The Neo4j Developer Manual v3.0

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Introduction

This is the developer manual for Neo4j version 3.0, authored by the Neo4j Team.

The main parts of the manual are:

- Introduction — Introducing graph database concepts and Neo4j.
- Get started — Get started using Neo4j: Cypher and Drivers.
- Cypher Query Language — Reference for the Cypher query language.
- Drivers — Uniform language driver manual.
- Appendix — An appendix that covers Neo4j status codes and a Graph database terminology.

Who should read this?

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

Chapter 1. Neo4j highlights

Connected data is all around us. Neo4j supports rapid development of graph powered systems that take advantage of the rich connectedness of data.

A native graph database: Neo4j is built from the ground up to be a graph database. The architecture is designed for optimizing fast management, storage, and traversal of nodes and relationships. In Neo4j, relationships are first class citizens that represent pre-materialized connections between entities. An operation known in the relational database world as a join, whose performance degrades exponentially with the number of relationships, is performed by Neo4j as navigation from one node to another, whose performance is linear.

This different approach to storing and querying connections between entities provides traversal performance of up to 4 million hops per second and core. As most graph searches are local to the larger neighborhood of a node, the total amount of data stored in a database will not affect operations runtime. Dedicated memory management, and highly scalable and memory efficient operations, contribute to the benefits.

Whiteboard friendly: The property graph approach allows consistent use of the same model throughout conception, design, implementation, storage, and visualization of any domain or use case. This allows all business stakeholders to participate throughout the development cycle. With the schema optional model, the domain model can be evolved continuously as requirements change, without penalty of expensive schema changes and migrations.

Cypher, the declarative graph query language, is designed to visually represent graph patterns of nodes and relationships. This highly capable, yet easily readable, query language is centered around the patterns that express concepts or questions from a specific domain. Cypher can also be extended for narrow optimizations for specific use cases.

Supports rapid development: Neo4j supports fast development of graph powered systems. Neo4j's development stems from the need to run real-time queries on highly related information; something no other database can provide. These unique Neo4j features get you up and running quickly and sustain fast application development for highly scalable applications.

Provides true data safety through ACID transactions: Neo4j uses transactions to guarantee that data is persisted in the case of hardware failure or system crashes.

Designed for business-critical and high-performance operations: Neo4j uses a replicated master-slave cluster setup. It can store hundreds of trillions of entities for the largest datasets imaginable while being sensitive to compact storage. Neo4j can be deployed as a scalable, fault-tolerant cluster of machines. Due to its high scalability, Neo4j clusters require only tens of machines, not hundreds or thousands, saving on cost and operational complexity. Other features for production applications include hot-backups and extensive monitoring.

Neo4j's application is only limited by your imagination.

Chapter 2. Graph Database Concepts

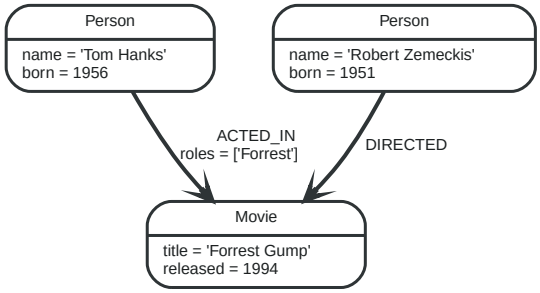
This chapter contains an introduction to the graph data model.

2.1. The Neo4j Graph Database

A graph database stores data in a graph, the most generic of data structures, capable of elegantly representing any kind of data in a highly accessible way.

For graph database terminology, see Terminology.

Here's an example graph which we will approach step by step in the following sections:



2.1.1. Nodes

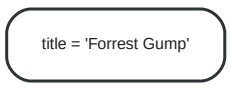
A graph records data in nodes and relationships. Both can have properties. This is sometimes referred to as the "Property Graph Model".

The fundamental units that form a graph are nodes and relationships. In Neo4j, both nodes and relationships can contain properties.

Nodes are often used to represent *entities,* but depending on the domain relationships may be used for that purpose as well.

In addition to having properties and relationships, nodes can also be labeled with one or more labels.

The simplest possible graph is a single Node. A Node can have zero or more named values referred to as *properties.* Let's start out with one node that has a single property named `title`:



The next step is to have multiple nodes. Let's add two more nodes and one more property on the node in the previous example:

2.1.2. Relationships

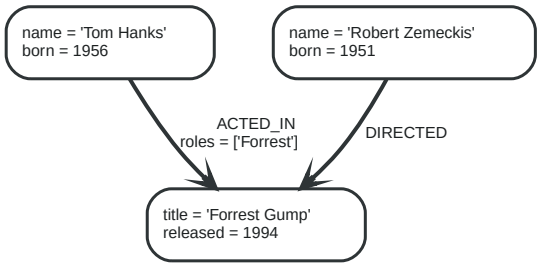
Relationships organize the nodes by connecting them. A relationship connects two nodes — a start node and an end node. Just like nodes, relationships can have properties.

Relationships between nodes are a key part of a graph database. They allow for finding related data. Just like nodes, relationships can have properties.

A relationship connects two nodes, and is guaranteed to have valid start and end nodes.

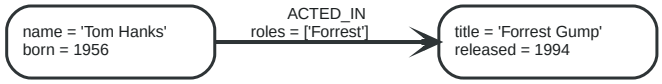
Relationships organize nodes into arbitrary structures, allowing a graph to resemble a list, a tree, a map, or a compound entity — any of which can be combined into yet more complex, richly inter-connected structures.

Our example graph will make a lot more sense once we add relationships to it:



Our example uses `ACTED_IN` and `DIRECTED` as relationship types. The `roles` property on the `ACTED_IN` relationship has an array value with a single item in it.

Below is an `ACTED_IN` relationship, with the `Tom Hanks` node as *start node* and `Forrest Gump` as *end node*.



You could also say that the `Tom Hanks` node has an *outgoing* relationship, while the `Forrest Gump` node has an *incoming* relationship.

Relationships are equally well traversed in either direction.

This means that there is no need to add duplicate relationships in the opposite direction (with regard to traversal or performance).

While relationships always have a direction, you can ignore the direction where it is not useful in your application.

Note that a node can have relationships to itself as well:

The example above would mean that `Tom Hanks KNOWS` himself.

To further enhance graph traversal all relationships have a relationship type.

Let's have a look at what can be found by simply following the relationships of a node in our example graph:

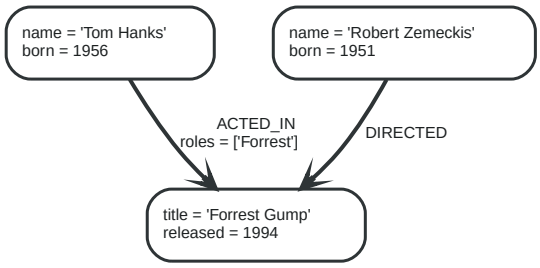


Table 1. Using relationship direction and type

What we want to know	Start from	Relationship type	Direction
get actors in movie	movie node	`ACTED_IN`	incoming
get movies with actor	person node	`ACTED_IN`	outgoing
get directors of movie	movie node	`DIRECTED`	incoming
get movies directed by	person node	`DIRECTED`	outgoing

2.1.3. Properties

Both nodes and relationships can have properties.

Properties are named values where the name is a string. The supported property values are:

- Numeric values,
- String values,
- Boolean values,
- Lists of any other type of value.

`NULL` *is not a valid property value.*
NULLs can instead be modeled by the absence of a key.

For further details on supported property values, see [property-values-detailed].

2.1.4. Labels

Labels assign roles or types to nodes.

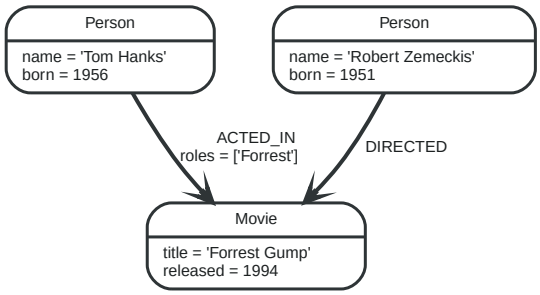
A label is a named graph construct that is used to group nodes into sets; all nodes labeled with the same label belongs to the same set. Many database queries can work with these sets instead of the whole graph, making queries easier to write and more efficient to execute. A node may be labeled with any number of labels, including none, making labels an optional addition to the graph.

Labels are used when defining constraints and adding indexes for properties (see Schema).

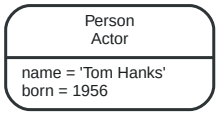
An example would be a label named `User` that you label all your nodes representing users with. With that in place, you can ask Neo4j to perform operations only on your user nodes, such as finding all users with a given name.

However, you can use labels for much more. For instance, since labels can be added and removed during runtime, they can be used to mark temporary states for your nodes. You might create an `Offline` label for phones that are offline, a `Happy` label for happy pets, and so on.

In our example, we'll add `Person` and `Movie` labels to our graph:



A node can have multiple labels, let's add an `Actor` label to the `Tom Hanks` node.



Label names

Any non-empty Unicode string can be used as a label name. In Cypher, you may need to use the backtick (`) syntax to avoid clashes with Cypher identifier rules or to allow non-alphanumeric characters in a label. By convention, labels are written with CamelCase notation, with the first letter in upper case. For instance, User or CarOwner.

Labels have an id space of an int, meaning the maximum number of labels the database can contain is roughly 2 billion.

2.1.5. Traversal

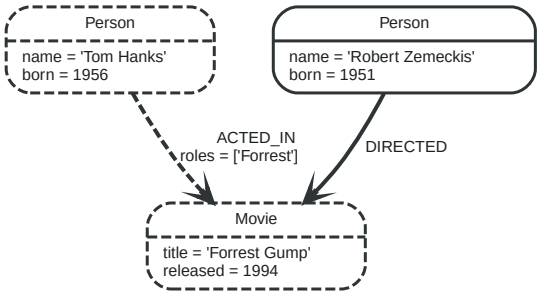
> *A traversal navigates through a graph to find paths.*

A traversal is how you query a graph, navigating from starting nodes to related nodes, finding answers to questions like "what music do my friends like that I don't yet own," or "if this power supply goes down, what web services are affected?"

Traversing a graph means visiting its nodes, following relationships according to some rules. In most cases only a subgraph is visited, as you already know where in the graph the interesting nodes and relationships are found.

Cypher provides a declarative way to query the graph powered by traversals and other techniques. See Cypher Query Language for more information.

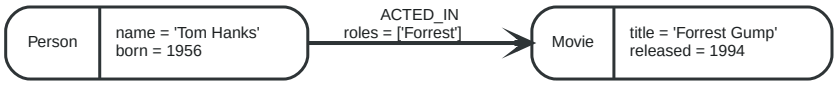
If we want to find out which movies Tom Hanks acted in according to our tiny example database, the traversal would start from the `Tom Hanks` node, follow any `ACTED_IN` relationships connected to the node, and end up with `Forrest Gump` as the result (see the dashed lines):



2.1.6. Paths

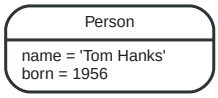
A path is one or more nodes with connecting relationships, typically retrieved as a query or traversal result.

In the previous example, the traversal result could be returned as a path:

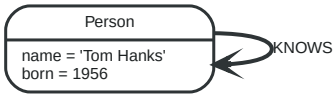


The path above has length one.

The shortest possible path has length zero — that is, it contains only a single node and no relationships — and can look like this:



This path has length one:



2.1.7. Schema

Neo4j is a schema-optional graph database.

You can use Neo4j without any schema. Optionally, you can introduce it in order to gain performance or modeling benefits. This allows a way of working where the schema does not get in your way until you are at a stage where you want to reap the benefits of having one.

Schema commands can only be applied on the master machine in a Neo4j cluster. If you apply them on a slave you will receive a `Neo.ClientError.Transaction.InvalidType` error code (see Neo4j Status Codes).

Indexes

Performance is gained by creating indexes, which improve the speed of looking up nodes in the database.

Once you have specified which properties to index, Neo4j will make sure your indexes are kept up to date as your graph evolves. Any operation that looks up nodes by the newly indexed properties will see a significant performance boost.

Indexes in Neo4j are *eventually available*. That means that when you first create an index the operation returns immediately. The index is *populating* in the background and so is not immediately available for querying. When the index has been fully populated it will eventually come *online*. That means that it is now ready to be used in queries.

If something should go wrong with the index, it can end up in a **failed** state. When it is failed, it will not be used to speed up queries. To rebuild it, you can drop and recreate the index. Look at logs for clues

about the failure.

For working with indexes in Cypher, see Indexes

Constraints

Neo4j can help keep your data clean. It does so using constraints. Constraints allow you to specify the rules for what your data should look like. Any changes that break these rules will be denied.

For working with constraints in Cypher, see Constraints

Get started

Chapter 3. Install Neo4j

Setting up a local environment for developing an application with Neo4j and its query language Cypher is easy. Download Neo4j from http://neo4j.com/download/ and follow the installation instructions for your operating system. Read more about deploying Neo4j in the Neo4j Operations Manual Deployment *(http://neo4j.com/docs/operations-manual/3.0/#deployment)*. To get started with Cypher, continue reading. Open up a web browser and point it to http://localhost:7474 to follow along and try out the queries explained below.

Chapter 4. Get started with Cypher

This guide will introduce you to Cypher, Neo4j's query language. It will help you:

- start thinking about graphs and patterns
- apply this knowledge to simple problems
- learn how to write Cypher statements

4.1. Patterns

Neo4j's Property Graphs are composed of nodes and relationships, either of which may have properties. Nodes represent entities, for example concepts, events, places and things. Relationships connect pairs of nodes.

However, nodes and relationships are simply low-level building blocks. The real strength of the property graph lies in its ability to encode *patterns* of connected nodes and relationships. A single node or relationship typically encodes very little information, but a pattern of nodes and relationships can encode arbitrarily complex ideas.

Cypher, Neo4j's query language, is strongly based on patterns. Specifically, patterns are used to match desired graph structures. Once a matching structure has been found or created, Neo4j can use it for further processing.

A simple pattern, which has only a single relationship, connects a pair of nodes (or, occasionally, a node to itself). For example, *a Person* `LIVES_IN` *a City* or *a City is* `PART_OF` *a Country*.

Complex patterns, using multiple relationships, can express arbitrarily complex concepts and support a variety of interesting use cases. For example, we might want to match instances where *a Person* `LIVES_IN` *a Country*. The following Cypher code combines two simple patterns into a (mildly) complex pattern which performs this match:

```
(:Person) -[:LIVES_IN]-> (:City) -[:PART_OF]-> (:Country)
```

Pattern recognition is fundamental to the way that the brain works. Consequently, humans are very good at working with patterns. When patterns are presented visually, for example in a diagram or map, humans can use them to recognize, specify, and understand concepts. As a pattern-based language, Cypher takes advantage of this capability.

Like SQL, used in relational databases, Cypher is a textual declarative query language. It uses a form of ASCII art *(https://en.wikipedia.org/wiki/ASCII_art)* to represent graph-related patterns. SQL-like clauses and keywords, for example `MATCH`, `WHERE` and `DELETE` are used to combine these patterns and specify desired actions.

This combination tells Neo4j which patterns to match and what to do with the matching items, for example nodes, relationships, paths and lists. However, Cypher does *not* tell Neo4j *how* to find nodes, traverse relationships etc.

Diagrams made up of icons and arrows are commonly used to visualize graphs. Textual annotations provide labels, define properties etc.

4.1.1. Node Syntax

Cypher uses a pair of parentheses (usually containing a text string) to represent a node, eg: `()`, `(foo)`. This is reminiscent of a circle or a rectangle with rounded end caps. Here are some ASCII-art encodings for example Neo4j nodes, providing varying types and amounts of detail:

```
()
(matrix)
(:Movie)
(matrix:Movie)
(matrix:Movie {title: "The Matrix"})
(matrix:Movie {title: "The Matrix", released: 1997})
```

The simplest form, `()`, represents an anonymous, uncharacterized node. If we want to refer to the node elsewhere, we can add a variable, for example: `(matrix)`. A variable is restricted to a single statement. It may have different (or no) meaning in another statement.

The `Movie` label (prefixed in use with a colon) declares the node's type. This restricts the pattern, keeping it from matching (say) a structure with an `Actor` node in this position. Neo4j's node indexes also use labels: each index is specific to the combination of a label and a property.

The node's properties, for example `title`, are represented as a list of key/value pairs, enclosed within a pair of braces, for example: `{name: "Keanu Reeves"}`. Properties can be used to store information and/or restrict patterns.

4.1.2. Relationship Syntax

Cypher uses a pair of dashes (`--`) to represent an undirected relationship. Directed relationships have an arrowhead at one end (`<-`, `->`). Bracketed expressions (`[…]`) can be used to add details. This may include variables, properties, and/or type information:

```
-->
-[role]->
-[:ACTED_IN]->
-[role:ACTED_IN]->
-[role:ACTED_IN {roles: ["Neo"]}]->
```

The syntax and semantics found within a relationship's bracket pair are very similar to those used between a node's parentheses. A variable (eg, `role`) can be defined, to be used elsewhere in the statement. The relationship's type (eg, `ACTED_IN`) is analogous to the node's label. The properties (eg, `roles`) are entirely equivalent to node properties. (Note that the value of a property may be an array.)

4.1.3. Pattern Syntax

Combining the syntax for nodes and relationships, we can express patterns. The following could be a simple pattern (or fact) in this domain:

```
(keanu:Person:Actor {name:  "Keanu Reeves"} )
<-[role:ACTED_IN    {roles: ["Neo"] } ]->
(matrix:Movie       {title: "The Matrix"} )
```

Like with node labels, the relationship type `ACTED_IN` is added as a symbol, prefixed with a colon: `:ACTED_IN`. Variables (eg, `role`) can be used elsewhere in the statement to refer to the relationship. Node and relationship properties use the same notation. In this case, we used an array property for the `roles`, allowing multiple roles to be specified.

Pattern Nodes vs. Database Nodes

When a node is used in a pattern, it *describes* zero or more nodes in the database. Similarly, each pattern describes zero or more paths of nodes and relationships.

4.1.4. Pattern Variables

To increase modularity and reduce repetition, Cypher allows patterns to be assigned to variables. This allows the matching paths to be inspected, used in other expressions, etc.

```
acted_in = (:Person)-[:ACTED_IN]->(:Movie)
```

The `acted_in` variable would contain two nodes and the connecting relationship for each path that was found or created. There are a number of functions to access details of a path, including `nodes(path)`, `rels(path)` (same as `relationships(path)`), and `length(path)`.

4.1.5. Clauses

Cypher statements typically have multiple *clauses*, each of which performs a specific task, for example:

- create and match patterns in the graph
- filter, project, sort, or paginate results
- compose partial statements

By combining Cypher clauses, we can compose more complex statements that express what we want to know or create. Neo4j then figures out how to achieve the desired goal in an efficient manner.

4.2. Patterns in Practice

4.2.1. Creating Data

We'll start by looking into the clauses that allow us to create data.

To add data, we just use the patterns we already know. By providing patterns we can specify what graph structures, labels and properties we would like to make part of our graph.

Obviously the simplest clause is called `CREATE`. It will just go ahead and directly create the patterns that you specify.

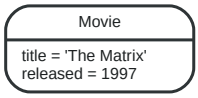
For the patterns we've looked at so far this could look like the following:

```
CREATE (:Movie { title:"The Matrix",released:1997 })
```

If we execute this statement, Cypher returns the number of changes, in this case adding 1 node, 1 label and 2 properties.

```
+-------------------+
| No data returned. |
+-------------------+
Nodes created: 1
Properties set: 2
Labels added: 1
```

As we started out with an empty database, we now have a database with a single node in it:



If case we also want to return the created data we can add a `RETURN` clause, which refers to the variable we've assigned to our pattern elements.

```
CREATE (p:Person { name:"Keanu Reeves", born:1964 })
RETURN p
```

This is what gets returned:

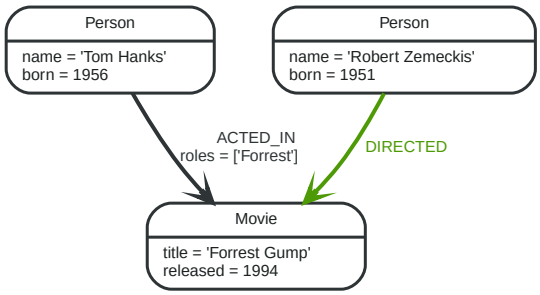
```
+--------------------------------------+
| p                                    |
+--------------------------------------+
| Node[1]{name:"Keanu Reeves",born:1964} |
+--------------------------------------+
1 row
Nodes created: 1
Properties set: 2
Labels added: 1
```

If we want to create more than one element, we can separate the elements with commas or use multiple `CREATE` statements.

We can of course also create more complex structures, like an `ACTED_IN` relationship with information about the character, or `DIRECTED` ones for the director.

```
CREATE (a:Person { name:"Tom Hanks",
  born:1956 })-[r:ACTED_IN { roles: ["Forrest"]}]->(m:Movie { title:"Forrest Gump",released:1994 })
CREATE (d:Person { name:"Robert Zemeckis", born:1951 })-[:DIRECTED]->(m)
RETURN a,d,r,m
```

This is the part of the graph we just updated:



In most cases, we want to connect new data to existing structures. This requires that we know how to find existing patterns in our graph data, which we will look at next.

4.2.2. Matching Patterns

Matching patterns is a task for the `MATCH` statement. We pass the same kind of patterns we've used so far to `MATCH` to describe what we're looking for. It is similar to *query by example*, only that our examples also include the structures.

A `MATCH` statement will search for the patterns we specify and return *one row per successful pattern match*.

To find the data we've created so far, we can start looking for all nodes labeled with the `Movie` label.

```
MATCH (m:Movie)
RETURN m
```

Here's the result:

This should show both *The Matrix* and *Forrest Gump*.

We can also look for a specific person, like *Keanu Reeves*.

```
MATCH (p:Person { name:"Keanu Reeves" })
RETURN p
```

This query returns the matching node:

Note that we only provide enough information to find the nodes, not all properties are required. In most cases you have key-properties like SSN, ISBN, emails, logins, geolocation or product codes to look for.

We can also find more interesting connections, like for instance the movies titles that *Tom Hanks* acted in and the roles he played.

```
MATCH (p:Person { name:"Tom Hanks" })-[r:ACTED_IN]->(m:Movie)
RETURN m.title, r.roles
```

```
+-----------------------------+
| m.title        | r.roles    |
+-----------------------------+
| "Forrest Gump" | ["Forrest"] |
+-----------------------------+
1 row
```

In this case we only returned the properties of the nodes and relationships that we were interested in. You can access them everywhere via a dot notation `identifer.property`.

Of course this only lists his role as *Forrest* in *Forrest Gump* because that's all data that we've added.

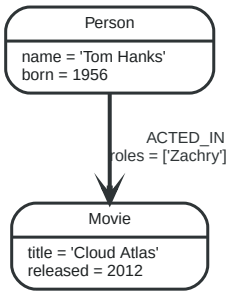
Now we know enough to connect new nodes to existing ones and can combine `MATCH` and `CREATE` to attach structures to the graph.

4.2.3. Attaching Structures

To extend the graph with new information, we first match the existing connection points and then attach the newly created nodes to them with relationships. Adding *Cloud Atlas* as a new movie for *Tom Hanks* could be achieved like this:

```
MATCH (p:Person { name:"Tom Hanks" })
CREATE (m:Movie { title:"Cloud Atlas",released:2012 })
CREATE (p)-[r:ACTED_IN { roles: ['Zachry']}]->(m)
RETURN p,r,m
```

Here's what the structure looks like in the database:



It is important to remember that we can assign variables to both nodes and relationships and use them later on, no matter if they were created or matched.

It is possible to attach both node and relationship in a single `CREATE` clause. For readability it helps to split them up though.

A tricky aspect of the combination of `MATCH` and `CREATE` is that we get *one row per matched pattern*. This causes subsequent `CREATE` statements to be executed once for each row. In many cases this is what you want. If that's not intended, please move the `CREATE` statement before the `MATCH`, or change the cardinality of the query with means discussed later or use the *get or create* semantics of the next clause: `MERGE`.

4.2.4. Completing Patterns

Whenever we get data from external systems or are not sure if certain information already exists in the graph, we want to be able to express a repeatable (idempotent) update operation. In Cypher `MERGE` has this function. It acts like a combination of `MATCH` *or* `CREATE`, which checks for the existence of data first before creating it. With `MERGE` you define a pattern to be found or created. Usually, as with `MATCH` you only want to include the key property to look for in your core pattern. `MERGE` allows you to provide additional properties you want to set `ON CREATE`.

If we wouldn't know if our graph already contained *Cloud Atlas* we could merge it in again.

```
MERGE (m:Movie { title:"Cloud Atlas" })
ON CREATE SET m.released = 2012
RETURN m
```

```
+-------------------------------------------+
| m                                         |
+-------------------------------------------+
| Node[5]{title:"Cloud Atlas",released:2012} |
+-------------------------------------------+
1 row
```

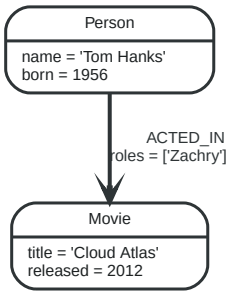
We get a result in any both cases: either the data (potentially more than one row) that was already in the graph or a single, newly created `Movie` node.

A `MERGE` clause without any previously assigned variables in it either matches the full pattern or creates the full pattern. It never produces a partial mix of matching and creating within a pattern. To achieve a partial match/create, make sure to use already defined variables for the parts that shouldn't be affected.

So foremost `MERGE` makes sure that you can't create duplicate information or structures, but it comes with the cost of needing to check for existing matches first. Especially on large graphs it can be costly to scan a large set of labeled nodes for a certain property. You can alleviate some of that by creating supporting indexes or constraints, which we'll discuss later. But it's still not for free, so whenever you're sure to not create duplicate data use `CREATE` over `MERGE`.

MERGE can also assert that a relationship is only created once. For that to work you *have to pass in* both nodes from a previous pattern match.

```
MATCH (m:Movie { title:"Cloud Atlas" })
MATCH (p:Person { name:"Tom Hanks" })
MERGE (p)-[r:ACTED_IN]->(m)
ON CREATE SET r.roles =['Zachry']
RETURN p,r,m
```

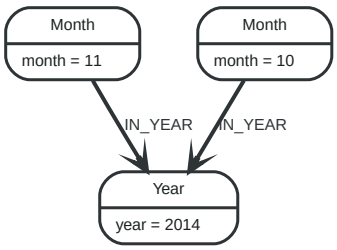


In case the direction of a relationship is arbitrary, you can leave off the arrowhead. MERGE will then check for the relationship in either direction, and create a new directed relationship if no matching relationship was found.

If you choose to pass in only one node from a preceding clause, MERGE offers an interesting functionality. It will then only match within the direct neighborhood of the provided node for the given pattern, and, if not found create it. This can come in very handy for creating for example tree structures.

```
CREATE (y:Year { year:2014 })
MERGE (y)<-[:IN_YEAR]-(m10:Month { month:10 })
MERGE (y)<-[:IN_YEAR]-(m11:Month { month:11 })
RETURN y,m10,m11
```

This is the graph structure that gets created:



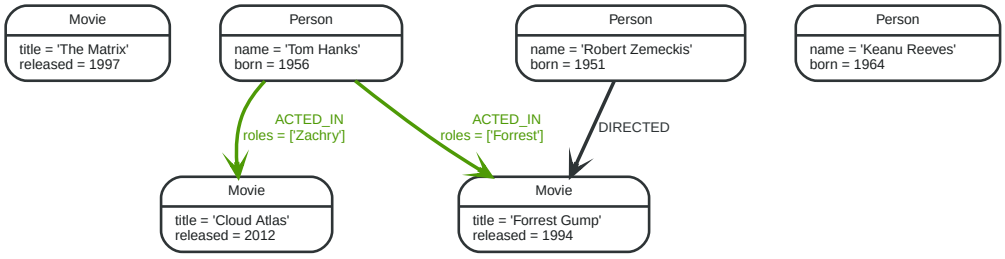
Here there is no global search for the two Month nodes; they are only searched for in the context of the *2014* Year node.

4.3. Getting correct results

Let's first get some data in to retrieve results from:

```
CREATE (matrix:Movie { title:"The Matrix",released:1997 })
CREATE (cloudAtlas:Movie { title:"Cloud Atlas",released:2012 })
CREATE (forrestGump:Movie { title:"Forrest Gump",released:1994 })
CREATE (keanu:Person { name:"Keanu Reeves", born:1964 })
CREATE (robert:Person { name:"Robert Zemeckis", born:1951 })
CREATE (tom:Person { name:"Tom Hanks", born:1956 })
CREATE (tom)-[:ACTED_IN { roles: ["Forrest"]}]->(forrestGump)
CREATE (tom)-[:ACTED_IN { roles: ['Zachry']}]->(cloudAtlas)
CREATE (robert)-[:DIRECTED]->(forrestGump)
```

This is the data we will start out with:



4.3.1. Filtering Results

So far we've matched patterns in the graph and always returned all results we found. Quite often there are conditions in play for what we want to see. Similar to in *SQL* those filter conditions are expressed in a `WHERE` clause. This clause allows to use any number of boolean expressions (predicates) combined with `AND`, `OR`, `XOR` and `NOT`. The simplest predicates are comparisons, especially equality.

```
MATCH (m:Movie)
WHERE m.title = "The Matrix"
RETURN m
```

```
+-------------------------------------------+
| m                                         |
+-------------------------------------------+
| Node[0]{title:"The Matrix",released:1997} |
+-------------------------------------------+
1 row
```

For equality on one or more properties, a more compact syntax can be used as well:

```
MATCH (m:Movie { title: "The Matrix" })
RETURN m
```

Other options are numeric comparisons, matching regular expressions and checking the existence of values within a list.

The `WHERE` clause below includes a regular expression match, a greater than comparison and a test to see if a value exists in a list.

```
MATCH (p:Person)-[r:ACTED_IN]->(m:Movie)
WHERE p.name =~ "K.+" OR m.released > 2000 OR "Neo" IN r.roles
RETURN p,r,m
```

```
+-----------------------------------------------------------------------------------------------------------
----------+
| p                                  | r                              | m
|
+-----------------------------------------------------------------------------------------------------------
----------+
| Node[5]{name:"Tom Hanks",born:1956} | :ACTED_IN[1]{roles:["Zachry"]} | Node[1]{title:"Cloud
Atlas",released:2012} |
+-----------------------------------------------------------------------------------------------------------
----------+
1 row
```

One aspect that might be a little surprising is that you can even use patterns as predicates. Where `MATCH` expands the number and shape of patterns matched, a pattern predicate restricts the current result set. It only allows the paths to pass that satisfy the additional patterns as well (or `NOT`).

```
MATCH (p:Person)-[:ACTED_IN]->(m)
WHERE NOT (p)-[:DIRECTED]->()
RETURN p,m
```

```
+-------------------------------------------------------------------------------------+
| p                                  | m                                              |
+-------------------------------------------------------------------------------------+
| Node[5]{name:"Tom Hanks",born:1956} | Node[1]{title:"Cloud Atlas",released:2012}  |
| Node[5]{name:"Tom Hanks",born:1956} | Node[2]{title:"Forrest Gump",released:1994} |
+-------------------------------------------------------------------------------------+
2 rows
```

Here we find actors, because they sport an `ACTED_IN` relationship but then skip those that ever `DIRECTED` any movie.

There are also more advanced ways of filtering like list-predicates which we will look at later on.

4.3.2. Returning Results

So far we've returned only nodes, relationships, or paths directly via their variables. But the `RETURN` clause can actually return any number of expressions. But what are actually expressions in Cypher?

The simplest expressions are literal values like numbers, strings and arrays as `[1,2,3]`, and maps like `{name:"Tom Hanks", born:1964, movies:["Forrest Gump", …], count:13}`. You can access individual properties of any node, relationship, or map with a dot-syntax like `n.name`. Individual elements or slices of arrays can be retrieved with subscripts like `names[0]` or `movies[1..-1]`. Each function evaluation like `length(array)`, `toInt("12")`, `substring("2014-07-01",0,4)`, or `coalesce(p.nickname,"n/a")` is also an expression.

Predicates that you'd use in `WHERE` count as boolean expressions.

Of course simpler expressions can be composed and concatenated to form more complex expressions.

By default the expression itself will be used as label for the column, in many cases you want to alias that with a more understandable name using `expression AS alias`. You can later on refer to that column using its alias.

```
MATCH (p:Person)
RETURN p, p.name AS name, upper(p.name), coalesce(p.nickname,"n/a") AS nickname, { name: p.name,
  label:head(labels(p))} AS person
```

```
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------+
| p                                        | name              | upper(p.name)     | nickname | person
|
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------+
| Node[3]{name:"Keanu Reeves",born:1964}    | "Keanu Reeves"    | "KEANU REEVES"    | "n/a"    | {name ->
"Keanu Reeves", label -> "Person"}    |
| Node[4]{name:"Robert Zemeckis",born:1951} | "Robert Zemeckis" | "ROBERT ZEMECKIS" | "n/a"    | {name ->
"Robert Zemeckis", label -> "Person"} |
| Node[5]{name:"Tom Hanks",born:1956}       | "Tom Hanks"       | "TOM HANKS"       | "n/a"    | {name ->
"Tom Hanks", label -> "Person"}       |
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------+
3 rows
```

If you're interested in unique results you can use the `DISTINCT` keyword after `RETURN` to indicate that.

4.3.3. Aggregating Information

In many cases you want to aggregate or group the data that you encounter while traversing patterns in your graph. In Cypher aggregation happens in the `RETURN` clause while computing your final results. Many common aggregation functions are supported, e.g. `count`, `sum`, `avg`, `min`, and `max`, but there are several more.

Counting the number of people in your database could be achieved by this:

```
MATCH (:Person)
RETURN count(*) AS people
```

```
+--------+
| people |
+--------+
| 3      |
+--------+
1 row
```

Please note that `NULL` values are skipped during aggregation. For aggregating only unique values use `DISTINCT`, like in `count(DISTINCT role)`.

Aggregation in Cypher just works. You specify which result columns you want to aggregate and *Cypher will use all non-aggregated columns as grouping keys*.

Aggregation affects which data is still visible in ordering or later query parts.

To find out how often an actor and director worked together, you'd run this statement:

```
MATCH (actor:Person)-[:ACTED_IN]->(movie:Movie)<-[:DIRECTED]-(director:Person)
RETURN actor,director,count(*) AS collaborations
```

```
+-------------------------------------------------------------------------------------------------------+
| actor                               | director                                  | collaborations |
+-------------------------------------------------------------------------------------------------------+
| Node[5]{name:"Tom Hanks",born:1956} | Node[4]{name:"Robert Zemeckis",born:1951} | 1              |
+-------------------------------------------------------------------------------------------------------+
1 row
```

Frequently you want to sort and paginate after aggregating a `count(x)`.

4.3.4. Ordering and Pagination

Ordering works like in other query languages, with an `ORDER BY expression [ASC|DESC]` clause. The expression can be any expression discussed before as long as it is computable from the returned information.

So for instance if you return `person.name` you can still `ORDER BY person.age` as both are accessible from the `person` reference. You cannot order by things that you can't infer from the information you return. This is especially important with aggregation and `DISTINCT` return values as both remove the visibility of data that is aggregated.

Pagination is a straightforward use of `SKIP {offset} LIMIT {count}`.

A common pattern is to aggregate for a count (score or frequency), order by it and only return the top-n entries.

For instance to find the most prolific actors you could do:

```
MATCH (a:Person)-[:ACTED_IN]->(m:Movie)
RETURN a,count(*) AS appearances
ORDER BY appearances DESC LIMIT 10;
```

```
+-------------------------------------------------+
| a                                 | appearances |
+-------------------------------------------------+
| Node[5]{name:"Tom Hanks",born:1956} | 2           |
+-------------------------------------------------+
1 row
```

4.3.5. Collecting Aggregation

The most helpful aggregation function is `collect()`, which, appropriately collects all aggregated values into a list. This comes very handy in many situations as no information of details is lost while aggregating.

`collect()` is well suited for retrieving typical parent-child structures, where one core entity (parent, root or head) is returned per row with all its dependent information in associated lists created with `collect()`. This means that there is no need to repeat the parent information per each child-row, or even running `n+1` statements to retrieve the parent and its children individually.

To retrieve the cast of each movie in our database this statement could be used:

```
MATCH (m:Movie)<-[:ACTED_IN]-(a:Person)
RETURN m.title AS movie, collect(a.name) AS cast, count(*) AS actors
```

```
+-----------------------------------------+
| movie          | cast          | actors |
+-----------------------------------------+
| "Forrest Gump" | ["Tom Hanks"] | 1      |
| "Cloud Atlas"  | ["Tom Hanks"] | 1      |
+-----------------------------------------+
2 rows
```

The lists created by `collect()` can either be used from the client consuming the Cypher results or directly within a statement with any of the list functions or predicates.

4.4. Composing large statements

Let's first get some data in to retrieve results from:

```
CREATE (matrix:Movie { title:"The Matrix",released:1997 })
CREATE (cloudAtlas:Movie { title:"Cloud Atlas",released:2012 })
CREATE (forrestGump:Movie { title:"Forrest Gump",released:1994 })
CREATE (keanu:Person { name:"Keanu Reeves", born:1964 })
CREATE (robert:Person { name:"Robert Zemeckis", born:1951 })
CREATE (tom:Person { name:"Tom Hanks", born:1956 })
CREATE (tom)-[:ACTED_IN { roles: ["Forrest"]}]->(forrestGump)
CREATE (tom)-[:ACTED_IN { roles: ['Zachry']}]->(cloudAtlas)
CREATE (robert)-[:DIRECTED]->(forrestGump)
```

4.4.1. UNION

A Cypher statement is usually quite compact. Expressing references between nodes as visual patterns makes them easy to understand.

If you want to combine the results of two statements that have the same result structure, you can use `UNION [ALL]`.

