The Neo4j Cypher Manual v4.0

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This is the Cypher manual for Neo4j version 4.0, authored by the Neo4j Team.

This manual covers the following areas:

- Introduction — Introducing the Cypher query language.
- Syntax — Learn Cypher query syntax.
- Clauses — Reference of Cypher query clauses.
- Functions — Reference of Cypher query functions.
- Administration — Working with databases, indexes, constraints and security in Cypher.
- Query tuning — Learn to analyze queries and tune them for performance.
- Execution plans — Cypher execution plans and operators.
- Deprecations, additions and compatibility — An overview of language developments across versions.
- Glossary of keywords — A glossary of Cypher keywords, with links to other parts of the Cypher manual.
- Cypher styleguide — A guide to the recommended style for writing Cypher queries.

Who should read this?

This manual is written for the developer of a Neo4j client application.

Chapter 1. Introduction

This section provides an introduction to the Cypher query language.

1.1. What is Cypher?

Cypher is a declarative graph query language that allows for expressive and efficient querying, updating and administering of the graph. It is designed to be suitable for both developers and operations professionals. Cypher is designed to be simple, yet powerful; highly complicated database queries can be easily expressed, enabling you to focus on your domain, instead of getting lost in database access.

Cypher is inspired by a number of different approaches and builds on established practices for expressive querying. Many of the keywords, such as `WHERE` and `ORDER BY`, are inspired by SQL. Pattern matching borrows expression approaches from SPARQL. Some of the list semantics are borrowed from languages such as Haskell and Python. Cypher's constructs, based on English prose and neat iconography, make queries easy, both to write and to read.

Structure

Cypher borrows its structure from SQL — queries are built up using various clauses.

Clauses are chained together, and they feed intermediate result sets between each other. For example, the matching variables from one `MATCH` clause will be the context that the next clause exists in.

The query language is comprised of several distinct clauses. These are discussed in more detail in the chapter on Clauses.

The following are a few examples of clauses used to read from the graph:

- `MATCH`: The graph pattern to match. This is the most common way to get data from the graph.
- `WHERE`: Not a clause in its own right, but rather part of `MATCH`, `OPTIONAL MATCH` and `WITH`. Adds constraints to a pattern, or filters the intermediate result passing through `WITH`.
- `RETURN`: What to return.

Let's see `MATCH` and `RETURN` in action.

Let's create a simple example graph with the following query:

```
CREATE (john:Person {name: 'John'})
CREATE (joe:Person {name: 'Joe'})
CREATE (steve:Person {name: 'Steve'})
CREATE (sara:Person {name: 'Sara'})
CREATE (maria:Person {name: 'Maria'})
CREATE (john)-[:FRIEND]->(joe)-[:FRIEND]->(steve)
CREATE (john)-[:FRIEND]->(sara)-[:FRIEND]->(maria)
```

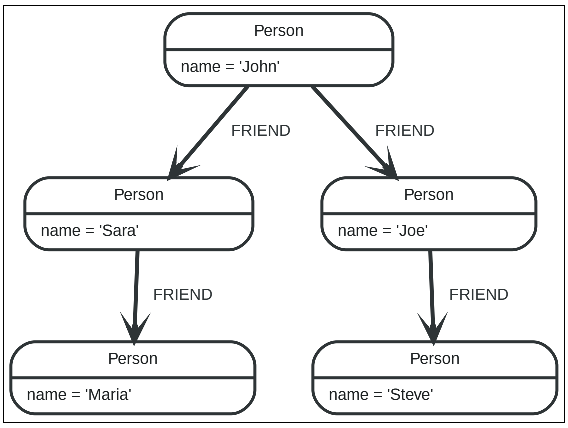


Figure 1. Example Graph

For example, here is a query which finds a user called **'John'** and **'John's'** friends (though not his direct friends) before returning both **'John'** and any friends-of-friends that are found.

```
MATCH (john {name: 'John'})-[:FRIEND]->()-[:FRIEND]->(fof)
RETURN john.name, fof.name
```

Resulting in:

```
+----------------------+
| john.name | fof.name |
+----------------------+
| "John"    | "Maria"  |
| "John"    | "Steve"  |
+----------------------+
2 rows
```

Next up we will add filtering to set more parts in motion:

We take a list of user names and find all nodes with names from this list, match their friends and return only those followed users who have a **'name'** property starting with **'S'**.

```
MATCH (user)-[:FRIEND]->(follower)
WHERE user.name IN ['Joe', 'John', 'Sara', 'Maria', 'Steve'] AND follower.name =~ 'S.*'
RETURN user.name, follower.name
```

Resulting in:

```
+---------------------------+
| user.name | follower.name |
+---------------------------+
| "Joe"     | "Steve"       |
| "John"    | "Sara"        |
+---------------------------+
2 rows
```

And these are examples of clauses that are used to update the graph:

- `CREATE` (and `DELETE`): Create (and delete) nodes and relationships.
- `SET` (and `REMOVE`): Set values to properties and add labels on nodes using `SET` and use `REMOVE` to remove them.
- `MERGE`: Match existing or create new nodes and patterns. This is especially useful together with unique constraints.

1.2. Neo4j databases and graphs

This section describes databases and graphs in Neo4j.

Cypher queries are executed against a Neo4j database, but normally apply to specific graphs. It is important to understand the meaning of these terms and exactly when a graph is not a database.

- DBMS
  - A Neo4j server is a *Database Management System* capable of containing and managing multiple databases. Client applications will connect to a database server and be able to open sessions against a particular database.
- Database
  - A database is a storage and retrieval mechanism for collecting data in a defined space on disk and in memory. A client session provides access to a single database in the DBMS. Cypher commands executed through this session will apply to the default graph within that database. It is never possible to operate against multiple databases at the same time. Transactions are specific to a database.
- Graph
  - This is a data model within a database. In Neo4j 4.0 there is only one graph within each database, and many administrative commands that refer to a specific graph do so using the database name.
  - In Neo4j 4.0 Fabric it is possible to refer to multiple graphs within the same transaction and Cypher query.

Most of the time Cypher queries are reading or updating queries which are run against a graph. There are, however, administrative commands that apply to a database, or to the entire DBMS. Such commands cannot be run in a session connected to a normal user database, but instead need to be run within a session connected to the special *system* database.

More on this requirement is described in the chapter on Administration.

1.2.1. The System Database and the Default Database

All Neo4j servers will contain a built-in database called `system` which behaves differently than all other databases. In particular, when connected to this database you can only perform a specific set of administrative functions, as described in detail in the section on administration. Most of the available administrative commands can only be run by users with specific administrative privileges. Information on configuring the security privileges is described in the Operations Manual as well as the section below on security commands.

A fresh installation of Neo4j will include two databases:

- `system` - the system database described above, containing meta-data on the DBMS and security configuration.
- `neo4j` - the default database, named using the config option `dbms.default_database=neo4j`.

1.2.2. Different editions of Neo4j

Neo4j has two editions, a commercial Enterprise Edition with additional performance and administrative features, and an open-source Community Edition. Cypher works almost identically between the two editions, and as such most of this manual will not differentiate between them. In the few cases where there is a difference in Cypher language support or behaviour between editions, these are highlighted as described below in Limited Support Features.

However it is worth listing up-front the key areas that are not supported in the open-source edition:

Feature	Enterprise	Community
Multi-database	Any number of user databases	Only `system` and one user database
Role-based security	User, Role and Privilege management for flexible access control and sub-graph access control.	Multi-user management. All users have full access rights.
Constraints	Existence constraints and multi-property `NODE KEY` constraints.	Only single property uniqueness constraints

1.2.3. Limited Support Features

Some elements of Cypher do not work in all deployments of Neo4j, and we use specific markers to highlight these cases:

Marker	Description	Example
`deprecated`	This feature is deprecated and will be removed in a future version	`DROP INDEX ON :Label(property)`
`enterprise-only`	This feature only works in the enterprise edition of Neo4j	`CREATE DATABASE foo`
`fabric`	This feature only works in a fabric deployment of Neo4j.	`USE fabric.graph(0)`

1.3. Querying, updating and administering

This section describes using Cypher for both querying and updating your graph, as well as administering graphs and databases.

In the introduction we described the common case of using Cypher to perform read-only queries of the graph. However, it is also possible to use Cypher to perform updates to the graph, import data into the graph, and perform administrative actions on graphs, databases and the entire DBMS.

All these various options are described in more detail in later sections, but it is worth summarizing a few key points first.

1.3.1. The structure of administrative queries

Cypher administrative queries cannot be combined with normal reading and writing queries. Each administrative query will perform either an update action to the `system` or a read of status information from the `system`. Some administrative commands make changes to a specific database, and will therefore be possible to run only when connected to the database of interest. Others make changes to the state of the entire DBMS and can only be run against the special `system` database. All administrative queries are described in more detail in the section on Administration.

1.3.2. The structure of update queries

If you read from the graph and then update the graph, your query implicitly has two parts — the reading is the first part, and the writing is the second part.

> A Cypher query part can either read and match on the graph, or make updates on it, not both simultaneously.

If your query only performs reads, Cypher will not actually match the pattern until you ask for the results. In an updating query, the semantics are that *all* the reading will be done before any writing is performed.

The only pattern where the query parts are implicit is when you first read and then write — any other order and you have to be explicit about your query parts. The parts are separated using the `WITH` statement. `WITH` is like an event horizon — it's a barrier between a plan and the finished execution of that plan.

When you want to filter using aggregated data, you have to chain together two reading query parts — the first one does the aggregating, and the second filters on the results coming from the first one.

```
MATCH (n {name: 'John'})-[:FRIEND]-(friend)
WITH n, count(friend) AS friendsCount
WHERE friendsCount > 3
RETURN n, friendsCount
```

Using `WITH`, you specify how you want the aggregation to happen, and that the aggregation has to be finished before Cypher can start filtering.

Here's an example of updating the graph, writing the aggregated data to the graph:

```
MATCH (n {name: 'John'})-[:FRIEND]-(friend)
WITH n, count(friend) AS friendsCount
SET n.friendsCount = friendsCount
RETURN n.friendsCount
```

You can chain together as many query parts as the available memory permits.

1.3.3. Returning data

Any query can return data. If a query only reads, it has to return data. If a read-query doesn't return any data, it serves no purpose, and is therefore not a valid Cypher query. Queries that update the graph don't have to return anything, but they can.

After all the parts of the query comes one final `RETURN` clause. `RETURN` is not part of any query part — it is a period symbol at the end of a query. The `RETURN` clause has three sub-clauses that come with it: `SKIP`/`LIMIT` and `ORDER BY`.

If you return nodes or relationships from a query that has just deleted them — beware, you are holding a pointer that is no longer valid.

1.4. Transactions

This section describes how Cypher queries work with database transactions.

All Cypher statements are explicitly run within a transaction. For read-only queries, the transaction will always succeed. For updating queries it is possible that a failure can occur for some reason, for example if the query attempts to violate a constraint, in which case the entire transaction is rolled back, and no changes are made to the graph. Every statement is executed within the context of the transaction, and nothing will be persisted to disk until that transaction is successfully committed.

In short, an updating query will always either fully succeed, or not succeed at all.

While it is not possible to run a Cypher query outside a transaction, it is possible to run multiple queries within a single transaction using the following sequence of operations:

1. Open a transaction,
2. Run multiple updating Cypher queries.
3. Commit all of them in one go.

Note that the transaction will hold the changes in memory until the whole query, or whole set of queries, has finished executing. A query that makes a large number of updates will consequently use large amounts of memory. For memory configuration in Neo4j, see the Neo4j Operations Manual → Memory configuration.

For examples of the API's used to start and commit transactions, refer to the API specific documentation:

- For information on using transactions with a Neo4j driver, see the Neo4j Driver manual → Sessions and transactions.
- For information on using transactions over the HTTP API, see the HTTP API documentation → Using the HTTP API.
- For information on using transactions within the embedded Core API, see the Java Reference → Executing Cypher queries from Java.

When writing procedures or using Neo4j embedded, remember that all iterators returned from an execution result should be either fully exhausted or closed. This ensures that the resources bound to them are properly released.

1.5. Cypher Result Uniqueness

While pattern matching, Neo4j Cypher makes sure to not include matches where the same graph relationship is found multiple times in a single path matching a particular pattern. This is called *relationship isomorphism* and is a very effective way of reducing the result set size and preventing infinite traversals. To understand this better, let's consider a few alternative options for uniqueness:

- *homomorphism*
  - No uniqueness checks are made. If the query is looking for paths of length `n` and the graph is composed of only two nodes `a` and `b`, connected by one relationship, a path of length `n` will be returned repeating the two nodes over and over. For example `MATCH p=()-[*5]-() RETURN nodes(p)` could return `[a,b,a,b,a,b]` as well as `[b,a,b,a,b,a]`.
- *node isomoprphism*
  - The same node cannot be returned more than once in the same result record. In the above two-node example, only paths of length 1 can be found. The path `[a,b,a]` would be filtered out because of duplication of node `b`, as would any other paths longer than length 1.
- *relationship isomorphism*
  - The same relationship cannot be returned more than once in the same result record. In the above two-node example, only paths of length 1 can be found. The single relationship between `a` and `b` can only exist once in the path result.

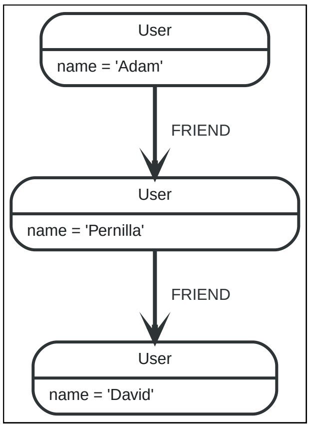
As can be seen in the above examples, in the case of variable length pattern expressions, it is particularly important to have a uniqueness check, or an infinite number of result records could be found.

Cypher makes use of *relationship isomorphism*. For example: looking for a user's friends of friends should not return said user.

To demonstrate this, let's create a few nodes and relationships:

```
CREATE (adam:User { name: 'Adam' }),(pernilla:User { name: 'Pernilla' }),(david:User { name: 'David'
  }),
  (adam)-[:FRIEND]->(pernilla),(pernilla)-[:FRIEND]->(david)
```

Which gives us the following graph:



Now let's look for friends of friends of Adam:

```
MATCH (user:User { name: 'Adam' })-[r1:FRIEND]-()-[r2:FRIEND]-(friend_of_a_friend)
RETURN friend_of_a_friend.name AS fofName
```

```
+----------+
| fofName |
+----------+
| "David" |
+----------+
1 row
```

In this query, Cypher makes sure to not return matches where the pattern relationships `r1` and `r2` point to the same graph relationship.

This is however not always desired. If the query should return the user, it is possible to spread the matching over multiple `MATCH` clauses, like so:

```
MATCH (user:User { name: 'Adam' })-[r1:FRIEND]-(friend)
MATCH (friend)-[r2:FRIEND]-(friend_of_a_friend)
RETURN friend_of_a_friend.name AS fofName
```

```
+----------+
| fofName |
+----------+
| "David" |
| "Adam"  |
+----------+
2 rows
```

Note that while the following query looks similar to the previous one, it is actually equivalent to the one before.

```
MATCH (user:User { name: 'Adam' })-[r1:FRIEND]-(friend),(friend)-[r2:FRIEND]-(friend_of_a_friend)
RETURN friend_of_a_friend.name AS fofName
```

Here, the `MATCH` clause has a single pattern with two paths, while the previous query has two distinct patterns.

```
+----------+
| fofName |
+----------+
| "David" |
+----------+
1 row
```

Chapter 2. Syntax

This section describes the syntax of the Cypher query language.

- The `[]` operator and `null`
- The `IN` operator and `null`
- Expressions that return `null`

2.1. Values and types

Cypher provides first class support for a number of data types.

These fall into several categories which will be described in detail in the following subsections:

- Property types
- Structural types
- Composite types

2.1.1. Property types

- Can be returned from Cypher queries
- Can be used as parameters
- Can be stored as properties
- Can be constructed with Cypher literals

Property types comprise:

- Number, an abstract type, which has the subtypes *Integer* and *Float*
- String
- Boolean
- The spatial type *Point*
- Temporal types: *Date*, *Time*, *LocalTime*, *DateTime*, *LocalDateTime* and *Duration*

The adjective *numeric*, when used in the context of describing Cypher functions or expressions, indicates that any type of Number applies (Integer or Float).

Homogeneous lists of simple types can also be stored as properties, although lists in general (see Composite types) cannot be stored.

Cypher also provides pass-through support for byte arrays, which can be stored as property values. Byte arrays are *not* considered a first class data type by Cypher, so do not have a literal representation.

Sorting of special characters

Strings that contain characters that do not belong to the *Basic Multilingual Plane* (*BMP*) can have inconsistent or non-deterministic ordering in Neo4j. BMP is a subset of all characters defined in Unicode. Expressed simply, it contains all common characters from all common languages.

The most significant characters *not* in BMP are those belonging to the *Supplementary Multilingual Plane* or the *Supplementary Ideographic Plane*. Examples are:

- Historic scripts and symbols and notation used within certain fields such as: Egyptian hieroglyphs, modern musical notation, mathematical alphanumerics.
- Emojis and other pictographic sets.
- Game symbols for playing cards, Mah Jongg, and dominoes.
- CJK Ideograph that were not included in earlier character encoding standards.

2.1.2. Structural types

▯ Can be returned from Cypher queries

▯ Cannot be used as parameters

▯ Cannot be stored as properties

▯ Cannot be constructed with Cypher literals

Structural types comprise:

- Nodes, comprising:
  - ▯ Id
  - ▯ Label(s)
  - ▯ Map (of properties)
- Relationships, comprising:
  - ▯ Id
  - ▯ Type
  - ▯ Map (of properties)
  - ▯ Id of the start and end nodes
- Paths
  - ▯ An alternating sequence of nodes and relationships

Nodes, relationships, and paths are returned as a result of pattern matching.

Labels are not values but are a form of pattern syntax.

2.1.3. Composite types

▯ Can be returned from Cypher queries

▯ Can be used as parameters

▯ Cannot be stored as properties

▯ Can be constructed with Cypher literals

Composite types comprise:

- **Lists** are heterogeneous, ordered collections of values, each of which has any property, structural or composite type.
- **Maps** are heterogeneous, unordered collections of (key, value) pairs, where:
  - the key is a String
  - the value has any property, structural or composite type

> Composite values can also contain `null`.

Special care must be taken when using `null` (see Working with `null`).

2.2. Naming rules and recommendations

We describe here rules and recommendations for the naming of node labels, relationship types, property names and variables.

2.2.1. Naming rules

- Must begin with an alphabetic letter.
  - This includes "non-English" characters, such as `å`, `ä`, `ö`, `ü` etc.
  - If a leading non-alphabetic character is required, use backticks for escaping; e.g. `` `^n` ``.
- Can contain numbers, but not as the first character.
  - To illustrate, `1first` is not allowed, whereas `first1` is allowed.
  - If a leading numeric character is required, use backticks for escaping; e.g. `` `1first` ``.
- Cannot contain symbols.
  - An exception to this rule is using underscore, as given by `my_variable`.
  - An ostensible exception to this rule is using `$` as the first character to denote a parameter, as given by `$myParam`.
  - If a leading symbolic character is required, use backticks for escaping; e.g. `` `$$n` ``.
- Can be very long, up to `65535` (`2^16 - 1`) or `65534` characters, depending on the version of Neo4j.
- Are case-sensitive.
  - Thus, `:PERSON`, `:Person` and `:person` are three different labels, and `n` and `N` are two different variables.
- Whitespace characters:
  - Leading and trailing whitespace characters will be removed automatically. For example, `MATCH ( a ) RETURN a` is equivalent to `MATCH (a) RETURN a`.
  - If spaces are required within a name, use backticks for escaping; e.g. `` `my variable has spaces` ``.

2.2.2. Scoping and namespace rules

- Node labels, relationship types and property names may re-use names.
  - The following query — with `a` for the label, type and property name — is valid: `CREATE (a:a {a: 'a'})-[r:a]→(b:a {a: 'a'})`.

- Variables for nodes and relationships must not re-use names within the same query scope.
    - The following query is not valid as the node and relationship both have the name `a`: `CREATE (a)-[a]→(b)`.

2.2.3. Recommendations

Here are the naming conventions we recommend using:

Node labels	Camel case, beginning with an upper-case character	`:VehicleOwner` rather than `:vehice_owner` etc.
Relationship types	Upper case, using underscore to separate words	`:OWNS_VEHICLE` rather than `:ownsVehicle` etc

2.3. Expressions

- Expressions in general
- Note on string literals
- `CASE` expressions
    - Simple `CASE` form: comparing an expression against multiple values
    - Generic `CASE` form: allowing for multiple conditionals to be expressed
    - Distinguishing between when to use the simple and generic `CASE` forms

2.3.1. Expressions in general

> Most expressions in Cypher evaluate to `null` if any of their inner expressions are `null`. Notable exceptions are the operators `IS NULL` and `IS NOT NULL`.

An expression in Cypher can be:

- A decimal (integer or float) literal: `13`, `-40000`, `3.14`, `6.022E23`.
- A hexadecimal integer literal (starting with `0x`): `0x13af`, `0xFC3A9`, `-0x66eff`.
- An octal integer literal (starting with `0`): `01372`, `02127`, `-05671`.
- A string literal: `'Hello'`, `"World"`.
- A boolean literal: `true`, `false`, `TRUE`, `FALSE`.
- A variable: `n`, `x`, `rel`, `myFancyVariable`, ``` `A name with weird stuff in it[]!` ```.
- A property: `n.prop`, `x.prop`, `rel.thisProperty`, ``` myFancyVariable.`(weird property name)` ```.
- A dynamic property: `n["prop"]`, `rel[n.city + n.zip]`, `map[coll[0]]`.
- A parameter: `$param`, `$0`
- A list of expressions: `['a', 'b']`, `[1, 2, 3]`, `['a', 2, n.property, $param]`, `[ ]`.
- A function call: `length(p)`, `nodes(p)`.
- An aggregate function: `avg(x.prop)`, `count(*)`.
- A path-pattern: `(a)-->()<--(b)`.
- An operator application: `1 + 2` and `3 < 4`.
- A predicate expression is an expression that returns true or false: `a.prop = 'Hello'`, `length(p) > 10`, `exists(a.name)`.

- An existential subquery is an expression that returns true or false: `EXISTS { MATCH (n)-[r]→(p) WHERE p.name = 'Sven' }`.
- A regular expression: `a.name =~ 'Tim.*'`
- A case-sensitive string matching expression: `a.surname STARTS WITH 'Sven'`, `a.surname ENDS WITH 'son'` or `a.surname CONTAINS 'son'`
- A `CASE` expression.

2.3.2. Note on string literals

String literals can contain the following escape sequences:

Escape sequence	Character
`\t`	Tab
`\b`	Backspace
`\n`	Newline
`\r`	Carriage return
`\f`	Form feed
`\'`	Single quote
`\"`	Double quote
`\\`	Backslash
`\uxxxx`	Unicode UTF-16 code point (4 hex digits must follow the `\u`)
`\Uxxxxxxxx`	Unicode UTF-32 code point (8 hex digits must follow the `\U`)

2.3.3. `CASE` expressions

Generic conditional expressions may be expressed using the well-known `CASE` construct. Two variants of `CASE` exist within Cypher: the simple form, which allows an expression to be compared against multiple values, and the generic form, which allows multiple conditional statements to be expressed.

The following graph is used for the examples below:

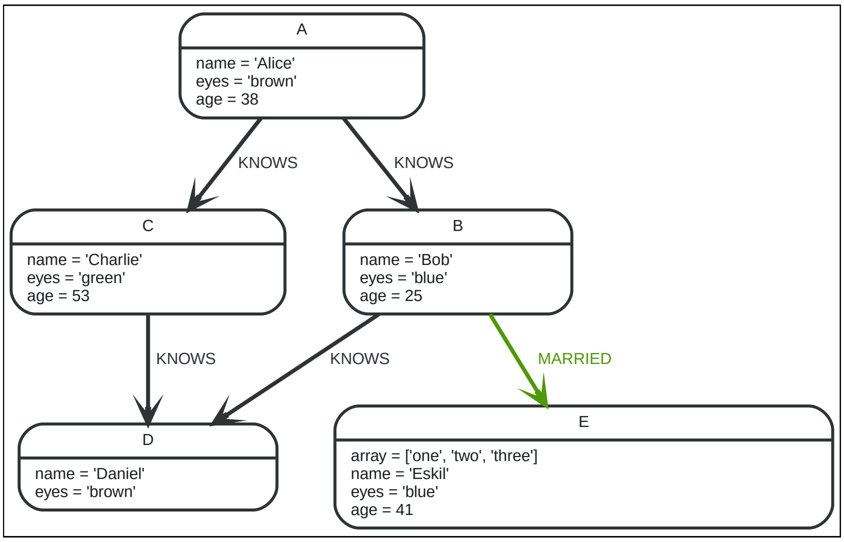


Figure 2. Graph

Simple `CASE` form: comparing an expression against multiple values

The expression is calculated, and compared in order with the `WHEN` clauses until a match is found. If no match is found, the expression in the `ELSE` clause is returned. However, if there is no `ELSE` case and no match is found, `null` will be returned.

Syntax:

```
CASE test
 WHEN value THEN result
  [WHEN ...]
  [ELSE default]
END
```

Arguments:

Name	Description
`test`	A valid expression.
`value`	An expression whose result will be compared to `test`.
`result`	This is the expression returned as output if `value` matches `test`.
`default`	If no match is found, `default` is returned.

Query

```
MATCH (n)
RETURN
CASE n.eyes
WHEN 'blue'
THEN 1
WHEN 'brown'
THEN 2
ELSE 3 END AS result
```

Table 1. Result

result
2
1
3
2
1
5 rows

Generic `CASE` form: allowing for multiple conditionals to be expressed

The predicates are evaluated in order until a `true` value is found, and the result value is used. If no match is found, the expression in the `ELSE` clause is returned. However, if there is no `ELSE` case and no match is found, `null` will be returned.

Syntax:

```
CASE
WHEN predicate THEN result
  [WHEN ...]
  [ELSE default]
END
```

Arguments:

Name	Description
`predicate`	A predicate that is tested to find a valid alternative.
`result`	This is the expression returned as output if `predicate` evaluates to `true`.
`default`	If no match is found, `default` is returned.

Query

```
MATCH (n)
RETURN
CASE
WHEN n.eyes = 'blue'
THEN 1
WHEN n.age < 40
THEN 2
ELSE 3 END AS result
```

Table 2. Result

result
`2`
`1`
`3`
`3`
`1`
5 rows

Distinguishing between when to use the simple and generic `CASE` forms

Owing to the close similarity between the syntax of the two forms, sometimes it may not be clear at the outset as to which form to use. We illustrate this scenario by means of the following query, in which there is an expectation that `age_10_years_ago` is `-1` if `n.age` is `null`:

Query

```
MATCH (n)
RETURN n.name,
CASE n.age
WHEN n.age IS NULL THEN -1
ELSE n.age - 10 END AS age_10_years_ago
```

However, as this query is written using the simple `CASE` form, instead of `age_10_years_ago` being `-1` for the node named `Daniel`, it is `null`. This is because a comparison is made between `n.age` and `n.age IS NULL`. As `n.age IS NULL` is a boolean value, and `n.age` is an integer value, the `WHEN n.age IS NULL THEN -1` branch is never taken. This results in the `ELSE n.age - 10` branch being taken instead, returning `null`.

Table 3. Result

n.name	age_10_years_ago
"Alice"	28
"Bob"	15
"Charlie"	43
"Daniel"	<null>
"Eskil"	31
5 rows	

The corrected query, behaving as expected, is given by the following generic CASE form:

Query

```
MATCH (n)
RETURN n.name,
CASE
WHEN n.age IS NULL THEN -1
ELSE n.age - 10 END AS age_10_years_ago
```

We now see that the age_10_years_ago correctly returns -1 for the node named Daniel.

Table 4. Result

n.name	age_10_years_ago
"Alice"	28
"Bob"	15
"Charlie"	43
"Daniel"	-1
"Eskil"	31
5 rows	

2.4. Variables

When you reference parts of a pattern or a query, you do so by naming them. The names you give the different parts are called variables.

In this example:

```
MATCH (n)-->(b)
RETURN b
```

The variables are n and b.

Information regarding the naming of variables may be found here.

Variables are only visible in the same query part

Variables are not carried over to subsequent queries. If multiple query parts are chained together using WITH, variables have to be listed in the WITH clause to be carried over to the next part. For more information see WITH.

2.5. Reserved keywords

We provide here a listing of reserved words, grouped by the categories from which they are drawn, all of which have a special meaning in Cypher. In addition to this, we list a number of words that are reserved for future use.

These reserved words are not permitted to be used as identifiers in the following contexts:

- Variables
- Function names
- Parameters

If any reserved keyword is escaped — i.e. is encapsulated by backticks `` ` ``, such as `` `AND` `` — it would become a valid identifier in the above contexts.

2.5.1. Clauses

- `CALL`
- `CREATE`
- `DELETE`
- `DETACH`
- `EXISTS`
- `FOREACH`
- `LOAD`
- `MATCH`
- `MERGE`
- `OPTIONAL`
- `REMOVE`
- `RETURN`
- `SET`
- `START`
- `UNION`
- `UNWIND`
- `WITH`

2.5.2. Subclauses

- `LIMIT`
- `ORDER`
- `SKIP`
- `WHERE`
- `YIELD`

2.5.3. Modifiers

- `ASC`

- `ASCENDING`
- `ASSERT`
- `BY`
- `CSV`
- `DESC`
- `DESCENDING`
- `ON`

2.5.4. Expressions

- `ALL`
- `CASE`
- `ELSE`
- `END`
- `THEN`
- `WHEN`

2.5.5. Operators

- `AND`
- `AS`
- `CONTAINS`
- `DISTINCT`
- `ENDS`
- `IN`
- `IS`
- `NOT`
- `OR`
- `STARTS`
- `XOR`

2.5.6. Schema

- `CONSTRAINT`
- `CREATE`
- `DROP`
- `EXISTS`
- `INDEX`
- `NODE`
- `KEY`
- `UNIQUE`

2.5.7. Hints

- `INDEX`
- `JOIN`
- `PERIODIC`
- `COMMIT`
- `SCAN`
- `USING`

2.5.8. Literals

- `false`
- `null`
- `true`

2.5.9. Reserved for future use

- `ADD`
- `DO`
- `FOR`
- `MANDATORY`
- `OF`
- `REQUIRE`
- `SCALAR`

2.6. Parameters

- Introduction
- String literal
- Regular expression
- Case-sensitive string pattern matching
- Create node with properties
- Create multiple nodes with properties
- Setting all properties on a node
- `SKIP` and `LIMIT`
- Node id
- Multiple node ids
- Calling procedures

2.6.1. Introduction

Cypher supports querying with parameters. This means developers don’t have to resort to string building to create a query. Additionally, parameters make caching of execution plans much easier for Cypher, thus leading to faster query execution times.

Parameters can be used for:

- literals and expressions
- node and relationship ids

Parameters cannot be used for the following constructs, as these form part of the query structure that is compiled into a query plan:

- property keys; so, `MATCH (n) WHERE n.$param = 'something'` is invalid
- relationship types
- labels

Parameters may consist of letters and numbers, and any combination of these, but cannot start with a number or a currency symbol.

Setting parameters when running a query is dependent on the client environment. For example:

- To set a parameter in Cypher Shell use `:param name => 'Joe'`. For more information refer to Operations Manual Cypher Shell - Query Parameters.
- For Neo4j Browser use the same syntax as Cypher Shell, `:param name => 'Joe'`.
- When using drivers, the syntax is dependent on the language choice. See the examples in Driver Manual Transactions.
- For usage via the Neo4j HTTP API, see the HTTP API documentation.

We provide below a comprehensive list of examples of parameter usage. In these examples, parameters are given in JSON; the exact manner in which they are to be submitted depends upon the driver being used.

The old parameter syntax `{param}` was deprecated in Neo4j 3.0 and removed entirely in Neo4j 4.0. Using it will result in a syntax error. However, it is still possible to use it, with warnings, if you prefix the query with `CYPHER 3.5`. See Cypher Compatibility for further information.

2.6.2. String literal

Parameters

```
{
  "name" : "Johan"
}
```

Query

```
MATCH (n:Person)
WHERE n.name = $name
RETURN n
```

You can use parameters in this syntax as well:

Parameters

```
{
  "name" : "Johan"
}
```

Query

```
MATCH (n:Person { name: $name })
RETURN n
```

2.6.3. Regular expression

Parameters

```
{
  "regex" : ".*h.*"
}
```

Query

```
MATCH (n:Person)
WHERE n.name =~ $regex
RETURN n.name
```

2.6.4. Case-sensitive string pattern matching

Parameters

```
{
  "name" : "Michael"
}
```

Query

```
MATCH (n:Person)
WHERE n.name STARTS WITH $name
RETURN n.name
```

2.6.5. Create node with properties

Parameters

```
{
  "props" : {
    "name" : "Andy",
    "position" : "Developer"
  }
}
```

Query

```
CREATE ($props)
```

2.6.6. Create multiple nodes with properties

Parameters

```
{
  "props" : [ {
    "awesome" : true,
    "name" : "Andy",
    "position" : "Developer"
  }, {
    "children" : 3,
    "name" : "Michael",
    "position" : "Developer"
  } ]
}
```

Query

```
UNWIND $props AS properties
CREATE (n:Person)
SET n = properties
RETURN n
```

2.6.7. Setting all properties on a node

Note that this will replace all the current properties.

Parameters

```
{
  "props" : {
    "name" : "Andy",
    "position" : "Developer"
  }
}
```

Query

```
MATCH (n:Person)
WHERE n.name='Michaela'
SET n = $props
```

2.6.8. `SKIP` and `LIMIT`

Parameters

```
{
  "s" : 1,
  "l" : 1
}
```

Query

```
MATCH (n:Person)
RETURN n.name
SKIP $s
LIMIT $l
```

2.6.9. Node id

Parameters

```
{
  "id" : 0
}
```

Query

```
MATCH (n)
WHERE id(n)= $id
RETURN n.name
```

2.6.10. Multiple node ids

Parameters

```
{
  "ids" : [ 0, 1, 2 ]
}
```

Query

```
MATCH (n)
WHERE id(n) IN $ids
RETURN n.name
```

2.6.11. Calling procedures

Parameters

```
{
  "indexname" : "My index"
}
```

Query

```
CALL db.resampleIndex($indexname)
```

2.7. Operators

- Comparison operators
  - Comparing two numbers
  - Using `STARTS WITH` to filter names
- Boolean operators
  - Using boolean operators to filter numbers
- String operators
  - Using a regular expression with `=~` to filter words
- Temporal operators
  - Adding and subtracting a *Duration* to or from a temporal instant
  - Adding and subtracting a *Duration* to or from another *Duration*
  - Multiplying and dividing a *Duration* with or by a number
- Map operators
  - Statically accessing the value of a nested map by key using the `.` operator"
  - Dynamically accessing the value of a map by key using the `[]` operator and a parameter
  - Using `IN` with `[]` on a nested list
- List operators
  - Concatenating two lists using `+`
  - Using `IN` to check if a number is in a list
  - Using `IN` for more complex list membership operations
  - Accessing elements in a list using the `[]` operator
  - Dynamically accessing an element in a list using the `[]` operator and a parameter
- Equality and comparison of values
- Ordering and comparison of values
- Chaining comparison operations

2.7.1. Operators at a glance

Aggregation operators	`DISTINCT`
Property operators	`.` for static property access, `[]` for dynamic property access, `=` for replacing all properties, `+=` for mutating specific properties
Mathematical operators	`+`, `-`, `*`, `/`, `%`, `^`
Comparison operators	`=`, `<>`, `<`, `>`, `<=`, `>=`, `IS NULL`, `IS NOT NULL`
String-specific comparison operators	`STARTS WITH`, `ENDS WITH`, `CONTAINS`
Boolean operators	`AND`, `OR`, `XOR`, `NOT`
String operators	`+` for concatenation, `=~` for regex matching
Temporal operators	`+` and `-` for operations between durations and temporal instants/durations, `*` and `/` for operations between durations and numbers
Map operators	`.` for static value access by key, `[]` for dynamic value access by key
List operators	`+` for concatenation, `IN` to check existence of an element in a list, `[]` for accessing element(s) dynamically

2.7.2. Aggregation operators

The aggregation operators comprise:

- remove duplicates values: `DISTINCT`

Using the `DISTINCT` operator

Retrieve the unique eye colors from `Person` nodes.

Query

```
CREATE (a:Person { name: 'Anne', eyeColor: 'blue' }),(b:Person { name: 'Bill', eyeColor: 'brown'
}),(c:Person { name: 'Carol', eyeColor: 'blue' })
WITH [a, b, c] AS ps
UNWIND ps AS p
RETURN DISTINCT p.eyeColor
```

Even though both **'Anne'** and **'Carol'** have blue eyes, **'blue'** is only returned once.

Table 5. Result

p.eyeColor
"blue"
"brown"
2 rows, Nodes created: 3 Properties set: 6 Labels added: 3

`DISTINCT` is commonly used in conjunction with aggregating functions.

2.7.3. Property operators

The property operators pertain to a node or a relationship, and comprise:

- statically access the property of a node or relationship using the dot operator: `.`
- dynamically access the property of a node or relationship using the subscript operator: `[]`
- property replacement `=` for replacing all properties of a node or relationship
- property mutation operator `+=` for setting specific properties of a node or relationship

Statically accessing a property of a node or relationship using the `.` operator

Query

```
CREATE (a:Person { name: 'Jane', livesIn: 'London' }),(b:Person { name: 'Tom', livesIn: 'Copenhagen' })
WITH a, b
MATCH (p:Person)
RETURN p.name
```

Table 6. Result

p.name
"Jane"
"Tom"

p.name
2 rows, Nodes created: 2 Properties set: 4 Labels added: 2

Filtering on a dynamically-computed property key using the `[]` operator

Query

```
CREATE (a:Restaurant { name: 'Hungry Jo', rating_hygiene: 10, rating_food: 7 }),(b:Restaurant { name:
'Buttercup Tea Rooms', rating_hygiene: 5, rating_food: 6 }),(c1:Category { name: 'hygiene' }),(c2:Category
{ name: 'food' })
WITH a, b, c1, c2
MATCH (restaurant:Restaurant),(category:Category)
WHERE restaurant["rating_" + category.name]> 6
RETURN DISTINCT restaurant.name
```

Table 7. Result

restaurant.name
"Hungry Jo"
1 row, Nodes created: 4 Properties set: 8 Labels added: 4

See Basic usage for more details on dynamic property access.

The behavior of the `[]` operator with respect to `null` is detailed here.

Replacing all properties of a node or relationship using the `=` operator

Query

```
CREATE (a:Person { name: 'Jane', age: 20 })
WITH a
MATCH (p:Person { name: 'Jane' })
SET p = { name: 'Ellen', livesIn: 'London' }
RETURN p.name, p.age, p.livesIn
```

All the existing properties on the node are replaced by those provided in the map; i.e. the `name` property is updated from `Jane` to `Ellen`, the `age` property is deleted, and the `livesIn` property is added.

Table 8. Result

p.name	p.age	p.livesIn
"Ellen"	<null>	"London"
1 row, Nodes created: 1 Properties set: 5 Labels added: 1		

See Replace all properties using a map and `=` for more details on using the property replacement operator `=`.

Mutating specific properties of a node or relationship using the `+=` operator

Query

```
CREATE (a:Person { name: 'Jane', age: 20 })
WITH a
MATCH (p:Person { name: 'Jane' })
SET p += { name: 'Ellen', livesIn: 'London' }
RETURN p.name, p.age, p.livesIn
```

The properties on the node are updated as follows by those provided in the map: the `name` property is updated from `Jane` to `Ellen`, the `age` property is left untouched, and the `livesIn` property is added.

Table 9. Result

p.name	p.age	p.livesIn
`"Ellen"`	`20`	`"London"`
1 row, Nodes created: 1 Properties set: 4 Labels added: 1		

See Mutate specific properties using a map and `+=` for more details on using the property mutation operator `+=`.

2.7.4. Mathematical operators

The mathematical operators comprise:

- addition: `+`
- subtraction or unary minus: `-`
- multiplication: `*`
- division: `/`
- modulo division: `%`
- exponentiation: `^`

Using the exponentiation operator `^`

Query

```
WITH 2 AS number, 3 AS exponent
RETURN number ^ exponent AS result
```

Table 10. Result

result
`8.0`
1 row

Using the unary minus operator `-`

Query

```
WITH -3 AS a, 4 AS b
RETURN b - a AS result
```

Table 11. Result

result
7
1 row

2.7.5. Comparison operators

The comparison operators comprise:

- equality: `=`
- inequality: `<>`
- less than: `<`
- greater than: `>`
- less than or equal to: `<=`
- greater than or equal to: `>=`
- `IS NULL`
- `IS NOT NULL`

String-specific comparison operators comprise:

- `STARTS WITH`: perform case-sensitive prefix searching on strings
- `ENDS WITH`: perform case-sensitive suffix searching on strings
- `CONTAINS`: perform case-sensitive inclusion searching in strings

Comparing two numbers

Query

```
WITH 4 AS one, 3 AS two
RETURN one > two AS result
```

Table 12. Result

result
true
1 row

See Equality and comparison of values for more details on the behavior of comparison operators, and Using ranges for more examples showing how these may be used.

Using `STARTS WITH` to filter names

Query

```
WITH ['John', 'Mark', 'Jonathan', 'Bill'] AS somenames
UNWIND somenames AS names
WITH names AS candidate
WHERE candidate STARTS WITH 'Jo'
RETURN candidate
```

Table 13. Result

candidate
"John"
"Jonathan"
2 rows

String matching contains more information regarding the string-specific comparison operators as well as additional examples illustrating the usage thereof.

2.7.6. Boolean operators

The boolean operators — also known as logical operators — comprise:

- conjunction: AND
- disjunction: OR,
- exclusive disjunction: XOR
- negation: NOT

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

Using boolean operators to filter numbers

Query

```
WITH [2, 4, 7, 9, 12] AS numberlist
UNWIND numberlist AS number
WITH number
WHERE number = 4 OR (number > 6 AND number < 10)
RETURN number
```

Table 14. Result

number
4
7
9
3 rows

2.7.7. String operators

The string operators comprise:

- concatenating strings: `+`
- matching a regular expression: `=~`

Using a regular expression with `=~` to filter words

Query

```
WITH ['mouse', 'chair', 'door', 'house'] AS wordlist
UNWIND wordlist AS word
WITH word
WHERE word =~ '.*ous.*'
RETURN word
```

Table 15. Result

word
"mouse"
"house"
2 rows

Further information and examples regarding the use of regular expressions in filtering can be found in Regular expressions. In addition, refer to String-specific comparison operators comprise: for details on string-specific comparison operators.

2.7.8. Temporal operators

Temporal operators comprise:

- adding a *Duration* to either a temporal instant or another *Duration*: `+`
- subtracting a *Duration* from either a temporal instant or another *Duration*: `-`
- multiplying a *Duration* with a number: `*`
- dividing a *Duration* by a number: `/`

The following table shows — for each combination of operation and operand type — the type of the value returned from the application of each temporal operator:

Operator	Left-hand operand	Right-hand operand	Type of result
`+`	Temporal instant	*Duration*	The type of the temporal instant
`+`	*Duration*	Temporal instant	The type of the temporal instant
`-`	Temporal instant	*Duration*	The type of the temporal instant
`+`	*Duration*	*Duration*	*Duration*
`-`	*Duration*	*Duration*	*Duration*
`*`	*Duration*	Number	*Duration*
`*`	Number	*Duration*	*Duration*
`/`	*Duration*	Number	*Duration*

Adding and subtracting a *Duration* to or from a temporal instant

Query

```
WITH localdatetime({ year:1984, month:10, day:11, hour:12, minute:31, second:14 }) AS aDateTime,
duration({ years: 12, nanoseconds: 2 }) AS aDuration
RETURN aDateTime + aDuration, aDateTime - aDuration
```

Table 16. Result

aDateTime + aDuration	aDateTime - aDuration
1996-10-11T12:31:14.000000002	1972-10-11T12:31:13.999999998
1 row	

Components of a *Duration* that do not apply to the temporal instant are ignored. For example, when adding a *Duration* to a *Date*, the *hours*, *minutes*, *seconds* and *nanoseconds* of the *Duration* are ignored (*Time* behaves in an analogous manner):

Query

```
WITH date({ year:1984, month:10, day:11 }) AS aDate, duration({ years: 12, nanoseconds: 2 }) AS aDuration
RETURN aDate + aDuration, aDate - aDuration
```

Table 17. Result

aDate + aDuration	aDate - aDuration
1996-10-11	1972-10-11
1 row	

Adding two durations to a temporal instant is not an associative operation. This is because non-existing dates are truncated to the nearest existing date:

Query

```
RETURN (date("2011-01-31")+ duration("P1M"))+ duration("P12M") AS date1, date("2011-01-
31")+(duration("P1M")+ duration("P12M")) AS date2
```

Table 18. Result

date1	date2
2012-02-28	2012-02-29
1 row	

Adding and subtracting a *Duration* to or from another *Duration*

Query

```
WITH duration({ years: 12, months: 5, days: 14, hours: 16, minutes: 12, seconds: 70, nanoseconds: 1 }) AS
duration1, duration({ months:1, days: -14, hours: 16, minutes: -12, seconds: 70 }) AS duration2
RETURN duration1, duration2, duration1 + duration2, duration1 - duration2
```

Table 19. Result

duration1	duration2	duration1 + duration2	duration1 - duration2
P12Y5M14DT16H13M10.000000001S	P1M-14DT15H49M10S	P12Y6MT32H2M20.000000001S	P12Y4M28DT24M0.000000001S

duration1	duration2	duration1 + duration2	duration1 - duration2
1 row			

Multiplying and dividing a *Duration* with or by a number

These operations are interpreted simply as component-wise operations with overflow to smaller units based on an average length of units in the case of division (and multiplication with fractions).

Query

```
WITH duration({ days: 14, minutes: 12, seconds: 70, nanoseconds: 1 }) AS aDuration
RETURN aDuration, aDuration * 2, aDuration / 3
```

Table 20. Result

aDuration	aDuration * 2	aDuration / 3
P14DT13M10.000000001S	P28DT26M20.000000002S	P4DT16H4M23.333333333S
1 row		

2.7.9. Map operators

The map operators comprise:

- statically access the value of a map by key using the dot operator: `.`
- dynamically access the value of a map by key using the subscript operator: `[]`

The behavior of the `[]` operator with respect to `null` is detailed in The `[]` operator and `null`.

Statically accessing the value of a nested map by key using the `.` operator

Query

```
WITH { person: { name: 'Anne', age: 25 }} AS p
RETURN p.person.name
```

Table 21. Result

p.person.name
"Anne"
1 row

Dynamically accessing the value of a map by key using the `[]` operator and a parameter

A parameter may be used to specify the key of the value to access:

Parameters

```
{
  "myKey" : "name"
}
```

Query

```
WITH { name: 'Anne', age: 25 } AS a
RETURN a[$myKey] AS result
```

Table 22. Result

result
"Anne"
1 row

More details on maps can be found in Maps.

2.7.10. List operators

The list operators comprise:

- concatenating lists `l₁` and `l₂`: `[l₁] + [l₂]`
- checking if an element `e` exists in a list `l`: `e IN [l]`
- dynamically accessing an element(s) in a list using the subscript operator: `[]`

The behavior of the `IN` and `[]` operators with respect to `null` is detailed here.

Concatenating two lists using `+`

Query

```
RETURN [1,2,3,4,5]+[6,7] AS myList
```

Table 23. Result

myList
[1,2,3,4,5,6,7]
1 row

Using `IN` to check if a number is in a list

Query

```
WITH [2, 3, 4, 5] AS numberlist
UNWIND numberlist AS number
WITH number
WHERE number IN [2, 3, 8]
RETURN number
```

Table 24. Result

number
2
3
2 rows

Using `IN` for more complex list membership operations

The general rule is that the `IN` operator will evaluate to `true` if the list given as the right-hand operand contains an element which has the same *type and contents (or value)* as the left-hand operand. Lists are only comparable to other lists, and elements of a list `innerList` are compared pairwise in ascending order from the first element in `innerList` to the last element in `innerList`.

The following query checks whether or not the list `[2, 1]` is an element of the list `[1, [2, 1], 3]`:

Query

```
RETURN [2, 1] IN [1,[2, 1], 3] AS inList
```

The query evaluates to `true` as the right-hand list contains, as an element, the list `[1, 2]` which is of the same type (a list) and contains the same contents (the numbers `2` and `1` in the given order) as the left-hand operand. If the left-hand operator had been `[1, 2]` instead of `[2, 1]`, the query would have returned `false`.

Table 25. Result

inList
`true`
1 row

At first glance, the contents of the left-hand operand and the right-hand operand *appear* to be the same in the following query:

Query

```
RETURN [1, 2] IN [1, 2] AS inList
```

However, `IN` evaluates to `false` as the right-hand operand does not contain an element that is of the same *type* — i.e. a *list* — as the left-hand-operand.

Table 26. Result

inList
`false`
1 row

The following query can be used to ascertain whether or not a list — obtained from, say, the labels() function — contains at least one element that is also present in another list:

```
MATCH (n)
WHERE size([label IN labels(n) WHERE label IN ['Person', 'Employee'] | 1]) > 0
RETURN count(n)
```

As long as `labels(n)` returns either `Person` or `Employee` (or both), the query will return a value greater than zero.

Accessing elements in a list using the `[]` operator

Query

```
WITH ['Anne', 'John', 'Bill', 'Diane', 'Eve'] AS names
RETURN names[1..3] AS result
```

The square brackets will extract the elements from the start index `1`, and up to (but excluding) the end index `3`.

Table 27. Result

result
`["John","Bill"]`
1 row

Dynamically accessing an element in a list using the `[]` operator and a parameter

A parameter may be used to specify the index of the element to access:

Parameters

```
{
  "myIndex" : 1
}
```

Query

```
WITH ['Anne', 'John', 'Bill', 'Diane', 'Eve'] AS names
RETURN names[$myIndex] AS result
```

Table 28. Result

result
`"John"`
1 row

Using `IN` with `[]` on a nested list

`IN` can be used in conjunction with `[]` to test whether an element exists in a nested list:

Parameters

```
{
  "myIndex" : 1
}
```

Query

```
WITH [[1, 2, 3]] AS l
RETURN 3 IN l[0] AS result
```

Table 29. Result

result
`true`
1 row

More details on lists can be found in Lists in general.

2.7.11. Equality and comparison of values

Equality

Cypher supports comparing values (see Values and types) by equality using the `=` and `<>` operators.

Values of the same type are only equal if they are the same identical value (e.g. `3 = 3` and `"x" <> "xy"`).

Maps are only equal if they map exactly the same keys to equal values and lists are only equal if they contain the same sequence of equal values (e.g. `[3, 4] = [1+2, 8/2]`).

Values of different types are considered as equal according to the following rules:

- Paths are treated as lists of alternating nodes and relationships and are equal to all lists that contain that very same sequence of nodes and relationships.
- Testing any value against `null` with both the `=` and the `<>` operators always is `null`. This includes `null = null` and `null <> null`. The only way to reliably test if a value `v` is `null` is by using the special `v IS NULL`, or `v IS NOT NULL` equality operators.

All other combinations of types of values cannot be compared with each other. Especially, nodes, relationships, and literal maps are incomparable with each other.

It is an error to compare values that cannot be compared.

2.7.12. Ordering and comparison of values

The comparison operators `<=`, `<` (for ascending) and `>=`, `>` (for descending) are used to compare values for ordering. The following points give some details on how the comparison is performed.

- Numerical values are compared for ordering using numerical order (e.g. `3 < 4` is true).
- The special value `java.lang.Double.NaN` is regarded as being larger than all other numbers.
- String values are compared for ordering using lexicographic order (e.g. `"x" < "xy"`).
- Boolean values are compared for ordering such that `false < true`.
- **Comparison** of spatial values:
  - Point values can only be compared within the same Coordinate Reference System (CRS) — otherwise, the result will be `null`.
  - For two points `a` and `b` within the same CRS, `a` is considered to be greater than `b` if `a.x > b.x` and `a.y > b.y` (and `a.z > b.z` for 3D points).
  - `a` is considered less than `b` if `a.x < b.x` and `a.y < b.y` (and `a.z < b.z` for 3D points).
  - If none if the above is true, the points are considered incomparable and any comparison operator between them will return `null`.
- **Ordering** of spatial values:
  - `ORDER BY` requires all values to be orderable.
  - Points are ordered after arrays and before temporal types.
  - Points of different CRS are ordered by the CRS code (the value of SRID field). For the currently supported set of Coordinate Reference Systems this means the order: 4326, 4979, 7302, 9157
  - Points of the same CRS are ordered by each coordinate value in turn, `x` first, then `y` and finally `z`.
  - Note that this order is different to the order returned by the spatial index, which will be the

order of the space filling curve.

- **Comparison** of temporal values:
  - Temporal instant values are comparable within the same type. An instant is considered less than another instant if it occurs before that instant in time, and it is considered greater than if it occurs after.
  - Instant values that occur at the same point in time — but that have a different time zone — are not considered equal, and must therefore be ordered in some predictable way. Cypher prescribes that, after the primary order of point in time, instant values be ordered by effective time zone offset, from west (negative offset from UTC) to east (positive offset from UTC). This has the effect that times that represent the same point in time will be ordered with the time with the earliest local time first. If two instant values represent the same point in time, and have the same time zone offset, but a different named time zone (this is possible for *DateTime* only, since *Time* only has an offset), these values are not considered equal, and ordered by the time zone identifier, alphabetically, as its third ordering component.
  - *Duration* values cannot be compared, since the length of a *day*, *month* or *year* is not known without knowing which *day*, *month* or *year* it is. Since *Duration* values are not comparable, the result of applying a comparison operator between two *Duration* values is `null`. If the type, point in time, offset, and time zone name are all equal, then the values are equal, and any difference in order is impossible to observe.
- **Ordering** of temporal values:
  - `ORDER BY` requires all values to be orderable.
  - Temporal instances are ordered after spatial instances and before strings.
  - Comparable values should be ordered in the same order as implied by their comparison order.
  - Temporal instant values are first ordered by type, and then by comparison order within the type.
  - Since no complete comparison order can be defined for *Duration* values, we define an order for `ORDER BY` specifically for *Duration*:
    - *Duration* values are ordered by normalising all components as if all years were `365.2425` days long (`PT8765H49M12S`), all months were `30.436875` (`1/12` year) days long (`PT730H29M06S`), and all days were `24` hours long [1: The `365.2425` days per year comes from the frequency of leap years. A leap year occurs on a year with an ordinal number divisible by `4`, that is not divisible by `100`, unless it divisible by `400`. This means that over `400` years there are `((365 * 4 + 1) * 25 - 1) * 4 + 1 = 146097` days, which means an average of `365.2425` days per year.].
- Comparing for ordering when one argument is `null` (e.g. `null < 3` is `null`).

2.7.13. Chaining comparison operations

Comparisons can be chained arbitrarily, e.g., `x < y <= z` is equivalent to `x < y AND y <= z`.

Formally, if `a, b, c, ..., y, z` are expressions and `op1, op2, ..., opN` are comparison operators, then `a op1 b op2 c ... y opN z` is equivalent to `a op1 b and b op2 c and ... y opN z`.

Note that `a op1 b op2 c` does not imply any kind of comparison between `a` and `c`, so that, e.g., `x < y > z` is perfectly legal (although perhaps not elegant).

The example:

```
MATCH (n) WHERE 21 < n.age <= 30 RETURN n
```

is equivalent to

```
MATCH (n) WHERE 21 < n.age AND n.age <= 30 RETURN n
```

Thus it will match all nodes where the age is between 21 and 30.

This syntax extends to all equality and inequality comparisons, as well as extending to chains longer than three.

For example:

```
a < b = c <= d <> e
```

Is equivalent to:

```
a < b AND b = c AND c <= d AND d <> e
```

For other comparison operators, see Comparison operators.

2.8. Comments

To add comments to your queries, use double slash. Examples:

```
MATCH (n) RETURN n //This is an end of line comment
```

```
MATCH (n)
//This is a whole line comment
RETURN n
```

```
MATCH (n) WHERE n.property = '//This is NOT a comment' RETURN n
```

2.9. Patterns

2.9.1. Introduction

Patterns and pattern-matching are at the very heart of Cypher, so being effective with Cypher requires a good understanding of patterns.

Using patterns, you describe the shape of the data you're looking for. For example, in the `MATCH` clause you describe the shape with a pattern, and Cypher will figure out how to get that data for you.

The pattern describes the data using a form that is very similar to how one typically draws the shape of property graph data on a whiteboard: usually as circles (representing nodes) and arrows between them to represent relationships.

Patterns appear in multiple places in Cypher: in `MATCH`, `CREATE` and `MERGE` clauses, and in pattern expressions. Each of these is described in more detail in:

- MATCH
- OPTIONAL MATCH
- CREATE
- MERGE
- Using path patterns in `WHERE`

2.9.2. Patterns for nodes

The very simplest 'shape' that can be described in a pattern is a node. A node is described using a pair of parentheses, and is typically given a name. For example:

```
(a)
```

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

2.9.3. Patterns for related nodes

A more powerful construct is a pattern that describes multiple nodes and relationships between them. Cypher patterns describe relationships by employing an arrow between two nodes. For example:

```
(a)-->(b)
```

This pattern describes a very simple data shape: two nodes, and a single relationship from one to the other. In this example, the two nodes are both named as `a` and `b` respectively, and the relationship is 'directed': it goes from `a` to `b`.

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

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

Such a series of connected nodes and relationships is called a "path".

Note that the naming of the nodes in these patterns is only necessary should one need to refer to the same node again, either later in the pattern or elsewhere in the Cypher query. If this is not necessary, then the name may be omitted, as follows:

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

2.9.4. Patterns for labels

In addition to simply describing the shape of a node in the pattern, one can also describe attributes. The most simple attribute that can be described in the pattern is a label that the node must have. For example:

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

One can also describe a node that has multiple labels:

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

2.9.5. Specifying properties

Nodes and relationships are the fundamental structures in a graph. Neo4j uses properties on both of these to allow for far richer models.

Properties can be expressed in patterns using a map-construct: curly brackets surrounding a number of key-expression pairs, separated by commas. E.g. a node with two properties on it would look like:

```
(a {name: 'Andy', sport: 'Brazilian Ju-Jitsu'})
```

A relationship with expectations on it is given by:

```
(a)-[{blocked: false}]->(b)
```

When properties appear in patterns, they add an additional constraint to the shape of the data. In the case of a `CREATE` clause, the properties will be set in the newly-created nodes and relationships. In the case of a `MERGE` clause, the properties will be used as additional constraints on the shape any existing data must have (the specified properties must exactly match any existing data in the graph). If no matching data is found, then `MERGE` behaves like `CREATE` and the properties will be set in the newly created nodes and relationships.

Note that patterns supplied to `CREATE` may use a single parameter to specify properties, e.g: `CREATE (node $paramName)`. This is not possible with patterns used in other clauses, as Cypher needs to know the property names at the time the query is compiled, so that matching can be done effectively.

2.9.6. Patterns for relationships

The simplest way to describe a relationship is by using the arrow between two nodes, as in the previous examples. Using this technique, you can describe that the relationship should exist and the directionality of it. If you don't care about the direction of the relationship, the arrow head can be omitted, as exemplified by:

```
(a)--(b)
```

As with nodes, relationships may also be given names. In this case, a pair of square brackets is used to break up the arrow and the variable is placed between. For example:

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

Much like labels on nodes, relationships can have types. To describe a relationship with a specific type, you can specify this as follows:

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

Unlike labels, relationships can only have one type. But if we'd like to describe some data such that the relationship could have any one of 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)
```

Note that this form of pattern can only be used to describe existing data (ie. when using a pattern with MATCH or as an expression). It will not work with CREATE or MERGE, since it's not possible to create a relationship with multiple types.

As with nodes, the name of the relationship can always be omitted, as exemplified by:

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

2.9.7. Variable-length pattern matching

Variable length pattern matching in versions 2.1.x and earlier does not enforce relationship uniqueness for patterns described within a single MATCH clause. This means that a query such as the following: `MATCH (a)-[r]->(b), p = (a)-[]->(c) RETURN *, relationships(p) AS rs` may include r as part of the rs set. This behavior has changed in versions 2.2.0 and later, in such a way that r will be excluded from the result set, as this better adheres to the rules of relationship uniqueness as documented here Cypher Result Uniqueness. If you have a query pattern that needs to retrace relationships rather than ignoring them as the relationship uniqueness rules normally dictate, you can accomplish this using multiple match clauses, as follows: `MATCH (a)-[r]->(b) MATCH p = (a)-[]->(c) RETURN *, relationships(p)`. This will work in all versions of Neo4j that support the MATCH clause, namely 2.0.0 and later.

Rather than describing a long path using a sequence of many node and relationship descriptions in a pattern, many relationships (and the intermediate nodes) can be described by specifying a length in the relationship description of a pattern. For example:

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

This describes a graph of three nodes and two relationship, all in one path (a path of length 2). This is equivalent to:

```
(a)-->()-->(b)
```

A range of lengths can also be specified: such relationship patterns are called 'variable length relationships'. For example:

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

This is a minimum length of 3, and a maximum of 5. It describes a graph of either 4 nodes and 3 relationships, 5 nodes and 4 relationships or 6 nodes and 5 relationships, all connected together in a single path.

Either bound can be omitted. For example, to describe paths of length 3 or more, use:

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

To describe paths of length 5 or less, use:

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

Both bounds can be omitted, allowing paths of any length to be described:

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

As a simple example, let's take the graph and query below:

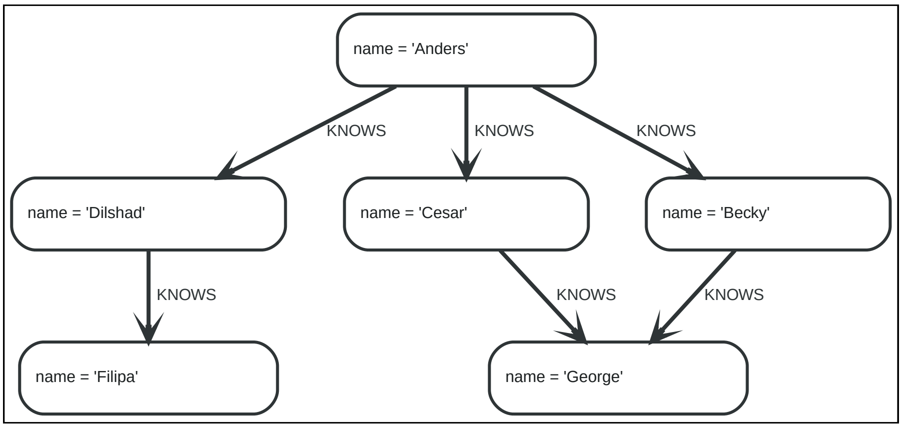


Figure 3. Graph

Query

```
MATCH (me)-[:KNOWS*1..2]-(remote_friend)
WHERE me.name = 'Filipa'
RETURN remote_friend.name
```

Table 30. Result

remote_friend.name
"Dilshad"
"Anders"
2 rows

This query finds data in the graph which a shape that fits the pattern: specifically a node (with the name property **'Filipa'**) and then the `KNOWS` related nodes, one or two hops away. This is a typical example of finding first and second degree friends.

Note that variable length relationships cannot be used with `CREATE` and `MERGE`.

2.9.8. Assigning to path variables

As described above, a series of connected nodes and relationships is called a "path". Cypher allows paths to be named using an identifer, as exemplified by:

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

You can do this in `MATCH`, `CREATE` and `MERGE`, but not when using patterns as expressions.

2.10. Temporal (Date/Time) values

Cypher has built-in support for handling temporal values, and the underlying database supports storing these temporal values as properties on nodes and relationships.

Refer to Temporal functions - instant types for information regarding temporal *functions* allowing for the creation and manipulation of temporal values.

Refer to Temporal operators for information regarding temporal *operators*.

Refer to Ordering and comparison of values for information regarding the comparison and ordering of temporal values.

2.10.1. Introduction

The following table depicts the temporal value types and supported components:

Type	Date support	Time support	Time zone support
Date	X		
Time		X	X
LocalTime		X	
DateTime	X	X	X
LocalDateTime	X	X	
Duration	-	-	-

Date, *Time*, *LocalTime*, *DateTime* and *LocalDateTime* are *temporal instant* types. A temporal instant value expresses a point in time with varying degrees of precision.

By contrast, *Duration* is not a temporal instant type. A *Duration* represents a temporal amount, capturing the difference in time between two instants, and can be negative. Duration only captures the amount of time between two instants, and thus does not encapsulate a start time and end time.

2.10.2. Time zones

Time zones are represented either as an offset from UTC, or as a logical identifier of a *named time zone* (these are based on the IANA time zone database). In either case the time is stored as UTC internally, and the time zone offset is only applied when the time is presented. This means that temporal instants can be ordered without taking time zone into account. If, however, two times are identical in UTC, then they are ordered by timezone.

When creating a time using a named time zone, the offset from UTC is computed from the rules in the time zone database to create a time instant in UTC, and to ensure the named time zone is a valid one.

It is possible for time zone rules to change in the IANA time zone database. For example, there could be alterations to the rules for daylight savings time in a certain area. If this occurs after the creation of a temporal instant, the presented time could differ from the originally-entered time, insofar as the local timezone is concerned. However, the absolute time in UTC would remain the same.

There are three ways of specifying a time zone in Cypher:

- Specifying the offset from UTC in hours and minutes (ISO 8601)
- Specifying a named time zone
- Specifying both the offset and the time zone name (with the requirement that these match)

The named time zone form uses the rules of the IANA time zone database to manage *daylight savings time* (DST).

The default time zone of the database can be configured using the configuration option `db.temporal.timezone`. This configuration option influences the creation of temporal types for the following functions:

- Getting the current date and time without specifying a time zone.
- Creating a temporal type from its components without specifying a time zone.
- Creating a temporal type by parsing a string without specifying a time zone.
- Creating a temporal type by combining or selecting values that do not have a time zone component, and without specifying a time zone.
- Truncating a temporal value that does not have a time zone component, and without specifying a time zone.

2.10.3. Temporal instants

Specifying temporal instants

A temporal instant consists of three parts; the `date`, the `time`, and the `timezone`. These parts may then be combined to produce the various temporal value types. Literal characters are denoted in **bold**.

Temporal instant type	Composition of parts
Date	<date>
Time	<time><timezone> or **T**<time><timezone>
LocalTime	<time> or **T**<time>
*DateTime**	<date>**T**<time><timezone>
*LocalDateTime**	<date>**T**<time>

*When `date` and `time` are combined, `date` must be complete; i.e. fully identify a particular day.

Specifying dates

Component	Format	Description
Year	`YYYY`	Specified with at least four digits (special rules apply in certain cases)
Month	`MM`	Specified with a double digit number from `01` to `12`
Week	`ww`	Always prefixed with `W` and specified with a double digit number from `01` to `53`
Quarter	`q`	Always prefixed with `Q` and specified with a single digit number from `1` to `4`
Day of the month	`DD`	Specified with a double digit number from `01` to `31`
Day of the week	`D`	Specified with a single digit number from `1` to `7`
Day of the quarter	`DD`	Specified with a double digit number from `01` to `92`
Ordinal day of the year	`DDD`	Specified with a triple digit number from `001` to `366`

If the year is before `0000` or after `9999`, the following additional rules apply:

- `-` must prefix any year before `0000`
- `+` must prefix any year after `9999`
- The year must be separated from the next component with the following characters:
  - `-` if the next component is month or day of the year
  - Either `-` or `W` if the next component is week of the year
  - `Q` if the next component is quarter of the year

If the year component is prefixed with either `-` or `+`, and is separated from the next component, `Year` is allowed to contain up to nine digits. Thus, the allowed range of years is between -999,999,999 and +999,999,999. For all other cases, i.e. the year is between `0000` and `9999` (inclusive), `Year` must have exactly four digits (the year component is interpreted as a year of the Common Era (CE)).

The following formats are supported for specifying dates:

Format	Description	Example	Interpretation of example
`YYYY-MM-DD`	Calendar date: `Year-Month-Day`	`2015-07-21`	`2015-07-21`
`YYYYMMDD`	Calendar date: `Year-Month-Day`	`20150721`	`2015-07-21`
`YYYY-MM`	Calendar date: `Year-Month`	`2015-07`	`2015-07-01`
`YYYYMM`	Calendar date: `Year-Month`	`201507`	`2015-07-01`
`YYYY-Www-D`	Week date: `Year-Week-Day`	`2015-W30-2`	`2015-07-21`
`YYYYWwwD`	Week date: `Year-Week-Day`	`2015W302`	`2015-07-21`
`YYYY-Www`	Week date: `Year-Week`	`2015-W30`	`2015-07-20`

Format	Description	Example	Interpretation of example
YYYYWww	Week date: Year-Week	2015W30	2015-07-20
YYYY-Qq-DD	Quarter date: Year-Quarter-Day	2015-Q2-60	2015-05-30
YYYYQqDD	Quarter date: Year-Quarter-Day	2015Q260	2015-05-30
YYYY-Qq	Quarter date: Year-Quarter	2015-Q2	2015-04-01
YYYYQq	Quarter date: Year-Quarter	2015Q2	2015-04-01
YYYY-DDD	Ordinal date: Year-Day	2015-202	2015-07-21
YYYYDDD	Ordinal date: Year-Day	2015202	2015-07-21
YYYY	Year	2015	2015-01-01

The least significant components can be omitted. Cypher will assume omitted components to have their lowest possible value. For example, `2013-06` will be interpreted as being the same date as `2013-06-01`.

Specifying times

Component	Format	Description
Hour	HH	Specified with a double digit number from 00 to 23
Minute	MM	Specified with a double digit number from 00 to 59
Second	SS	Specified with a double digit number from 00 to 59
fraction	sssssssss	Specified with a number from 0 to 999999999. It is not required to specify trailing zeros. fraction is an optional, sub-second component of Second. This can be separated from Second using either a full stop (.) or a comma (,). The fraction is in addition to the two digits of Second.

Cypher does not support leap seconds; UTC-SLS (*UTC with Smoothed Leap Seconds*) is used to manage the difference in time between UTC and TAI (*International Atomic Time*).

The following formats are supported for specifying times:

Format	Description	Example	Interpretation of example
HH:MM:SS.sssssssss	Hour:Minute:Second.fraction	21:40:32.142	21:40:32.142
HHMMSS.sssssssss	Hour:Minute:Second.fraction	214032.142	21:40:32.142
HH:MM:SS	Hour:Minute:Second	21:40:32	21:40:32.000
HHMMSS	Hour:Minute:Second	214032	21:40:32.000
HH:MM	Hour:Minute	21:40	21:40:00.000
HHMM	Hour:Minute	2140	21:40:00.000
HH	Hour	21	21:00:00.000

The least significant components can be omitted. For example, a time may be specified with `Hour` and `Minute`, leaving out `Second` and `fraction`. On the other hand, specifying a time with `Hour` and `Second`, while leaving out `Minute`, is not possible.

Specifying time zones

The time zone is specified in one of the following ways:

- As an offset from UTC
- Using the `Z` shorthand for the UTC (`±00:00`) time zone

When specifying a time zone as an offset from UTC, the rules below apply:

- The time zone always starts with either a plus (`+`) or minus (`-`) sign.
  - Positive offsets, i.e. time zones beginning with `+`, denote time zones east of UTC.
  - Negative offsets, i.e. time zones beginning with `-`, denote time zones west of UTC.
- A double-digit hour offset follows the `+`/`-` sign.
- An optional double-digit minute offset follows the hour offset, optionally separated by a colon (`:`).
- The time zone of the International Date Line is denoted either by `+12:00` or `-12:00`, depending on country.

When creating values of the *DateTime* temporal instant type, the time zone may also be specified using a named time zone, using the names from the IANA time zone database. This may be provided either in addition to, or in place of the offset. The named time zone is given last and is enclosed in square brackets (`[]`). Should both the offset and the named time zone be provided, the offset must match the named time zone.

The following formats are supported for specifying time zones:

Format	Description	Example	Supported for `DateTime`	Supported for `Time`
`Z`	UTC	`Z`	X	X
`±HH:MM`	`Hour:Minute`	`+09:30`	X	X
`±HH:MM[ZoneName]`	`Hour:Minute[ZoneName]`	`+08:45[Australia/Eucla]`	X	
`±HHMM`	`Hour:Minute`	`+0100`	X	X
`±HHMM[ZoneName]`	`Hour:Minute[ZoneName]`	`+0200[Africa/Johannesburg]`	X	
`±HH`	`Hour`	`-08`	X	X
`±HH[ZoneName]`	`Hour[ZoneName]`	`+08[Asia/Singapore]`	X	
`[ZoneName]`	`[ZoneName]`	`[America/Regina]`	X	

Examples

We show below examples of parsing temporal instant values using various formats. For more details, refer to An overview of temporal instant type creation.

Parsing a *DateTime* using the *calendar date* format:

Query

```
RETURN datetime('2015-06-24T12:50:35.556+0100') AS theDateTime
```

Table 31. Result

theDateTime
2015-06-24T12:50:35.556+01:00
1 row

Parsing a *LocalDateTime* using the *ordinal date* format:

Query

```
RETURN localdatetime('2015185T19:32:24') AS theLocalDateTime
```

Table 32. Result

theLocalDateTime
2015-07-04T19:32:24
1 row

Parsing a *Date* using the *week date* format:

Query

```
RETURN date('+2015-W13-4') AS theDate
```

Table 33. Result

theDate
2015-03-26
1 row

Parsing a *Time*:

Query

```
RETURN time('125035.556+0100') AS theTime
```

Table 34. Result

theTime
12:50:35.556+01:00
1 row

Parsing a *LocalTime*:

Query

```
RETURN localtime('12:50:35.556') AS theLocalTime
```

Table 35. Result

theLocalTime
`12:50:35.556`
1 row

Accessing components of temporal instants

Components of temporal instant values can be accessed as properties.

Table 36. Components of temporal instant values and where they are supported

Component	Description	Type	Range/Format	Date	DateTime	LocalDateTime	Time	LocalTime
`instant.year`	The `year` component represents the astronomical year number of the instant [2: This is in accordance with the Gregorian calendar; i.e. years AD/CE start at year 1, and the year before that (year 1 BC/BCE) is 0, while year 2 BCE is -1 etc.]	Integer	At least 4 digits. For more information, see the rules for using the `Year` component	X	X	X		
`instant.quarter`	The *quarter-of-the-year* component	Integer	`1` to `4`	X	X	X		
`instant.month`	The *month-of-the-year* component	Integer	`1` to `12`	X	X	X		
`instant.week`	The *week-of-the-year* component [3: The first week of any year is the week that contains the first Thursday of the year, and thus always contains January 4.]	Integer	`1` to `53`	X	X	X		

Component	Description	Type	Range/Format	Date	DateTime	LocalDateTime	Time	LocalTime
`instant.weekYear`	The *year* that the *week-of-year* component belongs to [4: For dates from December 29, this could be the next year, and for dates until January 3 this could be the previous year, depending on how week 1 begins.]	Integer	At least 4 digits. For more information, see the rules for using the `Year` component	X	X	X		
`instant.dayOfQuarter`	The *day-of-the-quarter* component	Integer	`1` to `92`	X	X	X		
`instant.day`	The *day-of-the-month* component	Integer	`1` to `31`	X	X	X		
`instant.ordinalDay`	The *day-of-the-year* component	Integer	`1` to `366`	X	X	X		
`instant.dayOfWeek`	The *day-of-the-week* component (the first day of the week is *Monday*)	Integer	`1` to `7`	X	X	X		
`instant.hour`	The *hour* component	Integer	`0` to `23`		X	X	X	X
`instant.minute`	The *minute* component	Integer	`0` to `59`		X	X	X	X
`instant.second`	The *second* component	Integer	`0` to `60`		X	X	X	X
`instant.millisecond`	The *millisecond* component	Integer	`0` to `999`		X	X	X	X
`instant.microsecond`	The *microsecond* component	Integer	`0` to `999999`		X	X	X	X
`instant.nanosecond`	The *nanosecond* component	Integer	`0` to `999999999`		X	X	X	X

Component	Description	Type	Range/Format	Date	DateTime	LocalDateTime	Time	LocalTime
`instant.timezone`	The *timezone* component	String	Depending on how the time zone was specified, this is either a time zone name or an offset from UTC in the format `±HHMM`		X		X	
`instant.offset`	The *timezone* offset	String	`±HHMM`		X		X	
`instant.offsetMinutes`	The *timezone* offset in minutes	Integer	`-1080` to `+1080`		X		X	
`instant.offsetSeconds`	The *timezone* offset in seconds	Integer	`-64800` to `+64800`		X		X	
`instant.epochMillis`	The number of milliseconds between `1970-01-01T00:00:00+0000` and the instant [5: `datetime().epochMillis` returns the equivalent value of the `timestamp()` function.]	Integer	Positive for instants after and negative for instants before `1970-01-01T00:00:00+0000`		X			
`instant.epochSeconds`	The number of seconds between `1970-01-01T00:00:00+0000` and the instant [6: For the *nanosecond* part of the *epoch* offset, the regular *nanosecond* component (`instant.nanosecond`) can be used.]	Integer	Positive for instants after and negative for instants before `1970-01-01T00:00:00+0000`		X			

The following query shows how to extract the components of a *Date* value:

Query

```
WITH date({ year:1984, month:10, day:11 }) AS d
RETURN d.year, d.quarter, d.month, d.week, d.weekYear, d.day, d.ordinalDay, d.dayOfWeek, d.dayOfQuarter
```

Table 37. Result

d.year	d.quarter	d.month	d.week	d.weekYear	d.day	d.ordinalDay	d.dayOfWeek	d.dayOfQuarter
1984	4	10	41	1984	11	285	4	11
1 row								

The following query shows how to extract the components of a *DateTime* value:

Query

```
WITH datetime({ year:1984, month:11, day:11, hour:12, minute:31, second:14, nanosecond: 645876123,
timezone:'Europe/Stockholm' }) AS d
RETURN d.year, d.quarter, d.month, d.week, d.weekYear, d.day, d.ordinalDay, d.dayOfWeek, d.dayOfQuarter,
d.hour, d.minute, d.second, d.millisecond, d.microsecond, d.nanosecond, d.timezone, d.offset,
d.offsetMinutes, d.epochSeconds, d.epochMillis
```

Table 38. Result

d.year	d.quarter	d.month	d.week	d.weekYear	d.day	d.ordinalDay	d.dayOfWeek	d.dayOfQuarter	d.hour	d.minute	d.second	d.millisecond	d.microsecond	d.nanosecond	d.timezone	d.offset	d.offsetMinutes	d.epochSeconds	d.epochMillis
1984	4	11	45	1984	11	316	7	42	12	31	14	645	645876	645876123	"Europe/Stockholm"	"+01:00"	60	469020674	469020674645
1 row																			

2.10.4. Durations

Specifying durations

A *Duration* represents a temporal amount, capturing the difference in time between two instants, and can be negative.

The specification of a *Duration* is prefixed with a `P`, and can use either a *unit-based form* or a *date-and-time-based form*:

- Unit-based form: `P[nY][nM][nW][nD][T[nH][nM][nS]]`
  - The square brackets (`[]`) denote an optional component (components with a zero value may be omitted).
  - The `n` denotes a numeric value which can be arbitrarily large.
  - The value of the last — and least significant — component may contain a decimal fraction.
  - Each component must be suffixed by a component identifier denoting the unit.
  - The unit-based form uses `M` as a suffix for both months and minutes. Therefore, time parts must always be preceded with `T`, even when no components of the date part are given.
- Date-and-time-based form: P<date>T<time>
  - Unlike the unit-based form, this form requires each component to be within the bounds of a valid *LocalDateTime*.

The following table lists the component identifiers for the unit-based form:

Component identifier	Description	Comments
`Y`	Years	
`M`	Months	Must be specified before `T`
`W`	Weeks	
`D`	Days	
`H`	Hours	
`M`	Minutes	Must be specified after `T`
`S`	Seconds	

Examples

The following examples demonstrate various methods of parsing *Duration* values. For more details, refer to Creating a *Duration* from a string.

Return a *Duration* of 14 *days*, 16 *hours* and 12 *minutes*:

Query

```
RETURN duration('P14DT16H12M') AS theDuration
```

Table 39. Result

theDuration
P14DT16H12M
1 row

Return a *Duration* of 5 *months*, 1 *day* and 12 *hours*:

Query

```
RETURN duration('P5M1.5D') AS theDuration
```

Table 40. Result

theDuration
P5M1DT12H
1 row

Return a *Duration* of 45 seconds:

Query

```
RETURN duration('PT0.75M') AS theDuration
```

Table 41. Result

theDuration
PT45S
1 row

Return a *Duration* of 2 *weeks*, 3 *days* and 12 *hours*:

Query

```
RETURN duration('P2.5W') AS theDuration
```

Table 42. Result

theDuration
P17DT12H
1 row

Accessing components of durations

A *Duration* can have several components. These are categorized into the following groups:

Component group	Constituent components
Months	*Years*, *Quarters* and *Months*
Days	*Weeks* and *Days*
Seconds	*Hours*, *Minutes*, *Seconds*, *Milliseconds*, *Microseconds* and *Nanoseconds*

Within each group, the components can be converted without any loss:

- There are always `4` *quarters* in `1` *year*.
- There are always `12` *months* in `1` *year*.
- There are always `3` *months* in `1` *quarter*.
- There are always `7` *days* in `1` *week*.
- There are always `60` *minutes* in `1` *hour*.
- There are always `60` *seconds* in `1` *minute* (Cypher uses UTC-SLS when handling leap seconds).
- There are always `1000` *milliseconds* in `1` *second*.
- There are always `1000` *microseconds* in `1` *millisecond*.
- There are always `1000` *nanoseconds* in `1` *microsecond*.

Please note that:

- There are not always `24` *hours* in `1` *day*; when switching to/from daylight savings time, a *day* can have `23` or `25` *hours*.
- There are not always the same number of *days* in a *month*.
- Due to leap years, there are not always the same number of *days* in a *year*.

Table 43. Components of Duration values and how they are truncated within their component group

Component	Component Group	Description	Type	Details
`duration.years`	Months	The total number of *years*	Integer	Each set of `4` *quarters* is counted as `1` *year*; each set of `12` *months* is counted as `1` *year*.
`duration.months`	Months	The total number of *months*	Integer	Each *year* is counted as `12` *months*; each *quarter* is counted as `3` *months*.

Component	Component Group	Description	Type	Details
`duration.days`	Days	The total number of *days*	Integer	Each *week* is counted as `7` *days*.
`duration.hours`	Seconds	The total number of *hours*	Integer	Each set of `60` *minutes* is counted as `1` *hour*; each set of `3600` *seconds* is counted as `1` *hour*.
`duration.minutes`	Seconds	The total number of *minutes*	Integer	Each *hour* is counted as `60` *minutes*; each set of `60` *seconds* is counted as `1` *minute*.
`duration.seconds`	Seconds	The total number of *seconds*	Integer	Each *hour* is counted as `3600` *seconds*; each *minute* is counted as `60` *seconds*.
`duration.milliseconds`	Seconds	The total number of *milliseconds*	Integer	
`duration.microseconds`	Seconds	The total number of *microseconds*	Integer	
`duration.nanoseconds`	Seconds	The total number of *nanoseconds*	Integer	

It is also possible to access the smaller (less significant) components of a component group bounded by the largest (most significant) component of the group:

Component	Component Group	Description	Type
`duration.monthsOfYear`	Months	The number of *months* in the group that do not make a whole *year*	Integer
`duration.minutesOfHour`	Seconds	The total number of *minutes* in the group that do not make a whole *hour*	Integer
`duration.secondsOfMinute`	Seconds	The total number of *seconds* in the group that do not make a whole *minute*	Integer
`duration.millisecondsOfSecond`	Seconds	The total number of *milliseconds* in the group that do not make a whole *second*	Integer
`duration.microsecondsOfSecond`	Seconds	The total number of *microseconds* in the group that do not make a whole *second*	Integer
`duration.nanosecondsOfSecond`	Seconds	The total number of *nanoseconds* in the group that do not make a whole *second*	Integer

The following query shows how to extract the components of a *Duration* value:

Query

```
WITH duration({ years: 1, months:4, days: 111, hours: 1, minutes: 1, seconds: 1, nanoseconds: 111111111 })
AS d
RETURN d.years, d.months, d.monthsOfYear, d.days, d.hours, d.minutes, d.minutesOfHour, d.seconds,
d.secondsOfMinute, d.milliseconds, d.millisecondsOfSecond, d.microseconds, d.microsecondsOfSecond,
d.nanoseconds, d.nanosecondsOfSecond
```

Table 44. Result

d.years	d.months	d.monthsOfYear	d.days	d.hours	d.minutes	d.minutesOfHour	d.seconds	d.secondsOfMinute	d.milliseconds	d.millisecondsOfSecond	d.microseconds	d.microsecondsOfSecond	d.nanoseconds	d.nanosecondsOfSecond
1	16	4	111	1	61	1	3661	1	3661111	111	3661111111	111111	3661111111111	111111111
1 row														

2.10.5. Examples

The following examples illustrate the use of some of the temporal functions and operators. Refer to Temporal functions - instant types and Temporal operators for more details.

Create a *Duration* representing 1.5 *days*:

Query

```
RETURN duration({ days: 1, hours: 12 }) AS theDuration
```

Table 45. Result

theDuration
P1DT12H
1 row

Compute the *Duration* between two temporal instants:

Query

```
RETURN duration.between(date('1984-10-11'), date('2015-06-24')) AS theDuration
```

Table 46. Result

theDuration
P30Y8M13D
1 row

Compute the number of days between two *Date* values:

Query

```
RETURN duration.inDays(date('2014-10-11'), date('2015-08-06')) AS theDuration
```

Table 47. Result

theDuration
P299D
1 row

Get the first *Date* of the current year:

Query

```
RETURN date.truncate('year') AS day
```

Table 48. Result

day
2020-01-01
1 row

Get the *Date* of the Thursday in the week of a specific date:

Query

```
RETURN date.truncate('week', date('2019-10-01'), { dayOfWeek: 4 }) AS thursday
```

Table 49. Result

thursday
2019-10-03
1 row

Get the *Date* of the last day of the next month:

Query

```
RETURN date.truncate('month', date()+ duration('P2M'))- duration('P1D') AS lastDay
```

Table 50. Result

lastDay
2020-02-29
1 row

Add a *Duration* to a *Date*:

Query

```
RETURN time('13:42:19')+ duration({ days: 1, hours: 12 }) AS theTime
```

Table 51. Result

theTime
01:42:19Z
1 row

Add two *Duration* values:

Query

```
RETURN duration({ days: 2, hours: 7 })+ duration({ months: 1, hours: 18 }) AS theDuration
```

Table 52. Result

theDuration
P1M2DT25H
1 row

Multiply a *Duration* by a number:

Query

```
RETURN duration({ hours: 5, minutes: 21 })* 14 AS theDuration
```

Table 53. Result

theDuration
PT74H54M
1 row

Divide a *Duration* by a number:

Query

```
RETURN duration({ hours: 3, minutes: 16 })/ 2 AS theDuration
```

Table 54. Result

theDuration
PT1H38M
1 row

Examine whether two instants are less than one day apart:

Query

