTP service.
#      user: user    # Required. The user of SFTP service.
#      password: password    # Optional. The password of SFTP service.
#      keyFile: keyFile    # Optional. The ssh key file path of SFTP service.
#      keyData: keyData    $ Optional. The ssh key file content of SFTP service.
#      passphrase: passphrase    # Optional. The ssh key passphrase of SFTP service.
#      path: "/events/20190918.export.csv"    # Required. The path of file in the SFTP service.
#  - hdfs:
#      address: "127.0.0.1:8020"    # Required. The address of HDFS service.
#      user: "hdfs"    # Optional. The user of HDFS service.
#      path: "/events/20190918.export.csv"    # Required. The path of file in the HDFS service.
    batch: 256
    csv:
      delimiter: "|"
      withHeader: false
      lazyQuotes: false
    tags:
    - name: Person
      id:
        type: "STRING"
        function: "hash"
#       index: 0
        concatItems:
          - person_
          - 0
          - _id
      props:
        - name: "firstName"
          type: "STRING"
          index: 1
        - name: "lastName"
          type: "STRING"
          index: 2
        - name: "gender"
          type: "STRING"
          index: 3
          nullable: true
          defaultValue: female
        - name: "birthday"
          type: "DATE"
          index: 4
          nullable: true
          nullValue: _NULL_
        - name: "creationDate"
          type: "DATETIME"
          index: 5
        - name: "locationIP"
          type: "STRING"
          index: 6
        - name: "browserUsed"
          type: "STRING"
          index: 7
  - path: ./knows.csv
    batch: 256
    edges:
    - name: KNOWS # person_knows_person
      src:
        id:
          type: "STRING"
          concatItems:
            - person_
            - 0
            - _id
      dst:
        id:
          type: "STRING"
          concatItems:
            - person_
            - 1
            - _id
```

```yaml
      props:
        - name: "creationDate"
          type: "DATETIME"
          index: 2
          nullable: true
          nullValue: _NULL_
          defaultValue: 0000-00-00T00:00:00
```

The configuration mainly includes the following parts:

- Specify the data source information.
- Specifies the batch size for executing statements.
- Specifies the CSV file format information.
- Specifies the schema mapping for Tag.
- Specifies the schema mapping for Edge type.

Parameter	Default value	Required	Description
`sources.path` `sources.s3` `sources.oss` `sources.ftp` `sources.sftp` `sources.hdfs`	-	No	Specify data source information, such as `source`. Configure multiple sources in mu items for different data sources.
`sources.batch`	`256`	No	The batch size for executing statements `manager.batch`.
`sources.csv.delimiter`	`,`	No	Specifies the delimiter for the CSV file. special characters as separators, they ne hexadecimal, i.e. `Ctrl+C`, the escape is wr characters in yaml format, see Escaped
`sources.csv.withHeader`	`false`	No	Whether to ignore the first record in the
`sources.csv.lazyQuotes`	`false`	No	Whether to allow lazy quotes. If `lazyQuote` doubled quote may appear in a quoted fi
`sources.tags.name`	-	Yes	The tag name.
`sources.tags.id.type`	`STRING`	No	The type of the VID.
`sources.tags.id.function`	-	No	Functions to generate the VID. Currentl
`sources.tags.id.index`	-	No	The column number corresponding to th this parameter must be configured.
`sources.tags.id.concatItems`	-	No	Used to concatenate two or more arrays for a constant, `int` for an index column. take effect.
`sources.tags.ignoreExistedIndex`	`true`	No	Whether to enable `IGNORE_EXISTED_INDEX`, th
`sources.tags.props.name`	-	Yes	The tag property name, which must mat
`sources.tags.props.type`	`STRING`	No	Property data type, supporting `BOOL`, `INT` `GEOGRAPHY(POINT)`, `GEOGRAPHY(LINESTRING)` and `G`
`sources.tags.props.index`	-	Yes	The property corresponds to the column
`sources.tags.props.nullable`	`false`	No	Whether this prop property can be `NULL`,
`sources.tags.props.nullValue`	-	No	Ignored when `nullable` is `false`. The valu when the value is equal to `nullValue`.
`sources.tags.props.alternativeIndices`	-	No	Ignored when `nullable` is `false`. The prop not equal to `nullValue`.
`sources.tags.props.defaultValue`	-	No	Ignored when `nullable` is `false`. The prop `alternativeIndices` are `nullValue`.
`sources.edges.name`	-	Yes	The edge type name.
`sources.edges.src.id.type`	`STRING`	No	The data type of the VID at the starting
`sources.edges.src.id.index`	-	Yes	The column number in the data file corr
`sources.edges.dst.id.type`	`STRING`	No	The data type of the VID at the destinati
`sources.edges.dst.id.index`	-	Yes	The column number in the data file corr
`sources.edges.rank.index`	-	No	The column number in the data file corr
`sources.edges.ignoreExistedIndex`	`true`	No	Whether to enable `IGNORE_EXISTED_INDEX`, th
`sources.edges.props.name`	-	Yes	The edge type property name, which mu

Parameter	Default value	Required	Description
`sources.edges.props.type`	`STRING`	No	Property data type, supporting `BOOL`, `INT` `GEOGRAPHY(POINT)`, `GEOGRAPHY(LINESTRING)` and `G`
`sources.edges.props.index`	-	Yes	The property corresponds to the column
`sources.edges.props.nullable`	-	No	Whether this prop property can be `NULL`,
`sources.edges.props.nullValue`	-	No	Ignored when `nullable` is `false`. The valu when the value is equal to `nullValue`.
`sources.edges.props.defaultValue`	-	No	Ignored when `nullable` is `false`. The prop `alternativeIndices` are `nullValue`.

Note

The sequence numbers of the columns in the CSV file start from 0, that is, the sequence numbers of the first column are 0, and the sequence numbers of the second column are 1.

Last update: May 26, 2023

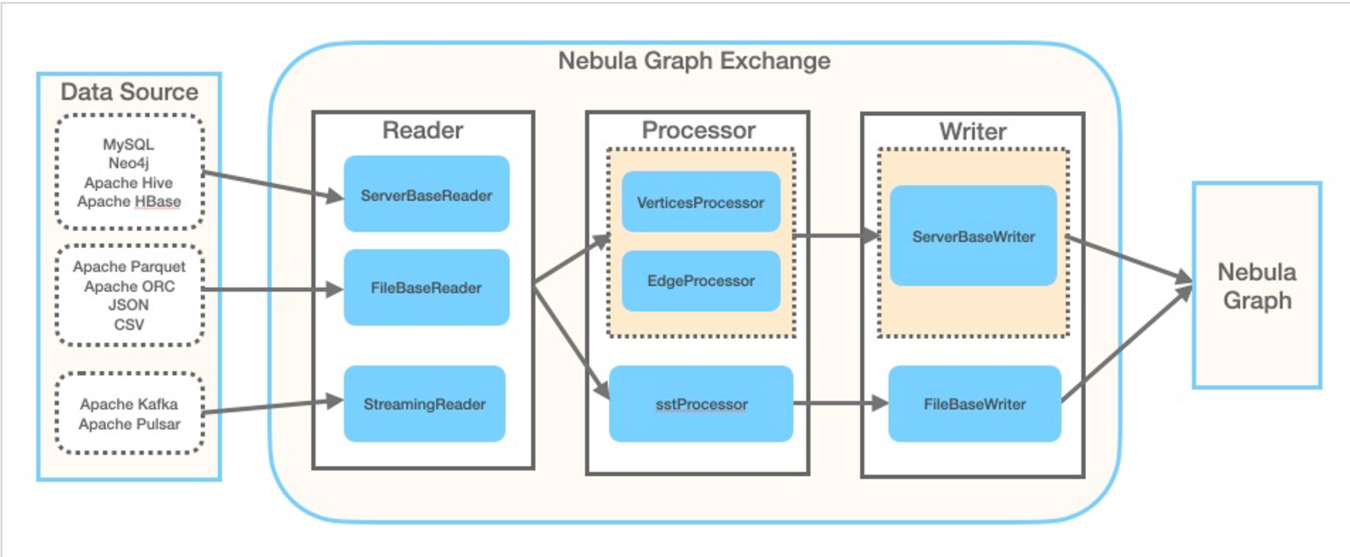
16. NebulaGraph Exchange

16.1 Introduction

16.1.1 What is NebulaGraph Exchange

NebulaGraph Exchange (Exchange) is an Apache Spark™ application for bulk migration of cluster data to NebulaGraph in a distributed environment, supporting batch and streaming data migration in a variety of formats.

Exchange consists of Reader, Processor, and Writer. After Reader reads data from different sources and returns a DataFrame, the Processor iterates through each row of the DataFrame and obtains the corresponding value based on the mapping between `fields` in the configuration file. After iterating through the number of rows in the specified batch, Writer writes the captured data to the NebulaGraph at once. The following figure illustrates the process by which Exchange completes the data conversion and migration.



Editions

Exchange has two editions, the Community Edition and the Enterprise Edition. The Community Edition is open source developed on GitHub. The Enterprise Edition supports not only the functions of the Community Edition but also adds additional features. For details, see Comparisons.

Scenarios

Exchange applies to the following scenarios:

- Streaming data from Kafka and Pulsar platforms, such as log files, online shopping data, activities of game players, information on social websites, financial transactions or geospatial services, and telemetry data from connected devices or instruments in the data center, are required to be converted into the vertex or edge data of the property graph and import them into the NebulaGraph database.
- Batch data, such as data from a time period, needs to be read from a relational database (such as MySQL) or a distributed file system (such as HDFS), converted into vertex or edge data for a property graph, and imported into the NebulaGraph database.
- A large volume of data needs to be generated into SST files that NebulaGraph can recognize and then imported into the NebulaGraph database.
- The data saved in NebulaGraph needs to be exported.

Enterpriseonly

Exporting the data saved in NebulaGraph is supported by Exchange Enterprise Edition only.

Advantages

Exchange has the following advantages:

- High adaptability: It supports importing data into the NebulaGraph database in a variety of formats or from a variety of sources, making it easy to migrate data.
- SST import: It supports converting data from different sources into SST files for data import.
- SSL encryption: It supports establishing the SSL encryption between Exchange and NebulaGraph to ensure data security.
- Resumable data import: It supports resumable data import to save time and improve data import efficiency.

Note

Resumable data import is currently supported when migrating Neo4j data only.

- Asynchronous operation: An insert statement is generated in the source data and sent to the Graph service. Then the insert operation is performed.
- Great flexibility: It supports importing multiple Tags and Edge types at the same time. Different Tags and Edge types can be from different data sources or in different formats.
- Statistics: It uses the accumulator in Apache Spark™ to count the number of successful and failed insert operations.
- Easy to use: It adopts the Human-Optimized Config Object Notation (HOCON) configuration file format and has an object-oriented style, which is easy to understand and operate.

Version compatibility

The correspondence between the NebulaGraph Exchange version (the JAR version), the NebulaGraph core version and the Spark version is as follows.

Exchange version	NebulaGraph version	Spark version
nebula-exchange_spark_3.0-3.0-SNAPSHOT.jar	nightly	3.3.x、3.2.x、3.1.x、3.0.x
nebula-exchange_spark_2.4-3.0-SNAPSHOT.jar	nightly	2.4.x
nebula-exchange_spark_2.2-3.0-SNAPSHOT.jar	nightly	2.2.x
nebula-exchange_spark_3.0-3.4.0.jar	3.x.x	3.3.x、3.2.x、3.1.x、3.0.x
nebula-exchange_spark_2.4-3.4.0.jar	3.x.x	2.4.x
nebula-exchange_spark_2.2-3.4.0.jar	3.x.x	2.2.x
nebula-exchange_spark_3.0-3.3.0.jar	3.x.x	3.3.x、3.2.x、3.1.x、3.0.x
nebula-exchange_spark_2.4-3.3.0.jar	3.x.x	2.4.x
nebula-exchange_spark_2.2-3.3.0.jar	3.x.x	2.2.x
nebula-exchange_spark_3.0-3.0.0.jar	3.x.x	3.3.x、3.2.x、3.1.x、3.0.x
nebula-exchange_spark_2.4-3.0.0.jar	3.x.x	2.4.x
nebula-exchange_spark_2.2-3.0.0.jar	3.x.x	2.2.x
nebula-exchange-2.6.3.jar	2.6.1、2.6.0	2.4.x
nebula-exchange-2.6.2.jar	2.6.1、2.6.0	2.4.x
nebula-exchange-2.6.1.jar	2.6.1、2.6.0	2.4.x
nebula-exchange-2.6.0.jar	2.6.1、2.6.0	2.4.x
nebula-exchange-2.5.2.jar	2.5.1、2.5.0	2.4.x
nebula-exchange-2.5.1.jar	2.5.1、2.5.0	2.4.x
nebula-exchange-2.5.0.jar	2.5.1、2.5.0	2.4.x
nebula-exchange-2.1.0.jar	2.0.1、2.0.0	2.4.x
nebula-exchange-2.0.1.jar	2.0.1、2.0.0	2.4.x
nebula-exchange-2.0.0.jar	2.0.1、2.0.0	2.4.x

Data source

Exchange 3.5.0 supports converting data from the following formats or sources into vertexes and edges that NebulaGraph can recognize, and then importing them into NebulaGraph in the form of nGQL statements:

- Data stored in HDFS or locally:
- Apache Parquet
- Apache ORC
- JSON
- CSV
- Apache HBase™
- Data repository:
- Hive
- MaxCompute
- Graph database: Neo4j (Client version 2.4.5-M1)
- Relational database:
- MySQL
- PostgreSQL
- Oracle
- Column database: ClickHouse
- Stream processing software platform: Apache Kafka®
- Publish/Subscribe messaging platform: Apache Pulsar 2.4.5
- JDBC

In addition to importing data as nGQL statements, Exchange supports generating SST files for data sources and then importing SST files via Console.

In addition, Exchange Enterprise Edition also supports exporting data to a CSV file or another graph space using NebulaGraph as data sources.

Release note

Release

Last update: March 13, 2023

16.1.2 Limitations

This topic describes some of the limitations of using Exchange 3.x.

JAR packages are available in two ways: compile them yourself or download them from the Maven repository.

If you are using NebulaGraph 1.x, use NebulaGraph Exchange 1.x.

Environment

Exchange 3.x supports the following operating systems:

- CentOS 7
- macOS

Software dependencies

To ensure the healthy operation of Exchange, ensure that the following software has been installed on the machine:

- Java version 1.8
- Scala version 2.10.7, 2.11.12, or 2.12.10
- Apache Spark. The requirements for Spark versions when using Exchange to export data from data sources are as follows. In the following table, Y means that the corresponding Spark version is supported, and N means not supported.

Note

Use the correct Exchange JAR file based on the Spark version. For example, for Spark version 2.4, use nebula-exchange_spark_2.4-3.5.0.jar.

Data source	Spark 2.2	Spark 2.4	Spark 3
CSV file	Y	N	Y
JSON file	Y	Y	Y
ORC file	Y	Y	Y
Parquet file	Y	Y	Y
HBase	Y	Y	Y
MySQL	Y	Y	Y
PostgreSQL	Y	Y	Y
Oracle	Y	Y	Y
ClickHouse	Y	Y	Y
Neo4j	N	Y	N
Hive	Y	Y	Y
MaxCompute	N	Y	N
Pulsar	N	Y	Untested
Kafka	N	Y	Untested
NebulaGraph	N	Y	N

Hadoop Distributed File System (HDFS) needs to be deployed in the following scenarios:

- Migrate HDFS data
- Generate SST files

Last update: October 31, 2022

16.2 Get Exchange

This topic introduces how to get the JAR file of NebulaGraph Exchange.

16.2.1 Download the JAR file directly

The JAR file of Exchange Community Edition can be downloaded directly.

To download Exchange Enterprise Edition, get NebulaGraph Enterprise Edition Package first.

16.2.2 Get the JAR file by compiling the source code

You can get the JAR file of Exchange Community Edition by compiling the source code. The following introduces how to compile the source code of Exchange.

Enterpriseonly

You can get Exchange Enterprise Edition in NebulaGraph Enterprise Edition Package only.

Prerequisites

- Install Maven.
- Install the correct version of Apache Spark. Exporting data from different sources requires different Spark versions. For more information, see Software dependencies.

16.2.3 Steps

1. Clone the repository `nebula-exchange` in the `/` directory.

```
git clone -b release-3.5 https://github.com/vesoft-inc/nebula-exchange.git
```

2. Switch to the directory `nebula-exchange`.

```
cd nebula-exchange
```

3. Package NebulaGraph Exchange. Run the following command based on the Spark version:

- For Spark 2.2:

```
mvn clean package -Dmaven.test.skip=true -Dgpg.skip -Dmaven.javadoc.skip=true \
-pl nebula-exchange_spark_2.2 -am -Pscala-2.11 -Pspark-2.2
```

- For Spark 2.4:

```
mvn clean package -Dmaven.test.skip=true -Dgpg.skip -Dmaven.javadoc.skip=true \
-pl nebula-exchange_spark_2.4 -am -Pscala-2.11 -Pspark-2.4
```

- For Spark 3.0:

```
mvn clean package -Dmaven.test.skip=true -Dgpg.skip -Dmaven.javadoc.skip=true \
-pl nebula-exchange_spark_3.0 -am -Pscala-2.12 -Pspark-3.0
```

After the compilation is successful, you can find the `nebula-exchange_spark_x.x-release-3.5.jar` file in the `nebula-exchange_spark_x.x/target/` directory. `x.x` indicates the Spark version, for example, `2.4`.

Note

The JAR file version changes with the release of the NebulaGraph Java Client. Users can view the latest version on the Releases page.

When migrating data, you can refer to configuration file `target/classes/application.conf`.

Failed to download the dependency package

If downloading dependencies fails when compiling:

- Check the network settings and ensure that the network is normal.
- Modify the `mirror` part of Maven installation directory `libexec/conf/settings.xml`:

```
<mirror>
 <id>alimaven</id>
 <mirrorOf>central</mirrorOf>
 <name>aliyun maven</name>
 <url>http://maven.aliyun.com/nexus/content/repositories/central/</url>
</mirror>
```

Last update: August 11, 2022

16.3 Exchange configurations

16.3.1 Options for import

After editing the configuration file, run the following commands to import specified source data into the NebulaGraph database.

- First import

```
<spark_install_path>/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-2.x.y.jar_path> -c <application.conf_path>
```

- Import the reload file

  If some data fails to be imported during the first import, the failed data will be stored in the reload file. Use the parameter `-r` to import the reload file.

```
<spark_install_path>/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-2.x.y.jar_path> -c <application.conf_path> -r "<reload_file_path>"
```

Note

The version number of a JAR file is subject to the name of the JAR file that is actually compiled.

Faq

If users use the yarn-cluster mode to submit a job, see the following command, **especially the two '--conf' commands in the example**.

```
$SPARK_HOME/bin/spark-submit     --master yarn-cluster \
--class com.vesoft.nebula.exchange.Exchange \
--files application.conf \
--conf spark.driver.extraClassPath=./ \
--conf spark.executor.extraClassPath=./ \
nebula-exchange-3.5.0.jar \
-c application.conf
```

The following table lists command parameters.

Parameter	Required	Default value	Description
`--class`	Yes	-	Specify the main class of the driver.
`--master`	Yes	-	Specify the URL of the master process in a Spark cluster. For more information, see master-urls.
`-c` / `--config`	Yes	-	Specify the path of the configuration file.
`-h` / `--hive`	No	`false`	Indicate support for importing Hive data.
`-D` / `--dry`	No	`false`	Check whether the format of the configuration file meets the requirements, but it does not check whether the configuration items of `tags` and `edges` are correct. This parameter cannot be added when users import data.
`-r` / `--reload`	No	-	Specify the path of the reload file that needs to be reloaded.

For more Spark parameter configurations, see Spark Configuration.

Last update: December 21, 2022

16.3.2 Parameters in the configuration file

This topic describes how to configure the file `application.conf` when users use NebulaGraph Exchange.

Before configuring the `application.conf` file, it is recommended to copy the file name `application.conf` and then edit the file name according to the file type of a data source. For example, change the file name to `csv_application.conf` if the file type of the data source is CSV.

The `application.conf` file contains the following content types:

- Spark configurations
- Hive configurations (optional)
- NebulaGraph configurations
- Vertex configurations
- Edge configurations

Spark configurations

This topic lists only some Spark parameters. For more information, see Spark Configuration.

Parameter	Type	Default value	Required	Description
`spark.app.name`	string	-	No	The drive name in Spark.
`spark.driver.cores`	int	`1`	No	The number of CPU cores used by a driver, only applicable to a cluster mode.
`spark.driver.maxResultSize`	string	`1G`	No	The total size limit (in bytes) of the serialized results of all partitions in a single Spark operation (such as collect). The minimum value is 1M, and 0 means unlimited.
`spark.executor.memory`	string	`1G`	No	The amount of memory used by a Spark driver which can be specified in units, such as 512M or 1G.
`spark.cores.max`	int	`16`	No	The maximum number of CPU cores of applications requested across clusters (rather than from each node) when a driver runs in a coarse-grained sharing mode on a standalone cluster or a Mesos cluster. The default value is `spark.deploy.defaultCores` on a Spark standalone cluster manager or the value of the `infinite` parameter (all available cores) on Mesos.

Hive configurations (optional)

Users only need to configure parameters for connecting to Hive if Spark and Hive are deployed in different clusters. Otherwise, please ignore the following configurations.

Parameter	Type	Default value	Required	Description
`hive.warehouse`	string	-	Yes	The warehouse path in HDFS. Enclose the path in double quotes and start with `hdfs://`.
`hive.connectionURL`	string	-	Yes	The URL of a JDBC connection. For example, `"jdbc:mysql://127.0.0.1:3306/hive_spark?characterEncoding=UTF-8"`.
`hive.connectionDriverName`	string	`"com.mysql.jdbc.Driver"`	Yes	The driver name.
`hive.connectionUserName`	list[string]	-	Yes	The username for connections.
`hive.connectionPassword`	list[string]	-	Yes	The account password.

NebulaGraph configurations

Parameter	Type	Default value	Required	Description
`nebula.address.graph`	list[string]	`["127.0.0.1:9669"]`	Yes	The addresses of all Graph services, including IPs and ports, separated by commas (,). Example: `["ip1:port1","ip2:port2","ip3:port3"]` .
`nebula.address.meta`	list[string]	`["127.0.0.1:9559"]`	Yes	The addresses of all Meta services, including IPs and ports, separated by commas (,). Example: `["ip1:port1","ip2:port2","ip3:port3"]` .
`nebula.user`	string	-	Yes	The username with write permissions for NebulaGraph.
`nebula.pswd`	string	-	Yes	The account password.
`nebula.space`	string	-	Yes	The name of the graph space where data needs to be imported.
`nebula.ssl.enable.graph`	bool	`false`	Yes	Enables the SSL encryption between Exchange and Graph services. If the value is `true` , the SSL encryption is enabled and the following SSL parameters take effect. If Exchange is run on a multi-machine cluster, you need to store the corresponding files in the same path on each machine when setting the following SSL-related paths.
`nebula.ssl.sign`	string	`ca`	Yes	Specifies the SSL sign. Optional values are `ca` and `self` .
`nebula.ssl.ca.param.caCrtFilePath`	string	Specifies the storage path of the CA certificate. It takes effect when the value of `nebula.ssl.sign` is `ca` .		
`nebula.ssl.ca.param.crtFilePath`	string	`"/path/crtFilePath"`	Yes	Specifies the storage path of the CRT certificate. It takes effect when the value of `nebula.ssl.sign` is `ca` .
`nebula.ssl.ca.param.keyFilePath`	string	`"/path/keyFilePath"`	Yes	Specifies the storage path of the key file. It takes effect when the value of `nebula.ssl.sign` is `ca` .
`nebula.ssl.self.param.crtFilePath`	string	`"/path/crtFilePath"`	Yes	Specifies the storage path of the CRT certificate. It takes effect when the value of `nebula.ssl.sign` is `self` .
`nebula.ssl.self.param.keyFilePath`	string	`"/path/keyFilePath"`	Yes	Specifies the storage path of the key file. It takes effect when the value of `nebula.ssl.sign` is `self` .
`nebula.ssl.self.param.password`	string	`"nebula"`	Yes	Specifies the storage path of the password. It takes effect when the value of `nebula.ssl.sign` is `self` .
`nebula.path.local`	string	`"/tmp"`	No	

Parameter	Type	Default value	Required	Description
				The local SST file path which needs to be set when users import SST files.
`nebula.path.remote`	string	`"/sst"`	No	The remote SST file path which needs to be set when users import SST files.
`nebula.path.hdfs.namenode`	string	`"hdfs://name_node:9000"`	No	The NameNode path which needs to be set when users import SST files.
`nebula.connection.timeout`	int	`3000`	No	The timeout set for Thrift connections. Unit: ms.
`nebula.connection.retry`	int	`3`	No	Retries set for Thrift connections.
`nebula.execution.retry`	int	`3`	No	Retries set for executing nGQL statements.
`nebula.error.max`	int	`32`	No	The maximum number of failures during the import process. When the number of failures reaches the maximum, the Spark job submitted will stop automatically .
`nebula.error.output`	string	`/tmp/errors`	No	The path to output error logs. Failed nGQL statement executions are saved in the error log.
`nebula.rate.limit`	int	`1024`	No	The limit on the number of tokens in the token bucket when importing data.
`nebula.rate.timeout`	int	`1000`	No	The timeout period for getting tokens from a token bucket. Unit: milliseconds.

Note

NebulaGraph doesn't support vertices without tags by default. To import vertices without tags, enable vertices without tags in the NebulaGraph cluster and then add parameter `nebula.enableTagless` to the Exchange configuration with the value `true`. For example:

```
nebula: {
    address:{
      graph:["127.0.0.1:9669"]
      meta:["127.0.0.1:9559"]
    }
    user: root
    pswd: nebula
    space: test
    enableTagless: true
    ......

 }
```

Vertex configurations

For different data sources, the vertex configurations are different. There are many general parameters and some specific parameters. General parameters and specific parameters of different data sources need to be configured when users configure vertices.

GENERAL PARAMETERS

Parameter	Type	Default value	Required	Description
`tags.name`	string	-	Yes	The tag name defined in NebulaGraph.
`tags.type.source`	string	-	Yes	Specify a data source. For example, `csv`.
`tags.type.sink`	string	`client`	Yes	Specify an import method. Optional values are `client` and `SST`.
`tags.fields`	list[string]	-	Yes	The header or column name of the column corresponding to properties. If there is a header or a column name, please use that name directly. If a CSV file does not have a header, use the form of `[_c0, _c1, _c2]` to represent the first column, the second column, the third column, and so on.
`tags.nebula.fields`	list[string]	-	Yes	Property names defined in NebulaGraph, the order of which must correspond to `tags.fields`. For example, `[_c1, _c2]` corresponds to `[name, age]`, which means that values in the second column are the values of the property `name`, and values in the third column are the values of the property `age`.
`tags.vertex.field`	string	-	Yes	The column of vertex IDs. For example, when a CSV file has no header, users can use `_c0` to indicate values in the first column are vertex IDs.
`tags.vertex.udf.separator`	string	-	No	Support merging multiple columns by custom rules. This parameter specifies the join character.
`tags.vertex.udf.oldColNames`	list	-	No	Support merging multiple columns by custom rules. This parameter specifies the names of the columns to be merged. Multiple columns are separated by commas.
`tags.vertex.udf.newColName`	string	-	No	Support merging multiple columns by custom rules. This parameter specifies the new column name.
`tags.batch`	int	`256`	Yes	The maximum number of vertices written into NebulaGraph in a single batch.
`tags.partition`	int	`32`	Yes	The number of Spark partitions.

SPECIFIC PARAMETERS OF PARQUET/JSON/ORC DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.path`	string	-	Yes	The path of vertex data files in HDFS. Enclose the path in double quotes and start with `hdfs://`.

SPECIFIC PARAMETERS OF CSV DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.path`	string	-	Yes	The path of vertex data files in HDFS. Enclose the path in double quotes and start with `hdfs://`.
`tags.separator`	string	`,`	Yes	The separator. The default value is a comma (,). For special characters, such as the control character `^A`, you can use ASCII octal `\001` or UNICODE encoded hexadecimal `\u0001`, for the control character `^B`, use ASCII octal `\002` or UNICODE encoded hexadecimal `\u0002`, for the control character `^C`, use ASCII octal `\003` or UNICODE encoded hexadecimal `\u0003`.
`tags.header`	bool	`true`	Yes	Whether the file has a header.

SPECIFIC PARAMETERS OF HIVE DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.exec`	string	-	Yes	The statement to query data sources. For example, `select name,age from mooc.users`.

SPECIFIC PARAMETERS OF MAXCOMPUTE DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.table`	string	-	Yes	The table name of the MaxCompute.
`tags.project`	string	-	Yes	The project name of the MaxCompute.
`tags.odpsUrl`	string	-	Yes	The odpsUrl of the MaxCompute service. For more information about odpsUrl, see Endpoints.
`tags.tunnelUrl`	string	-	Yes	The tunnelUrl of the MaxCompute service. For more information about tunnelUrl, see Endpoints.
`tags.accessKeyId`	string	-	Yes	The accessKeyId of the MaxCompute service.
`tags.accessKeySecret`	string	-	Yes	The accessKeySecret of the MaxCompute service.
`tags.partitionSpec`	string	-	No	Partition descriptions of MaxCompute tables.
`tags.sentence`	string	-	No	Statements to query data sources. The table name in the SQL statement is the same as the value of the table above.

SPECIFIC PARAMETERS OF NEO4J DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.exec`	string	-	Yes	Statements to query data sources. For example: `match (n:label) return n.neo4j-field-0`.
`tags.server`	string	`"bolt://127.0.0.1:7687"`	Yes	The server address of Neo4j.
`tags.user`	string	-	Yes	The Neo4j username with read permissions.
`tags.password`	string	-	Yes	The account password.
`tags.database`	string	-	Yes	The name of the database where source data is saved in Neo4j.
`tags.check_point_path`	string	`/tmp/test`	No	The directory set to import progress information, which is used for resuming transfers. If not set, the resuming transfer is disabled.

SPECIFIC PARAMETERS OF MYSQL/POSTGRESQL DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.host`	string	-	Yes	The MySQL/PostgreSQL server address.
`tags.port`	string	-	Yes	The MySQL/PostgreSQL server port.
`tags.database`	string	-	Yes	The database name.
`tags.table`	string	-	Yes	The name of a table used as a data source.
`tags.user`	string	-	Yes	The MySQL/PostgreSQL username with read permissions.
`tags.password`	string	-	Yes	The account password.
`tags.sentence`	string	-	Yes	Statements to query data sources. For example: `"select teamid, name from team order by teamid"`.

SPECIFIC PARAMETERS OF ORACLE DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.url`	string	-	Yes	The Oracle server address.
`tags.driver`	string	-	Yes	The Oracle driver address.
`tags.user`	string	-	Yes	The Oracle username with read permissions.
`tags.password`	string	-	Yes	The account password.
`tags.table`	string	-	Yes	The name of a table used as a data source.
`tags.sentence`	string	-	Yes	Statements to query data sources. For example: `"select playerid, name, age from player"`.

SPECIFIC PARAMETERS OF CLICKHOUSE DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.url`	string	-	Yes	The JDBC URL of ClickHouse.
`tags.user`	string	-	Yes	The ClickHouse username with read permissions.
`tags.password`	string	-	Yes	The account password.
`tags.numPartition`	string	-	Yes	The number of ClickHouse partitions.
`tags.sentence`	string	-	Yes	Statements to query data sources.

SPECIFIC PARAMETERS OF HBASE DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.host`	string	`127.0.0.1`	Yes	The Hbase server address.
`tags.port`	string	`2181`	Yes	The Hbase server port.
`tags.table`	string	-	Yes	The name of a table used as a data source.
`tags.columnFamily`	string	-	Yes	The column family to which a table belongs.

SPECIFIC PARAMETERS OF PULSAR DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.service`	string	`"pulsar://localhost:6650"`	Yes	The Pulsar server address.
`tags.admin`	string	`"http://localhost:8081"`	Yes	The admin URL used to connect pulsar.
`tags.options.<topic| topics| topicsPattern>`	string	-	Yes	Options offered by Pulsar, which can be configured by choosing one from `topic`, `topics`, and `topicsPattern`.
`tags.interval.seconds`	int	`10`	Yes	The interval for reading messages. Unit: seconds.

SPECIFIC PARAMETERS OF KAFKA DATA SOURCES

Parameter	Type	Default value	Required	Description
`tags.service`	string	-	Yes	The Kafka server address.
`tags.topic`	string	-	Yes	The message type.
`tags.interval.seconds`	int	`10`	Yes	The interval for reading messages. Unit: seconds.

SPECIFIC PARAMETERS FOR GENERATING SST FILES

Parameter	Type	Default value	Required	Description
`tags.path`	string	-	Yes	The path of the source file specified to generate SST files.
`tags.repartitionWithNebula`	bool	`true`	No	Whether to repartition data based on the number of partitions of graph spaces in NebulaGraph when generating the SST file. Enabling this function can reduce the time required to DOWNLOAD and INGEST SST files.

Edge configurations

For different data sources, configurations of edges are also different. There are general parameters and some specific parameters. General parameters and specific parameters of different data sources need to be configured when users configure edges.

For the specific parameters of different data sources for edge configurations, please refer to the introduction of specific parameters of different data sources above, and pay attention to distinguishing tags and edges.

GENERAL PARAMETERS

Parameter	Type	Default value	Required	Description
`edges.name`	string	-	Yes	The edge type name defined in NebulaGraph.
`edges.type.source`	string	-	Yes	The data source of edges. For example, `csv`.
`edges.type.sink`	string	`client`	Yes	The method specified to import data. Optional values are `client` and `SST`.
`edges.fields`	list[string]	-	Yes	The header or column name of the column corresponding to properties. If there is a header or column name, please use that name directly. If a CSV file does not have a header, use the form of `[_c0, _c1, _c2]` to represent the first column, the second column, the third column, and so on.
`edges.nebula.fields`	list[string]	-	Yes	Edge names defined in NebulaGraph, the order of which must correspond to `edges.fields`. For example, `[_c2, _c3]` corresponds to `[start_year, end_year]`, which means that values in the third column are the values of the start year, and values in the fourth column are the values of the end year.
`edges.source.field`	string	-	Yes	The column of source vertices of edges. For example, `_c0` indicates a value in the first column that is used as the source vertex of an edge.
`edges.target.field`	string	-	Yes	The column of destination vertices of edges. For example, `_c0` indicates a value in the first column that is used as the destination vertex of an edge.
`edges.ranking`	int	-	No	The column of rank values. If not specified, all rank values are `0` by default.
`edges.batch`	int	`256`	Yes	The maximum number of edges written into NebulaGraph in a single batch.
`edges.partition`	int	`32`	Yes	The number of Spark partitions.

SPECIFIC PARAMETERS FOR GENERATING SST FILES

Parameter	Type	Default value	Required	Description
`edges.path`	string	-	Yes	The path of the source file specified to generate SST files.
`edges.repartitionWithNebula`	bool	`true`	No	Whether to repartition data based on the number of partitions of graph spaces in NebulaGraph when generating the SST file. Enabling this function can reduce the time required to DOWNLOAD and INGEST SST files.

SPECIFIC PARAMETERS OF NEBULAGRAPH

Parameter	Type	Default value	Required	Description
`edges.path`	string	`"hdfs://namenode:9000/path/edge"`	Yes	Specifies the storage path of the CSV file. You need to set a new path and Exchange will automatically create the path you set. If you store the data to the HDFS server, the path format is the same as the default value, such as `"hdfs://192.168.8.177:9000/edge/follow"`. If you store the data to the local, the path format is `"file:///path/edge"`, such as `"file:///home/nebula/edge/follow"`. If there are multiple Edges, different directories must be set for each Edge.
`edges.noField`	bool	`false`	Yes	If the value is `true`, source vertex IDs, destination vertex IDs, and ranks will be exported, not the property data. If the vaue is `false`, ranks, source vertex IDs, destination vertex IDs, ranks, and the property data will be exported.
`edges.return.fields`	list	`[]`	Yes	Specifies the properties to be exported. For example, to export `start_year` and `end_year`, you need to set the parameter value to `["start_year","end_year"]`. This parameter only takes effect when the value of `edges.noField` is `false`.

Last update: May 22, 2023

16.4 Use NebulaGraph Exchange

16.4.1 Import data from CSV files

This topic provides an example of how to use Exchange to import NebulaGraph data stored in HDFS or local CSV files.

To import a local CSV file to NebulaGraph, see NebulaGraph Importer.

Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- Hadoop: 2.9.2, pseudo-distributed deployment

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- If files are stored in HDFS, ensure that the Hadoop service is running normally.

- If files are stored locally and NebulaGraph is a cluster architecture, you need to place the files in the same directory locally on each machine in the cluster.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: PROCESS CSV FILES

Confirm the following information:

1. Process CSV files to meet Schema requirements.

Note

Exchange supports uploading CSV files with or without headers.

2. Obtain the CSV file storage path.

STEP 3: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set CSV data source configuration. In this example, the copied file is called `csv_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    executor: {
        memory:1G
    }

    cores: {
```

```
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }

    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula

    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }

  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      # Specify the Tag name defined in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example: "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example: "file:///tmp/xx.csv".
      path: "hdfs://192.168.*.*:9000/data/vertex_player.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has headers, use the actual column names.
      fields: [_c1, _c2]

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [age, name]

      # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
      # The value of vertex must be the same as the column names in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:_c0
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
        # policy:hash
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Tag Team.
```

```
    {
      # Specify the Tag name defined in NebulaGraph.
      name: team
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example: "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example: "file:///tmp/xx.csv".
      path: "hdfs://192.168.*.*:9000/data/vertex_team.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has headers, use the actual column names.
      fields: [_c1]

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      # The value of vertex must be the same as the column names in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:_c0
        # policy:hash
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }


    # If more vertexes need to be added, refer to the previous configuration to add them.
  ]
  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # Specify the Edge Type name defined in NebulaGraph.
      name: follow
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example: "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example: "file:///tmp/xx.csv".
      path: "hdfs://192.168.*.*:9000/data/edge_follow.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has headers, use the actual column names.
      fields: [_c2]

      # Specify the column names in the edge table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [degree]

      # Specify a column as the source for the source and destination vertexes.
      # The value of vertex must be the same as the column names in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: _c0
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }
      target: {
        field: _c1
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
```

```
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # Specify a column as the source of the rank (optional).

      #ranking: rank

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge Type serve.
    {
      # Specify the Edge Type name defined in NebulaGraph.
      name: serve
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example: "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example: "file:///tmp/xx.csv".
      path: "hdfs://192.168.*.*:9000/data/edge_serve.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has headers, use the actual column names.
      fields: [_c2,_c3]

      # Specify the column names in the edge table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [start_year, end_year]

      # Specify a column as the source for the source and destination vertexes.
      # The value of vertex must be the same as the column names in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: _c0
      }
      target: {
        field: _c1
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # Specify a column as the source of the rank (optional).
      #ranking: _c5

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

  ]
    # If more edges need to be added, refer to the previous configuration to add them.
}
```

STEP 4: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import CSV data into NebulaGraph. For descriptions of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <csv_application.conf_path>
```

> **Note**
>
> JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/csv_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 5: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 6: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.2 Import data from JSON files

This topic provides an example of how to use Exchange to import NebulaGraph data stored in HDFS or local JSON files.

Data set

This topic takes the basketballplayer dataset as an example. Some sample data are as follows:

- player

```
{"id":"player100","age":42,"name":"Tim Duncan"}
{"id":"player101","age":36,"name":"Tony Parker"}
{"id":"player102","age":33,"name":"LaMarcus Aldridge"}
{"id":"player103","age":32,"name":"Rudy Gay"}
...
```

- team

```
{"id":"team200","name":"Warriors"}
{"id":"team201","name":"Nuggets"}
...
```

- follow

```
{"src":"player100","dst":"player101","degree":95}
{"src":"player101","dst":"player102","degree":90}
...
```

- serve

```
{"src":"player100","dst":"team204","start_year":"1997","end_year":"2016"}
{"src":"player101","dst":"team204","start_year":"1999","end_year":"2018"}
...
```

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- Hadoop: 2.9.2, pseudo-distributed deployment

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.
- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.
- If files are stored in HDFS, ensure that the Hadoop service is running properly.
- If files are stored locally and NebulaGraph is a cluster architecture, you need to place the files in the same directory locally on each machine in the cluster.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: PROCESS JSON FILES

Confirm the following information:

1. Process JSON files to meet Schema requirements.
2. Obtain the JSON file storage path.

STEP 3: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set JSON data source configuration. In this example, the copied file is called `json_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    executor: {
        memory:1G
    }

    cores: {
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and all Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }

    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula

    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }

  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      # Specify the Tag name defined in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to JSON.
        source: json

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the JSON file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.json".
      path: "hdfs://192.168.*.*:9000/data/vertex_player.json"

      # Specify the key name in the JSON file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple column names need to be specified, separate them by commas.
      fields: [age,name]

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [age, name]

      # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
      # The value of vertex must be the same as that in the JSON file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:id
      # udf:{
```

```
    #           separator:"_"
    #           oldColNames:[field-0,field-1,field-2]
    #           newColName:new-field
    #       }
    }

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
  }

  # Set the information about the Tag Team.
{
    # Specify the Tag name defined in NebulaGraph.
    name: team
    type: {
      # Specify the data source file format to JSON.
      source: json

      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    # Specify the path to the JSON file.
    # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
    # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.json".
    path: "hdfs://192.168.*.*:9000/data/vertex_team.json"

    # Specify the key name in the JSON file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
    # If multiple column names need to be specified, separate them by commas.
    fields: [name]

    # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    nebula.fields: [name]

    # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
    # The value of vertex must be the same as that in the JSON file.
    # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
    vertex: {
      field:id
    }


    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
  }


  # If more vertexes need to be added, refer to the previous configuration to add them.
 ]
 # Processing edges
 edges: [
  # Set the information about the Edge Type follow.
  {
    # Specify the Edge Type name defined in NebulaGraph.
    name: follow
    type: {
      # Specify the data source file format to JSON.
      source: json

      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    # Specify the path to the JSON file.
    # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
    # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.json".
    path: "hdfs://192.168.*.*:9000/data/edge_follow.json"

    # Specify the key name in the JSON file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
    # If multiple column names need to be specified, separate them by commas.
    fields: [degree]

    # Specify the column names in the edge table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    nebula.fields: [degree]

    # Specify a column as the source for the source and destination vertexes.
    # The value of vertex must be the same as that in the JSON file.
    # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
    source: {
      field: src
    # udf:{
    #           separator:"_"
    #           oldColNames:[field-0,field-1,field-2]
    #           newColName:new-field
    #       }
    }
```

```
      target: {
        field: dst
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }


      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge Type serve.
    {
      # Specify the Edge type name defined in NebulaGraph.
      name: serve
      type: {
        # Specify the data source file format to JSON.
        source: json

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the JSON file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.json".
      path: "hdfs://192.168.*.*:9000/data/edge_serve.json"

      # Specify the key name in the JSON file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple column names need to be specified, separate them by commas.
      fields: [start_year,end_year]

      # Specify the column names in the edge table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [start_year, end_year]

      # Specify a column as the source for the source and destination vertexes.
      # The value of vertex must be the same as that in the JSON file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: src
      }
      target: {
        field: dst
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: _c5

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

  ]
  # If more edges need to be added, refer to the previous configuration to add them.
}
```

STEP 4: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import JSON data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <json_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-echange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/json_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 5: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 6: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.3 Import data from ORC files

This topic provides an example of how to use Exchange to import NebulaGraph data stored in HDFS or local ORC files.