For instance if you want to list both actors and directors without using the alternative relationship-type syntax `()-[:ACTED_IN|:DIRECTED] ()` you can do this:

```
MATCH (actor:Person)-[r:ACTED_IN]->(movie:Movie)
RETURN actor.name AS name, type(r) AS acted_in, movie.title AS title
UNION
MATCH (director:Person)-[r:DIRECTED]->(movie:Movie)
RETURN director.name AS name, type(r) AS acted_in, movie.title AS title
```

```
+-------------------------------------------------+
| name              | acted_in   | title          |
+-------------------------------------------------+
| "Tom Hanks"       | "ACTED_IN" | "Cloud Atlas"  |
| "Tom Hanks"       | "ACTED_IN" | "Forrest Gump" |
| "Robert Zemeckis" | "DIRECTED" | "Forrest Gump" |
+-------------------------------------------------+
3 rows
```

4.4.2. WITH

In Cypher it's possible to chain fragments of statements together, much like you would do within a data-flow pipeline. Each fragment works on the output from the previous one and its results can feed into the next one.

You use the `WITH` clause to combine the individual parts and declare which data flows from one to the other. `WITH` is very much like `RETURN` with the difference that it doesn't finish a query but prepares the input for the next part. You can use the same expressions, aggregations, ordering and pagination as in the `RETURN` clause.

The only difference is that you *must* alias all columns as they would otherwise not be accessible. Only columns that you declare in your `WITH` clause is available in subsequent query parts.

See below for an example where we collect the movies someone appeared in, and then filter out those which appear in only one movie.

```
MATCH (person:Person)-[:ACTED_IN]->(m:Movie)
WITH person, count(*) AS appearances, collect(m.title) AS movies
WHERE appearances > 1
RETURN person.name, appearances, movies
```

```
+-------------------------------------------------------------+
| person.name | appearances | movies                          |
+-------------------------------------------------------------+
| "Tom Hanks" | 2           | ["Cloud Atlas","Forrest Gump"] |
+-------------------------------------------------------------+
1 row
```

If you want to filter by an aggregated value in SQL or similar languages you would have to use `HAVING`. That's a single purpose clause for filtering aggregated information. In Cypher, `WHERE` can be used in both cases.

4.5. Constraints and indexes

Labels are a convenient way to group nodes together. They are used to restrict queries, define constraints and create indexes.

4.5.1. Using constraints

You can specify unique constraints that guarantee uniqueness of a certain property on nodes with a specific label. These constraints are also used by the `MERGE` clause to make certain that a node only exists once.

The following is an example of how to use labels and add constraints and indexes to them. Let's start out by adding a constraint. In this case we decide that every `Movie` node should have a unique `title`.

```
CREATE CONSTRAINT ON (movie:Movie) ASSERT movie.title IS UNIQUE
```

Note that adding the unique constraint will implicitly add an index on that property, so we won't have to do that separately. If we drop a constraint but still want an index on that property, we will have to create the index explicitly.

Constraints can be added after a label is already in use, but that requires that the existing data complies with the constraints.

4.5.2. Using indexes

The main reason for using indexes in a graph database is to find the starting point in the graph as fast as possible. After that seek you rely on in-graph structures and the first class citizenship of relationships in the graph database to achieve high performance. Thus graph queries themselves do not need indexes to run fast.

Indexes can be added at any time. Note that it will take some time for an index to come online when there's existing data.

In this case we want to create an index to speed up finding actors by name in the database:

```
CREATE INDEX ON :Actor(name)
```

Now, let's add some data.

```
CREATE (actor:Actor { name:"Tom Hanks" }),(movie:Movie { title:'Sleepless IN Seattle' }),
  (actor)-[:ACTED_IN]->(movie);
```

Normally you don't specify indexes when querying for data. They will be used automatically. This means we that can simply look up the Tom Hanks node, and the index will kick in behind the scenes to boost performance.

```
MATCH (actor:Actor { name: "Tom Hanks" })
RETURN actor;
```

Cypher Query Language

The Cypher part is the authoritative source for details on the Cypher Query Language. For a short introduction, see What is Cypher?. To take your first steps with Cypher, see Get started with Cypher. For the terminology used, see Terminology.

Chapter 5. Introduction

To get an overview of Cypher, continue reading What is Cypher?. The rest of this chapter deals with the context of Cypher statements, like for example transaction management and how to use parameters. For the Cypher language reference itself see other chapters at Cypher Query Language. To take your first steps with Cypher, see Get started with Cypher. For the terminology used, see Terminology.

5.1. What is Cypher?

5.1.1. Introduction

Cypher is a declarative graph query language that allows for expressive and efficient querying and updating of the graph store. Cypher is a relatively simple but still very powerful language. Very complicated database queries can easily be expressed through Cypher. This allows you to focus on your domain instead of getting lost in database access.

Cypher is designed to be a humane query language, suitable for both developers and (importantly, we think) operations professionals. Our guiding goal is to make the simple things easy, and the complex things possible. Its constructs are based on English prose and neat iconography which helps to make queries more self-explanatory. We have tried to optimize the language for reading and not for writing.

Being a declarative language, Cypher focuses on the clarity of expressing *what* to retrieve from a graph, not on *how* to retrieve it. This is in contrast to imperative languages like Java, scripting languages like Gremlin *(http://gremlin.tinkerpop.com)*, and the JRuby Neo4j bindings *(https://github.com/neo4jrb/neo4j/)*. This approach makes query optimization an implementation detail instead of burdening the user with it and requiring her to update all traversals just because the physical database structure has changed (new indexes etc.).

Cypher is inspired by a number of different approaches and builds upon established practices for expressive querying. Most of the keywords like WHERE and ORDER BY are inspired by SQL *(http://en.wikipedia.org/wiki/SQL)*. Pattern matching borrows expression approaches from SPARQL *(http://en.wikipedia.org/wiki/SPARQL)*. Some of the collection semantics have been borrowed from languages such as Haskell and Python.

5.1.2. Structure

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

Clauses are chained together, and the 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. You can read more details about them later in the manual.

Here are a few 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.

Imagine an example graph like the following one:

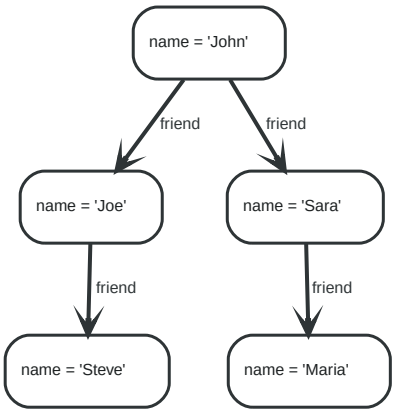


Figure 1. Example Graph

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"    | "Steve"  |
| "John"    | "Maria"  |
+----------------------+
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 here 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 uniqueness constraints.

For more Cypher examples, see [data-modeling-examples] as well as the rest of the Cypher part with details on the language. To use Cypher from Java, see [tutorials-cypher-java]. To take your first steps with Cypher, see Get started with Cypher.

5.2. Updating the graph

Cypher can be used for both querying and updating your graph.

5.2.1. The Structure of Updating Queries

A Cypher query part can't both match and update the graph at the same time.

Every part can either read and match on the graph, or make updates on it.

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.

If your query only performs reads, Cypher will be lazy and 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 actually happens.

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.friendCount = friendsCount
RETURN n.friendsCount
```

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

5.2.2. Returning data

Any query can return data. If your query only reads, it has to return data — it serves no purpose if it doesn't, and it is 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 graph elements from a query that has just deleted them — beware, you are holding a

pointer that is no longer valid. Operations on that node are undefined.

5.3. Transactions

Any query that updates the graph will run in a transaction. An updating query will always either fully succeed, or not succeed at all.

Cypher will either create a new transaction or run inside an existing one:

- If no transaction exists in the running context Cypher will create one and commit it once the query finishes.
- In case there already exists a transaction in the running context, the query will run inside it, and nothing will be persisted to disk until that transaction is successfully committed.

This can be used to have multiple queries be committed as a single transaction:

1. Open a transaction,
2. run multiple updating Cypher queries,
3. and commit all of them in one go.

Note that a query will hold the changes in memory until the whole query has finished executing. A large query will consequently need a JVM with lots of heap space.

For using transactions over the REST API, see Transactional Cypher HTTP endpoint.

When writing server extensions or using Neo4j embedded, remember that all iterators returned from an execution result should be either fully exhausted or closed to ensure that the resources bound to them will be properly released. Resources include transactions started by the query, so failing to do so may, for example, lead to deadlocks or other weird behavior.

5.4. Uniqueness

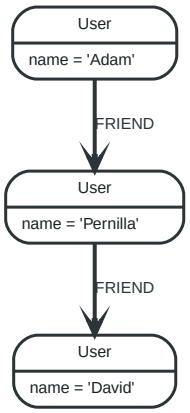
While pattern matching, Neo4j makes sure to not include matches where the same graph relationship is found multiple times in a single pattern. In most use cases, this is a sensible thing to do.

Example: looking for a user's friends of friends should not return said user.

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
```

5.5. Parameters

Cypher supports querying with parameters. This means developers don't have to resort to string building to create a query. In addition to that, it also makes caching of execution plans much easier for Cypher.

Parameters can be used for literals and expressions in the WHERE clause, for the index value in the START clause, index queries, and finally for node/relationship ids. Parameters can not be used as for property names, relationship types and labels, since these patterns are part of the query structure that is compiled into a query plan.

Accepted names for parameters are letters and numbers, and any combination of these.

For details on using parameters via the Neo4j REST API, see Transactional Cypher HTTP endpoint. For details on parameters when using the Neo4j embedded Java API, see [tutorials-cypher-parameters-java].

Below follows a comprehensive set of examples of parameter usage. The parameters are given as JSON here. Exactly how to submit them depends on the driver in use.

5.5.1. String literal

Parameters

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

Query

```
MATCH (n)
WHERE n.name = { name }
RETURN n
```

You can use parameters in this syntax as well:

Parameters

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

Query

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

5.5.2. Regular expression

Parameters

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

Query

```
MATCH (n)
WHERE n.name =~ { regex }
RETURN n.name
```

5.5.3. Case-sensitive string pattern matching

Parameters

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

Query

```
MATCH (n)
WHERE n.name STARTS WITH { name }
RETURN n.name
```

5.5.4. Create node with properties

Parameters

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

Query

```
CREATE ({ props })
```

5.5.5. Create multiple nodes with properties

Parameters

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

Query

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

5.5.6. Setting all properties on node

Note that this will replace all the current properties.

Parameters

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

Query

```
MATCH (n)
WHERE n.name='Michaela'
SET n = { props }
```

5.5.7. SKIP and LIMIT

Parameters

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

Query

```
MATCH (n)
RETURN n.name
SKIP { s }
LIMIT { l }
```

5.5.8. Node id

Parameters

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

Query

```
MATCH (n)
WHERE id(n)= { id }
RETURN n.name
```

5.5.9. Multiple node ids

Parameters

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

Query

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

5.5.10. Index value (legacy indexes)

Parameters

```
{
  "value" : "Michaela"
}
```

Query

```
START n=node:people(name = { value })
RETURN n
```

5.5.11. Index query (legacy indexes)

Parameters

```
{
  "query" : "name:Andreas"
}
```

Query

```
START n=node:people({ query })
RETURN n
```

5.6. Compatibility

Cypher is still changing rather rapidly. Parts of the changes are internal — we add new pattern matchers, aggregators and optimizations or write new query planners, which hopefully makes your queries run faster.

Other changes are directly visible to our users — the syntax is still changing. New concepts are being added and old ones changed to fit into new possibilities. To guard you from having to keep up with our syntax changes, Neo4j allows you to use an older parser, but still gain speed from new optimizations.

There are two ways you can select which parser to use. You can configure your database with the configuration parameter `cypher.default_language_version`, and enter which parser you'd like to use (see Supported Language Versions)). Any Cypher query that doesn't explicitly say anything else, will get the parser you have configured, or the latest parser if none is configured.

The other way is on a query by query basis. By simply putting `CYPHER 2.2` at the beginning, that particular query will be parsed with the 2.2 version of the parser. Below is an example using the `START` clause to access a legacy index:

```
CYPHER 2.2
START n=node:nodes(name = "A")
RETURN n
```

5.6.1. Accessing entities by id via START

In versions of Cypher prior to 2.2 it was also possible to access specific nodes or relationships using the START clause. In this case you could use a syntax like the following:

```
CYPHER 1.9
START n=node(42)
RETURN n
```

The use of the START clause to find nodes by ID was deprecated from Cypher 2.0 onwards and is now entirely disabled in Cypher 2.2 and up. You should instead make use of the MATCH clause for starting points. See Match for more information on the correct syntax for this. The START clause should only be used when accessing legacy indexes (see [indexing]).

5.6.2. Supported Language Versions

Neo4j 2.3 supports the following versions of the Cypher language:

- Neo4j Cypher 2.3
- Neo4j Cypher 2.2
- Neo4j Cypher 1.9

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 6. Syntax

The nitty-gritty details of Cypher syntax.

6.1. Values

All values that are handled by Cypher have a distinct type. The supported types of values are:

- Numeric values,
- String values,
- Boolean values,
- Nodes,
- Relationships,
- Paths,
- Maps from Strings to other values,
- Lists of any other type of value.

Most types of values can be constructed in a query using literal expressions (see Expressions). Special care must be taken when using `NULL`, as `NULL` is a value of every type (see Working with NULL). Nodes, relationships, and paths are returned as a result of pattern matching.

Note that labels are not values but are a form of pattern syntax.

6.2. Expressions

6.2.1. Expressions in general

An expression in Cypher can be:

- A decimal (integer or double) literal: `13`, `-40000`, `3.14`, `6.022E23`.
- A hexadecimal integer literal (starting with `0x`): `0x13zf`, `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`, `has(a.name)`.

- A regular expression: `a.name =~ "Tob.*"`
- A case-sensitive string matching expression: `a.surname STARTS WITH "Sven"`, `a.surname ENDS WITH "son"` or `a.surname CONTAINS "son"`
- A CASE expression.

6.2.2. Note on string literals

String literals can contain these 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`)

6.2.3. Case Expressions

Cypher supports CASE expressions, which is a generic conditional expression, similar to if/else statements in other languages. Two variants of CASE exist — the simple form and the generic form.

6.2.4. Simple CASE

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 used, or null, if no ELSE case exists.

Syntax:

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

Arguments:

- *test:* A valid expression.
- *value:* An expression whose result will be compared to the test expression.
- *result:* This is the result expression used if the value expression matches the test expression.
- *default:* The expression to use if no match is found.

Query

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

Result

```
+--------+
| result |
+--------+
| 2      |
| 1      |
| 3      |
| 2      |
| 1      |
+--------+
5 rows
```

6.2.5. Generic CASE

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 used, or null, if no ELSE case exists.

Syntax:

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

Arguments:

- *predicate:* A predicate that is tested to find a valid alternative.
- *result:* This is the result expression used if the predicate matches.
- *default:* The expression to use if no match is found.

Query

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

Result

```
+--------+
| result |
+--------+
| 2      |
| 1      |
| 3      |
| 3      |
| 1      |
+--------+
5 rows
```

6.3. 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`.

Variable names are case sensitive, and can contain underscores and alphanumeric characters (a-z, 0-9), but must always start with a letter. If other characters are needed, you can quote the variable using backquote (`) signs.

The same rules apply to property names.

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.

6.4. Operators

6.4.1. Mathematical operators

The mathematical operators are `+`, `-`, `*`, `/` and `%`, `^`.

6.4.2. Comparison operators

The comparison operators are `=`, `<>`, `<`, `>`, `>=`, `IS NULL`, and `IS NOT NULL`. See Equality and Comparison of Values on how they behave.

The operators `STARTS WITH`, `ENDS WITH` and `CONTAINS` can be used to search for a string value by its content.

6.4.3. Boolean operators

The boolean operators are `AND`, `OR`, `XOR`, `NOT`.

6.4.4. String operators

Strings can be concatenated using the `+` operator. For regular expression matching the `=~` operator is used.

6.4.5. List operators

Lists can be concatenated using the `+` operator. To check if an element exists in a list, you can use the IN operator.

6.4.6. Property operators

Since version 2.0, the previously existing property operators `?` and `!` have been removed. This syntax is no longer supported. Missing properties are now returned as NULL. Please use `(NOT(has(<ident>.prop)) OR <ident>.prop=<value>)` if you really need the old behavior of the `?` operator. — Also, the use of `?` for optional relationships has been removed in favor of the newly introduced `OPTIONAL MATCH` clause.

6.4.7. Equality and Comparison of Values

Equality

Cypher supports comparing values (see Values) 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.

6.4.8. 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`.

- Comparing for ordering when one argument is NULL is NULL (e.g. `NULL < 3` is NULL).
- It is an error to compare other types of values with each other for ordering.

6.4.9. 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 (though perhaps not pretty).

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.

6.5. 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
```

6.6. Patterns

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 details in:

- Match
- Optional Match
- Create
- Merge
- Using path patterns in WHERE

6.6.1. 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`.

6.6.2. Patterns for related nodes

More interesting is patterns that describe 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 way 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, like so:

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

6.6.3. 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)
```

6.6.4. 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: "Andres", sport: "Brazilian Ju-Jitsu" })
```

A relationship with expectations on it would could look like:

```
(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.

6.6.5. Describing 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, like so:

```
(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 like so:

```
(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, in this case like so:

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

Variable length

Variable length pattern matching in versions 2.1.x and earlier does not enforce relationship uniqueness for patterns described inside of a single `MATCH` clause. This means that a query such as the following: `MATCH (a)-[r] (b), (a)-[rs*] (c) RETURN` 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 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 (a)-[rs] (c) RETURN *`. 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)
```

And 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 query below:

Query

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

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 steps out. This is a typical example of finding first and second degree friends.

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

6.6.6. 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, like so:

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

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

6.7. Lists

Cypher has good support for lists.

6.7.1. 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
```

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]
```

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]
```

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]
```

Result

```
+-------------------+
| range(0,10)[0..3] |
+-------------------+
| [0,1,2]           |
+-------------------+
1 row
```

Query

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

Result

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

Query

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

Result

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

Query

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

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]
```

Result

```
+-----------------+
| range(0,10)[15] |
+-----------------+
| <null>          |
+-----------------+
1 row
```

Query

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

Result

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

You can get the size of a list like this:

Query

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

Result

```
+-------------------------+
| size(range(0,10)[0..3]) |
+-------------------------+
| 3                       |
+-------------------------+
1 row
```

6.7.2. 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
```

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
```

Result

```
+----------------+
| result         |
+----------------+
| [0,2,4,6,8,10] |
+----------------+
1 row
```

Query

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

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
```

6.7.3. Literal maps

From Cypher, you can also construct maps. Through REST you will get JSON objects; in Java they will be `java.util.Map<String,Object>`.

Query

```
RETURN { key : "Value", listKey: [{ inner: "Map1" }, { inner: "Map2" }]} AS result
```

Result

```
+----------------------------------------------------------------------+
| result                                                               |
+----------------------------------------------------------------------+
| {key -> "Value", listKey -> [{inner -> "Map1"},{inner -> "Map2"}]} |
+----------------------------------------------------------------------+
1 row
```

6.8. Working with NULL

6.8.1. 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.

6.8.2. Logical operations with NULL

The logical operators (AND, OR, XOR, IN, NOT) treat NULL as the ``unknown'' value of three-valued logic. Here is the truth table for AND, OR and XOR.

a	b	a AND b	a OR b	a XOR b
FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	NULL	FALSE	NULL	NULL
FALSE	TRUE	FALSE	TRUE	TRUE
TRUE	FALSE	FALSE	TRUE	TRUE
TRUE	NULL	NULL	TRUE	NULL
TRUE	TRUE	TRUE	TRUE	FALSE
NULL	FALSE	FALSE	NULL	NULL
NULL	NULL	NULL	NULL	NULL
NULL	TRUE	NULL	TRUE	NULL

6.8.3. 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.

6.8.4. 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 7. General Clauses

7.1. Return

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

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.

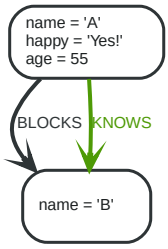


Figure 2. Graph

7.1.1. 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.

Result

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

7.1.2. 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.

Result

```
+-------------+
| r           |
+-------------+
| :KNOWS[0]{} |
+-------------+
1 row
```

7.1.3. 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.

Result

```
+--------+
| n.name |
+--------+
| "A"    |
+--------+
1 row
```

7.1.4. 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.

Result

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

7.1.5. Variable with uncommon characters

To introduce a placeholder that is made up of characters that are outside of 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

Result

```
+--------------------------------------+
| `This isn't a common variable`.happy |
+--------------------------------------+
| "Yes!"                               |
+--------------------------------------+
1 row
```

7.1.6. 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.

Result

```
+---------------------------+
| SomethingTotallyDifferent |
+---------------------------+
| 55                        |
+---------------------------+
1 row
```

7.1.7. 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.

Result

```
+--------+
| n.age  |
+--------+
| 55     |
| <null> |
+--------+
2 rows
```

7.1.8. 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.

Result

```
+-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------+
| a.age > 30 | "I'm a literal" | (a)-->()
|
+-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------+
| true       | "I'm a literal" |
[[Node[0]{name:"A",happy:"Yes!",age:55},:BLOCKS[1]{},Node[1]{name:"B"}],[Node[0]{name:"A",happy:"Yes!",age
:55},:KNOWS[0]{},Node[1]{name:"B"}]] |
+-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------+
1 row
```

7.1.9. 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.

Result

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

7.2. Order by

> `ORDER BY` *is a sub-clause following* `RETURN` *or* `WITH`*, and it specifies that the output should be sorted and how.*

Note that you can not 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.

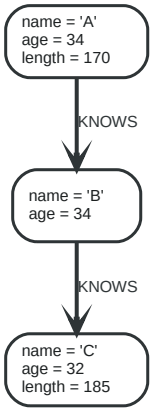


Figure 3. Graph

7.2.1. Order nodes by property

ORDER BY is used to sort the output.

Query

```
MATCH (n)
RETURN n
ORDER BY n.name
```

The nodes are returned, sorted by their name.

Result

```
+-------------------------------------+
| n                                   |
+-------------------------------------+
| Node[0]{name:"A",age:34,length:170} |
| Node[1]{name:"B",age:34}            |
| Node[2]{name:"C",age:32,length:185} |
+-------------------------------------+
3 rows
```

7.2.2. 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
ORDER BY n.age, n.name
```

This returns the nodes, sorted first by their age, and then by their name.

Result

```
+-----------------------------------+
| n                                 |
+-----------------------------------+
| Node[2]{name:"C",age:32,length:185} |
| Node[0]{name:"A",age:34,length:170} |
| Node[1]{name:"B",age:34}          |
+-----------------------------------+
3 rows
```

7.2.3. 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
ORDER BY n.name DESC
```

The example returns the nodes, sorted by their name reversely.

Result

```
+-----------------------------------+
| n                                 |
+-----------------------------------+
| Node[2]{name:"C",age:32,length:185} |
| Node[1]{name:"B",age:34}          |
| Node[0]{name:"A",age:34,length:170} |
+-----------------------------------+
3 rows
```

7.2.4. 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
ORDER BY n.length
```

The nodes are returned sorted by the length property, with a node without that property last.

Result

```
+-----------------------------------------------+
| n.length | n                                  |
+-----------------------------------------------+
| 170      | Node[0]{name:"A",age:34,length:170} |
| 185      | Node[2]{name:"C",age:32,length:185} |
| <null>   | Node[1]{name:"B",age:34}           |
+-----------------------------------------------+
3 rows
```

7.3. Limit

`LIMIT` *constrains the number of rows in the output.*

LIMIT accepts any expression that evaluates to a positive integer — however the expression cannot refer to nodes or relationships.

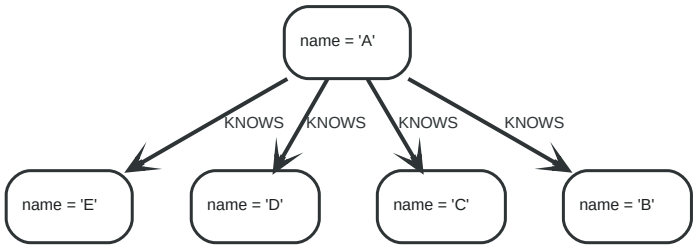


Figure 4. Graph

7.3.1. Return first part

To return a subset of the result, starting from the top, use this syntax:

Query

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

The top three items are returned by the example query.

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[0]{name:"A"} |
| Node[1]{name:"B"} |
| Node[2]{name:"C"} |
+-------------------+
3 rows
```

7.3.2. Return first from expression

Limit accepts any expression that evaluates to a positive integer as long as it is not referring to any external variables:

Parameters

```
{
  "p" : 12
}
```

Query

```
MATCH (n)
RETURN n
ORDER BY n.name
LIMIT toInt(3 * rand())+ 1
```

Returns one to three top items

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[0]{name:"A"} |
| Node[1]{name:"B"} |
+-------------------+
2 rows
```

7.4. Skip

`SKIP` defines from which row to start including the rows in the output.

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.

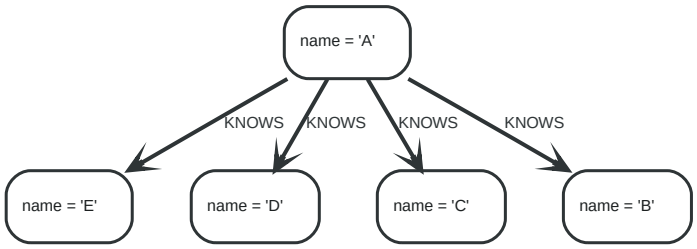


Figure 5. Graph

7.4.1. Skip first three

To return a subset of the result, starting from the fourth result, use the following syntax:

Query

```
MATCH (n)
RETURN n
ORDER BY n.name
SKIP 3
```

The first three nodes are skipped, and only the last two are returned in the result.

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[3]{name:"D"} |
| Node[4]{name:"E"} |
+-------------------+
2 rows
```

7.4.2. Return middle two

To return a subset of the result, starting from somewhere in the middle, use this syntax:

Query

```
MATCH (n)
RETURN n
ORDER BY n.name
SKIP 1
LIMIT 2
```

Two nodes from the middle are returned.

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[1]{name:"B"} |
| Node[2]{name:"C"} |
+-------------------+
2 rows
```

7.4.3. Skip first from expression

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
ORDER BY n.name
SKIP toInt(3*rand())+ 1
```

The first three nodes are skipped, and only the last two are returned in the result.

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[2]{name:"C"} |
| Node[3]{name:"D"} |
| Node[4]{name:"E"} |
+-------------------+
3 rows
```

7.5. 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.*

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 by 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 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.

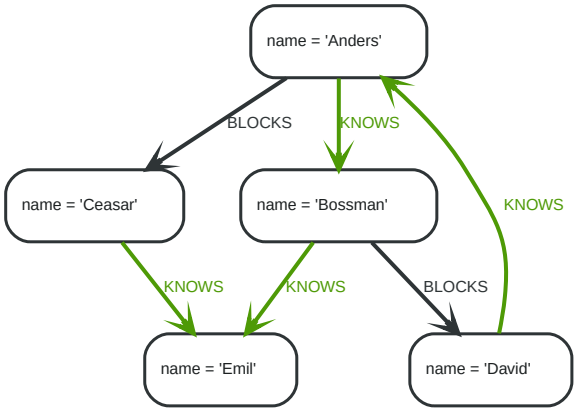


Figure 6. Graph

7.5.1. 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
```

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

Result

```
+------------------------+
| otherPerson            |
+------------------------+
| Node[0]{name:"Anders"} |
+------------------------+
1 row
```

7.5.2. 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, in a list.

Result

```
+---------------------------+
| collect(n.name)           |
+---------------------------+
| ["Emil","David","Ceasar"] |
+---------------------------+
1 row
```

7.5.3. Limit branching of your 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.

Result

```
+-----------+
| o.name    |
+-----------+
| "Bossman" |
| "Anders"  |
+-----------+
2 rows
```

7.6. Unwind

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

With UNWIND, you can transform any list back into individual rows. These lists can be parameters that were passed in, previously COLLECTed 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.

7.6.1. Unwind a list

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

Query

```
UNWIND[1,2,3] AS x
RETURN x
```

Each value of the original list is returned as an individual row.

Result

```
+---+
| x |
+---+
| 1 |
| 2 |
| 3 |
+---+
3 rows
```

7.6.2. Create 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 SET
```

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

Result

```
+-------+
| set   |
+-------+
| [1,2] |
+-------+
1 row
```

7.6.3. Create 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.

Result

```
+---+
| x |
+---+
| 1 |
| 2 |
+---+
2 rows
Nodes created: 3
Relationships created: 2
Properties set: 3
Labels added: 3
```

7.7. Union

The `UNION` clause is used to combine the result of multiple queries.

It 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.

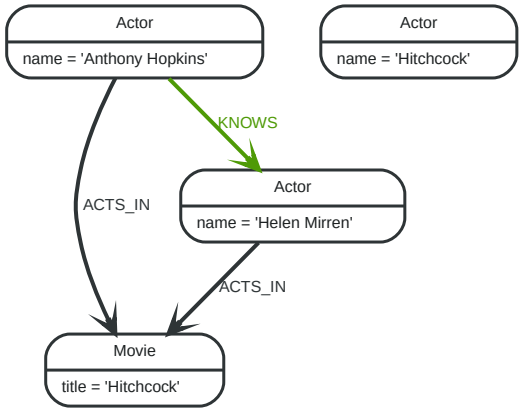


Figure 7. Graph

7.7.1. Combine two queries

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.

Result

```
+-------------------+
| name              |
+-------------------+
| "Anthony Hopkins" |
| "Helen Mirren"    |
| "Hitchcock"       |
| "Hitchcock"       |
+-------------------+
4 rows
```

7.7.2. 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.

Result

```
+-------------------+
| name              |
+-------------------+
| "Anthony Hopkins" |
| "Helen Mirren"    |
| "Hitchcock"       |
+-------------------+
3 rows
```

7.8. Call

The `CALL` clause is used to call a procedure deployed in the database.

The examples showing how to use arguments when invoking procedures all use the following procedure:

```
public class IndexingProcedure
{
    @Context
    public GraphDatabaseService db;

    /**
     * Adds a node to a named legacy index. Useful to, for instance, update
     * a full-text index through cypher.
     * @param indexName the name of the index in question
     * @param nodeId id of the node to add to the index
     * @param propKey property to index (value is read from the node)
     */
    @Procedure
    @PerformsWrites
    public void addNodeToIndex( @Name("indexName") String indexName,
                                @Name("node") long nodeId,
                                @Name("propKey" ) String propKey )
    {
        Node node = db.getNodeById( nodeId );
        db.index()
          .forNodes( indexName )
          .add( node, propKey, node.getProperty( propKey ) );
    }
}
```

This clause cannot be combined with other clauses.

7.8.1. Call a procedure

This invokes the built-in procedure 'db.labels', which lists all in-use labels in the database.

Query

```
CALL db.labels
```

Result

```
+-----------------+
| label           |
+-----------------+
| "User"          |
| "Administrator" |
+-----------------+
2 rows
```

7.8.2. Call a procedure with literal arguments

This invokes the example procedure `org.neo4j.procedure.example.addNodeToIndex` using arguments that are written out directly in the statement text. This is called literal arguments.

Query

```
CALL org.neo4j.procedure.example.addNodeToIndex('users', 0, 'name')
```

Since our example procedure does not return any result, the result is empty.

Result

```
+-------------------------------------------+
| No data returned, and nothing was changed. |
+-------------------------------------------+
```

7.8.3. Call a procedure with parameter arguments

This invokes the example procedure `org.neo4j.procedure.example.addNodeToIndex` using parameters. The procedure arguments are satisfied by matching the parameter keys to the named procedure arguments.

Parameters

```
{
  "indexName" : "users",
  "node" : 0,
  "propKey" : "name"
}
```

Query

```
CALL org.neo4j.procedure.example.addNodeToIndex
```

Since our example procedure does not return any result, the result is empty.

Result

```
+-------------------------------------------+
| No data returned, and nothing was changed. |
+-------------------------------------------+
```

7.8.4. Call a procedure with mixed literal and parameter arguments

This invokes the example procedure `org.neo4j.procedure.example.addNodeToIndex` using both literal and parameterized arguments.

Parameters

```
{
  "node" : 0
}
```

Query

```
CALL org.neo4j.procedure.example.addNodeToIndex('users', { node }, 'name')
```

Since our example procedure does not return any result, the result is empty.

Result

```
+-------------------------------------------+
| No data returned, and nothing was changed. |
+-------------------------------------------+
```

7.8.5. Call a procedure within a complex query

This invokes the built-in procedure 'db.labels' to count all in-use labels 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

Result

```
+-----------+
| numLabels |
+-----------+
| 2         |
+-----------+
1 row
```

7.8.6. Call a procedure within a complex query and rename its outputs

This invokes the built-in procedure 'db.propertyKeys' as part of counting the number of nodes per property key in-use 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

Result

```
+--------------------+
| prop   | numNodes |
+--------------------+
| "name" | 1        |
+--------------------+
1 row
```

Chapter 8. Reading Clauses

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.

8.1. Match

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

8.1.1. 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 of 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, and more about specifying hints to force Neo4j to solve a query in a specific way in Using.

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

The following graph is used for the examples below:

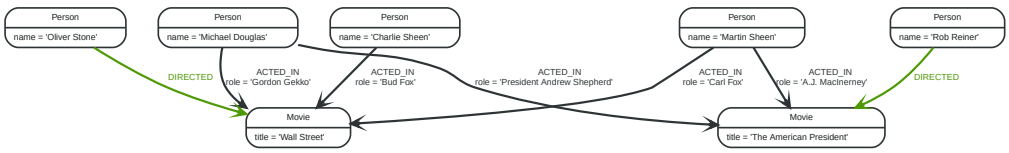


Figure 8. Graph

8.1.2. 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 2. 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 3. 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 4. Result

movie.title
"Wall Street"

movie.title
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 5. Result

movie.title
"Wall Street"
1 row

8.1.3. Relationship basics

Outgoing relationships

When the direction of a relationship is interesting, 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 6. Result

movie.title
"Wall Street"
1 row

Directed relationships and variable

If an variable is needed, 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 7. Result

type(r)
"DIRECTED"
1 row

Match by 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 8. Result

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

Match by 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 9. Result

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

Match by relationship type and use an 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 10. Result

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

8.1.4. Relationships in depth

Inside a single pattern, relationships will only be matched once. You can read more about this in 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
WITH SPACE`]->(charlie)
```

Which leads to the following graph:

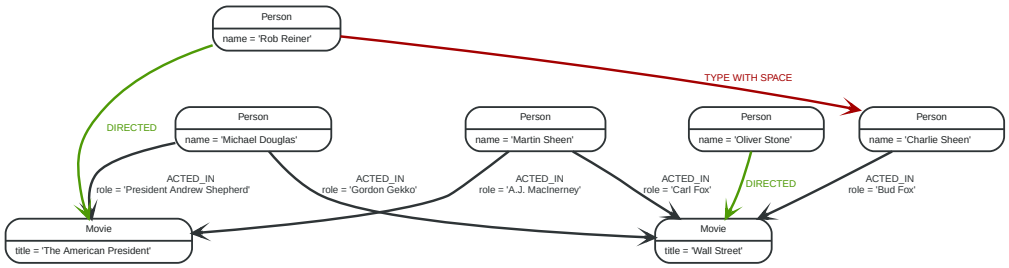


Figure 9. Graph

Query

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

Returns a relationship type with a space in it

Table 11. Result

type(r)
"TYPE WITH SPACE"

type(r)
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 acted in and its director.

Table 12. 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 by 1 to 3 hops.

Table 13. Result

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

Relationship variable in variable length relationships

When the connection between two nodes is of variable length, a relationship variable becomes a list of relationships.

Query

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

Returns a list of relationships.

Table 14. Result

r
[:ACTED_IN[0]\{role:"Bud Fox"\},:ACTED_IN[1]\{role:"Carl Fox"\}]
[:ACTED_IN[0]\{role:"Bud Fox"\},:ACTED_IN[2]\{role:"Gordon Gekko"\}]
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:

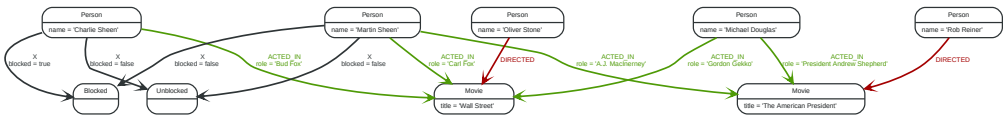


Figure 10. Graph

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 and Martin Sheen where all relationships have the blocked property set to FALSE.

Table 15. Result

p
[Node[0]\{name:"Charlie Sheen"\},:X[7]\{blocked:false\},Node[7]\{\},:X[8]\{blocked:false\},Node[1]\{name:"Martin Sheen"\}]
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 16. Result

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

Named path

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

Table 17. Result

p
[Node[2]\{name:"Michael Douglas"\},:ACTED_IN[5]\{role:"President Andrew Shepherd"\},Node[6]\{title:"The American President"\}]
[Node[2]\{name:"Michael Douglas"\},:ACTED_IN[2]\{role:"Gordon Gekko"\},Node[5]\{title:"Wall Street"\}]
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 18. 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	

8.1.5. 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. Inside of 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 19. Result

p
[Node[1]\{name:"Martin Sheen"\},:ACTED_IN[1]\{role:"Carl Fox"\},Node[5]\{title:"Wall Street"\},:DIRECTED[3]\{\},Node[3]\{name:"Oliver Stone"\}]
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 rels(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 20. Result

p
[Node[0]\{name:"Charlie Sheen"\},:ACTED_IN[0]\{role:"Bud Fox"\},Node[5]\{title:"Wall Street"\},:ACTED_IN[1]\{role:"Carl Fox"\},Node[1]\{name:"Martin Sheen"\}]
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' and 'Michael'.

Table 21. Result

p
[Node[1]\{name:"Martin Sheen"\},:ACTED_IN[1]\{role:"Carl Fox"\},Node[5]\{title:"Wall Street"\},:ACTED_IN[2]\{role:"Gordon Gekko"\},Node[2]\{name:"Michael Douglas"\}]
[Node[1]\{name:"Martin Sheen"\},:ACTED_IN[4]\{role:"A.J. MacInerney"\},Node[6]\{title:"The American President"\},:ACTED_IN[5]\{role:"President Andrew Shepherd"\},Node[2]\{name:"Michael Douglas"\}]
2 rows

8.1.6. 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 therefor recommended to rather use application generated ids.

Query

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

The corresponding node is returned.

Table 22. 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 23. 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 24. Result

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

8.2. 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.

8.2.1. 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 NULLs 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:

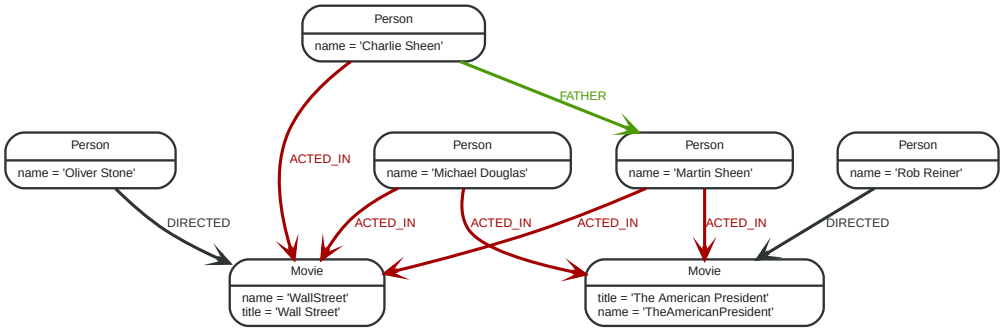


Figure 11. Graph

8.2.2. Relationship

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 it's place.

Query

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

Returns NULL, since the node has no outgoing relationships.

Result

```
+--------+
| x      |
+--------+
| <null> |
+--------+
1 row
```

8.2.3. 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.

Result

```
+-----------------+
| x      | x.name |
+-----------------+
| <null> | <null> |
+-----------------+
1 row
```

8.2.4. 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 r
```

This returns a node, and NULL, since the node has no outgoing `ACTS_IN` relationships.