```
WITH datetime('2015-07-21T21:40:32.142+0100') AS date1, datetime('2015-07-21T17:12:56.333+0100') AS date2
RETURN
CASE
WHEN date1 < date2
THEN date1 + duration("P1D")> date2
ELSE date2 + duration("P1D")> date1 END AS lessThanOneDayApart
```

Table 55. Result

lessThanOneDayApart
true
1 row

Return the abbreviated name of the current month:

Query

```
RETURN ["Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug", "Sep", "Oct", "Nov", "Dec"][date().month-
1] AS month
```

Table 56. Result

month
"Jan"

month
1 row

2.10.6. Temporal indexing

All temporal types can be indexed, and thereby support exact lookups for equality predicates. Indexes for temporal instant types additionally support range lookups.

2.11. Lists

Cypher has comprehensive support for lists.

- Lists in general
- List comprehension
- Pattern comprehension

Information regarding operators such as list concatenation (`+`), element existence checking (`IN`) and access (`[]`) can be found here. The behavior of the `IN` and `[]` operators with respect to `null` is detailed here.

2.11.1. Lists in general

A literal list is created by using brackets and separating the elements in the list with commas.

Query

```
RETURN [0, 1, 2, 3, 4, 5, 6, 7, 8, 9] AS list
```

Table 57. Result

list
`[0,1,2,3,4,5,6,7,8,9]`
1 row

In our examples, we'll use the `range` function. It gives you a list containing all numbers between given start and end numbers. Range is inclusive in both ends.

To access individual elements in the list, we use the square brackets again. This will extract from the start index and up to but not including the end index.

Query

```
RETURN range(0, 10)[3]
```

Table 58. Result

range(0, 10)[3]
`3`
1 row

You can also use negative numbers, to start from the end of the list instead.

Query

```
RETURN range(0, 10)[-3]
```

Table 59. Result

range(0, 10)[-3]
8
1 row

Finally, you can use ranges inside the brackets to return ranges of the list.

Query

```
RETURN range(0, 10)[0..3]
```

Table 60. Result

range(0, 10)[0..3]
[0,1,2]
1 row

Query

```
RETURN range(0, 10)[0..-5]
```

Table 61. Result

range(0, 10)[0..-5]
[0,1,2,3,4,5]
1 row

Query

```
RETURN range(0, 10)[-5..]
```

Table 62. Result

range(0, 10)[-5..]
[6,7,8,9,10]
1 row

Query

```
RETURN range(0, 10)[..4]
```

Table 63. Result

range(0, 10)[..4]
[0,1,2,3]
1 row

Out-of-bound slices are simply truncated, but out-of-bound single elements return `null`.

Query

```
RETURN range(0, 10)[15]
```

Table 64. Result

range(0, 10)[15]
<null>
1 row

Query

```
RETURN range(0, 10)[5..15]
```

Table 65. Result

range(0, 10)[5..15]
[5,6,7,8,9,10]
1 row

You can get the `size` of a list as follows:

Query

```
RETURN size(range(0, 10)[0..3])
```

Table 66. Result

size(range(0, 10)[0..3])
3
1 row

2.11.2. List comprehension

List comprehension is a syntactic construct available in Cypher for creating a list based on existing lists. It follows the form of the mathematical set-builder notation (set comprehension) instead of the use of map and filter functions.

Query

```
RETURN [x IN range(0,10) WHERE x % 2 = 0 | x^3] AS result
```

Table 67. Result

result
[0.0,8.0,64.0,216.0,512.0,1000.0]
1 row

Either the `WHERE` part, or the expression, can be omitted, if you only want to filter or map respectively.

Query

```
RETURN [x IN range(0,10) WHERE x % 2 = 0] AS result
```

Table 68. Result

result
[0,2,4,6,8,10]
1 row

Query

```
RETURN [x IN range(0,10)| x^3] AS result
```

Table 69. Result

result
[0.0,1.0,8.0,27.0,64.0,125.0,216.0,343.0,512.0,729.0,1000.0]
1 row

2.11.3. Pattern comprehension

Pattern comprehension is a syntactic construct available in Cypher for creating a list based on matchings of a pattern. A pattern comprehension will match the specified pattern just like a normal `MATCH` clause, with predicates just like a normal `WHERE` clause, but will yield a custom projection as specified.

The following graph is used for the example below:

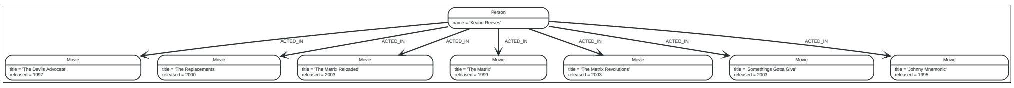


Figure 4. Graph

Query

```
MATCH (a:Person { name: 'Keanu Reeves' })
RETURN [(a)-->(b) WHERE b:Movie | b.released] AS years
```

Table 70. Result

years
[1997,2000,2003,1999,2003,2003,1995]
1 row

The whole predicate, including the `WHERE` keyword, is optional and may be omitted.

2.12. Maps

This section describes how to use maps in Cyphers.

- Literal maps
- Map projection

 Examples of map projection

The following graph is used for the examples below:

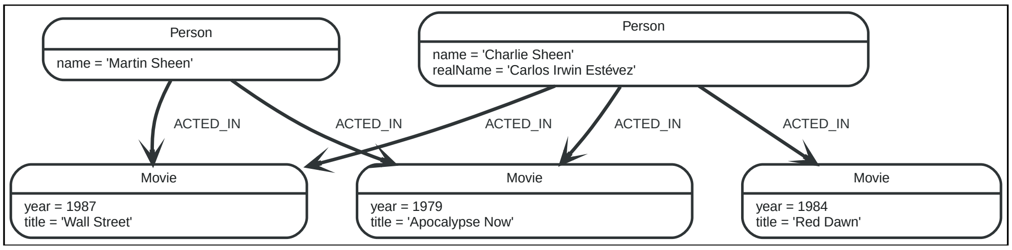


Figure 5. Graph

Information regarding property access operators such as `.` and `[]` can be found here. The behavior of the `[]` operator with respect to `null` is detailed here.

2.12.1. Literal maps

Cypher supports construction of maps. The key names in a map must be of type `String`. If returned through an HTTP API call, a JSON object will be returned. If returned in Java, an object of type `java.util.Map<String,Object>` will be returned.

Query

```
RETURN { key: 'Value', listKey: [{ inner: 'Map1' }, { inner: 'Map2' }]}
```

Table 71. Result

{ key: 'Value', listKey: [{ inner: 'Map1' }, { inner: 'Map2' }]}
`{listKey -> [{inner -> "Map1"},{inner -> "Map2"}], key -> "Value"}`
1 row

2.12.2. Map projection

Cypher supports a concept called "map projections". It allows for easily constructing map projections from nodes, relationships and other map values.

A map projection begins with the variable bound to the graph entity to be projected from, and contains a body of comma-separated map elements, enclosed by `{` and `}`.

`map_variable {map_element, [, …n]}`

A map element projects one or more key-value pairs to the map projection. There exist four different types of map projection elements:

- Property selector - Projects the property name as the key, and the value from the `map_variable` as the value for the projection.
- Literal entry - This is a key-value pair, with the value being arbitrary expression `key: <expression>`.
- Variable selector - Projects a variable, with the variable name as the key, and the value the variable is pointing to as the value of the projection. Its syntax is just the variable.
- All-properties selector - projects all key-value pairs from the `map_variable` value.

The following conditions apply:

- If the map_variable points to a null value, the whole map projection will evaluate to null.
- The key names in a map must be of type String.

Examples of map projections

Find **'Charlie Sheen'** and return data about him and the movies he has acted in. This example shows an example of map projection with a literal entry, which in turn also uses map projection inside the aggregating collect().

Query

```
MATCH (actor:Person { name: 'Charlie Sheen' })-[:ACTED_IN]->(movie:Movie)
RETURN actor { .name, .realName, movies: collect(movie { .title, .year })}
```

Table 72. Result

actor
{movies -> [{year -> 1979, title -> "Apocalypse Now"},{year -> 1984, title -> "Red Dawn"},{year -> 1987, title -> "Wall Street"}], realName -> "Carlos Irwin Estévez", name -> "Charlie Sheen"}
1 row

Find all persons that have acted in movies, and show number for each. This example introduces an variable with the count, and uses a variable selector to project the value.

Query

```
MATCH (actor:Person)-[:ACTED_IN]->(movie:Movie)
WITH actor, count(movie) AS nrOfMovies
RETURN actor { .name, nrOfMovies }
```

Table 73. Result

actor
{nrOfMovies -> 2, name -> "Martin Sheen"}
{nrOfMovies -> 3, name -> "Charlie Sheen"}
2 rows

Again, focusing on **'Charlie Sheen'**, this time returning all properties from the node. Here we use an all-properties selector to project all the node properties, and additionally, explicitly project the property age. Since this property does not exist on the node, a null value is projected instead.

Query

```
MATCH (actor:Person { name: 'Charlie Sheen' })
RETURN actor { .*, .age }
```

Table 74. Result

actor
{realName -> "Carlos Irwin Estévez", name -> "Charlie Sheen", age -> <null>}
1 row

2.13. Spatial values

Cypher has built-in support for handling spatial values (points), and the underlying database *supports storing these point values as properties on nodes and relationships.*

- Introduction
- Coordinate Reference Systems
  - Geographic coordinate reference systems
  - Cartesian coordinate reference systems
- Spatial instants
  - Creating points
  - Accessing components of points
- Spatial index
- Comparability and Orderability

> Refer to Spatial functions for information regarding spatial *functions* allowing for the creation and manipulation of spatial values.
>
> Refer to Ordering and comparison of values for information regarding the comparison and ordering of spatial values.

2.13.1. Introduction

Neo4j supports only one type of spatial geometry, the *Point* with the following characteristics:

- Each point can have either 2 or 3 dimensions. This means it contains either 2 or 3 64-bit floating point values, which together are called the *Coordinate*.
- Each point will also be associated with a specific Coordinate Reference System (CRS) that determines the meaning of the values in the *Coordinate*.
- Instances of *Point* and lists of *Point* can be assigned to node and relationship properties.
- Nodes with *Point* or *List(Point)* properties can be indexed using a spatial index. This is true for all CRS (and for both 2D and 3D). There is no special syntax for creating spatial indexes, as it is supported using the existing indexes.
- The distance function will work on points in all CRS and in both 2D and 3D but only if the two points have the same CRS (and therefore also same dimension).

2.13.2. Coordinate Reference Systems

Four Coordinate Reference Systems (CRS) are supported, each of which falls within one of two types: *geographic coordinates* modeling points on the earth, or *cartesian coordinates* modeling points in euclidean space:

- Geographic coordinate reference systems
  - WGS-84: longitude, latitude (x, y)
  - WGS-84-3D: longitude, latitude, height (x, y, z)
- Cartesian coordinate reference systems
  - Cartesian: x, y
  - Cartesian 3D: x, y, z

Data within different coordinate systems are entirely incomparable, and cannot be implicitly converted from one to the other. This is true even if they are both cartesian or both geographic. For example, if you search for 3D points using a 2D range, you will get no results. However, they can be ordered, as discussed in more detail in the section on Cypher ordering.

Geographic coordinate reference systems

Two Geographic Coordinate Reference Systems (CRS) are supported, modeling points on the earth:

- WGS 84 2D
  - A 2D geographic point in the *WGS 84* CRS is specified in one of two ways:
    - `longitude` and `latitude` (if these are specified, and the `crs` is not, then the `crs` is assumed to be `WGS-84`)
    - `x` and `y` (in this case the `crs` must be specified, or will be assumed to be `Cartesian`)
  - Specifying this CRS can be done using either the name 'wgs-84' or the SRID 4326 as described in Point(WGS-84)
- WGS 84 3D
  - A 3D geographic point in the *WGS 84* CRS is specified one of in two ways:
    - `longitude`, `latitude` and either `height` or `z` (if these are specified, and the `crs` is not, then the `crs` is assumed to be `WGS-84-3D`)
    - `x`, `y` and `z` (in this case the `crs` must be specified, or will be assumed to be `Cartesian-3D`)
  - Specifying this CRS can be done using either the name 'wgs-84-3d' or the SRID 4979 as described in Point(WGS-84-3D)

The units of the `latitude` and `longitude` fields are in decimal degrees, and need to be specified as floating point numbers using Cypher literals. It is not possible to use any other format, like 'degrees, minutes, seconds'. The units of the `height` field are in meters. When geographic points are passed to the `distance` function, the result will always be in meters. If the coordinates are in any other format or unit than supported, it is necessary to explicitly convert them. For example, if the incoming `$height` is a string field in kilometers, you would need to type `height: toFloat($height) * 1000`. Likewise if the results of the `distance` function are expected to be returned in kilometers, an explicit conversion is required. For example: `RETURN distance(a,b) / 1000 AS km`. An example demonstrating conversion on incoming and outgoing values is:

Query

```
WITH point({ latitude:toFloat('13.43'), longitude:toFloat('56.21')}) AS p1, point({
latitude:toFloat('13.10'), longitude:toFloat('56.41')}) AS p2
RETURN toInteger(distance(p1,p2)/1000) AS km
```

Table 75. Result

km
42
1 row

Cartesian coordinate reference systems

Two Cartesian Coordinate Reference Systems (CRS) are supported, modeling points in euclidean space:

- Cartesian 2D
  - A 2D point in the *Cartesian* CRS is specified with a map containing `x` and `y` coordinate values
  - Specifying this CRS can be done using either the name 'cartesian' or the SRID 7203 as described in Point(Cartesian)

* Cartesian 3D
  - A 3D point in the *Cartesian* CRS is specified with a map containing `x`, `y` and `z` coordinate values
  - Specifying this CRS can be done using either the name 'cartesian-3d' or the SRID 9157 as described in Point(Cartesian-3D)

The units of the `x`, `y` and `z` fields are unspecified and can mean anything the user intends them to mean. This also means that when two cartesian points are passed to the `distance` function, the resulting value will be in the same units as the original coordinates. This is true for both 2D and 3D points, as the *pythagoras* equation used is generalized to any number of dimensions. However, just as you cannot compare geographic points to cartesian points, you cannot calculate the distance between a 2D point and a 3D point. If you need to do that, explicitly transform the one type into the other. For example:

Query

```
WITH point({ x:3, y:0 }) AS p2d, point({ x:0, y:4, z:1 }) AS p3d
RETURN distance(p2d,p3d) AS bad, distance(p2d,point({ x:p3d.x, y:p3d.y })) AS good
```

Table 76. Result

bad	good
`<null>`	`5.0`
1 row	

2.13.3. Spatial instants

Creating points

All point types are created from two components:

* The *Coordinate* containing either 2 or 3 floating point values (64-bit)
* The Coordinate Reference System (or CRS) defining the meaning (and possibly units) of the values in the *Coordinate*

For most use cases it is not necessary to specify the CRS explicitly as it will be deduced from the keys used to specify the coordinate. Two rules are applied to deduce the CRS from the coordinate:

* Choice of keys:
  - If the coordinate is specified using the keys `latitude` and `longitude` the CRS will be assumed to be *Geographic* and therefor either `WGS-84` or `WGS-84-3D`.
  - If instead `x` and `y` are used, then the default CRS would be `Cartesian` or `Cartesian-3D`
* Number of dimensions:
  - If there are 2 dimensions in the coordinate, `x` & `y` or `longitude` & `latitude` the CRS will be a 2D CRS
  - If there is a third dimensions in the coordinate, `z` or `height` the CRS will be a 3D CRS

All fields are provided to the `point` function in the form of a map of explicitly named arguments. We specifically do not support an ordered list of coordinate fields because of the contradictory conventions between geographic and cartesian coordinates, where geographic coordinates normally list `y` before `x` (`latitude` before `longitude`). See for example the following query which returns points created in each of the four supported CRS. Take particular note of the order and keys of the coordinates in the original `point` function calls, and how those values are displayed in the results:

Query

```
RETURN point({ x:3, y:0 }) AS cartesian_2d, point({ x:0, y:4, z:1 }) AS cartesian_3d, point({ latitude:
12, longitude: 56 }) AS geo_2d, point({ latitude: 12, longitude: 56, height: 1000 }) AS geo_3d
```

Table 77. Result

cartesian_2d	cartesian_3d	geo_2d	geo_3d
`point({x: 3.0, y: 0.0, crs: 'cartesian'})`	`point({x: 0.0, y: 4.0, z: 1.0, crs: 'cartesian-3d'})`	`point({x: 56.0, y: 12.0, crs: 'wgs-84'})`	`point({x: 56.0, y: 12.0, z: 1000.0, crs: 'wgs-84-3d'})`
1 row			

For the geographic coordinates, it is important to note that the `latitude` value should always lie in the interval `[-90, 90]` and any other value outside this range will throw an exception. The `longitude` value should always lie in the interval `[-180, 180]` and any other value outside this range will be wrapped around to fit in this range. The `height` value and any cartesian coordinates are not explicitly restricted, and any value within the allowed range of the signed 64-bit floating point type will be accepted.

Accessing components of points

Just as we construct points using a map syntax, we can also access components as properties of the instance.

Table 78. Components of point instances and where they are supported

Component	Description	Type	Range/Format	WGS-84	WGS-84-3D	Cartesian	Cartesian-3D
`instant.x`	The first element of the *Coordinate*	Float	Number literal, range depends on CRS	X	X	X	X
`instant.y`	The second element of the *Coordinate*	Float	Number literal, range depends on CRS	X	X	X	X
`instant.z`	The third element of the *Coordinate*	Float	Number literal, range depends on CRS		X		X
`instant.latitude`	The *second* element of the *Coordinate* for geographic CRS, degrees North of the equator	Float	Number literal, `-90.0` to `90.0`	X	X		
`instant.longitude`	The *first* element of the *Coordinate* for geographic CRS, degrees East of the prime meridian	Float	Number literal, `-180.0` to `180.0`	X	X		

Component	Description	Type	Range/Format	WGS-84	WGS-84-3D	Cartesian	Cartesian-3D
`instant.height`	The third element of the *Coordinate* for geographic CRS, meters above the ellipsoid defined by the datum (WGS-84)	Float	Number literal, range limited only by the underlying 64-bit floating point type		X		
`instant.crs`	The name of the CRS	String	One of `wgs-84`, `wgs-84-3d`, `cartesian`, `cartesian-3d`	X	X	X	X
`instant.srid`	The internal Neo4j ID for the CRS	Integer	One of `4326`, `4979`, `7203`, `9157`	X	X	X	X

The following query shows how to extract the components of a *Cartesian 2D* point value:

Query

```
WITH point({ x:3, y:4 }) AS p
RETURN p.x, p.y, p.crs, p.srid
```

Table 79. Result

p.x	p.y	p.crs	p.srid
`3.0`	`4.0`	`"cartesian"`	`7203`
1 row			

The following query shows how to extract the components of a *WGS-84 3D* point value:

Query

```
WITH point({ latitude:3, longitude:4, height: 4321 }) AS p
RETURN p.latitude, p.longitude, p.height, p.x, p.y, p.z, p.crs, p.srid
```

Table 80. Result

p.latitude	p.longitude	p.height	p.x	p.y	p.z	p.crs	p.srid
`3.0`	`4.0`	`4321.0`	`4.0`	`3.0`	`4321.0`	`"wgs-84-3d"`	`4979`
1 row							

2.13.4. Spatial index

If there is a index on a particular `:Label(property)` combination, and a spatial point is assigned to that property on a node with that label, the node will be indexed in a spatial index. For spatial indexing, Neo4j uses space filling curves in 2D or 3D over an underlying generalized B+Tree. Points will be stored in up to four different trees, one for each of the four coordinate reference systems. This allows for both equality and range queries using exactly the same syntax and behaviour as for other property types. If two range predicates are used, which define minimum and maximum points, this will effectively result in a bounding box query. In addition, queries using the `distance` function can, under the right conditions, also use the index, as described in the section 'Spatial distance searches'.

2.13.5. Comparability and Orderability

Points with different CRS are not comparable. This means that any function operating on two points of different types will return `null`. This is true of the distance function as well as inequality comparisons. If these are used in a predicate, they will cause the associated `MATCH` to return no results.

Query

```
WITH point({ x:3, y:0 }) AS p2d, point({ x:0, y:4, z:1 }) AS p3d
RETURN distance(p2d,p3d), p2d < p3d, p2d = p3d, p2d <> p3d, distance(p2d,point({ x:p3d.x, y:p3d.y }))
```

Table 81. Result

distance(p2d,p3d)	p2d < p3d	p2d = p3d	p2d <> p3d	distance(p2d,point({ x:p3d.x, y:p3d.y }))
`<null>`	`<null>`	`false`	`true`	`5.0`
1 row				

However, all types are orderable. The Point types will be ordered after Numbers and before Temporal types. Points with different CRS with be ordered by their SRID numbers. For the current set of four CRS, this means the order is WGS84, WGS84-3D, Cartesian, Cartesian-3D.

Query

```
UNWIND [point({ x:3, y:0 }), point({ x:0, y:4, z:1 }), point({ srid:4326, x:12, y:56 }), point({
srid:4979, x:12, y:56, z:1000 })] AS point
RETURN point
ORDER BY point
```

Table 82. Result

point
`point({x: 12.0, y: 56.0, crs: 'wgs-84'})`
`point({x: 12.0, y: 56.0, z: 1000.0, crs: 'wgs-84-3d'})`
`point({x: 3.0, y: 0.0, crs: 'cartesian'})`
`point({x: 0.0, y: 4.0, z: 1.0, crs: 'cartesian-3d'})`
4 rows

2.14. Working with `null`

- Introduction to `null` in Cypher
- Logical operations with `null`
- The `IN` operator and `null`
- The `[]` operator and `null`
- Expressions that return `null`

2.14.1. Introduction to `null` in Cypher

In Cypher, `null` is used to represent missing or undefined values. Conceptually, `null` means 'a missing unknown value' and it is treated somewhat differently from other values. For example getting a property from a node that does not have said property produces `null`. Most expressions that take `null` as input will produce `null`. This includes boolean expressions that are used as predicates in the `WHERE` clause. In this case, anything that is not `true` is interpreted as being false.

null is not equal to null. Not knowing two values does not imply that they are the same value. So the expression null = null yields null and not true.

2.14.2. Logical operations with null

The logical operators (AND, OR, XOR, NOT) treat null as the 'unknown' value of three-valued logic.

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

2.14.3. The IN operator and null

The IN operator follows similar logic. If Cypher knows that something exists in a list, the result will be true. Any list that contains a null and doesn't have a matching element will return null. Otherwise, the result will be false. Here is a table with examples:

Expression	Result
2 IN [1, 2, 3]	true
2 IN [1, null, 3]	null
2 IN [1, 2, null]	true
2 IN [1]	false
2 IN []	false
null IN [1, 2, 3]	null
null IN [1, null, 3]	null
null IN []	false

Using all, any, none, and single follows a similar rule. If the result can be calculated definitely, true or false is returned. Otherwise null is produced.

2.14.4. The [] operator and null

Accessing a list or a map with null will result in null:

Expression	Result
[1, 2, 3][null]	null
[1, 2, 3, 4][null..2]	null
[1, 2, 3][1..null]	null

Expression	Result
{age: 25}[`null`]	`null`

Using parameters to pass in the bounds, such as `a[$lower..$upper]`, may result in a `null` for the lower or upper bound (or both). The following workaround will prevent this from happening by setting the absolute minimum and maximum bound values:

```
a[coalesce($lower,0)..coalesce($upper,size(a))]
```

2.14.5. Expressions that return `null`

- Getting a missing element from a list: `[][0]`, `head([])`
- Trying to access a property that does not exist on a node or relationship: `n.missingProperty`
- Comparisons when either side is `null`: `1 < null`
- Arithmetic expressions containing `null`: `1 + null`
- Function calls where any arguments are `null`: `sin(null)`

Chapter 3. Clauses

This section contains information on all the clauses in the Cypher query language.

- Reading clauses
- Projecting clauses
- Reading sub-clauses
- Reading hints
- Writing clauses
- Reading/Writing clauses
- Set operations
- Subquery clauses
- Multiple graphs
- Importing data
- Administration clauses

Reading clauses

These comprise clauses that read data from the database.

The flow of data within a Cypher query is an unordered sequence of maps with key-value pairs — a set of possible bindings between the variables in the query and values derived from the database. This set is refined and augmented by subsequent parts of the query.

Clause	Description
MATCH	Specify the patterns to search for in the database.
OPTIONAL MATCH	Specify the patterns to search for in the database while using `nulls` for missing parts of the pattern.

Projecting clauses

These comprise clauses that define which expressions to return in the result set. The returned expressions may all be aliased using `AS`.

Clause	Description
RETURN ... [AS]	Defines what to include in the query result set.
WITH ... [AS]	Allows query parts to be chained together, piping the results from one to be used as starting points or criteria in the next.
UNWIND ... [AS]	Expands a list into a sequence of rows.

Reading sub-clauses

These comprise sub-clauses that must operate as part of reading clauses.

Sub-clause	Description
WHERE	Adds constraints to the patterns in a `MATCH` or `OPTIONAL MATCH` clause or filters the results of a `WITH` clause.
WHERE EXISTS {...}	An existential sub-query used to filter the results of a `MATCH`, `OPTIONAL MATCH` or `WITH` clause.

Sub-clause	Description
ORDER BY [ASC[ENDING] | DESC[ENDING]]	A sub-clause following `RETURN` or `WITH`, specifying that the output should be sorted in either ascending (the default) or descending order.
SKIP	Defines from which row to start including the rows in the output.
LIMIT	Constrains the number of rows in the output.

Reading hints

These comprise clauses used to specify planner hints when tuning a query. More details regarding the usage of these — and query tuning in general — can be found in Planner hints and the USING keyword.

Hint	Description
USING INDEX	Index hints are used to specify which index, if any, the planner should use as a starting point.
USING INDEX SEEK	Index seek hint instructs the planner to use an index seek for this clause.
USING SCAN	Scan hints are used to force the planner to do a label scan (followed by a filtering operation) instead of using an index.
USING JOIN	Join hints are used to enforce a join operation at specified points.

Writing clauses

These comprise clauses that write the data to the database.

Clause	Description
CREATE	Create nodes and relationships.
DELETE	Delete nodes, relationships or paths. Any node to be deleted must also have all associated relationships explicitly deleted.
DETACH DELETE	Delete a node or set of nodes. All associated relationships will automatically be deleted.
SET	Update labels on nodes and properties on nodes and relationships.
REMOVE	Remove properties and labels from nodes and relationships.
FOREACH	Update data within a list, whether components of a path, or the result of aggregation.

Reading/Writing clauses

These comprise clauses that both read data from and write data to the database.

Clause	Description
MERGE	Ensures that a pattern exists in the graph. Either the pattern already exists, or it needs to be created.
--- ON CREATE	Used in conjunction with `MERGE`, this write sub-clause specifies the actions to take if the pattern needs to be created.
--- ON MATCH	Used in conjunction with `MERGE`, this write sub-clause specifies the actions to take if the pattern already exists.

Clause	Description
CALL [...YIELD]	Invokes a procedure deployed in the database and return any results.

Set operations

Clause	Description
UNION	Combines the result of multiple queries into a single result set. Duplicates are removed.
UNION ALL	Combines the result of multiple queries into a single result set. Duplicates are retained.

Subquery clauses

Clause	Description
CALL { ... }	Evaluates a subquery, typically used for post-union processing or aggregations.

Multiple graphs

Clause	Description
USE	Determines which graph a query, or query part, is executed against.

Importing data

Clause	Description
LOAD CSV	Use when importing data from CSV files.
--- USING PERIODIC COMMIT	This query hint may be used to prevent an out-of-memory error from occurring when importing large amounts of data using `LOAD CSV`.

Administration clauses

These comprise clauses used to manage databases, schema and security; further details can found in Administration.

Clause	Description
CREATE | DROP | START | STOP DATABASE	Create, drop, start or stop a database.
CREATE | DROP INDEX	Create or drop a constraint pertaining to either a node label or relationship type, and a property.
CREATE | DROP CONSTRAINT	Create or drop an index on all nodes with a particular label and property.
Users, roles, privileges	Manage users, roles and privileges for database, graph and sub-graph access control.

3.1. MATCH

The `MATCH` clause is used to search for the pattern described in it.

- Introduction
- Basic node finding

3.1.1. Introduction

The `MATCH` clause allows you to specify the patterns Neo4j will search for in the database. This is the primary way of getting data into the current set of bindings. It is worth reading up more on the specification of the patterns themselves in Patterns.

`MATCH` is often coupled to a `WHERE` part which adds restrictions, or predicates, to the `MATCH` patterns, making them more specific. The predicates are part of the pattern description, and should not be considered a filter applied only after the matching is done. *This means that `WHERE` should always be put together with the `MATCH` clause it belongs to.*

`MATCH` can occur at the beginning of the query or later, possibly after a `WITH`. If it is the first clause, nothing will have been bound yet, and Neo4j will design a search to find the results matching the clause and any associated predicates specified in any `WHERE` part. This could involve a scan of the database, a search for nodes having a certain label, or a search of an index to find starting points for the pattern matching. Nodes and relationships found by this search are available as *bound pattern elements,* and can be used for pattern matching of sub-graphs. They can also be used in any further `MATCH` clauses, where Neo4j will use the known elements, and from there find further unknown elements.

Cypher is declarative, and so usually the query itself does not specify the algorithm to use to perform the search. Neo4j will automatically work out the best approach to finding start nodes and matching patterns. Predicates in `WHERE` parts can be evaluated before pattern matching, during pattern matching, or after finding matches. However, there are cases where you can influence the decisions taken by the query compiler. Read more about indexes in Indexes for search performance, and more about specifying hints to force Neo4j to solve a query in a specific way in Planner hints and the USING keyword.

To understand more about the patterns used in the `MATCH` clause, read Patterns

The following graph is used for the examples below:

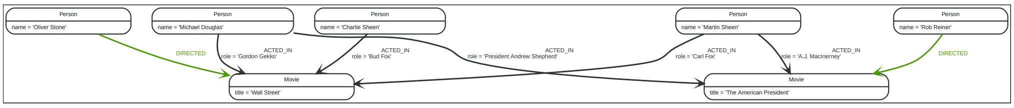


Figure 6. Graph

3.1.2. Basic node finding

Get all nodes

By just specifying a pattern with a single node and no labels, all nodes in the graph will be returned.

Query

```
MATCH (n)
RETURN n
```

Returns all the nodes in the database.

Table 83. Result

n
`Node[0]{name:"Charlie Sheen"}`
`Node[1]{name:"Martin Sheen"}`
`Node[2]{name:"Michael Douglas"}`
`Node[3]{name:"Oliver Stone"}`
`Node[4]{name:"Rob Reiner"}`
`Node[5]{title:"Wall Street"}`
`Node[6]{title:"The American President"}`
7 rows

Get all nodes with a label

Getting all nodes with a label on them is done with a single node pattern where the node has a label on it.

Query

```
MATCH (movie:Movie)
RETURN movie.title
```

Returns all the movies in the database.

Table 84. Result

movie.title
"Wall Street"
"The American President"
2 rows

Related nodes

The symbol `--` means *related to,* without regard to type or direction of the relationship.

Query

```
MATCH (director { name: 'Oliver Stone' })--(movie)
RETURN movie.title
```

Returns all the movies directed by **'Oliver Stone'**.

Table 85. Result

movie.title
"Wall Street"
1 row

Match with labels

To constrain your pattern with labels on nodes, you add it to your pattern nodes, using the label syntax.

Query

```
MATCH (:Person { name: 'Oliver Stone' })--(movie:Movie)
RETURN movie.title
```

Returns any nodes connected with the `Person` **'Oliver'** that are labeled `Movie`.

Table 86. Result

movie.title
"Wall Street"
1 row

3.1.3. Relationship basics

Outgoing relationships

When the direction of a relationship is of interest, it is shown by using `-->` or `<--`, like this:

Query

```
MATCH (:Person { name: 'Oliver Stone' })-->(movie)
RETURN movie.title
```

Returns any nodes connected with the `Person` **'Oliver'** by an outgoing relationship.

Table 87. Result

movie.title
"Wall Street"
1 row

Directed relationships and variable

If a variable is required, either for filtering on properties of the relationship, or to return the relationship, this is how you introduce the variable.

Query

```
MATCH (:Person { name: 'Oliver Stone' })-[r]->(movie)
RETURN type(r)
```

Returns the type of each outgoing relationship from **'Oliver'**.

Table 88. Result

type(r)
"DIRECTED"
1 row

Match on relationship type

When you know the relationship type you want to match on, you can specify it by using a colon together with the relationship type.

Query

```
MATCH (wallstreet:Movie { title: 'Wall Street' })<-[:ACTED_IN]-(actor)
RETURN actor.name
```

Returns all actors that `ACTED_IN` **'Wall Street'**.

Table 89. Result

actor.name
"Michael Douglas"
"Martin Sheen"
"Charlie Sheen"
3 rows

Match on multiple relationship types

To match on one of multiple types, you can specify this by chaining them together with the pipe symbol `|`.

Query

```
MATCH (wallstreet { title: 'Wall Street' })<-[:ACTED_IN|:DIRECTED]-(person)
RETURN person.name
```

Returns nodes with an ACTED_IN or DIRECTED relationship to **'Wall Street'**.

Table 90. Result

person.name
"Oliver Stone"
"Michael Douglas"
"Martin Sheen"
"Charlie Sheen"
4 rows

Match on relationship type and use a variable

If you both want to introduce an variable to hold the relationship, and specify the relationship type you want, just add them both, like this:

Query

```
MATCH (wallstreet { title: 'Wall Street' })<-[r:ACTED_IN]-(actor)
RETURN r.role
```

Returns ACTED_IN roles for **'Wall Street'**.

Table 91. Result

r.role
"Gordon Gekko"
"Carl Fox"
"Bud Fox"
3 rows

3.1.4. Relationships in depth

Inside a single pattern, relationships will only be matched once. You can read more about this in Cypher Result Uniqueness.

Relationship types with uncommon characters

Sometimes your database will have types with non-letter characters, or with spaces in them. Use ` (backtick) to quote these. To demonstrate this we can add an additional relationship between **'Charlie Sheen'** and **'Rob Reiner'**:

Query

```
MATCH (charlie:Person { name: 'Charlie Sheen' }),(rob:Person { name: 'Rob Reiner' })
CREATE (rob)-[:`TYPE INCLUDING A SPACE`]->(charlie)
```

Which leads to the following graph:

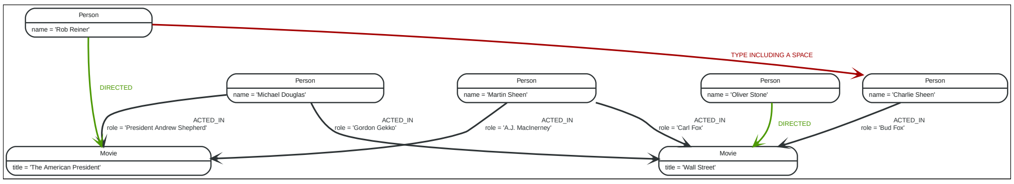


Figure 7. Graph

Query

```
MATCH (n { name: 'Rob Reiner' })-[r:`TYPE INCLUDING A SPACE`]->()
RETURN type(r)
```

Returns a relationship type with spaces in it.

Table 92. Result

type(r)
"TYPE INCLUDING A SPACE"
1 row

Multiple relationships

Relationships can be expressed by using multiple statements in the form of `()--()`, or they can be strung together, like this:

Query

```
MATCH (charlie { name: 'Charlie Sheen' })-[:ACTED_IN]->(movie)<-[:DIRECTED]-(director)
RETURN movie.title, director.name
```

Returns the movie **'Charlie Sheen'** acted in and its director.

Table 93. Result

movie.title	director.name
"Wall Street"	"Oliver Stone"
1 row	

Variable length relationships

Nodes that are a variable number of relationship→node hops away can be found using the following syntax: `-[:TYPE*minHops..maxHops]→`. `minHops` and `maxHops` are optional and default to 1 and infinity respectively. When no bounds are given the dots may be omitted. The dots may also be omitted when setting only one bound and this implies a fixed length pattern.

Query

```
MATCH (martin { name: 'Charlie Sheen' })-[:ACTED_IN*1..3]-(movie:Movie)
RETURN movie.title
```

Returns all movies related to **'Charlie Sheen'** by 1 to 3 hops.

Table 94. Result

movie.title
"Wall Street"

movie.title
"The American President"
"The American President"
3 rows

Relationship variable in variable length relationships

When the connection between two nodes is of variable length, the list of relationships comprising the connection can be returned using the following syntax:

Query

```
MATCH p =(actor { name: 'Charlie Sheen' })-[:ACTED_IN*2]-(co_actor)
RETURN relationships(p)
```

Returns a list of relationships.

Table 95. Result

relationships(p)
[:ACTED_IN[0]{role:"Bud Fox"},:ACTED_IN[2]{role:"Gordon Gekko"}]
[:ACTED_IN[0]{role:"Bud Fox"},:ACTED_IN[1]{role:"Carl Fox"}]
2 rows

Match with properties on a variable length path

A variable length relationship with properties defined on in it means that all relationships in the path must have the property set to the given value. In this query, there are two paths between **'Charlie Sheen'** and his father **'Martin Sheen'**. One of them includes a **'blocked'** relationship and the other doesn't. In this case we first alter the original graph by using the following query to add `BLOCKED` and `UNBLOCKED` relationships:

Query

```
MATCH (charlie:Person { name: 'Charlie Sheen' }),(martin:Person { name: 'Martin Sheen' })
CREATE (charlie)-[:X { blocked: FALSE }]->(:UNBLOCKED)<-[:X { blocked: FALSE }]-(martin)
CREATE (charlie)-[:X { blocked: TRUE }]->(:BLOCKED)<-[:X { blocked: FALSE }]-(martin)
```

This means that we are starting out with the following graph:

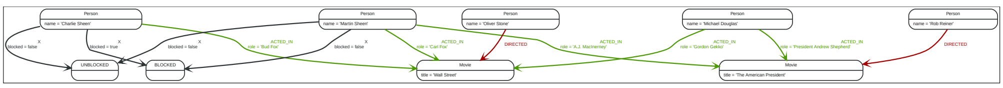


Figure 8. Graph

Query

```
MATCH p =(charlie:Person)-[* { blocked:false }]-(martin:Person)
WHERE charlie.name = 'Charlie Sheen' AND martin.name = 'Martin Sheen'
RETURN p
```

Returns the paths between **'Charlie Sheen'** and **'Martin Sheen'** where all relationships have the `blocked` property set to `false`.

Table 96. Result

p
(0)-[X,7]->(7)<-[X,8]-(1)
1 row

Zero length paths

Using variable length paths that have the lower bound zero means that two variables can point to the same node. If the path length between two nodes is zero, they are by definition the same node. Note that when matching zero length paths the result may contain a match even when matching on a relationship type not in use.

Query

```
MATCH (wallstreet:Movie { title: 'Wall Street' })-[*0..1]-(x)
RETURN x
```

Returns the movie itself as well as actors and directors one relationship away

Table 97. Result

x
Node[5]{title:"Wall Street"}
Node[3]{name:"Oliver Stone"}
Node[2]{name:"Michael Douglas"}
Node[1]{name:"Martin Sheen"}
Node[0]{name:"Charlie Sheen"}
5 rows

Named paths

If you want to return or filter on a path in your pattern graph, you can a introduce a named path.

Query

```
MATCH p =(michael { name: 'Michael Douglas' })-->()
RETURN p
```

Returns the two paths starting from **'Michael Douglas'**

Table 98. Result

p
(2)-[ACTED_IN,5]->(6)
(2)-[ACTED_IN,2]->(5)
2 rows

Matching on a bound relationship

When your pattern contains a bound relationship, and that relationship pattern doesn't specify direction, Cypher will try to match the relationship in both directions.

Query

```
MATCH (a)-[r]-(b)
WHERE id(r)= 0
RETURN a,b
```

This returns the two connected nodes, once as the start node, and once as the end node

Table 99. Result

a	b
Node[0]{name:"Charlie Sheen"}	Node[5]{title:"Wall Street"}
Node[5]{title:"Wall Street"}	Node[0]{name:"Charlie Sheen"}
2 rows	

3.1.5. Shortest path

Single shortest path

Finding a single shortest path between two nodes is as easy as using the `shortestPath` function. It's done like this:

Query

```
MATCH (martin:Person { name: 'Martin Sheen' }),(oliver:Person { name: 'Oliver Stone' }), p =
shortestPath((martin)-[*..15]-(oliver))
RETURN p
```

This means: find a single shortest path between two nodes, as long as the path is max 15 relationships long. Within the parentheses you define a single link of a path — the starting node, the connecting relationship and the end node. Characteristics describing the relationship like relationship type, max hops and direction are all used when finding the shortest path. If there is a `WHERE` clause following the match of a `shortestPath`, relevant predicates will be included in the `shortestPath`. If the predicate is a `none()` or `all()` on the relationship elements of the path, it will be used during the search to improve performance (see Shortest path planning).

Table 100. Result

p
(1)-[ACTED_IN,1]->(5)<-[DIRECTED,3]-(3)
1 row

Single shortest path with predicates

Predicates used in the `WHERE` clause that apply to the shortest path pattern are evaluated before deciding what the shortest matching path is.

Query

```
MATCH (charlie:Person { name: 'Charlie Sheen' }),(martin:Person { name: 'Martin Sheen' }), p =
shortestPath((charlie)-[*]-(martin))
WHERE NONE (r IN relationships(p) WHERE type(r)= 'FATHER')
RETURN p
```

This query will find the shortest path between **'Charlie Sheen'** and **'Martin Sheen'**, and the `WHERE` predicate will ensure that we don't consider the father/son relationship between the two.

Table 101. Result

p
(0)-[ACTED_IN,0]->(5)<-[ACTED_IN,1]-(1)
1 row

All shortest paths

Finds all the shortest paths between two nodes.

Query

```
MATCH (martin:Person { name: 'Martin Sheen' }),(michael:Person { name: 'Michael Douglas' }), p =
allShortestPaths((martin)-[*]-(michael))
RETURN p
```

Finds the two shortest paths between '**Martin Sheen**' and '**Michael Douglas**'.

Table 102. Result

p
(1)-[ACTED_IN,1]->(5)<-[ACTED_IN,2]-(2)
(1)-[ACTED_IN,4]->(6)<-[ACTED_IN,5]-(2)
2 rows

3.1.6. Get node or relationship by id

Node by id

Searching for nodes by id can be done with the `id()` function in a predicate.

Neo4j reuses its internal ids when nodes and relationships are deleted. This means that applications using, and relying on internal Neo4j ids, are brittle or at risk of making mistakes. It is therefore recommended to rather use application-generated ids.

Query

```
MATCH (n)
WHERE id(n)= 0
RETURN n
```

The corresponding node is returned.

Table 103. Result

n
Node[0]{name:"Charlie Sheen"}
1 row

Relationship by id

Search for relationships by id can be done with the `id()` function in a predicate.

This is not recommended practice. See Node by id for more information on the use of Neo4j ids.

Query

```
MATCH ()-[r]->()
WHERE id(r)= 0
RETURN r
```

The relationship with id `0` is returned.

Table 104. Result

r
`:ACTED_IN[0]{role:"Bud Fox"}`
1 row

Multiple nodes by id

Multiple nodes are selected by specifying them in an IN clause.

Query

```
MATCH (n)
WHERE id(n) IN [0, 3, 5]
RETURN n
```

This returns the nodes listed in the `IN` expression.

Table 105. Result

n
`Node[0]{name:"Charlie Sheen"}`
`Node[3]{name:"Oliver Stone"}`
`Node[5]{title:"Wall Street"}`
3 rows

3.2. OPTIONAL MATCH

> *The `OPTIONAL MATCH` clause is used to search for the pattern described in it, while using nulls for missing parts of the pattern.*

3.2.1. Introduction

`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. `OPTIONAL MATCH` could be considered the Cypher equivalent of the outer join in SQL.

Either the whole pattern is matched, or nothing is matched. Remember that `WHERE` is part of the pattern description, and the predicates will be considered while looking for matches, not after. This matters especially in the case of multiple (OPTIONAL) MATCH clauses, where it is crucial to put WHERE together with the MATCH it belongs to.

> To understand the patterns used in the OPTIONAL MATCH clause, read Patterns.

The following graph is used for the examples below:

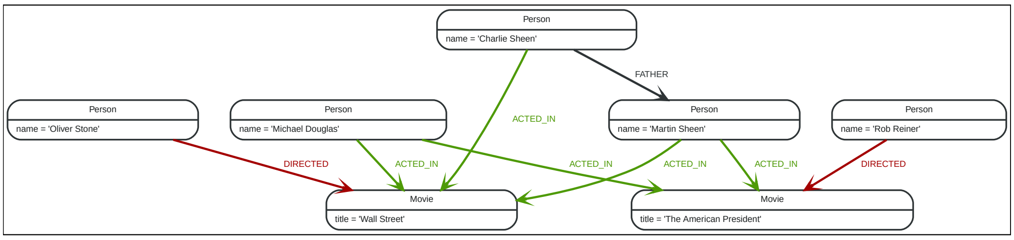


Figure 9. Graph

3.2.2. Optional relationships

If a relationship is optional, use the OPTIONAL MATCH clause. This is similar to how a SQL outer join works. If the relationship is there, it is returned. If it's not, null is returned in its place.

Query

```
MATCH (a:Movie { title: 'Wall Street' })
OPTIONAL MATCH (a)-->(x)
RETURN x
```

Returns null, since the node has no outgoing relationships.

Table 106. Result

x
<null>
1 row

3.2.3. Properties on optional elements

Returning a property from an optional element that is null will also return null.

Query

```
MATCH (a:Movie { title: 'Wall Street' })
OPTIONAL MATCH (a)-->(x)
RETURN x, x.name
```

Returns the element x (null in this query), and null as its name.

Table 107. Result

x	x.name
<null>	<null>
1 row	

3.2.4. Optional typed and named relationship

Just as with a normal relationship, you can decide which variable it goes into, and what relationship type you need.

Query

```
MATCH (a:Movie { title: 'Wall Street' })
OPTIONAL MATCH (a)-[r:ACTS_IN]->()
RETURN a.title, r
```

This returns the title of the node, **'Wall Street'**, and, since the node has no outgoing `ACTS_IN` relationships, `null` is returned for the relationship denoted by `r`.

Table 108. Result

a.title	r
"Wall Street"	<null>
1 row	

3.3. RETURN

The `RETURN` clause defines what to include in the query result set.

- Introduction
- Return nodes
- Return relationships
- Return property
- Return all elements
- Variable with uncommon characters
- Column alias
- Optional properties
- Other expressions
- Unique results

3.3.1. Introduction

In the `RETURN` part of your query, you define which parts of the pattern you are interested in. It can be nodes, relationships, or properties on these.

If what you actually want is the value of a property, make sure to not return the full node/relationship. This will improve performance.

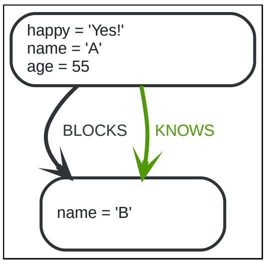


Figure 10. Graph

3.3.2. Return nodes

To return a node, list it in the `RETURN` statement.

Query

```
MATCH (n { name: 'B' })
RETURN n
```

The example will return the node.

Table 109. Result

n
`Node[1]{name:"B"}`
1 row

3.3.3. Return relationships

To return a relationship, just include it in the `RETURN` list.

Query

```
MATCH (n { name: 'A' })-[r:KNOWS]->(c)
RETURN r
```

The relationship is returned by the example.

Table 110. Result

r
`:KNOWS[0]{}`
1 row

3.3.4. Return property

To return a property, use the dot separator, like this:

Query

```
MATCH (n { name: 'A' })
RETURN n.name
```

The value of the property `name` gets returned.

Table 111. Result

n.name
"A"
1 row

3.3.5. Return all elements

When you want to return all nodes, relationships and paths found in a query, you can use the * symbol.

Query

```
MATCH p =(a { name: 'A' })-[r]->(b)
RETURN *
```

This returns the two nodes, the relationship and the path used in the query.

Table 112. Result

a	b	p	r
Node[0]{happy:"Yes!",name:"A",age:55}	Node[1]{name:"B"}	(0)-[BLOCKS,1]->(1)	:BLOCKS[1]{}
Node[0]{happy:"Yes!",name:"A",age:55}	Node[1]{name:"B"}	(0)-[KNOWS,0]->(1)	:KNOWS[0]{}
2 rows			

3.3.6. Variable with uncommon characters

To introduce a placeholder that is made up of characters that are not contained in the English alphabet, you can use the ` to enclose the variable, like this:

Query

```
MATCH (`This isn\'t a common variable`)
WHERE `This isn\'t a common variable`.name = 'A'
RETURN `This isn\'t a common variable`.happy
```

The node with name "A" is returned.

Table 113. Result

`This isn\'t a common variable`.happy
"Yes!"
1 row

3.3.7. Column alias

If the name of the column should be different from the expression used, you can rename it by using AS <new name>.

Query

```
MATCH (a { name: 'A' })
RETURN a.age AS SomethingTotallyDifferent
```

Returns the age property of a node, but renames the column.

Table 114. Result

SomethingTotallyDifferent
`55`
1 row

3.3.8. Optional properties

If a property might or might not be there, you can still select it as usual. It will be treated as `null` if it is missing.

Query

```
MATCH (n)
RETURN n.age
```

This example returns the age when the node has that property, or `null` if the property is not there.

Table 115. Result

n.age
`55`
`<null>`
2 rows

3.3.9. Other expressions

Any expression can be used as a return item — literals, predicates, properties, functions, and everything else.

Query

```
MATCH (a { name: 'A' })
RETURN a.age > 30, "I'm a literal",(a)-->()
```

Returns a predicate, a literal and function call with a pattern expression parameter.

Table 116. Result

a.age > 30	"I'm a literal"	(a)-->()
`true`	`"I'm a literal"`	`[(0)-[BLOCKS,1]->(1),(0)-[KNOWS,0]->(1)]`
1 row		

3.3.10. Unique results

`DISTINCT` retrieves only unique rows depending on the columns that have been selected to output.

Query

```
MATCH (a { name: 'A' })-->(b)
RETURN DISTINCT b
```

The node named "B" is returned by the query, but only once.

Table 117. Result

b
`Node[1]{name:"B"}`
1 row

3.4. WITH

The `WITH` clause allows query parts to be chained together, piping the results from one to be used as starting points or criteria in the next.

- Introduction
- Filter on aggregate function results
- Sort results before using collect on them
- Limit branching of a path search

3.4.1. Introduction

Using `WITH`, you can manipulate the output before it is passed on to the following query parts. The manipulations can be of the shape and/or number of entries in the result set.

One common usage of `WITH` is to limit the number of entries that are then passed on to other `MATCH` clauses. By combining `ORDER BY` and `LIMIT`, it's possible to get the top X entries by some criteria, and then bring in additional data from the graph.

Another use is to filter on aggregated values. `WITH` is used to introduce aggregates which can then be used in predicates in `WHERE`. These aggregate expressions create new bindings in the results. `WITH` can also, like `RETURN`, alias expressions that are introduced into the results using the aliases as the binding name.

`WITH` is also used to separate reading from updating of the graph. Every part of a query must be either read-only or write-only. When going from a writing part to a reading part, the switch must be done with a `WITH` clause.

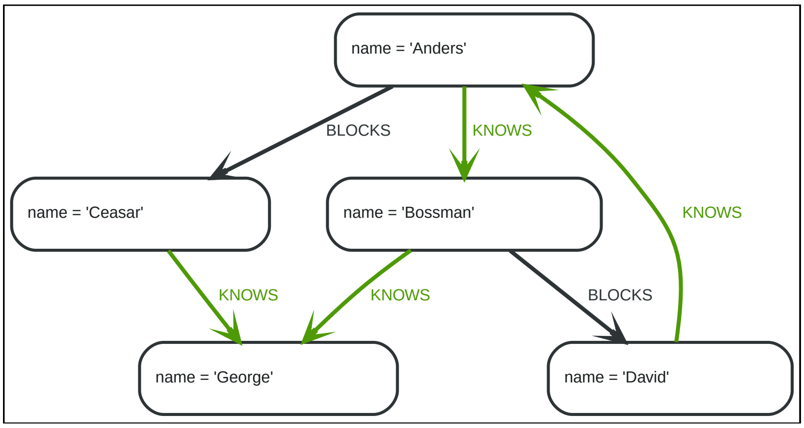


Figure 11. Graph

3.4.2. Filter on aggregate function results

Aggregated results have to pass through a `WITH` clause to be able to filter on.

Query

```
MATCH (david { name: 'David' })--(otherPerson)-->()
WITH otherPerson, count(*) AS foaf
WHERE foaf > 1
RETURN otherPerson.name
```

The name of the person connected to **'David'** with the at least more than one outgoing relationship will be returned by the query.

Table 118. Result

otherPerson.name
"Anders"
1 row

3.4.3. Sort results before using collect on them

You can sort your results before passing them to collect, thus sorting the resulting list.

Query

```
MATCH (n)
WITH n
ORDER BY n.name DESC LIMIT 3
RETURN collect(n.name)
```

A list of the names of people in reverse order, limited to 3, is returned in a list.

Table 119. Result

collect(n.name)
["George","David","Ceasar"]
1 row

3.4.4. Limit branching of a path search

You can match paths, limit to a certain number, and then match again using those paths as a base, as well as any number of similar limited searches.

Query

```
MATCH (n { name: 'Anders' })--(m)
WITH m
ORDER BY m.name DESC LIMIT 1
MATCH (m)--(o)
RETURN o.name
```

Starting at **'Anders'**, find all matching nodes, order by name descending and get the top result, then find all the nodes connected to that top result, and return their names.

Table 120. Result

o.name
"Bossman"
"Anders"
2 rows

3.5. UNWIND

`UNWIND` expands a list into a sequence of rows.

3.5.1. Introduction

With `UNWIND`, you can transform any list back into individual rows. These lists can be parameters that were passed in, previously `collect` -ed result or other list expressions.

One common usage of unwind is to create distinct lists. Another is to create data from parameter lists that are provided to the query.

`UNWIND` requires you to specify a new name for the inner values.

3.5.2. Unwinding a list

We want to transform the literal list into rows named `x` and return them.

Query

```
UNWIND [1, 2, 3, NULL ] AS x
RETURN x, 'val' AS y
```

Each value of the original list — including `null` — is returned as an individual row.

Table 121. Result

x	y
1	"val"
2	"val"
3	"val"
<null>	"val"
4 rows	

3.5.3. Creating a distinct list

We want to transform a list of duplicates into a set using `DISTINCT`.

Query

```
WITH [1, 1, 2, 2] AS coll
UNWIND coll AS x
WITH DISTINCT x
RETURN collect(x) AS setOfVals
```

Each value of the original list is unwound and passed through `DISTINCT` to create a unique set.

Table 122. Result

setOfVals
`[1,2]`
1 row

3.5.4. Using `UNWIND` with any expression returning a list

Any expression that returns a list may be used with `UNWIND`.

Query

```
WITH [1, 2] AS a,[3, 4] AS b
UNWIND (a + b) AS x
RETURN x
```

The two lists — *a* and *b* — are concatenated to form a new list, which is then operated upon by `UNWIND`.

Table 123. Result

x
`1`
`2`
`3`
`4`
4 rows

3.5.5. Using `UNWIND` with a list of lists

Multiple `UNWIND` clauses can be chained to unwind nested list elements.

Query

```
WITH [[1, 2],[3, 4], 5] AS nested
UNWIND nested AS x
UNWIND x AS y
RETURN y
```

The first `UNWIND` results in three rows for `x`, each of which contains an element of the original list (two of which are also lists); namely, `[1, 2]`, `[3, 4]` and `5`. The second `UNWIND` then operates on each of these rows in turn, resulting in five rows for `y`.

Table 124. Result

y
`1`

y
2
3
4
5
5 rows

3.5.6. Using UNWIND with an empty list

Using an empty list with UNWIND will produce no rows, irrespective of whether or not any rows existed beforehand, or whether or not other values are being projected.

Essentially, UNWIND [] reduces the number of rows to zero, and thus causes the query to cease its execution, returning no results. This has value in cases such as UNWIND v, where v is a variable from an earlier clause that may or may not be an empty list — when it is an empty list, this will behave just as a MATCH that has no results.

Query

```
UNWIND [] AS empty
RETURN empty, 'literal_that_is_not_returned'
```

Table 125. Result

(empty result)
0 rows

To avoid inadvertently using UNWIND on an empty list, CASE may be used to replace an empty list with a null:

```
WITH [] AS list
UNWIND
   CASE
      WHEN list = []
         THEN [null]
      ELSE list
   END AS emptylist
RETURN emptylist
```

3.5.7. Using UNWIND with an expression that is not a list

Using UNWIND on an expression that does not return a list, will return the same result as using UNWIND on a list that just contains that expression. As an example, UNWIND 5 is effectively equivalent to UNWIND[5]. The exception to this is when the expression returns null — this will reduce the number of rows to zero, causing it to cease its execution and return no results.

Query

```
UNWIND NULL AS x
RETURN x, 'some_literal'
```

Table 126. Result

(empty result)
0 rows

3.5.8. Creating nodes from a list parameter

Create a number of nodes and relationships from a parameter-list without using `FOREACH`.

Parameters

```
{
  "events" : [ {
    "year" : 2014,
    "id" : 1
  }, {
    "year" : 2014,
    "id" : 2
  } ]
}
```

Query

```
UNWIND $events AS event
MERGE (y:Year { year: event.year })
MERGE (y)<-[:IN]-(e:Event { id: event.id })
RETURN e.id AS x
ORDER BY x
```

Each value of the original list is unwound and passed through `MERGE` to find or create the nodes and relationships.

Table 127. Result

x
1
2
2 rows, Nodes created: 3 Relationships created: 2 Properties set: 3 Labels added: 3

3.6. WHERE

> `WHERE` *adds constraints to the patterns in a* `MATCH` *or* `OPTIONAL MATCH` *clause or filters the results of a* `WITH` *clause.*

3.6.1. Introduction

`WHERE` is not a clause in its own right — rather, it's part of `MATCH`, `OPTIONAL MATCH` and `WITH`.

In the case of `WITH`, `WHERE` simply filters the results.

For `MATCH` and `OPTIONAL MATCH` on the other hand, `WHERE` adds constraints to the patterns described. *It should not be seen as a filter after the matching is finished.*

> In the case of multiple `MATCH` / `OPTIONAL MATCH` clauses, the predicate in `WHERE` is always a part of the patterns in the directly preceding `MATCH` / `OPTIONAL MATCH`. Both results and performance may be impacted if the `WHERE` is put inside the wrong `MATCH` clause.

> Indexes may be used to optimize queries using `WHERE` in a variety of cases.

The following graph is used for the examples below:

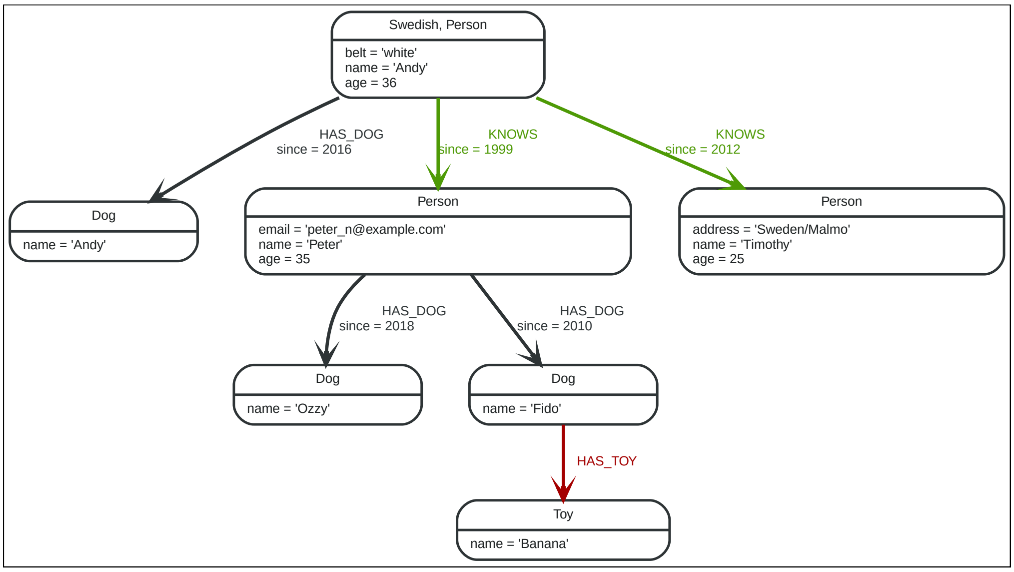


Figure 12. Graph

3.6.2. Basic usage

Boolean operations

You can use the boolean operators `AND`, `OR`, `XOR` and `NOT`. See Working with `null` for more information on how this works with `null`.

Query

```
MATCH (n:Person)
WHERE n.name = 'Peter' XOR (n.age < 30 AND n.name = 'Timothy') OR NOT (n.name = 'Timothy' OR n.name =
'Peter')
RETURN n.name, n.age
```

Table 128. Result

n.name	n.age
"Andy"	36
"Timothy"	25
"Peter"	35
3 rows	

Filter on node label

To filter nodes by label, write a label predicate after the `WHERE` keyword using `WHERE n:foo`.

Query

```
MATCH (n)
WHERE n:Swedish
RETURN n.name, n.age
```

The name and age for the **'Andy'** node will be returned.

Table 129. Result

n.name	n.age
"Andy"	36

n.name	n.age
1 row	

Filter on node property

To filter on a node property, write your clause after the `WHERE` keyword.

Query

```
MATCH (n:Person)
WHERE n.age < 30
RETURN n.name, n.age
```

The name and age values for the **'Timothy'** node are returned because he is less than 30 years of age.

Table 130. Result

n.name	n.age
"Timothy"	25
1 row	

Filter on relationship property

To filter on a relationship property, write your clause after the `WHERE` keyword.

Query

```
MATCH (n:Person)-[k:KNOWS]->(f)
WHERE k.since < 2000
RETURN f.name, f.age, f.email
```

The name, age and email values for the **'Peter'** node are returned because Andy has known him since before 2000.

Table 131. Result

f.name	f.age	f.email
"Peter"	35	"peter_n@example.com"
1 row		

Filter on dynamically-computed node property

To filter on a property using a dynamically computed name, use square bracket syntax.

Query

```
WITH 'AGE' AS propname
MATCH (n:Person)
WHERE n[toLower(propname)]< 30
RETURN n.name, n.age
```

The name and age values for the **'Timothy'** node are returned because he is less than 30 years of age.

Table 132. Result

n.name	n.age
"Timothy"	25
1 row	

Property existence checking

Use the `exists()` function to only include nodes or relationships in which a property exists.

Query

```
MATCH (n:Person)
WHERE EXISTS (n.belt)
RETURN n.name, n.belt
```

The name and belt for the **'Andy'** node are returned because he is the only one with a `belt` property.

> The `has()` function has been superseded by `exists()` and has been removed.

Table 133. Result

n.name	n.belt
"Andy"	"white"
1 row	

3.6.3. String matching

The prefix and suffix of a string can be matched using `STARTS WITH` and `ENDS WITH`. To undertake a substring search - i.e. match regardless of location within a string - use `CONTAINS`. The matching is *case-sensitive*. Attempting to use these operators on values which are not strings will return `null`.

Prefix string search using `STARTS WITH`

The `STARTS WITH` operator is used to perform case-sensitive matching on the beginning of a string.

Query

```
MATCH (n:Person)
WHERE n.name STARTS WITH 'Pet'
RETURN n.name, n.age
```

The name and age for the **'Peter'** node are returned because his name starts with **'Pet'**.

Table 134. Result

n.name	n.age
"Peter"	35
1 row	

Suffix string search using `ENDS WITH`

The `ENDS WITH` operator is used to perform case-sensitive matching on the ending of a string.

Query

```
MATCH (n:Person)
WHERE n.name ENDS WITH 'ter'
RETURN n.name, n.age
```

The name and age for the **'Peter'** node are returned because his name ends with **'ter'**.

Table 135. Result

n.name	n.age
"Peter"	35
1 row	

Substring search using `CONTAINS`

The `CONTAINS` operator is used to perform case-sensitive matching regardless of location within a string.

Query

```
MATCH (n:Person)
WHERE n.name CONTAINS 'ete'
RETURN n.name, n.age
```

The name and age for the **'Peter'** node are returned because his name contains with **'ete'**.

Table 136. Result

n.name	n.age
"Peter"	35
1 row	

String matching negation

Use the `NOT` keyword to exclude all matches on given string from your result:

Query

```
MATCH (n:Person)
WHERE NOT n.name ENDS WITH 'y'
RETURN n.name, n.age
```

The name and age for the **'Peter'** node are returned because his name does not end with **'y'**.

Table 137. Result

n.name	n.age
"Peter"	35
1 row	

3.6.4. Regular expressions

Cypher supports filtering using regular expressions. The regular expression syntax is inherited from the Java regular expressions. This includes support for flags that change how strings are matched, including case-insensitive `(?i)`, multiline `(?m)` and dotall `(?s)`. Flags are given at the beginning of the regular expression, for example `MATCH (n) WHERE n.name =~ '(?i)Lon.*' RETURN n` will return nodes with name 'London' or with name 'LonDoN'.

Matching using regular expressions

You can match on regular expressions by using `=~ 'regexp'`, like this:

Query

```
MATCH (n:Person)
WHERE n.name =~ 'Tim.*'
RETURN n.name, n.age
```

The name and age for the **'Timothy'** node are returned because his name starts with **'Tim'**.

Table 138. Result

n.name	n.age
"Timothy"	25
1 row	

Escaping in regular expressions

Characters like `.` or `*` have special meaning in a regular expression. To use these as ordinary characters, without special meaning, escape them.

Query

```
MATCH (n:Person)
WHERE n.email =~ '.*\\.com'
RETURN n.name, n.age, n.email
```

The name, age and email for the **'Peter'** node are returned because his email ends with **'.com'**.

Table 139. Result

n.name	n.age	n.email
"Peter"	35	"peter_n@example.com"
1 row		

Case-insensitive regular expressions

By pre-pending a regular expression with `(?i)`, the whole expression becomes case-insensitive.

Query

```
MATCH (n:Person)
WHERE n.name =~ '(?i)AND.*'
RETURN n.name, n.age
```

The name and age for the **'Andy'** node are returned because his name starts with **'AND'** irrespective of casing.

Table 140. Result

n.name	n.age
"Andy"	36

n.name	n.age
1 row	

3.6.5. Using path patterns in WHERE

Filter on patterns

Patterns are expressions in Cypher, expressions that return a list of paths. List expressions are also predicates — an empty list represents `false`, and a non-empty represents `true`.

So, patterns are not only expressions, they are also predicates. The only limitation to your pattern is that you must be able to express it in a single path. You cannot use commas between multiple paths like you do in `MATCH`. You can achieve the same effect by combining multiple patterns with `AND`.

Note that you cannot introduce new variables here. Although it might look very similar to the `MATCH` patterns, the `WHERE` clause is all about eliminating matched subgraphs. `MATCH (a)-[]→(b) is very different from WHERE (a)-[]→(b)`. The first will produce a subgraph for every path it can find between `a` and `b`, whereas the latter will eliminate any matched subgraphs where `a` and `b` do not have a directed relationship chain between them.

Query

```
MATCH (timothy:Person { name: 'Timothy' }),(other:Person)
WHERE other.name IN ['Andy', 'Peter'] AND (timothy)<--(other)
RETURN other.name, other.age
```

The name and age for nodes that have an outgoing relationship to the **'Timothy'** node are returned.

Table 141. Result

other.name	other.age
"Andy"	36
1 row	

Filter on patterns using NOT

The `NOT` operator can be used to exclude a pattern.

Query

```
MATCH (person:Person),(peter:Person { name: 'Peter' })
WHERE NOT (person)-->(peter)
RETURN person.name, person.age
```

Name and age values for nodes that do not have an outgoing relationship to the **'Peter'** node are returned.

Table 142. Result

person.name	person.age
"Timothy"	25
"Peter"	35
2 rows	

Filter on patterns with properties

You can also add properties to your patterns:

Query

```
MATCH (n:Person)
WHERE (n)-[:KNOWS]-({ name: 'Timothy' })
RETURN n.name, n.age
```

Finds all name and age values for nodes that have a `KNOWS` relationship to a node with the name **'Timothy'**.

Table 143. Result

n.name	n.age
"Andy"	36
1 row	

Filter on relationship type

You can put the exact relationship type in the `MATCH` pattern, but sometimes you want to be able to do more advanced filtering on the type. You can use the special property `type` to compare the type with something else. In this example, the query does a regular expression comparison with the name of the relationship type.

Query

```
MATCH (n:Person)-[r]->()
WHERE n.name='Andy' AND type(r)=~ 'K.*'
RETURN type(r), r.since
```

This returns all relationships having a type whose name starts with **'K'**.

Table 144. Result

type(r)	r.since
"KNOWS"	1999
"KNOWS"	2012
2 rows	

An existential subquery can be used to find out if a specified pattern exists at least once in the data. It can be used in the same way as a path pattern but it allows you to use `MATCH` and `WHERE` clauses internally. A subquery has a scope, as indicated by the opening and closing braces, `{` and `}`. Any variable that is defined in the outside scope can be referenced inside the subquery's own scope. Variables introduced inside the subquery are not part of the outside scope and therefore can't be accessed on the outside. If the subquery evaluates even once to anything that is not null, the whole expression will become true. This also means, that the system only needs to calculate the first occurrence where the subquery evaluates to something that is not null and can skip the rest of the work.

Syntax:

```
EXISTS {
 MATCH [Pattern]
 WHERE [Expression]
}
```

It is worth noting that the `MATCH` keyword can be omitted in subqueries and that the `WHERE` clause is optional.

3.6.6. Using existential subqueries in `WHERE`

Simple existential subquery

Variables introduced by the outside scope can be used in the inner `MATCH` clause. The following example shows this:

Query

```
MATCH (person:Person)
WHERE EXISTS {
  MATCH (person)-[:HAS_DOG]->(:Dog)
}
RETURN person.name as name
```

Table 145. Result

name
"Andy"
"Peter"
2 rows

Existential subquery with `WITH` clause

A `WHERE` clause can be used in conjunction to the `MATCH`. Variables introduced by the `MATCH` clause and the outside scope can be used in this scope.

Query

```
MATCH (person:Person)
WHERE EXISTS {
  MATCH (person)-[:HAS_DOG]->(dog :Dog)
  WHERE person.name = dog.name
}
RETURN person.name as name
```

Table 146. Result

name
"Andy"
1 row

Nesting existential subqueries

Existential subqueries can be nested like the following example shows. The nesting also affects the scopes. That means that it is possible to access all variables from inside the subquery which are either on the outside scope or defined in the very same subquery.

Query

```
MATCH (person:Person)
WHERE EXISTS {
  MATCH (person)-[:HAS_DOG]->(dog:Dog)
  WHERE EXISTS {
    MATCH (dog)-[:HAS_TOY]->(toy:Toy)
    WHERE toy.name = 'Banana'
  }
}
RETURN person.name as name
```

Table 147. Result

name
"Peter"
1 row

3.6.7. Lists

IN operator

To check if an element exists in a list, you can use the `IN` operator.

Query

```
MATCH (a:Person)
WHERE a.name IN ['Peter', 'Timothy']
RETURN a.name, a.age
```

This query shows how to check if a property exists in a literal list.

Table 148. Result

a.name	a.age
"Timothy"	25
"Peter"	35
2 rows	

3.6.8. Missing properties and values

Default to false if property is missing

As missing properties evaluate to `null`, the comparison in the example will evaluate to `false` for nodes without the `belt` property.

Query

```
MATCH (n:Person)
WHERE n.belt = 'white'
RETURN n.name, n.age, n.belt
```

Only the name, age and belt values of nodes with white belts are returned.

Table 149. Result

n.name	n.age	n.belt
"Andy"	36	"white"
1 row		

Default to `true` if property is missing

If you want to compare a property on a node or relationship, but only if it exists, you can compare the property against both the value you are looking for and `null`, like:

Query

```
MATCH (n:Person)
WHERE n.belt = 'white' OR n.belt IS NULL RETURN n.name, n.age, n.belt
ORDER BY n.name
```

This returns all values for all nodes, even those without the belt property.

Table 150. Result

n.name	n.age	n.belt
"Andy"	36	"white"
"Peter"	35	<null>
"Timothy"	25	<null>
3 rows		

Filter on `null`

Sometimes you might want to test if a value or a variable is `null`. This is done just like SQL does it, using `IS NULL`. Also like SQL, the negative is `IS NOT NULL`, although `NOT(IS NULL x)` also works.

Query

```
MATCH (person:Person)
WHERE person.name = 'Peter' AND person.belt IS NULL RETURN person.name, person.age, person.belt
```

The name and age values for nodes that have name **'Peter'** but no belt property are returned.

Table 151. Result

person.name	person.age	person.belt
"Peter"	35	<null>
1 row		

3.6.9. Using ranges

Simple range

To check for an element being inside a specific range, use the inequality operators `<`, `<=`, `>=`, `>`.

Query

```
MATCH (a:Person)
WHERE a.name >= 'Peter'
RETURN a.name, a.age
```

The name and age values of nodes having a name property lexicographically greater than or equal to **'Peter'** are returned.

Table 152. Result

a.name	a.age
"Timothy"	25
"Peter"	35
2 rows	

Composite range

Several inequalities can be used to construct a range.

Query

```
MATCH (a:Person)
WHERE a.name > 'Andy' AND a.name < 'Timothy'
RETURN a.name, a.age
```

The name and age values of nodes having a name property lexicographically between **'Andy'** and **'Timothy'** are returned.

Table 153. Result

a.name	a.age
"Peter"	35
1 row	

3.7. ORDER BY

> *`ORDER BY` is a sub-clause following `RETURN` or `WITH`, and it specifies that the output should be sorted and how.*

- Introduction
- Order nodes by property
- Order nodes by multiple properties
- Order nodes in descending order
- Ordering `null`

3.7.1. Introduction

Note that you cannot sort on nodes or relationships, just on properties on these. `ORDER BY` relies on comparisons to sort the output, see Ordering and comparison of values.

In terms of scope of variables, `ORDER BY` follows special rules, depending on if the projecting `RETURN` or `WITH` clause is either aggregating or `DISTINCT`. If it is an aggregating or `DISTINCT` projection, only the variables available in the projection are available. If the projection does not alter the output cardinality (which aggregation and `DISTINCT` do), variables available from before the projecting clause are also available. When the projection clause shadows already existing variables, only the new variables are available.

Lastly, it is not allowed to use aggregating expressions in the `ORDER BY` sub-clause if they are not also listed in the projecting clause. This last rule is to make sure that `ORDER BY` does not change the results, only the order of them.

The performance of Cypher queries using `ORDER BY` on node properties can be influenced by the existence and use of an index for finding the nodes. If the index can provide the nodes in the order requested in the query, Cypher can avoid the use of an expensive `Sort` operation. Read more about this capability in The use of indexes.

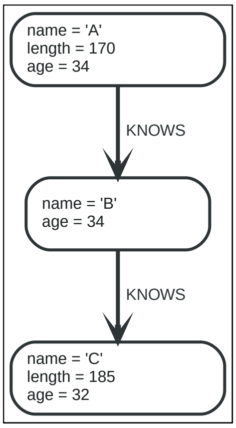


Figure 13. Graph

Strings that contain special characters can have inconsistent or non-deterministic ordering in Neo4j. For details, see Sorting of special characters.

3.7.2. Order nodes by property

`ORDER BY` is used to sort the output.

Query

```
MATCH (n)
RETURN n.name, n.age
ORDER BY n.name
```

The nodes are returned, sorted by their name.

Table 154. Result

n.name	n.age
"A"	34
"B"	34
"C"	32
3 rows	

3.7.3. Order nodes by multiple properties

You can order by multiple properties by stating each variable in the `ORDER BY` clause. Cypher will sort the result by the first variable listed, and for equals values, go to the next property in the `ORDER BY` clause, and so on.

Query

```
MATCH (n)
RETURN n.name, n.age
ORDER BY n.age, n.name
```

This returns the nodes, sorted first by their age, and then by their name.

Table 155. Result

n.name	n.age
"C"	32
"A"	34
"B"	34
3 rows	

3.7.4. Order nodes in descending order

By adding `DESC[ENDING]` after the variable to sort on, the sort will be done in reverse order.

Query

```
MATCH (n)
RETURN n.name, n.age
ORDER BY n.name DESC
```

The example returns the nodes, sorted by their name in reverse order.

Table 156. Result

n.name	n.age
"C"	32
"B"	34
"A"	34
3 rows	

3.7.5. Ordering `null`

When sorting the result set, `null` will always come at the end of the result set for ascending sorting, and first when doing descending sort.

Query

```
MATCH (n)
RETURN n.length, n.name, n.age
ORDER BY n.length
```

The nodes are returned sorted by the length property, with a node without that property last.

Table 157. Result

n.length	n.name	n.age
170	"A"	34
185	"C"	32

n.length	n.name	n.age
<null>	"B"	34
3 rows		

3.8. SKIP

`SKIP` defines from which row to start including the rows in the output.

- Introduction
- Skip first three rows
- Return middle two rows
- Using an expression with `SKIP` to return a subset of the rows

3.8.1. Introduction

By using `SKIP`, the result set will get trimmed from the top. Please note that no guarantees are made on the order of the result unless the query specifies the `ORDER BY` clause. `SKIP` accepts any expression that evaluates to a positive integer — however the expression cannot refer to nodes or relationships.

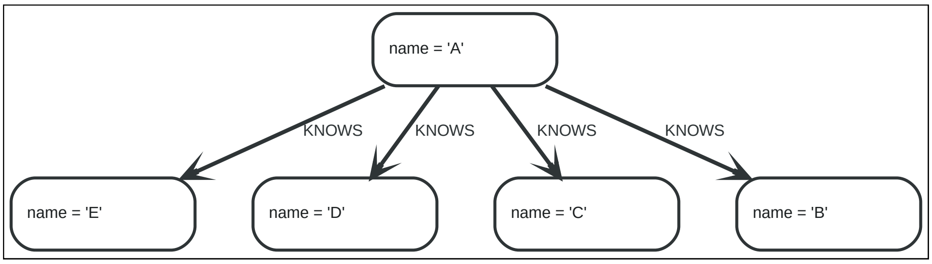


Figure 14. Graph

3.8.2. Skip first three rows

To return a subset of the result, starting from the fourth result, use the following syntax:

Query

```
MATCH (n)
RETURN n.name
ORDER BY n.name
SKIP 3
```

The first three nodes are skipped, and only the last two are returned in the result.

Table 158. Result

n.name
"D"
"E"
2 rows

3.8.3. Return middle two rows

To return a subset of the result, starting from somewhere in the middle, use this syntax:

Query

```
MATCH (n)
RETURN n.name
ORDER BY n.name
SKIP 1
LIMIT 2
```

Two nodes from the middle are returned.

Table 159. Result

n.name
"B"
"C"
2 rows

3.8.4. Using an expression with `SKIP` to return a subset of the rows

Skip accepts any expression that evaluates to a positive integer as long as it is not referring to any external variables:

Query

```
MATCH (n)
RETURN n.name
ORDER BY n.name
SKIP toInteger(3*rand())+ 1
```

The first three nodes are skipped, and only the last two are returned in the result.

Table 160. Result

n.name
"C"
"D"
"E"
3 rows

3.9. LIMIT

> `LIMIT` *constrains the number of rows in the output.*

3.9.1. Introduction

`LIMIT` accepts any expression that evaluates to a positive integer — however the expression cannot refer to nodes or relationships.

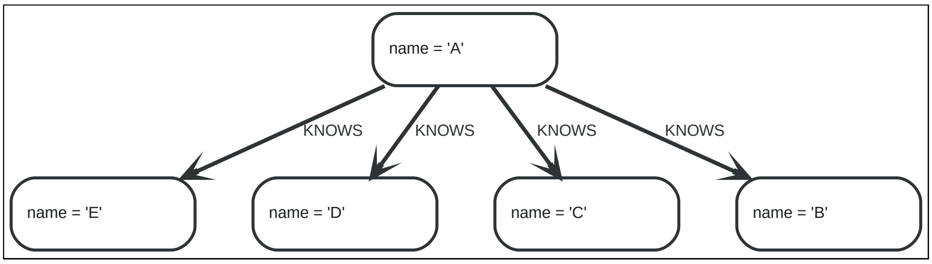


Figure 15. Graph

3.9.2. Return a subset of the rows

To return a subset of the result, starting from the top, use this syntax:

Query

```
MATCH (n)
RETURN n.name
ORDER BY n.name
LIMIT 3
```

The top three items are returned by the example query.

Table 161. Result

n.name
"A"
"B"
"C"
3 rows

3.9.3. Using an expression with `LIMIT` to return a subset of the rows

Limit accepts any expression that evaluates to a positive integer as long as it is not referring to any external variables:

Query

```
MATCH (n)
RETURN n.name
ORDER BY n.name
LIMIT toInteger(3 * rand())+ 1
```

Returns one to three top items.

Table 162. Result

n.name
"A"
1 row

3.10. CREATE

The `CREATE` clause is used to create nodes and relationships.

In the `CREATE` clause, patterns are used extensively. Read Patterns for an introduction.

3.10.1. Create nodes

Create single node

Creating a single node is done by issuing the following query:

Query

```
CREATE (n)
```

0 rows, Nodes created: 1

Create multiple nodes

Creating multiple nodes is done by separating them with a comma.

Query

```
CREATE (n),(m)
```

Table 163. Result

(empty result)
0 rows, Nodes created: 2

Create a node with a label

To add a label when creating a node, use the syntax below:

Query

```
CREATE (n:Person)
```

0 rows, Nodes created: 1, Labels added: 1

Create a node with multiple labels

To add labels when creating a node, use the syntax below. In this case, we add two labels.

Query

```
CREATE (n:Person:Swedish)
```

0 rows, Nodes created: 1, Labels added: 2

Create node and add labels and properties

When creating a new node with labels, you can add properties at the same time.

Query

```
CREATE (n:Person { name: 'Andy', title: 'Developer' })
```

0 rows, Nodes created: 1, Properties set: 2, Labels added: 1

Return created node

Creating a single node is done by issuing the following query:

Query

```
CREATE (a { name: 'Andy' })
RETURN a.name
```

The newly-created node is returned.

Table 164. Result

a.name
"Andy"
1 row, Nodes created: 1 Properties set: 1

3.10.2. Create relationships

Create a relationship between two nodes

To create a relationship between two nodes, we first get the two nodes. Once the nodes are loaded, we simply create a relationship between them.

Query

```
MATCH (a:Person),(b:Person)
WHERE a.name = 'A' AND b.name = 'B'
CREATE (a)-[r:RELTYPE]->(b)
RETURN type(r)
```

The created relationship is returned by the query.

Table 165. Result

type(r)
"RELTYPE"
1 row, Relationships created: 1

Create a relationship and set properties

Setting properties on relationships is done in a similar manner to how it's done when creating nodes. Note that the values can be any expression.

Query

```
MATCH (a:Person),(b:Person)
WHERE a.name = 'A' AND b.name = 'B'
CREATE (a)-[r:RELTYPE { name: a.name + '<->' + b.name }]->(b)
RETURN type(r), r.name
```

The newly-created relationship is returned by the example query.

Table 166. Result

type(r)	r.name
"RELTYPE"	"A<->B"
1 row, Relationships created: 1 Properties set: 1	

3.10.3. Create a full path

When you use `CREATE` and a pattern, all parts of the pattern that are not already in scope at this time will be created.

Query

```
CREATE p =(andy { name:'Andy' })-[:WORKS_AT]->(neo)<-[:WORKS_AT]-(michael { name: 'Michael' })
RETURN p
```

This query creates three nodes and two relationships in one go, assigns it to a path variable, and returns it.

Table 167. Result

p
(2)-[WORKS_AT,0]->(3)<-[WORKS_AT,1]-(4)
1 row, Nodes created: 3 Relationships created: 2 Properties set: 2

3.10.4. Use parameters with `CREATE`

Create node with a parameter for the properties

You can also create a graph entity from a map. All the key/value pairs in the map will be set as properties on the created relationship or node. In this case we add a `Person` label to the node as well.

Parameters

```
{
  "props" : {
    "name" : "Andy",
    "position" : "Developer"
  }
}
```

Query

```
CREATE (n:Person $props)
RETURN n
```

Table 168. Result

n
`Node[2]{name:"Andy",position:"Developer"}`
1 row, Nodes created: 1 Properties set: 2 Labels added: 1

Create multiple nodes with a parameter for their properties

By providing Cypher an array of maps, it will create a node for each map.

Parameters

```
{
  "props" : [ {
    "name" : "Andy",
    "position" : "Developer"
  }, {
    "name" : "Michael",
    "position" : "Developer"
  } ]
}
```

Query

```
UNWIND $props AS map
CREATE (n)
SET n = map
```

Table 169. Result

`(empty result)`
0 rows, Nodes created: 2 Properties set: 4

3.11. DELETE

The DELETE clause is used to delete nodes, relationships or paths.

- Introduction
- Delete a single node
- Delete all nodes and relationships
- Delete a node with all its relationships
- Delete relationships only

3.11.1. Introduction

For removing properties and labels, see REMOVE. Remember that you cannot delete a node without also deleting relationships that start or end on said node. Either explicitly delete the relationships, or use DETACH DELETE.

The examples start out with the following database:

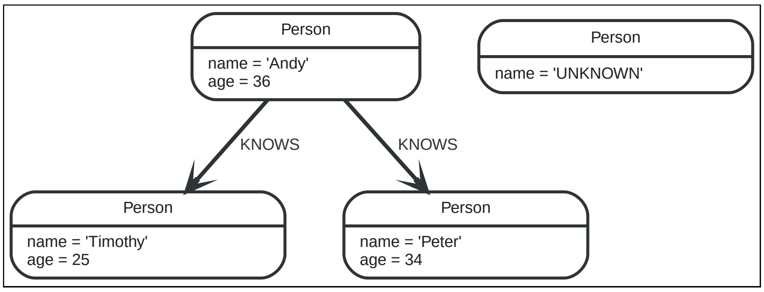


Figure 16. Graph

3.11.2. Delete single node

To delete a node, use the DELETE clause.

Query

```
MATCH (n:Person { name: 'UNKNOWN' })
DELETE n
```

Table 170. Result

(empty result)
0 rows, Nodes deleted: 1

3.11.3. Delete all nodes and relationships

This query isn't for deleting large amounts of data, but is useful when experimenting with small example data sets.

Query

```
MATCH (n)
DETACH DELETE n
```

Table 171. Result

(empty result)
0 rows, Nodes deleted: 4 Relationships deleted: 2

3.11.4. Delete a node with all its relationships

When you want to delete a node and any relationship going to or from it, use `DETACH DELETE`.

Query

```
MATCH (n { name: 'Andy' })
DETACH DELETE n
```

Table 172. Result

(empty result)
0 rows, Nodes deleted: 1 Relationships deleted: 2

For `DETACH DELETE` for users with restricted security privileges, see Operations Manual Fine-grained access control.

3.11.5. Delete relationships only

It is also possible to delete relationships only, leaving the node(s) otherwise unaffected.

Query