To import a local ORC file to NebulaGraph, see NebulaGraph Importer.

Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- Hadoop: 2.9.2, pseudo-distributed deployment

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- If files are stored in HDFS, ensure that the Hadoop service is running properly.

- If files are stored locally and NebulaGraph is a cluster architecture, you need to place the files in the same directory locally on each machine in the cluster.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: PROCESS ORC FILES

Confirm the following information:

1. Process ORC files to meet Schema requirements.
2. Obtain the ORC file storage path.

STEP 3: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set ORC data source configuration. In this example, the copied file is called `orc_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    executor: {
        memory:1G
    }

    cores: {
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and all Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
```

```
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }

    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula

    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }

  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      name: player
      type: {
        # Specify the data source file format to ORC.
        source: orc

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the ORC file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.orc".
      path: "hdfs://192.168.*.*:9000/data/vertex_player.orc"

      # Specify the key name in the ORC file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
      fields: [age,name]

      # Specify the property names defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [age, name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      # The value of vertex must be consistent with the field in the ORC file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:id
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Tag team.
    {
      # Specify the Tag name defined in NebulaGraph.
      name: team
      type: {
        # Specify the data source file format to ORC.
        source: orc

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the ORC file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.orc".
      path: "hdfs://192.168.*.*:9000/data/vertex_team.orc"

      # Specify the key name in the ORC file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
```

```
      fields: [name]

      # Specify the property names defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      # The value of vertex must be consistent with the field in the ORC file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:id
      }


      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }



    # If more vertexes need to be added, refer to the previous configuration to add them.
  ]
  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # Specify the Edge Type name defined in NebulaGraph.
      name: follow
      type: {
        # Specify the data source file format to ORC.
        source: orc

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the ORC file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.orc".
      path: "hdfs://192.168.*.*:9000/data/edge_follow.orc"

      # Specify the key name in the ORC file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
      fields: [degree]

      # Specify the property names defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [degree]

      # Specify a column as the source for the source and destination vertexes.
      # The value of vertex must be consistent with the field in the ORC file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: src
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }
      target: {
        field: dst
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge type serve.
    {
      # Specify the Edge type name defined in NebulaGraph.
      name: serve
      type: {
        # Specify the data source file format to ORC.
        source: orc

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }
```

```
      # Specify the path to the ORC file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.orc".
      path: "hdfs://192.168.*.*:9000/data/edge_serve.orc"

      # Specify the key name in the ORC file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
      fields: [start_year,end_year]

      # Specify the property names defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [start_year, end_year]

      # Specify a column as the source for the source and destination vertexes.
      # The value of vertex must be consistent with the field in the ORC file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: src
      }
      target: {
        field: dst
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: _c5

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

  # If more edges need to be added, refer to the previous configuration to add them.
}
```

STEP 4: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import ORC data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <orc_application.conf_path>
```

> **Note**
>
> JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/orc_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 5: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 6: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.4 Import data from Parquet files

This topic provides an example of how to use Exchange to import NebulaGraph data stored in HDFS or local Parquet files.

To import a local Parquet file to NebulaGraph, see NebulaGraph Importer.

Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- Hadoop: 2.9.2, pseudo-distributed deployment

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- If files are stored in HDFS, ensure that the Hadoop service is running properly.

- If files are stored locally and NebulaGraph is a cluster architecture, you need to place the files in the same directory locally on each machine in the cluster.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: PROCESS PARQUET FILES

Confirm the following information:

1. Process Parquet files to meet Schema requirements.
2. Obtain the Parquet file storage path.

STEP 3: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set Parquet data source configuration. In this example, the copied file is called `parquet_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    executor: {
        memory:1G
    }

    cores: {
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
```

```
    # Specify the IP addresses and ports for Graph and all Meta services.
    # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
    # Addresses are separated by commas.
    graph:["127.0.0.1:9669"]
    # the address of any of the meta services.
    # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
    meta:["127.0.0.1:9559"]
  }

  # The account entered must have write permission for the NebulaGraph space.
  user: root
  pswd: nebula

  # Fill in the name of the graph space you want to write data to in the NebulaGraph.
  space: basketballplayer
  connection: {
    timeout: 3000
    retry: 3
  }
  execution: {
    retry: 3
  }
  error: {
    max: 32
    output: /tmp/errors
  }
  rate: {
    limit: 1024
    timeout: 1000
  }
}

# Processing vertexes
tags: [
  # Set the information about the Tag player.
  {
    # Specify the Tag name defined in NebulaGraph.
    name: player
    type: {
      # Specify the data source file format to Parquet.
      source: parquet

      # Specifies how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    # Specify the path to the Parquet file.
    # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
    # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.parquet".
    path: "hdfs://192.168.*.13:9000/data/vertex_player.parquet"

    # Specify the key name in the Parquet file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
    # If multiple values need to be specified, separate them with commas.
    fields: [age,name]

    # Specify the property name defined in NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    nebula.fields: [age, name]

    # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
    # The value of vertex must be consistent with the field in the Parquet file.
    # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
    vertex: {
      field:id
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
  }

  # Set the information about the Tag team.
  {
    # Specify the Tag name defined in NebulaGraph.
    name: team
    type: {
      # Specify the data source file format to Parquet.
      source: parquet

      # Specifies how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    # Specify the path to the Parquet file.
    # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
    # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.parquet".
    path: "hdfs://192.168.11.13:9000/data/vertex_team.parquet"
```

```
      # Specify the key name in the Parquet file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
      fields: [name]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      # The value of vertex must be consistent with the field in the Parquet file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:id
      }


      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }


    # If more vertexes need to be added, refer to the previous configuration to add them.
  ]
  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # Specify the Edge Type name defined in NebulaGraph.
      name: follow
      type: {
        # Specify the data source file format to Parquet.
        source: parquet

        # Specifies how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Specify the path to the Parquet file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.parquet".
      path: "hdfs://192.168.11.13:9000/data/edge_follow.parquet"

      # Specify the key name in the Parquet file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
      fields: [degree]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [degree]

      # Specify a column as the source for the source and destination vertexes.
      # The values of vertex must be consistent with the fields in the Parquet file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: src
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }
      target: {
        field: dst
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge type serve.
    {
      # Specify the Edge type name defined in NebulaGraph.
      name: serve
      type: {
        # Specify the data source file format to Parquet.
        source: parquet

        # Specifies how to import the data into NebulaGraph: Client or SST.
        sink: client
```

```
      }

      # Specify the path to the Parquet file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx".
      # If the file is stored locally, use double quotation marks to enclose the file path, starting with file://. For example, "file:///tmp/xx.parquet".
      path: "hdfs://192.168.11.13:9000/data/edge_serve.parquet"

      # Specify the key name in the Parquet file in fields, and its corresponding value will serve as the data source for the properties specified in the NebulaGraph.
      # If multiple values need to be specified, separate them with commas.
      fields: [start_year,end_year]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [start_year, end_year]

      # Specify a column as the source for the source and destination vertexes.
      # The values of vertex must be consistent with the fields in the Parquet file.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: src
      }
      target: {
        field: dst
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: _c5

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

  ]
  # If more edges need to be added, refer to the previous configuration to add them.
}
```

STEP 4: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import Parquet data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <parquet_application.conf_path>
```

> **Note**
>
> JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/parquet_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 5: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 6: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.5 Import data from HBase

This topic provides an example of how to use Exchange to import NebulaGraph data stored in HBase.

Data set

This topic takes the basketballplayer dataset as an example.

In this example, the data set has been stored in HBase. All vertexes and edges are stored in the `player`, `team`, `follow`, and `serve` tables. The following are some of the data for each table.

```
hbase(main):002:0> scan "player"
ROW                              COLUMN+CELL
 player100                       column=cf:age, timestamp=1618881347530, value=42
 player100                       column=cf:name, timestamp=1618881354604, value=Tim Duncan
 player101                       column=cf:age, timestamp=1618881369124, value=36
 player101                       column=cf:name, timestamp=1618881379102, value=Tony Parker
 player102                       column=cf:age, timestamp=1618881386987, value=33
 player102                       column=cf:name, timestamp=1618881393370, value=LaMarcus Aldridge
 player103                       column=cf:age, timestamp=1618881402002, value=32
 player103                       column=cf:name, timestamp=1618881407882, value=Rudy Gay
 ...

hbase(main):003:0> scan "team"
ROW                              COLUMN+CELL
 team200                         column=cf:name, timestamp=1618881445563, value=Warriors
 team201                         column=cf:name, timestamp=1618881453636, value=Nuggets
 ...

hbase(main):004:0> scan "follow"
ROW                              COLUMN+CELL
 player100                       column=cf:degree, timestamp=1618881804853, value=95
 player100                       column=cf:dst_player, timestamp=1618881791522, value=player101
 player101                       column=cf:degree, timestamp=1618881824685, value=90
 player101                       column=cf:dst_player, timestamp=1618881816042, value=player102
 ...

hbase(main):005:0> scan "serve"
ROW                              COLUMN+CELL
 player100                       column=cf:end_year, timestamp=1618881899333, value=2016
 player100                       column=cf:start_year, timestamp=1618881890117, value=1997
 player100                       column=cf:teamid, timestamp=1618881875739, value=team204
 ...
```

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone
- Hadoop: 2.9.2, pseudo-distributed deployment
- HBase: 2.2.7
- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.
- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.
- The Hadoop service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set HBase data source configuration. In this example, the copied file is called `hbase_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
```

```
    cores: 1
    maxResultSize: 1G
  }
  cores: {
    max: 16
  }
}


# NebulaGraph configuration
nebula: {
  address:{
    # Specify the IP addresses and ports for Graph and all Meta services.
    # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
    # Addresses are separated by commas.
    graph:["127.0.0.1:9669"]
    # the address of any of the meta services.
    # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
    meta:["127.0.0.1:9559"]
  }
  # The account entered must have write permission for the NebulaGraph space.
  user: root
  pswd: nebula
  # Fill in the name of the graph space you want to write data to in the NebulaGraph.
  space: basketballplayer
  connection: {
    timeout: 3000
    retry: 3
  }
  execution: {
    retry: 3
  }
  error: {
    max: 32
    output: /tmp/errors
  }
  rate: {
    limit: 1024
    timeout: 1000
  }
}
# Processing vertexes
tags: [
  # Set information about Tag player.
  # If you want to set RowKey as the data source, enter rowkey and the actual column name of the column family.
  {
    # The Tag name in NebulaGraph.
    name: player
    type: {
      # Specify the data source file format to HBase.
      source: hbase
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }
    host:192.168.*.*
    port:2181
    table:"player"
    columnFamily:"cf"

    # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields: [age,name]
    nebula.fields: [age,name]

    # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
    # For example, if rowkey is the source of the VID, enter rowkey.
    vertex:{
        field:rowkey
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }


    # Number of pieces of data written to NebulaGraph in a single batch.
    batch: 256

    # Number of Spark partitions
    partition: 32
  }
  # Set Tag Team information.
  {
    name: team
    type: {
      source: hbase
      sink: client
    }
    host:192.168.*.*
    port:2181
    table:"team"
    columnFamily:"cf"
```

```
      fields: [name]
      nebula.fields: [name]
      vertex:{
          field:rowkey
      }
      batch: 256
      partition: 32
    }

  ]

  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # The corresponding Edge Type name in NebulaGraph.
      name: follow

      type: {
        # Specify the data source file format to HBase.
        source: hbase

        # Specify how to import the Edge type data into NebulaGraph.
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      host:192.168.*.*
      port:2181
      table:"follow"
      columnFamily:"cf"

      # Specify the column names in the follow table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [degree]
      nebula.fields: [degree]

      # In source, use a column in the follow table as the source of the edge's source vertex.
      # In target, use a column in the follow table as the source of the edge's destination vertex.
      source:{
          field:rowkey
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }


      target:{
          field:dst_player
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge Type serve.
    {
      name: serve
      type: {
        source: hbase
        sink: client
      }
      host:192.168.*.*
      port:2181
      table:"serve"
      columnFamily:"cf"

      fields: [start_year,end_year]
      nebula.fields: [start_year,end_year]
      source:{
          field:rowkey
      }

      target:{
          field:teamid
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank
```

```
      batch: 256
      partition: 32
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import HBase data into NebulaGraph. For descriptions of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <hbase_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/hbase_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.6 Import data from MySQL/PostgreSQL

This topic provides an example of how to use Exchange to export MySQL data and import to NebulaGraph. It also applies to exporting data from PostgreSQL into NebulaGraph.

Data set

This topic takes the basketballplayer dataset as an example.

In this example, the data set has been stored in MySQL. All vertexes and edges are stored in the `player`, `team`, `follow`, and `serve` tables. The following are some of the data for each table.

```
mysql> desc player;
+----------+-------------+------+-----+---------+-------+
| Field    | Type        | Null | Key | Default | Extra |
+----------+-------------+------+-----+---------+-------+
| playerid | varchar(30) | YES  |     | NULL    |       |
| age      | int         | YES  |     | NULL    |       |
| name     | varchar(30) | YES  |     | NULL    |       |
+----------+-------------+------+-----+---------+-------+

mysql> desc team;
+--------+-------------+------+-----+---------+-------+
| Field  | Type        | Null | Key | Default | Extra |
+--------+-------------+------+-----+---------+-------+
| teamid | varchar(30) | YES  |     | NULL    |       |
| name   | varchar(30) | YES  |     | NULL    |       |
+--------+-------------+------+-----+---------+-------+

mysql> desc follow;
+------------+-------------+------+-----+---------+-------+
| Field      | Type        | Null | Key | Default | Extra |
+------------+-------------+------+-----+---------+-------+
| src_player | varchar(30) | YES  |     | NULL    |       |
| dst_player | varchar(30) | YES  |     | NULL    |       |
| degree     | int         | YES  |     | NULL    |       |
+------------+-------------+------+-----+---------+-------+

mysql> desc serve;
+------------+-------------+------+-----+---------+-------+
| Field      | Type        | Null | Key | Default | Extra |
+------------+-------------+------+-----+---------+-------+
| playerid   | varchar(30) | YES  |     | NULL    |       |
| teamid     | varchar(30) | YES  |     | NULL    |       |
| start_year | int         | YES  |     | NULL    |       |
| end_year   | int         | YES  |     | NULL    |       |
+------------+-------------+------+-----+---------+-------+
```

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone
- Hadoop: 2.9.2, pseudo-distributed deployment
- MySQL: 8.0.23
- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.
- The Hadoop service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set MySQL data source configuration. In this case, the copied file is called `mysql_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
```

```
    }
    cores: {
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }
    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula
    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }
  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      # The Tag name in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to MySQL.
        source: mysql
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      host:192.168.*.*
      port:3306
      database:"basketball"
      table:"player"
      user:"test"
      password:"123456"
      sentence:"select playerid, age, name from player order by playerid;"

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [age,name]
      nebula.fields: [age,name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      vertex: {
        field:playerid
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }
    # Set the information about the Tag Team.
    {
      name: team
      type: {
        source: mysql
        sink: client
      }

      host:192.168.*.*
      port:3306
      database:"basketball"
      table:"team"
      user:"test"
```

```
    password:"123456"
    sentence:"select teamid, name from team order by teamid;"

    fields: [name]
    nebula.fields: [name]
    vertex: {
      field: teamid
    }
    batch: 256
    partition: 32
  }

]

# Processing edges
edges: [
  # Set the information about the Edge Type follow.
  {
    # The corresponding Edge Type name in NebulaGraph.
    name: follow

    type: {
      # Specify the data source file format to MySQL.
      source: mysql

      # Specify how to import the Edge type data into NebulaGraph.
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    host:192.168.*.*
    port:3306
    database:"basketball"
    table:"follow"
    user:"test"
    password:"123456"
    sentence:"select src_player,dst_player,degree from follow order by src_player;"

    # Specify the column names in the follow table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields: [degree]
    nebula.fields: [degree]

    # In source, use a column in the follow table as the source of the edge's source vertex.
    # In target, use a column in the follow table as the source of the edge's destination vertex.
    source: {
      field: src_player
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    target: {
      field: dst_player
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # (Optional) Specify a column as the source of the rank.
    #ranking: rank

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
  }

  # Set the information about the Edge Type serve.
  {
    name: serve
    type: {
      source: mysql
      sink: client
    }

    host:192.168.*.*
    port:3306
    database:"basketball"
    table:"serve"
    user:"test"
    password:"123456"
    sentence:"select playerid,teamid,start_year,end_year from serve order by playerid;"
    fields: [start_year,end_year]
    nebula.fields: [start_year,end_year]
    source: {
      field: playerid
    }
```

```
      target: {
        field: teamid
      }
      batch: 256
      partition: 32
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import MySQL data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <mysql_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/mysql_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.7 Import data from Oracle

This topic provides an example of how to use Exchange to export Oracle data and import to NebulaGraph.

Data set

This topic takes the basketballplayer dataset as an example.

In this example, the data set has been stored in Oracle. All vertexes and edges are stored in the `player`, `team`, `follow`, and `serve` tables. The following are some of the data for each table.

```
oracle> desc player;
+-----------+-------+---------------+
| Column    | Null  | Type          |
+-----------+-------+---------------+
| PLAYERID  |  -    | VARCHAR2(30)  |
| NAME      |  -    | VARCHAR2(30)  |
| AGE       |  -    | NUMBER        |
+-----------+-------+---------------+

oracle> desc team;
+-----------+-------+---------------+
| Column    | Null  | Type          |
+-----------+-------+---------------+
| TEAMID    |  -    | VARCHAR2(30)  |
| NAME      |  -    | VARCHAR2(30)  |
+-----------+-------+---------------+

oracle> desc follow;
+-------------+-------+---------------+
| Column      | Null  | Type          |
+-------------+-------+---------------+
| SRC_PLAYER  |  -    | VARCHAR2(30)  |
| DST_PLAYER  |  -    | VARCHAR2(30)  |
| DEGREE      |  -    | NUMBER        |
+-------------+-------+---------------+

oracle> desc serve;
+------------+-------+---------------+
| Column     | Null  | Type          |
+------------+-------+---------------+
| PLAYERID   |  -    | VARCHAR2(30)  |
| TEAMID     |  -    | VARCHAR2(30)  |
| START_YEAR |  -    | NUMBER        |
| END_YEAR   |  -    | NUMBER        |
+------------+-------+---------------+
```

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- Hadoop: 2.9.2, pseudo-distributed deployment

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.
- The Hadoop service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set Oracle data source configuration. In this case, the copied file is called `oracle_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
```

```
    }
    cores: {
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }
    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula
    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }
  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      # The Tag name in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to Oracle.
        source: oracle
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      url:"jdbc:oracle:thin:@host:1521:db"
      driver: "oracle.jdbc.driver.OracleDriver"
      user: "root"
      password: "123456"
      table: "basketball.player"
      sentence: "select playerid, name, age from player"

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [age,name]
      nebula.fields: [age,name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      vertex: {
        field:playerid
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }
    # Set the information about the Tag Team.
    {
      name: team
      type: {
        source: oracle
        sink: client
      }

      url:"jdbc:oracle:thin:@host:1521:db"
      driver: "oracle.jdbc.driver.OracleDriver"
      user: "root"
      password: "123456"
      table: "basketball.team"
      sentence: "select teamid, name from team"
```

```
    fields: [name]
    nebula.fields: [name]
    vertex: {
      field: teamid
    }
    batch: 256
    partition: 32
  }

]

# Processing edges
edges: [
  # Set the information about the Edge Type follow.
  {
    # The corresponding Edge Type name in NebulaGraph.
    name: follow

    type: {
      # Specify the data source file format to Oracle.
      source: oracle

      # Specify how to import the Edge type data into NebulaGraph.
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    url:"jdbc:oracle:thin:@host:1521:db"
    driver: "oracle.jdbc.driver.OracleDriver"
    user: "root"
    password: "123456"
    table: "basketball.follow"
    sentence: "select src_player, dst_player, degree from follow"

    # Specify the column names in the follow table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields: [degree]
    nebula.fields: [degree]

    # In source, use a column in the follow table as the source of the edge's source vertex.
    # In target, use a column in the follow table as the source of the edge's destination vertex.
    source: {
      field: src_player
    # udf:{
    #           separator:"_"
    #           oldColNames:[field-0,field-1,field-2]
    #           newColName:new-field
    #       }
    }

    target: {
      field: dst_player
    # udf:{
    #           separator:"_"
    #           oldColNames:[field-0,field-1,field-2]
    #           newColName:new-field
    #       }
    }

    # (Optional) Specify a column as the source of the rank.
    #ranking: rank

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
  }

  # Set the information about the Edge Type serve.
  {
    name: serve
    type: {
      source: oracle
      sink: client
    }

    url:"jdbc:oracle:thin:@host:1521:db"
    driver: "oracle.jdbc.driver.OracleDriver"
    user: "root"
    password: "123456"
    table: "basketball.serve"
    sentence: "select playerid, teamid, start_year, end_year from serve"

    fields: [start_year,end_year]
    nebula.fields: [start_year,end_year]
    source: {
      field: playerid
    }
    target: {
      field: teamid
    }
```

```
      batch: 256
      partition: 32
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import Oracle data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <oracle_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/oracle_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

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16.4.8 Import data from ClickHouse

This topic provides an example of how to use Exchange to import data stored on ClickHouse into NebulaGraph.

Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB
- Spark: 2.4.7, stand-alone
- Hadoop: 2.9.2, pseudo-distributed deployment
- ClickHouse: docker deployment yandex/clickhouse-server tag: latest(2021.07.01)
- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.
- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.
- The Hadoop service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set ClickHouse data source configuration. In this example, the copied file is called `clickhouse_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    cores: {
      max: 16
    }
  }

# NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }
    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula
    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
```

```
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }
  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      name: player
      type: {
        # Specify the data source file format to ClickHouse.
        source: clickhouse
        # Specify how to import the data of vertexes into NebulaGraph: Client or SST.
        sink: client
      }

      # JDBC URL of ClickHouse
      url:"jdbc:clickhouse://192.168.*.*:8123/basketballplayer"

      user:"user"
      password:"123456"

      # The number of ClickHouse partitions
      numPartition:"5"

      sentence:"select * from player"

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [name,age]
      nebula.fields: [name,age]

      # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
      vertex: {
        field:playerid
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
        # policy:hash
      }

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Tag Team.
    {
      name: team
      type: {
        source: clickhouse
        sink: client
      }
      url:"jdbc:clickhouse://192.168.*.*:8123/basketballplayer"
      user:"user"
      password:"123456"
      numPartition:"5"
      sentence:"select * from team"
      fields: [name]
      nebula.fields: [name]
      vertex: {
        field:teamid
      }
      batch: 256
      partition: 32
    }
  ]

  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # The corresponding Edge Type name in NebulaGraph.
      name: follow

      type: {
        # Specify the data source file format to ClickHouse.
        source: clickhouse
```

```
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # JDBC URL of ClickHouse
      url:"jdbc:clickhouse://192.168.*.*:8123/basketballplayer"

      user:"user"
      password:"123456"

      # The number of ClickHouse partitions.
      numPartition:"5"

      sentence:"select * from follow"

      # Specify the column names in the follow table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [degree]
      nebula.fields: [degree]

      # In source, use a column in the follow table as the source of the edge's source vertexes.
      source: {
        field:src_player
      # udf:{
      #           separator:"_"
      #           oldColNames:[field-0,field-1,field-2]
      #           newColName:new-field
      #       }
      }

      # In target, use a column in the follow table as the source of the edge's destination vertexes.
      target: {
        field:dst_player
      # udf:{
      #           separator:"_"
      #           oldColNames:[field-0,field-1,field-2]
      #           newColName:new-field
      #       }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge Type serve.
    {
      name: serve
      type: {
        source: clickhouse
        sink: client
      }
      url:"jdbc:clickhouse://192.168.*.*:8123/basketballplayer"
      user:"user"
      password:"123456"
      numPartition:"5"
      sentence:"select * from serve"
      fields: [start_year,end_year]
      nebula.fields: [start_year,end_year]
      source: {
        field:playerid
      }
      target: {
        field:teamid
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      batch: 256
      partition: 32
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import ClickHouse data into NebulaGraph. For descriptions of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <clickhouse_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/clickhouse_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.9 Import data from Neo4j

This topic provides an example of how to use Exchange to import NebulaGraph data stored in Neo4j.

Implementation method

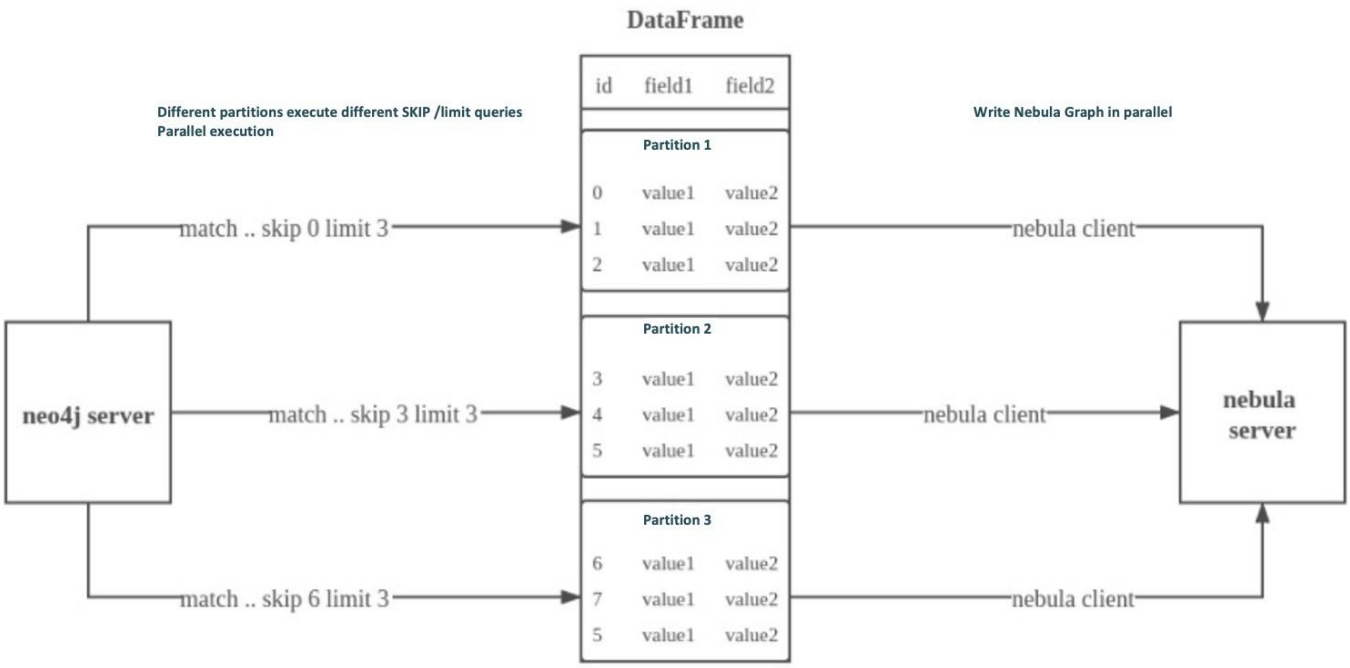
Exchange uses **Neo4j Driver 4.0.1** to read Neo4j data. Before batch export, you need to write Cypher statements that are automatically executed based on labels and relationship types and the number of Spark partitions in the configuration file to improve data export performance.

When Exchange reads Neo4j data, it needs to do the following:

1. The Reader in Exchange replaces the statement following the Cypher `RETURN` statement in the `exec` part of the configuration file with `COUNT(*)`, and executes this statement to get the total amount of data, then calculates the starting offset and size of each partition based on the number of Spark partitions.
2. (Optional) If the user has configured the `check_point_path` directory, Reader reads the files in the directory. In the transferring state, Reader calculates the offset and size that each Spark partition should have.
3. In each Spark partition, the Reader in Exchange adds different `SKIP` and `LIMIT` statements to the Cypher statement and calls the Neo4j Driver for parallel execution to distribute data to different Spark partitions.
4. The Reader finally processes the returned data into a DataFrame.

At this point, Exchange has finished exporting the Neo4j data. The data is then written in parallel to the NebulaGraph database.

The whole process is illustrated below.



Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU：Intel(R) Xeon(R) CPU E5-2697 v3 @ 2.60GHz
- CPU cores: 14
- Memory: 251 GB
- Spark: Stand-alone, 2.4.6 pre-build for Hadoop 2.7
- Neo4j: 3.5.20 Community Edition
- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with NebulaGraph write permission.
- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer
nebula> USE basketballplayer;

## Create the Tag player
nebula> CREATE TAG player(name string, age int);

## Create the Tag team
nebula> CREATE TAG team(name string);

## Create the Edge type follow
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: CONFIGURING SOURCE DATA

To speed up the export of Neo4j data, create indexes for the corresponding properties in the Neo4j database. For more information, refer to the Neo4j manual.

STEP 3: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set Neo4j data source configuration. In this example, the copied file is called `neo4j_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }

    driver: {
      cores: 1
      maxResultSize: 1G
    }

    executor: {
        memory:1G
    }

    cores: {
      max: 16
    }
  }


  # NebulaGraph configuration
  nebula: {
    address:{
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
```

```
    meta:["127.0.0.1:9559"]
  }
  user: root
  pswd: nebula
  space: basketballplayer

  connection: {
    timeout: 3000
    retry: 3
  }

  execution: {
    retry: 3
  }

  error: {
    max: 32
    output: /tmp/errors
  }

  rate: {
    limit: 1024
    timeout: 1000
  }
}

# Processing vertexes
tags: [


  # Set the information about the Tag player
  {
    name: player
    type: {
      source: neo4j
      sink: client
    }
    server: "bolt://192.168.*.*:7687"
    user: neo4j
    password:neo4j
    database:neo4j
    exec: "match (n:player) return n.id as id, n.age as age, n.name as name"
    fields: [age,name]
    nebula.fields: [age,name]
    vertex: {
      field:id
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }
    partition: 10
    batch: 1000
    check_point_path: /tmp/test
 }
# Set the information about the Tag Team
{
    name: team
    type: {
      source: neo4j
      sink: client
    }
    server: "bolt://192.168.*.*:7687"
    user: neo4j
    password:neo4j
    database:neo4j
    exec: "match (n:team) return n.id as id,n.name as name"
    fields: [name]
    nebula.fields: [name]
    vertex: {
      field:id
    }
    partition: 10
    batch: 1000
    check_point_path: /tmp/test
 }
]

# Processing edges
edges: [
  # Set the information about the Edge Type follow
  {
    name: follow
    type: {
      source: neo4j
      sink: client
    }
    server: "bolt://192.168.*.*:7687"
    user: neo4j
    password:neo4j
    database:neo4j
    exec: "match (a:player)-[r:follow]->(b:player) return a.id as src, b.id as dst, r.degree as degree  order by id(r)"
    fields: [degree]
```

```
      nebula.fields: [degree]
      source: {
        field: src
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }
      target: {
        field: dst
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }
      #ranking: rank
      partition: 10
      batch: 1000
      check_point_path: /tmp/test
    }
   # Set the information about the Edge Type serve
   {
      name: serve
      type: {
        source: neo4j
        sink: client
      }
      server: "bolt://192.168.*.*:7687"
      user: neo4j
      password:neo4j
      database:neo4j
      exec: "match (a:player)-[r:serve]->(b:team) return a.id as src, b.id as dst, r.start_year as start_year, r.end_year as end_year  order by id(r)"
      fields: [start_year,end_year]
      nebula.fields: [start_year,end_year]
      source: {
        field: src
      }
      target: {
        field: dst
      }
      #ranking: rank
      partition: 10
      batch: 1000
      check_point_path: /tmp/test
    }
   ]
}
```

Exec configuration

When configuring either the `tags.exec` or `edges.exec` parameters, you need to fill in the Cypher query. To prevent loss of data during import, it is strongly recommended to include `ORDER BY` clause in Cypher queries. Meanwhile, in order to improve data import efficiency, it is better to select indexed properties for ordering. If there is no index, users can also observe the default order and select the appropriate properties for ordering to improve efficiency. If the pattern of the default order cannot be found, users can order them by the ID of the vertex or relationship and set the `partition` to a small value to reduce the ordering pressure of Neo4j.

Note

Using the `ORDER BY` clause lengthens the data import time.

Exchange needs to execute different `SKIP` and `LIMIT` Cypher statements on different Spark partitions, so `SKIP` and `LIMIT` clauses cannot be included in the Cypher statements corresponding to `tags.exec` and `edges.exec`.

tags.vertex or edges.vertex configuration

NebulaGraph uses ID as the unique primary key when creating vertexes and edges, overwriting the data in that primary key if it already exists. So, if a Neo4j property value is given as the NebulaGraph'S ID and the value is duplicated in Neo4j, duplicate IDs will be generated. One and only one of their corresponding data will be stored in the NebulaGraph, and the others will be overwritten. Because the data import process is concurrently writing data to NebulaGraph, the final saved data is not guaranteed to be the latest data in Neo4j.

check_point_path configuration

If breakpoint transfers are enabled, to avoid data loss, the state of the database should not change between the breakpoint and the transfer. For example, data cannot be added or deleted, and the `partition` quantity configuration should not be changed.

STEP 4: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import Neo4j data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <neo4j_application.conf_path>
```

> **Note**
>
> JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/neo4j_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 5: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 6: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

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16.4.10 Import data from Hive

This topic provides an example of how to use Exchange to import NebulaGraph data stored in Hive.

Data set

This topic takes the basketballplayer dataset as an example.

In this example, the data set has been stored in Hive. All vertexes and edges are stored in the `player`, `team`, `follow`, and `serve` tables. The following are some of the data for each table.

```
scala> spark.sql("describe basketball.player").show
+--------+---------+-------+
|col_name|data_type|comment|
+--------+---------+-------+
|playerid|   string|   null|
|     age|   bigint|   null|
|    name|   string|   null|
+--------+---------+-------+

scala> spark.sql("describe basketball.team").show
+----------+---------+-------+
|  col_name|data_type|comment|
+----------+---------+-------+
|    teamid|   string|   null|
|      name|   string|   null|
+----------+---------+-------+

scala> spark.sql("describe basketball.follow").show
+----------+---------+-------+
|  col_name|data_type|comment|
+----------+---------+-------+
|src_player|   string|   null|
|dst_player|   string|   null|
|    degree|   bigint|   null|
+----------+---------+-------+

scala> spark.sql("describe basketball.serve").show
+----------+---------+-------+
|  col_name|data_type|comment|
+----------+---------+-------+
|  playerid|   string|   null|
|    teamid|   string|   null|
|start_year|   bigint|   null|
|  end_year|   bigint|   null|
+----------+---------+-------+
```

Note

The Hive data type `bigint` corresponds to the NebulaGraph `int`.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB
- Spark: 2.4.7, stand-alone
- Hadoop: 2.9.2, pseudo-distributed deployment
- Hive: 2.3.7, Hive Metastore database is MySQL 8.0.22
- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- Hadoop has been installed and started, and the Hive Metastore database (MySQL in this example) has been started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer
nebula> USE basketballplayer;

## Create the Tag player
nebula> CREATE TAG player(name string, age int);

## Create the Tag team
nebula> CREATE TAG team(name string);

## Create the Edge type follow
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: USE SPARK SQL TO CONFIRM HIVE SQL STATEMENTS

After the Spark-shell environment is started, run the following statements to ensure that Spark can read data in Hive.

```
scala> sql("select playerid, age, name from basketball.player").show
scala> sql("select teamid, name from basketball.team").show
scala> sql("select src_player, dst_player, degree from basketball.follow").show
scala> sql("select playerid, teamid, start_year, end_year from basketball.serve").show
```

The following is the result read from the table `basketball.player`.

```
+---------+----+-----------------+
| playerid| age|             name|
```

```
+---------+----+----------------+
|player100|  42|      Tim Duncan|
|player101|  36|     Tony Parker|
|player102|  33|LaMarcus Aldridge|
|player103|  32|        Rudy Gay|
|player104|  32| Marco Belinelli|
+---------+----+----------------+
...
```

STEP 3: MODIFY CONFIGURATION FILE

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set Hive data source configuration. In this example, the copied file is called `hive_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    cores: {
      max: 16
    }
  }

  # If Spark and Hive are deployed in different clusters, you need to configure the parameters for connecting to Hive. Otherwise, skip these configurations.
  #hive: {
  #  waredir: "hdfs://NAMENODE_IP:9000/apps/svr/hive-xxx/warehouse/"
  #  connectionURL: "jdbc:mysql://your_ip:3306/hive_spark?characterEncoding=UTF-8"
  #  connectionDriverName: "com.mysql.jdbc.Driver"
  #  connectionUserName: "user"
  #  connectionPassword: "password"
  #}

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and all Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }
    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula
    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }
  # Processing vertexes
  tags: [
    # Set the information about the Tag player.
    {
      # The Tag name in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to Hive.
        source: hive
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Set the SQL statement to read the data of player table in basketball database.
      exec: "select playerid, age, name from basketball.player"

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [age,name]
      nebula.fields: [age,name]
```

```
      # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
      vertex:{
        field:playerid
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }
    # Set the information about the Tag Team.
    {
      name: team
      type: {
        source: hive
        sink: client
      }
      exec: "select teamid, name from basketball.team"
      fields: [name]
      nebula.fields: [name]
      vertex: {
        field: teamid
      }
      batch: 256
      partition: 32
    }

  ]

  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # The corresponding Edge Type name in NebulaGraph.
      name: follow

      type: {
        # Specify the data source file format to Hive.
        source: hive

        # Specify how to import the Edge type data into NebulaGraph.
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Set the SQL statement to read the data of follow table in the basketball database.
      exec: "select src_player, dst_player, degree from basketball.follow"

      # Specify the column names in the follow table in Fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [degree]
      nebula.fields: [degree]

      # In source, use a column in the follow table as the source of the edge's starting vertex.
      # In target, use a column in the follow table as the source of the edge's destination vertex.
      source: {
        field: src_player
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      target: {
        field: dst_player
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32
    }

    # Set the information about the Edge Type serve.
    {
      name: serve
```

```
      type: {
        source: hive
        sink: client
      }
      exec: "select playerid, teamid, start_year, end_year from basketball.serve"
      fields: [start_year,end_year]
      nebula.fields: [start_year,end_year]
      source: {
        field: playerid
      }
      target: {
        field: teamid
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      batch: 256
      partition: 32
    }
  ]
}
```

STEP 4: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import Hive data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <hive_application.conf_path> -h
```

> **Note**

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/hive_application.conf -h
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 5: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 6: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.11 Import data from MaxCompute

This topic provides an example of how to use Exchange to import NebulaGraph data stored in MaxCompute.

Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB
- Spark: 2.4.7, stand-alone
- Hadoop: 2.9.2, pseudo-distributed deployment
- MaxCompute: Alibaba Cloud official version
- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.
- Exchange has been compiled, or download the compiled `.jar` file directly.
- Spark has been installed.
- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.
- The Hadoop service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set MaxCompute data source configuration. In this example, the copied file is called `maxcompute_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    cores: {
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }
    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula
    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
      timeout: 3000
```

```
    retry: 3
  }
  execution: {
    retry: 3
  }
  error: {
    max: 32
    output: /tmp/errors
  }
  rate: {
    limit: 1024
    timeout: 1000
  }
}
# Processing vertexes
tags: [
  # Set the information about the Tag player.
  {
    name: player
    type: {
      # Specify the data source file format to MaxCompute.
      source: maxcompute
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    # Table name of MaxCompute.
    table:player

    # Project name of MaxCompute.
    project:project

    # OdpsUrl and tunnelUrl for the MaxCompute service.
    # The address is https://help.aliyun.com/document_detail/34951.html.
    odpsUrl:"http://service.cn-hangzhou.maxcompute.aliyun.com/api"
    tunnelUrl:"http://dt.cn-hangzhou.maxcompute.aliyun.com"

    # AccessKeyId and accessKeySecret of the MaxCompute service.
    accessKeyId:xxx
    accessKeySecret:xxx

    # Partition description of the MaxCompute table. This configuration is optional.
    partitionSpec:"dt='partition1'"

    # Ensure that the table name in the SQL statement is the same as the value of the table above. This configuration is optional.
    sentence:"select id, name, age, playerid from player where id < 10"

    # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields:[name, age]
    nebula.fields:[name, age]

    # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
    vertex:{
      field: playerid
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
  }

  # Set the information about the Tag Team.
  {
    name: team
    type: {
      source: maxcompute
      sink: client
    }
    table:team
    project:project
    odpsUrl:"http://service.cn-hangzhou.maxcompute.aliyun.com/api"
    tunnelUrl:"http://dt.cn-hangzhou.maxcompute.aliyun.com"
    accessKeyId:xxx
    accessKeySecret:xxx
    partitionSpec:"dt='partition1'"
    sentence:"select id, name, teamid from team where id < 10"
    fields:[name]
    nebula.fields:[name]
    vertex:{
      field: teamid
    }
    batch: 256
    partition: 32
  }
]
```

```
# Processing edges
edges: [
  # Set the information about the Edge Type follow.
  {
    # The corresponding Edge Type name in NebulaGraph.
    name: follow

    type:{
      # Specify the data source file format to MaxCompute.
      source:maxcompute

      # Specify how to import the Edge type data into NebulaGraph.
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink:client
    }

    # Table name of MaxCompute.
    table:follow

    # Project name of MaxCompute.
    project:project

    # OdpsUrl and tunnelUrl for MaxCompute service.
    # The address is https://help.aliyun.com/document_detail/34951.html.
    odpsUrl:"http://service.cn-hangzhou.maxcompute.aliyun.com/api"
    tunnelUrl:"http://dt.cn-hangzhou.maxcompute.aliyun.com"

    # AccessKeyId and accessKeySecret of the MaxCompute service.
    accessKeyId:xxx
    accessKeySecret:xxx

    # Partition description of the MaxCompute table. This configuration is optional.
    partitionSpec:"dt='partition1'"

    # Ensure that the table name in the SQL statement is the same as the value of the table above. This configuration is optional.
    sentence:"select * from follow"

    # Specify the column names in the follow table in Fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields:[degree]
    nebula.fields:[degree]

    # In source, use a column in the follow table as the source of the edge's source vertex.
    source:{
      field: src_player
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # In target, use a column in the follow table as the source of the edge's destination vertex.
    target:{
      field: dst_player
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # (Optional) Specify a column as the source of the rank.
    #ranking: rank

    # The number of Spark partitions.
    partition:10

    # The number of data written to NebulaGraph in a single batch.
    batch:10
  }

  # Set the information about the Edge Type serve.
  {
    name: serve
    type:{
      source:maxcompute
      sink:client
    }
    table:serve
    project:project
    odpsUrl:"http://service.cn-hangzhou.maxcompute.aliyun.com/api"
    tunnelUrl:"http://dt.cn-hangzhou.maxcompute.aliyun.com"
    accessKeyId:xxx
    accessKeySecret:xxx
    partitionSpec:"dt='partition1'"
    sentence:"select * from serve"
    fields:[start_year,end_year]
    nebula.fields:[start_year,end_year]
    source:{
      field: playerid
    }
```

```
        target:{
          field: teamid
        }

        # (Optional) Specify a column as the source of the rank.
        #ranking: rank

        partition:10
        batch:10
      }
    ]
  }
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import MaxCompute data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <maxcompute_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/maxcompute_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.12 Import data from Pulsar

This topic provides an example of how to use Exchange to import NebulaGraph data stored in Pulsar.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- The Pulsar service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer
nebula> USE basketballplayer;

## Create the Tag player
nebula> CREATE TAG player(name string, age int);

## Create the Tag team
nebula> CREATE TAG team(name string);

## Create the Edge type follow
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set Pulsar data source configuration. In this example, the copied file is called `pulsar_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    cores: {
      max: 16
    }
  }


  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and all Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }

    # The account entered must have write permission for the NebulaGraph space.
    user: root
    pswd: nebula

    # Fill in the name of the graph space you want to write data to in the NebulaGraph.
    space: basketballplayer
    connection: {
```

```
      timeout: 3000
      retry: 3
    }
    execution: {
      retry: 3
    }
    error: {
      max: 32
      output: /tmp/errors
    }
    rate: {
      limit: 1024
      timeout: 1000
    }
  }
  # Processing vertices
  tags: [
    # Set the information about the Tag player.
    {
      # The corresponding Tag name in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to Pulsar.
        source: pulsar
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }
      # The address of the Pulsar server.
      service: "pulsar://127.0.0.1:6650"
      # admin.url of pulsar.
      admin: "http://127.0.0.1:8081"
      # The Pulsar option can be configured from topic, topics or topicsPattern.
      options: {
        topics: "topic1,topic2"
      }

      # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [age,name]
      nebula.fields: [age,name]

      # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
      vertex:{
          field:playerid
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }


      # The number of data written to NebulaGraph in a single batch.
      batch: 10

      # The number of Spark partitions.
      partition: 10
      # The interval for message reading. Unit: second.
      interval.seconds: 10
    }
    # Set the information about the Tag Team.
    {
      name: team
      type: {
        source: pulsar
        sink: client
      }
      service: "pulsar://127.0.0.1:6650"
      admin: "http://127.0.0.1:8081"
      options: {
        topics: "topic1,topic2"
      }
      fields: [name]
      nebula.fields: [name]
      vertex:{
          field:teamid
      }
      batch: 10
      partition: 10
      interval.seconds: 10
    }

  ]

  # Processing edges
  edges: [
    # Set the information about Edge Type follow
    {
      # The corresponding Edge Type name in NebulaGraph.
      name: follow

      type: {
        # Specify the data source file format to Pulsar.
```

```
        source: pulsar

        # Specify how to import the Edge type data into NebulaGraph.
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # The address of the Pulsar server.
      service: "pulsar://127.0.0.1:6650"
      # admin.url of pulsar.
      admin: "http://127.0.0.1:8081"
      # The Pulsar option can be configured from topic, topics or topicsPattern.
      options: {
        topics: "topic1,topic2"
      }

      # Specify the column names in the follow table in fields, and their corresponding values are specified as properties in the NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      # If multiple column names need to be specified, separate them by commas.
      fields: [degree]
      nebula.fields: [degree]

      # In source, use a column in the follow table as the source of the edge's source vertex.
      # In target, use a column in the follow table as the source of the edge's destination vertex.
      source:{
          field:src_player
      # udf:{
      #           separator:"_"
      #           oldColNames:[field-0,field-1,field-2]
      #           newColName:new-field
      #       }
      }

      target:{
          field:dst_player
      # udf:{
      #           separator:"_"
      #           oldColNames:[field-0,field-1,field-2]
      #           newColName:new-field
      #       }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 10

      # The number of Spark partitions.
      partition: 10

      # The interval for message reading. Unit: second.
      interval.seconds: 10
    }

    # Set the information about the Edge Type serve
    {
      name: serve
      type: {
        source: Pulsar
        sink: client
      }
      service: "pulsar://127.0.0.1:6650"
      admin: "http://127.0.0.1:8081"
      options: {
        topics: "topic1,topic2"
      }

      fields: [start_year,end_year]
      nebula.fields: [start_year,end_year]
      source:{
          field:playerid
      }

      target:{
          field:teamid
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      batch: 10
      partition: 10
      interval.seconds: 10
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import Pulsar data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <pulsar_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/pulsar_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.13 Import data from Kafka

This topic provides a simple guide to importing Data stored on Kafka into NebulaGraph using Exchange.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- The Kafka service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

Note

If some data is stored in Kafka's value field, you need to modify the source code, get the value from Kafka, parse the value through the from_JSON function, and return it as a Dataframe.

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set Kafka data source configuration. In this example, the copied file is called `kafka_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
    }
    cores: {
      max: 16
    }
  }


  # NebulaGraph configuration
  nebula: {
    address:{
      # Specify the IP addresses and ports for Graph and all Meta services.
      # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
      # Addresses are separated by commas.
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
```

```
    meta:["127.0.0.1:9559"]
  }
  # The account entered must have write permission for the NebulaGraph space.
  user: root
  pswd: nebula
  # Fill in the name of the graph space you want to write data to in the NebulaGraph.
  space: basketballplayer
  connection: {
    timeout: 3000
    retry: 3
  }
  execution: {
    retry: 3
  }
  error: {
    max: 32
    output: /tmp/errors
  }
  rate: {
    limit: 1024
    timeout: 1000
  }
}
# Processing vertexes
tags: [
  # Set the information about the Tag player.
  {

    # The corresponding Tag name in NebulaGraph.
    name: player
    type: {
      # Specify the data source file format to Kafka.
      source: kafka
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }
    # Kafka server address.
    service: "127.0.0.1:9092"
    # Message category.
    topic: "topic_name1"

    # Kafka data has a fixed domain name: key, value, topic, partition, offset, timestamp, timestampType.
    # If multiple fields need to be specified after Spark reads as DataFrame, separate them with commas.
    # Specify the field name in fields. For example, use key for name in NebulaGraph and value for age in Nebula, as shown in the following.
    fields: [key,value]
    nebula.fields: [name,age]

    # Specify a column of data in the table as the source of vertex VID in the NebulaGraph.
    # The key is the same as the value above, indicating that key is used as both VID and property name.
    vertex:{
        field:key
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }


    # The number of data written to NebulaGraph in a single batch.
    batch: 10

    # The number of Spark partitions.
    partition: 10
    # The interval for message reading. Unit: second.
    interval.seconds: 10
  }
  # Set the information about the Tag Team.
  {
    name: team
    type: {
      source: kafka
      sink: client
    }
    service: "127.0.0.1:9092"
    topic: "topic_name2"
    fields: [key]
    nebula.fields: [name]
    vertex:{
        field:key
    }
    batch: 10
    partition: 10
    interval.seconds: 10
  }

]

# Processing edges
edges: [
  # Set the information about the Edge Type follow.
  {
    # The corresponding Edge Type name in NebulaGraph.
    name: follow
```

```
      type: {
        # Specify the data source file format to Kafka.
        source: kafka

        # Specify how to import the Edge type data into NebulaGraph.
        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: client
      }

      # Kafka server address.
      service: "127.0.0.1:9092"
      # Message category.
      topic: "topic_name3"

      # Kafka data has a fixed domain name: key, value, topic, partition, offset, timestamp, timestampType.
      # If multiple fields need to be specified after Spark reads as DataFrame, separate them with commas.
      # Specify the field name in fields. For example, use key for degree in Nebula, as shown in the following.
      fields: [key]
      nebula.fields: [degree]

      # In source, use a column in the topic as the source of the edge's source vertex.
      # In target, use a column in the topic as the source of the edge's destination vertex.
      source:{
          field:timestamp
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }


      target:{
          field:offset
      # udf:{
      #            separator:"_"
      #            oldColNames:[field-0,field-1,field-2]
      #            newColName:new-field
      #        }
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      # The number of data written to NebulaGraph in a single batch.
      batch: 10

      # The number of Spark partitions.
      partition: 10

      # The interval for message reading. Unit: second.
      interval.seconds: 10
    }

    # Set the information about the Edge Type serve.
    {
      name: serve
      type: {
        source: kafka
        sink: client
      }
      service: "127.0.0.1:9092"
      topic: "topic_name4"

      fields: [timestamp,offset]
      nebula.fields: [start_year,end_year]
      source:{
          field:key
      }

      target:{
          field:value
      }

      # (Optional) Specify a column as the source of the rank.
      #ranking: rank

      batch: 10
      partition: 10
      interval.seconds: 10
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import Kafka data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <kafka_application.conf_path>
```

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/kafka_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.14 Import data from general JDBC

JDBC data refers to the data of various databases accessed through the JDBC interface. This topic provides an example of how to use Exchange to export MySQL data and import to NebulaGraph.

Data set

This topic takes the basketballplayer dataset as an example.

In this example, the data set has been stored in MySQL. All vertexes and edges are stored in the `player`, `team`, `follow`, and `serve` tables. The following are some of the data for each table.

```
mysql> desc player;
+----------+-------------+------+-----+---------+-------+
| Field    | Type        | Null | Key | Default | Extra |
+----------+-------------+------+-----+---------+-------+
| playerid | int         | YES  |     | NULL    |       |
| age      | int         | YES  |     | NULL    |       |
| name     | varchar(30) | YES  |     | NULL    |       |
+----------+-------------+------+-----+---------+-------+

mysql> desc team;
+--------+-------------+------+-----+---------+-------+
| Field  | Type        | Null | Key | Default | Extra |
+--------+-------------+------+-----+---------+-------+
| teamid | int         | YES  |     | NULL    |       |
| name   | varchar(30) | YES  |     | NULL    |       |
+--------+-------------+------+-----+---------+-------+

mysql> desc follow;
+------------+-------------+------+-----+---------+-------+
| Field      | Type        | Null | Key | Default | Extra |
+------------+-------------+------+-----+---------+-------+
| src_player | int         | YES  |     | NULL    |       |
| dst_player | int         | YES  |     | NULL    |       |
| degree     | int         | YES  |     | NULL    |       |
+------------+-------------+------+-----+---------+-------+

mysql> desc serve;
+------------+-------------+------+-----+---------+-------+
| Field      | Type        | Null | Key | Default | Extra |
+------------+-------------+------+-----+---------+-------+
| playerid   | int         | YES  |     | NULL    |       |
| teamid     | int         | YES  |     | NULL    |       |
| start_year | int         | YES  |     | NULL    |       |
| end_year   | int         | YES  |     | NULL    |       |
+------------+-------------+------+-----+---------+-------+
```

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB

- Spark: 2.4.7, stand-alone

- Hadoop: 2.9.2, pseudo-distributed deployment

- MySQL: 8.0.23

- NebulaGraph: 3.5.0. Deploy NebulaGraph with Docker Compose.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- Learn about the Schema created in NebulaGraph, including names and properties of Tags and Edge types, and more.

- The Hadoop service has been installed and started.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space.
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer.
nebula> USE basketballplayer;

## Create the Tag player.
nebula> CREATE TAG player(name string, age int);

## Create the Tag team.
nebula> CREATE TAG team(name string);

## Create the Edge type follow.
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve.
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set JDBC data source configuration. In this case, the copied file is called `jdbc_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }
    driver: {
      cores: 1
      maxResultSize: 1G
```

```
  }
  cores: {
    max: 16
  }
}

# NebulaGraph configuration
nebula: {
  address:{
    # Specify the IP addresses and ports for Graph and Meta services.
    # If there are multiple addresses, the format is "ip1:port","ip2:port","ip3:port".
    # Addresses are separated by commas.
    graph:["127.0.0.1:9669"]
    # the address of any of the meta services.
    # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
    meta:["127.0.0.1:9559"]
  }
  # The account entered must have write permission for the NebulaGraph space.
  user: root
  pswd: nebula
  # Fill in the name of the graph space you want to write data to in the NebulaGraph.
  space: basketballplayer
  connection: {
    timeout: 3000
    retry: 3
  }
  execution: {
    retry: 3
  }
  error: {
    max: 32
    output: /tmp/errors
  }
  rate: {
    limit: 1024
    timeout: 1000
  }
}
# Processing vertexes
tags: [
  # Set the information about the Tag player.
  {
    # The Tag name in NebulaGraph.
    name: player
    type: {
      # Specify the data source file format to JDBC.
      source: jdbc
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    # URL of the JDBC data source. The example is MySql database.
    url:"jdbc:mysql://127.0.0.1:3306/basketball?useUnicode=true&characterEncoding=utf-8"

    # JDBC driver
    driver:"com.mysql.cj.jdbc.Driver"

    # Database user name and password
    user:root
    password:"12345"

    table:player
    sentence:"select playerid, age, name from player order by playerid"

    # (optional)Multiple connections read parameters. See https://spark.apache.org/docs/latest/sql-data-sources-jdbc.html
    partitionColumn:playerid    # optional. Must be a numeric, date, or timestamp column from the table in question.
    lowerBound:1                # optional
    upperBound:5                # optional
    numPartitions:5             # optional


    fetchSize:2           # The JDBC fetch size, which determines how many rows to fetch per round trip.

    # Specify the column names in the player table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields: [age,name]
    nebula.fields: [age,name]

    # Specify a column of data in the table as the source of VIDs in the NebulaGraph.
    vertex: {
      field:playerid
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
```

```
  }
  # Set the information about the Tag Team.
  {
    name: team
    type: {
      source: jdbc
      sink: client
    }

    url:"jdbc:mysql://127.0.0.1:3306/basketball?useUnicode=true&characterEncoding=utf-8"
    driver:"com.mysql.cj.jdbc.Driver"
    user:root
    password:"12345"
    table:team
    sentence:"select teamid, name from team order by teamid"
    partitionColumn:teamid
    lowerBound:1
    upperBound:5
    numPartitions:5
    fetchSize:2

    fields: [name]
    nebula.fields: [name]
    vertex: {
      field: teamid
    }
    batch: 256
    partition: 32
  }

]

# Processing edges
edges: [
  # Set the information about the Edge Type follow.
  {
    # The corresponding Edge Type name in NebulaGraph.
    name: follow

    type: {
      # Specify the data source file format to JDBC.
      source: jdbc

      # Specify how to import the Edge type data into NebulaGraph.
      # Specify how to import the data into NebulaGraph: Client or SST.
      sink: client
    }

    url:"jdbc:mysql://127.0.0.1:3306/basketball?useUnicode=true&characterEncoding=utf-8"
    driver:"com.mysql.cj.jdbc.Driver"
    user:root
    password:"12345"
    table:follow
    sentence:"select src_player,dst_player,degree from follow order by src_player"
    partitionColumn:src_player
    lowerBound:1
    upperBound:5
    numPartitions:5
    fetchSize:2

    # Specify the column names in the follow table in fields, and their corresponding values are specified as properties in the NebulaGraph.
    # The sequence of fields and nebula.fields must correspond to each other.
    # If multiple column names need to be specified, separate them by commas.
    fields: [degree]
    nebula.fields: [degree]

    # In source, use a column in the follow table as the source of the edge's source vertex.
    # In target, use a column in the follow table as the source of the edge's destination vertex.
    source: {
      field: src_player
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    target: {
      field: dst_player
    # udf:{
    #            separator:"_"
    #            oldColNames:[field-0,field-1,field-2]
    #            newColName:new-field
    #        }
    }

    # (Optional) Specify a column as the source of the rank.
    #ranking: rank

    # The number of data written to NebulaGraph in a single batch.
    batch: 256

    # The number of Spark partitions.
    partition: 32
```

```
    }

    # Set the information about the Edge Type serve.
    {
      name: serve
      type: {
        source: jdbc
        sink: client
      }

      url:"jdbc:mysql://127.0.0.1:3306/basketball?useUnicode=true&characterEncoding=utf-8"
      driver:"com.mysql.cj.jdbc.Driver"
      user:root
      password:"12345"
      table:serve
      sentence:"select playerid,teamid,start_year,end_year from serve order by playerid"
      partitionColumn:playerid
      lowerBound:1
      upperBound:5
      numPartitions:5
      fetchSize:2

      fields: [start_year,end_year]
      nebula.fields: [start_year,end_year]
      source: {
        field: playerid
      }
      target: {
        field: teamid
      }
      batch: 256
      partition: 32
    }
  ]
}
```

STEP 3: IMPORT DATA INTO NEBULAGRAPH

Run the following command to import general JDBC data into NebulaGraph. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c <jdbc_application.conf_path>
```

> **Note**
>
> JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/jdbc_application.conf
```

You can search for `batchSuccess.<tag_name/edge_name>` in the command output to check the number of successes. For example, `batchSuccess.follow: 300`.

STEP 4: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the SHOW STATS command to view statistics.

STEP 5: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: May 22, 2023

16.4.15 Import data from SST files

This topic provides an example of how to generate the data from the data source into an SST (Sorted String Table) file and save it on HDFS, and then import it into NebulaGraph. The sample data source is a CSV file.

Precautions

- The SST file can be imported only in Linux.
- The default value of the property is not supported.

Background information

Exchange supports two data import modes:

- Import the data from the data source directly into NebulaGraph as **nGQL** statements.
- Generate the SST file from the data source, and use Console to import the SST file into NebulaGraph.

The following describes the scenarios, implementation methods, prerequisites, and steps for generating an SST file and importing data.

Scenarios

- Suitable for online services, because the generation almost does not affect services (just reads the Schema), and the import speed is fast.

> **Caution**
>
> Although the import speed is fast, write operations in the corresponding space are blocked during the import period (about 10 seconds). Therefore, you are advised to import data in off-peak hours.

- Suitable for scenarios with a large amount of data from data sources for its fast import speed.

Implementation methods

The underlying code in NebulaGraph uses RocksDB as the key-value storage engine. RocksDB is a storage engine based on the hard disk, providing a series of APIs for creating and importing SST files to help quickly import massive data.

The SST file is an internal file containing an arbitrarily long set of ordered key-value pairs for efficient storage of large amounts of key-value data. The entire process of generating SST files is mainly done by Exchange Reader, sstProcessor, and sstWriter. The whole data processing steps are as follows:

1. Reader reads data from the data source.
2. sstProcessor generates the SST file from the NebulaGraph's Schema information and uploads it to the HDFS. For details about the format of the SST file, see Data Storage Format.
3. sstWriter opens a file and inserts data. When generating SST files, keys must be written in sequence.
4. After the SST file is generated, RocksDB imports the SST file into NebulaGraph using the `IngestExternalFile()` method. For example:

```
IngestExternalFileOptions ifo;
# Import two SST files
Status s = db_->IngestExternalFile({"/home/usr/file1.sst", "/home/usr/file2.sst"}, ifo);
if (!s.ok()) {
  printf("Error while adding file %s and %s, Error %s\n",
         file_path1.c_str(), file_path2.c_str(), s.ToString().c_str());
  return 1;
}
```

When the `IngestExternalFile()` method is called, RocksDB copies the file to the data directory by default and blocks the RocksDB write operation. If the key range in the SST file overwrites the Memtable key range, flush the Memtable to the hard disk. After placing the SST file in an optimal location in the LSM tree, assign a global serial number to the file and turn on the write operation.

Data set

This topic takes the basketballplayer dataset as an example.

Environment

This example is done on MacOS. Here is the environment configuration information:

- Hardware specifications:
- CPU: 1.7 GHz Quad-Core Intel Core i7
- Memory: 16 GB
- Spark: 2.4.7, stand-alone
- Hadoop: 2.9.2, pseudo-distributed deployment
- NebulaGraph: 3.5.0.

Prerequisites

Before importing data, you need to confirm the following information:

- NebulaGraph has been installed and deployed with the following information:
- IP addresses and ports of Graph and Meta services.
- The user name and password with write permission to NebulaGraph.
- `--ws_storage_http_port` in the Meta service configuration file is the same as `--ws_http_port` in the Storage service configuration file. For example, `19779`.
- `--ws_meta_http_port` in the Graph service configuration file is the same as `--ws_http_port` in the Meta service configuration file. For example, `19559`.
- The information about the Schema, including names and properties of Tags and Edge types, and more.

- Exchange has been compiled, or download the compiled `.jar` file directly.

- Spark has been installed.

- JDK 1.8 or the later version has been installed and the environment variable `JAVA_HOME` has been configured.

- The Hadoop service has been installed and started.

Note

- To generate SST files of other data sources, see documents of the corresponding data source and check the prerequisites.
- To generate SST files only, users do not need to install the Hadoop service on the machine where the Storage service is deployed.
- To delete the SST file after the ingest (data import) operation, add the configuration `-- move_Files =true` to the Storage Service configuration file.

Steps

STEP 1: CREATE THE SCHEMA IN NEBULAGRAPH

Analyze the data to create a Schema in NebulaGraph by following these steps:

1. Identify the Schema elements. The Schema elements in the NebulaGraph are shown in the following table.

Element	Name	Property
Tag	`player`	`name string, age int`
Tag	`team`	`name string`
Edge Type	`follow`	`degree int`
Edge Type	`serve`	`start_year int, end_year int`

2. Create a graph space **basketballplayer** in the NebulaGraph and create a Schema as shown below.

```
## Create a graph space
nebula> CREATE SPACE basketballplayer \
        (partition_num = 10, \
        replica_factor = 1, \
        vid_type = FIXED_STRING(30));

## Use the graph space basketballplayer
nebula> USE basketballplayer;

## Create the Tag player
nebula> CREATE TAG player(name string, age int);

## Create the Tag team
nebula> CREATE TAG team(name string);

## Create the Edge type follow
nebula> CREATE EDGE follow(degree int);

## Create the Edge type serve
nebula> CREATE EDGE serve(start_year int, end_year int);
```

For more information, see Quick start workflow.

STEP 2: PROCESS CSV FILES

Confirm the following information:

1. Process CSV files to meet Schema requirements.

Note

Exchange supports uploading CSV files with or without headers.

2. Obtain the CSV file storage path.

STEP 3: MODIFY CONFIGURATION FILES

After Exchange is compiled, copy the conf file `target/classes/application.conf` to set SST data source configuration. In this example, the copied file is called `sst_application.conf`. For details on each configuration item, see Parameters in the configuration file.

```
{
  # Spark configuration
  spark: {
    app: {
      name: NebulaGraph Exchange 3.5.0
    }

    master:local

    driver: {
      cores: 1
      maxResultSize: 1G
    }

    executor: {
```

```
      memory:1G
    }

    cores:{
      max: 16
    }
  }

  # NebulaGraph configuration
  nebula: {
    address:{
      graph:["127.0.0.1:9669"]
      # the address of any of the meta services.
      # if your NebulaGraph server is in virtual network like k8s, please config the leader address of meta.
      meta:["127.0.0.1:9559"]
    }
    user: root
    pswd: nebula
    space: basketballplayer

    # SST file configuration
    path:{
        # The local directory that temporarily stores generated SST files
        local:"/tmp"

        # The path for storing the SST file in the HDFS
        remote:"/sst"

        # The NameNode address of HDFS
        hdfs.namenode: "hdfs://*.*.*.*:9000"
    }

    # The connection parameters of clients
    connection: {
      # The timeout duration of socket connection and execution. Unit: milliseconds.
      timeout: 30000
    }

    error: {
      # The maximum number of failures that will exit the application.
      max: 32
      # Failed import jobs are logged in the output path.
      output: /tmp/errors
    }

    # Use Google's RateLimiter to limit requests to NebulaGraph.
    rate: {
      # Steady throughput of RateLimiter.
      limit: 1024

      # Get the allowed timeout duration from RateLimiter. Unit: milliseconds.
      timeout: 1000
    }
  }


  # Processing vertices
  tags: [
    # Set the information about the Tag player.
    {
      # Specify the Tag name defined in NebulaGraph.
      name: player
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: sst
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx.csv".
      path: "hdfs://*.*.*.*:9000/dataset/vertex_player.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has a header, use the actual column name.
      fields: [_c1, _c2]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [age, name]

      # Specify a column of data in the table as the source of VIDs in NebulaGraph.
      # The value of vertex must be consistent with the column name in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:_c0
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
```

```
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32

      # Whether to repartition data based on the number of partitions of graph spaces in NebulaGraph when generating the SST file.
      repartitionWithNebula: false
    }

    # Set the information about the Tag Team.
    {
      # Specify the Tag name defined in NebulaGraph.
      name: team
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: sst
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx.csv".
      path: "hdfs://*.*.*.*:9000/dataset/vertex_team.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has a header, use the actual column name.
      fields: [_c1]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [name]

      # Specify a column of data in the table as the source of VIDs in NebulaGraph.
      # The value of vertex must be consistent with the column name in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      vertex: {
        field:_c0
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32

      # Whether to repartition data based on the number of partitions of graph spaces in NebulaGraph when generating the SST file.
      repartitionWithNebula: false
    }



    # If more vertices need to be added, refer to the previous configuration to add them.
  ]
  # Processing edges
  edges: [
    # Set the information about the Edge Type follow.
    {
      # The Edge Type name defined in NebulaGraph.
      name: follow
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: sst
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx.csv".
      path: "hdfs://*.*.*.*:9000/dataset/edge_follow.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has a header, use the actual column name.
      fields: [_c2]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [degree]

      # Specify a column as the source for the source and destination vertices.
      # The value of vertex must be consistent with the column name in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
```

```
        field: _c0
      }
      target: {
        field: _c1
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # (Optional) Specify a column as the source of the rank.

      #ranking: rank

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32

      # Whether to repartition data based on the number of partitions of graph spaces in NebulaGraph when generating the SST file.
      repartitionWithNebula: false
    }

    # Set the information about the Edge Type serve.
    {
      # Specify the Edge type name defined in NebulaGraph.
      name: serve
      type: {
        # Specify the data source file format to CSV.
        source: csv

        # Specify how to import the data into NebulaGraph: Client or SST.
        sink: sst
      }

      # Specify the path to the CSV file.
      # If the file is stored in HDFS, use double quotation marks to enclose the file path, starting with hdfs://. For example, "hdfs://ip:port/xx/xx.csv".
      path: "hdfs://*.*.*.*:9000/dataset/edge_serve.csv"

      # If the CSV file does not have a header, use [_c0, _c1, _c2, ..., _cn] to represent its header and indicate the columns as the source of the property values.
      # If the CSV file has a header, use the actual column name.
      fields: [_c2,_c3]

      # Specify the property name defined in NebulaGraph.
      # The sequence of fields and nebula.fields must correspond to each other.
      nebula.fields: [start_year, end_year]

      # Specify a column as the source for the source and destination vertices.
      # The value of vertex must be consistent with the column name in the above fields or csv.fields.
      # Currently, NebulaGraph 3.5.0 supports only strings or integers of VID.
      source: {
        field: _c0
      }
      target: {
        field: _c1
      }

      # The delimiter specified. The default value is comma.
      separator: ","

      # (Optional) Specify a column as the source of the rank.
      #ranking: _c5

      # If the CSV file has a header, set the header to true.
      # If the CSV file does not have a header, set the header to false. The default value is false.
      header: false

      # The number of data written to NebulaGraph in a single batch.
      batch: 256

      # The number of Spark partitions.
      partition: 32

      # Whether to repartition data based on the number of partitions of graph spaces in NebulaGraph when generating the SST file.
      repartitionWithNebula: false
    }

  ]
  # If more edges need to be added, refer to the previous configuration to add them.
}
```

STEP 4: GENERATE THE SST FILE

Run the following command to generate the SST file from the CSV source file. For a description of the parameters, see Options for import.

```
${SPARK_HOME}/bin/spark-submit --master "local" --conf spark.sql.shuffle.partition=<shuffle_concurrency> --class com.vesoft.nebula.exchange.Exchange <nebula-exchange-3.5.0.jar_path> -c
<sst_application.conf_path>
```

Note

When generating SST files, the shuffle operation of Spark will be involved. Note that the configuration of `spark.sql.shuffle.partition` should be added when you submit the command.

Note

JAR packages are available in two ways: compiled them yourself, or download the compiled `.jar` file directly.

For example:

```
${SPARK_HOME}/bin/spark-submit  --master "local" --conf spark.sql.shuffle.partition=200 --class com.vesoft.nebula.exchange.Exchange  /root/nebula-exchange/nebula-exchange/target/nebula-
exchange-3.5.0.jar  -c /root/nebula-exchange/nebula-exchange/target/classes/sst_application.conf
```

After the task is complete, you can view the generated SST file in the `/sst` directory (specified by the `nebula.path.remote` parameter) on HDFS.

Note

If you modify the Schema, such as rebuilding the graph space, modifying the Tag, or modifying the Edge type, you need to regenerate the SST file because the SST file verifies the space ID, Tag ID, and Edge ID.

STEP 5: IMPORT THE SST FILE

Note

Confirm the following information before importing:

- Confirm that the Hadoop service has been deployed on all the machines where the Storage service is deployed, and configure `HADOOP_HOME` and `JAVA_HOME`.
- The `--ws_storage_http_port` in the Meta service configuration file (add it manually if it does not exist) is the same as the `--ws_http_port` in the Storage service configuration file. For example, both are `19779`.
- The `--ws_meta_http_port` in the Graph service configuration file (add it manually if it does not exist) is the same as the `--ws_http_port` in the Meta service configuration file. For example, both are `19559`.

Connect to the NebulaGraph database using the client tool and import the SST file as follows:

1. Run the following command to select the graph space you created earlier.

```
nebula> USE basketballplayer;
```

2. Run the following command to download the SST file:

```
nebula> SUBMIT JOB DOWNLOAD HDFS "hdfs://<hadoop_address>:<hadoop_port>/<sst_file_path>";
```

For example:

```
nebula> SUBMIT JOB DOWNLOAD HDFS "hdfs://*.*.*.*:9000/sst";
```

3. Run the following command to import the SST file:

```
nebula> SUBMIT JOB INGEST;
```

Note

- To download the SST file again, delete the `download` folder in the space ID in the `data/storage/nebula` directory in the NebulaGraph installation path, and then download the SST file again. If the space has multiple copies, the `download` folder needs to be deleted on all machines where the copies are saved.
- If there is a problem with the import and re-importing is required, re-execute `SUBMIT JOB INGEST;`.

STEP 6: (OPTIONAL) VALIDATE DATA

Users can verify that data has been imported by executing a query in the NebulaGraph client (for example, NebulaGraph Studio). For example:

```
LOOKUP ON player YIELD id(vertex);
```

Users can also run the `SHOW STATS` command to view statistics.

STEP 7: (OPTIONAL) REBUILD INDEXES IN NEBULAGRAPH

With the data imported, users can recreate and rebuild indexes in NebulaGraph. For details, see Index overview.

Last update: March 13, 2023

16.5 Exchange FAQ

16.5.1 Compilation

Q: Some packages not in central repository failed to download, error: `Could not resolve dependencies for project xxx`

Please check the `mirror` part of Maven installation directory `libexec/conf/settings.xml` :

```
<mirror>
    <id>alimaven</id>
    <mirrorOf>central</mirrorOf>
    <name>aliyun maven</name>
    <url>http://maven.aliyun.com/nexus/content/repositories/central/</url>
</mirror>
```

Check whether the value of `mirrorOf` is configured to `*` . If it is, change it to `central` or `*,!SparkPackagesRepo,!bintray-streamnative-maven` .

Reason: There are two dependency packages in Exchange's `pom.xml` that are not in Maven's central repository. `pom.xml` configures the repository address for these two dependencies. If the `mirrorOf` value for the mirror address configured in Maven is `*` , all dependencies will be downloaded from the Central repository, causing the download to fail.

Q: Unable to download SNAPSHOT packages when compiling Exchange

Problem description: The system reports `Could not find artifact com.vesoft:client:jar:xxx-SNAPSHOT` when compiling.

Cause: There is no local Maven repository for storing or downloading SNAPSHOT packages. The default central repository in Maven only stores official releases, not development versions (SNAPSHOT).

Solution: Add the following configuration in the `profiles` scope of Maven's `setting.xml` file:

```
  <profile>
     <activation>
        <activeByDefault>true</activeByDefault>
     </activation>
     <repositories>
        <repository>
            <id>snapshots</id>
            <url>https://oss.sonatype.org/content/repositories/snapshots/</url>
            <snapshots>
               <enabled>true</enabled>
            </snapshots>
      </repository>
     </repositories>
  </profile>
```

16.5.2 Execution

Q: Error: `java.lang.ClassNotFoundException: com.vesoft.nebula.exchange.Exchange`

To submit a task in Yarn-Cluster mode, run the following command, **especially the two '--conf' commands in the example**.

```
$SPARK_HOME/bin/spark-submit --class com.vesoft.nebula.exchange.Exchange \
--master yarn-cluster \
--files application.conf \
--conf spark.driver.extraClassPath=./ \
--conf spark.executor.extraClassPath=./ \
nebula-exchange-3.0.0.jar \
-c application.conf
```

Q: Error: `method name xxx not found`

Generally, the port configuration is incorrect. Check the port configuration of the Meta service, Graph service, and Storage service.

Q: Error: NoSuchMethod, MethodNotFound (`Exception in thread "main" java.lang.NoSuchMethodError` , etc)

Most errors are caused by JAR package conflicts or version conflicts. Check whether the version of the error reporting service is the same as that used in Exchange, especially Spark, Scala, and Hive.

Q: When Exchange imports Hive data, error: `Exception in thread "main" org.apache.spark.sql.AnalysisException: Table or view not found`

Check whether the `-h` parameter is omitted in the command for submitting the Exchange task and whether the table and database are correct, and run the user-configured exec statement in spark-SQL to verify the correctness of the exec statement.

Q: Run error: `com.facebook.thrift.protocol.TProtocolException: Expected protocol id xxx`

Check that the NebulaGraph service port is configured correctly.

