Let Me Graph That For You

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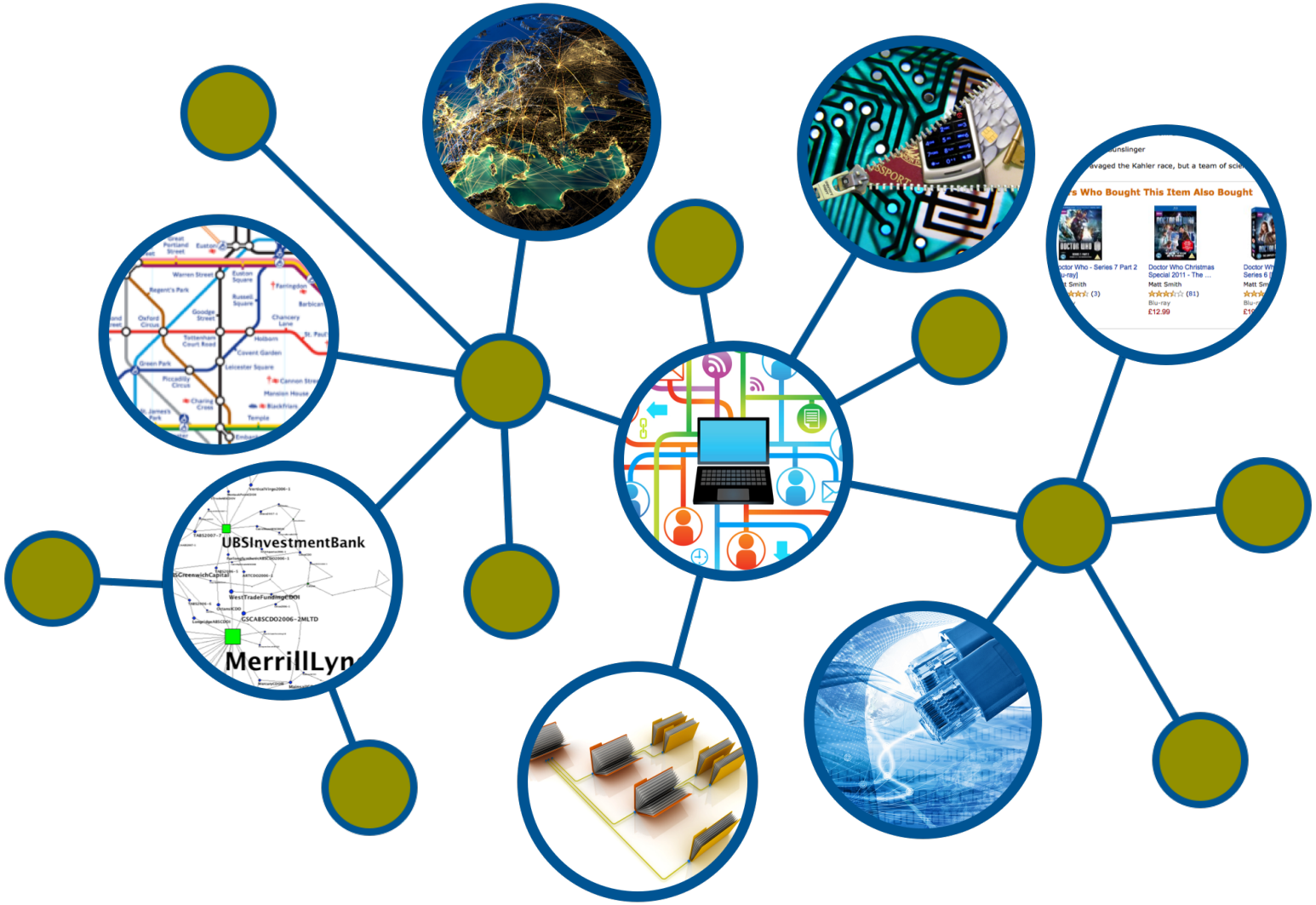
complexity = f(size, variable structure, connectedness)



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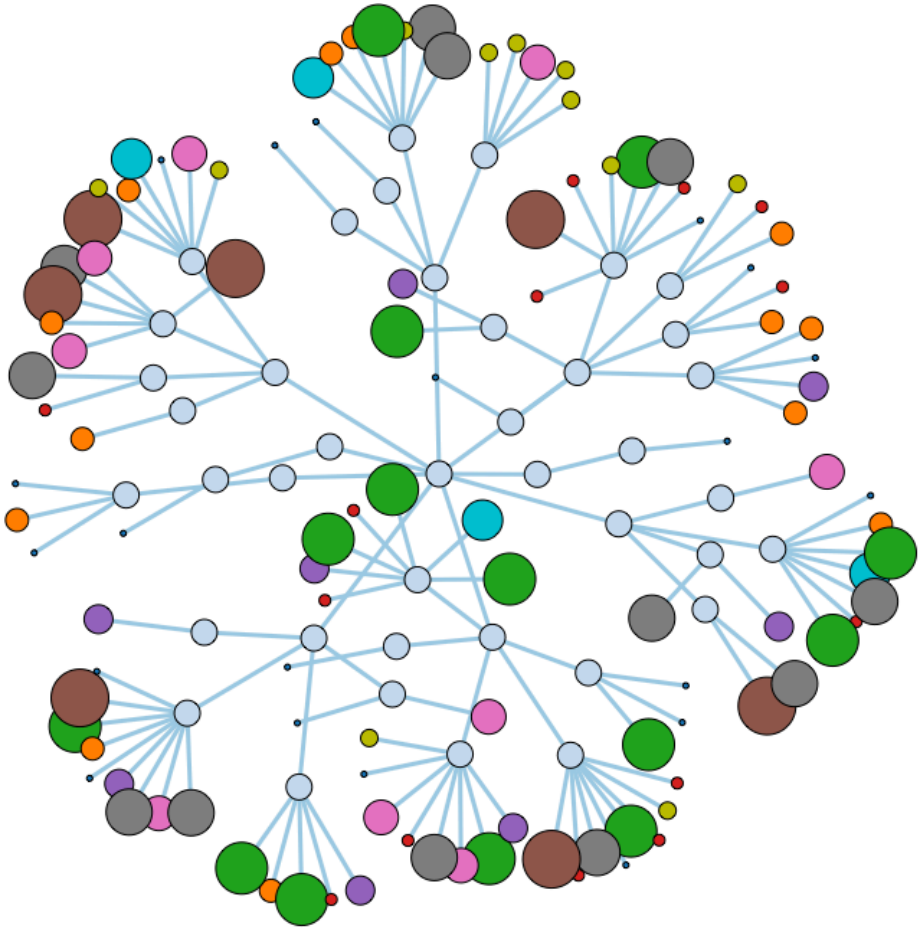
Graphs Are Everywhere



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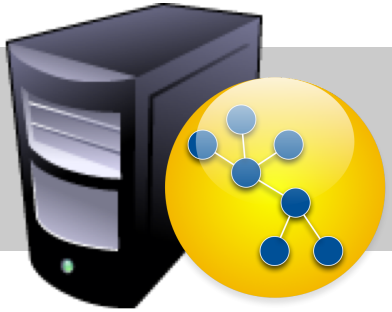
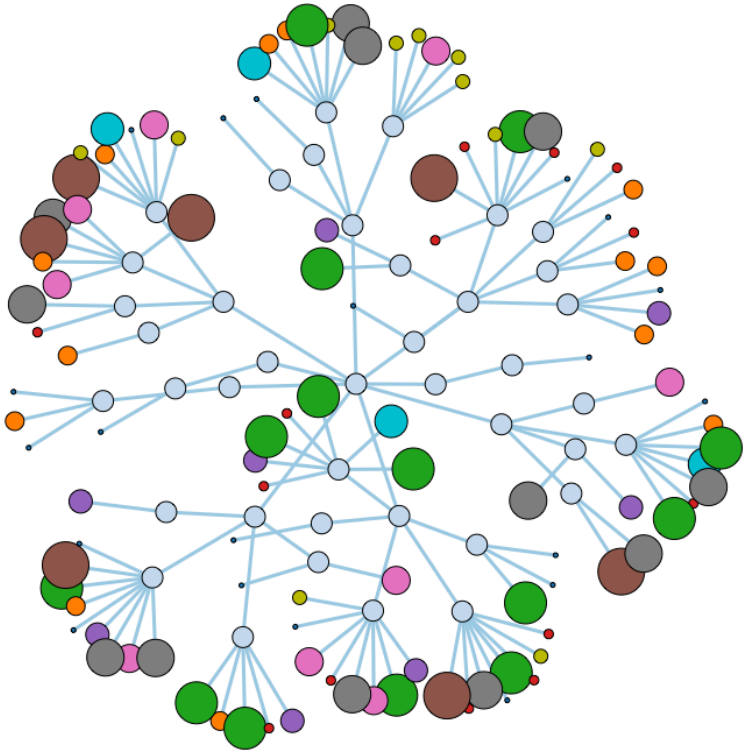
Graph Databases



- Store
- Manage
- Query



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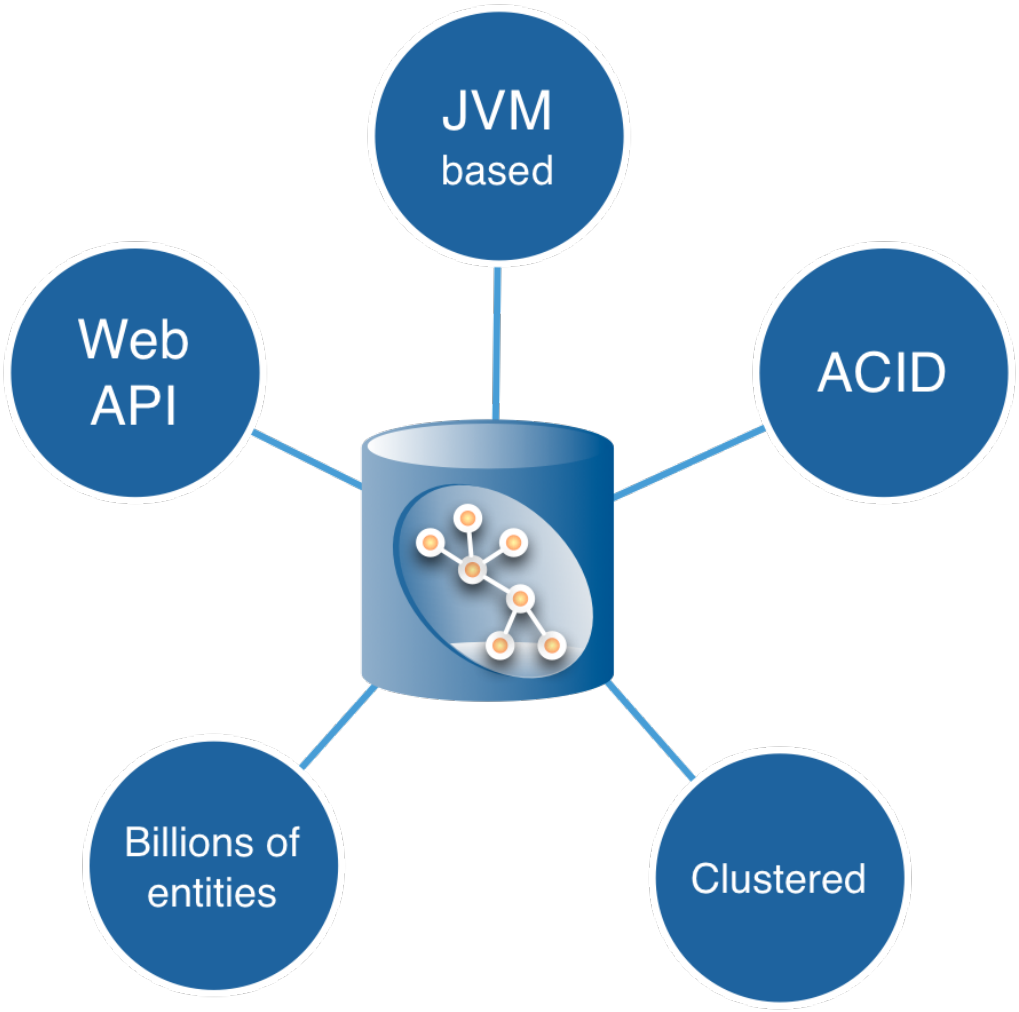
Neo4j is a Graph Database