```
MATCH (n { name: 'Andy' })-[r:KNOWS]->()
DELETE r
```

This deletes all outgoing `KNOWS` relationships from the node with the name **'Andy'**.

Table 173. Result

(empty result)
0 rows, Relationships deleted: 2

3.12. SET

The `SET` clause is used to update labels on nodes and properties on nodes and relationships.

- Introduction
- Set a property
- Update a property
- Remove a property
- Copy properties between nodes and relationships
- Replace all properties using a map and `=`
- Remove all properties using an empty map and `=`
- Mutate specific properties using a map and `+=`

- Set multiple properties using one SET clause
- Set a property using a parameter
- Set all properties using a parameter
- Set a label on a node
- Set multiple labels on a node

3.12.1. Introduction

SET can be used with a map — provided as a literal, a parameter, or a node or relationship — to set properties.

Setting labels on a node is an idempotent operation — nothing will occur if an attempt is made to set a label on a node that already has that label. The query statistics will state whether any updates actually took place.

The examples use this graph as a starting point:

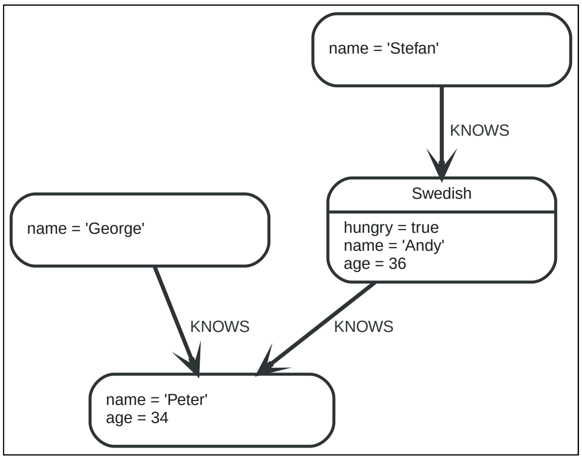


Figure 17. Graph

3.12.2. Set a property

Use SET to set a property on a node or relationship:

Query

```
MATCH (n { name: 'Andy' })
SET n.surname = 'Taylor'
RETURN n.name, n.surname
```

The newly-changed node is returned by the query.

Table 174. Result

n.name	n.surname
"Andy"	"Taylor"
1 row, Properties set: 1	

It is possible to set a property on a node or relationship using more complex expressions. For instance, in contrast to specifying the node directly, the following query shows how to set a property for a node selected by an expression:

Query

```
MATCH (n { name: 'Andy' })
SET (
CASE
WHEN n.age = 36
THEN n END ).worksIn = 'Malmo'
RETURN n.name, n.worksIn
```

Table 175. Result

n.name	n.worksIn
"Andy"	"Malmo"
1 row, Properties set: 1	

No action will be taken if the node expression evaluates to `null`, as shown in this example:

Query

```
MATCH (n { name: 'Andy' })
SET (
CASE
WHEN n.age = 55
THEN n END ).worksIn = 'Malmo'
RETURN n.name, n.worksIn
```

As no node matches the `CASE` expression, the expression returns a `null`. As a consequence, no updates occur, and therefore no `worksIn` property is set.

Table 176. Result

n.name	n.worksIn
"Andy"	<null>
1 row	

3.12.3. Update a property

`SET` can be used to update a property on a node or relationship. This query forces a change of type in the `age` property:

Query

```
MATCH (n { name: 'Andy' })
SET n.age = toString(n.age)
RETURN n.name, n.age
```

The `age` property has been converted to the string `'36'`.

Table 177. Result

n.name	n.age
"Andy"	"36"
1 row, Properties set: 1	

3.12.4. Remove a property

Although `REMOVE` is normally used to remove a property, it's sometimes convenient to do it using the `SET` command. A case in point is if the property is provided by a parameter.

Query

```
MATCH (n { name: 'Andy' })
SET n.name = NULL RETURN n.name, n.age
```

The `name` property is now missing.

Table 178. Result

n.name	n.age
`<null>`	`36`
1 row, Properties set: 1	

3.12.5. Copy properties between nodes and relationships

`SET` can be used to copy all properties from one node or relationship to another. This will remove *all* other properties on the node or relationship being copied to.

Query

```
MATCH (at { name: 'Andy' }),(pn { name: 'Peter' })
SET at = pn
RETURN at.name, at.age, at.hungry, pn.name, pn.age
```

The **'Andy'** node has had all its properties replaced by the properties of the **'Peter'** node.

Table 179. Result

at.name	at.age	at.hungry	pn.name	pn.age
`"Peter"`	`34`	`<null>`	`"Peter"`	`34`
1 row, Properties set: 3				

3.12.6. Replace all properties using a map and `=`

The property replacement operator `=` can be used with `SET` to replace all existing properties on a node or relationship with those provided by a map:

Query

```
MATCH (p { name: 'Peter' })
SET p = { name: 'Peter Smith', position: 'Entrepreneur' }
RETURN p.name, p.age, p.position
```

This query updated the `name` property from `Peter` to `Peter Smith`, deleted the `age` property, and added the `position` property to the **'Peter'** node.

Table 180. Result

p.name	p.age	p.position
`"Peter Smith"`	`<null>`	`"Entrepreneur"`
1 row, Properties set: 3		

3.12.7. Remove all properties using an empty map and =

All existing properties can be removed from a node or relationship by using SET with = and an empty map as the right operand:

Query

```
MATCH (p { name: 'Peter' })
SET p = { }
RETURN p.name, p.age
```

This query removed all the existing properties — namely, name and age — from the **'Peter'** node.

Table 181. Result

p.name	p.age
<null>	<null>
1 row, Properties set: 2	

3.12.8. Mutate specific properties using a map and +=

The property mutation operator += can be used with SET to mutate properties from a map in a fine-grained fashion:

- Any properties in the map that are not on the node or relationship will be *added*.
- Any properties not in the map that are on the node or relationship will be left as is.
- Any properties that are in both the map and the node or relationship will be *replaced* in the node or relationship. However, if any property in the map is null, it will be *removed* from the node or relationship.

Query

```
MATCH (p { name: 'Peter' })
SET p += { age: 38, hungry: TRUE , position: 'Entrepreneur' }
RETURN p.name, p.age, p.hungry, p.position
```

This query left the name property unchanged, updated the age property from 34 to 38, and added the hungry and position properties to the **'Peter'** node.

Table 182. Result

p.name	p.age	p.hungry	p.position
"Peter"	38	true	"Entrepreneur"
1 row, Properties set: 3			

In contrast to the property replacement operator =, providing an empty map as the right operand to += will not remove any existing properties from a node or relationship. In line with the semantics detailed above, passing in an empty map with += will have no effect:

Query

```
MATCH (p { name: 'Peter' })
SET p += { }
RETURN p.name, p.age
```

Table 183. Result

p.name	p.age
"Peter"	34
1 row	

3.12.9. Set multiple properties using one SET clause

Set multiple properties at once by separating them with a comma:

Query

```
MATCH (n { name: 'Andy' })
SET n.position = 'Developer', n.surname = 'Taylor'
```

Table 184. Result

(empty result)
0 rows, Properties set: 2

3.12.10. Set a property using a parameter

Use a parameter to set the value of a property:

Parameters

```
{
  "surname" : "Taylor"
}
```

Query

```
MATCH (n { name: 'Andy' })
SET n.surname = $surname
RETURN n.name, n.surname
```

A `surname` property has been added to the **'Andy'** node.

Table 185. Result

n.name	n.surname
"Andy"	"Taylor"
1 row, Properties set: 1	

3.12.11. Set all properties using a parameter

This will replace all existing properties on the node with the new set provided by the parameter.

Parameters

```
{
  "props" : {
    "name" : "Andy",
    "position" : "Developer"
  }
}
```

Query

```
MATCH (n { name: 'Andy' })
SET n = $props
RETURN n.name, n.position, n.age, n.hungry
```

The **'Andy'** node has had all its properties replaced by the properties in the `props` parameter.

Table 186. Result

n.name	n.position	n.age	n.hungry
"Andy"	"Developer"	<null>	<null>
1 row, Properties set: 4			

3.12.12. Set a label on a node

Use `SET` to set a label on a node:

Query

```
MATCH (n { name: 'Stefan' })
SET n:German
RETURN n.name, labels(n) AS labels
```

The newly-labeled node is returned by the query.

Table 187. Result

n.name	labels
"Stefan"	["German"]
1 row, Labels added: 1	

3.12.13. Set multiple labels on a node

Set multiple labels on a node with `SET` and use `:` to separate the different labels:

Query

```
MATCH (n { name: 'George' })
SET n:Swedish:Bossman
RETURN n.name, labels(n) AS labels
```

The newly-labeled node is returned by the query.

Table 188. Result

n.name	labels
"George"	["Swedish","Bossman"]
1 row, Labels added: 2	

3.13. REMOVE

The `REMOVE` clause is used to remove properties from nodes and relationships, and to remove labels from nodes.

- Introduction
- Remove a property
- Remove all properties
- Remove a label from a node
- Remove multiple labels from a node

3.13.1. Introduction

For deleting nodes and relationships, see DELETE.

> Removing labels from a node is an idempotent operation: if you try to remove a label from a node that does not have that label on it, nothing happens. The query statistics will tell you if something needed to be done or not.

The examples use the following database:

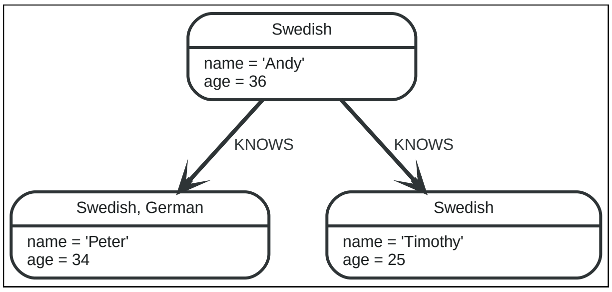


Figure 18. Graph

3.13.2. Remove a property

Neo4j doesn't allow storing `null` in properties. Instead, if no value exists, the property is just not there. So, `REMOVE` is used to remove a property value from a node or a relationship.

Query

```
MATCH (a { name: 'Andy' })
REMOVE a.age
RETURN a.name, a.age
```

The node is returned, and no property `age` exists on it.

Table 189. Result

a.name	a.age
"Andy"	<null>
1 row, Properties set: 1	

3.13.3. Remove all properties

`REMOVE` cannot be used to remove all existing properties from a node or relationship. Instead, using `SET` with `=` and an empty map as the right operand will clear all properties from the node or relationship.

3.13.4. Remove a label from a node

To remove labels, you use `REMOVE`.

Query

```
MATCH (n { name: 'Peter' })
REMOVE n:German
RETURN n.name, labels(n)
```

Table 190. Result

n.name	labels(n)
"Peter"	["Swedish"]
1 row, Labels removed: 1	

3.13.5. Remove multiple labels from a node

To remove multiple labels, you use `REMOVE`.

Query

```
MATCH (n { name: 'Peter' })
REMOVE n:German:Swedish
RETURN n.name, labels(n)
```

Table 191. Result

n.name	labels(n)
"Peter"	[]
1 row, Labels removed: 2	

3.14. FOREACH

The `FOREACH` clause is used to update data within a list, whether components of a path, or result of aggregation.

- Introduction
- Mark all nodes along a path

3.14.1. Introduction

Lists and paths are key concepts in Cypher. `FOREACH` can be used to update data, such as executing update commands on elements in a path, or on a list created by aggregation.

The variable context within the `FOREACH` parenthesis is separate from the one outside it. This means that if you `CREATE` a node variable within a `FOREACH`, you will *not* be able to use it outside of the foreach statement, unless you match to find it.

Within the `FOREACH` parentheses, you can do any of the updating commands — `CREATE`, `MERGE`, `DELETE`, and `FOREACH`.

If you want to execute an additional `MATCH` for each element in a list then `UNWIND` (see UNWIND) would be a more appropriate command.

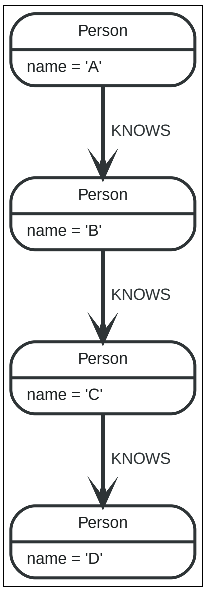


Figure 19. Graph

3.14.2. Mark all nodes along a path

This query will set the property `marked` to true on all nodes along a path.

Query

```
MATCH p =(begin)-[*]->(END )
WHERE begin.name = 'A' AND END .name = 'D'
FOREACH (n IN nodes(p)| SET n.marked = TRUE )
```

0 rows, Properties set: 4

3.15. MERGE

> *The `MERGE` clause ensures that a pattern exists in the graph. Either the pattern already exists, or it needs to be created.*

3.15.1. Introduction

`MERGE` either matches existing nodes and binds them, or it creates new data and binds that. It's like a combination of `MATCH` and `CREATE` that additionally allows you to specify what happens if the data was matched or created.

For example, you can specify that the graph must contain a node for a user with a certain name. If there isn't a node with the correct name, a new node will be created and its name property set.

When using `MERGE` on full patterns, the behavior is that either the whole pattern matches, or the whole pattern is created. `MERGE` will not partially use existing patterns — it's all or nothing. If partial matches are needed, this can be accomplished by splitting a pattern up into multiple `MERGE` clauses.

As with `MATCH`, `MERGE` can match multiple occurrences of a pattern. If there are multiple matches, they will all be passed on to later stages of the query.

The last part of `MERGE` is the `ON CREATE` and `ON MATCH`. These allow a query to express additional changes to the properties of a node or relationship, depending on if the element was `MATCH` -ed in the database or if it was `CREATE` -ed.

The following graph is used for the examples below:

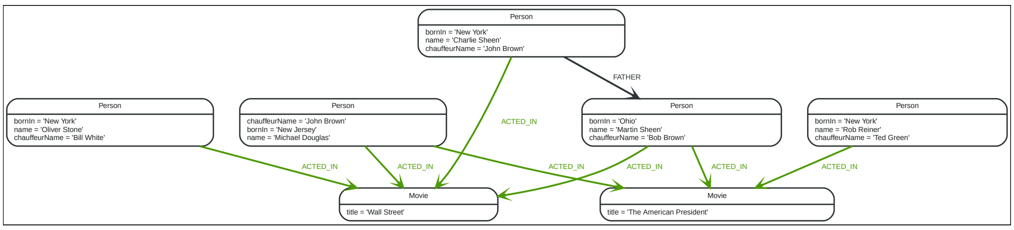


Figure 20. Graph

3.15.2. Merge nodes

Merge single node with a label

Merging a single node with the given label.

Query

```
MERGE (robert:Critic)
RETURN robert, labels(robert)
```

A new node is created because there are no nodes labeled `Critic` in the database.

Table 192. Result

robert	labels(robert)
`Node[7]{}`	`["Critic"]`
1 row, Nodes created: 1 Labels added: 1	

Merge single node with properties

Merging a single node with properties where not all properties match any existing node.

Query

```
MERGE (charlie { name: 'Charlie Sheen', age: 10 })
RETURN charlie
```

A new node with the name **'Charlie Sheen'** will be created since not all properties matched the existing **'Charlie Sheen'** node.

Table 193. Result

charlie
`Node[7]{name:"Charlie Sheen",age:10}`
1 row, Nodes created: 1 Properties set: 2

Merge single node specifying both label and property

Merging a single node with both label and property matching an existing node.

Query

```
MERGE (michael:Person { name: 'Michael Douglas' })
RETURN michael.name, michael.bornIn
```

'Michael Douglas' will be matched and the `name` and `bornIn` properties returned.

Table 194. Result

michael.name	michael.bornIn
`"Michael Douglas"`	`"New Jersey"`
1 row	

Merge single node derived from an existing node property

For some property 'p' in each bound node in a set of nodes, a single new node is created for each unique value for 'p'.

Query

```
MATCH (person:Person)
MERGE (city:City { name: person.bornIn })
RETURN person.name, person.bornIn, city
```

Three nodes labeled `City` are created, each of which contains a `name` property with the value of **'New York'**, **'Ohio'**, and **'New Jersey'**, respectively. Note that even though the `MATCH` clause results in three bound nodes having the value **'New York'** for the `bornIn` property, only a single **'New York'** node (i.e. a `City` node with a name of **'New York'**) is created. As the **'New York'** node is not matched for the first bound node, it is created. However, the newly-created **'New York'** node is matched and bound for the second and third bound nodes.

Table 195. Result

person.name	person.bornIn	city
"Charlie Sheen"	"New York"	Node[7]{name:"New York"}
"Martin Sheen"	"Ohio"	Node[8]{name:"Ohio"}
"Michael Douglas"	"New Jersey"	Node[9]{name:"New Jersey"}
"Oliver Stone"	"New York"	Node[7]{name:"New York"}
"Rob Reiner"	"New York"	Node[7]{name:"New York"}
5 rows, Nodes created: 3 Properties set: 3 Labels added: 3		

3.15.3. Use `ON CREATE` and `ON MATCH`

Merge with `ON CREATE`

Merge a node and set properties if the node needs to be created.

Query

```
MERGE (keanu:Person { name: 'Keanu Reeves' })
ON CREATE SET keanu.created = timestamp()
RETURN keanu.name, keanu.created
```

The query creates the **'keanu'** node and sets a timestamp on creation time.

Table 196. Result

keanu.name	keanu.created
"Keanu Reeves"	1579293276190
1 row, Nodes created: 1 Properties set: 2 Labels added: 1	

Merge with `ON MATCH`

Merging nodes and setting properties on found nodes.

Query

```
MERGE (person:Person)
ON MATCH SET person.found = TRUE RETURN person.name, person.found
```

The query finds all the `Person` nodes, sets a property on them, and returns them.

Table 197. Result

person.name	person.found
"Charlie Sheen"	true
"Martin Sheen"	true
"Michael Douglas"	true
"Oliver Stone"	true
"Rob Reiner"	true
5 rows, Properties set: 5	

Merge with `ON CREATE` and `ON MATCH`

Query

```
MERGE (keanu:Person { name: 'Keanu Reeves' })
ON CREATE SET keanu.created = timestamp()
ON MATCH SET keanu.lastSeen = timestamp()
RETURN keanu.name, keanu.created, keanu.lastSeen
```

The query creates the **'keanu'** node, and sets a timestamp on creation time. If **'keanu'** had already existed, a different property would have been set.

Table 198. Result

keanu.name	keanu.created	keanu.lastSeen
"Keanu Reeves"	1579293278164	<null>
1 row, Nodes created: 1 Properties set: 2 Labels added: 1		

Merge with `ON MATCH` setting multiple properties

If multiple properties should be set, simply separate them with commas.

Query

```
MERGE (person:Person)
ON MATCH SET person.found = TRUE , person.lastAccessed = timestamp()
RETURN person.name, person.found, person.lastAccessed
```

Table 199. Result

person.name	person.found	person.lastAccessed
"Charlie Sheen"	true	1579293279142
"Martin Sheen"	true	1579293279142
"Michael Douglas"	true	1579293279142
"Oliver Stone"	true	1579293279142
"Rob Reiner"	true	1579293279142
5 rows, Properties set: 10		

3.15.4. Merge relationships

Merge on a relationship

`MERGE` can be used to match or create a relationship.

Query

```
MATCH (charlie:Person { name: 'Charlie Sheen' }),(wallStreet:Movie { title: 'Wall Street' })
MERGE (charlie)-[r:ACTED_IN]->(wallStreet)
RETURN charlie.name, type(r), wallStreet.title
```

'Charlie Sheen' had already been marked as acting in **'Wall Street'**, so the existing relationship is found and returned. Note that in order to match or create a relationship when using `MERGE`, at least one bound node must be specified, which is done via the `MATCH` clause in the above example.

Table 200. Result

charlie.name	type(r)	wallStreet.title
`"Charlie Sheen"`	`"ACTED_IN"`	`"Wall Street"`
1 row		

Merge on multiple relationships

Query

```
MATCH (oliver:Person { name: 'Oliver Stone' }),(reiner:Person { name: 'Rob Reiner' })
MERGE (oliver)-[:DIRECTED]->(movie:Movie)<-[:ACTED_IN]-(reiner)
RETURN movie
```

In our example graph, **'Oliver Stone'** and **'Rob Reiner'** have never worked together. When we try to `MERGE` a "movie between them, Neo4j will not use any of the existing movies already connected to either person. Instead, a new **'movie'** node is created.

Table 201. Result

movie
`Node[7]{}`
1 row, Nodes created: 1 Relationships created: 2 Labels added: 1

Merge on an undirected relationship

`MERGE` can also be used with an undirected relationship. When it needs to create a new one, it will pick a direction.

Query

```
MATCH (charlie:Person { name: 'Charlie Sheen' }),(oliver:Person { name: 'Oliver Stone' })
MERGE (charlie)-[r:KNOWS]-(oliver)
RETURN r
```

As **'Charlie Sheen'** and **'Oliver Stone'** do not know each other this `MERGE` query will create a `KNOWS` relationship between them. The direction of the created relationship is arbitrary.

Table 202. Result

r
`:KNOWS[8]{}`

r
1 row, Relationships created: 1

Merge on a relationship between two existing nodes

MERGE can be used in conjunction with preceding MATCH and MERGE clauses to create a relationship between two bound nodes 'm' and 'n', where 'm' is returned by MATCH and 'n' is created or matched by the earlier MERGE.

Query

```
MATCH (person:Person)
MERGE (city:City { name: person.bornIn })
MERGE (person)-[r:BORN_IN]->(city)
RETURN person.name, person.bornIn, city
```

This builds on the example from Merge single node derived from an existing node property. The second MERGE creates a BORN_IN relationship between each person and a city corresponding to the value of the person's bornIn property. **'Charlie Sheen'**, **'Rob Reiner'** and **'Oliver Stone'** all have a BORN_IN relationship to the 'same' City node (**'New York'**).

Table 203. Result

person.name	person.bornIn	city
"Charlie Sheen"	"New York"	Node[7]{name:"New York"}
"Martin Sheen"	"Ohio"	Node[8]{name:"Ohio"}
"Michael Douglas"	"New Jersey"	Node[9]{name:"New Jersey"}
"Oliver Stone"	"New York"	Node[7]{name:"New York"}
"Rob Reiner"	"New York"	Node[7]{name:"New York"}
5 rows, Nodes created: 3 Relationships created: 5 Properties set: 3 Labels added: 3		

Merge on a relationship between an existing node and a merged node derived from a node property

MERGE can be used to simultaneously create both a new node 'n' and a relationship between a bound node 'm' and 'n'.

Query

```
MATCH (person:Person)
MERGE (person)-[r:HAS_CHAUFFEUR]->(chauffeur:Chauffeur { name: person.chauffeurName })
RETURN person.name, person.chauffeurName, chauffeur
```

As MERGE found no matches — in our example graph, there are no nodes labeled with Chauffeur and no HAS_CHAUFFEUR relationships — MERGE creates five nodes labeled with Chauffeur, each of which contains a name property whose value corresponds to each matched Person node's chauffeurName property value. MERGE also creates a HAS_CHAUFFEUR relationship between each Person node and the newly-created corresponding Chauffeur node. As **'Charlie Sheen'** and **'Michael Douglas'** both have a chauffeur with the same name — **'John Brown'** — a new node is created in each case, resulting in 'two' Chauffeur nodes having a name of **'John Brown'**, correctly denoting the fact that even though the name property may be identical, these are two separate people. This is in contrast to the example shown above in Merge on a relationship between two existing nodes, where we used the first MERGE to bind the City nodes to prevent them from being recreated (and thus duplicated) in the second MERGE.

Table 204. Result

person.name	person.chauffeurName	chauffeur
"Charlie Sheen"	"John Brown"	Node[7]{name:"John Brown"}
"Martin Sheen"	"Bob Brown"	Node[8]{name:"Bob Brown"}
"Michael Douglas"	"John Brown"	Node[9]{name:"John Brown"}
"Oliver Stone"	"Bill White"	Node[10]{name:"Bill White"}
"Rob Reiner"	"Ted Green"	Node[11]{name:"Ted Green"}
5 rows, Nodes created: 5 Relationships created: 5 Properties set: 5 Labels added: 5		

3.15.5. Using unique constraints with MERGE

Cypher prevents getting conflicting results from `MERGE` when using patterns that involve unique constraints. In this case, there must be at most one node that matches that pattern.

For example, given two unique constraints on `:Person(id)` and `:Person(ssn)`, a query such as `MERGE (n:Person {id: 12, ssn: 437})` will fail, if there are two different nodes (one with `id` 12 and one with `ssn` 437) or if there is only one node with only one of the properties. In other words, there must be exactly one node that matches the pattern, or no matching nodes.

Note that the following examples assume the existence of unique constraints that have been created using:

```
CREATE CONSTRAINT ON (n:Person) ASSERT n.name IS UNIQUE;
CREATE CONSTRAINT ON (n:Person) ASSERT n.role IS UNIQUE;
```

Merge using unique constraints creates a new node if no node is found

Merge using unique constraints creates a new node if no node is found.

Query

```
MERGE (laurence:Person { name: 'Laurence Fishburne' })
RETURN laurence.name
```

The query creates the **'laurence'** node. If **'laurence'** had already existed, `MERGE` would just match the existing node.

Table 205. Result

laurence.name
"Laurence Fishburne"
1 row, Nodes created: 1 Properties set: 1 Labels added: 1

Merge using unique constraints matches an existing node

Merge using unique constraints matches an existing node.

Query

```
MERGE (oliver:Person { name: 'Oliver Stone' })
RETURN oliver.name, oliver.bornIn
```

The **'oliver'** node already exists, so `MERGE` just matches it.

Table 206. Result

oliver.name	oliver.bornIn
"Oliver Stone"	"New York"
1 row	

Merge with unique constraints and partial matches

Merge using unique constraints fails when finding partial matches.

Query

```
MERGE (michael:Person { name: 'Michael Douglas', role: 'Gordon Gekko' })
RETURN michael
```

While there is a matching unique **'michael'** node with the name **'Michael Douglas'**, there is no unique node with the role of **'Gordon Gekko'** and `MERGE` fails to match.

Error message

```
Merge did not find a matching node michael and can not create a new node due to
conflicts with existing unique nodes
```

If we want to give Michael Douglas the role of Gordon Gekko, we can use the `SET` clause instead:

Query

```
MERGE (michael:Person { name: 'Michael Douglas' })
SET michael.role = 'Gordon Gekko'
```

Merge with unique constraints and conflicting matches

Merge using unique constraints fails when finding conflicting matches.

Query

```
MERGE (oliver:Person { name: 'Oliver Stone', role: 'Gordon Gekko' })
RETURN oliver
```

While there is a matching unique **'oliver'** node with the name **'Oliver Stone'**, there is also another unique node with the role of **'Gordon Gekko'** and `MERGE` fails to match.

Error message

```
Merge did not find a matching node oliver and can not create a new node due to
conflicts with existing unique nodes
```

Using map parameters with MERGE

MERGE does not support map parameters the same way CREATE does. To use map parameters with MERGE, it is necessary to explicitly use the expected properties, such as in the following example. For more information on parameters, see Parameters.

Parameters

```
{
  "param" : {
    "name" : "Keanu Reeves",
    "role" : "Neo"
  }
}
```

Query

```
MERGE (person:Person { name: $param.name, role: $param.role })
RETURN person.name, person.role
```

Table 207. Result

person.name	person.role
"Keanu Reeves"	"Neo"
1 row, Nodes created: 1 Properties set: 2 Labels added: 1	

3.16. CALL {} (subquery)

The CALL {} clause evaluates a subquery that returns some values.

3.16.1. Introduction

CALL allows to execute subqueries, i.e. queries inside of other queries. Subqueries allow you to compose queries, which is especially useful when working with UNION or aggregations.

The CALL clause is also used for calling procedures. For descriptions of the CALL clause in this context, refer to CALL procedure.

A subquery is evaluated for each incoming input row and may produce an arbitrary number of output rows. Every output row is then combined with the input row to build the result of the subquery. That means that a subquery will influence the number of rows. If the subquery does not return any rows, there will be no rows available after the subquery.

There are restrictions on what queries are allowed as subqueries and how they interact with the enclosing query:

- A subquery must end with a RETURN clause.

- A subquery cannot refer to variables from the enclosing query.
- A subquery cannot return variables with the same names as variables in the enclosing query.
- All variables that are returned from a subquery are afterwards available in the enclosing query.

The following graph is used for the examples below:

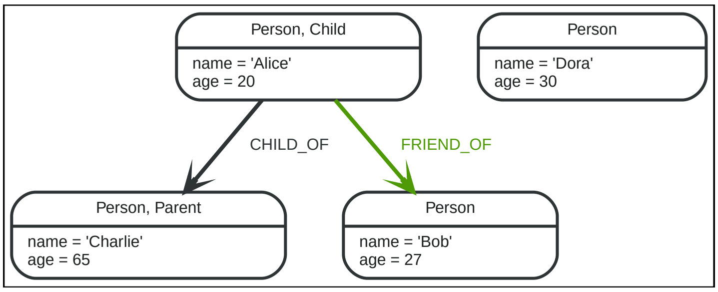


Figure 21. Graph

3.16.2. Post-union processing

Subqueries can be used to process the results of a `UNION` query further. This example query finds the youngest and the oldest person in the database and orders them by name.

Query

```
CALL {
  MATCH (p:Person) RETURN p ORDER BY p.age ASC LIMIT 1
  UNION
  MATCH (p:Person) RETURN p ORDER BY p.age DESC LIMIT 1
}
RETURN p.name, p.age ORDER BY p.name
```

Table 208. Result

p.name	p.age
"Alice"	20
"Charlie"	65
2 rows	

If different parts of a result should be matched differently, with some aggregation over the whole results, subqueries need to be used. This example query finds all persons with friends in one part of the union and all children with parents in the other part. Subsequently the number of friends and parents is counted together.

Query

```
CALL {
  MATCH (p:Person)-[:FRIEND_OF]->(other:Person) RETURN p, other
  UNION
  MATCH (p:Child)-[:CHILD_OF]->(other:Parent) RETURN p, other
}
RETURN DISTINCT p.name, count(other)
```

Table 209. Result

p.name	count(other)
"Alice"	2
1 row	

3.16.3. Aggregation and side-effects

Subqueries can be useful to do aggregations for each row and to isolate side-effects. This example query creates five `Clone` nodes for each existing person. The aggregation ensures that cardinality is not changed by the subquery. Without this, the result would be five times as many rows.

Query

```
MATCH (p:Person)
CALL {
  UNWIND range(1, 5) AS i
  CREATE (c:Clone)
  RETURN count(c) AS numberOfClones
}
RETURN p.name, numberOfClones
```

Table 210. Result

p.name	numberOfClones
"Alice"	5
"Bob"	5
"Charlie"	5
"Dora"	5
4 rows	

3.16.4. Correlated subqueries

This functionality is currently only available in Neo4j Fabric. Find out more about this feature in Operations Manual Fabric.

A correlated subquery is a subquery that uses variables defined outside of the `CALL` clause. To be able to use a variable in this way, the variable must be explicitly imported into the subquery.

Importing variables into subqueries

Variables are imported into a subquery using an importing `WITH` clause. As the subquery is evaluated for each incoming input row, the imported variables get bound to the corresponding values from the input row in each evaluation.

Query.

```
UNWIND [0, 1, 2] AS x
CALL {
  WITH x
  RETURN x*10 AS y
}
RETURN x, y
```

Table 211. Result

x	y
0	0
1	10
2	20
3 rows	

An importing `WITH` clause must:

* Consist only of simple references to outside variables - e.g. `WITH x, y, z`. Aliasing or expressions are not supported in importing `WITH` clauses - e.g. `WITH a AS b` or `WITH a+1 AS b`.
* Be the first clause of a subquery (or the second clause, if directly following a `USE` clause).

Aggregation on imported variables

Aggregations in subqueries are scoped to the subquery evaluation, also for imported variables, as shown in the following example:

Query.

```
UNWIND [0, 1, 2] AS x
CALL {
  WITH x
  RETURN max(x) AS xMax
}
RETURN x, xMax
```

Table 212. Result

x	xMax
0	0
1	1
2	2
3 rows	

The aggregation `max(x)` observes only a single value of `x` in each evaluation of the subquery, and thus simply evaluates to that same value.

3.17. CALL procedure

The `CALL` clause is used to call a procedure deployed in the database.

* Introduction
* Call a procedure using `CALL`
* View the signature for a procedure
* Call a procedure using a quoted namespace and name
* Call a procedure with literal arguments
* Call a procedure with parameter arguments
* Call a procedure with mixed literal and parameter arguments
* Call a procedure with literal and default arguments
* Call a procedure within a complex query using `CALL…YIELD`
* Call a procedure and filter its results
* Call a procedure within a complex query and rename its outputs

3.17.1. Introduction

Procedures are called using the `CALL` clause.

The CALL clause is also used to evaluate a subquery. For descriptions of the CALL clause in this context, refer to CALL {} (subquery).

Each procedure call needs to specify all required procedure arguments. This may be done either explicitly, by using a comma-separated list wrapped in parentheses after the procedure name, or implicitly by using available query parameters as procedure call arguments. The latter form is available only in a so-called standalone procedure call, when the whole query consists of a single CALL clause.

Most procedures return a stream of records with a fixed set of result fields, similar to how running a Cypher query returns a stream of records. The YIELD sub-clause is used to explicitly select which of the available result fields are returned as newly-bound variables from the procedure call to the user or for further processing by the remaining query. Thus, in order to be able to use YIELD, the names (and types) of the output parameters need be known in advance. Each yielded result field may optionally be renamed using aliasing (i.e. `resultFieldName AS newName`). All new variables bound by a procedure call are added to the set of variables already bound in the current scope. It is an error if a procedure call tries to rebind a previously bound variable (i.e. a procedure call cannot shadow a variable that was previously bound in the current scope).

This section explains how to determine a procedure's input parameters (needed for CALL) and output parameters (needed for YIELD).

Inside a larger query, the records returned from a procedure call with an explicit YIELD may be further filtered using a WHERE sub-clause followed by a predicate (similar to WITH … WHERE …).

If the called procedure declares at least one result field, YIELD may generally not be omitted. However YIELD may always be omitted in a standalone procedure call. In this case, all result fields are yielded as newly-bound variables from the procedure call to the user.

Neo4j supports the notion of VOID procedures. A VOID procedure is a procedure that does not declare any result fields and returns no result records and that has explicitly been declared as VOID. Calling a VOID procedure may only have a side effect and thus does neither allow nor require the use of YIELD. Calling a VOID procedure in the middle of a larger query will simply pass on each input record (i.e. it acts like `WITH *` in terms of the record stream).

Neo4j comes with a number of built-in procedures. For a list of these, see Operations Manual Built-in procedures.

Users can also develop custom procedures and deploy to the database. See Java Reference Procedures and functions for details.

3.17.2. Call a procedure using CALL

This calls the built-in procedure `db.labels`, which lists all labels used in the database.

Query

```
CALL db.labels
```

Table 213. Result

label
"User"
"Administrator"
2 rows

3.17.3. View the signature for a procedure

To `CALL` a procedure, its input parameters need to be known, and to use `YIELD`, its output parameters need to be known. The built-in procedure `dbms.procedures` returns the name, signature and description for all procedures. The following query can be used to return the signature for a particular procedure:

Query

```
CALL dbms.procedures() YIELD name, signature
WHERE name='dbms.listConfig'
RETURN signature
```

We can see that the `dbms.listConfig` has one input parameter, `searchString`, and three output parameters, `name`, `description` and `value`.

Table 214. Result

signature
"dbms.listConfig(searchString = :: STRING?) :: (name :: STRING?, description :: STRING?, value :: STRING?, dynamic :: BOOLEAN?)"
1 row

3.17.4. Call a procedure using a quoted namespace and name

This calls the built-in procedure `db.labels`, which lists all labels used in the database.

Query

```
CALL `db`.`labels`
```

3.17.5. Call a procedure with literal arguments

This calls the example procedure `dbms.security.createUser` using literal arguments. The arguments are written out directly in the statement text.

Query

```
CALL dbms.security.createUser('johnsmith', 'h6u4%kr', FALSE )
```

Since our example procedure does not return any result, the result is empty.

3.17.6. Call a procedure with parameter arguments

This calls the example procedure `dbms.security.createUser` using parameters as arguments. Each procedure argument is taken to be the value of a corresponding statement parameter with the same name (or null if no such parameter has been given).

Parameters

```
{
  "username" : "johnsmith",
  "password" : "h6u4%kr",
  "requirePasswordChange" : false
}
```

Query

```
CALL dbms.security.createUser
```

Since our example procedure does not return any result, the result is empty.

3.17.7. Call a procedure with mixed literal and parameter arguments

This calls the example procedure `dbms.security.createUser` using both literal and parameter arguments.

Parameters

```
{
  "password" : "h6u4%kr"
}
```

Query

```
CALL dbms.security.createUser('username', $password, 'requirePasswordChange')
```

Since our example procedure does not return any result, the result is empty.

3.17.8. Call a procedure with literal and default arguments

This calls the example procedure `dbms.security.createUser` using literal arguments. That is, arguments that are written out directly in the statement text, and a trailing default argument that is provided by the procedure itself.

Query

```
CALL dbms.security.createUser('johnsmith', 'h6u4%kr')
```

Since our example procedure does not return any result, the result is empty.

3.17.9. Call a procedure within a complex query using `CALL YIELD`

This calls the built-in procedure `db.labels` to count all labels used in the database.

Query

```
CALL db.labels() YIELD label
RETURN count(label) AS numLabels
```

Since the procedure call is part of a larger query, all outputs must be named explicitly.

3.17.10. Call a procedure and filter its results

This calls the built-in procedure `db.labels` to count all in-use labels in the database that contain the word 'User'.

Query

```
CALL db.labels() YIELD label
WHERE label CONTAINS 'User'
RETURN count(label) AS numLabels
```

Since the procedure call is part of a larger query, all outputs must be named explicitly.

3.17.11. Call a procedure within a complex query and rename its outputs

This calls the built-in procedure `db.propertyKeys` as part of counting the number of nodes per property key that is currently used in the database.

Query

```
CALL db.propertyKeys() YIELD propertyKey AS prop
MATCH (n)
WHERE n[prop] IS NOT NULL RETURN prop, count(n) AS numNodes
```

Since the procedure call is part of a larger query, all outputs must be named explicitly.

3.18. UNION

> *The `UNION` clause is used to combine the result of multiple queries.*

- Introduction
- Combine two queries and retain duplicates
- Combine two queries and remove duplicates

3.18.1. Introduction

`UNION` combines the results of two or more queries into a single result set that includes all the rows that belong to all queries in the union.

The number and the names of the columns must be identical in all queries combined by using `UNION`.

To keep all the result rows, use `UNION ALL`. Using just `UNION` will combine and remove duplicates from the result set.

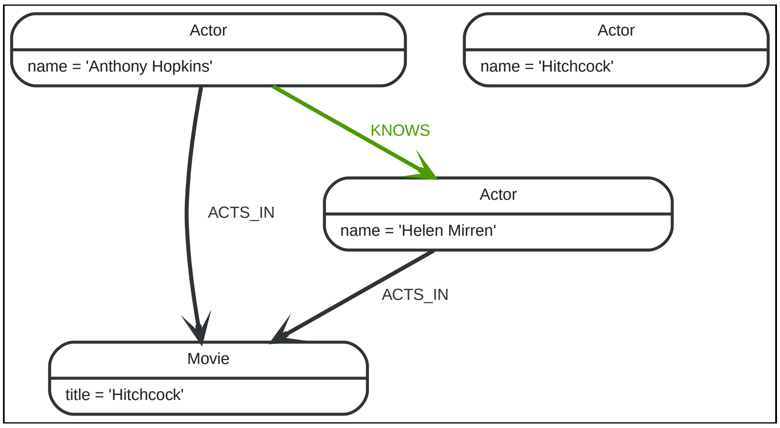


Figure 22. Graph

3.18.2. Combine two queries and retain duplicates

Combining the results from two queries is done using `UNION ALL`.

Query

```
MATCH (n:Actor)
RETURN n.name AS name
UNION ALL MATCH (n:Movie)
RETURN n.title AS name
```

The combined result is returned, including duplicates.

Table 215. Result

name
"Anthony Hopkins"
"Helen Mirren"
"Hitchcock"
"Hitchcock"
4 rows

3.18.3. Combine two queries and remove duplicates

By not including `ALL` in the `UNION`, duplicates are removed from the combined result set

Query

```
MATCH (n:Actor)
RETURN n.name AS name
UNION
MATCH (n:Movie)
RETURN n.title AS name
```

The combined result is returned, without duplicates.

Table 216. Result

name
"Anthony Hopkins"
"Helen Mirren"
"Hitchcock"
3 rows

3.19. USE

> *The `USE` clause determines which graph a query, or query part, is executed against.*

3.19.1. Introduction

The `USE` clause determines which graph a query, or query part, is executed against.

> This functionality is currently only available in Neo4j Fabric. Find out more about this feature in Operations Manual → Fabric.

3.19.2. Syntax

The `USE` clause can only appear as the first clause of:

- Queries:

```
USE <graph>
<other clauses>
```

- Union parts:

```
USE <graph>
<other clauses>
  UNION
USE <graph>
<other clauses>
```

- Subqueries:

```
CALL {
  USE <graph>
  <other clauses>
}
```

  In subqueries, a `USE` clause may appear as the second clause, if directly following an importing `WITH` clause

3.19.3. Examples

In the following examples we assume that we have configured a Fabric database called `exampleFabricSetup`.

Query graph by name

The graph that we wish to query is configured to be referred to by the name `exampleDatabaseName`.

Query.

```
USE exampleFabricSetup.exampleDatabaseName
```

Query graph by graph ID

The graph we wish to query is configured with the graph id `0`, which is why we can refer to it using the built-in function `graph()` with the argument `0`:

Query.

```
USE exampleFabricSetup.graph(0)
```

3.20. LOAD CSV

`LOAD CSV` is used to import data from CSV files.

3.20.1. Introduction

- The URL of the CSV file is specified by using `FROM` followed by an arbitrary expression evaluating to the URL in question.
- It is required to specify a variable for the CSV data using `AS`.
- CSV files can be stored on the database server and are then accessible using a `file:///` URL. Alternatively, `LOAD CSV` also supports accessing CSV files via *HTTPS*, *HTTP*, and *FTP*.
- `LOAD CSV` supports resources compressed with *gzip* and *Deflate*. Additionally `LOAD CSV` supports locally stored CSV files compressed with *ZIP*.
- `LOAD CSV` will follow *HTTP* redirects but for security reasons it will not follow redirects that changes the protocol, for example if the redirect is going from *HTTPS* to *HTTP*.
- `LOAD CSV` is often used in conjunction with the query hint `PERIODIC COMMIT`; more information on this may be found in `PERIODIC COMMIT` query hint.

Configuration settings for file URLs

dbms.security.allow_csv_import_from_file_urls

This setting determines if Cypher will allow the use of `file:///` URLs when loading data using `LOAD CSV`. Such URLs identify files on the filesystem of the database server. Default is *true*. Setting `dbms.security.allow_csv_import_from_file_urls=false` will completely disable access to the file system for `LOAD CSV`.

dbms.directories.import

Sets the root directory for `file:///` URLs used with the Cypher `LOAD CSV` clause. This should be set to a single directory relative to the Neo4j installation path on the database server. All requests to load from `file:///` URLs will then be relative to the specified directory. The default value set in the config settings is *import*. This is a security measure which prevents the database from accessing files outside the standard import directory, similar to how a Unix `chroot` operates. Setting this to an empty field will allow access to all files within the Neo4j installation folder. Commenting out this setting will disable the security feature, allowing all files in the local system to be imported. This is definitely not recommended.

File URLs will be resolved relative to the `dbms.directories.import` directory. For example, a file URL will typically look like `file:///myfile.csv` or `file:///myproject/myfile.csv`.

- If `dbms.directories.import` is set to the default value *import*, using the above URLs in `LOAD CSV` would read from *<NEO4J_HOME>/import/myfile.csv* and *<NEO4J_HOME>/import/myproject/myfile.csv* respectively.
- If it is set to */data/csv*, using the above URLs in `LOAD CSV` would read from *<NEO4J_HOME>/data/csv/myfile.csv* and *<NEO4J_HOME>/data/csv/myproject/myfile.csv* respectively.

See the examples below for further details.

3.20.2. CSV file format

The CSV file to use with `LOAD CSV` must have the following characteristics:

- the character encoding is UTF-8;
- the end line termination is system dependent, e.g., it is `\n` on unix or `\r\n` on windows;
- the default field terminator is `,`;
- the field terminator character can be change by using the option `FIELDTERMINATOR` available in the `LOAD CSV` command;
- quoted strings are allowed in the CSV file and the quotes are dropped when reading the data;
- the character for string quotation is double quote `"`;
- if `dbms.import.csv.legacy_quote_escaping` is set to the default value of `true`, `\` is used as an escape character;
- a double quote must be in a quoted string and escaped, either with the escape character or a second double quote.

3.20.3. Import data from a CSV file

To import data from a CSV file into Neo4j, you can use `LOAD CSV` to get the data into your query. Then you write it to your database using the normal updating clauses of Cypher.

artists.csv

```
1,ABBA,1992
2,Roxette,1986
3,Europe,1979
4,The Cardigans,1992
```

Query

```
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists.csv' AS line
CREATE (:Artist { name: line[1], year: toInteger(line[2])})
```

A new node with the `Artist` label is created for each row in the CSV file. In addition, two columns from the CSV file are set as properties on the nodes.

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

3.20.4. Import data from a CSV file containing headers

When your CSV file has headers, you can view each row in the file as a map instead of as an array of strings.

artists-with-headers.csv

```
Id,Name,Year
1,ABBA,1992
2,Roxette,1986
3,Europe,1979
4,The Cardigans,1992
```

Query

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists-with-headers.csv' AS line
CREATE (:Artist { name: line.Name, year: toInteger(line.Year)})
```

This time, the file starts with a single row containing column names. Indicate this using `WITH HEADERS` and you can access specific fields by their corresponding column name.

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

3.20.5. Import data from a CSV file with a custom field delimiter

Sometimes, your CSV file has other field delimiters than commas. You can specify which delimiter your file uses, using `FIELDTERMINATOR`. Hexadecimal representation of the unicode character encoding can be used if prepended by `\u`. The encoding must be written with four digits. For example, `\u002C` is equivalent to `;`.

artists-fieldterminator.csv

```
1;ABBA;1992
2;Roxette;1986
3;Europe;1979
4;The Cardigans;1992
```

Query

```
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists-fieldterminator.csv' AS line
FIELDTERMINATOR ';'
CREATE (:Artist { name: line[1], year: toInteger(line[2])})
```

As values in this file are separated by a semicolon, a custom `FIELDTERMINATOR` is specified in the `LOAD CSV` clause.

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

3.20.6. Importing large amounts of data

If the CSV file contains a significant number of rows (approaching hundreds of thousands or millions), `USING PERIODIC COMMIT` can be used to instruct Neo4j to perform a commit after a number of rows. This reduces the memory overhead of the transaction state. By default, the commit will happen every 1000 rows. For more information, see `PERIODIC COMMIT` query hint.

Query

```
USING PERIODIC COMMIT
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists.csv' AS line
CREATE (:Artist { name: line[1], year: toInteger(line[2])})
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

3.20.7. Setting the rate of periodic commits

You can set the number of rows as in the example, where it is set to 500 rows.

Query

```
USING PERIODIC COMMIT 500
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists.csv' AS line
CREATE (:Artist { name: line[1], year: toInteger(line[2])})
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

3.20.8. Import data containing escaped characters

In this example, we both have additional quotes around the values, as well as escaped quotes inside one value.

artists-with-escaped-char.csv

```
"1","The ""Symbol""","1992"
```

Query

```
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists-with-escaped-char.csv' AS line
CREATE (a:Artist { name: line[1], year: toInteger(line[2])})
RETURN a.name AS name, a.year AS year, size(a.name) AS size
```

Note that strings are wrapped in quotes in the output here. You can see that when comparing to the length of the string in this case!

Result

```
+------------------------------+
| name           | year | size |
+------------------------------+
| "The "Symbol"" | 1992 | 12   |
+------------------------------+
1 row
Nodes created: 1
Properties set: 2
Labels added: 1
```

3.20.9. Using linenumber() with LOAD CSV

For certain scenarios, like debugging a problem with a csv file, it may be useful to get the current line number that `LOAD CSV` is operating on. The `linenumber()` function provides exactly that or `null` if called without a `LOAD CSV` context.

artists.csv

```
1,ABBA,1992
2,Roxette,1986
3,Europe,1979
4,The Cardigans,1992
```

Query

```
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists.csv' AS line
RETURN linenumber() AS number, line
```

Result

```
+-----------------------------------------+
| number | line                           |
+-----------------------------------------+
| 1      | ["1","ABBA","1992"]            |
| 2      | ["2","Roxette","1986"]         |
| 3      | ["3","Europe","1979"]          |
| 4      | ["4","The Cardigans","1992"]   |
+-----------------------------------------+
4 rows
```

3.20.10. Using file() with LOAD CSV

For certain scenarios, like debugging a problem with a csv file, it may be useful to get the absolute path of the file that `LOAD CSV` is operating on. The `file()` function provides exactly that or `null` if called without a `LOAD CSV` context.

artists.csv

```
1,ABBA,1992
2,Roxette,1986
3,Europe,1979
4,The Cardigans,1992
```

Query

```
LOAD CSV FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/artists.csv' AS line
RETURN DISTINCT file() AS path
```

Since `LOAD CSV` can temporary download a file to process it, it is important to note that `file()` will always return the path on disk. This is why you see different URIs in this example. If `LOAD CSV` is invoked with a `file:///` URL that points to your disk `file()` will return that same path.

Result

```
+-----------------------------------------------------------------------------------------------------------
---------+
| path
|
+-----------------------------------------------------------------------------------------------------------
---------+
| "/opt/teamcity-agent/work/1a0193e4fce41a56/cypher/cypher-docs/target/docs/dev/ql/load-csv/csv-
files/artists.csv" |
+-----------------------------------------------------------------------------------------------------------
---------+
1 row
```

Chapter 4. Functions

This section contains information on all functions in the Cypher query language.

- Predicate functions [Summary | Detail]
- Scalar functions [Summary | Detail]
- Aggregating functions [Summary | Detail]
- List functions [Summary | Detail]
- Mathematical functions - numeric [Summary | Detail]
- Mathematical functions - logarithmic [Summary | Detail]
- Mathematical functions - trigonometric [Summary | Detail]
- String functions [Summary | Detail]
- Temporal functions - instant types [Summary | Detail]
- Temporal functions - duration [Summary | Detail]
- Spatial functions [Summary | Detail]
- User-defined functions [Summary | Detail]
- LOAD CSV functions [Summary | Detail]

Related information may be found in Operators.

Please note

- Functions in Cypher return `null` if an input parameter is `null`.
- Functions taking a string as input all operate on *Unicode characters* rather than on a standard `char[]`. For example, the `size()` function applied to any *Unicode character* will return **1**, even if the character does not fit in the 16 bits of one `char`.

Predicate functions

These functions return either true or false for the given arguments.

Function	Description
all()	Tests whether the predicate holds for all elements in a list.
any()	Tests whether the predicate holds for at least one element in a list.
exists()	Returns true if a match for the pattern exists in the graph, or if the specified property exists in the node, relationship or map.
none()	Returns true if the predicate holds for no element in a list.
single()	Returns true if the predicate holds for exactly one of the elements in a list.

Scalar functions

These functions return a single value.

Function	Description
coalesce()	Returns the first non-`null` value in a list of expressions.
endNode()	Returns the end node of a relationship.

Function	Description
head()	Returns the first element in a list.
id()	Returns the id of a relationship or node.
last()	Returns the last element in a list.
length()	Returns the length of a path.
properties()	Returns a map containing all the properties of a node or relationship.
randomUUID()	Returns a string value corresponding to a randomly-generated UUID.
size()	Returns the number of items in a list.
size() applied to pattern expression	Returns the number of sub-graphs matching the pattern expression.
size() applied to string	Returns the number of Unicode characters in a string.
startNode()	Returns the start node of a relationship.
timestamp()	Returns the difference, measured in milliseconds, between the current time and midnight, January 1, 1970 UTC.
toBoolean()	Converts a string value to a boolean value.
toFloat()	Converts an integer or string value to a floating point number.
toInteger()	Converts a floating point or string value to an integer value.
type()	Returns the string representation of the relationship type.

Aggregating functions

These functions take multiple values as arguments, and calculate and return an aggregated value from them.

Function	Description
avg() - Numeric values	Returns the average of a set of numeric values.
avg() - Durations	Returns the average of a set of Durations.
collect()	Returns a list containing the values returned by an expression.
count()	Returns the number of values or rows.
max()	Returns the maximum value in a set of values.
min()	Returns the minimum value in a set of values.
percentileCont()	Returns the percentile of a value over a group using linear interpolation.
percentileDisc()	Returns the nearest value to the given percentile over a group using a rounding method.
stDev()	Returns the standard deviation for the given value over a group for a sample of a population.
stDevP()	Returns the standard deviation for the given value over a group for an entire population.
sum() - Numeric values	Returns the sum of a set of numeric values.
sum() - Durations	Returns the sum of a set of Durations.

List functions

These functions return lists of other values. Further details and examples of lists may be found in Lists.

Function	Description
keys()	Returns a list containing the string representations for all the property names of a node, relationship, or map.
labels()	Returns a list containing the string representations for all the labels of a node.
nodes()	Returns a list containing all the nodes in a path.
range()	Returns a list comprising all integer values within a specified range.
reduce()	Runs an expression against individual elements of a list, storing the result of the expression in an accumulator.
relationships()	Returns a list containing all the relationships in a path.
reverse()	Returns a list in which the order of all elements in the original list have been reversed.
tail()	Returns all but the first element in a list.

Mathematical functions - numeric

These functions all operate on numerical expressions only, and will return an error if used on any other values.

Function	Description
abs()	Returns the absolute value of a number.
ceil()	Returns the smallest floating point number that is greater than or equal to a number and equal to a mathematical integer.
floor()	Returns the largest floating point number that is less than or equal to a number and equal to a mathematical integer.
rand()	Returns a random floating point number in the range from 0 (inclusive) to 1 (exclusive); i.e. `[0,1)`.
round()	Returns the value of a number rounded to the nearest integer.
sign()	Returns the signum of a number: `0` if the number is `0`, `-1` for any negative number, and `1` for any positive number.

Mathematical functions - logarithmic

These functions all operate on numerical expressions only, and will return an error if used on any other values.

Function	Description
e()	Returns the base of the natural logarithm, `e`.
exp()	Returns `e^n`, where `e` is the base of the natural logarithm, and `n` is the value of the argument expression.
log()	Returns the natural logarithm of a number.
log10()	Returns the common logarithm (base 10) of a number.
sqrt()	Returns the square root of a number.

Mathematical functions - trigonometric

These functions all operate on numerical expressions only, and will return an error if used on any other values.

All trigonometric functions operate on radians, unless otherwise specified.

Function	Description
acos()	Returns the arccosine of a number in radians.
asin()	Returns the arcsine of a number in radians.
atan()	Returns the arctangent of a number in radians.
atan2()	Returns the arctangent2 of a set of coordinates in radians.
cos()	Returns the cosine of a number.
cot()	Returns the cotangent of a number.
degrees()	Converts radians to degrees.
haversin()	Returns half the versine of a number.
pi()	Returns the mathematical constant *pi*.
radians()	Converts degrees to radians.
sin()	Returns the sine of a number.
tan()	Returns the tangent of a number.

String functions

These functions are used to manipulate strings or to create a string representation of another value.

Function	Description
left()	Returns a string containing the specified number of leftmost characters of the original string.
lTrim()	Returns the original string with leading whitespace removed.
replace()	Returns a string in which all occurrences of a specified string in the original string have been replaced by another (specified) string.
reverse()	Returns a string in which the order of all characters in the original string have been reversed.
right()	Returns a string containing the specified number of rightmost characters of the original string.
rTrim()	Returns the original string with trailing whitespace removed.
split()	Returns a list of strings resulting from the splitting of the original string around matches of the given delimiter.
substring()	Returns a substring of the original string, beginning with a 0-based index start and length.
toLower()	Returns the original string in lowercase.
toString()	Converts an integer, float, boolean or temporal type (i.e. Date, Time, LocalTime, DateTime, LocalDateTime or Duration) value to a string.
toUpper()	Returns the original string in uppercase.
trim()	Returns the original string with leading and trailing whitespace removed.

Temporal functions - instant types

Values of the temporal types — *Date*, *Time*, *LocalTime*, *DateTime*, and *LocalDateTime* — can be created manipulated using the following functions:

Function	Description
date()	Returns the current *Date*.
date.transaction()	Returns the current *Date* using the `transaction` clock.
date.statement()	Returns the current *Date* using the `statement` clock.
date.realtime()	Returns the current *Date* using the `realtime` clock.
date({year [, month, day]})	Returns a calendar (Year-Month-Day) *Date*.
date({year [, week, dayOfWeek]})	Returns a week (Year-Week-Day) *Date*.
date({year [, quarter, dayOfQuarter]})	Returns a quarter (Year-Quarter-Day) *Date*.
date({year [, ordinalDay]})	Returns an ordinal (Year-Day) *Date*.
date(string)	Returns a *Date* by parsing a string.
date({map})	Returns a *Date* from a map of another temporal value's components.
date.truncate()	Returns a *Date* obtained by truncating a value at a specific component boundary. Truncation summary.
datetime()	Returns the current *DateTime*.
datetime.transaction()	Returns the current *DateTime* using the `transaction` clock.
datetime.statement()	Returns the current *DateTime* using the `statement` clock.
datetime.realtime()	Returns the current *DateTime* using the `realtime` clock.
datetime({year [, month, day, …]})	Returns a calendar (Year-Month-Day) *DateTime*.
datetime({year [, week, dayOfWeek, …]})	Returns a week (Year-Week-Day) *DateTime*.
datetime({year [, quarter, dayOfQuarter, …]})	Returns a quarter (Year-Quarter-Day) *DateTime*.
datetime({year [, ordinalDay, …]})	Returns an ordinal (Year-Day) *DateTime*.
datetime(string)	Returns a *DateTime* by parsing a string.
datetime({map})	Returns a *DateTime* from a map of another temporal value's components.
datetime({epochSeconds})	Returns a *DateTime* from a timestamp.
datetime.truncate()	Returns a *DateTime* obtained by truncating a value at a specific component boundary. Truncation summary.
localdatetime()	Returns the current *LocalDateTime*.
localdatetime.transaction()	Returns the current *LocalDateTime* using the `transaction` clock.
localdatetime.statement()	Returns the current *LocalDateTime* using the `statement` clock.
localdatetime.realtime()	Returns the current *LocalDateTime* using the `realtime` clock.
localdatetime({year [, month, day, …]})	Returns a calendar (Year-Month-Day) *LocalDateTime*.
localdatetime({year [, week, dayOfWeek, …]})	Returns a week (Year-Week-Day) *LocalDateTime*.
localdatetime({year [, quarter, dayOfQuarter, …]})	Returns a quarter (Year-Quarter-Day) *DateTime*.
localdatetime({year [, ordinalDay, …]})	Returns an ordinal (Year-Day) *LocalDateTime*.
localdatetime(string)	Returns a *LocalDateTime* by parsing a string.
localdatetime({map})	Returns a *LocalDateTime* from a map of another temporal value's components.

Function	Description
localdatetime.truncate()	Returns a *LocalDateTime* obtained by truncating a value at a specific component boundary. Truncation summary.
localtime()	Returns the current *LocalTime*.
localtime.transaction()	Returns the current *LocalTime* using the `transaction` clock.
localtime.statement()	Returns the current *LocalTime* using the `statement` clock.
localtime.realtime()	Returns the current *LocalTime* using the `realtime` clock.
localtime({hour [, minute, second, …]})	Returns a *LocalTime* with the specified component values.
localtime(string)	Returns a *LocalTime* by parsing a string.
localtime({time [, hour, …]})	Returns a *LocalTime* from a map of another temporal value's components.
localtime.truncate()	Returns a *LocalTime* obtained by truncating a value at a specific component boundary. Truncation summary.
time()	Returns the current *Time*.
time.transaction()	Returns the current *Time* using the `transaction` clock.
time.statement()	Returns the current *Time* using the `statement` clock.
time.realtime()	Returns the current *Time* using the `realtime` clock.
time({hour [, minute, …]})	Returns a *Time* with the specified component values.
time(string)	Returns a *Time* by parsing a string.
time({time [, hour, …, timezone]})	Returns a *Time* from a map of another temporal value's components.
time.truncate()	Returns a *Time* obtained by truncating a value at a specific component boundary. Truncation summary.

Temporal functions - duration

Duration values of the temporal types can be created manipulated using the following functions:

Function	Description
duration({map})	Returns a *Duration* from a map of its components.
duration(string)	Returns a *Duration* by parsing a string.
duration.between()	Returns a *Duration* equal to the difference between two given instants.
duration.inMonths()	Returns a *Duration* equal to the difference in whole months, quarters or years between two given instants.
duration.inDays()	Returns a *Duration* equal to the difference in whole days or weeks between two given instants.
duration.inSeconds()	Returns a *Duration* equal to the difference in seconds and fractions of seconds, or minutes or hours, between two given instants.

Spatial functions

These functions are used to specify 2D or 3D points in a geographic or cartesian Coordinate Reference System and to calculate the geodesic distance between two points.

Function	Description
distance()	Returns a floating point number representing the geodesic distance between any two points in the same CRS.

Function	Description
point() - Cartesian 2D	Returns a 2D point object, given two coordinate values in the Cartesian coordinate system.
point() - Cartesian 3D	Returns a 3D point object, given three coordinate values in the Cartesian coordinate system.
point() - WGS 84 2D	Returns a 2D point object, given two coordinate values in the WGS 84 geographic coordinate system.
point() - WGS 84 3D	Returns a 3D point object, given three coordinate values in the WGS 84 geographic coordinate system.

User-defined functions

User-defined functions are written in Java, deployed into the database and are called in the same way as any other Cypher function. There are two main types of functions that can be developed and used:

Type	Description	Usage	Developing
Scalar	For each row the function takes parameters and returns a result	Using UDF	Extending Neo4j (UDF)
Aggregating	Consumes many rows and produces an aggregated result	Using aggregating UDF	Extending Neo4j (Aggregating UDF)

LOAD CSV functions

LOAD CSV functions can be used to get information about the file that is processed by `LOAD CSV`.

Function	Description
linenumber()	Returns the line number that `LOAD CSV` is currently using.
file()	Returns the absolute path of the file that `LOAD CSV` is using.

4.1. Predicate functions

> *Predicates are boolean functions that return true or false for a given set of non-null input. They are most commonly used to filter out subgraphs in the* `WHERE` *part of a query.*

Functions:

- all()
- any()
- exists()
- none()
- single()

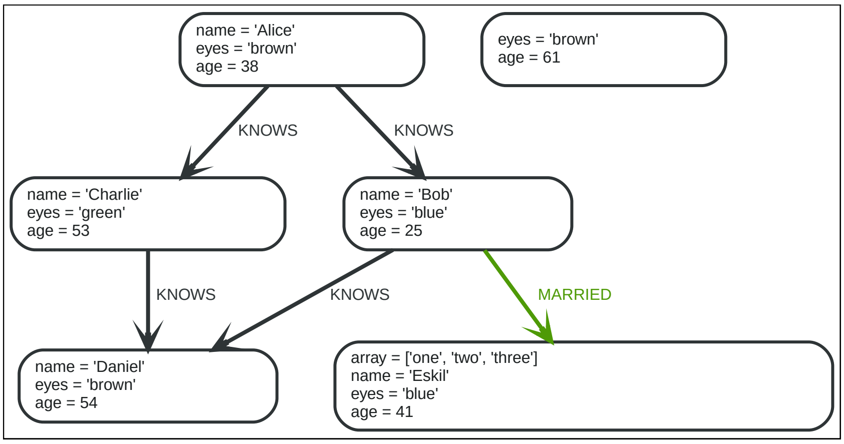


Figure 23. Graph

4.1.1. all()

`all()` returns true if the predicate holds for all elements in the given list. `null` is returned if the list is `null` or all of its elements are `null`.

Syntax: `all(variable IN list WHERE predicate)`

Returns:

A Boolean.

Arguments:

Name	Description
`list`	An expression that returns a list.
`variable`	This is the variable that can be used from within the predicate.
`predicate`	A predicate that is tested against all items in the list.

Query

```
MATCH p =(a)-[*1..3]->(b)
WHERE a.name = 'Alice' AND b.name = 'Daniel' AND ALL (x IN nodes(p) WHERE x.age > 30)
RETURN p
```

All nodes in the returned paths will have an `age` property of at least **'30'**.

Table 217. Result

p
`(0)-[KNOWS,1]->(2)-[KNOWS,3]->(3)`
1 row

4.1.2. any()

`any()` returns true if the predicate holds for at least one element in the given list. `null` is returned if the list is `null` or all of its elements are `null`.

Syntax: `any(variable IN list WHERE predicate)`

Returns:

A Boolean.

Arguments:

Name	Description
`list`	An expression that returns a list.
`variable`	This is the variable that can be used from within the predicate.
`predicate`	A predicate that is tested against all items in the list.

Query

```
MATCH (a)
WHERE a.name = 'Eskil' AND ANY (x IN a.array WHERE x = 'one')
RETURN a.name, a.array
```

All nodes in the returned paths have at least one **'one'** value set in the array property named `array`.

Table 218. Result

a.name	a.array
`"Eskil"`	`["one","two","three"]`
1 row	

4.1.3. exists()

`exists()` returns true if a match for the given pattern exists in the graph, or if the specified property exists in the node, relationship or map. `null` is returned if the input argument is `null`.

Syntax: `exists(pattern-or-property)`

Returns:

A Boolean.

Arguments:

Name	Description
`pattern-or-property`	A pattern or a property (in the form 'variable.prop').

Query

```
MATCH (n)
WHERE EXISTS (n.name)
RETURN n.name AS name, EXISTS ((n)-[:MARRIED]->()) AS is_married
```

The names of all nodes with the `name` property are returned, along with a boolean `true` / `false` indicating if they are married.

Table 219. Result

name	is_married
`"Alice"`	`false`

name	is_married
"Bob"	true
"Charlie"	false
"Daniel"	false
"Eskil"	false
5 rows	

Query

```
MATCH (a),(b)
WHERE EXISTS (a.name) AND NOT EXISTS (b.name)
OPTIONAL MATCH (c:DoesNotExist)
RETURN a.name AS a_name, b.name AS b_name, EXISTS (b.name) AS b_has_name, c.name AS c_name, EXISTS
(c.name) AS c_has_name
ORDER BY a_name, b_name, c_name
LIMIT 1
```

Three nodes are returned: one with a name property, one without a name property, and one that does not exist (e.g., is `null`). This query exemplifies the behavior of `exists()` when operating on `null` nodes.

Table 220. Result

a_name	b_name	b_has_name	c_name	c_has_name
"Alice"	<null>	false	<null>	<null>
1 row				

4.1.4. none()

`none()` returns true if the predicate holds for no element in the given list. `null` is returned if the list is `null` or all of its elements are `null`.

Syntax: `none(variable IN list WHERE predicate)`

Returns:

A Boolean.

Arguments:

Name	Description
`list`	An expression that returns a list.
`variable`	This is the variable that can be used from within the predicate.
`predicate`	A predicate that is tested against all items in the list.

Query

```
MATCH p =(n)-[*1..3]->(b)
WHERE n.name = 'Alice' AND NONE (x IN nodes(p) WHERE x.age = 25)
RETURN p
```

No node in the returned paths has an `age` property set to **'25'**.

Table 221. Result

p
`(0)-[KNOWS,1]->(2)`
`(0)-[KNOWS,1]->(2)-[KNOWS,3]->(3)`
2 rows

4.1.5. single()

`single()` returns true if the predicate holds for exactly one of the elements in the given list. `null` is returned if the list is `null` or all of its elements are `null`.

Syntax: `single(variable IN list WHERE predicate)`

Returns:

A Boolean.

Arguments:

Name	Description
`list`	An expression that returns a list.
`variable`	This is the variable that can be used from within the predicate.
`predicate`	A predicate that is tested against all items in the list.

Query

```
MATCH p =(n)-->(b)
WHERE n.name = 'Alice' AND SINGLE (var IN nodes(p) WHERE var.eyes = 'blue')
RETURN p
```

Exactly one node in every returned path has the `eyes` property set to **'blue'**.

Table 222. Result

p
`(0)-[KNOWS,0]->(1)`
1 row

4.2. Scalar functions

Scalar functions return a single value.

> The `length()` and `size()` functions are quite similar, and so it is important to take note of the difference. `length()` only works for paths, while `size()` only works for the three types: strings, lists and pattern expressions.

Functions:

- coalesce()
- endNode()
- head()

- id()
- last()
- length()
- properties()
- randomUUID()
- size()
- Size of pattern expression
- Size of string
- startNode()
- timestamp()
- toBoolean()
- toFloat()
- toInteger()
- type()

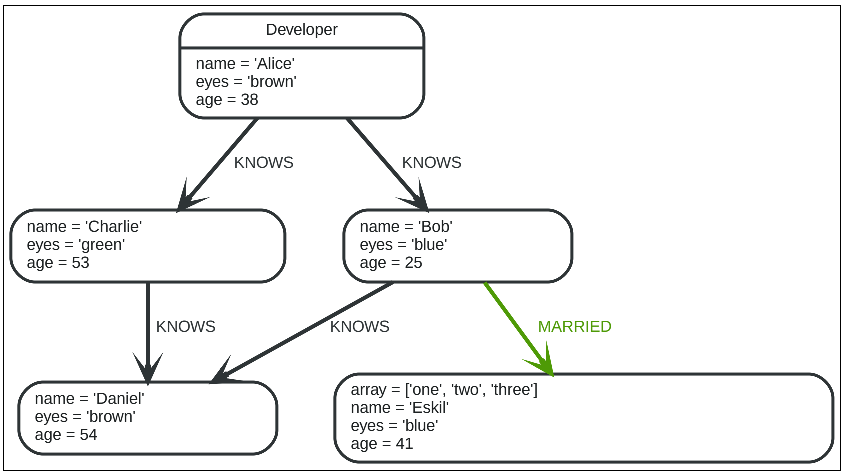


Figure 24. Graph

4.2.1. coalesce()

`coalesce()` returns the first non-`null` value in the given list of expressions.

Syntax: `coalesce(expression [, expression]*)`

Returns:

The type of the value returned will be that of the first non-`null` expression.

Arguments:

Name	Description
`expression`	An expression which may return `null`.

Considerations:

`null` will be returned if all the arguments are `null`.

Query

```
MATCH (a)
WHERE a.name = 'Alice'
RETURN coalesce(a.hairColor, a.eyes)
```

Table 223. Result

coalesce(a.hairColor, a.eyes)
`"brown"`
1 row

4.2.2. endNode()

`endNode()` returns the end node of a relationship.

Syntax: `endNode(relationship)`

Returns:

A Node.

Arguments:

Name	Description
`relationship`	An expression that returns a relationship.

Considerations:

`endNode(null)` returns `null`.

Query

```
MATCH (x:Developer)-[r]-()
RETURN endNode(r)
```

Table 224. Result

endNode(r)
`Node[2]{name:"Charlie",eyes:"green",age:53}`
`Node[1]{name:"Bob",eyes:"blue",age:25}`
2 rows

4.2.3. head()

`head()` returns the first element in a list.

Syntax: `head(list)`

Returns:

The type of the value returned will be that of the first element of `list`.

Arguments:

Name	Description
`list`	An expression that returns a list.

Considerations:

`head(null)` returns `null`.
If the first element in `list` is `null`, `head(list)` will return `null`.

Query

```
MATCH (a)
WHERE a.name = 'Eskil'
RETURN a.array, head(a.array)
```

The first element in the list is returned.

Table 225. Result

a.array	head(a.array)
`["one","two","three"]`	`"one"`
1 row	

4.2.4. id()

`id()` returns the id of a relationship or node.

Syntax: `id(expression)`

Returns:

An Integer.

Arguments:

Name	Description
`expression`	An expression that returns a node or a relationship.

Considerations:

`id(null)` returns `null`.

Query

```
MATCH (a)
RETURN id(a)
```

The node id for each of the nodes is returned.

Table 226. Result

id(a)
`0`
`1`
`2`

id(a)
3
4
5 rows

4.2.5. last()

`last()` returns the last element in a list.

Syntax: `last(expression)`

Returns:

The type of the value returned will be that of the last element of `list`.

Arguments:

Name	Description
`list`	An expression that returns a list.

Considerations:

`last(null)` returns `null`.
If the last element in `list` is `null`, `last(list)` will return `null`.

Query

```
MATCH (a)
WHERE a.name = 'Eskil'
RETURN a.array, last(a.array)
```

The last element in the list is returned.

Table 227. Result

a.array	last(a.array)
["one","two","three"]	"three"
1 row	

4.2.6. length()

`length()` returns the length of a path.

Syntax: `length(path)`

Returns:

An Integer.

Arguments:

Name	Description
`path`	An expression that returns a path.

Considerations:

`length(null)` returns `null`.

Query

```
MATCH p =(a)-->(b)-->(c)
WHERE a.name = 'Alice'
RETURN length(p)
```

The length of the path `p` is returned.

Table 228. Result

length(p)
`2`
`2`
`2`
3 rows

4.2.7. properties()

`properties()` returns a map containing all the properties of a node or relationship. If the argument is already a map, it is returned unchanged.

Syntax: `properties(expression)`

Returns:

A Map.

Arguments:

Name	Description
`expression`	An expression that returns a node, a relationship, or a map.

Considerations:

`properties(null)` returns `null`.

Query

```
CREATE (p:Person { name: 'Stefan', city: 'Berlin' })
RETURN properties(p)
```

Table 229. Result

properties(p)
`{city -> "Berlin", name -> "Stefan"}`

properties(p)
1 row, Nodes created: 1 Properties set: 2 Labels added: 1

4.2.8. randomUUID()

`randomUUID()` returns a randomly-generated Universally Unique Identifier (UUID), also known as a Globally Unique Identifier (GUID). This is a 128-bit value with strong guarantees of uniqueness.

Syntax: `randomUUID()`

Returns:

A String.

Query

```
RETURN randomUUID() AS uuid
```

Table 230. Result

uuid
`"21d0f774-3740-499f-bb23-efa210a65b4c"`
1 row

A randomly-generated UUID is returned.

4.2.9. size()

`size()` returns the number of elements in a list.

Syntax: `size(list)`

Returns:

An Integer.

Arguments:

Name	Description
`list`	An expression that returns a list.

Considerations:

`size(null)` returns `null`.

Query

```
RETURN size(['Alice', 'Bob'])
```

Table 231. Result

size(['Alice', 'Bob'])
`2`
1 row

The number of elements in the list is returned.

4.2.10. size() applied to pattern expression

This is the same `size()` method as described above, but instead of passing in a list directly, a pattern expression can be provided that can be used in a match query to provide a new set of results. These results are a *list* of paths. The size of the result is calculated, not the length of the expression itself.

Syntax: `size(pattern expression)`

Arguments:

Name	Description
`pattern expression`	A pattern expression that returns a list.

Query

```
MATCH (a)
WHERE a.name = 'Alice'
RETURN size((a)-->()-->()) AS fof
```

Table 232. Result

fof
`3`
1 row

The number of sub-graphs matching the pattern expression is returned.

4.2.11. size() applied to string

`size()` returns the number of Unicode characters in a string.

Syntax: `size(string)`

Returns:

An Integer.

Arguments:

Name	Description
`string`	An expression that returns a string value.

Considerations:

`size(null)` returns `null`.

Query

```
MATCH (a)
WHERE size(a.name)> 6
RETURN size(a.name)
```

Table 233. Result

size(a.name)
7
1 row

The number of characters in the string **'Charlie'** is returned.

4.2.12. startNode()

`startNode()` returns the start node of a relationship.

Syntax: `startNode(relationship)`

Returns:

A Node.

Arguments:

Name	Description
`relationship`	An expression that returns a relationship.

Considerations:

`startNode(null)` returns `null`.

Query

```
MATCH (x:Developer)-[r]-()
RETURN startNode(r)
```

Table 234. Result

startNode(r)
Node[0]{name:"Alice",eyes:"brown",age:38}
Node[0]{name:"Alice",eyes:"brown",age:38}
2 rows

4.2.13. timestamp()

`timestamp()` returns the difference, measured in milliseconds, between the current time and midnight, January 1, 1970 UTC. It is the equivalent of `datetime().epochMillis`.

Syntax: `timestamp()`

Returns:

An Integer.

Considerations:

`timestamp()` will return the same value during one entire query, even for long-running queries.

Query

```
RETURN timestamp()
```

The time in milliseconds is returned.

Table 235. Result

timestamp()
1579292948490
1 row

4.2.14. toBoolean()

`toBoolean()` converts a string value to a boolean value.

Syntax: `toBoolean(expression)`

Returns:

A Boolean.

Arguments:

Name	Description
`expression`	An expression that returns a boolean or string value.

Considerations:

`toBoolean(null)` returns `null`.
If `expression` is a boolean value, it will be returned unchanged.
If the parsing fails, `null` will be returned.

Query

```
RETURN toBoolean('TRUE'), toBoolean('not a boolean')
```

Table 236. Result

toBoolean('TRUE')	toBoolean('not a boolean')
`true`	`<null>`
1 row	

4.2.15. toFloat()

`toFloat()` converts an integer or string value to a floating point number.

Syntax: `toFloat(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	An expression that returns a numeric or string value.

Considerations:

`toFloat(null)` returns `null`.
If `expression` is a floating point number, it will be returned unchanged.
If the parsing fails, `null` will be returned.

Query

```
RETURN toFloat('11.5'), toFloat('not a number')
```

Table 237. Result

toFloat('11.5')	toFloat('not a number')
`11.5`	`<null>`
1 row	

4.2.16. toInteger()

`toInteger()` converts a floating point or string value to an integer value.

Syntax: `toInteger(expression)`

Returns:

An Integer.

Arguments:

Name	Description
`expression`	An expression that returns a numeric or string value.

Considerations:

`toInteger(null)` returns `null`.
If `expression` is an integer value, it will be returned unchanged.
If the parsing fails, `null` will be returned.

Query

```
RETURN toInteger('42'), toInteger('not a number')
```

Table 238. Result

toInteger('42')	toInteger('not a number')
42	<null>
1 row	

4.2.17. type()

`type()` returns the string representation of the relationship type.

Syntax: `type(relationship)`

Returns:

A String.

Arguments:

Name	Description
relationship	An expression that returns a relationship.

Considerations:

`type(null)` returns `null`.

Query

```
MATCH (n)-[r]->()
WHERE n.name = 'Alice'
RETURN type(r)
```

The relationship type of `r` is returned.

Table 239. Result

type(r)
"KNOWS"
"KNOWS"
2 rows

4.3. Aggregating functions

To calculate aggregated data, Cypher offers aggregation, analogous to SQL's `GROUP BY`.

Aggregating functions take a set of values and calculate an aggregated value over them. Examples are `avg()` that calculates the average of multiple numeric values, or `min()` that finds the smallest numeric or string value in a set of values. When we say below that an aggregating function operates on a *set of values*, we mean these to be the result of the application of the inner expression (such as `n.age`) to all the records within the same aggregation group.

Aggregation can be computed over all the matching subgraphs, or it can be further divided by introducing grouping keys. These are non-aggregate expressions, that are used to group the values going into the aggregate functions.

Assume we have the following return statement:

```
RETURN n, count(*)
```

We have two return expressions: `n`, and `count(). The first, n, is not an aggregate function, and so it will be the grouping key. The latter, count()` is an aggregate expression. The matching subgraphs will be divided into different buckets, depending on the grouping key. The aggregate function will then be run on these buckets, calculating an aggregate value per bucket.

To use aggregations to sort the result set, the aggregation must be included in the `RETURN` to be used in the `ORDER BY`.

The `DISTINCT` operator works in conjunction with aggregation. It is used to make all values unique before running them through an aggregate function. More information about `DISTINCT` may be found here.

Functions:

- avg() - Numeric values
- avg() - Durations
- collect()
- count()
- max()
- min()
- percentileCont()
- percentileDisc()
- stDev()
- stDevP()
- sum() - Numeric values
- sum() - Durations

The following graph is used for the examples below:

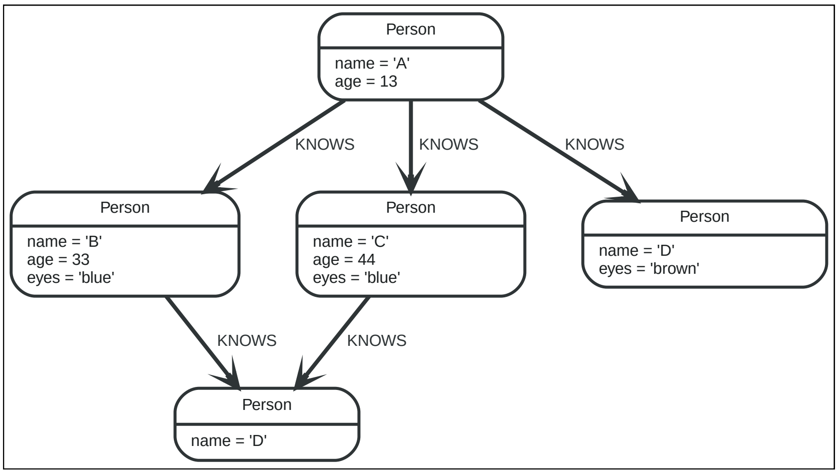


Figure 25. Graph

4.3.1. avg() - Numeric values

`avg()` returns the average of a set of numeric values.

Syntax: `avg(expression)`

Returns:

Either an Integer or a Float, depending on the values returned by `expression` and whether or not the calculation overflows.

Arguments:

Name	Description
`expression`	An expression returning a set of numeric values.

Considerations:

Any `null` values are excluded from the calculation.
`avg(null)` returns `null`.

Query

```
MATCH (n:Person)
RETURN avg(n.age)
```

The average of all the values in the property `age` is returned.

Table 240. Result

avg(n.age)
`30.0`
1 row

4.3.2. avg() - Durations

`avg()` returns the average of a set of Durations.

Syntax: `avg(expression)`

Returns:

A Duration.

Arguments:

Name	Description
`expression`	An expression returning a set of Durations.

Considerations:

Any `null` values are excluded from the calculation.
`avg(null)` returns `null`.

Query

```
UNWIND [duration('P2DT3H'), duration('PT1H45S')] AS dur
RETURN avg(dur)
```

The average of the two supplied Durations is returned.

Table 241. Result

avg(dur)
`P1DT2H22.5S`
1 row

4.3.3. collect()

`collect()` returns a list containing the values returned by an expression. Using this function aggregates data by amalgamating multiple records or values into a single list.

Syntax: `collect(expression)`

Returns:

A list containing heterogeneous elements; the types of the elements are determined by the values returned by `expression`.

Arguments:

Name	Description
`expression`	An expression returning a set of values.

Considerations:

Any `null` values are ignored and will not be added to the list.
`collect(null)` returns an empty list.

Query

```
MATCH (n:Person)
RETURN collect(n.age)
```

All the values are collected and returned in a single list.

Table 242. Result

collect(n.age)
`[13,33,44]`
1 row

4.3.4. count()

`count()` returns the number of values or rows, and appears in two variants:

- `count(*)` returns the number of matching rows, and
- `count(expr)` returns the number of non-`null` values returned by an expression.

Syntax: `count(expression)`

Returns:

An Integer.

Arguments:

Name	Description
`expression`	An expression.

Considerations:

`count(*)` includes rows returning `null`.
`count(expr)` ignores `null` values.
`count(null)` returns `0`.

Using `count(*)` to return the number of nodes

`count(*)` can be used to return the number of nodes; for example, the number of nodes connected to some node `n`.

Query

```
MATCH (n { name: 'A' })-->(x)
RETURN labels(n), n.age, count(*)
```

The labels and `age` property of the start node `n` and the number of nodes related to `n` are returned.

Table 243. Result

labels(n)	n.age	count(*)
`["Person"]`	`13`	`3`
1 row		

Using `count(*)` to group and count relationship types

`count(*)` can be used to group relationship types and return the number.

Query

```
MATCH (n { name: 'A' })-[r]->()
RETURN type(r), count(*)
```

The relationship types and their group count are returned.

Table 244. Result

type(r)	count(*)
`"KNOWS"`	`3`
1 row	

Using `count(expression)` to return the number of values

Instead of simply returning the number of rows with `count(*)`, it may be more useful to return the actual number of values returned by an expression.

Query

```
MATCH (n { name: 'A' })-->(x)
RETURN count(x)
```

The number of nodes connected to the start node is returned.

Table 245. Result

count(x)
3
1 row

Counting non-`null` values

`count(expression)` can be used to return the number of non-`null` values returned by the expression.

Query

```
MATCH (n:Person)
RETURN count(n.age)
```

The number of `:Person` nodes having an `age` property is returned.

Table 246. Result

count(n.age)
3
1 row

Counting with and without duplicates

In this example we are trying to find all our friends of friends, and count them:

- The first aggregate function, `count(DISTINCT friend_of_friend)`, will only count a `friend_of_friend` once, as `DISTINCT` removes the duplicates.
- The second aggregate function, `count(friend_of_friend)`, will consider the same `friend_of_friend` multiple times.

Query

```
MATCH (me:Person)-->(friend:Person)-->(friend_of_friend:Person)
WHERE me.name = 'A'
RETURN count(DISTINCT friend_of_friend), count(friend_of_friend)
```

Both `B` and `C` know `D` and thus `D` will get counted twice when not using `DISTINCT`.

Table 247. Result

count(DISTINCT friend_of_friend)	count(friend_of_friend)
1	2
1 row	

4.3.5. max()

`max()` returns the maximum value in a set of values.

Syntax: `max(expression)`

Returns:

A property type, or a list, depending on the values returned by `expression`.

Arguments:

Name	Description
`expression`	An expression returning a set containing any combination of property types and lists thereof.

Considerations:

Any `null` values are excluded from the calculation.
In a mixed set, any numeric value is always considered to be higher than any string value, and any string value is always considered to be higher than any list.
Lists are compared in dictionary order, i.e. list elements are compared pairwise in ascending order from the start of the list to the end.
`max(null)` returns `null`.

Query

```
UNWIND [1, 'a', NULL , 0.2, 'b', '1', '99'] AS val
RETURN max(val)
```

The highest of all the values in the mixed set — in this case, the numeric value `1` — is returned. Note that the (string) value `"99"`, which may *appear* at first glance to be the highest value in the list, is considered to be a lower value than `1` as the latter is a string.

Table 248. Result

max(val)
`1`
1 row

Query

```
UNWIND [[1, 'a', 89],[1, 2]] AS val
RETURN max(val)
```

The highest of all the lists in the set — in this case, the list `[1, 2]` — is returned, as the number `2` is considered to be a higher value than the string `"a"`, even though the list `[1, 'a', 89]` contains more elements.

Table 249. Result

max(val)
`[1,2]`
1 row

Query

```
MATCH (n:Person)
RETURN max(n.age)
```

The highest of all the values in the property `age` is returned.

Table 250. Result

max(n.age)
`44`
1 row

4.3.6. min()

`min()` returns the minimum value in a set of values.

Syntax: `min(expression)`

Returns:

A property type, or a list, depending on the values returned by `expression`.

Arguments:

Name	Description
`expression`	An expression returning a set containing any combination of property types and lists thereof.

Considerations:

Any `null` values are excluded from the calculation.
In a mixed set, any string value is always considered to be lower than any numeric value, and any list is always considered to be lower than any string.
Lists are compared in dictionary order, i.e. list elements are compared pairwise in ascending order from the start of the list to the end.
`min(null)` returns `null`.