- For source, RPM, or DEB installations, configure the port number corresponding to `--port` in the configuration file for each service.
- For docker installation, configure the docker mapped port number as follows:

  Execute `docker-compose ps` in the `nebula-docker-compose` directory, for example:

```
$ docker-compose ps
              Name                              Command                 State                                                 Ports
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
nebula-docker-compose_graphd_1      /usr/local/nebula/bin/nebu ...   Up (healthy)   0.0.0.0:33205->19669/tcp, 0.0.0.0:33204->19670/tcp, 0.0.0.0:9669->9669/tcp
nebula-docker-compose_metad0_1      ./bin/nebula-metad --flagf ...   Up (healthy)   0.0.0.0:33165->19559/tcp, 0.0.0.0:33162->19560/tcp, 0.0.0.0:33167->9559/tcp, 9560/tcp
nebula-docker-compose_metad1_1      ./bin/nebula-metad --flagf ...   Up (healthy)   0.0.0.0:33166->19559/tcp, 0.0.0.0:33163->19560/tcp, 0.0.0.0:33168->9559/tcp, 9560/tcp
nebula-docker-compose_metad2_1      ./bin/nebula-metad --flagf ...   Up (healthy)   0.0.0.0:33161->19559/tcp, 0.0.0.0:33160->19560/tcp, 0.0.0.0:33164->9559/tcp, 9560/tcp
nebula-docker-compose_storaged0_1   ./bin/nebula-storaged --fl ...   Up (healthy)   0.0.0.0:33180->19779/tcp, 0.0.0.0:33178->19780/tcp, 9777/tcp, 9778/tcp, 0.0.0.0:33183->9779/tcp, 9780/
tcp
nebula-docker-compose_storaged1_1   ./bin/nebula-storaged --fl ...   Up (healthy)   0.0.0.0:33175->19779/tcp, 0.0.0.0:33172->19780/tcp, 9777/tcp, 9778/tcp, 0.0.0.0:33177->9779/tcp, 9780/
tcp
nebula-docker-compose_storaged2_1   ./bin/nebula-storaged --fl ...   Up (healthy)   0.0.0.0:33184->19779/tcp, 0.0.0.0:33181->19780/tcp, 9777/tcp, 9778/tcp, 0.0.0.0:33185->9779/tcp, 9780/
tcp
```

  Check the `Ports` column to find the docker mapped port number, for example:

  - The port number available for Graph service is 9669.

  - The port number for Meta service are 33167, 33168, 33164.

  - The port number for Storage service are 33183, 33177, 33185.

Q: Error: `Exception in thread "main" com.facebook.thrift.protocol.TProtocolException: The field 'code' has been assigned the invalid value -4`

Check whether the version of Exchange is the same as that of NebulaGraph. For more information, see Limitations.

Q: How to correct the messy code when importing Hive data into NebulaGraph?

It may happen if the property value of the data in Hive contains Chinese characters. The solution is to add the following options before the JAR package path in the import command:

```
--conf spark.driver.extraJavaOptions=-Dfile.encoding=utf-8
--conf spark.executor.extraJavaOptions=-Dfile.encoding=utf-8
```

Namely:

```
<spark_install_path>/bin/spark-submit --master "local" \
--conf spark.driver.extraJavaOptions=-Dfile.encoding=utf-8 \
--conf spark.executor.extraJavaOptions=-Dfile.encoding=utf-8 \
--class com.vesoft.nebula.exchange.Exchange \
<nebula-exchange-3.x.y.jar_path> -c <application.conf_path>
```

In YARN, use the following command:

```
<spark_install_path>/bin/spark-submit \
--class com.vesoft.nebula.exchange.Exchange \
--master yarn-cluster \
--files <application.conf_path> \
--conf spark.driver.extraClassPath=./ \
--conf spark.executor.extraClassPath=./ \
```

```
--conf spark.driver.extraJavaOptions=-Dfile.encoding=utf-8 \
--conf spark.executor.extraJavaOptions=-Dfile.encoding=utf-8 \
<nebula-exchange-3.x.y.jar_path> \
-c application.conf
```

Q: org.rocksdb.RocksDBException: While open a file for appending: /path/sst/1-xxx.sst: No such file or directory

Solution:

1. Check if `/path` exists. If not, or if the path is set incorrectly, create or correct it.
2. Check if Spark's current user on each machine has the operation permission on `/path`. If not, grant the permission.

16.5.3 Configuration

Q: Which configuration fields will affect import performance?

- batch: The number of data contained in each nGQL statement sent to the NebulaGraph service.
- partition: The number of Spark data partitions, indicating the number of concurrent data imports.
- nebula.rate: Get a token from the token bucket before sending a request to NebulaGraph.
  - limit: Represents the size of the token bucket.
  - timeout: Represents the timeout period for obtaining the token.

The values of these four parameters can be adjusted appropriately according to the machine performance. If the leader of the Storage service changes during the import process, you can adjust the values of these four parameters to reduce the import speed.

16.5.4 Others

Q: Which versions of NebulaGraph are supported by Exchange?

See Limitations.

Q: What is the relationship between Exchange and Spark Writer?

Exchange is the Spark application developed based on Spark Writer. Both are suitable for bulk migration of cluster data to NebulaGraph in a distributed environment, but later maintenance work will be focused on Exchange. Compared with Spark Writer, Exchange has the following improvements:

- It supports more abundant data sources, such as MySQL, Neo4j, Hive, HBase, Kafka, Pulsar, etc.
- It fixed some problems of Spark Writer. For example, when Spark reads data from HDFS, the default source data is String, which may be different from the NebulaGraph's Schema. So Exchange adds automatic data type matching and type conversion. When the data type in the NebulaGraph's Schema is non-String (e.g. double), Exchange converts the source data of String type to the corresponding type.

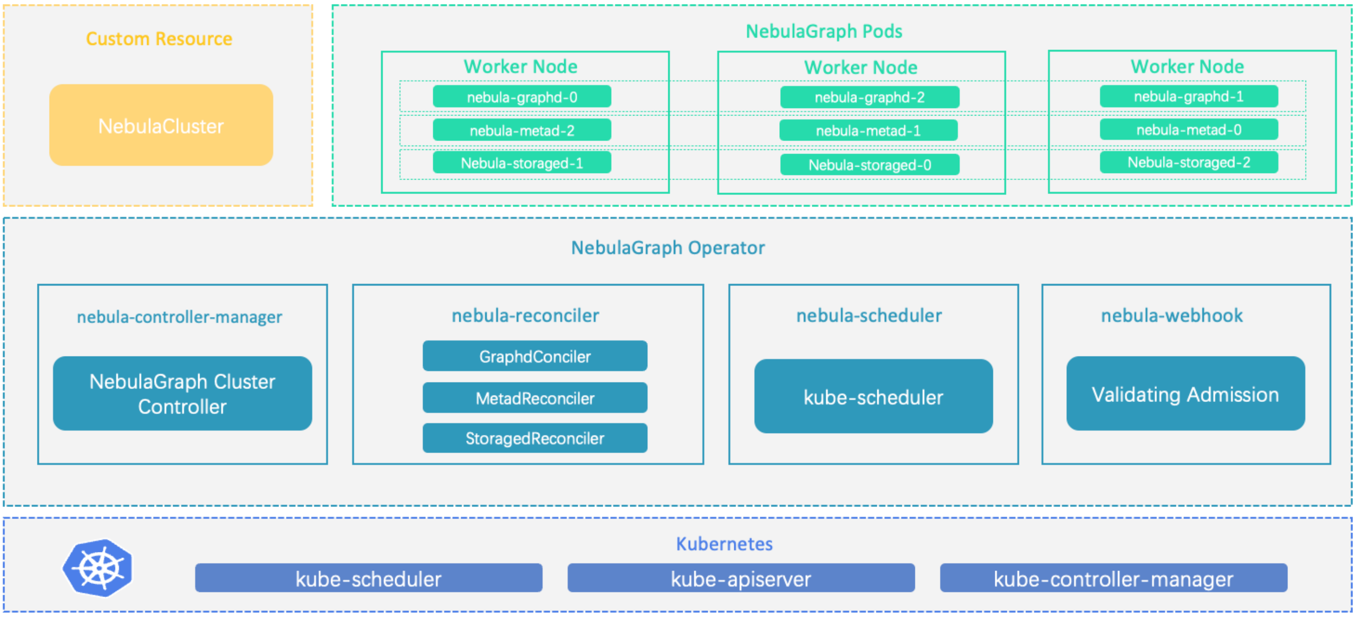
Last update: December 21, 2022

17. NebulaGraph Operator

17.1 What is NebulaGraph Operator

17.1.1 Concept

NebulaGraph Operator is a tool to automate the deployment, operation, and maintenance of NebulaGraph clusters on Kubernetes. Building upon the excellent scalability mechanism of Kubernetes, NebulaGraph introduced its operation and maintenance knowledge into the Kubernetes system, which makes NebulaGraph a real cloud-native graph database.



17.1.2 How it works

For resource types that do not exist within Kubernetes, you can register them by adding custom API objects. The common way is to use the CustomResourceDefinition.

NebulaGraph Operator abstracts the deployment management of NebulaGraph clusters as a CRD. By combining multiple built-in API objects including StatefulSet, Service, and ConfigMap, the routine management and maintenance of a NebulaGraph cluster are coded as a control loop in the Kubernetes system. When a CR instance is submitted, NebulaGraph Operator drives database clusters to the final state according to the control process.

17.1.3 Features

The following features are already available in NebulaGraph Operator:

- **Deploy and uninstall clusters**: NebulaGraph Operator simplifies the process of deploying and uninstalling clusters for users. NebulaGraph Operator allows you to quickly create, update, or delete a NebulaGraph cluster by simply providing the corresponding CR file. For more information, see Deploy NebulaGraph Clusters with Kubectl or Deploy NebulaGraph Clusters with Helm.
- **Cluster Upgrade**: NebulaGraph Operator supports cluster upgrading from version 3.0.0 to version 3.5.0.
- **Self-Healing**: NebulaGraph Operator calls interfaces provided by NebulaGraph clusters to dynamically sense cluster service status. Once an exception is detected, NebulaGraph Operator performs fault tolerance. For more information, see Self-Healing.
- **Balance Scheduling**: Based on the scheduler extension interface, the scheduler provided by NebulaGraph Operator evenly distributes Pods in a NebulaGraph cluster across all nodes.

17.1.4 Limitations

Version limitations

NebulaGraph Operator does not support the v1.x version of NebulaGraph. NebulaGraph Operator version and the corresponding NebulaGraph version are as follows:

NebulaGraph	NebulaGraph Operator
3.0.0 ~ 3.4.1	1.3.0, 1.4.0 ~ 1.4.2
3.0.0 ~ 3.3.x	1.0.0, 1.1.0, 1.2.0
2.5.x ~ 2.6.x	0.9.0
2.5.x	0.8.0

Legacy version compatibility

- The 1.x version NebulaGraph Operator is not compatible with NebulaGraph of version below v3.x.
- Starting from NebulaGraph Operator 0.9.0, logs and data are stored separately. Using NebulaGraph Operator 0.9.0 or later versions to manage a NebulaGraph 2.5.x cluster created with Operator 0.8.0 can cause compatibility issues. You can backup the data of the NebulaGraph 2.5.x cluster and then create a 2.6.x cluster with Operator 0.9.0.

Feature limitations

The NebulaGraph Operator scaling feature is only available for the Enterprise Edition of NebulaGraph clusters and does not support scaling the Community Edition version of NebulaGraph clusters.

17.1.5 Release note

Release

Last update: May 11, 2023

17.2 Overview of using NebulaGraph Operator

To use NebulaGraph Operator to connect to NebulaGraph databases, see steps as follows:

1. Install NebulaGraph Operator.
2. Create a NebulaGraph cluster.

   For more information, see Deploy NebulaGraph clusters with Kubectl or Deploy NebulaGraph clusters with Helm.
3. Connect to a NebulaGraph database.

Last update: August 11, 2022

17.3 Deploy NebulaGraph Operator

You can deploy NebulaGraph Operator with Helm.

17.3.1 Background

NebulaGraph Operator automates the management of NebulaGraph clusters, and eliminates the need for you to install, scale, upgrade, and uninstall NebulaGraph clusters, which lightens the burden on managing different application versions.

17.3.2 Prerequisites

Before installing NebulaGraph Operator, you need to install the following software and ensure the correct version of the software :

Software	Requirement
Kubernetes	>= 1.16
Helm	>= 3.2.0
CoreDNS	>= 1.6.0

Note

- If using a role-based access control policy, you need to enable RBAC (optional).
- CoreDNS is a flexible and scalable DNS server that is installed for Pods in NebulaGraph clusters.

17.3.3 Steps

Install NebulaGraph Operator

1. Add the NebulaGraph Operator Helm repository.

```
helm repo add nebula-operator https://vesoft-inc.github.io/nebula-operator/charts
```

2. Update information of available charts locally from repositories.

```
helm repo update
```

For more information about `helm repo`, see Helm Repo.

3. Create a namespace for NebulaGraph Operator.

```
kubectl create namespace <namespace_name>
```

For example, run the following command to create a namespace named `nebula-operator-system`.

```
kubectl create namespace nebula-operator-system
```

- All the resources of NebulaGraph Operator are deployed in this namespace.
- You can also use a different name.

4. Install NebulaGraph Operator.

```
helm install nebula-operator nebula-operator/nebula-operator --namespace=<namespace_name> --version=${chart_version}
```

For example, the command to install NebulaGraph Operator of version 1.5.0 is as follows.

```
helm install nebula-operator nebula-operator/nebula-operator --namespace=nebula-operator-system --version=1.5.0
```

- `nebula-operator-system` is a user-created namespace name. If you have not created this namespace, run `kubectl create namespace nebula-operator-system` to create one. You can also use a different name.
- `1.5.0` is the version of the nebula-operator chart. When not specifying `--version`, the latest version of the nebula-operator chart is used by default. Run `helm search repo -l nebula-operator` to see chart versions.

You can customize the configuration items of the NebulaGraph Operator chart before running the installation command. For more information, see **Customize Helm charts** below.

Customize Helm charts

When executing the `helm install [NAME] [CHART] [flags]` command to install a chart, you can specify the chart configuration. For more information, see Customizing the Chart Before Installing.

View the related configuration options in the nebula-operator chart configuration file.

Alternatively, you can view the configurable options through the command `helm show values nebula-operator/nebula-operator`, as shown below.

For example:

```
[k8s@master ~]$ helm show values nebula-operator/nebula-operator
image:
  nebulaOperator:
    image: vesoft/nebula-operator:v1.5.0
    imagePullPolicy: Always
  kubeRBACProxy:
    image: gcr.io/kubebuilder/kube-rbac-proxy:v0.13.0
    imagePullPolicy: Always
  kubeScheduler:
    image: registry.k8s.io/kube-scheduler:v1.24.11
    imagePullPolicy: Always

imagePullSecrets: []
kubernetesClusterDomain: ""

controllerManager:
  create: true
  replicas: 2
  env: []
  resources:
    limits:
      cpu: 200m
      memory: 200Mi
    requests:
      cpu: 100m
      memory: 100Mi

admissionWebhook:
  create: false

scheduler:
  create: true
  schedulerName: nebula-scheduler
  replicas: 2
  env: []
  resources:
    limits:
      cpu: 200m
      memory: 20Mi
    requests:
      cpu: 100m
      memory: 100Mi
```

Part of the above parameters are described as follows:

Parameter	Default value	Description
`image.nebulaOperator.image`	`vesoft/nebula-operator:v1.5.0`	The image of NebulaGraph Operator, version of which is 1.5.0.
`image.nebulaOperator.imagePullPolicy`	`IfNotPresent`	The image pull policy in Kubernetes.
`imagePullSecrets`	-	The image pull secret in Kubernetes.
`kubernetesClusterDomain`	`cluster.local`	The cluster domain.
`controllerManager.create`	`true`	Whether to enable the controller-manager component.
`controllerManager.replicas`	`2`	The numeric value of controller-manager replicas.
`admissionWebhook.create`	`false`	Whether to enable Admission Webhook. This option is disabled. To enable it, set the value to `true` and you will need to install cert-manager.
`shceduler.create`	`true`	Whether to enable Scheduler.
`shceduler.schedulerName`	`nebula-scheduler`	The Scheduler name.
`shceduler.replicas`	`2`	The numeric value of nebula-scheduler replicas.

You can run `helm install [NAME] [CHART] [flags]` to specify chart configurations when installing a chart. For more information, see Customizing the Chart Before Installing.

The following example shows how to specify the NebulaGraph Operator's AdmissionWebhook mechanism to be turned on when you install NebulaGraph Operator (AdmissionWebhook is disabled by default):

```
helm install nebula-operator nebula-operator/nebula-operator --namespace=<nebula-operator-system> --set admissionWebhook.create=true
```

For more information about `helm install`, see Helm Install.

Update NebulaGraph Operator

1. Update the information of available charts locally from chart repositories.

```
helm repo update
```

2. Update NebulaGraph Operator by passing configuration parameters via `--set`.

- `--set`: Overrides values using the command line. For configurable items, see the above-mentioned section **Customize Helm charts**.

  For example, to enable the AdmissionWebhook, run the following command:

```
helm upgrade nebula-operator nebula-operator/nebula-operator --namespace=nebula-operator-system --version=1.5.0 --set admissionWebhook.create=true
```

  For more information, see Helm upgrade.

Upgrade NebulaGraph Operator

Legacy version compatibility

- Does not support upgrading 0.9.0 and below version NebulaGraph Operator to 1.x.
- The 1.x version NebulaGraph Operator is not compatible with NebulaGraph of version below v3.x.

1. Update the information of available charts locally from chart repositories.

```
helm repo update
```

2. Upgrade Operator to v1.5.0.

```
helm upgrade nebula-operator nebula-operator/nebula-operator --namespace=<namespace_name> --version=1.5.0
```

For example:

```
helm upgrade nebula-operator nebula-operator/nebula-operator --namespace=nebula-operator-system --version=1.5.0
```

Output:

```
Release "nebula-operator" has been upgraded. Happy Helming!
NAME: nebula-operator
LAST DEPLOYED: Tue Apr 16 02:21:08 2022
NAMESPACE: nebula-operator-system
STATUS: deployed
REVISION: 3
TEST SUITE: None
NOTES:
NebulaGraph Operator installed!
```

3. Pull the latest CRD configuration file.

Note

You need to upgrade the corresponding CRD configurations after NebulaGraph Operator is upgraded. Otherwise, the creation of NebulaGraph clusters will fail. For information about the CRD configurations, see apps.nebula-graph.io_nebulaclusters.yaml.

a. Pull the NebulaGraph Operator chart package.

```
helm pull nebula-operator/nebula-operator --version=1.5.0
```

- `--version`: The NebulaGraph Operator version you want to upgrade to. If not specified, the latest version will be pulled.

b. Run `tar -zxvf` to unpack the charts.

For example: To unpack v1.5.0 chart to the `/tmp` path, run the following command:

```
tar -zxvf nebula-operator-1.5.0.tgz -C /tmp
```

- `-C /tmp`: If not specified, the chart files will be unpacked to the current directory.

4. Upgrade the CRD configuration file in the `nebula-operator` directory.

```
kubectl apply -f crds/nebulacluster.yaml
```

Output:

```
customresourcedefinition.apiextensions.k8s.io/nebulaclusters.apps.nebula-graph.io configured
```

Uninstall NebulaGraph Operator

1. Uninstall the NebulaGraph Operator chart.

```
helm uninstall nebula-operator --namespace=<nebula-operator-system>
```

2. Delete CRD.

```
kubectl delete crd nebulaclusters.apps.nebula-graph.io
```

17.3.4 What's next

Automate the deployment of NebulaGraph clusters with NebulaGraph Operator. For more information, see Deploy NebulaGraph Clusters with Kubectl or Deploy NebulaGraph Clusters with Helm.

Last update: May 9, 2023

17.4 Deploy clusters

17.4.1 Deploy NebulaGraph clusters with Kubectl

Legacy version compatibility

The 1.x version NebulaGraph Operator is not compatible with NebulaGraph of version below v3.x.

Prerequisites

- You have installed NebulaGraph Operator
- You have created StorageClass

Create clusters

The following example shows how to create a NebulaGraph cluster by creating a cluster named `nebula`.

1. Create a file named `apps_v1alpha1_nebulacluster.yaml`.

- For a NebulaGraph Community cluster

  Create a file named `apps_v1alpha1_nebulacluster.yaml`. For the file content, see the sample configuration.

The parameters in the file are described as follows:

Parameter	Default value	Description
`metadata.name`	-	The name of the created NebulaGraph cluster.
`spec.graphd.replicas`	`1`	The numeric value of replicas of the Graphd service.
`spec.graphd.images`	`vesoft/nebula-graphd`	The container image of the Graphd service.
`spec.graphd.version`	`v3.5.0`	The version of the Graphd service.
`spec.graphd.service`	-	The Service configurations for the Graphd service.
`spec.graphd.logVolumeClaim.storageClassName`	-	The log disk storage configurations for the Graphd service.
`spec.metad.replicas`	`1`	The numeric value of replicas of the Metad service.
`spec.metad.images`	`vesoft/nebula-metad`	The container image of the Metad service.
`spec.metad.version`	`v3.5.0`	The version of the Metad service.
`spec.metad.dataVolumeClaim.storageClassName`	-	The data disk storage configurations for the Metad service.
`spec.metad.logVolumeClaim.storageClassName`	-	The log disk storage configurations for the Metad service.
`spec.storaged.replicas`	`3`	The numeric value of replicas of the Storaged service.
`spec.storaged.images`	`vesoft/nebula-storaged`	The container image of the Storaged service.
`spec.storaged.version`	`v3.5.0`	The version of the Storaged service.
`spec.storaged.dataVolumeClaims.resources.requests.storage`	-	Data disk storage size for the Storaged service. You can specify multiple data disks to store data. When multiple disks are specified, the storage path is `/usr/local/nebula/data1`, `/usr/local/nebula/data2`, etc.
`spec.storaged.dataVolumeClaims.resources.storageClassName`	-	The data disk storage configurations for Storaged. If not specified, the global storage parameter is applied.
`spec.storaged.logVolumeClaim.storageClassName`	-	The log disk storage configurations for the Storaged service.
`spec.storaged.enableAutoBalance`	`true`	Whether to balance data automatically.
`spec.reference.name`	-	The name of the dependent controller.
`spec.schedulerName`	-	The scheduler name.
`spec.imagePullPolicy`	The image policy to pull the NebulaGraph image. For details, see Image pull policy.	The image pull policy in Kubernetes.
`spec.logRotate`	-	Log rotation configuration. For more information, see Manage cluster logs.
`spec.enablePVReclaim`	`false`	Define whether to automatically delete PVCs and release data after deleting the

Parameter	Default value	Description
		cluster. For more information, see Reclaim PVs.

2. Create a NebulaGraph cluster.

```
kubectl create -f apps_v1alpha1_nebulacluster.yaml
```

Output:

```
nebulacluster.apps.nebula-graph.io/nebula created
```

3. Check the status of the NebulaGraph cluster.

```
kubectl get nebulaclusters.apps.nebula-graph.io nebula
```

Output:

```
NAME     GRAPHD-DESIRED   GRAPHD-READY   METAD-DESIRED   METAD-READY   STORAGED-DESIRED   STORAGED-READY   AGE
nebula   1                1              1               1             3                  3                86s
```

Scaling clusters

- The cluster scaling feature is for NebulaGraph Enterprise Edition only.

Delete clusters

Run the following command to delete a NebulaGraph cluster with Kubectl:

```
kubectl delete -f apps_v1alpha1_nebulacluster.yaml
```

What's next

Connect to NebulaGraph databases

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17.4.2 Deploy NebulaGraph clusters with Helm

Legacy version compatibility

The 1.x version NebulaGraph Operator is not compatible with NebulaGraph of version below v3.x.

Prerequisite

- You have installed NebulaGraph Operator
- You have created StorageClass

Create clusters

1. Add the NebulaGraph Operator Helm repository.

```
helm repo add nebula-operator https://vesoft-inc.github.io/nebula-operator/charts
```

2. Update information of available charts locally from chart repositories.

```
helm repo update
```

3. Set environment variables to your desired values.

```
export NEBULA_CLUSTER_NAME=nebula         # The desired NebulaGraph cluster name.
export NEBULA_CLUSTER_NAMESPACE=nebula    # The desired namespace where your NebulaGraph cluster locates.
export STORAGE_CLASS_NAME=fast-disks             # The name of the StorageClass that has been created.
```

4. Create a namespace for your NebulaGraph cluster (If you have created one, skip this step).

```
kubectl create namespace "${NEBULA_CLUSTER_NAMESPACE}"
```

5. Apply the variables to the Helm chart to create a NebulaGraph cluster.

```
helm install "${NEBULA_CLUSTER_NAME}" nebula-operator/nebula-cluster \
    <!--
    # Configure the access address and port (default port is '9119') that points to the LM. You must configure this parameter in order to obtain the license information. Only for NebulaGraph Enterprise Edition clusters.
    --set nebula.metad.licenseManagerURL=`192.168.8.XXX:9119` \
    -->
    --set nameOverride=${NEBULA_CLUSTER_NAME} \
    --set nebula.storageClassName="${STORAGE_CLASS_NAME}" \
    # Specify the version of the NebulaGraph cluster.
    --set nebula.version=v3.5.0 \
    # Specify the version of the nebula-cluster chart. If not specified, the latest version of the chart is installed by default.
    --version=1.5.0
    --namespace="${NEBULA_CLUSTER_NAMESPACE}" \
```

6. Check the status of the NebulaGraph cluster you created.

```
kubectl -n "${NEBULA_CLUSTER_NAMESPACE}" get pod -l "app.kubernetes.io/cluster=${NEBULA_CLUSTER_NAME}"
```

Output:

```
NAME                READY   STATUS    RESTARTS   AGE
nebula-graphd-0     1/1     Running   0          5m34s
nebula-graphd-1     1/1     Running   0          5m34s
nebula-metad-0      1/1     Running   0          5m34s
nebula-metad-1      1/1     Running   0          5m34s
nebula-metad-2      1/1     Running   0          5m34s
nebula-storaged-0   1/1     Running   0          5m34s
nebula-storaged-1   1/1     Running   0          5m34s
nebula-storaged-2   1/1     Running   0          5m34s
```

Scaling clusters

- The cluster scaling feature is for NebulaGraph Enterprise Edition only.

Delete clusters

Run the following command to delete a NebulaGraph cluster with Helm:

```
helm uninstall "${NEBULA_CLUSTER_NAME}" --namespace="${NEBULA_CLUSTER_NAMESPACE}"
```

Or use variable values to delete a NebulaGraph cluster with Helm:

```
helm uninstall nebula --namespace=nebula
```

What's next

Connect to NebulaGraph Databases

Configuration parameters of the nebula-cluster Helm chart

Parameter	Default value	Description
`nameOverride`	`nil`	Replaces the name of the chart in the `Chart.yaml` file.
`nebula.version`	`v3.5.0`	The version of NebulaGraph.
`nebula.imagePullPolicy`	`IfNotPresent`	The NebulaGraph image pull policy. For details, see Image pull policy.
`nebula.storageClassName`	`nil`	The StorageClass name. StorageClass is the default persistent volume type.
`nebula.schedulerName`	`default-scheduler`	The scheduler name of a NebulaGraph cluster.
`nebula.reference`	`{"name": "statefulsets.apps", "version": "v1"}`	The workload referenced for a NebulaGraph cluster.
`nebula.graphd.image`	`vesoft/nebula-graphd`	The image name for a Graphd service. Uses the value of `nebula.version` as its version.
`nebula.graphd.replicas`	`2`	The number of the Graphd service.
`nebula.graphd.env`	`[]`	The environment variables for the Graphd service.
`nebula.graphd.resources`	`{"resources":{"requests":{"cpu":"500m","memory":"500Mi"},"limits":{"cpu":"1","memory":"1Gi"}}}`	The resource configurations for the Graphd service.
`nebula.graphd.logStorage`	`500Mi`	The log disk storage capacity for the Graphd service.
`nebula.graphd.podLabels`	`{}`	Labels for the Graphd pod in a NebulaGraph cluster.
`nebula.graphd.podAnnotations`	`{}`	Pod annotations for the Graphd pod in a NebulaGraph cluster.
`nebula.graphd.nodeSelector`	`{}`	Labels for the Graphd pod to be scheduled to the specified node.
`nebula.graphd.tolerations`	`{}`	Tolerations for the Graphd pod.
`nebula.graphd.affinity`	`{}`	Affinity for the Graphd pod.
`nebula.graphd.readinessProbe`	`{}`	ReadinessProbe for the Graphd pod.
`nebula.graphd.sidecarContainers`	`{}`	Sidecar containers for the Graphd pod.
`nebula.graphd.sidecarVolumes`	`{}`	Sidecar volumes for the Graphd pod.
`nebula.metad.image`	`vesoft/nebula-metad`	The image name for a Metad service. Uses the value of `nebula.version` as its version.
`nebula.metad.replicas`	`3`	The number of the Metad service.
`nebula.metad.env`	`[]`	The environment variables for the Metad service.
`nebula.metad.resources`	`{"resources":{"requests":{"cpu":"500m","memory":"500Mi"},"limits":{"cpu":"1","memory":"1Gi"}}}`	The resource configurations for the Metad service.
`nebula.metad.logStorage`	`500Mi`	The log disk capacity for the Metad service.
`nebula.metad.dataStorage`	`1Gi`	The data disk capacity for the Metad service.
`nebula.metad.licenseManagerURL`	`{}`	

Parameter	Default value	Description
		Configure the URL that points to the LM, which consists of the access address and port number (default port `9119`) of the LM. For example, `192.168.8.100:9119`. **You must configure this parameter in order to obtain the license information; otherwise, the enterprise edition cluster cannot be used.**
`nebula.metad.podLabels`	`{}`	Labels for the Metad pod in a NebulaGraph cluster.
`nebula.metad.podAnnotations`	`{}`	Pod annotations for the Metad pod in a NebulaGraph cluster.
`nebula.metad.nodeSelector`	`{}`	Labels for the Metad pod to be scheduled to the specified node.
`nebula.metad.tolerations`	`{}`	Tolerations for the Metad pod.
`nebula.metad.affinity`	`{}`	Affinity for the Metad pod.
`nebula.metad.readinessProbe`	`{}`	ReadinessProbe for the Metad pod.
`nebula.metad.sidecarContainers`	`{}`	Sidecar containers for the Metad pod.
`nebula.metad.sidecarVolumes`	`{}`	Sidecar volumes for the Metad pod.
`nebula.storaged.image`	`vesoft/nebula-storaged`	The image name for a Storaged service. Uses the value of `nebula.version` as its version.
`nebula.storaged.replicas`	`3`	The number of Storaged services.
`nebula.storaged.env`	`[]`	The environment variables for Storaged services.
`nebula.storaged.resources`	`{"resources":{"requests":{"cpu":"500m","memory":"500Mi"},"limits":{"cpu":"1","memory":"1Gi"}}}`	The resource configurations for Storagedss services.
`nebula.storaged.logStorage`	`500Mi`	The log disk capacity for the Metad service.
`nebula.storaged.dataStorage`	`1Gi`	The data disk capacity for the Metad service.
`nebula.storaged.podLabels`	`{}`	Labels for the Metad pod in a NebulaGraph cluster.
`nebula.storaged.podAnnotations`	`{}`	Pod annotations for the Metad pod in a NebulaGraph cluster.
`nebula.storaged.nodeSelector`	`{}`	Labels for the Metad pod to be scheduled to the specified node.
`nebula.storaged.tolerations`	`{}`	Tolerations for the Metad pod.
`nebula.storaged.affinity`	`{}`	Affinity for the Metad pod.
`nebula.storaged.readinessProbe`	`{}`	ReadinessProbe for the Metad pod.
`nebula.storaged.sidecarContainers`	`{}`	Sidecar containers for the Metad pod.
`nebula.storaged.sidecarVolumes`	`{}`	Sidecar volumes for the Metad pod.
`imagePullSecrets`	`[]`	The Secret to pull the NebulaGraph cluster image.

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17.5 Connect to NebulaGraph databases with Nebular Operator

After creating a NebulaGraph cluster with NebulaGraph Operator on Kubernetes, you can connect to NebulaGraph databases from within the cluster and outside the cluster.

17.5.1 Prerequisites

Create a NebulaGraph cluster with NebulaGraph Operator on Kubernetes. For more information, see Deploy NebulaGraph clusters with Kubectl or Deploy NebulaGraph clusters with Helm.

17.5.2 Connect to NebulaGraph databases from outside a NebulaGraph cluster via `NodePort`

You can create a `NodePort` type Service to access internal cluster services from outside the cluster using any node IP and the exposed node port. You can also utilize load balancing services provided by cloud vendors (such as Azure, AWS, etc.) by setting the Service type to `LoadBalancer`. This allows external access to internal cluster services through the public IP and port of the load balancer provided by the cloud vendor.

The Service of type `NodePort` forwards the front-end requests via the label selector `spec.selector` to Graphd pods with labels `app.kubernetes.io/cluster: <cluster-name>` and `app.kubernetes.io/component: graphd`.

After creating a NebulaGraph cluster based on the example template, where `spec.graphd.service.type=NodePort`, the NebulaGraph Operator will automatically create a NodePort type Service named `<cluster-name>-graphd-svc` in the same namespace. You can directly connect to the NebulaGraph database through any node IP and the exposed node port (see step 4 below). You can also create a custom Service according to your needs.

Steps:

1. Create a YAML file named `graphd-nodeport-service.yaml`. The file contents are as follows:

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/cluster: nebula
    app.kubernetes.io/component: graphd
    app.kubernetes.io/managed-by: nebula-operator
    app.kubernetes.io/name: nebula-graph
  name: nebula-graphd-svc-nodeport
  namespace: default
spec:
  externalTrafficPolicy: Local
  ports:
  - name: thrift
    port: 9669
    protocol: TCP
    targetPort: 9669
  - name: http
    port: 19669
    protocol: TCP
    targetPort: 19669
  selector:
    app.kubernetes.io/cluster: nebula
    app.kubernetes.io/component: graphd
    app.kubernetes.io/managed-by: nebula-operator
    app.kubernetes.io/name: nebula-graph
  type: NodePort   # Set the type to NodePort.
```

- NebulaGraph uses port `9669` by default. `19669` is the HTTP port of the Graph service in a NebulaGraph cluster.
- The value of `targetPort` is the port mapped to the database Pods, which can be customized.

2. Run the following command to create a NodePort Service.

```
kubectl create -f graphd-nodeport-service.yaml
```

3. Check the port mapped on all of your cluster nodes.

```
kubectl get services -l app.kubernetes.io/cluster=<nebula> # <nebula> is the name of your NebulaGraph cluster.
```

Output:

```
NAME                        TYPE       CLUSTER-IP     EXTERNAL-IP   PORT(S)                                        AGE
nebula-graphd-svc-nodeport  NodePort   10.107.153.129 <none>        9669:32236/TCP,19669:31674/TCP,19670:31057/TCP   24h
...
```

As you see, the mapped port of NebulaGraph databases on all cluster nodes is `32236`.

4. Connect to NebulaGraph databases with your node IP and the node port above.

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- <nebula_console_name> -addr <node_ip> -port <node_port> -u <username> -p <password>
```

For example:

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- nebula-console -addr 192.168.8.24 -port 32236 -u root -p vesoft
If you don't see a command prompt, try pressing enter.

(root@nebula) [(none)]>
```

- `--image`: The image for the tool NebulaGraph Console used to connect to NebulaGraph databases.
- `<nebula-console>`: The custom Pod name. The above example uses `nebula-console`.
- `-addr`: The IP of any node in a NebulaGraph cluster. The above example uses `192.168.8.24`.
- `-port`: The mapped port of NebulaGraph databases on all cluster nodes. The above example uses `32236`.
- `-u`: The username of your NebulaGraph account. Before enabling authentication, you can use any existing username. The default username is root.
- `-p`: The password of your NebulaGraph account. Before enabling authentication, you can use any characters as the password.

17.5.3 Connect to NebulaGraph databases from within a NebulaGraph cluster

You can also create a `ClusterIP` type Service to provide an access point to the NebulaGraph database for other Pods within the cluster. By using the Service's IP and the Graph service's port number (9669), you can connect to the NebulaGraph database. For more information, see ClusterIP.

1. Create a file named `graphd-clusterip-service.yaml`. The file contents are as follows:

```yaml
apiVersion: v1
kind: Service
metadata:
  labels:
    app.kubernetes.io/cluster: nebula
    app.kubernetes.io/component: graphd
    app.kubernetes.io/managed-by: nebula-operator
    app.kubernetes.io/name: nebula-graph
  name: nebula-graphd-svc
  namespace: default
spec:
  externalTrafficPolicy: Local
  ports:
  - name: thrift
    port: 9669
    protocol: TCP
    targetPort: 9669
  - name: http
    port: 19669
    protocol: TCP
    targetPort: 19669
  selector:
    app.kubernetes.io/cluster: nebula
    app.kubernetes.io/component: graphd
    app.kubernetes.io/managed-by: nebula-operator
    app.kubernetes.io/name: nebula-graph
  type: ClusterIP  # Set the type to ClusterIP.
```

- NebulaGraph uses port `9669` by default. `19669` is the HTTP port of the Graph service in a NebulaGraph cluster.
- `targetPort` is the port mapped to the database Pods, which can be customized.

2. Create a ClusterIP Service.

```
kubectl create -f graphd-clusterip-service.yaml
```

3. Check the IP of the Service:

```
$ kubectl get service -l app.kubernetes.io/cluster=<nebula>  # <nebula> is the name of your NebulaGraph cluster.
NAME                       TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)                                          AGE
nebula-graphd-svc          ClusterIP   10.98.213.34    <none>        9669/TCP,19669/TCP,19670/TCP                     23h
...
```

4. Run the following command to connect to the NebulaGraph database using the IP of the `<cluster-name>-graphd-svc` Service above:

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- <nebula_console_name> -addr <cluster_ip>  -port <service_port> -u <username> -p <password>
```

For example:

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- nebula-console -addr 10.98.213.34  -port 9669 -u root -p vesoft

- `--image`: The image for the tool NebulaGraph Console used to connect to NebulaGraph databases.
- `<nebula-console>`: The custom Pod name.
- `-addr`: The IP of the `ClusterIP` Service, used to connect to Graphd services.
- `-port`: The port to connect to Graphd services, the default port of which is `9669`.
- `-u`: The username of your NebulaGraph account. Before enabling authentication, you can use any existing username. The default username is root.
- `-p`: The password of your NebulaGraph account. Before enabling authentication, you can use any characters as the password.

A successful connection to the database is indicated if the following is returned:

```bash
If you don't see a command prompt, try pressing enter.

(root@nebula) [(none)]>
```

You can also connect to NebulaGraph databases with **Fully Qualified Domain Name (FQDN)**. The domain format is `<cluster-name>-graphd.<cluster-namespace>.svc.<CLUSTER_DOMAIN>`. The default value of `CLUSTER_DOMAIN` is `cluster.local`.

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- <nebula_console_name> -addr <cluster_name>-graphd-svc.default.svc.cluster.local -port <service_port> -u <username> -p <password>
```
```

`service_port` is the port to connect to Graphd services, the default port of which is `9669`.

17.5.4 Connect to NebulaGraph databases from outside a NebulaGraph cluster via Ingress

When dealing with multiple pods in a cluster, managing services for each pod separately is not a good practice. Ingress is a Kubernetes resource that provides a unified entry point for accessing multiple services. Ingress can be used to expose multiple services under a single IP address.

Nginx Ingress is an implementation of Kubernetes Ingress. Nginx Ingress watches the Ingress resource of a Kubernetes cluster and generates the Ingress rules into Nginx configurations that enable Nginx to forward 7 layers of traffic.

You can use Nginx Ingress to connect to a NebulaGraph cluster from outside the cluster using a combination of the host network and DaemonSet pattern.

As the host network is used, the Nginx Ingress pod cannot be scheduled to the same node. To avoid listening port conflicts, some nodes can be selected and labeled as edge nodes in advance, which are specially used for the Nginx Ingress deployment. Nginx Ingress is then deployed on these nodes in a DaemonSet mode.