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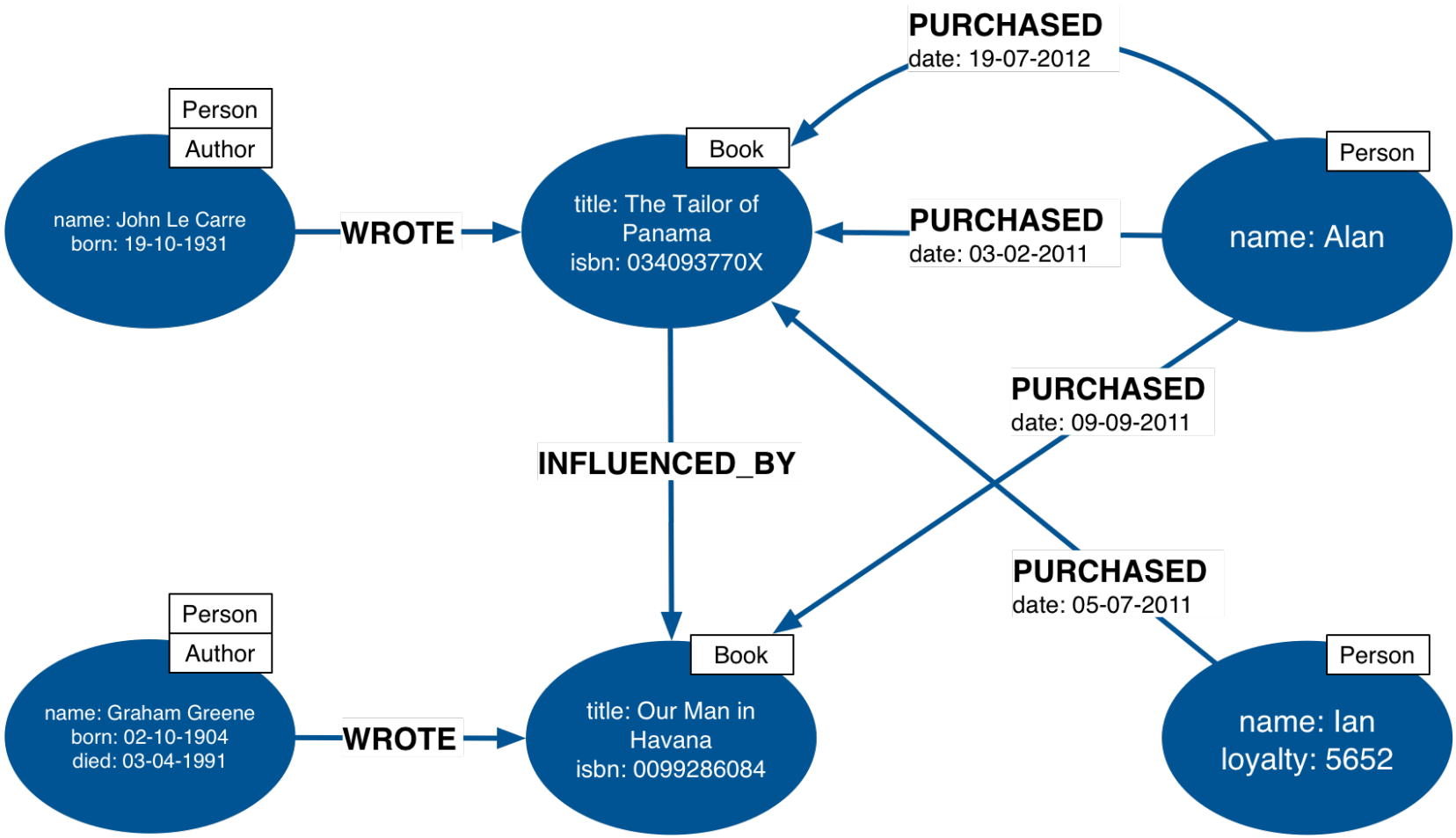
Labeled Property Graph



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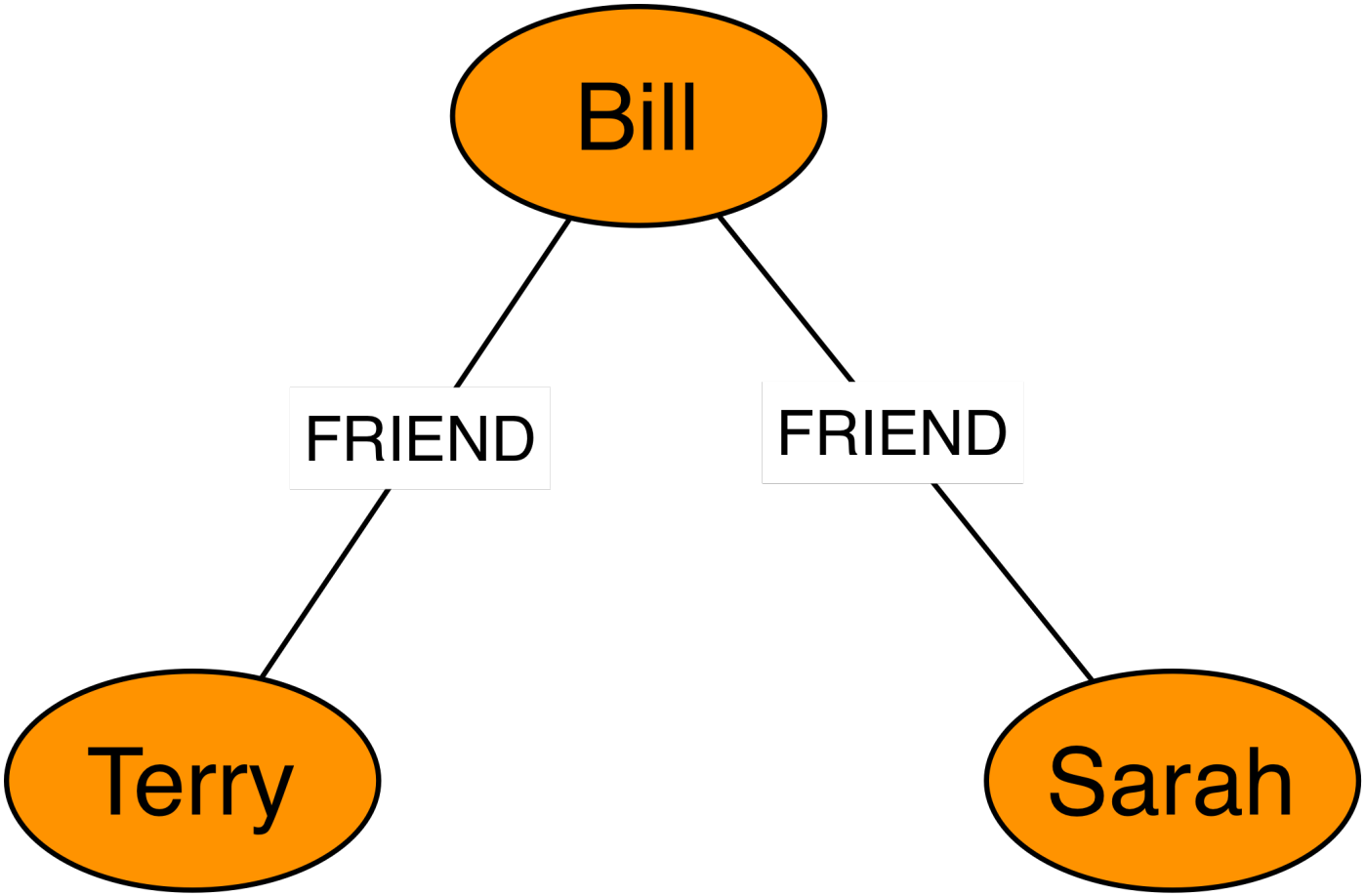
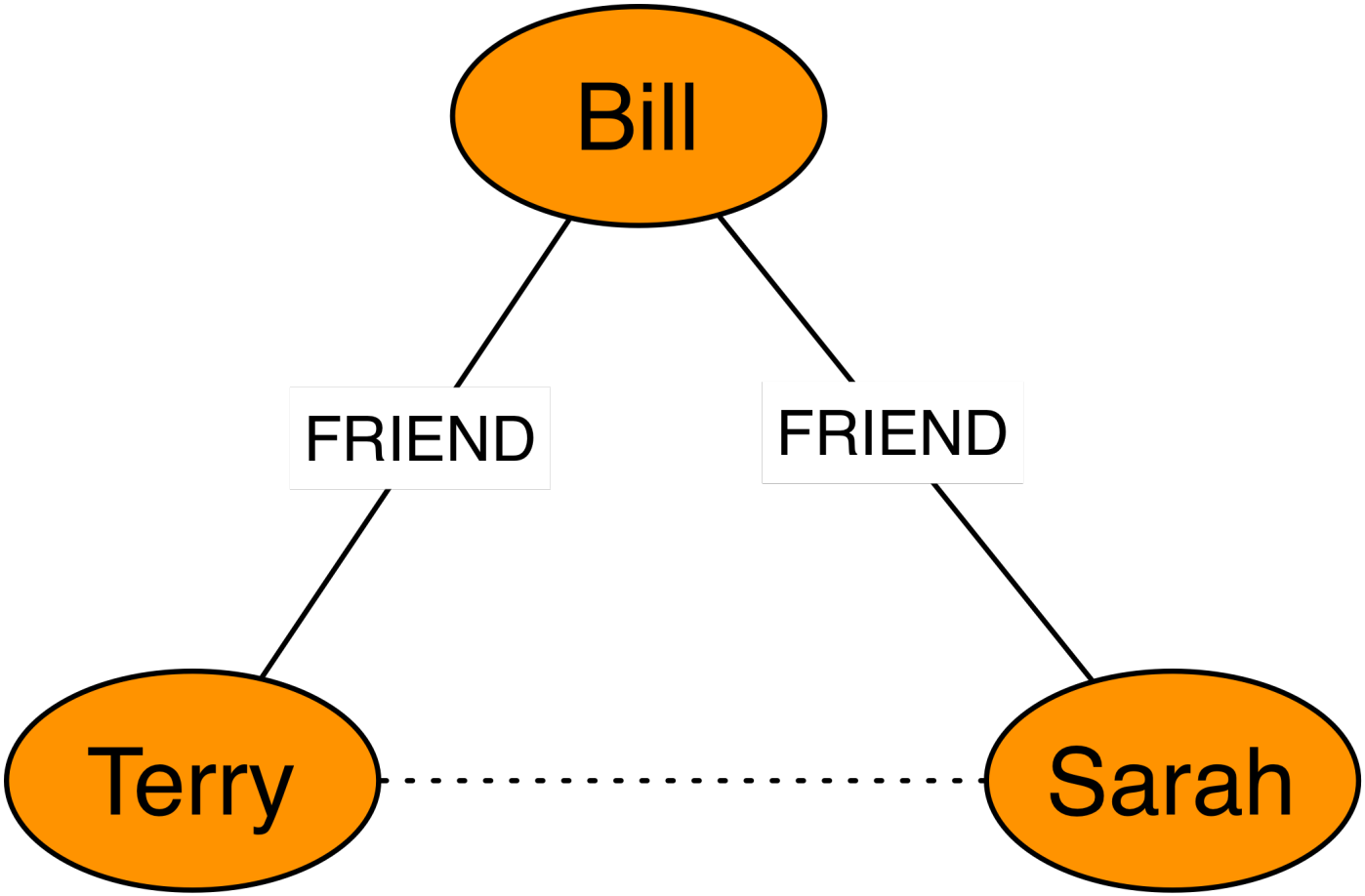
Making Connections

