Paths in semantic search: A back and forth story

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PUC Chile

The story

Navigational capabilities are important for graph data models.

RDF is a new data model.

- It can be considered as a graph data model, but it has some non-trivial new features.

Interaction between databases and semantic web.

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- ← Need for navigational capabilities in SPARQL
- → Extensive use of regular expressions to specify paths in graph databases and XML
- ← Regular expressions are included in SPARQL 1.1, but with a multiset (bag) semantics

The story (cont.)

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- ➔ ...
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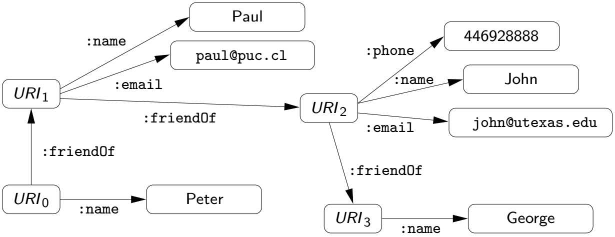
SPARQL 1.0 provides limited navigational capabilities



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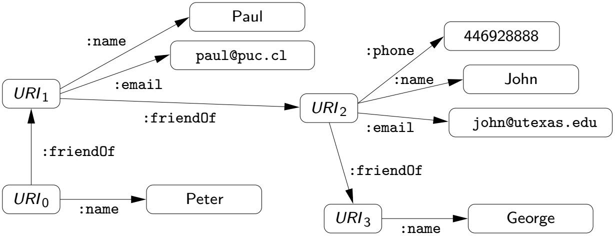


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SELECT ?x
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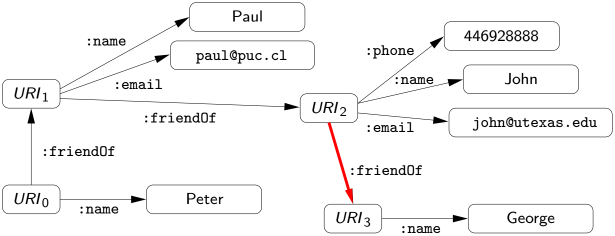


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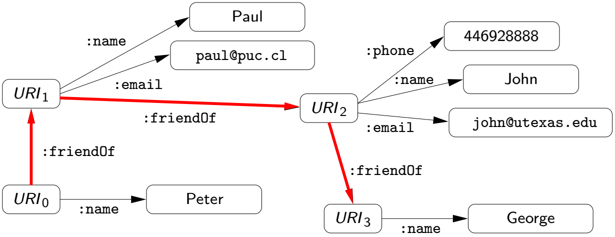


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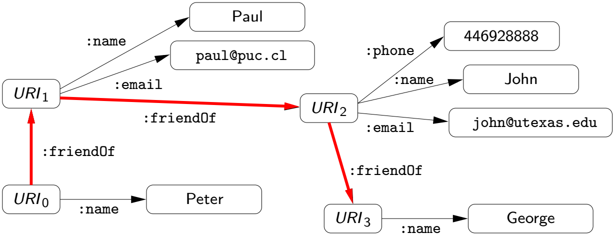
A possible solution: Regular expressions in graph databases



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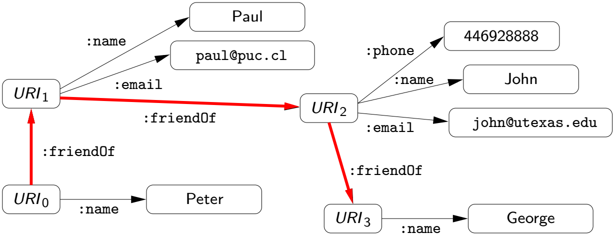


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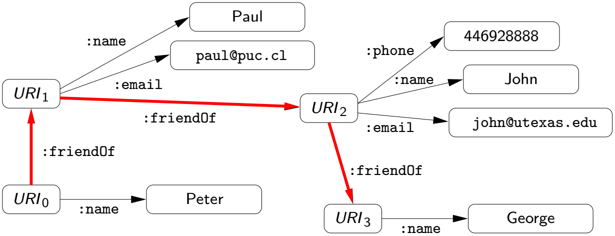


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SELECT ?x
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- Semantics
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All this has to be done considering the use cases.