Result

```
+--------+
| r      |
+--------+
| <null> |
+--------+
1 row
```

8.3. Where

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

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

In the case of `WITH` and `START`, `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.

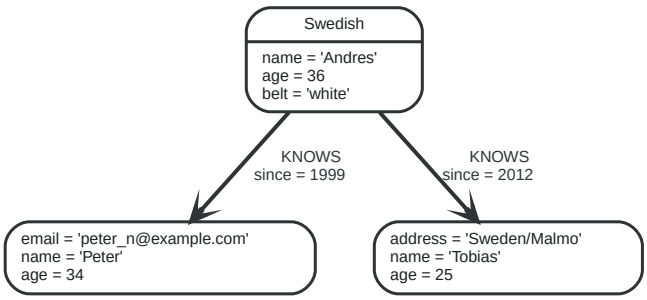


Figure 12. Graph

8.3.1. Basic usage

Boolean operations

You can use the expected boolean operators `AND` and `OR`, and also the boolean function `NOT`. See Working with NULL for more information on how this works with NULL.

Query

```
MATCH (n)
WHERE n.name = 'Peter' XOR (n.age < 30 AND n.name = "Tobias") OR NOT (n.name = "Tobias" OR
  n.name="Peter")
RETURN n
```

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"}                  |
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25}        |
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34}    |
+-------------------------------------------------------------+
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
```

The "Andres" node will be returned.

Result

```
+-------------------------------------------+
| n                                         |
+-------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"} |
+-------------------------------------------+
1 row
```

Filter on node property

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

Query

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

"Tobias" is returned because he is younger than 30.

Result

```
+-----------------------------------------------------+
| n                                                   |
+-----------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25} |
+-----------------------------------------------------+
1 row
```

Filter on relationship property

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

Query

```
MATCH (n)-[k:KNOWS]->(f)
WHERE k.since < 2000
RETURN f
```

"Peter" is returned because Andres knows him since before 2000.

Result

```
+-------------------------------------------------------------+
| f                                                           |
+-------------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-------------------------------------------------------------+
1 row
```

Filter on dynamic node property

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

Parameters

```
{
  "prop" : "AGE"
}
```

Query

```
MATCH (n)
WHERE n[toLower({ prop })]< 30
RETURN n
```

"Tobias" is returned because he is younger than 30.

Result

```
+-----------------------------------------------------+
| n                                                   |
+-----------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25} |
+-----------------------------------------------------+
1 row
```

Property exists

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

Query

```
MATCH (n)
WHERE exists(n.belt)
RETURN n
```

"Andres" will be returned because he is the only one with a `belt` property.

The `HAS()` function has been superseded by `EXISTS()` and has been removed.

Result

```
+-------------------------------------------+
| n                                         |
+-------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"} |
+-------------------------------------------+
1 row
```

8.3.2. String matching

The start and end of strings can be matched using `STARTS WITH` and `ENDS WITH`. To match regardless of location in a string, use `CONTAINS`. The matching is *case-sensitive*.

Match the start of a string

The `STARTS WITH` operator is used to perform case-sensitive matching on the start of strings.

Query

```
MATCH (n)
WHERE n.name STARTS WITH 'Pet'
RETURN n
```

"Peter" will be returned because his name starts with `Pet`.

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-------------------------------------------------------------+
1 row
```

Match the end of a string

The `ENDS WITH` operator is used to perform case-sensitive matching on the end of strings.

Query

```
MATCH (n)
WHERE n.name ENDS WITH 'ter'
RETURN n
```

"Peter" will be returned because his name ends with `ter`.

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-------------------------------------------------------------+
1 row
```

Match anywhere in a string

The `CONTAINS` operator is used to perform case-sensitive matching regardless of location in strings.

Query

```
MATCH (n)
WHERE n.name CONTAINS 'ete'
RETURN n
```

"Peter" will be returned because his name contains `ete`.

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-------------------------------------------------------------+
1 row
```

String matching negation

Use the `NOT` keyword to exclude all matches on given string from your result:

Query

```
MATCH (n)
WHERE NOT n.name ENDS WITH 's'
RETURN n
```

"Peter" will be returned because his name does not end with `s`.

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-------------------------------------------------------------+
1 row
```

8.3.3. Regular expressions

Cypher supports filtering using regular expressions. The regular expression syntax is inherited from the Java regular expressions *(https://docs.oracle.com/javase/7/docs/api/java/util/regex/Pattern.html)*. 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 start 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`.

Regular expressions

You can match on regular expressions by using `=~ "regexp"`, like this:

Query

```
MATCH (n)
WHERE n.name =~ 'Tob.*'
RETURN n
```

"Tobias" is returned because his name starts with `Tob`.

Result

```
+-------------------------------------------------------+
| n                                                     |
+-------------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25} |
+-------------------------------------------------------+
1 row
```

Escaping in regular expressions

If you need a forward slash inside of your regular expression, escape it. Remember that back slash needs to be escaped in string literals.

Query

```
MATCH (n)
WHERE n.address =~ 'Sweden\\/Malmo'
RETURN n
```

"Tobias" is returned because his address is in `Sweden/Malmo`.

Result

```
+-------------------------------------------------------+
| n                                                     |
+-------------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25} |
+-------------------------------------------------------+
1 row
```

Case insensitive regular expressions

By pre-pending a regular expression with `(?i)`, the whole expression becomes case insensitive.

Query

```
MATCH (n)
WHERE n.name =~ '(?i)ANDR.*'
RETURN n
```

"Andres" is returned because his name starts with `ANDR` regardless of case.

Result

```
+-------------------------------------------+
| n                                         |
+-------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"} |
+-------------------------------------------+
1 row
```

8.3.4. 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 can not 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 can not 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`, and the latter will eliminate any matched subgraphs where `a` and `b` do not have a directed relationship chain between them.

Query

```
MATCH (tobias { name: 'Tobias' }),(others)
WHERE others.name IN ['Andres', 'Peter'] AND (tobias)<--(others)
RETURN others
```

Nodes that have an outgoing relationship to the "Tobias" node are returned.

Result

```
+-----------------------------------------+
| others                                  |
+-----------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"} |
+-----------------------------------------+
1 row
```

Filter on patterns using NOT

The `NOT` function can be used to exclude a pattern.

Query

```
MATCH (persons),(peter { name: 'Peter' })
WHERE NOT (persons)-->(peter)
RETURN persons
```

Nodes that do not have an outgoing relationship to the "Peter" node are returned.

Result

```
+-------------------------------------------------------+
| persons                                               |
+-------------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25}     |
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-------------------------------------------------------+
2 rows
```

Filter on patterns with properties

You can also add properties to your patterns:

Query

```
MATCH (n)
WHERE (n)-[:KNOWS]-({ name:'Tobias' })
RETURN n
```

Finds all nodes that have a KNOWS relationship to a node with the name "Tobias".

Result

```
+-------------------------------------------+
| n                                         |
+-------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"} |
+-------------------------------------------+
1 row
```

Filtering 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)-[r]->()
WHERE n.name='Andres' AND type(r)=~ 'K.*'
RETURN r
```

This returns relationships that has a type whose name starts with `K`.

Result

```
+----------------------+
| r                    |
+----------------------+
| :KNOWS[1]{since:1999} |
| :KNOWS[0]{since:2012} |
+----------------------+
2 rows
```

8.3.5. Lists

IN operator

To check if an element exists in a list, you can use the `IN` operator.

Query

```
MATCH (a)
WHERE a.name IN ["Peter", "Tobias"]
RETURN a
```

This query shows how to check if a property exists in a literal list.

Result

```
+-----------------------------------------------------------+
| a                                                         |
+-----------------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25}      |
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-----------------------------------------------------------+
2 rows
```

8.3.6. Missing properties and values

Default to false if property is missing

As missing properties evaluate to NULL, the comparision in the example will evaluate to FALSE for nodes without the belt property.

Query

```
MATCH (n)
WHERE n.belt = 'white'
RETURN n
```

Only nodes with white belts are returned.

Result

```
+-------------------------------------------+
| n                                         |
+-------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"} |
+-------------------------------------------+
1 row
```

Default to true if property is missing

If you want to compare a property on a graph element, but only if it exists, you can compare the property against both the value you are looking for and NULL, like:

Query

```
MATCH (n)
WHERE n.belt = 'white' OR n.belt IS NULL RETURN n
ORDER BY n.name
```

This returns all nodes, even those without the belt property.

Result

```
+-----------------------------------------------------------+
| n                                                         |
+-----------------------------------------------------------+
| Node[0]{name:"Andres",age:36,belt:"white"}                |
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25}      |
+-----------------------------------------------------------+
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, with `IS NULL`. Also like SQL, the negative is `IS NOT NULL`, although `NOT(IS NULL x)` also works.

Query

```
MATCH (person)
WHERE person.name = 'Peter' AND person.belt IS NULL RETURN person
```

Nodes that have name `Peter` but no belt property are returned.

Result

```
+-----------------------------------------------------------+
| person                                                    |
+-----------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-----------------------------------------------------------+
1 row
```

8.3.7. Using ranges

Simple range

To check for an element being inside a specific range, use the inequality operators <, , >=, >.

Query

```
MATCH (a)
WHERE a.name >= 'Peter'
RETURN a
```

Nodes having a name property lexicographically greater than or equal to 'Peter' are returned.

Result

```
+-----------------------------------------------------------+
| a                                                         |
+-----------------------------------------------------------+
| Node[1]{address:"Sweden/Malmo",name:"Tobias",age:25}     |
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-----------------------------------------------------------+
2 rows
```

Composite range

Several inequalities can be used to construct a range.

Query

```
MATCH (a)
WHERE a.name > 'Andres' AND a.name < 'Tobias'
RETURN a
```

Nodes having a name property lexicographically between 'Andres' and 'Tobias' are returned.

Result

```
+-----------------------------------------------------------+
| a                                                         |
+-----------------------------------------------------------+
| Node[2]{email:"peter_n@example.com",name:"Peter",age:34} |
+-----------------------------------------------------------+
1 row
```

8.4. Start

Find starting points through legacy indexes.

The START clause should only be used when accessing legacy indexes (see [indexing]). In all other cases, use MATCH instead (see Match).

In Cypher, every query describes a pattern, and in that pattern one can have multiple starting points. A starting point is a relationship or a node where a pattern is anchored. Using START you can only introduce starting points by legacy index seeks. Note that trying to use a legacy index that doesn't exist will generate an error.

This is the graph the examples are using:

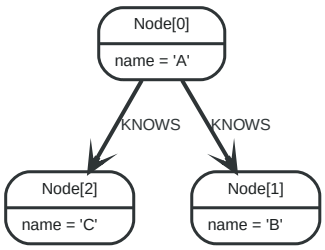


Figure 13. Graph

8.4.1. Get node or relationship from index

Node by index seek

When the starting point can be found by using index seeks, it can be done like this: `node:index-name(key = "value")`. In this example, there exists a node index named `nodes`.

Query

```
START n=node:nodes(name = "A")
RETURN n
```

The query returns the node indexed with the name "A".

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[0]{name:"A"} |
+-------------------+
1 row
```

Relationship by index seek

When the starting point can be found by using index seeks, it can be done like this: `relationship:index-name(key = "value")`.

Query

```
START r=relationship:rels(name = "Andrés")
RETURN r
```

The relationship indexed with the name property set to "Andrés" is returned by the query.

Result

```
+--------------------------+
| r                        |
+--------------------------+
| :KNOWS[0]{name:"Andrés"} |
+--------------------------+
1 row
```

Node by index query

When the starting point can be found by more complex Lucene queries, this is the syntax to use: `node:index-name("query")`.This allows you to write more advanced index queries.

Query

```
START n=node:nodes("name:A")
RETURN n
```

The node indexed with name "A" is returned by the query.

Result

```
+-------------------+
| n                 |
+-------------------+
| Node[0]{name:"A"} |
+-------------------+
1 row
```

8.5. Aggregation

8.5.1. Introduction

To calculate aggregated data, Cypher offers aggregation, much like SQL's GROUP BY.

Aggregate functions take multiple input values and calculate an aggregated value from them. Examples are avg that calculates the average of multiple numeric values, or min that finds the smallest numeric value in a set of values.

Aggregation can be done over all the matching subgraphs, or it can be further divided by introducing key values. These are non-aggregate expressions, that are used to group the values going into the aggregate functions.

So, if the return statement looks something like this:

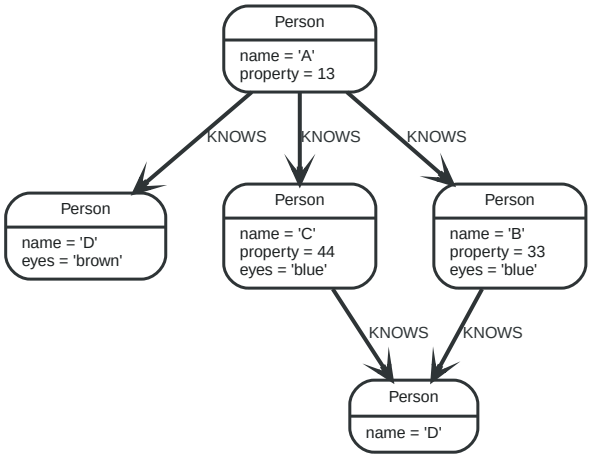
```
RETURN n, count(*)
```

We have two return expressions: `n`, and `count()`. The first, `n`, is no aggregate function, and so it will be the grouping key. The latter, `count()` is an aggregate expression. So the matching subgraphs will be divided into different buckets, depending on the grouping key. The aggregate function will then run on these buckets, calculating the aggregate values.

If you want to use aggregations to sort your result set, the aggregation must be included in the RETURN to be used in your ORDER BY.

The last piece of the puzzle is the DISTINCT keyword. It is used to make all values unique before running them through an aggregate function.

An example might be helpful. In this case, we are running the query against the following data:



Query

```
MATCH (me:Person)-->(friend:Person)-->(friend_of_friend:Person)
WHERE me.name = 'A'
RETURN count(DISTINCT friend_of_friend), count(friend_of_friend)
```

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 see a `friend_of_friend` once — DISTINCT removes the duplicates. The latter aggregate function, count(friend_of_friend), might very well see the same `friend_of_friend` multiple times. In this case, both B and C know D and thus D will get counted twice, when not using DISTINCT.

Result

```
+-----------------------------------------------------------+
| count(distinct friend_of_friend) | count(friend_of_friend) |
+-----------------------------------------------------------+
| 1                                | 2                       |
+-----------------------------------------------------------+
1 row
```

The following examples are assuming the example graph structure below.

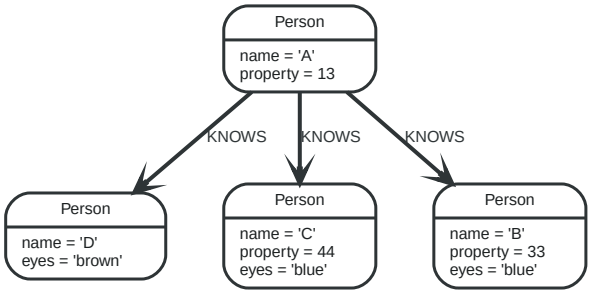


Figure 14. Graph

8.5.2. COUNT

`COUNT` *is used to count the number of rows.*

`COUNT` can be used in two forms — `COUNT(*)` which just counts the number of matching rows, and `COUNT(<expression>)`, which counts the number of non-`NULL` values in `<expression>`.

Count nodes

To count the number of nodes, for example the number of nodes connected to one node, you can use `count(*)`.

Query

```
MATCH (n { name: 'A' })-->(x)
RETURN n, count(*)
```

This returns the start node and the count of related nodes.

Result

```
+-----------------------------------------+
| n                             | count(*) |
+-----------------------------------------+
| Node[0]{name:"A",property:13} | 3        |
+-----------------------------------------+
1 row
```

Group Count Relationship Types

To count the groups of relationship types, return the types and count them with `count(*)`.

Query

```
MATCH (n { name: 'A' })-[r]->()
RETURN type(r), count(*)
```

The relationship types and their group count is returned by the query.

Result

```
+--------------------+
| type(r) | count(*) |
+--------------------+
| "KNOWS" | 3        |
+--------------------+
1 row
```

Count entities

Instead of counting the number of results with `count(*)`, it might be more expressive to include the name of the variable you care about.

Query

```
MATCH (n { name: 'A' })-->(x)
RETURN count(x)
```

The example query returns the number of connected nodes from the start node.

Result

```
+----------+
| count(x) |
+----------+
| 3        |
+----------+
1 row
```

Count non-null values

You can count the non-`NULL` values by using count(<expression>).

Query

```
MATCH (n:Person)
RETURN count(n.property)
```

The count of related nodes with the `property` property set is returned by the query.

Result

```
+-------------------+
| count(n.property) |
+-------------------+
| 3                 |
+-------------------+
1 row
```

8.5.3. Statistics

sum

The sum aggregation function simply sums all the numeric values it encounters. NULLs are silently dropped.

Query

```
MATCH (n:Person)
RETURN sum(n.property)
```

This returns the sum of all the values in the property `property`.

Result

```
+-----------------+
| sum(n.property) |
+-----------------+
| 90              |
+-----------------+
1 row
```

avg

avg calculates the average of a numeric column.

Query

```
MATCH (n:Person)
RETURN avg(n.property)
```

The average of all the values in the property `property` is returned by the example query.

Result

```
+-----------------+
| avg(n.property) |
+-----------------+
| 30.0            |
+-----------------+
1 row
```

percentileDisc

percentileDisc calculates the percentile of a given value over a group, with a percentile from 0.0 to 1.0. It uses a rounding method, returning the nearest value to the percentile. For interpolated values, see percentileCont.

Query

```
MATCH (n:Person)
RETURN percentileDisc(n.property, 0.5)
```

The 50th percentile of the values in the property `property` is returned by the example query. In this case, 0.5 is the median, or 50th percentile.

Result

```
+---------------------------------+
| percentileDisc(n.property, 0.5) |
+---------------------------------+
| 33                              |
+---------------------------------+
1 row
```

percentileCont

percentileCont calculates the percentile of a 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.

Query

```
MATCH (n:Person)
RETURN percentileCont(n.property, 0.4)
```

The 40th percentile of the values in the property `property` is returned by the example query, calculated with a weighted average.

Result

```
+---------------------------------+
| percentileCont(n.property, 0.4) |
+---------------------------------+
| 29.0                            |
+---------------------------------+
1 row
```

stdev

stdev calculates the standard deviation for a 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,

stdevp should be used.

Query

```
MATCH (n)
WHERE n.name IN ['A', 'B', 'C']
RETURN stdev(n.property)
```

The standard deviation of the values in the property `property` is returned by the example query.

Result

```
+--------------------+
| stdev(n.property)  |
+--------------------+
| 15.716233645501712 |
+--------------------+
1 row
```

stdevp

stdevp calculates the standard deviation for a 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.

Query

```
MATCH (n)
WHERE n.name IN ['A', 'B', 'C']
RETURN stdevp(n.property)
```

The population standard deviation of the values in the property `property` is returned by the example query.

Result

```
+--------------------+
| stdevp(n.property) |
+--------------------+
| 12.832251036613439 |
+--------------------+
1 row
```

max

max find the largest value in a numeric column.

Query

```
MATCH (n:Person)
RETURN max(n.property)
```

The largest of all the values in the property `property` is returned.

Result

```
+-----------------+
| max(n.property) |
+-----------------+
| 44              |
+-----------------+
1 row
```

min

min takes a numeric property as input, and returns the smallest value in that column.

Query

```
MATCH (n:Person)
RETURN min(n.property)
```

This returns the smallest of all the values in the property `property`.

Result

```
+-----------------+
| min(n.property) |
+-----------------+
| 13              |
+-----------------+
1 row
```

8.5.4. collect

collect collects all the values into a list. It will ignore NULLs.

Query

```
MATCH (n:Person)
RETURN collect(n.property)
```

Returns a single row, with all the values collected.

Result

```
+---------------------+
| collect(n.property) |
+---------------------+
| [13,33,44]          |
+---------------------+
1 row
```

8.5.5. DISTINCT

All aggregation functions also take the DISTINCT modifier, which removes duplicates from the values. So, to count the number of unique eye colors from nodes related to `a`, this query can be used:

Query

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

Returns the number of eye colors.

Result

```
+------------------------+
| count(distinct b.eyes) |
+------------------------+
| 2                      |
+------------------------+
1 row
```

8.6. Load CSV

`LOAD CSV` *is used to import data from CSV files.*

- 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`.
- `LOAD CSV` supports resources compressed with *gzip*, *Deflate*, as well as *ZIP* archives.
- 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` 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*.

Configuration settings for file URLs

[config_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*.

[config_dbms.directories.import]

Sets the root directory for `file:///` URLs used with the Cypher `LOAD CSV` clause. This must be set to a single directory on the filesystem of the database server, and will make all requests to load from `file:///` URLs relative to the specified directory (similar to how a unix chroot operates). By default, this setting is not configured.

- When not set, file URLs will be resolved as relative to the root of the database server filesystem. If this is the case, a file URL will typically look like `file:///home/username/myfile.csv` or `file:///C:/Users/username/myfile.csv`. Using these URLs in `LOAD CSV` will read content from files on the database server filesystem, specifically `/home/username/myfile.csv` and `C:\Users\username\myfile.csv` respectively. *For security reasons you may not want users to be able to load files located anywhere on the database server filesystem and should set* `dbms.directories.import` *to a safe directory to load files from.*
- When set, file URLs will be resolved as relative to the directory it's set to. In this case a file URL will typically look like `file:///myfile.csv` or `file:///myproject/myfile.csv`.
  - If set to `import` using the above URLs in `LOAD CSV` would read content from `import/myfile.csv` and `import/myproject/myfile.csv` respectively, where both are relative to the neo4j root directory.
  - If set to `/home/neo4j` using the above URLs in `LOAD CSV` would read content from `/home/neo4j/myfile.csv` and `/home/neo4j/myproject/myfile.csv` respectively.

See the examples below for further details.

There is also a worked example, see Importing CSV files with Cypher.

8.6.1. 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 `"`;
- the escape character is `\`.

8.6.2. 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 'http://neo4j.com/docs/3.0.1/csv/artists.csv' AS line
CREATE (:Artist { name: line[1], year: toInt(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
```

8.6.3. 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 'http://neo4j.com/docs/3.0.1/csv/artists-with-headers.csv' AS line
CREATE (:Artist { name: line.Name, year: toInt(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
```

8.6.4. 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.

artists-fieldterminator.csv

```
"1";"ABBA";"1992"
"2";"Roxette";"1986"
"3";"Europe";"1979"
"4";"The Cardigans";"1992"
```

Query

```
LOAD CSV FROM 'http://neo4j.com/docs/3.0.1/csv/artists-fieldterminator.csv' AS line FIELDTERMINATOR
  ';'
CREATE (:Artist { name: line[1], year: toInt(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
```

8.6.5. 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 Using Periodic Commit.

Query

```
USING PERIODIC COMMIT
LOAD CSV FROM 'http://neo4j.com/docs/3.0.1/csv/artists.csv' AS line
CREATE (:Artist { name: line[1], year: toInt(line[2])})
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

8.6.6. 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 'http://neo4j.com/docs/3.0.1/csv/artists.csv' AS line
CREATE (:Artist { name: line[1], year: toInt(line[2])})
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Nodes created: 4
Properties set: 8
Labels added: 4
```

8.6.7. 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 'http://neo4j.com/docs/3.0.1/csv/artists-with-escaped-char.csv' AS line
CREATE (a:Artist { name: line[1], year: toInt(line[2])})
RETURN a.name AS name, a.year AS year, length(a.name) AS length
```

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 | length |
+--------------------------------+
| "The "Symbol"" | 1992 | 12     |
+--------------------------------+
1 row
Nodes created: 1
Properties set: 2
Labels added: 1
```

Chapter 9. Writing Clauses

Write data to the database.

9.1. Create

The CREATE clause is used to create graph elements — nodes and relationships.

In the CREATE clause, patterns are used a lot. Read Patterns for an introduction.

9.1.1. Create nodes

Create single node

Creating a single node is done by issuing the following query.

Query

```
CREATE (n)
```

Nothing is returned from this query, except the count of affected nodes.

Result

```
+-------------------+
| No data returned. |
+-------------------+
Nodes created: 1
```

Create multiple nodes

Creating multiple nodes is done by separating them with a comma.

Query

```
CREATE (n),(m)
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
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)
```

Nothing is returned from this query.

Result

```
+-------------------+
| No data returned. |
+-------------------+
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)
```

Nothing is returned from this query.

Result

```
+-------------------+
| No data returned. |
+-------------------+
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 : 'Andres', title : 'Developer' })
```

Nothing is returned from this query.

Result

```
+-------------------+
| No data returned. |
+-------------------+
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 : 'Andres' })
RETURN a
```

The newly created node is returned.

Result

```
+------------------------+
| a                      |
+------------------------+
| Node[0]{name:"Andres"} |
+------------------------+
1 row
Nodes created: 1
Properties set: 1
```

9.1.2. 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 = 'Node A' AND b.name = 'Node B'
CREATE (a)-[r:RELTYPE]->(b)
RETURN r
```

The created relationship is returned by the query.

Result

```
+---------------+
| r             |
+---------------+
| :RELTYPE[0]{} |
+---------------+
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 = 'Node A' AND b.name = 'Node B'
CREATE (a)-[r:RELTYPE { name : a.name + '<->' + b.name }]->(b)
RETURN r
```

The newly created relationship is returned by the example query.

Result

```
+-------------------------------------+
| r                                   |
+-------------------------------------+
| :RELTYPE[0]{name:"Node A<->Node B"} |
+-------------------------------------+
1 row
Relationships created: 1
Properties set: 1
```

9.1.3. 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 =(andres { name:'Andres' })-[: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.

Result

```
+-------------------------------------------------------------------------------------------+
| p                                                                                         |
+-------------------------------------------------------------------------------------------+
| [Node[0]{name:"Andres"},:WORKS_AT[0]{},Node[1]{},:WORKS_AT[1]{},Node[2]{name:"Michael"}] |
+-------------------------------------------------------------------------------------------+
1 row
Nodes created: 3
Relationships created: 2
Properties set: 2
```

9.1.4. 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" : "Andres",
    "position" : "Developer"
  }
}
```

Query

```
CREATE (n:Person { props })
RETURN n
```

Result

```
+-------------------------------------------+
| n                                         |
+-------------------------------------------+
| Node[0]{name:"Andres",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" : "Andres",
    "position" : "Developer"
  }, {
    "name" : "Michael",
    "position" : "Developer"
  } ]
}
```

Query

```
UNWIND { props } AS map
CREATE (n)
SET n = map
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Nodes created: 2
Properties set: 4
```

9.2. Merge

> *The MERGE clause ensures that a pattern exists in the graph. Either the pattern already exists, or it needs to be created.*

9.2.1. 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 MATCHed in the database or if it was CREATEd.

The rule planner (see How are queries executed?) expands a MERGE pattern from the end point that has the variable with the lowest lexicographical order. This means that it might choose a suboptimal expansion path, expanding from a node with a higher degree. The pattern `MERGE (a:A)-[:R] (b:B)` will always expand from a to b, so if it is known that b nodes are a better choice for start point, renaming variables could improve performance.

The following graph is used for the examples below:

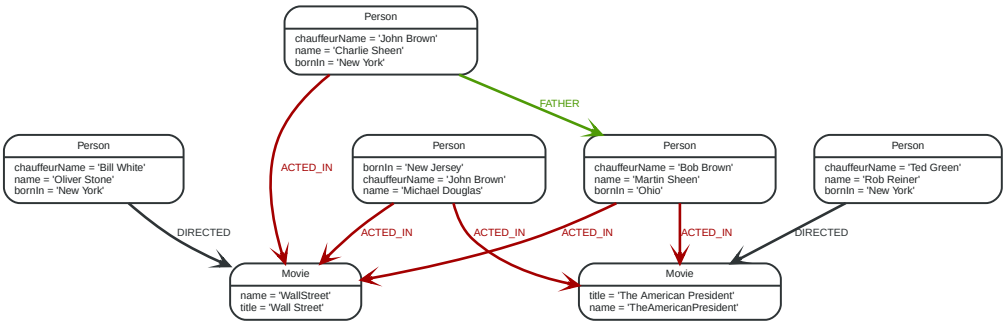


Figure 15. Graph

9.2.2. Merge nodes

Merge single node with a label

Merging a single node with a 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.

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.

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.

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.

Result

```
+-------------------------------------------------------------------+
| person.name       | person.bornIn | city                          |
+-------------------------------------------------------------------+
| "Rob Reiner"      | "New York"    | Node[7]{name:"New York"}      |
| "Oliver Stone"    | "New York"    | Node[7]{name:"New York"}      |
| "Charlie Sheen"   | "New York"    | Node[7]{name:"New York"}      |
| "Michael Douglas" | "New Jersey"  | Node[8]{name:"New Jersey"} |
| "Martin Sheen"    | "Ohio"        | Node[9]{name:"Ohio"}          |
+-------------------------------------------------------------------+
5 rows
Nodes created: 3
Properties set: 3
Labels added: 3
```

9.2.3. 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.

Result

```
+--------------------------------+
| keanu.name     | keanu.created |
+--------------------------------+
| "Keanu Reeves" | 1462500491262 |
+--------------------------------+
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.

Result

```
+----------------------------------+
| person.name       | person.found |
+----------------------------------+
| "Rob Reiner"      | true         |
| "Oliver Stone"    | true         |
| "Charlie Sheen"   | true         |
| "Michael Douglas" | true         |
| "Martin Sheen"    | true         |
+----------------------------------+
5 rows
Properties set: 5
```

Merge with ON CREATE and ON MATCH

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()
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.

Result

```
+-----------------------------------------------+
| keanu.name     | keanu.created | keanu.lastSeen |
+-----------------------------------------------+
| "Keanu Reeves" | 1462500494945 | <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
```

Result

```
+-------------------------------------------------------+
| person.name       | person.found | person.lastAccessed |
+-------------------------------------------------------+
| "Rob Reiner"      | true         | 1462500493713       |
| "Oliver Stone"    | true         | 1462500493713       |
| "Charlie Sheen"   | true         | 1462500493713       |
| "Michael Douglas" | true         | 1462500493713       |
| "Martin Sheen"    | true         | 1462500493713       |
+-------------------------------------------------------+
5 rows
Properties set: 10
```

9.2.4. 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.

Result

```
+-----------------------------------------------+
| charlie.name    | type(r)    | wallStreet.title |
+-----------------------------------------------+
| "Charlie Sheen" | "ACTED_IN" | "Wall Street"    |
+-----------------------------------------------+
1 row
```

Merge on multiple relationships

When MERGE is used on a whole pattern, either everything matches, or everything is created.

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.

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.

Result

```
+-------------+
| r           |
+-------------+
| :KNOWS[8]{} |
+-------------+
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').

Result

```
+-------------------------------------------------------------------+
| person.name       | person.bornIn | city                          |
+-------------------------------------------------------------------+
| "Rob Reiner"      | "New York"    | Node[7]{name:"New York"}      |
| "Oliver Stone"    | "New York"    | Node[7]{name:"New York"}      |
| "Charlie Sheen"   | "New York"    | Node[7]{name:"New York"}      |
| "Michael Douglas" | "New Jersey"  | Node[8]{name:"New Jersey"}    |
| "Martin Sheen"    | "Ohio"        | Node[9]{name:"Ohio"}          |
+-------------------------------------------------------------------+
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.

Result

```
+-----------------------------------------------------------------------+
| person.name       | person.chauffeurName | chauffeur                  |
+-----------------------------------------------------------------------+
| "Rob Reiner"      | "Ted Green"          | Node[7]{name:"Ted Green"}  |
| "Oliver Stone"    | "Bill White"         | Node[8]{name:"Bill White"} |
| "Charlie Sheen"   | "John Brown"         | Node[9]{name:"John Brown"} |
| "Michael Douglas" | "John Brown"         | Node[10]{name:"John Brown"}|
| "Martin Sheen"    | "Bob Brown"          | Node[11]{name:"Bob Brown"} |
+-----------------------------------------------------------------------+
5 rows
Nodes created: 5
Relationships created: 5
Properties set: 5
Labels added: 5
```

9.2.5. Using unique constraints with MERGE

Cypher prevents getting conflicting results from MERGE when using patterns that involve uniqueness constrains. In this case, there must be at most one node that matches that pattern.

For example, given two uniqueness constraints on `:Person(id)` and :Person(ssn): then 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 uniqueness 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.

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.

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 and can not create a new node due to conflicts
with both existing and missing unique nodes. The conflicting constraints are on:
:Person.name and :Person.role
```

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 and can not create a new node due to conflicts
with both existing and missing unique nodes. The conflicting constraints are on:
:Person.name and :Person.role
```

9.2.6. Using map parameters with MERGE

MERGE does not support map parameters like for example CREATE does. To use map parameters with MERGE, it is necessary to explicitly use the expected properties, like 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
```

Result

```
+------------------------------+
| person.name    | person.role |
+------------------------------+
| "Keanu Reeves" | "Neo"       |
+------------------------------+
1 row
Nodes created: 1
Properties set: 2
Labels added: 1
```

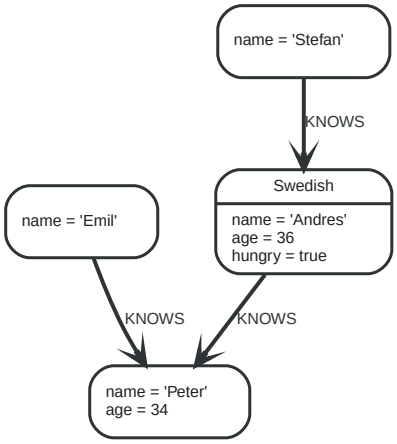
9.3. Set

The SET clause is used to update labels on nodes and properties on nodes and relationships.

SET can also be used with maps from parameters to set properties.

Setting labels on a node is an idempotent operations — if you try to set a label on a node that already has that label on it, nothing happens. The query statistics will tell you if something needed to be done or not.

The examples use this graph as a starting point:



9.3.1. Set a property

To set a property on a node or relationship, use SET.

Query

```
MATCH (n { name: 'Andres' })
SET n.surname = 'Taylor'
RETURN n
```

The newly changed node is returned by the query.

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[0]{surname:"Taylor",name:"Andres",age:36,hungry:true} |
+-------------------------------------------------------------+
1 row
Properties set: 1
```

9.3.2. Remove a property

Normally you remove a property by using <<query-remove,REMOVE>>, but it's sometimes handy to do it using the SET command. One example is if the property comes from a parameter.

Query

```
MATCH (n { name: 'Andres' })
SET n.name = NULL RETURN n
```

The node is returned by the query, and the name property is now missing.

Result

```
+-----------------------------+
| n                           |
+-----------------------------+
| Node[0]{hungry:true,age:36} |
+-----------------------------+
1 row
Properties set: 1
```

9.3.3. Copying properties between nodes and relationships

You can also use SET to copy all properties from one graph element to another. Remember that doing this will remove all other properties on the receiving graph element.

Query

```
MATCH (at { name: 'Andres' }),(pn { name: 'Peter' })
SET at = pn
RETURN at, pn
```

The Andres node has had all it's properties replaced by the properties in the Peter node.

Result

```
+-------------------------------------------------------------+
| at                           | pn                           |
+-------------------------------------------------------------+
| Node[0]{name:"Peter",age:34} | Node[2]{name:"Peter",age:34} |
+-------------------------------------------------------------+
1 row
Properties set: 3
```

9.3.4. Adding properties from maps

When setting properties from a map (literal, paremeter, or graph element), you can use the `+=` form of `SET` to only add properties, and not remove any of the existing properties on the graph element.

Query

```
MATCH (peter { name: 'Peter' })
SET peter += { hungry: TRUE , position: 'Entrepreneur' }
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Properties set: 2
```

9.3.5. Set a property using a parameter

Use a parameter to give the value of a property.

Parameters

```
{
  "surname" : "Taylor"
}
```

Query

```
MATCH (n { name: 'Andres' })
SET n.surname = { surname }
RETURN n
```

The Andres node has got an surname added.

Result

```
+-------------------------------------------------------------+
| n                                                           |
+-------------------------------------------------------------+
| Node[0]{surname:"Taylor",name:"Andres",age:36,hungry:true} |
+-------------------------------------------------------------+
1 row
Properties set: 1
```

9.3.6. 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" : "Andres",
    "position" : "Developer"
  }
}
```

Query

```
MATCH (n { name: 'Andres' })
SET n = { props }
RETURN n
```

The Andres node has had all it's properties replaced by the properties in the props parameter.