Ingress does not support TCP or UDP services. For this reason, the nginx-ingress-controller pod uses the flags `--tcp-services-configmap` and `--udp-services-configmap` to point to an existing ConfigMap where the key refers to the external port to be used and the value refers to the format of the service to be exposed. The format of the value is `<namespace/service_name>:<service_port>`.

For example, the configurations of the ConfigMap named as `tcp-services` is as follows:

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: tcp-services
  namespace: nginx-ingress
data:
  # update
  9769: "default/nebula-graphd-svc:9669"
```

Steps are as follows.

1. Create a file named `nginx-ingress-daemonset-hostnetwork.yaml`.

   Click on nginx-ingress-daemonset-hostnetwork.yaml to view the complete content of the example YAML file.

   > **Note**
   >
   > The resource objects in the YAML file above use the namespace `nginx-ingress`. You can run `kubectl create namespace nginx-ingress` to create this namespace, or you can customize the namespace.

2. Label a node where the DaemonSet named `nginx-ingress-controller` in the above YAML file (The node used in this example is named `worker2` with an IP of `192.168.8.160`) runs.

```
kubectl label node worker2 nginx-ingress=true
```

3. Run the following command to enable Nginx Ingress in the cluster you created.

```
kubectl create -f nginx-ingress-daemonset-hostnetwork.yaml
```

   Output:

```
configmap/nginx-ingress-controller created
configmap/tcp-services created
serviceaccount/nginx-ingress created
serviceaccount/nginx-ingress-backend created
clusterrole.rbac.authorization.k8s.io/nginx-ingress created
clusterrolebinding.rbac.authorization.k8s.io/nginx-ingress created
role.rbac.authorization.k8s.io/nginx-ingress created
rolebinding.rbac.authorization.k8s.io/nginx-ingress created
service/nginx-ingress-controller-metrics created
service/nginx-ingress-default-backend created
service/nginx-ingress-proxy-tcp created
daemonset.apps/nginx-ingress-controller created
```

   Since the network type that is configured in Nginx Ingress is `hostNetwork`, after successfully deploying Nginx Ingress, with the IP (`192.168.8.160`) of the node where Nginx Ingress is deployed and with the external port (`9769`) you define, you can access NebulaGraph.

4. Use the IP address and the port configured in the preceding steps. You can connect to NebulaGraph with NebulaGraph Console.

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- <nebula_console_name> -addr <host_ip> -port <external_port> -u <username> -p <password>
```

   Output:

```
kubectl run -ti --image vesoft/nebula-console:v3.5.0 --restart=Never -- nebula-console -addr 192.168.8.160 -port 9769 -u root -p vesoft
```

- `--image`: The image for the tool NebulaGraph Console used to connect to NebulaGraph databases.
- `<nebula-console>` The custom Pod name. The above example uses `nebula-console`.
- `-addr`: The IP of the node where Nginx Ingress is deployed. The above example uses `192.168.8.160`.
- `-port`: The port used for external network access. The above example uses `9769`.
- `-u`: The username of your NebulaGraph account. Before enabling authentication, you can use any existing username. The default username is root.
- `-p`: The password of your NebulaGraph account. Before enabling authentication, you can use any characters as the password.

  A successful connection to the database is indicated if the following is returned:

```
If you don't see a command prompt, try pressing enter.
(root@nebula) [(none)]>
```

Last update: April 19, 2023

17.6 Configure clusters

17.6.1 Customize configuration parameters for a NebulaGraph cluster

Meta, Storage, and Graph services in a NebulaGraph Cluster have their own configuration settings, which are defined in the YAML file of the NebulaGraph cluster instance as `config`. These settings are mapped and loaded into the corresponding service's ConfigMap in Kubernetes. At the time of startup, the configuration present in the ConfigMap is mounted onto the directory `/usr/local/nebula/etc/` for every service.

Note

It is not available to customize configuration parameters for NebulaGraph Clusters deployed with Helm.

The structure of `config` is as follows.

```
Config map[string]string `json:"config,omitempty"`
```

Prerequisites

You have created a NebulaGraph cluster. For how to create a cluster with Kubectl, see Create a cluster with Kubectl.

Steps

The following example uses a cluster named `nebula` and the cluster's configuration file named `nebula_cluster.yaml` to show how to set `config` for the Graph service in a NebulaGraph cluster.

1. Run the following command to access the edit page of the `nebula` cluster.

```
kubectl edit nebulaclusters.apps.nebula-graph.io nebula
```

2. Add `enable_authorize` and `auth_type` under `spec.graphd.config`.

```
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
  namespace: default
spec:
  graphd:
    resources:
      requests:
        cpu: "500m"
        memory: "500Mi"
      limits:
        cpu: "1"
        memory: "1Gi"
    replicas: 1
    image: vesoft/nebula-graphd
    version: v3.5.0
    storageClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    config: // Custom configuration parameters for the Graph service in a cluster.
      "enable_authorize": "true"
      "auth_type": "password"
...
```

To add the `config` for the Meta and Storage services, add `spec.metad.config` and `spec.storaged.config` respectively.

3. Run `kubectl apply -f nebula_cluster.yaml` to push your configuration changes to the cluster.

After customizing the parameters `enable_authorize` and `auth_type`, the configurations in the corresponding ConfigMap (`nebula-graphd`) of the Graph service will be overwritten.

Modify cluster configurations online

Cluster configurations are modified online by calling the HTTP interface, without the need to restart the cluster Pod.

It should be noted that only when all configuration items in `config` are the parameters that can be dynamically modified at runtime, can the operation of online modifications be triggered. If the configuration items in `config` contain parameters that cannot be dynamically modified, then the cluster configuration will be updated by restarting the Pod.

For information about the parameters that can be dynamically modified for each service, see the parameter table column of **Whether supports runtime dynamic modifications** in Meta service configuration parameters, Storage service configuration parameters, and Graph service configuration parameters, respectively.

Learn more

For more information about the configuration parameters of Meta, Storage, and Graph services, see Meta service configuration parameters, Storage service configuration parameters, and Graph service configuration parameters.

Last update: April 19, 2023

17.6.2 Reclaim PVs

NebulaGraph Operator uses PVs (Persistent Volumes) and PVCs (Persistent Volume Claims) to store persistent data. If you accidentally deletes a NebulaGraph cluster, by default, PV and PVC objects and the relevant data will be retained to ensure data security.

You can also define the automatic deletion of PVCs to release data by setting the parameter `spec.enablePVReclaim` to `true` in the configuration file of the cluster instance. As for whether PV will be deleted automatically after PVC is deleted, you need to customize the PV reclaim policy. See reclaimPolicy in StorageClass and PV Reclaiming for details.

Prerequisites

You have created a cluster. For how to create a cluster with Kubectl, see Create a cluster with Kubectl.

Steps

The following example uses a cluster named `nebula` and the cluster's configuration file named `nebula_cluster.yaml` to show how to set `enablePVReclaim`:

1. Run the following command to access the edit page of the `nebula` cluster.

```
kubectl edit nebulaclusters.apps.nebula-graph.io nebula
```

2. Add `enablePVReclaim` and set its value to `true` under `spec`.

```
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
spec:
  enablePVReclaim: true  //Set its value to true.
  graphd:
    image: vesoft/nebula-graphd
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    replicas: 1
    resources:
      limits:
        cpu: "1"
        memory: 1Gi
      requests:
        cpu: 500m
        memory: 500Mi
    version: v3.5.0
  imagePullPolicy: IfNotPresent
  metad:
    dataVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    image: vesoft/nebula-metad
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    replicas: 1
    resources:
      limits:
        cpu: "1"
        memory: 1Gi
      requests:
        cpu: 500m
        memory: 500Mi
    version: v3.5.0
  nodeSelector:
    nebula: cloud
  reference:
    name: statefulsets.apps
    version: v1
  schedulerName: default-scheduler
  storaged:
    dataVolumeClaims:
    - resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    - resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    image: vesoft/nebula-storaged
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    replicas: 3
    resources:
      limits:
        cpu: "1"
        memory: 1Gi
      requests:
        cpu: 500m
        memory: 500Mi
    version: v3.5.0
...
```

3. Run `kubectl apply -f nebula_cluster.yaml` to push your configuration changes to the cluster.

Last update: March 13, 2023

17.6.3 Balance storage data after scaling out

Enterpriseonly

This feature is for NebulaGraph Enterprise Edition only.

After the Storage service is scaled out, you can decide whether to balance the data in the Storage service.

The scaling out of the NebulaGraph's Storage service is divided into two stages. In the first stage, the status of all pods is changed to `Ready`. In the second stage, the commands of `BALANCE DATA` and `BALANCE LEADER` are executed to balance data. These two stages decouple the scaling out process of the controller replica from the balancing data process, so that you can choose to perform the data balancing operation during low traffic period. The decoupling of the scaling out process from the balancing process can effectively reduce the impact on online services during data migration.

You can define whether to balance data automatically or not with the parameter `enableAutoBalance` in the configuration file of the CR instance of the cluster you created.

Prerequisites

You have created a NebulaGraph cluster. For how to create a cluster with Kubectl, see Create a cluster with Kubectl.

Steps

The following example uses a cluster named `nebula` and the cluster's configuration file named `nebula_cluster.yaml` to show how to set `enableAutoBalance`.

1. Run the following command to access the edit page of the `nebula` cluster.

```
kubectl edit nebulaclusters.apps.nebula-graph.io nebula
```

2. Add `enableAutoBalance` and set its value to `true` under `spec.storaged`.

```yaml
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
spec:
  graphd:
    image: vesoft/nebula-graphd
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    replicas: 1
    resources:
      limits:
        cpu: "1"
        memory: 1Gi
      requests:
        cpu: 500m
        memory: 500Mi
    version: v3.5.0
  imagePullPolicy: IfNotPresent
  metad:
    dataVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    image: vesoft/nebula-metad
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    replicas: 1
    resources:
      limits:
        cpu: "1"
        memory: 1Gi
      requests:
        cpu: 500m
        memory: 500Mi
    version: v3.5.0
  nodeSelector:
    nebula: cloud
  reference:
    name: statefulsets.apps
    version: v1
  schedulerName: default-scheduler
  storaged:
    enableAutoBalance: true   //Set its value to true which means storage data will be balanced after the Storage service is scaled out.
    dataVolumeClaims:
    - resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    - resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    image: vesoft/nebula-storaged
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    replicas: 3
    resources:
      limits:
        cpu: "1"
        memory: 1Gi
      requests:
        cpu: 500m
        memory: 500Mi
```

```
    version: v3.5.0
...
```

- When the value of `enableAutoBalance` is set to `true`, the Storage data will be automatically balanced after the Storage service is scaled out.
- When the value of `enableAutoBalance` is set to `false`, the Storage data will not be automatically balanced after the Storage service is scaled out.
- When the `enableAutoBalance` parameter is not set, the system will not automatically balance Storage data by default after the Storage service is scaled out.

3. Run `kubectl apply -f nebula_cluster.yaml` to push your configuration changes to the cluster.

Last update: December 21, 2022

17.6.4 Manage cluster logs

Running logs of NebulaGraph cluster services (graphd, metad, storaged) are generated and stored in the `/usr/local/nebula/logs` directory of each service container by default.

View logs

To view the running logs of a NebulaGraph cluster, you can use the `kubectl logs` command.

For example, to view the running logs of the Storage service:

```
// View the name of the Storage service Pod, nebula-storaged-0.
$ kubectl get pods -l app.kubernetes.io/component=storaged
NAME                             READY   STATUS    RESTARTS      AGE
nebula-storaged-0                1/1     Running   0             45h
...

// Enter the container storaged of the Storage service.
$ kubectl exec -it nebula-storaged-0 -c storaged -- /bin/bash

// View the running logs of the Storage service.
$ cd /usr/local/nebula/logs
```

Clean logs

Running logs generated by cluster services during runtime will occupy disk space. To avoid occupying too much disk space, the Operator uses a sidecar container to periodically clean and archive logs.

To facilitate log collection and management, each NebulaGraph service deploys a sidecar container responsible for collecting logs generated by the service container and sending them to the specified log disk. The sidecar container automatically cleans and archives logs using the logrotate tool.

In the YAML configuration file of the cluster instance, you can configure log rotation to automatically clean and archive logs through the `spec.logRotate` field. By default, the log rotation feature is turned off. Here is an example of enabling log rotation:

```yaml
...
spec:
  graphd:
    config:
      # Whether to include a timestamp in the log file name. "true" means yes, "false" means no.
      "timestamp_in_logfile_name": "false"
  metad:
    config:
      "timestamp_in_logfile_name": "false"
  storaged:
    config:
      "timestamp_in_logfile_name": "false"
  logRotate: # Log rotation configuration
    # The number of times a log file is rotated before being deleted. The default value is 5, and 0 means the log file will not be rotated before being deleted.
    rotate: 5
    # The log file is rotated only if it grows larger than the specified size. The default value is 200M.
    size: "200M"
```

Collect logs

If you don't want to mount additional log disks to back up log files, or if you want to collect logs and send them to a log center using services like fluent-bit, you can configure logs to be output to standard error. The Operator uses the glog tool to log to standard error output.

Caution

Currently, NebulaGraph Operator only collects standard error logs。

In the YAML configuration file of the cluster instance, you can configure logging to standard error output in the `config` and `env` fields of each service.

```yaml
...
spec:
  graphd:
    config:
      # Whether to redirect standard error to a separate output file. The default value is false, which means it is not redirected.
      redirect_stdout: "false"
      # The severity level of log content: INFO, WARNING, ERROR, and FATAL. The corresponding values are 0, 1, 2, and 3.
      stderrthreshold: "0"
    env:
    - name: GLOG_logtostderr # Write log to standard error output instead of a separate file.
      value: "1" # 1 represents writing to standard error output, and 0 represents writing to a file.
    image: vesoft/nebula-graphd
    replicas: 1
    resources:
      requests:
        cpu: 500m
        memory: 500Mi
    service:
      externalTrafficPolicy: Local
      type: NodePort
    version: v3.5.0
  metad:
    config:
      redirect_stdout: "false"
      stderrthreshold: "0"
    dataVolumeClaim:
      resources:
        requests:
          storage: 1Gi
      storageClassName: ebs-sc
    env:
    - name: GLOG_logtostderr
      value: "1"
    image: vesoft/nebula-metad
  ...
```

Last update: April 19, 2023

17.6.5 Enable SSL Encryption in Nebula Graph

SSL encryption is a commonly used network security technology that ensures secure communication between the client and server. Its working principle is mainly to protect data transmitted over the network by using encryption algorithms to prevent data interception or tampering during transmission. During the SSL connection establishment process, the server sends a digital certificate containing a public key and some identity information to the client. This certificate is issued by a trusted third-party Certification Authority (CA). The client verifies this digital certificate to confirm the identity of the server. In the NebulaGraph environment running in Kubernetes, you can enable SSL encryption, and both the client and server need to verify their identities to ensure secure communication between the client and server, and also between servers. This article explains how to enable SSL encryption in NebulaGraph running in K8s.

Prerequisites

- NebulaGraph Operator has been installed.
- A NebulaGraph cluster has been created. For details, see Create a NebulaGraph cluster with kubectl or Create a NebulaGraph cluster with Helm.
- Certificates and their corresponding private keys have been generated for the client and server, and the CA certificate has been generated. For details, see Generate Certificates Manually.

Configure certifications

Operator provides the `sslCerts` field to specify the encrypted certificates. The `sslCerts` field contains three subfields: `serverSecret`, `clientSecret`, and `caSecret`. These three fields are used to specify the Secret names of the NebulaGraph server certificate, client certificate, and CA certificate, respectively. When the user specifies these three fields, Operator reads the certificate content from the corresponding Secret and mounts it into the cluster's Pod.

In a K8s cluster, SSL type Secrets use `tls.crt` and `tls.key` as the default names for the server or client certificate file and private key file, and the default name for the CA certificate file is `ca.crt` (the CA certificate does not need to configure a private key). If you change the names of the certificate file and private key, you need to add corresponding subfields in the `sslCerts` field to specify the new certificate and private key names, and specify the new names when creating the Secret.

```
sslCerts:
  # Name of the Secret containing the server certificate.
  serverSecret: "server-cert"
  # Name of the server certificate file. Defaults to tls.crt. No configuration is needed when using the default name.
  serverPublicKey: ""
  # Name of the server private key file. Defaults to tls.key. No configuration is needed when using the default name.
  serverPrivateKey: ""
  # Name of the Secret containing the client certificate.
  clientSecret: "client-cert"
  # Name of the client certificate file. Defaults to tls.crt. No configuration is needed when using the default name.
  clientPublicKey: ""
  # Name of the client private key file. Defaults to tls.key. No configuration is needed when using the default name.
  clientPrivateKey: ""
  # Name of the Secret containing the CA certificate.
  caSecret: "ca-cert"
  # Name of the CA certificate file. Defaults to ca.crt. No configuration is needed when using the default name.
  caPublicKey: ""
```

You can use the `insecureSkipVerify` field to decide whether the client will verify the server's certificate chain and hostname. In production environments, it is recommended to set this to `false` to ensure the security of communication. If set to `true`, the client will not verify the server's certificate chain and hostname.

```
sslCerts:
  # Determines whether the client needs to verify the server's certificate when establishing an SSL connection.
  insecureSkipVerify: false
```

When the certificates are approaching expiration, they can be automatically updated by installing cert-manager. NebulaGraph will monitor changes to the certificate directory files, and once a change is detected, it will load the new certificate content into memory.

Encryption strategies

NebulaGraph offers three encryption strategies that you can choose and configure according to your needs.

- Encryption of all inter-service communication

  If you want to encrypt all data transmission between the client, Graph service, Meta service, and Storage service, you need to add the `enable_ssl = true` field to each service.

  Here is an example configuration:

```yaml
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
  namespace: default
spec:
  sslCerts:
    serverSecret: "server-cert"
    clientSecret: "client-cert"
    caSecret: "ca-cert"
  graphd:
    config:
      enable_ssl: "true"
  metad:
    config:
      enable_ssl: "true"
  storaged:
    config:
      enable_ssl: "true"
```

- Encryption of only Graph service communication

  If the K8s cluster is deployed in the same data center and only the port of the Graph service is exposed externally, you can choose to encrypt only data transmission between the client and the Graph service. In this case, other services can communicate internally without encryption. Just add the `enable_graph_ssl = true` field to the Graph service.

  Here is an example configuration:

```yaml
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
  namespace: default
spec:
  sslCerts:
    serverSecret: "server-cert"
    caSecret: "ca-cert"
  graphd:
    config:
      enable_graph_ssl: "true"
```

- Encryption of only Meta service communication

  If you need to transmit confidential information to the Meta service, you can choose to encrypt data transmission related to the Meta service. In this case, you need to add the `enable_meta_ssl = true` configuration to each component.

  Here is an example configuration:

```yaml
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
  namespace: default
spec:
  sslCerts:
    serverSecret: "server-cert"
    clientSecret: "client-cert"
    caSecret: "ca-cert"
  graphd:
    config:
      enable_meta_ssl: "true"
  metad:
    config:
      enable_meta_ssl: "true"
  storaged:
    config:
      enable_meta_ssl: "true"
```

Steps

1. Use the pre-generated server and client certificates and private keys, and the CA certificate to create a Secret for each.

- Examples to create an SSL type Secret for the server or client:

```
kubectl create secret tls <client/server-cert-secret> --key=<client/server.key> --cert=<client/server.crt>
```

- `tls` : Indicates that the type of secret being created is TLS, which is used to store SSL/TLS certificates.
- `<client/server-cert-secret>` : Specifies the name of the new secret being created, which can be customized.
- `--key=<client/server.key>` : Specifies the path to the private key file of the SSL/TLS certificate to be stored in the secret.
- `--cert=<client/server.crt>` : Specifies the path to the public key certificate file of the SSL/TLS certificate to be stored in the secret.

- Create an encrypted CA certificate secret without specifying the private key of the CA.

```
kubectl create secret tls <ca-cert-secret> --key --cert=<ca.crt>
```

- `<ca-cert-secret>` : The name of the Secret to be created.
- `<ca.crt>` : The path to the CA certificate file stored in the Secret.

2. Add server certificate, client certificate, CA certificate configuration, and encryption policy configuration in the corresponding cluster instance YAML file.

   For example, add encryption configuration for transmission data between client, Graph service, Meta service, and Storage service.

```
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
  namespace: default
spec:
  sslCerts:
    serverSecret: "server-cert"  // The name of the server Certificate Secret.
    clientSecret: "client-cert"  // The name of the client Certificate Secret.
    caSecret: "ca-cert"          // The name of the CA Certificate Secret.
  graphd:
    config:
      enable_ssl: "true"
  metad:
    config:
      enable_ssl: "true"
  storaged:
    config:
      enable_ssl: "true"
```

3. Use `kubectl apply -f` to apply the file to the Kubernetes cluster.

This will enable SSL encryption in NebulaGraph and enhance the security of the data.

Last update: May 23, 2023

17.7 Upgrade NebulaGraph clusters created with NebulaGraph Operator

This topic introduces how to upgrade a NebulaGraph cluster created with NebulaGraph Operator.

Legacy version compatibility

The 1.x version NebulaGraph Operator is not compatible with NebulaGraph of version below v3.x.

17.7.1 Limits

- Only for upgrading the NebulaGraph clusters created with NebulaGraph Operator.
- Only support upgrading the NebulaGraph version from 3.0.0 to 3.5.0.

17.7.2 Upgrade a NebulaGraph cluster with Kubectl

Prerequisites

You have created a NebulaGraph cluster with Kubectl. For details, see Create a NebulaGraph cluster with Kubectl.

The version of the NebulaGraph cluster to be upgraded in this topic is `3.0.0`, and its YAML file name is `apps_v1alpha1_nebulacluster.yaml`.

Steps

1. Check the image version of the services in the cluster.

```
kubectl get pods -l app.kubernetes.io/cluster=nebula  -o jsonpath="{.items[*].spec.containers[*].image}" |tr -s '[[:space:]]' '\n' |sort |uniq -c
```

Output:

```
      1 vesoft/nebula-graphd:3.0.0
      1 vesoft/nebula-metad:3.0.0
      3 vesoft/nebula-storaged:3.0.0
```

2. Edit the `apps_v1alpha1_nebulacluster.yaml` file by changing the values of all the `version` parameters from 3.0.0 to v3.5.0.

The modified YAML file reads as follows:

```
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
spec:
  graphd:
    resources:
      requests:
        cpu: "500m"
        memory: "500Mi"
      limits:
        cpu: "1"
        memory: "1Gi"
    replicas: 1
    image: vesoft/nebula-graphd
    version: v3.5.0 //Change the value from 3.0.0 to v3.5.0.
    service:
      type: NodePort
      externalTrafficPolicy: Local
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
  metad:
    resources:
      requests:
        cpu: "500m"
        memory: "500Mi"
      limits:
        cpu: "1"
```

```
        memory: "1Gi"
    replicas: 1
    image: vesoft/nebula-metad
    version: v3.5.0 //Change the value from 3.0.0 to v3.5.0.
    dataVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
  storaged:
    resources:
      requests:
        cpu: "500m"
        memory: "500Mi"
      limits:
        cpu: "1"
        memory: "1Gi"
    replicas: 3
    image: vesoft/nebula-storaged
    version: v3.5.0 //Change the value from 3.0.0 to v3.5.0.
    dataVolumeClaims:
    - resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    - resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
    logVolumeClaim:
      resources:
        requests:
          storage: 2Gi
      storageClassName: fast-disks
  reference:
    name: statefulsets.apps
    version: v1
  schedulerName: default-scheduler
  imagePullPolicy: Always
```

3. Run the following command to apply the version update to the cluster CR.

```
kubectl apply -f apps_v1alpha1_nebulacluster.yaml
```

4. After waiting for about 2 minutes, run the following command to see if the image versions of the services in the cluster have been changed to v3.5.0.

```
kubectl get pods -l app.kubernetes.io/cluster=nebula  -o jsonpath="{.items[*].spec.containers[*].image}" |tr -s '[[:space:]]' '\n' |sort |uniq -c
```

Output:

```
      1 vesoft/nebula-graphd:v3.5.0
      1 vesoft/nebula-metad:v3.5.0
      3 vesoft/nebula-storaged:v3.5.0
```

17.7.3 Upgrade a NebulaGraph cluster with Helm

Prerequisites

You have created a NebulaGraph cluster with Helm. For details, see Create a NebulaGraph cluster with Helm.

Steps

1. Update the information of available charts locally from chart repositories.

```
helm repo update
```

2. Set environment variables to your desired values.

```
export NEBULA_CLUSTER_NAME=nebula         # The desired NebulaGraph cluster name.
export NEBULA_CLUSTER_NAMESPACE=nebula    # The desired namespace where your NebulaGraph cluster locates.
```

3. Upgrade a NebulaGraph cluster.

For example, upgrade a cluster to v3.5.0.

```
helm upgrade "${NEBULA_CLUSTER_NAME}" nebula-operator/nebula-cluster \
    --namespace="${NEBULA_CLUSTER_NAMESPACE}" \
    --set nameOverride=${NEBULA_CLUSTER_NAME} \
    --set nebula.version=v3.5.0
```

The value of `--set nebula.version` specifies the version of the cluster you want to upgrade to.

4. Run the following command to check the status and version of the upgraded cluster.

   Check cluster status:

```
$ kubectl -n "${NEBULA_CLUSTER_NAMESPACE}" get pod -l "app.kubernetes.io/cluster=${NEBULA_CLUSTER_NAME}"
NAME                READY   STATUS    RESTARTS   AGE
nebula-graphd-0     1/1     Running   0          2m
nebula-graphd-1     1/1     Running   0          2m
nebula-metad-0      1/1     Running   0          2m
nebula-metad-1      1/1     Running   0          2m
nebula-metad-2      1/1     Running   0          2m
nebula-storaged-0   1/1     Running   0          2m
nebula-storaged-1   1/1     Running   0          2m
nebula-storaged-2   1/1     Running   0          2m
```

   Check cluster version:

```
$ kubectl get pods -l app.kubernetes.io/cluster=nebula  -o jsonpath="{.items[*].spec.containers[*].image}" |tr -s '[[:space:]]' '\n' |sort |uniq -c
      1 vesoft/nebula-graphd:v3.5.0
      1 vesoft/nebula-metad:v3.5.0
      3 vesoft/nebula-storaged:v3.5.0
```

17.7.4 Accelerate the upgrade process

The upgrade process of a cluster is a rolling update process and can be time-consuming due to the state transition of the leader partition replicas in the Storage service. You can configure the `enableForceUpdate` field in the cluster instance's YAML file to skip the leader partition replica transfer operation, thereby accelerating the upgrade process. For more information, see Specify a rolling update strategy.

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17.8 NebulaGraph cluster rolling update strategy

NebulaGraph clusters use a distributed architecture to divide data into multiple logical partitions, which are typically evenly distributed across different nodes. In distributed systems, there are usually multiple replicas of the same data. To ensure the consistency of data across multiple replicas, NebulaGraph clusters use the Raft protocol to synchronize multiple partition replicas. In the Raft protocol, each partition elects a leader replica, which is responsible for handling write requests, while follower replicas handle read requests.

When a NebulaGraph cluster created by NebulaGraph Operator performs a rolling update, a storage node temporarily stops providing services for the update. For an overview of rolling updates, see Performing a Rolling Update. If the node hosting the leader replica stops providing services, it will result in the unavailability of read and write operations for that partition. To avoid this situation, by default, Operator migrates the leader replicas to other unaffected nodes during the rolling update process of a NebulaGraph cluster. This way, when a storage node is being updated, the leader replicas on other nodes can continue processing client requests, ensuring the read and write availability of the cluster.

The process of migrating all leader replicas from one storage node to the other nodes may take a long time. To better control the rolling update duration, Operator provides a field called `enableForceUpdate`. When it is confirmed that there is no external access traffic, you can set this field to `true`. This way, the leader replicas will not be migrated to other nodes, thereby speeding up the rolling update process.

17.8.1 Rolling update trigger conditions

Operator triggers a rolling update of the NebulaGraph cluster under the following circumstances:

- The version of the NebulaGraph cluster changes.
- The configuration of the NebulaGraph cluster changes.

17.8.2 Specify a rolling update strategy

In the YAML file for creating a cluster instance, add the `spec.storaged.enableForceUpdate` field and set it to `true` or `false` to control the rolling update speed.

When `enableForceUpdate` is set to `true`, it means that the partition leader replicas will not be migrated, thus speeding up the rolling update process. Conversely, when set to `false`, it means that the leader replicas will be migrated to other nodes to ensure the read and write availability of the cluster. The default value is `false`.

Caution

When setting `enableForceUpdate` to `true`, make sure there is no traffic entering the cluster for read and write operations. This is because this setting will force the cluster pods to be rebuilt, and during this process, data loss or client request failures may occur.

Configuration example:

```
...
spec:
...
  storaged:
    enableForceUpdate: true // When set to true, it speeds up the rolling update process.
    ...
```

Last update: March 27, 2023

17.9 Backup and restore data using NebulaGraph Operator

This article introduces how to back up and restore data of the NebulaGraph cluster on Kubernetes.

Enterpriseonly

This feature is only for the enterprise edition NebulaGraph clusters on Kubernetes.

17.9.1 Overview

NebulaGraph BR (Enterprise Edition) is a command line tool for data backup and recovery of NebulaGraph enterprise edition. NebulaGraph Operator is based on the BR tool to achieve data backup and recovery for NebulaGraph clusters on Kubernetes.

When backing up data, NebulaGraph Operator creates a Job to back up the data in the NebulaGraph cluster to the specified storage service.

When restoring data, NebulaGraph Operator checks the specified backup NebulaGraph cluster for existence, and whether the access to remote storage is normally based on the information defined in the NebulaRestore resource object. It then creates a new cluster and restores the backup data to the new NebulaGraph cluster. For more information, see restore flowchart.

17.9.2 Prerequisites

To backup and restore data using NebulaGraph Operator, the following conditions must be met:

- Nebula Operator version >= 1.4.0.
- The enterprise edition NebulaGraph cluster deployed on Kubernetes is running.
- In the YAML file used to create the cluster, `spec.enableBR` is set to true.

```
// Partial content of a sample cluster YAML file.
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaCluster
metadata:
  name: nebula
spec:
enableBR: true // Set to true to enable the backup and restore function.
...
```

- Only storage services that use the S3 protocol (such as AWS S3, Minio, etc.) can be used to back up and restore data.
- Sufficient computing resources are available in the cluster to restore data.

17.9.3 Backup

Notes

- NebulaGraph Operator supports full and incremental backups.
- During data backup, DDL and DML statements in the specified graph space will be blocked. We recommend performing the operation during off-peak hours, such as from 2:00 am to 5:00 am.
- The cluster executing incremental backups and the cluster specified for the last backup must be the same, and the (storage bucket) path for the last backup must be the same.
- Ensure that the time between each incremental backup and the last backup is less than a `wal_ttl`.
- Specifying the backup data of a specified graph space is not supported.

Full backup

When backing up data to a storage service compatible with the S3 protocol, you need to create a backup Job, which will back up the full NebulaGraph data to the specified storage location.

Here is an example of the YAML file for a full backup Job:

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: nebula-full-backup
spec:
  parallelism: 1
  ttlSecondsAfterFinished: 60
  template:
    spec:
      restartPolicy: OnFailure
      containers:
        - image: vesoft/br-ent:v3.5.0
          imagePullPolicy: Always
          name: backup
          command:
            - /bin/sh
            - -ecx
            - exec /usr/local/bin/nebula-br backup full
            - --meta $META_ADDRESS:9559
            - --storage s3://$BUCKET
            - --s3.access_key $ACCESS_KEY
            - --s3.secret_key $SECRET_KEY
            - --s3.region $REGION
            - --s3.endpoint https://s3.$REGION.amazonaws.com
```

Incremental backup

Except for the name of the Job and the command specified in `spec.template.spec.containers[0].command`, the YAML file for incremental backup is the same as that for a full backup. Here is an example of the YAML file for incremental backup:

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: nebula-incr-backup
spec:
  parallelism: 1
  ttlSecondsAfterFinished: 60
  template:
    spec:
      restartPolicy: OnFailure
      containers:
        - image: vesoft/br-ent:v3.5.0
          imagePullPolicy: Always
          name: backup
          command:
            - /bin/sh
            - -ecx
            - exec /usr/local/bin/nebula-br backup incr
            - --meta $META_ADDRESS:9559
            - --base $BACKUP_NAME
            - --storage s3://$BUCKET
            - --s3.access_key $ACCESS_KEY
            - --s3.secret_key $SECRET_KEY
            - --s3.region $REGION
            - --s3.endpoint https://s3.$REGION.amazonaws.com
```

Parameter description

The main parameters are described as follows:

Parameter	Default value	Description
`spec.parallelism`	1	The number of tasks executed in parallel.
`spec.ttlSecondsAfterFinished`	60	The time to keep task information after the task is completed.
`spec.template.spec.containers[0].image`	`vesoft/br-ent:3.5.0`	The image address of the NebulaGraph BR Enterprise Edition tool.
`spec.template.spec.containers[0].command`	-	The command for backing up data to the storage service compatible with the S3 protocol. For descriptions of the options in the command, see Parametr description.

For more settings of the Job, see Kubernetes Jobs.

After the YAML file for the backup Job is set, run the following command to start the backup Job:

```
kubectl apply -f <backup_file_name>.yaml
```

When the data backup succeeds, a backup file is generated in the specified storage location. For example, the backup file name is `BACKUP_2023_02_12_10_04_16`.

17.9.4 Restore

Notes

- After the data recovery is successful, a new cluster will be created, and the old cluster will not be deleted. Users can decide whether to delete the old cluster themselves.
- There will be a period of service unavailability during the data recovery process, so it is recommended to perform the operation during a low period of business activity.

Process

When restoring data from a compatible S3 protocol service, you need to create a Secret to store the credentials for accessing the compatible S3 protocol service. Then create a resource object (NebulaRestore) for restoring the data, which will instruct the Operator to create a new NebulaGraph cluster based on the information defined in this resource object and restore the backup data to the newly created cluster.

Here is an example YAML for restoring data based on the backup file `BACKUP_2023_02_12_10_04_16`:

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: aws-s3-secret
type: Opaque
data:
  access-key: QVNJQVEOWFlxxx
  secret-key: ZFJ6OEdNcDdxenMwVGxxx
---
apiVersion: apps.nebula-graph.io/v1alpha1
kind: NebulaRestore
metadata:
  name: restore1
spec:
  br:
    clusterName: nebula
    backupName: "BACKUP_2023_02_12_10_04_16"
    concurrency: 5
    s3:
      region: "us-west-2"
      bucket: "nebula-br-test"
      endpoint: "https://s3.us-west-2.amazonaws.com"
      secretName: "aws-s3-secret"
```

Parameter Description

- Secret

Parameter	Default Value	Description
`metadata.name`	-	The name of the Secret.
`type`	`Opaque`	The type of the Secret. See Types of Secret for more information.
`data.access-key`	-	The AccessKey for accessing the S3 protocol-compatible storage service.
`data.secret-key`	-	The SecretKey for accessing the S3 protocol-compatible storage service.

- NebulaRestore

Parameter	Default Value	Description
`metadata.name`	-	The name of the resource object NebulaRestore.
`spec.br.clusterName`	-	The name of the backup cluster.
`spec.br.backupName`	-	The name of the backup file. Restore data based on this backup file.
`spec.br.concurrency`	`5`	The number of concurrent downloads when restoring data. The default value is `5`.
`spec.br.s3.region`	-	The geographical region where the S3 storage bucket is located.
`spec.br.s3.bucket`	-	The path of the S3 storage bucket where backup data is stored.
`spec.br.s3.endpoint`	-	The access address of the S3 storage bucket.
`spec.br.s3.secretName`	-	The name of the Secret that is used to access the S3 storage bucket.

After setting up the YAML file for restoring the data, run the following command to start the restore job:

```
kubectl apply -f <restore_file_name>.yaml
```

Run the following command to check the status of the NebulaRestore object.

```bash kubectl get rt -w

---

Last update: March 13, 2023
```

17.10 Self-healing

NebulaGraph Operator calls the interface provided by NebulaGraph clusters to dynamically sense cluster service status. Once an exception is detected (for example, a component in a NebulaGraph cluster stops running), NebulaGraph Operator automatically performs fault tolerance. This topic shows how Nebular Operator performs self-healing by simulating cluster failure of deleting one Storage service Pod in a NebulaGraph cluster.

17.10.1 Prerequisites

Install NebulaGraph Operator

17.10.2 Steps

1. Create a NebulaGraph cluster. For more information, see Deploy NebulaGraph clusters with Kubectl or Deploy NebulaGraph clusters with Helm.
2. Delete the Pod named `<cluster_name>-storaged-2` after all pods are in the `Running` status.

```
kubectl delete pod <cluster-name>-storaged-2 --now
```

`<cluster_name>` is the name of your NebulaGraph cluster.

3. NebulaGraph Operator automates the creation of the Pod named `<cluster-name>-storaged-2` to perform self-healing.

Run the `kubectl get pods` command to check the status of the Pod `<cluster-name>-storaged-2`.

