
Introduction to
Graph Databases
neo4j
v 1.0

What is a graph?

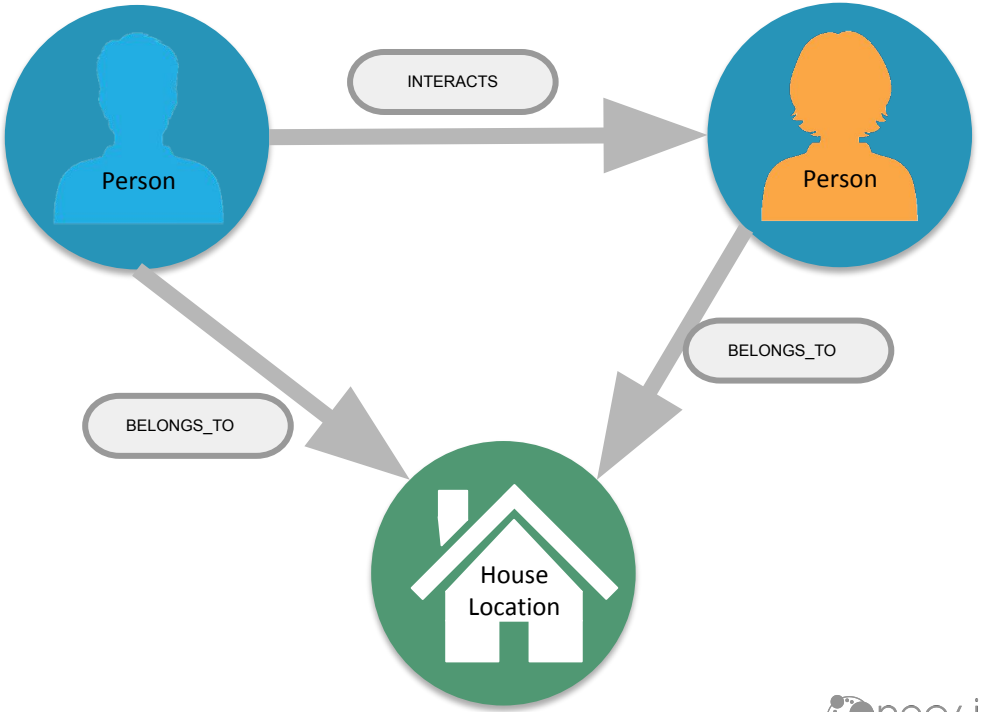
- Nodes
- Relationships
- Properties
- Labels

Nodes

- Nouns in your model
- Represent the objects or entities in the graph
- Can be *labeled*:
  - Person
  - House
  - Location
  - Region

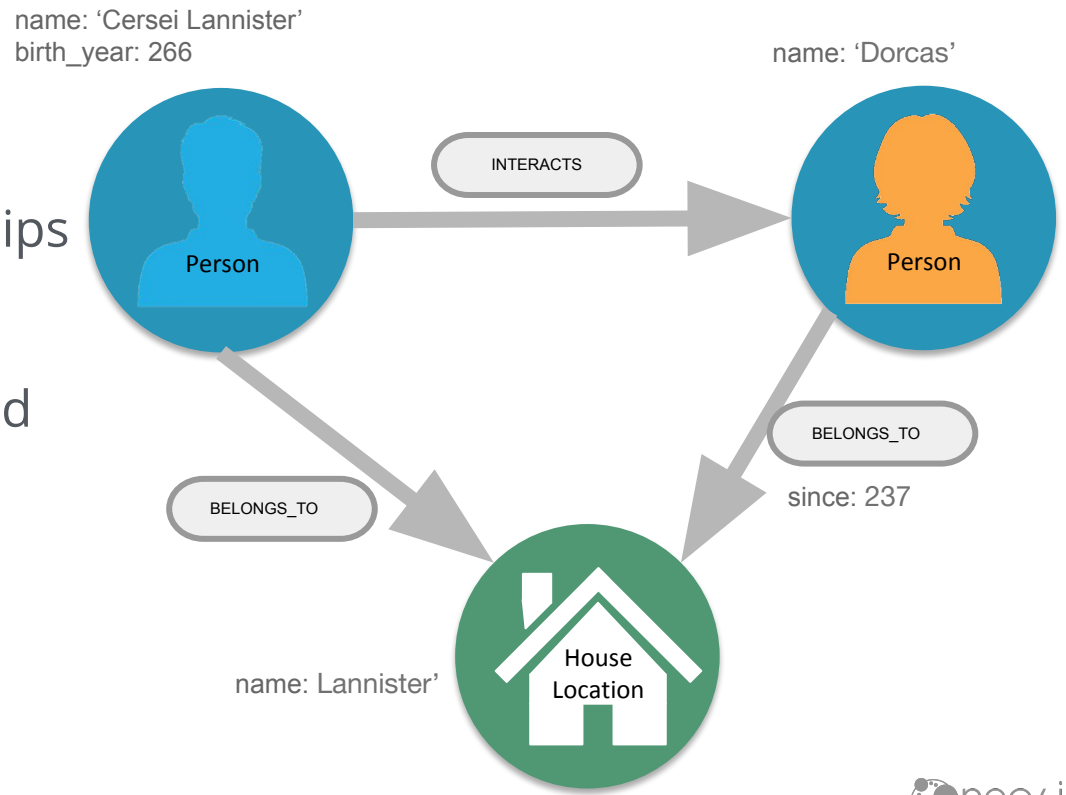
Relationships

- Verbs in your model
- Represent the connection between nodes in the graph
- Has a type:
  - INTERACTS
  - BELONGS_TO
- Directed relationship



Properties

- Adjectives to describe nodes
- Adverbs to describe relationships
- Property:
  - Key/value pair
  - Can be optional or required
  - Values can be unique for nodes
  - Values have no type



Modeling relational to graph

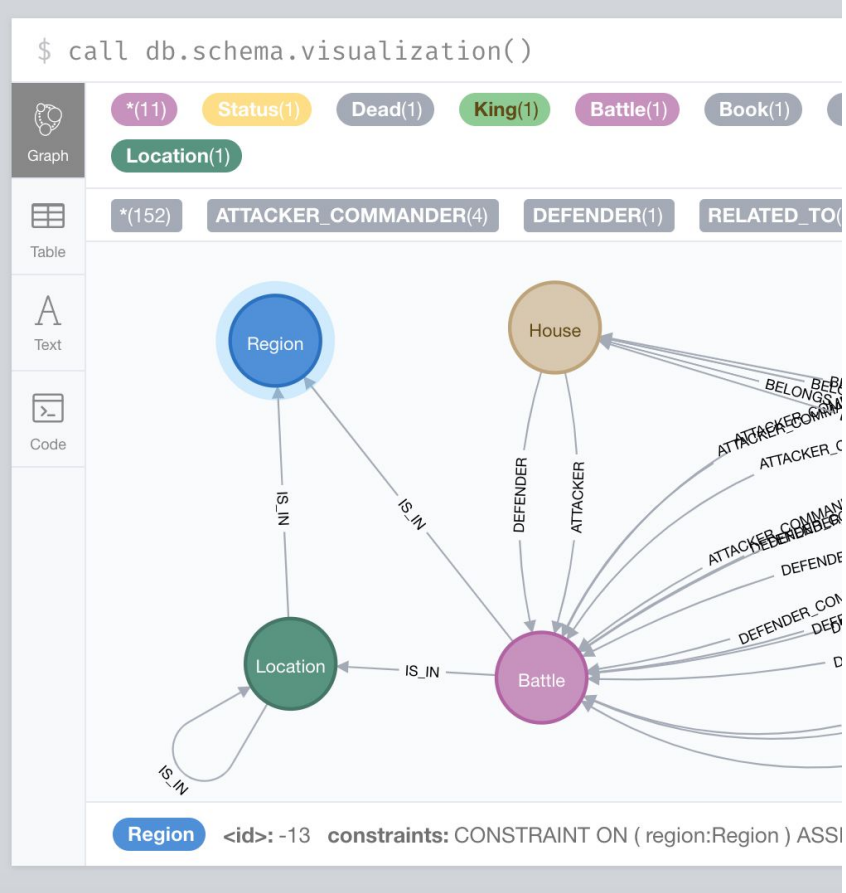
In some ways they're similar:

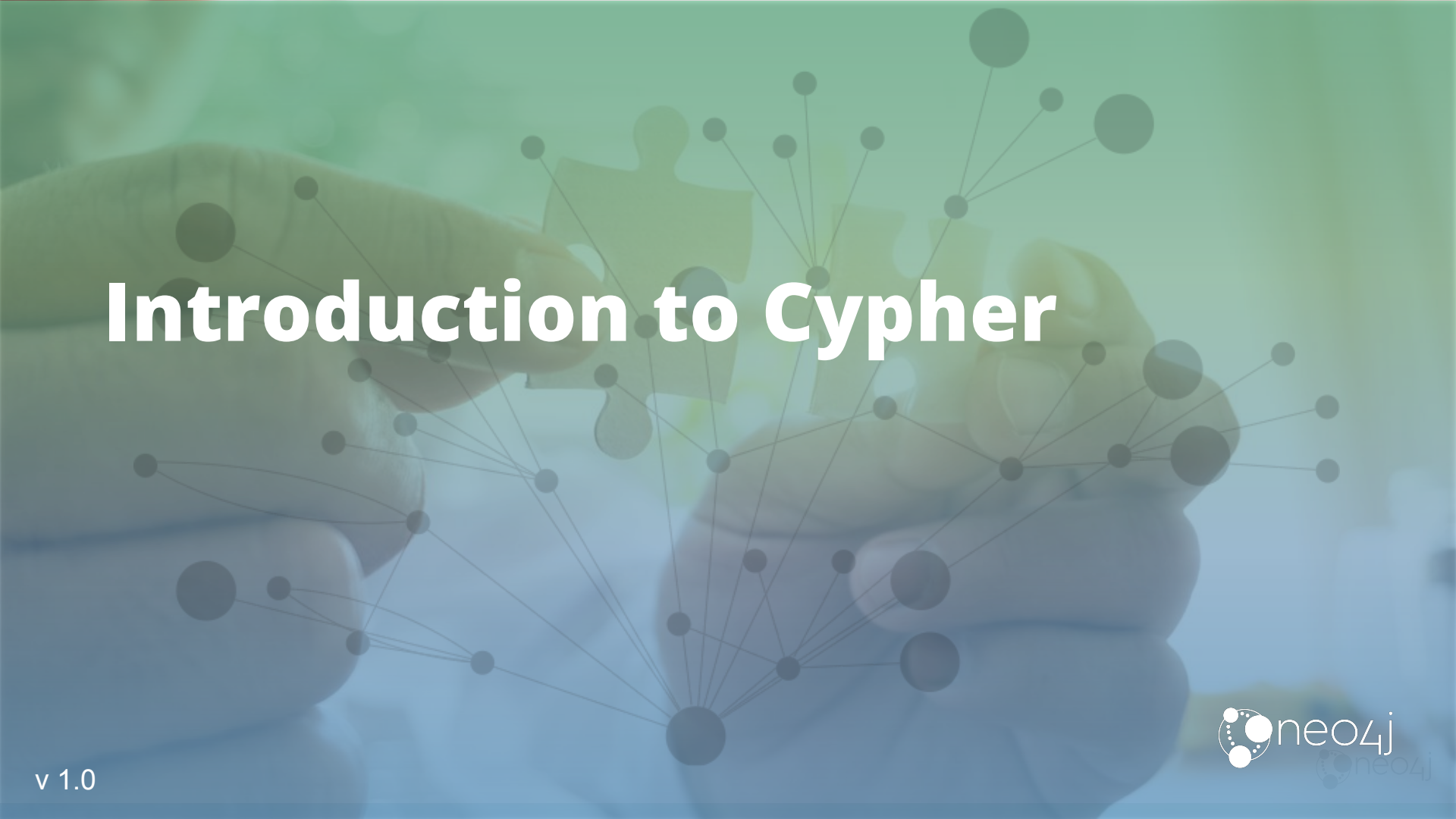
Relational	Graph
Rows	Nodes
Joins	Relationships
Table names	Labels
Columns	Properties

In some ways they're not:

Relational	Graph
Each column must have a field value.	Nodes with the same label aren't required to have the same set of properties.
Joins are calculated at query time.	Relationships are stored on disk when they are created.
A row can belong to one table.	A node can have many labels.

Neo4j GOT model: CALL db.schema.visualization()




Introduction to Cypher
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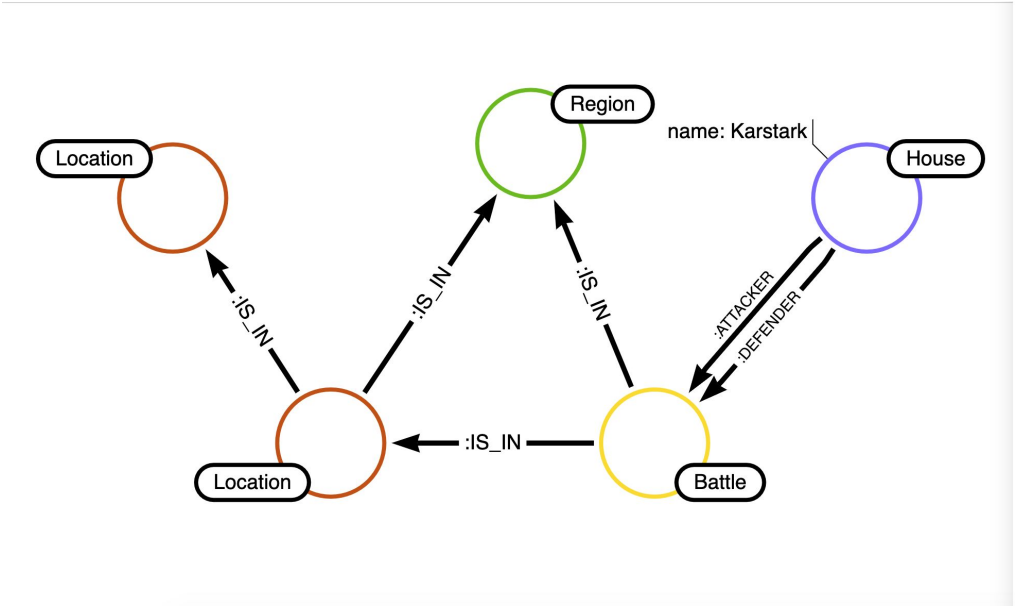
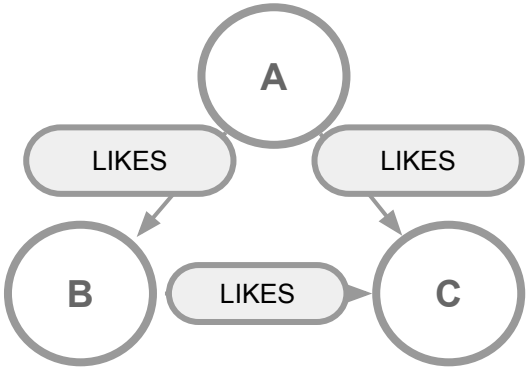
neo4j

What is Cypher?