Result

```
+--------------------------------------------+
| n                                          |
+--------------------------------------------+
| Node[0]{name:"Andres",position:"Developer"} |
+--------------------------------------------+
1 row
Properties set: 4
```

9.3.7. Set multiple properties using one SET clause

If you want to set multiple properties in one go, simply separate them with a comma.

Query

```
MATCH (n { name: 'Andres' })
SET n.position = 'Developer', n.surname = 'Taylor'
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Properties set: 2
```

9.3.8. Set a label on a node

To set a label on a node, use SET.

Query

```
MATCH (n { name: 'Stefan' })
SET n :German
RETURN n
```

The newly labeled node is returned by the query.

Result

```
+------------------------+
| n                      |
+------------------------+
| Node[3]{name:"Stefan"} |
+------------------------+
1 row
Labels added: 1
```

9.3.9. Set multiple labels on a node

To set multiple labels on a node, use SET and separate the different labels using :.

Query

```
MATCH (n { name: 'Emil' })
SET n :Swedish:Bossman
RETURN n
```

The newly labeled node is returned by the query.

Result

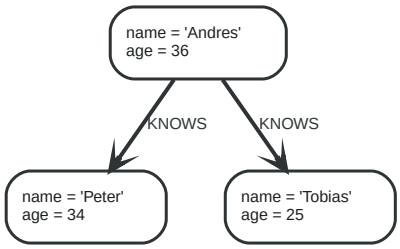
```
+----------------------+
| n                    |
+----------------------+
| Node[1]{name:"Emil"} |
+----------------------+
1 row
Labels added: 2
```

9.4. Delete

The `DELETE` clause is used to delete graph elements — nodes, relationships or paths.

For removing properties and labels, see Remove. Remember that you can not 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:



9.4.1. Delete single node

To delete a node, use the DELETE clause.

Query

```
MATCH (n:Useless)
DELETE n
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Nodes deleted: 1
```

9.4.2. Delete all nodes and relationships

This query isn't for deleting large amounts of data, but is nice when playing around with small example data sets.

Query

```
MATCH (n)
DETACH DELETE n
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes deleted: 3
Relationships deleted: 2
```

9.4.3. 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:'Andres' })
DETACH DELETE n
```

Result

```
+--------------------+
| No data returned. |
+--------------------+
Nodes deleted: 1
Relationships deleted: 2
```

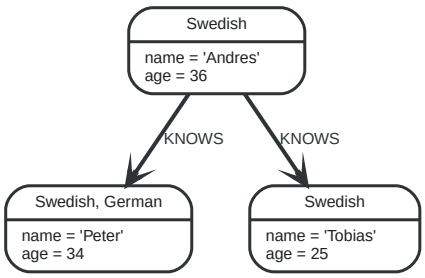
9.5. Remove

The REMOVE clause is used to remove properties and labels from graph elements.

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 start out with the following database:



9.5.1. Remove a property

Neo4j doesn't allow storing null in properties. Instead, if no value exists, the property is just not there. So, to remove a property value on a node or a relationship, is also done with REMOVE.

Query

```
MATCH (andres { name: 'Andres' })
REMOVE andres.age
RETURN andres
```

The node is returned, and no property age exists on it.

Result

```
+------------------------+
| andres                 |
+------------------------+
| Node[0]{name:"Andres"} |
+------------------------+
1 row
Properties set: 1
```

9.5.2. Remove a label from a node

To remove labels, you use REMOVE.

Query

```
MATCH (n { name: 'Peter' })
REMOVE n:German
RETURN n
```

Result

```
+------------------------------+
| n                            |
+------------------------------+
| Node[2]{name:"Peter",age:34} |
+------------------------------+
1 row
Labels removed: 1
```

9.5.3. Removing multiple labels

To remove multiple labels, you use REMOVE.

Query

```
MATCH (n { name: 'Peter' })
REMOVE n:German:Swedish
RETURN n
```

Result

```
+------------------------------+
| n                            |
+------------------------------+
| Node[2]{name:"Peter",age:34} |
+------------------------------+
1 row
Labels removed: 2
```

9.6. Foreach

> *The FOREACH clause is used to update data within a list, whether components of a path, or result of aggregation.*

Lists and paths are key concepts in Cypher. To use them for updating data, you can use the FOREACH construct. It allows you to do updating commands on elements in a path, or a list created by

aggregation.

The variable context inside of the foreach parenthesis is separate from the one outside it. This means that if you `CREATE` a node variable inside of a `FOREACH`, you will *not* be able to use it outside of the foreach statement, unless you match to find it.

Inside of the `FOREACH` parentheses, you can do any of the updating commands — `CREATE`, `CREATE UNIQUE`, `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.

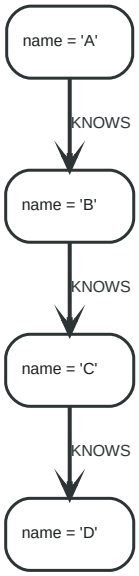


Figure 16. Data for the examples

9.6.1. 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 )
```

Nothing is returned from this query, but four properties are set.

Result

```
+-------------------+
| No data returned. |
+-------------------+
Properties set: 4
```

9.7. Create Unique

> *The `CREATE UNIQUE` clause is a mix of `MATCH` and `CREATE` — it will match what it can, and create what is missing.*

9.7.1. Introduction

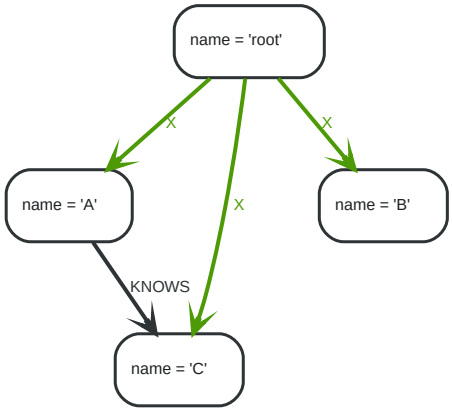
<<query-merge,MERGE>> might be what you want to use instead of CREATE UNIQUE. Note however, that MERGE doesn't give as strong guarantees for relationships being unique.

CREATE UNIQUE is in the middle of MATCH and CREATE — it will match what it can, and create what is missing. CREATE UNIQUE will always make the least change possible to the graph — if it can use parts of the existing graph, it will.

Another difference to MATCH is that CREATE UNIQUE assumes the pattern to be unique. If multiple matching subgraphs are found an error will be generated.

In the CREATE UNIQUE clause, patterns are used a lot. Read Patterns for an introduction.

The examples start out with the following data set:



9.7.2. Create unique nodes

Create node if missing

If the pattern described needs a node, and it can't be matched, a new node will be created.

Query

```
MATCH (root { name: 'root' })
CREATE UNIQUE (root)-[:LOVES]-(someone)
RETURN someone
```

The root node doesn't have any `LOVES` relationships, and so a node is created, and also a relationship to that node.

Result

```
+-----------+
| someone   |
+-----------+
| Node[4]{} |
+-----------+
1 row
Nodes created: 1
Relationships created: 1
```

Create nodes with values

The pattern described can also contain values on the node. These are given using the following syntax: `prop : <expression>`.

Query

```
MATCH (root { name: 'root' })
CREATE UNIQUE (root)-[:X]-(leaf { name:'D' })
RETURN leaf
```

No node connected with the root node has the name D, and so a new node is created to match the pattern.

Result

```
+------------------+
| leaf             |
+------------------+
| Node[4]{name:"D"} |
+------------------+
1 row
Nodes created: 1
Relationships created: 1
Properties set: 1
```

Create labeled node if missing

If the pattern described needs a labeled node and there is none with the given labels, Cypher will create a new one.

Query

```
MATCH (a { name: 'A' })
CREATE UNIQUE (a)-[:KNOWS]-(c:blue)
RETURN c
```

The A node is connected in a `KNOWS` relationship to the c node, but since C doesn't have the `:blue` label, a new node labeled as `:blue` is created along with a `KNOWS` relationship from A to it.

Result

```
+-----------+
| c         |
+-----------+
| Node[4]{} |
+-----------+
1 row
Nodes created: 1
Relationships created: 1
Labels added: 1
```

9.7.3. Create unique relationships

Create relationship if it is missing

CREATE UNIQUE is used to describe the pattern that should be found or created.

Query

```
MATCH (lft { name: 'A' }),(rgt)
WHERE rgt.name IN ['B', 'C']
CREATE UNIQUE (lft)-[r:KNOWS]->(rgt)
RETURN r
```

The left node is matched agains the two right nodes. One relationship already exists and can be matched, and the other relationship is created before it is returned.

Result

```
+-------------+
| r           |
+-------------+
| :KNOWS[4]{} |
| :KNOWS[3]{} |
+-------------+
2 rows
Relationships created: 1
```

Create relationship with values

Relationships to be created can also be matched on values.

Query

```
MATCH (root { name: 'root' })
CREATE UNIQUE (root)-[r:X { since:'forever' }]-()
RETURN r
```

In this example, we want the relationship to have a value, and since no such relationship can be found, a new node and relationship are created. Note that since we are not interested in the created node, we don't name it.

Result

```
+------------------------+
| r                      |
+------------------------+
| :X[4]{since:"forever"} |
+------------------------+
1 row
Nodes created: 1
Relationships created: 1
Properties set: 1
```

9.7.4. Describe complex pattern

The pattern described by CREATE UNIQUE can be separated by commas, just like in MATCH and CREATE.

Query

```
MATCH (root { name: 'root' })
CREATE UNIQUE (root)-[:FOO]->(x),(root)-[:BAR]->(x)
RETURN x
```

This example pattern uses two paths, separated by a comma.

Result

```
+-----------+
| x         |
+-----------+
| Node[4]{} |
+-----------+
1 row
Nodes created: 1
Relationships created: 2
```

9.8. Importing CSV files with Cypher

This tutorial will show you how to import data from CSV files using LOAD CSV.

In this example, we're given three CSV files: a list of persons, a list of movies, and a list of which role was played by some of these persons in each movie.

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 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.

For more details, see Load CSV.

Using the following Cypher queries, we'll create a node for each person, a node for each movie and a relationship between the two with a property denoting the role. We're also keeping track of the country in which each movie was made.

Let's start with importing the persons:

```
LOAD CSV WITH HEADERS FROM "http://neo4j.com/docs/3.0.1/csv/import/persons.csv" AS csvLine
CREATE (p:Person { id: toInt(csvLine.id), name: csvLine.name })
```

The CSV file we're using looks like this:

persons.csv

```
id,name
1,Charlie Sheen
2,Oliver Stone
3,Michael Douglas
4,Martin Sheen
5,Morgan Freeman
```

Now, let's import the movies. This time, we're also creating a relationship to the country in which the movie was made. If you are storing your data in a SQL database, this is the one-to-many relationship type.

We're using MERGE to create nodes that represent countries. Using MERGE avoids creating duplicate country nodes in the case where multiple movies have been made in the same country.

When using MERGE or MATCH with LOAD CSV we need to make sure we have an index (see Indexes) or a unique constraint (see Constraints) on the property we're merging. This will ensure the query executes in a performant way.

Before running our query to connect movies and countries we'll create an index for the name property on the Country label to ensure the query runs as fast as it can:

```
CREATE INDEX ON :Country(name)
```

```
LOAD CSV WITH HEADERS FROM "http://neo4j.com/docs/3.0.1/csv/import/movies.csv" AS csvLine
MERGE (country:Country { name: csvLine.country })
CREATE (movie:Movie { id: toInt(csvLine.id), title: csvLine.title, year:toInt(csvLine.year)})
CREATE (movie)-[:MADE_IN]->(country)
```

movies.csv

```
id,title,country,year
1,Wall Street,USA,1987
2,The American President,USA,1995
3,The Shawshank Redemption,USA,1994
```

Lastly, we create the relationships between the persons and the movies. Since the relationship is a many to many relationship, one actor can participate in many movies, and one movie has many actors in it. We have this data in a separate file.

We'll index the id property on Person and Movie nodes. The id property is a temporary property used to look up the appropriate nodes for a relationship when importing the third file. By indexing the id property, node lookup (e.g. by MATCH) will be much faster. Since we expect the ids to be unique in each set, we'll create a unique constraint. This protects us from invalid data since constraint creation will fail if there are multiple nodes with the same id property. Creating a unique constraint also creates a unique index (which is faster than a regular index).

```
CREATE CONSTRAINT ON (person:Person) ASSERT person.id IS UNIQUE
```

```
CREATE CONSTRAINT ON (movie:Movie) ASSERT movie.id IS UNIQUE
```

Now importing the relationships is a matter of finding the nodes and then creating relationships between them.

For this query we'll use USING PERIODIC COMMIT (see Using Periodic Commit) which is helpful for queries that operate on large CSV files. This hint tells Neo4j that the query might build up inordinate amounts of transaction state, and so needs to be periodically committed. In this case we also set the limit to `500` rows per commit.

```
USING PERIODIC COMMIT 500
LOAD CSV WITH HEADERS FROM "http://neo4j.com/docs/3.0.1/csv/import/roles.csv" AS csvLine
MATCH (person:Person { id: toInt(csvLine.personId)}),(movie:Movie { id: toInt(csvLine.movieId)})
CREATE (person)-[:PLAYED { role: csvLine.role }]->(movie)
```

roles.csv

```
personId,movieId,role
1,1,Bud Fox
4,1,Carl Fox
3,1,Gordon Gekko
4,2,A.J. MacInerney
3,2,President Andrew Shepherd
5,3,Ellis Boyd 'Red' Redding
```

Finally, as the id property was only necessary to import the relationships, we can drop the constraints and the id property from all movie and person nodes.

```
DROP CONSTRAINT ON (person:Person) ASSERT person.id IS UNIQUE
```

```
DROP CONSTRAINT ON (movie:Movie) ASSERT movie.id IS UNIQUE
```

```
MATCH (n)
WHERE n:Person OR n:Movie
REMOVE n.id
```

9.9. Using Periodic Commit

See Importing CSV files with Cypher on how to import data from CSV files.

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`. You can optionally set the limit for the number of rows per commit like so: `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 10. Functions

This chapter contains information on all functions in Cypher. Note that related information exists in Operators.

Most functions in Cypher will return `NULL` if an input parameter is `NULL`.

10.1. Predicates

Predicates are boolean functions that return true or false for a given set of input. They are most commonly used to filter out subgraphs in the `WHERE` part of a query.

See also Comparison operators.

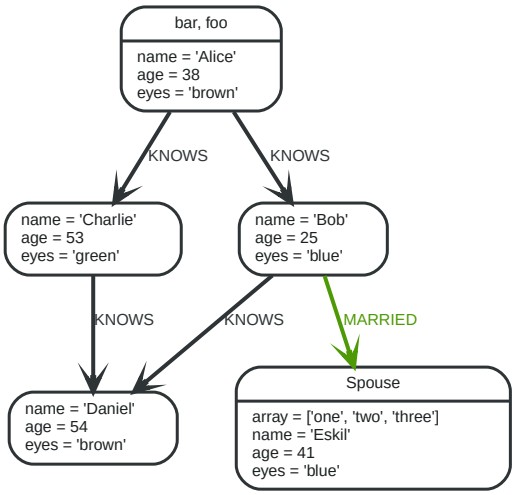


Figure 17. Graph

10.1.1. all()

Tests whether a predicate holds for all elements of this list.

Syntax: `all(variable IN list WHERE predicate)`

Arguments:

- *list:* An expression that returns a list
- *variable:* This is the variable that can be used from 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.

Result

```
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
| p
|
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
|
[Node[0]{name:"Alice",age:38,eyes:"brown"},:KNOWS[1]{},Node[2]{name:"Charlie",age:53,eyes:"green"},:KNOWS[
3]{},Node[3]{name:"Daniel",age:54,eyes:"brown"}] |
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
1 row
```

10.1.2. any()

Tests whether a predicate holds for at least one element in the list.

Syntax: `any(variable IN list WHERE predicate)`

Arguments:

- *list:* An expression that returns a list
- *variable:* This is the variable that can be used from 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
```

All nodes in the returned paths has at least one `one` value set in the array property named `array`.

Result

```
+-----------------------------------------------------------------------+
| a                                                                     |
+-----------------------------------------------------------------------+
| Node[4]{array:["one","two","three"],name:"Eskil",age:41,eyes:"blue"} |
+-----------------------------------------------------------------------+
1 row
```

10.1.3. none()

Returns true if the predicate holds for no element in the list.

Syntax: `none(variable in list WHERE predicate)`

Arguments:

- *list:* An expression that returns a list
- *variable:* This is the variable that can be used from 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 nodes in the returned paths has a `age` property set to `25`.

Result

```
+-------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
| p
|
+-------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
| [Node[0]{name:"Alice",age:38,eyes:"brown"},:KNOWS[1]{},Node[2]{name:"Charlie",age:53,eyes:"green"}]
|
|
[Node[0]{name:"Alice",age:38,eyes:"brown"},:KNOWS[1]{},Node[2]{name:"Charlie",age:53,eyes:"green"},:KNOWS[
3]{},Node[3]{name:"Daniel",age:54,eyes:"brown"}] |
+-------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
2 rows
```

10.1.4. single()

Returns true if the predicate holds for exactly one of the elements in the list.

Syntax: `single(variable in list WHERE predicate)`

Arguments:

- *list:* An expression that returns a list
- *variable:* This is the variable that can be used from 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 will have the `eyes` property set to `"blue"`.

Result

```
+-------------------------------------------------------------------------------------------------+
| p                                                                                               |
+-------------------------------------------------------------------------------------------------+
| [Node[0]{name:"Alice",age:38,eyes:"brown"},:KNOWS[0]{},Node[1]{name:"Bob",age:25,eyes:"blue"}] |
+-------------------------------------------------------------------------------------------------+
1 row
```

10.1.5. exists()

Returns true if a match for the pattern exists in the graph, or the property exists in the node, relationship or map.

Syntax: `exists( pattern-or-property )`

Arguments:

- *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
```

This query returns all the nodes with a name property along with a boolean true/false indicating if they are married.

Result

```
+-------------------------+
| name      | is_married  |
+-------------------------+
| "Alice"   | false       |
| "Bob"     | true        |
| "Charlie" | false       |
| "Daniel"  | false       |
| "Eskil"   | false       |
+-------------------------+
5 rows
```

10.2. 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. Due to backwards compatibility, `length()` currently works on four types: strings, paths, lists and pattern expressions. However, for clarity it is recommended to only use `length()` on strings and paths, and use the new `size()` function on lists and pattern expressions. `length()` on those types may be deprecated in future.

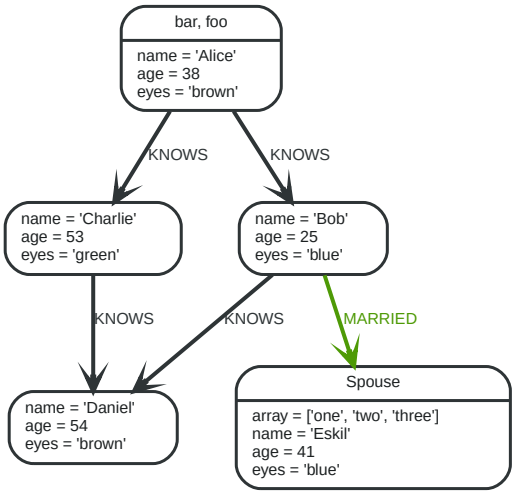


Figure 18. Graph

10.2.1. size()

To return or filter on the size of a list, use the `size()` function.

Syntax: `size( list )`

Arguments:

- *list:* An expression that returns a list

Query

```
RETURN size(['Alice', 'Bob']) AS col
```

The number of items in the list is returned by the query.

Result

```
+-----+
| col |
+-----+
| 2   |
+-----+
1 row
```

10.2.2. Size of pattern expression

This is the same `size()` method described before, but instead of passing in a list directly, you provide a pattern expression that can be used in a match query to provide a new set of results. The size of the result is calculated, not the length of the expression itself.

Syntax: `size( pattern expression )`

Arguments:

- *pattern expression:* A pattern expression that returns a list

Query

```
MATCH (a)
WHERE a.name='Alice'
RETURN size((a)-->()-->()) AS fof
```

The number of sub-graphs matching the pattern expression is returned by the query.

Result

```
+-----+
| fof |
+-----+
| 3   |
+-----+
1 row
```

10.2.3. length()

To return or filter on the length of a path, use the `LENGTH()` function.

Syntax: `length( path )`

Arguments:

- *path:* An expression that returns a path

Query

```
MATCH p=(a)-->(b)-->(c)
WHERE a.name='Alice'
RETURN length(p)
```

The length of the path `p` is returned by the query.

Result

```
+-----------+
| length(p) |
+-----------+
| 2         |
| 2         |
| 2         |
+-----------+
3 rows
```

10.2.4. Length of string

To return or filter on the length of a string, use the `LENGTH()` function.

Syntax: `length( string )`

Arguments:

- *string:* An expression that returns a string

Query

```
MATCH (a)
WHERE length(a.name)> 6
RETURN length(a.name)
```

The length of the name `Charlie` is returned by the query.

Result

```
+----------------+
| length(a.name) |
+----------------+
| 7              |
+----------------+
1 row
```

10.2.5. type()

Returns a string representation of the relationship type.

Syntax: `type( relationship )`

Arguments:

- *relationship:* A relationship.

Query

```
MATCH (n)-[r]->()
WHERE n.name='Alice'
RETURN type(r)
```

The relationship type of `r` is returned by the query.

Result

```
+---------+
| type(r) |
+---------+
| "KNOWS" |
| "KNOWS" |
+---------+
2 rows
```

10.2.6. id()

Returns the id of the relationship or node.

Syntax: `id( property-container )`

Arguments:

- *property-container:* A node or a relationship.

Query

```
MATCH (a)
RETURN id(a)
```

This returns the node id for three nodes.

Result

```
+-------+
| id(a) |
+-------+
| 0     |
| 1     |
| 2     |
| 3     |
| 4     |
+-------+
5 rows
```

10.2.7. coalesce()

Returns the first non-NULL value in the list of expressions passed to it. In case all arguments are NULL, NULL will be returned.

Syntax: `coalesce( expression [, expression]* )`

Arguments:

- *expression:* The expression that might return NULL.

Query

```
MATCH (a)
WHERE a.name='Alice'
RETURN coalesce(a.hairColor, a.eyes)
```

Result

```
+------------------------------+
| coalesce(a.hairColor, a.eyes) |
+------------------------------+
| "brown"                      |
+------------------------------+
1 row
```

10.2.8. head()

`head()` returns the first element in a list.

Syntax: `head( expression )`

Arguments:

- *expression:* This expression should return a list of some kind.

Query

```
MATCH (a)
WHERE a.name='Eskil'
RETURN a.array, head(a.array)
```

The first node in the path is returned.

Result

```
+---------------------------------------+
| a.array               | head(a.array) |
+---------------------------------------+
| ["one","two","three"] | "one"         |
+---------------------------------------+
1 row
```

10.2.9. last()

`last()` returns the last element in a list.

Syntax: `last( expression )`

Arguments:

- *expression:* This expression should return a list of some kind.

Query

```
MATCH (a)
WHERE a.name='Eskil'
RETURN a.array, last(a.array)
```

The last node in the path is returned.

Result

```
+---------------------------------------+
| a.array               | last(a.array) |
+---------------------------------------+
| ["one","two","three"] | "three"       |
+---------------------------------------+
1 row
```

10.2.10. timestamp()

`timestamp()` returns the difference, measured in milliseconds, between the current time and midnight, January 1, 1970 UTC. It will return the same value during the whole one query, even if the query is a long running one.

Syntax: `timestamp()`

Arguments:

Query

```
RETURN timestamp()
```

The time in milliseconds is returned.

Result

```
+---------------+
| timestamp()   |
+---------------+
| 1462500541123 |
+---------------+
1 row
```

10.2.11. startNode()

`startNode()` returns the starting node of a relationship

Syntax: `startNode( relationship )`

Arguments:

- *relationship:* An expression that returns a relationship

Query

```
MATCH (x:foo)-[r]-()
RETURN startNode(r)
```

Result

```
+-----------------------------------------+
| startNode(r)                            |
+-----------------------------------------+
| Node[0]{name:"Alice",age:38,eyes:"brown"} |
| Node[0]{name:"Alice",age:38,eyes:"brown"} |
+-----------------------------------------+
2 rows
```

10.2.12. endNode()

`endNode()` returns the end node of a relationship

Syntax: `endNode( relationship )`

Arguments:

- *relationship:* An expression that returns a relationship

Query

```
MATCH (x:foo)-[r]-()
RETURN endNode(r)
```

Result

```
+-------------------------------------------+
| endNode(r)                                |
+-------------------------------------------+
| Node[2]{name:"Charlie",age:53,eyes:"green"} |
| Node[1]{name:"Bob",age:25,eyes:"blue"}      |
+-------------------------------------------+
2 rows
```

10.2.13. properties()

`properties()` converts the arguments to a map of its properties. If the argument is a node or a relationship, the returned map is a map of its properties .If the argument is already a map, it is returned unchanged.

Syntax: `properties( expression )`

Arguments:

- *expression:* An expression that returns a node, a relationship, or a map

Query

```
CREATE (p:Person { name: 'Stefan', city: 'Berlin' })
RETURN properties(p)
```

Result

```
+--------------------------------------+
| properties(p)                        |
+--------------------------------------+
| {name -> "Stefan", city -> "Berlin"} |
+--------------------------------------+
1 row
Nodes created: 1
Properties set: 2
Labels added: 1
```

10.2.14. toInt()

`toInt()` converts the argument to an integer. A string is parsed as if it was an integer number. If the parsing fails, NULL will be returned. A floating point number will be cast into an integer.

Syntax: `toInt( expression )`

Arguments:

- *expression:* An expression that returns anything

Query

```
RETURN toInt("42"), toInt("not a number")
```

Result

```
+-------------------------------------+
| toInt("42") | toInt("not a number") |
+-------------------------------------+
| 42          | <null>                |
+-------------------------------------+
1 row
```

10.2.15. toFloat()

`toFloat()` converts the argument to a float. A string is parsed as if it was an floating point number. If the parsing fails, NULL will be returned. An integer will be cast to a floating point number.

Syntax: `toFloat( expression )`

Arguments:

- *expression:* An expression that returns anything

Query

```
RETURN toFloat("11.5"), toFloat("not a number")
```

Result

```
+-----------------------------------------+
| toFloat("11.5") | toFloat("not a number") |
+-----------------------------------------+
| 11.5            | <null>                  |
+-----------------------------------------+
1 row
```

10.3. List functions

List functions return lists of things — nodes in a path, and so on.

See also List operators.

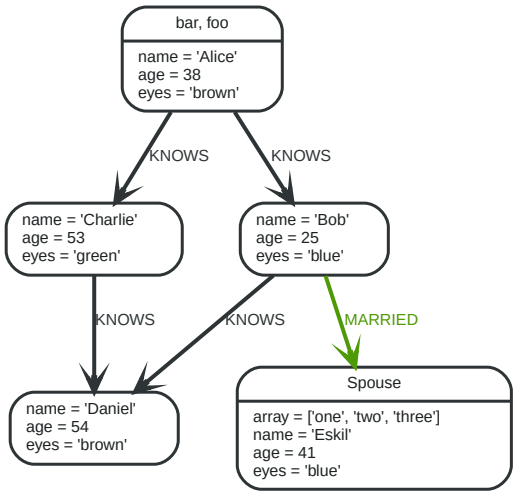


Figure 19. Graph

10.3.1. nodes()

Returns all nodes in a path.

Syntax: `nodes( path )`

Arguments:

- *path:* A path.

Query

```
MATCH p=(a)-->(b)-->(c)
WHERE a.name='Alice' AND c.name='Eskil'
RETURN nodes(p)
```

All the nodes in the path `p` are returned by the example query.

Result

```
+-------------------------------------------------------------------------------------------------------------------
-----------------------------------------------+
| nodes(p)
|
+-------------------------------------------------------------------------------------------------------------------
-----------------------------------------------+
|
[Node[0]{name:"Alice",age:38,eyes:"brown"},Node[1]{name:"Bob",age:25,eyes:"blue"},Node[4]{array:["one","tw
o","three"],name:"Eskil",age:41,eyes:"blue"}] |
+-------------------------------------------------------------------------------------------------------------------
-----------------------------------------------+
1 row
```

10.3.2. relationships()

Returns all relationships in a path.

Syntax: `relationships( path )`

Arguments:

- *path:* A path.

Query

```
MATCH p=(a)-->(b)-->(c)
WHERE a.name='Alice' AND c.name='Eskil'
RETURN relationships(p)
```

All the relationships in the path `p` are returned.

Result

```
+----------------------------+
| relationships(p)           |
+----------------------------+
| [:KNOWS[0]{},:MARRIED[4]{}] |
+----------------------------+
1 row
```

10.3.3. labels()

Returns a list of string representations for the labels attached to a node.

Syntax: `labels( node )`

Arguments:

- *node:* Any expression that returns a single node

Query

```
MATCH (a)
WHERE a.name='Alice'
RETURN labels(a)
```

The labels of `n` is returned by the query.

Result

```
+---------------+
| labels(a)     |
+---------------+
| ["bar","foo"] |
+---------------+
1 row
```

10.3.4. keys()

Returns a list of string representations for the property names of a node, relationship, or map.

Syntax: `keys(  property-container )`

Arguments:

- *property-container:* A node, a relationship, or a literal map.

Query

```
MATCH (a)
WHERE a.name='Alice'
RETURN keys(a)
```

The name of the properties of `n` is returned by the query.

Result

```
+----------------------+
| keys(a)              |
+----------------------+
| ["name","age","eyes"] |
+----------------------+
1 row
```

10.3.5. extract()

To return a single property, or the value of a function from a list of nodes or relationships, you can use `extract()`. It will go through a list, run an expression on every element, and return the results in a list with these values. It works like the `map` method in functional languages such as Lisp and Scala.

Syntax: `extract( variable IN list | expression )`

Arguments:

- *list:* An expression that returns a list
- *variable:* The closure will have a variable introduced in it's context. Here you decide which variable to use.
- *expression:* This expression will run once per value in the list, and produces the result list.

Query

```
MATCH p=(a)-->(b)-->(c)
WHERE a.name='Alice' AND b.name='Bob' AND c.name='Daniel'
RETURN extract(n IN nodes(p)| n.age) AS extracted
```

The age property of all nodes in the path are returned.

Result

```
+------------+
| extracted  |
+------------+
| [38,25,54] |
+------------+
1 row
```

10.3.6. filter()

`filter()` returns all the elements in a list that comply to a predicate.

Syntax: `filter(variable IN list WHERE predicate)`

Arguments:

- *list:* An expression that returns a list
- *variable:* This is the variable that can be used from the predicate.
- *predicate:* A predicate that is tested against all items in the list.

Query

```
MATCH (a)
WHERE a.name='Eskil'
RETURN a.array, filter(x IN a.array WHERE size(x)= 3)
```

This returns the property named `array` and a list of values in it, which have size `3`.

Result

```
+-------------------------------------------------------------------+
| a.array               | filter(x in a.array WHERE size(x) = 3) |
+-------------------------------------------------------------------+
| ["one","two","three"] | ["one","two"]                          |
+-------------------------------------------------------------------+
1 row
```

10.3.7. tail()

`tail()` returns all but the first element in a list.

Syntax: `tail( expression )`

Arguments:

- *expression:* This expression should return a list of some kind.

Query

```
MATCH (a)
WHERE a.name='Eskil'
RETURN a.array, tail(a.array)
```

This returns the property named `array` and all elements of that property except the first one.

Result

```
+-----------------------------------------+
| a.array               | tail(a.array)   |
+-----------------------------------------+
| ["one","two","three"] | ["two","three"] |
+-----------------------------------------+
1 row
```

10.3.8. range()

`range()` returns numerical values in a range. The default distance between values in the range is `1`. The r is inclusive in both ends.

Syntax: `range( start, end [, step] )`

Arguments:

- *start:* A numerical expression.
- *end:* A numerical expression.
- *step:* A numerical expression.

Query

```
RETURN range(0,10), range(2,18,3)
```

Two lists of numbers in the given ranges are returned.

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
```

10.3.9. reduce()

To run an expression against individual elements of a list, and store the result of the expression in an accumulator, you can use `reduce()`. It will go through a list, run an expression on every element, storing the partial result in the accumulator. It works like the `fold` or `reduce` method in functional languages such as Lisp and Scala.

Syntax: `reduce( accumulator = initial, variable IN list | expression )`

Arguments:

- *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 it's context. Here you decide which variable to use.
- *expression:* This expression will run once per value in the list, and produces 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.

Result

```
+-----------+
| reduction |
+-----------+
| 117       |
+-----------+
1 row
```

10.4. Math functions

> *These functions all operate on numerical expressions only, and will return an error if used on any other values. See also Mathematical operators..*

The following graph is used for the examples below:

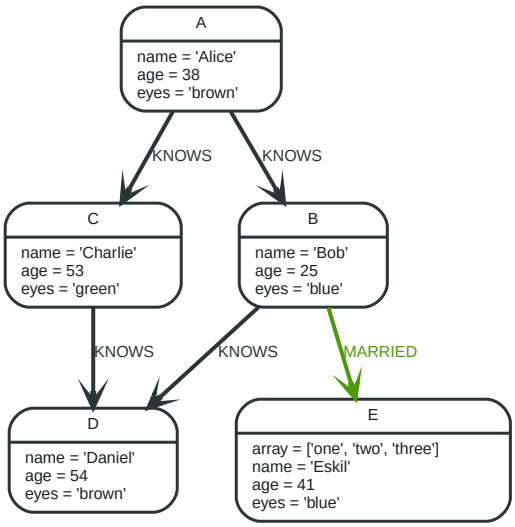


Figure 20. Graph

10.4.1. Number functions

abs()

`abs()` returns the absolute value for a number.

Syntax: `abs( expression )`

Arguments:

- *expression:* A numeric expression.

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 25. Result

a.age	e.age	abs(a.age - e.age)
38	41	3
1 row		

ceil()

`ceil()` returns the smallest integer greater than or equal to the argument.

Syntax: `ceil( expression )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN ceil(0.1)
```

The ceil of `0.1`.

Table 26. Result

ceil(0.1)
1.0
1 row

floor()

`floor()` returns the greatest integer less than or equal to the expression.

Syntax: `floor( expression )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN floor(0.9)
```

The floor of `0.9` is returned.

Table 27. Result

floor(0.9)
0.0
1 row

round()

`round()` returns the numerical expression, rounded to the nearest integer.

Syntax: `round( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN round(3.141592)
```

`3.0` is returned.

Table 28. Result

round(3.141592)
3.0
1 row

sign()

`sign()` returns the signum of a number — zero if the expression is zero, `-1` for any negative number,

and `1` for any positive number.

Syntax: `sign( expression )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN sign(-17), sign(0.1)
```

The signs of `-17` and `0.1` are returned.

Table 29. Result

sign(-17)	sign(0.1)
-1	1
1 row	

rand()

`rand()` returns a random number in the range from 0 (inclusive) to 1 (exclusive), [0,1). The numbers returned follow an approximate uniform distribution.

Syntax: `rand()`

Arguments:

Query

```
RETURN rand()
```

A random number is returned.

Table 30. Result

rand()
0.04166747260084902
1 row

10.4.2. Logarithmic functions

log()

`log()` returns the natural logarithm of the expression.

Syntax: `log( expression )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN log(27)
```

The natural logarithm of `27` is returned.

Table 31. Result

log(27)
3.295836866004329
1 row

log10()

`log10()` returns the common logarithm (base 10) of the expression.

Syntax: `log10( expression )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN log10(27)
```

The common logarithm of `27` is returned.

Table 32. Result

log10(27)
1.4313637641589874
1 row

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 )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN exp(2)
```

`e` to the power of `2` is returned.

Table 33. Result

exp(2)
7.38905609893065

exp(2)
1 row

e()

`e()` returns the base of the natural logarithm, `e`.

Syntax: `e()`

Arguments:

Query

```
RETURN e()
```

The base of the natural logarithm, `e`, is returned.

Table 34. Result

e()
2.718281828459045
1 row

sqrt()

`sqrt()` returns the square root of a number.

Syntax: `sqrt( expression )`

Arguments:

- *expression:* A numeric expression.

Query

```
RETURN sqrt(256)
```

The square root of `256` is returned.

Table 35. Result

sqrt(256)
16.0
1 row

10.4.3. Trigonometric functions

All trigonometric functions operate on radians, unless otherwise specified.

sin()

`sin()` returns the sine of the expression.

Syntax: `sin( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN sin(0.5)
```

The sine of `0.5` is returned.

Table 36. Result

sin(0.5)
0.479425538604203
1 row

cos()

`cos()` returns the cosine of the expression.

Syntax: `cos( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN cos(0.5)
```

The cosine of `0.5`.

Table 37. Result

cos(0.5)
0.8775825618903728
1 row

tan()

`tan()` returns the tangent of the expression.

Syntax: `tan( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN tan(0.5)
```

The tangent of `0.5` is returned.

Table 38. Result

tan(0.5)
0.5463024898437905
1 row

cot()

`cot()` returns the cotangent of the expression.

Syntax: `cot( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN cot(0.5)
```

The cotangent of `0.5`.

Table 39. Result

cot(0.5)
1.830487721712452
1 row

asin()

`asin()` returns the arcsine of the expression, in radians.

Syntax: `asin( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN asin(0.5)
```

The arcsine of `0.5`.

Table 40. Result

asin(0.5)
0.5235987755982989
1 row

acos()

`acos()` returns the arccosine of the expression, in radians.

Syntax: `abs( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN acos(0.5)
```

The arccosine of `0.5`.

Table 41. Result

acos(0.5)
1.0471975511965979
1 row

atan()

`atan()` returns the arctangent of the expression, in radians.

Syntax: `atan( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN atan(0.5)
```

The arctangent of `0.5`.

Table 42. Result

atan(0.5)
0.4636476090008061
1 row

atan2()

`atan2()` returns the arctangent2 of a set of coordinates, in radians.

Syntax: `atan2( expression1, expression2 )`

Arguments:

- *expression1:* A numeric expression for y that represents the angle in radians.
- *expression2:* A numeric expression for x that represents the angle in radians.

Query

```
RETURN atan2(0.5, 0.6)
```

The arctangent2 of `0.5` and `0.6`.

Table 43. Result

atan2(0.5, 0.6)
0.6947382761967033
1 row

pi()

`pi()` returns the mathematical constant pi.

Syntax: `pi()`

Arguments:

Query

```
RETURN pi()
```

The constant pi is returned.

Table 44. Result

pi()
3.141592653589793
1 row

degrees()

`degrees()` converts radians to degrees.

Syntax: `degrees( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN degrees(3.14159)
```

The number of degrees in something close to pi.