Query

```
UNWIND [1, 'a', NULL , 0.2, 'b', '1', '99'] AS val
RETURN min(val)
```

The lowest of all the values in the mixed set — in this case, the string value `"1"` — is returned. Note that the (numeric) value `0.2`, which may *appear* at first glance to be the lowest value in the list, is considered to be a higher value than `"1"` as the latter is a string.

Table 251. Result

min(val)
`"1"`
1 row

Query

```
UNWIND ['d',[1, 2],['a', 'c', 23]] AS val
RETURN min(val)
```

The lowest of all the values in the set — in this case, the list `['a', 'c', 23]` — is returned, as (i) the two lists are considered to be lower values than the string `"d"`, and (ii) the string `"a"` is considered to be a lower value than the numerical value `1`.

Table 252. Result

min(val)
`["a","c",23]`
1 row

Query

```
MATCH (n:Person)
RETURN min(n.age)
```

The lowest of all the values in the property `age` is returned.

Table 253. Result

min(n.age)
`13`
1 row

4.3.7. percentileCont()

`percentileCont()` returns the percentile of the given value over a group, with a percentile from 0.0 to 1.0. It uses a linear interpolation method, calculating a weighted average between two values if the desired percentile lies between them. For nearest values using a rounding method, see `percentileDisc`.

Syntax: `percentileCont(expression, percentile)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.
`percentile`	A numeric value between 0.0 and 1.0

Considerations:

Any `null` values are excluded from the calculation.
`percentileCont(null, percentile)` returns `null`.

Query

```
MATCH (n:Person)
RETURN percentileCont(n.age, 0.4)
```

The 40th percentile of the values in the property `age` is returned, calculated with a weighted average. In this case, 0.4 is the median, or 40th percentile.

Table 254. Result

percentileCont(n.age, 0.4)
`29.0`
1 row

4.3.8. percentileDisc()

`percentileDisc()` returns the percentile of the given value over a group, with a percentile from 0.0 to 1.0. It uses a rounding method and calculates the nearest value to the percentile. For interpolated values, see `percentileCont`.

Syntax: `percentileDisc(expression, percentile)`

Returns:

Either an Integer or a Float, depending on the values returned by `expression` and whether or not the calculation overflows.

Arguments:

Name	Description
`expression`	A numeric expression.
`percentile`	A numeric value between 0.0 and 1.0

Considerations:

Any `null` values are excluded from the calculation.
`percentileDisc(null, percentile)` returns `null`.

Query

```
MATCH (n:Person)
RETURN percentileDisc(n.age, 0.5)
```

The 50th percentile of the values in the property `age` is returned.

Table 255. Result

percentileDisc(n.age, 0.5)
`33`
1 row

4.3.9. stDev()

`stDev()` returns the standard deviation for the given value over a group. It uses a standard two-pass method, with `N - 1` as the denominator, and should be used when taking a sample of the population for an unbiased estimate. When the standard variation of the entire population is being calculated, `stdDevP` should be used.

Syntax: `stDev(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

Any `null` values are excluded from the calculation.
`stDev(null)` returns `0`.

Query

```
MATCH (n)
WHERE n.name IN ['A', 'B', 'C']
RETURN stDev(n.age)
```

The standard deviation of the values in the property `age` is returned.

Table 256. Result

stDev(n.age)
`15.716233645501712`
1 row

4.3.10. stDevP()

`stDevP()` returns the standard deviation for the given value over a group. It uses a standard two-pass method, with `N` as the denominator, and should be used when calculating the standard deviation for an entire population. When the standard variation of only a sample of the population is being calculated, `stDev` should be used.

Syntax: `stDevP(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

Any `null` values are excluded from the calculation.
`stDevP(null)` returns `0`.

Query

```
MATCH (n)
WHERE n.name IN ['A', 'B', 'C']
RETURN stDevP(n.age)
```

The population standard deviation of the values in the property `age` is returned.

Table 257. Result

stDevP(n.age)
`12.832251036613439`
1 row

4.3.11. sum() - Numeric values

`sum()` returns the sum of a set of numeric values.

Syntax: `sum(expression)`

Returns:

Either an Integer or a Float, depending on the values returned by `expression`.

Arguments:

Name	Description
`expression`	An expression returning a set of numeric values.

Considerations:

Any `null` values are excluded from the calculation.
`sum(null)` returns `0`.

Query

```
MATCH (n:Person)
RETURN sum(n.age)
```

The sum of all the values in the property `age` is returned.

Table 258. Result

sum(n.age)
`90`
1 row

4.3.12. sum() - Durations

`sum()` returns the sum of a set of Durations.

Syntax: `sum(expression)`

Returns:

A Duration.

Arguments:

Name	Description
`expression`	An expression returning a set of Durations.

Considerations:

Any `null` values are excluded from the calculation.

Query

```
UNWIND [duration('P2DT3H'), duration('PT1H45S')] AS dur
RETURN sum(dur)
```

The sum of the two supplied Durations is returned.

Table 259. Result

sum(dur)
`P2DT4H45S`
1 row

4.4. List functions

List functions return lists of things — nodes in a path, and so on.

Further details and examples of lists may be found in Lists and List operators.

Functions:

- keys()
- labels()
- nodes()
- range()
- reduce()
- relationships()
- reverse()
- tail()

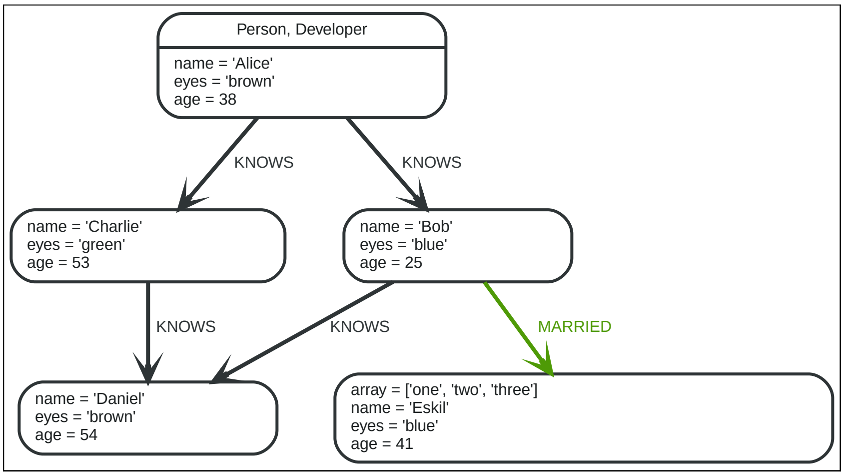


Figure 26. Graph

4.4.1. keys()

`keys` returns a list containing the string representations for all the property names of a node, relationship, or map.

Syntax: `keys(expression)`

Returns:

A list containing String elements.

Arguments:

Name	Description
`expression`	An expression that returns a node, a relationship, or a map.

Considerations:

`keys(null)` returns `null`.

Query

```
MATCH (a)
WHERE a.name = 'Alice'
RETURN keys(a)
```

A list containing the names of all the properties on the node bound to `a` is returned.

Table 260. Result

keys(a)
`["name","eyes","age"]`
1 row

4.4.2. labels()

`labels` returns a list containing the string representations for all the labels of a node.

Syntax: `labels(node)`

Returns:

A list containing String elements.

Arguments:

Name	Description
`node`	An expression that returns a single node.

Considerations:

`labels(null)` returns `null`.

Query

```
MATCH (a)
WHERE a.name = 'Alice'
RETURN labels(a)
```

A list containing all the labels of the node bound to `a` is returned.

Table 261. Result

labels(a)
`["Person","Developer"]`
1 row

4.4.3. nodes()

`nodes()` returns a list containing all the nodes in a path.

Syntax: `nodes(path)`

Returns:

A list containing Node elements.

Arguments:

Name	Description
`path`	An expression that returns a path.

Considerations:

`nodes(null)` returns `null`.

Query

```
MATCH p =(a)-->(b)-->(c)
WHERE a.name = 'Alice' AND c.name = 'Eskil'
RETURN nodes(p)
```

A list containing all the nodes in the path `p` is returned.

Table 262. Result

nodes(p)
[Node[0]{name:"Alice",eyes:"brown",age:38},Node[1]{name:"Bob",eyes:"blue",age:25},Node[4]{array:["one","two","three"],name:"Eskil",eyes:"blue",age:41}]
1 row

4.4.4. range()

`range()` returns a list comprising all integer values within a range bounded by a start value `start` and end value `end`, where the difference `step` between any two consecutive values is constant; i.e. an arithmetic progression. The range is inclusive, and the arithmetic progression will therefore always contain `start` and — depending on the values of `start`, `step` and `end` — `end`.

Syntax: `range(start, end [, step])`

Returns:

A list of Integer elements.

Arguments:

Name	Description
`start`	An expression that returns an integer value.
`end`	An expression that returns an integer value.
`step`	A numeric expression defining the difference between any two consecutive values, with a default of `1`.

Query

```
RETURN range(0, 10), range(2, 18, 3)
```

Two lists of numbers in the given ranges are returned.

Table 263. Result

range(0, 10)	range(2, 18, 3)
[0,1,2,3,4,5,6,7,8,9,10]	[2,5,8,11,14,17]
1 row	

4.4.5. reduce()

`reduce()` returns the value resulting from the application of an expression on each successive element in a list in conjunction with the result of the computation thus far. This function will iterate through each element `e` in the given list, run the expression on `e` — taking into account the current partial result — and store the new partial result in the accumulator. This function is analogous to the `fold` or `reduce` method in functional languages such as Lisp and Scala.

Syntax: `reduce(accumulator = initial, variable IN list | expression)`

Returns:

The type of the value returned depends on the arguments provided, along with the semantics of `expression`.

Arguments:

Name	Description
accumulator	A variable that will hold the result and the partial results as the list is iterated.
initial	An expression that runs once to give a starting value to the accumulator.
list	An expression that returns a list.
variable	The closure will have a variable introduced in its context. We decide here which variable to use.
expression	This expression will run once per value in the list, and produce the result value.

Query

```
MATCH p =(a)-->(b)-->(c)
WHERE a.name = 'Alice' AND b.name = 'Bob' AND c.name = 'Daniel'
RETURN reduce(totalAge = 0, n IN nodes(p)| totalAge + n.age) AS reduction
```

The `age` property of all nodes in the path are summed and returned as a single value.

Table 264. Result

reduction
117
1 row

4.4.6. relationships()

`relationships()` returns a list containing all the relationships in a path.

Syntax: `relationships(path)`

Returns:

A list containing Relationship elements.

Arguments:

Name	Description
path	An expression that returns a path.

Considerations:

`relationships(null)` returns `null`.

Query

```
MATCH p =(a)-->(b)-->(c)
WHERE a.name = 'Alice' AND c.name = 'Eskil'
RETURN relationships(p)
```

A list containing all the relationships in the path `p` is returned.

Table 265. Result

relationships(p)
[:KNOWS[0]{},:MARRIED[4]{}]
1 row

4.4.7. reverse()

`reverse()` returns a list in which the order of all elements in the original list have been reversed.

Syntax: `reverse(original)`

Returns:

A list containing homogeneous or heterogeneous elements; the types of the elements are determined by the elements within `original`.

Arguments:

Name	Description
`original`	An expression that returns a list.

Considerations:

Any `null` element in `original` is preserved.

Query

```
WITH [4923,'abc',521, NULL , 487] AS ids
RETURN reverse(ids)
```

Table 266. Result

reverse(ids)
[487,<null>,521,"abc",4923]
1 row

4.4.8. tail()

`tail()` returns a list l_{result} containing all the elements, excluding the first one, from a list `list`.

Syntax: `tail(list)`

Returns:

A list containing heterogeneous elements; the types of the elements are determined by the elements in `list`.

Arguments:

Name	Description
`list`	An expression that returns a list.

Query

```
MATCH (a)
WHERE a.name = 'Eskil'
RETURN a.array, tail(a.array)
```

The property named `array` and a list comprising all but the first element of the `array` property are returned.

Table 267. Result

a.array	tail(a.array)
["one","two","three"]	["two","three"]
1 row	

4.5. Mathematical functions - numeric

These functions all operate on numeric expressions only, and will return an error if used on any other values. See also Mathematical operators.

Functions:

- abs()
- ceil()
- floor()
- rand()
- round()
- sign()

The following graph is used for the examples below:

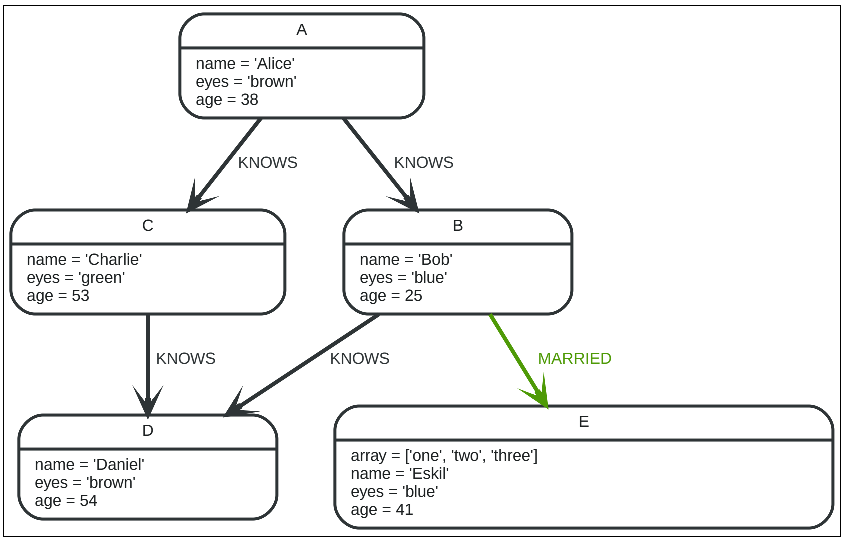


Figure 27. Graph

4.5.1. abs()

`abs()` returns the absolute value of the given number.

Syntax: `abs(expression)`

Returns:

The type of the value returned will be that of `expression`.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`abs(null)` returns `null`.
If `expression` is negative, `-(expression)` (i.e. the *negation* of `expression`) is returned.

Query

```
MATCH (a),(e)
WHERE a.name = 'Alice' AND e.name = 'Eskil'
RETURN a.age, e.age, abs(a.age - e.age)
```

The absolute value of the age difference is returned.

Table 268. Result

a.age	e.age	abs(a.age - e.age)
38	41	3
1 row		

4.5.2. ceil()

`ceil()` returns the smallest floating point number that is greater than or equal to the given number and equal to a mathematical integer.

Syntax: `ceil(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`ceil(null)` returns `null`.

Query

```
RETURN ceil(0.1)
```

The ceil of `0.1` is returned.

Table 269. Result

ceil(0.1)
`1.0`
1 row

4.5.3. floor()

`floor()` returns the largest floating point number that is less than or equal to the given number and equal to a mathematical integer.

Syntax: `floor(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`floor(null)` returns `null`.

Query

```
RETURN floor(0.9)
```

The floor of `0.9` is returned.

Table 270. Result

floor(0.9)
`0.0`
1 row

4.5.4. rand()

`rand()` returns a random floating point number in the range from 0 (inclusive) to 1 (exclusive); i.e. `[0,1)`. The numbers returned follow an approximate uniform distribution.

Syntax: `rand()`

Returns:

A Float.

Query

```
RETURN rand()
```

A random number is returned.

Table 271. Result

rand()
`0.7312823088502193`
1 row

4.5.5. round()

`round()` returns the value of the given number rounded to the nearest integer.

Syntax: `round(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`round(null)` returns `null`.

Query

```
RETURN round(3.141592)
```

`3.0` is returned.

Table 272. Result

round(3.141592)
`3.0`
1 row

4.5.6. sign()

`sign()` returns the signum of the given number: `0` if the number is `0`, `-1` for any negative number, and `1` for any positive number.

Syntax: `sign(expression)`

Returns:

An Integer.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`sign(null)` returns `null`.

Query

```
RETURN sign(-17), sign(0.1)
```

The signs of `-17` and `0.1` are returned.

Table 273. Result

sign(-17)	sign(0.1)
`-1`	`1`
1 row	

4.6. Mathematical functions - logarithmic

> *These functions all operate on numeric expressions only, and will return an error if used on any other values. See also Mathematical operators.*

Functions:

- e()
- exp()
- log()
- log10()
- sqrt()

4.6.1. e()

`e()` returns the base of the natural logarithm, `e`.

Syntax: `e()`

Returns:

A Float.

Query

```
RETURN e()
```

The base of the natural logarithm, `e`, is returned.

Table 274. Result

e()
`2.718281828459045`
1 row

4.6.2. exp()

`exp()` returns `e^n`, where `e` is the base of the natural logarithm, and `n` is the value of the argument expression.

Syntax: `e(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`exp(null)` returns `null`.

Query

```
RETURN exp(2)
```

`e` to the power of `2` is returned.

Table 275. Result

exp(2)
`7.38905609893065`
1 row

4.6.3. log()

`log()` returns the natural logarithm of a number.

Syntax: `log(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`log(null)` returns `null`.
`log(0)` returns `null`.

Query

```
RETURN log(27)
```

The natural logarithm of `27` is returned.

Table 276. Result

log(27)
`3.295836866004329`
1 row

4.6.4. log10()

`log10()` returns the common logarithm (base 10) of a number.

Syntax: `log10(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`log10(null)` returns `null`.
`log10(0)` returns `null`.

Query

```
RETURN log10(27)
```

The common logarithm of `27` is returned.

Table 277. Result

log10(27)
`1.4313637641589874`
1 row

4.6.5. sqrt()

`sqrt()` returns the square root of a number.

Syntax: `sqrt(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression.

Considerations:

`sqrt(null)` returns `null`.
`sqrt(<any negative number>)` returns `null`

Query

```
RETURN sqrt(256)
```

The square root of `256` is returned.

Table 278. Result

sqrt(256)
`16.0`
1 row

4.7. Mathematical functions - trigonometric

> *These functions all operate on numeric expressions only, and will return an error if used on any other values. See also Mathematical operators.*

Functions:

- acos()
- asin()
- atan()
- atan2()
- cos()
- cot()
- degrees()
- haversin()
- Spherical distance using the `haversin()` function
- pi()
- radians()
- sin()
- tan()

4.7.1. acos()

`acos()` returns the arccosine of a number in radians.

Syntax: `acos(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`acos(null)` returns `null`.
If (`expression` < -1) or (`expression` > 1), then (`acos(expression)`) returns `null`.

Query

```
RETURN acos(0.5)
```

The arccosine of `0.5` is returned.

Table 279. Result

acos(0.5)
`1.0471975511965979`
1 row

4.7.2. asin()

`asin()` returns the arcsine of a number in radians.

Syntax: `asin(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`asin(null)` returns `null`.
If (`expression` < -1) or (`expression` > 1), then (`asin(expression)`) returns `null`.

Query

```
RETURN asin(0.5)
```

The arcsine of `0.5` is returned.

Table 280. Result

asin(0.5)
`0.5235987755982989`
1 row

4.7.3. atan()

`atan()` returns the arctangent of a number in radians.

Syntax: `atan(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`atan(null)` returns `null`.

Query

```
RETURN atan(0.5)
```

The arctangent of `0.5` is returned.

Table 281. Result

atan(0.5)
`0.4636476090008061`
1 row

4.7.4. atan2()

`atan2()` returns the arctangent2 of a set of coordinates in radians.

Syntax: `atan2(expression1, expression2)`

Returns:

A Float.

Arguments:

Name	Description
`expression1`	A numeric expression for y that represents the angle in radians.
`expression2`	A numeric expression for x that represents the angle in radians.

Considerations:

`atan2(null, null)`, `atan2(null, expression2)` and `atan(expression1, null)` all return `null`.

Query

```
RETURN atan2(0.5, 0.6)
```

The arctangent2 of `0.5` and `0.6` is returned.

Table 282. Result

atan2(0.5, 0.6)
`0.6947382761967033`
1 row

4.7.5. cos()

`cos()` returns the cosine of a number.

Syntax: `cos(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`cos(null)` returns `null`.

Query

```
RETURN cos(0.5)
```

The cosine of `0.5` is returned.

Table 283. Result

cos(0.5)
`0.8775825618903728`
1 row

4.7.6. cot()

`cot()` returns the cotangent of a number.

Syntax: `cot(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`cot(null)` returns `null`.
`cot(0)` returns `null`.

Query

```
RETURN cot(0.5)
```

The cotangent of `0.5` is returned.

Table 284. Result

cot(0.5)
`1.830487721712452`
1 row

4.7.7. degrees()

`degrees()` converts radians to degrees.

Syntax: `degrees(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`degrees(null)` returns `null`.

Query

```
RETURN degrees(3.14159)
```

The number of degrees in something close to *pi* is returned.

Table 285. Result

degrees(3.14159)
`179.9998479605043`

degrees(3.14159)
1 row

4.7.8. haversin()

`haversin()` returns half the versine of a number.

Syntax: `haversin(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`haversin(null)` returns `null`.

Query

```
RETURN haversin(0.5)
```

The haversine of `0.5` is returned.

Table 286. Result

haversin(0.5)
`0.06120871905481362`
1 row

4.7.9. Spherical distance using the `haversin()` function

The `haversin()` function may be used to compute the distance on the surface of a sphere between two points (each given by their latitude and longitude). In this example the spherical distance (in km) between Berlin in Germany (at lat 52.5, lon 13.4) and San Mateo in California (at lat 37.5, lon -122.3) is calculated using an average earth radius of 6371 km.

Query

```
CREATE (ber:City { lat: 52.5, lon: 13.4 }),(sm:City { lat: 37.5, lon: -122.3 })
RETURN 2 * 6371 * asin(sqrt(haversin(radians(sm.lat - ber.lat))+ cos(radians(sm.lat))*
cos(radians(ber.lat))* haversin(radians(sm.lon - ber.lon)))) AS dist
```

The estimated distance between **'Berlin'** and **'San Mateo'** is returned.

Table 287. Result

dist
`9129.969740051658`

dist
1 row, Nodes created: 2 Properties set: 4 Labels added: 2

4.7.10. pi()

`pi()` returns the mathematical constant *pi*.

Syntax: `pi()`

Returns:

A Float.

Query

```
RETURN pi()
```

The constant *pi* is returned.

Table 288. Result

pi()
`3.141592653589793`
1 row

4.7.11. radians()

`radians()` converts degrees to radians.

Syntax: `radians(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in degrees.

Considerations:

`radians(null)` returns `null`.

Query

```
RETURN radians(180)
```

The number of radians in `180` degrees is returned (pi).

Table 289. Result

radians(180)
3.141592653589793
1 row

4.7.12. sin()

`sin()` returns the sine of a number.

Syntax: `sin(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`sin(null)` returns `null`.

Query

```
RETURN sin(0.5)
```

The sine of `0.5` is returned.

Table 290. Result

sin(0.5)
0.479425538604203
1 row

4.7.13. tan()

`tan()` returns the tangent of a number.

Syntax: `tan(expression)`

Returns:

A Float.

Arguments:

Name	Description
`expression`	A numeric expression that represents the angle in radians.

Considerations:

`tan(null)` returns `null`.

Query

```
RETURN tan(0.5)
```

The tangent of `0.5` is returned.

Table 291. Result

tan(0.5)
`0.5463024898437905`
1 row

4.8. String functions

> *These functions all operate on string expressions only, and will return an error if used on any other values. The exception to this rule is `toString()`, which also accepts numbers, booleans and temporal values (i.e. Date, Time. LocalTime, DateTime, LocalDateTime or Duration values).*

Functions taking a string as input all operate on *Unicode characters* rather than on a standard `char[]`. For example, the `size()` function applied to any *Unicode character* will return **1**, even if the character does not fit in the 16 bits of one `char`.

> When `toString()` is applied to a temporal value, it returns a string representation suitable for parsing by the corresponding temporal functions. This string will therefore be formatted according to the ISO 8601 format.

See also String operators.

Functions:

- left()
- lTrim()
- replace()
- reverse()
- right()
- rTrim()
- split()
- substring()
- toLower()
- toString()
- toUpper()
- trim()

4.8.1. left()

`left()` returns a string containing the specified number of leftmost characters of the original string.

Syntax: `left(original, length)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.
`n`	An expression that returns a positive integer.

Considerations:

`left(null, length)` and `left(null, null)` both return `null`
`left(original, null)` will raise an error.
If `length` is not a positive integer, an error is raised.
If `length` exceeds the size of `original`, `original` is returned.

Query

```
RETURN left('hello', 3)
```

Table 292. Result

left('hello', 3)
`"hel"`
1 row

4.8.2. ltrim()

`lTrim()` returns the original string with leading whitespace removed.

Syntax: `lTrim(original)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.

Considerations:

`lTrim(null)` returns `null`

Query

```
RETURN lTrim('   hello')
```

Table 293. Result

lTrim(' hello')
"hello"
1 row

4.8.3. replace()

`replace()` returns a string in which all occurrences of a specified string in the original string have been replaced by another (specified) string.

Syntax: `replace(original, search, replace)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.
`search`	An expression that specifies the string to be replaced in `original`.
`replace`	An expression that specifies the replacement string.

Considerations:

If any argument is `null`, `null` will be returned.
If `search` is not found in `original`, `original` will be returned.

Query

```
RETURN replace("hello", "l", "w")
```

Table 294. Result

replace("hello", "l", "w")
"hewwo"
1 row

4.8.4. reverse()

`reverse()` returns a string in which the order of all characters in the original string have been reversed.

Syntax: `reverse(original)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.

Considerations:

`reverse(null)` returns `null`.

Query

```
RETURN reverse('anagram')
```

Table 295. Result

reverse('anagram')
"margana"
1 row

4.8.5. right()

`right()` returns a string containing the specified number of rightmost characters of the original string.

Syntax: `right(original, length)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.
`n`	An expression that returns a positive integer.

Considerations:

`right(null, length)` and `right(null, null)` both return `null`
`right(original, null)` will raise an error.
If `length` is not a positive integer, an error is raised.
If `length` exceeds the size of `original`, `original` is returned.

Query

```
RETURN right('hello', 3)
```

Table 296. Result

right('hello', 3)
"llo"

right('hello', 3)
1 row

4.8.6. rtrim()

`rTrim()` returns the original string with trailing whitespace removed.

Syntax: `rTrim(original)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.

Considerations:

`rTrim(null)` returns `null`

Query

```
RETURN rTrim('hello   ')
```

Table 297. Result

rTrim('hello ')
`"hello"`
1 row

4.8.7. split()

`split()` returns a list of strings resulting from the splitting of the original string around matches of the given delimiter.

Syntax: `split(original, splitDelimiter)`

Returns:

A list of Strings.

Arguments:

Name	Description
`original`	An expression that returns a string.
`splitDelimiter`	The string with which to split `original`.

Considerations:

`split(null, splitDelimiter)` and `split(original, null)` both return `null`

Query

```
RETURN split('one,two', ',')
```

Table 298. Result

split('one,two', ',')
["one","two"]
1 row

4.8.8. substring()

`substring()` returns a substring of the original string, beginning with a 0-based index start and length.

Syntax: `substring(original, start [, length])`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.
`start`	An expression that returns a positive integer, denoting the position at which the substring will begin.
`length`	An expression that returns a positive integer, denoting how many characters of `original` will be returned.

Considerations:

`start` uses a zero-based index.
If `length` is omitted, the function returns the substring starting at the position given by `start` and extending to the end of `original`.
If `original` is `null`, `null` is returned.
If either `start` or `length` is `null` or a negative integer, an error is raised.
If `start` is `0`, the substring will start at the beginning of `original`.
If `length` is `0`, the empty string will be returned.

Query

```
RETURN substring('hello', 1, 3), substring('hello', 2)
```

Table 299. Result

substring('hello', 1, 3)	substring('hello', 2)
"ell"	"llo"
1 row	

4.8.9. toLower()

`toLower()` returns the original string in lowercase.

Syntax: `toLower(original)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.

Considerations:

`toLower(null)` returns `null`

Query

```
RETURN toLower('HELLO')
```

Table 300. Result

toLower('HELLO')
`"hello"`
1 row

4.8.10. toString()

`toString()` converts an integer, float or boolean value to a string.

Syntax: `toString(expression)`

Returns:

A String.

Arguments:

Name	Description
`expression`	An expression that returns a number, a boolean, or a string.

Considerations:

`toString(null)` returns `null`
If `expression` is a string, it will be returned unchanged.

Query

```
RETURN toString(11.5), toString('already a string'), toString(TRUE ), toString(date({ year:1984, month:10,
day:11 })) AS dateString, toString(datetime({ year:1984, month:10, day:11, hour:12, minute:31, second:14,
millisecond: 341, timezone: 'Europe/Stockholm' })) AS datetimeString, toString(duration({ minutes: 12,
seconds: -60 })) AS durationString
```

Table 301. Result

toString(11.5)	toString('already a string')	toString(TRUE)	dateString	datetimeString	durationString
"11.5"	"already a string"	"true"	"1984-10-11"	"1984-10-11T12:31:14.341+01:00[Europe/Stockholm]"	"PT11M"
1 row					

4.8.11. toUpper()

`toUpper()` returns the original string in uppercase.

Syntax: `toUpper(original)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.

Considerations:

`toUpper(null)` returns `null`

Query

```
RETURN toUpper('hello')
```

Table 302. Result

toUpper('hello')
"HELLO"
1 row

4.8.12. trim()

`trim()` returns the original string with leading and trailing whitespace removed.

Syntax: `trim(original)`

Returns:

A String.

Arguments:

Name	Description
`original`	An expression that returns a string.

Considerations:

`trim(null)` returns `null`

Query

```
RETURN trim('   hello   ')
```

Table 303. Result

trim(' hello ')
"hello"
1 row

4.9. Temporal functions - instant types

Cypher provides functions allowing for the creation and manipulation of values for each temporal type — Date, Time, LocalTime, DateTime, and LocalDateTime.

See also Temporal (Date/Time) values and Temporal operators.

Temporal instant types

- An overview of temporal instant type creation
- Controlling which clock to use
- Truncating temporal values

Functions:

- date()
  - Getting the current *Date*
  - Creating a calendar (Year-Month-Day) *Date*
  - Creating a week (Year-Week-Day) *Date*
  - Creating a quarter (Year-Quarter-Day) *Date*
  - Creating an ordinal (Year-Day) *Date*
  - Creating a *Date* from a string
  - Creating a *Date* using other temporal values as components
  - Truncating a *Date*
- datetime()
  - Getting the current *DateTime*
  - Creating a calendar (Year-Month-Day) *DateTime*
  - Creating a week (Year-Week-Day) *DateTime*
  - Creating a quarter (Year-Quarter-Day) *DateTime*
  - Creating an ordinal (Year-Day) *DateTime*
  - Creating a *DateTime* from a string
  - Creating a *DateTime* using other temporal values as components
  - Creating a *DateTime* from a timestamp

4.9.1. Temporal instant types

An introduction to temporal instant types, including descriptions of creation functions, clocks, and truncation.

An overview of temporal instant type creation

Each function bears the same name as the type, and construct the type they correspond to in one of four ways:

- Capturing the current time
- Composing the components of the type
- Parsing a string representation of the temporal value
- Selecting and composing components from another temporal value by
    - either combining temporal values (such as combining a *Date* with a *Time* to create a *DateTime*), or
    - selecting parts from a temporal value (such as selecting the *Date* from a *DateTime*); the *extractors* — groups of components which can be selected — are:
        - `date` — contains all components for a *Date* (conceptually *year*, *month* and *day*).
        - `time` — contains all components for a *Time* (*hour*, *minute*, *second*, and sub-seconds; namely

millisecond, *microsecond* and *nanosecond*). If the type being created and the type from which the time component is being selected both contain `timezone` (and a `timezone` is not explicitly specified) the `timezone` is also selected.

   - `datetime` — selects all components, and is useful for overriding specific components. Analogously to `time`, if the type being created and the type from which the time component is being selected both contain `timezone` (and a `timezone` is not explicitly specified) the `timezone` is also selected.

- In effect, this allows for the *conversion* between different temporal types, and allowing for 'missing' components to be specified.

Table 304. Temporal instant type creation functions

Function	Date	Time	LocalTime	DateTime	LocalDateTime
Getting the current value	X	X	X	X	X
Creating a calendar-based (Year-Month-Day) value	X			X	X
Creating a week-based (Year-Week-Day) value	X			X	X
Creating a quarter-based (Year-Quarter-Day) value	X			X	X
Creating an ordinal (Year-Day) value	X			X	X
Creating a value from time components		X	X		
Creating a value from other temporal values using extractors (i.e. converting between different types)	X	X	X	X	X
Creating a value from a string	X	X	X	X	X
Creating a value from a timestamp				X	

All the temporal instant types — including those that do not contain time zone information support such as *Date*, *LocalTime* and *DateTime* — allow for a time zone to specified for the functions that retrieve the current instant. This allows for the retrieval of the current instant in the specified time zone.

Controlling which clock to use

The functions which create temporal instant values based on the current instant use the `statement` clock as default. However, there are three different clocks available for more fine-grained control:

- `transaction`: The same instant is produced for each invocation within the same transaction. A different time may be produced for different transactions.
- `statement`: The same instant is produced for each invocation within the same statement. A different time may be produced for different statements within the same transaction.

- `realtime`: The instant produced will be the live clock of the system.

The following table lists the different sub-functions for specifying the clock to be used when creating the current temporal instant value:

Type	default	transaction	statement	realtime
Date	date()	date.transaction()	date.statement()	date.realtime()
Time	time()	time.transaction()	time.statement()	time.realtime()
LocalTime	localtime()	localtime.transaction()	localtime.statement()	localtime.realtime()
DateTime	datetime()	datetime.transaction()	datetime.statement()	datetime.realtime()
LocalDateTime	localdatetime()	localdatetime.transaction()	localdatetime.statement()	localdatetime.realtime()

Truncating temporal values

A temporal instant value can be created by truncating another temporal instant value at the nearest preceding point in time at a specified component boundary (namely, a *truncation unit*). A temporal instant value created in this way will have all components which are less significant than the specified truncation unit set to their default values.

It is possible to supplement the truncated value by providing a map containing components which are less significant than the truncation unit. This will have the effect of overriding the default values which would otherwise have been set for these less significant components.

The following truncation units are supported:

- `millennium`: Select the temporal instant corresponding to the *millenium* of the given instant.
- `century`: Select the temporal instant corresponding to the *century* of the given instant.
- `decade`: Select the temporal instant corresponding to the *decade* of the given instant.
- `year`: Select the temporal instant corresponding to the *year* of the given instant.
- `weekYear`: Select the temporal instant corresponding to the first day of the first week of the *week-year* of the given instant.
- `quarter`: Select the temporal instant corresponding to the *quarter of the year* of the given instant.
- `month`: Select the temporal instant corresponding to the *month* of the given instant.
- `week`: Select the temporal instant corresponding to the *week* of the given instant.
- `day`: Select the temporal instant corresponding to the *month* of the given instant.
- `hour`: Select the temporal instant corresponding to the *hour* of the given instant.
- `minute`: Select the temporal instant corresponding to the *minute* of the given instant.
- `second`: Select the temporal instant corresponding to the *second* of the given instant.
- `millisecond`: Select the temporal instant corresponding to the *millisecond* of the given instant.
- `microsecond`: Select the temporal instant corresponding to the *microsecond* of the given instant.

The following table lists the supported truncation units and the corresponding sub-functions:

Truncation unit	Date	Time	LocalTime	DateTime	LocalDateTime
`millennium`	date.truncate('millennium', input)			datetime.truncate('millennium', input)	localdatetime.truncate('millennium', input)

Truncation unit	Date	Time	LocalTime	DateTime	LocalDateTime
`century`	date.truncate('century', input)			datetime.truncate('century', input)	localdatetime.truncate('century', input)
`decade`	date.truncate('decade', input)			datetime.truncate('decade', input)	localdatetime.truncate('decade', input)
`year`	date.truncate('year', input)			datetime.truncate('year', input)	localdatetime.truncate('year', input)
`weekYear`	date.truncate('weekYear', input)			datetime.truncate('weekYear', input)	localdatetime.truncate('weekYear', input)
`quarter`	date.truncate('quarter', input)			datetime.truncate('quarter', input)	localdatetime.truncate('quarter', input)
`month`	date.truncate('month', input)			datetime.truncate('month', input)	localdatetime.truncate('month', input)
`week`	date.truncate('week', input)			datetime.truncate('week', input)	localdatetime.truncate('week', input)
`day`	date.truncate('day', input)	time.truncate('day', input)	localtime.truncate('day', input)	datetime.truncate('day', input)	localdatetime.truncate('day', input)
`hour`		time.truncate('hour', input)	localtime.truncate('hour', input)	datetime.truncate('hour', input)	localdatetime.truncate('hour',input)
`minute`		time.truncate('minute', input)	localtime.truncate('minute', input)	datetime.truncate('minute', input)	localdatetime.truncate('minute', input)
`second`		time.truncate('second', input)	localtime.truncate('second', input)	datetime.truncate('second', input)	localdatetime.truncate('second', input)
`millisecond`		time.truncate('millisecond', input)	localtime.truncate('millisecond', input)	datetime.truncate('millisecond', input)	localdatetime.truncate('millisecond', input)
`microsecond`		time.truncate('microsecond', input)	localtime.truncate('microsecond', input)	datetime.truncate('microsecond', input)	localdatetime.truncate('microsecond', input)

4.9.2. Date: `date()`

Details for using the `date()` function.

- Getting the current *Date*
- Creating a calendar (Year-Month-Day) *Date*
- Creating a week (Year-Week-Day) *Date*
- Creating a quarter (Year-Quarter-Day) *Date*
- Creating an ordinal (Year-Day) *Date*
- Creating a *Date* from a string
- Creating a *Date* using other temporal values as components
- Truncating a *Date*

Getting the current *Date*

`date()` returns the current *Date* value. If no time zone parameter is specified, the local time zone will be used.

Syntax: `date([ {timezone} ])`

Returns:

A Date.

Arguments:

Name	Description
`A single map consisting of the following:`	
`timezone`	A string expression that represents the time zone

Considerations:

If no parameters are provided, `date()` must be invoked (`date({})` is invalid).

Query

```
RETURN date() AS currentDate
```

The current date is returned.

Table 305. Result

currentDate
`2020-01-17`
1 row

Query

```
RETURN date({ timezone: 'America/Los Angeles' }) AS currentDateInLA
```

The current date in California is returned.

Table 306. Result

currentDateInLA
`2020-01-17`
1 row

date.transaction()

`date.transaction()` returns the current *Date* value using the `transaction` clock. This value will be the same for each invocation within the same transaction. However, a different value may be produced for different transactions.

Syntax: `date.transaction([ {timezone} ])`

Returns:

A Date.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN date.transaction() AS currentDate
```

Table 307. Result

currentDate
`2020-01-17`
1 row

date.statement()

`date.statement()` returns the current *Date* value using the `statement` clock. This value will be the same for each invocation within the same statement. However, a different value may be produced for different statements within the same transaction.

Syntax: `date.statement([ {timezone} ])`

Returns:

A Date.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN date.statement() AS currentDate
```

Table 308. Result

currentDate
`2020-01-17`
1 row

date.realtime()

`date.realtime()` returns the current *Date* value using the `realtime` clock. This value will be the live clock of the system.

Syntax: `date.realtime([ {timezone} ])`

Returns:

A Date.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN date.realtime() AS currentDate
```

Table 309. Result

currentDate
`2020-01-17`
1 row

Query

```
RETURN date.realtime('America/Los Angeles') AS currentDateInLA
```

Table 310. Result

currentDateInLA
`2020-01-17`
1 row

Creating a calendar (Year-Month-Day) *Date*

`date()` returns a *Date* value with the specified *year*, *month* and *day* component values.

Syntax: `date({year [, month, day]})`

Returns:

A Date.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`month`	An integer between `1` and `12` that specifies the month.
`day`	An integer between `1` and `31` that specifies the day of the month.

Considerations:

The *day of the month* component will default to `1` if `day` is omitted.
The *month* component will default to `1` if `month` is omitted.
If `month` is omitted, `day` must also be omitted.

Query

```
UNWIND [
  date({year:1984, month:10, day:11}),
  date({year:1984, month:10}),
  date({year:1984})
] as theDate
RETURN theDate
```

Table 311. Result

theDate
1984-10-11
1984-10-01
1984-01-01
3 rows

Creating a week (Year-Week-Day) *Date*

`date()` returns a *Date* value with the specified *year*, *week* and *dayOfWeek* component values.

Syntax: `date({year [, week, dayOfWeek]})`

Returns:

A Date.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`week`	An integer between `1` and `53` that specifies the week.
`dayOfWeek`	An integer between `1` and `7` that specifies the day of the week.

Considerations:

The *day of the week* component will default to `1` if `dayOfWeek` is omitted.
The *week* component will default to `1` if `week` is omitted.
If `week` is omitted, `dayOfWeek` must also be omitted.

Query

```
UNWIND [
  date({year:1984, week:10, dayOfWeek:3}),
  date({year:1984, week:10}),
  date({year:1984})
] as theDate
RETURN theDate
```

Table 312. Result

theDate
1984-03-07
1984-03-05
1984-01-01
3 rows

Creating a quarter (Year-Quarter-Day) *Date*

`date()` returns a *Date* value with the specified *year*, *quarter* and *dayOfQuarter* component values.

Syntax: `date({year [, quarter, dayOfQuarter]})`

Returns:

A Date.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`quarter`	An integer between `1` and `4` that specifies the quarter.
`dayOfQuarter`	An integer between `1` and `92` that specifies the day of the quarter.

Considerations:

The *day of the quarter* component will default to `1` if `dayOfQuarter` is omitted.
The *quarter* component will default to `1` if `quarter` is omitted.
If `quarter` is omitted, `dayOfQuarter` must also be omitted.

Query

```
UNWIND [
  date({year:1984, quarter:3, dayOfQuarter: 45}),
  date({year:1984, quarter:3}),
  date({year:1984})
] as theDate
RETURN theDate
```

Table 313. Result

theDate
1984-08-14
1984-07-01
1984-01-01
3 rows

Creating an ordinal (Year-Day) *Date*

`date()` returns a *Date* value with the specified *year* and *ordinalDay* component values.

Syntax: `date({year [, ordinalDay]})`

Returns:

A Date.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`ordinalDay`	An integer between `1` and `366` that specifies the ordinal day of the year.

Considerations:

The *ordinal day of the year* component will default to `1` if `ordinalDay` is omitted.

Query

```
UNWIND [
  date({year:1984, ordinalDay:202}),
  date({year:1984})
] as theDate
RETURN theDate
```

The date corresponding to `11 February 1984` is returned.

Table 314. Result

theDate
`1984-07-20`
`1984-01-01`
2 rows

Creating a *Date* from a string

`date()` returns the *Date* value obtained by parsing a string representation of a temporal value.

Syntax: `date(temporalValue)`

Returns:

A Date.

Arguments:

Name	Description
`temporalValue`	A string representing a temporal value.

Considerations:

`temporalValue` must comply with the format defined for dates.

`temporalValue` must denote a valid date; i.e. a `temporalValue` denoting `30 February 2001` is invalid.
`date(null)` returns null.

Query

```
UNWIND [
  date('2015-07-21'),
  date('2015-07'),
  date('201507'),
  date('2015-W30-2'),
  date('2015202'),
  date('2015')
] as theDate
RETURN theDate
```

Table 315. Result

theDate
2015-07-21
2015-07-01
2015-07-01
2015-07-21
2015-07-21
2015-01-01
6 rows

Creating a *Date* using other temporal values as components

`date()` returns the *Date* value obtained by selecting and composing components from another temporal value. In essence, this allows a *DateTime* or *LocalDateTime* value to be converted to a *Date*, and for "missing" components to be provided.

Syntax: `date({date [, year, month, day, week, dayOfWeek, quarter, dayOfQuarter, ordinalDay]})`

Returns:

A Date.

Arguments:

Name	Description
`A single map consisting of the following:`	
`date`	A *Date* value.
`year`	An expression consisting of at least four digits that specifies the year.
`month`	An integer between `1` and `12` that specifies the month.
`day`	An integer between `1` and `31` that specifies the day of the month.
`week`	An integer between `1` and `53` that specifies the week.
`dayOfWeek`	An integer between `1` and `7` that specifies the day of the week.
`quarter`	An integer between `1` and `4` that specifies the quarter.

Name	Description
`dayOfQuarter`	An integer between `1` and `92` that specifies the day of the quarter.
`ordinalDay`	An integer between `1` and `366` that specifies the ordinal day of the year.

Considerations:

If any of the optional parameters are provided, these will override the corresponding components of `date`.
`date(dd)` may be written instead of `date({date: dd})`.

Query

```
UNWIND [
  date({year:1984, month:11, day:11}),
  localdatetime({year:1984, month:11, day:11, hour:12, minute:31, second:14}),
  datetime({year:1984, month:11, day:11, hour:12, timezone: '+01:00'})
] as dd
RETURN date({date: dd}) AS dateOnly,
   date({date: dd, day: 28}) AS dateDay
```

Table 316. Result

dateOnly	dateDay
`1984-11-11`	`1984-11-28`
`1984-11-11`	`1984-11-28`
`1984-11-11`	`1984-11-28`
3 rows	

Truncating a *Date*

`date.truncate()` returns the *Date* value obtained by truncating a specified temporal instant value at the nearest preceding point in time at the specified component boundary (which is denoted by the truncation unit passed as a parameter to the function). In other words, the *Date* returned will have all components that are less significant than the specified truncation unit set to their default values.

It is possible to supplement the truncated value by providing a map containing components which are less significant than the truncation unit. This will have the effect of *overriding* the default values which would otherwise have been set for these less significant components. For example, `day` — with some value `x` — may be provided when the truncation unit is `year` in order to ensure the returned value has the *day* set to `x` instead of the default *day* (which is `1`).

Syntax: `date.truncate(unit [, temporalInstantValue [, mapOfComponents ] ])`

Returns:

A Date.

Arguments:

Name	Description
`unit`	A string expression evaluating to one of the following: {`millennium`, `century`, `decade`, `year`, `weekYear`, `quarter`, `month`, `week`, `day`}.
`temporalInstantValue`	An expression of one of the following types: {*DateTime*, *LocalDateTime*, *Date*}.

Name	Description
`mapOfComponents`	An expression evaluating to a map containing components less significant than `unit`.

Considerations:

Any component that is provided in `mapOfComponents` must be less significant than `unit`; i.e. if `unit` is 'day', `mapOfComponents` cannot contain information pertaining to a *month*.
Any component that is not contained in `mapOfComponents` and which is less significant than `unit` will be set to its minimal value.
If `mapOfComponents` is not provided, all components of the returned value which are less significant than `unit` will be set to their default values.
If `temporalInstantValue` is not provided, it will be set to the current date, i.e. `date.truncate(unit)` is equivalent of `date.truncate(unit, date())`.

Query

```
WITH datetime({year:2017, month:11, day:11, hour:12, minute:31, second:14, nanosecond: 645876123,
timezone: '+01:00'}) AS d
RETURN date.truncate('millennium', d) AS truncMillenium,
       date.truncate('century', d) AS truncCentury,
       date.truncate('decade', d) AS truncDecade,
       date.truncate('year', d, {day:5}) AS truncYear,
       date.truncate('weekYear', d) AS truncWeekYear,
       date.truncate('quarter', d) AS truncQuarter,
       date.truncate('month', d) AS truncMonth,
       date.truncate('week', d, {dayOfWeek:2}) AS truncWeek,
       date.truncate('day', d) AS truncDay
```

Table 317. Result

truncMillenium	truncCentury	truncDecade	truncYear	truncWeekYear	truncQuarter	truncMonth	truncWeek	truncDay
`2000-01-01`	`2000-01-01`	`2010-01-01`	`2017-01-05`	`2017-01-02`	`2017-10-01`	`2017-11-01`	`2017-11-07`	`2017-11-11`
1 row								

4.9.3. DateTime: `datetime()`

Details for using the `datetime()` function.

- Getting the current *DateTime*
- Creating a calendar (Year-Month-Day) *DateTime*
- Creating a week (Year-Week-Day) *DateTime*
- Creating a quarter (Year-Quarter-Day) *DateTime*
- Creating an ordinal (Year-Day) *DateTime*
- Creating a *DateTime* from a string
- Creating a *DateTime* using other temporal values as components
- Creating a *DateTime* from a timestamp
- Truncating a *DateTime*

Getting the current *DateTime*

`datetime()` returns the current *DateTime* value. If no time zone parameter is specified, the default time zone will be used.

Syntax: `datetime([ {timezone} ])`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`timezone`	A string expression that represents the time zone

Considerations:

If no parameters are provided, `datetime()` must be invoked (`datetime({})` is invalid).

Query

```
RETURN datetime() AS currentDateTime
```

The current date and time using the local time zone is returned.

Table 318. Result

currentDateTime
`2020-01-17T20:29:12.378Z`
1 row

Query

```
RETURN datetime({ timezone: 'America/Los Angeles' }) AS currentDateTimeInLA
```

The current date and time of day in California is returned.

Table 319. Result

currentDateTimeInLA
`2020-01-17T12:29:12.396-08:00[America/Los_Angeles]`
1 row

datetime.transaction()

`datetime.transaction()` returns the current *DateTime* value using the `transaction` clock. This value will be the same for each invocation within the same transaction. However, a different value may be produced for different transactions.

Syntax: `datetime.transaction([ {timezone} ])`

Returns:

A DateTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN datetime.transaction() AS currentDateTime
```

Table 320. Result

currentDateTime
`2020-01-17T20:29:12.418Z`
1 row

Query

```
RETURN datetime.transaction('America/Los Angeles') AS currentDateTimeInLA
```

Table 321. Result

currentDateTimeInLA
`2020-01-17T12:29:12.435-08:00[America/Los_Angeles]`
1 row

datetime.statement()

`datetime.statement()` returns the current *DateTime* value using the `statement` clock. This value will be the same for each invocation within the same statement. However, a different value may be produced for different statements within the same transaction.

Syntax: `datetime.statement([ {timezone} ])`

Returns:

A DateTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN datetime.statement() AS currentDateTime
```

Table 322. Result

currentDateTime
`2020-01-17T20:29:12.452Z`
1 row

datetime.realtime()

`datetime.realtime()` returns the current *DateTime* value using the `realtime` clock. This value will be the live clock of the system.

Syntax: `datetime.realtime([ {timezone} ])`

Returns:

A DateTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN datetime.realtime() AS currentDateTime
```

Table 323. Result

currentDateTime
`2020-01-17T20:29:12.483333Z`
1 row

Creating a calendar (Year-Month-Day) *DateTime*

`datetime()` returns a *DateTime* value with the specified *year*, *month*, *day*, *hour*, *minute*, *second*, *millisecond*, *microsecond*, *nanosecond* and *timezone* component values.

Syntax: `datetime({year [, month, day, hour, minute, second, millisecond, microsecond, nanosecond, timezone]})`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`month`	An integer between `1` and `12` that specifies the month.
`day`	An integer between `1` and `31` that specifies the day of the month.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.

Name	Description
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.
`timezone`	An expression that specifies the time zone.

Considerations:

The *month* component will default to `1` if `month` is omitted.
The *day of the month* component will default to `1` if `day` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
The *timezone* component will default to the configured default time zone if `timezone` is omitted.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `month`, `day`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year`, `month` and `day`, but specifying `year`, `month`, `day` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
UNWIND [
  datetime({year:1984, month:10, day:11, hour:12, minute:31, second:14, millisecond: 123, microsecond:
456, nanosecond: 789}),
  datetime({year:1984, month:10, day:11, hour:12, minute:31, second:14, millisecond: 645, timezone:
'+01:00'}),
  datetime({year:1984, month:10, day:11, hour:12, minute:31, second:14, nanosecond: 645876123, timezone:
'Europe/Stockholm'}),
  datetime({year:1984, month:10, day:11, hour:12, minute:31, second:14, timezone: '+01:00'}),
  datetime({year:1984, month:10, day:11, hour:12, minute:31, second:14}),
  datetime({year:1984, month:10, day:11, hour:12, minute:31, timezone: 'Europe/Stockholm'}),
  datetime({year:1984, month:10, day:11, hour:12, timezone: '+01:00'}),
  datetime({year:1984, month:10, day:11, timezone: 'Europe/Stockholm'})
] as theDate
RETURN theDate
```

Table 324. Result

theDate
`1984-10-11T12:31:14.123456789Z`
`1984-10-11T12:31:14.645+01:00`
`1984-10-11T12:31:14.645876123+01:00[Europe/Stockholm]`
`1984-10-11T12:31:14+01:00`
`1984-10-11T12:31:14Z`
`1984-10-11T12:31+01:00[Europe/Stockholm]`
`1984-10-11T12:00+01:00`
`1984-10-11T00:00+01:00[Europe/Stockholm]`
8 rows

Creating a week (Year-Week-Day) *DateTime*

`datetime()` returns a *DateTime* value with the specified *year*, *week*, *dayOfWeek*, *hour*, *minute*, *second*, *millisecond*, *microsecond*, *nanosecond* and *timezone* component values.

Syntax: `datetime({year [, week, dayOfWeek, hour, minute, second, millisecond, microsecond, nanosecond, timezone]})`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`week`	An integer between `1` and `53` that specifies the week.
`dayOfWeek`	An integer between `1` and `7` that specifies the day of the week.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.
`timezone`	An expression that specifies the time zone.

Considerations:

The *week* component will default to `1` if `week` is omitted.
The *day of the week* component will default to `1` if `dayOfWeek` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
The *timezone* component will default to the configured default time zone if `timezone` is omitted.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `week`, `dayOfWeek`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year`, `week` and `dayOfWeek`, but specifying `year`, `week`, `dayOfWeek` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
UNWIND [
  datetime({year:1984, week:10, dayOfWeek:3, hour:12, minute:31, second:14, millisecond: 645}),
  datetime({year:1984, week:10, dayOfWeek:3, hour:12, minute:31, second:14, microsecond: 645876, timezone:
'+01:00'}),
  datetime({year:1984, week:10, dayOfWeek:3, hour:12, minute:31, second:14, nanosecond: 645876123,
timezone: 'Europe/Stockholm'}),
  datetime({year:1984, week:10, dayOfWeek:3, hour:12, minute:31, second:14, timezone:
'Europe/Stockholm'}),
  datetime({year:1984, week:10, dayOfWeek:3, hour:12, minute:31, second:14}),
  datetime({year:1984, week:10, dayOfWeek:3, hour:12, timezone: '+01:00'}),
  datetime({year:1984, week:10, dayOfWeek:3, timezone: 'Europe/Stockholm'})
] as theDate
RETURN theDate
```

Table 325. Result

theDate
`1984-03-07T12:31:14.645Z`
`1984-03-07T12:31:14.645876+01:00`
`1984-03-07T12:31:14.645876123+01:00[Europe/Stockholm]`
`1984-03-07T12:31:14+01:00[Europe/Stockholm]`
`1984-03-07T12:31:14Z`
`1984-03-07T12:00+01:00`
`1984-03-07T00:00+01:00[Europe/Stockholm]`
7 rows

Creating a quarter (Year-Quarter-Day) *DateTime*

`datetime()` returns a *DateTime* value with the specified *year*, *quarter*, *dayOfQuarter*, *hour*, *minute*, *second*, *millisecond*, *microsecond*, *nanosecond* and *timezone* component values.

Syntax: `datetime({year [, quarter, dayOfQuarter, hour, minute, second, millisecond, microsecond, nanosecond, timezone]})`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`quarter`	An integer between `1` and `4` that specifies the quarter.
`dayOfQuarter`	An integer between `1` and `92` that specifies the day of the quarter.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.

Name	Description
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.
`timezone`	An expression that specifies the time zone.

Considerations:

The *quarter* component will default to `1` if `quarter` is omitted.
The *day of the quarter* component will default to `1` if `dayOfQuarter` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
The *timezone* component will default to the configured default time zone if `timezone` is omitted.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `quarter`, `dayOfQuarter`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year`, `quarter` and `dayOfQuarter`, but specifying `year`, `quarter`, `dayOfQuarter` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
UNWIND [
  datetime({year:1984, quarter:3, dayOfQuarter: 45, hour:12, minute:31, second:14, microsecond: 645876}),
  datetime({year:1984, quarter:3, dayOfQuarter: 45, hour:12, minute:31, second:14, timezone: '+01:00'}),
  datetime({year:1984, quarter:3, dayOfQuarter: 45, hour:12, timezone: 'Europe/Stockholm'}),
  datetime({year:1984, quarter:3, dayOfQuarter: 45})
] as theDate
RETURN theDate
```

Table 326. Result

theDate
`1984-08-14T12:31:14.645876Z`
`1984-08-14T12:31:14+01:00`
`1984-08-14T12:00+02:00[Europe/Stockholm]`
`1984-08-14T00:00Z`
4 rows

Creating an ordinal (Year-Day) *DateTime*

`datetime()` returns a *DateTime* value with the specified *year*, *ordinalDay*, *hour*, *minute*, *second*, *millisecond*, *microsecond*, *nanosecond* and *timezone* component values.

Syntax: `datetime({year [, ordinalDay, hour, minute, second, millisecond, microsecond, nanosecond, timezone]})`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`ordinalDay`	An integer between `1` and `366` that specifies the ordinal day of the year.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.
`timezone`	An expression that specifies the time zone.

Considerations:

The *ordinal day of the year* component will default to `1` if `ordinalDay` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
The *timezone* component will default to the configured default time zone if `timezone` is omitted.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `ordinalDay`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year` and `ordinalDay`, but specifying `year`, `ordinalDay` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
UNWIND [
  datetime({year:1984, ordinalDay:202, hour:12, minute:31, second:14, millisecond: 645}),
  datetime({year:1984, ordinalDay:202, hour:12, minute:31, second:14, timezone: '+01:00'}),
  datetime({year:1984, ordinalDay:202, timezone: 'Europe/Stockholm'}),
  datetime({year:1984, ordinalDay:202})
] as theDate
RETURN theDate
```

Table 327. Result

theDate
1984-07-20T12:31:14.645Z
1984-07-20T12:31:14+01:00
1984-07-20T00:00+02:00[Europe/Stockholm]
1984-07-20T00:00Z
4 rows

Creating a *DateTime* from a string

datetime() returns the *DateTime* value obtained by parsing a string representation of a temporal value.

Syntax: datetime(temporalValue)

Returns:

A DateTime.

Arguments:

Name	Description
temporalValue	A string representing a temporal value.

Considerations:

temporalValue must comply with the format defined for dates, times and time zones.
The *timezone* component will default to the configured default time zone if it is omitted.
temporalValue must denote a valid date and time; i.e. a temporalValue denoting 30 February 2001 is invalid.
datetime(null) returns null.

Query

```
UNWIND [
  datetime('2015-07-21T21:40:32.142+0100'),
  datetime('2015-W30-2T214032.142Z'),
  datetime('2015T214032-0100'),
  datetime('20150721T21:40-01:30'),
  datetime('2015-W30T2140-02'),
  datetime('2015202T21+18:00'),
  datetime('2015-07-21T21:40:32.142[Europe/London]'),
  datetime('2015-07-21T21:40:32.142-04[America/New_York]')
] AS theDate
RETURN theDate
```

Table 328. Result

theDate
2015-07-21T21:40:32.142+01:00
2015-07-21T21:40:32.142Z
2015-01-01T21:40:32-01:00
2015-07-21T21:40-01:30
2015-07-20T21:40-02:00
2015-07-21T21:00+18:00

theDate
`2015-07-21T21:40:32.142+01:00[Europe/London]`
`2015-07-21T21:40:32.142-04:00[America/New_York]`
8 rows

Creating a *DateTime* using other temporal values as components

`datetime()` returns the *DateTime* value obtained by selecting and composing components from another temporal value. In essence, this allows a *Date*, *LocalDateTime*, *Time* or *LocalTime* value to be converted to a *DateTime*, and for "missing" components to be provided.

Syntax: `datetime({datetime [, year, …, timezone]}) | datetime({date [, year, …, timezone]}) | datetime({time [, year, …, timezone]}) | datetime({date, time [, year, …, timezone]})`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`datetime`	A *DateTime* value.
`date`	A *Date* value.
`time`	A *Time* value.
`year`	An expression consisting of at least four digits that specifies the year.
`month`	An integer between `1` and `12` that specifies the month.
`day`	An integer between `1` and `31` that specifies the day of the month.
`week`	An integer between `1` and `53` that specifies the week.
`dayOfWeek`	An integer between `1` and `7` that specifies the day of the week.
`quarter`	An integer between `1` and `4` that specifies the quarter.
`dayOfQuarter`	An integer between `1` and `92` that specifies the day of the quarter.
`ordinalDay`	An integer between `1` and `366` that specifies the ordinal day of the year.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Name	Description
`timezone`	An expression that specifies the time zone.

Considerations:

If any of the optional parameters are provided, these will override the corresponding components of `datetime`, `date` and/or `time`.
`datetime(dd)` may be written instead of `datetime({datetime: dd})`.
Selecting a *Time* or *DateTime* value as the `time` component also selects its time zone. If a *LocalTime* or *LocalDateTime* is selected instead, the default time zone is used. In any case, the time zone can be overridden explicitly.
Selecting a *DateTime* as the `datetime` component and overwriting the time zone will adjust the local time to keep the same point in time.
Selecting a *DateTime* or *Time* as the `time` component and overwriting the time zone will adjust the local time to keep the same point in time.

The following query shows the various usages of `datetime({date [, year, …, timezone]})`

Query

```
WITH date({year:1984, month:10, day:11}) AS dd
RETURN datetime({date:dd, hour: 10, minute: 10, second: 10}) AS dateHHMMSS,
       datetime({date:dd, hour: 10, minute: 10, second: 10, timezone:'+05:00'}) AS dateHHMMSSTimezone,
       datetime({date:dd, day: 28, hour: 10, minute: 10, second: 10}) AS dateDDHHMMSS,
       datetime({date:dd, day: 28, hour: 10, minute: 10, second: 10, timezone:'Pacific/Honolulu'}) AS
dateDDHHMMSSTimezone
```

Table 329. Result

dateHHMMSS	dateHHMMSSTimezone	dateDDHHMMSS	dateDDHHMMSSTimezone
`1984-10-11T10:10:10Z`	`1984-10-11T10:10:10+05:00`	`1984-10-28T10:10:10Z`	`1984-10-28T10:10:10-10:00[Pacific/Honolulu]`
1 row			

The following query shows the various usages of `datetime({time [, year, …, timezone]})`

Query

```
WITH time({hour:12, minute:31, second:14, microsecond: 645876, timezone: '+01:00'}) AS tt
RETURN datetime({year:1984, month:10, day:11, time:tt}) AS YYYYMMDDTime,
       datetime({year:1984, month:10, day:11, time:tt, timezone:'+05:00'}) AS YYYYMMDDTimeTimezone,
       datetime({year:1984, month:10, day:11, time:tt, second: 42}) AS YYYYMMDDTimeSS,
       datetime({year:1984, month:10, day:11, time:tt, second: 42, timezone:'Pacific/Honolulu'}) AS
YYYYMMDDTimeSSTimezone
```

Table 330. Result

YYYYMMDDTime	YYYYMMDDTimeTimezone	YYYYMMDDTimeSS	YYYYMMDDTimeSSTimezone
`1984-10-11T12:31:14.645876+01:00`	`1984-10-11T16:31:14.645876+05:00`	`1984-10-11T12:31:42.645876+01:00`	`1984-10-11T01:31:42.645876-10:00[Pacific/Honolulu]`
1 row			

The following query shows the various usages of `datetime({date, time [, year, …, timezone]})`; i.e. combining a *Date* and a *Time* value to create a single *DateTime* value:

Query

```
WITH date({year:1984, month:10, day:11}) AS dd,
     localtime({hour:12, minute:31, second:14, millisecond: 645}) AS tt
RETURN datetime({date:dd, time:tt}) as dateTime,
      datetime({date:dd, time:tt, timezone:'+05:00'}) AS dateTimeTimezone,
      datetime({date:dd, time:tt, day: 28, second: 42}) AS dateTimeDDSS,
      datetime({date:dd, time:tt, day: 28, second: 42, timezone:'Pacific/Honolulu'}) AS
dateTimeDDSSTimezone
```

Table 331. Result

dateTime	dateTimeTimezone	dateTimeDDSS	dateTimeDDSSTimezone
`1984-10-11T12:31:14.645Z`	`1984-10-11T12:31:14.645+05:00`	`1984-10-28T12:31:42.645Z`	`1984-10-28T12:31:42.645-10:00[Pacific/Honolulu]`
1 row			

The following query shows the various usages of `datetime({datetime [, year, …, timezone]})`

Query

```
WITH datetime({year:1984, month:10, day:11, hour:12, timezone: 'Europe/Stockholm'}) AS dd
RETURN datetime({datetime:dd}) AS dateTime,
       datetime({datetime:dd, timezone:'+05:00'}) AS dateTimeTimezone,
       datetime({datetime:dd, day: 28, second: 42}) AS dateTimeDDSS,
       datetime({datetime:dd, day: 28, second: 42, timezone:'Pacific/Honolulu'}) AS dateTimeDDSSTimezone
```

Table 332. Result

dateTime	dateTimeTimezone	dateTimeDDSS	dateTimeDDSSTimezone
`1984-10-11T12:00+01:00[Europe/Stockholm]`	`1984-10-11T16:00+05:00`	`1984-10-28T12:00:42+01:00[Europe/Stockholm]`	`1984-10-28T01:00:42-10:00[Pacific/Honolulu]`
1 row			

Creating a *DateTime* from a timestamp

`datetime()` returns the *DateTime* value at the specified number of *seconds* or *milliseconds* from the UNIX epoch in the UTC time zone.

Conversions to other temporal instant types from UNIX epoch representations can be achieved by transforming a *DateTime* value to one of these types.

Syntax: `datetime({ epochSeconds | epochMillis })`

Returns:

A DateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`epochSeconds`	A numeric value representing the number of seconds from the UNIX epoch in the UTC time zone.
`epochMillis`	A numeric value representing the number of milliseconds from the UNIX epoch in the UTC time zone.

Considerations:

`epochSeconds`/`epochMillis` may be used in conjunction with `nanosecond`

Query

```
RETURN datetime({ epochSeconds:timestamp()/ 1000, nanosecond: 23 }) AS theDate
```

Table 333. Result

theDate
`2020-01-17T20:29:13.000000023Z`
1 row

Query

```
RETURN datetime({ epochMillis: 424797300000 }) AS theDate
```

Table 334. Result

theDate
`1983-06-18T15:15Z`
1 row

Truncating a *DateTime*

`datetime.truncate()` returns the *DateTime* value obtained by truncating a specified temporal instant value at the nearest preceding point in time at the specified component boundary (which is denoted by the truncation unit passed as a parameter to the function). In other words, the *DateTime* returned will have all components that are less significant than the specified truncation unit set to their default values.

It is possible to supplement the truncated value by providing a map containing components which are less significant than the truncation unit. This will have the effect of *overriding* the default values which would otherwise have been set for these less significant components. For example, `day` — with some value `x` — may be provided when the truncation unit is `year` in order to ensure the returned value has the *day* set to `x` instead of the default *day* (which is `1`).

Syntax: `datetime.truncate(unit [, temporalInstantValue [, mapOfComponents ] ])`

Returns:

A DateTime.

Arguments:

Name	Description
`unit`	A string expression evaluating to one of the following: {`millennium`, `century`, `decade`, `year`, `weekYear`, `quarter`, `month`, `week`, `day`, `hour`, `minute`, `second`, `millisecond`, `microsecond`}.
`temporalInstantValue`	An expression of one of the following types: {*DateTime*, *LocalDateTime*, *Date*}.
`mapOfComponents`	An expression evaluating to a map containing components less significant than `unit`. During truncation, a time zone can be attached or overridden using the key `timezone`.

Considerations:

`temporalInstantValue` cannot be a *Date* value if `unit` is one of {`hour`, `minute`, `second`, `millisecond`, `microsecond`}.
The time zone of `temporalInstantValue` may be overridden; for example, `datetime.truncate('minute', input, {timezone:'+0200'})`.
If `temporalInstantValue` is one of {*Time*, *DateTime*} — a value with a time zone — and the time zone is overridden, no time conversion occurs.
If `temporalInstantValue` is one of {*LocalDateTime*, *Date*} — a value without a time zone — and the time zone is not overridden, the configured default time zone will be used.
Any component that is provided in `mapOfComponents` must be less significant than `unit`; i.e. if `unit` is 'day', `mapOfComponents` cannot contain information pertaining to a *month*.
Any component that is not contained in `mapOfComponents` and which is less significant than `unit` will be set to its minimal value.
If `mapOfComponents` is not provided, all components of the returned value which are less significant than `unit` will be set to their default values.
If `temporalInstantValue` is not provided, it will be set to the current date, time and timezone, i.e. `datetime.truncate(unit)` is equivalent of `datetime.truncate(unit, datetime())`.

Query

```
WITH datetime({year:2017, month:11, day:11, hour:12, minute:31, second:14, nanosecond: 645876123,
timezone: '+03:00'}) AS d
RETURN datetime.truncate('millennium', d, {timezone:'Europe/Stockholm'}) AS truncMillenium,
       datetime.truncate('year', d, {day:5}) AS truncYear,
       datetime.truncate('month', d) AS truncMonth,
       datetime.truncate('day', d, {millisecond:2}) AS truncDay,
       datetime.truncate('hour', d) AS truncHour,
       datetime.truncate('second', d) AS truncSecond
```

Table 335. Result

truncMillenium	truncYear	truncMonth	truncDay	truncHour	truncSecond
`2000-01-01T00:00+01:00[Europe/Stockholm]`	`2017-01-05T00:00+03:00`	`2017-11-01T00:00+03:00`	`2017-11-11T00:00:00.002+03:00`	`2017-11-11T12:00+03:00`	`2017-11-11T12:31:14+03:00`
1 row					

4.9.4. LocalDateTime: `localdatetime()`

Details for using the `localdatetime()` function.

- Getting the current *LocalDateTime*
- Creating a calendar (Year-Month-Day) *LocalDateTime*
- Creating a week (Year-Week-Day) *LocalDateTime*
- Creating a quarter (Year-Quarter-Day) *LocalDateTime*
- Creating an ordinal (Year-Day) *LocalDateTime*
- Creating a *LocalDateTime* from a string
- Creating a *LocalDateTime* using other temporal values as components
- Truncating a *LocalDateTime*

Getting the current *LocalDateTime*

`localdatetime()` returns the current *LocalDateTime* value. If no time zone parameter is specified, the local time zone will be used.

Syntax: `localdatetime([ {timezone} ])`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`timezone`	A string expression that represents the time zone

Considerations:

If no parameters are provided, `localdatetime()` must be invoked (`localdatetime({})` is invalid).

Query

```
RETURN localdatetime() AS now
```

The current local date and time (i.e. in the local time zone) is returned.

Table 336. Result

now
`2020-01-17T20:29:13.290`
1 row

Query

```
RETURN localdatetime({ timezone: 'America/Los Angeles' }) AS now
```

The current local date and time in California is returned.

Table 337. Result

now
`2020-01-17T12:29:13.310`
1 row

localdatetime.transaction()

`localdatetime.transaction()` returns the current *LocalDateTime* value using the `transaction` clock. This value will be the same for each invocation within the same transaction. However, a different value may be produced for different transactions.

Syntax: `localdatetime.transaction([ {timezone} ])`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN localdatetime.transaction() AS now
```

Table 338. Result

now
`2020-01-17T20:29:13.328`
1 row

localdatetime.statement()

`localdatetime.statement()` returns the current *LocalDateTime* value using the `statement` clock. This value will be the same for each invocation within the same statement. However, a different value may be produced for different statements within the same transaction.

Syntax: `localdatetime.statement([ {timezone} ])`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN localdatetime.statement() AS now
```

Table 339. Result

now
`2020-01-17T20:29:13.349`
1 row

localdatetime.realtime()

`localdatetime.realtime()` returns the current *LocalDateTime* value using the `realtime` clock. This value will be the live clock of the system.

Syntax: `localdatetime.realtime([ {timezone} ])`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN localdatetime.realtime() AS now
```

Table 340. Result

now
`2020-01-17T20:29:13.380207`
1 row

Query

```
RETURN localdatetime.realtime('America/Los Angeles') AS nowInLA
```

Table 341. Result

nowInLA
`2020-01-17T12:29:13.397009`
1 row

Creating a calendar (Year-Month-Day) *LocalDateTime*

`localdatetime()` returns a *LocalDateTime* value with the specified *year*, *month*, *day*, *hour*, *minute*, *second*, *millisecond*, *microsecond* and *nanosecond* component values.

Syntax: `localdatetime({year [, month, day, hour, minute, second, millisecond, microsecond, nanosecond]})`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`month`	An integer between `1` and `12` that specifies the month.
`day`	An integer between `1` and `31` that specifies the day of the month.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.

Name	Description
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

The *month* component will default to `1` if `month` is omitted.
The *day of the month* component will default to `1` if `day` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `month`, `day`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year`, `month` and `day`, but specifying `year`, `month`, `day` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
RETURN localdatetime({ year:1984, month:10, day:11, hour:12, minute:31, second:14, millisecond: 123,
microsecond: 456, nanosecond: 789 }) AS theDate
```

Table 342. Result

theDate
`1984-10-11T12:31:14.123456789`
1 row

Creating a week (Year-Week-Day) *LocalDateTime*

`localdatetime()` returns a *LocalDateTime* value with the specified *year*, *week*, *dayOfWeek*, *hour*, *minute*, *second*, *millisecond*, *microsecond* and *nanosecond* component values.

Syntax: `localdatetime({year [, week, dayOfWeek, hour, minute, second, millisecond, microsecond, nanosecond]})`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.

Name	Description
`week`	An integer between `1` and `53` that specifies the week.
`dayOfWeek`	An integer between `1` and `7` that specifies the day of the week.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

The *week* component will default to `1` if `week` is omitted.
The *day of the week* component will default to `1` if `dayOfWeek` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `week`, `dayOfWeek`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year`, `week` and `dayOfWeek`, but specifying `year`, `week`, `dayOfWeek` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
RETURN localdatetime({ year:1984, week:10, dayOfWeek:3, hour:12, minute:31, second:14, millisecond: 645 })
AS theDate
```

Table 343. Result

theDate
`1984-03-07T12:31:14.645`
1 row

Creating a quarter (Year-Quarter-Day) *DateTime*

`localdatetime()` returns a *LocalDateTime* value with the specified *year*, *quarter*, *dayOfQuarter*, *hour*, *minute*, *second*, *millisecond*, *microsecond* and *nanosecond* component values.

Syntax: `localdatetime({year [, quarter, dayOfQuarter, hour, minute, second, millisecond, microsecond, nanosecond]})`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`quarter`	An integer between `1` and `4` that specifies the quarter.
`dayOfQuarter`	An integer between `1` and `92` that specifies the day of the quarter.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

The *quarter* component will default to `1` if `quarter` is omitted.
The *day of the quarter* component will default to `1` if `dayOfQuarter` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `quarter`, `dayOfQuarter`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year`, `quarter` and `dayOfQuarter`, but specifying `year`, `quarter`, `dayOfQuarter` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
RETURN localdatetime({ year:1984, quarter:3, dayOfQuarter: 45, hour:12, minute:31, second:14, nanosecond:
645876123 }) AS theDate
```

Table 344. Result

theDate
`1984-08-14T12:31:14.645876123`
1 row

Creating an ordinal (Year-Day) *LocalDateTime*

`localdatetime()` returns a *LocalDateTime* value with the specified *year*, *ordinalDay*, *hour*, *minute*, *second*, *millisecond*, *microsecond* and *nanosecond* component values.

Syntax: `localdatetime({year [, ordinalDay, hour, minute, second, millisecond, microsecond, nanosecond]})`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`year`	An expression consisting of at least four digits that specifies the year.
`ordinalDay`	An integer between `1` and `366` that specifies the ordinal day of the year.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

The *ordinal day of the year* component will default to `1` if `ordinalDay` is omitted.
The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `year`, `ordinalDay`, `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `year` and `ordinalDay`, but specifying `year`, `ordinalDay` and `minute` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
RETURN localdatetime({ year:1984, ordinalDay:202, hour:12, minute:31, second:14, microsecond: 645876 }) AS
theDate
```

Table 345. Result

theDate
1984-07-20T12:31:14.645876
1 row

Creating a *LocalDateTime* from a string

`localdatetime()` returns the *LocalDateTime* value obtained by parsing a string representation of a temporal value.

Syntax: `localdatetime(temporalValue)`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`temporalValue`	A string representing a temporal value.

Considerations:

`temporalValue` must comply with the format defined for dates and times.
`temporalValue` must denote a valid date and time; i.e. a `temporalValue` denoting `30 February 2001` is invalid.
`localdatetime(null)` returns null.

Query

```
UNWIND [
  localdatetime('2015-07-21T21:40:32.142'),
  localdatetime('2015-W30-2T214032.142'),
  localdatetime('2015-202T21:40:32'),
  localdatetime('2015202T21')
] AS theDate
RETURN theDate
```

Table 346. Result

theDate
2015-07-21T21:40:32.142
2015-07-21T21:40:32.142
2015-07-21T21:40:32
2015-07-21T21:00
4 rows

Creating a *LocalDateTime* using other temporal values as components

`localdatetime()` returns the *LocalDateTime* value obtained by selecting and composing components from another temporal value. In essence, this allows a *Date*, *DateTime*, *Time* or *LocalTime* value to be converted to a *LocalDateTime*, and for "missing" components to be provided.

Syntax: `localdatetime({datetime [, year, …, nanosecond]}) | localdatetime({date [, year, …, nanosecond]}) | localdatetime({time [, year, …, nanosecond]}) | localdatetime({date, time [, year, …, nanosecond]})`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`datetime`	A *DateTime* value.
`date`	A *Date* value.
`time`	A *Time* value.
`year`	An expression consisting of at least four digits that specifies the year.
`month`	An integer between `1` and `12` that specifies the month.
`day`	An integer between `1` and `31` that specifies the day of the month.
`week`	An integer between `1` and `53` that specifies the week.
`dayOfWeek`	An integer between `1` and `7` that specifies the day of the week.
`quarter`	An integer between `1` and `4` that specifies the quarter.
`dayOfQuarter`	An integer between `1` and `92` that specifies the day of the quarter.
`ordinalDay`	An integer between `1` and `366` that specifies the ordinal day of the year.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

If any of the optional parameters are provided, these will override the corresponding components of `datetime`, `date` and/or `time`.
`localdatetime(dd)` may be written instead of `localdatetime({datetime: dd})`.

The following query shows the various usages of `localdatetime({date [, year, …, nanosecond]})`

Query

```
WITH date({year:1984, month:10, day:11}) AS dd
RETURN localdatetime({date:dd, hour: 10, minute: 10, second: 10}) AS dateHHMMSS,
       localdatetime({date:dd, day: 28, hour: 10, minute: 10, second: 10}) AS dateDDHHMMSS
```

Table 347. Result

dateHHMMSS	dateDDHHMMSS
`1984-10-11T10:10:10`	`1984-10-28T10:10:10`
1 row	

The following query shows the various usages of `localdatetime({time [, year, …, nanosecond]})`

Query

```
WITH time({hour:12, minute:31, second:14, microsecond: 645876, timezone: '+01:00'}) AS tt
RETURN localdatetime({year:1984, month:10, day:11, time:tt}) AS YYYYMMDDTime,
       localdatetime({year:1984, month:10, day:11, time:tt, second: 42}) AS YYYYMMDDTimeSS
```

Table 348. Result

YYYYMMDDTime	YYYYMMDDTimeSS
`1984-10-11T12:31:14.645876`	`1984-10-11T12:31:42.645876`
1 row	

The following query shows the various usages of `localdatetime({date, time [, year, …, nanosecond]})`; i.e. combining a *Date* and a *Time* value to create a single *LocalDateTime* value:

Query

```
WITH date({year:1984, month:10, day:11}) AS dd,
     time({hour:12, minute:31, second:14, microsecond: 645876, timezone: '+01:00'}) AS tt
RETURN localdatetime({date:dd, time:tt}) AS dateTime,
       localdatetime({date:dd, time:tt, day: 28, second: 42}) AS dateTimeDDSS
```

Table 349. Result

dateTime	dateTimeDDSS
`1984-10-11T12:31:14.645876`	`1984-10-28T12:31:42.645876`
1 row	

The following query shows the various usages of `localdatetime({datetime [, year, …, nanosecond]})`

Query

```
WITH datetime({year:1984, month:10, day:11, hour:12, timezone: '+01:00'}) as dd
RETURN localdatetime({datetime:dd}) as dateTime,
       localdatetime({datetime:dd, day: 28, second: 42}) as dateTimeDDSS
```

Table 350. Result

dateTime	dateTimeDDSS
`1984-10-11T12:00`	`1984-10-28T12:00:42`
1 row	

Truncating a *LocalDateTime*

`localdatetime.truncate()` returns the *LocalDateTime* value obtained by truncating a specified temporal instant value at the nearest preceding point in time at the specified component boundary (which is denoted by the truncation unit passed as a parameter to the function). In other words, the *LocalDateTime* returned will have all components that are less significant than the specified truncation unit set to their default values.

It is possible to supplement the truncated value by providing a map containing components which are less significant than the truncation unit. This will have the effect of *overriding* the default values which would otherwise have been set for these less significant components. For example, `day` — with some value `x` — may be provided when the truncation unit is `year` in order to ensure the returned value has the *day* set to `x` instead of the default *day* (which is `1`).

Syntax: `localdatetime.truncate(unit [, temporalInstantValue [, mapOfComponents ] ])`

Returns:

A LocalDateTime.

Arguments:

Name	Description
`unit`	A string expression evaluating to one of the following: {`millennium`, `century`, `decade`, `year`, `weekYear`, `quarter`, `month`, `week`, `day`, `hour`, `minute`, `second`, `millisecond`, `microsecond`}.
`temporalInstantValue`	An expression of one of the following types: {*DateTime*, *LocalDateTime*, *Date*}.
`mapOfComponents`	An expression evaluating to a map containing components less significant than `unit`.

Considerations:

`temporalInstantValue` cannot be a *Date* value if `unit` is one of {`hour`, `minute`, `second`, `millisecond`, `microsecond`}.
Any component that is provided in `mapOfComponents` must be less significant than `unit`; i.e. if `unit` is 'day', `mapOfComponents` cannot contain information pertaining to a *month*.
Any component that is not contained in `mapOfComponents` and which is less significant than `unit` will be set to its minimal value.
If `mapOfComponents` is not provided, all components of the returned value which are less significant than `unit` will be set to their default values.
If `temporalInstantValue` is not provided, it will be set to the current date and time, i.e. `localdatetime.truncate(unit)` is equivalent of `localdatetime.truncate(unit, localdatetime())`.

Query

```
WITH localdatetime({year:2017, month:11, day:11, hour:12, minute:31, second:14, nanosecond: 645876123}) AS
d
RETURN localdatetime.truncate('millennium', d) AS truncMillenium,
       localdatetime.truncate('year', d, {day:2}) AS truncYear,
       localdatetime.truncate('month', d) AS truncMonth,
       localdatetime.truncate('day', d) AS truncDay,
       localdatetime.truncate('hour', d, {nanosecond:2}) AS truncHour,
       localdatetime.truncate('second', d) AS truncSecond
```

Table 351. Result

truncMillenium	truncYear	truncMonth	truncDay	truncHour	truncSecond
`2000-01-01T00:00`	`2017-01-02T00:00`	`2017-11-01T00:00`	`2017-11-11T00:00`	`2017-11-11T12:00:00.000000002`	`2017-11-11T12:31:14`
1 row					

4.9.5. LocalTime: `localtime()`

Details for using the `localtime()` function.

Getting the current *LocalTime*

`localtime()` returns the current *LocalTime* value. If no time zone parameter is specified, the local time zone will be used.

Syntax: `localtime([ {timezone} ])`

Returns:

A LocalTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`timezone`	A string expression that represents the time zone

Considerations:

If no parameters are provided, `localtime()` must be invoked (`localtime({})` is invalid).

Query

```
RETURN localtime() AS now
```

The current local time (i.e. in the local time zone) is returned.

Table 352. Result

now
`20:29:13.804`
1 row

Query

```
RETURN localtime({ timezone: 'America/Los Angeles' }) AS nowInLA
```

The current local time in California is returned.

Table 353. Result

nowInLA
`12:29:13.824`
1 row

localtime.transaction()

`localtime.transaction()` returns the current *LocalTime* value using the `transaction` clock. This value will be the same for each invocation within the same transaction. However, a different value may be produced for different transactions.

Syntax: `localtime.transaction([ {timezone} ])`

Returns:

A LocalTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN localtime.transaction() AS now
```

Table 354. Result

now
`20:29:13.851`
1 row

localtime.statement()

`localtime.statement()` returns the current *LocalTime* value using the `statement` clock. This value will be the same for each invocation within the same statement. However, a different value may be produced for different statements within the same transaction.

Syntax: `localtime.statement([ {timezone} ])`

Returns:

A LocalTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN localtime.statement() AS now
```

Table 355. Result

now
`20:29:13.866`
1 row

Query

```
RETURN localtime.statement('America/Los Angeles') AS nowInLA
```

Table 356. Result

nowInLA
12:29:13.883
1 row

localtime.realtime()

`localtime.realtime()` returns the current *LocalTime* value using the `realtime` clock. This value will be the live clock of the system.

Syntax: `localtime.realtime([ {timezone} ])`

Returns:

A LocalTime.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN localtime.realtime() AS now
```

Table 357. Result

now
20:29:13.915292
1 row

Creating a *LocalTime*

`localtime()` returns a *LocalTime* value with the specified *hour*, *minute*, *second*, *millisecond*, *microsecond* and *nanosecond* component values.

Syntax: `localtime({hour [, minute, second, millisecond, microsecond, nanosecond]})`

Returns:

A LocalTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`hour`	An integer between `0` and `23` that specifies the hour of the day.