- Declarative query language
- Focuses on **what**, not how to retrieve
- Uses keywords such as **MATCH**, **WHERE**, **CREATE**
- Runs in the database server for the graph
- ASCII art to represent nodes and relationships

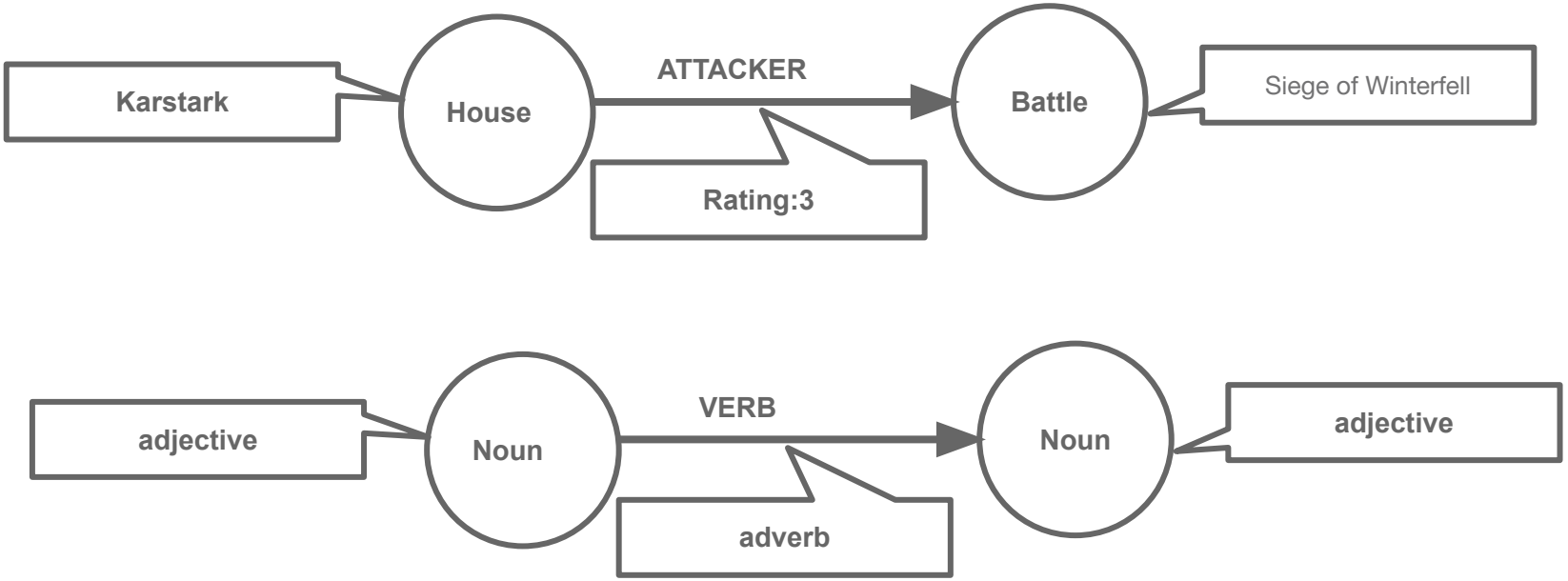


Cypher is ASCII Art



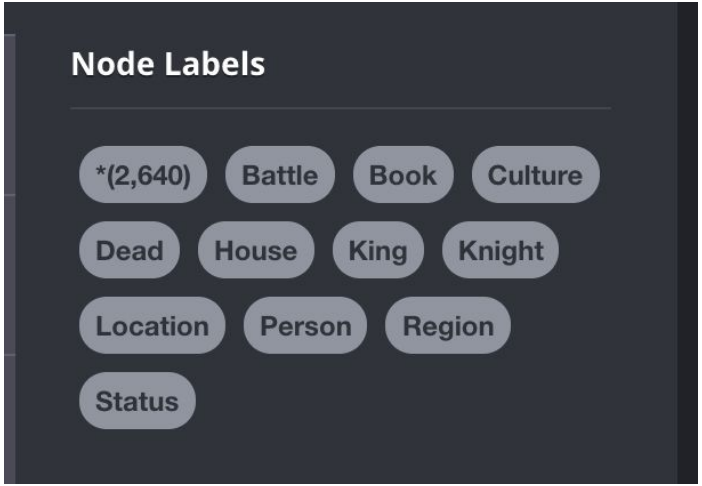

```
(A)-[:LIKES]->(B),(A)-[:LIKES]->(C),(B)-[:LIKES]->(C)

    (A)-[:LIKES]->(B)-[:LIKES]->(C)<-[:LIKES]-(A)
```

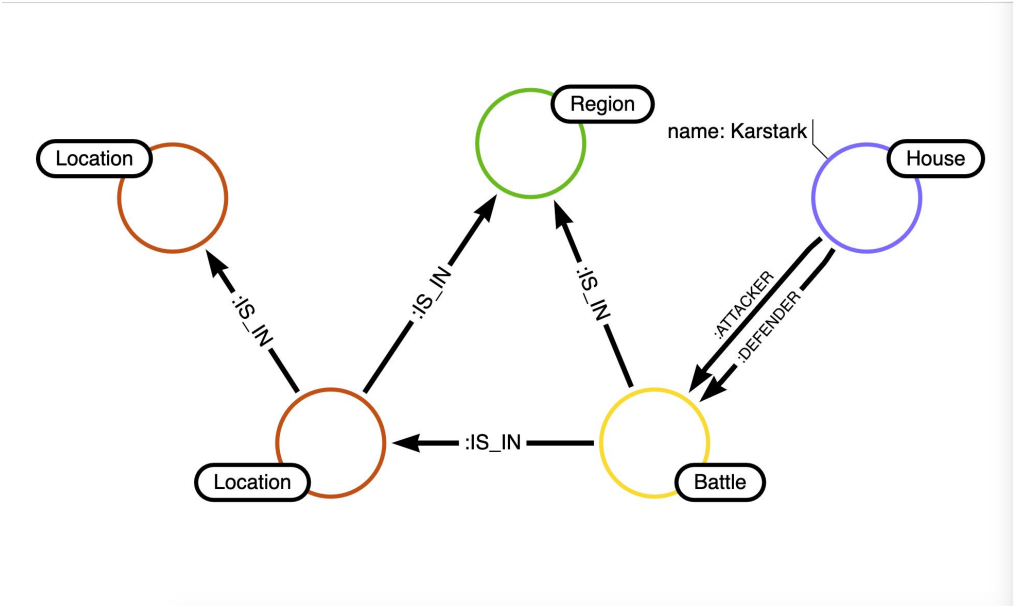
Cypher is readable



Labels

```
(:Location)
(p:Region)
(:Battle)
(l:House)
```



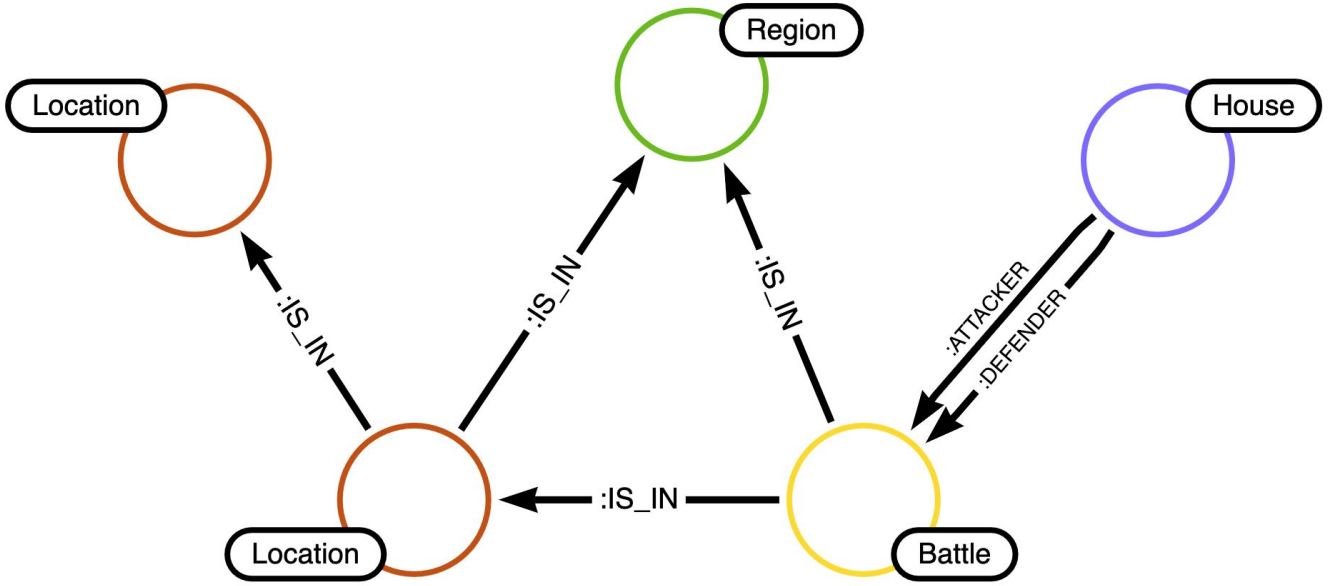


Using MATCH to retrieve nodes

```
MATCH (n) // returns all nodes in the graph
RETURN n
```

```
MATCH (p:House) // returns all House nodes in the graph
RETURN p
```