Table 45. Result

degrees(3.14159)
179.99984796050427
1 row

radians()

`radians()` returns the common logarithm (base 10) of the expression.

Syntax: `radians( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in degrees.

Query

```
RETURN radians(180)
```

The number of radians in `180` degrees is returned (pi).

Table 46. Result

radians(180)
3.141592653589793
1 row

haversin()

`haversin()` returns half the versine of the expression.

Syntax: `haversin( expression )`

Arguments:

- *expression:* A numeric expression that represents the angle in radians.

Query

```
RETURN haversin(0.5)
```

The haversine of `0.5` is returned.

Table 47. Result

haversin(0.5)
0.06120871905481362
1 row

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 48. Result

dist
9129.969740051658

dist
1 row Nodes created: 2 Properties set: 4 Labels added: 2

10.5. 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 and booleans.

See also String operators.

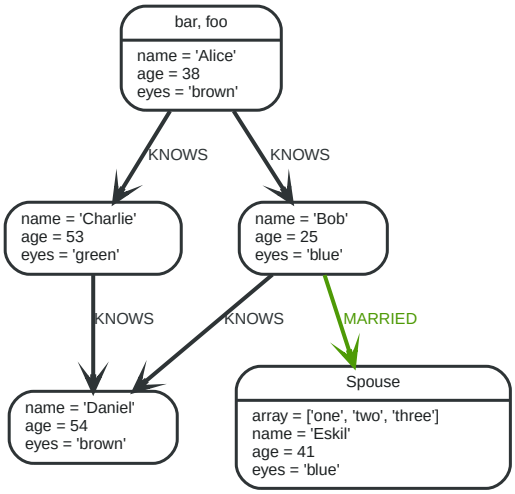


Figure 21. Graph

10.5.1. replace()

`replace()` returns a string with the search string replaced by the replace string. It replaces all occurrences.

Syntax: `replace( original, search, replace )`

Arguments:

- *original:* An expression that returns a string
- *search:* An expression that returns a string to search for
- *replace:* An expression that returns the string to replace the search string with

Query

```
RETURN replace("hello", "l", "w")
```

Result

```
+---------------------------+
| replace("hello", "l", "w") |
+---------------------------+
| "hewwo"                   |
+---------------------------+
1 row
```

10.5.2. substring()

`substring()` returns a substring of the original, with a 0-based index start and length. If length is omitted, it returns a substring from start until the end of the string.

Syntax: `substring( original, start [, length] )`

Arguments:

- *original:* An expression that returns a string
- *start:* An expression that returns a positive number
- *length:* An expression that returns a positive number

Query

```
RETURN substring("hello", 1, 3), substring("hello", 2)
```

Result

```
+-------------------------------------------------+
| substring("hello", 1, 3) | substring("hello", 2) |
+-------------------------------------------------+
| "ell"                    | "llo"                 |
+-------------------------------------------------+
1 row
```

10.5.3. left()

`left()` returns a string containing the left n characters of the original string.

Syntax: `left( original, length )`

Arguments:

- *original:* An expression that returns a string
- *n:* An expression that returns a positive number

Query

```
RETURN left("hello", 3)
```

Result

```
+------------------+
| left("hello", 3) |
+------------------+
| "hel"            |
+------------------+
1 row
```

10.5.4. right()

`right()` returns a string containing the right n characters of the original string.

Syntax: `right( original, length )`

Arguments:

- *original:* An expression that returns a string
- *n:* An expression that returns a positive number

Query

```
RETURN right("hello", 3)
```

Result

```
+-------------------+
| right("hello", 3) |
+-------------------+
| "llo"             |
+-------------------+
1 row
```

10.5.5. ltrim()

`ltrim()` returns the original string with whitespace removed from the left side.

Syntax: `ltrim( original )`

Arguments:

- *original:* An expression that returns a string

Query

```
RETURN ltrim("   hello")
```

Result

```
+-------------------+
| ltrim("   hello") |
+-------------------+
| "hello"           |
+-------------------+
1 row
```

10.5.6. rtrim()

`rtrim()` returns the original string with whitespace removed from the right side.

Syntax: `rtrim( original )`

Arguments:

- *original:* An expression that returns a string

Query

```
RETURN rtrim("hello   ")
```

Result

```
+-------------------+
| rtrim("hello   ") |
+-------------------+
| "hello"           |
+-------------------+
1 row
```

10.5.7. trim()

`trim()` returns the original string with whitespace removed from both sides.

Syntax: `trim( original )`

Arguments:

- *original:* An expression that returns a string

Query

```
RETURN trim("   hello   ")
```

Result

```
+---------------------+
| trim("   hello   ") |
+---------------------+
| "hello"             |
+---------------------+
1 row
```

10.5.8. lower()

`lower()` returns the original string in lowercase.

Syntax: `lower( original )`

Arguments:

- *original:* An expression that returns a string

Query

```
RETURN lower("HELLO")
```

Result

```
+----------------+
| lower("HELLO") |
+----------------+
| "hello"        |
+----------------+
1 row
```

10.5.9. upper()

`upper()` returns the original string in uppercase.

Syntax: `upper( original )`

Arguments:

- *original:* An expression that returns a string

Query

```
RETURN upper("hello")
```

Result

```
+----------------+
| upper("hello") |
+----------------+
| "HELLO"        |
+----------------+
1 row
```

10.5.10. split()

`split()` returns the sequence of strings witch are delimited by split patterns.

Syntax: `split( original, splitPattern )`

Arguments:

- *original:* An expression that returns a string
- *splitPattern:* The string to split the original string with

Query

```
RETURN split("one,two", ",")
```

Result

```
+-----------------------+
| split("one,two", ",") |
+-----------------------+
| ["one","two"]         |
+-----------------------+
1 row
```

10.5.11. reverse()

`reverse()` returns the original string reversed.

Syntax: `reverse( original )`

Arguments:

- *original:* An expression that returns a string

Query

```
RETURN reverse("anagram")
```

Result

```
+--------------------+
| reverse("anagram") |
+--------------------+
| "margana"          |
+--------------------+
1 row
```

10.5.12. toString()

`toString()` converts the argument to a string. It converts integral and floating point numbers and booleans to strings, and if called with a string will leave it unchanged.

Syntax: `toString( expression )`

Arguments:

- *expression:* An expression that returns a number, a boolean, or a string

Query

```
RETURN toString(11.5), toString("already a string"), toString(TRUE )
```

Result

```
+-----------------------------------------------------------------+
| toString(11.5) | toString("already a string") | toString(true) |
+-----------------------------------------------------------------+
| "11.5"         | "already a string"           | "true"         |
+-----------------------------------------------------------------+
1 row
```

Chapter 11. Schema

Neo4j 2.0 introduced an optional schema for the graph, based around the concept of labels. Labels are used in the specification of indexes, and for defining constraints on the graph. Together, indexes and constraints are the schema of the graph. Cypher includes data definition language (DDL) statements for manipulating the schema.

11.1. Indexes

A database index is a redundant copy of information in the database for the purpose of making retrieving said 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.

Cypher allows the creation of indexes over a property for all nodes that have a given label. Once an index has been created, it will automatically be managed and kept up to date by the database whenever the graph is changed. Neo4j will automatically pick up and start using the index once it has been created and brought online.

11.1.1. Create an index

To create an index on a property for all nodes that have a label, use CREATE INDEX ON. Note that the index is not immediately available, but will be created in the background.

Query

```
CREATE INDEX ON :Person(name)
```

Result

```
+-------------------------------------------+
| No data returned, and nothing was changed. |
+-------------------------------------------+
```

11.1.2. Drop an index

To drop an index on all nodes that have a label and property combination, use the DROP INDEX clause.

Query

```
DROP INDEX ON :Person(name)
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Indexes removed: 1
```

11.1.3. Use index

There is usually no need to specify which indexes to use in a query, Cypher will figure that out by itself. For example the query below will use the `Person(name)` index, if it exists. If you want Cypher to use specific indexes, you can enforce it using hints. See Using.

Query

```
MATCH (person:Person { name: 'Andres' })
RETURN person
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+---------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other         |
+-----------------+----------------+------+---------+-----------+---------------+
| +ProduceResults |              1 |    1 |       0 | person    | person        |
| |               +----------------+------+---------+-----------+---------------+
| +NodeIndexSeek  |              1 |    1 |       2 | person    | :Person(name) |
+-----------------+----------------+------+---------+-----------+---------------+

Total database accesses: 2
```

11.1.4. Use index with WHERE using equality

Indexes are also automatically used for equality comparisons of an indexed property in the WHERE clause. If you want Cypher to use specific indexes, you can enforce it using hints. See Using.

Query

```
MATCH (person:Person)
WHERE person.name = 'Andres'
RETURN person
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+---------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other         |
+-----------------+----------------+------+---------+-----------+---------------+
| +ProduceResults |              1 |    1 |       0 | person    | person        |
| |               +----------------+------+---------+-----------+---------------+
| +NodeIndexSeek  |              1 |    1 |       2 | person    | :Person(name) |
+-----------------+----------------+------+---------+-----------+---------------+

Total database accesses: 2
```

11.1.5. Use index with WHERE using inequality

Indexes are also automatically used for inequality (range) comparisons of an indexed property in the WHERE clause. If you want Cypher to use specific indexes, you can enforce it using hints. See Using.

Query

```
MATCH (person:Person)
WHERE person.name > 'B'
RETURN person
```

Query Plan

```
+----------------------+----------------+------+---------+-----------+---------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Variables | Other                           |
+----------------------+----------------+------+---------+-----------+---------------------------------+
| +ProduceResults      |             10 |    1 |       0 | person    | person                          |
| |                    +----------------+------+---------+-----------+---------------------------------+
| +NodeIndexSeekByRange |             10 |    1 |       2 | person    | :Person(name) > {  AUTOSTRING0} |
+----------------------+----------------+------+---------+-----------+---------------------------------+

Total database accesses: 2
```

11.1.6. Use index with IN

The IN predicate on `person.name` in the following query will use the `Person(name)` index, if it exists. If you want Cypher to use specific indexes, you can enforce it using hints. See Using.

Query

```
MATCH (person:Person)
WHERE person.name IN ['Andres', 'Mark']
RETURN person
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+---------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other         |
+-----------------+----------------+------+---------+-----------+---------------+
| +ProduceResults |              2 |    2 |       0 | person    | person        |
| |               +----------------+------+---------+-----------+---------------+
| +NodeIndexSeek  |              2 |    2 |       4 | person    | :Person(name) |
+-----------------+----------------+------+---------+-----------+---------------+

Total database accesses: 4
```

11.1.7. Use index with STARTS WITH

The `STARTS WITH` predicate on `person.name` in the following query will use the `Person(name)` index, if it exists.

Query

```
MATCH (person:Person)
WHERE person.name STARTS WITH 'And'
RETURN person
```

Query Plan

```
+----------------------+----------------+------+---------+-----------
+-------------------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Variables | Other
|
+----------------------+----------------+------+---------+-----------
+-------------------------------------------+
| +ProduceResults      |             26 |    1 |       0 | person    | person
|
| |                    +----------------+------+---------+-----------
+-------------------------------------------+
| +NodeIndexSeekByRange |             26 |    1 |       2 | person    | :Person(name STARTS WITH {
AUTOSTRING0}) |
+----------------------+----------------+------+---------+-----------
+-------------------------------------------+

Total database accesses: 2
```

11.1.8. Use index when checking for the existence of a property

The `has(p.name)` predicate in the following query will use the `Person(name)` index, if it exists.

Query

```
MATCH (p:Person)
WHERE exists(p.name)
RETURN p
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+---------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other         |
+-----------------+----------------+------+---------+-----------+---------------+
| +ProduceResults |              2 |    2 |       0 | p         | p             |
| |               +----------------+------+---------+-----------+---------------+
| +NodeIndexScan  |              2 |    2 |       3 | p         | :Person(name) |
+-----------------+----------------+------+---------+-----------+---------------+

Total database accesses: 3
```

11.2. Constraints

Neo4j helps enforce data integrity with the use of constraints. Constraints can be applied to either nodes or relationships. Unique node property constraints can be created, as well as node and relationship property existence constraints.

You can use unique property constraints to 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.

You can use property existence constraints to ensure that a property exists for all nodes with a specific label or for all relationships with a specific type. All queries that try to create new nodes or relationships without the property, or queries that try to remove the mandatory property will now fail.

Property existence constraints are only available in the Neo4j Enterprise Edition. Note that databases with property existence constraints cannot be opened using Neo4j Community Edition.

You can have multiple constraints for a given label and you can also combine unique and property existence constraints on the same property.

Remember that 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''.

Note that adding a unique property constraint on a property will also add an index on that property, so you cannot add such an index separately. Cypher will use that index for lookups just like other indexes. If you drop a unique property constraint and still want an index on the property, you will have to create the index.

The existing constraints can be listed using the REST API, see [rest-api-schema-constraints].

11.2.1. Unique node property constraints

Create uniqueness constraint

To create a constraint that makes sure that your database will never contain more than one node with a specific label and one property value, use the `IS UNIQUE` syntax.

Query

```
CREATE CONSTRAINT ON (book:Book) ASSERT book.isbn IS UNIQUE
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Unique constraints added: 1
```

Drop uniqueness 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
```

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 breaks 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 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:
Multiple nodes with label `Book` have property `isbn` = '1449356265':
  node(0)
  node(1)
```

11.2.2. Node property existence constraints

Create node property existence constraint

To create a constraint that makes sure that all nodes with a certain label have a certain property, use the `ASSERT exists(variable.propertyName)` syntax.

Query

```
CREATE CONSTRAINT ON (book:Book) ASSERT exists(book.isbn)
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Property existence constraints added: 1
```

Drop 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
```

Create a node that complies with property existence constraints

Create a `Book` node with an existing `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 breaks 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 1 with label "Book" must have the property "isbn" due to a constraint
```

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" due to a constraint
```

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` has no value for property `isbn`
```

11.2.3. Relationship property existence constraints

Create relationship property existence constraint

To create a constraint that makes sure that all relationships with a certain type have a certain property, use the `ASSERT exists(variable.propertyName)` syntax.

Query

```
CREATE CONSTRAINT ON ()-[like:LIKED]-() ASSERT exists(like.day)
```

Result

```
+-------------------+
| No data returned. |
+-------------------+
Property existence constraints added: 1
```

Drop 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
```

Create a relationship that complies with property existence constraints

Create a `LIKED` relationship with an existing `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 breaks 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 1 with type "LIKED" must have the property "day" due to a constraint
```

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" due to a constraint
```

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` has no value for property `day`
```

11.3. Statistics

When you issue a Cypher query, it gets compiled to an execution plan (see Execution Plans) that can run and answer your question. To produce an efficient plan for your query, Neo4j needs information about your database, such as the schema — what indexes and constraints do exist? Neo4j will also use statistical information it keeps about your database to optimize the execution plan. With this information, Neo4j can decide which access pattern leads to the best performing plans.

The statistical information that Neo4j keeps is:

1. The number of nodes with a certain label.

2. Selectivity per index.
3. The number of relationships by type.
4. The number of relationships by type, ending or starting from a node with a specific label.

Neo4j keeps the statistics up to date in two different ways. For label counts for example, the number is updated whenever you set or remove a label from a node. For indexes, Neo4j needs to scan the full index to produce the selectivity number. Since this is potentially a very time-consuming operation, these numbers are collected in the background when enough data on the index has been changed.

11.3.1. Configuration options

Execution plans are cached and will not be replanned until the statistical information used to produce the plan has changed. The following configuration options allows you to control how sensitive replanning should be to updates of the database.

`dbms.index_sampling.background_enabled`
: Controls whether indexes will automatically be re-sampled when they have been updated enough. The Cypher query planner depends on accurate statistics to create efficient plans, so it is important it is kept up to date as the database evolves.

If background sampling is turned off, make sure to trigger manual sampling when data has been updated.

`dbms.index_sampling.update_percentage`
: Controls how large portion of the index has to have been updated before a new sampling run is triggered.

`cypher.statistics_divergence_threshold`
: Controls how much the above statistical information is allowed to change before an execution plan is considered stale and has to be replanned. If the relative change in any of statistics is larger than this threshold, the plan will be thrown away and a new one will be created. A threshold of 0.0 means *always replan*, and a value of 1.0 means *never replan*.

11.3.2. Managing statistics from the shell

Usage:

`schema sample -a`
: will sample all indexes.

`schema sample -l Person -p name`
: will sample the index for label `Person` on property `name` (if existing).

`schema sample -a -f`
: will force a sample of all indexes.

`schema sample -f -l :Person -p name`
: will force sampling of a specific index.

Chapter 12. Query Tuning

Neo4j works very hard 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 least data should get filtered out as early as possible in order to reduce the amount of work that has to be done at later stages of query execution. This also goes for what gets returned: avoid returning whole nodes and relationships — instead, pick the data you need and return only that. 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 execution engine. To minimize the resources used for this, make sure 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.

12.1. How are queries executed?

Each query is turned into an execution plan by something called the *execution planner*. The execution plan tells Neo4j which operations to perform when executing the query. Two different execution planning strategies are included in Neo4j:

Rule
: This planner has rules that are used to produce execution plans. The planner considers available indexes, but does not use statistical information to guide the query compilation.

Cost
: This planner uses the statistics service in Neo4j to assign cost to alternative plans and picks the cheapest one. While this should lead to superior execution plans in most cases, it is still under development.

By default, Neo4j 3.0 will use the cost planner for some queries, but not all. You can force it to use a specific planner by using the `cypher.planner` configuration setting (see [config_cypher.planner]), or by prepending your query with `CYPHER planner=cost` or `CYPHER planner=rule`. Neo4j might still not use the planner you selected — not all queries are solvable by the cost planner at this point.

You can see which planner was used by looking at the execution plan.

When Cypher is building execution plans, it looks at the schema to see if it can find indexes it can use. These index decisions are only valid until the schema changes, so adding or removing indexes leads to the execution plan cache being flushed.

12.2. How do I profile 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.

12.3. 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 "http://neo4j.com/docs/3.0.1/csv/query-tuning/movies.csv" AS line
MERGE (m:Movie { title:line.title })
ON CREATE SET m.released = toInt(line.released), m.tagline = line.tagline
```

```
LOAD CSV WITH HEADERS FROM 'http://neo4j.com/docs/3.0.1/csv/query-tuning/actors.csv' AS line
MATCH (m:Movie { title:line.title })
MERGE (p:Person { name:line.name })
ON CREATE SET p.born = toInt(line.born)
MERGE (p)-[:ACTED_IN { roles:split(line.roles,";")}]->(m)
```

```
LOAD CSV WITH HEADERS FROM 'http://neo4j.com/docs/3.0.1/csv/query-tuning/directors.csv' AS line
MATCH (m:Movie { title:line.title })
MERGE (p:Person { name:line.name })
ON CREATE SET p.born = toInt(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 How do I profile 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 3.0

Planner COST

Runtime INTERPRETED

+-----------------+----------------+------+---------+-----------+--------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other                    |
+-----------------+----------------+------+---------+-----------+--------------------------+
| +ProduceResults |             16 |    1 |       0 | p         | p                        |
| |               +----------------+------+---------+-----------+--------------------------+
| +Filter         |             16 |    1 |     163 | p         | p.name == {  AUTOSTRING0} |
| |               +----------------+------+---------+-----------+--------------------------+
| +AllNodesScan   |            163 |  163 |     164 | 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.

Moving up to the previous row we see the Filter operator which will check the `name` property on each of the nodes passed through by `AllNodesScan`.

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 3.0

Planner COST

Runtime INTERPRETED

+------------------+----------------+------+---------+-----------+--------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables | Other                    |
+------------------+----------------+------+---------+-----------+--------------------------+
| +ProduceResults  |             13 |    1 |       0 | p         | p                        |
| |                +----------------+------+---------+-----------+--------------------------+
| +Filter          |             13 |    1 |     125 | p         | p.name == {  AUTOSTRING0} |
| |                +----------------+------+---------+-----------+--------------------------+
| +NodeByLabelScan |            125 |  125 |     126 | 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 ON :Person(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 3.0

Planner COST

Runtime INTERPRETED

+-----------------+----------------+------+---------+-----------+---------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other         |
+-----------------+----------------+------+---------+-----------+---------------+
| +ProduceResults |              1 |    1 |       0 | p         | p             |
| |               +----------------+------+---------+-----------+---------------+
| +NodeIndexSeek  |              1 |    1 |       2 | 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 a schema index seek (see Indexes) to find the appropriate node.

12.4. Using

> *The USING clause is used to influence the decisions of the planner when building an execution plan for a query.*

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.

12.4.1. 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 wrong one from a performance point of view. And in some circumstances (albeit rarely) it is better not to use an index at all.

You can force Neo4j to use a specific starting point through the `USING` clause. This is called giving a planner hint. There are three types of planner hints: index hints, scan hints, and join hints.

You cannot use planner hints if your query has a `START` clause.

The following graph is used for the examples below:

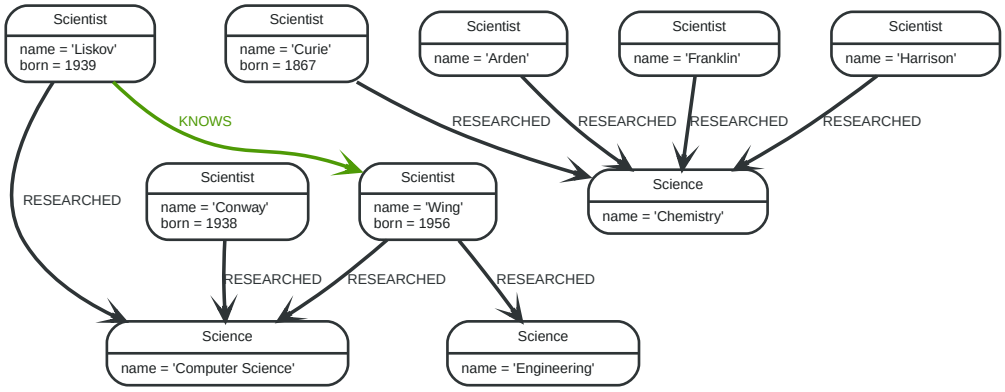


Figure 22. Graph

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

```
+------------------+----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables
| Other                                               |
+------------------+----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +ProduceResults  |              0 |    1 |       0 | column
| column                                              |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Projection      |              0 |    1 |       0 | column -- anon[122], anon[41], anon[68], conway,
cs, liskov, wing | {  AUTOINT3}                                        |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Filter          |              0 |    1 |       2 | anon[122], anon[41], anon[68], conway, cs, liskov,
wing           | liskov.name == {  AUTOSTRING0} AND liskov:Scientist |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Expand(All)     |              0 |    1 |       3 | anon[41], liskov -- anon[122], anon[68], conway,
cs, wing         | (wing)<-[:KNOWS]-(liskov)                           |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Filter          |              1 |    2 |       2 | anon[122], anon[68], conway, cs, wing
| NOT(anon[122] == anon[68]) AND wing:Scientist       |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Expand(All)     |              1 |    3 |       4 | anon[68], wing -- anon[122], conway, cs
| (cs)<-[:RESEARCHED]-(wing)                          |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Filter          |              0 |    1 |       4 | anon[122], conway, cs
| conway.name == {  AUTOSTRING2} AND conway:Scientist |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Expand(All)     |              3 |    3 |       4 | anon[122], conway -- cs
| (cs)<-[:RESEARCHED]-(conway)                        |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +Filter          |              1 |    1 |       3 | cs
| cs.name == {  AUTOSTRING1}                          |
| |                +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+
| +NodeByLabelScan |              3 |    3 |       4 | cs
| :Science                                            |
+------------------+----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------------------+

Total database accesses: 26
```

12.4.2. 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)` 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

```
+-----------------+----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables
| Other                                                                             |
+-----------------+----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +ProduceResults |              0 |    1 |       0 | column
| column                                                                            |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Projection     |              0 |    1 |       1 | column -- anon[122], anon[41], anon[68], conway, cs,
liskov, wing | liskov.born                                                                |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Filter         |              0 |    1 |       3 | anon[122], anon[41], anon[68], conway, cs, liskov,
wing           | NOT(anon[122] == anon[68]) AND conway.name == {  AUTOSTRING2} AND conway:Scientist |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Expand(All)    |              0 |    3 |       4 | anon[122], conway -- anon[41], anon[68], cs, liskov,
wing         | (cs)<-[:RESEARCHED]-(conway)                                               |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Filter         |              0 |    1 |       4 | anon[41], anon[68], cs, liskov, wing
| cs:Science AND cs.name == {  AUTOSTRING1}                                         |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Expand(All)    |              0 |    2 |       3 | anon[68], cs -- anon[41], liskov, wing
| (wing)-[:RESEARCHED]->(cs)                                                        |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Filter         |              0 |    1 |       1 | anon[41], liskov, wing
| wing:Scientist                                                                    |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +Expand(All)    |              0 |    1 |       2 | anon[41], wing -- liskov
| (liskov)-[:KNOWS]->(wing)                                                         |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------------------------------------------------+
| +NodeIndexSeek  |              1 |    1 |       2 | 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

```
+-----------------+----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables
| Other                                   |
+-----------------+----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +ProduceResults  |              0 |    1 |       0 | column
| column                                  |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +Projection      |              0 |    1 |       1 | column -- anon[122], anon[41], anon[68], conway,
cs, liskov, wing | liskov.born                                  |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +Filter          |              0 |    1 |       0 | anon[122], anon[41], anon[68], conway, cs, liskov,
wing           | NOT(anon[122] == anon[68])                |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +NodeHashJoin    |              0 |    1 |       0 | anon[41], anon[68], liskov, wing -- anon[122],
conway, cs         | cs                                       |
| |\              +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| | +Filter        |              1 |    1 |       1 | anon[122], conway, cs
| cs.name == {  AUTOSTRING1}              |
| | |             +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| | +Expand(All)   |              1 |    1 |       2 | anon[122], cs -- conway
| (conway)-[:RESEARCHED]->(cs)            |
| | |             +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| | +NodeIndexSeek |              1 |    1 |       2 | conway
| :Scientist(name)                        |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +Filter          |              0 |    1 |       4 | anon[41], anon[68], cs, liskov, wing
| cs:Science AND cs.name == {  AUTOSTRING1} |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +Expand(All)     |              0 |    2 |       3 | anon[68], cs -- anon[41], liskov, wing
| (wing)-[:RESEARCHED]->(cs)              |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +Filter          |              0 |    1 |       1 | anon[41], liskov, wing
| wing:Scientist                          |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +Expand(All)     |              0 |    1 |       2 | anon[41], wing -- liskov
| (liskov)-[:KNOWS]->(wing)               |
| |               +----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+
| +NodeIndexSeek   |              1 |    1 |       2 | liskov
| :Scientist(name)                        |
+-----------------+----------------+------+---------
+-----------------------------------------------------------------------
+-----------------------------------------+

Total database accesses: 18
```

12.4.3. 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

```
+------------------+----------------+------+---------+-------------
+--------------------------------------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables   | Other
|
+------------------+----------------+------+---------+-------------
+--------------------------------------------------------------------+
| +ProduceResults  |              0 |    2 |       0 | column      | column
|
| |                +----------------+------+---------+-------------
+--------------------------------------------------------------------+
| +Projection      |              0 |    2 |       2 | column -- s | s.born
|
| |                +----------------+------+---------+-------------
+--------------------------------------------------------------------+
| +Filter          |              0 |    2 |       7 | s           |
AndedPropertyComparablePredicates(s,s.born,s.born < {  AUTOINT0}) |
| |                +----------------+------+---------+-------------
+--------------------------------------------------------------------+
| +NodeByLabelScan |              7 |    7 |       8 | s           | :Scientist
|
+------------------+----------------+------+---------+-------------
+--------------------------------------------------------------------+

Total database accesses: 17
```

12.4.4. 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

```
+-----------------+----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables
| Other                                   |
+-----------------+----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| +ProduceResults  |              0 |    1 |       0 | column
| column                                  |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| +Projection      |              0 |    1 |       1 | column -- anon[122], anon[41], anon[68], conway,
cs, liskov, wing | wing.born                                        |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| +NodeHashJoin    |              0 |    1 |       0 | anon[41], liskov -- anon[122], anon[68], conway,
cs, wing         | wing                                             |
| |\              +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| | +Filter        |              1 |    2 |       0 | anon[122], anon[68], conway, cs, wing
| NOT(anon[122] == anon[68])              |
| | |             +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| | +Expand(All)   |              1 |    3 |       4 | anon[68], wing -- anon[122], conway, cs
| (cs)<-[:RESEARCHED]-(wing)              |
| | |             +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| | +Filter        |              0 |    1 |       2 | anon[122], conway, cs
| cs:Science AND cs.name == {  AUTOSTRING1} |
| | |             +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| | +Expand(All)   |              1 |    1 |       2 | anon[122], cs -- conway
| (conway)-[:RESEARCHED]->(cs)            |
| | |             +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| | +NodeIndexSeek |              1 |    1 |       2 | conway
| :Scientist(name)                        |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| +Filter          |              0 |    1 |       1 | anon[41], liskov, wing
| wing:Scientist                          |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| +Expand(All)     |              0 |    1 |       2 | anon[41], wing -- liskov
| (liskov)-[:KNOWS]->(wing)               |
| |               +----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+
| +NodeIndexSeek   |              1 |    1 |       2 | liskov
| :Scientist(name)                        |
+-----------------+----------------+------+---------
+-------------------------------------------------------------------
+-----------------------------------------+

Total database accesses: 16
```

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

```
+-----------------+----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables
| Other                                          |
+-----------------+----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +ProduceResults  |              0 |    1 |       0 | column
| column                                         |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +Projection      |              0 |    1 |       1 | column -- anon[136], anon[41], anon[82], cs,
liskov, wing | wing.born                                       |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +Filter          |              0 |    1 |       0 | anon[136], anon[41], anon[82], cs, liskov, wing
| NOT(anon[136] == anon[82])                     |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +NodeHashJoin    |              0 |    1 |       0 | anon[41], anon[82], wing -- anon[136], cs, liskov
| liskov, cs                                     |
| |\              +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| | +Filter        |              1 |    1 |       2 | anon[136], cs, liskov
| cs:Science AND cs.name == {  AUTOSTRING2}      |
| | |             +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| | +Expand(All)   |              1 |    1 |       2 | anon[136], cs -- liskov
| (liskov)-[:RESEARCHED]->(cs)                   |
| | |             +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| | +NodeIndexSeek |              1 |    1 |       2 | liskov
| :Scientist(name)                               |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +Filter          |              0 |    1 |       4 | anon[41], anon[82], cs, liskov, wing
| cs:Science AND cs.name == {  AUTOSTRING2}      |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +Expand(All)     |              0 |    2 |       3 | anon[82], cs -- anon[41], liskov, wing
| (wing)-[:RESEARCHED]->(cs)                     |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +Filter          |              0 |    1 |       2 | anon[41], liskov, wing
| wing:Scientist AND wing.name == {  AUTOSTRING1} |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +Expand(All)     |              0 |    1 |       2 | anon[41], wing -- liskov
| (liskov)-[:KNOWS]->(wing)                      |
| |               +----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+
| +NodeIndexSeek   |              1 |    1 |       2 | liskov
| :Scientist(name)                               |
+-----------------+----------------+------+---------
+-------------------------------------------------------
+------------------------------------------------+

Total database accesses: 20
```

Chapter 13. Execution Plans

Neo4j breaks down the work of executing a query into small pieces called operators. Each operator is responsible for a small part of the overall query. The operators are connected together in a pattern called a execution plan.

Each operator is annotated with statistics.

`Rows`
: The number of rows that the operator produced. Only available if the query was profiled.

`EstimatedRows`
: If Neo4j used the cost-based compiler you will see the estimated number of rows that will be produced by the operator. 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.

See How do I profile a query? for how to view the execution plan for your query.

For a deeper understanding of how each operator works, see the relevant section. Operators are grouped into high-level categories. Please remember that the statistics of the actual database where the queries run on will decide the plan used. There is no guarantee that a specific query will always be solved with the same plan.

13.1. Starting point operators

These operators find parts of the graph from which to start.

13.1.1. All Nodes Scan

Reads all nodes from the node store. The variable that will contain the nodes is seen in the arguments. If your query is using this operator, you are very likely to see performance problems on any non-trivial database.

Query

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

Query Plan

```
+-----------------+----------------+------+---------+-----------+-------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other |
+-----------------+----------------+------+---------+-----------+-------+
| +ProduceResults |             35 |   35 |       0 | n         | n     |
| |               +----------------+------+---------+-----------+-------+
| +AllNodesScan   |             35 |   35 |      36 | n         |       |
+-----------------+----------------+------+---------+-----------+-------+

Total database accesses: 36
```

13.1.2. Directed Relationship By Id Seek

Reads one or more relationships by id from the relationship store. Produces both the relationship and the nodes on either side.

Query

```
MATCH (n1)-[r]->()
WHERE id(r)= 0
RETURN r, n1
```

Query Plan

```
+-----------------------------------+----------------+------+---------+-----------------
+-------------------------------------------+
| Operator                          | Estimated Rows | Rows | DB Hits | Variables       | Other
|
+-----------------------------------+----------------+------+---------+-----------------
+-------------------------------------------+
| +ProduceResults                   |              1 |    1 |       0 | n1, r           | r, n1
|
| |                                 +----------------+------+---------+-----------------
+-------------------------------------------+
| +DirectedRelationshipByIdSeekPipe |              1 |    1 |       1 | anon[17], n1, r |
EntityByIdRhs(SingleSeekArg({  AUTOINT0})) |
+-----------------------------------+----------------+------+---------+-----------------
+-------------------------------------------+

Total database accesses: 1
```

13.1.3. Node by Id seek

Reads one or more nodes by id from the node store.

Query

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

Query Plan

```
+-----------------+----------------+------+---------+-----------+-------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other |
+-----------------+----------------+------+---------+-----------+-------+
| +ProduceResults |              1 |    1 |       0 | n         | n     |
| |               +----------------+------+---------+-----------+-------+
| +NodeByIdSeek   |              1 |    1 |       1 | n         |       |
+-----------------+----------------+------+---------+-----------+-------+

Total database accesses: 1
```

13.1.4. Node by label scan

Using the label index, fetches all nodes with a specific label on them from the node label index.

Query

```
MATCH (person:Person)
RETURN person
```

Query Plan

```
+------------------+----------------+------+---------+-----------+---------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables | Other   |
+------------------+----------------+------+---------+-----------+---------+
| +ProduceResults  |             14 |   14 |       0 | person    | person  |
| |                +----------------+------+---------+-----------+---------+
| +NodeByLabelScan |             14 |   14 |      15 | person    | :Person |
+------------------+----------------+------+---------+-----------+---------+

Total database accesses: 15
```

13.1.5. Node index seek

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 called NodeUniqueIndexSeek instead.

Query

```
MATCH (location:Location { name: "Malmo" })
RETURN location
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+-----------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other           |
+-----------------+----------------+------+---------+-----------+-----------------+
| +ProduceResults |              1 |    1 |       0 | location  | location        |
| |               +----------------+------+---------+-----------+-----------------+
| +NodeIndexSeek  |              1 |    1 |       2 | location  | :Location(name) |
+-----------------+----------------+------+---------+-----------+-----------------+

Total database accesses: 2
```

13.1.6. Node index range seek

Finds nodes using an index seek where the value of the property matches a given prefix string. This operator can be used for STARTS WITH and comparators such as <, >, and >=

Query

```
MATCH (l:Location)
WHERE l.name STARTS WITH 'Lon'
RETURN l
```

Query Plan

```
+----------------------+----------------+------+---------+-----------
+---------------------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Variables | Other
|
+----------------------+----------------+------+---------+-----------
+---------------------------------------------+
| +ProduceResults      |             26 |    1 |       0 | l         | l
|
| |                    +----------------+------+---------+-----------
+---------------------------------------------+
| +NodeIndexSeekByRange |             26 |    1 |       2 | l         | :Location(name STARTS WITH {
AUTOSTRING0}) |
+----------------------+----------------+------+---------+-----------
+---------------------------------------------+

Total database accesses: 2
```

13.1.7. Node index contains scan

An index contains scan goes through all values stored in an index, and searches for entries containing a specific string. This is slower than an index seek, since all entries need to be examined, but still faster than the indirection needed by a label scan and then a property store filter.

Query

```
MATCH (l:Location)
WHERE l.name CONTAINS 'al'
RETURN l
```

Query Plan

```
+-----------------------+----------------+------+---------+-----------+---------------------------------
+
| Operator              | Estimated Rows | Rows | DB Hits | Variables | Other
|
+-----------------------+----------------+------+---------+-----------+---------------------------------
+
| +ProduceResults       |             10 |    2 |       0 | l         | l
|
| |                     +----------------+------+---------+-----------+---------------------------------
+
| +NodeIndexContainsScan |             10 |    2 |       3 | l         | :Location(name); {  AUTOSTRING0}
|
+-----------------------+----------------+------+---------+-----------+---------------------------------
+

Total database accesses: 3
```

13.1.8. Node index scan

An index scan goes through all values stored in an index, and can be used to find all nodes with a particular label having a specified property (e.g. `exists(n.prop)`).

Query

```
MATCH (l:Location)
WHERE exists(l.name)
RETURN l
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+-----------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other           |
+-----------------+----------------+------+---------+-----------+-----------------+
| +ProduceResults |             10 |   10 |       0 | l         | l               |
| |               +----------------+------+---------+-----------+-----------------+
| +NodeIndexScan  |             10 |   10 |      11 | l         | :Location(name) |
+-----------------+----------------+------+---------+-----------+-----------------+

Total database accesses: 11
```

13.1.9. Undirected Relationship By Id Seek

Reads one or more relationships by id from the relationship store. For each relationship, two rows are produced with start and end nodes arranged differently.

Query