Name	Description
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `hour` and `minute`, but specifying `hour` and `second` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
UNWIND [
  localtime({hour:12, minute:31, second:14, nanosecond: 789, millisecond: 123, microsecond: 456}),
  localtime({hour:12, minute:31, second:14}),
  localtime({hour:12})
] as theTime
RETURN theTime
```

Table 358. Result

theTime
`12:31:14.123456789`
`12:31:14`
`12:00`
3 rows

Creating a *LocalTime* from a string

`localtime()` returns the *LocalTime* value obtained by parsing a string representation of a temporal value.

Syntax: `localtime(temporalValue)`

Returns:

A LocalTime.

Arguments:

Name	Description
`temporalValue`	A string representing a temporal value.

Considerations:

`temporalValue` must comply with the format defined for times.
`temporalValue` must denote a valid time; i.e. a `temporalValue` denoting `13:46:64` is invalid.
`localtime(null)` returns null.

Query

```
UNWIND [
  localtime('21:40:32.142'),
  localtime('214032.142'),
  localtime('21:40'),
  localtime('21')
] AS theTime
RETURN theTime
```

Table 359. Result

theTime
`21:40:32.142`
`21:40:32.142`
`21:40`
`21:00`
4 rows

Creating a *LocalTime* using other temporal values as components

`localtime()` returns the *LocalTime* value obtained by selecting and composing components from another temporal value. In essence, this allows a *DateTime*, *LocalDateTime* or *Time* value to be converted to a *LocalTime*, and for "missing" components to be provided.

Syntax: `localtime({time [, hour, …, nanosecond]})`

Returns:

A LocalTime.

Arguments:

Name	Description
`A single map consisting of the following:`	
`time`	A *Time* value.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.

Name	Description
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.

Considerations:

If any of the optional parameters are provided, these will override the corresponding components of `time`.
`localtime(tt)` may be written instead of `localtime({time: tt})`.

Query

```
WITH time({hour:12, minute:31, second:14, microsecond: 645876, timezone: '+01:00'}) AS tt
RETURN localtime({time:tt}) AS timeOnly,
       localtime({time:tt, second: 42}) AS timeSS
```

Table 360. Result

timeOnly	timeSS
`12:31:14.645876`	`12:31:42.645876`
1 row	

Truncating a *LocalTime*

`localtime.truncate()` returns the *LocalTime* value obtained by truncating a specified temporal instant value at the nearest preceding point in time at the specified component boundary (which is denoted by the truncation unit passed as a parameter to the function). In other words, the *LocalTime* returned will have all components that are less significant than the specified truncation unit set to their default values.

It is possible to supplement the truncated value by providing a map containing components which are less significant than the truncation unit. This will have the effect of *overriding* the default values which would otherwise have been set for these less significant components. For example, `minute` — with some value `x` — may be provided when the truncation unit is `hour` in order to ensure the returned value has the *minute* set to `x` instead of the default *minute* (which is `1`).

Syntax: `localtime.truncate(unit [, temporalInstantValue [, mapOfComponents ] ])`

Returns:

A LocalTime.

Arguments:

Name	Description
`unit`	A string expression evaluating to one of the following: {`day`, `hour`, `minute`, `second`, `millisecond`, `microsecond`}.
`temporalInstantValue`	An expression of one of the following types: {*DateTime*, *LocalDateTime*, *Time*, *LocalTime*}.
`mapOfComponents`	An expression evaluating to a map containing components less significant than `unit`.

Considerations:

Truncating time to day — i.e. `unit` is 'day' — is supported, and yields midnight at the start of the day (`00:00`), regardless of the value of `temporalInstantValue`. However, the time zone of `temporalInstantValue` is retained.
Any component that is provided in `mapOfComponents` must be less significant than `unit`; i.e. if `unit` is 'second', `mapOfComponents` cannot contain information pertaining to a *minute*.
Any component that is not contained in `mapOfComponents` and which is less significant than `unit` will be set to its minimal value.
If `mapOfComponents` is not provided, all components of the returned value which are less significant than `unit` will be set to their default values.
If `temporalInstantValue` is not provided, it will be set to the current time, i.e. `localtime.truncate(unit)` is equivalent of `localtime.truncate(unit, localtime())`.

Query

```
WITH time({hour:12, minute:31, second:14, nanosecond: 645876123, timezone: '-01:00'}) AS t
RETURN localtime.truncate('day', t) AS truncDay,
       localtime.truncate('hour', t) AS truncHour,
       localtime.truncate('minute', t, {millisecond:2}) AS truncMinute,
       localtime.truncate('second', t) AS truncSecond,
       localtime.truncate('millisecond', t) AS truncMillisecond,
       localtime.truncate('microsecond', t) AS truncMicrosecond
```

Table 361. Result

truncDay	truncHour	truncMinute	truncSecond	truncMillisecond	truncMicrosecond
`00:00`	`12:00`	`12:31:00.002`	`12:31:14`	`12:31:14.645`	`12:31:14.645876`
1 row					

4.9.6. Time: `time()`

Details for using the `time()` function.

- Getting the current *Time*
- Creating a *Time*
- Creating a *Time* from a string
- Creating a *Time* using other temporal values as components
- Truncating a *Time*

Getting the current *Time*

`time()` returns the current *Time* value. If no time zone parameter is specified, the local time zone will be used.

Syntax: `time([ {timezone} ])`

Returns:

A Time.

Arguments:

Name	Description
`A single map consisting of the following:`	
`timezone`	A string expression that represents the time zone

Considerations:

If no parameters are provided, `time()` must be invoked (`time({})` is invalid).

Query

```
RETURN time() AS currentTime
```

The current time of day using the local time zone is returned.

Table 362. Result

currentTime
`20:29:14.103Z`
1 row

Query

```
RETURN time({ timezone: 'America/Los Angeles' }) AS currentTimeInLA
```

The current time of day in California is returned.

Table 363. Result

currentTimeInLA
`12:29:14.118-08:00`
1 row

time.transaction()

`time.transaction()` returns the current *Time* value using the `transaction` clock. This value will be the same for each invocation within the same transaction. However, a different value may be produced for different transactions.

Syntax: `time.transaction([ {timezone} ])`

Returns:

A Time.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN time.transaction() AS currentTime
```

Table 364. Result

currentTime
`20:29:14.135Z`
1 row

time.statement()

`time.statement()` returns the current *Time* value using the `statement` clock. This value will be the same for each invocation within the same statement. However, a different value may be produced for different statements within the same transaction.

Syntax: `time.statement([ {timezone} ])`

Returns:

A Time.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN time.statement() AS currentTime
```

Table 365. Result

currentTime
`20:29:14.155Z`
1 row

Query

```
RETURN time.statement('America/Los Angeles') AS currentTimeInLA
```

Table 366. Result

currentTimeInLA
`12:29:14.173-08:00`
1 row

time.realtime()

`time.realtime()` returns the current *Time* value using the `realtime` clock. This value will be the live clock of the system.

Syntax: `time.realtime([ {timezone} ])`

Returns:

A Time.

Arguments:

Name	Description
`timezone`	A string expression that represents the time zone

Query

```
RETURN time.realtime() AS currentTime
```

Table 367. Result

currentTime
20:29:14.201971Z
1 row

Creating a *Time*

`time()` returns a *Time* value with the specified *hour*, *minute*, *second*, *millisecond*, *microsecond*, *nanosecond* and *timezone* component values.

Syntax: `time({hour [, minute, second, millisecond, microsecond, nanosecond, timezone]})`

Returns:

A Time.

Arguments:

Name	Description
`A single map consisting of the following:`	
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.
`timezone`	An expression that specifies the time zone.

Considerations:

The *hour* component will default to `0` if `hour` is omitted.
The *minute* component will default to `0` if `minute` is omitted.
The *second* component will default to `0` if `second` is omitted.
Any missing `millisecond`, `microsecond` or `nanosecond` values will default to `0`.
The *timezone* component will default to the configured default time zone if `timezone` is omitted.
If `millisecond`, `microsecond` and `nanosecond` are given in combination (as part of the same set of parameters), the individual values must be in the range `0` to `999`.
The least significant components in the set `hour`, `minute`, and `second` may be omitted; i.e. it is possible to specify only `hour` and `minute`, but specifying `hour` and `second` is not permitted.
One or more of `millisecond`, `microsecond` and `nanosecond` can only be specified as long as `second` is also specified.

Query

```
UNWIND [
  time({hour:12, minute:31, second:14, millisecond: 123, microsecond: 456, nanosecond: 789}),
  time({hour:12, minute:31, second:14, nanosecond: 645876123}),
  time({hour:12, minute:31, second:14, microsecond: 645876, timezone: '+01:00'}),
  time({hour:12, minute:31, timezone: '+01:00'}),
  time({hour:12, timezone: '+01:00'})
] AS theTime
RETURN theTime
```

Table 368. Result

theTime
`12:31:14.123456789Z`
`12:31:14.645876123Z`
`12:31:14.645876+01:00`
`12:31+01:00`
`12:00+01:00`
5 rows

Creating a *Time* from a string

`time()` returns the *Time* value obtained by parsing a string representation of a temporal value.

Syntax: `time(temporalValue)`

Returns:

A Time.

Arguments:

Name	Description
`temporalValue`	A string representing a temporal value.

Considerations:

`temporalValue` must comply with the format defined for times and time zones.
The *timezone* component will default to the configured default time zone if it is omitted.
`temporalValue` must denote a valid time; i.e. a `temporalValue` denoting `15:67` is invalid.
`time(null)` returns null.

Query

```
UNWIND [
  time('21:40:32.142+0100'),
  time('214032.142Z'),
  time('21:40:32+01:00'),
  time('214032-0100'),
  time('21:40-01:30'),
  time('2140-00:00'),
  time('2140-02'),
  time('22+18:00')
] AS theTime
RETURN theTime
```

Table 369. Result

theTime
`21:40:32.142+01:00`
`21:40:32.142Z`
`21:40:32+01:00`
`21:40:32-01:00`
`21:40-01:30`
`21:40Z`
`21:40-02:00`
`22:00+18:00`
8 rows

Creating a *Time* using other temporal values as components

`time()` returns the *Time* value obtained by selecting and composing components from another temporal value. In essence, this allows a *DateTime*, *LocalDateTime* or *LocalTime* value to be converted to a *Time*, and for "missing" components to be provided.

Syntax: `time({time [, hour, …, timezone]})`

Returns:

A Time.

Arguments:

Name	Description
`A single map consisting of the following:`	
`time`	A *Time* value.
`hour`	An integer between `0` and `23` that specifies the hour of the day.
`minute`	An integer between `0` and `59` that specifies the number of minutes.
`second`	An integer between `0` and `59` that specifies the number of seconds.
`millisecond`	An integer between `0` and `999` that specifies the number of milliseconds.
`microsecond`	An integer between `0` and `999,999` that specifies the number of microseconds.
`nanosecond`	An integer between `0` and `999,999,999` that specifies the number of nanoseconds.
`timezone`	An expression that specifies the time zone.

Considerations:

If any of the optional parameters are provided, these will override the corresponding components of `time`.
`time(tt)` may be written instead of `time({time: tt})`.
Selecting a *Time* or *DateTime* value as the `time` component also selects its time zone. If a *LocalTime* or *LocalDateTime* is selected instead, the default time zone is used. In any case, the time zone can be overridden explicitly.

Selecting a *DateTime* or *Time* as the `time` component and overwriting the time zone will adjust the local time to keep the same point in time.

Query

```
WITH localtime({hour:12, minute:31, second:14, microsecond: 645876}) AS tt
RETURN time({time:tt}) AS timeOnly,
       time({time:tt, timezone:'+05:00'}) AS timeTimezone,
       time({time:tt, second: 42}) AS timeSS,
       time({time:tt, second: 42, timezone:'+05:00'}) AS timeSSTimezone
```

Table 370. Result

timeOnly	timeTimezone	timeSS	timeSSTimezone
`12:31:14.645876Z`	`12:31:14.645876+05:00`	`12:31:42.645876Z`	`12:31:42.645876+05:00`
1 row			

Truncating a *Time*

`time.truncate()` returns the *Time* value obtained by truncating a specified temporal instant value at the nearest preceding point in time at the specified component boundary (which is denoted by the truncation unit passed as a parameter to the function). In other words, the *Time* returned will have all components that are less significant than the specified truncation unit set to their default values.

It is possible to supplement the truncated value by providing a map containing components which are less significant than the truncation unit. This will have the effect of *overriding* the default values which would otherwise have been set for these less significant components. For example, `minute` — with some value `x` — may be provided when the truncation unit is `hour` in order to ensure the returned value has the *minute* set to `x` instead of the default *minute* (which is `1`).

Syntax: `time.truncate(unit [, temporalInstantValue [, mapOfComponents ] ])`

Returns:

A Time.

Arguments:

Name	Description
`unit`	A string expression evaluating to one of the following: {`day`, `hour`, `minute`, `second`, `millisecond`, `microsecond`}.
`temporalInstantValue`	An expression of one of the following types: {*DateTime*, *LocalDateTime*, *Time*, *LocalTime*}.
`mapOfComponents`	An expression evaluating to a map containing components less significant than `unit`. During truncation, a time zone can be attached or overridden using the key `timezone`.

Considerations:

Truncating time to day — i.e. `unit` is 'day' — is supported, and yields midnight at the start of the day (`00:00`), regardless of the value of `temporalInstantValue`. However, the time zone of `temporalInstantValue` is retained.
The time zone of `temporalInstantValue` may be overridden; for example, `time.truncate('minute', input, {timezone:'+0200'})`.
If `temporalInstantValue` is one of {*Time*, *DateTime*} — a value with a time zone — and the time zone is overridden, no time conversion occurs.
If `temporalInstantValue` is one of {*LocalTime*, *LocalDateTime*, *Date*} — a value without a time zone — and the time zone is not overridden, the configured default time zone will be used.

Any component that is provided in `mapOfComponents` must be less significant than `unit`; i.e. if `unit` is 'second', `mapOfComponents` cannot contain information pertaining to a *minute*.
Any component that is not contained in `mapOfComponents` and which is less significant than `unit` will be set to its minimal value.
If `mapOfComponents` is not provided, all components of the returned value which are less significant than `unit` will be set to their default values.
If `temporalInstantValue` is not provided, it will be set to the current time and timezone, i.e. `time.truncate(unit)` is equivalent of `time.truncate(unit, time())`.

Query

```
WITH time({ hour:12, minute:31, second:14, nanosecond: 645876123, timezone: '-01:00' }) AS t
RETURN time.truncate('day', t) AS truncDay, time.truncate('hour', t) AS truncHour, time.truncate('minute',
t) AS truncMinute, time.truncate('second', t) AS truncSecond, time.truncate('millisecond', t, {
nanosecond:2 }) AS truncMillisecond, time.truncate('microsecond', t) AS truncMicrosecond
```

Table 371. Result

truncDay	truncHour	truncMinute	truncSecond	truncMillisecond	truncMicrosecond
`00:00-01:00`	`12:00-01:00`	`12:31-01:00`	`12:31:14-01:00`	`12:31:14.645000002-01:00`	`12:31:14.645876-01:00`
1 row					

4.10. Temporal functions - duration

Cypher provides functions allowing for the creation and manipulation of values for a Duration temporal type.

See also Temporal (Date/Time) values and Temporal operators.

duration():

- Creating a *Duration* from duration components
- Creating a *Duration* from a string
- Computing the *Duration* between two temporal instants

Information regarding specifying and accessing components of a *Duration* value can be found here.

4.10.1. Creating a *Duration* from duration components

`duration()` can construct a *Duration* from a map of its components in the same way as the temporal instant types.

- `years`
- `quarters`
- `months`
- `weeks`
- `days`
- `hours`
- `minutes`

* seconds
* milliseconds
* microseconds
* nanoseconds

Syntax: `duration([ {years, quarters, months, weeks, days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds} ])`

Returns:

A Duration.

Arguments:

Name	Description
A single map consisting of the following:	
years	A numeric expression.
quarters	A numeric expression.
months	A numeric expression.
weeks	A numeric expression.
days	A numeric expression.
hours	A numeric expression.
minutes	A numeric expression.
seconds	A numeric expression.
milliseconds	A numeric expression.
microseconds	A numeric expression.
nanoseconds	A numeric expression.

Considerations:

At least one parameter must be provided (`duration()` and `duration({})` are invalid).
There is no constraint on how many of the parameters are provided.
It is possible to have a *Duration* where the amount of a smaller unit (e.g. `seconds`) exceeds the threshold of a larger unit (e.g. `days`).
The values of the parameters may be expressed as decimal fractions.
The values of the parameters may be arbitrarily large.
The values of the parameters may be negative.

Query

```
UNWIND [
  duration({days: 14, hours:16, minutes: 12}),
  duration({months: 5, days: 1.5}),
  duration({months: 0.75}),
  duration({weeks: 2.5}),
  duration({minutes: 1.5, seconds: 1, milliseconds: 123, microseconds: 456, nanoseconds: 789}),
  duration({minutes: 1.5, seconds: 1, nanoseconds: 123456789})
] AS aDuration
RETURN aDuration
```

Table 372. Result

aDuration
P14DT16H12M
P5M1DT12H
P22DT19H51M49.5S
P17DT12H
PT1M31.123456789S
PT1M31.123456789S
6 rows

4.10.2. Creating a *Duration* from a string

`duration()` returns the *Duration* value obtained by parsing a string representation of a temporal amount.

Syntax: `duration(temporalAmount)`

Returns:

A Duration.

Arguments:

Name	Description
`temporalAmount`	A string representing a temporal amount.

Considerations:

`temporalAmount` must comply with either the unit based form or date-and-time based form defined for *Durations*.

Query

```
UNWIND [
  duration("P14DT16H12M"),
  duration("P5M1.5D"),
  duration("P0.75M"),
  duration("PT0.75M"),
  duration("P2012-02-02T14:37:21.545")
] AS aDuration
RETURN aDuration
```

Table 373. Result

aDuration
P14DT16H12M
P5M1DT12H
P22DT19H51M49.5S
PT45S
P2012Y2M2DT14H37M21.545S
5 rows

4.10.3. Computing the *Duration* between two temporal instants

`duration()` has sub-functions which compute the *logical difference* (in days, months, etc) between two temporal instant values:

- `duration.between(a, b)`: Computes the difference in multiple components between instant `a` and instant `b`. This captures month, days, seconds and sub-seconds differences separately.
- `duration.inMonths(a, b)`: Computes the difference in whole months (or quarters or years) between instant `a` and instant `b`. This captures the difference as the total number of months. Any difference smaller than a whole month is disregarded.
- `duration.inDays(a, b)`: Computes the difference in whole days (or weeks) between instant `a` and instant `b`. This captures the difference as the total number of days. Any difference smaller than a whole day is disregarded.
- `duration.inSeconds(a, b)`: Computes the difference in seconds (and fractions of seconds, or minutes or hours) between instant `a` and instant `b`. This captures the difference as the total number of seconds.

duration.between()

`duration.between()` returns the *Duration* value equal to the difference between the two given instants.

Syntax: `duration.between(instant1, instant2)`

Returns:

A Duration.

Arguments:

Name	Description
`instant1`	An expression returning any temporal instant type (*Date* etc) that represents the starting instant.
`instant2`	An expression returning any temporal instant type (*Date* etc) that represents the ending instant.

Considerations:

If `instant2` occurs earlier than `instant1`, the resulting *Duration* will be negative.
If `instant1` has a time component and `instant2` does not, the time component of `instant2` is assumed to be midnight, and vice versa.
If `instant1` has a time zone component and `instant2` does not, the time zone component of `instant2` is assumed to be the same as that of `instant1`, and vice versa.
If `instant1` has a date component and `instant2` does not, the date component of `instant2` is assumed to be the same as that of `instant1`, and vice versa.

Query

```
UNWIND [
  duration.between(date("1984-10-11"), date("1985-11-25")),
  duration.between(date("1985-11-25"), date("1984-10-11")),
  duration.between(date("1984-10-11"), datetime("1984-10-12T21:40:32.142+0100")),
  duration.between(date("2015-06-24"), localtime("14:30")),
  duration.between(localtime("14:30"), time("16:30+0100")),
  duration.between(localdatetime("2015-07-21T21:40:32.142"), localdatetime("2016-07-21T21:45:22.142")),
  duration.between(datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/Stockholm'}),
datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/London'}))
] AS aDuration
RETURN aDuration
```

Table 374. Result

aDuration
P1Y1M14D
P-1Y-1M-14D
P1DT21H40M32.142S
PT14H30M
PT2H
P1YT4M50S
PT1H
7 rows

duration.inMonths()

`duration.inMonths()` returns the *Duration* value equal to the difference in whole months, quarters or years between the two given instants.

Syntax: `duration.inMonths(instant₁, instant₂)`

Returns:

A Duration.

Arguments:

Name	Description
`instant₁`	An expression returning any temporal instant type (*Date* etc) that represents the starting instant.
`instant₂`	An expression returning any temporal instant type (*Date* etc) that represents the ending instant.

Considerations:

If `instant₂` occurs earlier than `instant₁`, the resulting *Duration* will be negative.
If `instant₁` has a time component and `instant₂` does not, the time component of `instant₂` is assumed to be midnight, and vice versa.
If `instant₁` has a time zone component and `instant₂` does not, the time zone component of `instant₂` is assumed to be the same as that of `instant₁`, and vice versa.
If `instant₁` has a date component and `instant₂` does not, the date component of `instant₂` is assumed to be the same as that of `instant₁`, and vice versa.
Any difference smaller than a whole month is disregarded.

Query

```
UNWIND [
  duration.inMonths(date("1984-10-11"), date("1985-11-25")),
  duration.inMonths(date("1985-11-25"), date("1984-10-11")),
  duration.inMonths(date("1984-10-11"), datetime("1984-10-12T21:40:32.142+0100")),
  duration.inMonths(date("2015-06-24"), localtime("14:30")),
  duration.inMonths(localdatetime("2015-07-21T21:40:32.142"), localdatetime("2016-07-21T21:45:22.142")),
  duration.inMonths(datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/Stockholm'}),
datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/London'}))
] AS aDuration
RETURN aDuration
```

Table 375. Result

aDuration
P1Y1M
P-1Y-1M
PT0S
PT0S
P1Y
PT0S
6 rows

duration.inDays()

`duration.inDays()` returns the *Duration* value equal to the difference in whole days or weeks between the two given instants.

Syntax: `duration.inDays(instant₁, instant₂)`

Returns:

A Duration.

Arguments:

Name	Description
`instant₁`	An expression returning any temporal instant type (*Date* etc) that represents the starting instant.
`instant₂`	An expression returning any temporal instant type (*Date* etc) that represents the ending instant.

Considerations:

If `instant₂` occurs earlier than `instant₁`, the resulting *Duration* will be negative.
If `instant₁` has a time component and `instant₂` does not, the time component of `instant₂` is assumed to be midnight, and vice versa.
If `instant₁` has a time zone component and `instant₂` does not, the time zone component of `instant₂` is assumed to be the same as that of `instant₁`, and vice versa.
If `instant₁` has a date component and `instant₂` does not, the date component of `instant₂` is assumed to be the same as that of `instant₁`, and vice versa.
Any difference smaller than a whole day is disregarded.

Query

```
UNWIND [
  duration.inDays(date("1984-10-11"), date("1985-11-25")),
  duration.inDays(date("1985-11-25"), date("1984-10-11")),
  duration.inDays(date("1984-10-11"), datetime("1984-10-12T21:40:32.142+0100")),
  duration.inDays(date("2015-06-24"), localtime("14:30")),
  duration.inDays(localdatetime("2015-07-21T21:40:32.142"), localdatetime("2016-07-21T21:45:22.142")),
  duration.inDays(datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/Stockholm'}),
datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/London'}))
] AS aDuration
RETURN aDuration
```

Table 376. Result

aDuration
`P410D`
`P-410D`
`P1D`
`PT0S`
`P366D`
`PT0S`
6 rows

duration.inSeconds()

`duration.inSeconds()` returns the *Duration* value equal to the difference in seconds and fractions of seconds, or minutes or hours, between the two given instants.

Syntax: `duration.inSeconds(instant₁, instant₂)`

Returns:

A Duration.

Arguments:

Name	Description
`instant₁`	An expression returning any temporal instant type (*Date* etc) that represents the starting instant.
`instant₂`	An expression returning any temporal instant type (*Date* etc) that represents the ending instant.

Considerations:

If `instant₂` occurs earlier than `instant₁`, the resulting *Duration* will be negative.
If `instant₁` has a time component and `instant₂` does not, the time component of `instant₂` is assumed to be midnight, and vice versa.
If `instant₁` has a time zone component and `instant₂` does not, the time zone component of `instant₂` is assumed to be the same as that of `instant₁`, and vice versa.
If `instant₁` has a date component and `instant₂` does not, the date component of `instant₂` is assumed to be the same as that of `instant₁`, and vice versa.

Query

```
UNWIND [
  duration.inSeconds(date("1984-10-11"), date("1984-10-12")),
  duration.inSeconds(date("1984-10-12"), date("1984-10-11")),
  duration.inSeconds(date("1984-10-11"), datetime("1984-10-12T01:00:32.142+0100")),
  duration.inSeconds(date("2015-06-24"), localtime("14:30")),
  duration.inSeconds(datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/Stockholm'}),
datetime({year: 2017, month: 10, day: 29, hour: 0, timezone: 'Europe/London'}))
] AS aDuration
RETURN aDuration
```

Table 377. Result

aDuration
`PT24H`
`PT-24H`
`PT25H32.142S`
`PT14H30M`
`PT1H`
5 rows

4.11. Spatial functions

These functions are used to specify 2D or 3D points in a Coordinate Reference System (CRS) and to calculate the geodesic distance between two points.

Functions:

- distance()
- point() - WGS 84 2D
- point() - WGS 84 3D
- point() - Cartesian 2D
- point() - Cartesian 3D

The following graph is used for some of the examples below.

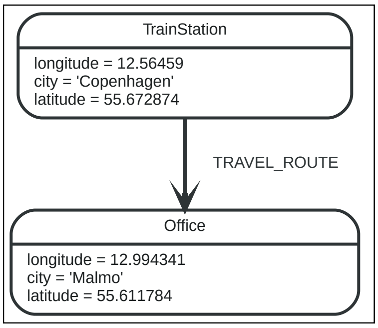


Figure 28. Graph

4.11.1. distance()

`distance()` returns a floating point number representing the geodesic distance between two points in the same Coordinate Reference System (CRS).

- If the points are in the *Cartesian* CRS (2D or 3D), then the units of the returned distance will be the same as the units of the points, calculated using Pythagoras' theorem.
- If the points are in the *WGS-84* CRS (2D), then the units of the returned distance will be meters, based on the haversine formula over a spherical earth approximation.
- If the points are in the *WGS-84* CRS (3D), then the units of the returned distance will be meters.
  - The distance is calculated in two steps.
    - First, a haversine formula over a spherical earth is used, at the average height of the two points.
    - To account for the difference in height, Pythagoras' theorem is used, combining the previously calculated spherical distance with the height difference.
  - This formula works well for points close to the earth's surface; for instance, it is well-suited for calculating the distance of an airplane flight. It is less suitable for greater heights, however, such as when calculating the distance between two satellites.

Syntax: `distance(point1, point2)`

Returns:

A Float.

Arguments:

Name	Description
`point1`	A point in either a geographic or cartesian coordinate system.
`point2`	A point in the same CRS as 'point1'.

Considerations:

`distance(null, null)`, `distance(null, point2)` and `distance(point1, null)` all return `null`.
Attempting to use points with different Coordinate Reference Systems (such as WGS 84 2D and WGS 84 3D) will return `null`.

Query

```
WITH point({ x: 2.3, y: 4.5, crs: 'cartesian' }) AS p1, point({ x: 1.1, y: 5.4, crs: 'cartesian' }) AS p2
RETURN distance(p1,p2) AS dist
```

The distance between two 2D points in the *Cartesian* CRS is returned.

Table 378. Result

dist
`1.5`
1 row

Query

```
WITH point({ longitude: 12.78, latitude: 56.7, height: 100 }) AS p1, point({ latitude: 56.71, longitude:
12.79, height: 100 }) AS p2
RETURN distance(p1,p2) AS dist
```

The distance between two 3D points in the *WGS 84* CRS is returned.

Table 379. Result

dist
1269.9148706779097
1 row

Query

```
MATCH (t:TrainStation)-[:TRAVEL_ROUTE]->(o:Office)
WITH point({ longitude: t.longitude, latitude: t.latitude }) AS trainPoint, point({ longitude:
o.longitude, latitude: o.latitude }) AS officePoint
RETURN round(distance(trainPoint, officePoint)) AS travelDistance
```

The distance between the train station in Copenhagen and the Neo4j office in Malmo is returned.

Table 380. Result

travelDistance
27842.0
1 row

Query

```
RETURN distance(NULL , point({ longitude: 56.7, latitude: 12.78 })) AS d
```

If `null` is provided as one or both of the arguments, `null` is returned.

Table 381. Result

d
`<null>`
1 row

4.11.2. point() - WGS 84 2D

`point({longitude | x, latitude | y [, crs][, srid]})` returns a 2D point in the *WGS 84* CRS corresponding to the given coordinate values.

Syntax: `point({longitude | x, latitude | y [, crs][, srid]})`

Returns:

A 2D point in *WGS 84*.

Arguments:

Name	Description
`A single map consisting of the following:`	
`longitude/x`	A numeric expression that represents the longitude/x value in decimal degrees
`latitude/y`	A numeric expression that represents the latitude/y value in decimal degrees
`crs`	The optional string 'WGS-84'
`srid`	The optional number 4326

Considerations:

If any argument provided to `point()` is `null`, `null` will be returned.
If the coordinates are specified using `latitude` and `longitude`, the `crs` or `srid` fields are optional and inferred to be `'WGS-84'` (srid=4326).
If the coordinates are specified using `x` and `y`, then either the `crs` or `srid` field is required if a geographic CRS is desired.

Query

```
RETURN point({ longitude: 56.7, latitude: 12.78 }) AS point
```

A 2D point with a `longitude` of `56.7` and a `latitude` of `12.78` in the *WGS 84* CRS is returned.

Table 382. Result

point
`point({x: 56.7, y: 12.78, crs: 'wgs-84'})`
1 row

Query

```
RETURN point({ x: 2.3, y: 4.5, crs: 'WGS-84' }) AS point
```

`x` and `y` coordinates may be used in the *WGS 84* CRS instead of `longitude` and `latitude`, respectively, providing `crs` is set to `'WGS-84'`, or `srid` is set to `4326`.

Table 383. Result

point
`point({x: 2.3, y: 4.5, crs: 'wgs-84'})`
1 row

Query

```
MATCH (p:Office)
RETURN point({ longitude: p.longitude, latitude: p.latitude }) AS officePoint
```

A 2D point representing the coordinates of the city of Malmo in the *WGS 84* CRS is returned.

Table 384. Result

officePoint
`point({x: 12.994341, y: 55.611784, crs: 'wgs-84'})`
1 row

Query

```
RETURN point(NULL ) AS p
```

If `null` is provided as the argument, `null` is returned.

Table 385. Result

p
`<null>`

p
1 row

4.11.3. point() - WGS 84 3D

`point({longitude | x, latitude | y, height | z, [, crs][, srid]})` returns a 3D point in the *WGS 84* CRS corresponding to the given coordinate values.

Syntax: `point({longitude | x, latitude | y, height | z, [, crs][, srid]})`

Returns:

A 3D point in *WGS 84*.

Arguments:

Name	Description
`A single map consisting of the following:`	
`longitude/x`	A numeric expression that represents the longitude/x value in decimal degrees
`latitude/y`	A numeric expression that represents the latitude/y value in decimal degrees
`height/z`	A numeric expression that represents the height/z value in meters
`crs`	The optional string 'WGS-84-3D'
`srid`	The optional number 4979

Considerations:

If any argument provided to `point()` is `null`, `null` will be returned.
If the `height/z` key and value is not provided, a 2D point in the *WGS 84* CRS will be returned.
If the coordinates are specified using `latitude` and `longitude`, the `crs` or `srid` fields are optional and inferred to be `'WGS-84-3D'` (srid=4979).
If the coordinates are specified using `x` and `y`, then either the `crs` or `srid` field is required if a geographic CRS is desired.

Query

```
RETURN point({ longitude: 56.7, latitude: 12.78, height: 8 }) AS point
```

A 3D point with a `longitude` of `56.7`, a `latitude` of `12.78` and a height of `8` meters in the *WGS 84* CRS is returned.

Table 386. Result

point
`point({x: 56.7, y: 12.78, z: 8.0, crs: 'wgs-84-3d'})`
1 row

4.11.4. point() - Cartesian 2D

`point({x, y [, crs][, srid]})` returns a 2D point in the *Cartesian* CRS corresponding to the given coordinate values.

Syntax: `point({x, y [, crs][, srid]})`

Returns:

A 2D point in *Cartesian*.

Arguments:

Name	Description
`A single map consisting of the following:`	
`x`	A numeric expression
`y`	A numeric expression
`crs`	The optional string 'cartesian'
`srid`	The optional number 7203

Considerations:

If any argument provided to `point()` is `null`, `null` will be returned.
The `crs` or `srid` fields are optional and default to the *Cartesian* CRS (which means `srid:7203`).

Query

```
RETURN point({ x: 2.3, y: 4.5 }) AS point
```

A 2D point with an `x` coordinate of `2.3` and a `y` coordinate of `4.5` in the *Cartesian* CRS is returned.

Table 387. Result

point
`point({x: 2.3, y: 4.5, crs: 'cartesian'})`
1 row

4.11.5. point() - Cartesian 3D

`point({x, y, z, [, crs][, srid]})` returns a 3D point in the *Cartesian* CRS corresponding to the given coordinate values.

Syntax: `point({x, y, z, [, crs][, srid]})`

Returns:

A 3D point in *Cartesian*.

Arguments:

Name	Description
`A single map consisting of the following:`	
`x`	A numeric expression
`y`	A numeric expression
`z`	A numeric expression
`crs`	The optional string 'cartesian-3D'

Name	Description
`srid`	The optional number 9157

Considerations:

If any argument provided to `point()` is `null`, `null` will be returned.
If the `z` key and value is not provided, a 2D point in the *Cartesian* CRS will be returned.
The `crs` or `srid` fields are optional and default to the *3D Cartesian* CRS (which means `srid:9157`).

Query

```
RETURN point({ x: 2.3, y: 4.5, z: 2 }) AS point
```

A 3D point with an `x` coordinate of `2.3`, a `y` coordinate of `4.5` and a `z` coordinate of `2` in the *Cartesian* CRS is returned.

Table 388. Result

point
`point({x: 2.3, y: 4.5, z: 2.0, crs: 'cartesian-3d'})`
1 row

4.12. User-defined functions

> *User-defined functions are written in Java, deployed into the database and are called in the same way as any other Cypher function.*

There are two main types of functions that can be developed and used:

Type	Description	Usage	Developing
Scalar	For each row the function takes parameters and returns a result	Using UDF	Extending Neo4j (UDF)
Aggregating	Consumes many rows and produces an aggregated result	Using aggregating UDF	Extending Neo4j (Aggregating UDF)

4.12.1. User-defined scalar functions

For each incoming row the function takes parameters and returns a single result.

This example shows how you invoke a user-defined function called `join` from Cypher.

Call a user-defined function

This calls the user-defined function `org.neo4j.procedure.example.join()`.

Query

```
MATCH (n:Member)
RETURN org.neo4j.function.example.join(collect(n.name)) AS members
```

Table 389. Result

members
"John,Paul,George,Ringo"
1 row

For developing and deploying user-defined functions in Neo4j, see Extending Neo4j User-defined functions.

4.12.2. User-defined aggregation functions

Aggregating functions consume many rows and produces a single aggregated result.

This example shows how you invoke a user-defined aggregation function called `longestString` from Cypher.

Call a user-defined aggregation function

This calls the user-defined function `org.neo4j.function.example.longestString()`.

Query

```
MATCH (n:Member)
RETURN org.neo4j.function.example.longestString(n.name) AS member
```

Table 390. Result

member
"George"
1 row

4.13. LOAD CSV functions

LOAD CSV functions can be used to get information about the file that is processed by `LOAD CSV`.

> **!** The functions described on this page are only useful when run on a query that uses `LOAD CSV`. In all other contexts they will always return `null`.

Functions:

- linenumber()
- file()

4.13.1. linenumber()

`linenumber()` returns the line number that `LOAD CSV` is currently using.

Syntax: `linenumber()`

Returns:

An Integer.

Considerations:

`null` will be returned if this function is called without a `LOAD CSV` context.

4.13.2. file()

`file()` returns the absolute path of the file that `LOAD CSV` is using.

Syntax: `file()`

Returns:

A String.

Considerations:

`null` will be returned if this function is called without a `LOAD CSV` context.

Chapter 5. Administration

This section explains how to use Cypher to administer Neo4j databases, such as creating databases, managing indexes and constraints, and managing security.

Neo4j supports the management of manage multiple databases within the same DBMS. The metadata for these databases, including the associated security model, is maintained in a special database called the `system` database. Most administrative commands must be executed against the `system` database because they involve editing the metadata for the entire system. This includes all commands related to managing multiple databases as well as all commands for defining the security model: users, roles and privileges. The administrative commands that are specific to the schema of an individual database are still executed against that specific database. These include index and constraint management commands.

5.1. Databases

This section explains how to use Cypher to manage Neo4j databases: creating, deleting, starting and stopping individual databases within a single server.

5.1.1. Introduction

Neo4j allows the same server to manage multiple databases. The metadata for these databases, including the associated security model, is maintained in a special database called the `system` database. All multi-database administrative commands need to be executing against the `system` database.

5.1.2. Listing databases

There are three different commands for listing databases. Listing all databases, listing a particular database or listing the default database.

All available databases can be seen using the command `SHOW DATABASES`.

Query

```
SHOW DATABASES
```

Table 391. Result

name	address	role	requestedStatus	currentStatus	error	default
"neo4j"	"localhost:7687"	"standalone"	"online"	"online"	""	true
"system"	"localhost:7687"	"standalone"	"online"	"online"	""	false
2 rows						

A particular database can be seen using the command `SHOW DATABASE name`.

Query

```
SHOW DATABASE system
```

Table 392. Result

name	address	role	requestedStatus	currentStatus	error	default
"system"	"localhost:7687"	"standalone"	"online"	"online"	""	false

name	address	role	requestedStatus	currentStatus	error	default
1 row						

The default database can be seen using the command `SHOW DEFAULT DATABASE`.

Query

```
SHOW DEFAULT DATABASE
```

Table 393. Result

name	address	role	requestedStatus	currentStatus	error
"neo4j"	"localhost:7687"	"standalone"	"online"	"online"	""
1 row					

Note that for failed databases, the `currentStatus` and `requestedStatus` are different. This often implies an error, but **does not always**. For example, a database may take a while to transition from `offline` to `online` due to performing recovery. Or, during normal operation a database's `currentStatus` may be transiently different from its `requestedStatus` due to a necessary automatic process, such as one Neo4j instance copying store files from another. The possible statuses are `initial`, `online`, `offline`, `store copying` and `unknown`.

5.1.3. Creating databases

Databases can be created using `CREATE DATABASE`.

Query

```
CREATE DATABASE customers
```

0 rows, System updates: 1

When a database has been created, it will show up in the listing provided by the command `SHOW DATABASES`.

Query

```
SHOW DATABASES
```

Table 394. Result

name	address	role	requestedStatus	currentStatus	error	default
"neo4j"	"localhost:7687"	"standalone"	"online"	"online"	""	true
"system"	"localhost:7687"	"standalone"	"online"	"online"	""	false
"customers"	"localhost:7687"	"standalone"	"online"	"online"	""	false
3 rows						

This command is optionally idempotent, with the default behavior to throw an exception if the database already exists. Appending `IF NOT EXISTS` to the command will ensure that no exception is thrown and nothing happens should the database already exist. Adding `OR REPLACE` to the command will result in any existing database being deleted and a new one created.

Query

```
CREATE DATABASE customers IF NOT EXISTS
```

Query

```
CREATE OR REPLACE DATABASE customers
```

This is equivalent to running `DROP DATABASE customers IF EXISTS` followed by `CREATE DATABASE customers`.

The `IF NOT EXISTS` and `OR REPLACE` parts of this command cannot be used together.

5.1.4. Stopping databases

Databases can be stopped using the command `STOP DATABASE`.

Query

```
STOP DATABASE customers
```

0 rows, System updates: 1

The status of the stopped database can be seen using the command `SHOW DATABASE name`.

Query

```
SHOW DATABASE customers
```

Table 395. Result

name	address	role	requestedStatus	currentStatus	error	default
"customers"	"localhost:7687"	"standalone"	"offline"	"offline"	""	false
1 row						

5.1.5. Starting databases

Databases can be started using the command `START DATABASE`.

Query

```
START DATABASE customers
```

0 rows, System updates: 1

The status of the started database can be seen using the command `SHOW DATABASE name`.

Query

```
SHOW DATABASE customers
```

Table 396. Result

name	address	role	requestedStatus	currentStatus	error	default
"customers"	"localhost:7687"	"standalone"	"online"	"online"	""	false
1 row						

5.1.6. Deleting databases

Databases can be deleted using the command `DROP DATABASE`.

Query

```
DROP DATABASE customers
```

0 rows, System updates: 1

When a database has been deleted, it will no longer show up in the listing provided by the command `SHOW DATABASES`.

Query

```
SHOW DATABASES
```

Table 397. Result

name	address	role	requestedStatus	currentStatus	error	default
"neo4j"	"localhost:7687"	"standalone"	"online"	"online"	""	true
"system"	"localhost:7687"	"standalone"	"online"	"online"	""	false
2 rows						

This command is optionally idempotent, with the default behavior to throw an exception if the database does not exists. Appending `IF EXISTS` to the command will ensure that no exception is thrown and nothing happens should the database not exist.

Query

```
DROP DATABASE customers IF EXISTS
```

5.2. Indexes for search performance

This section explains how to manage indexes used for search performance.

- Introduction
- Syntax
- Composite index limitations
- Examples
  - Create a single-property index
  - Create a composite index

- Drop an index
- List indexes
- Deprecated syntax

This section describes how to manage indexes. For query performance purposes, it is important to also understand how the indexes are used by the Cypher planner. Refer to Query tuning for examples and in-depth discussions on how query plans result from different index and query scenarios. See specifically The use of indexes for examples of how various index scenarios result in different query plans.

For information on index configuration and limitations, refer to Operations Manual Index configuration.

5.2.1. Introduction

A database index is a redundant copy of some of the data in the database for the purpose of making searches of related data more efficient. This comes at the cost of additional storage space and slower writes, so deciding what to index and what not to index is an important and often non-trivial task.

Once an index has been created, it will be managed and kept up to date by the DBMS. Neo4j will automatically pick up and start using the index once it has been created and brought online.

Cypher enables the creation of indexes on one or more properties for all nodes that have a given label:

- An index that is created on a single property for any given label is called a *single-property index*.
- An index that is created on more than one property for any given label is called a *composite index*.

Differences in the usage patterns between composite and single-property indexes are described in Composite index limitations.

The following is true for indexes:

- Best practice is to give the index a name when it is created. If the index is not explicitly named, it will get an auto-generated name.
- The index name must be unique among both indexes and constraints.
- Index creation is not idempotent. An error will be thrown if you attempt to create the same index twice.

5.2.2. Syntax

Table 398. Syntax for managing indexes

Command	Description	Comment

`CREATE INDEX [index_name]`
`FOR (n:LabelName)`
`ON (n.propertyName)`
	Create a single-property index.	Best practice is to give the index a name when it is created. If the index is not explicitly named, it will get an auto-generated name.
		
		The index name must be unique among both indexes and constraints.
		
		Index creation is not idempotent. An error will be thrown if you attempt to create the same index twice.

`CREATE INDEX [index_name]`
`FOR (n:LabelName)`
`ON (n.propertyName_1,`
`    n.propertyName_2,`
`    …`
`    n.propertyName_n)`
	Create a composite index.	

`DROP INDEX index_name`	Drop an index	
`CALL db.indexes`	List all indexes in the database.	
`DROP INDEX ON :LabelName(propertyName)`	Drop a single-property index without specifying a name.	This syntax is deprecated.

`DROP INDEX ON :LabelName (n.propertyName_1,`
`n.propertyName_2,`
`…`
`n.propertyName_n)`
	Drop a composite index without specifying a name.	

Planner hints and the USING keyword describes how to make the Cypher planner use specific indexes (especially in cases where the planner would not necessarily have used them).

5.2.3. Composite index limitations

Like single-property indexes, composite indexes support all predicates:

- equality check: `n.prop = value`
- list membership check: `n.prop IN list`
- existence check: `exists(n.prop)`
- range search: `n.prop > value`
- prefix search: `STARTS WITH`
- suffix search: `ENDS WITH`
- substring search: `CONTAINS`

However, predicates might be planned as existence check and a filter. For most predicates, this can be avoided by following these restrictions:

- If there is any `equality check` and `list membership check` predicates, they need to be for the first properties defined by the index.

* There can be up to one `range search` or `prefix search` predicate.
* There can be any number of `existence check` predicates.
* Any predicate after a `range search`, `prefix search` or `existence check` predicate has to be an `existence check` predicate.

However, the `suffix search` and `substring search` predicates are always planned as existence check and a filter and any predicates following after will therefore also be planned as such.

For example, an index on `:Label(prop1,prop2,prop3,prop4,prop5,prop6)` and predicates:

```
WHERE n.prop1 = 'x' AND n.prop2 = 1 AND n.prop3 > 5 AND n.prop4 < 'e' AND n.prop5 = true AND
exists(n.prop6)
```

will be planned as:

```
WHERE n.prop1 = 'x' AND n.prop2 = 1 AND n.prop3 > 5 AND exists(n.prop4) AND exists(n.prop5) AND
exists(n.prop6)
```

with filters on `n.prop4 < 'e'` and `n.prop5 = true`, since `n.prop3` has a `range search` predicate.

And an index on `:Label(prop1,prop2)` with predicates:

```
WHERE n.prop1 ENDS WITH 'x' AND n.prop2 = false
```

will be planned as:

```
WHERE exists(n.prop1) AND exists(n.prop2)
```

with filters on `n.prop1 ENDS WITH 'x'` and `n.prop2 = false`, since `n.prop1` has a `suffix search` predicate.

Composite indexes require predicates on all properties indexed. If there are predicates on only a subset of the indexed properties, it will not be possible to use the composite index. To get this kind of fallback behavior, it is necessary to create additional indexes on the relevant sub-set of properties or on single properties.

5.2.4. Examples

Create a single-property index

A named index on a single property for all nodes that have a particular label can be created with `CREATE INDEX index_name FOR (n:Label) ON (n.property)`. Note that the index is not immediately available, but will be created in the background.

Query

```
CREATE INDEX index_name FOR (n:Person)
ON (n.surname)
```

Note that the index name needs to be unique.

Result

```
+--------------------+
| No data returned. |
+--------------------+
Indexes added: 1
```

Create a composite index

A named index on multiple properties for all nodes that have a particular label — i.e. a composite index — can be created with `CREATE INDEX index_name FOR (n:Label) ON (n.prop1, …, n.propN)`. Only nodes labeled with the specified label and which contain all the properties in the index definition will be added to the index. Note that the composite index is not immediately available, but will be created in the background. The following statement will create a named composite index on all nodes labeled with `Person` and which have both an `age` and `country` property:

Query

```
CREATE INDEX index_name FOR (n:Person)
ON (n.age, n.country)
```

Note that the index name needs to be unique.

Result

```
+--------------------+
| No data returned. |
+--------------------+
Indexes added: 1
```

Drop an index

An index on all nodes that have a label and property/properties combination can be dropped using the name with the `DROP INDEX index_name` command.

Query

```
DROP INDEX index_name
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Indexes removed: 1
```

List indexes

Calling the built-in procedure `db.indexes` will list all indexes, including their names.

Query

```
CALL db.indexes
```

Result

```
+-----------------------------------------------------------------------------------------------------------
----------------------------------------+
| id | name              | state    | populationPercent | uniqueness  | type    | entityType |
labelsOrTypes | properties     | provider          |
+-----------------------------------------------------------------------------------------------------------
----------------------------------------+
| 2  | "index_58a1c03e" | "ONLINE" | 100.0             | "NONUNIQUE" | "BTREE" | "NODE"     | ["Person"]
| ["location"]  | "native-btree-1.0" |
| 3  | "index_d7c12ba3" | "ONLINE" | 100.0             | "NONUNIQUE" | "BTREE" | "NODE"     | ["Person"]
| ["highScore"] | "native-btree-1.0" |
| 1  | "index_deeafdb2" | "ONLINE" | 100.0             | "NONUNIQUE" | "BTREE" | "NODE"     | ["Person"]
| ["firstname"] | "native-btree-1.0" |
+-----------------------------------------------------------------------------------------------------------
----------------------------------------+
3 rows
```

Deprecated syntax

Drop a single-property index

An index on all nodes that have a label and single property combination can be dropped with `DROP INDEX ON :Label(property)`.

Query

```
DROP INDEX ON :Person(firstname)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Indexes removed: 1
```

Drop a composite index

A composite index on all nodes that have a label and multiple property combination can be dropped with `DROP INDEX ON :Label(prop1, …, propN)`. The following statement will drop a composite index on all nodes labeled with `Person` and which have both an `age` and `country` property:

Query

```
DROP INDEX ON :Person(age, country)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Indexes removed: 1
```

5.3. Indexes for full-text search

This section describes how to use full-text indexes, to enable full-text search.

- Introduction
- Procedures to manage full-text indexes

* Create and configure full-text indexes
* Query full-text indexes
* Drop full-text indexes

5.3.1. Introduction

Full-text indexes are powered by the Apache Lucene indexing and search library, and can be used to index nodes and relationships by string properties. A full-text index allows you to write queries that match within the *contents* of indexed string properties. For instance, the btree indexes described in previous sections can only do exact matching or prefix matches on strings. A full-text index will instead tokenize the indexed string values, so it can match *terms* anywhere within the strings. How the indexed strings are tokenized and broken into terms, is determined by what analyzer the full-text index is configured with. For instance, the *swedish* analyzer knows how to tokenize and stem Swedish words, and will avoid indexing Swedish stop words.

Full-text indexes:

* support the indexing of both nodes and relationships.
* support configuring custom analyzers, including analyzers that are not included with Lucene itself.
* can be queried using the Lucene query language.
* can return the *score* for each result from a query.
* are kept up to date automatically, as nodes and relationships are added, removed, and modified.
* will automatically populate newly created indexes with the existing data in a store.
* can be checked by the consistency checker, and they can be rebuilt if there is a problem with them.
* are a projection of the store, and can only index nodes and relationships by the contents of their properties.
* can support any number of documents in a single index.
* are created, dropped, and updated transactionally, and is automatically replicated throughout a cluster.
* can be accessed via Cypher procedures.
* can be configured to be *eventually consistent*, in which index updating is moved from the commit path to a background thread. Using this feature, it is possible to work around the slow Lucene writes from the performance critical commit process, thus removing the main bottlenecks for Neo4j write performance.

At first sight, the construction of full-text indexes can seem similar to regular indexes. However there are some things that are interesting to note: In contrast to btree indexes, a full-text index

* can be applied to more than one label.
* can be applied to relationship types (one or more).
* can be applied to more than one property at a time (similar to a *composite index*) but with an important difference: While a composite index applies only to entities that match the indexed label and *all* of the indexed properties, full-text index will index entities that have at least one of the indexed labels or relationship types, and at least one of the indexed properties.

For information on how to configure full-text indexes, refer to Operations Manual Indexes to support full-text search.

5.3.2. Procedures to manage full-text indexes

Full-text indexes are managed through built-in procedures. The most common procedures are listed in the table below:

Usage	Procedure	Description
Create full-text node index	`db.index.fulltext.createNodeIndex`	Create a node fulltext index for the given labels and properties. The optional 'config' map parameter can be used to supply settings to the index. Supported settings are 'analyzer', for specifying what analyzer to use when indexing and querying. Use the `db.index.fulltext.listAvailableAnalyzers` procedure to see what options are available. And 'eventually_consistent' which can be set to 'true' to make this index eventually consistent, such that updates from committing transactions are applied in a background thread.
Create full-text relationship index	`db.index.fulltext.createRelationshipIndex`	Create a relationship fulltext index for the given relationship types and properties. The optional 'config' map parameter can be used to supply settings to the index. Supported settings are 'analyzer', for specifying what analyzer to use when indexing and querying. Use the `db.index.fulltext.listAvailableAnalyzers` procedure to see what options are available. And 'eventually_consistent' which can be set to 'true' to make this index eventually consistent, such that updates from committing transactions are applied in a background thread.
List available analyzers	`db.index.fulltext.listAvailableAnalyzers`	List the available analyzers that the full-text indexes can be configured with.
Use full-text node index	`db.index.fulltext.queryNodes`	Query the given full-text index. Returns the matching nodes and their Lucene query score, ordered by score.
Use full-text relationship index	`db.index.fulltext.queryRelationships`	Query the given full-text index. Returns the matching relationships and their Lucene query score, ordered by score.
Drop full-text index	`db.index.fulltext.drop`	Drop the specified index.
Eventually consistent indexes	`db.index.fulltext.awaitEventuallyConsistentIndexRefresh`	Wait for the updates from recently committed transactions to be applied to any eventually-consistent full-text indexes.

5.3.3. Create and configure full-text indexes

Full-text indexes are created with the `db.index.fulltext.createNodeIndex` and `db.index.fulltext.createRelationshipIndex` procedures. An index must be given a unique name when created, which is used to reference the specific index when querying or dropping it. A full-text index applies to a list of labels or a list of relationship types, for node and relationship indexes respectively, and then a list of property names.

For instance, if we have a movie with a title.

Query

```
CREATE (m:Movie { title: "The Matrix" })
RETURN m.title
```

Table 399. Result

m.title
"The Matrix"
1 row, Nodes created: 1 Properties set: 1 Labels added: 1

And we have a full-text index on the `title` and `description` properties of movies and books.

Query

```
CALL db.index.fulltext.createNodeIndex("titlesAndDescriptions",["Movie", "Book"],["title", "description"])
```

Then our movie node from above will be included in the index, even though it only have one of the indexed labels, and only one of the indexed properties:

Query

```
CALL db.index.fulltext.queryNodes("titlesAndDescriptions", "matrix") YIELD node, score
RETURN node.title, node.description, score
```

Table 400. Result

node.title	node.description	score
"The Matrix"	<null>	0.7799721956253052
1 row		

The same is true for full-text indexes on relationships. Though a relationship can only have one type, a relationship full-text index can index multiple types, and all relationships will be included that match one of the relationship types, and at least one of the indexed properties.

The `db.index.fulltext.createNodeIndex` and `db.index.fulltext.createRelationshipIndex` procedures take an optional fourth argument, called `config`. The `config` parameter is a map from string to string, and can be used to set index-specific configuration settings. The `analyzer` setting can be used to configure an index-specific analyzer. The possible values for the `analyzer` setting can be listed with the `db.index.fulltext.listAvailableAnalyzers` procedure. The `eventually_consistent` setting, if set to `"true"`, will put the index in an *eventually consistent* update mode. this means that updates will be applied in a background thread "as soon as possible", instead of during transaction commit like other indexes.

Query

```
CALL db.index.fulltext.createRelationshipIndex("taggedByRelationshipIndex",["TAGGED_AS"],["taggedByUser"],
{ analyzer: "url_or_email", eventually_consistent: "true" })
```

In this example, an eventually consistent relationship full-text index is created for the `TAGGED_AS` relationship type, and the `taggedByUser` property, and the index uses the `url_or_email` analyzer. This could, for instance, be a system where people are assigning tags to documents, and where the index on the `taggedByUser` property will allow them to quickly find all of the documents they have tagged. Had it not been for the relationship index, one would have had to add artificial connective nodes between the tags and the documents in the data model, just so these nodes could be indexed.

Table 401. Result

(empty result)
0 rows

5.3.4. Query full-text indexes

Full-text indexes will, in addition to any exact matches, also return *approximate* matches to a given query. Both the property values that are indexed, and the queries to the index, are processed through the analyzer such that the index can find that don't *exactly* matches. The `score` that is returned alongside each result entry, represents how well the index thinks that entry matches the given query. The results are always returned in *descending score order*, where the best matching result entry is put first. To illustrate, in the example below, we search our movie database for "Full Metal Jacket", and even though there is an exact match as the first result, we also get three other less interesting results:

Query

```
CALL db.index.fulltext.queryNodes("titlesAndDescriptions", "Full Metal Jacket") YIELD node, score
RETURN node.title, score
```

Table 402. Result

node.title	score
"Full Metal Jacket"	1.4111186265945435
"Full Moon High"	0.44524085521698
"The Jacket"	0.3509606122970581
"Yellow Jacket"	0.3509606122970581
4 rows	

Full-text indexes are powered by the Apache Lucene indexing and search library. This means that we can use Lucene's full-text query language to express what we wish to search for. For instance, if we are only interested in exact matches, then we can quote the string we are searching for.

Query

```
CALL db.index.fulltext.queryNodes("titlesAndDescriptions", "\"Full Metal Jacket\"") YIELD node, score
RETURN node.title, score
```

When we put "Full Metal Jacket" in quotes, Lucene only gives us exact matches.

Table 403. Result

node.title	score
"Full Metal Jacket"	1.4111186265945435
1 row	

Lucene also allows us to use logical operators, such as `AND` and `OR`, to search for terms:

Query

```
CALL db.index.fulltext.queryNodes("titlesAndDescriptions", 'full AND metal') YIELD node, score
RETURN node.title, score
```

Only the "Full Metal Jacket" movie in our database has both the words "full" and "metal".

Table 404. Result

node.title	score
"Full Metal Jacket"	1.1113792657852173
1 row	

It is also possible to search for only specific properties, by putting the property name and a colon in front of the text being searched for.

Query

```
CALL db.index.fulltext.queryNodes("titlesAndDescriptions", 'description:"surreal adventure"') YIELD node,
score
RETURN node.title, node.description, score
```

Table 405. Result

node.title	node.description	score
"Metallica Through The Never"	"The movie follows the young roadie Trip through his surreal adventure with the band."	0.2615291476249695
1 row		

A complete description of the Lucene query syntax can be found in the Lucene documentation.

5.3.5. Drop full-text indexes

A full-text node index is dropped by using the procedure `db.index.fulltext.drop`.

In the following example, we will drop the `taggedByRelationshipIndex` that we created previously:

Query

```
CALL db.index.fulltext.drop("taggedByRelationshipIndex")
```

Table 406. Result

(empty result)
0 rows

5.4. Constraints

This section explains how to manage constraints used for ensuring data integrity.

• Deprecated syntax

5.4.1. Introduction

The following constraint types are available:

Unique node property constraints
Unique property constraints ensure that property values are unique for all nodes with a specific label. Unique constraints do not mean that all nodes have to have a unique value for the properties — nodes without the property are not subject to this rule.

Node property existence constraints
Node property existence constraints ensure that a property exists for all nodes with a specific label. Queries that try to create new nodes of the specified label, but without this property, will fail. The same is true for queries that try to remove the mandatory property.

Relationship property existence constraints
Property existence constraints ensure that a property exists for all relationships with a specific type. All queries that try to create relationships of the specified type, but without this property, will fail. The same is true for queries that try to remove the mandatory property.

Node key constraints
Node key constraints ensure that, for a given label and set of properties:

i. All the properties exist on all the nodes with that label.
ii. The combination of the property values is unique.

Queries attempting to do any of the following will fail:

- Create new nodes without all the properties or where the combination of property values is not unique.
- Remove one of the mandatory properties.
- Update the properties so that the combination of property values is no longer unique.

Unique node property constraints, node property existence constraints and relationship property existence constraints are only available in Neo4j Enterprise Edition. Databases containing one of these constraint types cannot be opened using Neo4j Community Edition.

Creating a constraint has the following implications on indexes:

- Adding a unique property constraint on a property will also add a single-property index on that property, so such an index cannot be added separately.
- Adding a node key constraint for a set of properties will also add a composite index on those properties, so such an index cannot be added separately.
- Cypher will use these indexes for lookups just like other indexes. Refer to Indexes for search performance for more details on indexes.
- If a unique property constraint is dropped and the single-property index on the property is still required, the index will need to be created explicitly.
- If a node key constraint is dropped and the composite-property index on the properties is still required, the index will need to be created explicitly.

Additionally, the following is true for constraints:

* A given label can have multiple constraints, and unique and property existence constraints can be combined on the same property.
* Adding constraints is an atomic operation that can take a while — all existing data has to be scanned before Neo4j can turn the constraint 'on'.
* Best practice is to give the constraint a name when it is created. If the constraint is not explicitly named, it will get an auto-generated name.
* The constraint name must be unique among both indexes and constraints.
* Constraint creation is not idempotent. An error will be thrown if you attempt to create the same constraint twice.

5.4.2. Syntax

Table 407. Syntax for managing indexes

Command	Description	Comment
`CREATE CONSTRAINT [constraint_name] ON (n:LabelName) ASSERT n.propertyName IS UNIQUE`	Create a unique node property constraint.	Best practice is to give the constraint a name when it is created. If the constraint is not explicitly named, it will get an auto-generated name. The constraint name must be unique among both indexes and constraints. Constraint creation is not idempotent. An error will be thrown if you attempt to create the same constraint twice.
`CREATE CONSTRAINT [constraint_name] ON (n:LabelName) ASSERT EXISTS (n.propertyName)`	Create a node property existence constraint.	
`CREATE CONSTRAINT [constraint_name] ON ()-[R:RELATIONSHIP_TYPE]-() ASSERT EXISTS (R.propertyName)`	Create a relationship property existence constraint.	
`CREATE CONSTRAINT [constraint_name] ON (n:LabelName) ASSERT (n.propertyName_1, n.propertyName_2, … n.propertyName_n) IS NODE KEY`	Create a node key constraint.	
`DROP CONSTRAINT constraint_name`	Drop a constraint.	
`CALL db.constraints`	List all constraints in the database.	

Command	Description	Comment

`DROP CONSTRAINT`
`ON (n:LabelName)`
`ASSERT n.propertyName IS UNIQUE`
	Drop a unique constraint without specifying a name.	This syntax is deprecated.

`DROP CONSTRAINT`
`ON (n:LabelName)`
`ASSERT EXISTS (n.propertyName)`
	Drop an exists constraint without specifying a name.	

`DROP CONSTRAINT`
`ON ()-[R:RELATIONSHIP_TYPE]-()`
`ASSERT EXISTS (R.propertyName)`
	Drop a relationship property existence constraint without specifying a name.	

`DROP CONSTRAINT`
`ON (n:LabelName)`
`ASSERT (n.propertyName_1,`
`n.propertyName_2,`
`…`
`n.propertyName_n)`
`IS NODE KEY`
	Drop a node key constraint without specifying a name.	

5.4.3. Examples

Unique node property constraints

Create a unique constraint

When creating a unique constraint, a name can be provided. The constraint ensures that your database will never contain more than one node with a specific label and one property value.

Query

```
CREATE CONSTRAINT constraint_name
ON (book:Book) ASSERT book.isbn IS UNIQUE
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Unique constraints added: 1
```

Create a node that complies with unique property constraints

Create a `Book` node with an `isbn` that isn't already in the database.

Query

```
CREATE (book:Book { isbn: '1449356265', title: 'Graph Databases' })
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Nodes created: 1
Properties set: 2
Labels added: 1
```

Create a node that violates a unique property constraint

Create a `Book` node with an `isbn` that is already used in the database.

Query

```
CREATE (book:Book { isbn: '1449356265', title: 'Graph Databases' })
```

In this case the node isn't created in the graph.

Error message

```
Node(0) already exists with label `Book` and property `isbn` = '1449356265'
```

Failure to create a unique property constraint due to conflicting nodes

Create a unique property constraint on the property `isbn` on nodes with the `Book` label when there are two nodes with the same `isbn`.

Query

```
CREATE CONSTRAINT ON (book:Book) ASSERT book.isbn IS UNIQUE
```

In this case the constraint can't be created because it is violated by existing data. We may choose to use Indexes for search performance instead or remove the offending nodes and then re-apply the constraint.

Error message

```
Unable to create CONSTRAINT ON ( book:Book ) ASSERT (book.isbn) IS UNIQUE:
Both Node(0) and Node(1) have the label `Book` and property `isbn` = '1449356265'
```

Node property existence constraints

Create a node property existence constraint

When creating a node property existence constraint, a name can be provided. The constraint ensures that all nodes with a certain label have a certain property.

Query

```
CREATE CONSTRAINT constraint_name
ON (book:Book) ASSERT EXISTS (book.isbn)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Property existence constraints added: 1
```

Create a node that complies with property existence constraints

Create a `Book` node with an `isbn` property.

Query

```
CREATE (book:Book { isbn: '1449356265', title: 'Graph Databases' })
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 1
Properties set: 2
Labels added: 1
```

Create a node that violates a property existence constraint

Trying to create a `Book` node without an `isbn` property, given a property existence constraint on `:Book(isbn)`.

Query

```
CREATE (book:Book { title: 'Graph Databases' })
```

In this case the node isn't created in the graph.

Error message

```
Node(0) with label `Book` must have the property `isbn`
```

Removing an existence constrained node property

Trying to remove the `isbn` property from an existing node `book`, given a property existence constraint on `:Book(isbn)`.

Query

```
MATCH (book:Book { title: 'Graph Databases' })
REMOVE book.isbn
```

In this case the property is not removed.

Error message

```
Node(0) with label `Book` must have the property `isbn`
```

Failure to create a node property existence constraint due to existing node

Create a constraint on the property `isbn` on nodes with the `Book` label when there already exists a node without an `isbn`.

Query

```
CREATE CONSTRAINT ON (book:Book) ASSERT EXISTS (book.isbn)
```

In this case the constraint can't be created because it is violated by existing data. We may choose to remove the offending nodes and then re-apply the constraint.

Error message

```
Unable to create CONSTRAINT ON ( book:Book ) ASSERT exists(book.isbn):
Node(0) with label `Book` must have the property `isbn`
```

Relationship property existence constraints

Create a relationship property existence constraint

When creating a relationship property existence constraint, a name can be provided. The constraint ensures all relationships with a certain type have a certain property.

Query

```
CREATE CONSTRAINT constraint_name
ON ()-[like:LIKED]-() ASSERT EXISTS (like.day)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Property existence constraints added: 1
```

Create a relationship that complies with property existence constraints

Create a `LIKED` relationship with a `day` property.

Query

```
CREATE (user:User)-[like:LIKED { day: 'yesterday' }]->(book:Book)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 2
Relationships created: 1
Properties set: 1
Labels added: 2
```

Create a relationship that violates a property existence constraint

Trying to create a `LIKED` relationship without a `day` property, given a property existence constraint `:LIKED(day)`.

Query

```
CREATE (user:User)-[like:LIKED]->(book:Book)
```

In this case the relationship isn't created in the graph.

Error message

```
Relationship(0) with type `LIKED` must have the property `day`
```

Removing an existence constrained relationship property

Trying to remove the `day` property from an existing relationship `like` of type `LIKED`, given a property existence constraint `:LIKED(day)`.

Query

```
MATCH (user:User)-[like:LIKED]->(book:Book)
REMOVE like.day
```

In this case the property is not removed.

Error message

```
Relationship(0) with type `LIKED` must have the property `day`
```

Failure to create a relationship property existence constraint due to existing relationship

Create a constraint on the property `day` on relationships with the `LIKED` type when there already exists a relationship without a property named `day`.

Query

```
CREATE CONSTRAINT ON ()-[like:LIKED]-() ASSERT EXISTS (like.day)
```

In this case the constraint can't be created because it is violated by existing data. We may choose to remove the offending relationships and then re-apply the constraint.

Error message

```
Unable to create CONSTRAINT ON ()-[ liked:LIKED ]-() ASSERT exists(liked.day):
Relationship(0) with type `LIKED` must have the property `day`
```

Node key constraints

Create a node key constraint

When creating a node key constraint, a name can be provided. The constraint ensures that all nodes with a particular label have a set of defined properties whose combined value is unique and all properties in the set are present.

Query

```
CREATE CONSTRAINT constraint_name
ON (n:Person) ASSERT (n.firstname, n.surname) IS NODE KEY
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Node key constraints added: 1
```

Create a node that complies with node key constraints

Create a `Person` node with both a `firstname` and `surname` property.

Query

```
CREATE (p:Person { firstname: 'John', surname: 'Wood', age: 55 })
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes created: 1
Properties set: 3
Labels added: 1
```

Create a node that violates a node key constraint

Trying to create a `Person` node without a `surname` property, given a node key constraint on `:Person(firstname, surname)`, will fail.

Query

```
CREATE (p:Person { firstname: 'Jane', age: 34 })
```

In this case the node isn't created in the graph.

Error message

```
Node(0) with label `Person` must have the properties (firstname, surname)
```

Removing a `NODE KEY`-constrained property

Trying to remove the `surname` property from an existing node `Person`, given a `NODE KEY` constraint on `:Person(firstname, surname)`.

Query

```
MATCH (p:Person { firstname: 'John', surname: 'Wood' })
REMOVE p.surname
```

In this case the property is not removed.

Error message

```
Node(0) with label `Person` must have the properties (firstname, surname)
```

Failure to create a node key constraint due to existing node

Trying to create a node key constraint on the property `surname` on nodes with the `Person` label will fail when a node without a `surname` already exists in the database.

Query

```
CREATE CONSTRAINT ON (n:Person) ASSERT (n.firstname, n.surname) IS NODE KEY
```

In this case the node key constraint can't be created because it is violated by existing data. We may choose to remove the offending nodes and then re-apply the constraint.

Error message

```
Unable to create CONSTRAINT ON ( person:Person ) ASSERT exists(person.firstname,
person.surname):
Node(0) with label `Person` must have the properties (firstname, surname)
```

Drop a constraint

A constraint can be dropped using the name with the `DROP CONSTRAINT constraint_name` command. It is the same command for unique property, property existence and node key constraints.

Query

```
DROP CONSTRAINT constraint_name
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Named constraints removed: 1
```

List constraints

Calling the built-in procedure `db.constraints` will list all constraints, including their names.

Query

```
CALL db.constraints
```

Result

```
+--------------------------------------------------------------------------------------+
| name                  | description                                                  |
+--------------------------------------------------------------------------------------+
| "constraint_ca412c3d" | "CONSTRAINT ON ( book:Book ) ASSERT (book.isbn) IS UNIQUE" |
+--------------------------------------------------------------------------------------+
1 row
```

Deprecated syntax

Drop a unique constraint

By using `DROP CONSTRAINT`, you remove a constraint from the database.

Query

```
DROP CONSTRAINT ON (book:Book) ASSERT book.isbn IS UNIQUE
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Unique constraints removed: 1
```

Drop a node property existence constraint

By using `DROP CONSTRAINT`, you remove a constraint from the database.

Query

```
DROP CONSTRAINT ON (book:Book) ASSERT EXISTS (book.isbn)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Property existence constraints removed: 1
```

Drop a relationship property existence constraint

To remove a constraint from the database, use `DROP CONSTRAINT`.

Query

```
DROP CONSTRAINT ON ()-[like:LIKED]-() ASSERT EXISTS (like.day)
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Property existence constraints removed: 1
```

Drop a node key constraint

Use `DROP CONSTRAINT` to remove a node key constraint from the database.

Query

```
DROP CONSTRAINT ON (n:Person) ASSERT (n.firstname, n.surname) IS NODE KEY
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Node key constraints removed: 1
```

5.5. Security

This section explains how to use Cypher to manage Neo4j role-based access control and fine-grained security.

5.5.1. Introduction

This section introduces the sections on how to manage Neo4j role-based access control and fine-grained security.

Neo4j has a complex security model stored in the system graph, maintained in a special database called the `system` database. All administrative commands need to be executing against the `system` database. For more information on how to manage multiple databases, refer to the section on administering databases. Neo4j 3.1 introduced the concept of *role-based access control*. It was possible to create users and assign them to roles to control whether the users could read, write and administer the database. In Neo4j 4.0 this model was enhanced significantly with the addition of *privileges* which are the underlying access-control rules by which the users rights are defined. The original built-in roles still exist with almost the exact same access rights, but they are no-longer statically defined. Instead they are defined in terms of their underlying *privileges* and they can be modified by adding an removing these access rights. In addition any new roles created can by assigned any combination of *privileges* to create the specific access control desired. A major additional capability is *sub-graph* access control whereby read-access to the graph can be limited to specific combinations of label, relationship-type and property.

5.5.2. User and role management

This section explains how to use Cypher to manage Neo4j role-based access control through users and roles.

User Management

Users can be created and managed using a set of Cypher administration commands executed against the `system` database.

Table 408. User management command syntax

Command	Description	Type of user	Available in Community Edition
`SHOW USERS`	List all users	Admin	+
`SHOW USER name PRIVILEGES`	List the privileges granted to a user	Admin	-
`CREATE [OR REPLACE] USER name [IF NOT EXISTS] SET PASSWORD password [[SET PASSWORD] CHANGE [NOT] REQUIRED] [SET STATUS {ACTIVE | SUSPENDED}]`	Create a new user	Admin	+
`ALTER USER name SET { PASSWORD password [[SET PASSWORD] CHANGE [NOT] REQUIRED] [SET STATUS {ACTIVE | SUSPENDED} ] | PASSWORD CHANGE [NOT] REQUIRED [SET STATUS {ACTIVE | SUSPENDED}] | STATUS {ACTIVE | SUSPENDED}`	Modify the settings for an existing user	Admin	-
`ALTER CURRENT USER SET PASSWORD FROM original TO password`	Change the current user's password	Normal user	+
`DROP USER name [IF EXISTS]`	Drop (remove) an existing user	Admin	+

Listing users

Available users can be seen using `SHOW USERS` which will produce a table of users with four columns:

Table 409. List users output

Column	Description	Available in Community Edition
user	user name	+
roles	roles granted to the user	-
passwordChangeRequired	if `true` the user must change their password at next login	+
suspended	if `true` the user is currently suspended (cannot log in)	-

Query

```
SHOW USERS
```

Table 410. Result

user	roles	passwordChangeRequired	suspended
"neo4j"	["admin"]	true	false
1 row			

When first starting a Neo4j DBMS, there is always a single default user `neo4j` with administrative privileges. It is possible to set the initial password using neo4j-admin set-initial-password, otherwise it is necessary to change the password after first login.

> The `SHOW USER name PRIVILEGES` command is described in Listing privileges.

Creating users

Users can be created using `CREATE USER`.

Command syntax

```
CREATE [OR REPLACE] USER name [IF NOT EXISTS]
      SET PASSWORD password
      [[SET PASSWORD] CHANGE [NOT] REQUIRED]
      [SET STATUS {ACTIVE | SUSPENDED}]
```

If the optional `SET PASSWORD CHANGE [NOT] REQUIRED` is omitted then the default is `CHANGE REQUIRED`. The default for `SET STATUS` is `ACTIVE`. The `password` can either be a string value or a string parameter.

For example, we can create the user `jake` in a suspended state and the requirement to change his password.

Query

```
CREATE USER jake
SET PASSWORD 'abc' CHANGE REQUIRED
SET STATUS SUSPENDED
```

0 rows, System updates: 1

> The SUSPENDED flag is an enterprise feature.

The created user will appear on the list provided by `SHOW USERS`.

Query

```
SHOW USERS
```

Table 411. Result

user	roles	passwordChangeRequired	suspended
"neo4j"	["admin"]	true	false
"jake"	[]	true	true
2 rows			

When creating a user, their initial list of roles is empty. In Neo4j community-edition this is not important as all users have implied administator privileges. In Neo4j enterprise-edition a new user like this will have no rights and it is important to grant roles to the user.

The `CREATE USER` command is optionally idempotent, with the default behavior to throw an exception if the user already exists. Appending `IF NOT EXISTS` to the command will ensure that no exception is thrown and nothing happens should the user already exist. Adding `OR REPLACE` to the command will result in any existing user being deleted and a new one created.

Query

```
CREATE USER jake IF NOT EXISTS SET PASSWORD 'xyz'
```

0 rows

Query

```
CREATE OR REPLACE USER jake
SET PASSWORD 'xyz'
```

0 rows, System updates: 2

This is equivalent to running `DROP USER jake IF EXISTS` followed by `CREATE USER jake SET PASSWORD 'xyz'`.

The `IF NOT EXISTS` and `OR REPLACE` parts of this command cannot be used together.

Modifying users

Users can be modified using `ALTER USER`.

Command syntax

```
ALTER USER name SET {
      PASSWORD password
            [[SET PASSWORD] CHANGE [NOT] REQUIRED]
            [SET STATUS {ACTIVE | SUSPENDED} ] |
      PASSWORD CHANGE [NOT] REQUIRED
            [SET STATUS {ACTIVE | SUSPENDED}] |
      STATUS {ACTIVE | SUSPENDED}
}
```

The `password` can either be a string value or a string parameter.

For example, we can modify the user `jake` with a new password and active status as well as remove the requirement to change his password.

Query

```
ALTER USER jake
SET PASSWORD 'abc123' CHANGE NOT REQUIRED
SET STATUS ACTIVE
```

0 rows, System updates: 1

When altering a user it is only necessary to specify the changes required. For example, leaving out any `STATUS` change part of the query will leave that unchanged.

The changes to the user will appear on the list provided by `SHOW USERS`.

Query

```
SHOW USERS
```

Table 412. Result

user	roles	passwordChangeRequired	suspended
"neo4j"	["admin"]	true	false
"jake"	[]	false	false
2 rows			

Changing the current user's password

Users can change their own password using `ALTER CURRENT USER SET PASSWORD`. The old password is required in addition to the new one, and either or both can be a string value or a string parameter. When a user executes this command it will change their password as well as set the `CHANGE NOT REQUIRED` flag.

Query

```
ALTER CURRENT USER
SET PASSWORD FROM 'abc123' TO '123xyz'
```

0 rows, System updates: 1

This command only works for a logged in user and cannot be run with auth disabled.

Deleting users

Users can be deleted using `DROP USER`.

Query

```
DROP USER jake
```

0 rows, System updates: 1

When a user has been deleted, it will no longer appear on the list provided by `SHOW USERS`.

Query

```
SHOW USERS
```

Table 413. Result

user	roles	passwordChangeRequired	suspended
"neo4j"	["admin"]	true	false
1 row			

This command is optionally idempotent, with the default behavior to throw an exception if the user does not exists. Appending `IF EXISTS` to the command will ensure that no exception is thrown and nothing happens should the user not exist.

Query

```
DROP USER jake IF EXISTS
```

0 rows

Role Management

Roles can be created and managed using a set of Cypher administration commands executed against the `system` database.

Table 414. Role management command syntax

Command	Description
`SHOW [ALL|POPULATED] ROLES [WITH USERS]`	List roles
`SHOW ROLE name PRIVILEGES`	List the privileges granted to a role
`CREATE [OR REPLACE] ROLE name [IF NOT EXISTS] [AS COPY OF name]`	Create a new role
`DROP ROLE name [IF EXISTS]`	Drop (remove) an existing role
`GRANT ROLE name[, ...] TO user[, ...]`	Assign one or multiple roles to one or multiple users
`REVOKE ROLE name[, ...] FROM user[, ...]`	Remove one or multiple roles from one or multiple users

Listing roles

Available roles can be seen using `SHOW ROLES`.

Query

```
SHOW ROLES
```

This is the same command as `SHOW ALL ROLES`. When first starting a Neo4j DBMS there are a number of built-in roles:

- `reader` - can perform read-only queries on all databases except `system`
- `editor` - can perform read and write operations on all databases except `system`, but cannot make new labels or relationship types
- `publisher` - can do the same as `editor`, but also create new labels and relationship types.
- `architect` - can do the same as `architect` as well as create and manage indexes and constraints
- `admin` - can do the same as all the above, as well as manage databases, users, roles and privileges

Table 415. Result

role	isBuiltIn
"admin"	true
"publisher"	true
"editor"	true
"reader"	true
"architect"	true
"role1"	false
"role2"	false
7 rows	

There are multiple versions of this command, the default being `SHOW ALL ROLES`. To only show roles that are assigned to users, the command is `SHOW POPULATED ROLES`. To see which users are assigned to roles `WITH USERS` can be appended to the commands. This will give one result row for each user, so if a role is assigned to two users then it will show up twice in the result.

Query

```
SHOW POPULATED ROLES
WITH USERS
```

The table of results contains two columns, the first is the role name, and the other a flag indicating whether the role is a built-in role or a custom role.

Table 416. Result

role	isBuiltIn	member
"admin"	true	"neo4j"
1 row		

The `SHOW ROLE name PRIVILEGES` command is found in Listing privileges.

Creating roles

Roles can be created using `CREATE ROLE`.

Query

```
CREATE ROLE myrole
```

0 rows, System updates: 1

A role can also be copied, keeping its privileges, using `CREATE ROLE AS COPY OF`.

Query

```
CREATE ROLE mysecondrole AS COPY OF myrole
```

0 rows, System updates: 1

The created roles will appear on the list provided by `SHOW ROLES`.

Query

```
SHOW ROLES
```

Table 417. Result

role	isBuiltIn
"admin"	true
"publisher"	true
"editor"	true
"reader"	true
"architect"	true
"role1"	false
"role2"	false
"myrole"	false
"mysecondrole"	false
9 rows	

These command versions are optionally idempotent, with the default behavior to throw an exception if the role already exists. Appending `IF NOT EXISTS` to the command will ensure that no exception is thrown and nothing happens should the role already exist. Adding `OR REPLACE` to the command will result in any existing role being deleted and a new one created.

Query

```
CREATE ROLE myrole IF NOT EXISTS
```

0 rows

Query

```
CREATE OR REPLACE ROLE myrole
```

0 rows, System updates: 2

This is equivalent to running `DROP ROLE myrole IF EXISTS` followed by `CREATE ROLE myrole`.

> The `IF NOT EXISTS` and `OR REPLACE` parts of this command cannot be used together.

Deleting roles

Roles can be deleted using `DROP ROLE` command.

Query

```
DROP ROLE mysecondrole
```

0 rows, System updates: 1

When a role has been deleted, it will no longer appear on the list provided by `SHOW ROLES`.

Query

```
SHOW ROLES
```

Table 418. Result

role	isBuiltIn
"admin"	true
"publisher"	true
"editor"	true
"reader"	true
"architect"	true
"role1"	false
"role2"	false
7 rows	

This command is optionally idempotent, with the default behavior to throw an exception if the role does not exists. Appending `IF EXISTS` to the command will ensure that no exception is thrown and nothing happens should the role not exist.

Query

```
DROP ROLE mysecondrole IF EXISTS
```

0 rows

Assigning roles to users

Users can be given access rights by assigning them roles using `GRANT ROLE`.

Query

```
GRANT ROLE myrole TO jake
```

0 rows, System updates: 1

The roles assigned to each user can be seen in the list provided by `SHOW USERS`.

Query

```
SHOW USERS
```

Table 419. Result

user	roles	passwordChangeRequired	suspended
"neo4j"	["admin"]	true	false
"jake"	["myrole"]	false	false
"user1"	[]	true	false
"user2"	[]	true	false
"user3"	[]	true	false
5 rows			

It is possible to assign multiple roles to multiple users in one command.

Query

```
GRANT ROLES role1, role2 TO user1, user2, user3
```

0 rows, System updates: 6

Revoking roles from users

Users can lose access rights by revoking roles from them using `REVOKE ROLE`.

Query

```
REVOKE ROLE myrole FROM jake
```

0 rows

The roles revoked from users can no longer be seen in the list provided by `SHOW USERS`.

Query

```
SHOW USERS
```

Table 420. Result

user	roles	passwordChangeRequired	suspended
"neo4j"	["admin"]	true	false
"jake"	[]	false	false
"user1"	[]	true	false
"user2"	[]	true	false
"user3"	[]	true	false
5 rows			

It is possible to revoke multiple roles from multiple users in one command.

Query

```
REVOKE ROLES role1, role2 FROM user1, user2, user3
```

0 rows

5.5.3. Graph and sub-graph access control

This section explains how to use Cypher to manage privileges for Neo4j role-based access control and fine-grained security.

- The `GRANT`, `DENY` and `REVOKE` commands
- Listing privileges
- The `TRAVERSE` privilege
- The `READ` privilege

- The MATCH privilege
- The WRITE privilege
- The REVOKE command

Privileges control the access rights to graph elements using a combined whitelist/blacklist mechanism. It is possible to grant access, or deny access, or a combination of the two. The user will be able to access the resource if they have a grant (whitelist) and do not have a deny (blacklist) relevant to that resource. All other combinations of `GRANT` and `DENY` will result in the matching subgraph being invisible. It will appear to the user as if they have a smaller database (smaller graph).

> If a user was not also provided with the database `ACCESS` privilege then access to the entire database will be denied. Information about the database access privilege can be found in The ACCESS privilege.

The `GRANT`, `DENY` and `REVOKE` commands

The `GRANT` command allows an administrator to grant a privilege to a role in order to access an entity. The `DENY` command allows an administrator to deny a privilege to a role in order to prevent access to an entity. The `REVOKE` command allows an administrator to remove a previously granted or denied privilege. The syntax is:

Table 421. Privilege command syntax

Command	Description
`GRANT graph-privilege ON GRAPH[S] {name | *} [entity] TO roles`	Grant a privilege to one or multiple roles
`DENY graph-privilege ON GRAPH[S] {name | *} [entity] TO roles`	Deny a privilege to one or multiple roles
`REVOKE GRANT graph-privilege ON GRAPH[S] {name | *} [entity] FROM roles`	Revoke a granted privilege from one or multiple roles
`REVOKE DENY graph-privilege ON GRAPH[S] {name | *} [entity] FROM roles`	Revoke a denied privilege from one or multiple roles
`REVOKE graph-privilege ON GRAPH[S] {name | *} [entity] FROM roles`	Revoke a granted or denied privilege from one or multiple roles

> These commands are almost identical to the database-privileges except for the use of the term `GRAPH`, the addition of an `entity` term, and the set of available *database-privileges* differs from the *graph-privileges*.

Where the components are:

- *graph-privilege*
  - `TRAVERSE`

allows the specified entities to be found

- `READ {props}`

  allows the specified properties to be read on the found entities. Note that granting property READ access does not imply that the entities with that property can be found. For example if there is also a DENY on it, the entity will not be found. The props can be `*` which means all properties.

- `MATCH {props}`

  this combines both TRAVERSE and READ allowing an entity to be found and its properties read.

- `WRITE`

  this privilege can only be assigned to all nodes, relationships and properties in the entire graph (this means that the entity part of the command must also be `ELEMENTS *` and cannot be more specific).

- *dbname*
  - The graph or graphs to associate the privilege with. In {neo4j.version} there can be only one graph per database, and therefor this command uses the database name to refer to that graph. Note that if you delete a database and create a new one with the same name, the new one will *NOT* have any of the privileges specifically assigned to the deleted graph.
  - Multiple graph names can be specified, comma-separated.
  - It can be `*` which means all graphs. Any new databases created after this command will also be associated with these privileges.
- *entity*
  - The graph elements this privilege applies to:
    - `NODES` label (nodes with the specified label(s)).
    - `RELATIONSHIPS` type (relationships of the specific type(s)).
    - `ELEMENTS` label (both nodes and relationships).
  - The label or type can be `*` which means all labels or types.
  - Multiple labels or types can be specified, comma-separated.
  - Defaults to `ELEMENTS *` if omitted.
- *roles*
  - The role or roles to associate the privilege with, comma-separated.

It is important to note that using DENY does NOT erase a GRANT command; they both exist. The only way to erase a privilege is with REVOKE.

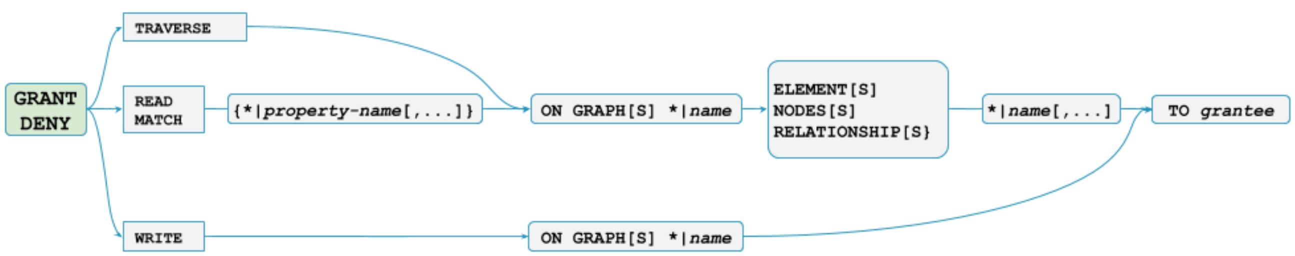


Figure 29. GRANT and DENY Syntax

Listing privileges

Available privileges for all roles can be seen using `SHOW PRIVILEGES`.

Query

