A low-level approach for graph database query processor

Graph database is a database that uses graph structures for semantic queries with nodes, edges (i.e. relationships), and properties to represent and store data. The relationships allow data in the store to be linked together directly and, in many cases, retrieved with one operation.

Cypher is a declarative graph query language that allows for expressive and efficient data querying in a property graph. The language was designed with the power and capability of SQL in mind, but based on the components and needs of a graph database.

Problem

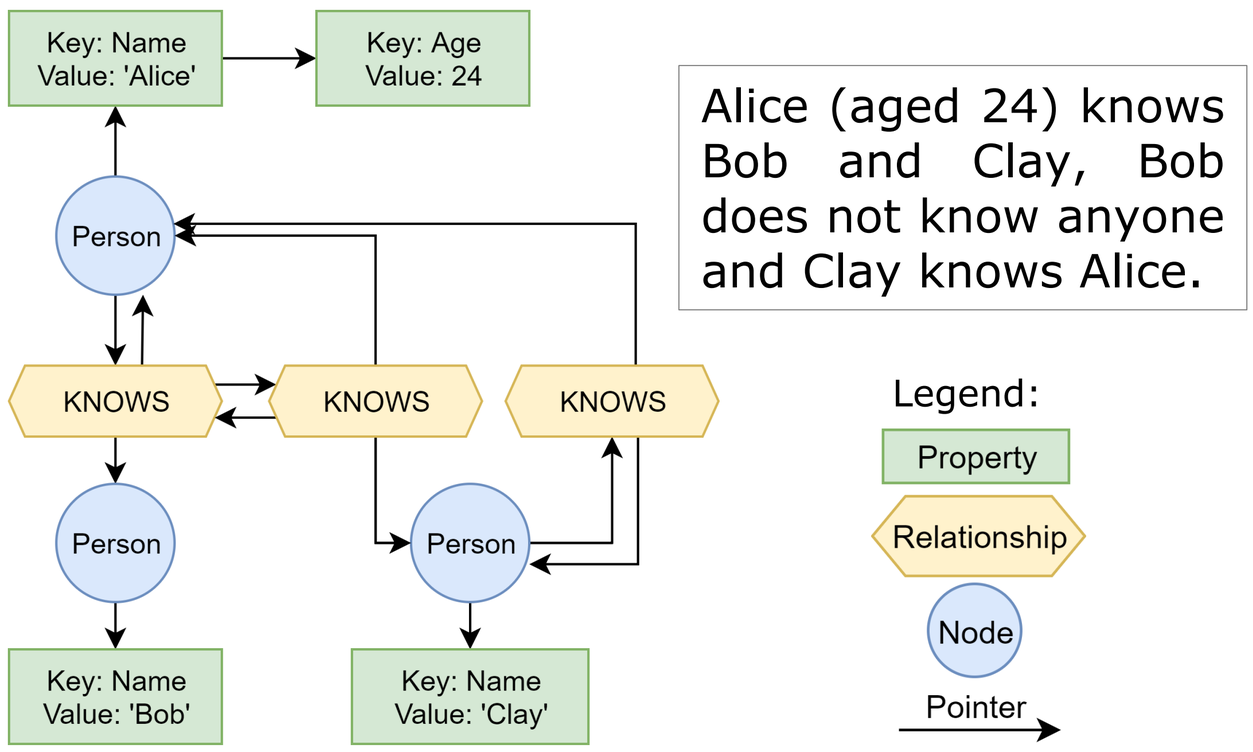
Graph DBMS can run many kinds of queries, possibly in parallel, and sometimes with transaction isolation. Therefore it **may be slower** than specialized, one-time query written in C.

Goal

Since graph data can be stored manifoldly, goal of this project is to **boost Cypher queries performance** assuming data storage as in one of the most popular graph database—Neo4j.