```
MATCH (n1)-[r]-()
WHERE id(r)= 1
RETURN r, n1
```

Query Plan

```
+--------------------------------+----------------+------+---------+-----------------+-------+
| Operator                       | Estimated Rows | Rows | DB Hits | Variables       | Other |
+--------------------------------+----------------+------+---------+-----------------+-------+
| +ProduceResults                |              1 |    2 |       0 | n1, r           | r, n1 |
| |                              +----------------+------+---------+-----------------+-------+
| +UndirectedRelationshipByIdSeek |              1 |    2 |       1 | anon[16], n1, r |       |
+--------------------------------+----------------+------+---------+-----------------+-------+

Total database accesses: 1
```

13.2. Expand operators

Thes operators explore the graph by expanding graph patterns.

13.2.1. Expand All

Given a start node, expand-all will follow relationships coming in or out, depending on the pattern relationship. Can also handle variable length pattern relationships.

Query

```
MATCH (p:Person { name: "me" })-[:FRIENDS_WITH]->(fof)
RETURN fof
```

Query Plan

```
+-----------------+----------------+------+---------+--------------------+----------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables          | Other                      |
+-----------------+----------------+------+---------+--------------------+----------------------------+
| +ProduceResults |              0 |    1 |       0 | fof                | fof                        |
| |               +----------------+------+---------+--------------------+----------------------------+
| +Expand(All)    |              0 |    1 |       2 | anon[30], fof -- p | (p)-[:FRIENDS_WITH]->(fof) |
| |               +----------------+------+---------+--------------------+----------------------------+
| +NodeIndexSeek  |              1 |    1 |       2 | p                  | :Person(name)              |
+-----------------+----------------+------+---------+--------------------+----------------------------+

Total database accesses: 4
```

13.2.2. Expand Into

When both the start and end node have already been found, expand-into is used to find all connecting relationships between the two nodes.

Query

```
MATCH (p:Person { name: "me" })-[:FRIENDS_WITH]->(fof)-->(p)
RETURN fof
```

Query Plan

```
+-----------------+----------------+------+---------+-----------------------------
+---------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables                   | Other
|
+-----------------+----------------+------+---------+-----------------------------
+---------------------------+
| +ProduceResults |              0 |    0 |       0 | fof                         | fof
|
| |               +----------------+------+---------+-----------------------------
+---------------------------+
| +Filter         |              0 |    0 |       0 | anon[30], anon[53], fof, p  | NOT(anon[30] ==
anon[53])  |
| |               +----------------+------+---------+-----------------------------
+---------------------------+
| +Expand(Into)   |              0 |    0 |       0 | anon[30] -- anon[53], fof, p | (p)-[:FRIENDS_WITH]-
>(fof) |
| |               +----------------+------+---------+-----------------------------
+---------------------------+
| +Expand(All)    |              0 |    0 |       1 | anon[53], fof -- p          | (p)<--(fof)
|
| |               +----------------+------+---------+-----------------------------
+---------------------------+
| +NodeIndexSeek  |              1 |    1 |       2 | p                           | :Person(name)
|
+-----------------+----------------+------+---------+-----------------------------
+---------------------------+

Total database accesses: 3
```

13.2.3. Optional Expand All

Optional expand traverses relationships from a given node, and makes sure that predicates are evaluated before producing rows.

If no matching relationships are found, a single row with `NULL` for the relationship and end node variable is produced.

Query

```
MATCH (p:Person)
OPTIONAL MATCH (p)-[works_in:WORKS_IN]->(l)
WHERE works_in.duration > 180
RETURN p, l
```

Query Plan

```
+----------------------+----------------+------+---------+------------------
+-------------------------------+
| Operator             | Estimated Rows | Rows | DB Hits | Variables        | Other
|
+----------------------+----------------+------+---------+------------------
+-------------------------------+
| +ProduceResults      |             14 |   15 |       0 | l, p             | p, l
|
| |                    +----------------+------+---------+------------------
+-------------------------------+
| +OptionalExpand(All) |             14 |   15 |      44 | l, works_in -- p | (p)-[works_in:WORKS_IN]->(l)
|
| |                    +----------------+------+---------+------------------
+-------------------------------+
| +NodeByLabelScan     |             14 |   14 |      15 | p                | :Person
|
+----------------------+----------------+------+---------+------------------
+-------------------------------+

Total database accesses: 59
```

13.3. Combining operators

The combining operators are used to piece together other operators.

The following graph is used for the examples below:

Figure 23. Graph

13.3.1. Apply

`Apply` works by performing a nested loop. Every row being produced on the left-hand side of the `Apply` operator will be fed to the leaf operator on the right-hand side, and then `Apply` will yield the combined results. `Apply`, being a nested loop, can be seen as a warning that a better plan was not found.

Query

```
MATCH (p:Person)-[:FRIENDS_WITH]->(f)
WITH p, count(f) AS fs
WHERE fs > 2
OPTIONAL MATCH (p)-[:WORKS_IN]->(city)
RETURN city.name
```

Finds all the people with more than two friends and returns the city they work in.

Query plan

```
+----------------------+----------------+--------------------------------------------
+--------------------------+
| Operator             | Estimated Rows | Variables                                  | Other
|
+----------------------+----------------+--------------------------------------------
+--------------------------+
| +ProduceResults      |              1 | city.name                                  | city.name
|
| |                    +----------------+--------------------------------------------
+--------------------------+
| +Projection          |              1 | city.name -- anon[70], anon[93], city, fs, p | city.name
|
| |                    +----------------+--------------------------------------------
+--------------------------+
| +OptionalExpand(All) |              1 | anon[93], city -- anon[70], fs, p          | (p)-[:WORKS_IN]-
>(city)  |
| |                    +----------------+--------------------------------------------
+--------------------------+
| +Filter              |              1 | anon[70], fs, p                            | anon[70]
|
| |                    +----------------+--------------------------------------------
+--------------------------+
| +Projection          |              1 | anon[70] -- fs, p                          | p; fs; fs > {
AUTOINT0} |
| |                    +----------------+--------------------------------------------
+--------------------------+
| +EagerAggregation    |              1 | fs -- p                                    | p
|
| |                    +----------------+--------------------------------------------
+--------------------------+
| +Expand(All)         |              2 | anon[17], f -- p                           | (p)-
[:FRIENDS_WITH]->(f) |
| |                    +----------------+--------------------------------------------
+--------------------------+
| +NodeByLabelScan     |             14 | p                                          | :Person
|
+----------------------+----------------+--------------------------------------------
+--------------------------+

Total database accesses: ?
```

13.3.2. SemiApply

Tests for the existence of a pattern predicate. `SemiApply` takes a row from its child operator and feeds it to the leaf operator on the right-hand side. If the right-hand side operator tree yields at least one row, the row from the left-hand side 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]->()
RETURN p.name
```

Finds all the people who have friends.

Query plan

```
+------------------+----------------+-------------------------+-------------------------+
| Operator         | Estimated Rows | Variables               | Other                   |
+------------------+----------------+-------------------------+-------------------------+
| +ProduceResults  |             11 | p.name                  | p.name                  |
| |                +----------------+-------------------------+-------------------------+
| +Projection      |             11 | p.name -- p             | p.name                  |
| |                +----------------+-------------------------+-------------------------+
| +SemiApply       |             11 | p                       |                         |
| |\               +----------------+-------------------------+-------------------------+
| | +Expand(All)   |              2 | anon[27], anon[45] -- p | (p)-[:FRIENDS_WITH]->() |
| | |              +----------------+-------------------------+-------------------------+
| | +Argument      |             14 | p                       |                         |
| |                +----------------+-------------------------+-------------------------+
| +NodeByLabelScan |             14 | p                       | :Person                 |
+------------------+----------------+-------------------------+-------------------------+

Total database accesses: ?
```

13.3.3. AntiSemiApply

Tests for the existence of a pattern predicate. `SemiApply` takes a row from its child operator and feeds it to the leaf operator on the right-hand side. If the right-hand side operator tree yields at least one row, the row from the left-hand side is yielded by the `SemiApply` operator. This makes `SemiApply` a filtering operator, used mostly for pattern predicates in queries.

Query

```
MATCH (me:Person { name: "me" }),(other:Person)
WHERE NOT (me)-[:FRIENDS_WITH]->(other)
RETURN other.name
```

Finds the names of all the people who are not my friends.

Query plan

```
+--------------------+----------------+-------------------------+-------------------------------+
| Operator           | Estimated Rows | Variables               | Other                         |
+--------------------+----------------+-------------------------+-------------------------------+
| +ProduceResults    |              4 | other.name              | other.name                    |
| |                  +----------------+-------------------------+-------------------------------+
| +Projection        |              4 | other.name -- me, other | other.name                    |
| |                  +----------------+-------------------------+-------------------------------+
| +AntiSemiApply     |              4 | me, other               |                               |
| |\                 +----------------+-------------------------+-------------------------------+
| | +Expand(Into)    |              0 | anon[62] -- me, other   | (me)-[:FRIENDS_WITH]->(other) |
| | |                +----------------+-------------------------+-------------------------------+
| | +Argument        |             14 | me, other               |                               |
| |                  +----------------+-------------------------+-------------------------------+
| +CartesianProduct  |             14 | me -- other             |                               |
| |\                 +----------------+-------------------------+-------------------------------+
| | +NodeByLabelScan |             14 | other                   | :Person                       |
| |                  +----------------+-------------------------+-------------------------------+
| +NodeIndexSeek     |              1 | me                      | :Person(name)                 |
+--------------------+----------------+-------------------------+-------------------------------+

Total database accesses: ?
```

13.3.4. LetSemiApply

Tests for the existence of a pattern predicate. When a query contains multiple pattern predicates `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 a another operator.

Query

```
MATCH (other:Person)
WHERE (other)-[:FRIENDS_WITH]->() OR (other)-[:WORKS_IN]->()
RETURN other.name
```

Finds the names of all the people who have a friend or who work somewhere. The `LetSemiApply` operator will be used to check for the existence of the `FRIENDS_WITH` relationship from each person.

Query plan

```
+--------------------+----------------+------------------------------+-----------------------------+
| Operator           | Estimated Rows | Variables                    | Other                       |
+--------------------+----------------+------------------------------+-----------------------------+
| +ProduceResults    |             13 | other.name                   | other.name                  |
| |                  +----------------+------------------------------+-----------------------------+
| +Projection        |             13 | other.name -- anon[27], other | other.name                  |
| |                  +----------------+------------------------------+-----------------------------+
| +SelectOrSemiApply |             13 | anon[27] -- other            | anon[27]                    |
| |\                 +----------------+------------------------------+-----------------------------+
| | +Expand(All)     |             15 | anon[66], anon[80] -- other  | (other)-[:WORKS_IN]->()     |
| | |                +----------------+------------------------------+-----------------------------+
| | +Argument        |             14 | other                        |                             |
| |                  +----------------+------------------------------+-----------------------------+
| +LetSemiApply      |             14 | anon[27] -- other            |                             |
| |\                 +----------------+------------------------------+-----------------------------+
| | +Expand(All)     |              2 | anon[35], anon[53] -- other  | (other)-[:FRIENDS_WITH]->() |
| | |                +----------------+------------------------------+-----------------------------+
| | +Argument        |             14 | other                        |                             |
| |                  +----------------+------------------------------+-----------------------------+
| +NodeByLabelScan   |             14 | other                        | :Person                     |
+--------------------+----------------+------------------------------+-----------------------------+

Total database accesses: ?
```

13.3.5. LetAntiSemiApply

Tests for the absence of a pattern predicate. When a query contains multiple pattern predicates `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. The following query will find all the people who don't have any friends or who work somewhere.

Query

```
MATCH (other:Person)
WHERE NOT ((other)-[:FRIENDS_WITH]->()) OR (other)-[:WORKS_IN]->()
RETURN other.name
```

Finds all the people who don't have any friends or who work somewhere. The `LetAntiSemiApply` operator will be used to check for the absence of the `FRIENDS_WITH` relationship from each person.

Query plan

```
+--------------------+----------------+------------------------------+-----------------------------+
| Operator           | Estimated Rows | Variables                    | Other                       |
+--------------------+----------------+------------------------------+-----------------------------+
| +ProduceResults    |             11 | other.name                   | other.name                  |
| |                  +----------------+------------------------------+-----------------------------+
| +Projection        |             11 | other.name -- anon[31], other | other.name                  |
| |                  +----------------+------------------------------+-----------------------------+
| +SelectOrSemiApply |             11 | anon[31] -- other            | anon[31]                    |
| |\                 +----------------+------------------------------+-----------------------------+
| | +Expand(All)     |             15 | anon[71], anon[85] -- other  | (other)-[:WORKS_IN]->()     |
| | |                +----------------+------------------------------+-----------------------------+
| | +Argument        |             14 | other                        |                             |
| |                  +----------------+------------------------------+-----------------------------+
| +LetAntiSemiApply  |             14 | anon[31] -- other            |                             |
| |\                 +----------------+------------------------------+-----------------------------+
| | +Expand(All)     |              2 | anon[39], anon[57] -- other  | (other)-[:FRIENDS_WITH]->() |
| | |                +----------------+------------------------------+-----------------------------+
| | +Argument        |             14 | other                        |                             |
| |                  +----------------+------------------------------+-----------------------------+
| +NodeByLabelScan   |             14 | other                        | :Person                     |
+--------------------+----------------+------------------------------+-----------------------------+

Total database accesses: ?
```

13.3.6. SelectOrSemiApply

Tests for the existence of a pattern predicate and evaluates a predicate. This operator allows for the mixing of normal predicates and pattern predicates that check for the existence of a pattern. First the normal expression predicate is evaluated, and only if it returns `false` the costly pattern predicate evaluation is performed.

Query

```
MATCH (other:Person)
WHERE other.age > 25 OR (other)-[:FRIENDS_WITH]->()
RETURN other.name
```

Finds the names of all people who have friends, or are older than 25.

Query plan

```
+--------------------+----------------+------------------------------+-----------------------------+
| Operator           | Estimated Rows | Variables                    | Other                       |
+--------------------+----------------+------------------------------+-----------------------------+
| +ProduceResults    |             11 | other.name                   | other.name                  |
| |                  +----------------+------------------------------+-----------------------------+
| +Projection        |             11 | other.name -- other          | other.name                  |
| |                  +----------------+------------------------------+-----------------------------+
| +SelectOrSemiApply |             11 | other                        | other.age > {  AUTOINT0}    |
| |\                 +----------------+------------------------------+-----------------------------+
| | +Expand(All)     |              2 | anon[53], anon[71] -- other  | (other)-[:FRIENDS_WITH]->() |
| | |                +----------------+------------------------------+-----------------------------+
| | +Argument        |             14 | other                        |                             |
| |                  +----------------+------------------------------+-----------------------------+
| +NodeByLabelScan   |             14 | other                        | :Person                     |
+--------------------+----------------+------------------------------+-----------------------------+

Total database accesses: ?
```

13.3.7. SelectOrAntiSemiApply

Tests for the absence of a pattern predicate and evaluates a predicate.

Query

```
MATCH (other:Person)
WHERE other.age > 25 OR NOT (other)-[:FRIENDS_WITH]->()
RETURN other.name
```

Finds the names of all people who do not have friends, or are older than 25.

Query plan

```
+-----------------------+----------------+-----------------------------+-----------------------------+
| Operator              | Estimated Rows | Variables                   | Other                       |
+-----------------------+----------------+-----------------------------+-----------------------------+
| +ProduceResults       |              4 | other.name                  | other.name                  |
| |                     +----------------+-----------------------------+-----------------------------+
| +Projection           |              4 | other.name -- other         | other.name                  |
| |                     +----------------+-----------------------------+-----------------------------+
| +SelectOrAntiSemiApply |              4 | other                       | other.age > {  AUTOINT0}    |
| |\                    +----------------+-----------------------------+-----------------------------+
| | +Expand(All)        |              2 | anon[57], anon[75] -- other | (other)-[:FRIENDS_WITH]->() |
| | |                   +----------------+-----------------------------+-----------------------------+
| | +Argument           |             14 | other                       |                             |
| |                     +----------------+-----------------------------+-----------------------------+
| +NodeByLabelScan      |             14 | other                       | :Person                     |
+-----------------------+----------------+-----------------------------+-----------------------------+

Total database accesses: ?
```

13.3.8. ConditionalApply

Checks whether a variable is not `null`, and if so the right-hand side will be executed.

Query

```
MERGE (p:Person { name: 'Andres' })
ON MATCH SET p.exists = TRUE
```

Looks for the existence of a person called Andres, and if found sets the `exists` property to `true`.

Query plan

```
+----------------------+----------------+-----------+---------------+
| Operator             | Estimated Rows | Variables | Other         |
+----------------------+----------------+-----------+---------------+
| +ProduceResults      |              1 |           |               |
| |                    +----------------+-----------+---------------+
| +EmptyResult         |                |           |               |
| |                    +----------------+-----------+---------------+
| +AntiConditionalApply |              1 | p         |               |
| |\                   +----------------+-----------+---------------+
| | +MergeCreateNode   |              1 | p         |               |
| |                    +----------------+-----------+---------------+
| +ConditionalApply    |              1 | p         |               |
| |\                   +----------------+-----------+---------------+
| | +SetNodeProperty   |              1 | p         |               |
| | |                  +----------------+-----------+---------------+
| | +Argument          |              1 | p         |               |
| |                    +----------------+-----------+---------------+
| +Optional            |              1 | p         |               |
| |                    +----------------+-----------+---------------+
| +NodeIndexSeek       |              1 | p         | :Person(name) |
+----------------------+----------------+-----------+---------------+

Total database accesses: ?
```

13.3.9. AntiConditionalApply

Checks whether a variable is `null`, and if so the right-hand side will be executed.

Query

```
MERGE (p:Person { name: 'Andres' })
ON CREATE SET p.exists = TRUE
```

Looks for the existence of a person called Andres, and if not found, creates one and sets the `exists` property to `true`.

Query plan

```
+----------------------+----------------+-----------+---------------+
| Operator             | Estimated Rows | Variables | Other         |
+----------------------+----------------+-----------+---------------+
| +ProduceResults      |              1 |           |               |
| |                    +----------------+-----------+---------------+
| +EmptyResult         |                |           |               |
| |                    +----------------+-----------+---------------+
| +AntiConditionalApply|              1 | p         |               |
| |\                   +----------------+-----------+---------------+
| | +SetNodeProperty   |              1 | p         |               |
| | |                  +----------------+-----------+---------------+
| | +MergeCreateNode   |              1 | p         |               |
| |                    +----------------+-----------+---------------+
| +Optional            |              1 | p         |               |
| |                    +----------------+-----------+---------------+
| +NodeIndexSeek       |              1 | p         | :Person(name) |
+----------------------+----------------+-----------+---------------+

Total database accesses: ?
```

13.3.10. AssertSameNode

This operator is used to ensure that no uniqueness constraints are violated.

Query

```
MERGE (t:Team { name: 'Engineering', id: 42 })
```

Looks for the existence of a team with the supplied name and id, and if one does not exist, it will be created. Due to the existence of two uniqueness constraints on `:Team(name)` and `:Team(id)`, any node that would be found by the `UniqueIndexSeek`s must be the very same node, or the constraints would be violated.

Query plan

```
+--------------------------------+----------------+-----------+-------------+
| Operator                       | Estimated Rows | Variables | Other       |
+--------------------------------+----------------+-----------+-------------+
| +ProduceResults                |              1 |           |             |
| |                              +----------------+-----------+-------------+
| +EmptyResult                   |                |           |             |
| |                              +----------------+-----------+-------------+
| +AntiConditionalApply          |              1 | t         |             |
| |\                             +----------------+-----------+-------------+
| | +MergeCreateNode             |              1 | t         |             |
| |                              +----------------+-----------+-------------+
| +Optional                      |              1 | t         |             |
| |                              +----------------+-----------+-------------+
| +AssertSameNode                |              0 | t         |             |
| |\                             +----------------+-----------+-------------+
| | +NodeUniqueIndexSeek(Locking) |              1 | t         | :Team(id)   |
| |                              +----------------+-----------+-------------+
| +NodeUniqueIndexSeek(Locking)  |              1 | t         | :Team(name) |
+--------------------------------+----------------+-----------+-------------+

Total database accesses: ?
```

13.3.11. NodeHashJoin

Using a hash table, a `NodeHashJoin` joins the input coming from the left with the input coming from the right.

Query

```
MATCH (andy:Person { name:'Andreas' })-[:WORKS_IN]->(loc)<-[:WORKS_IN]-(matt:Person { name:'Mattis' })
RETURN loc.name
```

Returns the name of the location where the matched persons both work.

Query plan

```
+------------------+----------------+-------------------------------------------------
+---------------------------+
| Operator         | Estimated Rows | Variables                                       | Other
|
+------------------+----------------+-------------------------------------------------
+---------------------------+
| +ProduceResults  |             10 | loc.name                                        | loc.name
|
| |                +----------------+-------------------------------------------------
+---------------------------+
| +Projection      |             10 | loc.name -- anon[37], anon[56], andy, loc, matt | loc.name
|
| |                +----------------+-------------------------------------------------
+---------------------------+
| +Filter          |             10 | anon[37], anon[56], andy, loc, matt             | NOT(anon[37] ==
anon[56]) |
| |                +----------------+-------------------------------------------------
+---------------------------+
| +NodeHashJoin    |             10 | anon[37], andy -- anon[56], loc, matt           | loc
|
| |\               +----------------+-------------------------------------------------
+---------------------------+
| | +Expand(All)   |             19 | anon[56], loc -- matt                           | (matt)-
[:WORKS_IN]->(loc) |
| | |              +----------------+-------------------------------------------------
+---------------------------+
| | +NodeIndexSeek |              1 | matt                                            | :Person(name)
|
| |                +----------------+-------------------------------------------------
+---------------------------+
| +Expand(All)     |             19 | anon[37], loc -- andy                           | (andy)-
[:WORKS_IN]->(loc) |
| |                +----------------+-------------------------------------------------
+---------------------------+
| +NodeIndexSeek   |              1 | andy                                            | :Person(name)
|
+------------------+----------------+-------------------------------------------------
+---------------------------+

Total database accesses: ?
```

13.3.12. Triadic

Triadic 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 in a set, and use that set to check if the friend-of-friends are already connected to me.

Query

```
MATCH (me:Person)-[:FRIENDS_WITH]-()-[:FRIENDS_WITH]-(other)
WHERE NOT (me)-[:FRIENDS_WITH]-(other)
RETURN other.name
```

Finds the names of all friends of my friends that are not already my friends.

Query plan

```
+-------------------+----------------+-------------------------------------------------------
+----------------------------+
| Operator          | Estimated Rows | Variables                                             | Other
|
+-------------------+----------------+-------------------------------------------------------
+----------------------------+
| +ProduceResults   |              0 | other.name                                            | other.name
|
| |                 +----------------+-------------------------------------------------------
+----------------------------+
| +Projection       |              0 | other.name -- anon[18], anon[35], anon[37], me, other | other.name
|
| |                 +----------------+-------------------------------------------------------
+----------------------------+
| +TriadicSelection |              0 | anon[18], anon[35], me -- anon[37], other             | me,
anon[35], other        |
| |\                +----------------+-------------------------------------------------------
+----------------------------+
| | +Filter         |              0 | anon[37], other                                       |
NOT(anon[18] == anon[37])  |
| | |               +----------------+-------------------------------------------------------
+----------------------------+
| | +Expand(All)    |              0 | anon[37], other                                       | ()-
[:FRIENDS_WITH]-(other) |
| | |               +----------------+-------------------------------------------------------
+----------------------------+
| | +Argument       |              4 |                                                       |
|
| |                 +----------------+-------------------------------------------------------
+----------------------------+
| +Expand(All)      |              4 | anon[18], anon[35] -- me                              | (me)-
[:FRIENDS_WITH]-()    |
| |                 +----------------+-------------------------------------------------------
+----------------------------+
| +NodeByLabelScan  |             14 | me                                                    | :Person
|
+-------------------+----------------+-------------------------------------------------------
+----------------------------+

Total database accesses: ?
```

13.4. Row operators

These operators take rows produced by another operator and transform them to a different set of rows

13.4.1. Eager

For isolation purposes this operator makes sure that operations that affect subsequent operations are executed fully for the whole dataset before continuing execution. Otherwise it could trigger endless loops, matching data again, that was just created. The Eager operator can cause high memory usage when importing data or migrating graph structures. In such cases split up your operations into simpler steps e.g. you can import nodes and relationships separately. Alternatively return the records to be updated and run an update statement afterwards.

Query

```
MATCH (a)-[r]-(b)
DELETE r,a,b
MERGE ()
```

Query Plan

```
+-------------------------+----------------+------+---------+----------------------+--------------+
| Operator                | Estimated Rows | Rows | DB Hits | Variables            | Other        |
+-------------------------+----------------+------+---------+----------------------+--------------+
| +ProduceResults         |              1 |    0 |       0 |                      |              |
| |                       +----------------+------+---------+----------------------+--------------+
| +EmptyResult            |                |    0 |       0 |                      |              |
| |                       +----------------+------+---------+----------------------+--------------+
| +Apply                  |              1 |  504 |       0 | a, b, r -- anon[38]  |              |
| |\                      +----------------+------+---------+----------------------+--------------+
| | +AntiConditionalApply |              1 |  504 |       0 | anon[38]             |              |
| | |\                    +----------------+------+---------+----------------------+--------------+
| | | +MergeCreateNode    |              1 |    0 |       0 | anon[38]             |              |
| | |                     +----------------+------+---------+----------------------+--------------+
| | +Optional             |             35 |  504 |       0 | anon[38]             |              |
| | |                     +----------------+------+---------+----------------------+--------------+
| | +AllNodesScan         |             35 |  504 |     540 | anon[38]             |              |
| |                       +----------------+------+---------+----------------------+--------------+
| +Eager                  |                |   36 |       0 | a, b, r              |              |
| |                       +----------------+------+---------+----------------------+--------------+
| +Delete(3)              |             36 |   36 |      39 | a, b, r              |              |
| |                       +----------------+------+---------+----------------------+--------------+
| +Eager                  |                |   36 |       0 | a, b, r              |              |
| |                       +----------------+------+---------+----------------------+--------------+
| +Expand(All)            |             36 |   36 |      71 | a, r -- b            | (b)-[r:]-(a) |
| |                       +----------------+------+---------+----------------------+--------------+
| +AllNodesScan           |             35 |   35 |      36 | b                    |              |
+-------------------------+----------------+------+---------+----------------------+--------------+

Total database accesses: 686
```

13.4.2. Distinct

Removes duplicate rows from the incoming stream of rows.

Query

```
MATCH (l:Location)<-[:WORKS_IN]-(p:Person)
RETURN DISTINCT l
```

Query Plan

```
+------------------+----------------+------+---------+------------------+----------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables        | Other                |
+------------------+----------------+------+---------+------------------+----------------------+
| +ProduceResults  |             14 |    6 |       0 | l                | l                    |
| |                +----------------+------+---------+------------------+----------------------+
| +Distinct        |             14 |    6 |       0 | l                | l                    |
| |                +----------------+------+---------+------------------+----------------------+
| +Filter          |             15 |   15 |      15 | anon[19], l, p   | p:Person             |
| |                +----------------+------+---------+------------------+----------------------+
| +Expand(All)     |             15 |   15 |      25 | anon[19], p -- l | (l)<-[:WORKS_IN]-(p) |
| |                +----------------+------+---------+------------------+----------------------+
| +NodeByLabelScan |             10 |   10 |      11 | l                | :Location            |
+------------------+----------------+------+---------+------------------+----------------------+

Total database accesses: 51
```

13.4.3. Eager Aggregation

Eagerly loads underlying results and stores it in a hash-map, using the grouping keys as the keys for the map.

Query

```
MATCH (l:Location)<-[:WORKS_IN]-(p:Person)
RETURN l.name AS location, COLLECT(p.name) AS people
```

Query Plan

```
+------------------+----------------+------+---------+---------------------------+----------------------
+
| Operator         | Estimated Rows | Rows | DB Hits | Variables                 | Other
|
+------------------+----------------+------+---------+---------------------------+----------------------
+
| +ProduceResults  |              4 |    6 |       0 | location, people          | location, people
|
| |                +----------------+------+---------+---------------------------+----------------------
+
| +EagerAggregation |             4 |    6 |      15 | people -- location        | location
|
| |                +----------------+------+---------+---------------------------+----------------------
+
| +Projection      |             15 |   15 |      15 | location -- anon[19], l, p | l.name; p
|
| |                +----------------+------+---------+---------------------------+----------------------
+
| +Filter          |             15 |   15 |      15 | anon[19], l, p            | p:Person
|
| |                +----------------+------+---------+---------------------------+----------------------
+
| +Expand(All)     |             15 |   15 |      25 | anon[19], p -- l          | (l)<-[:WORKS_IN]-(p)
|
| |                +----------------+------+---------+---------------------------+----------------------
+
| +NodeByLabelScan |             10 |   10 |      11 | l                         | :Location
|
+------------------+----------------+------+---------+---------------------------+----------------------
+

Total database accesses: 81
```

13.4.4. Node Count From Count Store

Use the count store to answer questions about node counts. This is much faster than eager aggregation which achieves the same result by actually counting. However the count store only saves a limited range of combinations, so eager aggregation 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

```
+-------------------------+----------------+------+---------+-----------+-----------------------------+
| Operator                | Estimated Rows | Rows | DB Hits | Variables | Other                       |
+-------------------------+----------------+------+---------+-----------+-----------------------------+
| +ProduceResults         |              4 |    1 |       0 | people    | people                      |
| |                       +----------------+------+---------+-----------+-----------------------------+
| +NodeCountFromCountStore |             4 |    1 |       0 | people    | count( (:Person) ) AS people |
+-------------------------+----------------+------+---------+-----------+-----------------------------+

Total database accesses: 0
```

13.4.5. Relationship Count From Count Store

Use the count store to answer questions about relationship counts. This is much faster than eager aggregation which achieves the same result by actually counting. However the count store only saves a limited range of combinations, so eager aggregation 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

```
+-----------------------------------+----------------+------+---------+-----------
+-------------------------------------------+
| Operator                          | Estimated Rows | Rows | DB Hits | Variables | Other
|
+-----------------------------------+----------------+------+---------+-----------
+-------------------------------------------+
| +ProduceResults                   |              4 |    1 |       0 | jobs      | jobs
|
| |                                 +----------------+------+---------+-----------
+-------------------------------------------+
| +RelationshipCountFromCountStore |              4 |    1 |       1 | jobs      | count( (:Person)-
[:WORKS_IN]->() ) AS jobs |
+-----------------------------------+----------------+------+---------+-----------
+-------------------------------------------+

Total database accesses: 1
```

13.4.6. Filter

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

```
+------------------+----------------+------+---------+-----------+-----------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables | Other                       |
+------------------+----------------+------+---------+-----------+-----------------------------+
| +ProduceResults  |             14 |    0 |       0 | p         | p                           |
| |                +----------------+------+---------+-----------+-----------------------------+
| +Filter          |             14 |    0 |      14 | p         | p.name ~= /{  AUTOSTRING0}/ |
| |                +----------------+------+---------+-----------+-----------------------------+
| +NodeByLabelScan |             14 |   14 |      15 | p         | :Person                     |
+------------------+----------------+------+---------+-----------+-----------------------------+

Total database accesses: 29
```

13.4.7. Limit

Returns the first 'n' rows from the incoming input.

Query

```
MATCH (p:Person)
RETURN p
LIMIT 3
```

Query Plan

```
+------------------+----------------+------+---------+-----------+------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables | Other      |
+------------------+----------------+------+---------+-----------+------------+
| +ProduceResults  |              3 |    3 |       0 | p         | p          |
| |                +----------------+------+---------+-----------+------------+
| +Limit           |              3 |    3 |       0 | p         | Literal(3) |
| |                +----------------+------+---------+-----------+------------+
| +NodeByLabelScan |             14 |    3 |       4 | p         | :Person    |
+------------------+----------------+------+---------+-----------+------------+

Total database accesses: 4
```

13.4.8. Projection

For each row from its input, projection evaluates a set of expressions and produces a row with the results of the expressions.

Query

```
RETURN "hello" AS greeting
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+-----------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other           |
+-----------------+----------------+------+---------+-----------+-----------------+
| +ProduceResults |              1 |    1 |       0 | greeting  | greeting        |
| |               +----------------+------+---------+-----------+-----------------+
| +Projection     |              1 |    1 |       0 | greeting  | {  AUTOSTRING0} |
+-----------------+----------------+------+---------+-----------+-----------------+

Total database accesses: 0
```

13.4.9. Skip

Skips 'n' rows from the incoming rows

Query

```
MATCH (p:Person)
RETURN p
ORDER BY p.id
SKIP 1
```

Query Plan

```
+------------------+----------------+------+---------+----------------------------+-----------------------
+
| Operator         | Estimated Rows | Rows | DB Hits | Variables                  | Other
|
+------------------+----------------+------+---------+----------------------------+-----------------------
+
| +ProduceResults  |             14 |   13 |       0 | p                          | p
|
| |                +----------------+------+---------+----------------------------+-----------------------
+
| +Projection      |             14 |   13 |       0 | p -- anon[35], anon[59], p | anon[35]
|
| |                +----------------+------+---------+----------------------------+-----------------------
+
| +Skip            |             14 |   13 |       0 | anon[35], anon[59], p      | {  AUTOINT0}
|
| |                +----------------+------+---------+----------------------------+-----------------------
+
| +Sort            |             14 |   14 |       0 | anon[35], anon[59], p      | anon[59]
|
| |                +----------------+------+---------+----------------------------+-----------------------
+
| +Projection      |             14 |   14 |      28 | anon[59] -- anon[35], p    | anon[35]; anon[35].id
|
| |                +----------------+------+---------+----------------------------+-----------------------
+
| +Projection      |             14 |   14 |       0 | anon[35] -- p              | p
|
| |                +----------------+------+---------+----------------------------+-----------------------
+
| +NodeByLabelScan |             14 |   14 |      15 | p                          | :Person
|
+------------------+----------------+------+---------+----------------------------+-----------------------
+

Total database accesses: 43
```

13.4.10. Sort

Sorts rows by a provided key.

Query

```
MATCH (p:Person)
RETURN p
ORDER BY p.name
```

Query Plan

```
+------------------+----------------+------+---------+----------------------------
+-------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables                  | Other
|
+------------------+----------------+------+---------+----------------------------
+-------------------------+
| +ProduceResults  |             14 |   14 |       0 | p                          | p
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Projection      |             14 |   14 |       0 | p -- anon[24], anon[37], p | anon[24]
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Sort            |             14 |   14 |       0 | anon[24], anon[37], p      | anon[37]
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Projection      |             14 |   14 |      14 | anon[37] -- anon[24], p    | anon[24];
anon[24].name |
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Projection      |             14 |   14 |       0 | anon[24] -- p              | p
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +NodeByLabelScan |             14 |   14 |      15 | p                          | :Person
|
+------------------+----------------+------+---------+----------------------------
+-------------------------+

Total database accesses: 29
```

13.4.11. Top

Returns the first 'n' rows sorted by a provided key. The physical operator is called `Top`. Instead of sorting the whole input, only the top X rows are kept.

Query

```
MATCH (p:Person)
RETURN p
ORDER BY p.name
LIMIT 2
```

Query Plan

```
+------------------+----------------+------+---------+----------------------------
+-------------------------+
| Operator         | Estimated Rows | Rows | DB Hits | Variables                  | Other
|
+------------------+----------------+------+---------+----------------------------
+-------------------------+
| +ProduceResults  |              2 |    2 |       0 | p                          | p
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Projection      |              2 |    2 |       0 | p -- anon[24], anon[37], p | anon[24]
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Top             |              2 |    2 |       0 | anon[24], anon[37], p      | Literal(2); anon[37]
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Projection      |             14 |   14 |      14 | anon[37] -- anon[24], p    | anon[24];
anon[24].name |
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +Projection      |             14 |   14 |       0 | anon[24] -- p              | p
|
| |                +----------------+------+---------+----------------------------
+-------------------------+
| +NodeByLabelScan |             14 |   14 |      15 | p                          | :Person
|
+------------------+----------------+------+---------+----------------------------
+-------------------------+

Total database accesses: 29
```

13.4.12. Union

Union concatenates the results from the right plan after the results of the left plan.

Query

```
MATCH (p:Location)
RETURN p.name
UNION ALL MATCH (p:Country)
RETURN p.name
```

Query Plan

```
+--------------------+----------------+------+---------+-------------+-----------+
| Operator           | Estimated Rows | Rows | DB Hits | Variables   | Other     |
+--------------------+----------------+------+---------+-------------+-----------+
| +ProduceResults    |             10 |   11 |       0 | p.name      | p.name    |
| |                  +----------------+------+---------+-------------+-----------+
| +Union             |             10 |   11 |       0 | p.name      |           |
| |\                 +----------------+------+---------+-------------+-----------+
| | +Projection      |              1 |    1 |       1 | p.name -- p | p.name    |
| | |                +----------------+------+---------+-------------+-----------+
| | +NodeByLabelScan |              1 |    1 |       2 | p           | :Country  |
| |                  +----------------+------+---------+-------------+-----------+
| +Projection        |             10 |   10 |      10 | p.name -- p | p.name    |
| |                  +----------------+------+---------+-------------+-----------+
| +NodeByLabelScan   |             10 |   10 |      11 | p           | :Location |
+--------------------+----------------+------+---------+-------------+-----------+

Total database accesses: 24
```

13.4.13. Unwind

Takes a list of values and returns one row per item in the list.

Query

```
UNWIND range(1,5) AS value
RETURN value;
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+-------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other |
+-----------------+----------------+------+---------+-----------+-------+
| +ProduceResults |             10 |    5 |       0 | value     | value |
| |               +----------------+------+---------+-----------+-------+
| +Unwind         |             10 |    5 |       0 | value     |       |
| |               +----------------+------+---------+-----------+-------+
| +EmptyRow       |              1 |    1 |       0 |           |       |
+-----------------+----------------+------+---------+-----------+-------+

Total database accesses: 0
```

13.4.14. Call Procedure

Return all labels sorted by name

Query

```
CALL db.labels() YIELD label
RETURN *
ORDER BY label
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+---------------------------------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables | Other                           |
+-----------------+----------------+------+---------+-----------+---------------------------------+
| +ProduceResults |          10000 |    4 |       0 | label     | label                           |
| |               +----------------+------+---------+-----------+---------------------------------+
| +Sort           |          10000 |    4 |       0 | label     | label                           |
| |               +----------------+------+---------+-----------+---------------------------------+
| +ProcedureCall  |          10000 |    4 |       1 | label     | db.labels() :: (label :: String) |
| |               +----------------+------+---------+-----------+---------------------------------+
| +EmptyRow       |              1 |    1 |       0 |           |                                 |
+-----------------+----------------+------+---------+-----------+---------------------------------+

Total database accesses: 1
```

13.5. Update Operators

These operators are used in queries that update the graph.