```
SHOW PRIVILEGES
```

Lists all privileges for all roles. The table contains columns describing the privilege:

- access: whether the privilege is granted or denied (whitelist or blacklist)
- action: which type of privilege this is: access, traverse, read, write, token, schema or admin
- resource: what type of scope this privilege applies to: the entire dbms, a database, a graph or sub-graph access
- graph: the specific database or graph this privilege applies to
- segement: for sub-graph access control, this describes the scope in terms of labels or relationship types
- role: the role the privilege is granted to

Table 422. Result

access	action	resource	graph	segment	role
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"admin"
"GRANTED"	"write"	"all_properties"	"*"	"NODE(*)"	"admin"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"admin"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"admin"
"GRANTED"	"write"	"all_properties"	"*"	"RELATIONSHIP(*)"	"admin"
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"admin"
"GRANTED"	"access"	"database"	"*"	"database"	"admin"
"GRANTED"	"admin"	"database"	"*"	"database"	"admin"
"GRANTED"	"schema"	"database"	"*"	"database"	"admin"
"GRANTED"	"token"	"database"	"*"	"database"	"admin"
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"architect"
"GRANTED"	"write"	"all_properties"	"*"	"NODE(*)"	"architect"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"architect"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"architect"
"GRANTED"	"write"	"all_properties"	"*"	"RELATIONSHIP(*)"	"architect"
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"architect"
"GRANTED"	"access"	"database"	"*"	"database"	"architect"
"GRANTED"	"schema"	"database"	"*"	"database"	"architect"
"GRANTED"	"token"	"database"	"*"	"database"	"architect"
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"editor"
"GRANTED"	"write"	"all_properties"	"*"	"NODE(*)"	"editor"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"editor"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"editor"
"GRANTED"	"write"	"all_properties"	"*"	"RELATIONSHIP(*)"	"editor"

access	action	resource	graph	segment	role
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"editor"
"GRANTED"	"access"	"database"	"*"	"database"	"editor"
"DENIED"	"access"	"database"	"neo4j"	"database"	"noAccessUsers"
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"publisher"
"GRANTED"	"write"	"all_properties"	"*"	"NODE(*)"	"publisher"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"publisher"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"publisher"
"GRANTED"	"write"	"all_properties"	"*"	"RELATIONSHIP(*)"	"publisher"
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"publisher"
"GRANTED"	"access"	"database"	"*"	"database"	"publisher"
"GRANTED"	"token"	"database"	"*"	"database"	"publisher"
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"reader"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"reader"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"reader"
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"reader"
"GRANTED"	"access"	"database"	"*"	"database"	"reader"
"GRANTED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
41 rows					

Available privileges for a particular role can be seen using `SHOW ROLE name PRIVILEGES`.

Query

```
SHOW ROLE regularUsers PRIVILEGES
```

Lists all privileges for role 'regularUsers'

Table 423. Result

access	action	resource	graph	segment	role
"GRANTED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
1 row					

Available privileges for a particular user can be seen using `SHOW USER name PRIVILEGES`.

Query

```
SHOW USER jake PRIVILEGES
```

Lists all privileges for user 'jake'

Table 424. Result

access	action	resource	graph	segment	role	user
"GRANTED"	"access"	"database"	"neo4j"	"database"	"regularUsers"	"jake"
1 row						

The `TRAVERSE` privilege

Users can be granted the right to find nodes and relationships using the `GRANT TRAVERSE` privilege.

Command syntax

```
GRANT TRAVERSE
    ON GRAPH[S] {name | *}
        [
           { NODE[S] | RELATIONSHIP[S] | ELEMENT[S] }
           [ { * | labels } ]
        ]
    TO roles
```

For example, we can allow the user `jake`, who has role 'regularUsers' to find all nodes with the label `Post`.

Query

```
GRANT TRAVERSE
ON GRAPH neo4j NODES Post TO regularUsers
```

0 rows, System updates: 1

The `TRAVERSE` privilege can also be denied.

Command syntax

```
DENY TRAVERSE
    ON GRAPH[S] {name | *}
        [
           { NODE[S] | RELATIONSHIP[S] | ELEMENT[S] }
           [ { * | labels } ]
        ]
    TO roles
```

For example, we can disallow the user `jake`, who has role 'regularUsers' to find all nodes with the label `Payments`.

Query

```
DENY TRAVERSE
ON GRAPH neo4j NODES Payments TO regularUsers
```

0 rows, System updates: 1

The `READ` privilege

Users can be granted the right to do property reads on nodes and relationships using the `GRANT READ` privilege. It is very important to note that users can only read properties on entities that they are allowed to find in the first place.

Command syntax

```
GRANT READ
    { * | properties }
    ON GRAPH[S] {name | *}
        [
            { NODE[S] | RELATIONSHIP[S] | ELEMENT[S] }
            [ { * | labels } ]
        ]
    TO roles
```

For example, we can allow the user `jake`, who has role 'regularUsers' to read all properties on nodes with the label `Post`. The `*` implies that the ability to read all properties also extends to properties that might be added in the future.

Query

```
GRANT READ { * }
ON GRAPH neo4j NODES Post TO regularUsers
```

0 rows, System updates: 1

The `READ` privilege can also be denied.

Command syntax

```
DENY READ
    { * | properties }
    ON GRAPH[S] {name | *}
        [
            { NODE[S] | RELATIONSHIP[S] | ELEMENT[S] }
            [ { * | labels } ]
        ]
    TO roles
```

Although we just granted the user 'jake' the right to read all properties, we may want to hide the `secret` property. The following example shows how to do that.

Query

```
DENY READ { secret }
ON GRAPH neo4j NODES Post TO regularUsers
```

0 rows, System updates: 1

The `MATCH` privilege

As a shorthand for `TRAVERSE` and `READ`, users can be granted the right to find and do property reads on nodes and relationships using the `GRANT MATCH` privilege.

Command syntax

```
GRANT MATCH
    { * | properties }
    ON GRAPH[S] {name | *}
        [
            { NODE[S] | RELATIONSHIP[S] | ELEMENT[S] }
            [ { * | labels } ]
        ]
    TO roles
```

For example if you want to grant the ability to read the properties `language` and `length` for nodes with the label `Message`, as well as the ability to find these nodes, to a role `regularUsers` you can use the following `GRANT MATCH` query.

Query

```
GRANT
MATCH { language, length }
ON GRAPH neo4j NODES Message TO regularUsers
```

0 rows, System updates: 3

Like all other privileges, the `MATCH` privilege can also be denied.

Command syntax

```
DENY MATCH
    { * | properties }
    ON GRAPH[S] {name | *}
        [
            { NODE[S] | RELATIONSHIP[S] | ELEMENT[S] }
            [ { * | labels } ]
        ]
    TO roles
```

Please note that the effect of denying a `MATCH` privilege depends on whether concrete property keys are specified or a `. If you specify concrete property keys then DENY MATCH will only deny reading those properties. Finding the elements to traverse would still be allowed. If you specify` instead then both traversal of the element and all property reads will be disallowed. The following queries will show examples for this.

Denying to read the property ´content´ on nodes with the label `Message` for the role `regularUsers` would look like the following query. Although not being able to read this specific property, nodes with that label can still be traversed (and, depending on other grants, other properties on it could still be read).

Query

```
DENY
MATCH { content }
ON GRAPH neo4j NODES Message TO regularUsers
```

0 rows, System updates: 1

The following query exemplifies how it would look like if you want to deny both reading all properties and traversing nodes labeled with `Account`.

Query

```
DENY
MATCH { * }
ON GRAPH neo4j NODES Account TO regularUsers
```

0 rows, System updates: 2

Please note that `REVOKE MATCH` is not allowed, instead revoke the individual `READ` and `TRAVERSE` privileges.

The `WRITE` privilege

The `WRITE` privilege can be used to allow the ability to write on a graph. At the moment, granting the `WRITE` privilege implies that you can do any write operation on any part of the graph.

Command syntax

```
GRANT WRITE
    ON GRAPH[S] {name | *}
    [ ELEMENT[S] * ]
    TO roles
```

For example, granting the ability to write on the graph `neo4j` to the role `regularUsers` would be achieved using:

Query

```
GRANT WRITE
ON GRAPH neo4j TO regularUsers
```

0 rows, System updates: 2

Unlike with `GRANT READ` it is not possible to restrict `WRITE` privileges to specific ELEMENTS, NODES or RELATIONSHIPS.

For example, using `NODES A` will produce a syntax error.

Query

```
GRANT WRITE
ON GRAPH neo4j NODES A TO regularUsers
```

The use of ELEMENT, NODE or RELATIONSHIP with the WRITE privilege is not supported in this version. (line 1, column 1 (offset: 0))
"GRANT WRITE"
^

The `WRITE` privilege can also be denied.

Command syntax

```
DENY WRITE
    ON GRAPH[S] {name | *}
    [ ELEMENT[S] * ]
    TO roles
```

For example, denying the ability to write on the graph `neo4j` to the role `regularUsers` would be achieved using:

Query

```
DENY WRITE
ON GRAPH neo4j TO regularUsers
```

0 rows, System updates: 2

Users with `WRITE` privilege but restricted `TRAVERSE` privileges will not be able to do `DETACH DELETE` in all cases. See Operations Manual Fine-grained access control for more info.

The `REVOKE` command

Privileges that were granted or denied earlier can be revoked using the `REVOKE` command.

Command syntax

```
REVOKE
    [ { GRANT | DENY } ] graph-privilege
    FROM roles
```

Please note that `REVOKE MATCH` is not allowed, instead revoke the individual `READ` and `TRAVERSE` privileges.

An example usage of the REVOKE command is given here:

Query

```
REVOKE GRANT TRAVERSE
ON GRAPH neo4j NODES Post FROM regularUsers
```

0 rows

While it can be explicitly specified that revoke should remove a GRANT or DENY, it is also possible to revoke either one by not specifying at all as the next example demonstrates. Because of this, if there happen to be a GRANT and a DENY on the same privilege, it would remove both.

Query

```
REVOKE TRAVERSE
ON GRAPH neo4j NODES Payments FROM regularUsers
```

0 rows

5.5.4. Security of administration

> *This section explains how to use Cypher to manage Neo4j administrative privileges.*

All of the commands described in the enclosing Administration section require that the user executing the commands has the rights to do so. These privileges can be conferred either by granting the user the admin role, which enables all administrative rights, or by granting specific combinations of privileges.

The admin role

The built-in role admin includes a number of privileges allowing users granted this role the ability to perform administrative tasks. These include the rights to perform the following classes of tasks:

- Manage database security for controlling the rights to perform actions on specific databases:
  - Manage access to a database and the right to start and stop a database
  - Manage indexes and constraints
  - Allow the creation of labels, relationship types or property names

- Manage DBMS security for controlling the rights to perform actions on the entire system:
  - Manage multiple databases
  - Manage users and roles
  - Change configuration parameters
  - Manage transactions
  - Manage sub-graph privileges
  - Manage procedure security

These rights are conferred using privileges that can be managed using `GRANT`, `DENY` and `REVOKE` commands, with the exception of the *DBMS Security* privileges which are only available within the built-in `admin` role.

Query

```
SHOW ROLE admin PRIVILEGES
```

Table 425. Result

access	action	resource	graph	segment	role
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"admin"
"GRANTED"	"write"	"all_properties"	"*"	"NODE(*)"	"admin"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"admin"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"admin"
"GRANTED"	"write"	"all_properties"	"*"	"RELATIONSHIP(*)"	"admin"
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"admin"
"GRANTED"	"access"	"database"	"*"	"database"	"admin"
"GRANTED"	"admin"	"database"	"*"	"database"	"admin"
"GRANTED"	"schema"	"database"	"*"	"database"	"admin"
"GRANTED"	"token"	"database"	"*"	"database"	"admin"
10 rows					

Database administration

This section explains how to use Cypher to manage privileges for Neo4j database administrative rights.

As described in the section on sub-graph security, the `GRANT` command allows an administrator to grant a privilege to a role in order to access an entity. The `DENY` command allows an administrator to deny a privilege to a role in order to prevent access to an entity. The `REVOKE` command allows an administrator to remove a previously granted or denied privilege. The syntax is:

Table 426. Privilege command syntax

Command	Description
`GRANT database-privilege ON DATABASE[S] {dbname | *} TO role[, ...]`	Grant a privilege to one or multiple roles

Command	Description
`DENY database-privilege ON DATABASE[S] {dbname | *} TO role[, ...]`	Deny a privilege to one or multiple roles
`REVOKE GRANT database-privilege ON DATABASE[S] {dbname | *} FROM role[, ...]`	Revoke a granted privilege from one or multiple roles
`REVOKE DENY database-privilege ON DATABASE[S] {dbname | *} FROM role[, ...]`	Revoke a denied privilege from one or multiple roles
`REVOKE database-privilege ON DATABASE[S] {dbname | *} FROM role[, ...]`	Revoke a granted or denied privilege from one or multiple roles

These commands are very similar to the graph-privileges except for the use of the term `DATABASE`, no `entity` and and the set of available *database-privileges* differs from the *graph-privileges*.

Where the components are:

- *database-privilege*
  - `ACCESS`

    allows access for a specific database/graph
  - `START`

    allows the specified database to be started
  - `STOP`

    allows the specified database to be stopped
  - `CREATE INDEX`

    allows indexes to be created on the specified database.
  - `DROP INDEX`

    allows indexes to be deleted on the specified database.
  - `INDEX [MANAGEMENT]`

    allows indexes to be created and deleted on the specified database.
  - `CREATE CONSTRAINT`

    allows constraints to be created on the specified database.
  - `DROP CONSTRAINT`

    allows constraints to be deleted on the specified database.

- `CONSTRAINT [MANAGEMENT]`

  allows constraints to be created and deleted on the specified database.

- `CREATE NEW [NODE] LABEL`

  allows labels to be created so that future nodes can be assigned them.

- `CREATE NEW [RELATIONSHIP] TYPE`

  allows relationship types to be created so that future relationships can be created with these types.

- `CREATE NEW [PROPERTY] NAME`

  allows property names to be created so that nodes and relationships can have properties with these names assigned.

- `NAME [MANAGEMENT]`

  allows all of the name management capabilities: node labels, relationship types and property names.

- `ALL [[DATABASE] PRIVILEGES]`

  allows all of the above privileges to be enabled for the specified database.

- *dbname*
  - The database to associate the privilege with. Note that if you delete a database and create a new one with the same name, the new one will NOT have any of the privileges specifically assigned to the deleted database.
  - It can be `*` which means all databases. Any new databases created after this command will also be associated with these privileges.
- *role[, ...]*
  - The role or roles to associate the privilege with, comma-separated.

It is important to note that using DENY does NOT erase a GRANT command; they both exist. The only way to erase a privilege is with REVOKE.

Table 427. Database management command syntax

Command	Description
`GRANT ACCESS ON DATABASE[S] {name | *} TO role[, ...]`	Allow the specified role or roles to access the database `name` or all databases
`GRANT {START | STOP} ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to start or stop the database `name` or all databases

Command	Description

`GRANT {CREATE | DROP} INDEX[ES]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create or delete indexes on the database `name` or all databases

`GRANT INDEX[ES] [MANAGEMENT]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create and delete indexes on the database `name` or all databases

`GRANT {CREATE | DROP} CONSTRAINT[S]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create or delete indexes on the database `name` or all databases

`GRANT CONSTRAINT[S] [MANAGEMENT]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create and delete constraints on the database `name` or all databases

`GRANT CREATE NEW [NODE] LABEL[S]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create new labels for nodes in the database `name` or all databases

`GRANT CREATE NEW [RELATIONSHIP] TYPE[S]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create new types for relationships in the database `name` or all databases

`GRANT CREATE NEW [PROPERTY] NAME[S]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create new names for properties in the database `name` or all databases

`GRANT NAME [MANAGEMENT]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to create new labels, relationship types and property names in the database `name` or all databases

`GRANT ALL [[DATABASE] PRIVILEGES]`
`    ON DATABASE[S] {name | *}`
`    TO role[, ...]`
	Enable the specified role or roles to perform all of the above database actions on the database `name` or all databases

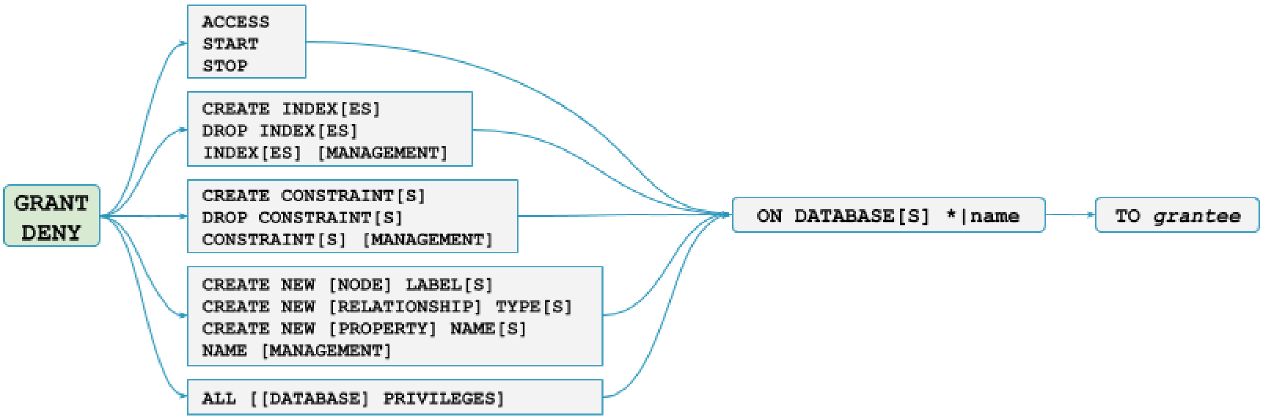


Figure 30. Syntax of GRANT and DENY Database Privileges

The database ACCESS privilege

The ACCESS privilege can be used to enable the ability to access a database. If this is not granted to users, they will not even be able to start transactions on the relevant database.

Command syntax

```
GRANT ACCESS
    ON DATABASE[S] {dbname | *}
    TO role[, ...]
```

For example, granting the ability to access the database neo4j to the role regularUsers is done using the following query.

Query

```
GRANT ACCESS
ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

The ACCESS privilege can also be denied.

Command syntax

```
DENY ACCESS
    ON DATABASE[S] {dbname | *}
    TO role[, ...]
```

For example, denying the ability to access to the database neo4j to the role regularUsers is done using the following query.

Query

```
DENY ACCESS
ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

The privileges granted can be seen using the SHOW PRIVILEGES command:

Query

```
SHOW ROLE regularUsers PRIVILEGES
```

Table 428. Result

access	action	resource	graph	segment	role
"DENIED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
2 rows					

The database START/STOP privileges

The START privilege can be used to enable the ability to start a database.

Command syntax

```
GRANT START
    ON DATABASE[S] {dbname | *}
    TO role[, ...]
```

For example, granting the ability to start the database neo4j to the role regularUsers is done using the following query.

Query

```
GRANT
START
ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

The START privilege can also be denied.

Command syntax

```
DENY START
    ON DATABASE[S] {dbname | *}
    TO role[, ...]
```

For example, denying the ability to start to the database neo4j to the role regularUsers is done using the following query.

Query

```
DENY
START
ON DATABASE system TO regularUsers
```

0 rows, System updates: 1

The STOP privilege can be used to enable the ability to stop a database.

Command syntax

```
GRANT STOP
    ON DATABASE[S] {dbname | *}
    TO role[, ...]
```

For example, granting the ability to stop the database `neo4j` to the role `regularUsers` is done using the following query.

Query

```
GRANT STOP
ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

The `STOP` privilege can also be denied.

Command syntax

```
DENY STOP
    ON DATABASE[S] {dbname | *}
    TO role[, ...]
```

For example, denying the ability to stop to the database `neo4j` to the role `regularUsers` is done using the following query.

Query

```
DENY STOP
ON DATABASE system TO regularUsers
```

0 rows, System updates: 1

The privileges granted can be seen using the `SHOW PRIVILEGES` command:

Query

```
SHOW ROLE regularUsers PRIVILEGES
```

Table 429. Result

access	action	resource	graph	segment	role
"DENIED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"start_database"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"stop_database"	"database"	"neo4j"	"database"	"regularUsers"
"DENIED"	"start_database"	"database"	"system"	"database"	"regularUsers"
"DENIED"	"stop_database"	"database"	"system"	"database"	"regularUsers"
6 rows					

The `INDEX MANAGEMENT` privileges

Indexes can be created or deleted with the `CREATE INDEX` and `DROP INDEX` commands. The privilege to do this can be granted with `GRANT CREATE INDEX` and `GRANT DROP INDEX` commands.

Table 430. Index management command syntax

Command	Description
`GRANT {CREATE | DROP} INDEX[ES] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create or delete indexes on the database `name` or all databases
`GRANT INDEX[ES] [MANAGEMENT] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create and delete indexes on the database `name` or all databases

For example, granting the ability to create indexes on the database `neo4j` to the role `regularUsers` is done using the following query.

Query

```
GRANT
CREATE INDEX ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

The `CONSTRAINT MANAGEMENT` privileges

Constraints can be created or deleted with the `CREATE CONSTRAINT` and `DROP CONSTRAINT` commands. The privilege to do this can be granted with `GRANT CREATE CONSTRAINT` and `GRANT DROP CONSTRAINT` commands.

Table 431. Constraint management command syntax

Command	Description
`GRANT {CREATE | DROP} CONSTRAINT[S] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create or delete constraints on the database `name` or all databases
`GRANT CONSTRAINT[S] [MANAGEMENT] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create and delete constraints on the database `name` or all databases

For example, granting the ability to create constraints on the database `neo4j` to the role `regularUsers` is done using the following query.

Query

```
GRANT
CREATE CONSTRAINT ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

The `NAME MANAGEMENT` privileges

The right to create new labels, relationship types or propery names is different from the right to create nodes, relationships or properties. The latter is managed using database `WRITE` privileges, while the former is managed using specific `GRANT/DENY CREATE NEW …` commands for each type.

Table 432. Label, relationship type and property name management command syntax

Command	Description
`GRANT CREATE NEW [NODE] LABEL[S] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create new labels for nodes in the database `name` or all databases
`GRANT CREATE NEW [RELATIONSHIP] TYPE[S] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create new types for relationships in the database `name` or all databases
`GRANT CREATE NEW [PROPERTY] NAME[S] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create new names for properties in the database `name` or all databases
`GRANT NAME [MANAGEMENT] ON DATABASE[S] {name | *} TO role[, ...]`	Enable the specified role or roles to create new labels, relationship types and property names in the database `name` or all databases

For example, granting the ability to create new properties on nodes or relationships in the database `neo4j` to the role `regularUsers` is done using the following query.

Query

```
GRANT
CREATE NEW PROPERTY NAME
ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 1

Granting all database administration privileges

Conferring the right to perform all of the above tasks can be achieved with a single command:

Command syntax

```
GRANT ALL [[DATABASE] PRIVILEGES]
    ON DATABASE[S] {name | *}
    TO role[, ...]
```

For example, granting the ability to access, start and stop all databases and create indexes, constraints, labels, relationship types and property names on the database `neo4j` to the role `regularUsers` is done using the following query.

Query

```
GRANT ALL DATABASE PRIVILEGES
ON DATABASE neo4j TO regularUsers
```

0 rows, System updates: 4

The privileges granted can be seen using the `SHOW PRIVILEGES` command:

Query

```
SHOW ROLE regularUsers PRIVILEGES
```

Table 433. Result

access	action	resource	graph	segment	role
"DENIED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"access"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"create_constraint"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"create_index"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"create_label"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"create_propertykey"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"create_reltype"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"drop_constraint"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"drop_index"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"start_database"	"database"	"neo4j"	"database"	"regularUsers"
"GRANTED"	"stop_database"	"database"	"neo4j"	"database"	"regularUsers"
"DENIED"	"start_database"	"database"	"system"	"database"	"regularUsers"
"DENIED"	"stop_database"	"database"	"system"	"database"	"regularUsers"
13 rows					

DBMS administration

All DBMS privileges are relevant system-wide. Like user management, they do not belong to one specific database or graph. For more details on the differences between graphs, databases and the DBMS, refer to Neo4j databases and graphs.

As described above, the `admin` role has a number of built-in privileges that cannot be assigned using Cypher commands. These include:

- Create or drop databases
- Change configuration parameters
- Manage transactions
- Manage users and roles (role management by itself is assignable using Cypher commands)
- Manage sub-graph privileges
- Manage procedure security

The easiest way to enable a user to perform these tasks is to grant them the `admin` role. The only subset of these privileges that is assignable using Cypher commands is role management. However, it is possible to make a custom role with a subset of these privileges.

Using a custom role to manage DBMS privileges

If it is desired to have an administrator with a subset of privileges that includes all DBMS privileges, but not all database privileges, this can be achieved by copying the `admin` role and revoking or denying some privileges.

First we copy the 'admin' role:

Query

```
CREATE ROLE usermanager AS COPY OF admin
```

0 rows, System updates: 2

Then we DENY ACCESS to normal databases:

Query

```
DENY ACCESS
ON DATABASE * TO usermanager
```

0 rows, System updates: 1

And DENY START and STOP for normal databases:

Query

```
DENY
START
ON DATABASE * TO usermanager
```

0 rows, System updates: 1

Query

```
DENY STOP
ON DATABASE * TO usermanager
```

0 rows, System updates: 1

And DENY index and constraint management:

Query

```
DENY INDEX MANAGEMENT
ON DATABASE * TO usermanager
```

0 rows, System updates: 2

Query

```
DENY CONSTRAINT MANAGEMENT
ON DATABASE * TO usermanager
```

0 rows, System updates: 2

And finally DENY label, relationship type and property name:

Query

```
DENY NAME MANAGEMENT
ON DATABASE * TO usermanager
```

0 rows, System updates: 3

The resulting role should have privileges that only allow the DBMS capabilities, like user and role management:

Query

```
SHOW ROLE usermanager PRIVILEGES
```

Lists all privileges for role 'usermanager'

Table 434. Result

access	action	resource	graph	segment	role
"GRANTED"	"read"	"all_properties"	"*"	"NODE(*)"	"usermanager"
"GRANTED"	"write"	"all_properties"	"*"	"NODE(*)"	"usermanager"
"GRANTED"	"traverse"	"graph"	"*"	"NODE(*)"	"usermanager"
"GRANTED"	"read"	"all_properties"	"*"	"RELATIONSHIP(*)"	"usermanager"
"GRANTED"	"write"	"all_properties"	"*"	"RELATIONSHIP(*)"	"usermanager"
"GRANTED"	"traverse"	"graph"	"*"	"RELATIONSHIP(*)"	"usermanager"
"DENIED"	"access"	"database"	"*"	"database"	"usermanager"
"GRANTED"	"access"	"database"	"*"	"database"	"usermanager"
"GRANTED"	"admin"	"database"	"*"	"database"	"usermanager"
"DENIED"	"create_constraint"	"database"	"*"	"database"	"usermanager"
"DENIED"	"create_index"	"database"	"*"	"database"	"usermanager"
"DENIED"	"create_label"	"database"	"*"	"database"	"usermanager"
"DENIED"	"create_propertykey"	"database"	"*"	"database"	"usermanager"
"DENIED"	"create_reltype"	"database"	"*"	"database"	"usermanager"
"DENIED"	"drop_constraint"	"database"	"*"	"database"	"usermanager"
"DENIED"	"drop_index"	"database"	"*"	"database"	"usermanager"
"GRANTED"	"schema"	"database"	"*"	"database"	"usermanager"
"DENIED"	"start_database"	"database"	"*"	"database"	"usermanager"
"DENIED"	"stop_database"	"database"	"*"	"database"	"usermanager"
"GRANTED"	"token"	"database"	"*"	"database"	"usermanager"
20 rows					

The dbms `ROLE MANAGEMENT` privileges

The dbms privileges for role management are assignable using Cypher administrative commands. They can be granted, denied and revoked like other privileges.

Table 435. Role management privileges command syntax

Command	Description
`GRANT CREATE ROLE ON DBMS TO role[, ...]`	Enable the specified role or roles to create new roles

Command	Description
`GRANT DROP ROLE ON DBMS TO role[, ...]`	Enable the specified role or roles to delete roles
`GRANT ASSIGN ROLE ON DBMS TO role[, ...]`	Enable the specified role or roles to assign roles to users
`GRANT REMOVE ROLE ON DBMS TO role[, ...]`	Enable the specified role or roles to remove roles from users
`GRANT SHOW ROLE ON DBMS TO role[, ...]`	Enable the specified role or roles to list roles
`GRANT ROLE MANAGEMENT ON DBMS TO role[, ...]`	Enable the specified role or roles to create, delete, assign, remove and list roles

The ability to add roles can be granted via the `CREATE ROLE` privilege. The following query shows an example of this:

Query

```
GRANT
CREATE ROLE
ON DBMS TO roleAdder
```

0 rows, System updates: 1

The resulting role should have privileges that only allow adding roles:

Query

```
SHOW ROLE roleAdder PRIVILEGES
```

Lists all privileges for role 'roleAdder'

Table 436. Result

access	action	resource	graph	segment	role
"GRANTED"	"create_role"	"database"	"*"	"database"	"roleAdder"
1 row					

The ability to delete roles can be granted via the `DROP ROLE` privilege. The following query shows an example of this:

Query

```
GRANT DROP ROLE
ON DBMS TO roleDropper
```

0 rows, System updates: 1

The resulting role should have privileges that only allow deleting roles:

Query

```
SHOW ROLE roleDropper PRIVILEGES
```

Lists all privileges for role 'roleDropper'

Table 437. Result

access	action	resource	graph	segment	role
"GRANTED"	"drop_role"	"database"	"*"	"database"	"roleDropper"
1 row					

The ability to assign roles to users can be granted via the `ASSIGN ROLE` privilege. The following query shows an example of this:

Query

```
GRANT ASSIGN ROLE
ON DBMS TO roleAssigner
```

0 rows, System updates: 1

The resulting role should have privileges that only allow assigning/granting roles:

Query

```
SHOW ROLE roleAssigner PRIVILEGES
```

Lists all privileges for role 'roleAssigner'

Table 438. Result

access	action	resource	graph	segment	role
"GRANTED"	"assign_role"	"database"	"*"	"database"	"roleAssigner"
1 row					

The ability to remove roles from users can be granted via the `REMOVE ROLE` privilege. The following query shows an example of this:

Query

```
GRANT
REMOVE ROLE
ON DBMS TO roleRemover
```

0 rows, System updates: 1

The resulting role should have privileges that only allow removing/revoking roles:

Query

```
SHOW ROLE roleRemover PRIVILEGES
```

Lists all privileges for role 'roleRemover'

Table 439. Result

access	action	resource	graph	segment	role
"GRANTED"	"remove_role"	"database"	"*"	"database"	"roleRemover"
1 row					

The ability to show roles can be granted via the `SHOW ROLE` privilege. The following query shows an example of this:

Query

```
GRANT SHOW ROLE
ON DBMS TO roleShower
```

0 rows, System updates: 1

The resulting role should have privileges that only allow showing roles:

Query

```
SHOW ROLE roleShower PRIVILEGES
```

Lists all privileges for role 'roleShower'

Table 440. Result

access	action	resource	graph	segment	role
"GRANTED"	"show_role"	"database"	"*"	"database"	"roleShower"
1 row					

All of the above mentioned privileges can be granted via the `ROLE MANAGEMENT` privilege. The following query shows an example of this:

Query

```
GRANT ROLE MANAGEMENT
ON DBMS TO roleManager
```

0 rows, System updates: 1

The resulting role should have all privileges to manage roles:

Query

```
SHOW ROLE roleManager PRIVILEGES
```

Lists all privileges for role 'roleManager'

Table 441. Result

access	action	resource	graph	segment	role
"GRANTED"	"role_management"	"database"	"*"	"database"	"roleManager"
1 row					

Chapter 6. Query tuning

This section describes query tuning for the Cypher query language.

Neo4j aims to execute queries as fast as possible.

However, when optimizing for maximum query execution performance, it may be helpful to rephrase queries using knowledge about the domain and the application.

The overall goal of manual query performance optimization is to ensure that only necessary data is retrieved from the graph. At the very least, data should get filtered out as early as possible in order to reduce the amount of work that has to be done in the later stages of query execution. This also applies to what gets returned: returning whole nodes and relationships ought to be avoided in favour of selecting and returning only the data that is needed. You should also make sure to set an upper limit on variable length patterns, so they don't cover larger portions of the dataset than needed.

Each Cypher query gets optimized and transformed into an execution plan by the Cypher query planner. To minimize the resources used for this, try to use parameters instead of literals when possible. This allows Cypher to re-use your queries instead of having to parse and build new execution plans.

To read more about the execution plan operators mentioned in this chapter, see Execution plans.

6.1. Cypher query options

This section describes the query options available in Cypher.

Query execution can be fine-tuned through the use of query options. In order to use one or more of these options, the query must be prepended with `CYPHER`, followed by the query option(s), as exemplified thus: `CYPHER query-option [further-query-options] query`.

6.1.1. Cypher version

Occasionally, there is a requirement to use a previous version of the Cypher compiler when running a query. Here we detail the available versions:

Query option	Description	Default?
`3.5`	This will force the query to use Neo4j Cypher 3.5.	
`4.0`	This will force the query to use Neo4j Cypher 4.0. As this is the default version, it is not necessary to use this option explicitly.	X

In Neo4j 4.0 the support for Cypher 3.5 is provided only at the parser level. The consequence is that some underlying features available in Neo4j 3.5 are no longer available and will result in runtime errors. Please refer to the discussion in Cypher Compatibility for more information on which features are affected.

6.1.2. Cypher runtime

Using the execution plan, the query is executed — and records returned — by the Cypher *runtime*. Depending on whether Neo4j Enterprise Edition or Neo4j Community Edition is used, there are three different runtimes available. In Enterprise Edition, the Cypher query planner selects the runtime, falling back to alternative runtimes as follows:

- Try the pipelined runtime first.
- If the pipelined runtime does not support the query, then fall back to use the slotted runtime.
- Finally, if the slotted runtime does not support the query, fall back to the interpreted runtime. The interpreted runtime supports all queries, and is the only option in Neo4j Community Edition.

Interpreted

In this runtime, the operators in the execution plan are chained together in a tree, where each non-leaf operator feeds from one or two child operators. The tree thus comprises nested iterators, and the records are streamed in a pipelined manner from the top iterator, which pulls from the next iterator and so on.

Slotted

This is very similar to the interpreted runtime, except that there are additional optimizations regarding the way in which the records are streamed through the iterators. This results in improvements to both the performance and memory usage of the query. In effect, this can be thought of as the 'faster interpreted' runtime.

Pipelined

The pipelined runtime was introduced in Neo4j 4.0 as a replacement for the older compiled runtime used in the Neo4j 3.x versions. It combines some of the advantages of the compiled runtime in a new architecture that allows for support of a wider range of queries. Algorithms are employed to intelligently group the operators in the execution plan in order to generate new combinations and orders of execution which are optimised for performance and memory usage. While this should lead to superior performance in most cases (over both the interpreted and slotted runtimes), it is still under development and does not support all possible operators or queries (the slotted runtime covers all operators and queries).

Option	Description	Default?
`runtime=interpreted`	This will force the query planner to use the interpreted runtime.	This is not used in Enterprise Edition unless explicitly asked for. It is the only option for all queries in Community Edition—it is not necessary to specify this option in Community Edition.
`runtime=slotted`	This will cause the query planner to use the slotted runtime.	This is the default option for all queries which are not supported by `runtime=pipelined` in Enterprise Edition.
`runtime=pipelined`	This will cause the query planner to use the pipelined runtime if it supports the query. If the pipelined runtime does not support the query, the planner will fall back to the slotted runtime.	This is the default option for some queries in Enterprise Edition.

6.2. Profiling a query

There are two options to choose from when you want to analyze a query by looking at its execution plan:

`EXPLAIN`
: If you want to see the execution plan but not run the statement, prepend your Cypher statement with `EXPLAIN`. The statement will always return an empty result and make no changes to the database.

`PROFILE`
: If you want to run the statement and see which operators are doing most of the work, use `PROFILE`. This will run your statement and keep track of how many rows pass through each operator, and how much each operator needs to interact with the storage layer to retrieve the necessary data. Please note that *profiling your query uses more resources,* so you should not profile unless you are actively working on a query.

See Execution plans for a detailed explanation of each of the operators contained in an execution plan.

> Being explicit about what types and labels you expect relationships and nodes to have in your query helps Neo4j use the best possible statistical information, which leads to better execution plans. This means that when you know that a relationship can only be of a certain type, you should add that to the query. The same goes for labels, where declaring labels on both the start and end nodes of a relationship helps Neo4j find the best way to execute the statement.

6.3. The use of indexes

This section describes the query plans when indexes are used in various scenarios.

The task of tuning calls for different indexes depending on what the queries look like. Therefore, it is important to have a fundamental understanding of how the indexes operate. This section describes the query plans that result from different index scenarios.

Please refer to Indexes for search performance for instructions on how to create and maintain the indexes themselves.

6.3.1. A simple example

In the example below, the query will use a `Person(firstname)` index, if it exists.

Query

```
MATCH (person:Person { firstname: 'Andy' })
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+--------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Order                 | Variables | Other              |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+--------------------+
| +ProduceResults |              1 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC | person    |                    |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+--------------------+
| +NodeIndexSeek  |              1 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC | person    | :Person(firstname) |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+--------------------+

Total database accesses: 2
```

6.3.2. Equality check using `WHERE` (single-property index)

A query containing equality comparisons of a single indexed property in the `WHERE` clause is backed automatically by the index. It is also possible for a query with multiple `OR` predicates to use multiple indexes, if indexes exist on the properties. For example, if indexes exist on both `:Label(p1)` and `:Label(p2)`, `MATCH (n:Label) WHERE n.p1 = 1 OR n.p2 = 2 RETURN n` will use both indexes.

Query

```
MATCH (person:Person)
WHERE person.firstname = 'Andy'
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+--------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Order                | Variables | Other              |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+--------------------+
| +ProduceResults |              1 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC | person    |                    |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+--------------------+
| +NodeIndexSeek  |              1 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC | person    | :Person(firstname) |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+--------------------+

Total database accesses: 2
```

6.3.3. Equality check using WHERE (composite index)

A query containing equality comparisons for all the properties of a composite index will automatically be backed by the same index. However, the query does not need to have equality on all properties. It can have ranges and existence predicates as well. But in these cases rewrites might happen depending on which properties have which predicates, see composite index limitations. The following query will use the composite index defined earlier:

Query

```
MATCH (n:Person)
WHERE n.age = 35 AND n.country = 'UK'
RETURN n
```

However, the query `MATCH (n:Person) WHERE n.age = 35 RETURN n` will not be backed by the composite index, as the query does not contain a predicate on the `country` property. It will only be backed by an index on the `Person` label and `age` property defined thus: `:Person(age)`; i.e. a single-property index.

Result

```
+-----------------------------------------------------------------------------------------+
| n                                                                                       |
+-----------------------------------------------------------------------------------------+
| Node[0]{country:"UK",highScore:54321,firstname:"John",surname:"Smith",name:"john",age:35} |
+-----------------------------------------------------------------------------------------+
1 row
```

6.3.4. Range comparisons using WHERE (single-property index)

Single-property indexes are also automatically used for inequality (range) comparisons of an indexed property in the WHERE clause.

Query

```
MATCH (person:Person)
WHERE person.firstname > 'B'
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order                | Variables | Other                               |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+
| +ProduceResults       |              1 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC | person    |                                     |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+
| +NodeIndexSeekByRange |              1 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC | person    | :Person(firstname) > $  AUTOSTRING0 |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+

Total database accesses: 2
```

6.3.5. Range comparisons using `WHERE` (composite index)

Composite indexes are also automatically used for inequality (range) comparisons of indexed properties in the `WHERE` clause. Equality or list membership check predicates may precede the range predicate. However, predicates after the range predicate may be rewritten as an existence check predicate and a filter as described in composite index limitations.

Query

```
MATCH (person:Person)
WHERE person.firstname > 'B' AND person.highScore > 10000
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------------------------------+-----------
+-------------------------------------------------------+
| Operator                     | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Order                                       | Variables | Other
|
+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------------------------------+-----------
+-------------------------------------------------------+
| +ProduceResults              |              0 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC, person.highScore ASC | person    |
|
| |                            +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------------------------------+-----------
+-------------------------------------------------------+
| +Filter                      |              0 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC, person.highScore ASC | person    | cache[person.highScore] > $`  AUTOINT1`
|
| |                            +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------------------------------+-----------
+-------------------------------------------------------+
| +NodeIndexSeek(range,exists) |              0 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC, person.highScore ASC | person    | :Person(firstname,highScore),
cache[person.highScore] |
+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------------------------------+-----------
+-------------------------------------------------------+

Total database accesses: 2
```

6.3.6. Multiple range comparisons using WHERE (single-property index)

When the WHERE clause contains multiple inequality (range) comparisons for the same property, these can be combined in a single index range seek.

Query

```
MATCH (person:Person)
WHERE 10000 < person.highScore < 20000
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------
+----------------------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order               | Variables | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------
+----------------------------------------------------------------------+
| +ProduceResults       |              1 |    1 |       0 |               0 |                 0 |
0.0000 | person.highScore ASC | person    |
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------
+----------------------------------------------------------------------+
| +NodeIndexSeekByRange |              1 |    1 |       2 |               0 |                 0 |
0.0000 | person.highScore ASC | person    | :Person(highScore) > $  AUTOINT1 AND :Person(highScore) < $
AUTOINT0 |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------
+----------------------------------------------------------------------+

Total database accesses: 2
```

6.3.7. Multiple range comparisons using WHERE (composite index)

When the `WHERE` clause contains multiple inequality (range) comparisons for the same property, these can be combined in a single index range seek. That single range seek created in the following query will then use the composite index `Person(highScore, name)` if it exists.

Query

```
MATCH (person:Person)
WHERE 10000 < person.highScore < 20000 AND EXISTS (person.name)
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+-------------------------+
| Operator                      | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Variables | Other                   |
+-------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+-------------------------+
| +ProduceResults               |              1 |    1 |       0 |               0 |                 0 |
0.0000 | person    |                         |
| |                             +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+-------------------------+
| +NodeIndexSeek(range,exists) |              1 |    1 |       2 |               0 |                 0 |
0.0000 | person    | :Person(highScore,name) |
+-------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+-------------------------+

Total database accesses: 2
```

6.3.8. List membership check using `IN` (single-property index)

The `IN` predicate on `person.firstname` in the following query will use the single-property index `Person(firstname)` if it exists.

Query

```
MATCH (person:Person)
WHERE person.firstname IN ['Andy', 'John']
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables | Other              |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+
| +ProduceResults |             24 |    2 |       0 |               0 |                 0 |
0.0000 | person    |                    |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+
| +NodeIndexSeek  |             24 |    2 |       4 |               0 |                 0 |
0.0000 | person    | :Person(firstname) |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+

Total database accesses: 4
```

6.3.9. List membership check using `IN` (composite index)

The `IN` predicates on `person.age` and `person.country` in the following query will use the composite index `Person(age, country)` if it exists.

Query

```
MATCH (person:Person)
WHERE person.age IN [10, 20, 35] AND person.country IN ['Sweden', 'USA', 'UK']
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+------------------------------------+----------------+------+---------+-----------------
+-------------------+----------------------+-----------+----------------------+
| Operator                           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache
Misses | Page Cache Hit Ratio | Variables | Other                |
+------------------------------------+----------------+------+---------+-----------------
+-------------------+----------------------+-----------+----------------------+
| +ProduceResults                    |            451 |    1 |       0 |               0 |
0 |               0.0000 | person    |                      |
| |                                  +----------------+------+---------+-----------------
+-------------------+----------------------+-----------+----------------------+
| +NodeIndexSeek(equality,equality) |            451 |    1 |      10 |               0 |
0 |               0.0000 | person    | :Person(age,country) |
+------------------------------------+----------------+------+---------+-----------------
+-------------------+----------------------+-----------+----------------------+

Total database accesses: 10
```

6.3.10. Prefix search using `STARTS WITH` (single-property index)

The `STARTS WITH` predicate on `person.firstname` in the following query will use the `Person(firstname)` index, if it exists.

Query

```
MATCH (person:Person)
WHERE person.firstname STARTS WITH 'And'
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------
+------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order                | Variables | Other                                          |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------
+------------------------------------------------+
| +ProduceResults       |              2 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC | person    |                                                |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------
+------------------------------------------------+
| +NodeIndexSeekByRange |              2 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC | person    | :Person(firstname STARTS WITH $`  AUTOSTRING0`) |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------
+------------------------------------------------+

Total database accesses: 2
```

6.3.11. Prefix search using `STARTS WITH` (composite index)

The `STARTS WITH` predicate on `person.firstname` in the following query will use the `Person(firstname,surname)` index, if it exists. Any (non-existence check) predicate on `person.surname` will be rewritten as existence check with a filter. However, if the predicate on `person.firstname` is a equality check then a `STARTS WITH` on `person.surname` would also use the index (without rewrites). More information about how the rewriting works can be found in composite index limitations.

Query

```
MATCH (person:Person)
WHERE person.firstname STARTS WITH 'And' AND EXISTS (person.surname)
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+----------------------------+
| Operator                     | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Variables | Other                      |
+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+----------------------------+
| +ProduceResults              |              1 |    1 |       0 |               0 |                 0 |
0.0000 | person    |                            |
| |                            +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+----------------------------+
| +NodeIndexSeek(range,exists) |              1 |    1 |       2 |               0 |                 0 |
0.0000 | person    | :Person(firstname,surname) |
+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+----------------------------+

Total database accesses: 2
```

6.3.12. Suffix search using `ENDS WITH` (single-property index)

The `ENDS WITH` predicate on `person.firstname` in the following query will use the `Person(firstname)` index, if it exists. All values stored in the `Person(firstname)` index will be searched, and entries ending with `'hn'` will be returned. This means that although the search will not be optimized to the extent of queries using `=`, `IN`, `>`, `<` or `STARTS WITH`, it is still faster than not using an index in the first place. Composite indexes are currently not able to support `ENDS WITH`.

Query

```
MATCH (person:Person)
WHERE person.firstname ENDS WITH 'hn'
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+-------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order                | Variables | Other                               |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+-------------------------------------+
| +ProduceResults       |              2 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC | person    |                                     |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+-------------------------------------+
| +NodeIndexEndsWithScan |              2 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC | person    | :Person(firstname); $`  AUTOSTRING0` |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+-----------+-------------------------------------+

Total database accesses: 2
```

6.3.13. Suffix search using `ENDS WITH` (composite index)

The `ENDS WITH` predicate on `person.surname` in the following query will use the `Person(surname,age)` index, if it exists. However, it will be rewritten as existence check and a filter due to the index not supporting actual suffix searches for composite indexes, this is still faster than not using an index in the first place. Any (non-existence check) predicate on `person.age` will also be rewritten as existence check with a filter. More information about how the rewriting works can be found in composite index limitations.

Query

```
MATCH (person:Person)
WHERE person.surname ENDS WITH '300' AND EXISTS (person.age)
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables | Other                                                 |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| +ProduceResults |             11 |    1 |       0 |               0 |                 0 |
0.0000 | person    |                                                     |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| +Filter         |             11 |    1 |       0 |               0 |                 0 |
0.0000 | person    | cache[person.surname] ENDS WITH $`  AUTOSTRING0` |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| +NodeIndexScan  |            106 |  303 |     304 |               0 |                 0 |
0.0000 | person    | :Person(surname,age), cache[person.surname]      |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+

Total database accesses: 304
```

6.3.14. Substring search using `CONTAINS` (single-property index)

The `CONTAINS` predicate on `person.firstname` in the following query will use the `Person(firstname)` index, if it exists. All values stored in the `Person(firstname)` index will be searched, and entries containing `'h'` will be returned. This means that although the search will not be optimized to the extent of queries using `=`, `IN`, `>`, `<` or `STARTS WITH`, it is still faster than not using an index in the first place. Composite indexes are currently not able to support `CONTAINS`.

Query

```
MATCH (person:Person)
WHERE person.firstname CONTAINS 'h'
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order                | Variables | Other                               |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+
| +ProduceResults       |              2 |    1 |       0 |               0 |                 0 |
0.0000 | person.firstname ASC | person    |                                     |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+
| +NodeIndexContainsScan |              2 |    1 |       2 |               0 |                 0 |
0.0000 | person.firstname ASC | person    | :Person(firstname); $`  AUTOSTRING0` |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+-----------+-------------------------------------+

Total database accesses: 2
```

6.3.15. Substring search using `CONTAINS` (composite index)

The `CONTAINS` predicate on `person.surname` in the following query will use the `Person(surname,age)` index, if it exists. However, it will be rewritten as existence check and a filter due to the index not supporting actual suffix searches for composite indexes, this is still faster than not using an index in the first place. Any (non-existence check) predicate on `person.age` will also be rewritten as existence check with a filter. More information about how the rewriting works can be found in composite index limitations.

Query

```
MATCH (person:Person)
WHERE person.surname CONTAINS '300' AND EXISTS (person.age)
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables | Other                                           |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| +ProduceResults |             11 |    1 |       0 |               0 |                 0 |
0.0000 | person    |                                                   |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| +Filter         |             11 |    1 |       0 |               0 |                 0 |
0.0000 | person    | cache[person.surname] CONTAINS $`  AUTOSTRING0` |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+
| +NodeIndexScan  |            106 |  303 |     304 |               0 |                 0 |
0.0000 | person    | :Person(surname,age), cache[person.surname]     |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------------------------------+

Total database accesses: 304
```

6.3.16. Existence check using `exists` (single-property index)

The `exists(p.firstname)` predicate in the following query will use the `Person(firstname)` index, if it exists.

Query

```
MATCH (p:Person)
WHERE EXISTS (p.firstname)
RETURN p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables | Other              |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+
| +ProduceResults |              2 |    2 |       0 |               0 |                 0 |
0.0000 | p         |                    |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+
| +NodeIndexScan  |              2 |    2 |       3 |               0 |                 0 |
0.0000 | p         | :Person(firstname) |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------+

Total database accesses: 3
```

6.3.17. Existence check using `exists` (composite index)

The `exists(p.firstname)` and `exists(p.surname)` predicate in the following query will use the `Person(firstname,surname)` index, if it exists. Any (non-existence check) predicate on `person.surname` will be rewritten as existence check with a filter.

Query

```
MATCH (p:Person)
WHERE EXISTS (p.firstname) AND EXISTS (p.surname)
RETURN p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables | Other                       |
+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------+
| +ProduceResults |              1 |    2 |       0 |               0 |                 0 |
0.0000 | p         |                             |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------+
| +NodeIndexScan  |              1 |    2 |       3 |               0 |                 0 |
0.0000 | p         | :Person(firstname,surname) |
+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------------------+

Total database accesses: 3
```

6.3.18. Spatial distance searches (single-property index)

If a property with point values is indexed, the index is used for spatial distance searches as well as for range queries.

Query

```
MATCH (p:Person)
WHERE distance(p.location, point({ x: 1, y: 2 }))< 2
RETURN p.location
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------
+--------------------------------------------------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables        | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------
+--------------------------------------------------------------------------------------------------+
| +ProduceResults       |              0 |    9 |       0 |               0 |                 0 |
0.0000 | p, p.location   |
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------
+--------------------------------------------------------------------------------------------------+
| +Projection           |              0 |    9 |       0 |               0 |                 0 |
0.0000 | p.location -- p | {p.location : cache[p.location]}
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------
+--------------------------------------------------------------------------------------------------+
| +Filter               |              0 |    9 |       0 |               0 |                 0 |
0.0000 | p               | distance(cache[p.location], point({x: $`  AUTOINT0`, y: $`  AUTOINT1`})) < $`
AUTOINT2`          |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------
+--------------------------------------------------------------------------------------------------+
| +NodeIndexSeekByRange |              0 |    9 |      10 |               0 |                 0 |
0.0000 | p               | :Person(location) WHERE distance(_,point(x,y)) < Parameter(  AUTOINT2,Integer),
cache[p.location] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------
+--------------------------------------------------------------------------------------------------+

Total database accesses: 10
```

6.3.19. Spatial distance searches (composite index)

If a property with point values is indexed, the index is used for spatial distance searches as well as for range queries. Any following (non-existence check) predicates (here on property `p.name` for index `:Person(place,name)`) will be rewritten as existence check with a filter.

Query

```
MATCH (p:Person)
WHERE distance(p.place, point({ x: 1, y: 2 }))< 2 AND EXISTS (p.name)
RETURN p.place
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-------------------------------+-----------------+-------+----------+------------------+-------------------
+----------------------+--------------
+------------------------------------------------------------------------------------+
| Operator                      | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Variables     | Other
|
+-------------------------------+-----------------+-------+----------+------------------+-------------------
+----------------------+--------------
+------------------------------------------------------------------------------------+
| +ProduceResults               |              69 |     9 |        0 |                0 |                 0 |
0.0000 | p, p.place    |
|
| |                             +-----------------+-------+----------+------------------+-------------------
+----------------------+--------------
+------------------------------------------------------------------------------------+
| +Projection                   |              69 |     9 |        0 |                0 |                 0 |
0.0000 | p.place -- p | {p.place : cache[p.place]}
|
| |                             +-----------------+-------+----------+------------------+-------------------
+----------------------+--------------
+------------------------------------------------------------------------------------+
| +Filter                       |              69 |     9 |        0 |                0 |                 0 |
0.0000 | p            | distance(cache[p.place], point({x: $`  AUTOINT0`, y: $`  AUTOINT1`})) < $`
AUTOINT2` |
| |                             +-----------------+-------+----------+------------------+-------------------
+----------------------+--------------
+------------------------------------------------------------------------------------+
| +NodeIndexSeek(range,exists) |              69 |     9 |       10 |                0 |                 0 |
0.0000 | p            | :Person(place,name), cache[p.place]
|
+-------------------------------+-----------------+-------+----------+------------------+-------------------
+----------------------+--------------
+------------------------------------------------------------------------------------+

Total database accesses: 10
```

6.3.20. Spatial bounding box searches (single-property index)

The ability to do index seeks on bounded ranges works even with the 2D and 3D spatial `Point` types.

Query

```
MATCH (person:Person)
WHERE point({ x: 1, y: 5 })< person.location < point({ x: 2, y: 6 })
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------
+-----------------------------------------------------------------------------------------------------------
--------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------
+-----------------------------------------------------------------------------------------------------------
--------------------+
| +ProduceResults       |              0 |    1 |       0 |               0 |                 0 |
0.0000 | person    |
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------
+-----------------------------------------------------------------------------------------------------------
--------------------+
| +NodeIndexSeekByRange |              0 |    1 |       2 |               0 |                 0 |
0.0000 | person    | :Person(location) > point({x: $  AUTOINT2, y: $  AUTOINT3}) AND :Person(location) <
point({x: $  AUTOINT0, y: $  AUTOINT1}) |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------
+-----------------------------------------------------------------------------------------------------------
--------------------+

Total database accesses: 2
```

6.3.21. Spatial bounding box searches (composite index)

The ability to do index seeks on bounded ranges works even with the 2D and 3D spatial `Point` types. Any following (non-existence check) predicates (here on property `p.firstname` for index `:Person(place,firstname)`) will be rewritten as existence check with a filter. For index `:Person(firstname,place)`, if the predicate on `firstname` is equality or list membership then the bounded range is handled as a range itself. If the predicate on `firstname` is anything else then the bounded range is rewritten to existence and filter.

Query

```
MATCH (person:Person)
WHERE point({ x: 1, y: 5 })< person.place < point({ x: 2, y: 6 }) AND EXISTS (person.firstname)
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-------------------------------+-----------------+------+---------+------------------+-------------------
+----------------------+-----------+--------------------------+
| Operator                      | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Variables | Other                    |
+-------------------------------+-----------------+------+---------+------------------+-------------------
+----------------------+-----------+--------------------------+
| +ProduceResults               |               0 |    1 |       0 |                0 |                 0 |
0.0000 | person    |                          |
| |                             +-----------------+------+---------+------------------+-------------------
+----------------------+-----------+--------------------------+
| +NodeIndexSeek(range,exists) |               0 |    1 |       2 |                0 |                 0 |
0.0000 | person    | :Person(place,firstname) |
+-------------------------------+-----------------+------+---------+------------------+-------------------
+----------------------+-----------+--------------------------+

Total database accesses: 2
```

6.4. Basic query tuning example

We'll start with a basic example to help you get the hang of profiling queries. The following examples will use a movies data set.

Let's start by importing the data:

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/query-tuning/movies.csv' AS line
MERGE (m:Movie { title: line.title })
ON CREATE SET m.released = toInteger(line.released), m.tagline = line.tagline
```

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/query-tuning/actors.csv' AS line
MATCH (m:Movie { title: line.title })
MERGE (p:Person { name: line.name })
ON CREATE SET p.born = toInteger(line.born)
MERGE (p)-[:ACTED_IN { roles:split(line.roles, ';')}]->(m)
```

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/query-tuning/directors.csv' AS
line
MATCH (m:Movie { title: line.title })
MERGE (p:Person { name: line.name })
ON CREATE SET p.born = toInteger(line.born)
MERGE (p)-[:DIRECTED]->(m)
```

Let's say we want to write a query to find **'Tom Hanks'**. The naive way of doing this would be to write the following:

```
MATCH (p { name: 'Tom Hanks' })
RETURN p
```

This query will find the **'Tom Hanks'** node but as the number of nodes in the database increase it will become slower and slower. We can profile the query to find out why that is.

You can learn more about the options for profiling queries in Profiling a query but in this case we're going to prefix our query with `PROFILE`:

```
PROFILE
MATCH (p { name: 'Tom Hanks' })
RETURN p
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables | Other                       |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| +ProduceResults |             16 |    1 |       0 |               0 |                 0 |
0.0000 | p         |                           |
| |             +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| +Filter         |             16 |    1 |     163 |               0 |                 0 |
0.0000 | p         | p.name = $`  AUTOSTRING0` |
| |             +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| +AllNodesScan   |            163 |  163 |     164 |               0 |                 0 |
0.0000 | p         |                           |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+

Total database accesses: 327
```

The first thing to keep in mind when reading execution plans is that you need to read from the bottom up.

In that vein, starting from the last row, the first thing we notice is that the value in the `Rows` column seems high given there is only one node with the name property **'Tom Hanks'** in the database. If we look across to the `Operator` column we'll see that AllNodesScan has been used which means that the query planner scanned through all the nodes in the database.

This seems like an inefficient way of finding **'Tom Hanks'** given that we are looking at many nodes that aren't even people and therefore aren't what we're looking for.

The solution to this problem is that whenever we're looking for a node we should specify a label to help the query planner narrow down the search space. For this query we'd need to add a `Person` label.

```
MATCH (p:Person { name: 'Tom Hanks' })
RETURN p
```

This query will be faster than the first one but as the number of people in our database increase we again notice that the query slows down.

Again we can profile the query to work out why:

```
PROFILE
MATCH (p:Person { name: 'Tom Hanks' })
RETURN p
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables | Other                     |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| +ProduceResults  |             13 |    1 |       0 |               0 |                 0 |
0.0000 | p         |                          |
| |                +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| +Filter          |             13 |    1 |     125 |               0 |                 0 |
0.0000 | p         | p.name = $`  AUTOSTRING0` |
| |                +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+
| +NodeByLabelScan |            125 |  125 |     126 |               0 |                 0 |
0.0000 | p         | :Person                  |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+--------------------------+

Total database accesses: 251
```

This time the `Rows` value on the last row has reduced so we're not scanning some nodes that we were before which is a good start. The NodeByLabelScan operator indicates that we achieved this by first doing a linear scan of all the `Person` nodes in the database.

Once we've done that we again scan through all those nodes using the `Filter` operator, comparing the name property of each one.

This might be acceptable in some cases but if we're going to be looking up people by name frequently then we'll see better performance if we create an index on the `name` property for the `Person` label:

```
CREATE INDEX FOR (p:Person)
ON (p.name)
```

Now if we run the query again it will run more quickly:

```
MATCH (p:Person { name: 'Tom Hanks' })
RETURN p
```

Let's profile the query to see why that is:

```
PROFILE
MATCH (p:Person { name: 'Tom Hanks' })
RETURN p
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Order       | Variables | Other         |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +ProduceResults |              1 |    1 |       0 |               0 |                 0 |
0.0000 | p.name ASC | p         |               |
| |             +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +NodeIndexSeek  |              1 |    1 |       2 |               0 |                 0 |
0.0000 | p.name ASC | p         | :Person(name) |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+

Total database accesses: 2
```

Our execution plan is down to a single row and uses the Node Index Seek operator which does an index seek (see Indexes for search performance) to find the appropriate node.

6.5. Advanced query tuning example

This section describes some more subtle optimizations based on new native index capabilities

6.5.1. Introduction

One of the most important and useful ways of optimizing Cypher queries involves creating appropriate indexes. This is described in more detail in Indexes for search performance, and demonstrated in Basic query tuning example. In summary, an index will be based on the combination of a `Label` and a `property`. Any Cypher query that searches for nodes with a specific label and some predicate on the property (equality, range or existence) will be planned to use the index if the cost planner deems that to be the most efficient solution.

In order to benefit from enhancements provided by native indexes, it is useful to understand when *index-backed property lookup* and *index-backed order by* will come into play. In Neo4j 3.4 and earlier, the fact that the index contains the property value, and the results are returned in a specific order, was not used improve the performance of any later part of the query that might depend on the property value or result order.

Let's explain how to use these features with a more advanced query tuning example.

If you are upgrading an existing store to 4.0.0, it may be necessary to drop and re-create existing indexes. For information on native index support and upgrade considerations regarding indexes, see Operations Manual Indexes.

6.5.2. The data set

In this example we will demonstrate the impact native indexes can have on query performance under certain conditions. We'll use a movies dataset to illustrate this more advanced query tuning.

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/query-tuning/movies.csv' AS line
MERGE (m:Movie { title: line.title })
ON CREATE SET m.released = toInteger(line.released), m.tagline = line.tagline
```

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/query-tuning/actors.csv' AS line
MATCH (m:Movie { title: line.title })
MERGE (p:Person { name: line.name })
ON CREATE SET p.born = toInteger(line.born)
MERGE (p)-[:ACTED_IN { roles:split(line.roles, ';')}]->(m)
```

```
LOAD CSV WITH HEADERS FROM 'https://neo4j.com/docs/cypher-manual/4.0/csv/query-tuning/directors.csv' AS
line
MATCH (m:Movie { title: line.title })
MERGE (p:Person { name: line.name })
ON CREATE SET p.born = toInteger(line.born)
MERGE (p)-[:DIRECTED]->(m)
```

```
CREATE INDEX FOR (p:Person)
ON (p.name)
```

```
CALL db.awaitIndexes
```

```
CALL db.indexes
```

```
+-----------------------------------------------------------------------------------------------------------
------------------------------------+
| id | name              | state    | populationPercent | uniqueness  | type    | entityType |
labelsOrTypes | properties | provider           |
+-----------------------------------------------------------------------------------------------------------
------------------------------------+
| 1  | "index_5c0607ad" | "ONLINE" | 100.0             | "NONUNIQUE" | "BTREE" | "NODE"     | ["Person"]
| ["name"]   | "native-btree-1.0" |
+-----------------------------------------------------------------------------------------------------------
------------------------------------+
1 row
```

6.5.3. Index-backed property-lookup

Let's say we want to write a query to find persons with the name 'Tom' that acted in a movie.

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name STARTS WITH 'Tom'
RETURN p.name, count(m)
```

```
+---------------------------+
| p.name         | count(m) |
+---------------------------+
| "Tom Cruise"   | 3        |
| "Tom Hanks"    | 12       |
| "Tom Skerritt" | 1        |
+---------------------------+
3 rows
```

We have asked the database to return all the actors with the first name 'Tom'. There are three of them: *'Tom Cruise'*, *'Tom Skerritt'* and *'Tom Hanks'*. In previous versions of Neo4j, the final clause `RETURN p.name` would cause the database to take the node `p` and look up its properties and return the value of the property `name`. With native indexes, however, we can leverage the fact that indexes store the property values. In this case, it means that the names can be looked up directly from the index. This allows Cypher to avoid the second call to the database to find the property, which can save time on very large queries.

If we profile the above query, we see that the `NodeIndexScan` in the `Variables` column contains `cache[p.name]`, which means that `p.name` is retrieved from the index. We can also see that the `Projection` has no `DB Hits`, which means it does not have to access the database again.

```
PROFILE
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name STARTS WITH 'Tom'
RETURN p.name, count(m)
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order      | Variables         | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+
| +ProduceResults       |              1 |    3 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count(m), p.name |                                                            |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+
| +OrderedAggregation   |              1 |    3 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count(m), p.name | p.name                                                     |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+
| +Filter               |              1 |   16 |      16 |               0 |                 0 |
0.0000 | p.name ASC | anon[17], m, p   | m:Movie                                                    |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+
| +Expand(All)          |              1 |   16 |      20 |               0 |                 0 |
0.0000 | p.name ASC | anon[17], m -- p | (p)-[:ACTED_IN]->(m)                                       |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+
| +NodeIndexSeekByRange |              1 |    4 |       5 |               0 |                 0 |
0.0000 | p.name ASC | p                | :Person(name STARTS WITH $`  AUTOSTRING0`), cache[p.name] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------
+------------------------------------------------------------+

Total database accesses: 41
```

If we change the query, such that it can no longer use an index, we will see that there will be no `cache[p.name]` in the Variables, and that the `Projection` now has `DB Hits`, since it accesses the database again to retrieve the name.

```
PROFILE
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
RETURN p.name, count(m)
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables         | Other                |
+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+
| +ProduceResults   |             13 |  102 |       0 |               0 |                 0 |
0.0000 | count(m), p.name |                      |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+
| +EagerAggregation |             13 |  102 |     172 |               0 |                 0 |
0.0000 | count(m), p.name | p.name               |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+
| +Filter           |            172 |  172 |     172 |               0 |                 0 |
0.0000 | anon[17], m, p   | p:Person             |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+
| +Expand(All)      |            172 |  172 |     210 |               0 |                 0 |
0.0000 | anon[17], p -- m | (m)<-[:ACTED_IN]-(p) |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+
| +NodeByLabelScan  |             38 |   38 |      39 |               0 |                 0 |
0.0000 | m                | :Movie               |
+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------+----------------------+

Total database accesses: 593
```

It is important to note that not all property types are supported, because not all are supported by native indexes. Additionally, some property types such as the spatial type `Point`, are indexed in an index that is designed to be approximate and cannot return the values. For non-native indexes and the spatial type `Point`, there will still be a second database access to retrieve those values. In indexes with mixed values, only those values that cannot be looked up from the index will trigger another database access action.

Predicates that can be used to enable this optimization are:

- Existence (`WHERE exists(n.name)`)
- Equality (e.g. `WHERE n.name = 'Tom Hanks'`)
- Range (eg. `WHERE n.uid > 1000 AND n.uid < 2000`)
- Prefix (eg. `WHERE n.name STARTS WITH 'Tom'`)
- Suffix (eg. `WHERE n.name ENDS WITH 'Hanks'`)
- Substring (eg. `WHERE n.name CONTAINS 'a'`)
- Several predicates of the above types combined using `OR`, given that all of them are on the same property (eg. `WHERE n.prop < 10 OR n.prop = 'infinity'`)

If there is an existence constraint on the property, no predicate is required to trigger the optimization. For example, `CREATE CONSTRAINT constraint_name ON (p:Person) ASSERT exists(p.name)`

Aggregating functions

For all built-in aggregating functions in Cypher, the *index-backed property-lookup* optimization can be used even without a predicate. Consider this query which returns the number of distinct names of people in the movies dataset:

```
PROFILE
MATCH (p:Person)
RETURN count(DISTINCT p.name) AS numberOfNames
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------+-----------------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables      | Other                       |
+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------+-----------------------------+
| +ProduceResults   |              1 |    1 |       0 |               0 |                 0 |
0.0000 | numberOfNames |                             |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+---------------+-----------------------------+
| +EagerAggregation |              1 |    1 |       0 |               0 |                 0 |
0.0000 | numberOfNames |                             |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+---------------+-----------------------------+
| +NodeIndexScan    |            125 |  125 |     126 |               0 |                 0 |
0.0000 | p             | :Person(name), cache[p.name] |
+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------+-----------------------------+

Total database accesses: 126
```

Note that the `NodeIndexScan` in the `Variables` column contains `cache[p.name]` and that the `EagerAggregation` has no `DB Hits`. In this case, the semantics of aggregating functions works like an implicit existence constraint because `Person` nodes without the property `name` will not affect the result of an aggregation.

6.5.4. Index-backed order by

Now consider the following refinement to the query:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name STARTS WITH 'Tom'
RETURN p.name, count(m)
ORDER BY p.name
```

```
+--------------------------+
| p.name         | count(m) |
+--------------------------+
| "Tom Cruise"   | 3        |
| "Tom Hanks"    | 12       |
| "Tom Skerritt" | 1        |
+--------------------------+
3 rows
```

We are asking for the results in ascending alphabetical order. The native index happens to store String properties in ascending alphabetical order, and Cypher knows this. In Neo4j 3.4 and earlier, Cypher would plan a `Sort` operation to sort the results, which means building a collection in memory and running a sort algorithm on it. For large result sets this can be expensive in terms of both memory and time. If you are using the native index, Cypher will recognise that the index already returns data in the correct order, and skip the `Sort` operation.

Indexes storing values of the spatial type `Point`, and non-native indexes, cannot be relied on to return the values in the correct order. This means that for Cypher to enable this optimization, the query needs a predicate that limits the type of the property to some type that is guaranteed to be in the right order.

To demonstrate this effect, let's remove the String prefix predicate so that Cypher no longer knows the type of the property, and replace it with an existence predicate. Now the database can no longer guarantee the order. If we profile the query we will see the `Sort` operation:

```
PROFILE
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
USING INDEX p:Person(name)
WHERE EXISTS (p.name)
RETURN p.name, count(m)
ORDER BY p.name
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Order      | Variables        | Other                        |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| +ProduceResults    |             13 |  102 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count(m), p.name |                              |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| +Sort              |             13 |  102 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count(m), p.name | p.name                       |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| +EagerAggregation  |             13 |  102 |       0 |               0 |                 0 |
0.0000 |            | count(m), p.name | p.name                       |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| +Filter            |            172 |  172 |     172 |               0 |                 0 |
0.0000 |            | anon[17], m, p   | m:Movie                      |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| +Expand(All)       |            172 |  172 |     297 |               0 |                 0 |
0.0000 |            | anon[17], m -- p | (p)-[:ACTED_IN]->(m)         |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+
| +NodeIndexScan     |            125 |  125 |     126 |               0 |                 0 |
0.0000 |            | p                | :Person(name), cache[p.name] |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------+------------------------------+

Total database accesses: 595
```

The `Order` column describes the order of rows after each operator. We see that the order is undefined until the `Sort` operator. Now if we add back the predicate that gives us the property type information, we will see the `Sort` operation is no longer there:

```
PROFILE
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name STARTS WITH 'Tom'
RETURN p.name, count(m)
ORDER BY p.name
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order      | Variables         | Other
|
+-----------------------+-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+
| +ProduceResults       |               1 |     3 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count(m), p.name |                                                          |
| |                     +-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+
| +OrderedAggregation   |               1 |     3 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count(m), p.name | p.name                                                   |
| |                     +-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+
| +Filter               |               1 |    16 |      16 |               0 |                 0 |
0.0000 | p.name ASC | anon[17], m, p   | m:Movie                                                  |
| |                     +-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+
| +Expand(All)          |               1 |    16 |      20 |               0 |                 0 |
0.0000 | p.name ASC | anon[17], m -- p | (p)-[:ACTED_IN]->(m)                                     |
| |                     +-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+
| +NodeIndexSeekByRange |               1 |     4 |       5 |               0 |                 0 |
0.0000 | p.name ASC | p                | :Person(name STARTS WITH $`  AUTOSTRING0`), cache[p.name] |
+-----------------------+-----------------+-------+---------+-----------------+-------------------
+----------------------+------------+-----------------
+----------------------------------------------------------+

Total database accesses: 41
```

We also see that the `Order` column contains `p.name ASC` from the index seek operation, meaning that the rows are ordered by `p.name` in ascending order.

Index-backed order by can also be used for queries that expect their results is descending order, but with slightly lower performance.

> In cases where the Cypher planner is unable to remove the `Sort` operator, like in the first example, the planner can utilize knowledge of *required order* after each operator to plan the `Sort` operator at a point in the plan with optimal cardinality.

`min()` and `max()`

For the `min` and `max` functions, the *index-backed order by* optimization can be used to avoid aggregation and instead utilize the fact that the minimum/maximum value is the first/last one in a sorted index. Consider the following query which returns the fist actor in alphabetical order:

```
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name STARTS WITH ''
RETURN min(p.name) AS name
```

```
+-----------------+
| name            |
+-----------------+
| "Aaron Sorkin" |
+-----------------+
1 row
```

To demonstrate the effect of *index-backed order by*, let's remove the String prefix predicate so that Cypher no longer knows the type of the property, and replace it with an existence predicate. Now the database can no longer guarantee the order. If we profile the query we will see the `EagerAggregation` operation:

```
PROFILE
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
USING INDEX p:Person(name)
WHERE EXISTS (p.name)
RETURN min(p.name) AS name
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables        | Other                           |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+
| +ProduceResults    |              1 |    1 |       0 |               0 |                 0 |
0.0000 | name             |                             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+
| +EagerAggregation |              1 |    1 |       0 |               0 |                 0 |
0.0000 | name             |                             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+
| +Filter            |            172 |  172 |     172 |               0 |                 0 |
0.0000 | anon[17], m, p   | m:Movie                     |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+
| +Expand(All)       |            172 |  172 |     297 |               0 |                 0 |
0.0000 | anon[17], m -- p | (p)-[:ACTED_IN]->(m)        |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+
| +NodeIndexScan     |            125 |  125 |     126 |               0 |                 0 |
0.0000 | p                | :Person(name), cache[p.name] |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------+-----------------------------+

Total database accesses: 595
```

Now if we add back the predicate that gives us the property type information, we will see that the `EagerAggregation` operation gets replaced by `Projection` followed by `Limit` followed by `Optional`:

```
PROFILE
MATCH (p:Person)-[:ACTED_IN]->(m:Movie)
WHERE p.name STARTS WITH ''
RETURN min(p.name) AS name
```

```
Compiler CYPHER 4.0

Planner COST

Runtime INTERPRETED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order      | Variables              | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +ProduceResults       |              1 |    1 |       0 |               0 |                 0 |
0.0000 | name ASC   | anon[17], m, name, p   |                                                    |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +Optional             |              1 |    1 |       0 |               0 |                 0 |
0.0000 | name ASC   | anon[17], m, name, p   |                                                    |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +Limit                |              1 |    1 |       0 |               0 |                 0 |
0.0000 | name ASC   | anon[17], m, name, p   | 1                                                  |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +Projection           |              1 |    1 |       0 |               0 |                 0 |
0.0000 | name ASC   | name -- anon[17], m, p | {name : cache[p.name]}                             |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +Filter               |              1 |    1 |       1 |               0 |                 0 |
0.0000 | p.name ASC | anon[17], m, p         | m:Movie                                            |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +Expand(All)          |              1 |    1 |       2 |               0 |                 0 |
0.0000 | p.name ASC | anon[17], m -- p       | (p)-[:ACTED_IN]->(m)                               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+
| +NodeIndexSeekByRange |              1 |    1 |       2 |               0 |                 0 |
0.0000 | p.name ASC | p                      | :Person(name STARTS WITH $`  AUTOSTRING0`), cache[p.name] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------------------
+----------------------------------------------------------+

Total database accesses: 5
```

In the first case, all nodes in the index are scanned to find the name that is first in alphabetic order. In the second case, we will simply pick the first value from the index. This is reflected in the fact that the `total database access` is lower, indicating a faster query. For large datasets, this can improve performance dramatically.

Index-backed order by can also be used for corresponding queries with the `max` function, but with slightly lower performance.

Restrictions

The optimization can only work on native indexes, and only if we query for a specific type, in order to rule out the spatial type `Point`. Predicates that can be used to enable this optimization are:

- Equality (e.g. `WHERE n.name = 'Tom Hanks'`)
- Range (eg. `WHERE n.uid > 1000 AND n.uid < 2000`)

* Prefix (eg. `WHERE n.name STARTS WITH 'Tom'`)
* Suffix (eg. `WHERE n.name ENDS WITH 'Hanks'`)
* Substring (eg. `WHERE n.name CONTAINS 'a'`)

Predicates that will not work:

* Several predicates combined using `OR` because the property type might differ between the predicates
* Existence (eg. `WHERE exists(n.email)`) because no property type information is given

An existence constraint does not include any type information either and will thus not be enough to trigger *index-backed order by*.

6.6. Planner hints and the USING keyword

A planner hint is used to influence the decisions of the planner when building an execution plan for a query. Planner hints are specified in a query with the `USING` keyword.

Forcing planner behavior is an advanced feature, and should be used with caution by experienced developers and/or database administrators only, as it may cause queries to perform poorly.

* Introduction
* Index hints
* Scan hints
* Join hints
* `PERIODIC COMMIT` query hint

6.6.1. Introduction

When executing a query, Neo4j needs to decide where in the query graph to start matching. This is done by looking at the `MATCH` clause and the `WHERE` conditions and using that information to find useful indexes, or other starting points.

However, the selected index might not always be the best choice. Sometimes multiple indexes are possible candidates, and the query planner picks the suboptimal one from a performance point of view. Moreover, in some circumstances (albeit rarely) it is better not to use an index at all.

Neo4j can be forced to use a specific starting point through the `USING` keyword. This is called giving a planner hint. There are four types of planner hints: index hints, scan hints, join hints, and the `PERIODIC COMMIT` query hint.

The following graph is used for the examples below:

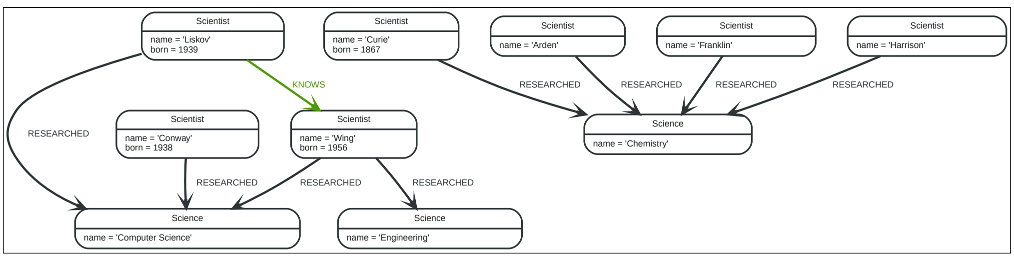


Figure 31. Graph

Query

```
MATCH (liskov:Scientist { name:'Liskov' })-[:KNOWS]->(wing:Scientist)-[:RESEARCHED]->(cs:Science {
name:'Computer Science' })<-[:RESEARCHED]-(conway:Scientist { name: 'Conway' })
RETURN 1 AS column
```

The following query will be used in some of the examples on this page. It has intentionally been constructed in such a way that the statistical information will be inaccurate for the particular subgraph that this query matches. For this reason, it can be improved by supplying planner hints.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order           | Variables
| Other                                 |
+-------------------+----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| +ProduceResults   |              0 |    1 |       0 |     0.147 | conway.name ASC | anon[126], anon[43],
anon[70], column, conway, cs, liskov, wing    |                                        |
| |                 +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| +Projection       |              0 |    1 |       0 |     0.026 | conway.name ASC | column -- anon[126],
anon[43], anon[70], conway, cs, liskov, wing | {column : $`  AUTOINT3`}               |
| |                 +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| +NodeHashJoin     |              0 |    1 |       0 |     0.820 | conway.name ASC | anon[43], liskov --
anon[126], anon[70], conway, cs, wing          | wing                                    |
| |\                +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| | +Filter         |              0 |    2 |       0 |           |                 | anon[126], anon[70],
conway, cs, wing                             | not `anon[126]` = `anon[70]`           |
| | |               +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| | +Expand(All)    |              0 |    3 |       4 |           | conway.name ASC | anon[70], wing --
anon[126], conway, cs                          | (cs)<-[:RESEARCHED]-(wing)             |
| | |               +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| | +Filter         |              0 |    1 |       3 |           | conway.name ASC | anon[126], conway, cs
| cs.name = $`  AUTOSTRING1`; cs:Science |
| | |               +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| | +Expand(All)    |              0 |    1 |       2 |           | conway.name ASC | anon[126], cs --
conway                                         | (conway)-[:RESEARCHED]->(cs)           |
| | |               +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| | +NodeIndexSeek |              0 |    1 |       2 |           | conway.name ASC | conway
| :Scientist(name)                      |
| |                 +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| +Filter           |              0 |    1 |       1 |           | liskov.name ASC | anon[43], liskov,
wing                                           | wing:Scientist                         |
| |                 +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| +Expand(All)      |              0 |    1 |       3 |           | liskov.name ASC | anon[43], wing --
liskov                                         | (liskov)-[:KNOWS]->(wing)              |
| |                 +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+
| +NodeIndexSeek    |              0 |    1 |       2 |           | liskov.name ASC | liskov
| :Scientist(name)                      |
+-------------------+----------------+------+---------+-----------+-----------------
+------------------------------------------------------------------
+---------------------------------------+

Total database accesses: 17
```

6.6.2. Index hints

Index hints are used to specify which index, if any, the planner should use as a starting point. This can be beneficial in cases where the index statistics are not accurate for the specific values that the query at hand is known to use, which would result in the planner picking a non-optimal index. To supply an index hint, use `USING INDEX variable:Label(property)` or `USING INDEX SEEK variable:Label(property)` after the applicable `MATCH` clause.

It is possible to supply several index hints, but keep in mind that several starting points will require the use of a potentially expensive join later in the query plan.

Query using an index hint

The query above will not naturally pick an index to solve the plan. This is because the graph is very small, and label scans are faster for small databases. In general, however, query performance is ranked by the dbhit metric, and we see that using an index is slightly better for this query.

Query

```
MATCH (liskov:Scientist { name:'Liskov' })-[:KNOWS]->(wing:Scientist)-[:RESEARCHED]->(cs:Science {
name:'Computer Science' })<-[:RESEARCHED]-(conway:Scientist { name: 'Conway' })
USING INDEX liskov:Scientist(name)
RETURN liskov.born AS column
```

Returns the year **'Barbara Liskov'** was born.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order           | Variables
| Other                                 |
+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +ProduceResults   |              0 |    1 |       0 |     0.054 | conway.name ASC | anon[126], anon[43],
anon[70], column, conway, cs, liskov, wing   |                                         |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +Projection       |              0 |    1 |       3 |     0.084 | conway.name ASC | column -- anon[126],
anon[43], anon[70], conway, cs, liskov, wing | {column : liskov.born}                  |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +NodeHashJoin     |              0 |    1 |       0 |     0.082 | conway.name ASC | anon[43], liskov --
anon[126], anon[70], conway, cs, wing         | wing                                     |
| |\                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Filter         |              0 |    2 |       0 |           |                 | anon[126], anon[70],
conway, cs, wing                             | not `anon[126]` = `anon[70]`            |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Expand(All)    |              0 |    3 |       4 |           | conway.name ASC | anon[70], wing --
anon[126], conway, cs                           | (cs)<-[:RESEARCHED]-(wing)              |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Filter         |              0 |    1 |       3 |           | conway.name ASC | anon[126], conway, cs
| cs.name = $`  AUTOSTRING1`; cs:Science |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Expand(All)    |              0 |    1 |       2 |           | conway.name ASC | anon[126], cs --
conway                                          | (conway)-[:RESEARCHED]->(cs)            |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +NodeIndexSeek |              0 |    1 |       2 |           | conway.name ASC | conway
| :Scientist(name)                      |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +Filter           |              0 |    1 |       1 |           | liskov.name ASC | anon[43], liskov,
wing                                            | wing:Scientist                          |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +Expand(All)      |              0 |    1 |       3 |           | liskov.name ASC | anon[43], wing --
liskov                                          | (liskov)-[:KNOWS]->(wing)               |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +NodeIndexSeek    |              0 |    1 |       2 |           | liskov.name ASC | liskov
| :Scientist(name)                      |
+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+

Total database accesses: 20
```

Query using an index seek hint

Similar to the index (scan) hint, but an index seek will be used rather than an index scan. Index seeks require no post filtering, they are most efficient when a relatively small number of nodes have the specified value on the queried property.

Query

```
MATCH (liskov:Scientist { name:'Liskov' })-[:KNOWS]->(wing:Scientist)-[:RESEARCHED]->(cs:Science {
name:'Computer Science' })<-[:RESEARCHED]-(conway:Scientist { name: 'Conway' })
USING INDEX SEEK liskov:Scientist(name)
RETURN liskov.born AS column
```

Returns the year **'Barbara Liskov'** was born.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order           | Variables
| Other                                  |
+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +ProduceResults   |              0 |    1 |       0 |     0.060 | conway.name ASC | anon[126], anon[43],
anon[70], column, conway, cs, liskov, wing    |                                        |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +Projection       |              0 |    1 |       3 |     0.057 | conway.name ASC | column -- anon[126],
anon[43], anon[70], conway, cs, liskov, wing | {column : liskov.born}                 |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +NodeHashJoin     |              0 |    1 |       0 |     0.077 | conway.name ASC | anon[43], liskov --
anon[126], anon[70], conway, cs, wing          | wing                                   |
| |\                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Filter         |              0 |    2 |       0 |           |                 | anon[126], anon[70],
conway, cs, wing                             | not `anon[126]` = `anon[70]`           |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Expand(All)    |              0 |    3 |       4 |           | conway.name ASC | anon[70], wing --
anon[126], conway, cs                            | (cs)<-[:RESEARCHED]-(wing)             |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Filter         |              0 |    1 |       3 |           | conway.name ASC | anon[126], conway, cs
| cs.name = $`  AUTOSTRING1`; cs:Science |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Expand(All)    |              0 |    1 |       2 |           | conway.name ASC | anon[126], cs --
conway                                             | (conway)-[:RESEARCHED]->(cs)           |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +NodeIndexSeek |              0 |    1 |       2 |           | conway.name ASC | conway
| :Scientist(name)                       |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +Filter           |              0 |    1 |       1 |           | liskov.name ASC | anon[43], liskov,
wing                                               | wing:Scientist                         |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +Expand(All)      |              0 |    1 |       3 |           | liskov.name ASC | anon[43], wing --
liskov                                             | (liskov)-[:KNOWS]->(wing)              |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +NodeIndexSeek    |              0 |    1 |       2 |           | liskov.name ASC | liskov
| :Scientist(name)                       |
+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+

Total database accesses: 20
```

Query using multiple index hints

Supplying one index hint changed the starting point of the query, but the plan is still linear, meaning it only has one starting point. If we give the planner yet another index hint, we force it to use two starting points, one at each end of the match. It will then join these two branches using a join operator.