Triadic Closure – Closing Triangles



Triadic Closure – Closing Triangles



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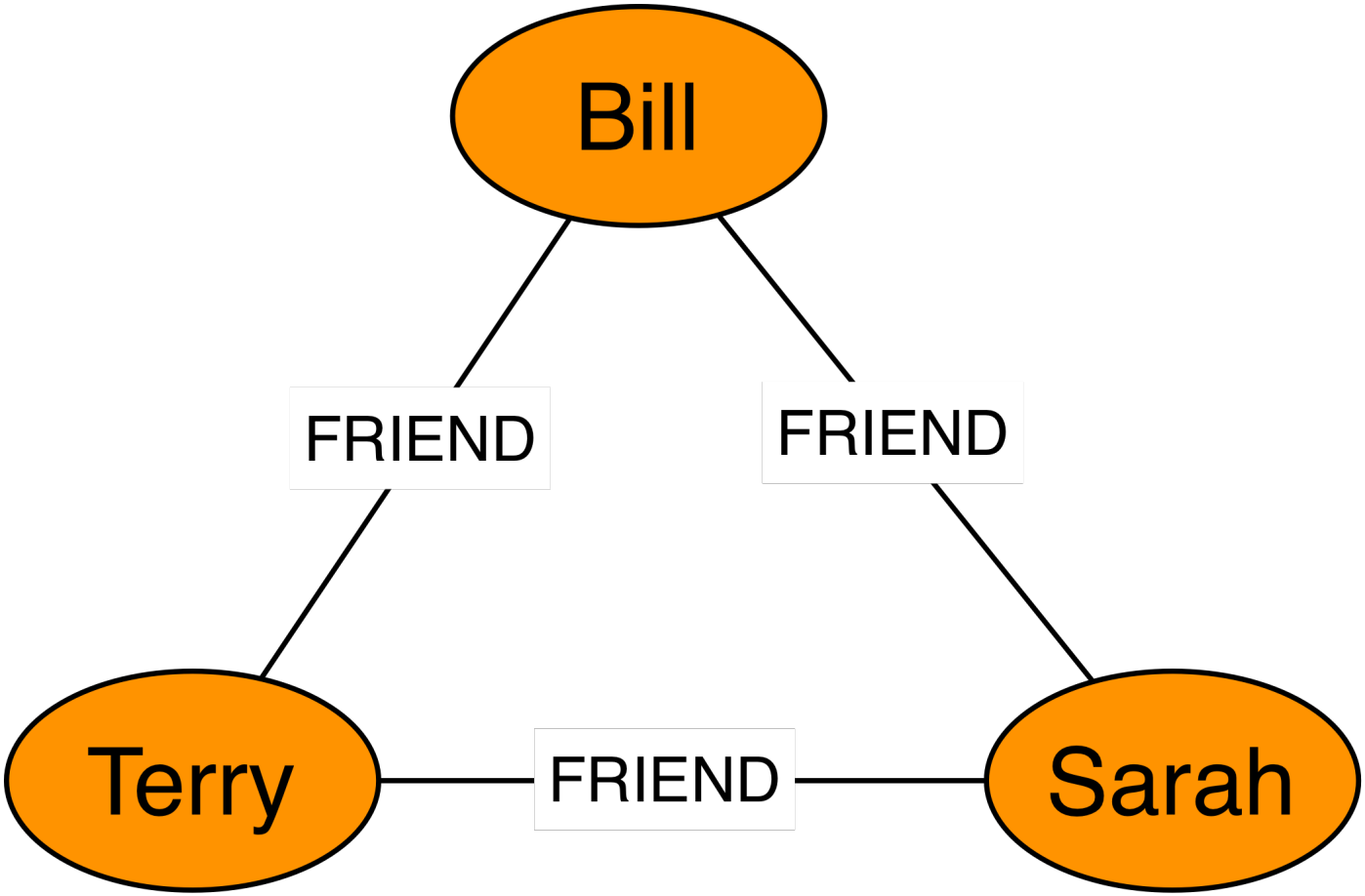
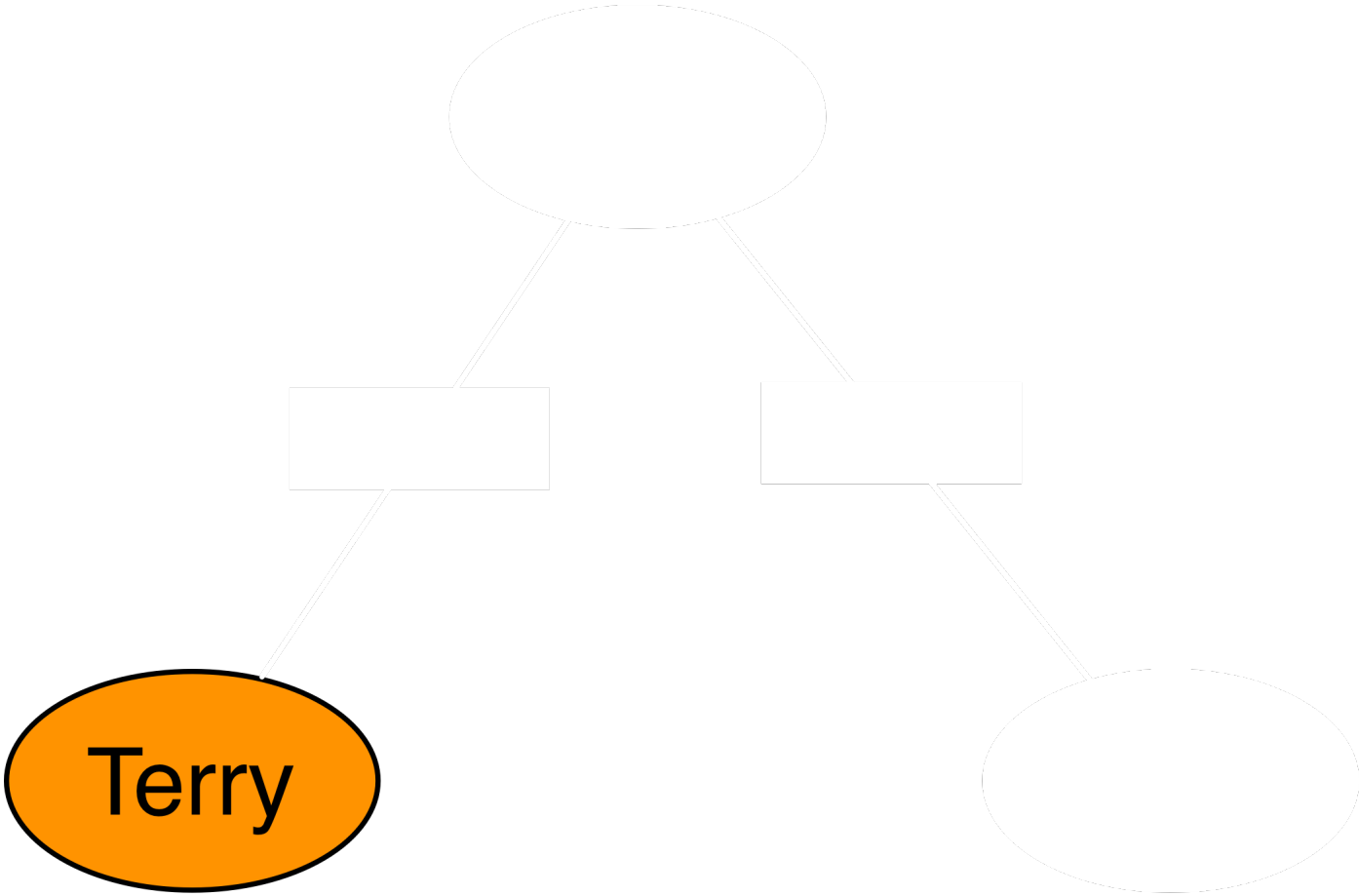
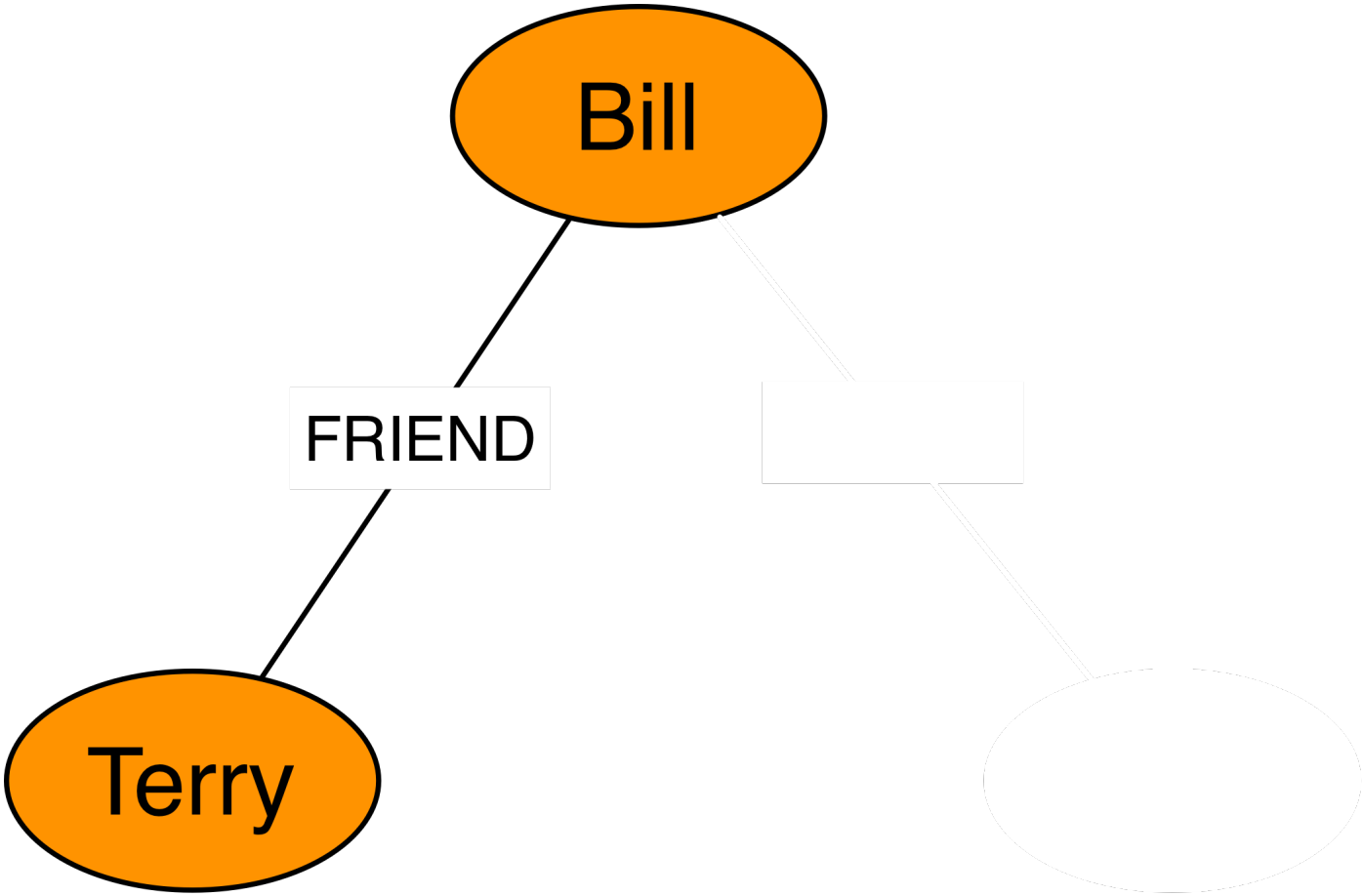
Triadic Closure – Closing Triangles