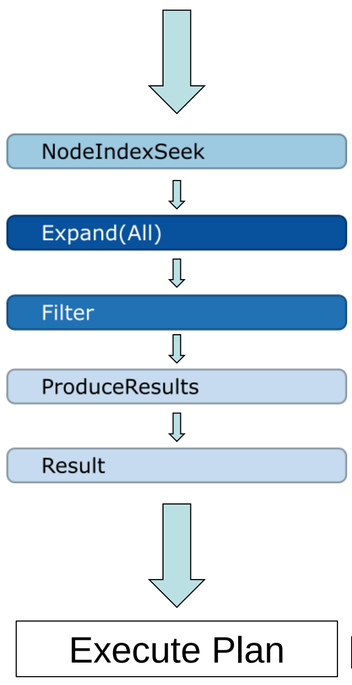
Solution

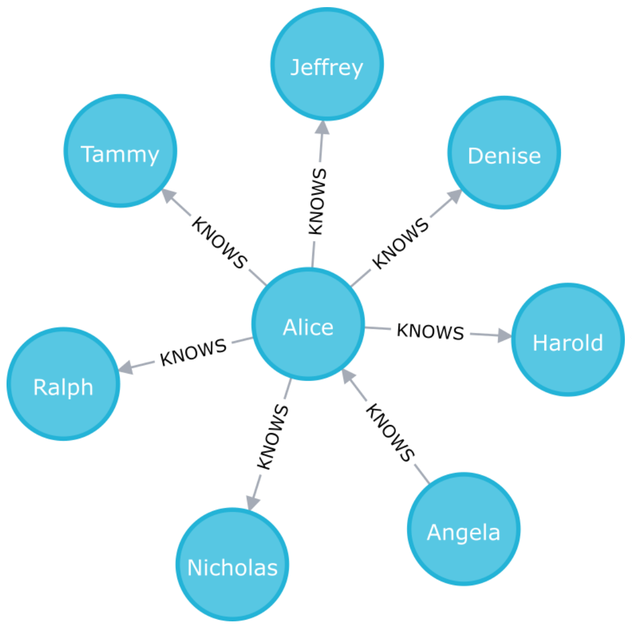
Inspired by the lecture held by Tiark Rompf: "A PL & Compiler View on Data Management and ML Systems" and his presented paper [1], we will try to write **Cypher to C query compiler** for Neo4j data storage. In Neo4j, entities are stored on disk by leveraging linking [2] as shown on the graph on the right. Since entities there have fixed, maximum size, we can achieve similar performance boost as in [1] by utilizing pointers in C language and directly reference entities throughout memory or file. Below, two diagrams present Cypher Neo4j processor behaviour (left) and how we could interpret Cypher and generate C queries to get the same result, but faster (right).



Cypher Neo4j processor

```
MATCH (n: Person)-[:KNOWS]->(m: Person)
WHERE n.name = 'Alice'
```





Cypher queries in C

```
MATCH (n: Person)-[:KNOWS]->(m: Person)
WHERE n.name = 'Alice'
```

Scala Cypher Interpreter

C language generator

Execute C

Sample code snippet how Cypher interpreter may look like

```
def stm: Parser[Operator] =
  matchClause ~ whereClause ~ returnClause ...
def matchClause: Parser[Operator=>Operator =
 "MATCH" ~> ...
def whereClause: Parser[Operator=>Operator =
 opt("WHERE" ~> ...
def returnClause: Parser[Operator=>Operator =
 "RETURN" ~> ...
```

Sample code snippet how C generator may look like (also written in Scala)

```
def execOp(o: Operator)(yld: Record => Unit):
Unit = o match {
  case Match(node1, relationship, node2) => ...
  case Filter(condition) => ...
  case Project(fieldList) => ...
}
```

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References

[1] Tiark Rompf, Nada Amin, "Functional Pearl: A SQL to C Compiler in 500 Lines of Code"

[2] "Understanding Neo4j's data on disk": https://neo4j.com/developer/kb/understanding-data-on-disk/

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