Query

```
MATCH (liskov:Scientist { name:'Liskov' })-[:KNOWS]->(wing:Scientist)-[:RESEARCHED]->(cs:Science {
name:'Computer Science' })<-[:RESEARCHED]-(conway:Scientist { name: 'Conway' })
USING INDEX liskov:Scientist(name)
USING INDEX conway:Scientist(name)
RETURN liskov.born AS column
```

Returns the year **'Barbara Liskov'** was born, using a slightly better plan.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order           | Variables
| Other                                 |
+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +ProduceResults   |              0 |    1 |       0 |     0.053 | conway.name ASC | anon[126], anon[43],
anon[70], column, conway, cs, liskov, wing   |                                         |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +Projection       |              0 |    1 |       3 |     0.046 | conway.name ASC | column -- anon[126],
anon[43], anon[70], conway, cs, liskov, wing | {column : liskov.born}                  |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +NodeHashJoin     |              0 |    1 |       0 |     0.080 | conway.name ASC | anon[43], liskov --
anon[126], anon[70], conway, cs, wing          | wing                                    |
| |\                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Filter         |              0 |    2 |       0 |           |                 | anon[126], anon[70],
conway, cs, wing                             | not `anon[126]` = `anon[70]`            |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Expand(All)    |              0 |    3 |       4 |           | conway.name ASC | anon[70], wing --
anon[126], conway, cs                            | (cs)<-[:RESEARCHED]-(wing)              |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Filter         |              0 |    1 |       3 |           | conway.name ASC | anon[126], conway, cs
| cs.name = $`  AUTOSTRING1`; cs:Science |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +Expand(All)    |              0 |    1 |       2 |           | conway.name ASC | anon[126], cs --
conway                                            | (conway)-[:RESEARCHED]->(cs)            |
| | |               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| | +NodeIndexSeek |              0 |    1 |       2 |           | conway.name ASC | conway
| :Scientist(name)                     |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +Filter           |              0 |    1 |       1 |           | liskov.name ASC | anon[43], liskov,
wing                                             | wing:Scientist                          |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +Expand(All)      |              0 |    1 |       3 |           | liskov.name ASC | anon[43], wing --
liskov                                           | (liskov)-[:KNOWS]->(wing)               |
| |                 +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+
| +NodeIndexSeek    |              0 |    1 |       2 |           | liskov.name ASC | liskov
| :Scientist(name)                     |
+-------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+---------------------------------------+

Total database accesses: 20
```

6.6.3. Scan hints

If your query matches large parts of an index, it might be faster to scan the label and filter out nodes that do not match. To do this, you can use `USING SCAN variable:Label` after the applicable `MATCH` clause. This will force Cypher to not use an index that could have been used, and instead do a label scan.

Hinting a label scan

If the best performance is to be had by scanning all nodes in a label and then filtering on that set, use `USING SCAN`.

Query

```
MATCH (s:Scientist)
USING SCAN s:Scientist
WHERE s.born < 1939
RETURN s.born AS column
```

Returns all scientists born before '**1939**'.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+-------------+-------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables   | Other                         |
+------------------+----------------+------+---------+-------------+-------------------------------+
| +ProduceResults  |              3 |    2 |       0 | column, s   |                               |
| |                +----------------+------+---------+-------------+-------------------------------+
| +Projection      |              3 |    2 |       0 | column -- s | {column : cache[s.born]}      |
| |                +----------------+------+---------+-------------+-------------------------------+
| +Filter          |              3 |    2 |      18 | s           | cache[s.born] < $`  AUTOINT0` |
| |                +----------------+------+---------+-------------+-------------------------------+
| +NodeByLabelScan |             10 |    7 |       8 | s           | :Scientist                    |
+------------------+----------------+------+---------+-------------+-------------------------------+

Total database accesses: 26
```

6.6.4. Join hints

Join hints are the most advanced type of hints, and are not used to find starting points for the query execution plan, but to enforce that joins are made at specified points. This implies that there has to be more than one starting point (leaf) in the plan, in order for the query to be able to join the two branches ascending from these leaves. Due to this nature, joins, and subsequently join hints, will force the planner to look for additional starting points, and in the case where there are no more good ones, potentially pick a very bad starting point. This will negatively affect query performance. In other cases, the hint might force the planner to pick a *seemingly* bad starting point, which in reality proves to be a very good one.

Hinting a join on a single node

In the example above using multiple index hints, we saw that the planner chose to do a join on the `cs` node. This means that the relationship between `wing` and `cs` was traversed in the outgoing direction, which is better statistically because the pattern `()-[:RESEARCHED]→(:Science)` is more common than the pattern `(:Scientist)-[:RESEARCHED]→()`. However, in the actual graph, the `cs` node only has two such relationships, so expanding from it will be beneficial to expanding from the `wing` node. We can force the join to happen on `wing` instead with a join hint.

Query

```
MATCH (liskov:Scientist { name:'Liskov' })-[:KNOWS]->(wing:Scientist)-[:RESEARCHED]->(cs:Science {
name:'Computer Science' })<-[:RESEARCHED]-(conway:Scientist { name: 'Conway' })
USING INDEX liskov:Scientist(name)
USING INDEX conway:Scientist(name)
USING JOIN ON wing
RETURN wing.born AS column
```

Returns the birth date of **'Jeanette Wing'**, using a slightly better plan.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Time (ms) | Order           | Variables
| Other                                  |
+------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +ProduceResults  |              0 |    1 |       0 |     0.054 | conway.name ASC | anon[126], anon[43],
anon[70], column, conway, cs, liskov, wing   |                                        |
| |                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +Projection      |              0 |    1 |       3 |     0.085 | conway.name ASC | column -- anon[126],
anon[43], anon[70], conway, cs, liskov, wing | {column : wing.born}                   |
| |                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +NodeHashJoin    |              0 |    1 |       0 |     0.072 | conway.name ASC | anon[43], liskov --
anon[126], anon[70], conway, cs, wing         | wing                                   |
| |\               +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Filter        |              0 |    2 |       0 |           |                 | anon[126], anon[70],
conway, cs, wing                             | not `anon[126]` = `anon[70]`           |
| | |              +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Expand(All)   |              0 |    3 |       4 |           | conway.name ASC | anon[70], wing --
anon[126], conway, cs                            | (cs)<-[:RESEARCHED]-(wing)             |
| | |              +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Filter        |              0 |    1 |       3 |           | conway.name ASC | anon[126], conway, cs
| cs.name = $`  AUTOSTRING1`; cs:Science |
| | |              +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +Expand(All)   |              0 |    1 |       2 |           | conway.name ASC | anon[126], cs --
conway                                             | (conway)-[:RESEARCHED]->(cs)           |
| | |              +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| | +NodeIndexSeek |              0 |    1 |       2 |           | conway.name ASC | conway
| :Scientist(name)                       |
| |                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +Filter          |              0 |    1 |       1 |           | liskov.name ASC | anon[43], liskov,
wing                                             | wing:Scientist                         |
| |                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +Expand(All)     |              0 |    1 |       3 |           | liskov.name ASC | anon[43], wing --
liskov                                           | (liskov)-[:KNOWS]->(wing)              |
| |                +----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+
| +NodeIndexSeek   |              0 |    1 |       2 |           | liskov.name ASC | liskov
| :Scientist(name)                       |
+------------------+----------------+------+---------+-----------+-----------------
+-------------------------------------------------------------------
+----------------------------------------+

Total database accesses: 20
```

Hinting a join on multiple nodes

The query planner can be made to produce a join between several specific points. This requires the query to expand from the same node from several directions.

Query

```
MATCH (liskov:Scientist { name:'Liskov' })-[:KNOWS]->(wing:Scientist { name:'Wing' })-[:RESEARCHED]-
>(cs:Science { name:'Computer Science' })<-[:RESEARCHED]-(liskov)
USING INDEX liskov:Scientist(name)
USING JOIN ON liskov, cs
RETURN wing.born AS column
```

Returns the birth date of '**Jeanette Wing**'.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+----------------------+----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Time (ms) | Order           | Variables
| Other                                        |
+----------------------+----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| +ProduceResults      |              0 |    1 |       0 |     0.067 | wing.name ASC   | anon[142],
anon[43], anon[86], column, cs, liskov, wing   |                                              |
| |                    +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| +Projection          |              0 |    1 |       3 |     0.055 | wing.name ASC   | column --
anon[142], anon[43], anon[86], cs, liskov, wing | {column : wing.born}                         |
| |                    +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| +Filter              |              0 |    1 |       0 |     0.139 | wing.name ASC   | anon[142],
anon[43], anon[86], cs, liskov, wing           | not `anon[142]` = `anon[86]`                 |
| |                    +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| +NodeHashJoin        |              0 |    1 |       0 |    25.566 | wing.name ASC   | anon[142] --
anon[43], anon[86], cs, liskov, wing         | liskov, cs                                   |
| |\                   +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| | +NodeHashJoin      |              0 |    1 |       0 |     0.076 | wing.name ASC   | anon[43], liskov
-- anon[86], cs, wing                      | wing                                         |
| | |\                 +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| | | +Filter          |              0 |    1 |       6 |           |                 | anon[86], cs, wing
| cs:Science; cache[cs.name] = $`  AUTOSTRING2` |
| | | |                +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| | | +Expand(All)     |              0 |    2 |       4 |           | wing.name ASC   | anon[86], cs --
wing                                       | (wing)-[:RESEARCHED]->(cs)                   |
| | | |                +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| | | +NodeIndexSeek   |              0 |    1 |       2 |           |                 | wing
| :Scientist(name)                             |
| | |                  +----------------+------+---------+-----------+-----------------
+---------------------------------------------------------
+----------------------------------------------+
| | +Expand(Into)      |              0 |    1 |       4 |    15.843 | liskov.name ASC | anon[43] --
liskov, wing                                 | (liskov)-[:KNOWS]->(wing)                    |
```

```
| | |                +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+
| | +CartesianProduct |              0 |    1 |       0 |     0.037 | liskov.name ASC | liskov -- wing
|                                                |
| | |\               +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+
| | | +NodeIndexSeek  |              0 |    1 |       2 |     0.106 | wing.name ASC   | wing
| :Scientist(name)                               |
| | |                +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+
| | +NodeIndexSeek    |              0 |    1 |       2 |     0.918 |                 | liskov
| :Scientist(name)                               |
| |                  +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+
| +Filter             |              0 |    1 |       3 |           | liskov.name ASC | anon[142], cs,
liskov                                      | cs:Science; cache[cs.name] = $`  AUTOSTRING2` |
| |                  +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+
| +Expand(All)        |              0 |    1 |       3 |           | liskov.name ASC | anon[142], cs --
liskov                                    | (liskov)-[:RESEARCHED]->(cs)              |
| |                  +----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+
| +NodeIndexSeek      |              0 |    1 |       2 |           | liskov.name ASC | liskov
| :Scientist(name)                               |
+---------------------+----------------+------+---------+-----------+-----------------
+------------------------------------------------------------
+----------------------------------------------+

Total database accesses: 31
```

6.6.5. `PERIODIC COMMIT` query hint

Importing large amounts of data using `LOAD CSV` with a single Cypher query may fail due to memory constraints. This will manifest itself as an `OutOfMemoryError`.

For this situation *only,* Cypher provides the global `USING PERIODIC COMMIT` query hint for updating queries using `LOAD CSV`. If required, the limit for the number of rows per commit may be set as follows: `USING PERIODIC COMMIT 500`.

`PERIODIC COMMIT` will process the rows until the number of rows reaches a limit. Then the current transaction will be committed and replaced with a newly opened transaction. If no limit is set, a default value will be used.

See Importing large amounts of data in LOAD CSV for examples of `USING PERIODIC COMMIT` with and without setting the number of rows per commit.

> Using `PERIODIC COMMIT` will prevent running out of memory when importing large amounts of data. However, it will also break transactional isolation and thus it should only be used where needed.

Chapter 7. Execution plans

This section describes the characteristics of query execution plans and provides details about each of the operators.

7.1. Introduction

The task of executing a query is decomposed into *operators*, each of which implements a specific piece of work. The operators are combined into a tree-like structure called an *execution plan*. Each operator in the execution plan is represented as a node in the tree. Each operator takes as input zero or more rows, and produces as output zero or more rows. This means that the output from one operator becomes the input for the next operator. Operators that join two branches in the tree combine input from two incoming streams and produce a single output.

Evaluation model

Evaluation of the execution plan begins at the leaf nodes of the tree. Leaf nodes have no input rows and generally comprise operators such as scans and seeks. These operators obtain the data directly from the storage engine, thus incurring database hits. Any rows produced by leaf nodes are then piped into their parent nodes, which in turn pipe their output rows to their parent nodes and so on, all the way up to the root node. The root node produces the final results of the query.

Eager and lazy evaluation

In general, query evaluation is *lazy*: most operators pipe their output rows to their parent operators as soon as they are produced. This means that a child operator may not be fully exhausted before the parent operator starts consuming the input rows produced by the child.

However, some operators, such as those used for aggregation and sorting, need to aggregate all their rows before they can produce output. Such operators need to complete execution in its entirety before any rows are sent to their parents as input. These operators are called *eager* operators, and are denoted as such in Execution plan operators at a glance. Eagerness can cause high memory usage and may therefore be the cause of query performance issues.

Statistics

Each operator is annotated with statistics.

`Rows`
: The number of rows that the operator produced. This is only available if the query was profiled.

`EstimatedRows`
: This is the estimated number of rows that is expected to be produced by the operator. The estimate is an approximate number based on the available statistical information. The compiler uses this estimate to choose a suitable execution plan.

`DbHits`
: Each operator will ask the Neo4j storage engine to do work such as retrieving or updating data. A *database hit* is an abstract unit of this storage engine work. The actions triggering a database hit are listed in Database hits (DbHits).

`Page Cache Hits`, `Page Cache Misses`, `Page Cache Hit Ratio`
: These metrics are only shown for some queries when using Neo4j Enterprise Edition. The page cache is used to cache data and avoid accessing disk, so having a high number of `hits` and a low number of `misses` will typically make the query run faster.

`Time`
: `Time` is only shown for some operators when using the `pipelined` runtime. The number shown is the time in milliseconds it took to execute the given operator.

To produce an efficient plan for a query, the Cypher query planner requires information about the Neo4j database. This information includes which indexes and constraints are available, as well as various statistics maintained by the database. The Cypher query planner uses this information to determine which access patterns will produce the best execution plan.

The statistical information maintained by Neo4j is:

1. The number of nodes having a certain label.
2. The number of relationships by type.
3. Selectivity per index.
4. The number of relationships by type, ending with or starting from a node with a specific label.

Information about how the statistics are kept up to date, as well as configuration options for managing query replanning and caching, can be found in the Operations Manual Statistics and execution plans.

Query tuning describes how to tune Cypher queries. In particular, see Profiling a query for how to view the execution plan for a query and Planner hints and the USING keyword for how to use *hints* to influence the decisions of the planner when building an execution plan for a query.

For a deeper understanding of how each operator works, refer to Execution plan operators at a glance and the linked sections per operator. Please remember that the statistics of the particular database where the queries run will decide the plan used. There is no guarantee that a specific query will always be solved with the same plan.

7.2. Execution plan operators at a glance

This table comprises all the execution plan operators ordered lexicographically.

- *Leaf* operators, in most cases, locate the starting nodes and relationships required in order to execute the query.
- *Updating* operators are used in queries that update the graph.
- *Eager* operators accumulate all their rows before piping them to the next operator.

Name	Description	Leaf?	Updating?	Considerations
AllNodesScan	Reads all nodes from the node store.	Y		
AntiConditionalApply	Performs a nested loop. If a variable is `null`, the right-hand side will be executed.			
AntiSemiApply	Performs a nested loop. Tests for the absence of a pattern predicate.			

Name	Description	Leaf?	Updating?	Considerations
Apply	Performs a nested loop. Yields rows from both the left-hand and right-hand side operators.			
Argument	Indicates the variable to be used as an argument to the right-hand side of an `Apply` operator.	Y		
AssertSameNode	Used to ensure that no unique constraints are violated.			
CacheProperties	Reads node or relationship properties and caches them.			
CartesianProduct	Produces a cartesian product of the inputs from the left-hand and right-hand operators.			
ConditionalApply	Performs a nested loop. If a variable is not `null`, the right-hand side will be executed.			
CreateIndex	Creates an index on a property for all nodes having a certain label.	Y	Y	
CreateNodeKeyConstraint	Creates a node key constraint on a set of properties for all nodes having a certain label.	Y	Y	
Create	Creates nodes and relationships.		Y	
CreateNodePropertyExistenceConstraint	Creates an existence constraint on a property for all nodes having a certain label.	Y	Y	
CreateRelationshipPropertyExistenceConstraint	Creates an existence constraint on a property for all relationships of a certain type.	Y	Y	
CreateUniqueConstraint	Creates a unique constraint on a property for all nodes having a certain label.	Y	Y	
Delete	Deletes a node or relationship.		Y	
DetachDelete	Deletes a node and its relationships.		Y	
DirectedRelationshipByIdSeek	Reads one or more relationships by id from the relationship store.	Y		
Distinct	Drops duplicate rows from the incoming stream of rows.			Eager

Name	Description	Leaf?	Updating?	Considerations
DropIndex (deprecated syntax)	Drops an index from a property for all nodes having a certain label.	Y	Y	
DropIndex (new syntax)	Drops an index using its name.	Y	Y	
DropConstraint	Drops a constraint using its name.	Y	Y	
DropNodeKeyConstraint	Drops a node key constraint from a set of properties for all nodes having a certain label.	Y	Y	
DropNodePropertyExistenceConstraint	Drops an existence constraint from a property for all nodes having a certain label.	Y	Y	
DropRelationshipPropertyExistenceConstraint	Drops an existence constraint from a property for all relationships of a certain type.	Y	Y	
DropResult	Produces zero rows when an expression is guaranteed to produce an empty result.			
DropUniqueConstraint	Drops a unique constraint from a property for all nodes having a certain label.	Y	Y	
Eager	For isolation purposes, `Eager` ensures that operations affecting subsequent operations are executed fully for the whole dataset before continuing execution.			Eager
EagerAggregation	Evaluates a grouping expression.			Eager
EmptyResult	Eagerly loads all incoming data and discards it.			
EmptyRow	Returns a single row with no columns.	Y		
Expand(All)	Traverses incoming or outgoing relationships from a given node.			
Expand(Into)	Finds all relationships between two nodes.			
Filter	Filters each row coming from the child operator, only passing through rows that evaluate the predicates to `true`.			

Name	Description	Leaf?	Updating?	Considerations
Foreach	Performs a nested loop. Yields rows from the left-hand operator and discards rows from the right-hand operator.			
LetAntiSemiApply	Performs a nested loop. Tests for the absence of a pattern predicate in queries containing multiple pattern predicates.			
LetSelectOrSemiApply	Performs a nested loop. Tests for the presence of a pattern predicate that is combined with other predicates.			
LetSelectOrAntiSemiApply	Performs a nested loop. Tests for the absence of a pattern predicate that is combined with other predicates.			
LetSemiApply	Performs a nested loop. Tests for the presence of a pattern predicate in queries containing multiple pattern predicates.			
Limit	Returns the first 'n' rows from the incoming input.			
LoadCSV	Loads data from a CSV source into the query.	Y		
LockNodes	Locks the start and end node when creating a relationship.			
MergeCreateNode	Creates the node when failing to find the node.	Y	Y	
MergeCreateRelationship	Creates the relationship when failing to find the relationship.		Y	
NodeByIdSeek	Reads one or more nodes by id from the node store.	Y		
NodeByLabelScan	Fetches all nodes with a specific label from the node label index.	Y		
NodeCountFromCountStore	Uses the count store to answer questions about node counts.	Y		
NodeHashJoin	Executes a hash join on node ids.			Eager
NodeIndexContainsScan	Examines all values stored in an index, searching for entries containing a specific string.	Y		

Name	Description	Leaf?	Updating?	Considerations
NodeIndexEndsWithScan	Examines all values stored in an index, searching for entries ending in a specific string.	Y		
NodeIndexScan	Examines all values stored in an index, returning all nodes with a particular label having a specified property.	Y		
NodeIndexSeek	Finds nodes using an index seek.	Y		
NodeIndexSeekByRange	Finds nodes using an index seek where the value of the property matches the given prefix string.	Y		
NodeLeftOuterHashJoin	Executes a left outer hash join.			Eager
NodeRightOuterHashJoin	Executes a right outer hash join.			Eager
NodeUniqueIndexSeek	Finds nodes using an index seek within a unique index.	Y		
NodeUniqueIndexSeekByRange	Finds nodes using an index seek within a unique index where the value of the property matches the given prefix string.	Y		
OrderedAggregation	Like `EagerAggregation` but relies on the ordering of incoming rows. Is not eager.			
OrderedDistinct	Like `Distinct` but relies on the ordering of incoming rows.			
Optional	Yields a single row with all columns set to `null` if no data is returned by its source.			
OptionalExpand(All)	Traverses relationships from a given node, producing a single row with the relationship and end node set to `null` if the predicates are not fulfilled.			
OptionalExpand(Into)	Traverses all relationships between two nodes, producing a single row with the relationship and end node set to `null` if no matching relationships are found (the start node will be the node with the smallest degree).			

Name	Description	Leaf?	Updating?	Considerations
PartialSort	Sorts a row by multiple columns if there is already an ordering.			
PartialTop	Returns the first 'n' rows sorted by multiple columns if there is already an ordering.			
ProcedureCall	Calls a procedure.			
ProduceResults	Prepares the result so that it is consumable by the user.			
ProjectEndpoints	Projects the start and end node of a relationship.			
Projection	Evaluates a set of expressions, producing a row with the results thereof.	Y		
RelationshipCountFromCountStore	Uses the count store to answer questions about relationship counts.	Y		
RemoveLabels	Deletes labels from a node.		Y	
RollUpApply	Performs a nested loop. Executes a pattern expression or pattern comprehension.			
SelectOrAntiSemiApply	Performs a nested loop. Tests for the absence of a pattern predicate if an expression predicate evaluates to `false`.			
SelectOrSemiApply	Performs a nested loop. Tests for the presence of a pattern predicate if an expression predicate evaluates to `false`.			
SemiApply	Performs a nested loop. Tests for the presence of a pattern predicate.			
SetLabels	Sets labels on a node.		Y	
SetNodePropertiesFromMap	Sets properties from a map on a node.		Y	
SetProperty	Sets a property on a node or relationship.		Y	
SetRelationshipPropertiesFromMap	Sets properties from a map on a relationship.		Y	
Skip	Skips 'n' rows from the incoming rows.			
Sort	Sorts rows by a provided key.			Eager

Name	Description	Leaf?	Updating?	Considerations
Top	Returns the first 'n' rows sorted by a provided key.			Eager
TriadicSelection	Solves triangular queries, such as the very common 'find my friend-of-friends that are not already my friend'.			
UndirectedRelationshipByIdSeek	Reads one or more relationships by id from the relationship store.	Y		
Union	Concatenates the results from the right-hand operator with the results from the left-hand operator.			
Unwind	Returns one row per item in a list.			
ValueHashJoin	Executes a hash join on arbitrary values.			Eager
VarLengthExpand(All)	Traverses variable-length relationships from a given node.			
VarLengthExpand(Into)	Finds all variable-length relationships between two nodes.			
VarLengthExpand(Pruning)	Traverses variable-length relationships from a given node and only returns unique end nodes.			

7.3. Database hits (DbHits)

Each operator will send a request to the storage engine to do work such as retrieving or updating data. A *database hit* is an abstract unit of this storage engine work.

We list below all the actions that trigger one or more database hits:

- Create actions
  - Create a node
  - Create a relationship
  - Create a new node label
  - Create a new relationship type
  - Create a new ID for property keys with the same name
- Delete actions
  - Delete a node
  - Delete a relationship
- Update actions
  - Set one or more labels on a node
  - Remove one or more labels from a node

- Node-specific actions
  - Get a node by its ID
  - Get the degree of a node
  - Determine whether a node is dense
  - Determine whether a label is set on a node
  - Get the labels of a node
  - Get a property of a node
  - Get an existing node label
  - Get the name of a label by its ID, or its ID by its name
- Relationship-specific actions
  - Get a relationship by its ID
  - Get a property of a relationship
  - Get an existing relationship type
  - Get a relationship type name by its ID, or its ID by its name
- General actions
  - Get the name of a property key by its ID, or its ID by the key name
  - Find a node or relationship through an index seek or index scan
  - Find a path in a variable-length expand
  - Find a shortest path
  - Ask the count store for a value
- Schema actions
  - Add an index
  - Drop an index
  - Get the reference of an index
  - Create a constraint
  - Drop a constraint
- Call a procedure
- Call a user-defined function

The presented value can vary slightly depending on the Cypher runtime that was used to execute the query. In the pipelined runtime the number of *database hits* will typically be higher since it uses a more accurate way of measuring.

7.4. Operators

All operators are listed here, grouped by the similarity of their characteristics.

7.4.1. All Nodes Scan

The `AllNodesScan` operator reads all nodes from the node store. The variable that will contain the nodes is seen in the arguments. Any query using this operator is likely to encounter performance problems on a non-trivial database.

Query

```
MATCH (n)
RETURN n
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables |
+-----------------+----------------+------+---------+-----------+
| +ProduceResults |             35 |   35 |       0 | n         |
| |               +----------------+------+---------+-----------+
| +AllNodesScan   |             35 |   35 |      36 | n         |
+-----------------+----------------+------+---------+-----------+

Total database accesses: 36
```

7.4.2. Directed Relationship By Id Seek

The `DirectedRelationshipByIdSeek` operator reads one or more relationships by id from the relationship store, and produces both the relationship and the nodes on either side.

Query

```
MATCH (n1)-[r]->()
WHERE id(r)= 0
RETURN r, n1
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------------------+----------------+------+---------+-----------------
+-----------------------------------------------------------------------------------+
| Operator                      | Estimated Rows | Rows | DB Hits | Variables       | Other
|
+-------------------------------+----------------+------+---------+-----------------
+-----------------------------------------------------------------------------------+
| +ProduceResults               |              1 |    1 |       0 | anon[17], n1, r |
|
| |                             +----------------+------+---------+-----------------
+-----------------------------------------------------------------------------------+
| +DirectedRelationshipByIdSeek |              1 |    1 |       1 | anon[17], n1, r |
EntityByIdRhs(ManySeekableArgs(ListLiteral(List(Parameter(  AUTOINT0,Integer))))) |
+-------------------------------+----------------+------+---------+-----------------
+-----------------------------------------------------------------------------------+

Total database accesses: 1
```

7.4.3. Node By Id Seek

The `NodeByIdSeek` operator reads one or more nodes by id from the node store.

Query

```
MATCH (n)
WHERE id(n)= 0
RETURN n
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables |
+-----------------+----------------+------+---------+-----------+
| +ProduceResults |              1 |    1 |       0 | n         |
| |               +----------------+------+---------+-----------+
| +NodeByIdSeek   |              1 |    1 |       1 | n         |
+-----------------+----------------+------+---------+-----------+

Total database accesses: 1
```

7.4.4. Node By Label Scan

The `NodeByLabelScan` operator fetches all nodes with a specific label from the node label index.

Query

```
MATCH (person:Person)
RETURN person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+-----------+---------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables | Other   |
+------------------+----------------+------+---------+-----------+---------+
| +ProduceResults  |             14 |   14 |       0 | person    |         |
| |                +----------------+------+---------+-----------+---------+
| +NodeByLabelScan |             14 |   14 |      15 | person    | :Person |
+------------------+----------------+------+---------+-----------+---------+

Total database accesses: 15
```

7.4.5. Node Index Seek

The `NodeIndexSeek` operator finds nodes using an index seek. The node variable and the index used is shown in the arguments of the operator. If the index is a unique index, the operator is instead called NodeUniqueIndexSeek.

Query

```
MATCH (location:Location { name: 'Malmo' })
RETURN location
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+-------------------+-----------+-----------------+
| Operator         | Estimated Rows | Rows | DB Hits | Order             | Variables | Other           |
+------------------+----------------+------+---------+-------------------+-----------+-----------------+
| +ProduceResults  |              1 |    1 |       0 | location.name ASC | location  |                 |
| |                +----------------+------+---------+-------------------+-----------+-----------------+
| +NodeIndexSeek   |              1 |    1 |       2 | location.name ASC | location  | :Location(name) |
+------------------+----------------+------+---------+-------------------+-----------+-----------------+

Total database accesses: 2
```

7.4.6. Node Unique Index Seek

The `NodeUniqueIndexSeek` operator finds nodes using an index seek within a unique index. The node variable and the index used is shown in the arguments of the operator. If the index is not unique, the operator is instead called NodeIndexSeek. If the index seek is used to solve a MERGE clause, it will also be marked with `(Locking)`. This makes it clear that any nodes returned from the index will be locked in order to prevent concurrent conflicting updates.

Query

```
MATCH (t:Team { name: 'Malmo' })
RETURN t
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+----------------------+----------------+------+---------+------------+-----------+-------------+
| Operator             | Estimated Rows | Rows | DB Hits | Order      | Variables | Other       |
+----------------------+----------------+------+---------+------------+-----------+-------------+
| +ProduceResults      |              1 |    0 |       0 | t.name ASC | t         |             |
| |                    +----------------+------+---------+------------+-----------+-------------+
| +NodeUniqueIndexSeek |              1 |    0 |       1 | t.name ASC | t         | :Team(name) |
+----------------------+----------------+------+---------+------------+-----------+-------------+

Total database accesses: 1
```

7.4.7. Node Index Seek By Range

The `NodeIndexSeekByRange` operator finds nodes using an index seek where the value of the property matches a given prefix string. `NodeIndexSeekByRange` can be used for `STARTS WITH` and comparison operators such as `<`, `>`, `<=` and `>=`. If the index is a unique index, the operator is instead called `NodeUniqueIndexSeekByRange`.

Query

```
MATCH (l:Location)
WHERE l.name STARTS WITH 'Lon'
RETURN l
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------+------------+-----------
+----------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Time (ms) | Order      | Variables | Other
|
+-----------------------+----------------+------+---------+-----------+------------+-----------
+----------------------------------------------+
| +ProduceResults       |              2 |    1 |       0 |     0.225 | l.name ASC | l         |
|
| |                     +----------------+------+---------+-----------+------------+-----------
+----------------------------------------------+
| +NodeIndexSeekByRange |              2 |    1 |       2 |     0.254 | l.name ASC | l         |
:Location(name STARTS WITH $`  AUTOSTRING0`) |
+-----------------------+----------------+------+---------+-----------+------------+-----------
+----------------------------------------------+

Total database accesses: 2
```

7.4.8. Node Unique Index Seek By Range

The `NodeUniqueIndexSeekByRange` operator finds nodes using an index seek within a unique index, where the value of the property matches a given prefix string. `NodeUniqueIndexSeekByRange` is used by `STARTS WITH` and comparison operators such as `<`, `>`, `<=` and `>=`. If the index is not unique, the operator is instead called `NodeIndexSeekByRange`.

Query

```
MATCH (t:Team)
WHERE t.name STARTS WITH 'Ma'
RETURN t
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------------------+----------------+------+---------+-----------+------------+-----------
+-----------------------------------------+
| Operator                    | Estimated Rows | Rows | DB Hits | Time (ms) | Order      | Variables |
Other                                     |
+-----------------------------+----------------+------+---------+-----------+------------+-----------
+-----------------------------------------+
| +ProduceResults             |              2 |    0 |       0 |     0.012 | t.name ASC | t         |
|
| |                           +----------------+------+---------+-----------+------------+-----------
+-----------------------------------------+
| +NodeUniqueIndexSeekByRange |              2 |    0 |       1 |     0.176 | t.name ASC | t         |
:Team(name STARTS WITH $`  AUTOSTRING0`) |
+-----------------------------+----------------+------+---------+-----------+------------+-----------
+-----------------------------------------+

Total database accesses: 1
```

7.4.9. Node Index Contains Scan

The `NodeIndexContainsScan` operator examines all values stored in an index, searching for entries containing a specific string; for example, in queries including `CONTAINS`. Although this is slower than an index seek (since all entries need to be examined), it is still faster than the indirection resulting from a label scan using `NodeByLabelScan`, and a property store filter.

Query

```
MATCH (l:Location)
WHERE l.name CONTAINS 'al'
RETURN l
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------------+----------------+------+---------+------------+-----------
+----------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Order      | Variables | Other
|
+-----------------------+----------------+------+---------+------------+-----------
+----------------------------------+
| +ProduceResults       |              0 |    2 |       0 | l.name ASC | l         |
|
| |                     +----------------+------+---------+------------+-----------
+----------------------------------+
| +NodeIndexContainsScan |              0 |    2 |       3 | l.name ASC | l         | :Location(name); $`
AUTOSTRING0`  |
+-----------------------+----------------+------+---------+------------+-----------
+----------------------------------+

Total database accesses: 3
```

7.4.10. Node Index Ends With Scan

The `NodeIndexEndsWithScan` operator examines all values stored in an index, searching for entries ending in a specific string; for example, in queries containing `ENDS WITH`. Although this is slower than an index seek (since all entries need to be examined), it is still faster than the indirection resulting from a label scan using `NodeByLabelScan`, and a property store filter.

Query

```
MATCH (l:Location)
WHERE l.name ENDS WITH 'al'
RETURN l
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------------+----------------+------+---------+------------+-----------
+-----------------------------------+
| Operator               | Estimated Rows | Rows | DB Hits | Order      | Variables | Other
|
+------------------------+----------------+------+---------+------------+-----------
+-----------------------------------+
| +ProduceResults        |              0 |    0 |       0 | l.name ASC | l         |
|
| |                      +----------------+------+---------+------------+-----------
+-----------------------------------+
| +NodeIndexEndsWithScan |              0 |    0 |       1 | l.name ASC | l         | :Location(name); $`
AUTOSTRING0`  |
+------------------------+----------------+------+---------+------------+-----------
+-----------------------------------+

Total database accesses: 1
```

7.4.11. Node Index Scan

The `NodeIndexScan` operator examines all values stored in an index, returning all nodes with a particular label having a specified property.

Query

```
MATCH (l:Location)
WHERE EXISTS (l.name)
RETURN l
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+-----------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other           |
+-----------------+----------------+------+---------+-----------+-----------------+
| +ProduceResults |             10 |   10 |       0 | l         |                 |
| |               +----------------+------+---------+-----------+-----------------+
| +NodeIndexScan  |             10 |   10 |      11 | l         | :Location(name) |
+-----------------+----------------+------+---------+-----------+-----------------+

Total database accesses: 11
```

7.4.12. Undirected Relationship By Id Seek

The `UndirectedRelationshipByIdSeek` operator reads one or more relationships by id from the relationship store. As the direction is unspecified, two rows are produced for each relationship as a result of alternating the combination of the start and end node.

Query

```
MATCH (n1)-[r]-()
WHERE id(r)= 1
RETURN r, n1
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+--------------------------------+----------------+------+---------+-----------------+
| Operator                       | Estimated Rows | Rows | DB Hits | Variables       |
+--------------------------------+----------------+------+---------+-----------------+
| +ProduceResults                |              1 |    2 |       0 | anon[16], n1, r |
| |                              +----------------+------+---------+-----------------+
| +UndirectedRelationshipByIdSeek |              1 |    2 |       1 | anon[16], n1, r |
+--------------------------------+----------------+------+---------+-----------------+

Total database accesses: 1
```

7.4.13. Apply

All the different `Apply` operators (listed below) share the same basic functionality: they perform a nested loop by taking a single row from the left-hand side, and using the Argument operator on the right-hand side, execute the operator tree on the right-hand side. The versions of the `Apply` operators differ in how the results are managed. The `Apply` operator (i.e. the standard version) takes the row produced by the right-hand side — which at this point contains data from both the left-hand and right-hand sides — and yields it..

Query

```
MATCH (p:Person { name:'me' })
MATCH (q:Person { name: p.secondName })
RETURN p, q
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+-------------+-----------+---------------
+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order       | Variables | Other
|
+-------------------+----------------+------+---------+-----------+-------------+-----------+---------------
+
| +ProduceResults   |              1 |    0 |       0 |           | p.name ASC  | p, q      |
|
| |                 +----------------+------+---------+-----------+-------------+-----------+---------------
+
| +Apply            |              1 |    0 |       0 |     0.005 | p.name ASC  | p, q      |
|
| |\                +----------------+------+---------+-----------+-------------+-----------+---------------
+
| | +NodeIndexSeek  |              1 |    0 |       0 |           |             | q -- p    | :Person(name)
|
| |                 +----------------+------+---------+-----------+-------------+-----------+---------------
+
| +NodeIndexSeek    |              1 |    1 |       2 |     0.200 | p.name ASC  | p         | :Person(name)
|
+-------------------+----------------+------+---------+-----------+-------------+-----------+---------------
+

Total database accesses: 2
```

7.4.14. Semi Apply

The `SemiApply` operator tests for the presence of a pattern predicate, and is a variation of the Apply operator. If the right-hand side operator yields at least one row, the row from the left-hand side operator is yielded by the `SemiApply` operator. This makes `SemiApply` a filtering operator, used mostly for pattern predicates in queries.

Query

```
MATCH (p:Person)
WHERE (p)-[:FRIENDS_WITH]->(:Person)
RETURN p.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables              | Other                                  |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| +ProduceResults    |             11 |    2 |       0 |               0 |                 0 |
0.0000 | p, p.name            |                                        |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| +Projection        |             11 |    2 |       2 |               1 |                 0 |
1.0000 | p.name -- p          | {p.name : cache[p.name]}               |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| +SemiApply         |             11 |    2 |       0 |               0 |                 0 |
0.0000 | p                    |                                        |
| |\                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| | +CacheProperties |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE45,   REL27, p   | cache[p.name]                          |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| | +Filter          |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE45,   REL27, p   | `  NODE45`:Person                      |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| | +Expand(All)     |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE45,   REL27 -- p | (p)-[  REL27:FRIENDS_WITH]->(  NODE45) |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| | +Argument        |             14 |   14 |       0 |               0 |                 0 |
0.0000 | p                    |                                        |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+
| +NodeByLabelScan   |             14 |   14 |      15 |               2 |                 0 |
1.0000 | p                    | :Person                                |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------------+----------------------------------------+

Total database accesses: 35
```

7.4.15. Anti Semi Apply

The `AntiSemiApply` operator tests for the absence of a pattern, and is a variation of the Apply operator. If the right-hand side operator yields no rows, the row from the left-hand side operator is yielded by the `AntiSemiApply` operator. This makes `AntiSemiApply` a filtering operator, used for pattern predicates in queries.

Query

```
MATCH (me:Person { name: "me" }),(other:Person)
WHERE NOT (me)-[:FRIENDS_WITH]->(other)
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Order          | Variables                  | Other                                |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| +ProduceResults     |              4 |   13 |       0 |               0 |                 0 |
0.0000 | me.name ASC | me, other, other.name    |                                      |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| +Projection         |              4 |   13 |      13 |               1 |                 0 |
1.0000 | me.name ASC | other.name -- me, other | {other.name : cache[other.name]}     |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| +AntiSemiApply      |              4 |   13 |       0 |               0 |                 0 |
0.0000 | me.name ASC | me, other                 |                                      |
| |\                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| | +CacheProperties |              0 |    0 |       0 |               0 |                 0 |
0.0000 |             |   REL62, me, other      | cache[other.name]                    |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| | +Expand(Into)     |              0 |    0 |      50 |              16 |                 0 |
1.0000 |             |   REL62 -- me, other    | (me)-[  REL62:FRIENDS_WITH]->(other) |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| | +Argument         |             14 |   14 |       0 |               0 |                 0 |
0.0000 |             | me, other                 |                                      |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| +CartesianProduct   |             14 |   14 |       0 |               0 |                 0 |
0.0000 | me.name ASC | me -- other               |                                      |
| |\                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| | +NodeByLabelScan |             14 |   14 |      15 |               2 |                 0 |
1.0000 |             | other                     | :Person                              |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+
| +NodeIndexSeek      |              1 |    1 |       2 |               0 |                 1 |
0.0000 | me.name ASC | me                        | :Person(name)                        |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------------------+--------------------------------------+

Total database accesses: 80
```

7.4.16. Let Semi Apply

The `LetSemiApply` operator tests for the presence of a pattern predicate, and is a variation of the Apply operator. When a query contains multiple pattern predicates separated with `OR`, `LetSemiApply` will be used to evaluate the first of these. It will record the result of evaluating the predicate but will leave any filtering to another operator. In the example, `LetSemiApply` will be used to check for the presence of the `FRIENDS_WITH` relationship from each person.

Query

```
MATCH (other:Person)
WHERE (other)-[:FRIENDS_WITH]->(:Person) OR (other)-[:WORKS_IN]->(:Location)
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+---------------------+----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| Operator            | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables                     | Other                                   |
+---------------------+----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| +ProduceResults     |             13 |   14 |       0 |               0 |                 0 |
0.0000 | anon[27], other, other.name   |                                      |
| |                   +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| +Projection         |             13 |   14 |      14 |               1 |                 0 |
1.0000 | other.name -- anon[27], other | {other.name : cache[other.name]}     |
| |                   +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| +SelectOrSemiApply  |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[27] -- other             | `anon[27]`                           |
| |\                  +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +Filter           |             15 |    0 |      12 |               0 |                 0 |
0.0000 |   NODE87,   REL73, other      | `  NODE87`:Location                  |
| | |                 +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +Expand(All)      |             15 |   12 |      24 |              12 |                 0 |
1.0000 |   NODE87,   REL73 -- other    | (other)-[  REL73:WORKS_IN]->(  NODE87)     |
| | |                 +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +Argument         |             14 |   12 |       0 |               0 |                 0 |
0.0000 | other                         |                                      |
| |                   +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| +LetSemiApply       |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[27] -- other             |                                      |
| |\                  +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +CacheProperties  |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE53,   REL35, other      | cache[other.name]                    |
| | |                 +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +Filter           |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE53,   REL35, other      | `  NODE53`:Person                    |
| | |                 +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +Expand(All)      |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE53,   REL35 -- other    | (other)-[  REL35:FRIENDS_WITH]->(  NODE53) |
| | |                 +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| | +Argument         |             14 |   14 |       0 |               0 |                 0 |
0.0000 | other                         |                                      |
| |                   +----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+
| +NodeByLabelScan    |             14 |   14 |      15 |               2 |                 0 |
1.0000 | other                         | :Person                              |
+---------------------+----------------+------+---------+-----------------+-------------------
+-----------------------+------------------------------+-----------------------------------------+

Total database accesses: 83
```

7.4.17. Let Anti Semi Apply

The `LetAntiSemiApply` operator tests for the absence of a pattern, and is a variation of the Apply operator. When a query contains multiple negated pattern predicates — i.e. predicates separated with `OR`, where at least one predicate contains `NOT` — `LetAntiSemiApply` will be used to evaluate the first of these. It will record the result of evaluating the predicate but will leave any filtering to another operator. In the example, `LetAntiSemiApply` will be used to check for the absence of the `FRIENDS_WITH` relationship from each person.

Query

```
MATCH (other:Person)
WHERE NOT ((other)-[:FRIENDS_WITH]->(:Person)) OR (other)-[:WORKS_IN]->(:Location)
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables                     | Other                                      |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +ProduceResults    |             11 |   14 |       0 |               0 |                 0 |
0.0000 | anon[32], other, other.name   |                                            |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +Projection        |             11 |   14 |      14 |               1 |                 0 |
1.0000 | other.name -- anon[32], other | {other.name : cache[other.name]}           |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +SelectOrSemiApply |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[32] -- other             | `anon[32]`                                 |
| |\                 +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Filter          |             15 |    0 |       2 |               0 |                 0 |
0.0000 |   NODE93,   REL79, other      | `  NODE93`:Location                        |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Expand(All)     |             15 |    2 |       4 |               2 |                 0 |
1.0000 |   NODE93,   REL79 -- other    | (other)-[  REL79:WORKS_IN]->(  NODE93)     |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Argument        |             14 |    2 |       0 |               0 |                 0 |
0.0000 | other                         |                                            |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +LetAntiSemiApply  |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[32] -- other             |                                            |
| |\                 +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +CacheProperties |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE58,   REL40, other      | cache[other.name]                          |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Filter          |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE58,   REL40, other      | `  NODE58`:Person                          |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Expand(All)     |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE58,   REL40 -- other    | (other)-[  REL40:FRIENDS_WITH]->(  NODE58) |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Argument        |             14 |   14 |       0 |               0 |                 0 |
0.0000 | other                         |                                            |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +NodeByLabelScan   |             14 |   14 |      15 |               2 |                 0 |
1.0000 | other                         | :Person                                    |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+

Total database accesses: 53
```

7.4.18. Select Or Semi Apply

The `SelectOrSemiApply` operator tests for the presence of a pattern predicate and evaluates a predicate, and is a variation of the Apply operator. This operator allows for the mixing of normal predicates and pattern predicates that check for the presence of a pattern. First, the normal expression predicate is evaluated, and, only if it returns `false`, is the costly pattern predicate evaluated.

Query

```
MATCH (other:Person)
WHERE other.age > 25 OR (other)-[:FRIENDS_WITH]->(:Person)
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+---------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| Operator            | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables                  | Other                                     |
+---------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +ProduceResults     |             11 |    2 |       0 |               0 |                 0 |
0.0000 | other, other.name          |                                           |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +Projection         |             11 |    2 |       2 |               1 |                 0 |
1.0000 | other.name -- other        | {other.name : cache[other.name]}          |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +SelectOrSemiApply  |             14 |    2 |      14 |               0 |                 0 |
0.0000 | other                      | other.age > $`  AUTOINT0`                 |
| |\                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +CacheProperties  |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE71,   REL53, other   | cache[other.name]                         |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Filter           |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE71,   REL53, other   | `  NODE71`:Person                         |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Expand(All)      |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE71,   REL53 -- other | (other)-[  REL53:FRIENDS_WITH]->(  NODE71) |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Argument         |             14 |   14 |       0 |               0 |                 0 |
0.0000 | other                      |                                           |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +NodeByLabelScan    |             14 |   14 |      15 |               2 |                 0 |
1.0000 | other                      | :Person                                   |
+---------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+

Total database accesses: 49
```

7.4.19. Select Or Anti Semi Apply

The `SelectOrAntiSemiApply` operator is used to evaluate `OR` between a predicate and a negative pattern predicate (i.e. a pattern predicate preceded with `NOT`), and is a variation of the Apply operator. If the predicate returns `true`, the pattern predicate is not tested. If the predicate returns `false` or `null`, `SelectOrAntiSemiApply` will instead test the pattern predicate.

Query

```
MATCH (other:Person)
WHERE other.age > 25 OR NOT (other)-[:FRIENDS_WITH]->(:Person)
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables                   | Other                                      |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| +ProduceResults       |              4 |   12 |       0 |               0 |                 0 |
0.0000 | other, other.name          |                                            |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| +Projection           |              4 |   12 |      12 |               1 |                 0 |
1.0000 | other.name -- other        | {other.name : cache[other.name]}           |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| +SelectOrAntiSemiApply |            14 |   12 |      14 |               0 |                 0 |
0.0000 | other                      | other.age > $`  AUTOINT0`                  |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| | +CacheProperties    |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE75,   REL57, other   | cache[other.name]                          |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| | +Filter             |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE75,   REL57, other   | `  NODE75`:Person                          |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| | +Expand(All)        |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE75,   REL57 -- other | (other)-[  REL57:FRIENDS_WITH]->(  NODE75) |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| | +Argument           |             14 |   14 |       0 |               0 |                 0 |
0.0000 | other                      |                                            |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+
| +NodeByLabelScan      |             14 |   14 |      15 |               2 |                 0 |
1.0000 | other                      | :Person                                    |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------------+--------------------------------------------+

Total database accesses: 59
```

7.4.20. Let Select Or Semi Apply

The `LetSelectOrSemiApply` operator is planned for pattern predicates that are combined with other predicates using `OR`. This is a variation of the Apply operator.

Query

```
MATCH (other:Person)
WHERE (other)-[:FRIENDS_WITH]->(:Person) OR (other)-[:WORKS_IN]->(:Location) OR other.age = 5
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables                  | Other                                     |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +ProduceResults       |             13 |   14 |       0 |               0 |                 0 |
0.0000 | anon[27], other, other.name   |                                           |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +Projection           |             13 |   14 |      14 |               1 |                 0 |
1.0000 | other.name -- anon[27], other | {other.name : cache[other.name]}          |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +SelectOrSemiApply    |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[27] -- other             | `anon[27]`                                |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Filter             |             15 |    0 |      12 |               0 |                 0 |
0.0000 |   NODE87,   REL73, other      | `  NODE87`:Location                       |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Expand(All)        |             15 |   12 |      24 |              12 |                 0 |
1.0000 |   NODE87,   REL73 -- other    | (other)-[  REL73:WORKS_IN]->(  NODE87)     |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Argument           |             14 |   12 |       0 |               0 |                 0 |
0.0000 | other                         |                                           |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +LetSelectOrSemiApply |             14 |   14 |      14 |               0 |                 0 |
0.0000 | anon[27] -- other             | other.age = $`  AUTOINT0`                 |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +CacheProperties    |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE53,   REL35, other      | cache[other.name]                         |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Filter             |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE53,   REL35, other      | `  NODE53`:Person                         |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Expand(All)        |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE53,   REL35 -- other    | (other)-[  REL35:FRIENDS_WITH]->(  NODE53) |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| | +Argument           |             14 |   14 |       0 |               0 |                 0 |
0.0000 | other                         |                                           |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+
| +NodeByLabelScan      |             14 |   14 |      15 |               2 |                 0 |
1.0000 | other                         | :Person                                   |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------+-------------------------------------------+

Total database accesses: 97
```

7.4.21. Let Select Or Anti Semi Apply

The `LetSelectOrAntiSemiApply` operator is planned for negated pattern predicates — i.e. pattern predicates preceded with `NOT` — that are combined with other predicates using `OR`. This operator is a variation of the Apply operator.

Query

```
MATCH (other:Person)
WHERE NOT (other)-[:FRIENDS_WITH]->(:Person) OR (other)-[:WORKS_IN]->(:Location) OR other.age = 5
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+---------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| Operator                  | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables                     | Other                                      |
+---------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +ProduceResults           |             11 |   14 |       0 |               0 |                 0 |
0.0000 | anon[31], other, other.name   |                                            |
| |                         +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +Projection               |             11 |   14 |      14 |               1 |                 0 |
1.0000 | other.name -- anon[31], other | {other.name : cache[other.name]}           |
| |                         +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +SelectOrSemiApply        |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[31] -- other             | `anon[31]`                                 |
| |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Filter                 |             15 |    0 |       2 |               0 |                 0 |
0.0000 |   NODE91,   REL77, other      | `  NODE91`:Location                        |
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Expand(All)            |             15 |    2 |       4 |               2 |                 0 |
1.0000 |   NODE91,   REL77 -- other    | (other)-[  REL77:WORKS_IN]->(  NODE91)     |
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Argument               |             14 |    2 |       0 |               0 |                 0 |
0.0000 | other                         |                                            |
| |                         +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +LetSelectOrAntiSemiApply |             14 |   14 |      14 |               0 |                 0 |
0.0000 | anon[31] -- other             | other.age = $`  AUTOINT0`                  |
| |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +CacheProperties        |              2 |    0 |       0 |               0 |                 0 |
0.0000 |   NODE57,   REL39, other      | cache[other.name]                          |
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Filter                 |              2 |    0 |       2 |               1 |                 0 |
1.0000 |   NODE57,   REL39, other      | `  NODE57`:Person                          |
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Expand(All)            |              2 |    2 |      16 |              15 |                 0 |
1.0000 |   NODE57,   REL39 -- other    | (other)-[  REL39:FRIENDS_WITH]->(  NODE57) |
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| | +Argument               |             14 |   14 |       0 |               0 |                 0 |
0.0000 | other                         |                                            |
| |                         +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+
| +NodeByLabelScan          |             14 |   14 |      15 |               2 |                 0 |
1.0000 | other                         | :Person                                    |
+---------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------------------+--------------------------------------------+

Total database accesses: 67
```

7.4.22. Conditional Apply

The `ConditionalApply` operator checks whether a variable is not `null`, and if so, the right child operator will be executed. This operator is a variation of the Apply operator.

Query

```
MERGE (p:Person { name: 'Andy' })
ON MATCH SET p.exists = TRUE
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order      | Variables | Other         |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| +ProduceResults       |              1 |    0 |       0 |               0 |                   0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| +EmptyResult          |              1 |    0 |       0 |               0 |                   0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| +AntiConditionalApply |              1 |    1 |       0 |               0 |                   0 |
0.0000 |            | p         |               |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| | +MergeCreateNode    |              1 |    0 |       0 |               0 |                   0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| +ConditionalApply     |              1 |    1 |       0 |               0 |                   0 |
0.0000 |            | p         |               |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| | +SetProperty        |              1 |    1 |       3 |               2 |                     |
|            | p          |               |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| | +Argument           |              1 |    1 |       0 |               0 |                   0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| +Optional             |              1 |    1 |       0 |               0 |                   0 |
0.0000 | p.name ASC | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+
| +NodeIndexSeek        |              1 |    1 |       2 |               0 |                   1 |
0.0000 | p.name ASC | p         | :Person(name) |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+------------+---------------+

Total database accesses: 5
```

7.4.23. Anti Conditional Apply

The `AntiConditionalApply` operator checks whether a variable is `null`, and if so, the right child operator will be executed. This operator is a variation of the Apply operator.

Query

```
MERGE (p:Person { name: 'Andy' })
ON CREATE SET p.exists = TRUE
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order      | Variables | Other         |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +ProduceResults       |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +EmptyResult          |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +AntiConditionalApply |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | p         |               |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| | +SetProperty        |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | p         |               |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| | +MergeCreateNode    |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +Optional             |              1 |    1 |       0 |               0 |                 0 |
0.0000 | p.name ASC | p         |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+
| +NodeIndexSeek        |              1 |    1 |       2 |               0 |                 1 |
0.0000 | p.name ASC | p         | :Person(name) |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+---------------+

Total database accesses: 2
```

7.4.24. Roll Up Apply

The `RollUpApply` operator is used to execute an expression which takes as input a pattern, and returns a list with content from the matched pattern; for example, when using a pattern expression or pattern comprehension in a query. This operator is a variation of the Apply operator.

Query

```
MATCH (p:Person)
RETURN p.name,[(p)-[:WORKS_IN]->(location)| location.name] AS cities
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| Operator            | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables                               | Other                                 |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| +ProduceResults     |             14 |   14 |       0 |               0 |                 0 |
0.0000 | cities, p, p.name                  |                                     |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| +Projection         |             14 |   14 |      14 |               0 |                 0 |
0.0000 | p.name -- cities, p                | {p.name : cache[p.name]}            |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| +RollUpApply        |             14 |   14 |       0 |               0 |                 0 |
0.0000 | cities -- p                        | cities                              |
| |\                  +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| | +Projection       |              0 |   15 |      15 |               0 |                 0 |
0.0000 | anon[32] --   REL38, location, p | { : location.name}                  |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| | +CacheProperties |              0 |   15 |      15 |               2 |                 0 |
1.0000 |   REL38, location, p               | cache[p.name]                       |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| | +Expand(All)      |              0 |   15 |      29 |              15 |                 0 |
1.0000 |   REL38, location -- p             | (p)-[  REL38:WORKS_IN]->(location) |
| | |                 +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| | +Argument         |              1 |   14 |       0 |               0 |                 0 |
0.0000 | p                                  |                                     |
| |                   +----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+
| +NodeByLabelScan    |             14 |   14 |      15 |               2 |                 0 |
1.0000 | p                                  | :Person                             |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------------------------------+-----------------------------------+

Total database accesses: 88
```

7.4.25. Argument

The `Argument` operator indicates the variable to be used as an argument to the right-hand side of an Apply operator.

Query

```
MATCH (s:Person { name: 'me' })
MERGE (s)-[:FRIENDS_WITH]->(s)
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| Operator                    | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Order      | Variables     | Other                    |
+-----------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| +ProduceResults             |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s   |                          |
| |                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| +EmptyResult                |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s   |                          |
| |                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| +Apply                      |              1 |    1 |       0 |               0 |                 0 |
0.0000 | s.name ASC | anon[40], s   |                          |
| |\                          +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | +AntiConditionalApply     |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s   |                          |
| | |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | | +MergeCreateRelationship |              1 |    1 |       2 |               2 |                 0 |
1.0000 |            | anon[40] -- s |                          |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | | +Argument               |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s             |                          |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | +AntiConditionalApply     |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s   |                          |
| | |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | | +Optional               |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s   |                          |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | | +Expand(Into)           |              0 |    0 |       4 |               1 |                 0 |
1.0000 |            | anon[40] -- s | (s)-[:FRIENDS_WITH]->(s) |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | | +LockNodes              |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s             | s                        |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | | +Argument               |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s             |                          |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | +Optional                 |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s   |                          |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | +Expand(Into)             |              0 |    0 |       4 |               3 |                 0 |
1.0000 |            | anon[40] -- s | (s)-[:FRIENDS_WITH]->(s) |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| | +Argument                 |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s             |                          |
| |                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+
| +NodeIndexSeek              |              1 |    1 |       2 |               0 |                 1 |
0.0000 | s.name ASC | s             | :Person(name)            |
+-----------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------+--------------------------+

Total database accesses: 12
```

7.4.26. Expand All

Given a start node, and depending on the pattern relationship, the `Expand(All)` operator will traverse incoming or outgoing relationships.

Query

```
MATCH (p:Person { name: 'me' })-[:FRIENDS_WITH]->(fof)
RETURN fof
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+------------+--------------------
+----------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Order      | Variables          | Other
|
+------------------+----------------+------+---------+------------+--------------------
+----------------------------+
| +ProduceResults |              0 |    1 |       0 | p.name ASC | anon[30], fof, p   |
|
| |               +----------------+------+---------+------------+--------------------
+----------------------------+
| +Expand(All)    |              0 |    1 |       3 | p.name ASC | anon[30], fof -- p | (p)-
[:FRIENDS_WITH]->(fof) |
| |               +----------------+------+---------+------------+--------------------
+----------------------------+
| +NodeIndexSeek  |              1 |    1 |       2 | p.name ASC | p                  | :Person(name)
|
+------------------+----------------+------+---------+------------+--------------------
+----------------------------+

Total database accesses: 5
```

7.4.27. Expand Into

When both the start and end node have already been found, the `Expand(Into)` operator is used to find all relationships connecting the two nodes. As both the start and end node of the relationship are already in scope, the node with the smallest degree will be used. This can make a noticeable difference when dense nodes appear as end points.

Query

```
MATCH (p:Person { name: 'me' })-[:FRIENDS_WITH]->(fof)-->(p)
RETURN fof
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Time (ms) | Order      | Variables
| Other                         |
+-----------------+----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+
| +ProduceResults |              0 |    0 |       0 |     0.000 | p.name ASC | anon[30], anon[53], fof, p
|                               |
| |               +----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+
| +Filter         |              0 |    0 |       0 |     0.000 | p.name ASC | anon[30], anon[53], fof, p
| not `anon[30]` = `anon[53]` |
| |               +----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+
| +Expand(Into)   |              0 |    0 |       0 |     0.005 | p.name ASC | anon[30] -- anon[53], fof,
p | (p)-[:FRIENDS_WITH]->(fof)  |
| |               +----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+
| +Expand(All)    |              0 |    0 |       3 |           | p.name ASC | anon[53], fof -- p
| (p)<--(fof)                   |
| |               +----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+
| +NodeIndexSeek  |              1 |    1 |       2 |           | p.name ASC | p
| :Person(name)                 |
+-----------------+----------------+------+---------+-----------+------------
+-----------------------------+-----------------------------+

Total database accesses: 5
```

7.4.28. Optional Expand All

The `OptionalExpand(All)` operator is analogous to Expand(All), apart from when no relationships match the direction, type and property predicates. In this situation, `OptionalExpand(all)` will return a single row with the relationship and end node set to `null`.

Query

```
MATCH (p:Person)
OPTIONAL MATCH (p)-[works_in:WORKS_IN]->(l)
WHERE works_in.duration > 180
RETURN p, l
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+----------------------+----------------+------+---------+-----------+------------------
+-----------------------------------------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Time (ms) | Variables        | Other
|
+----------------------+----------------+------+---------+-----------+------------------
+-----------------------------------------------------------------+
| +ProduceResults      |             14 |   15 |       0 |     0.354 | l, p, works_in   |
|
| |                    +----------------+------+---------+-----------+------------------
+-----------------------------------------------------------------+
| +OptionalExpand(All) |             14 |   15 |      44 |     1.648 | l, works_in -- p |
works_in.duration > $`  AUTOINT0`; (p)-[works_in:WORKS_IN]->(l) |
| |                    +----------------+------+---------+-----------+------------------
+-----------------------------------------------------------------+
| +NodeByLabelScan     |             14 |   14 |      15 |     0.172 | p                | :Person
|
+----------------------+----------------+------+---------+-----------+------------------
+-----------------------------------------------------------------+

Total database accesses: 59
```

7.4.29. Optional Expand Into

The `OptionalExpand(Into)` operator is analogous to Expand(Into), apart from when no matching relationships are found. In this situation, `OptionalExpand(Into)` will return a single row with the relationship and end node set to `null`. As both the start and end node of the relationship are already in scope, the node with the smallest degree will be used. This can make a noticeable difference when dense nodes appear as end points.

Query

```
MATCH (p:Person)-[works_in:WORKS_IN]->(l)
OPTIONAL MATCH (l)-->(p)
RETURN p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------+----------------------------
+------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Time (ms) | Variables                  | Other
|
+-----------------------+----------------+------+---------+-----------+----------------------------
+------------------------------+
| +ProduceResults       |             15 |   15 |       0 |     0.287 | anon[61], l, p, works_in   |
|
| |                     +----------------+------+---------+-----------+----------------------------
+------------------------------+
| +OptionalExpand(Into) |             15 |   15 |      48 |     0.986 | anon[61] -- l, p, works_in | (l)--
>(p)                    |
| |                     +----------------+------+---------+-----------+----------------------------
+------------------------------+
| +Expand(All)          |             15 |   15 |      33 |           | l, works_in -- p           | (p)-
[works_in:WORKS_IN]->(l) |
| |                     +----------------+------+---------+-----------+----------------------------
+------------------------------+
| +NodeByLabelScan      |             14 |   14 |      15 |           | p                          |
:Person                      |
+-----------------------+----------------+------+---------+-----------+----------------------------
+------------------------------+

Total database accesses: 96
```

7.4.30. VarLength Expand All

Given a start node, the `VarLengthExpand(All)` operator will traverse variable-length relationships.

Query

```
MATCH (p:Person)-[:FRIENDS_WITH *1..2]-(q:Person)
RETURN p, q
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------------+----------------+------+---------+------------------
+-----------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Variables        | Other
|
+-----------------------+----------------+------+---------+------------------
+-----------------------------+
| +ProduceResults       |              4 |    6 |       0 | anon[17], p, q   |
|
| |                     +----------------+------+---------+------------------
+-----------------------------+
| +Filter               |              4 |    6 |       6 | anon[17], p, q   | q:Person
|
| |                     +----------------+------+---------+------------------
+-----------------------------+
| +VarLengthExpand(All) |              4 |    6 |      47 | anon[17], q -- p | (p)-[:FRIENDS_WITH*..2]-(q)
|
| |                     +----------------+------+---------+------------------
+-----------------------------+
| +NodeByLabelScan      |             14 |   14 |      15 | p                | :Person
|
+-----------------------+----------------+------+---------+------------------
+-----------------------------+

Total database accesses: 68
```

7.4.31. VarLength Expand Into

When both the start and end node have already been found, the `VarLengthExpand(Into)` operator is used to find all variable-length relationships connecting the two nodes.

Query

```
MATCH (p:Person)-[:FRIENDS_WITH *1..2]-(p:Person)
RETURN p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------------+----------------+------+---------+----------------+-----------------------------+
| Operator               | Estimated Rows | Rows | DB Hits | Variables      | Other                       |
+------------------------+----------------+------+---------+----------------+-----------------------------+
| +ProduceResults        |              0 |    0 |       0 | anon[17], p    |                             |
| |                      +----------------+------+---------+----------------+-----------------------------+
| +VarLengthExpand(Into) |              0 |    0 |      47 | anon[17] -- p  | (p)-[:FRIENDS_WITH*..2]-(p) |
| |                      +----------------+------+---------+----------------+-----------------------------+
| +NodeByLabelScan       |             14 |   14 |      15 | p              | :Person                     |
+------------------------+----------------+------+---------+----------------+-----------------------------+

Total database accesses: 62
```

7.4.32. VarLength Expand Pruning

Given a start node, the `VarLengthExpand(Pruning)` operator will traverse variable-length relationships much like the `VarLengthExpand(All)` operator. However, as an optimization, some paths will not be explored if they are guaranteed to produce an end node that has already been found (by means of a previous path traversal). This will only be used in cases where the individual paths are not of interest. This operator guarantees that all the end nodes produced will be unique.

Query

```
MATCH (p:Person)-[:FRIENDS_WITH *3..4]-(q:Person)
RETURN DISTINCT p, q
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+----------------------------+-----------------+------+---------+-----------+-----------
+------------------------------+
| Operator                   | Estimated Rows | Rows | DB Hits | Time (ms) | Variables | Other
|
+----------------------------+-----------------+------+---------+-----------+-----------
+------------------------------+
| +ProduceResults            |              0 |    0 |       0 |     0.007 | p, q      |
|
| |                          +-----------------+------+---------+-----------+-----------
+------------------------------+
| +Distinct                  |              0 |    0 |       0 |     0.018 | p, q      | p, q
|
| |                          +-----------------+------+---------+-----------+-----------
+------------------------------+
| +Filter                    |              0 |    0 |       0 |     0.020 | p, q      | q:Person
|
| |                          +-----------------+------+---------+-----------+-----------
+------------------------------+
| +VarLengthExpand(Pruning)  |              0 |    0 |      32 |     9.616 | q -- p    | (p)-
[:FRIENDS_WITH*3..4]-(q) |
| |                          +-----------------+------+---------+-----------+-----------
+------------------------------+
| +NodeByLabelScan           |             14 |   14 |      15 |     0.102 | p         | :Person
|
+----------------------------+-----------------+------+---------+-----------+-----------
+------------------------------+

Total database accesses: 47
```

7.4.33. Assert Same Node

The `AssertSameNode` operator is used to ensure that no unique constraints are violated. The example looks for the presence of a team with the supplied name and id, and if one does not exist, it will be created. Owing to the existence of two unique constraints on `:Team(name)` and `:Team(id)`, any node that would be found by the `UniqueIndexSeek` must be the very same node, or the constraints would be violated.

Query

```
MERGE (t:Team { name: 'Engineering', id: 42 })
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+----------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| Operator                         | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses
| Page Cache Hit Ratio | Order      | Variables | Other       |
+----------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| +ProduceResults                  |              1 |    0 |       0 |               0 |                 0
|               0.0000 |            | t         |             |
| |                                +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| +EmptyResult                     |              1 |    0 |       0 |               0 |                 0
|               0.0000 |            | t         |             |
| |                                +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| +AntiConditionalApply            |              1 |    1 |       0 |               0 |                 0
|               0.0000 |            | t         |             |
| |\                               +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| | +MergeCreateNode               |              1 |    0 |       0 |               0 |                 0
|               0.0000 |            | t         |             |
| |                                +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| +Optional                        |              1 |    1 |       0 |               0 |                 0
|               0.0000 | t.id ASC   | t         |             |
| |                                +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| +AssertSameNode                  |              0 |    1 |       0 |               0 |                 0
|               0.0000 | t.id ASC   | t         |             |
| |\                               +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| | +NodeUniqueIndexSeek(Locking) |              1 |    1 |       1 |               0 |                 1
|               0.0000 | t.name ASC | t         | :Team(name) |
| |                                +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+
| +NodeUniqueIndexSeek(Locking)   |              1 |    1 |       1 |               0 |                 1
|               0.0000 | t.id ASC   | t         | :Team(id)   |
+----------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------+-------------+

Total database accesses: 2
```

7.4.34. Drop Result

The `DropResult` operator produces zero rows. It is applied when it can be deduced through static analysis that the result of an expression will be empty, such as when a predicate guaranteed to return `false` (e.g. `1 > 5`) is used in a query.

Query

```
MATCH (p)
WHERE FALSE RETURN p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults |              0 |    0 |       0 |               0 |                 0 |
0.0000 | p         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +DropResult     |              0 |    0 |       0 |               0 |                 0 |
0.0000 | p         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +AllNodesScan   |             35 |    0 |       0 |               0 |                 0 |
0.0000 | p         |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 0
```

7.4.35. Empty Result

The `EmptyResult` operator eagerly loads all incoming data and discards it.

Query

```
CREATE (:Person)
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[8]   |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +EmptyResult    |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[8]   |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +Create         |              1 |    1 |       1 |               0 |                 0 |
0.0000 | anon[8]   |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 1
```

7.4.36. Produce Results

The ProduceResults operator prepares the result so that it is consumable by the user, such as transforming internal values to user values. It is present in every single query that returns data to the user, and has little bearing on performance optimisation.

Query

```
MATCH (n)
RETURN n
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables |
+-----------------+----------------+------+---------+-----------+
| +ProduceResults |             35 |   35 |       0 | n         |
| |               +----------------+------+---------+-----------+
| +AllNodesScan   |             35 |   35 |      36 | n         |
+-----------------+----------------+------+---------+-----------+

Total database accesses: 36
```

7.4.37. Load CSV

The LoadCSV operator loads data from a CSV source into the query. It is used whenever the LOAD CSV clause is used in a query.

Query

```
LOAD CSV FROM 'https://neo4j.com/docs/cypher-refcard/3.3/csv/artists.csv' AS line
RETURN line
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults |              1 |    4 |       0 |               0 |                 0 |
0.0000 | line      |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +LoadCSV        |              1 |    4 |       0 |               0 |                 0 |
0.0000 | line      |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 0
```

7.4.38. Hash joins in general

Hash joins have two inputs: the build input and probe input. The query planner assigns these roles so that the smaller of the two inputs is the build input. The build input is pulled in eagerly, and is used to build a probe table. Once this is complete, the probe table is checked for each row coming from the probe input side.

In query plans, the build input is always the left operator, and the probe input the right operator.

There are four hash join operators:

- NodeHashJoin
- ValueHashJoin
- NodeLeftOuterHashJoin
- NodeRightOuterHashJoin

7.4.39. Node Hash Join

The `NodeHashJoin` operator is a variation of the hash join. `NodeHashJoin` executes the hash join on node ids. As primitive types and arrays can be used, it can be done very efficiently.

Query

```
MATCH (bob:Person { name:'Bob' })-[:WORKS_IN]->(loc)<-[:WORKS_IN]-(matt:Person { name:'Mattis' })
RETURN loc.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Time (ms) | Order         | Variables
| Other                          |
+------------------+----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| +ProduceResults  |             10 |    0 |       0 |     0.000 | matt.name ASC | anon[32], anon[51],
bob, loc, loc.name, matt     |                              |
| |                +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| +Projection      |             10 |    0 |       0 |     0.000 | matt.name ASC | loc.name -- anon[32],
anon[51], bob, loc, matt | {loc.name : loc.name}        |
| |                +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| +Filter          |             10 |    0 |       0 |     0.000 | matt.name ASC | anon[32], anon[51],
bob, loc, matt               | not `anon[32]` = `anon[51]` |
| |                +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| +NodeHashJoin    |             10 |    0 |       0 |     0.030 | matt.name ASC | anon[32], bob --
anon[51], loc, matt             | loc                          |
| |\               +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| | +Expand(All)   |             19 |    0 |       0 |           | matt.name ASC | anon[51], loc -- matt
| (matt)-[:WORKS_IN]->(loc)    |
| | |              +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| | +NodeIndexSeek |              1 |    0 |       1 |           | matt.name ASC | matt
| :Person(name)                |
| |                +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| +Expand(All)     |             19 |    1 |       3 |           | bob.name ASC  | anon[32], loc -- bob
| (bob)-[:WORKS_IN]->(loc)     |
| |                +----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+
| +NodeIndexSeek   |              1 |    1 |       2 |           | bob.name ASC  | bob
| :Person(name)                |
+------------------+----------------+------+---------+-----------+---------------
+--------------------------------------------------+-----------------------------+

Total database accesses: 6
```

7.4.40. Value Hash Join

The `ValueHashJoin` operator is a variation of the hash join. This operator allows for arbitrary values to be used as the join key. It is most frequently used to solve predicates of the form: `n.prop1 = m.prop2` (i.e. equality predicates between two property columns).

Query

```
MATCH (p:Person),(q:Person)
WHERE p.age = q.age
RETURN p,q
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+---------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------+
| Operator            | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables | Other         |
+---------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------+
| +ProduceResults     |              0 |    0 |       0 |               0 |                 0 |
0.0000 | p, q      |               |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------+
| +ValueHashJoin      |              0 |    0 |      14 |               0 |                 0 |
0.0000 | p -- q    | p.age = q.age |
| |\                +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------+
| | +NodeByLabelScan |             14 |    0 |       1 |               2 |                 0 |
1.0000 | q         | :Person       |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------+
| +NodeByLabelScan    |             14 |   14 |      15 |               2 |                 0 |
1.0000 | p         | :Person       |
+---------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------------+

Total database accesses: 30
```

7.4.41. Node Left/Right Outer Hash Join

The `NodeLeftOuterHashJoin` and `NodeRightOuterHashJoin` operators are variations of the hash join. The query below can be planned with either a left or a right outer join. The decision depends on the cardinalities of the left-hand and right-hand sides; i.e. how many rows would be returned, respectively, for `(a:Person)` and `(a)-→(b:Person)`. If `(a:Person)` returns fewer results than `(a)-→(b:Person)`, a left outer join — indicated by `NodeLeftOuterHashJoin` — is planned. On the other hand, if `(a:Person)` returns more results than `(a)-→(b:Person)`, a right outer join — indicated by `NodeRightOuterHashJoin` — is planned instead.

Query

```
MATCH (a:Person)
OPTIONAL MATCH (a)-->(b:Person)
USING JOIN ON a
RETURN a.name, b.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| Operator                | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables                        | Other                                                 |
+-------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| +ProduceResults         |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[36], a, a.name, b, b.name   |                                                   |
| |                       +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| +Projection             |             14 |   14 |      12 |               0 |                 0 |
0.0000 | a.name, b.name -- anon[36], a, b | {a.name : cache[a.name], b.name : cache[b.name]} |
| |                       +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| +NodeRightOuterHashJoin |             14 |   14 |       0 |               0 |                 0 |
0.0000 | anon[36], b -- a                 | a                                                 |
| |\                      +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| | +NodeByLabelScan      |             14 |   14 |      15 |               2 |                 0 |
1.0000 | a                                | :Person                                           |
| |                       +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| +CacheProperties        |              2 |    2 |       4 |               2 |                 0 |
1.0000 | anon[36], a, b                   | cache[a.name]; cache[b.name]                      |
| |                       +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| +Expand(All)            |              2 |    2 |      16 |              15 |                 0 |
1.0000 | anon[36], a -- b                 | (b)<--(a)                                         |
| |                       +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+
| +NodeByLabelScan        |             14 |   14 |      15 |               2 |                 0 |
1.0000 | b                                | :Person                                           |
+-------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------------------
+---------------------------------------------------+

Total database accesses: 62
```

7.4.42. Triadic Selection

The `TriadicSelection` operator is used to solve triangular queries, such as the very common 'find my friend-of-friends that are not already my friend'. It does so by putting all the friends into a set, and uses the set to check if the friend-of-friends are already connected to me. The example finds the names of all friends of my friends that are not already my friends.

Query

```
MATCH (me:Person)-[:FRIENDS_WITH]-()-[:FRIENDS_WITH]-(other)
WHERE NOT (me)-[:FRIENDS_WITH]-(other)
RETURN other.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables                                             | Other                      |
+--------------------+----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| +ProduceResults    |              0 |    2 |       0 |              0 |                 0 |
0.0000 | anon[18], anon[35], anon[37], me, other, other.name   |                             |
| |                  +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| +Projection        |              0 |    2 |       2 |              2 |                 0 |
1.0000 | other.name -- anon[18], anon[35], anon[37], me, other | {other.name : other.name}   |
| |                  +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| +TriadicSelection |              0 |    2 |       0 |              0 |                 0 |
0.0000 | anon[18], anon[35], anon[37], me, other               | me, anon[35], other         |
| |\                 +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| | +Filter          |              0 |    2 |       0 |              0 |                 0 |
0.0000 | anon[18], anon[35], anon[37], me, other               | not `anon[18]` = `anon[37]` |
| | |                +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| | +Expand(All)     |              0 |    6 |      10 |              4 |                 0 |
1.0000 | anon[37], other -- anon[18], anon[35], me             | ()-[:FRIENDS_WITH]-(other)  |
| | |                +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| | +Argument        |              4 |    4 |       0 |              0 |                 0 |
0.0000 | anon[18], anon[35], me                                |                             |
| |                  +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| +Expand(All)       |              4 |    4 |      18 |             15 |                 0 |
1.0000 | anon[18], anon[35] -- me                              | (me)-[:FRIENDS_WITH]-()     |
| |                  +----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+
| +NodeByLabelScan   |             14 |   14 |      15 |              2 |                 0 |
1.0000 | me                                                    | :Person                     |
+--------------------+----------------+------+---------+----------------+-------------------
+----------------------+-------------------------------------------------------
+-----------------------------+

Total database accesses: 45
```

7.4.43. Cartesian Product

The `CartesianProduct` operator produces a cartesian product of the two inputs — each row coming from the left child operator will be combined with all the rows from the right child operator. `CartesianProduct` generally exhibits bad performance and ought to be avoided if possible.

Query

```
MATCH (p:Person),(t:Team)
RETURN p, t
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------+-----------+---------+
| Operator           | Estimated Rows | Rows | DB Hits | Time (ms) | Variables | Other   |
+--------------------+----------------+------+---------+-----------+-----------+---------+
| +ProduceResults    |            140 |  140 |       0 |     2.805 | p, t      |         |
| |                  +----------------+------+---------+-----------+-----------+---------+
| +CartesianProduct  |            140 |  140 |       0 |     0.449 | t -- p    |         |
| |\                 +----------------+------+---------+-----------+-----------+---------+
| | +NodeByLabelScan |             14 |   14 |      15 |     0.053 | p         | :Person |
| |                  +----------------+------+---------+-----------+-----------+---------+
| +NodeByLabelScan   |             10 |   10 |      11 |     0.111 | t         | :Team   |
+--------------------+----------------+------+---------+-----------+-----------+---------+

Total database accesses: 26
```

7.4.44. Foreach

The `Foreach` operator executes a nested loop between the left child operator and the right child operator. In an analogous manner to the Apply operator, it takes a row from the left-hand side and, using the Argument operator, provides it to the operator tree on the right-hand side. `Foreach` will yield all the rows coming in from the left-hand side; all results from the right-hand side are pulled in and discarded.

Query

```
FOREACH (value IN [1,2,3]| CREATE (:Person { age: value }))
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables          |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +ProduceResults |              1 |    0 |       0 |               0 |                 0 |
0.0000 |                   |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +EmptyResult    |              1 |    0 |       0 |               0 |                 0 |
0.0000 |                   |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +Foreach        |              1 |    1 |       0 |               0 |                 0 |
0.0000 |                   |
| |\              +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| | +Create       |              1 |    3 |       9 |               0 |                 0 |
0.0000 | anon[36] -- value |
| | |             +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| | +Argument     |              1 |    3 |       0 |               0 |                 0 |
0.0000 | value             |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +EmptyRow       |              1 |    1 |       0 |               0 |                 0 |
0.0000 |                   |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+

Total database accesses: 9
```

7.4.45. Eager

For isolation purposes, the `Eager` operator ensures that operations affecting subsequent operations are executed fully for the whole dataset before continuing execution. Information from the stores is fetched in a lazy manner; i.e. the pattern matching might not be fully exhausted before updates are applied. To guarantee reasonable semantics, the query planner will insert `Eager` operators into the query plan to prevent updates from influencing pattern matching; this scenario is exemplified by the query below, where the `DELETE` clause influences the `MATCH` clause. The `Eager` operator can cause high memory usage when importing data or migrating graph structures. In such cases, the operations should be split into simpler steps; e.g. importing nodes and relationships separately. Alternatively, the records to be updated can be returned, followed by an update statement.

Query

```
MATCH (a)-[r]-(b)
DELETE r,a,b
MERGE ()
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables           | Other        |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +ProduceResults       |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[38], a, b, r   |              |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +EmptyResult          |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[38], a, b, r   |              |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +Apply                |              1 |  504 |       0 |               0 |                 0 |
0.0000 | a, b, r -- anon[38] |              |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| | +AntiConditionalApply |            1 |  504 |       0 |               0 |                 0 |
0.0000 | anon[38]            |              |
| | |\                  +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| | | +MergeCreateNode  |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[38]            |              |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| | +Optional           |             35 |  504 |       0 |               0 |                 0 |
0.0000 | anon[38]            |              |
| | |                   +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| | +AllNodesScan       |             35 |  504 |     540 |               0 |                 0 |
0.0000 | anon[38]            |              |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +Eager                |             36 |   36 |       0 |               0 |                 0 |
0.0000 | a, b, r             |              |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +Delete(3)            |             36 |   36 |      39 |              20 |                 0 |
2.0000 | a, b, r             |              |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +Eager                |             36 |   36 |       0 |               0 |                 0 |
0.0000 | a, b, r             |              |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +Expand(All)          |             36 |   36 |      71 |              22 |                 0 |
1.0000 | b, r -- a           | (a)-[r:]-(b) |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+
| +AllNodesScan         |             35 |   35 |      36 |               1 |                 0 |
1.0000 | a                   |              |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+---------------------+--------------+

Total database accesses: 686
```

7.4.46. Eager Aggregation

The `EagerAggregation` operator evaluates a grouping expression and uses the result to group rows into different groupings. For each of these groupings, `EagerAggregation` will then evaluate all aggregation functions and return the result. To do this, `EagerAggregation`, as the name implies, needs to pull in all data eagerly from its source and build up state, which leads to increased memory pressure in the system.

Query

```
MATCH (l:Location)<-[:WORKS_IN]-(p:Person)
RETURN l.name AS location, collect(p.name) AS people
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+------------------
+----------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Variables        | Other
|
+-------------------+----------------+------+---------+-----------+------------------
+----------------------+
| +ProduceResults   |              4 |    6 |       0 |     0.199 | location, people |
|
| |                 +----------------+------+---------+-----------+------------------
+----------------------+
| +EagerAggregation |              4 |    6 |      30 |     0.030 | location, people | location
|
| |                 +----------------+------+---------+-----------+------------------
+----------------------+
| +Filter           |             15 |   15 |      15 |           | anon[19], l, p   | p:Person
|
| |                 +----------------+------+---------+-----------+------------------
+----------------------+
| +Expand(All)      |             15 |   15 |      26 |           | anon[19], p -- l | (l)<-[:WORKS_IN]-
(p) |
| |                 +----------------+------+---------+-----------+------------------
+----------------------+
| +CacheProperties  |             10 |   10 |      20 |           | l                | cache[l.name]
|
| |                 +----------------+------+---------+-----------+------------------
+----------------------+
| +NodeByLabelScan  |             10 |   10 |      11 |           | l                | :Location
|
+-------------------+----------------+------+---------+-----------+------------------
+----------------------+

Total database accesses: 102
```

7.4.47. Ordered Aggregation

The `OrderedAggregation` operator is an optimization of the `EagerAggregation` operator that takes advantage of the ordering of the incoming rows. This operator uses lazy evaluation and has a lower memory pressure in the system than the `EagerAggregation` operator.

Query

```
MATCH (p:Person)
WHERE p.name STARTS WITH 'P'
RETURN p.name, count(*) AS count
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------
+-----------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order       | Variables      | Other                                                 |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------
+-----------------------------------------------------------+
| +ProduceResults       |              0 |    2 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count, p.name |                                                             |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------
+-----------------------------------------------------------+
| +OrderedAggregation   |              0 |    2 |       0 |               0 |                 0 |
0.0000 | p.name ASC | count, p.name | p.name                                                      |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------
+-----------------------------------------------------------+
| +NodeIndexSeekByRange |              0 |    2 |       3 |               0 |                 1 |
0.0000 | p.name ASC | p             | :Person(name STARTS WITH $`  AUTOSTRING0`), cache[p.name] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+---------------
+-----------------------------------------------------------+

Total database accesses: 3
```

7.4.48. Node Count From Count Store

The `NodeCountFromCountStore` operator uses the count store to answer questions about node counts. This is much faster than the `EagerAggregation` operator which achieves the same result by actually counting. However, as the count store only stores a limited range of combinations, `EagerAggregation` will still be used for more complex queries. For example, we can get counts for all nodes, and nodes with a label, but not nodes with more than one label.

Query

```
MATCH (p:Person)
RETURN count(p) AS people
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+--------------------------+----------------+------+---------+-----------
+------------------------------------+
| Operator                 | Estimated Rows | Rows | DB Hits | Variables | Other
|
+--------------------------+----------------+------+---------+-----------
+------------------------------------+
| +ProduceResults          |              1 |    1 |       0 | people    |
|
| |                        +----------------+------+---------+-----------
+------------------------------------+
| +NodeCountFromCountStore |              1 |    1 |       1 | people    | count( (:Some(Person)) ) AS
people |
+--------------------------+----------------+------+---------+-----------
+------------------------------------+

Total database accesses: 1
```

7.4.49. Relationship Count From Count Store

The `RelationshipCountFromCountStore` operator uses the count store to answer questions about relationship counts. This is much faster than the `EagerAggregation` operator which achieves the same result by actually counting. However, as the count store only stores a limited range of combinations, `EagerAggregation` will still be used for more complex queries. For example, we can get counts for all relationships, relationships with a type, relationships with a label on one end, but not relationships with labels on both end nodes.

Query

```
MATCH (p:Person)-[r:WORKS_IN]->()
RETURN count(r) AS jobs
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+----------------------------------+----------------+------+---------+-----------
+--------------------------------------------+
| Operator                         | Estimated Rows | Rows | DB Hits | Variables | Other
|
+----------------------------------+----------------+------+---------+-----------
+--------------------------------------------+
| +ProduceResults                  |              1 |    1 |       0 | jobs      |
|
| |                                +----------------+------+---------+-----------
+--------------------------------------------+
| +RelationshipCountFromCountStore |              1 |    1 |       1 | jobs      | count( (:Person)-
[:WORKS_IN]->() ) AS jobs |
+----------------------------------+----------------+------+---------+-----------
+--------------------------------------------+

Total database accesses: 1
```

7.4.50. Distinct

The `Distinct` operator removes duplicate rows from the incoming stream of rows. To ensure only distinct elements are returned, `Distinct` will pull in data lazily from its source and build up state. This may lead to increased memory pressure in the system.

Query

```
MATCH (l:Location)<-[:WORKS_IN]-(p:Person)
RETURN DISTINCT l
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+------------------
+-----------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Variables         | Other
|
+-------------------+----------------+------+---------+-----------+------------------
+-----------------------+
| +ProduceResults  |             14 |    6 |       0 |     0.110 | l                 |
|
| |                +----------------+------+---------+-----------+------------------
+-----------------------+
| +Distinct        |             14 |    6 |       0 |     0.093 | l                 | l
|
| |                +----------------+------+---------+-----------+------------------
+-----------------------+
| +Filter          |             15 |   15 |      15 |           | anon[19], l, p    | p:Person
|
| |                +----------------+------+---------+-----------+------------------
+-----------------------+
| +Expand(All)     |             15 |   15 |      26 |           | anon[19], p -- l | (l)<-[:WORKS_IN]-(p)
|
| |                +----------------+------+---------+-----------+------------------
+-----------------------+
| +NodeByLabelScan |             10 |   10 |      11 |           | l                 | :Location
|
+-------------------+----------------+------+---------+-----------+------------------
+-----------------------+

Total database accesses: 52
```

7.4.51. Ordered Distinct

The `OrderedDistinct` operator is an optimization of the `Distinct` operator that takes advantage of the ordering of the incoming rows. This operator has a lower memory pressure in the system than the `Distinct` operator.