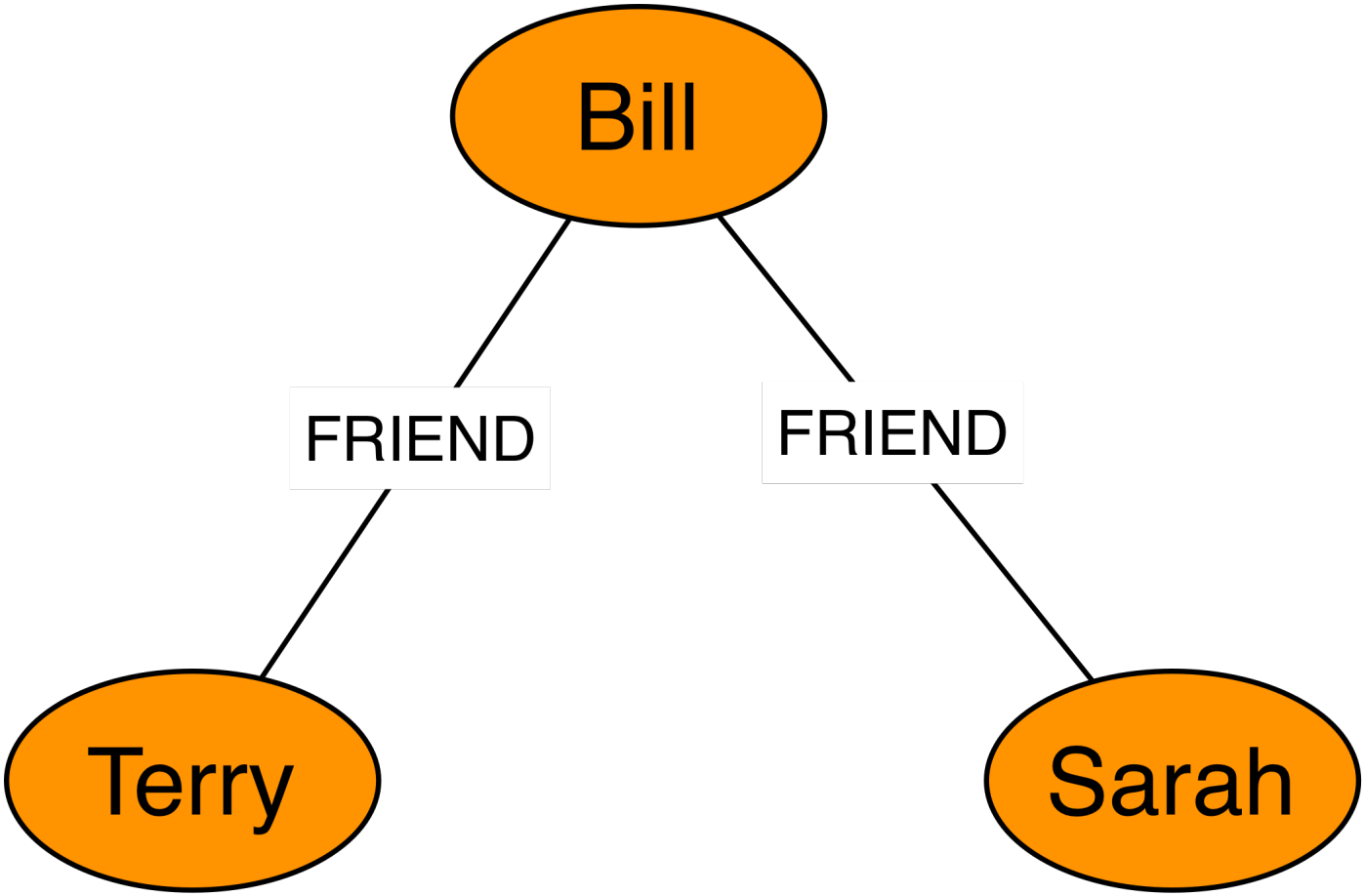
Recommending New Connections



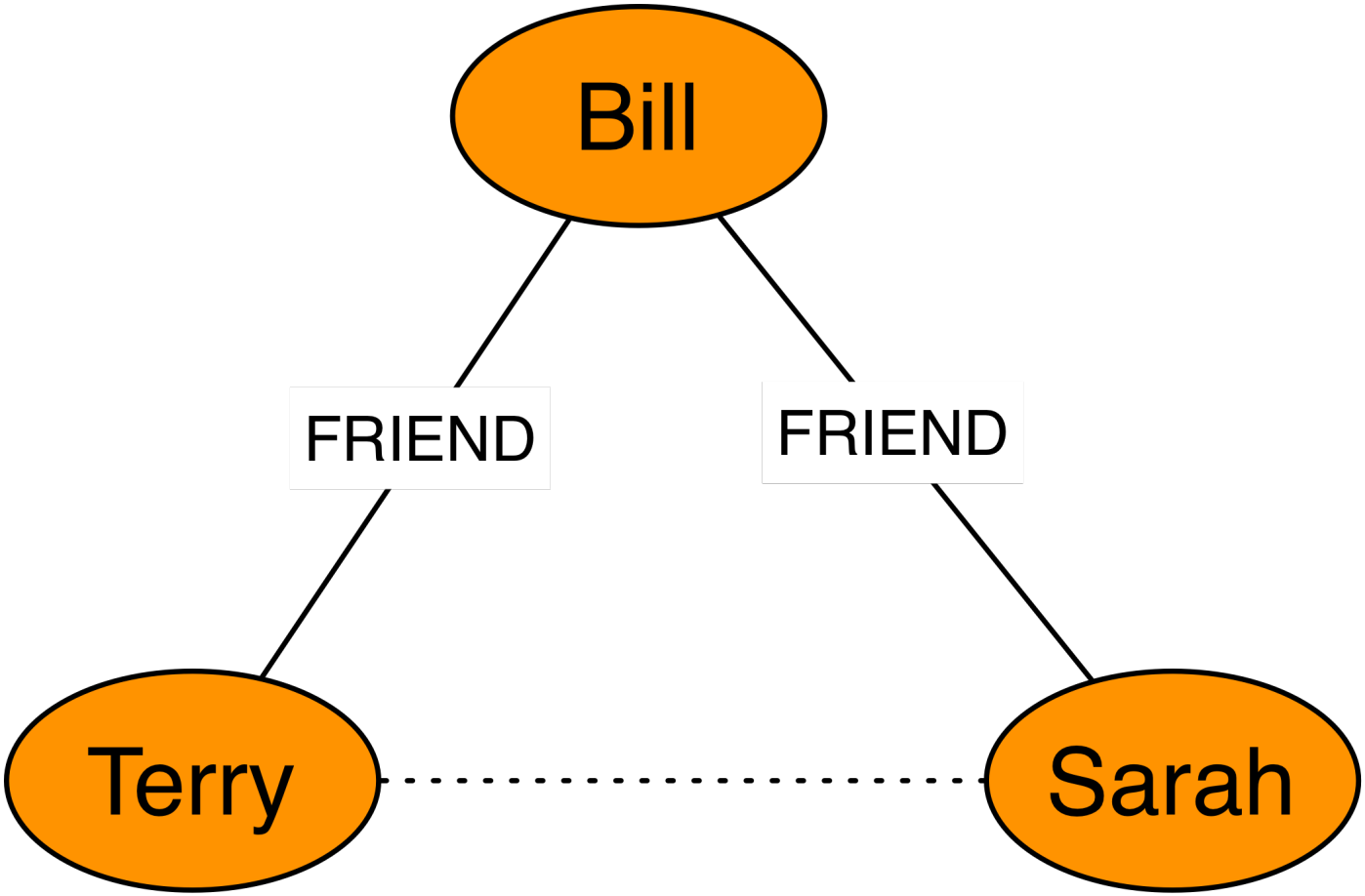
Immediate Friendships



Means and Motive



Recommendation



Recommend New Connections

```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```

Find Terry

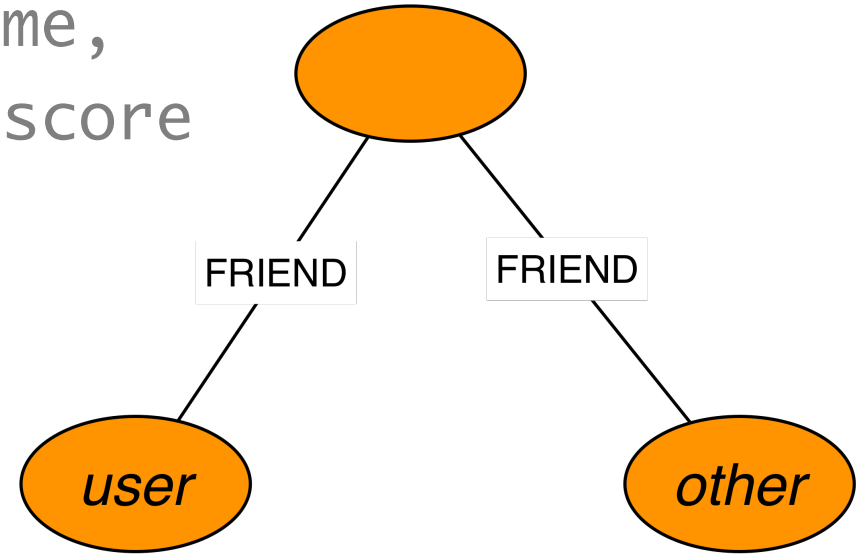
```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```

Find Terry's Friends' Friends

```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```

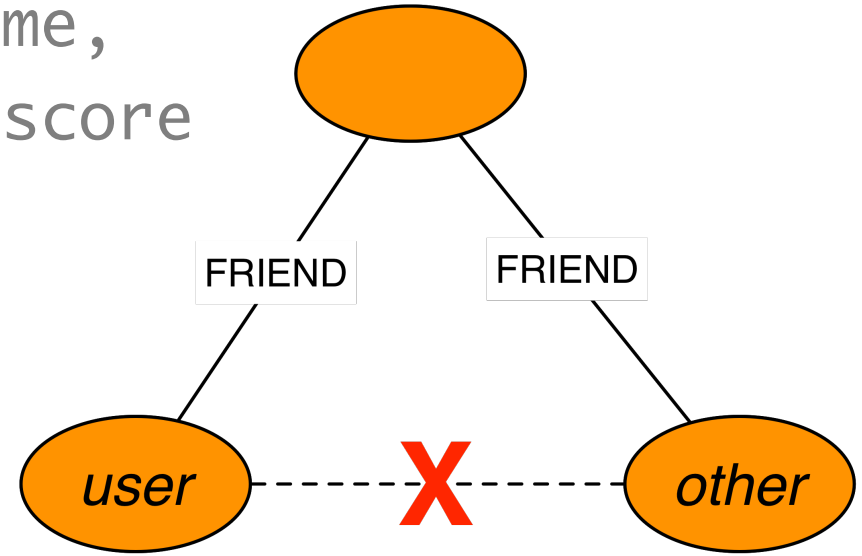
Find Terry's Friends' Friends

```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```



…Who Terry Doesn't Know

```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```



Count Matches Per Person

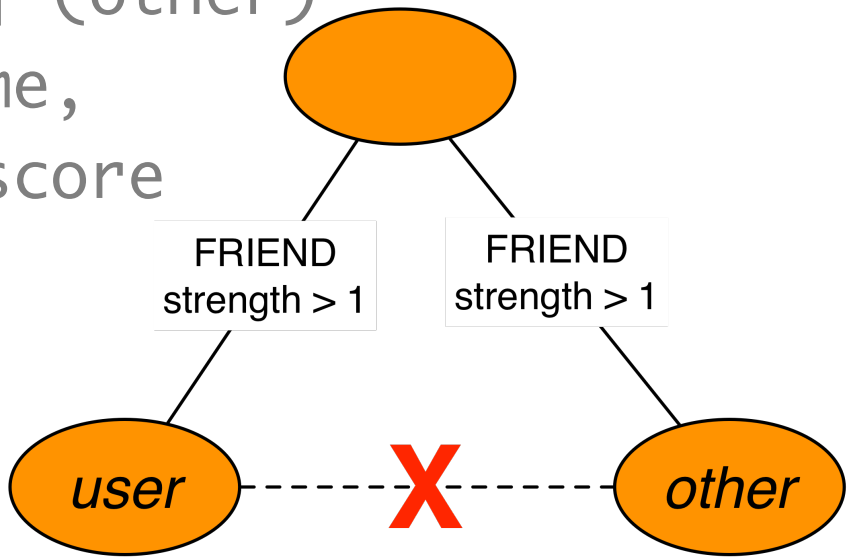
```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```

Return The Results

```
MATCH (user:User{name:'Terry'})
      -[:FRIEND*2]-
      (other:User)
WHERE NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```

Taking Account of Friendship Strength