Syntax and semantics of property paths

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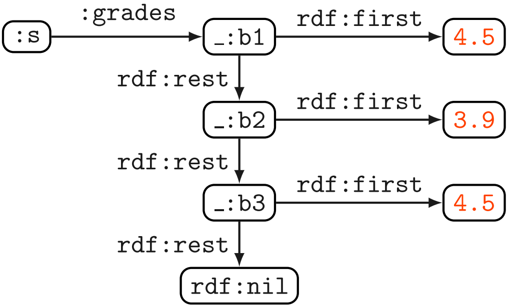

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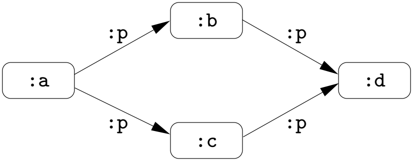


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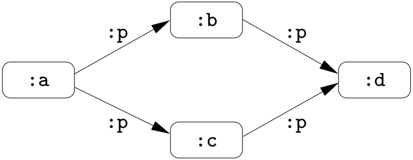


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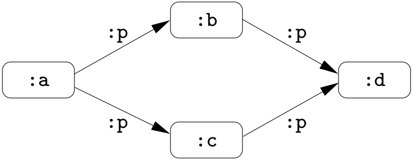


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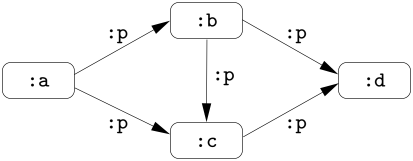


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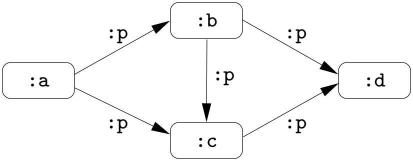


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But how do we evaluate $*$?

- How do we deal with cycles?

Definition of the semantics of $*$

Evaluation of *path*$*$

"the algorithm extends the multiset of results by one application of path. If a node has been visited for path, it is not a candidate for another step. A node can be visited multiple times if different paths visit it."

SPARQL 1.1 Last Call (Jan 2012)

Definition of the semantics of $*$

Evaluation of *path$*$*

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SPARQL 1.1 Last Call (Jan 2012)

- SPARQL 1.1 document provides a special procedure to handle cycles and make the count

Is this a good semantics?