Query

```
MATCH (p:Person)
WHERE p.name STARTS WITH 'P'
RETURN DISTINCT p.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------
+------------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order       | Variables | Other                                                  |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------
+------------------------------------------------------------+
| +ProduceResults       |              0 |    2 |       0 |               0 |                 0 |
0.0000 | p.name ASC | p.name    |                                                        |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------
+------------------------------------------------------------+
| +OrderedDistinct      |              0 |    2 |       0 |               0 |                 0 |
0.0000 | p.name ASC | p.name    | p.name                                                 |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------
+------------------------------------------------------------+
| +NodeIndexSeekByRange |              0 |    2 |       3 |               0 |                 1 |
0.0000 | p.name ASC | p         | :Person(name STARTS WITH $`  AUTOSTRING0`), cache[p.name] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+-----------
+------------------------------------------------------------+

Total database accesses: 3
```

7.4.52. Filter

The `Filter` operator filters each row coming from the child operator, only passing through rows that evaluate the predicates to `true`.

Query

```
MATCH (p:Person)
WHERE p.name =~ '^a.*'
RETURN p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+-----------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other                             |
+-----------------+----------------+------+---------+-----------+-----------------------------------+
| +ProduceResults |             14 |    0 |       0 | p         |                                   |
| |               +----------------+------+---------+-----------+-----------------------------------+
| +Filter         |             14 |    0 |       0 | p         | cache[p.name] =~ $`  AUTOSTRING0` |
| |               +----------------+------+---------+-----------+-----------------------------------+
| +NodeIndexScan  |             14 |   14 |      15 | p         | :Person(name), cache[p.name]      |
+-----------------+----------------+------+---------+-----------+-----------------------------------+

Total database accesses: 15
```

7.4.53. Limit

The `Limit` operator returns the first 'n' rows from the incoming input.

Query

```
MATCH (p:Person)
RETURN p
LIMIT 3
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+----------+
| Operator          | Estimated Rows | Rows | DB Hits | Variables | Other    |
+-------------------+----------------+------+---------+-----------+----------+
| +ProduceResults   |              3 |    3 |       0 | p         |          |
| |                 +----------------+------+---------+-----------+----------+
| +Limit            |              3 |    3 |       0 | p         | 3        |
| |                 +----------------+------+---------+-----------+----------+
| +NodeByLabelScan |              14 |    4 |       5 | p         | :Person |
+-------------------+----------------+------+---------+-----------+----------+

Total database accesses: 5
```

7.4.54. Skip

The `Skip` operator skips 'n' rows from the incoming rows.

Query

```
MATCH (p:Person)
RETURN p
ORDER BY p.id
SKIP 1
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+
| Operator          | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Order     | Variables | Other         |
+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+
| +ProduceResults  |             14 |   13 |       0 |               2 |                 0 |
1.0000 | p.id ASC | p, p.id   |               |
| |                +----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+
| +Skip             |             14 |   13 |       0 |               0 |                 0 |
0.0000 | p.id ASC | p, p.id   | $`  AUTOINT0` |
| |                +----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+
| +Sort             |             14 |   14 |       0 |               0 |                 0 |
0.0000 | p.id ASC | p, p.id   | p.id          |
| |                +----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+
| +Projection       |             14 |   14 |      14 |               2 |                 0 |
1.0000 |          | p.id -- p | {p.id : p.id} |
| |                +----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+
| +NodeByLabelScan |             14 |   14 |      15 |               2 |                 0 |
1.0000 |          | p         | :Person       |
+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------+-----------+---------------+

Total database accesses: 29
```

7.4.55. Sort

The `Sort` operator sorts rows by a provided key. In order to sort the data, all data from the source operator needs to be pulled in eagerly and kept in the query state, which will lead to increased memory pressure in the system.

Query

```
MATCH (p:Person)
RETURN p
ORDER BY p.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+------------+-------------
+--------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order      | Variables    | Other
|
+-------------------+----------------+------+---------+-----------+------------+-------------
+--------------------+
| +ProduceResults  |             14 |   14 |       0 |     0.170 | p.name ASC | p, p.name    |
|
| |                +----------------+------+---------+-----------+------------+-------------
+--------------------+
| +Sort            |             14 |   14 |       0 |     0.094 | p.name ASC | p, p.name    | p.name
|
| |                +----------------+------+---------+-----------+------------+-------------
+--------------------+
| +Projection      |             14 |   14 |      28 |           |            | p.name -- p | {p.name :
p.name} |
| |                +----------------+------+---------+-----------+------------+-------------
+--------------------+
| +NodeByLabelScan |             14 |   14 |      15 |           |            | p            | :Person
|
+-------------------+----------------+------+---------+-----------+------------+-------------
+--------------------+

Total database accesses: 43
```

7.4.56. Partial Sort

The `PartialSort` operator is an optimization of the `Sort` operator that takes advantage of the ordering of the incoming rows. This operator uses lazy evaluation and has a lower memory pressure in the system than the `Sort` operator. Partial sort is only applicable when sorting on multiple columns.

Query

```
MATCH (p:Person)
WHERE p.name STARTS WITH 'P'
RETURN p
ORDER BY p.name, p.age
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+------------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order                  | Variables          | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+------------------------------------------------------------+
| +ProduceResults       |              0 |    2 |       0 |               2 |                 0 |
1.0000 | p.name ASC, p.age ASC | p, p.age, p.name   |
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+------------------------------------------------------------+
| +PartialSort          |              0 |    2 |       0 |               0 |                 0 |
0.0000 | p.name ASC, p.age ASC | p, p.age, p.name   | p.name; p.age
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+------------------------------------------------------------+
| +Projection           |              0 |    2 |       2 |               0 |                 0 |
0.0000 | p.name ASC            | p.age, p.name -- p | {p.name : cache[p.name], p.age : p.age}
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+------------------------------------------------------------+
| +NodeIndexSeekByRange |              0 |    2 |       3 |               0 |                 1 |
0.0000 | p.name ASC            | p                  | :Person(name STARTS WITH $`  AUTOSTRING0`),
cache[p.name] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+------------------------------------------------------------+

Total database accesses: 5
```

7.4.57. Top

The `Top` operator returns the first 'n' rows sorted by a provided key. Instead of sorting the entire input, only the top 'n' rows are retained.

Query

```
MATCH (p:Person)
RETURN p
ORDER BY p.name
LIMIT 2
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------+------------+-------------
+--------------------+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order      | Variables    | Other
|
+-------------------+----------------+------+---------+-----------+------------+-------------
+--------------------+
| +ProduceResults   |              2 |    2 |       0 |     0.085 | p.name ASC | p, p.name    |
|
| |                 +----------------+------+---------+-----------+------------+-------------
+--------------------+
| +Top              |              2 |    2 |       0 |     0.046 | p.name ASC | p, p.name    | p.name; 2
|
| |                 +----------------+------+---------+-----------+------------+-------------
+--------------------+
| +Projection       |             14 |   14 |      28 |           |            | p.name -- p | {p.name :
p.name} |
| |                 +----------------+------+---------+-----------+------------+-------------
+--------------------+
| +NodeByLabelScan |             14 |   14 |      15 |           |            | p            | :Person
|
+-------------------+----------------+------+---------+-----------+------------+-------------
+--------------------+

Total database accesses: 43
```

7.4.58. Partial Top

The `PartialTop` operator is an optimization of the `Top` operator that takes advantage of the ordering of the incoming rows. This operator uses lazy evaluation and has a lower memory pressure in the system than the `Top` operator. Partial top is only applicable when sorting on multiple columns.

Query

```
MATCH (p:Person)
WHERE p.name STARTS WITH 'P'
RETURN p
ORDER BY p.name, p.age
LIMIT 2
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+----------------------------------------------------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order                  | Variables          | Other
|
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+----------------------------------------------------------+
| +ProduceResults       |              0 |    2 |       0 |               2 |                 0 |
1.0000 | p.name ASC, p.age ASC | p, p.age, p.name   |
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+----------------------------------------------------------+
| +PartialTop           |              0 |    2 |       0 |               0 |                 0 |
0.0000 | p.name ASC, p.age ASC | p, p.age, p.name   | p.name; p.age; 2
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+----------------------------------------------------------+
| +Projection           |              0 |    2 |       2 |               0 |                 0 |
0.0000 | p.name ASC            | p.age, p.name -- p | {p.name : cache[p.name], p.age : p.age}
|
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+----------------------------------------------------------+
| +NodeIndexSeekByRange |              0 |    2 |       3 |               0 |                 1 |
0.0000 | p.name ASC            | p                  | :Person(name STARTS WITH $`  AUTOSTRING0`),
cache[p.name] |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------------+--------------------
+----------------------------------------------------------+

Total database accesses: 5
```

7.4.59. Union

The `Union` operator concatenates the results from the right child operator with the results from the left child operator.

Query

```
MATCH (p:Location)
RETURN p.name
UNION ALL MATCH (p:Country)
RETURN p.name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables           | Other                     |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| +ProduceResults    |             20 |   11 |       0 |               0 |                 0 |
0.0000 | p.name             |                           |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| +Union             |             20 |   11 |       0 |               0 |                 0 |
0.0000 | p.name             |                           |
| |\                 +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| | +Projection      |             10 |    1 |       0 |               0 |                 0 |
0.0000 | p.name -- p.name, p | {  p.name@55 : `p.name`}  |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| | +Projection      |             10 |    1 |       1 |               0 |                 0 |
0.0000 | p.name -- p         | {  p.name@115 : `p`.name} |
| | |                +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| | +NodeByLabelScan |             10 |    1 |       2 |               2 |                 0 |
1.0000 | p                  | :Country                  |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| +Projection        |             10 |   10 |       0 |               0 |                 0 |
0.0000 | p.name -- p.name, p | {  p.name@55 : `p.name`}  |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| +Projection        |             10 |   10 |      10 |               2 |                 0 |
1.0000 | p.name -- p         | {  p.name@40 : `p`.name}  |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+
| +NodeByLabelScan   |             10 |   10 |      11 |               2 |                 0 |
1.0000 | p                  | :Location                 |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------------------------+

Total database accesses: 24
```

7.4.60. Unwind

The `Unwind` operator returns one row per item in a list.

Query

```
UNWIND range(1, 5) AS value
RETURN value
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+--------------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other                                |
+-----------------+----------------+------+---------+-----------+--------------------------------------+
| +ProduceResults |             10 |    5 |       0 | value     |                                      |
| |               +----------------+------+---------+-----------+--------------------------------------+
| +Unwind         |             10 |    5 |       0 | value     | range($`  AUTOINT0`, $`  AUTOINT1`) |
+-----------------+----------------+------+---------+-----------+--------------------------------------+

Total database accesses: 0
```

7.4.61. Lock Nodes

The `LockNodes` operator locks the start and end node when creating a relationship.

Query

```
MATCH (s:Person { name: 'me' })
MERGE (s)-[:FRIENDS_WITH]->(s)
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| Operator                     | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Order      | Variables      | Other                    |
+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +ProduceResults              |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s    |                          |
| |                            +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +EmptyResult                 |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s    |                          |
| |                            +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +Apply                       |              1 |    1 |       0 |               0 |                 0 |
0.0000 | s.name ASC | anon[40], s    |                          |
| |\                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +AntiConditionalApply      |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s    |                          |
| | |\                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +MergeCreateRelationship |              1 |    1 |       2 |               2 |                 0 |
1.0000 |            | anon[40] -- s |                          |
| | | |                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Argument                |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s              |                          |
| | |                          +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +AntiConditionalApply      |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s    |                          |
| | |\                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Optional                |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s    |                          |
| | | |                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Expand(Into)            |              0 |    0 |       4 |               1 |                 0 |
1.0000 |            | anon[40] -- s | (s)-[:FRIENDS_WITH]->(s) |
| | | |                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +LockNodes               |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s              | s                        |
| | | |                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Argument                |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s              |                          |
| | |                          +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +Optional                  |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | anon[40], s    |                          |
| | |                          +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +Expand(Into)              |              0 |    0 |       4 |               3 |                 0 |
1.0000 |            | anon[40] -- s | (s)-[:FRIENDS_WITH]->(s) |
| | |                          +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +Argument                  |              1 |    1 |       0 |               0 |                 0 |
0.0000 |            | s              |                          |
| |                            +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +NodeIndexSeek               |              1 |    1 |       2 |               0 |                 1 |
0.0000 | s.name ASC | s              | :Person(name)            |
+------------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+

Total database accesses: 12
```

7.4.62. Optional

The `Optional` operator is used to solve some OPTIONAL MATCH queries. It will pull data from its source, simply passing it through if any data exists. However, if no data is returned by its source, `Optional` will yield a single row with all columns set to `null`.

Query

```
MATCH (p:Person { name:'me' })
OPTIONAL MATCH (q:Person { name: 'Lulu' })
RETURN p, q
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-------------------+-----------------+------+---------+-----------+-------------+-----------+---------------
+
| Operator          | Estimated Rows | Rows | DB Hits | Time (ms) | Order       | Variables | Other
|
+-------------------+-----------------+------+---------+-----------+-------------+-----------+---------------
+
| +ProduceResults  |               1 |    1 |       0 |     0.114 | p.name ASC | p, q      |
|
| |                +-----------------+------+---------+-----------+-------------+-----------+---------------
+
| +Apply           |               1 |    1 |       0 |     0.005 | p.name ASC | p -- q    |
|
| |\               +-----------------+------+---------+-----------+-------------+-----------+---------------
+
| | +Optional      |               1 |    1 |       0 |     0.025 | q.name ASC | q         |
|
| | |              +-----------------+------+---------+-----------+-------------+-----------+---------------
+
| | +NodeIndexSeek |               1 |    0 |       1 |     0.084 | q.name ASC | q         | :Person(name)
|
| |                +-----------------+------+---------+-----------+-------------+-----------+---------------
+
| +NodeIndexSeek   |               1 |    1 |       2 |     0.194 | p.name ASC | p         | :Person(name)
|
+-------------------+-----------------+------+---------+-----------+-------------+-----------+---------------
+

Total database accesses: 3
```

7.4.63. Project Endpoints

The `ProjectEndpoints` operator projects the start and end node of a relationship.

Query

```
CREATE (n)-[p:KNOWS]->(m)
WITH p AS r
MATCH (u)-[r]->(v)
RETURN u, v
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| Operator             | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables            | Other    |
+----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| +ProduceResults      |             18 |    1 |       0 |               0 |                 0 |
0.0000 | m, n, p, r, u, v   |          |
| |                    +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| +Apply               |             18 |    1 |       0 |               0 |                 0 |
0.0000 | m, n, p -- r, u, v |          |
| |\                   +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| | +ProjectEndpoints  |             18 |    1 |       0 |               0 |                 0 |
0.0000 | u, v -- r          | r, u, v |
| | |                  +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| | +Argument          |              1 |    1 |       0 |               0 |                 0 |
0.0000 | r                  |          |
| |                    +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| +Projection          |              1 |    1 |       0 |               0 |                 0 |
0.0000 | r -- m, n, p       | {r : p} |
| |                    +----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+
| +Create              |              1 |    1 |       4 |               0 |                 0 |
0.0000 | m, n, p            |          |
+----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+--------------------+---------+

Total database accesses: 4
```

7.4.64. Projection

For each incoming row, the `Projection` operator evaluates a set of expressions and produces a row with the results of the expressions.

Query

```
RETURN 'hello' AS greeting
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other                        |
+-----------------+----------------+------+---------+-----------+------------------------------+
| +ProduceResults |              1 |    1 |       0 | greeting  |                              |
| |               +----------------+------+---------+-----------+------------------------------+
| +Projection     |              1 |    1 |       0 | greeting  | {greeting : $`  AUTOSTRING0`} |
+-----------------+----------------+------+---------+-----------+------------------------------+

Total database accesses: 0
```

7.4.65. Empty Row

The `EmptyRow` operator returns a single row with no columns.

Query

```
FOREACH (value IN [1,2,3]| CREATE (:Person { age: value }))
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables         |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +ProduceResults |              1 |    0 |       0 |               0 |                 0 |
0.0000 |                  |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +EmptyResult    |              1 |    0 |       0 |               0 |                 0 |
0.0000 |                  |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +Foreach        |              1 |    1 |       0 |               0 |                 0 |
0.0000 |                  |
| |\              +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| | +Create       |              1 |    3 |       9 |               0 |                 0 |
0.0000 | anon[36] -- value |
| | |             +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| | +Argument     |              1 |    3 |       0 |               0 |                 0 |
0.0000 | value            |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+
| +EmptyRow       |              1 |    1 |       0 |               0 |                 0 |
0.0000 |                  |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------------+

Total database accesses: 9
```

7.4.66. Procedure Call

The `ProcedureCall` operator indicates an invocation to a procedure.

Query

```
CALL db.labels() YIELD label
RETURN *
ORDER BY label
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------+-----------+-----------
+----------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Time (ms) | Order     | Variables | Other
|
+-----------------+----------------+------+---------+-----------+-----------+-----------
+----------------------------------+
| +ProduceResults |          10000 |    4 |       0 |     0.053 | label ASC | label     |
|
| |               +----------------+------+---------+-----------+-----------+-----------
+----------------------------------+
| +Sort           |          10000 |    4 |       0 |     0.114 | label ASC | label     | label
|
| |               +----------------+------+---------+-----------+-----------+-----------
+----------------------------------+
| +ProcedureCall  |          10000 |    4 |         |     0.961 |           | label     | db.labels() ::
(label :: String) |
+-----------------+----------------+------+---------+-----------+-----------+-----------
+----------------------------------+

Total database accesses: ?
```

7.4.67. Cache Properties

The `CacheProperties` operator reads nodes and relationship properties and caches them in the current row. Future accesses to these properties can avoid reading from the store which will speed up the query. In the plan below we will cache `l.name` before `Expand(All)` where there are fewer rows.

Query

```
MATCH (l:Location)<-[:WORKS_IN]-(p:Person)
RETURN l.name AS location, p.name AS name
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+------------------+----------------+------+---------+---------------------------------
+-------------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables                        | Other
|
+------------------+----------------+------+---------+---------------------------------
+-------------------------------------------+
| +ProduceResults  |             15 |   15 |       0 | anon[19], l, location, name, p   |
|
| |                +----------------+------+---------+---------------------------------
+-------------------------------------------+
| +Projection      |             15 |   15 |      30 | location, name -- anon[19], l, p | {location :
cache[l.name], name : p.name} |
| |                +----------------+------+---------+---------------------------------
+-------------------------------------------+
| +Filter          |             15 |   15 |      15 | anon[19], l, p                   | p:Person
|
| |                +----------------+------+---------+---------------------------------
+-------------------------------------------+
| +Expand(All)     |             15 |   15 |      26 | anon[19], p -- l                 | (l)<-
[:WORKS_IN]-(p)                      |
| |                +----------------+------+---------+---------------------------------
+-------------------------------------------+
| +CacheProperties |             10 |   10 |      20 | l                                | cache[l.name]
|
| |                +----------------+------+---------+---------------------------------
+-------------------------------------------+
| +NodeByLabelScan |             10 |   10 |      11 | l                                | :Location
|
+------------------+----------------+------+---------+---------------------------------
+-------------------------------------------+

Total database accesses: 102
```

7.4.68. Create Nodes / Relationships

The `Create` operator is used to create nodes and relationships.

Query

```
CREATE (max:Person { name: 'Max' }),(chris:Person { name: 'Chris' })
CREATE (max)-[:FRIENDS_WITH]->(chris)
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables            |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+
| +ProduceResults |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[79], chris, max |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+
| +EmptyResult    |              1 |    0 |       0 |               0 |                 0 |
0.0000 | anon[79], chris, max |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+
| +Create         |              1 |    1 |       8 |               0 |                 0 |
0.0000 | anon[79], chris, max |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------------+

Total database accesses: 8
```

7.4.69. Delete

The `Delete` operator is used to delete a node or a relationship.

Query

```
MATCH (me:Person { name: 'me' })-[w:WORKS_IN { duration: 190 }]->(london:Location { name: 'London' })
DELETE w
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Order              | Variables        | Other                          |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +ProduceResults    |              0 |    0 |       0 |               0 |                 0 |
0.0000 |                  | london, me, w   |                             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +EmptyResult       |              0 |    0 |       0 |               0 |                 0 |
0.0000 |                  | london, me, w   |                             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +Delete            |              0 |    1 |       1 |               2 |                 0 |
1.0000 | me.name ASC      | london, me, w   |                             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +Eager             |              0 |    1 |       0 |               0 |                 0 |
0.0000 | me.name ASC      | london, me, w   |                             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +Filter            |              0 |    1 |       1 |               2 |                 0 |
1.0000 | me.name ASC      | london, me, w   | w.duration = $`  AUTOINT1`  |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +Expand(Into)      |              0 |    1 |       4 |               3 |                 0 |
1.0000 | me.name ASC      | w -- london, me | (me)-[w:WORKS_IN]->(london) |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +CartesianProduct |              1 |    1 |       0 |               0 |                 0 |
0.0000 | me.name ASC      | me -- london    |                             |
| |\                 +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| | +NodeIndexSeek   |              1 |    1 |       2 |               0 |                 1 |
0.0000 | london.name ASC | london          | :Location(name)             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+
| +NodeIndexSeek     |              1 |    1 |       2 |               0 |                 1 |
0.0000 | me.name ASC      | me              | :Person(name)               |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+----------------+----------------+----------------------------+

Total database accesses: 10
```

7.4.70. Detach Delete

The `DetachDelete` operator is used in all queries containing the DETACH DELETE clause, when deleting nodes and their relationships.

Query

```
MATCH (p:Person)
DETACH DELETE p
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------+
| Operator          | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Variables | Other    |
+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------+
| +ProduceResults   |             14 |    0 |       0 |               0 |                 0 |
0.0000 | p          |         |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------+
| +EmptyResult      |             14 |    0 |       0 |               0 |                 0 |
0.0000 | p          |         |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------+
| +DetachDelete     |             14 |   14 |       0 |              48 |                 0 |
1.0000 | p          |         |
| |                 +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------+
| +NodeByLabelScan |             14 |   14 |      15 |               2 |                 0 |
1.0000 | p          | :Person |
+-------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+---------+

Total database accesses: 15
```

7.4.71. Merge Create Node

The `MergeCreateNode` operator is used when creating a node as a result of a MERGE clause failing to find the node.

Query

```
MERGE (:Person { name: 'Sally' })
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| Operator              | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order            | Variables | Other         |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| +ProduceResults       |              1 |    0 |       0 |               0 |                 0 |
0.0000 |                  | anon[7]   |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| +EmptyResult          |              1 |    0 |       0 |               0 |                 0 |
0.0000 |                  | anon[7]   |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| +AntiConditionalApply |              1 |    1 |       0 |               0 |                 0 |
0.0000 |                  | anon[7]   |               |
| |\                    +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| | +MergeCreateNode    |              1 |    1 |       3 |               0 |                 0 |
0.0000 |                  | anon[7]   |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| +Optional             |              1 |    1 |       0 |               0 |                 0 |
0.0000 | anon[7].name ASC | anon[7]   |               |
| |                     +----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+
| +NodeIndexSeek        |              1 |    0 |       1 |               0 |                 1 |
0.0000 | anon[7].name ASC | anon[7]   | :Person(name) |
+-----------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------------+-----------+---------------+

Total database accesses: 4
```

7.4.72. Merge Create Relationship

The `MergeCreateRelationship` operator is used when creating a relationship as a result of a MERGE clause failing to find the relationship.

Query

```
MATCH (s:Person { name: 'Sally' })
MERGE (s)-[:FRIENDS_WITH]->(s)
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| Operator                    | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses |
Page Cache Hit Ratio | Order      | Variables      | Other                    |
+-----------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +ProduceResults             |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43], s    |                          |
| |                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +EmptyResult                |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43], s    |                          |
| |                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +Apply                      |              1 |    0 |       0 |               0 |                 0 |
0.0000 | s.name ASC | anon[43], s    |                          |
| |\                          +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +AntiConditionalApply     |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43], s    |                          |
| | |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +MergeCreateRelationship |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43] -- s |                          |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Argument               |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | s              |                          |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +AntiConditionalApply     |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43], s    |                          |
| | |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Optional               |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43], s    |                          |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Expand(Into)           |              0 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43] -- s | (s)-[:FRIENDS_WITH]->(s) |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +LockNodes              |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | s              | s                        |
| | | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | | +Argument               |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | s              |                          |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +Optional                 |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43], s    |                          |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +Expand(Into)             |              0 |    0 |       0 |               0 |                 0 |
0.0000 |            | anon[43] -- s | (s)-[:FRIENDS_WITH]->(s) |
| | |                         +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| | +Argument                 |              1 |    0 |       0 |               0 |                 0 |
0.0000 |            | s              |                          |
| |                           +----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+
| +NodeIndexSeek              |              1 |    0 |       1 |               0 |                 1 |
0.0000 | s.name ASC | s              | :Person(name)            |
+-----------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+------------+----------------+--------------------------+

Total database accesses: 1
```

7.4.73. Set Labels

The `SetLabels` operator is used when setting labels on a node.

Query

```
MATCH (n)
SET n:Person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +EmptyResult    |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +SetLabels      |             35 |   35 |      35 |               2 |                 0 |
1.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +AllNodesScan   |             35 |   35 |      36 |               1 |                 0 |
1.0000 | n         |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 71
```

7.4.74. Remove Labels

The `RemoveLabels` operator is used when deleting labels from a node.

Query

```
MATCH (n)
REMOVE n:Person
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator         | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables |
+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +EmptyResult    |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +RemoveLabels   |             35 |   35 |      35 |               2 |                 0 |
1.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +AllNodesScan   |             35 |   35 |      36 |               1 |                 0 |
1.0000 | n         |
+------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 71
```

7.4.75. Set Node Properties From Map

The `SetNodePropertiesFromMap` operator is used when setting properties from a map on a node.

Query

```
MATCH (n)
SET n = { weekday: 'Monday', meal: 'Lunch' }
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator                 | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Variables |
+--------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults          |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |                        +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +EmptyResult             |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |                        +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +SetNodePropertiesFromMap |            35 |   35 |     141 |               3 |                 0 |
1.0000 | n         |
| |                        +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +AllNodesScan            |             35 |   35 |      36 |               1 |                 0 |
1.0000 | n         |
+--------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 177
```

7.4.76. Set Relationship Properties From Map

The `SetRelationshipPropertiesFromMap` operator is used when setting properties from a map on a relationship.

Query

```
MATCH (n)-[r]->(m)
SET r = { weight: 5, unit: 'kg' }
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------------------------+----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+
| Operator                          | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache
Misses | Page Cache Hit Ratio | Variables | Other          |
+-----------------------------------+----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+
| +ProduceResults                   |             18 |    0 |       0 |               0 |
0 |                0.0000 | m, n, r   |                |
| |                                 +----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+
| +EmptyResult                      |             18 |    0 |       0 |               0 |
0 |                0.0000 | m, n, r   |                |
| |                                 +----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+
| +SetRelationshipPropertiesFromMap |             18 |   18 |      69 |               0 |
0 |                0.0000 | m, n, r   |                |
| |                                 +----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+
| +Expand(All)                      |             18 |   18 |      53 |              22 |
0 |                1.0000 | n, r -- m | (m)<-[r:]-(n) |
| |                                 +----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+
| +AllNodesScan                     |             35 |   35 |      36 |               1 |
0 |                1.0000 | m         |                |
+-----------------------------------+----------------+------+---------+-----------------
+-------------------+----------------------+-----------+---------------+

Total database accesses: 158
```

7.4.77. Set Property

The `SetProperty` operator is used when setting a property on a node or relationship.

Query

```
MATCH (n)
SET n.checked = TRUE
```

Query Plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache Hit
Ratio | Variables |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +ProduceResults |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +EmptyResult    |             35 |    0 |       0 |               0 |                 0 |
0.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +SetProperty    |             35 |   35 |      38 |               1 |                 0 |
1.0000 | n         |
| |               +----------------+------+---------+-----------------+-------------------
+----------------------+-----------+
| +AllNodesScan   |             35 |   35 |      36 |               1 |                 0 |
1.0000 | n         |
+-----------------+----------------+------+---------+-----------------+-------------------
+----------------------+-----------+

Total database accesses: 74
```

7.4.78. Create Unique Constraint

The `CreateUniqueConstraint` operator creates a unique constraint on a property for all nodes having a certain label. The following query will create a unique constraint with the name `uniqueness` on the `name` property of nodes with the `Country` label.

Query

```
CREATE CONSTRAINT uniqueness
ON (c:Country) ASSERT c.name IS UNIQUE
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+----------------------------------+------------+
| Operator                         | Other      |
+----------------------------------+------------+
| +CreateUniquePropertyConstraint  | uniqueness |
+----------------------------------+------------+

Total database accesses: ?
```

7.4.79. Drop Unique Constraint

The `DropUniqueConstraint` operator removes a unique constraint from a property for all nodes having a certain label. The following query will drop a unique constraint on the `name` property of nodes with the `Country` label.

Query

```
DROP CONSTRAINT ON (c:Country) ASSERT c.name IS UNIQUE
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+-------------------------------+
| Operator                      |
+-------------------------------+
| +DropUniquePropertyConstraint |
+-------------------------------+

Total database accesses: ?
```

7.4.80. Create Node Property Existence Constraint

The `CreateNodePropertyExistenceConstraint` operator creates an existence constraint with the name `existence` on a property for all nodes having a certain label. This will only appear in Enterprise Edition.

Query

```
CREATE CONSTRAINT existence
ON (p:Person) ASSERT EXISTS (p.name)
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+-----------------------------------------+-----------+
| Operator                                | Other     |
+-----------------------------------------+-----------+
| +CreateNodePropertyExistenceConstraint  | existence |
+-----------------------------------------+-----------+

Total database accesses: ?
```

7.4.81. Drop Node Property Existence Constraint

The `DropNodePropertyExistenceConstraint` operator removes an existence constraint from a property for all nodes having a certain label. This will only appear in Enterprise Edition.

Query

```
DROP CONSTRAINT ON (p:Person) ASSERT EXISTS (p.name)
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+---------------------------------------+
| Operator                              |
+---------------------------------------+
| +DropNodePropertyExistenceConstraint |
+---------------------------------------+

Total database accesses: ?
```

7.4.82. Create Node Key Constraint

The `CreateNodeKeyConstraint` operator creates a node key constraint with the name `node_key` which ensures that all nodes with a particular label have a set of defined properties whose combined value is unique, and where all properties in the set are present. This will only appear in Enterprise Edition.

Query

```
CREATE CONSTRAINT node_key
ON (e:Employee) ASSERT (e.firstname, e.surname) IS NODE KEY
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+--------------------------+----------+
| Operator                 | Other    |
+--------------------------+----------+
| +CreateNodeKeyConstraint | node_key |
+--------------------------+----------+

Total database accesses: ?
```

7.4.83. Drop Node Key Constraint

The `DropNodeKeyConstraint` operator removes a node key constraint from a set of properties for all nodes having a certain label. This will only appear in Enterprise Edition.

Query

```
DROP CONSTRAINT ON (e:Employee) ASSERT (e.firstname, e.surname) IS NODE KEY
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+------------------------+
| Operator               |
+------------------------+
| +DropNodeKeyConstraint |
+------------------------+

Total database accesses: ?
```

7.4.84. Create Relationship Property Existence Constraint

The `CreateRelationshipPropertyExistenceConstraint` operator creates an existence constraint with the name `existence` on a property for all relationships of a certain type. This will only appear in Enterprise Edition.

Query

```
CREATE CONSTRAINT existence
ON ()-[l:LIKED]-() ASSERT EXISTS (l.when)
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+-------------------------------------------------+-----------+
| Operator                                        | Other     |
+-------------------------------------------------+-----------+
| +CreateRelationshipPropertyExistenceConstraint | existence |
+-------------------------------------------------+-----------+

Total database accesses: ?
```

7.4.85. Drop Relationship Property Existence Constraint

The `DropRelationshipPropertyExistenceConstraint` operator removes an existence constraint from a property for all relationships of a certain type. This will only appear in Enterprise Edition.

Query

```
DROP CONSTRAINT ON ()-[l:LIKED]-() ASSERT EXISTS (l.when)
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+-----------------------------------------------+
| Operator                                      |
+-----------------------------------------------+
| +DropRelationshipPropertyExistenceConstraint |
+-----------------------------------------------+

Total database accesses: ?
```

7.4.86. Drop Constraint by name

The `DropConstraint` operator removes a constraint using the name of the constraint, no matter the type.

Query

```
DROP CONSTRAINT name
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+-----------------+-------+
| Operator        | Other |
+-----------------+-------+
| +DropConstraint | name  |
+-----------------+-------+

Total database accesses: ?
```

7.4.87. Create Index

The `CreateIndex` operator creates an index on a property for all nodes having a certain label. The following query will create an index with the name `my_index` on the `name` property of nodes with the `Country` label.

Query

```
CREATE INDEX my_index FOR (c:Country)
ON (c.name)
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+--------------+----------+
| Operator     | Other    |
+--------------+----------+
| +CreateIndex | my_index |
+--------------+----------+

Total database accesses: ?
```

7.4.88. Drop Index

The `DropIndex` operator removes an index from a property for all nodes having a certain label. The following query will drop an index on the `name` property of nodes with the `Country` label.

Query

```
DROP INDEX ON :Country(name)
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+------------+
| Operator   |
+------------+
| +DropIndex |
+------------+

Total database accesses: ?
```

7.4.89. Drop Index by name

The `DropIndex` operator removes an index using the name of the index.

Query

```
DROP INDEX name
```

Query Plan

```
Compiler CYPHER 4.0

Planner ADMINISTRATION

Runtime SCHEMA

Runtime version 4.0

+------------+-------+
| Operator   | Other |
+------------+-------+
| +DropIndex | name  |
+------------+-------+

Total database accesses: ?
```

7.5. Shortest path planning

> *Shortest path finding in Cypher and how it is planned.*

Planning shortest paths in Cypher can lead to different query plans depending on the predicates that need to be evaluated. Internally, Neo4j will use a fast bidirectional breadth-first search algorithm if the predicates can be evaluated whilst searching for the path. Therefore, this fast algorithm will always be certain to return the right answer when there are universal predicates on the path; for example, when searching for the shortest path where all nodes have the `Person` label, or where there are no nodes with a `name` property.

If the predicates need to inspect the whole path before deciding on whether it is valid or not, this fast algorithm cannot be relied on to find the shortest path, and Neo4j may have to resort to using a slower exhaustive depth-first search algorithm to find the path. This means that query plans for shortest path queries with non-universal predicates will include a fallback to running the exhaustive search to find the path should the fast algorithm not succeed. For example, depending on the data, an answer to a shortest path query with existential predicates — such as the requirement that at least one node contains the property `name='Charlie Sheen'` — may not be able to be found by the fast algorithm. In this case, Neo4j will fall back to using the exhaustive search to enumerate all paths and potentially return an answer.

The running times of these two algorithms may differ by orders of magnitude, so it is important to ensure that the fast approach is used for time-critical queries.

When the exhaustive search is planned, it is still only executed when the fast algorithm fails to find any matching paths. The fast algorithm is always executed first, since it is possible that it can find a valid path even though that could not be guaranteed at planning time.

Please note that falling back to the exhaustive search may prove to be a very time consuming strategy in some cases; such as when there is no shortest path between two nodes. Therefore, in these cases, it is recommended to set `cypher.forbid_exhaustive_shortestpath` to `true`, as explained in Operations Manual Configuration settings

7.5.1. Shortest path with fast algorithm

Query

```
MATCH (ms:Person { name: 'Martin Sheen' }),(cs:Person { name: 'Charlie Sheen' }), p = shortestPath((ms)-
[:ACTED_IN*]-(cs))
WHERE ALL (r IN relationships(p) WHERE EXISTS (r.role))
RETURN p
```

This query can be evaluated with the fast algorithm — there are no predicates that need to see the whole path before being evaluated.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime PIPELINED

Runtime version 4.0

+---------------------+-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| Operator            | Estimated Rows | Rows | DB Hits | Time (ms) | Variables              | Other
|
+---------------------+-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| +ProduceResults     |               0 |    1 |       0 |     0.662 | anon[104], cs, ms, p   |
|
| |                   +-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| +ShortestPath       |               0 |    1 |       5 |    31.485 | anon[104], p -- cs, ms | {p0 : all(r
IN relationships(p) WHERE EXISTS(r.role))} |
| |                   +-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| +CartesianProduct   |               0 |    1 |       0 |     0.051 | ms -- cs               |
|
| |\                  +-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| | +Filter           |               0 |    1 |      10 |           | cs                     | cs.name = $`
AUTOSTRING1`                              |
| | |                 +-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| | +NodeByLabelScan  |              10 |    5 |       6 |           | cs                     | :Person
|
| |                   +-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| +Filter             |               0 |    1 |      10 |           | ms                     | ms.name = $`
AUTOSTRING0`                              |
| |                   +-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+
| +NodeByLabelScan    |              10 |    5 |       6 |           | ms                     | :Person
|
+---------------------+-----------------+------+---------+-----------+------------------------
+-------------------------------------------------------+

Total database accesses: 37
```

7.5.2. Shortest path with additional predicate checks on the paths

Consider using the exhaustive search as a fallback

Predicates used in the `WHERE` clause that apply to the shortest path pattern are evaluated before deciding what the shortest matching path is.

Query

```
MATCH (cs:Person { name: 'Charlie Sheen' }),(ms:Person { name: 'Martin Sheen' }), p = shortestPath((cs)-
[*]-(ms))
WHERE length(p)> 1
RETURN p
```

This query, in contrast with the one above, needs to check that the whole path follows the predicate before we know if it is valid or not, and so the query plan will also include the fallback to the slower exhaustive search algorithm

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+---------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| Operator                  | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page
Cache Hit Ratio | Order       | Variables                         | Other
|
+---------------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| +ProduceResults           |              1 |    1 |       0 |               1 |                 0 |
1.0000 | cs.name ASC | anon[86], anon[104], cs, ms, p   |
|
| |                         +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| +AntiConditionalApply     |              1 |    1 |       0 |               0 |                 0 |
0.0000 | cs.name ASC | anon[86], anon[104], cs, ms, p   |
|
| |\                        +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| | +Top                    |              0 |    0 |       0 |               0 |                 0 |
0.0000 |             | anon[86], anon[104], cs, ms, p   | anon[86]; 1
|
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| | +Projection             |              0 |    0 |       0 |               0 |                 0 |
0.0000 |             | anon[86] -- anon[104], cs, ms, p | { : length(p)}
|
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| | +Filter                 |              0 |    0 |       0 |               0 |                 0 |
0.0000 |             | anon[104], cs, ms, p             | length(p) > $`  AUTOINT2`
|
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| | +Projection             |              0 |    0 |       0 |               0 |                 0 |
0.0000 |             | anon[104], cs, ms, p             | {p :
PathExpression(NodePathStep(Variable(cs),MultiRelationshipPathStep(Variable(anon[104]),BOTH,Some(Variable(
ms)),NilPathStep)))} |
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| | +VarLengthExpand(Into) |              0 |    0 |       0 |               0 |                 0 |
0.0000 |             | anon[104], cs, ms, p             | (cs)-[:*]-(ms)
|
| | |                       +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| | +Argument               |              4 |    0 |       0 |               0 |                 0 |
0.0000 |             | anon[104], cs, ms, p             |
|
| |                         +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------------------
+-----------------------------------------------------------------------------------------------------------
----------------------------+
| +Apply                    |              4 |    1 |       0 |               0 |                 0 |
0.0000 | cs.name ASC | anon[104], cs, ms, p             |
|
| |\                        +----------------+------+---------+-----------------+-------------------
```

```
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+
| | +Optional               |              1 |     1 |        0 |              0 |                 0 |
0.0000 |             | anon[104], cs, ms, p          |
|
| | |                        +----------------+------+---------+----------------+-------------------
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+
| | +ShortestPath           |              1 |     1 |        1 |              8 |                 0 |
1.0000 |             | anon[104], p -- cs, ms        | {p0 : length(p) > $`  AUTOINT2`}
|
| | |                        +----------------+------+---------+----------------+-------------------
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+
| | +Argument               |              4 |     1 |        0 |              0 |                 0 |
0.0000 |             | cs, ms                        |
|
| |                          +----------------+------+---------+----------------+-------------------
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+
| +CartesianProduct         |              4 |     1 |        0 |              0 |                 0 |
0.0000 | cs.name ASC | cs -- ms                      |
|
| |\                         +----------------+------+---------+----------------+-------------------
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+
| | +NodeIndexSeek          |              2 |     1 |        2 |              1 |                 0 |
1.0000 | ms.name ASC | ms                            | :Person(name)
|
| |                          +----------------+------+---------+----------------+-------------------
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+
| +NodeIndexSeek            |              2 |     1 |        2 |              0 |                 1 |
0.0000 | cs.name ASC | cs                            | :Person(name)
|
+----------------------------+----------------+------+---------+----------------+-------------------
+---------------------+-------------+--------------------------------
+------------------------------------------------------------------------------------------------------------
---------------------------+

Total database accesses: 5
```

The way the bigger exhaustive query plan works is by using `Apply`/`Optional` to ensure that when the fast algorithm does not find any results, a `null` result is generated instead of simply stopping the result stream. On top of this, the planner will issue an `AntiConditionalApply`, which will run the exhaustive search if the path variable is pointing to `null` instead of a path.

An `ErrorPlan` operator will appear in the execution plan in cases where (i) `cypher.forbid_exhaustive_shortestpath` is set to `true`, and (ii) the fast algorithm is not able to find the shortest path.

Prevent the exhaustive search from being used as a fallback

Query

```
MATCH (cs:Person { name: 'Charlie Sheen' }),(ms:Person { name: 'Martin Sheen' }), p = shortestPath((cs)-
[*]-(ms))
WITH p
WHERE length(p)> 1
RETURN p
```

This query, just like the one above, needs to check that the whole path follows the predicate before we know if it is valid or not. However, the inclusion of the `WITH` clause means that the query plan will not include the fallback to the slower exhaustive search algorithm. Instead, any paths found by the fast algorithm will subsequently be filtered, which may result in no answers being returned.

Query plan

```
Compiler CYPHER 4.0

Planner COST

Runtime SLOTTED

Runtime version 4.0

+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Page Cache Hits | Page Cache Misses | Page Cache
Hit Ratio | Order       | Variables              | Other                     |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| +ProduceResults    |              1 |    1 |       0 |               1 |                 0 |
1.0000 | cs.name ASC | anon[104], cs, ms, p   |                           |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| +Filter            |              1 |    1 |       0 |               0 |                 0 |
0.0000 | cs.name ASC | anon[104], cs, ms, p   | length(p) > $`  AUTOINT2` |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| +ShortestPath      |              4 |    1 |       1 |               8 |                 0 |
1.0000 | cs.name ASC | anon[104], p -- cs, ms | {}                        |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| +CartesianProduct |              4 |    1 |       0 |               0 |                 0 |
0.0000 | cs.name ASC | cs -- ms               |                           |
| |\                 +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| | +NodeIndexSeek  |              2 |    1 |       2 |               1 |                 0 |
1.0000 | ms.name ASC | ms                     | :Person(name)             |
| |                  +----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+
| +NodeIndexSeek     |              2 |    1 |       2 |               1 |                 0 |
1.0000 | cs.name ASC | cs                     | :Person(name)             |
+--------------------+----------------+------+---------+-----------------+-------------------
+----------------------+-------------+------------------------+---------------------------+

Total database accesses: 5
```

Chapter 8. Deprecations, additions and compatibility

Cypher is a language that is constantly evolving. New features get added to the language continuously, and occasionally, some features become deprecated and are subsequently removed.

8.1. Removals, deprecations, additions, and extensions

The following tables list all of the features which have been removed, deprecated, added, or extended in Cypher. Replacement syntax for deprecated and removed features are also indicated.

8.1.1. Version 4.0

Feature	Type	Change	Details
`rels()`	Function	Removed	Replaced by relationships()
`toInt()`	Function	Removed	Replaced by toInteger()
`lower()`	Function	Removed	Replaced by toLower()
`upper()`	Function	Removed	Replaced by toUpper()
`extract()`	Function	Removed	Replaced by list comprehension
`filter()`	Function	Removed	Replaced by list comprehension
`length()`	Function	Restricted	Restricted to only work on paths. See length() for more details.
`size()`	Function	Restricted	No longer works for paths. Only works for strings, lists and pattern expressions. See size() for more details.
`CYPHER planner=rule` (Rule planner)	Functionality	Removed	The `RULE` planner was removed in 3.2, but still possible to trigger using `START` or `CREATE UNIQUE` clauses. Now it is completely removed.

Feature	Type	Change	Details
`CREATE UNIQUE`	Clause	Removed	Running queries with this clause will cause a syntax error. Running with `CYPHER 3.5` will cause a runtime error due to the removal of the rule planner.
`START`	Clause	Removed	Running queries with this clause will cause a syntax error. Running with `CYPHER 3.5` will cause a runtime error due to the removal of the rule planner.
Explicit indexes	Functionality	Removed	The removal of the `RULE` planner in 3.2 was the beginning of the end for explicit indexes. Now they are completely removed, including the removal of the built-in procedures for Neo4j 3.3 to 3.5.
`MATCH (n)-[rs*]-() RETURN rs`	Syntax	Removed	Replaced by `MATCH p=(n)-[*]-() RETURN relationships(p) AS rs`
`MATCH (n)-[:A|:B|:C {foo: 'bar'}]-() RETURN n`	Syntax	Removed	Replaced by `MATCH (n)-[:A|B|C {foo: 'bar'}]-() RETURN n`
`MATCH (n)-[x:A|:B|:C]-() RETURN n`	Syntax	Removed	Replaced by `MATCH (n)-[x:A|B|C]-() RETURN n`
`MATCH (n)-[x:A|:B|:C*]-() RETURN n`	Syntax	Removed	Replaced by `MATCH (n)-[x:A|B|C*]-() RETURN n`
`{parameter}`	Syntax	Removed	Replaced by $parameter
`CYPHER runtime=pipelined` (Pipelined runtime)	Functionality	Added	This Neo4j Enterprise Edition only feature involves a new runtime that has many performance enhancements.
`CYPHER runtime=compiled` (Compiled runtime)	Functionality	Removed	Replaced by the new `pipelined` runtime which covers a much wider range of queries.
`CREATE INDEX [name] FOR (n:Label) ON (n.prop)`	Syntax	Added	New syntax for creating indexes, which can include a name.
`CREATE CONSTRAINT [name] ON …`	Syntax	Extended	The create constraint syntax can now include a name.
`DROP INDEX name`	Syntax	Added	New command for dropping an index by name.
`DROP CONSTRAINT name`	Syntax	Added	New command for dropping a constraint by name, no matter the type.
`CREATE INDEX ON :Label(prop)`	Syntax	Deprecated	Replaced by `CREATE INDEX FOR (n:Label) ON (n.prop)`
`DROP INDEX ON :Label(prop)`	Syntax	Deprecated	Replaced by `DROP INDEX name`
`DROP CONSTRAINT ON (n:Label) ASSERT (n.prop) IS NODE KEY`	Syntax	Deprecated	Replaced by `DROP CONSTRAINT name`
`DROP CONSTRAINT ON (n:Label) ASSERT (n.prop) IS UNIQUE`	Syntax	Deprecated	Replaced by `DROP CONSTRAINT name`

Feature	Type	Change	Details
`DROP CONSTRAINT ON (n:Label) ASSERT exists(n.prop)`	Syntax	Deprecated	Replaced by `DROP CONSTRAINT name`
`DROP CONSTRAINT ON ()-[r:Type]-() ASSERT exists(r.prop)`	Syntax	Deprecated	Replaced by `DROP CONSTRAINT name`
Multi-database administration	Functionality	Added	New Cypher commands for administering multiple databases
Security administration	Functionality	Added	New Cypher commands for administering role-based access-control
Fine-grained security	Functionality	Added	New Cypher commands for administering dbms, database, graph and sub-graph access control

8.1.2. Version 3.5

Feature	Type	Change	Details
`CYPHER runtime=compiled` (Compiled runtime)	Functionality	Deprecated	The compiled runtime will be discontinued in the next major release. It might still be used for default queries in order to not cause regressions, but explicitly requesting it will not be possible.
`extract()`	Function	Deprecated	Replaced by list comprehension
`filter()`	Function	Deprecated	Replaced by list comprehension

8.1.3. Version 3.4

Feature	Type	Change	Details
Spatial point types	Functionality	Amendment	A point — irrespective of which Coordinate Reference System is used — can be stored as a property and is able to be backed by an index. Prior to this, a point was a virtual property only.
point() - Cartesian 3D	Function	Added	
point() - WGS 84 3D	Function	Added	
randomUUID()	Function	Added	
Temporal types	Functionality	Added	Supports storing, indexing and working with the following temporal types: Date, Time, LocalTime, DateTime, LocalDateTime and Duration.
Temporal functions	Functionality	Added	Functions allowing for the creation and manipulation of values for each temporal type — *Date*, *Time*, *LocalTime*, *DateTime*, *LocalDateTime* and *Duration*.

Feature	Type	Change	Details
Temporal operators	Functionality	Added	Operators allowing for the manipulation of values for each temporal type — *Date*, *Time*, *LocalTime*, *DateTime*, *LocalDateTime* and *Duration*.
toString()	Function	Extended	Now also allows temporal values as input (i.e. values of type *Date*, *Time*, *LocalTime*, *DateTime*, *LocalDateTime* or *Duration*).

8.1.4. Version 3.3

Feature	Type	Change	Details
`START`	Clause	Removed	As in Cypher 3.2, any queries using the `START` clause will revert back to Cypher 3.1 `planner=rule`. However, there are built-in procedures for Neo4j versions 3.3 to 3.5 for accessing explicit indexes. The procedures will enable users to use the current version of Cypher and the cost planner together with these indexes. An example of this is `CALL db.index.explicit.searchNodes('my_index','email:me*')`.
`CYPHER runtime=slotted` (Faster interpreted runtime)	Functionality	Added	Neo4j Enterprise Edition only
max(), min()	Function	Extended	Now also supports aggregation over sets containing lists of strings and/or numbers, as well as over sets containing strings, numbers, and lists of strings and/or numbers

8.1.5. Version 3.2

Feature	Type	Change	Details
`CYPHER planner=rule` (Rule planner)	Functionality	Removed	All queries now use the cost planner. Any query prepended thus will fall back to using Cypher 3.1.
`CREATE UNIQUE`	Clause	Removed	Running such queries will fall back to using Cypher 3.1 (and use the rule planner)
`START`	Clause	Removed	Running such queries will fall back to using Cypher 3.1 (and use the rule planner)
`MATCH (n)-[rs*]-() RETURN rs`	Syntax	Deprecated	Replaced by `MATCH p=(n)-[*]-() RETURN relationships(p) AS rs`
`MATCH (n)-[:A|:B|:C {foo: 'bar'}]-() RETURN n`	Syntax	Deprecated	Replaced by `MATCH (n)-[:A|B|C {foo: 'bar'}]-() RETURN n`
`MATCH (n)-[x:A|:B|:C]-() RETURN n`	Syntax	Deprecated	Replaced by `MATCH (n)-[x:A|B|C]-() RETURN n`

Feature	Type	Change	Details
`MATCH (n)-[x:A|:B|:C*]-() RETURN n`	Syntax	Deprecated	Replaced by `MATCH (n)-[x:A|B|C*]-() RETURN n`
User-defined aggregation functions	Functionality	Added	
Composite indexes	Index	Added	
Node Key	Index	Added	Neo4j Enterprise Edition only
`CYPHER runtime=compiled` (Compiled runtime)	Functionality	Added	Neo4j Enterprise Edition only
reverse()	Function	Extended	Now also allows a list as input
max(), min()	Function	Extended	Now also supports aggregation over a set containing both strings and numbers

8.1.6. Version 3.1

Feature	Type	Change	Details
`rels()`	Function	Deprecated	Replaced by relationships()
`toInt()`	Function	Deprecated	Replaced by toInteger()
`lower()`	Function	Deprecated	Replaced by toLower()
`upper()`	Function	Deprecated	Replaced by toUpper()
toBoolean()	Function	Added	
Map projection	Syntax	Added	
Pattern comprehension	Syntax	Added	
User-defined functions	Functionality	Added	
CALL...YIELD...WHERE	Clause	Extended	Records returned by `YIELD` may be filtered further using `WHERE`

8.1.7. Version 3.0

Feature	Type	Change	Details
`has()`	Function	Removed	Replaced by exists()
`str()`	Function	Removed	Replaced by toString()
`{parameter}`	Syntax	Deprecated	Replaced by $parameter
properties()	Function	Added	
CALL [...YIELD]	Clause	Added	
point() - Cartesian 2D	Function	Added	
point() - WGS 84 2D	Function	Added	
distance()	Function	Added	
User-defined procedures	Functionality	Added	
toString()	Function	Extended	Now also allows Boolean values as input

8.2. Compatibility

The ability of Neo4j to support multiple older versions of the Cypher language has been changing. In versions of Neo4j before 3.5 the backwards compatibility layer included the Cypher language parser, planner and runtime. All supported versions of Cypher would run on the same Neo4j kernel. In Neo4j 3.4, however, this was changed such that the compatibility layer no longer included the runtime. This meant that running, for example, a `CYPHER 3.1` query inside Neo4j 3.5 would plan the query using the 3.1 planner, and run it using the 3.5 runtime and kernel. In Neo4j 4.0 this was changed again, such that the compatibility layer includes only the parser. For example, running a `CYPHER 3.5` query inside Neo4j will parse older language features, but plan using the 4.0 planner, and run using the 4.0 runtime and kernel. The primary reason for this change has been optimizations in the Cypher runtime to allow Cypher query to perform better.

Older versions of the language can still be accessed if required. There are two ways to select which version to use in queries.

1. Setting a version for all queries: You can configure your database with the configuration parameter `cypher.default_language_version`, and enter which version you'd like to use (see Supported language versions). Every Cypher query will use this version, provided the query hasn't explicitly been configured as described in the next item below.
2. Setting a version on a query by query basis: The other method is to set the version for a particular query. Prepending a query with `CYPHER 3.5` will execute the query with the version of Cypher included in Neo4j 3.5.

Below is an example using the older parameter syntax `{param}`:

```
CYPHER 3.5
MATCH (n:Person)
WHERE n.age > {agelimit}
RETURN n.name, n.age
```

Without the `CYPHER 3.5` prefix this query would fail with a syntax error. With `CYPHER 3.5` however, it will only generate a warning and still work.

In Neo4j 4.0 some older language features are understood by the Cypher parser even if they are no longer supported by the Neo4j kernel. These features will result in runtime errors. See the table at Cypher Version 4.0 for the list of affected features.

8.3. Supported language versions

Neo4j 4.0 supports the following versions of the Cypher language:

- Neo4j Cypher 3.5
- Neo4j Cypher 4.0

Each release of Neo4j supports a limited number of old Cypher Language Versions. When you upgrade to a new release of Neo4j, please make sure that it supports the Cypher language version you need. If not, you may need to modify your queries to work with a newer Cypher language version.

Chapter 9. Glossary of keywords

This section comprises a glossary of all the keywords — grouped by category and thence ordered lexicographically — in the Cypher query language.

9.1. Clauses

Clause	Category	Description
CALL [...YIELD]	Reading/Writing	Invoke a procedure deployed in the database.
CALL {...}	Reading/Writing	Evaluates a subquery, typically used for post-union processing or aggregations.
CREATE	Writing	Create nodes and relationships.
CREATE CONSTRAINT [existence] ON (n:Label) ASSERT exists(n.property)	Schema	Create a constraint ensuring that all nodes with a particular label have a certain property.
CREATE CONSTRAINT [node_key] ON (n:Label) ASSERT (n.prop1, …, n.propN) IS NODE KEY	Schema	Create a constraint ensuring all nodes with a particular label have all the specified properties and that the combination of property values is unique; i.e. ensures existence and uniqueness.
CREATE CONSTRAINT [existence] ON ()-[r:REL_TYPE]-() ASSERT exists(r.property)	Schema	Create a constraint ensuring that all relationship with a particular type have a certain property.
CREATE CONSTRAINT [uniqueness] ON (n:Label) ASSERT n.property IS UNIQUE	Schema	Create a constraint ensuring the uniqueness of the combination of node label and property value for a particular property key across all nodes.
CREATE INDEX [single] FOR (n:Label) ON (n.property)	Schema	Create an index on all nodes with a particular label and a single property; i.e. create a single-property index.
CREATE INDEX [composite] FOR (n:Label) ON (n.prop1, …, n.propN)	Schema	Create an index on all nodes with a particular label and multiple properties; i.e. create a composite index.
DELETE	Writing	Delete nodes, relationships or paths. Any node to be deleted must also have all associated relationships explicitly deleted.
DETACH DELETE	Writing	Delete a node or set of nodes. All associated relationships will automatically be deleted.
DROP CONSTRAINT name	Schema	Drop a constraint using the name.

Clause	Category	Description
DROP INDEX name	Schema	Drop an index using the name.
FOREACH	Writing	Update data within a list, whether components of a path, or the result of aggregation.
LIMIT	Reading sub-clause	A sub-clause used to constrain the number of rows in the output.
LOAD CSV	Importing data	Use when importing data from CSV files.
MATCH	Reading	Specify the patterns to search for in the database.
MERGE	Reading/Writing	Ensures that a pattern exists in the graph. Either the pattern already exists, or it needs to be created.
ON CREATE	Reading/Writing	Used in conjunction with `MERGE`, specifying the actions to take if the pattern needs to be created.
ON MATCH	Reading/Writing	Used in conjunction with `MERGE`, specifying the actions to take if the pattern already exists.
OPTIONAL MATCH	Reading	Specify the patterns to search for in the database while using `nulls` for missing parts of the pattern.
ORDER BY [ASC[ENDING] | DESC[ENDING]]	Reading sub-clause	A sub-clause following `RETURN` or `WITH`, specifying that the output should be sorted in either ascending (the default) or descending order.
REMOVE	Writing	Remove properties and labels from nodes and relationships.
RETURN … [AS]	Projecting	Defines what to include in the query result set.
SET	Writing	Update labels on nodes and properties on nodes and relationships.
SKIP	Reading/Writing	A sub-clause defining from which row to start including the rows in the output.
UNION	Set operations	Combines the result of multiple queries. Duplicates are removed.
UNION ALL	Set operations	Combines the result of multiple queries. Duplicates are retained.
UNWIND … [AS]	Projecting	Expands a list into a sequence of rows.
USE	Multiple graphs	Determines which graph a query, or query part, is executed against.
USING INDEX variable:Label(property)	Hint	Index hints are used to specify which index, if any, the planner should use as a starting point.
USING INDEX SEEK variable:Label(property)	Hint	Index seek hint instructs the planner to use an index seek for this clause.
USING JOIN ON variable	Hint	Join hints are used to enforce a join operation at specified points.
USING PERIODIC COMMIT	Hint	This query hint may be used to prevent an out-of-memory error from occurring when importing large amounts of data using `LOAD CSV`.

Clause	Category	Description
USING SCAN variable:Label	Hint	Scan hints are used to force the planner to do a label scan (followed by a filtering operation) instead of using an index.
WITH ... [AS]	Projecting	Allows query parts to be chained together, piping the results from one to be used as starting points or criteria in the next.
WHERE	Reading sub-clause	A sub-clause used to add constraints to the patterns in a `MATCH` or `OPTIONAL MATCH` clause, or to filter the results of a `WITH` clause.
WHERE EXISTS {...}	Reading sub-clause	An existential sub-query used to filter the results of a `MATCH`, `OPTIONAL MATCH` or `WITH` clause.

9.2. Operators

Operator	Category	Description
%	Mathematical	Modulo division
*	Mathematical	Multiplication
*	Temporal	Multiplying a duration with a number
+	Mathematical	Addition
+	String	Concatenation
+=	Property	Property mutation
+	List	Concatenation
+	Temporal	Adding two durations, or a duration and a temporal instant
-	Mathematical	Subtraction or unary minus
-	Temporal	Subtracting a duration from a temporal instant or from another duration
.	Map	Static value access by key
.	Property	Static property access
/	Mathematical	Division
/	Temporal	Dividing a duration by a number
<	Comparison	Less than
<=	Comparison	Less than or equal to
<>	Comparison	Inequality
=	Comparison	Equality
=	Property	Property replacement
=~	String	Regular expression match
>	Comparison	Greater than
>=	Comparison	Greater than or equal to
AND	Boolean	Conjunction
CONTAINS	String comparison	Case-sensitive inclusion search
DISTINCT	Aggregation	Duplicate removal

Operator	Category	Description
ENDS WITH	String comparison	Case-sensitive suffix search
IN	List	List element existence check
IS NOT NULL	Comparison	Non-`null` check
IS NULL	Comparison	`null` check
NOT	Boolean	Negation
OR	Boolean	Disjunction
STARTS WITH	String comparison	Case-sensitive prefix search
XOR	Boolean	Exclusive disjunction
[]	Map	Subscript (dynamic value access by key)
[]	Property	Subscript (dynamic property access)
[]	List	Subscript (accessing element(s) in a list)
^	Mathematical	Exponentiation

9.3. Functions

Function	Category	Description
abs()	Numeric	Returns the absolute value of a number.
acos()	Trigonometric	Returns the arccosine of a number in radians.
all()	Predicate	Tests whether the predicate holds for all elements in a list.
any()	Predicate	Tests whether the predicate holds for at least one element in a list.
asin()	Trigonometric	Returns the arcsine of a number in radians.
atan()	Trigonometric	Returns the arctangent of a number in radians.
atan2()	Trigonometric	Returns the arctangent2 of a set of coordinates in radians.
avg()	Aggregating	Returns the average of a set of values.
ceil()	Numeric	Returns the smallest floating point number that is greater than or equal to a number and equal to a mathematical integer.
coalesce()	Scalar	Returns the first non-`null` value in a list of expressions.
collect()	Aggregating	Returns a list containing the values returned by an expression.
cos()	Trigonometric	Returns the cosine of a number.
cot()	Trigonometric	Returns the cotangent of a number.
count()	Aggregating	Returns the number of values or rows.
date()	Temporal	Returns the current *Date*.
date({year [, month, day]})	Temporal	Returns a calendar (Year-Month-Day) *Date*.

Function	Category	Description
date({year [, week, dayOfWeek]})	Temporal	Returns a week (Year-Week-Day) *Date*.
date({year [, quarter, dayOfQuarter]})	Temporal	Returns a quarter (Year-Quarter-Day) *Date*.
date({year [, ordinalDay]})	Temporal	Returns an ordinal (Year-Day) *Date*.
date(string)	Temporal	Returns a *Date* by parsing a string.
date({map})	Temporal	Returns a *Date* from a map of another temporal value's components.
date.realtime()	Temporal	Returns the current *Date* using the `realtime` clock.
date.statement()	Temporal	Returns the current *Date* using the `statement` clock.
date.transaction()	Temporal	Returns the current *Date* using the `transaction` clock.
date.truncate()	Temporal	Returns a *Date* obtained by truncating a value at a specific component boundary. Truncation summary.
datetime()	Temporal	Returns the current *DateTime*.
datetime({year [, month, day, ...]})	Temporal	Returns a calendar (Year-Month-Day) *DateTime*.
datetime({year [, week, dayOfWeek, ...]})	Temporal	Returns a week (Year-Week-Day) *DateTime*.
datetime({year [, quarter, dayOfQuarter, ...]})	Temporal	Returns a quarter (Year-Quarter-Day) *DateTime*.
datetime({year [, ordinalDay, ...]})	Temporal	Returns an ordinal (Year-Day) *DateTime*.
datetime(string)	Temporal	Returns a *DateTime* by parsing a string.
datetime({map})	Temporal	Returns a *DateTime* from a map of another temporal value's components.
datetime({epochSeconds})	Temporal	Returns a *DateTime* from a timestamp.
datetime.realtime()	Temporal	Returns the current *DateTime* using the `realtime` clock.
datetime.statement()	Temporal	Returns the current *DateTime* using the `statement` clock.
datetime.transaction()	Temporal	Returns the current *DateTime* using the `transaction` clock.
datetime.truncate()	Temporal	Returns a *DateTime* obtained by truncating a value at a specific component boundary. Truncation summary.
degrees()	Trigonometric	Converts radians to degrees.
distance()	Spatial	Returns a floating point number representing the geodesic distance between any two points in the same CRS.
duration({map})	Temporal	Returns a *Duration* from a map of its components.
duration(string)	Temporal	Returns a *Duration* by parsing a string.
duration.between()	Temporal	Returns a *Duration* equal to the difference between two given instants.
duration.inDays()	Temporal	Returns a *Duration* equal to the difference in whole days or weeks between two given instants.

Function	Category	Description
duration.inMonths()	Temporal	Returns a *Duration* equal to the difference in whole months, quarters or years between two given instants.
duration.inSeconds()	Temporal	Returns a *Duration* equal to the difference in seconds and fractions of seconds, or minutes or hours, between two given instants.
e()	Logarithmic	Returns the base of the natural logarithm, `e`.
endNode()	Scalar	Returns the end node of a relationship.
exists()	Predicate	Returns true if a match for the pattern exists in the graph, or if the specified property exists in the node, relationship or map.
exp()	Logarithmic	Returns `e^n`, where `e` is the base of the natural logarithm, and `n` is the value of the argument expression.
floor()	Numeric	Returns the largest floating point number that is less than or equal to a number and equal to a mathematical integer.
haversin()	Trigonometric	Returns half the versine of a number.
head()	Scalar	Returns the first element in a list.
id()	Scalar	Returns the id of a relationship or node.
keys()	List	Returns a list containing the string representations for all the property names of a node, relationship, or map.
labels()	List	Returns a list containing the string representations for all the labels of a node.
last()	Scalar	Returns the last element in a list.
left()	String	Returns a string containing the specified number of leftmost characters of the original string.
length()	Scalar	Returns the length of a path.
localdatetime()	Temporal	Returns the current *LocalDateTime*.
localdatetime({year [, month, day, …]})	Temporal	Returns a calendar (Year-Month-Day) *LocalDateTime*.
localdatetime({year [, week, dayOfWeek, …]})	Temporal	Returns a week (Year-Week-Day) *LocalDateTime*.
localdatetime({year [, quarter, dayOfQuarter, …]})	Temporal	Returns a quarter (Year-Quarter-Day) *DateTime*.
localdatetime({year [, ordinalDay, …]})	Temporal	Returns an ordinal (Year-Day) *LocalDateTime*.
localdatetime(string)	Temporal	Returns a *LocalDateTime* by parsing a string.
localdatetime({map})	Temporal	Returns a *LocalDateTime* from a map of another temporal value's components.
localdatetime.realtime()	Temporal	Returns the current *LocalDateTime* using the `realtime` clock.
localdatetime.statement()	Temporal	Returns the current *LocalDateTime* using the `statement` clock.

Function	Category	Description
localdatetime.transaction()	Temporal	Returns the current *LocalDateTime* using the `transaction` clock.
localdatetime.truncate()	Temporal	Returns a *LocalDateTime* obtained by truncating a value at a specific component boundary. Truncation summary.
localtime()	Temporal	Returns the current *LocalTime*.
localtime({hour [, minute, second, …]})	Temporal	Returns a *LocalTime* with the specified component values.
localtime(string)	Temporal	Returns a *LocalTime* by parsing a string.
localtime({time [, hour, …]})	Temporal	Returns a *LocalTime* from a map of another temporal value's components.
localtime.realtime()	Temporal	Returns the current *LocalTime* using the `realtime` clock.
localtime.statement()	Temporal	Returns the current *LocalTime* using the `statement` clock.
localtime.transaction()	Temporal	Returns the current *LocalTime* using the `transaction` clock.
localtime.truncate()	Temporal	Returns a *LocalTime* obtained by truncating a value at a specific component boundary. Truncation summary.
log()	Logarithmic	Returns the natural logarithm of a number.
log10()	Logarithmic	Returns the common logarithm (base 10) of a number.
lTrim()	String	Returns the original string with leading whitespace removed.
max()	Aggregating	Returns the maximum value in a set of values.
min()	Aggregating	Returns the minimum value in a set of values.
nodes()	List	Returns a list containing all the nodes in a path.
none()	Predicate	Returns true if the predicate holds for no element in a list.
percentileCont()	Aggregating	Returns the percentile of the given value over a group using linear interpolation.
percentileDisc()	Aggregating	Returns the nearest value to the given percentile over a group using a rounding method.
pi()	Trigonometric	Returns the mathematical constant *pi*.
point() - Cartesian 2D	Spatial	Returns a 2D point object, given two coordinate values in the Cartesian coordinate system.
point() - Cartesian 3D	Spatial	Returns a 3D point object, given three coordinate values in the Cartesian coordinate system.
point() - WGS 84 2D	Spatial	Returns a 2D point object, given two coordinate values in the WGS 84 coordinate system.

Function	Category	Description
point() - WGS 84 3D	Spatial	Returns a 3D point object, given three coordinate values in the WGS 84 coordinate system.
properties()	Scalar	Returns a map containing all the properties of a node or relationship.
radians()	Trigonometric	Converts degrees to radians.
rand()	Numeric	Returns a random floating point number in the range from 0 (inclusive) to 1 (exclusive); i.e. `[0, 1)`.
randomUUID()	Scalar	Returns a string value corresponding to a randomly-generated UUID.
range()	List	Returns a list comprising all integer values within a specified range.
reduce()	List	Runs an expression against individual elements of a list, storing the result of the expression in an accumulator.
relationships()	List	Returns a list containing all the relationships in a path.
replace()	String	Returns a string in which all occurrences of a specified string in the original string have been replaced by another (specified) string.
reverse()	List	Returns a list in which the order of all elements in the original list have been reversed.
reverse()	String	Returns a string in which the order of all characters in the original string have been reversed.
right()	String	Returns a string containing the specified number of rightmost characters of the original string.
round()	Numeric	Returns the value of a number rounded to the nearest integer.
rTrim()	String	Returns the original string with trailing whitespace removed.
sign()	Numeric	Returns the signum of a number: `0` if the number is `0`, `-1` for any negative number, and `1` for any positive number.
sin()	Trigonometric	Returns the sine of a number.
single()	Predicate	Returns true if the predicate holds for exactly one of the elements in a list.
size()	Scalar	Returns the number of items in a list.
size() applied to pattern expression	Scalar	Returns the number of sub-graphs matching the pattern expression.
size() applied to string	Scalar	Returns the number of Unicode characters in a string.
split()	String	Returns a list of strings resulting from the splitting of the original string around matches of the given delimiter.
sqrt()	Logarithmic	Returns the square root of a number.
startNode()	Scalar	Returns the start node of a relationship.

Function	Category	Description
stDev()	Aggregating	Returns the standard deviation for the given value over a group for a sample of a population.
stDevP()	Aggregating	Returns the standard deviation for the given value over a group for an entire population.
substring()	String	Returns a substring of the original string, beginning with a 0-based index start and length.
sum()	Aggregating	Returns the sum of a set of numeric values.
tail()	List	Returns all but the first element in a list.
tan()	Trigonometric	Returns the tangent of a number.
time()	Temporal	Returns the current *Time*.
time({hour [, minute, …]})	Temporal	Returns a *Time* with the specified component values.
time(string)	Temporal	Returns a *Time* by parsing a string.
time({time [, hour, …, timezone]})	Temporal	Returns a *Time* from a map of another temporal value's components.
time.realtime()	Temporal	Returns the current *Time* using the `realtime` clock.
time.statement()	Temporal	Returns the current *Time* using the `statement` clock.
time.transaction()	Temporal	Returns the current *Time* using the `transaction` clock.
time.truncate()	Temporal	Returns a *Time* obtained by truncating a value at a specific component boundary. Truncation summary.
timestamp()	Scalar	Returns the difference, measured in milliseconds, between the current time and midnight, January 1, 1970 UTC.
toBoolean()	Scalar	Converts a string value to a boolean value.
toFloat()	Scalar	Converts an integer or string value to a floating point number.
toInteger()	Scalar	Converts a floating point or string value to an integer value.
toLower()	String	Returns the original string in lowercase.
toString()	String	Converts an integer, float, boolean or temporal (i.e. Date, Time, LocalTime, DateTime, LocalDateTime or Duration) value to a string.
toUpper()	String	Returns the original string in uppercase.
trim()	String	Returns the original string with leading and trailing whitespace removed.
type()	Scalar	Returns the string representation of the relationship type.

9.4. Expressions

Name	Description
CASE Expression	A generic conditional expression, similar to if/else statements available in other languages.

9.5. Cypher query options

Name	Type	Description
CYPHER $version query	Version	This will force `'query'` to use Neo4j Cypher `$version`. The default is `3.3`.
CYPHER runtime=interpreted query	Runtime	This will force the query planner to use the interpreted runtime. This is the only option in Neo4j Community Edition.
CYPHER runtime=slotted query	Runtime	This will cause the query planner to use the slotted runtime. This is only available in Neo4j Enterprise Edition.
CYPHER runtime=compiled query	Runtime	This will cause the query planner to use the compiled runtime if it supports `'query'`. This is only available in Neo4j Enterprise Edition.

9.6. Administrative commands

The following commands are only executable against the `system` database:

Command	Admin category	Description
ALTER CURRENT USER SET PASSWORD FROM … TO	User and role	Change the password of the user that is currently logged in.
ALTER USER … [SET PASSWORD {password [CHANGE [NOT] REQUIRED] | CHANGE [NOT] REQUIRED}] [SET STATUS {ACTIVE | SUSPENDED}]	User and role	Changes a user account. Changes can include setting a new password, setting the account status and enabling that the user should change the password upon next login.
CREATE [OR REPLACE] DATABASE … [IF NOT EXISTS]	Database	Creates a new database.
CREATE [OR REPLACE] ROLE … [IF NOT EXISTS] [AS COPY OF]	User and role	Creates new roles.
CREATE [OR REPLACE] USER … [IF NOT EXISTS] SET PASSWORD … [[SET PASSWORD] CHANGE [NOT] REQUIRED] [SET STATUS {ACTIVE | SUSPENDED}]	User and role	Creates a new user and sets the password for the new account. Optionally the account status can also be set and if the user should change the password upon first login.
DENY … ON DATABASE … TO	Privilege	Denies a database or schema privilege to one or multiple roles.
DENY … ON DBMS TO	Privilege	Denies a DBMS privilege to one or multiple roles.
DENY … ON GRAPH … [NODES | RELATIONSHIPS | ELEMENTS] … TO	Privilege	Denies a graph privilege for one or multiple specified elements to one or multiple roles.
DROP DATABASE … [IF EXISTS]	Database	Deletes a specified database.
DROP ROLE … [IF EXISTS]	User and role	Deletes a specified role.
DROP USER … [IF EXISTS]	User and role	Deletes a specified user.

Command	Admin category	Description
GRANT ... ON DATABASE ... TO	Privilege	Assigns a database or schema privilege to one or multiple roles.
GRANT ... ON DBMS TO	Privilege	Assigns a DBMS privilege to one or multiple roles.
GRANT ... ON GRAPH ... [NODES | RELATIONSHIPS | ELEMENTS] ... TO	Privilege	Assigns a graph privilege for one or multiple specified elements to one or multiple roles.
GRANT ROLE[S] ... TO	User and role	Assigns one or multiple roles to one or multiple users.
SHOW [ROLE ... | USER ... | ALL] PRIVILEGES	Privilege	Returns information about role, user or all privileges.
START DATABASE	Database	Starts up a specified database.
STOP DATABASE	Database	Stops a specified database.
REVOKE [GRANT | DENY] ... ON DATABASE ... FROM	Privilege	Removes a database or schema privilege from one or multiple roles.
REVOKE [GRANT | DENY] ... ON DBMS FROM	Privilege	Removes a DBMS privilege from one or multiple roles.
REVOKE [GRANT | DENY] ... ON GRAPH ... [NODES | RELATIONSHIPS | ELEMENTS] ... FROM	Privilege	Removes a graph privilege for one or multiple specified elements from one or multiple roles
REVOKE ROLE[S] ... FROM	User and role	Removes one or multiple roles from one or multiple users.
SHOW [ALL | POPULATED] ROLES [WITH USERS]	User and role	Returns information about all or populated roles, optionally including the assigned users.
SHOW DATABASE	Database	Returns information about a specified database.
SHOW DATABASES	Database	Returns information about all databases.
SHOW DEFAULT DATABASE	Database	Returns information about the default database.
SHOW USERS	User and role	Returns information about all users.

9.7. Privilege Actions

Name	Category	Description
ACCESS	Database	Determines whether a user can access a specific database.
ALL DATABASE PRIVILEGES	Database and schema	Implies all privileges from the categories Database and Schema for a specific database.
ASSIGN ROLE	DBMS	Determines whether the user can grant roles.
CONSTRAINT MANAGEMENT	Schema	Determines whether a user is allowed to create and drop constraints on a specific database.
CREATE CONSTRAINT	Schema	Determines whether a user is allowed to create constraints on a specific database.
CREATE INDEX	Schema	Determines whether a user is allowed to create indexes on a specific database.

Name	Category	Description
CREATE NEW NODE LABEL	Schema	Determines whether a user is allowed to create new node labels on a specific database.
CREATE NEW PROPERTY NAME	Schema	Determines whether a user is allowed to create new property names on a specific database.
CREATE NEW RELATIONSHIP TYPE	Schema	Determines whether a user is allowed to create new relationship types on a specific database.
CREATE ROLE	DBMS	Determines whether the user can create new roles.
DROP CONSTRAINT	Schema	Determines whether a user is allowed to drop constraints on a specific database.
DROP INDEX	Schema	Determines whether a user is allowed to drop indexes on a specific database.
DROP ROLE	DBMS	Determines whether the user can delete roles.
INDEX MANAGEMENT	Schema	Determines whether a user is allowed to create and drop indexes on a specific database.
MATCH	GRAPH	Determines whether the properties of an element (node, relationship or both) can be read and the element can be found and traversed while executing queries on the specified graph.
NAME MANAGEMENT	Schema	Determines whether a user is allowed to create new labels, types and property names on a specific database.
READ	GRAPH	Determines whether the properties of an element (node, relationship or both) can be read while executing queries on the specified graph.
REMOVE ROLE	DBMS	Determines whether the user can revoke roles.
ROLE MANAGEMENT	DBMS	Determines whether the user can create, drop, grant, revoke and show roles.
SHOW ROLE	DBMS	Determines whether the user can get information about existing and assigned roles.
START	Database	Determines whether a user can start up a specific database.
STOP	Database	Determines whether a user can stop a specific running database.
TRAVERSE	GRAPH	Determines whether an element (node, relationship or both) can be found and traversed while executing queries on the specified graph.
WRITE	GRAPH	Determines whether the user can execute write operations on the specified graph.

Appendix A: Cypher styleguide

This appendix contains the recommended style when writing Cypher queries.

This appendix contains the following:

- General recommendations
- Indentations and line breaks
- Casing
- Spacing
- Patterns
- Meta characters

The purpose of the styleguide is to make the code as easy to read as possible, and thereby contributing to lower cost of maintenance.

For rules and recommendations for naming of labels, relationship types and properties, please see the Naming rules and recommendations.

A.1. General recommendations

- When using Cypher language constructs in prose, use a `monospaced` font and follow the styling rules.
- When referring to labels and relationship types, the colon should be included as follows: `:Label`, `:REL_TYPE`.
- When referring to functions, use lower camel case and parentheses should be used as follows: `shortestPath()`. Arguments should normally not be included.
- If you are storing Cypher statements in a separate file, use the file extension `.cypher`.

A.2. Indentation and line breaks

- Start a new clause on a new line.

  Bad

```
MATCH (n) WHERE n.name CONTAINS 's' RETURN n.name
```

  Good

```
MATCH (n)
WHERE n.name CONTAINS 's'
RETURN n.name
```

- Indent `ON CREATE` and `ON MATCH` with two spaces. Put `ON CREATE` before `ON MATCH` if both are present.

  Bad

```
MERGE (n) ON CREATE SET n.prop = 0
MERGE (a:A)-[:T]-(b:B)
ON MATCH SET b.name = 'you'
ON CREATE SET a.name = 'me'
RETURN a.prop
```

Good

```
MERGE (n)
  ON CREATE SET n.prop = 0
MERGE (a:A)-[:T]-(b:B)
  ON CREATE SET a.name = 'me'
  ON MATCH SET b.name = 'you'
RETURN a.prop
```

- Start a subquery on a new line after the opening brace, indented with two (additional) spaces. Leave the closing brace on its own line.

Bad

```
MATCH (a:A)
WHERE
  EXISTS { MATCH (a)-->(b:B) WHERE b.prop = $param }
RETURN a.foo
```

Also bad

```
MATCH (a:A)
WHERE EXISTS
{MATCH (a)-->(b:B)
WHERE b.prop = $param}
RETURN a.foo
```

Good

```
MATCH (a:A)
WHERE EXISTS {
  MATCH (a)-->(b:B)
  WHERE b.prop = $param
}
RETURN a.foo
```

- Do not break the line if the simplified subquery form is used.

Bad

```
MATCH (a:A)
WHERE EXISTS {
  (a)-->(b:B)
}
RETURN a.prop
```

Good

```
MATCH (a:A)
WHERE EXISTS { (a)-->(b:B) }
RETURN a.prop
```

A.3. Casing

- Write keywords in upper case.

Bad

```
match (p:Person)
where p.name starts with 'Ma'
return p.name
```

Good

```
MATCH (p:Person)
WHERE p.name STARTS WITH 'Ma'
RETURN p.name
```

- Write the value `null` in lower case.

  Bad

  ```
  WITH NULL AS n1, Null AS n2
  RETURN n1 IS NULL AND n2 IS NOT NULL
  ```

  Good

  ```
  WITH null AS n1, null as n2
  RETURN n1 IS NULL AND n2 IS NOT NULL
  ```

- Write boolean literals (`true` and `false`) in lower case.

  Bad

  ```
  WITH TRUE AS b1, False AS b2
  RETURN b1 AND b2
  ```

  Good

  ```
  WITH true AS b1, false AS b2
  RETURN b1 AND b2
  ```

- Use camel case, starting with a lower-case character, for:
  - functions
  - properties
  - variables
  - parameters

    Bad

    ```
    CREATE (N {Prop: 0})
    WITH RAND() AS Rand, $pArAm AS MAP
    RETURN Rand, MAP.property_key, Count(N)
    ```

    Good

    ```
    CREATE (n {prop: 0})
    WITH rand() AS rand, $param AS map
    RETURN rand, map.propertyKey, count(n)
    ```

A.4. Spacing

- For literal maps:
  - No space between the opening brace and the first key
  - No space between key and colon
  - One space between colon and value

- No space between value and comma
- One space between comma and next key
- No space between the last value and the closing brace

Bad

```
WITH { key1 :'value' ,key2  :  42 } AS map
RETURN map
```

Good

```
WITH {key1: 'value', key2: 42} AS map
RETURN map
```

- One space between label/type predicates and property predicates in patterns.

Bad

```
MATCH (p:Person{property: -1})-[:KNOWS   {since: 2016}]->()
RETURN p.name
```

Good

```
MATCH (p:Person {property: -1})-[:KNOWS {since: 2016}]->()
RETURN p.name
```

- No space in patterns.

Bad

```
MATCH (:Person) --> (:Vehicle)
RETURN count(*)
```

Good

```
MATCH (:Person)-->(:Vehicle)
RETURN count(*)
```

- Use a wrapping space around operators.

Bad

```
MATCH p=(s)-->(e)
WHERE s.name<>e.name
RETURN length(p)
```

Good

```
MATCH p = (s)-->(e)
WHERE s.name <> e.name
RETURN length(p)
```

- No space in label predicates.

Bad

```
MATCH (person    : Person  :  Owner  )
RETURN person.name
```

Good

```
MATCH (person:Person:Owner)
RETURN person.name
```

- Use a space after each comma in lists and enumerations.

Bad

```
MATCH (),()
WITH ['a','b',3.14] AS list
RETURN list,2,3,4
```

Good

```
MATCH (), ()
WITH ['a', 'b', 3.14] AS list
RETURN list, 2, 3, 4
```

- No padding space within function call parentheses.

Bad

```
RETURN split( 'original', 'i' )
```

Good

```
RETURN split('original', 'i')
```

- Use padding space within simple subquery expressions.

Bad

```
MATCH (a:A)
WHERE EXISTS {(a)-->(b:B)}
RETURN a.prop
```

Good

```
MATCH (a:A)
WHERE EXISTS { (a)-->(b:B) }
RETURN a.prop
```

A.5. Patterns

- When patterns wrap lines, break after arrows, not before.

Bad

```
MATCH (:Person)-->(vehicle:Car)-->(:Company)
      <--(:Country)
RETURN count(vehicle)
```

Good

```
MATCH (:Person)-->(vehicle:Car)-->(:Company)<--
      (:Country)
RETURN count(vehicle)
```

- Use anonymous nodes and relationships when the variable would not be used.

Bad

```
CREATE (a:End {prop: 42}),
       (b:End {prop: 3}),
       (c:Begin {prop: id(a)})
```

Good

```
CREATE (a:End {prop: 42}),
       (:End {prop: 3}),
       (:Begin {prop: id(a)})
```

- Chain patterns together to avoid repeating variables.

Bad

```
MATCH (:Person)-->(vehicle:Car), (vehicle:Car)-->(:Company)
RETURN count(vehicle)
```

Good

```
MATCH (:Person)-->(vehicle:Car)-->(:Company)
RETURN count(vehicle)
```

- Put named nodes before anonymous nodes.

Bad

```
MATCH ()-->(vehicle:Car)-->(manufacturer:Company)
WHERE manufacturer.foundedYear < 2000
RETURN vehicle.mileage
```

Good

```
MATCH (manufacturer:Company)<--(vehicle:Car)<--()
WHERE manufacturer.foundedYear < 2000
RETURN vehicle.mileage
```

- Keep anchor nodes at the beginning of the `MATCH` clause.

Bad

```
MATCH (:Person)-->(vehicle:Car)-->(manufacturer:Company)
WHERE manufacturer.foundedYear < 2000
RETURN vehicle.mileage
```

Good

```
MATCH (manufacturer:Company)<--(vehicle:Car)<--(:Person)
WHERE manufacturer.foundedYear < 2000
RETURN vehicle.mileage
```

- Prefer outgoing (left to right) pattern relationships to incoming pattern relationships.

  Bad

  ```
  MATCH (:Country)-->(:Company)<--(vehicle:Car)<--(:Person)
  RETURN vehicle.mileage
  ```

  Good

  ```
  MATCH (:Person)-->(vehicle:Car)-->(:Company)<--(:Country)
  RETURN vehicle.mileage
  ```

A.6. Meta-characters

- Use single quotes, `'`, for literal string values.

  Bad

  ```
  RETURN "Cypher"
  ```

  Good

  ```
  RETURN 'Cypher'
  ```

  - Disregard this rule for literal strings that contain a single quote character. If the string has both, use the form that creates the fewest escapes. In the case of a tie, prefer single quotes.

    Bad

    ```
    RETURN 'Cypher\'s a nice language', "Mats' quote: \"statement\""
    ```

    Good

    ```
    RETURN "Cypher's a nice language", 'Mats\' quote: "statement"'
    ```

- Avoid having to use back-ticks to escape characters and keywords.

  Bad

  ```
  MATCH (`odd-ch@racter$`:`Spaced Label` {`&property`: 42})
  RETURN labels(`odd-ch@racter$`)
  ```

  Good

  ```
  MATCH (node:NonSpacedLabel {property: 42})
  RETURN labels(node)
  ```

- Do not use a semicolon at the end of the statement.

  Bad

  ```
  RETURN 1;
  ```

Good

```
RETURN 1
```

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