```
MATCH (user:User{name:'Terry'})
      -[rels:FRIEND*2]-
      (other:User)
WHERE ALL(r IN rels WHERE r.strength > 1)
AND NOT (user)-[:FRIEND]-(other)
RETURN other.name AS name,
       COUNT(other) AS score
ORDER BY score DESC
```

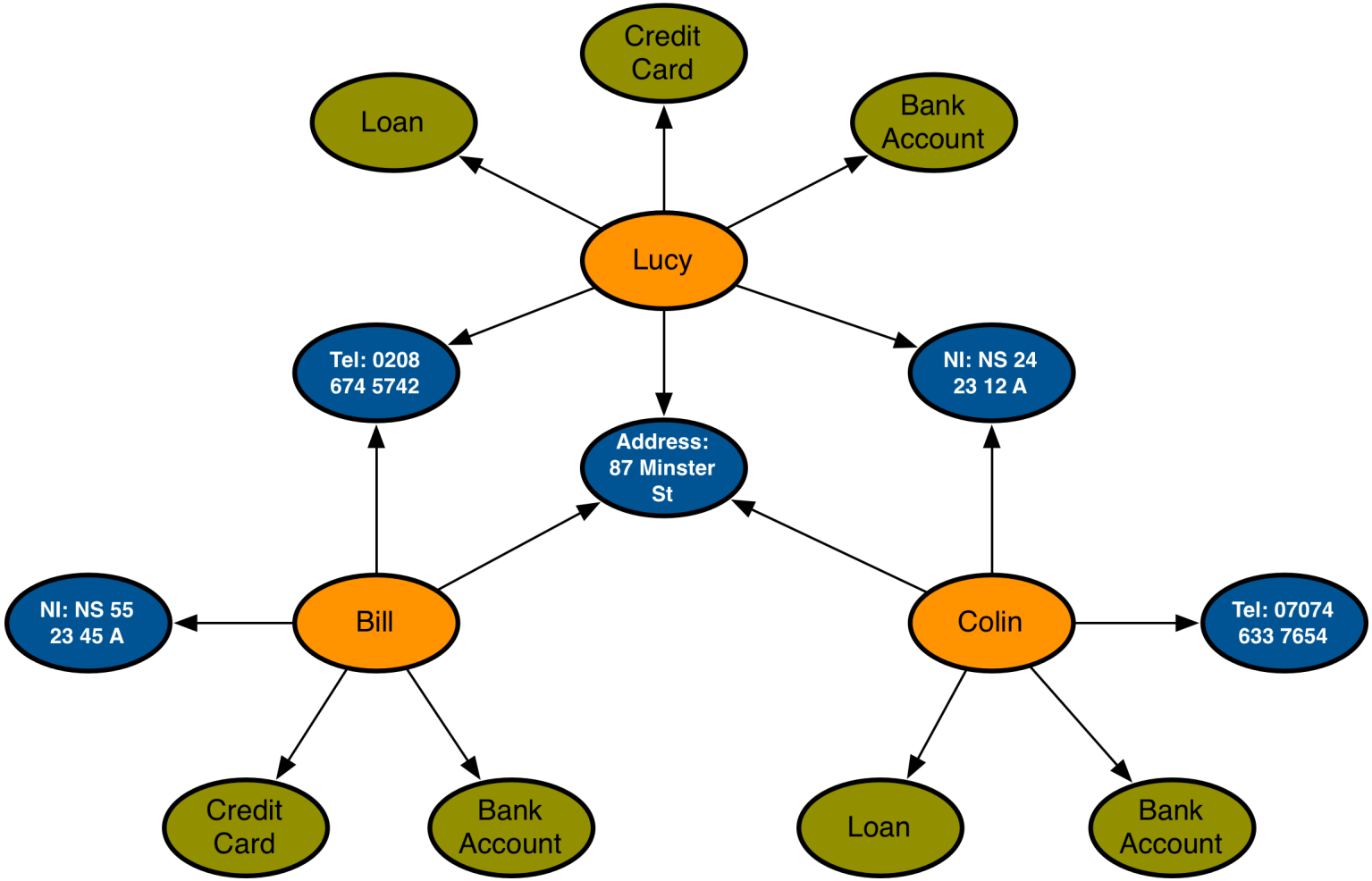


Nowhere To Hide

First-Party Fraud

- Fraudsters apply for credit
  - No intention of repaying
- Appear normal until they "burst out"
  - Clear out accounts
- Fraud ring
  - Share bits of identity (NI, address, telephone)
  - Coordinated "burst out"

Fraud Ring



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Query

- Create new applicant
- Connect applicant to identity info
  - Reuse existing identify info where possible

Then

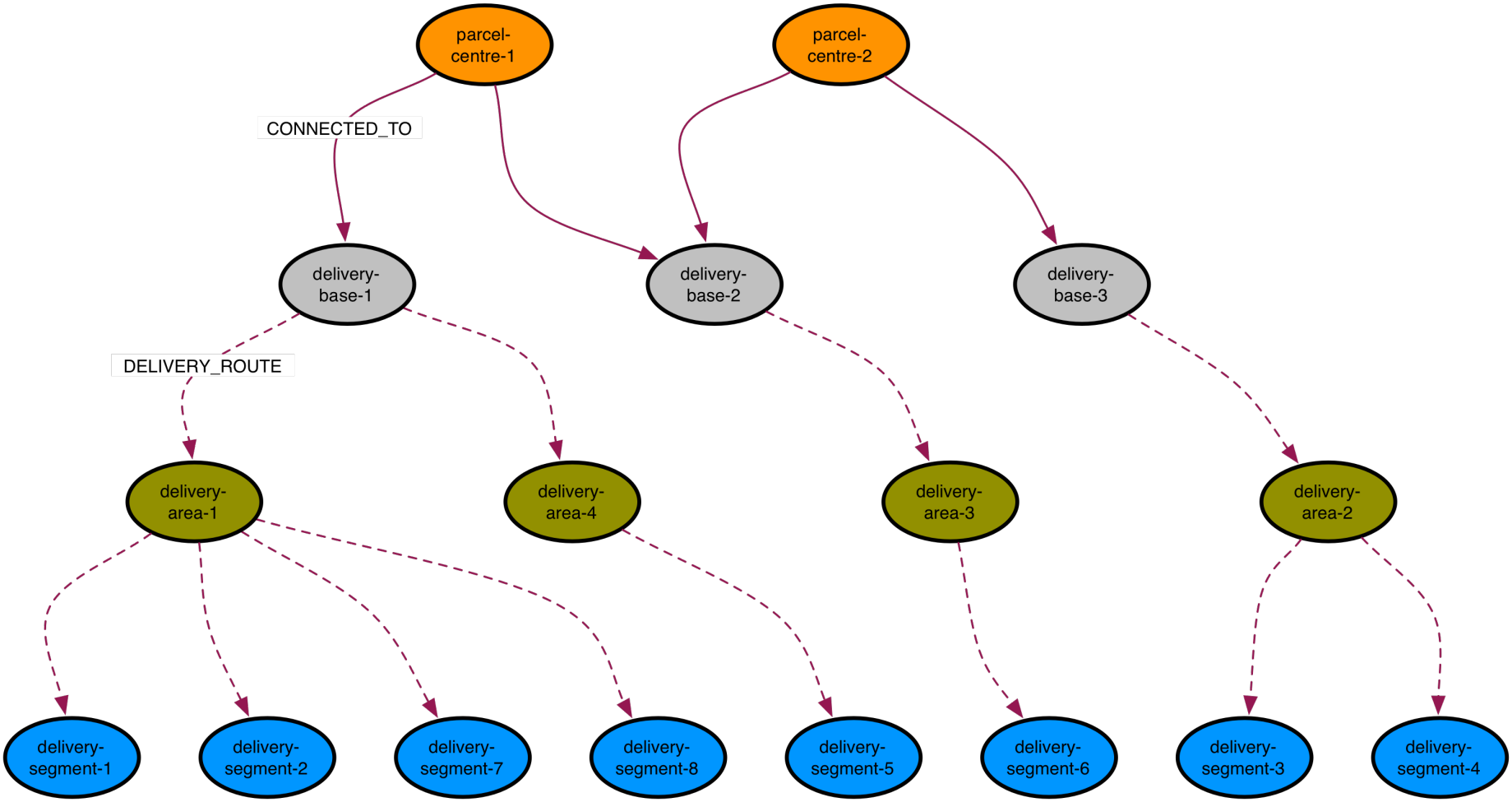
- Select applicant's identity info
- Crawl surrounding graph