```
...
nebula-cluster-storaged-1        1/1     Running           0          5d23h
nebula-cluster-storaged-2        0/1     ContainerCreating   0          1s
...
```

```
...
nebula-cluster-storaged-1        1/1     Running     0          5d23h
nebula-cluster-storaged-2        1/1     Running     0          4m2s
...
```

When the status of `<cluster-name>-storaged-2` is changed from `ContainerCreating` to `Running`, the self-healing is performed successfully.

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17.11 FAQ

17.11.1 Does NebulaGraph Operator support the v1.x version of NebulaGraph?

No, because the v1.x version of NebulaGraph does not support DNS, and NebulaGraph Operator requires the use of DNS.

17.11.2 Is cluster stability guaranteed if using local storage?

There is no guarantee. Using local storage means that the Pod is bound to a specific node, and NebulaGraph Operator does not currently support failover in the event of a failure of the bound node.

17.11.3 How to ensure the stability of a cluster when scaling the cluster?

It is suggested to back up data in advance so that you can roll back data in case of failure.

17.11.4 Is the replica in the Operator docs the same as the replica in the NebulaGraph core docs?

They are different concepts. A replica in the Operator docs indicates a pod replica in K8s, while a replica in the core docs is a replica of a NebulaGraph storage partition.

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18. Graph computing

18.1 Algorithm overview

Graph computing can detect the graph structure, such as the communities in a graph and the division of a graph. It can also reveal the inherent characteristics of the correlation between various vertexes, such as the centrality and similarity of the vertices. This topic introduces the algorithms and parameters supported by NebulaGraph.

Note

This topic only introduces the parameters of NebulaGraph Analytics. For details about the parameters of NebulaGraph Algorithm, see algorithm.

Note

The algorithm parameters need to be set when performing graph computing, and there are requirements for data sources. The data source needs to contain source vertexes and destination vertexes. PageRank, DegreeWithTime, SSSP, APSP, LPA, HANP, and Louvain algorithms must include weight.

- If the data source comes from HDFS, users need to specify a CSV file that contains `src` and `dst` columns. Some algorithms also need to contain a `weight` column.
- If the data source comes from NebulaGraph, users need to specify the edge types that provide `src` and `dst` columns. Some algorithms also need to specify the properties of the edge types as `weight` columns.

18.1.1 Node importance measurement

PageRank

The PageRank algorithm calculates the relevance and importance of vertices based on their relationships. It is commonly used in search engine page rankings. If a page is linked by many other pages, the page is more important (PageRank value is higher). If a page with a high PageRank value links to other pages, the PageRank value of the linked pages will increase.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`ITERATIONS`	`10`	The maximum number of iterations.
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`EPS`	`0.0001`	The convergence accuracy. When the difference between the result of two iterations is less than the `EPS` value, the iteration is not continued.
`DAMPING`	`0.85`	The damping coefficient. It is the jump probability after visiting a page.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	double	The PageRank value of the vertex.

KCore

The KCore algorithm is used to calculate the subgraph composed of no vertexes less than K degree, usually used in community discovery, financial risk control and other scenarios. The calculation result is one of the most commonly used reference values to judge the importance of a vertex, which reflects the propagation ability of a vertex.

Parameter descriptions are as follows:

- NebulaGraph Analytics

- Input parameters

Parameter	Predefined value	Description
`TYPE`	`vertex`	The calculation type. Available values are `vertex` and `subgraph`. When set to `vertex`, the system calculates the number of cores for each vertex.
`KMIN`	`1`	Set the minimum value of K when performing the range calculation. Takes effect only when `TYPE` = `subgraph`.
`KMAX`	`1000000`	Set the maximum value of K when performing the range calculation. Takes effect only when `TYPE` = `subgraph`.

- Output parameters when `TYPE=vertex`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	int	Outputs the core degree of the vertex.

- Output parameters when `TYPE=subgraph`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	The same with `VID`	Outputs the neighbors of the vertex.

DegreeCentrality (NStepDegree)

The DegreeCentrality algorithm is used to find the popular vertexes in a graph. Degree centrality measures the number of incoming or outgoing (or both) relationships from a vertex, depending on the direction of the projection of the relationship. The greater the degree of a vertex is, the higher the degree centrality of the vertex is, and the more important the vertex is in the network.

Note

NebulaGraph Analytics only estimates DegreeCentrality roughly.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`STEP`	`3`	The degree of calculation. `-1` means infinity.
`BITS`	`6`	The hyperloglog bit width for cardinality estimation.
`TYPE`	`both`	The direction of the edges for calculation. Optional values are `in`, `out` and `both`.

- Output parameters when `TYPE=both`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`BOTH_DEGREE`	int	Outputs the bidirectional degree centrality of the vertex.
`OUT_DEGREE`	int	Outputs the outbound degree centrality of the vertex.
`IN_DEGREE`	int	Outputs the inbound degree centrality of the vertex.

- Output parameters when `TYPE=out`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`OUT_DEGREE`	int	Outputs the outbound degree centrality of the vertex.

- Output parameters when `TYPE=in`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`IN_DEGREE`	int	Outputs the inbound degree centrality of the vertex.

DegreeWithTime

The DegreeWithTime algorithm is used to count neighbors based on the time range of edges to find out the popular vertexes in a graph.

Note

This algorithm is supported by NebulaGraph Analytics only.

Parameter descriptions are as follows:

- Input parameters

Parameter	Predefined value	Description
`ITERATIONS`	`10`	The maximum number of iterations.
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`BEGIN_TIME`	-	The begin time.
`END_TIME`	-	The end time.

- Output parameters when `TYPE=both`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`BOTH_DEGREE`	int	Outputs the bidirectional popularity of the vertex.
`OUT_DEGREE`	int	Outputs the outbound popularity of the vertex.
`IN_DEGREE`	int	Outputs the inbound popularity of the vertex.

- Output parameters when `TYPE=out`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`OUT_DEGREE`	int	Outputs the outbound popularity of the vertex.

- Output parameters when `TYPE=in`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`IN_DEGREE`	int	Outputs the inbound popularity of the vertex.

BetweennessCentrality

The BetweennessCentrality algorithm is used to detect the amount of influence a vertex has on the flow of information in a graph. It is used to find the vertexes that act as bridges between one part of the graph and another. Each vertex is given a score, the betweenness centrality score, based on the number of shortest paths through that vertex.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`ITERATIONS`	`10`	The maximum number of iterations.
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`CHOSEN`	`-1`	The selected vertex ID, `-1` means random selection.
`CONSTANT`	`2`	The constant.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	double	The betweenness centrality score of the vertex.

ClosenessCentrality

The ClosenessCentrality algorithm is used to calculate the reciprocal of the average of the shortest distance from one vertex to all other reachable vertexes. The larger the value is, the closer the vertex is to the center of the graph, and it can also be used to measure how long it takes for information to be transmitted from that vertex to other vertexes.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`NUM_SAMPLES`	`10`	The number of sample vertices.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	double	The closeness centrality score of the vertex.

18.1.2 Path

APSP

The APSP (Full Graph Shortest Path) algorithm is used to find all shortest paths between two vertexes in a graph.

Note

This algorithm is supported by NebulaGraph Analytics only.

Parameter descriptions are as follows:

- Output parameters

Parameter	Type	Description
`VID1`	Determined by `vid_type`	The VID of the source vertex.
`VID2`	Determined by `vid_type`	The VID of the destination vertex.
`DISTANCE`	double	Outputs the distance from `VID1` to `VID2`.

SSSP

The SSSP (Single source shortest Path) algorithm is used to calculate the shortest path length from a given vertex (source vertex) to other vertexes. It is usually used in scenarios such as network routing and path designing.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`ROOT`	-	The VID of the source vertex.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The VID of the source vertex.
`DISTANCE`	double	Outputs the distance from `ROOT` to `VID`.

BFS

The BFS (Breadth First traversal) algorithm is a basic graph traversal algorithm. It gives a source vertex and accesses other vertexes with increasing hops, that is, it traverses all the adjacent vertexes of the vertex first and then extends to the adjacent vertexes of the adjacent vertexes.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`ROOT`	-	The VID of the source vertex.

- Output parameters

Parameter	Type	Description
`ROOT`	Determined by `vid_type`	The VID of the source vertex.
`VISITED`	int	Outputs the number of the vertex accessed by `ROOT`.

ShortestPath

The ShortestPath algorithm is used to find the shortest path between any two vertices in the graph, which is frequently applied in scenarios such as path design and network planning.

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`src`	`"100"`	Starting vertices. Multiple VIDs are separated by commas (,).
`dst`	`"200"`	Destination vertices. Multiple VIDs are separated by commas (,).

- Output parameters

Parameter	Type	Description
`VALUE`	list	Returns the vertices in the shortest path. The format is `src, vid1,vid2...dst`. If there are multiple shortest paths between two vertices, only one path is returned.

18.1.3 Community discovery

LPA

The LPA (label propagation) algorithm is a semi-supervised learning method based on graph. Its basic idea is to use label information of labeled vertexes to predict label information of unlabeled vertexes. vertexes include labeled and unlabeled data, and their edges represent the similarity of two vertexes. The labels of vertexes are transferred to other vertexes according to the similarity. Label data is like a source that can be labeled for unlabeled data. The greater the similarity of vertexes is, the easier the label is to spread.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`ITERATIONS`	`10`	The maximum number of iterations.
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`IS_CALC_MODULARITY`	`false`	Whether to calculate modularity.
`IS_OUTPUT_MODULARITY`	`false`	Whether to calculate and output module degrees. When set to `true`, the default output is to the third column of the file, but it can also be output to NebulaGraph with options `-nebula_output_props` and `-nebula_output_types`. Output to NebulaGraph is not yet supported when using Explorer.
`IS_STAT_COMMUNITY`	`false`	Whether to count the number of communities.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`LABEL`	The same with `VID`	Outputs the vertex IDs that have the same label.

HANP

The HANP (Hop Preference & Node Preference) algorithm is an optimization algorithm of LPA algorithm, which considers other information of labels, such as degree information, distance information, etc., and introduces attenuation coefficient during propagation to prevent transition propagation.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`ITERATIONS`	`10`	The maximum number of iterations.
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`PREFERENCE`	`1.0`	The bias of the neighbor vertex degree. `m>0` indicates biasing the neighbor with high vertex degree, `m<0` indicates biasing the neighbor with low vertex degree, and `m=0` indicates ignoring the neighbor vertex degree.
`HOP_ATT`	`0.1`	The attenuation coefficient. The value ranges from `0` to `1`. The larger the value, the faster it decays and the fewer times it can be passed.
`IS_OUTPUT_MODULARITY`	`false`	Whether to calculate and output module degrees. When set to `true`, the default output is to the third column of the file, but it can also be output to NebulaGraph with options `-nebula_output_props` and `-nebula_output_types`. Output to NebulaGraph is not yet supported when using Explorer.
`IS_STAT_COMMUNITY`	`false`	Whether to count the number of communities.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`LABEL`	The same with `VID`	Outputs the vertex IDs that have the same label.

ConnectedComponent

The ConnectedComponent algorithm is used to calculate a subgraph of a graph in which all vertexes are connected to each other. Strongly Connected Component takes the path direction into account, while Weakly Connected Component does not.

Note

NebulaGraph Analytics only supports Weakly Connected Component.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`IS_CALC_MODULARITY`	`false`	Whether to calculate modularity.
`IS_OUTPUT_MODULARITY`	`false`	Whether to calculate and output module degrees. When set to `true`, the default output is to the third column of the file, but it can also be output to NebulaGraph with options `-nebula_output_props` and `-nebula_output_types`. Output to NebulaGraph is not yet supported when using Explorer.
`IS_STAT_COMMUNITY`	`false`	Whether to count the number of communities.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`LABEL`	The same with `VID`	Outputs the vertex IDs that have the same label.

Louvain

The Louvain algorithm is a community discovery algorithm based on modularity. This algorithm performs well in efficiency and effect, and can be used to find hierarchical community structures. Its optimization goal is to maximize the modularity of the whole community network. Modularity is used to distinguish the differences in link density within and between communities, and to measure how well each vertex divides the community. In general, a good clustering approach will result in more modularity within communities than between communities.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`IS_DIRECTED`	`true`	Whether to consider the direction of the edges. If set to `false`, the system automatically adds the reverse edge.
`OUTER_ITERATION`	`20`	The maximum number of iterations in the first phase.
`INNER_ITERATION`	`10`	The maximum number of iterations in the second phase.
`IS_CALC_MODULARITY`	`false`	Whether to calculate modularity.
`IS_OUTPUT_MODULARITY`	`false`	Whether to calculate and output module degrees. When set to `true`, the default output is to the third column of the file, but it can also be output to NebulaGraph with options `-nebula_output_props` and `-nebula_output_types`. Output to NebulaGraph is not yet supported when using Explorer.
`IS_STAT_COMMUNITY`	`false`	Whether to count the number of communities.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`LABEL`	The same with `VID`	Outputs the vertex IDs that have the same label.

InfoMap

The InfoMap algorithm uses double encoding to classify directed graphs into communities. The encoding reuse of nodes in different communities can greatly shorten the length of description information. In terms of implementation, the algorithm includes the PageRank algorithm, which converts a random walk into a random surf.

Note

This algorithm is supported by NebulaGraph Analytics only.

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`pagerank_iter`	`10`	The maximum number of iterations of the internal PageRank algorithm.
`pagerank_threshold`	`0.0001`	The convergence accuracy of the internal PageRank algorithm.
`teleport_prob`	`0.15`	The teleportation probability.
`inner_iter`	`3`	The number of inner iterations.
`outer_iter`	`2`	The number of outer iterations.
`comm_info_num`	`100`	The number of communities exported.

- Output parameters

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`LABEL`	The same with `VID`	Outputs the vertex IDs that have the same label.

18.1.4 Graph feature

TriangleCount

The TriangleCount algorithm is used to count the number of triangles in a graph. The more triangles, the higher the degree of vertex association in the graph, the tighter the organizational relationship.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`OPT`	`3`	The calculation type. Optional values are `1`, `2` and `3`. `1` indicates counting the entire graph, `2` indicates counting through each vertex, `3` indicates listing all triangles.
`REMOVED_DUPLICATION_EDGE`	`true`	Whether to exclude repeated edges.
`REMOVED_SELF_EDGE`	`true`	Whether to exclude self-loop edge.

- Output parameters when `OPT=1`

Parameter	Type	Description
`COUNT`	int	Outputs the number of the triangles in the full graph space.

- Output parameters when `OPT=2`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`COUNT`	int	Outputs the number of the triangles based on the vertex.

- Output parameters when `OPT=3`

Parameter	Type	Description
`VID1`	The same with `VID`	Outputs the ID of the vertex A that forms the triangle.
`VID2`	The same with `VID`	Outputs the ID of the vertex B that forms the triangle.
`VID3`	The same with `VID`	Outputs the ID of the vertex C that forms the triangle.

Node2Vec

The Node2Vec algorithm proposed a more reasonable graph feature learning method based on DeepWalk, and proposed a semi-supervised algorithm for scalable feature learning in networks. SGD was used to optimize a custom graph-based objective function, which could maximize the network domain information of nodes reserved in d-dimensional feature space. Based on the random walk, a second order random walk process is designed, which is equivalent to an extension of DeepWalk algorithm, and preserves the graph characteristics of neighbor nodes. Applicable to node function similarity comparison, node structure similarity comparison, community clustering and other scenarios.R

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters |Parameter|Predefined value|Description| |:--|:--|:--| | `is_weighted` | `false` | Random walk with bias or not.| | `p` | `1.0` | The backward bias for random walk.| | `q` | `0.5` | The forward bias for random walk.| | `epoch` | `1` | The number of iterations.| | `step` | `10` | The number of steps per iteration.| | `rate` | `0.02` | The rate of the random walk.|
- Output parameters Output multiple columns where vertices in the same column are associated.

Tree_stat

The Tree_stat algorithm counts the width or depth of a subgraph with a specified root vertex.

Note

This algorithm is supported by NebulaGraph Analytics only.

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`root`	`100`	The VID of the root vertex.
`stat`	`width,depth`	Counts width or depth. Multiple values are separated by commas (,).

- Output parameters

Parameter	Type	Description
`VALUE`	list	Returns a row of statistics in the same format as the `stat` parameter.

HyperANF

The HyperANF algorithm is used to evaluate the average distance between any two vertices in a graph.

Note

This algorithm is supported by NebulaGraph Analytics only.

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`bits`	`6`	The bit length of the HyperLogLog counter. The value ranges from 6 to 16.

- Output parameters

Parameter	Type	Description
`VALUE`	double	The average distance.

18.1.5 Clustering

ClusteringCoefficient

The ClusteringCoefficient algorithm is used to calculate the clustering degree of vertexes in a graph. In all kinds of network structures reflecting the real world, especially social network structures, network groups with relatively high density tend to be formed between various vertexes. In other words, compared with the networks randomly connected between two vertexes, the aggregation coefficient of the real world network is higher.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`TYPE`	`local`	The clustering type. Optional values are `local` and `global`. `local` indicates counting through each vertex, `global` indicates counting the entire graph.
`REMOVED_DUPLICATION_EDGE`	`true`	Whether to exclude repeated edges.
`REMOVED_SELF_EDGE`	`true`	Whether to exclude self-loop edge.

- Output parameters when `TYPE=local`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	double	Outputs the clustering coefficient of the vertex.

- Output parameters when `TYPE=global`

Parameter	Type	Description
`VID`	Determined by `vid_type`	The vertex ID.
`VALUE`	double	Outputs the clustering coefficient of the full graph space. There is only one line of data.

18.1.6 Similarity

Jaccard

The Jaccard algorithm is used to calculate the similarity of two vertexes (or sets) and predict the relationship between them. It is suitable for social network friend recommendation, relationship prediction and other scenarios.

Parameter descriptions are as follows:

- NebulaGraph Analytics
- Input parameters

Parameter	Predefined value	Description
`IDS1`	-	A set of VIDs. Multiple VIDs are separated by commas (,). It is not allowed to be empty.
`IDS2`	-	A set of VIDs. Multiple VIDs are separated by commas (,). It can be empty, and empty represents all vertexes.
`REMOVED_SELF_EDGE`	`true`	Whether to exclude self-loop edges.

- Output parameters

Parameter	Type	Description
`VID1`	Determined by `vid_type`	The ID of the first vertex.
`VID2`	Determined by `vid_type`	The ID of the second vertex.
`VALUE`	double	The similarity between `VID1` and `VID2`.

Last update: March 13, 2023

18.2 NebulaGraph Algorithm

NebulaGraph Algorithm (Algorithm) is a Spark application based on GraphX. It uses a complete algorithm tool to perform graph computing on the data in the NebulaGraph database by submitting a Spark task. You can also programmatically use the algorithm under the lib repository to perform graph computing on DataFrame.

18.2.1 Version compatibility

The correspondence between the NebulaGraph Algorithm release and the NebulaGraph core release is as follows.

NebulaGraph	NebulaGraph Algorithm
nightly	3.0-SNAPSHOT
3.0.0 ~ 3.4.x	3.x.0
2.6.x	2.6.x
2.5.0、2.5.1	2.5.0
2.0.0、2.0.1	2.1.0

18.2.2 Prerequisites

Before using the NebulaGraph Algorithm, users need to confirm the following information:

- The NebulaGraph services have been deployed and started. For details, see NebulaGraph Installation.
- The Spark version is 2.4.x.
- The Scala version is 2.11.
- (Optional) If users need to clone, compile, and package the latest Algorithm in Github, install Maven.

18.2.3 Limitations

- For non-integer String data, it is recommended to use the algorithm interface. You can use the `dense_rank` function of SparkSQL to encode the data as the Long type instead of the String type.
- Graph computing outputs vertex datasets, and the algorithm results are stored in DataFrames as the properties of vertices. You can do further operations such as statistics and filtering according to your business requirements.

!!!

```
Before Algorithm v3.1.0, when submitting the algorithm package directly, the data of the vertex ID must be an integer. That is, the vertex ID can be INT or String, but the data itself is an integer.
```

18.2.4 Supported algorithms

The graph computing algorithms supported by NebulaGraph Algorithm are as follows.

Algorithm	Description	Scenario	Properties name	Properties type
PageRank	The rank of pages	Web page ranking, key node mining	pagerank	double/ string
Louvain	Louvain	Community mining, hierarchical clustering	louvain	int/string
KCore	K core	Community discovery, financial risk control	kcore	int/string
LabelPropagation	Label propagation	Information spreading, advertising, and community discovery	lpa	int/string
Hanp	Label propagation advanced	Community discovery, recommendation system	hanp	int/string
ConnectedComponent	Weakly connected component	Community discovery, island discovery	cc	int/string
StronglyConnectedComponent	Strongly connected component	Community discovery	scc	int/string
ShortestPath	The shortest path	Path planning, network planning	shortestpath	string
TriangleCount	Triangle counting	Network structure analysis	trianglecount	int/string
GraphTriangleCount	Graph triangle counting	Network structure and tightness analysis	count	int
BetweennessCentrality	Intermediate centrality	Key node mining, node influence computing	betweenness	double/ string
ClosenessCentrality	Closeness centrality	Key node mining, node influence computing	closeness	double/ string
DegreeStatic	Degree of statistical	Graph structure analysis	degree,inDegree,outDegree	int/string
ClusteringCoefficient	Aggregation coefficient	Recommendation system, telecom fraud analysis	clustercoefficient	double/ string
Jaccard			jaccard	string

Algorithm	Description	Scenario	Properties name	Properties type
	Jaccard similarity	Similarity computing, recommendation system		
BFS	Breadth-First Search	Sequence traversal, shortest path planning	bfs	string
DFS	Depth-First Search	Sequence traversal, shortest path planning	dfs	string
Node2Vec	-	Graph classification	node2vec	string

Note

When writing the algorithm results into the NebulaGraph, make sure that the tag in the corresponding graph space has properties names and data types corresponding to the table above.

18.2.5 Implementation methods

NebulaGraph Algorithm implements the graph calculating as follows:

1. Read the graph data of DataFrame from the NebulaGraph database using the NebulaGraph Spark Connector.
2. Transform the graph data of DataFrame to the GraphX graph.
3. Use graph algorithms provided by GraphX (such as PageRank) or self-implemented algorithms (such as Louvain).

For detailed implementation methods, see Scala file.

18.2.6 Get NebulaGraph Algorithm

Compile and package

1. Clone the repository `nebula-algorithm`.

```
$ git clone -b v3.0.0 https://github.com/vesoft-inc/nebula-algorithm.git
```

2. Enter the directory `nebula-algorithm`.

```
$ cd nebula-algorithm
```

3. Compile and package.

```
$ mvn clean package -Dgpg.skip -Dmaven.javadoc.skip=true -Dmaven.test.skip=true
```

After the compilation, a similar file `nebula-algorithm-3.x.x.jar` is generated in the directory `nebula-algorithm/target`.

Download maven from the remote repository

Download address

18.2.7 How to use

Use algorithm interface (recommended)

The `lib` repository provides 10 common graph algorithms.

1. Add dependencies to the file `pom.xml`.

```
<dependency>
     <groupId>com.vesoft</groupId>
     <artifactId>nebula-algorithm</artifactId>
     <version>3.0.0</version>
</dependency>
```

2. Use the algorithm (take PageRank as an example) by filling in parameters. For more examples, see example.

Note

By default, the DataFrame that executes the algorithm sets the first column as the starting vertex, the second column as the destination vertex, and the third column as the edge weights (not the rank in the NebulaGraph).

```
val prConfig = new PRConfig(5, 1.0)
val louvainResult = PageRankAlgo.apply(spark, data, prConfig, false)
```

If your vertex IDs are Strings, see Pagerank Example for how to encoding and decoding them.

Submit the algorithm package directly

1. Set the Configuration file.

```
{
  # Configurations related to Spark
  spark: {
    app: {
        name: LPA
        # The number of partitions of Spark
        partitionNum:100
    }
    master:local
  }

  data: {
    # Data source. Optional values are nebula, csv, and json.
    source: csv
    # Data sink. The algorithm result will be written into this sink. Optional values are nebula, csv, and text.
    sink: nebula
    # Whether the algorithm has a weight.
    hasWeight: false
  }

  # Configurations related to NebulaGraph
  nebula: {
    # Data source. When NebulaGraph is the data source of the graph computing, the configuration of `nebula.read` is valid.
    read: {
        # The IP addresses and ports of all Meta services. Multiple addresses are separated by commas (,). Example: "ip1:port1,ip2:port2".
        # To deploy NebulaGraph by using Docker Compose, fill in the port with which Docker Compose maps to the outside.
        # Check the status with `docker-compose ps`.
        metaAddress: "192.168.*.10:9559"
        # The name of the graph space in NebulaGraph.
        space: basketballplayer
        # Edge types in NebulaGraph. When there are multiple labels, the data of multiple edges will be merged.
        labels: ["serve"]
        # The property name of each edge type in NebulaGraph. This property will be used as the weight column of the algorithm. Make sure that it corresponds to the edge type.
        weightCols: ["start_year"]
    }

    # Data sink. When the graph computing result sinks into NebulaGraph, the configuration of `nebula.write` is valid.
    write:{
        # The IP addresses and ports of all Graph services. Multiple addresses are separated by commas (,). Example: "ip1:port1,ip2:port2".
        # To deploy by using Docker Compose, fill in the port with which Docker Compose maps to the outside.
        # Check the status with `docker-compose ps`.
        graphAddress: "192.168.*.11:9669"
        # The IP addresses and ports of all Meta services. Multiple addresses are separated by commas (,). Example: "ip1:port1,ip2:port2".
        # To deploy NebulaGraph by using Docker Compose, fill in the port with which Docker Compose maps to the outside.
        # Check the staus with `docker-compose ps`.
        metaAddress: "192.168.*.12:9559"
        user:root
        pswd:nebula
        # Before submitting the graph computing task, create the graph space and tag.
```

```
        # The name of the graph space in NebulaGraph.
        space:nb
        # The name of the tag in NebulaGraph. The graph computing result will be written into this tag. The property name of this tag is as follows.
        # PageRank: pagerank
        # Louvain: louvain
        # ConnectedComponent: cc
        # StronglyConnectedComponent: scc
        # LabelPropagation: lpa
        # ShortestPath: shortestpath
        # DegreeStatic: degree,inDegree,outDegree
        # KCore: kcore
        # TriangleCount: tranglecpunt
        # BetweennessCentrality: betweennedss
        tag:pagerank
    }
    }

  local: {
    # Data source. When the data source is csv or json, the configuration of `local.read` is valid.
    read:{
        filePath: "hdfs://127.0.0.1:9000/edge/work_for.csv"
        # If the CSV file has a header or it is a json file, use the header. If not, use [_c0, _c1, _c2, ..., _cn] instead.
        # The header of the source VID column.
        srcId:"_c0"
        # The header of the destination VID column.
        dstId:"_c1"
        # The header of the weight column.
        weight: "_c2"
        # Whether the csv file has a header.
        header: false
        # The delimiter in the csv file.
        delimiter:","
    }

    # Data sink. When the graph computing result sinks to the csv or text file, the configuration of `local.write` is valid.
    write:{
        resultPath:/tmp/
    }
    }


  algorithm: {
    # The algorithm to execute. Optional values are as follow:
    # pagerank, louvain, connectedcomponent, labelpropagation, shortestpaths,
    # degreestatic, kcore, stronglyconnectedcomponent, trianglecount ,
    # betweenness, graphtriangleCount.
    executeAlgo: pagerank

    # PageRank
    pagerank: {
        maxIter: 10
        resetProb: 0.15
    }

    # Louvain
    louvain: {
        maxIter: 20
        internalIter: 10
        tol: 0.5
    }

   # ...

}
}
```

Note

When `sink: nebula` is configured, it means that the algorithm results will be written back to the NebulaGraph cluster. The property names of the tag have implicit conventions. For details, see **Supported algorithms** section of this topic.

2. Submit the graph computing task.

```
${SPARK_HOME}/bin/spark-submit --master <mode> --class com.vesoft.nebula.algorithm.Main <nebula-algorithm-3.0.0.jar_path> -p <application.conf_path>
```

Example:

```
${SPARK_HOME}/bin/spark-submit --master "local" --class com.vesoft.nebula.algorithm.Main /root/nebula-algorithm/target/nebula-algorithm-3.0-SNAPSHOT.jar -p /root/nebula-algorithm/src/main/resources/application.conf
```

Last update: March 13, 2023

19. NebulaGraph Spark Connector

NebulaGraph Spark Connector is a Spark connector application for reading and writing NebulaGraph data in Spark standard format. NebulaGraph Spark Connector consists of two parts: Reader and Writer.

- Reader

  Provides a Spark SQL interface. This interface can be used to read NebulaGraph data. It reads one vertex or edge type data at a time and assemble the result into a Spark DataFrame.

- Writer

  Provides a Spark SQL interface. This interface can be used to write DataFrames into NebulaGraph in a row-by-row or batch-import way.

For more information, see NebulaGraph Spark Connector.

19.1 Version compatibility

The correspondence between the NebulaGraph Spark Connector version, the NebulaGraph core version and the Spark version is as follows.

Spark Connector version	NebulaGraph version	Spark version
nebula-spark-connector_3.0-3.0-SNAPSHOT.jar	nightly	3.x
nebula-spark-connector_2.2-3.0-SNAPSHOT.jar	nightly	2.2.x
nebula-spark-connector-3.0-SNAPSHOT.jar	nightly	2.4.x
nebula-spark-connector_2.2-3.4.0.jar	3.x	2.2.x
nebula-spark-connector-3.4.0.jar	3.x	2.4.x
nebula-spark-connector_2.2-3.3.0.jar	3.x	2.2.x
nebula-spark-connector-3.3.0.jar	3.x	2.4.x
nebula-spark-connector-3.0.0.jar	3.x	2.4.x
nebula-spark-connector-2.6.1.jar	2.6.0, 2.6.1	2.4.x
nebula-spark-connector-2.6.0.jar	2.6.0, 2.6.1	2.4.x
nebula-spark-connector-2.5.1.jar	2.5.0, 2.5.1	2.4.x
nebula-spark-connector-2.5.0.jar	2.5.0, 2.5.1	2.4.x
nebula-spark-connector-2.1.0.jar	2.0.0, 2.0.1	2.4.x
nebula-spark-connector-2.0.1.jar	2.0.0, 2.0.1	2.4.x
nebula-spark-connector-2.0.0.jar	2.0.0, 2.0.1	2.4.x

19.2 Use cases

NebulaGraph Spark Connector applies to the following scenarios:

- Migrate data between different NebulaGraph clusters.
- Migrate data between different graph spaces in the same NebulaGraph cluster.
- Migrate data between NebulaGraph and other data sources.
- Graph computing with NebulaGraph Algorithm.

19.3 Benefits

The features of NebulaGraph Spark Connector 3.4.0 are as follows:

- Supports multiple connection settings, such as timeout period, number of connection retries, number of execution retries, etc.
- Supports multiple settings for data writing, such as setting the corresponding column as vertex ID, starting vertex ID, destination vertex ID or attributes.
- Supports non-attribute reading and full attribute reading.
- Supports reading NebulaGraph data into VertexRDD and EdgeRDD, and supports non-Long vertex IDs.
- Unifies the extended data source of SparkSQL, and uses DataSourceV2 to extend NebulaGraph data.
- Three write modes, `insert`, `update` and `delete`, are supported. `insert` mode will insert (overwrite) data, `update` mode will only update existing data, and `delete` mode will only delete data.

19.4 Release note

Release

19.5 Get NebulaGraph Spark Connector

19.5.1 Compile package

1. Clone repository `nebula-spark-connector`.

```
$ git clone -b release-3.4 https://github.com/vesoft-inc/nebula-spark-connector.git
```

2. Enter the `nebula-spark-connector` directory.

2. Compile package. The procedure varies with Spark versions.

Note

Spark of the corresponding version has been installed.

- Spark 2.4

```
```bash
$ mvn clean package -Dmaven.test.skip=true -Dgpg.skip -Dmaven.javadoc.skip=true -pl nebula-spark-connector -am -Pscala-2.11 -Pspark-2.4
```
```

- Spark 2.2

```
```bash
$ mvn clean package -Dmaven.test.skip=true -Dgpg.skip -Dmaven.javadoc.skip=true -pl nebula-spark-connector_2.2 -am -Pscala-2.11 -Pspark-2.2
```
```

- Spark 3.x

```
```bash
$ mvn clean package -Dmaven.test.skip=true -Dgpg.skip -Dmaven.javadoc.skip=true -pl nebula-spark-connector_3.0 -am -Pscala-2.12 -Pspark-3.0
```
```

After compilation, a similar file `nebula-spark-connector-3.4.0-SHANPSHOT.jar` is generated in the directory `target` of the folder.

19.5.2 Download maven remote repository

Download

19.6 How to use

When using NebulaGraph Spark Connector to reading and writing NebulaGraph data, You can refer to the following code.

```
# Read vertex and edge data from NebulaGraph.
spark.read.nebula().loadVerticesToDF()
spark.read.nebula().loadEdgesToDF()

# Write dataframe data into NebulaGraph as vertex and edges.
dataframe.write.nebula().writeVertices()
dataframe.write.nebula().writeEdges()
```

`nebula()` receives two configuration parameters, including connection configuration and read-write configuration.

19.6.1 Reading data from NebulaGraph

```
val config = NebulaConnectionConfig
  .builder()
  .withMetaAddress("127.0.0.1:9559")
  .withConenctionRetry(2)
  .withExecuteRetry(2)
  .withTimeout(6000)
  .build()

val nebulaReadVertexConfig: ReadNebulaConfig = ReadNebulaConfig
  .builder()
  .withSpace("test")
  .withLabel("person")
  .withNoColumn(false)
  .withReturnCols(List("birthday"))
  .withLimit(10)
  .withPartitionNum(10)
  .build()
val vertex = spark.read.nebula(config, nebulaReadVertexConfig).loadVerticesToDF()

val nebulaReadEdgeConfig: ReadNebulaConfig = ReadNebulaConfig
  .builder()
  .withSpace("test")
  .withLabel("knows")
  .withNoColumn(false)
  .withReturnCols(List("degree"))
  .withLimit(10)
  .withPartitionNum(10)
```

```
  .build()
val edge = spark.read.nebula(config, nebulaReadEdgeConfig).loadEdgesToDF()
```

- `NebulaConnectionConfig` is the configuration for connecting to the nebula graph, as described below.

Parameter	Required	Description
`withMetaAddress`	Yes	Specifies the IP addresses and ports of all Meta Services. Separate multiple addresses with commas. The format is `ip1:port1,ip2:port2,...` . Read data is no need to configure `withGraphAddress` .
`withConnectionRetry`	No	The number of retries that the NebulaGraph Java Client connected to the NebulaGraph. The default value is `1` .
`withExecuteRetry`	No	The number of retries that the NebulaGraph Java Client executed query statements. The default value is `1` .
`withTimeout`	No	The timeout for the NebulaGraph Java Client request response. The default value is `6000` , Unit: ms.

- `ReadNebulaConfig` is the configuration to read NebulaGraph data, as described below.

Parameter	Required	Description
`withSpace`	Yes	NebulaGraph space name.
`withLabel`	Yes	The Tag or Edge type name within the NebulaGraph space.
`withNoColumn`	No	Whether the property is not read. The default value is `false` , read property. If the value is `true` , the property is not read, the `withReturnCols` configuration is invalid.
`withReturnCols`	No	Configures the set of properties for vertex or edges to read. the format is `List(property1,property2,...)` , The default value is `List()` , indicating that all properties are read.
`withLimit`	No	Configure the number of rows of data read from the server by the NebulaGraph Java Storage Client at a time. The default value is `1000` .
`withPartitionNum`	No	Configures the number of Spark partitions to read the NebulaGraph data. The default value is `100` . This value should not exceed the number of slices in the graph space (partition_num).

19.6.2 Write data into NebulaGraph

Note

The values of columns in a dataframe are automatically written to the NebulaGraph as property values.

```
val config = NebulaConnectionConfig
  .builder()
  .withMetaAddress("127.0.0.1:9559")
  .withGraphAddress("127.0.0.1:9669")
  .withConenctionRetry(2)
  .build()

val nebulaWriteVertexConfig: WriteNebulaVertexConfig = WriteNebulaVertexConfig
  .builder()
  .withSpace("test")
  .withTag("person")
  .withVidField("id")
  .withVidPolicy("hash")
  .withVidAsProp(true)
  .withUser("root")
  .withPasswd("nebula")
  .withBatch(1000)
  .build()
df.write.nebula(config, nebulaWriteVertexConfig).writeVertices()

val nebulaWriteEdgeConfig: WriteNebulaEdgeConfig = WriteNebulaEdgeConfig
  .builder()
```

```
  .withSpace("test")
  .withEdge("friend")
  .withSrcIdField("src")
  .withSrcPolicy(null)
  .withDstIdField("dst")
  .withDstPolicy(null)
  .withRankField("degree")
  .withSrcAsProperty(true)
  .withDstAsProperty(true)
  .withRankAsProperty(true)
  .withUser("root")
  .withPasswd("nebula")
  .withBatch(1000)
  .build()
df.write.nebula(config, nebulaWriteEdgeConfig).writeEdges()
```

The default write mode is `insert`, which can be changed to `update` or `delete` via `withWriteMode` configuration:

```
val config = NebulaConnectionConfig
  .builder()
  .withMetaAddress("127.0.0.1:9559")
  .withGraphAddress("127.0.0.1:9669")
  .build()
val nebulaWriteVertexConfig = WriteNebulaVertexConfig
  .builder()
  .withSpace("test")
  .withTag("person")
  .withVidField("id")
  .withVidAsProp(true)
  .withBatch(1000)
  .withWriteMode(WriteMode.UPDATE)
```