Linked list example:

```
SELECT ?x
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Couldn't these use cases be handled with a simpler semantics?

- Isn't a problem to use an arbitrary procedure to count paths? What are we counting?

Is this a good semantics? (cont.)

Regular expressions with an *existential* semantics have been widely studied and used in databases.

- Why don't we take advantage of this experience?

Is this a good semantics? (cont.)

Regular expressions with an *existential* semantics have been widely studied and used in databases.

- Why don't we take advantage of this experience?

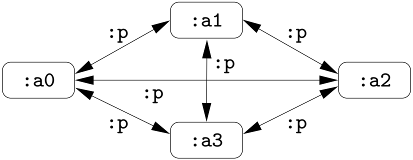
A new problem need to be solved: Counting the number of paths in a graph that conform to a regular expression

- How difficult is this problem?

Some experimental results with synthetic data

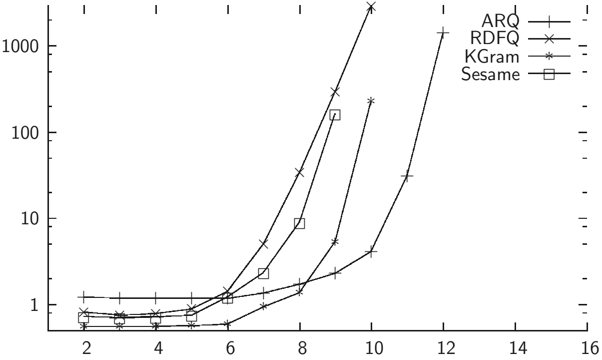
Data:

- cliques (complete graphs) of different size
- from 2 nodes (87 bytes) to 13 nodes (970 bytes)



RDF clique with 4 nodes (127 bytes)

Some experimental results with synthetic data

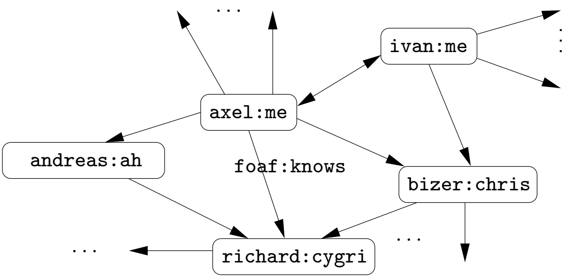


SELECT * WHERE { :a0 (:p)* :a1 }

Some experimental results with real data

Data:

- Social Network data given by `foaf:knows` links
- Crawled from Axel Polleres' foaf document (3 steps)
- Different documents, deleting some nodes



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Input	ARQ	RDFQ	Kgram	Sesame
9.2KB	5.13	75.70	313.37	–
10.9KB	8.20	325.83	–	–
11.4KB	65.87	–	–	–