  - Look for expansive clusters of account holders

Path Calculations

Problem

- Increase in parcel traffic
  - Amazon, eBay
  - Current infrastructure can't cope
- Calculate optimal route
  - Under 40ms
  - Routes vary over time
- Numbers:
  - 2000-3000 parcels per second
  - 25 national parcel centres, 2 million postcodes, 30 million address

Period 1



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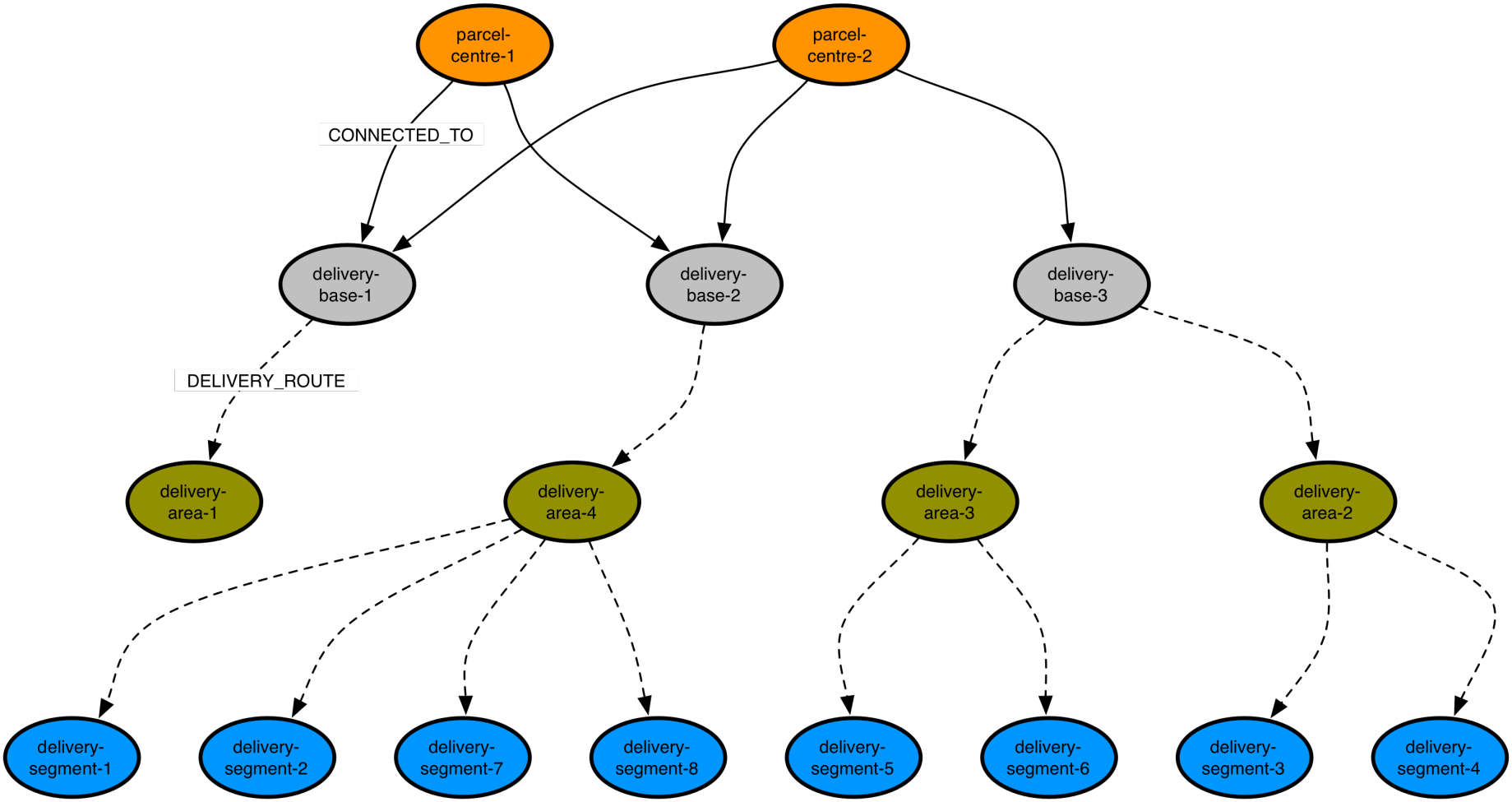
Period 2



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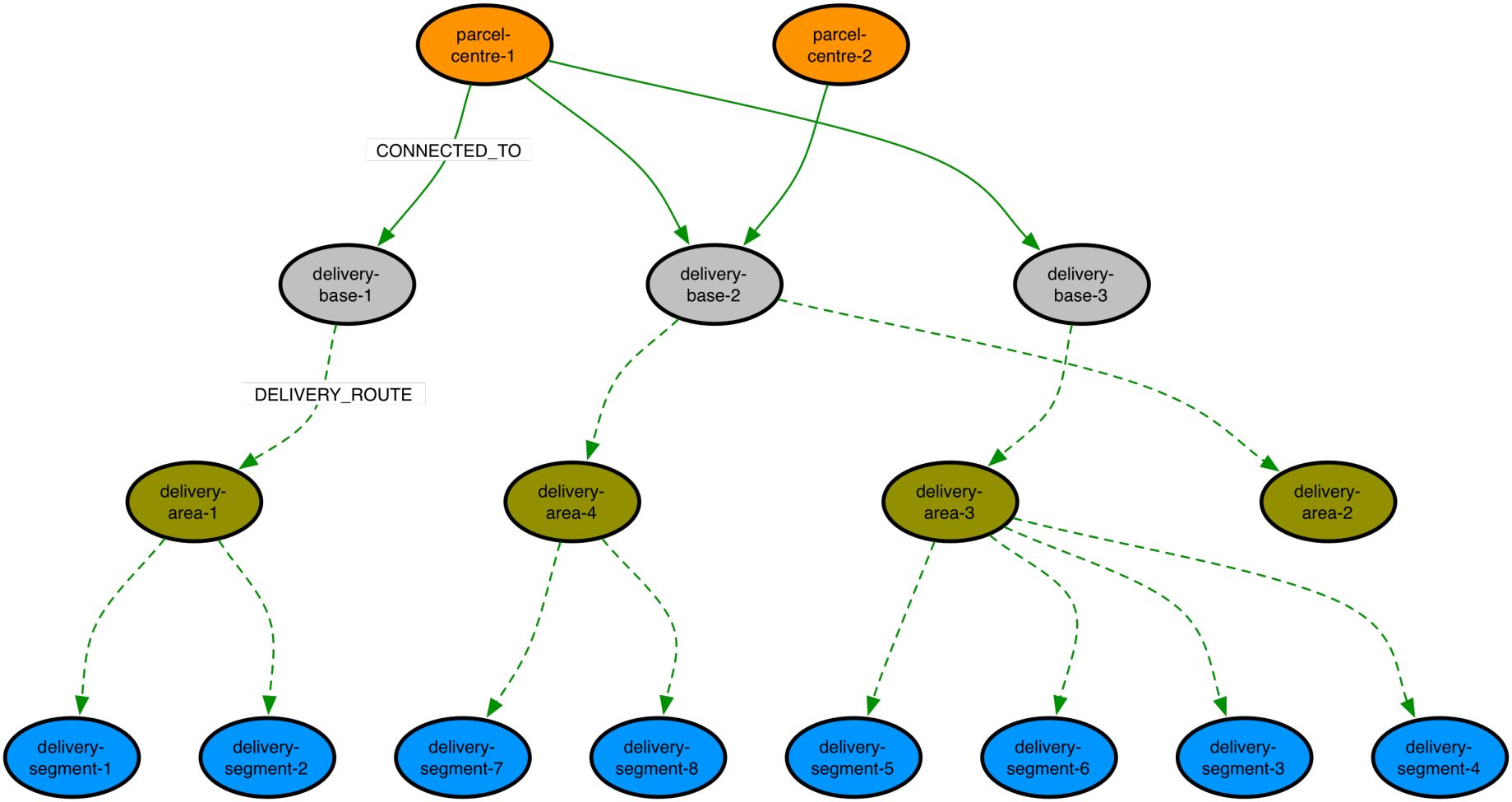
Period 3



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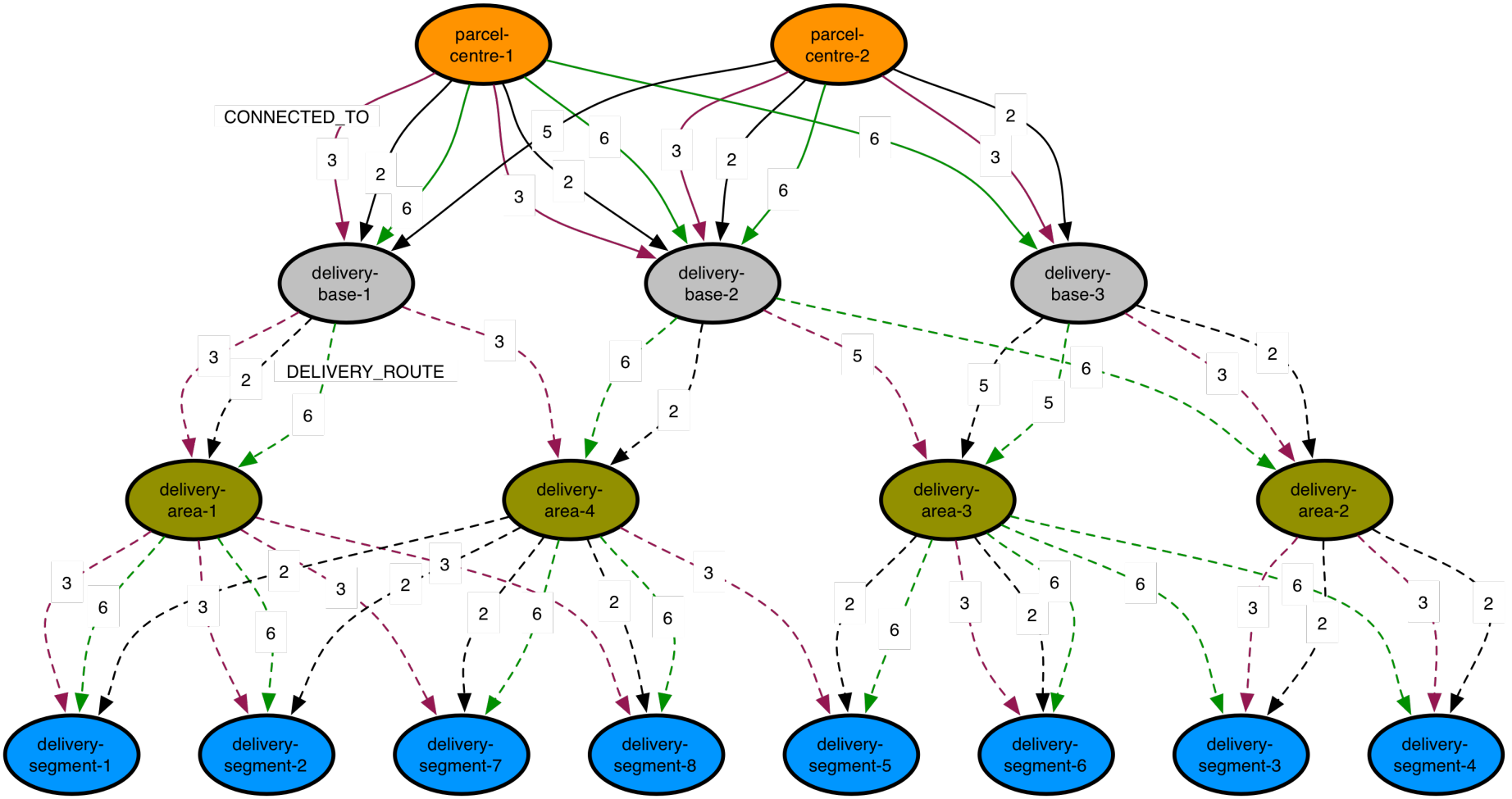
The Full Graph



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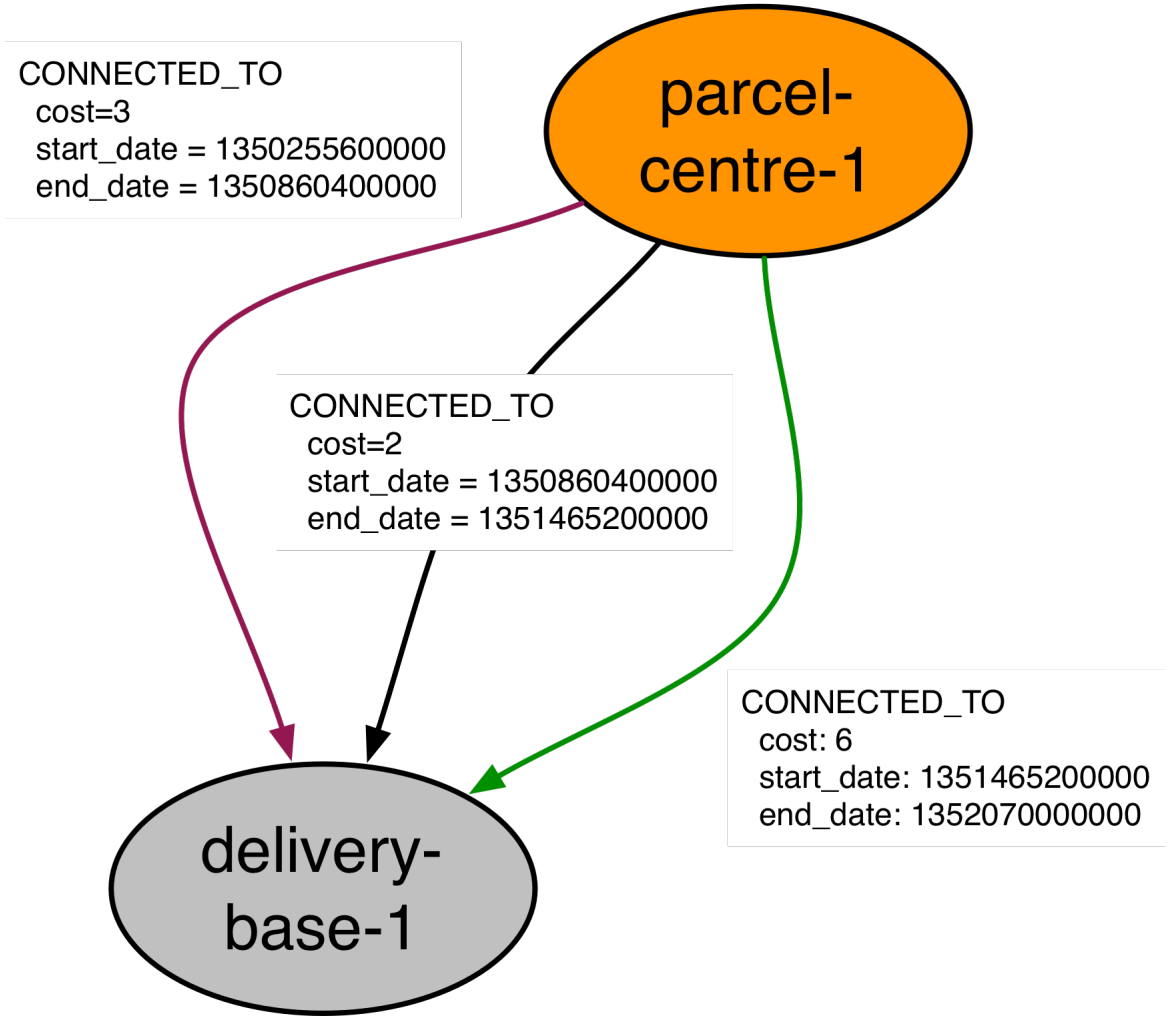
CONNECTED_TO
cost=3