```
    .build()
df.write.nebula(config, nebulaWriteVertexConfig).writeVertices()
```

- `NebulaConnectionConfig` is the configuration for connecting to the nebula graph, as described below.

Parameter	Required	Description
`withMetaAddress`	Yes	Specifies the IP addresses and ports of all Meta Services. Separate multiple addresses with commas. The format is `ip1:port1,ip2:port2,...`.
`withGraphAddress`	Yes	Specifies the IP addresses and ports of Graph Services. Separate multiple addresses with commas. The format is `ip1:port1,ip2:port2,...`.
`withConnectionRetry`	No	Number of retries that the NebulaGraph Java Client connected to the NebulaGraph. The default value is `1`.

- `WriteNebulaVertexConfig` is the configuration of the write vertex, as described below.

Parameter	Required	Description
`withSpace`	Yes	NebulaGraph space name.
`withTag`	Yes	The Tag name that needs to be associated when a vertex is written.
`withVidField`	Yes	The column in the DataFrame as the vertex ID.
`withVidPolicy`	No	When writing the vertex ID, NebulaGraph use mapping function, supports HASH only. No mapping is performed by default.
`withVidAsProp`	No	Whether the column in the DataFrame that is the vertex ID is also written as an property. The default value is `false`. If set to `true`, make sure the Tag has the same property name as `VidField`.
`withUser`	No	NebulaGraph user name. If authentication is disabled, you do not need to configure the user name and password.
`withPasswd`	No	The password for the NebulaGraph user name.
`withBatch`	Yes	The number of rows of data written at a time. The default value is `1000`.
`withWriteMode`	No	Write mode. The optional values are `insert`, `update` and `delete`. The default value is `insert`.
`withDeleteEdge`	No	Whether to delete the related edges synchronously when deleting a vertex. The default value is `false`. It takes effect when `withWriteMode` is `delete`.

- `WriteNebulaEdgeConfig` is the configuration of the write edge, as described below.

Parameter	Required	Description
`withSpace`	Yes	NebulaGraph space name.
`withEdge`	Yes	The Edge type name that needs to be associated when a edge is written.
`withSrcIdField`	Yes	The column in the DataFrame as the vertex ID.
`withSrcPolicy`	No	When writing the starting vertex ID, NebulaGraph use mapping function, supports HASH only. No mapping is performed by default.
`withDstIdField`	Yes	The column in the DataFrame that serves as the destination vertex.
`withDstPolicy`	No	When writing the destination vertex ID, NebulaGraph use mapping function, supports HASH only. No mapping is performed by default.
`withRankField`	No	The column in the DataFrame as the rank. Rank is not written by default.
`withSrcAsProperty`	No	Whether the column in the DataFrame that is the starting vertex is also written as an property. The default value is `false`. If set to `true`, make sure Edge type has the same property name as `SrcIdField`.
`withDstAsProperty`	No	Whether column that are destination vertex in the DataFrame are also written as property. The default value is `false`. If set to `true`, make sure Edge type has the same property name as `DstIdField`.
`withRankAsProperty`	No	Whether column in the DataFrame that is the rank is also written as property.The default value is `false`. If set to `true`, make sure Edge type has the same property name as `RankField`.
`withUser`	No	NebulaGraph user name. If authentication is disabled, you do not need to configure the user name and password.
`withPasswd`	No	The password for the NebulaGraph user name.
`withBatch`	Yes	The number of rows of data written at a time. The default value is `1000`.
`withWriteMode`	No	Write mode. The optional values are `insert`, `update` and `delete`. The default value is `insert`.

Last update: March 27, 2023

20. NebulaGraph Flink Connector

NebulaGraph Flink Connector is a connector that helps Flink users quickly access NebulaGraph. NebulaGraph Flink Connector supports reading data from the NebulaGraph database or writing other external data to the NebulaGraph database.

For more information, see NebulaGraph Flink Connector.

20.1 Use cases

NebulaGraph Flink Connector applies to the following scenarios:

- Migrate data between different NebulaGraph clusters.
- Migrate data between different graph spaces in the same NebulaGraph cluster.
- Migrate data between NebulaGraph and other data sources.

20.2 Release note

Release

Last update: August 11, 2022

21. NebulaGraph Bench

NebulaGraph Bench is a performance test tool for NebulaGraph using the LDBC data set.

21.1 Scenario

- Generate test data and import NebulaGraph.
- Performance testing in the NebulaGraph cluster.

21.2 Release note

Release

21.3 Test process

For detailed usage instructions, see NebulaGraph Bench.

Last update: August 11, 2022

22. Appendix

22.1 Release Note

22.1.1 NebulaGraph 3.5.0 release notes

Features

- Support full table scan without index. #5416
- Support UDF. #4804 #5391
- Support expressions like `v.tag` in return statements. #5440
- Support `json_extract` function in UPDATE statements. #5457
- Support TCK format in EXPLAIN output. #5414
- DML supports parameters. #5328

Optimizations

- Support TTL in milliseconds. #5430
- Enhance attribute trimming in aggregation functions. #5301
- Improve the performance of traversal executor. #5308
- Optimize FIND ALL PATH performance. #5409
- Removes some Raft locks to improve performance. #5451
- Optimize predicate function filtering for variable-length edges. #5464 #5470 #5481 #5503
- Parallel traversal executor. #5314
- MATCH supports ID collection. #5360
- Refactor the GO planner. #5369
- Add some Graph performance options in the configuration file. #5463
- Add maximum connection number flag. #5309

Bug fixes

- Fix the defect where RocksDB data import invalidates the leader lease. #5271
- Fix the error message when `DESC USER` does not exist. #5345
- Fix the defect where `CREATE IF NOT EXIST` fails when SPACE exists. #5375
- Fix the incorrect edge direction in GetNeighbors plan. #5386
- Fix the client IP format in the `SHOW SESSIONS` command. #5388
- Fix the defect where attributes are pruned in USE and MATCH. #5263
- Fix the defect where the filter is not pushed down in some cases. #5395
- Fix the defect where the filter is incorrectly filtered in some cases. #5422
- Fix the incorrect handling of internal variables in pattern expressions. #5424
- Fix defects involving EMPTY comparisons. #5433
- Fix the defect where duplicate columns are returned when all columns are requested in MATCH. #5443
- Fix the error in comparing paths involving reflexive edges. #5444
- Fix the defect of redefining aliases in a MATCH path. #5446
- Fix the type check defect when inserting geographical location values. #5460

- Fix the crash in a shortest path. #5472
- Fix the crash in GEO. #5475
- Fix the error in `MATCH...contains`. #5485
- Fix the bug of incorrect session count in concurrency. #5496
- Fix the defect of SUBGRAPH and PATH parameters. #5500
- Fix the defect in regular expressions. #5507

Changes

- Disable `edge list join`, not supporting the use of edge list in multiple patterns. #5268
- Remove GLR parser, needs to change `YIELD 1--1` to `YIELD 1- -1`. #5290

Legacy versions

Release notes of legacy versions

Last update: May 19, 2023

22.1.2 NebulaGraph Studio release notes

v3.6.0

- Feature
- Support viewing the creation statements of the schema.
- Add a product feedback page.

- Enhancement
- Remove the timeout limit for slow queries.
- Display browser compatibility hints.
- Optimize the login page.
- Support adding comments with `#` on the console page.
- Optimize the console page.

- Bugfix
- Fix the bug that the list has not been refreshed after uploading files.
- Fix the invalid error message of the schema drafting.
- Fix the bug that the **view schema** data has not been cleared after switching the login user.
- Fix the presentation problem of the thumbnail in the schema drafting.

Last update: February 3, 2023

22.1.3 NebulaGraph Dashboard Community Edition 3.5.0 release notes

Community Edition 3.4.0

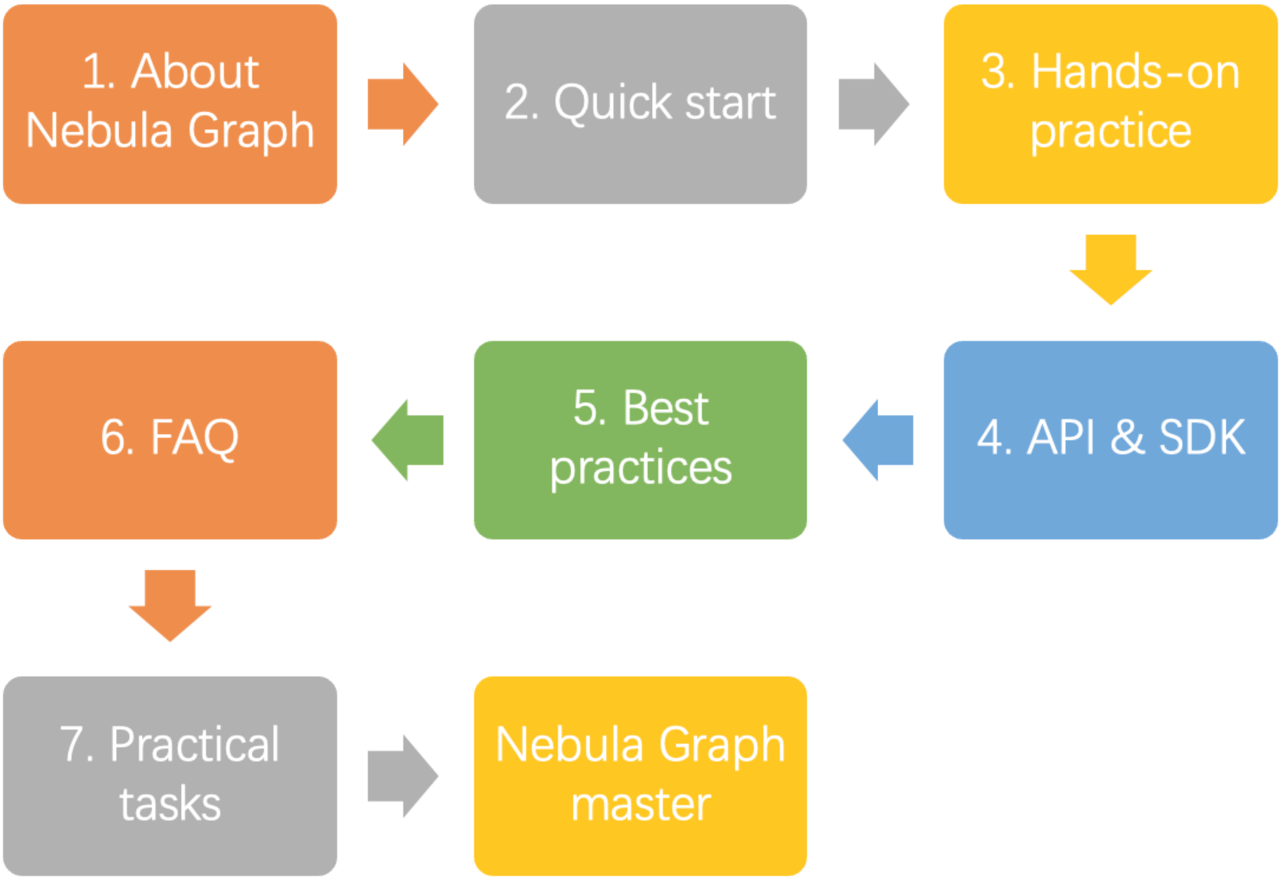
- Feature
- Support the built-in dashboard.service script to manage the Dashboard services with one-click and view the Dashboard version.
- Support viewing the configuration of Meta services.

- Enhancement
- Adjust the directory structure and simplify the deployment steps.
- Display the names of the monitoring metrics on the overview page of `machine`.
- Optimize the calculation of monitoring metrics such as `num_queries`, and adjust the display to time series aggregation.

Last update: March 13, 2023

22.2 NebulaGraph learning path

This topic is for anyone interested in learning more about NebulaGraph. You can master NebulaGraph from zero to hero through the documentation and videos in NebulaGraph learning path.



After completing the NebulaGraph learning path, taking NebulaGraph Certification exams will earn you certifications. For more information, see the **Get NebulaGraph Certifications** section below.

22.2.1 1. About NebulaGraph

1.1 What is NebulaGraph?

Document	Video
What is NebulaGraph	NebulaGraph

1.2 Data models

Document
Data modeling

1.3 Path

Document
Path

1.4 NebulaGraph architecture

Document
Meta service
Graph service
Storage service

22.2.2 2. Quick start

2.1 Install NebulaGraph

Document	Video
Install with a RPM or DEB package	-
Install with a TAR package	-
Install with Docker	Install NebulaGraph with Docker and Docker Compose
Install from source	Install NebulaGraph with Source Code

2.2 Start NebulaGraph

Document
Start and stop NebulaGraph

2.3 Connect to NebulaGraph

Document
Connect to NebulaGraph

2.4 Use nGQL statements

Document
nGQL cheatsheet

22.2.3 3. Hands-on practices

3.1 Deploy a multi-machine cluster

Document
Deploy a NebulaGraph cluster with RPM/DEB

3.2 Upgrade NebulaGraph

Document
Upgrade NebulaGraph to release-3.5

3.3 Configure NebulaGraph

Document
Configure Meta
Configure Graph
Configure Storage
Configure Linux kernel

3.4 Configure logs

Document
Log managements

3.5 O&M and Management

- Account authentication and authorization

Document
Local authentication
OpenLDAP
User management
Roles and privileges

- Balance the distribution of partitions

Document
Storage load balancing

- Monitoring

Document
NebulaGraph metrics
RocksDB statistics

- Data snapshot

Document
Create snapshots

- Backup & Restore

Document
Backup&Restore

- SSL encryption

Document
SSL

3.6 Performance tuning

Document
Graph data modeling suggestions
System design suggestions
Compaction

3.7 Derivative software

- Visualization

Visualization tools	Document	Video
Data visualization	NebulaGraph Studio	NebulaGraph Studio
Data monitoring and O&M	NebulaGraph Dashboard Community Edition NebulaGraph Dashboard Enterprise Edition	-
Data analysis	NebulaGraph Explorer Enterprise Edition	-

- Data import and export

Import and export	Document	Video
Data import	NebulaGraph Importer	NebulaGraph Importer
Data import	NebulaGraph Spark Connector	-
Data import	NebulaGraph Flink Connector	-
Data import	NebulaGraph Exchange Community Edition	-
Data export	NebulaGraph Exchange Enterprise Edition	-

- Performance test

Document
NebulaGraph Bench

- Cluster O&M

Document
NebulaGraph Operator

- Graph algorithm

Document
NebulaGraph Algorithm

- Clients

Document
NebulaGraph Console
NebulaGraph CPP
NebulaGraph Java
NebulaGraph Python
NebulaGraph Go

22.2.4 4. API & SDK

Document
API & SDK

22.2.5 5. Best practices

Document
Handling Tens of Billions of Threat Intelligence Data with Graph Database at Kuaishou
Import data from Neo4j to NebulaGraph via NebulaGraph Exchange: Best Practices
Hands-On Experience: Import Data to NebulaGraph with Spark
How to Select a Graph Database: Best Practices at RoyalFlush
Practicing NebulaGraph Operator on Cloud
Using Ansible to Automate Deployment of NebulaGraph Cluster

22.2.6 6. FAQ

Document
FAQ

22.2.7 7. Practical tasks

You can check if you have mastered NebulaGraph by completing the following practical tasks.

Task	Reference
Compile the source code of NebulaGraph	Install NebulaGraph by compiling the source code
Deploy Studio, Dashboard, and Explorer	Deploy Studio, Deploy Dashboard, and Deploy Explorer
Load test NebulaGraph with K6	NebulaGraph Bench
Query LDBC data (such as queries for vertices, paths, or subgraphs.)	LDBC and interactive-short-1.cypher

22.2.8 8. Get NebulaGraph Certifications

Now you could get NebulaGraph Certifications from NebulaGraph Academy.

- NebulaGraph Certified Insider(NGCI): The NGCI certification provides a birdview to graph databases and the NebulaGraph database. Passing NGCI shows that you have a good understanding of NebulaGraph.
- NebulaGraph Certified Professional(NGCP): The NGCP certification drives you deep into the NebulaGraph database and its ecosystem, providing a 360-degree view of the leading-edge graph database. Passing NGCP proves that you are a professional with a profound understanding of NebulaGraph.

22.2.9 Reference documents

- For an introduction to the principles of NebulaGraph, see Nebula Graph: An open source distributed graph database.
- For the principle description of NebulaGraph indexes, see Section 2.4 in the Nebula Graph: An open source distributed graph database paper.
- For an overview of the NebulaGraph language, see Section 2.8 in the Nebula Graph: An open source distributed graph database paper.

Last update: October 20, 2022

22.3 FAQ

This topic lists the frequently asked questions for using NebulaGraph 3.5.0. You can use the search box in the help center or the search function of the browser to match the questions you are looking for.

If the solutions described in this topic cannot solve your problems, ask for help on the NebulaGraph forum or submit an issue on GitHub issue.

22.3.1 About manual updates

"Why is the behavior in the manual not consistent with the system?"

NebulaGraph is still under development. Its behavior changes from time to time. Users can submit an issue to inform the team if the manual and the system are not consistent.

Note

If you find some errors in this topic:

1. Click the `pencil` button at the top right side of this page.
2. Use markdown to fix this error. Then click "Commit changes" at the bottom, which will start a Github pull request.
3. Sign the CLA. This pull request will be merged after the acceptance of at least two reviewers.

22.3.2 About legacy version compatibility

Version compatibility

Neubla Graph 3.5.0 is **not compatible** with NebulaGraph 1.x nor 2.0-RC in both data formats and RPC-protocols, and **vice versa**. The service process may **quit** if using an **lower version** client to connect to a **higher version** server.

To upgrade data formats, see Upgrade NebulaGraph to the current version. Users must upgrade all clients.

22.3.3 About execution errors

"How to resolve the error `SemanticError: Missing yield clause.` ?"

Starting with NebulaGraph 3.0.0, the statements `LOOKUP`, `GO`, and `FETCH` must output results with the `YIELD` clause. For more information, see YIELD.

"How to resolve the error `Host not enough!` ?"

From NebulaGraph version 3.0.0, the Storage services added in the configuration files **CANNOT** be read or written directly. The configuration files only register the Storage services into the Meta services. You must run the `ADD HOSTS` command to read and write data on Storage servers. For more information, see Manage Storage hosts.

"How to resolve the error `To get the property of the vertex in 'v.age', should use the format 'var.tag.prop'` ?"

From NebulaGraph version 3.0.0, patterns support matching multiple tags at the same time, so you need to specify a tag name when querying properties. The original statement `RETURN variable_name.property_name` is changed to `RETURN variable_name.<tag_name>.property_name`.

"How to resolve the error `Storage Error E_RPC_FAILURE` ?"

The reason for this error is usually that the storaged process returns too many data back to the graphd process. Possible solutions are as follows:

- Modify configuration files: Modify the value of `--storage_client_timeout_ms` in the `nebula-graphd.conf` file to extend the connection timeout of the Storage client. This configuration is measured in milliseconds (ms). For example, set `--storage_client_timeout_ms=60000` . If this parameter is not specified in the `nebula-graphd.conf` file, specify it manually. Tip: Add `--local_config=true` at the beginning of the configuration file and restart the service.
- Optimize the query statement: Reduce queries that scan the entire database. No matter whether `LIMIT` is used to limit the number of returned results, use the `GO` statement to rewrite the `MATCH` statement (the former is optimized, while the latter is not).
- Check whether the Storaged process has OOM. (`dmesg |grep nebula`).
- Use better SSD or memory for the Storage Server.
- Retry.

"How to resolve the error `The leader has changed. Try again later` ?"

It is a known issue. Just retry 1 to N times, where N is the partition number. The reason is that the meta client needs some heartbeats to update or errors to trigger the new leader information.

If this error occurs when logging in to NebulaGraph, you can consider using `df -h` to view the disk space and check whether the local disk is full.

Unable to download SNAPSHOT packages when compiling Exchange, Connectors, or Algorithm

Problem description: The system reports `Could not find artifact com.vesoft:client:jar:xxx-SNAPSHOT` when compiling.

Cause: There is no local Maven repository for storing or downloading SNAPSHOT packages. The default central repository in Maven only stores official releases, not development versions (SNAPSHOTs).

Solution: Add the following configuration in the `profiles` scope of Maven's `setting.xml` file:

```
<profile>
   <activation>
      <activeByDefault>true</activeByDefault>
   </activation>
   <repositories>
      <repository>
          <id>snapshots</id>
          <url>https://oss.sonatype.org/content/repositories/snapshots/</url>
          <snapshots>
             <enabled>true</enabled>
          </snapshots>
    </repository>
   </repositories>
</profile>
```

"How to resolve `[ERROR (-1004)]: SyntaxError: syntax error near` ?"

In most cases, a query statement requires a `YIELD` or a `RETURN` . Check your query statement to see if `YIELD` or `RETURN` is provided.

"How to resolve the error `can't solve the start vids from the sentence` ?"

The graphd process requires `start vids` to begin a graph traversal. The `start vids` can be specified by the user. For example:

```
> GO FROM ${vids} ...
> MATCH (src) WHERE id(src) == ${vids}
# The "start vids" are explicitly given by ${vids}.
```

It can also be found from a property index. For example:

```
# CREATE TAG INDEX IF NOT EXISTS i_player ON player(name(20));
# REBUILD TAG INDEX i_player;
```

```
> LOOKUP ON player WHERE player.name == "abc" | ... YIELD ...
> MATCH (src) WHERE src.name == "abc" ...
# The "start vids" are found from the property index "name".
```

Otherwise, an error like `can’t solve the start vids from the sentence` will be returned.

"How to resolve the error `Wrong vertex id type: 1001`?"

Check whether the VID is `INT64` or `FIXED_STRING(N)` set by `create space`. For more information, see create space.

"How to resolve the error `The VID must be a 64-bit integer or a string fitting space vertex id length limit.`?"

Check whether the length of the VID exceeds the limitation. For more information, see create space.

"How to resolve the error `edge conflict` or `vertex conflict`?"

NebulaGraph may return such errors when the Storage service receives multiple requests to insert or update the same vertex or edge within milliseconds. Try the failed requests again later.

"How to resolve the error `RPC failure in MetaClient: Connection refused`?"

The reason for this error is usually that the metad service status is unusual, or the network of the machine where the metad and graphd services are located is disconnected. Possible solutions are as follows:

- Check the metad service status on the server where the metad is located. If the service status is unusual, restart the metad service.
- Use `telnet meta-ip:port` to check the network status under the server that returns an error.
- Check the port information in the configuration file. If the port is different from the one used when connecting, use the port in the configuration file or modify the configuration.

"How to resolve the error `StorageClientBase.inl:214] Request to "x.x.x.x":9779 failed: N6apache6thrift9transport19TTransportExceptionE: Timed Out` in `nebula-graph.INFO`?"

The reason for this error may be that the amount of data to be queried is too large, and the storaged process has timed out. Possible solutions are as follows:

- When importing data, set Compaction manually to make read faster.
- Extend the RPC connection timeout of the Graph service and the Storage service. Modify the value of `--storage_client_timeout_ms` in the `nebula-graphd.conf` file. This configuration is measured in milliseconds (ms). The default value is 60000ms.

"How to resolve the error `MetaClient.cpp:65] Heartbeat failed, status:Wrong cluster!` in `nebula-storaged.INFO`, or `HBProcessor.cpp:54] Reject wrong cluster host "x.x.x.x":9771!` in `nebula-metad.INFO`?"

The reason for this error may be that the user has modified the IP or the port information of the metad process, or the storage service has joined other clusters before. Possible solutions are as follows:

Delete the `cluster.id` file in the installation directory where the storage machine is deployed (the default installation directory is `/usr/local/nebula`), and restart the storaged service.

"How to resolve the error `Storage Error: More than one request trying to add/update/delete one edge/vertex at he same time.`?"

The reason for this error is that the current NebulaGraph version does not support concurrent requests to the same vertex or edge at the same time. To solve this error, re-execute your commands.

22.3.4 About design and functions

"How is the `time spent` value at the end of each return message calculated?"

Take the returned message of `SHOW SPACES` as an example:

```
nebula> SHOW SPACES;
+--------------------+
| Name               |
+--------------------+
| "basketballplayer" |
+--------------------+
Got 1 rows (time spent 1235/1934 us)
```

- The first number `1235` shows the time spent by the database itself, that is, the time it takes for the query engine to receive a query from the client, fetch the data from the storage server, and perform a series of calculations.
- The second number `1934` shows the time spent from the client's perspective, that is, the time it takes for the client from sending a request, receiving a response, and displaying the result on the screen.

"Why does the port number of the `nebula-storaged` process keep showing red after connecting to NebulaGraph?"

Because the `nebula-storaged` process waits for `nebula-metad` to add the current Storage service during the startup process. The Storage works after it receives the ready signal. Starting from NebulaGraph 3.0.0, the Meta service cannot directly read or write data in the Storage service that you add in the configuration file. The configuration file only registers the Storage service to the Meta service. You must run the `ADD HOSTS` command to enable the Meta to read and write data in the Storage service. For more information, see Manage Storage hosts.

"Why is there no line separating each row in the returned result of NebulaGraph 2.6.0?"

This is caused by the release of NebulaGraph Console 2.6.0, not the change of NebulaGraph core. And it will not affect the content of the returned data itself.

About dangling edges

A dangling edge is an edge that only connects to a single vertex and only one part of the edge connects to the vertex.

Dangling edges may appear in NebulaGraph 3.5.0 as the design. And there is no `MERGE` statements of openCypher. The guarantee for dangling edges depends entirely on the application level. For more information, see INSERT VERTEX, DELETE VERTEX, INSERT EDGE, DELETE EDGE.

"Can I set `replica_factor` as an even number in `CREATE SPACE` statements, e.g., `replica_factor = 2`?"

NO.

The Storage service guarantees its availability based on the Raft consensus protocol. The number of failed replicas must not exceed half of the total replica number.

When the number of machines is 1, `replica_factor` can only be set to `1`.

When there are enough machines and `replica_factor=2`, if one replica fails, the Storage service fails. No matter `replica_factor=3` or `replica_factor=4`, if more than one replica fails, the Storage Service fails. To prevent unnecessary waste of resources, we recommend that you set an odd replica number.

We suggest that you set `replica_factor=3` for a production environment and `replica_factor=1` for a test environment. Do not use an even number.

"Is stopping or killing slow queries supported?"

Yes. For more information, see Kill query.

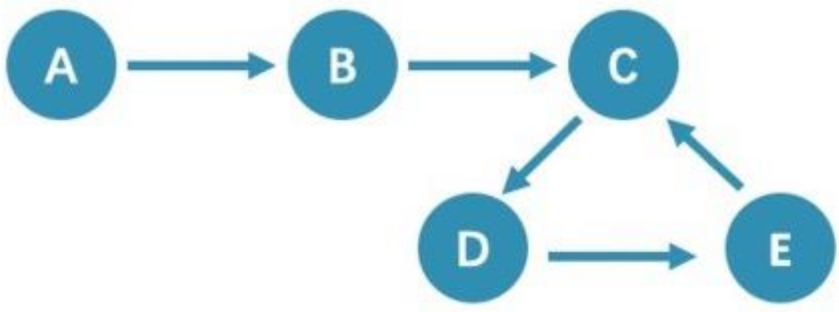
"Why are the query results different when using `GO` and `MATCH` to execute the same semantic query?"

The possible reasons are listed as follows.

- `GO` statements find the dangling edges.
- `RETURN` commands do not specify the sequence.
- The dense vertex truncation limitation defined by `max_edge_returned_per_vertex` in the Storage service is triggered.

- Using different types of paths may cause different query results.
- `GO` statements use `walk`. Both vertices and edges can be repeatedly visited in graph traversal.
- `MATCH` statements are compatible with openCypher and use `trail`. Only vertices can be repeatedly visited in graph traversal.

The example is as follows.



All queries that start from `A` with 5 hops will end at `C` (`A->B->C->D->E->C`). If it is 6 hops, the `GO` statement will end at `D` (`A->B->C->D->E->C->D`), because the edge `C->D` can be visited repeatedly. However, the `MATCH` statement returns empty, because edges cannot be visited repeatedly.

Therefore, using `GO` and `MATCH` to execute the same semantic query may cause different query results.

For more information, see Wikipedia.

"How to count the vertices/edges number of each tag/edge type?"

See show-stats.

"How to get all the vertices/edge of each tag/edge type?"

1. Create and rebuild the index.

```
> CREATE TAG INDEX IF NOT EXISTS i_player ON player();
> REBUILD TAG INDEX IF NOT EXISTS i_player;
```

2. Use `LOOKUP` or `MATCH`. For example:

```
> LOOKUP ON player;
> MATCH (n:player) RETURN n;
```

For more information, see `INDEX`, `LOOKUP`, and `MATCH`.

"Can non-English characters be used as identifiers, such as the names of graph spaces, tags, edge types, properties, and indexes?"

Yes, for more information, see Keywords and reserved words.

"How to get the out-degree/the in-degree of a given vertex?"

The out-degree of a vertex refers to the number of edges starting from that vertex, while the in-degree refers to the number of edges pointing to that vertex.

```
nebula > MATCH (s)-[e]->() WHERE id(s) == "given" RETURN count(e); #Out-degree
nebula > MATCH (s)<-[e]-() WHERE id(s) == "given" RETURN count(e); #In-degree
```

This is a very slow operation to get the out/in degree since no accelaration can be applied (no indices or caches). It also could be out-of-memory when hitting a supper-node.

"How to quickly get the out-degree and in-degree of all vertices?"

There is no such command.

You can use NebulaGraph Algorithm.

22.3.5 About operation and maintenance

"The runtime log files are too large. How to recycle the logs?"

By default, the runtime logs of NebulaGraph are stored in `/usr/local/nebula/logs/`. The INFO level log files are `nebula-graphd.INFO, nebula-storaged.INFO, nebula-metad.INFO`. If an alarm or error occurs, the suffixes are modified as `.WARNING` or `.ERROR`.

NebulaGraph uses glog to print logs. `glog` cannot recycle the outdated files. To rotate logs, you can:

- Use crontab to delete logs periodically. For more information, see `Glog should delete old log files automatically`.
- Use logrotate to manage log files. Before using logrotate, modify the configurations of corresponding services and set `timestamp_in_logfile_name` to `false`.

"How to check the NebulaGraph version?"

If the service is running: run command `SHOW HOSTS META` in `nebula-console`. See SHOW HOSTS.

If the service is not running:

Different installation methods make the method of checking the version different. The instructions are as follows:

If the service is not running, run the command `./<binary_name> --version` to get the version and the Git commit IDs of the NebulaGraph binary files. For example:

```
$ ./nebula-graphd --version
```

- If you deploy NebulaGraph with Docker Compose

  Check the version of NebulaGraph deployed by Docker Compose. The method is similar to the previous method, except that you have to enter the container first. The commands are as follows:

  ```
  docker exec -it nebula-docker-compose_graphd_1 bash
  cd bin/
  ./nebula-graphd --version
  ```

- If you install NebulaGraph with RPM/DEB package

  Run `rpm -qa |grep nebula` to check the version of NebulaGraph.

"After changing the name of the host, the old one keeps displaying `OFFLINE`. What should I do?"

Hosts with the status of `OFFLINE` will be automatically deleted after one day.

"How do I view the dmp file?"

The dmp file is an error report file detailing the exit of the process and can be viewed with the gdb utility. the Coredump file is saved in the directory of the startup binary (by default it is `/usr/local/nebula`) and is generated automatically when the NebulaGraph service crashes.

1. Check the Core file process name, pid is usually a numeric value.

```
$ file core.<pid>
```

2. Use gdb to debug.

```
$ gdb <process.name> core.<pid>
```

3. View the contents of the file.

```
$(gdb) bt
```

For example:

```
$ file core.1316027
core.1316027: ELF 64-bit LSB core file, x86-64, version 1 (SYSV), SVR4-style, from '/home/workspace/fork/nebula-debug/bin/nebula-metad --flagfile /home/k', real uid: 1008, effective uid: 1008, real gid: 1008, effective gid: 1008, execfn: '/home/workspace/fork/nebula-debug/bin/nebula-metad', platform: 'x86_64'

$ gdb /home/workspace/fork/nebula-debug/bin/nebula-metad core.1316027

$(gdb) bt
#0  0x00007f9de58fecf5 in __memcpy_ssse3_back () from /lib64/libc.so.6
#1  0x0000000000eb2299 in void std::__cxx11::basic_string<char, std::char_traits<char>, std::allocator<char> >::_M_construct<char*>(char*, char*, std::forward_iterator_tag) ()
#2  0x0000000000ef71a7 in nebula::meta::cpp2::QueryDesc::QueryDesc(nebula::meta::cpp2::QueryDesc const&) ()
...
```

If you are not clear about the information that dmp prints out, you can post the printout with the OS version, hardware configuration, error logs before and after the Core file was created and actions that may have caused the error on the NebulaGraph forum.

How can I set the NebulaGraph service to start automatically on boot via systemctl?

1. Execute `systemctl enable` to start the metad, graphd and storaged services.

```
[root]# systemctl enable nebula-metad.service
Created symlink from /etc/systemd/system/multi-user.target.wants/nebula-metad.service to /usr/lib/systemd/system/nebula-metad.service.
[root]# systemctl enable nebula-graphd.service
Created symlink from /etc/systemd/system/multi-user.target.wants/nebula-graphd.service to /usr/lib/systemd/system/nebula-graphd.service.
[root]# systemctl enable nebula-storaged.service
Created symlink from /etc/systemd/system/multi-user.target.wants/nebula-storaged.service to /usr/lib/systemd/system/nebula-storaged.service.
```

2. Configure the service files for metad, graphd and storaged to set the service to pull up automatically.

Caution

The following points need to be noted when configuring the service file. - The paths of the PIDFile, ExecStart, ExecReload and ExecStop parameters need to be the same as those on the server. - RestartSec is the length of time (in seconds) to wait before restarting, which can be modified according to the actual situation. - (Optional) StartLimitInterval is the unlimited restart, the default is 10 seconds if the restart exceeds 5 times, and set to 0 means unlimited restart. - (Optional) LimitNOFILE is the maximum number of open files for the service, the default is 1024 and can be changed according to the actual situation.

Configure the service file for the metad service.

```
$ vi /usr/lib/systemd/system/nebula-metad.service

[Unit]
Description=Nebula Graph Metad Service
After=network.target

[Service ]
Type=forking
Restart=always
RestartSec=15s
PIDFile=/usr/local/nebula/pids/nebula-metad.pid
```

```
ExecStart=/usr/local/nebula/scripts/nebula.service start metad
ExecReload=/usr/local/nebula/scripts/nebula.service restart metad
ExecStop=/usr/local/nebula/scripts/nebula.service stop metad
PrivateTmp=true
StartLimitInterval=0
LimitNOFILE=1024

[Install]
WantedBy=multi-user.target
```

Configure the service file for the graphd service.

```
$ vi /usr/lib/systemd/system/nebula-graphd.service
[Unit]
Description=Nebula Graph Graphd Service
After=network.target

[Service]
Type=forking
Restart=always
RestartSec=15s
PIDFile=/usr/local/nebula/pids/nebula-graphd.pid
ExecStart=/usr/local/nebula/scripts/nebula.service start graphd
ExecReload=/usr/local/nebula/scripts/nebula.service restart graphd
ExecStop=/usr/local/nebula/scripts/nebula.service stop graphd
PrivateTmp=true
StartLimitInterval=0
LimitNOFILE=1024

[Install]
WantedBy=multi-user.target
```

Configure the service file for the storaged service.

```
$ vi /usr/lib/systemd/system/nebula-storaged.service
[Unit]
Description=Nebula Graph Storaged Service
After=network.target

[Service]
Type=forking
Restart=always
RestartSec=15s
PIDFile=/usr/local/nebula/pids/nebula-storaged.pid
ExecStart=/usr/local/nebula/scripts/nebula.service start storaged
ExecReload=/usr/local/nebula/scripts/nebula.service restart storaged
ExecStop=/usr/local/nebula/scripts/nebula.service stop storaged
PrivateTmp=true
StartLimitInterval=0
LimitNOFILE=1024

[Install]
WantedBy=multi-user.target
```

3. Reload the configuration file.

```
[root]# sudo systemctl daemon-reload
```

4. Restart the service.

```
$ systemctl restart nebula-metad.service
$ systemctl restart nebula-graphd.service
$ systemctl restart nebula-storaged.service
```

22.3.6 About connections

"Which ports should be opened on the firewalls?"

If you have not modified the predefined ports in the Configurations, open the following ports for the NebulaGraph services:

Service	Port
Meta	9559, 9560, 19559
Graph	9669, 19669
Storage	9777 ~ 9780, 19779

If you have customized the configuration files and changed the predefined ports, find the port numbers in your configuration files and open them on the firewalls.

For those eco-tools, see the corresponding document.

The following are the default ports used by NebulaGraph core and peripheral tools.

No.	Product / Service	Type	Default	Description
1	NebulaGraph	TCP	9669	Graph service RPC daemon listening port (commonly used for client connections to the Graph service).
2	NebulaGraph	TCP	19669	Graph service HTTP port.
3	NebulaGraph	TCP	19670	Graph service HTTP/2 port. (Deprecated after version 3.x)
4	NebulaGraph	TCP	9559	Meta service RPC daemon listening port. (Commonly used by Graph and Storage services for querying and updating metadata in the graph database).
5	NebulaGraph	TCP	9560	Raft communication port between Meta services.
6	NebulaGraph	TCP	19559	Meta service HTTP port.
7	NebulaGraph	TCP	19560	Meta service HTTP/2 port. (Deprecated after version 3.x)
8	NebulaGraph	TCP	9777	Drainer service port in Storage services (exposed only in Enterprise Edition clusters).
9	NebulaGraph	TCP	9778	Admin service port in Storage services.
10	NebulaGraph	TCP	9779	Storage service RPC daemon listening port. (Commonly used by Graph services for data storage-related operations, such as reading, writing, or deleting data).
11	NebulaGraph	TCP	9780	Raft communication port between Storage services.
12	NebulaGraph	TCP	19779	Storage service HTTP port.
13	NebulaGraph	TCP	19780	Storage service HTTP/2 port. (Deprecated after version 3.x)
14	NebulaGraph	TCP	8888	Backup and restore Agent service port. The Agent is a daemon running on each machine in the cluster, responsible for starting and stopping NebulaGraph services and uploading and downloading backup files.
15	NebulaGraph	TCP	9789, 9790, and 9788	Full-text index Raft Listener port, which reads data from Storage services and writes it to the Elasticsearch cluster. Also the port for Storage Listener in inter-cluster data synchronization, used for synchronizing Storage data from the primary cluster. Ports 9790 and 9788 are generated by adding and subtracting one from port 9789.
16	NebulaGraph	TCP	9200	NebulaGraph uses this port for HTTP communication with Elasticsearch to perform full-text search queries and manage full-text indexes.
17	NebulaGraph	TCP	9569, 9570, and 9568	Meta Listener port in inter-cluster data synchronization, used for synchronizing Meta data from the primary cluster. Ports 9570 and 9568 are generated by adding and subtracting one from port 9569.
18	NebulaGraph	TCP	9889, 9890, and 9888	Drainer service port in inter-cluster data synchronization, used for synchronizing Storage and Meta data to the primary cluster. Ports 9890 and 9888 are generated by adding and subtracting one from port 9889.
19	NebulaGraph Studio	TCP	7001	Studio web service port.
20		TCP	8090	

No.	Product / Service	Type	Default	Description
	NebulaGraph Dashboard			Nebula HTTP Gateway dependency service port. Provides an HTTP interface for cluster services to interact with the NebulaGraph database using nGQL statements.
21	NebulaGraph Dashboard	TCP	9200	Nebula Stats Exporter dependency service port. Collects cluster performance metrics, including service IP addresses, versions, and monitoring metrics (such as query count, query latency, heartbeat latency, etc.).
22	NebulaGraph Dashboard	TCP	9100	Node Exporter dependency service port. Collects resource information for machines in the cluster, including CPU, memory, load, disk, and traffic.
23	NebulaGraph Dashboard	TCP	9091	Prometheus service port. Time-series database for storing monitoring data.
24	NebulaGraph Dashboard	TCP	7003	Dashboard Community Edition web service port.
25	NebulaGraph Dashboard	TCP	7005	Dashboard Enterprise Edition web service port.
26	NebulaGraph Dashboard	TCP	9093	Alertmanager service port. Receives alerts from Prometheus and sends alert notifications to Dashboard.
27	NebulaGraph Explorer	TCP	7002	Explorer web service port.

"How to test whether a port is open or closed?"

You can use telnet as follows to check for port status.

```
telnet <ip> <port>
```

Note

If you cannot use the telnet command, check if telnet is installed or enabled on your host.

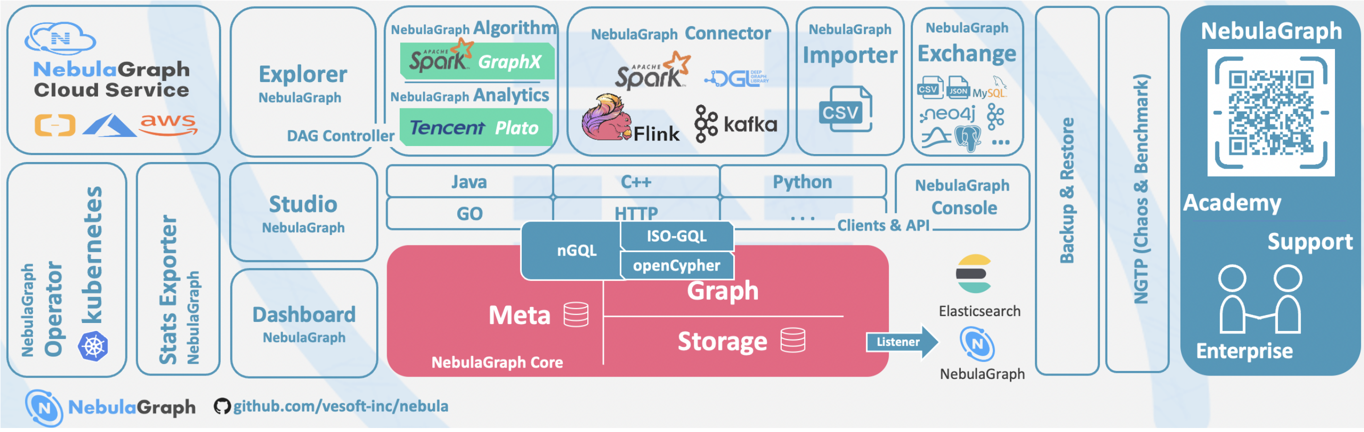
For example:

```
// If the port is open:
$ telnet 192.168.1.10 9669
Trying 192.168.1.10...
Connected to 192.168.1.10.
Escape character is '^]'.

