aDFS: An Almost Depth-First-Search Distributed Graph-Querying System

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Graphs and Graph Queries

- Graphs are everywhere!
  - Oracle Labs PGX.Distributed
- Graph queries
  - Allow flexible exploration of graphs
  - Similar to SQL for RDBMs
  - PGX.D’s aDFS uses PGQL (pgql-lang.org)

Like SQL but adds **MATCH**

```
-- Info of authors who like each other and have < 10 years of age difference
SELECT a1.name, a2.name, a1.country = a2.country,
       ABS(a1.salary - a2.salary) AS salary_diff
MATCH (a1:author) -[:likes]-> (a2:author) -[:likes]-> (a1)
WHERE ABS(a1.age - a2.age) < 10
ORDER BY salary_diff DESC
```

Any user expression in projections and filters

Requires **homomorphic matching** and returns **all result permutations**
Complexities in Graph-Query Execution

- Limited locality (especially in a distributed system)
- Intermediate (and final) result explosion

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**1 hop**

```
SELECT COUNT(*) MATCH (a)->()
+------------------------+------------------------+------------------------+
<p>| COUNT(*) | | 1,468,365,182 |</p>
<table>
<thead>
<tr>
<th>-----------</th>
</tr>
</thead>
</table>
```

**2 hops**

```
SELECT COUNT(*) MATCH (a)->()--()
+------------------------+------------------------+------------------------+
<p>| COUNT(*) | | 9,324,563,362,739 |</p>
<table>
<thead>
<tr>
<th>-----------</th>
</tr>
</thead>
</table>
```

-- Info of authors who like each other and have < 10 years of age difference

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Need a distributed solution that is flexible and can handle the **scale**

Twitter graph

PGX.D aDFS
8 machines
~20 minutes
~8B matches/s
Agenda

1. Introduction / Motivation
2. aDFS Design
3. Evaluation
4. Conclusions
aDFS Design Principles

1. **Asynchronous operation**
   - Workers operate independently
     - on traversals where there is work
   - Workers buffer and forget remote traversals
   \[\rightarrow\text{Workers do not block due to remote communication}\]

2. **(Almost) Depth-first traversal**
   - Eager completion of matches
   - Fine-grained flow control
   \[\rightarrow\text{Control memory consumption}\]

In-memory distributed execution with controllable memory usage
From a PGQL Query to an aDFS Execution Plan

SELECT ... 
MATCH 
(a)->(b), 
(b)->(c), 
(c)->(d) 
WHERE ... 

A list of stages that “know” how to 
1. match a vertex 
2. move to next stage
Asynchronous DFS/BFS Traversals

MATCH (a) → (b) → (c) → (d)

Is “strict” DFS the best approach? No!
Experimental Evaluation
Q1: cycle (a) \(\rightarrow\) (b) \(\rightarrow\) (a)  
Q2: 2-hops (a) \(\rightarrow\) (b) \(\rightarrow\) (c)

- aDFS and GraphFrames with 8 machines / others single machine
- aDFS configured with 1GB memory per machine / others have access to whole machine memory (768 GB)
- Did not complete in 8 hours
- Hang due to out of memory

**Only aDFS can handle the scale**
Conclusions & Future Work

• **aDFS is a fast and scalable distributed graph querying engine**
  • Provides flexible PGQL querying
  • Combines BFS / DFS
  • Limits max memory usage

• **Current and future work** – extend PGQL capabilities, e.g.,
  • Reachability Path Queries (RPQs), e.g., (p1:person) -/:friend*-> (p2:person)
  • Sub-queries
  • SHORTEST / CHEAPEST paths

Thank you!
Reach out to vasileios.trigonakis@oracle.com for questions, but also internship / job opportunities!