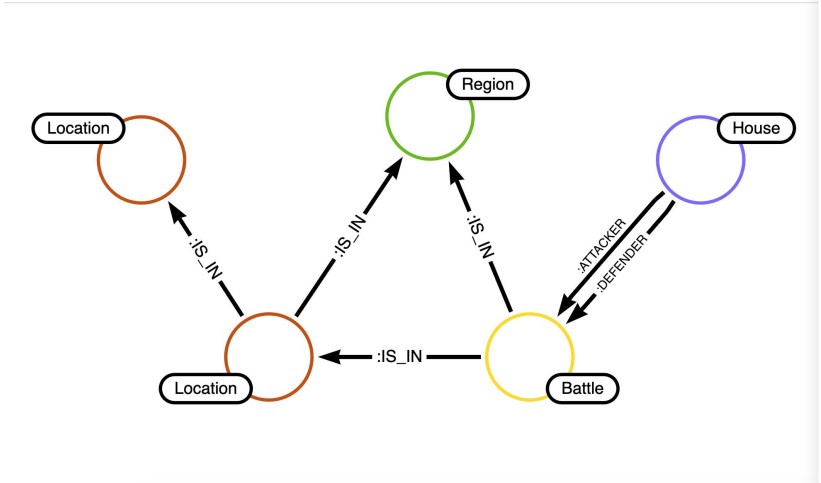
Relationships



ASCII art for nodes and relationships

```
 ()          // a node
()--()       // 2 nodes have some type of relationship
()-->()      // the first node has a relationship to the second node
()<--()      // the second node has a relationship to the first node
```

Querying using relationships



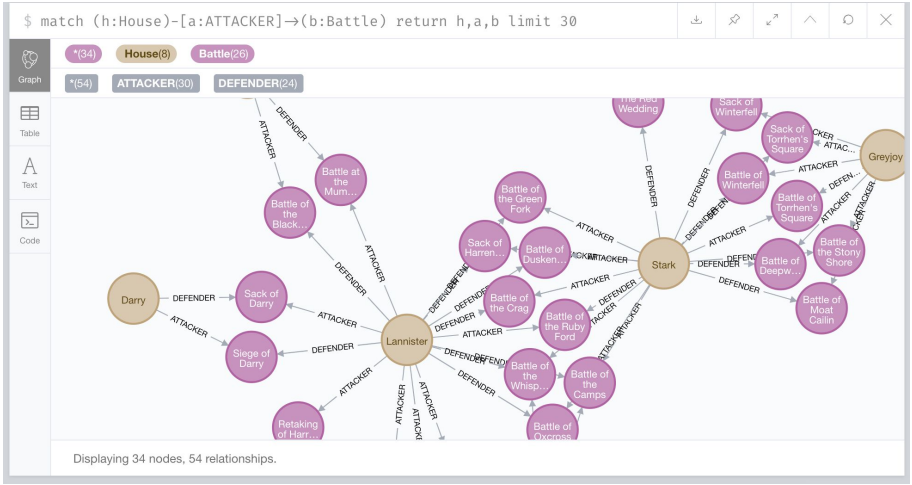

```
MATCH (h:House)-[:ATTACKER]->(b:Battle)
RETURN h.name, b.name
```

```
MATCH (h:House)--(b:Battle) // any relationship
RETURN h.name, b.name
```

Using a relationship in a query

Find the Houses attacking in a battle returning the nodes and relationships found:

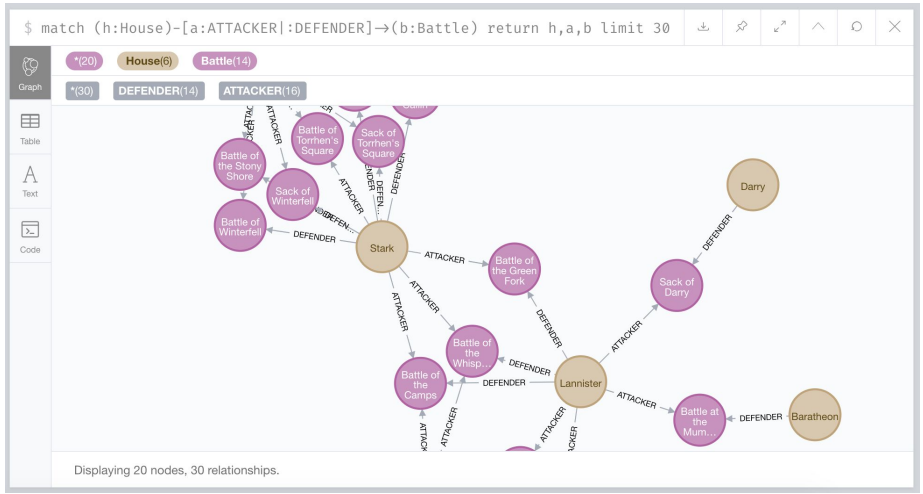
```
match (h:House)-[a:ATTACKER]->(b:Battle)
return h,a,b limit 30
```



Querying by multiple relationships

Find the Houses attacking or defending in a battle returning the nodes and relationships found:

```
match (h:House)-[a:ATTACKER|:DEFENDER]->(b:Battle)
return h,a,b limit 30
```



neo4j


APOC
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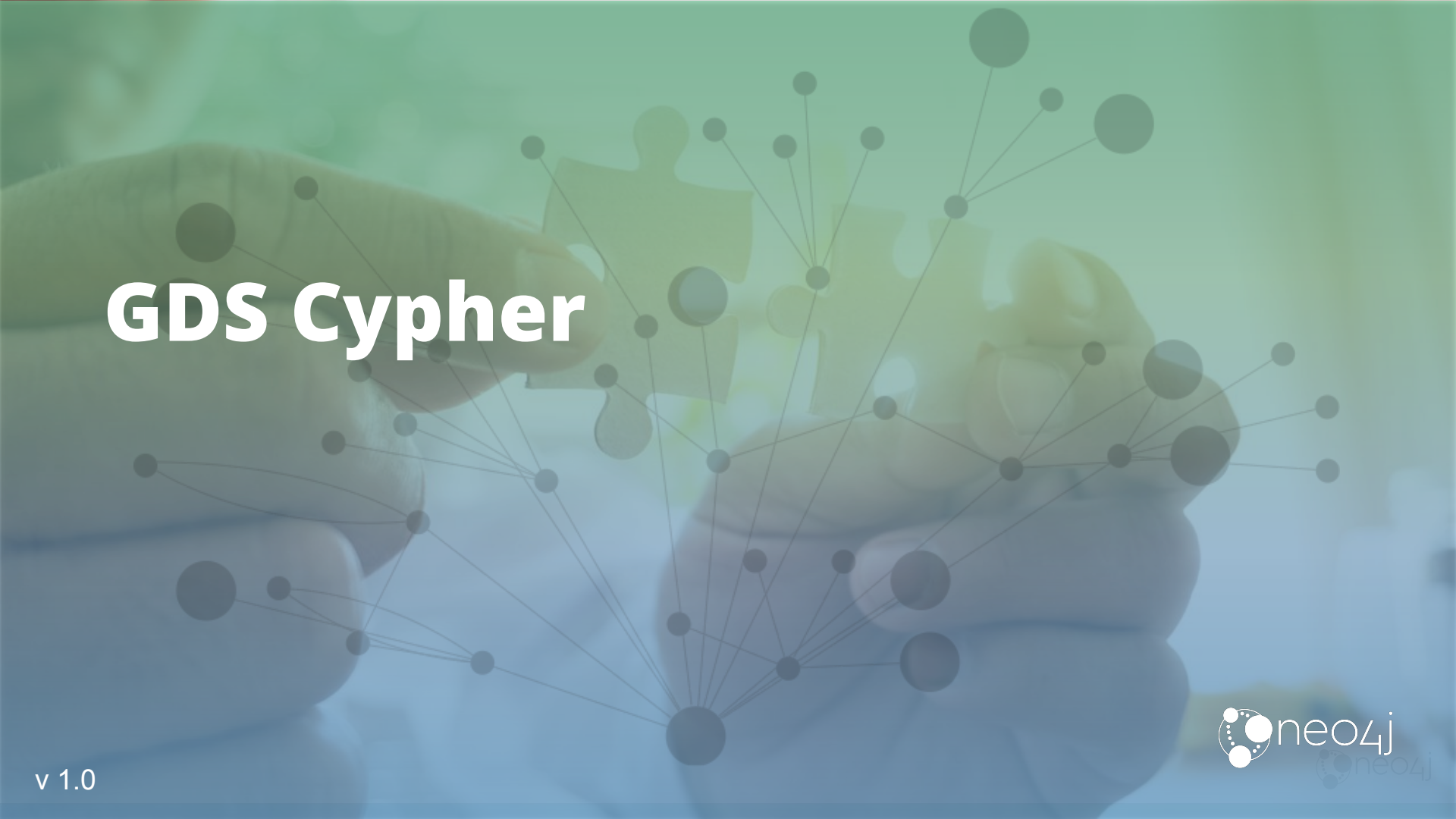
APOC