start_date = 1350255600000
end_date = 1350860400000
parcel-centre-1
CONNECTED_TO
cost=2
start_date = 1350860400000
end_date = 1351465200000
CONNECTED_TO
cost: 6
start_date: 1351465200000
end_date: 1352070000000
delivery-base-1

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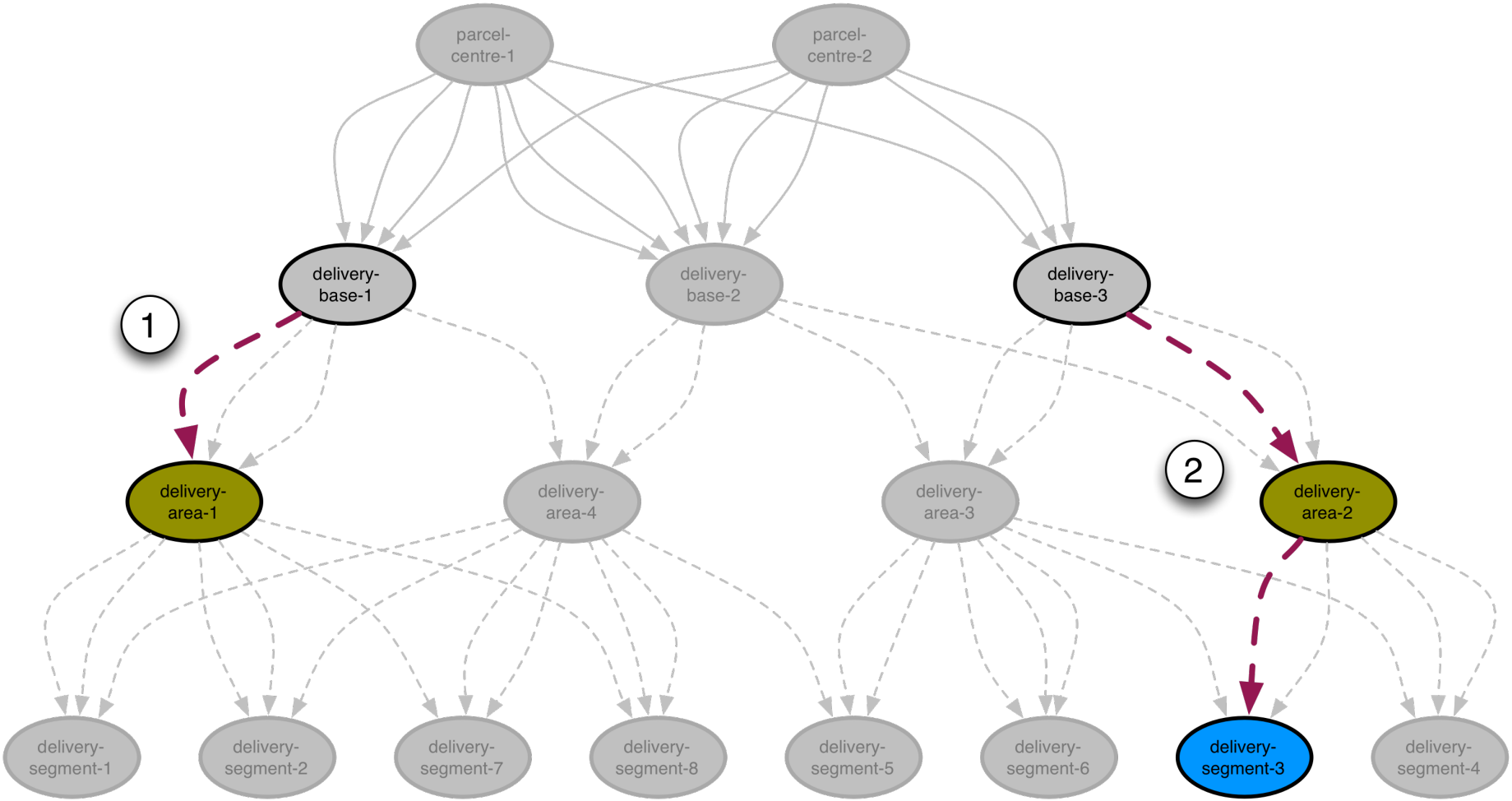
Steps 1 and 2



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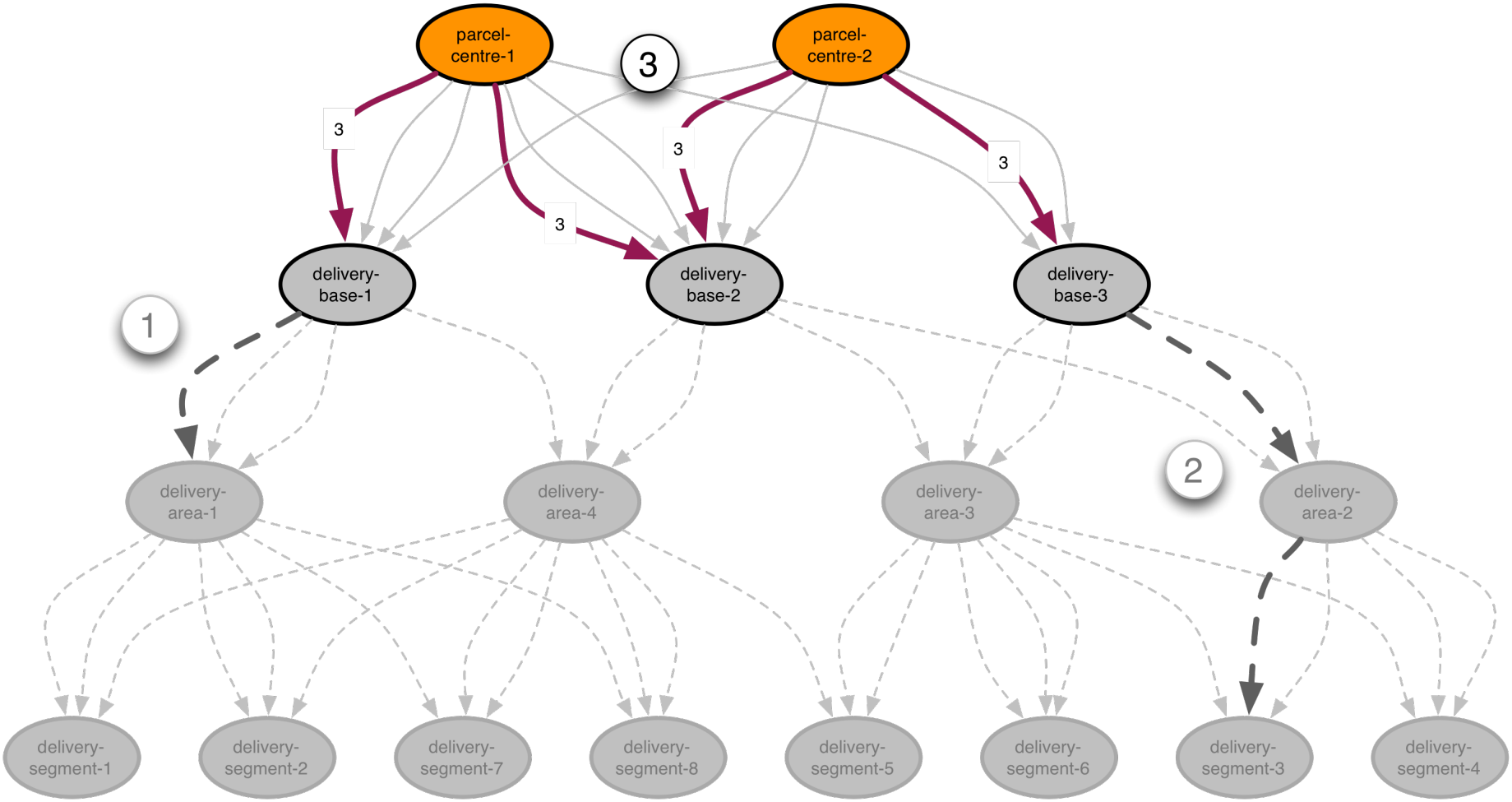
Step 3


parcel-centre-1
parcel-centre-2
3
3
3
3
3
delivery-base-1
delivery-base-2
delivery-base-3
1
2
delivery-area-1
delivery-area-4
delivery-area-3
delivery-area-2
delivery-segment-1
delivery-segment-2
delivery-segment-7
delivery-segment-8
delivery-segment-5
delivery-segment-6
delivery-segment-3
delivery-segment-4

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Paths