13.5.1. Constraint Operation

Creates a constraint on a (label,property) pair. The following query will create a unique constraint on the `name` property of nodes with the `Country` label.

Query

```
CREATE CONSTRAINT ON (c:Country) ASSERT c.name IS UNIQUE
```

Query Plan

```
+-------------------------+
| Operator                |
+-------------------------+
| +CreateUniqueConstraint |
+-------------------------+

Total database accesses: ?
```

13.5.2. Empty Result

Eagerly loads everything coming in to the EmptyResult operator and discards it.

Query

```
CREATE (:Person)
```

Query Plan

```
+-----------------+----------------+------+---------+-----------+
| Operator        | Estimated Rows | Rows | DB Hits | Variables |
+-----------------+----------------+------+---------+-----------+
| +ProduceResults |              1 |    0 |       0 |           |
| |               +----------------+------+---------+-----------+
| +EmptyResult    |                |    0 |       0 |           |
| |               +----------------+------+---------+-----------+
| +CreateNode     |              1 |    1 |       2 | anon[8]   |
+-----------------+----------------+------+---------+-----------+

Total database accesses: 2
```

13.5.3. Update Graph

Applies updates to the graph.

Query

```
CYPHER planner=rule
CREATE (:Person { name: "Alistair" })
```

Query Plan

```
+--------------+------+---------+-----------+------------+
| Operator     | Rows | DB Hits | Variables | Other      |
+--------------+------+---------+-----------+------------+
| +EmptyResult |    0 |       0 |           |            |
| |            +------+---------+-----------+------------+
| +UpdateGraph |    1 |       4 | anon[7]   | CreateNode |
+--------------+------+---------+-----------+------------+

Total database accesses: 4
```

13.5.4. Merge Into

When both the start and end node have already been found, merge-into is used to find all connecting relationships or creating a new relationship between the two nodes.

Query

```
CYPHER planner=rule
MATCH (p:Person { name: "me" }),(f:Person { name: "Andres" })
MERGE (p)-[:FRIENDS_WITH]->(f)
```

Query Plan

```
+--------------+------+---------+------------------+--------------------------------+
| Operator     | Rows | DB Hits | Variables        | Other                          |
+--------------+------+---------+------------------+--------------------------------+
| +EmptyResult |    0 |       0 |                  |                                |
| |            +------+---------+------------------+--------------------------------+
| +Merge(Into) |    1 |       5 | anon[68] -- f, p | (p)-[:FRIENDS_WITH]->(f)       |
| |            +------+---------+------------------+--------------------------------+
| +SchemaIndex |    1 |       2 | f -- p           | {  AUTOSTRING1}; :Person(name) |
| |            +------+---------+------------------+--------------------------------+
| +SchemaIndex |    1 |       2 | p                | {  AUTOSTRING0}; :Person(name) |
+--------------+------+---------+------------------+--------------------------------+

Total database accesses: 9
```

13.6. 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.

13.6.1. Shortest path with fast algorithm

Query

```
MATCH (ms:Person { name:'Martin Sheen' }),(cs:Person { name:'Charlie Sheen' }), p = shortestPath((ms)-
[rels:ACTED_IN*]-(cs))
WHERE ALL (r IN rels 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

```
+--------------------+----------------+------+---------+-------------------
+--------------------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Variables         | Other
|
+--------------------+----------------+------+---------+-------------------
+--------------------------------------+
| +ProduceResults    |              1 |    1 |       0 | p                 | p
|
| |                  +----------------+------+---------+-------------------
+--------------------------------------+
| +ShortestPath      |              1 |    1 |       9 | p, rels -- cs, ms | all(r in rels where
hasProp(r.role)) |
| |                  +----------------+------+---------+-------------------
+--------------------------------------+
| +CartesianProduct  |              1 |    1 |       0 | ms -- cs          |
|
| |\                 +----------------+------+---------+-------------------
+--------------------------------------+
| | +Filter          |              1 |    1 |       5 | cs                | cs.name == {  AUTOSTRING1}
|
| | |                +----------------+------+---------+-------------------
+--------------------------------------+
| | +NodeByLabelScan |              5 |    5 |       6 | cs                | :Person
|
| |                  +----------------+------+---------+-------------------
+--------------------------------------+
| +Filter            |              1 |    1 |       5 | ms                | ms.name == {  AUTOSTRING0}
|
| |                  +----------------+------+---------+-------------------
+--------------------------------------+
| +NodeByLabelScan   |              5 |    5 |       6 | ms                | :Person
|
+--------------------+----------------+------+---------+-------------------
+--------------------------------------+

Total database accesses: 31
```

13.6.2. 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

```
+--------------------------+----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| Operator                 | Estimated Rows | Rows | DB Hits | Variables                         | Other
|
+--------------------------+----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| +ProduceResults          |              0 |    1 |       0 | p                                 | p
|
| |                        +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| +AntiConditionalApply    |              0 |    1 |       0 | cs -- anon[93], anon[112], ms, p |
|
| |\                       +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Top1                  |              0 |    0 |       0 | anon[93], anon[112], ms, p       | anon[93]
|
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Projection            |              0 |    0 |       0 | anon[93] -- anon[112], ms, p     |
length(p)                                     |
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Filter                |              0 |    0 |       0 | anon[112], ms, p                 |
length(p) > {  AUTOINT2}                      |
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Projection            |              0 |    0 |       0 | p -- anon[112], ms               |
ProjectedPath(Set(anon[112], cs),<function2>) |
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +VarLengthExpand(Into) |              0 |    0 |       0 | anon[112], ms                    | (cs)-
[:*]->(ms)                                    |
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Argument              |              1 |    0 |       0 |                                   |
|
| |                        +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| +Apply                   |              1 |    1 |       0 | cs, ms -- anon[112], p           |
|
| |\                       +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Optional              |              1 |    1 |       0 | anon[112], p                     |
|
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +ShortestPath          |              0 |    1 |       1 | anon[112], p                     |
length(p) > {  AUTOINT2}                      |
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Argument              |              1 |    1 |       0 |                                   |
|
| |                        +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| +CartesianProduct        |              1 |    1 |       0 | cs -- ms                         |
|
| |\                       +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +Filter                |              1 |    1 |       5 | ms                               | ms.name
== {  AUTOSTRING1}                            |
| | |                      +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| | +NodeByLabelScan       |              5 |    5 |       6 | ms                               | :Person
|
| |                        +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| +Filter                  |              1 |    1 |       5 | cs                               | cs.name
== {  AUTOSTRING0}                            |
| |                        +----------------+------+---------+-----------------------------------
+-----------------------------------------------+
| +NodeByLabelScan         |              5 |    5 |       6 | cs                               | :Person
|
+--------------------------+----------------+------+---------+-----------------------------------
+-----------------------------------------------+

Total database accesses: 23
```

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.

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

```
+--------------------+----------------+------+---------+-----------------------------------
+-----------------------------+
| Operator           | Estimated Rows | Rows | DB Hits | Variables                         | Other
|
+--------------------+----------------+------+---------+-----------------------------------
+-----------------------------+
| +ProduceResults    |              1 |    1 |       0 | p                                 | p
|
| |                  +----------------+------+---------+-----------------------------------
+-----------------------------+
| +Filter            |              1 |    1 |       0 | anon[146], anon[112], cs, ms, p   | anon[146]
|
| |                  +----------------+------+---------+-----------------------------------
+-----------------------------+
| +Projection        |              1 |    1 |       0 | anon[146] -- anon[112], cs, ms, p | p; length(p)
> {  AUTOINT2} |
| |                  +----------------+------+---------+-----------------------------------
+-----------------------------+
| +ShortestPath      |              1 |    1 |       1 | anon[112], p -- cs, ms            |
|
| |                  +----------------+------+---------+-----------------------------------
+-----------------------------+
| +CartesianProduct  |              1 |    1 |       0 | cs -- ms                          |
|
| |\                 +----------------+------+---------+-----------------------------------
+-----------------------------+
| | +Filter          |              1 |    1 |       5 | ms                                | ms.name == {
AUTOSTRING1}  |
| | |                +----------------+------+---------+-----------------------------------
+-----------------------------+
| | +NodeByLabelScan |              5 |    5 |       6 | ms                                | :Person
|
| |                  +----------------+------+---------+-----------------------------------
+-----------------------------+
| +Filter            |              1 |    1 |       5 | cs                                | cs.name == {
AUTOSTRING0}  |
| |                  +----------------+------+---------+-----------------------------------
+-----------------------------+
| +NodeByLabelScan   |              5 |    5 |       6 | cs                                | :Person
|
+--------------------+----------------+------+---------+-----------------------------------
+-----------------------------+

Total database accesses: 23
```

Drivers

Neo4j Drivers are drivers for the Neo4j database *(http://neo4j.com/)*. The drivers use the Bolt protocol and have uniform design and use.

Chapter 14. Introduction

The preferred way to access a Neo4j server from an application is to use a Neo4j driver.

The Neo4j Driver API is the preferred means of programmatic interaction with a Neo4j database server. It implements the Bolt protocol and is available in four languages: C#.NET, Java, JavaScript, and Python.

The API is defined independently of any programming language. This allows for a high degree of uniformity across languages. Uniformity means that the same features are included in all the drivers. The uniformity also influences the design of the API in each language. This provides consistency across drivers, while retaining affinity with the idioms of each programming language.

Chapter 15. Getting Started

Get up and running quickly with a minimal working example.

15.1. Get the driver

15.1.1. Versions

Consult the version table to determine which version of the driver to use with a particular Neo4j server.

Table 49. Supported versions

Driver version	Neo4j version	Bolt protocol version
1.0	3.0	1

You can download the driver source or acquire it with one of the dependency managers of your language.

Example 1. Example: Acquire the driver

```
npm install neo4j-driver@1.0.1
```

15.2. Use the driver

Each Neo4j driver has a database object for creating a driver. To use a driver, follow this pattern:

1. Ask the *database* object for a new driver.
2. Ask the *driver* object for a new session.
3. Use the *session* object to run statements. It returns an object representing the results.
4. Process the *results*.
5. Close the session.

Example 2. Example: Use the driver

For a minimal working example, the following imports are necessary.

```
var neo4j = require('neo4j-driver').v1;
```

These can then be used to run a statement against the server.

```
var driver = neo4j.driver("bolt://localhost", neo4j.auth.basic("neo4j", "neo4j"));
var session = driver.session();
session
  .run( "CREATE (a:Person {name:'Arthur', title:'King'})" )
  .then( function()
  {
    return session.run( "MATCH (a:Person) WHERE a.name = 'Arthur' RETURN a.name AS name, a.title AS
title" )
  })
  .then( function( result ) {
    console.log( result.records[0].get("title") + " " + result.records[0].get("name") );
    session.close();
    driver.close();
  })
```

As seen above, it is possible to run statements directly from the session object. The session will take care of opening and closing the transaction. The session also provides the opportunity for a user to manage the transaction explicitly. See Transaction management for details.

Chapter 16. Driver

A driver is used to connect to a Neo4j server. It provides sessions that are used to execute statements and retrieve results.

16.1. Construction

The driver package includes a graph database object. This object provides driver instances. When requesting a driver instance from the database object a URL is provided. The URL declares the protocol, host name, and port for the Neo4j server.

16.1.1. Bolt URL format

A Bolt URL follows the standard URL pattern of `scheme://hostname:port`. For example, `bolt://server:1234` would connect using the Bolt protocol to `server` on port `1234`. If no port is provided in the URL, the default port `7687` is used. For example, `bolt://server` amounts to the same as `bolt://server:7687`.

Example 3. Example: Create a driver

```
driverGlobal = neo4j.driver("bolt://localhost", neo4j.auth.basic("neo4j", "neo4j"));
```

16.2. Configuration

In addition to the Bolt URL, the driver can be configured for:

- session pool size
- session pool behavior
- authentication strategies
- logging

Name	Description	Default
Session pool size (*)	Max number of sessions per URL.	`50`
Logging	Provide a logging facility for the driver.	`N/A`

(*) The .NET and Python drivers provide *idle session pool size*, which is the maximum number of idle sessions to be pooled by the driver. There is no limit to how many sessions that can be created, but a maximum limits how many sessions will be buffered after they are returned to the session pool.

Example 4. Example: Create a driver with configuration

```
var driver = neo4j.driver("bolt://localhost", neo4j.auth.basic("neo4j", "neo4j"), {
connectionPoolSize: 50});
```

16.2.1. Encryption and authentication

All Neo4j drivers support encrypting the traffic between the Neo4j driver and the Neo4j instance using

SSL/TLS. Neo4j will by default allow both encrypted and unencrypted connections from drivers. This can be modified to require encryption for all connections. Please see the Neo4j Operations Manual Configuring Bolt Connectors *(http://neo4j.com/docs/operations-manual/3.0/#_configuring_bolt_connectors)* for more information.

We strongly encourage using encryption to keep authentication credentials and data stored in Neo4j secure. Because of this most drivers will turn encryption on by default. However, due to technical limitations, the .NET driver does not have encryption enabled by default. For similar reasons, the JavaScript driver does not have encryption enabled by default when running inside a Web Browser.

Encryption

The driver can be configured to turn on or off TLS encryption. Encryption should only be turned off in a trusted, internal network. While most drivers default to enabling encryption, it is good practice to configure encryption explicitly. This makes it clear encryption is used for other developers reading the code and minimizes the risk of mistakes from relying on defaults.

Example 5. Example: Configure driver to require TLS encryption

```
var driver = neo4j.driver("bolt://localhost", neo4j.auth.basic("neo4j", "neo4j"), {
  // In NodeJS, encryption is on by default. In the web bundle, it is off.
  encrypted:true
});
```

Trust

When establishing an encrypted connection, it needs to be verified that the remote peer is who we expected to connect to. Without verifying this, an attacker can easily perform a so-called "man-in-the-middle" attack, tricking the driver to establish an encrypted connection with her instead of the Neo4j Instance. Because of this, Neo4j drivers do not offer a way to establish encrypted connections without also establishing trust.

Two trust strategies are available:

- Trust on first use.
- Trust signed certificate.

Trust on first use means that the driver will trust the first connection to a host to be safe and intentional. On subsequent connections, the driver will verify that it communicates with the same host as on the first connection. To ensure that this authentication strategy is valid, the first connection to the server must be established in a trusted network environment.

This strategy is the same as the default strategy used by the `ssh` command line tool. It provides a good degree of security with no configuration. For this reason it is the default strategy on all platforms that support it.

Because of technical limitations this strategy is not available for the .NET platform or when using the JavaScript driver inside a web browser.

Example 6. Example: Configure driver to trust on first use

```
var driver = neo4j.driver("bolt://localhost", neo4j.auth.basic("neo4j", "neo4j"), {
  // Note that trust-on-first-use is not available in the browser bundle,
  // in NodeJS, trust-on-first-use is the default trust mode. In the browser
  // it is TRUST_SIGNED_CERTIFICATES.
  trust: "TRUST_ON_FIRST_USE",
  encrypted:true
});
```

Trust signed certificate means that the driver will only connect to a Neo4j server if it provides a certificate trusted by the driver. A trusted certificate is a certificate explicitly configured to be trusted by the driver or, more commonly, a certificate signed by a certificate the driver trusts. All drivers support this trust strategy.

The way to install a trusted certificate for use by a driver varies for different drivers. The Java driver directly accepts the file path to the trusted certificate and loads the certificate automatically at runtime. The .NET and Python drivers require the certificate to first be installed into the operating system's trusted certificate store.

Example 7. Example: Configure driver to trust signed certificate

```
var driver = neo4j.driver("bolt://localhost", neo4j.auth.basic("neo4j", "neo4j"), {
  trust: "TRUST_SIGNED_CERTIFICATES",
  // Configuring which certificates to trust here is only available
  // in NodeJS. In the browser bundle the browsers list of trusted
  // certificates is used, due to technical limitations in some browsers.
  trustedCertificates : ["path/to/ca.crt"],
  encrypted:true
});
```

Authenticate user

The server will require the driver to provide authentication credentials for the user to connect to the database, unless authentication has been disabled.

Example 8. Example: Connecting the driver to a server with authentication disabled

```
var driver = neo4j.driver("bolt://localhost", {
  // In NodeJS, encryption is on by default. In the web bundle, it is off.
  encrypted:true
});
```

If communication between the driver and the server is not encrypted, authentication credentials are sent as plain text. It is highly recommended to use encryption when using authentication.

When connecting to Neo4j for the first time, the user must change the default password. Given a fresh Neo4j server installation, any attempt to connect to the Neo4j server with the default password will provide a notifcation indicating that the credentials have expired and the password needs to be updated. The browser can be used to change the expired password.

16.3. Lifecycle

For most use cases it is recommended to use a single driver instance throughout an application. The only reason to create multiple driver instances is to connect to multiple servers. This may be useful when connecting to multiple members of a cluster, or for pulling data out of one database to push to another. In other cases, a single driver instance usually serves the needs of a single application.

Chapter 17. Session

All interaction with a Neo4j server takes place within a session.

A session is used to run statements against Neo4j. A session is obtained from a driver object. It allows for running statements against the database.

The driver has a session pool which can be configured. Sessions are returned to the pool when they are closed. It is important to close sessions, to allow them to return to the pool and be reused.

It is important to provide for the closing of a session in the case where an exception is thrown. Make sure that the exceptional path of execution, as well as the ordinary, closes the session.

17.1. Run a statement

The session can run statements directly. If a statement is run directly from a session, the session will take care of wrapping it in a transaction.

Example 9. Example: Run a statement

```
session
  .run( "CREATE (person:Person {name: {name}})", {name: "Arthur"} )
```

It is always recommended to use parameters, but it is possible to run a query with literal values as well.

Why it's important to use parameters

Using parameters have significant performance and security benefits, including:

- It allows the query planner to reuse its plans, which makes queries much more efficient.
- It protects the database from Cypher injection attacks, where malicious query clauses are added from poorly typed or filtered input.

Example 10. Example: Run a statement without parameters

```
session
  .run( "CREATE (p:Person { name: 'Arthur' })" )
```

17.2. Transaction management

When the session runs a statement directly, it creates an implicit transaction. The session can also create explicit transactions to be managed manually. When explicitly told to begin a new transaction, the session will return a transaction object. The transaction object allows for fine-grained transaction control.

For details on transactions in Neo4j see the Neo4j Java Developer Reference *(http://neo4j.com/docs/java-reference/3.0/#transactions)*.

Example 11. Example: Run a statement in a manually managed transaction

```
var tx = session.beginTransaction();
tx.run( "CREATE (:Person {name: 'Guinevere'})" );
tx.commit();
```

The manually managed transaction can also be rolled back.

Example 12. Example: Roll back a manually managed transaction

```
var tx = session.beginTransaction();
tx.run( "CREATE (:Person {name: 'Merlin'})" );
tx.rollback();
```

Chapter 18. Results

Results returned from Neo4j are presented as a stream of records.

When a statement is run, results are returned as a record stream. The stream itself is represented by a result cursor which is used to access the individual records. The individual records can be accessed one at a time, or all at once. Results are valid until the next statement is run or until the end of the current transaction, whichever comes first. To hold on to the results while running additional statements, or to use the results outside of the scope of the current transaction, the results must be retained by assigning them to a variable.

18.1. The result cursor

A result cursor provides access to the stream of records that make up the results. The cursor is moved through the stream and points to each record in turn. Before the cursor is moved onto the first record, it points *before* the first record. When the cursor has traversed to the end of the result stream, summary information and metadata are available.

Result records are loaded lazily as the cursor is moved through the stream. This means that the cursor must be moved to the first result before this result can be consumed. It also means that the entire stream must be explicitly consumed before summary information and metadata is available. It is generally best practice to explicitly consume results and close sessions, in particular when running update statements. This applies even if the summary information is not required. Failing to consume a result can lead to unpredictable behaviour as there will be no guarantee that the server has seen and handled the Cypher statement.

Example 13. Example: Use a result cursor

```
var searchTerm = "Sword";
session
  .run( "MATCH (weapon:Weapon) WHERE weapon.name CONTAINS {term} RETURN weapon.name", {term :
searchTerm} )
  .subscribe({
    onNext: function(record) {
      console.log("" + record.get("weapon.name"));
    },
    onCompleted: function() {
      session.close();
    },
    onError: function(error) {
      console.log(error);
    }
  });
```

18.2. The record

The result record stream is made up of individual records. A record provides an immutable view of a part of a result. It is an ordered map of keys and values. These key-value pairs are called *fields*. As the fields are both keyed and ordered, the value of a field can be accessed either by position *(0-based Integer)* or by key *(String)*.

Access values by key or position

- To access values by position, use a `0`-based integer.
- To access values by key, use a string.

Example 14. Example: Use a record

```
var searchTerm = "Arthur";
session
  .run( "MATCH (weapon:Weapon) WHERE weapon.owner CONTAINS {term} RETURN weapon.name,
weapon.material, weapon.size", {term : searchTerm} )
  .subscribe({
    onNext: function(record) {
      var sword = [];
      record.forEach(function(value, key)
      {
        sword.push(key + ": " + value);
      });
      console.log(sword);
    },
    onCompleted: function() {
      session.close();
    },
    onError: function(error) {
      console.log(error);
    }
  });
```

18.2.1. Retaining Results

The result record stream is available until another statement is run in the session, or until the current transaction is closed. To hold on to the results beyond this scope, the results need to be explicitly *retained*. For retaining results, each driver offers methods that collect the result stream and translate it into standard data structures for each language. Retained results can be processed, while the session is free to take on the next workload. The saved results can also be used directly to run a new statement.

Example 15. Example: Retain results for further processing

```
session
  .run("MATCH (knight:Person:Knight) WHERE knight.castle = {castle} RETURN knight.name AS name",
{castle: "Camelot"})
  .then(function (result) {
    var records = [];
    for (i = 0; i < result.records.length; i++) {
      records.push(result.records[i]);
    }
    return records;
  })
  .then(function (records) {
    for(i = 0; i < records.length; i ++)
    {
      console.log(records[i].get("name") + " is a knight of Camelot");
    }
  });
```

Example 16. Example: Use results in a new query

```
session
  .run("MATCH (knight:Person:Knight) WHERE knight.castle = {castle} RETURN id(knight) AS knight_id",
{"castle": "Camelot"})
  .subscribe({
    onNext: function(record) {
      session
        .run("MATCH (knight) WHERE id(knight) = {id} MATCH (king:Person) WHERE king.name = {king}
CREATE (knight)-[:DEFENDS]->(king)",
        {"id": record.get("knight_id"), "king": "Arthur"});
    },
    onCompleted: function() {
      session
        .run("MATCH (:Knight)-[:DEFENDS]->() RETURN count(*)")
        .then(function (result) {
          console.log("Count is " + result.records[0].get(0).toInt());
        });
    },
    onError: function(error) {
      console.log(error);
    }
  });
```

18.3. Result summary

Metadata can be retrieved along with the result stream. An example is the query plan obtained by prepending a Cypher query with `PROFILE` or `EXPLAIN`. The following example will produce an explain plan with accurate numbers by running the query in the database. This will output a query profile (see the Neo4j Manual *(http://neo4j.com/docs/stable/how-do-i-profile-a-query.html)* for more information about query profiling).

Example 17. Example: Profile query and print execution plan

```
session
  .run("PROFILE MATCH (p:Person {name: {name}}) RETURN id(p)", {name: "Arthur"})
  .then(function (result) {
    console.log(result.summary.profile);
  });
```

Neo4j may also provide notifications for a query, for example, warning when a query will cause the execution engine to build a cartesian product. The following example will produce an explain plan with estimated numbers, without actually running the query in the database.

Example 18. Example: Explain query and print notifications

```
session
  .run("EXPLAIN MATCH (king), (queen) RETURN king, queen")
  .then(function (result) {
    var notifications = result.summary.notifications, i;
    for (i = 0; i < notifications.length; i++) {
      console.log(notifications[i].code);
    }
  });
```

Chapter 19. Types

A driver translates between the type system of its language and the type system used in Neo4j.

Neo4j has a system of data types for processing and storing data. Drivers translate between application language types and the Neo4j type system. To pass parameters and process results, it is important to know the basics of the Neo4j type system and to understand how the Neo4j types are mapped in the driver.

The following Neo4j types are valid both for parameters and results:

- Boolean
- Integer
- Float
- String
- List
- Map

Maps and lists can be processed by the database and used in a statement. Lists in which the elements share a single primitive Neo4j type can be stored as properties on nodes and relationships. Maps, and lists in which the elements have mixed types, can not be stored as properties.

In addition to the types valid both for parameters and results, the following Neo4j types are valid for results only:

- Node
- Relationship
- Path

The Neo4j driver maps Neo4j types to native language types as follows:

Example 19. Map Neo4j types to native language types

Neo4j	JavaScript
`Null`	`null`
`Boolean`	`Boolean`
`Integer`	`Integer (*)`
`Float`	`Number`
`String`	`String`
`List`	`Array`
`Map`	`Object`
`Node`	`Node (*)`
`Relationship`	`Relationship (*)`
`Path`	`Path (*)`

Chapter 20. Errors

There are two types of errors that the user of a driver may need to be aware of. The more likely error to encounter is the Cypher error. A Cypher error occurs when the server is unable to run the statement that it receives from the driver.

Cypher errors encountered using a Neo4j driver are the same as those that can be encountered anywhere Cypher is used. This includes the Neo4j Browser, Neo4j Shell, the Cypher HTTP endpoint, the embedded API, and within a Java stored procedure. See Neo4j Status Codes for further details.

Example 20. Handling a Cypher error

```
session
  .run("Then will cause a syntax error")
  .catch( function(err) {
    expect(err.fields[0].code).toBe( "Neo.ClientError.Statement.SyntaxError" );
    done();
  });
```

HTTP API

The HTTP API.

Chapter 21. Transactional Cypher HTTP endpoint

The Neo4j transactional HTTP endpoint allows you to execute a series of Cypher statements within the scope of a transaction. The transaction may be kept open across multiple HTTP requests, until the client chooses to commit or roll back. Each HTTP request can include a list of statements, and for convenience you can include statements along with a request to begin or commit a transaction.

The server guards against orphaned transactions by using a timeout. If there are no requests for a given transaction within the timeout period, the server will roll it back. You can configure the timeout in the server configuration, by setting `dbms.transaction_timeout` to the number of seconds before timeout. The default timeout is 60 seconds.

- Literal line breaks are not allowed inside Cypher statements.
- Open transactions are not shared among members of an HA cluster. Therefore, if you use this endpoint in an HA cluster, you must ensure that all requests for a given transaction are sent to the same Neo4j instance.
- Cypher queries with USING PERIODIC COMMIT (see Using Periodic Commit) may only be executed when creating a new transaction and immediately committing it with a single HTTP request (see Begin and commit a transaction in one request for how to do that).
- When a request fails the transaction will be rolled back. By checking the result for the presence/absence of the `transaction` key you can figure out if the transaction is still open.

21.1. Streaming

Responses from the HTTP API can be transmitted as JSON streams, resulting in better performance and lower memory overhead on the server side. To use streaming, supply the header `X-Stream: true` with each request.

In order to speed up queries in repeated scenarios, try not to use literals but replace them with parameters wherever possible. This will let the server cache query plans. See Parameters for more information.

21.2. Begin and commit a transaction in one request

If there is no need to keep a transaction open across multiple HTTP requests, you can begin a transaction, execute statements, and commit with just a single HTTP request.

Example request

- **POST** http://localhost:7474/db/data/transaction/commit
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE (n) RETURN id(n)"
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "results" : [ {
    "columns" : [ "id(n)" ],
    "data" : [ {
      "row" : [ 78 ],
      "meta" : [ null ]
    } ]
  } ],
  "errors" : [ ]
}
```

21.3. Execute multiple statements

You can send multiple Cypher statements in the same request. The response will contain the result of each statement.

Example request

- **POST** http://localhost:7474/db/data/transaction/commit
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE (n) RETURN id(n)"
  }, {
    "statement" : "CREATE (n {props}) RETURN n",
    "parameters" : {
      "props" : {
        "name" : "My Node"
      }
    }
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "results" : [ {
    "columns" : [ "id(n)" ],
    "data" : [ {
      "row" : [ 74 ],
      "meta" : [ null ]
    } ]
  }, {
    "columns" : [ "n" ],
    "data" : [ {
      "row" : [ {
        "name" : "My Node"
      } ],
      "meta" : [ {
        "id" : 75,
        "type" : "node",
        "deleted" : false
      } ]
    } ]
  } ],
  "errors" : [ ]
}
```

21.4. Begin a transaction

You begin a new transaction by posting zero or more Cypher statements to the transaction endpoint. The server will respond with the result of your statements, as well as the location of your open transaction.

Example request

- **POST** http://localhost:7474/db/data/transaction
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE (n {props}) RETURN n",
    "parameters" : {
      "props" : {
        "name" : "My Node"
      }
    }
  } ]
}
```

Example response

- **201:** Created
- **Content-Type:** application/json
- **Location:** http://localhost:7474/db/data/transaction/46

```
{
  "commit" : "http://localhost:7474/db/data/transaction/46/commit",
  "results" : [ {
    "columns" : [ "n" ],
    "data" : [ {
      "row" : [ {
        "name" : "My Node"
      } ],
      "meta" : [ {
        "id" : 82,
        "type" : "node",
        "deleted" : false
      } ]
    } ]
  } ],
  "transaction" : {
    "expires" : "Fri, 06 May 2016 00:59:43 +0000"
  },
  "errors" : [ ]
}
```

21.5. Execute statements in an open transaction

Given that you have an open transaction, you can make a number of requests, each of which executes additional statements, and keeps the transaction open by resetting the transaction timeout.

Example request

- **POST** http://localhost:7474/db/data/transaction/48
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE (n) RETURN n"
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "commit" : "http://localhost:7474/db/data/transaction/48/commit",
  "results" : [ {
    "columns" : [ "n" ],
    "data" : [ {
      "row" : [ { } ],
      "meta" : [ {
        "id" : 83,
        "type" : "node",
        "deleted" : false
      } ]
    } ]
  } ],
  "transaction" : {
    "expires" : "Fri, 06 May 2016 00:59:43 +0000"
  },
  "errors" : [ ]
}
```

21.6. Reset transaction timeout of an open transaction

Every orphaned transaction is automatically expired after a period of inactivity. This may be prevented by resetting the transaction timeout.

The timeout may be reset by sending a keep-alive request to the server that executes an empty list of statements. This request will reset the transaction timeout and return the new time at which the transaction will expire as an RFC1123 formatted timestamp value in the ``transaction'' section of the response.

Example request

- **POST** http://localhost:7474/db/data/transaction/38
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "commit" : "http://localhost:7474/db/data/transaction/38/commit",
  "results" : [ ],
  "transaction" : {
    "expires" : "Fri, 06 May 2016 00:59:42 +0000"
  },
  "errors" : [ ]
}
```

21.7. Commit an open transaction

Given you have an open transaction, you can send a commit request. Optionally, you submit additional statements along with the request that will be executed before committing the transaction.

Example request

- **POST** http://localhost:7474/db/data/transaction/42/commit
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE (n) RETURN id(n)"
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "results" : [ {
    "columns" : [ "id(n)" ],
    "data" : [ {
      "row" : [ 77 ],
      "meta" : [ null ]
    } ]
  } ],
  "errors" : [ ]
}
```

21.8. Rollback an open transaction

Given that you have an open transaction, you can send a rollback request. The server will rollback the transaction. Any further statements trying to run in this transaction will fail immediately.

Example request

- **DELETE** http://localhost:7474/db/data/transaction/39
- **Accept:** application/json; charset=UTF-8

Example response

- **200:** OK
- **Content-Type:** application/json; charset=UTF-8

```
{
  "results" : [ ],
  "errors" : [ ]
}
```

21.9. Include query statistics

By setting `includeStats` to `true` for a statement, query statistics will be returned for it.

Example request

- **POST** http://localhost:7474/db/data/transaction/commit
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE (n) RETURN id(n)",
    "includeStats" : true
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "results" : [ {
    "columns" : [ "id(n)" ],
    "data" : [ {
      "row" : [ 76 ],
      "meta" : [ null ]
    } ],
    "stats" : {
      "contains_updates" : true,
      "nodes_created" : 1,
      "nodes_deleted" : 0,
      "properties_set" : 0,
      "relationships_created" : 0,
      "relationship_deleted" : 0,
      "labels_added" : 0,
      "labels_removed" : 0,
      "indexes_added" : 0,
      "indexes_removed" : 0,
      "constraints_added" : 0,
      "constraints_removed" : 0
    }
  } ],
  "errors" : [ ]
}
```


21.10. Return results in graph format

If you want to understand the graph structure of nodes and relationships returned by your query, you can specify the "graph" results data format. For example, this is useful when you want to visualise the graph structure. The format collates all the nodes and relationships from all columns of the result, and also flattens collections of nodes and relationships, including paths.

Example request

- **POST** http://localhost:7474/db/data/transaction/commit
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "CREATE ( bike:Bike { weight: 10 } ) CREATE ( frontWheel:Wheel { spokes: 3 } ) CREATE ( backWheel:Wheel { spokes: 32 } ) CREATE p1 = (bike)-[:HAS { position: 1 } ]->(frontWheel) CREATE p2 = (bike)-[:HAS { position: 2 } ]->(backWheel) RETURN bike, p1, p2",
    "resultDataContents" : [ "row", "graph" ]
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json


```
{
  "results" : [ {
    "columns" : [ "bike", "p1", "p2" ],
    "data" : [ {
      "row" : [ {
        "weight" : 10
      }, [ {
        "weight" : 10
      }, {
        "position" : 1
      }, {
        "spokes" : 3
      } ], [ {
        "weight" : 10
```

```
      }, {
        "position" : 2
      }, {
        "spokes" : 32
      } ] ],
      "meta" : [ {
        "id" : 79,
        "type" : "node",
        "deleted" : false
      }, [ {
        "id" : 79,
        "type" : "node",
        "deleted" : false
      }, {
        "id" : 33,
        "type" : "relationship",
        "deleted" : false
      }, {
        "id" : 80,
        "type" : "node",
        "deleted" : false
      } ], [ {
        "id" : 79,
        "type" : "node",
        "deleted" : false
      }, {
        "id" : 34,
        "type" : "relationship",
        "deleted" : false
      }, {
        "id" : 81,
        "type" : "node",
        "deleted" : false
      } ] ],
      "graph" : {
        "nodes" : [ {
          "id" : "80",
          "labels" : [ "Wheel" ],
          "properties" : {
            "spokes" : 3
          }
        }, {
          "id" : "81",
          "labels" : [ "Wheel" ],
          "properties" : {
            "spokes" : 32
          }
        }, {
          "id" : "79",
          "labels" : [ "Bike" ],
          "properties" : {
            "weight" : 10
          }
        } ],
        "relationships" : [ {
          "id" : "33",
          "type" : "HAS",
          "startNode" : "79",
          "endNode" : "80",
          "properties" : {
            "position" : 1
          }
        }, {
          "id" : "34",
          "type" : "HAS",
          "startNode" : "79",
          "endNode" : "81",
          "properties" : {
            "position" : 2
          }
        } ]
      }
    } ]
  } ],
  "errors" : [ ]
}
```

21.11. Handling errors

The result of any request against the transaction endpoint is streamed back to the client. Therefore the server does not know whether the request will be successful or not when it sends the HTTP status code.

Because of this, all requests against the transactional endpoint will return 200 or 201 status code, regardless of whether statements were successfully executed. At the end of the response payload, the server includes a list of errors that occurred while executing statements. If this list is empty, the request completed successfully.

If any errors occur while executing statements, the server will roll back the transaction.

In this example, we send the server an invalid statement to demonstrate error handling.

For more information on the status codes, see Neo4j Status Codes.