- Add-on Neo4j library
- Custom implementations of certain functionality, that can’t be (easily) expressed in Cypher itself
- ~450 procedures and functions

- **CALL**ed from Cypher
  - CALL apoc.meta.stats();
  - CALL apoc.cypher.run(some cypher statement);



GDS Cypher

v 1.0

Important Cypher Keywords - GDS Training

- WHERE
- COUNT
- ORDER BY
- DISTINCT
- WITH
- COLLECT
- UNWIND
- SIZE
- CALL

Filtering queries using WHERE

Previously you retrieved nodes as follows:

```
MATCH (h:House {name:'Darry'})-[r:DEFENDER]->(b:Battle)
RETURN h,b
```

A more flexible syntax for the same query is:

```
MATCH (h:House)-[r:DEFENDER]->(b:Battle)
WHERE h.name = 'Darry'
RETURN h,b
```

Testing more than equality:

```
MATCH (h:House)-[r:DEFENDER]->(b:Battle)
WHERE h.name = 'Darry' or b.name='Sack of
Winterfell'
RETURN h,b
```

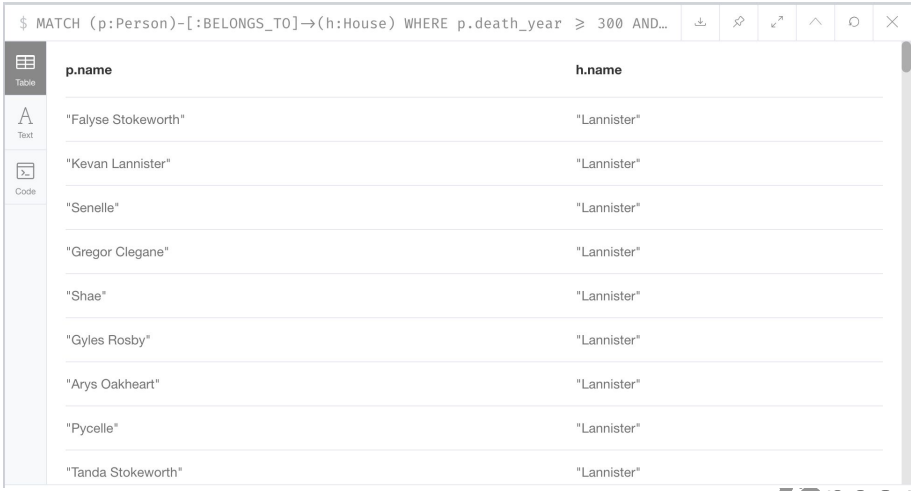
Specifying ranges in WHERE clauses

This query to find all people who belonged to a house and died between 300 and 1200.

```
MATCH (p:Person)-[:BELONGS_TO]->(h:House)
WHERE p.death_year >= 300 AND p.death_year <= 1200
RETURN p.name, h.name
```

Is the same as:

```
MATCH (p:Person)-[:BELONGS_TO]->(h:House)
WHERE 300 <= p.death_year <= 1200
RETURN p.name, h.name
```



Aggregation in Cypher

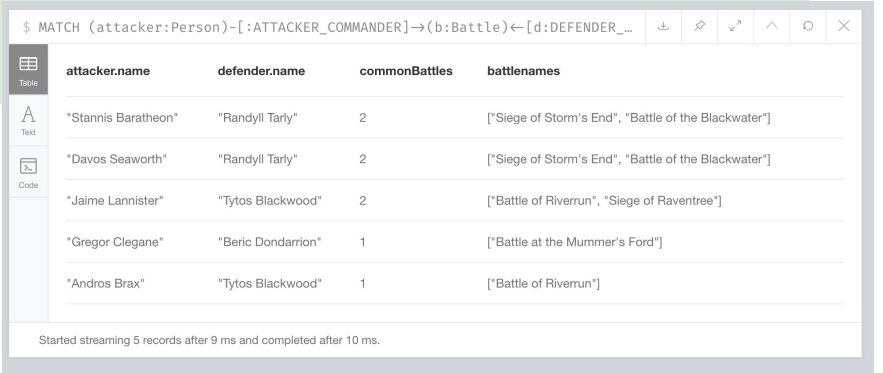
- Different from SQL - no need to specify a grouping key.
- As soon as you use an aggregation function, all non-aggregated result columns automatically become grouping keys.
- Implicit grouping based upon fields in the RETURN clause.

```
// implicitly groups by h.name
MATCH (a:Person)-[:BELONGS_TO]->(h:House)
RETURN h.name, count(*)as Household
```

Counting results

Find all of the attacking and defending commanders who were in a battle, return the count of the number paths found between attacker and defender and collect the battle names as a list:

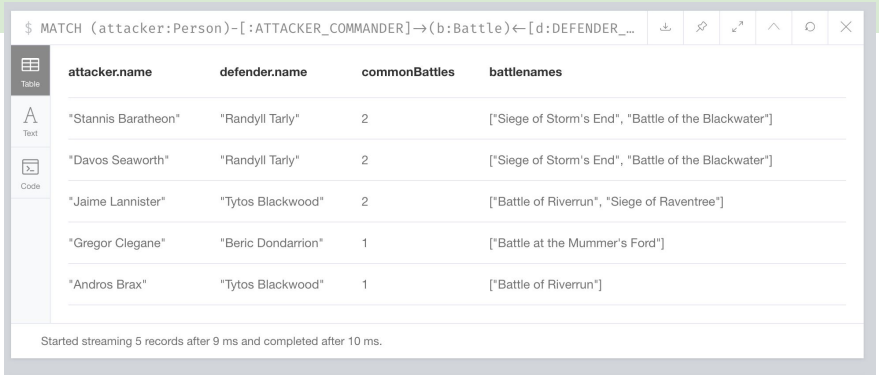
```
MATCH
(attacker:Person)-[:ATTACKER_COMMANDER]->(b:Battle)<-[d:DEFENDER_COMMANDER]-
(defender:Person)
RETURN attacker.name, defender.name, count(b) AS commonBattles,
       collect(b.name) AS battlenames
       order by commonBattles desc limit 5
```



Ordering results

You can return results in order based upon the property value:

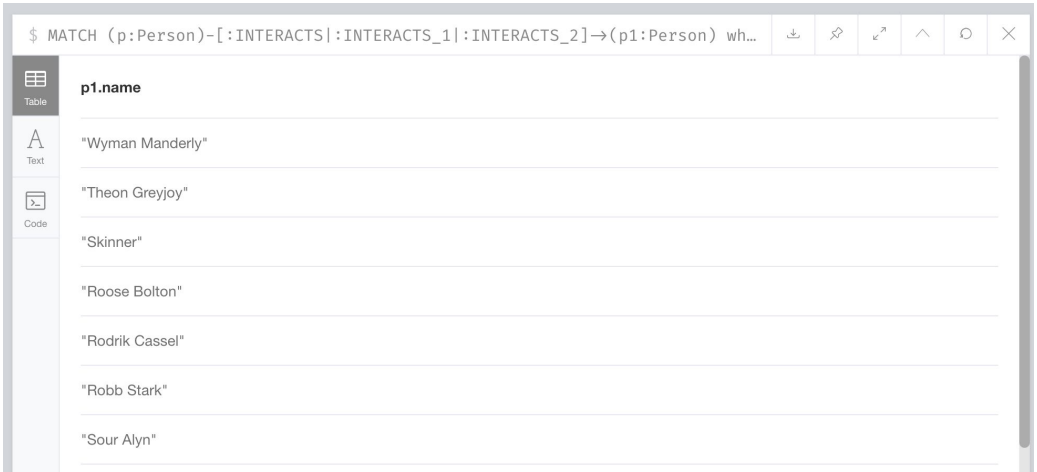
```
MATCH
(attacker:Person)-[:ATTACKER_COMMANDER]->(b:Battle)<-[d:DEFENDER_COMMANDER]-
(defender:Person)
RETURN attacker.name, defender.name, count(b) AS commonBattles,
       collect(b.name) AS battlenames
       ORDER BY commonBattles desc limit 5
```



Eliminating duplication

We can eliminate the duplication in this query by specifying the DISTINCT keyword as follows:

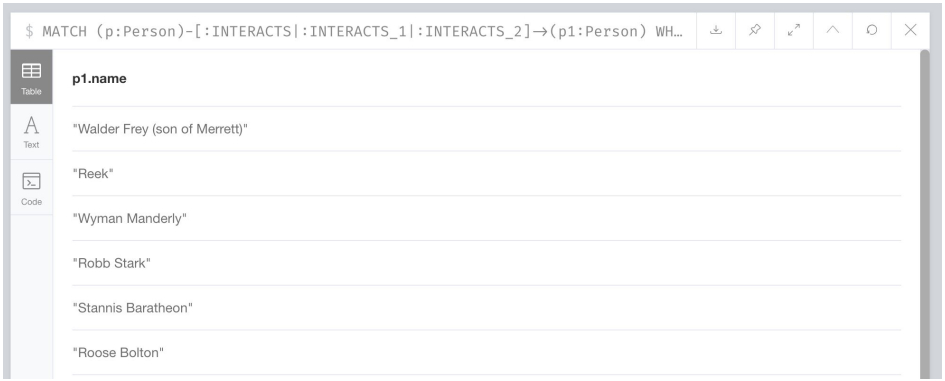
```
MATCH (p:Person)-[:INTERACTS|:INTERACTS_1|:INTERACTS_2]->(p1:Person)
WHERE p.name = 'Ramsay Snow'
RETURN distinct p1.name
```



Using WITH and DISTINCT to eliminate duplication

We can also eliminate the duplication in this query by specifying WITH DISTINCT as follows:

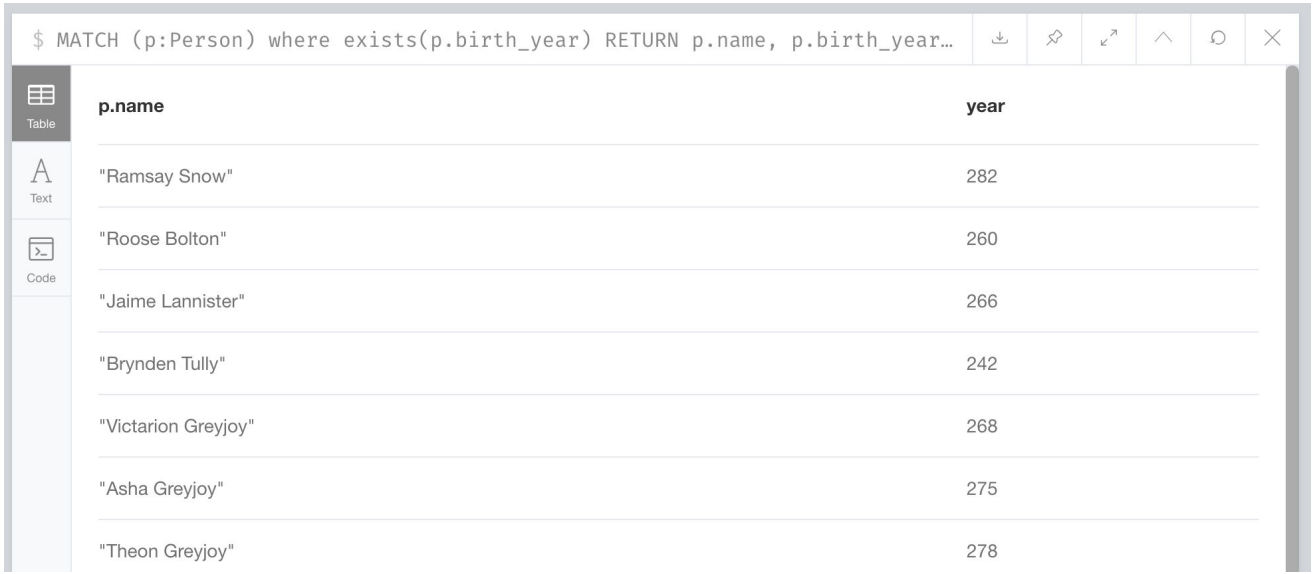
```
MATCH (p:Person)-[:INTERACTS|:INTERACTS_1|:INTERACTS_2]->(p1:Person)
WHERE p.name = 'Ramsay Snow'
WITH distinct p1
RETURN p1.name
```



Limiting results

What are the names of the ten youngest persons?

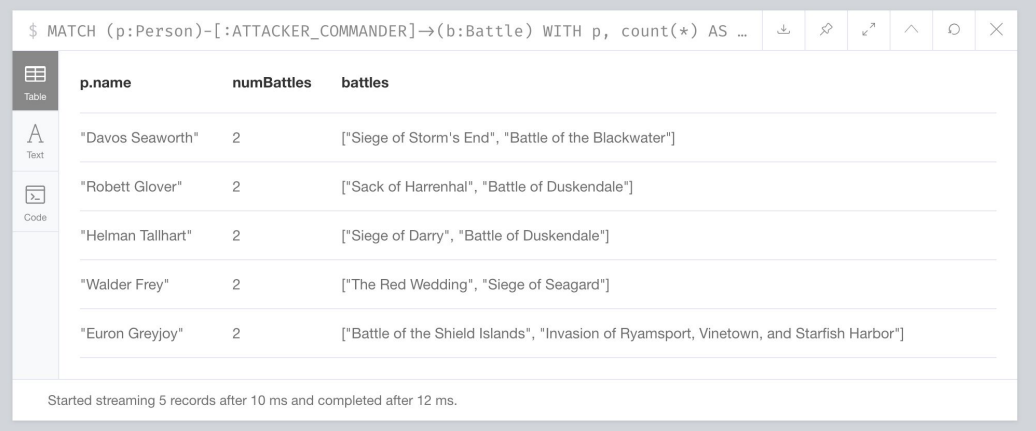
```
MATCH (p:Person) where exists(p.birth_year)
RETURN p.name, p.birth_year as year ORDER BY p.birth_year DESC  LIMIT
10
```



Controlling number of results using WITH

Retrieve the persons who were the ATTACKER_COMMANDER in two battles, returning the list of battles:

```
MATCH (p:Person)-[:ATTACKER_COMMANDER]->(b:Battle)
WITH p, count(*) AS numBattles, collect(b.name) as battles
WHERE numBattles = 2
RETURN p.name, numBattles, battles
```