13.2KB	292.43	–	–	–
14.8KB	–	–	–	–
17.2KB	–	–	–	–
20.5KB	–	–	–	–
25.8KB	–	–	–	–

(time in seconds, timeout = 1hr)

Counting the number of solutions

Data: Clique of size n

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every solution is a copy of the empty mapping (| | in ARQ)

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9	13,700
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`{ :a0 (:p)* :a1 }`   `{ :a0 ((:p)*)* :a1 }`

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10.9KB	43	122,631	8.4MB
11.4KB	47	1,739,331	120MB
13.2KB	52	8,511,943	587MB
14.8KB	54	–	–

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What is going on?

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It is possible to construct a formula for calculating the number of solutions in the clique experiment.

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79 Yottabytes for the answer over a file of 379 bytes

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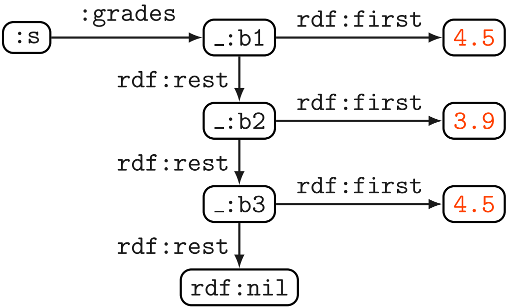
Are we done? Some questions have to be answered.

- Is this a reasonable semantics? `(:a/:b/:c)` counts, but `(:a/:b/:c)*` does not
- Is the language expressive enough?

A pure existential semantics can handle the use cases

Linked list example:

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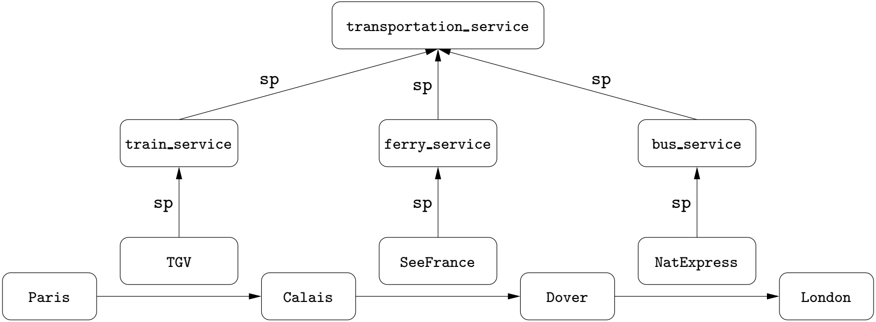
Expressiveness: There is still some work to do

List the pairs *a*, *b* of cities such that there is a way to travel from *a* to *b*.