Example request

- **POST** http://localhost:7474/db/data/transaction/47/commit
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "This is not a valid Cypher Statement."
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "results" : [ ],
  "errors" : [ {
    "code" : "Neo.ClientError.Statement.SyntaxError",
    "message" : "Invalid input 'T': expected <init> (line 1, column 1 (offset: 0))\n\"This is not a valid
Cypher Statement.\"\n ^"
  } ]
}
```

21.12. Handling errors in an open transaction

Whenever there is an error in a request the server will rollback the transaction. By inspecting the response for the presence/absence of the `transaction` key you can tell if the transaction is still open

Example request

- **POST** http://localhost:7474/db/data/transaction/45
- **Accept:** application/json; charset=UTF-8
- **Content-Type:** application/json

```
{
  "statements" : [ {
    "statement" : "This is not a valid Cypher Statement."
  } ]
}
```

Example response

- **200:** OK
- **Content-Type:** application/json

```
{
  "commit" : "http://localhost:7474/db/data/transaction/45/commit",
  "results" : [ ],
  "errors" : [ {
    "code" : "Neo.ClientError.Statement.SyntaxError",
    "message" : "Invalid input 'T': expected <init> (line 1, column 1 (offset: 0))\n\"This is not a valid
Cypher Statement.\"\n ^"
  } ]
}
```

Chapter 22. Authentication and Authorization

In order to prevent unauthorized access to Neo4j, the HTTP API supports authorization and authentication. When enabled, requests to the HTTP API must be authorized using the username and password of a valid user. Authorization is enabled by default, see the Operations Manual *(http://neo4j.com/docs/operations-manual/3.0/#security-server-auth)* for how to disable it.

When Neo4j is first installed you can authenticate with the default user `neo4j` and the default password `neo4j`. However, the default password must be changed (see User status and password changing) before access to resources will be permitted. This can easily be done via the Neo4j Browser, or via direct HTTP calls.

The username and password combination is local to each Neo4j instance. If you wish to have multiple instances in a cluster, you should ensure that all instances share the same credential. For automated deployments, you may also copy security configuration from another Neo4j instance (see Copying security configuration from one instance to another).

22.1. Authenticating

22.1.1. Missing authorization

If an Authorization header is not supplied, the server will reply with an error.

Example request

- **GET** http://localhost:7474/db/data/
- **Accept:** application/json; charset=UTF-8

Example response

- **401:** Unauthorized
- **Content-Type:** application/json; charset=UTF-8
- **WWW-Authenticate:** Basic realm="Neo4j"

```
{
  "errors" : [ {
    "code" : "Neo.ClientError.Security.Unauthorized",
    "message" : "No authentication header supplied."
  } ]
}
```

22.1.2. Authenticate to access the server

Authenticate by sending a username and a password to Neo4j using HTTP Basic Auth. Requests should include an Authorization header, with a value of Basic <payload>, where "payload" is a base64 encoded string of "username:password".

Example request

- **GET** http://localhost:7474/user/neo4j
- **Accept:** application/json; charset=UTF-8
- **Authorization:** Basic bmVvNGo6c2VjcmV0

Example response

- **200:** OK
- **Content-Type:** application/json; charset=UTF-8

```
{
  "password_change_required" : false,
  "password_change" : "http://localhost:7474/user/neo4j/password",
  "username" : "neo4j"
}
```

22.1.3. Incorrect authentication

If an incorrect username or password is provided, the server replies with an error.

Example request

- **POST** http://localhost:7474/db/data/
- **Accept:** application/json; charset=UTF-8
- **Authorization:** Basic bmVvNGo6aW5jb3JyZWN0

Example response

- **401:** Unauthorized
- **Content-Type:** application/json; charset=UTF-8
- **WWW-Authenticate:** Basic realm="Neo4j"

```
{
  "errors" : [ {
    "code" : "Neo.ClientError.Security.Unauthorized",
    "message" : "Invalid username or password."
  } ]
}
```

22.1.4. Required password changes

In some cases, like the very first time Neo4j is accessed, the user will be required to choose a new password. The database will signal that a new password is required and deny access.

See [rest-api-security-user-status-and-password-changing] for how to set a new password.

Example request

- **GET** http://localhost:7474/db/data/
- **Accept:** application/json; charset=UTF-8
- **Authorization:** Basic bmVvNGo6bmVvNGo=

Example response

- **403:** Forbidden
- **Content-Type:** application/json; charset=UTF-8

```
{
  "password_change" : "http://localhost:7474/user/neo4j/password",
  "errors" : [ {
    "code" : "Neo.ClientError.Security.Forbidden",
    "message" : "User is required to change their password."
  } ]
}
```

22.2. User status and password changing

22.2.1. User status

Given that you know the current password, you can ask the server for the user status.

Example request

- **GET** http://localhost:7474/user/neo4j
- **Accept:** application/json; charset=UTF-8
- **Authorization:** Basic bmVvNGo6c2VjcmV0

Example response

- **200:** OK
- **Content-Type:** application/json; charset=UTF-8

```
{
  "password_change_required" : false,
  "password_change" : "http://localhost:7474/user/neo4j/password",
  "username" : "neo4j"
}
```

22.2.2. User status on first access

On first access, and using the default password, the user status will indicate that the users password requires changing.

Example request

- **GET** http://localhost:7474/user/neo4j
- **Accept:** application/json; charset=UTF-8
- **Authorization:** Basic bmVvNGo6bmVvNGo=

Example response

- **200:** OK
- **Content-Type:** application/json; charset=UTF-8

```
{
  "password_change_required" : true,
  "password_change" : "http://localhost:7474/user/neo4j/password",
  "username" : "neo4j"
}
```

22.2.3. Changing the user password

Given that you know the current password, you can ask the server to change a users password. You can choose any password you like, as long as it is different from the current password.

Example request

- **POST** http://localhost:7474/user/neo4j/password
- **Accept:** application/json; charset=UTF-8
- **Authorization:** Basic bmVvNGo6bmVvNGo=
- **Content-Type:** application/json

```
{
  "password" : "secret"
}
```

Example response

- **200:** OK

```

```

22.3. Access when auth is disabled

When auth has been disabled in the configuration, requests can be sent without an Authorization header.

22.4. Copying security configuration from one instance to another

In many cases, such as automated deployments, you may want to start a Neo4j instance with pre-configured authentication and authorization. This is possible by copying the auth database file from a pre-existing Neo4j instance to your new instance.

This file is located at *data/dbms/auth*, and simply copying that file into a new Neo4j instance will transfer your password and authorization token.

Procedures

> *User-defined procedures are written in Java, deployed into the database, and called from Cypher.*

A *procedure* is a mechanism that allows Neo4j to be extended by writing custom code which can be invoked directly from Cypher. Procedures can take arguments, perform operations on the database, and return results.

Procedures are written in Java and compiled into *jar* files. They can be deployed to the database by dropping a *jar* file into the *$NEO4J_HOME/plugins* directory on each standalone or clustered server. The database must be re-started on each server to pick up new procedures.

Procedures are the preferred means for extending Neo4j. Examples of use cases for procedures are:

1. To provide access to functionality that is not available in Cypher, such as manual indexes and schema introspection.
2. To provide access to third party systems.
3. To perform graph-global operations, such as counting connected components or finding dense nodes.
4. To express a procedural operation that is difficult to express declaratively with Cypher.

Chapter 23. Calling procedures

To call a stored procedure, use a Cypher `CALL` clause. The procedure name must be fully qualified, so a procedure named `findDenseNodes` defined in the package `org.neo4j.examples` could be called using:

```
CALL org.neo4j.examples.findDenseNodes(1000)
```

A `CALL` may be the only clause within a Cypher statement or may be combined with other clauses. Arguments can be supplied directly within the query or taken from the associated parameter set. For full details, see the Cypher documentation on the `CALL` clause.

Chapter 24. Built-in procedures

Neo4j comes bundled with a number of built-in procedures. These are listed in the table below:

Procedure name	Command to invoke procedure	What it does
`ListLabels`	`CALL db.labels()`	List all labels in the database.
`ListRelationshipTypes`	`CALL db.relationshipTypes()`	List all relationship types in the database.
`ListPropertyKeys`	`CALL db.propertyKeys()`	List all property keys in the database.
`ListIndexes`	`CALL db.indexes()`	List all indexes in the database.
`ListConstraints`	`CALL db.constraints()`	List all constraints in the database.
`ListProcedures`	`CALL dbms.procedures()`	List all procedures in the DBMS.
`ListComponents`	`CALL dbms.components()`	List DBMS components and their versions.
`QueryJmx`	`CALL dbms.queryJmx(query)`	Query JMX management data by domain and name. For instance, "org.neo4j:*".
`AlterUserPassword`	`CALL dbms.changePassword(query)`	Change the user password.

Chapter 25. User-defined procedures

The example discussed below is available as a repository on GitHub *(https://github.com/neo4j-examples/neo4j-procedure-template)*. To get started quickly you can fork the repository and work with the code as you follow along in the guide below.

Custom procedures are written in the Java programming language. Procedures are deployed via a *jar* file that contains the code itself along with any dependencies (excluding Neo4j). These files should be placed into the *plugin* directory of each standalone database or cluster member and will become available following the next database restart.

The example that follows shows the steps to create and deploy a new procedure.

25.1. Set up a new project

A project can be set up in any way that allows for compiling a procedure and producing a *jar* file. Below is an example configuration using the Maven *(https://maven.apache.org/)* build system. For readability, only excerpts from the Maven *pom.xml* file are shown here, the whole file is available from the Neo4j Procedure Template *(https://github.com/neo4j-examples/neo4j-procedure-template)* repository.

Setting up a project with Maven

```
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:schemaLocation="http://maven.apache.org/POM/4.0.0
                        http://maven.apache.org/xsd/maven-4.0.0.xsd">
 <modelVersion>4.0.0</modelVersion>

 <groupId>org.neo4j.example</groupId>
 <artifactId>procedure-template</artifactId>
 <version>1.0.0-SNAPSHOT</version>

 <packaging>jar</packaging>
 <name>Neo4j Procedure Template</name>
 <description>A template project for building a Neo4j Procedure</description>

 <properties>
   <neo4j.version>3.0.0-SNAPSHOT</neo4j.version>
 </properties>
```

Next, the build dependencies are defined. The following two sections are included in the *pom.xml* between `<dependencies></dependencies>` tags.

The first dependency section includes the procedure API that procedures use at runtime. The scope is set to `provided`, because once the procedure is deployed to a Neo4j instance, this dependency is provided by Neo4j. If non-Neo4j dependencies are added to the project, their scope should normally be `compile`.

```
<dependency>
  <groupId>org.neo4j</groupId>
  <artifactId>neo4j</artifactId>
  <version>${neo4j.version}</version>
  <scope>provided</scope>
</dependency>
```

Next, the dependencies necessary for testing the procedure are added:

- Neo4j Harness, a utility that allows for starting a lightweight Neo4j instance. It is used to start Neo4j with a specific procedure deployed, which greatly simplifies testing.
- The Neo4j Java driver, used to send cypher statements that call the procedure.

- JUnit, a common Java test framework.

```
<dependency>
  <groupId>org.neo4j.test</groupId>
  <artifactId>neo4j-harness</artifactId>
  <version>${neo4j.version}</version>
  <scope>test</scope>
</dependency>

<dependency>
  <groupId>org.neo4j.driver</groupId>
  <artifactId>neo4j-java-driver</artifactId>
  <version>1.0-SNAPSHOT</version>
  <scope>test</scope>
</dependency>

<dependency>
  <groupId>junit</groupId>
  <artifactId>junit</artifactId>
  <version>4.12</version>
  <scope>test</scope>
</dependency>
```

Along with declaring the dependencies used by the procedure it is also necessary to define the steps that Maven will go through to build the project. The goal is first to *compile* the source, then to *package* it in a *jar* that can be deployed to a Neo4j instance.

Procedures require at least Java 8, so the version `1.8` should be defined as the *source* and *target version* in the configuration for the Maven compiler plugin.

The Maven Shade *(https://maven.apache.org/plugins/maven-shade-plugin/)* plugin is used to package the compiled procedure. It also includes all dependencies in the package, unless the dependency scope is set to *test* or *provided*.

Once the procedure has been deployed to the *plugins* directory of each Neo4j instance and the instances have restarted, the procedure is available for use.

```
<build>
 <plugins>
   <plugin>
     <artifactId>maven-compiler-plugin</artifactId>
     <configuration>
       <source>1.8</source>
       <target>1.8</target>
     </configuration>
   </plugin>
   <plugin>
     <artifactId>maven-shade-plugin</artifactId>
     <executions>
       <execution>
         <phase>package</phase>
         <goals>
           <goal>shade</goal>
         </goals>
       </execution>
     </executions>
   </plugin>
 </plugins>
</build>
```

Until the GA release of Neo4j 3.0, the dependency on Neo4j requires that a *snapshot repository* is configured. This repository is where Maven will find the latest build of Neo4j to use as a dependency.

```
<repositories>
 <repository>
   <id>neo4j-snapshot-repository</id>
   <name>Maven 2 snapshot repository for Neo4j</name>
   <url>http://m2.neo4j.org/content/repositories/snapshots</url>
   <snapshots><enabled>true</enabled></snapshots>
   <releases><enabled>false</enabled></releases>
 </repository>
</repositories>
```

25.2. Writing integration tests

The test dependencies include *Neo4j Harness* and *JUnit*. These can be used to write integration tests for procedures.

First, we decide what the procedure should do, then we write a test that proves that it does it right. Finally we write a procedure that passes the test.

Below is a template for testing a procedure that accesses Neo4j's full-text indexes from Cypher.

Writing tests for procedures

```
package example;

import org.junit.Rule;
import org.junit.Test;
import org.neo4j.driver.v1.*;
import org.neo4j.graphdb.factory.GraphDatabaseSettings;
import org.neo4j.harness.junit.Neo4jRule;

import static org.hamcrest.core.IsEqual.equalTo;
import static org.junit.Assert.assertThat;
import static org.neo4j.driver.v1.Values.parameters;

public class ManualFullTextIndexTest
{
    // This rule starts a Neo4j instance for us
    @Rule
    public Neo4jRule neo4j = new Neo4jRule()

            // This is the Procedure we want to test
            .withProcedure( FullTextIndex.class );

    @Test
    public void shouldAllowIndexingAndFindingANode() throws Throwable
    {
        // In a try-block, to make sure we close the driver after the test
        try( Driver driver = GraphDatabase.driver( neo4j.boltURI() , Config.build().withEncryptionLevel(
Config.EncryptionLevel.NONE ).toConfig() ) )
        {

            // Given I've started Neo4j with the FullTextIndex procedure class
            //       which my 'neo4j' rule above does.
            Session session = driver.session();

            // And given I have a node in the database
            long nodeId = session.run( "CREATE (p:User {name:'Brookreson'}) RETURN id(p)" )
                    .single()
                    .get( 0 ).asLong();

            // When I use the index procedure to index a node
            session.run( "CALL example.index({id}, ['name'])", parameters( "id", nodeId ) );

            // Then I can search for that node with lucene query syntax
            StatementResult result = session.run( "CALL example.search('User', 'name:Brook*')" );
            assertThat( result.single().get( "nodeId" ).asLong(), equalTo( nodeId ) );
        }
    }
}
```

25.3. Writing a procedure

With the test in place, we write a procedure procedure that fulfils the expectations of the test. The full example is available in the Neo4j Procedure Template *(https://github.com/neo4j-examples/neo4j-procedure-template)* repository.

Particular things to note:

- All procedures are annotated `@Procedure`. Procedures that write to the database are additionally annotated `@PerformsWrites`.
- The *context* of the procedure, which is the same as each resource that the procedure wants to use, is annotated `@Context`.
- The *input* and *output*.

For more details, see the API documentation for procedures *(http://neo4j.com/docs/java-reference/3.0/javadocs/index.html?org/neo4j/procedure/Procedure.html)*.

The correct way to signal an error from within a procedure is to throw a `RuntimeException`.

```
package example;

import java.util.List;
import java.util.Map;
import java.util.Set;
import java.util.stream.Stream;

import org.neo4j.graphdb.GraphDatabaseService;
import org.neo4j.graphdb.Label;
import org.neo4j.graphdb.Node;
import org.neo4j.graphdb.index.Index;
import org.neo4j.graphdb.index.IndexManager;
import org.neo4j.logging.Log;
import org.neo4j.procedure.Context;
import org.neo4j.procedure.Name;
import org.neo4j.procedure.PerformsWrites;
import org.neo4j.procedure.Procedure;

import static org.neo4j.helpers.collection.MapUtil.stringMap;

/**
 * This is an example showing how you could expose Neo4j's full text indexes as
 * two procedures - one for updating indexes, and one for querying by label and
 * the lucene query language.
 */
public class FullTextIndex
{
    // Only static fields and @Context-annotated fields are allowed in
    // Procedure classes. This static field is the configuration we use
    // to create full-text indexes.
    private static final Map<String,String> FULL_TEXT =
            stringMap( IndexManager.PROVIDER, "lucene", "type", "fulltext" );

    // This field declares that we need a GraphDatabaseService
    // as context when any procedure in this class is invoked
    @Context
    public GraphDatabaseService db;

    // This gives us a log instance that outputs messages to the
    // standard log, `neo4j.log`
    @Context
    public Log log;

    /**
     * This declares the first of two procedures in this class - a
     * procedure that performs queries in a manual index.
     *
     * It returns a Stream of Records, where records are
     * specified per procedure. This particular procedure returns
     * a stream of {@link SearchHit} records.
```

```
     *
     * The arguments to this procedure are annotated with the
     * {@link Name} annotation and define the position, name
     * and type of arguments required to invoke this procedure.
     * There is a limited set of types you can use for arguments,
     * these are as follows:
     *
     * <ul>
     *     <li>{@link String}</li>
     *     <li>{@link Long} or {@code long}</li>
     *     <li>{@link Double} or {@code double}</li>
     *     <li>{@link Number}</li>
     *     <li>{@link Boolean} or {@code boolean}</li>
     *     <li>{@link java.util.Map} with key {@link String} and value {@link Object}</li>
     *     <li>{@link java.util.List} of elements of any valid argument type, including {@link
java.util.List}</li>
     *     <li>{@link Object}, meaning any of the valid argument types</li>
     * </ul>
     *
     * @param label the label name to query by
     * @param query the lucene query, for instance `name:Brook*` to
     *              search by property `name` and find any value starting
     *              with `Brook`. Please refer to the Lucene Query Parser
     *              documentation for full available syntax.
     * @return the nodes found by the query
     */
    @Procedure("example.search")
    @PerformsWrites
    public Stream<SearchHit> search( @Name("label") String label,
                                     @Name("query") String query )
    {
        String index = indexName( label );

        // Avoid creating the index, if it's not there we won't be
        // finding anything anyway!
        if( !db.index().existsForNodes( index ))
        {
            // Just to show how you'd do logging
            log.debug( "Skipping index query since index does not exist: `%s`", index );
            return Stream.empty();
        }

        // If there is an index, do a lookup and convert the result
        // to our output record.
        return db.index()
                .forNodes( index )
                .query( query )
                .stream()
                .map( SearchHit::new );
    }

    /**
     * This is the second procedure defined in this class, it is used to update the
     * index with nodes that should be queryable. You can send the same node multiple
     * times, if it already exists in the index the index will be updated to match
     * the current state of the node.
     *
     * This procedure works largely the same as {@link #search(String, String)},
     * with two notable differences. One, it is annotated with {@link PerformsWrites},
     * which is <i>required</i> if you want to perform updates to the graph in your
     * procedure.
     *
     * Two, it returns {@code void} rather than a stream. This is simply a short-hand
     * for saying our procedure always returns an empty stream of empty records.
     *
     * @param nodeId the id of the node to index
     * @param propKeys a list of property keys to index, only the ones the node
     *                 actually contains will be added
     */
    @Procedure("example.index")
    @PerformsWrites
    public void index( @Name("nodeId") long nodeId,
                       @Name("properties") List<String> propKeys )
    {
        Node node = db.getNodeById( nodeId );

        // Load all properties for the node once and in bulk,
        // the resulting set will only contain those properties in `propKeys`
        // that the node actually contains.
        Set<Map.Entry<String,Object>> properties =
```

```
                node.getProperties( propKeys.toArray( new String[0] ) ).entrySet();

        // Index every label (this is just as an example, we could filter which labels to index)
        for ( Label label : node.getLabels() )
        {
            Index<Node> index = db.index().forNodes( indexName( label.name() ), FULL_TEXT );

            // In case the node is indexed before, remove all occurrences of it so
            // we don't get old or duplicated data
            index.remove( node );

            // And then index all the properties
            for ( Map.Entry<String,Object> property : properties )
            {
                index.add( node, property.getKey(), property.getValue() );
            }
        }
    }


    /**
     * This is the output record for our search procedure. All procedures
     * that return results return them as a Stream of Records, where the
     * records are defined like this one - customized to fit what the procedure
     * is returning.
     *
     * These classes can only have public non-final fields, and the fields must
     * be one of the following types:
     *
     * <ul>
     *     <li>{@link String}</li>
     *     <li>{@link Long} or {@code long}</li>
     *     <li>{@link Double} or {@code double}</li>
     *     <li>{@link Number}</li>
     *     <li>{@link Boolean} or {@code boolean}</li>
     *     <li>{@link org.neo4j.graphdb.Node}</li>
     *     <li>{@link org.neo4j.graphdb.Relationship}</li>
     *     <li>{@link org.neo4j.graphdb.Path}</li>
     *     <li>{@link java.util.Map} with key {@link String} and value {@link Object}</li>
     *     <li>{@link java.util.List} of elements of any valid field type, including {@link
java.util.List}</li>
     *     <li>{@link Object}, meaning any of the valid field types</li>
     * </ul>
     */
    public static class SearchHit
    {
        // This records contain a single field named 'nodeId'
        public long nodeId;

        public SearchHit( Node node )
        {
            this.nodeId = node.getId();
        }
    }

    private String indexName( String label )
    {
        return "label-" + label;
    }
}
```

Appendix

Chapter 26. Neo4j Status Codes

The transactional endpoint may in any response include zero or more status codes, indicating issues or information for the client. Each status code follows the same format: "Neo.[Classification].[Category].[Title]". The fact that a status code is returned by the server does always mean there is a fatal error. Status codes can also indicate transient problems that may go away if you retry the request.

What the effect of the status code is can be determined by its classification.

This is not the same thing as HTTP status codes. Neo4j Status Codes are returned in the response body, at the very end of the response.

26.1. Classifications

Classification	Description	Effect on transaction
`ClientError`	The Client sent a bad request - changing the request might yield a successful outcome.	Rollback
`ClientNotification`	There are notifications about the request sent by the client.	None
`TransientError`	The database cannot service the request right now, retrying later might yield a successful outcome.	Rollback
`DatabaseError`	The database failed to service the request.	Rollback

26.2. Status codes

This is a complete list of all status codes Neo4j may return, and what they mean.

Status Code	Description
`Neo.ClientError.General.ForbiddenOnReadOnlyDatabase`	This is a read only database, writing or modifying the database is not allowed.
`Neo.ClientError.LegacyIndex.LegacyIndexNotFound`	The request (directly or indirectly) referred to a legacy index that does not exist.
`Neo.ClientError.Procedure.ProcedureCallFailed`	Failed to invoke a procedure. See the detailed error description for exact cause.
`Neo.ClientError.Procedure.ProcedureNotFound`	A request referred to a procedure that is not registered with this database instance. If you are deploying custom procedures in a cluster setup, ensure all instances in the cluster have the procedure jar file deployed.
`Neo.ClientError.Procedure.ProcedureRegistrationFailed`	The database failed to register a procedure, refer to the associated error message for details.
`Neo.ClientError.Procedure.TypeError`	A procedure is using or receiving a value of an invalid type.
`Neo.ClientError.Request.Invalid`	The client provided an invalid request.
`Neo.ClientError.Request.InvalidFormat`	The client provided a request that was missing required fields, or had values that are not allowed.
`Neo.ClientError.Request.TransactionRequired`	The request cannot be performed outside of a transaction, and there is no transaction present to use. Wrap your request in a transaction and retry.
`Neo.ClientError.Schema.ConstraintAlreadyExists`	Unable to perform operation because it would clash with a pre-existing constraint.
`Neo.ClientError.Schema.ConstraintNotFound`	The request (directly or indirectly) referred to a constraint that does not exist.
`Neo.ClientError.Schema.ConstraintValidationFailed`	A constraint imposed by the database was violated.

Status Code	Description
Neo.ClientError.Schema.ConstraintVerificationFailed	Unable to create constraint because data that exists in the database violates it.
Neo.ClientError.Schema.ForbiddenOnConstraintIndex	A requested operation can not be performed on the specified index because the index is part of a constraint. If you want to drop the index, for instance, you must drop the constraint.
Neo.ClientError.Schema.IndexAlreadyExists	Unable to perform operation because it would clash with a pre-existing index.
Neo.ClientError.Schema.IndexNotFound	The request (directly or indirectly) referred to an index that does not exist.
Neo.ClientError.Schema.TokenNameError	A token name, such as a label, relationship type or property key, used is not valid. Tokens cannot be empty strings and cannot be null.
Neo.ClientError.Security.AuthenticationRateLimit	The client has provided incorrect authentication details too many times in a row.
Neo.ClientError.Security.CredentialsExpired	The credentials have expired and need to be updated.
Neo.ClientError.Security.EncryptionRequired	A TLS encrypted connection is required.
Neo.ClientError.Security.Forbidden	An attempt was made to perform an unauthorized action.
Neo.ClientError.Security.Unauthorized	The client is unauthorized due to authentication failure.
Neo.ClientError.Statement.ArgumentError	The statement is attempting to perform operations using invalid arguments
Neo.ClientError.Statement.ArithmeticError	Invalid use of arithmetic, such as dividing by zero.
Neo.ClientError.Statement.ConstraintVerificationFailed	A constraint imposed by the statement is violated by the data in the database.
Neo.ClientError.Statement.EntityNotFound	The statement is directly referring to an entity that does not exist.
Neo.ClientError.Statement.LabelNotFound	The statement is referring to a label that does not exist.
Neo.ClientError.Statement.ParameterMissing	The statement is referring to a parameter that was not provided in the request.
Neo.ClientError.Statement.PropertyNotFound	The statement is referring to a property that does not exist.
Neo.ClientError.Statement.SemanticError	The statement is syntactically valid, but expresses something that the database cannot do.
Neo.ClientError.Statement.SyntaxError	The statement contains invalid or unsupported syntax.
Neo.ClientError.Statement.TypeError	The statement is attempting to perform operations on values with types that are not supported by the operation.
Neo.ClientError.Transaction.ForbiddenDueToTransactionType	The transaction is of the wrong type to service the request. For instance, a transaction that has had schema modifications performed in it cannot be used to subsequently perform data operations, and vice versa.
Neo.ClientError.Transaction.TransactionAccessedConcurrently	There were concurrent requests accessing the same transaction, which is not allowed.
Neo.ClientError.Transaction.TransactionEventHandlerFailed	A transaction event handler threw an exception. The transaction will be rolled back.
Neo.ClientError.Transaction.TransactionHookFailed	Transaction hook failure.
Neo.ClientError.Transaction.TransactionMarkedAsFailed	Transaction was marked as both successful and failed. Failure takes precedence and so this transaction was rolled back although it may have looked like it was going to be committed
Neo.ClientError.Transaction.TransactionNotFound	The request referred to a transaction that does not exist.

Status Code	Description
Neo.ClientError.Transaction.TransactionTerminated	The current transaction has been marked as terminated, meaning no more interactions with it are allowed. There are several reasons this happens - the client might have asked for the transaction to be terminated, an operator might have asked for the database to be shut down, or the current instance is about to go through a cluster role switch. Simply retry your operation in a new transaction.
Neo.ClientError.Transaction.TransactionValidationFailed	Transaction changes did not pass validation checks
Neo.ClientNotification.Statement.CartesianProductWarning	This query builds a cartesian product between disconnected patterns.
Neo.ClientNotification.Statement.DynamicPropertyWarning	Queries using dynamic properties will use neither index seeks nor index scans for those properties
Neo.ClientNotification.Statement.EagerOperatorWarning	The execution plan for this query contains the Eager operator, which forces all dependent data to be materialized in main memory before proceeding
Neo.ClientNotification.Statement.ExhaustiveShortestPathWarning	Exhaustive shortest path has been planned for your query that means that shortest path graph algorithm might not be used to find the shortest path. Hence an exhaustive enumeration of all paths might be used in order to find the requested shortest path.
Neo.ClientNotification.Statement.FeatureDeprecationWarning	This feature is deprecated and will be removed in future versions.
Neo.ClientNotification.Statement.JoinHintUnfulfillableWarning	The database was unable to plan a hinted join.
Neo.ClientNotification.Statement.JoinHintUnsupportedWarning	Queries with join hints are not supported by the RULE planner.
Neo.ClientNotification.Statement.NoApplicableIndexWarning	Adding a schema index may speed up this query.
Neo.ClientNotification.Statement.PlannerUnsupportedWarning	This query is not supported by the COST planner.
Neo.ClientNotification.Statement.RuntimeUnsupportedWarning	This query is not supported by the compiled runtime.
Neo.ClientNotification.Statement.UnboundedVariableLengthPatternWarning	The provided pattern is unbounded, consider adding an upper limit to the number of node hops.
Neo.ClientNotification.Statement.UnknownLabelWarning	The provided label is not in the database.
Neo.ClientNotification.Statement.UnknownPropertyKeyWarning	The provided property key is not in the database
Neo.ClientNotification.Statement.UnknownRelationshipTypeWarning	The provided relationship type is not in the database.
Neo.DatabaseError.General.IndexCorruptionDetected	The request (directly or indirectly) referred to an index that is in a failed state. The index needs to be dropped and recreated manually.
Neo.DatabaseError.General.SchemaCorruptionDetected	A malformed schema rule was encountered. Please contact your support representative.
Neo.DatabaseError.General.UnknownError	An unknown error occurred.
Neo.DatabaseError.Schema.ConstraintCreationFailed	Creating a requested constraint failed.
Neo.DatabaseError.Schema.ConstraintDropFailed	The database failed to drop a requested constraint.
Neo.DatabaseError.Schema.IndexCreationFailed	Failed to create an index.
Neo.DatabaseError.Schema.IndexDropFailed	The database failed to drop a requested index.
Neo.DatabaseError.Schema.LabelAccessFailed	The request accessed a label that did not exist.
Neo.DatabaseError.Schema.LabelLimitReached	The maximum number of labels supported has been reached, no more labels can be created.

Status Code	Description
Neo.DatabaseError.Schema.PropertyKeyAccessFailed	The request accessed a property that does not exist.
Neo.DatabaseError.Schema.RelationshipTypeAccessFailed	The request accessed a relationship type that does not exist.
Neo.DatabaseError.Schema.SchemaRuleAccessFailed	The request referred to a schema rule that does not exist.
Neo.DatabaseError.Schema.SchemaRuleDuplicateFound	The request referred to a schema rule that is defined multiple times.
Neo.DatabaseError.Statement.ExecutionFailed	The database was unable to execute the statement.
Neo.DatabaseError.Transaction.TransactionCommitFailed	The database was unable to commit the transaction.
Neo.DatabaseError.Transaction.TransactionLogError	The database was unable to write transaction to log.
Neo.DatabaseError.Transaction.TransactionRollbackFailed	The database was unable to roll back the transaction.
Neo.DatabaseError.Transaction.TransactionStartFailed	The database was unable to start the transaction.
Neo.TransientError.General.DatabaseUnavailable	The database is not currently available to serve your request, refer to the database logs for more details. Retrying your request at a later time may succeed.
Neo.TransientError.General.OutOfMemoryError	There is not enough memory to perform the current task. Please try increasing 'dbms.memory.heap.max_size' in the process wrapper configuration (normally in 'conf/neo4j-wrapper.conf' or, if you are using Neo4j Desktop, found through the user interface) or if you are running an embedded installation increase the heap by using '-Xmx' command line flag, and then restart the database.
Neo.TransientError.General.StackOverFlowError	There is not enough stack size to perform the current task. This is generally considered to be a database error, so please contact Neo4j support. You could try increasing the stack size: for example to set the stack size to 2M, add `dbms.jvm.additional=-Xss2M' to in the process wrapper configuration (normally in 'conf/neo4j-wrapper.conf' or, if you are using Neo4j Desktop, found through the user interface) or if you are running an embedded installation just add -Xss2M as command line flag.
Neo.TransientError.Network.CommunicationError	An unknown network failure occurred, a retry may resolve the issue.
Neo.TransientError.Schema.SchemaModifiedConcurrently	The database schema was modified while this transaction was running, the transaction should be retried.
Neo.TransientError.Security.ModifiedConcurrently	The user was modified concurrently to this request.
Neo.TransientError.Statement.ExternalResourceFailed	Access to an external resource failed
Neo.TransientError.Transaction.ConstraintsChanged	Database constraints changed since the start of this transaction
Neo.TransientError.Transaction.DeadlockDetected	This transaction, and at least one more transaction, has acquired locks in a way that it will wait indefinitely, and the database has aborted it. Retrying this transaction will most likely be successful.
Neo.TransientError.Transaction.InstanceStateChanged	Transactions rely on assumptions around the state of the Neo4j instance they execute on. For instance, transactions in a cluster may expect that they are executing on an instance that can perform writes. However, instances may change state while the transaction is running. This causes assumptions the instance has made about how to execute the transaction to be violated - meaning the transaction must be rolled back. If you see this error, you should retry your operation in a new transaction.
Neo.TransientError.Transaction.LockSessionExpired	The lock session under which this transaction was started is no longer valid.

Chapter 27. Terminology

The terminology used for Cypher and Neo4j is drawn from the worlds of database design and graph theory. This section provides cross-linked summaries of common terms.

In some cases, multiple terms (e.g., arc, edge, relationship) may be used for the same or similar concept. An asterisk (*) to the right of a term indicates that the term is commonly used for Neo4j and Cypher.

acyclic

for a graph or subgraph: when there is no way to start at some node `n` and follow a sequence of adjacent relationships that eventually loops back to `n` again. The opposite of cyclic.

adjacent

nodes sharing an incident (that is, directly-connected) relationship or relationships sharing an incident node.

attribute

Synonym for property.

arc

graph theory: a synonym for a directed relationship.

array

container that holds a number of elements. The element types can be the types supported by the underlying graph storage layer, but all elements must be of the same type.

aggregating expression

expression that summarizes a set of values, like computing their sum or their maximum.

clause

component of a Cypher query or command; starts with an identifying keyword (for example `CREATE`). The following clauses currently exist in Cypher: `CREATE`, `CREATE UNIQUE`, `DELETE`, `FOREACH`, `LOAD CSV`, `MATCH`, `MERGE`, `OPTIONAL MATCH`, `REMOVE`, `RETURN`, `SET`, `START`, `UNION`, and `WITH`.

co-incident

alternative term for adjacent relationships, which share a common node.

collection

container that holds a number of values. The values can have mixed types.

command

a statement that operates on the database without affecting the data graph or returning content from it.

commit

successful completion of a transaction, ensuring durability of any changes made.

constraint

part of a database schema: defines a contract that the database will never break (for example, uniqueness of a property on all nodes that have a specific label).

cyclic

The opposite of acyclic.

Cypher
: a special-purpose programming language for describing queries and operations on a graph database, with accompanying natural language concepts.

DAG
: a directed, acyclic graph: there are no cyclic paths and all the relationships are directed.

data graph
: graph stored in the database. See also property graph.

data record
: a unit of storage containing an arbitrary unordered collection of properties.

degree
: *of a node:* is the number of relationships leaving or entering (if directed) the node; loops are counted twice.

directed relationship
: a relationship that has a direction; that is the relationship has a source node and a destination node. The opposite of an undirected relationship. All relationships in a Neo4j graph are directed.

edge
: *graph theory:* a synonym for undirected relationship.

execution result
: all statements return an execution result. For queries, this can contain an iterator of result rows.

execution plan
: parsed and compiled statement that is ready for Neo4j to execute. An execution plan consists of the physical operations that need to be performed in order to achieve the intent of the statement.

expression
: produces values; may be used in *projections*, as a *predicate*, or when setting *properties* on graph elements.

graph
: 1. data graph,
  2. property graph,
  3. *graph theory:* set of vertices and edges.

graph database
: a database that uses graph-based structures (for example, nodes, relationships, properties) to represent and store data.

graph element
: a node, relationship, or path which is part of a graph.

variable
: variables are named bindings to values (for example, collections, scalars) in a statement. For example, in `MATCH (n) RETURN n`, `n` is a variable.

incident
: adjacent relationship attached to a node or a node attached to a relationship.

incoming relationship

pertaining to a directed relationship: from the point of view of a node `n`, this is any relationship `r` arriving at `n`, exemplified by `()-[:r]->(n)`. The opposite of outgoing.

index

data structure that improves performance of a database by redundantly storing the same information in a way that is faster to read.

intermediate result

set of variables and values (record) passed from one clause to another during query execution. This is internal to the execution of a given query.

label

marks a node as a member of a named subset. A node may be assigned zero or more labels. Labels are written as `:label` in Cypher (the actual label is prefixed by a colon). Note: *graph theory:* This differs from mathematical graphs, where a label applies uniquely to a single vertex.

loop

a relationship that connects a node to itself.

neighbor

of node: another node, connected by a common relationship; *of relationship:* another relationship, connected to a common node.

*node**

data record within a data graph; contains an arbitrary collection of properties. Nodes may have zero, one, or more labels and are optionally connected by relationships. Similar to vertex.

null

`NULL` is a special marker, used to indicate that a data item does not exist in the graph or that the value of an expression is unknown or inapplicable.

operator

there are three categories of operators in Cypher:

1. *Arithmetic,* such as `+`, `/`, `%` etc.;
2. *Logical,* such as `OR`, `AND`, `NOT` etc.; and
3. *Comparison,* such as `<`, `>`, `=` etc.

outgoing relationship

pertaining to a directed relationship: from the point of view of a node `n`, this is any relationship `r` leaving `n`, exemplified by `(n)-[:r]->()`. The opposite of incoming relationship.

pattern graph

graph used to express the shape (that is, connectivity pattern) of the data being searched for in the data graph. This is what `MATCH` and `WHERE` describe in a Cypher query.

*path**

collection of alternating nodes and relationships that corresponds to a walk in the data graph.

parameter

named value provided when running a statement. Parameters allow Cypher to efficiently re-use execution plans without having to parse and recompile every statement when only a literal value changes.

predicate

expression that returns `TRUE`, `FALSE` or `NULL`. When used in `WHERE`, `NULL` is treated as `FALSE`.

projection
: an operation taking result rows as both input and output data. This may be a subset of the variables provided in the input, a calculation based on variables in the input, or both. The relevant clauses are `WITH` and `RETURN`.

*property**
: named value stored in a node or relationship. Synonym for attribute.

property graph
: a graph having directed, typed relationships. Each node or relationship may have zero or more associated properties.

*query**
: statement that reads or writes data from the database

*relationship**
: data record in a property graph that associates an ordered pair of nodes. Similar to arc and edge.

relationship type
: marks a relationship as a member of a named subset. A relationship must be assigned one and only one type. For example, in the Cypher pattern `(start)-[:TYPE] (to)`, `TYPE` is the relationship type.

result row
: each query returns an iterator of result rows, which represents the result of executing the query. Each result row is a set of key-value pairs (a record).

rollback
: abort of the containing transaction, effectively undoing any changes defined inside the transaction.

schema
: persistent database state that describes available indexes and enabled constraints for the data graph.

schema command
: statement that updates the schema.

statement
: text string containing a Cypher query or command.

type
: types classify values. Each value in Cypher has a concrete type. Supported types are:

  - string,
  - boolean,
  - the number types (double, integer, long),
  - the map types (plain maps, nodes, and relationships),
  - and collections of any concrete type.

  The type hierarchy supports several other types (for example, any, scalar, derived map, collection). These are used to classify values and collections of values having different concrete types.

transaction

A transaction comprises a unit of work performed against a database. It is treated in a coherent and reliable way, independent of other transactions. A transaction, by definition, must be atomic, consistent, isolated, and durable.

transitive closure

of a graph: is a graph which contains a relationship from node x to node y whenever there is a directed path from x to y; For example, if there is a relationship from a to b, and another from b to c, then the transitive closure includes a relationship from a to c.

undirected relationship

a relationship that doesn't have a direction. The opposite of directed relationship.

vertex

graph theory: the fundamental unit used to form a mathematical graph (plural: vertices). See node.

Chapter 28. License

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