Additional processing using WITH

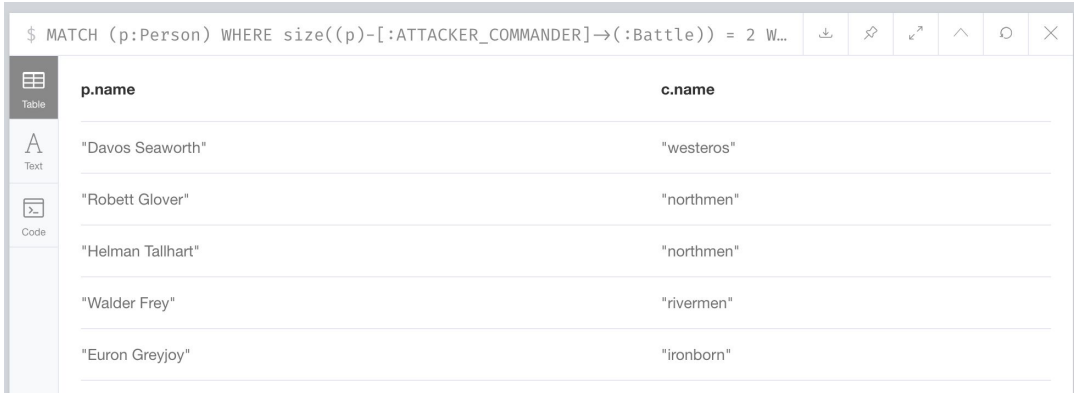
Use the WITH clause to perform intermediate processing or data flow operations.

```
MATCH (p:Person)-[:ATTACKER_COMMANDER]->(b:Battle)
WITH p, count(*) AS numBattles, collect(b.name) as battles
WHERE numBattles = 2
RETURN p.name, numBattles, battles
```

Additional processing using WITH

Find all person who were an ATTACKER_COMMANDER in 2 battles, and find (optionally) the cultures they belong to and return the person and the culture:

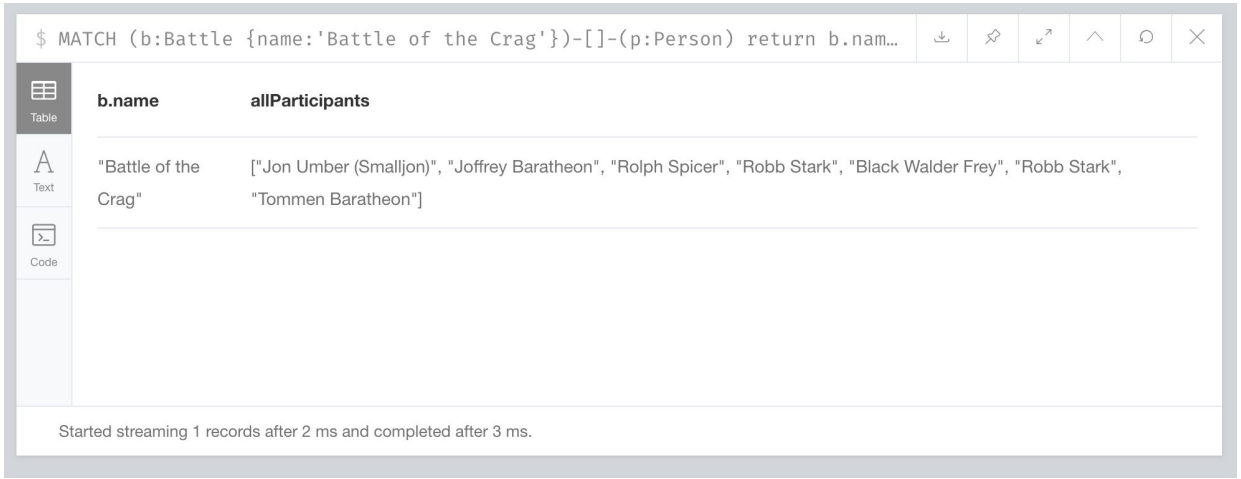
```
MATCH (p:Person)
WHERE size((p)-[:ATTACKER_COMMANDER]->(:Battle)) = 2
WITH p
OPTIONAL MATCH (p)-[:MEMBER_OF_CULTURE]->(c:Culture)
RETURN p.name, c.name;
```



Collecting results

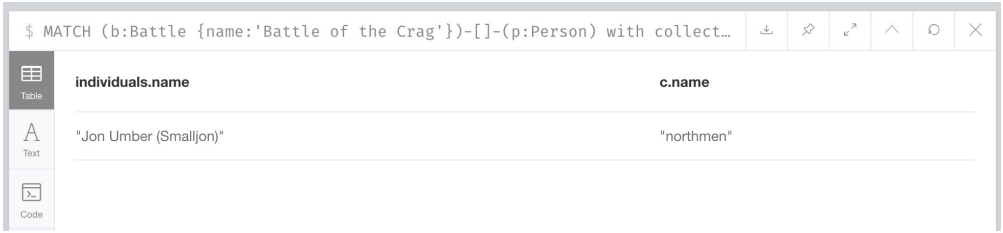
Find the participants in the ‘Battle of the Crag’ and return them as a single list.

```
MATCH (b:Battle {name:'Battle of the Crag'})-[]-(p:Person)
return b.name, collect(p.name) as allParticipants
```



UNWIND

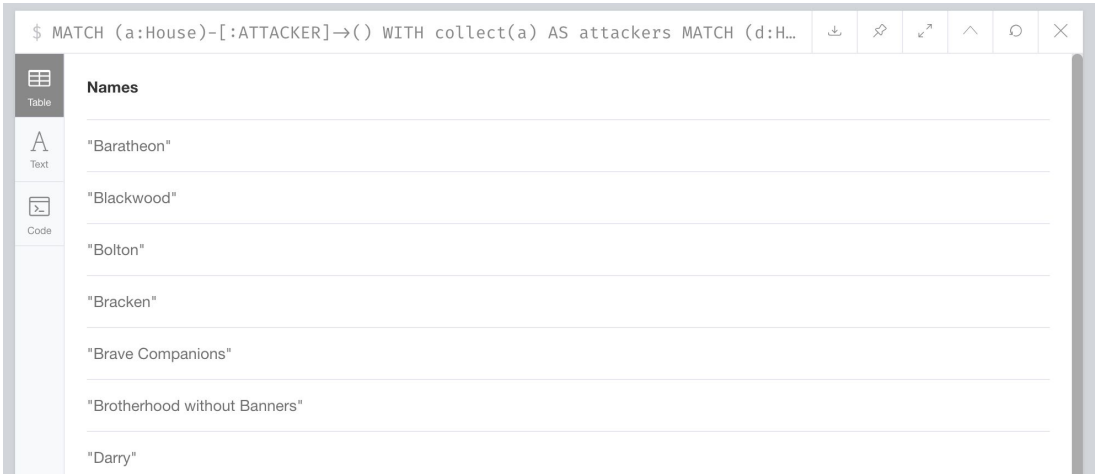
- Transform a collection into **rows**.
- Very useful for working with collections of properties, nodes, paths and sorting, etc.
- Allows collecting a set of nodes to avoid requerying.
- Especially useful after aggregation where you want to partition the data and perform further processing of the selected aggregated data.




```
MATCH (b:Battle {name:'Battle of the
Crag'})-[]-(p:Person)
with collect(p) as allParticipants
unwind allParticipants as individuals
match
(individuals)-[:MEMBER_OF_CULTURE]->(c:
Culture)
return individuals.name, c.name
```

Another UNWIND example

```
MATCH (a:House)-[:ATTACKER]->()
WITH collect(a) AS attackers
MATCH (d:House)-[:DEFENDER]->()
WITH attackers, collect(d) AS defenders
UNWIND (attackers + defenders) AS houses
WITH DISTINCT(houses)
RETURN  houses.name as Names ORDER BY Names LIMIT 10
```



How much longer will this guy talk?

Call and Yield - Neo4j Procedures

- Procedures are called using the CALL clause.
- Procedures have a signature and **YIELD** a result.
- **call dbms.listProcedures()** shows all available procedures

EXAMPLE:

```
CALL gds.graph.create.estimate('Person', 'INTERACTS') YIELD
nodeCount, relationshipCount, requiredMemory
```

Call and Yield - Neo4j Procedures

- Procedures are called using the CALL clause.
- Procedures have a signature and **YIELD** a result.
  - Signatures for procedures are in the documentation.