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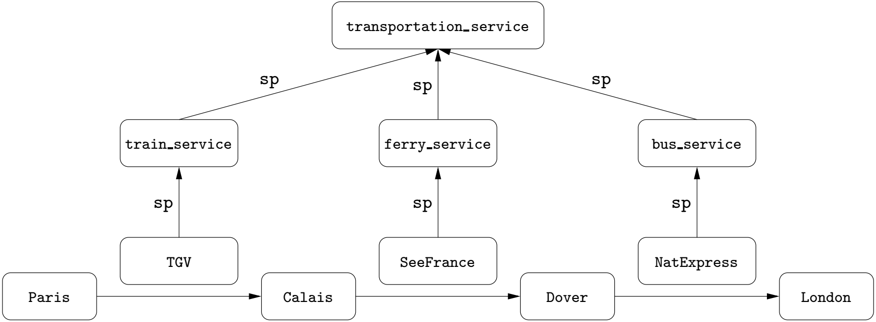

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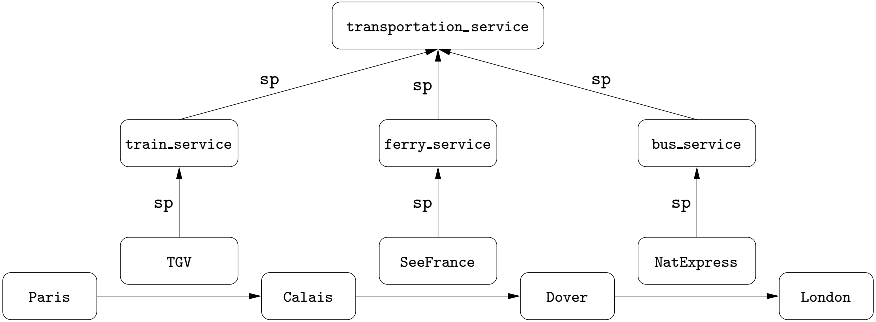

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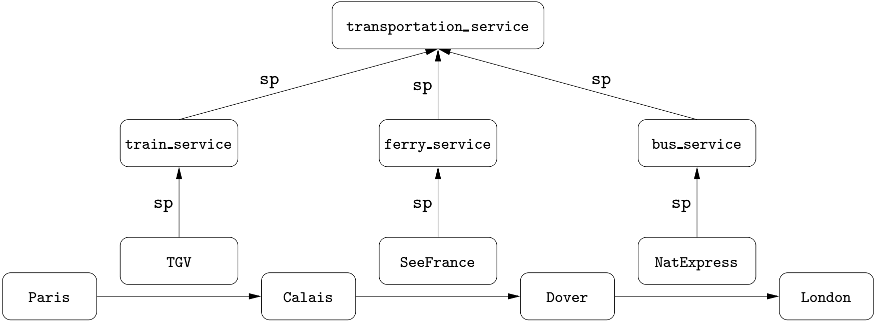

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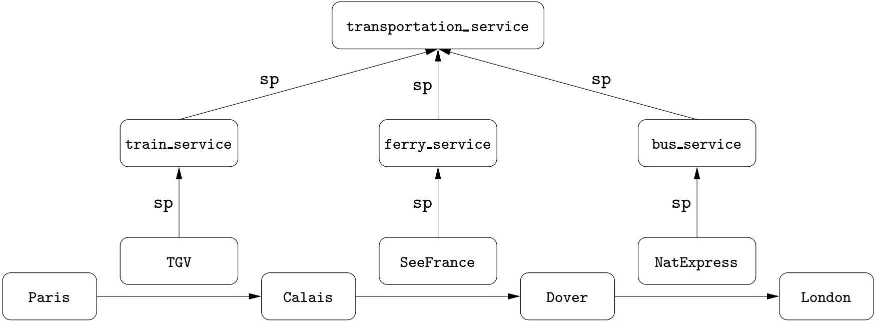

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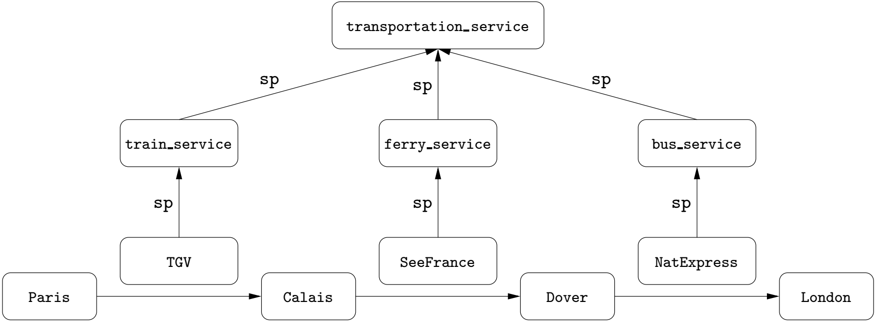

nSPARQL: `?x (next::[(next::sp)*/ ])+ ?y`

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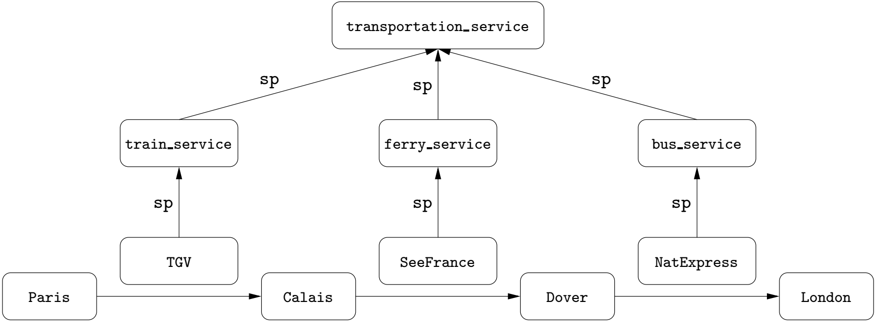

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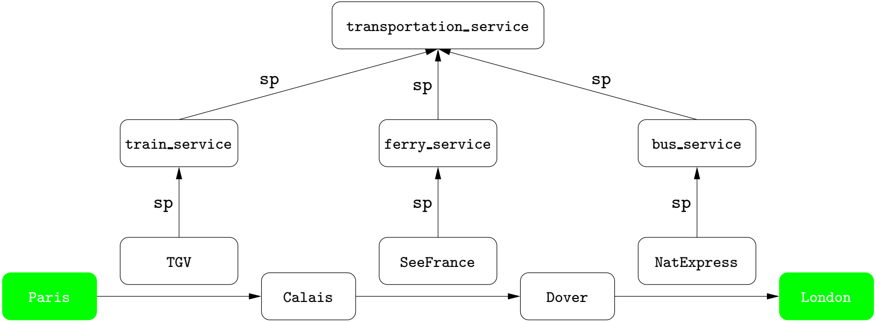

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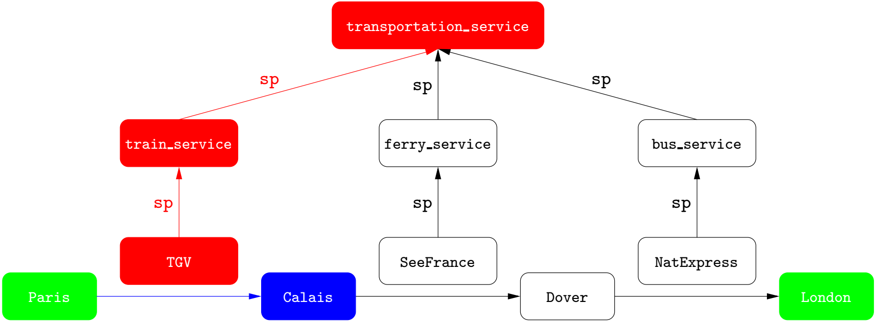

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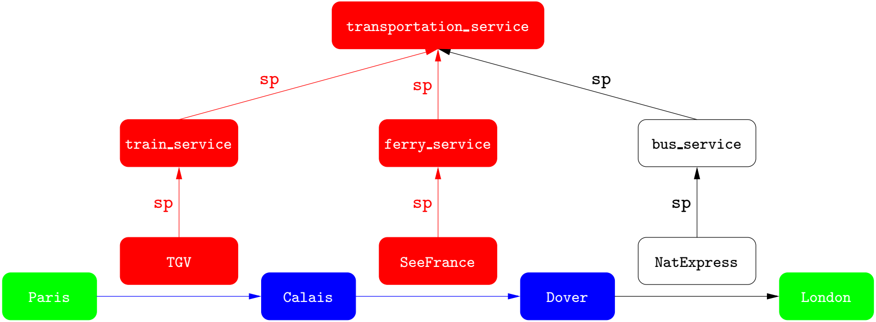

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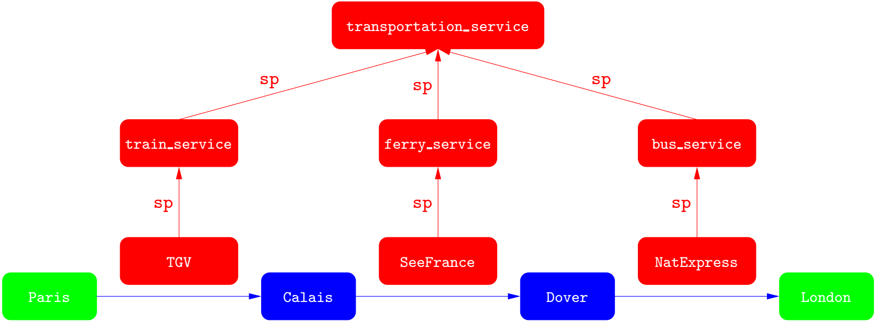

nSPARQL: `?x (next::[(next::sp)*/transportation_service])+ ?y`

Expressiveness: There is still some work to do (cont.)

In the previous example, it would be great to be able to list some paths from *a* to *b*.

- This feature is needed in many use cases

This feature is present in some graph/RDF query languages, but it has not been standardized.

- Paths can be returned as strings in Cypher (Neo4j)
- Virtuoso provides some options in the transitivity extension that allow to store paths in the output table