```
MATCH  path=(from{name:'X'})
             -[:CONNECTED_TO*1..4]->
            (to{name:'Y'})
RETURN path AS shortestPath,
       reduce(weight=0,
              r in relationships(path) |
              weight + r.weight) AS total
ORDER BY total ASC
LIMIT 1
```

Match Variable-Length Path

```
MATCH  path=(from{name:'X'})
             -[:CONNECTED_TO*1..4]->
            (to{name:'Y'})
RETURN path AS shortestPath,
       reduce(weight=0,
              r in relationships(path) |
              weight + r.weight) AS total
ORDER BY total ASC
LIMIT 1
```

Calculate Path Weight

```
MATCH  path=(from{name:'X'})
             -[:CONNECTED_TO*1..4]->
            (to{name:'Y'})
RETURN path AS shortestPath,
       reduce(weight=0,
              r in relationships(path) |
              weight + r.weight) AS total
ORDER BY total ASC
LIMIT 1
```

Return Shortest Weighted Path

```
MATCH  path=(from{name:'X'})
             -[:CONNECTED_TO*1..4]->
            (to{name:'Y'})
RETURN path AS shortestPath,
       reduce(weight=0,
              r in relationships(path) |
              weight + r.weight) AS total
ORDER BY total ASC
LIMIT 1
```

Full Query

```
MATCH (s:Location {name:{startLocation}}),
      (e:Location {name:{endLocation}})
MATCH upLeg = (s)<-[:DELIVERY_ROUTE*1..2]-(db1)
WHERE all(r in relationships(upLeg)
          WHERE r.start_date <= {intervalStart}
          AND r.end_date >= {intervalEnd})
WITH  e, upLeg, db1
MATCH downLeg = (db2)-[:DELIVERY_ROUTE*1..2]->(e)
WHERE all(r in relationships(downLeg)
          WHERE r.start_date <= {intervalStart}
          AND r.end_date >= {intervalEnd})
WITH  db1, db2, upLeg, downLeg
MATCH topRoute = (db1)<-[:CONNECTED_TO]-()-[:CONNECTED_TO*1..3]-(db2)
WHERE all(r in relationships(topRoute)
          WHERE r.start_date <= {intervalStart}
          AND r.end_date >= {intervalEnd})
WITH  upLeg, downLeg, topRoute,
      reduce(weight=0, r in relationships(topRoute) | weight+r.cost) AS score
      ORDER BY score ASC
      LIMIT 1
RETURN (nodes(upLeg) + tail(nodes(topRoute)) + tail(nodes(downLeg))) AS route
```

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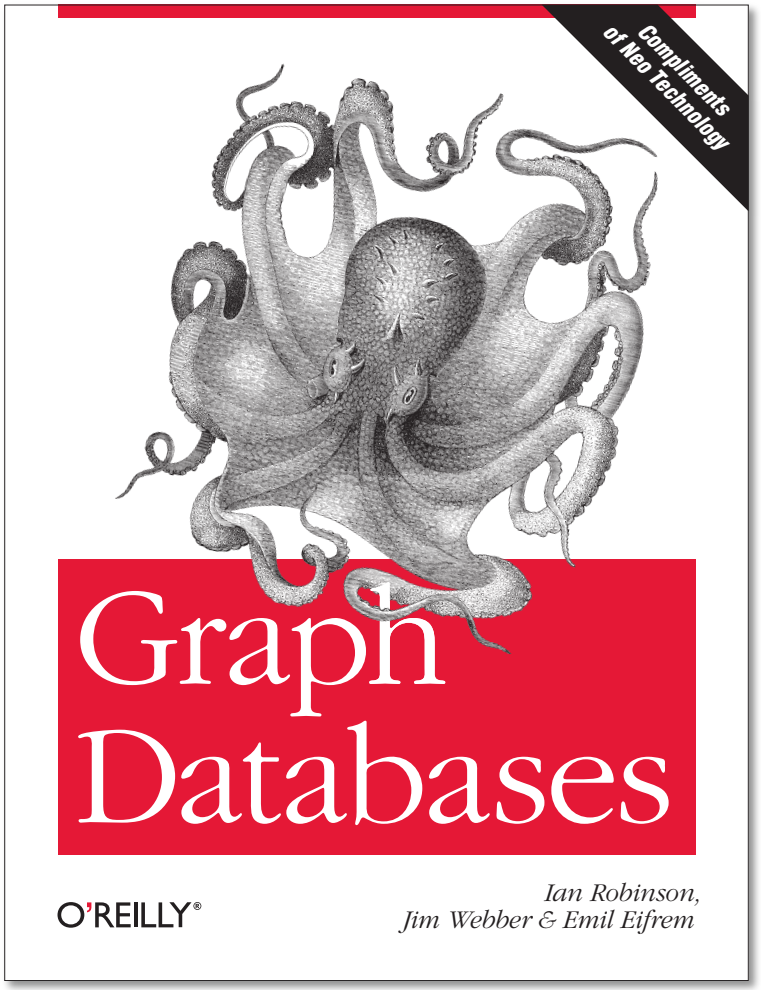

Thank you

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