- GDS Example:


```
CALL gds.wcc.stream('myGraph', { relationshipWeightProperty: 'weight', threshold:
1.0 , concurrency:4})
YIELD nodeId, componentId
RETURN gds.util.asNode(nodeId).name AS Name, componentId AS ComponentId
ORDER BY ComponentId, Name
```

Data Modeling

Developing the initial graph data model

1. Define high-level domain requirements
2. Create sample data for modeling purposes
3. Define the questions for the domain
4. Identify entities
5. Identify connections between entities
6. Test the model against the questions
7. Test scalability

Domain requirements

- Description of the application
- Identify stakeholders, developers
- Identify users of the application (people, systems)
- Enumerate the use cases that are agreed upon by all stakeholders where users are part of the use case

Developing the initial graph data model

1. Define domain requirements
2. Create sample data for modeling purposes
3. Define the questions for the domain
4. Identify entities
5. Identify connections between entities
6. Test the model against the questions
7. Test scalability

Identify the entities from the questions

- Nouns
  - Entities are the generic nouns (example: City)
  - Name the entities which will be nodes in the graph:
    - Unambiguous meaning for the name
    - Agreement by stakeholders
  - Can entities be grouped or categorized?
    - Pets, dogs, cats
- Properties for the entities
  - Property value is a proper noun for the name of the entity (example: Boston)
  - Uniquely identify an entity
  - Used to describe the entity to answer questions (anchor for the query)

Developing the initial graph data model

1. Define domain requirements
2. Create sample data for modeling purposes
3. Define the questions for the domain
4. Identify entities
5. Identify connections between entities
6. Test the model against the questions
7. Test scalability

Identify connections between entities

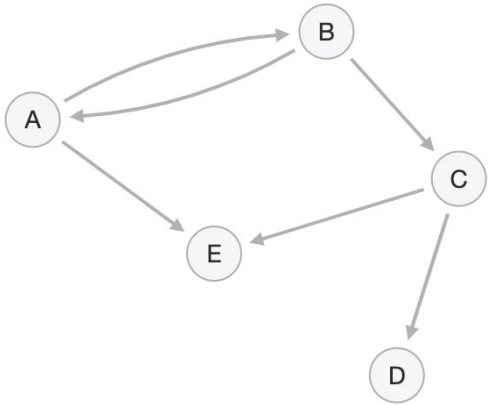
- The purpose of the model is to answer questions about the data.
- Connections are the verbs in the questions derived from use cases.
- Most questions are typically about the the connectedness of the data:
  - What ingredients are used in a recipe?

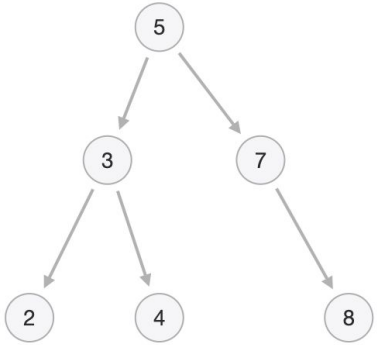
  - Who is married to this person?

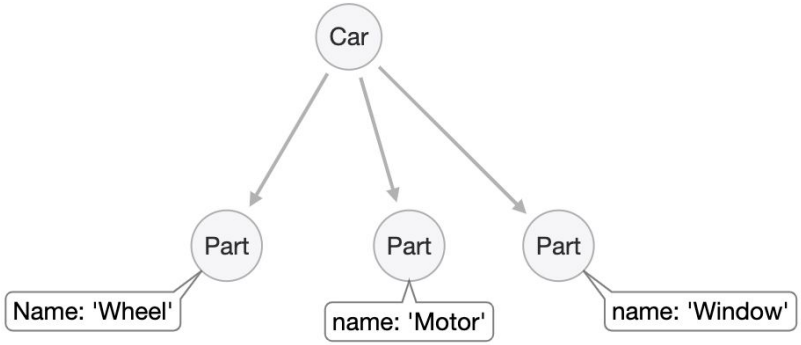
- Exactly **one** node at the end of every relationship (connection).
- A relationship must have direction when it is created.

Graph structure

- Relationships define the **structure** of the graph which is the **model**:
  - Between nodes of same type
  - Between nodes of different types
  - Determine navigational paths used at runtime (optimization)
  - Can also connect two different models in a graph
    - HR model connects to Payroll model

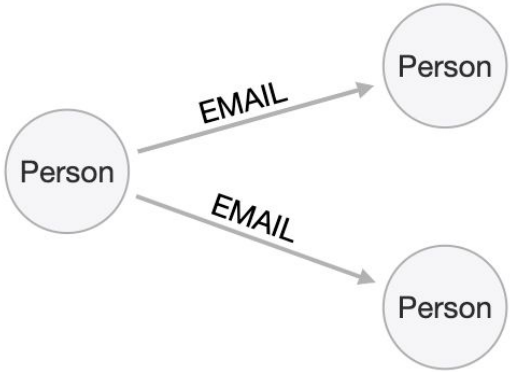


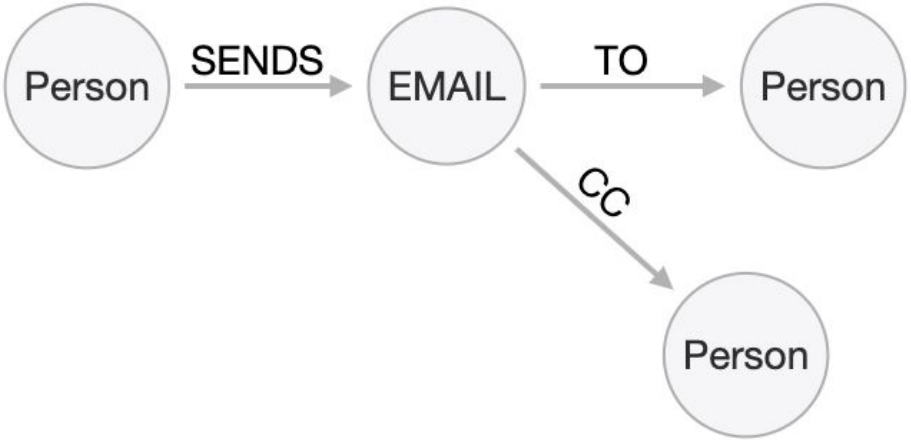




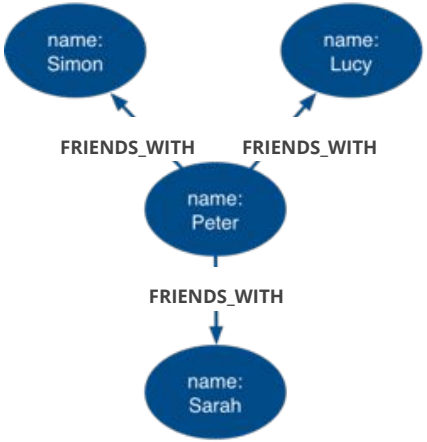
Naming relationships

- Stakeholders must agree upon name that denotes the verbs.
- Avoid names that could be construed as nouns (for example **email**)
- Neo4j has a limit of 64K relationship types (names)

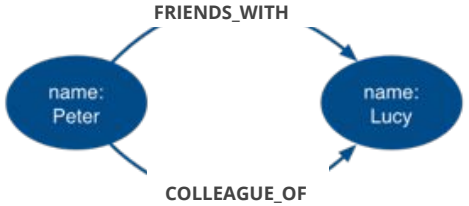




How many relationships?



Nodes can have more than one relationship



Nodes can be connected by more than one relationship

Self relationships are allowed

How important is direction?

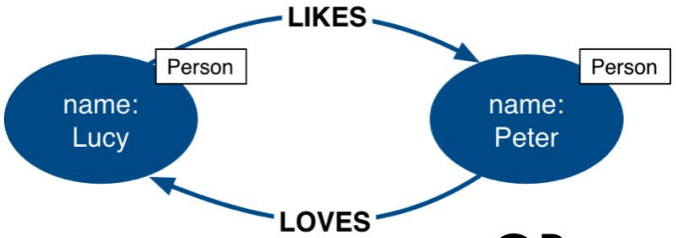
Direction is required for creating the model and in particular for implementing the model (Cypher code) in the underlying Neo4j graph.

Whether direction is used for queries depends on the question:

- What are the names of the episodes of the Dr. Who series? (direction not used for the query)
- What episode follows The Ark in Space? (direction used for the query)

Qualifying a relationship

Use properties to describe the weight or quality of the relationship.



OR