// If the port is closed or blocked:
$ telnet 192.168.1.10 9777
Trying 192.168.1.10...
telnet: connect to address 192.168.1.10: Connection refused
```

Last update: May 22, 2023

22.4 Ecosystem tools overview



Compatibility

The core release number naming rule is `X.Y.Z`, which means `Major version X`, `Medium version Y`, and `Minor version Z`. The upgrade requirements for the client are:

- Upgrade the core from `X.Y.Z1` to `X.Y.Z2`: It means that the core is fully forward compatible and is usually used for bugfixes. It is recommended to upgrade the minor version of the core as soon as possible. At this time, the client can stay **not upgraded**.
- Upgrade the core from `X.Y1.*` to `X.Y2.*`: It means that there is some incompatibility of API, syntax, and return value. It is usually used to add functions, improve performance, and optimize code. The client needs to be upgraded to `X.Y2.*`.
- Upgrade the core from `X1.*.*` to `X2.*.*`: It means that there is a major incompatibility in storage formats, API, syntax, etc. You need to use tools to upgrade the core data. The client must be upgraded.
- The default core and client do not support downgrade: You cannot downgrade from `X.Y.Z2` to `X.Y.Z1`.
- The release cycle of a `Y` version is about 6 months, and its maintenance and support cycle is 6 months.
- The version released at the beginning of the year is usually named `X.0.0`, and in the middle of the year, it is named `X.5.0`.
- The file name contains `RC` to indicate an unofficial version (`Release Candidate`) that is only used for preview. Its maintenance period is only until the next RC or official version is released. Its client, data compatibility, etc. are not guaranteed.
- The files with `nightly`, `SNAPSHOT`, or date are the nightly versions. There is no quality assurance and maintenance period.

22.4.1 NebulaGraph Studio

NebulaGraph Studio (Studio for short) is a graph database visualization tool that can be accessed through the Web. It can be used with NebulaGraph DBMS to provide one-stop services such as composition, data import, writing nGQL queries, and graph exploration. For details, see What is NebulaGraph Studio.

Note

The release of the Studio is independent of NebulaGraph core, and its naming method is also not the same as the core naming rules.

NebulaGraph version	Studio version
v3.5.0	v3.7.0

22.4.2 NebulaGraph Dashboard Community Edition

NebulaGraph Dashboard Community Edition (Dashboard for short) is a visualization tool for monitoring the status of machines and services in the NebulaGraph cluster. For details, see What is NebulaGraph Dashboard.

NebulaGraph version	Dashboard Community version
v3.5.0	v3.5.0

22.4.3 NebulaGraph Dashboard Enterprise Edition

NebulaGraph Dashboard Enterprise Edition (Dashboard for short) is a visualization tool that monitors and manages the status of machines and services in NebulaGraph cluster. For details, see What is NebulaGraph Dashboard.

NebulaGraph version	Dashboard Enterprise version
v3.5.0	v3.5.0

22.4.4 NebulaGraph Explorer

NebulaGraph Explorer (Explorer for short) is a graph exploration visualization tool that can be accessed through the Web. It is used with the NebulaGraph core to visualize interaction with graph data. Users can quickly become map experts, even without experience in map data manipulation. For details, see What is NebulaGraph Explorer.

NebulaGraph version	Explorer Enterprise version
v3.5.0	v3.5.0

22.4.5 NebulaGraph Stats Exporter

Nebula-stats-exporter exports monitor metrics to Promethus.

NebulaGraph version	Stats Exporter version
v3.5.0	v3.3.0

22.4.6 NebulaGraph Exchange

NebulaGraph Exchange (Exchange for short) is an Apache Spark&trade application for batch migration of data in a cluster to NebulaGraph in a distributed environment. It can support the migration of batch data and streaming data in a variety of different formats. For details, see What is NebulaGraph Exchange.

NebulaGraph version	Exchange Community version	Exchange Enterprise version
v3.5.0	v3.5.0	v3.5.0

22.4.7 NebulaGraph Operator

NebulaGraph Operator (Operator for short) is a tool to automate the deployment, operation, and maintenance of NebulaGraph clusters on Kubernetes. Building upon the excellent scalability mechanism of Kubernetes, NebulaGraph introduced its operation and maintenance knowledge into the Kubernetes system, which makes NebulaGraph a real cloud-native graph database. For more information, see What is NebulaGraph Operator.

NebulaGraph version	Operator version
v3.5.0	v1.5.0

22.4.8 NebulaGraph Importer

NebulaGraph Importer (Importer for short) is a CSV file import tool for NebulaGraph. The Importer can read the local CSV file, and then import the data into the NebulaGraph database. For details, see What is NebulaGraph Importer.

NebulaGraph version	Importer version
v3.5.0	v4.0.0

22.4.9 NebulaGraph Spark Connector

NebulaGraph Spark Connector is a Spark connector that provides the ability to read and write NebulaGraph data in the Spark standard format. NebulaGraph Spark Connector consists of two parts, Reader and Writer. For details, see What is NebulaGraph Spark Connector.

NebulaGraph version	Spark Connector version
v3.5.0	v3.4.0

22.4.10 NebulaGraph Flink Connector

NebulaGraph Flink Connector is a connector that helps Flink users quickly access NebulaGraph. It supports reading data from the NebulaGraph database or writing data read from other external data sources to the NebulaGraph database. For details, see What is NebulaGraph Flink Connector.

NebulaGraph version	Flink Connector version
v3.5.0	v3.5.0

22.4.11 NebulaGraph Algorithm

NebulaGraph Algorithm (Algorithm for short) is a Spark application based on GraphX, which uses a complete algorithm tool to analyze data in the NebulaGraph database by submitting a Spark task To perform graph computing, use the algorithm under the lib repository through programming to perform graph computing for DataFrame. For details, see What is NebulaGraph Algorithm.

NebulaGraph version	Algorithm version
v3.5.0	v3.0.0

22.4.12 NebulaGraph Console

NebulaGraph Console is the native CLI client of NebulaGraph. For how to use it, see NebulaGraph Console.

NebulaGraph version	Console version
v3.5.0	v3.5.0

22.4.13 NebulaGraph Docker Compose

Docker Compose can quickly deploy NebulaGraph clusters. For how to use it, please refer to Docker Compose Deployment NebulaGraph.

NebulaGraph version	Docker Compose version
v3.5.0	v3.5.0

22.4.14 Backup & Restore

Backup&Restore (BR for short) is a command line interface (CLI) tool that can help back up the graph space data of NebulaGraph, or restore it through a backup file data.

NebulaGraph version	BR version
v3.5.0	v3.3.0

22.4.15 NebulaGraph Bench

NebulaGraph Bench is used to test the baseline performance data of NebulaGraph. It uses the standard data set of LDBC.

NebulaGraph version	Bench version
v3.5.0	v1.2.0

22.4.16 API, SDK

Compatibility

Select the latest version of `X.Y.*` which is the same as the core version.

NebulaGraph version	Language
v3.5.0	C++
v3.5.0	Go
v3.5.0	Python
v3.5.0	Java
v3.5.0	HTTP

22.4.17 Not Released

- Rust Client
- Node.js Client
- Object Graph Mapping Library (OGM, or ORM)

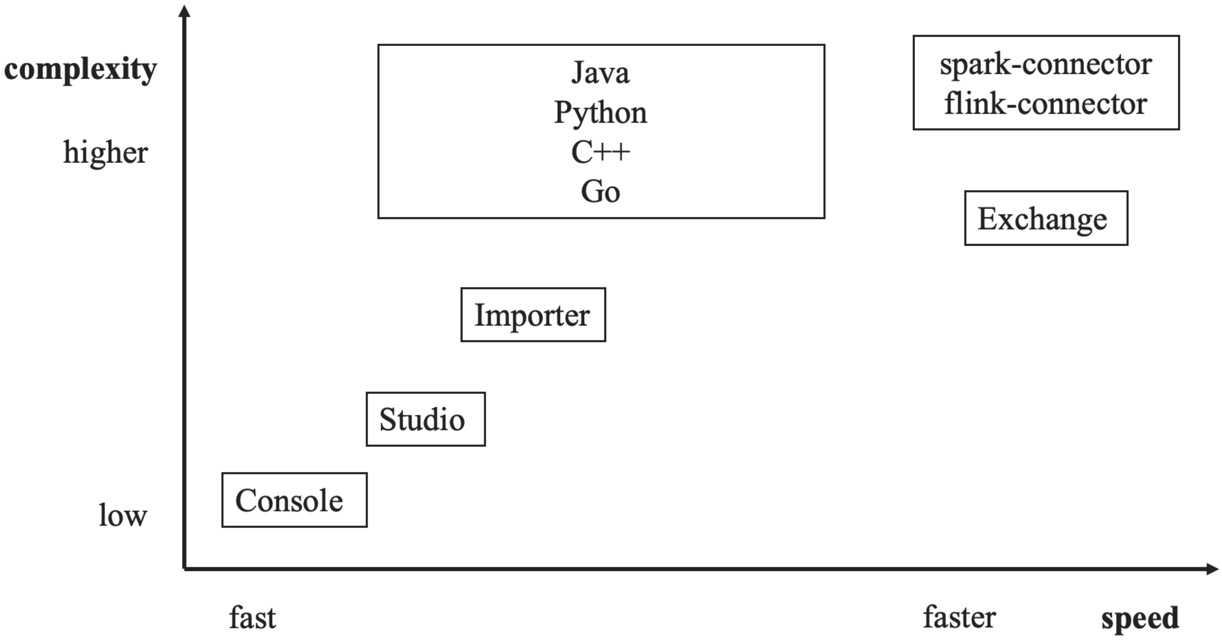
Last update: May 11, 2023

22.5 Import tools

There are many ways to write NebulaGraph 3.5.0:

- Import with the command -f: This method imports a small number of prepared nGQL files, which is suitable to prepare for a small amount of manual test data.
- Import with Studio: This method uses a browser to import multiple csv files of this machine. A single file cannot exceed 100 MB, and its format is limited.
- Import with Importer: This method imports multiple csv files on a single machine with unlimited size and flexible format.
- Import with Exchange: This method imports from various distribution sources, such as Neo4j, Hive, MySQL, etc., which requires a Spark cluster.
- Import with Spark-connector/Flink-connector: This method has corresponding components (Spark/Flink) and writes a small amount of code.
- Import with C++/GO/Java/Python SDK: This method imports in the way of writing programs, which requires certain programming and tuning skills.

The following figure shows the positions of these ways:



Last update: August 11, 2022

22.6 How to Contribute

22.6.1 Before you get started

Commit an issue on the github or forum

You are welcome to contribute any code or files to the project. But firstly we suggest you raise an issue on the github or the forum to start a discussion with the community. Check through the topic for Github.

Sign the Contributor License Agreement (CLA)

What is CLA?

Here is the vesoft inc. Contributor License Agreement.

Click the **Sign in with GitHub to agree** button to sign the CLA.

If you have any questions, send an email to `info@vesoft.com`.

22.6.2 Modify a single document

This manual is written in the Markdown language. Click the `pencil` icon on the right of the document title to commit the modification.

This method applies to modify a single document only.

22.6.3 Batch modify or add files

This method applies to contribute codes, modify multiple documents in batches, or add new documents.

22.6.4 Step 1: Fork in the github.com

The NebulaGraph project has many repositories. Take the nebul repository for example:

1. Visit https://github.com/vesoft-inc/nebula.
2. Click the `Fork` button to establish an online fork.

22.6.5 Step 2: Clone Fork to Local Storage

1. Define a local working directory.

```
# Define the working directory.
working_dir=$HOME/Workspace
```

2. Set `user` to match the Github profile name.

```
user={the Github profile name}
```

3. Create your clone.

```
mkdir -p $working_dir
cd $working_dir
git clone https://github.com/$user/nebula.git
# or: git clone git@github.com:$user/nebula.git

cd $working_dir/nebula
git remote add upstream https://github.com/vesoft-inc/nebula.git
# or: git remote add upstream git@github.com:vesoft-inc/nebula.git

# Never push to upstream master since you do not have write access.
git remote set-url --push upstream no_push

# Confirm that the remote branch is valid.
```

```
# The correct format is:
# origin    git@github.com:$(user)/nebula.git (fetch)
# origin    git@github.com:$(user)/nebula.git (push)
# upstream  https://github.com/vesoft-inc/nebula (fetch)
# upstream  no_push (push)
git remote -v
```

4. (Optional) Define a pre-commit hook.

   Please link the NebulaGraph pre-commit hook into the `.git` directory.

   This hook checks the commits for formatting, building, doc generation, etc.

```
cd $working_dir/nebula/.git/hooks
ln -s $working_dir/nebula/.linters/cpp/hooks/pre-commit.sh .
```

   Sometimes, the pre-commit hook cannot be executed. You have to execute it manually.

```
cd $working_dir/nebula/.git/hooks
chmod +x pre-commit
```

22.6.6 Step 3: Branch

1. Get your local master up to date.

```
cd $working_dir/nebula
git fetch upstream
git checkout master
git rebase upstream/master
```

2. Checkout a new branch from master.

```
git checkout -b myfeature
```

Note

Because the PR often consists of several commits, which might be squashed while being merged into upstream. We strongly suggest you to open a separate topic branch to make your changes on. After merged, this topic branch can be just abandoned, thus you could synchronize your master branch with upstream easily with a rebase like above. Otherwise, if you commit your changes directly into master, you need to use a hard reset on the master branch. For example:

```
git fetch upstream
git checkout master
git reset --hard upstream/master
git push --force origin master
```

22.6.7 Step 4: Develop

- Code style

NebulaGraph adopts `cpplint` to make sure that the project conforms to Google's coding style guides. The checker will be implemented before the code is committed.

- Unit tests requirements

  Please add unit tests for the new features or bug fixes.

- Build your code with unit tests enabled

  For more information, see Install NebulaGraph by compiling the source code.

  Note

  Make sure you have enabled the building of unit tests by setting `-DENABLE_TESTING=ON`.

- Run tests

  In the root directory of `nebula`, run the following command:

```
cd nebula/build
ctest -j$(nproc)
```

22.6.8 Step 5: Bring Your Branch Update to Date

```
# While on your myfeature branch.
git fetch upstream
git rebase upstream/master
```

Users need to bring the head branch up to date after other contributors merge PR to the base branch.

22.6.9 Step 6: Commit

Commit your changes.

```
git commit -a
```

Users can use the command `--amend` to re-edit the previous code.

22.6.10 Step 7: Push

When ready to review or just to establish an offsite backup, push your branch to your fork on `github.com`:

```
git push origin myfeature
```

22.6.11 Step 8: Create a Pull Request

1. Visit your fork at `https://github.com/$user/nebula` (replace `$user` here).
2. Click the `Compare & pull request` button next to your `myfeature` branch.

22.6.12 Step 9: Get a Code Review

Once your pull request has been created, it will be assigned to at least two reviewers. Those reviewers will do a thorough code review to make sure that the changes meet the repository's contributing guidelines and other quality standards.

22.6.13 Add test cases

For detailed methods, see How to add test cases.

22.6.14 Donation

Step 1: Confirm the project donation

Contact the official NebulaGraph staff via email, WeChat, Slack, etc. to confirm the donation project. The project will be donated to the NebulaGraph Contrib organization.

Email address: info@vesoft.com

WeChat: NebulaGraphbot

Slack: Join Slack

Step 2: Get the information of the project recipient

The NebulaGraph official staff will give the recipient ID of the NebulaGraph Contrib project.

Step 3: Donate a project

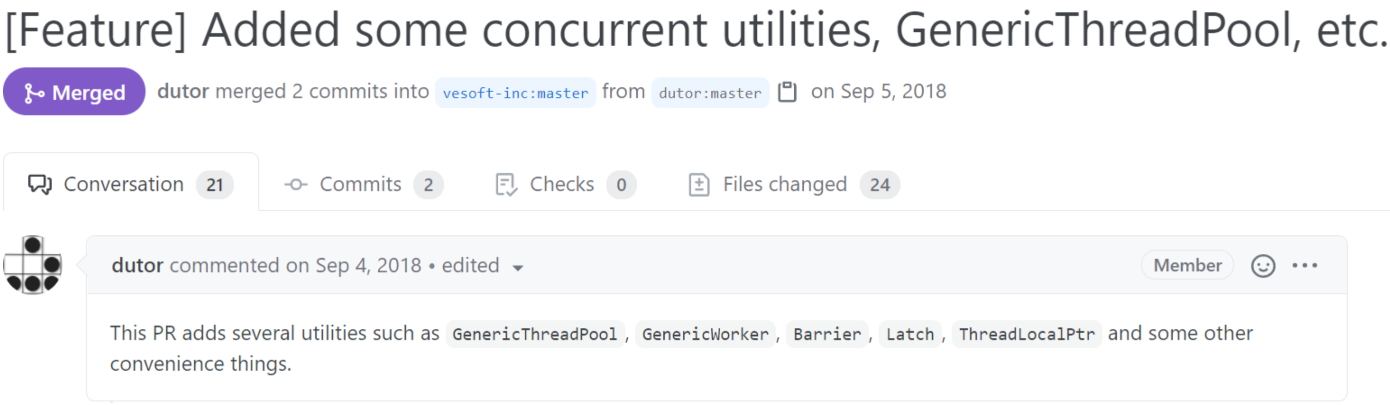
The user transfers the project to the recipient of this donation, and the recipient transfers the project to the NebulaGraph Contrib organization. After the donation, the user will continue to lead the development of community projects as a Maintainer.

For operations of transferring a repository on GitHub, see Transferring a repository owned by your user account.

Last update: January 6, 2023

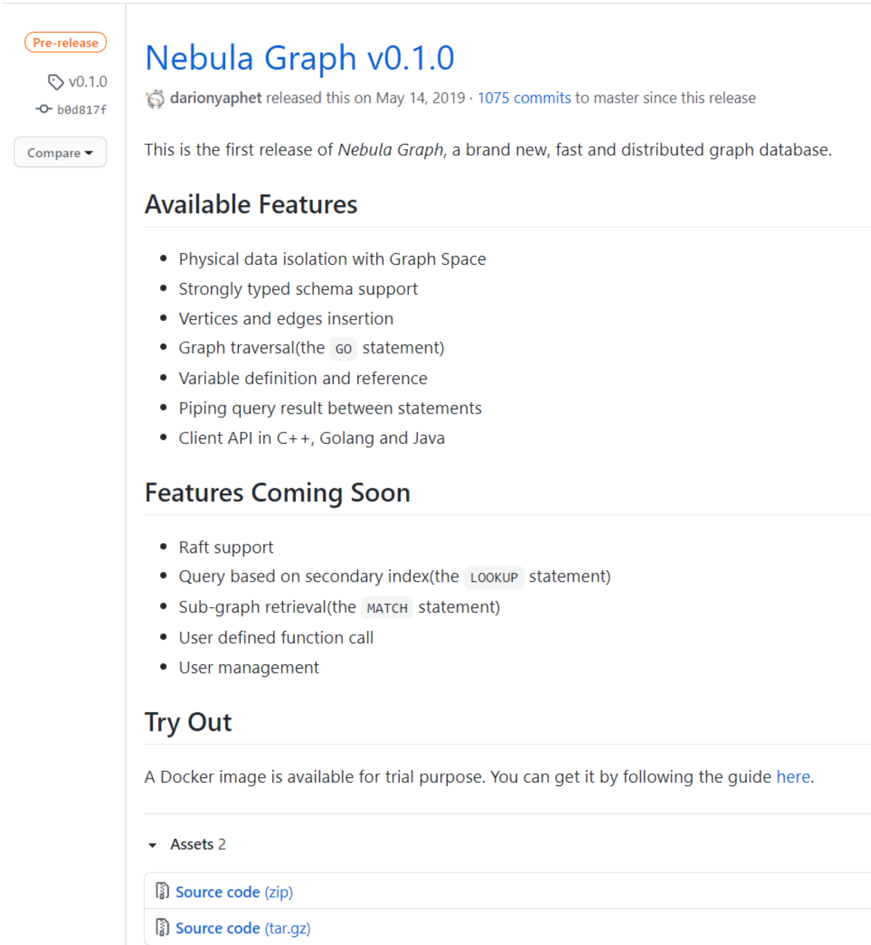
22.7 History timeline for NebulaGraph

1. 2018.9: dutor wrote and submitted the first line of NebulaGraph database code.



2. 2019.5: NebulaGraph v0.1.0-alpha was released as open-source.

NebulaGraph v1.0.0-beta, v1.0.0-rc1, v1.0.0-rc2, v1.0.0-rc3, and v1.0.0-rc4 were released one after another within a year thereafter.



Pre-release

v0.1.0

b0d817f

Compare

Nebula Graph v0.1.0

darionyaphet released this on May 14, 2019 · 1075 commits to master since this release

This is the first release of *Nebula Graph*, a brand new, fast and distributed graph database.

Available Features

- Physical data isolation with Graph Space
- Strongly typed schema support
- Vertices and edges insertion
- Graph traversal(the `GO` statement)
- Variable definition and reference
- Piping query result between statements
- Client API in C++, Golang and Java

Features Coming Soon

- Raft support
- Query based on secondary index(the `LOOKUP` statement)
- Sub-graph retrieval(the `MATCH` statement)
- User defined function call
- User management

Try Out

A Docker image is available for trial purpose. You can get it by following the guide here.

Assets 2

Source code (zip)

Source code (tar.gz)

3. 2019.7: NebulaGraph's debut at HBaseCon[1]. @dangleptr

4. 2020.3: NebulaGraph v2.0 was starting developed in the final stage of v1.0 development.
5. 2020.6: The first major version of NebulaGraph v1.0.0 GA was released.

v1.0.0
06a5db4
Verified
Compare

V1.0.0 GA

jude-zhu released this on Jun 10, 2020 · 146 commits to master since this release

Basic Features

- Online DDL & DML. Support updating schemas and data without stopping or affecting your ongoing operations.
- Graph traversal. `GO` statement supports forward/reverse and bidirectional graph traversal. `GO minHops TO maxHops` is supported to get variable hops relationships.
- Aggregate. Support aggregation functions such as `GROUP BY`, `ORDER BY`, and `LIMIT`.
- Composite query. Support composite clauses: `UNION`, `UNION DISTINCT`, `INTERSECT`, and `MINUS`.
- PIPE statements. The result yielded from the previous statement could be piped to the next statement as input.
- Use defined variables. Support user-defined variables to pass the result of a query to another.
- Index. Both the single-property index and composite index are supported to make searches of related data more efficient. `LOOKUP ON` statement is to query on the index.

Advanced Features

- Privilege Management. Support user authentication and role-based access control. Nebula Graph can easily integrate with third-party authentication systems. There are five built-in roles in Nebula Graph: `GOD`, `ADMIN`, `DBA`, `USER`, and `GUEST`. Each role has its corresponding privileges.
- Support Reservoir Sampling, which will retrieve k elements randomly for the sampling of the supernode at the complexity of `O(n)`.
- Cluster snapshot. Support creating snapshots for the cluster as an online backup strategy.
- TTL. Support TTL to expire items after a certain amount of time automatically.
- Operation & Maintenance
  - Scale in/out. Support online scale in/out and load balance for storage
  - `HOSTS` clause to manage storage hosts
  - `CONFIGS` clause to manage configuration options
- Job Manager & Scheduler. A tool for job managing and scheduling. Currently, `COMPACT` and `FLUSH` jobs are supported.
- Graph Algorithms. Support finding the full path and the shortest path between vertices.
- Provide OLAP interfaces to integrate with third-party graph analytics platforms.
- Support multiple character sets and collations. The default `CHARSET` and `COLLATE` are `utf8` and `utf8_bin`.

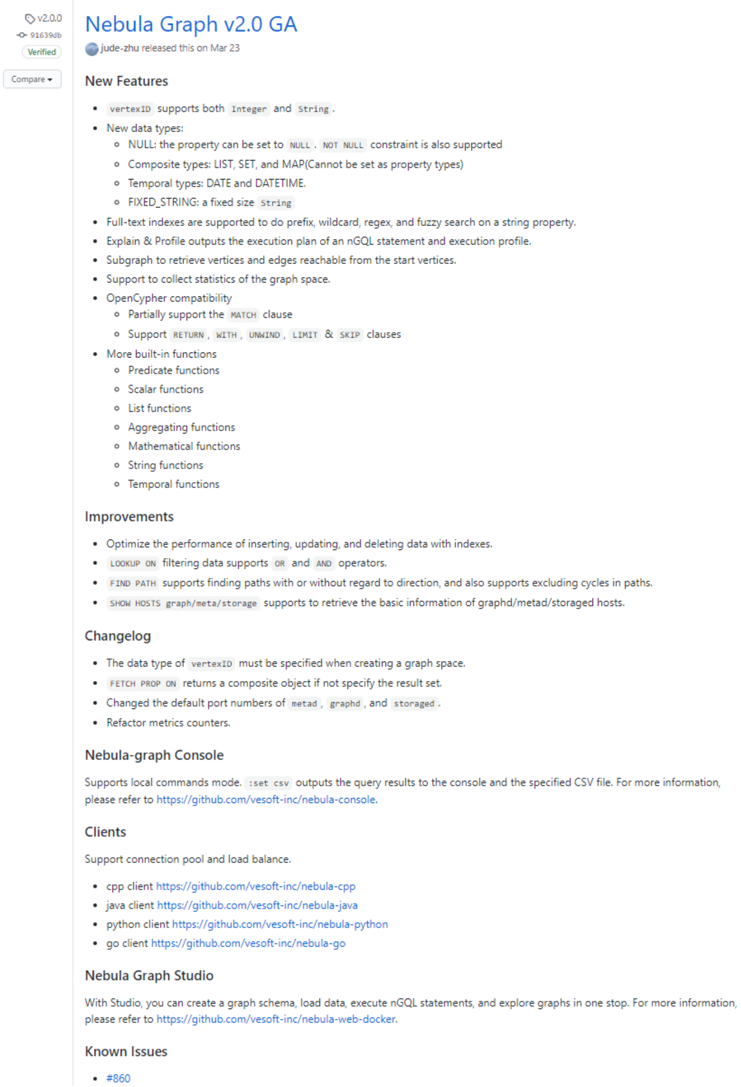
Clients

- Java Client. Support source code building and downloading from the MVN repository, see Java Client for more details.
- Python Client. Support source code building and installation with pip, see Python Client for more details.
- Golang Client. Install the client with the command `go get -u -v github.com/vesoft-inc/nebula-go`, see Go Client for more details.

Nebula Graph Studio

A graphical user interface for working with Nebula Graph. Support querying, designing schema, data loading, and graph exploring. See Nebula Graph Studio for more details.

6. 2021.3: The second major version of NebulaGraph v2.0 GA was released.



v2.0.0

91639db

Verified

Compare

Nebula Graph v2.0 GA

jude-zhu released this on Mar 23

New Features

- `vertexID` supports both `Integer` and `String`.
- New data types:
  - NULL: the property can be set to `NULL`. `NOT NULL` constraint is also supported
  - Composite types: LIST, SET, and MAP(Cannot be set as property types)
  - Temporal types: DATE and DATETIME.
  - FIXED_STRING: a fixed size `String`
- Full-text indexes are supported to do prefix, wildcard, regex, and fuzzy search on a string property.
- Explain & Profile outputs the execution plan of an nGQL statement and execution profile.
- Subgraph to retrieve vertices and edges reachable from the start vertices.
- Support to collect statistics of the graph space.
- OpenCypher compatibility
  - Partially support the `MATCH` clause
  - Support `RETURN`, `WITH`, `UNWIND`, `LIMIT` & `SKIP` clauses
- More built-in functions
  - Predicate functions
  - Scalar functions
  - List functions
  - Aggregating functions
  - Mathematical functions
  - String functions
  - Temporal functions

Improvements

- Optimize the performance of inserting, updating, and deleting data with indexes.
- `LOOKUP ON` filtering data supports `OR` and `AND` operators.
- `FIND PATH` supports finding paths with or without regard to direction, and also supports excluding cycles in paths.
- `SHOW HOSTS graph/meta/storage` supports to retrieve the basic information of graphd/metad/storaged hosts.

Changelog

- The data type of `vertexID` must be specified when creating a graph space.
- `FETCH PROP ON` returns a composite object if not specify the result set.
- Changed the default port numbers of `metad`, `graphd`, and `storaged`.
- Refactor metrics counters.

Nebula-graph Console

Supports local commands mode. `:set csv` outputs the query results to the console and the specified CSV file. For more information, please refer to https://github.com/vesoft-inc/nebula-console.

Clients

Support connection pool and load balance.

- cpp client https://github.com/vesoft-inc/nebula-cpp
- java client https://github.com/vesoft-inc/nebula-java
- python client https://github.com/vesoft-inc/nebula-python
- go client https://github.com/vesoft-inc/nebula-go

Nebula Graph Studio

With Studio, you can create a graph schema, load data, execute nGQL statements, and explore graphs in one stop. For more information, please refer to https://github.com/vesoft-inc/nebula-web-docker.

Known Issues

- #860

7. 2021.8: NebulaGraph v2.5.0 was released.
8. 2021.10: NebulaGraph v2.6.0 was released.
9. 2022.2: NebulaGraph v3.0.0 was released.
10. 2022.4: NebulaGraph v3.1.0 was released.
11. 2022.7: NebulaGraph v3.2.0 was released.
12. 2022.10: NebulaGraph v3.3.0 was released.
13. 2023.2: NebulaGraph v3.4.0 was released.
14. 2023.5: NebulaGraph v3.5.0 was released.

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1. NebulaGraph v1.x supports both RocksDB and HBase as its storage engines. NebulaGraph v2.x removes HBase supports. ↩

Last update: May 19, 2023

22.8 Error code

NebulaGraph returns an error code when an error occurs. This topic describes the details of the error code returned.

Note

- If an error occurs but no error code is returned, or if the error code description is unclear, we welcome your feedback or suggestions on the forum or GitHub.
- When the code returned is `0`, it means that the operation is successful.

Error name	Error Code	Description
E_DISCONNECTED	-1	Lost connection
E_FAIL_TO_CONNECT	-2	Unable to establish connection
E_RPC_FAILURE	-3	RPC failure
E_LEADER_CHANGED	-4	Raft leader has been changed
E_SPACE_NOT_FOUND	-5	Graph space does not exist
E_TAG_NOT_FOUND	-6	Tag does not exist
E_EDGE_NOT_FOUND	-7	Edge type does not exist
E_INDEX_NOT_FOUND	-8	Index does not exist
E_EDGE_PROP_NOT_FOUND	-9	Edge type property does not exist
E_TAG_PROP_NOT_FOUND	-10	Tag property does not exist
E_ROLE_NOT_FOUND	-11	The current role does not exist
E_CONFIG_NOT_FOUND	-12	The current configuration does not exist
E_MACHINE_NOT_FOUND	-13	The current host does not exist
E_LISTENER_NOT_FOUND	-15	Listener does not exist
E_PART_NOT_FOUND	-16	The current partition does not exist
E_KEY_NOT_FOUND	-17	Key does not exist
E_USER_NOT_FOUND	-18	User does not exist
E_STATS_NOT_FOUND	-19	Statistics do not exist
E_SERVICE_NOT_FOUND	-20	No current service found
E_DRAINER_NOT_FOUND	-21	Drainer does not exist
E_DRAINER_CLIENT_NOT_FOUND	-22	Drainer client does not exist
E_PART_STOPPED	-23	The current partition has already been stopped
E_BACKUP_FAILED	-24	Backup failed
E_BACKUP_EMPTY_TABLE	-25	The backed-up table is empty
E_BACKUP_TABLE_FAILED	-26	Table backup failure
E_PARTIAL_RESULT	-27	MultiGet could not get all data
E_REBUILD_INDEX_FAILED	-28	Index rebuild failed
E_INVALID_PASSWORD	-29	Password is invalid
E_FAILED_GET_ABS_PATH	-30	Unable to get absolute path
E_BAD_USERNAME_PASSWORD	-1001	Authentication failed
E_SESSION_INVALID	-1002	Invalid session
E_SESSION_TIMEOUT	-1003	Session timeout
E_SYNTAX_ERROR	-1004	Syntax error
E_EXECUTION_ERROR	-1005	Execution error
E_STATEMENT_EMPTY	-1006	Statement is empty

Error name	Error Code	Description
`E_BAD_PERMISSION`	`-1008`	Permission denied
`E_SEMANTIC_ERROR`	`-1009`	Semantic error
`E_TOO_MANY_CONNECTIONS`	`-1010`	Maximum number of connections exceeded
`E_PARTIAL_SUCCEEDED`	`-1011`	Access to storage failed (only some requests succeeded)
`E_NO_HOSTS`	`-2001`	Host does not exist
`E_EXISTED`	`-2002`	Host already exists
`E_INVALID_HOST`	`-2003`	Invalid host
`E_UNSUPPORTED`	`-2004`	The current command, statement, or function is not supported
`E_NOT_DROP`	`-2005`	Not allowed to drop
`E_CONFIG_IMMUTABLE`	`-2007`	Configuration items cannot be changed
`E_CONFLICT`	`-2008`	Parameters conflict with meta data
`E_INVALID_PARM`	`-2009`	Invalid parameter
`E_WRONGCLUSTER`	`-2010`	Wrong cluster
`E_ZONE_NOT_ENOUGH`	`-2011`	Listener conflicts
`E_ZONE_IS_EMPTY`	`-2012`	Host not exist
`E_SCHEMA_NAME_EXISTS`	`-2013`	Schema name already exists
`E_RELATED_INDEX_EXISTS`	`-2014`	There are still indexes related to tag or edge, cannot drop it
`E_RELATED_SPACE_EXISTS`	`-2015`	There are still some space on the host, cannot drop it
`E_STORE_FAILURE`	`-2021`	Failed to store data
`E_STORE_SEGMENT_ILLEGAL`	`-2022`	Illegal storage segment
`E_BAD_BALANCE_PLAN`	`-2023`	Invalid data balancing plan
`E_BALANCED`	`-2024`	The cluster is already in the data balancing status
`E_NO_RUNNING_BALANCE_PLAN`	`-2025`	There is no running data balancing plan
`E_NO_VALID_HOST`	`-2026`	Lack of valid hosts
`E_CORRUPTED_BALANCE_PLAN`	`-2027`	A data balancing plan that has been corrupted
`E_IMPROPER_ROLE`	`-2030`	Failed to recover user role
`E_INVALID_PARTITION_NUM`	`-2031`	Number of invalid partitions
`E_INVALID_REPLICA_FACTOR`	`-2032`	Invalid replica factor
`E_INVALID_CHARSET`	`-2033`	Invalid character set
`E_INVALID_COLLATE`	`-2034`	Invalid character sorting rules
`E_CHARSET_COLLATE_NOT_MATCH`	`-2035`	Character set and character sorting rule mismatch
`E_SNAPSHOT_FAILURE`	`-2040`	Failed to generate a snapshot
`E_BLOCK_WRITE_FAILURE`	`-2041`	Failed to write block data
`E_ADD_JOB_FAILURE`	`-2044`	Failed to add new task
`E_STOP_JOB_FAILURE`	`-2045`	Failed to stop task

Error name	Error Code	Description
E_SAVE_JOB_FAILURE	-2046	Failed to save task information
E_BALANCER_FAILURE	-2047	Data balancing failed
E_JOB_NOT_FINISHED	-2048	The current task has not been completed
E_TASK_REPORT_OUT_DATE	-2049	Task report failed
E_JOB_NOT_IN_SPACE	-2050	The current task is not in the graph space
E_JOB_NEED_RECOVER	-2051	The current task needs to be resumed
E_JOB_ALREADY_FINISH	-2052	The job status has already been failed or finished
E_JOB_SUBMITTED	-2053	Job default status
E_JOB_NOT_STOPPABLE	-2054	The given job do not support stop
E_JOB_HAS_NO_TARGET_STORAGE	-2055	The leader distribution has not been reported, so can't send task to storage
E_INVALID_JOB	-2065	Invalid task
E_BACKUP_BUILDING_INDEX	-2066	Backup terminated (index being created)
E_BACKUP_SPACE_NOT_FOUND	-2067	Graph space does not exist at the time of backup
E_RESTORE_FAILURE	-2068	Backup recovery failed
E_SESSION_NOT_FOUND	-2069	Session does not exist
E_LIST_CLUSTER_FAILURE	-2070	Failed to get cluster information
E_LIST_CLUSTER_GET_ABS_PATH_FAILURE	-2071	Failed to get absolute path when getting cluster information
E_LIST_CLUSTER_NO_AGENT_FAILURE	-2072	Unable to get an agent when getting cluster information
E_QUERY_NOT_FOUND	-2073	Query not found
E_AGENT_HB_FAILUE	-2074	Failed to receive heartbeat from agent
E_HOST_CAN_NOT_BE_ADDED	-2082	The host can not be added for it's not a storage host
E_ACCESS_ES_FAILURE	-2090	Failed to access elasticsearch
E_GRAPH_MEMORY_EXCEEDED	-2600	Graph memory exceeded
E_CONSENSUS_ERROR	-3001	Consensus cannot be reached during an election
E_KEY_HAS_EXISTS	-3002	Key already exists
E_DATA_TYPE_MISMATCH	-3003	Data type mismatch
E_INVALID_FIELD_VALUE	-3004	Invalid field value
E_INVALID_OPERATION	-3005	Invalid operation
E_NOT_NULLABLE	-3006	Current value is not allowed to be empty
E_FIELD_UNSET	-3007	Field value must be set if the field value is NOT NULL or has no default value
E_OUT_OF_RANGE	-3008	The value is out of the range of the current type
E_DATA_CONFLICT_ERROR	-3010	Data conflict
E_WRITE_STALLED	-3011	Writes are delayed
E_IMPROPER_DATA_TYPE	-3021	Incorrect data type

Error name	Error Code	Description
`E_INVALID_SPACEVIDLEN`	`-3022`	Invalid VID length
`E_INVALID_FILTER`	`-3031`	Invalid filter
`E_INVALID_UPDATER`	`-3032`	Invalid field update
`E_INVALID_STORE`	`-3033`	Invalid KV storage
`E_INVALID_PEER`	`-3034`	Peer invalid
`E_RETRY_EXHAUSTED`	`-3035`	Out of retries
`E_TRANSFER_LEADER_FAILED`	`-3036`	Leader change failed
`E_INVALID_STAT_TYPE`	`-3037`	Invalid stat type
`E_INVALID_VID`	`-3038`	VID is invalid
`E_LOAD_META_FAILED`	`-3040`	Failed to load meta information
`E_FAILED_TO_CHECKPOINT`	`-3041`	Failed to generate checkpoint
`E_CHECKPOINT_BLOCKED`	`-3042`	Generating checkpoint is blocked
`E_FILTER_OUT`	`-3043`	Data is filtered
`E_INVALID_DATA`	`-3044`	Invalid data
`E_MUTATE_EDGE_CONFLICT`	`-3045`	Concurrent write conflicts on the same edge
`E_MUTATE_TAG_CONFLICT`	`-3046`	Concurrent write conflict on the same vertex
`E_OUTDATED_LOCK`	`-3047`	Lock is invalid
`E_INVALID_TASK_PARA`	`-3051`	Invalid task parameter
`E_USER_CANCEL`	`-3052`	The user canceled the task
`E_TASK_EXECUTION_FAILED`	`-3053`	Task execution failed
`E_PLAN_IS_KILLED`	`-3060`	Execution plan was cleared
`E_NO_TERM`	`-3070`	The heartbeat process was not completed when the request was received
`E_OUTDATED_TERM`	`-3071`	Out-of-date heartbeat received from the old leader (the new leader has been elected)
`E_WRITE_WRITE_CONFLICT`	`-3073`	Concurrent write conflicts with later requests
`E_RAFT_UNKNOWN_PART`	`-3500`	Unknown partition
`E_RAFT_LOG_GAP`	`-3501`	Raft logs lag behind
`E_RAFT_LOG_STALE`	`-3502`	Raft logs are out of date
`E_RAFT_TERM_OUT_OF_DATE`	`-3503`	Heartbeat messages are out of date
`E_RAFT_UNKNOWN_APPEND_LOG`	`-3504`	Unknown additional logs
`E_RAFT_WAITING_SNAPSHOT`	`-3511`	Waiting for the snapshot to complete
`E_RAFT_SENDING_SNAPSHOT`	`-3512`	There was an error sending the snapshot
`E_RAFT_INVALID_PEER`	`-3513`	Invalid receiver
`E_RAFT_NOT_READY`	`-3514`	Raft did not start
`E_RAFT_STOPPED`	`-3515`	Raft has stopped

Error name	Error Code	Description
`E_RAFT_BAD_ROLE`	`-3516`	Wrong role
`E_RAFT_WAL_FAIL`	`-3521`	Write to a WAL failed
`E_RAFT_HOST_STOPPED`	`-3522`	The host has stopped
`E_RAFT_TOO_MANY_REQUESTS`	`-3523`	Too many requests
`E_RAFT_PERSIST_SNAPSHOT_FAILED`	`-3524`	Persistent snapshot failed
`E_RAFT_RPC_EXCEPTION`	`-3525`	RPC exception
`E_RAFT_NO_WAL_FOUND`	`-3526`	No WAL logs found
`E_RAFT_HOST_PAUSED`	`-3527`	Host suspended
`E_RAFT_WRITE_BLOCKED`	`-3528`	Writes are blocked
`E_RAFT_BUFFER_OVERFLOW`	`-3529`	Cache overflow
`E_RAFT_ATOMIC_OP_FAILED`	`-3530`	Atomic operation failed
`E_LEADER_LEASE_FAILED`	`-3531`	Leader lease expired
`E_RAFT_CAUGHT_UP`	`-3532`	Data has been synchronized on Raft
`E_STORAGE_MEMORY_EXCEEDED`	`-3600`	Storage memory exceeded
`E_LOG_GAP`	`-4001`	Drainer logs lag behind
`E_LOG_STALE`	`-4002`	Drainer logs are out of date
`E_INVALID_DRAINER_STORE`	`-4003`	The drainer data storage is invalid
`E_SPACE_MISMATCH`	`-4004`	Graph space mismatch
`E_PART_MISMATCH`	`-4005`	Partition mismatch
`E_DATA_CONFLICT`	`-4006`	Data conflict
`E_REQ_CONFLICT`	`-4007`	Request conflict
`E_DATA_ILLEGAL`	`-4008`	Illegal data
`E_CACHE_CONFIG_ERROR`	`-5001`	Cache configuration error
`E_NOT_ENOUGH_SPACE`	`-5002`	Insufficient space
`E_CACHE_MISS`	`-5003`	No cache hit
`E_CACHE_WRITE_FAILURE`	`-5005`	Write cache failed
`E_NODE_NUMBER_EXCEED_LIMIT`	`-7001`	Number of machines exceeded the limit
`E_PARSING_LICENSE_FAILURE`	`-7002`	Failed to resolve certificate
`E_UNKNOWN`	`-8000`	Unknown error

Last update: December 29, 2022

https://docs.nebula-graph.io/3.5.0