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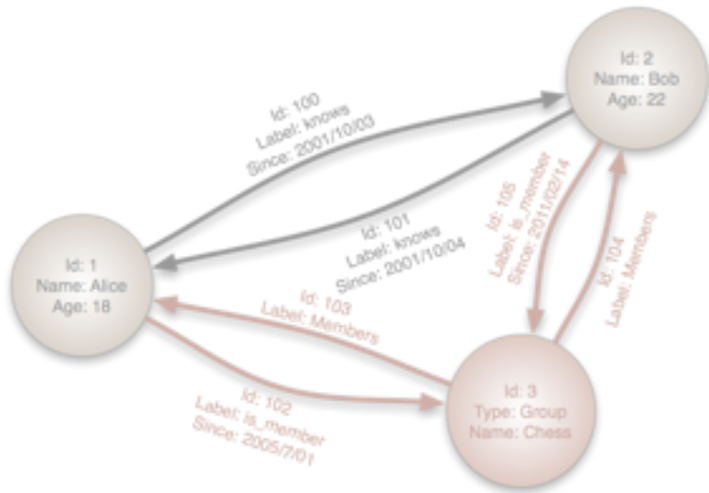
graphs are everywhere

Graph Databases Use Cases



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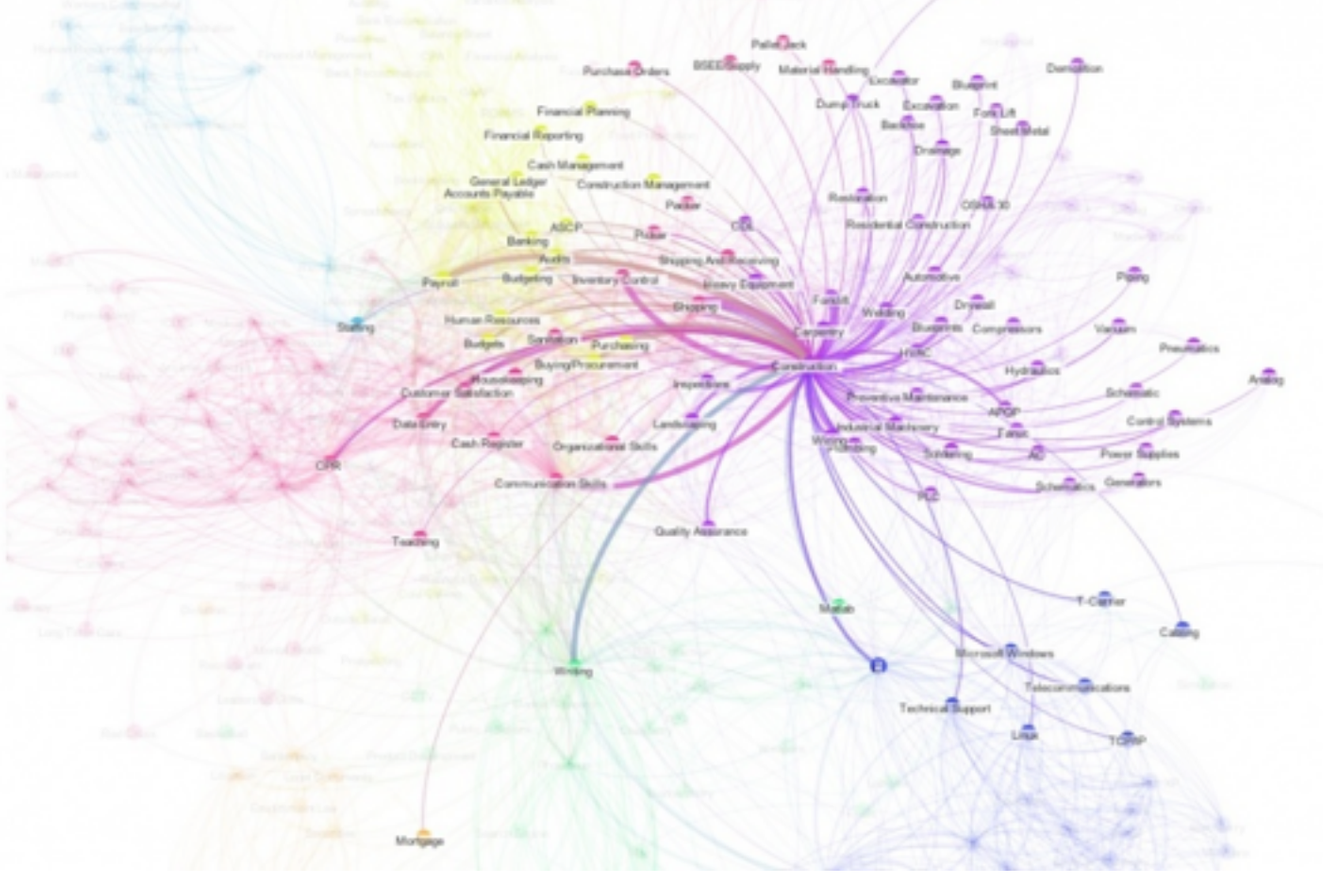
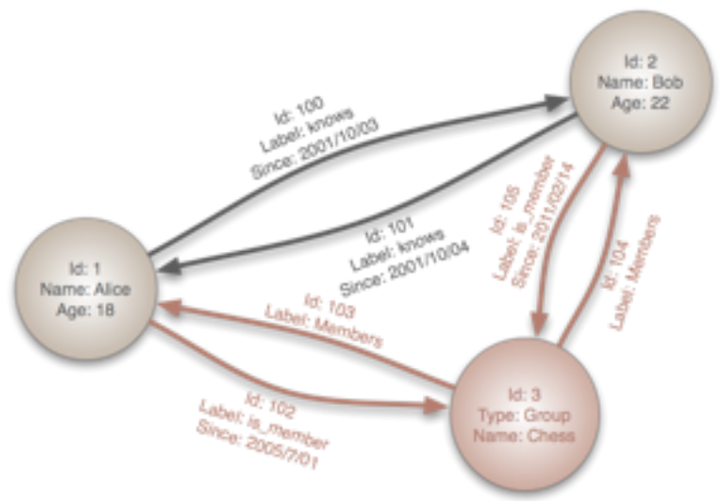
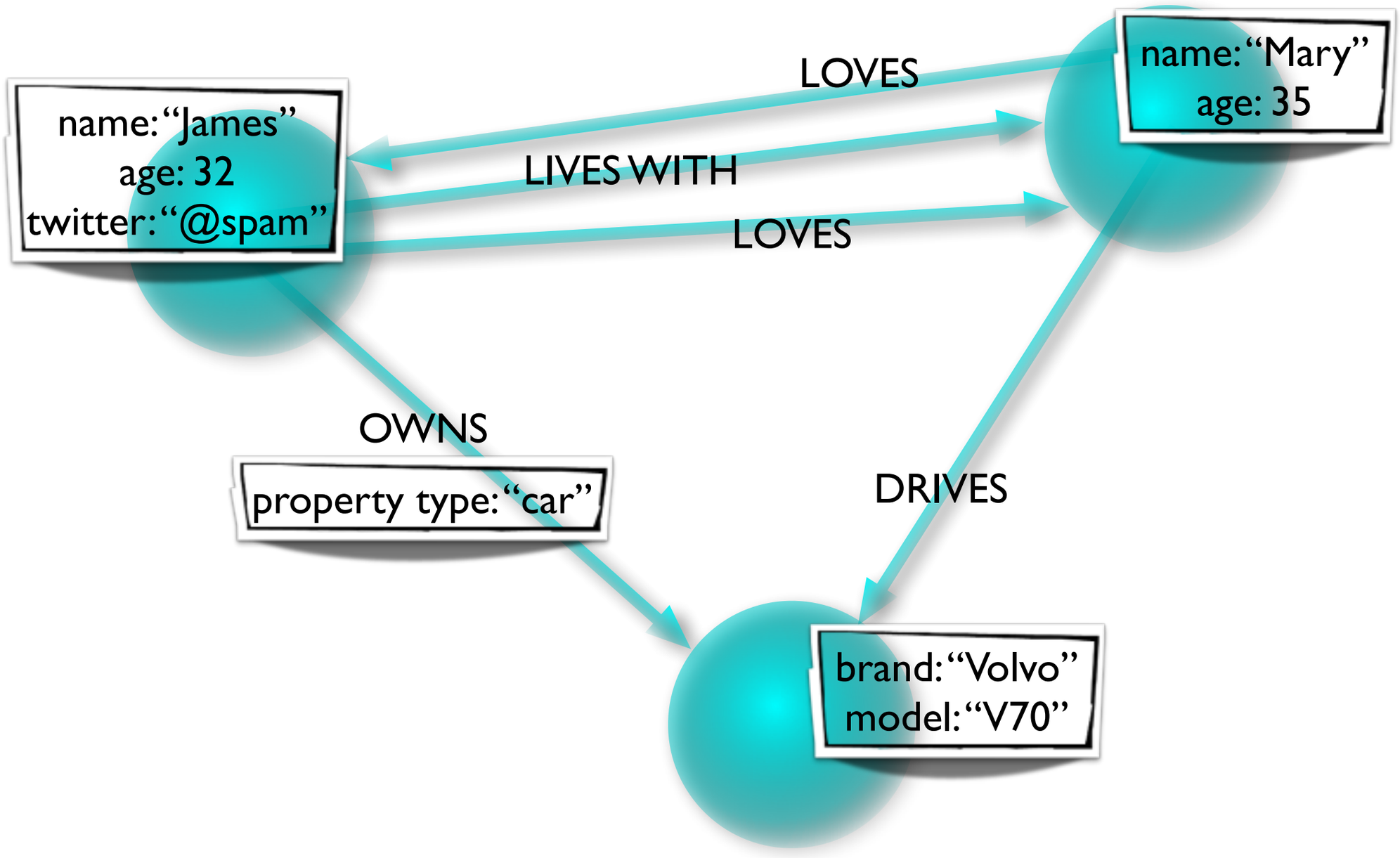
What's a Graph?





Graph data model



Relational Tables

SQL Join Hell (1)

Customer

Id	Name	Address
1	Robert	3
2	Lars	7
3	Michael	23

Address

Id	Location
3	Berlin
4	Munich
7	Dresden
23	Leipzig

1:1 Relationship

Customer

Id	Name
1	Robert
2	Lars
3	Michael

Address

Id	Customer	Location
3	1	Berlin
7	2	Dresden
8	2	New York
23	3	Leipzig

1:n Relationship

Customer

Id	Name
1	Robert
2	Lars
3	Michael

CustomerAddress

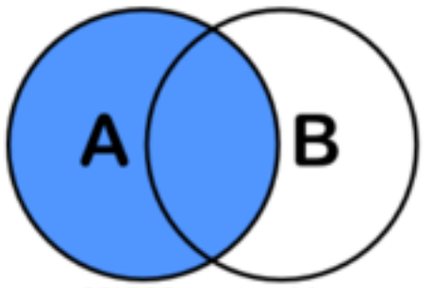
CId	AId
1	3
2	7
2	8
3	23

Address

Id	Location
3	Berlin
7	Dresden
8	New York
23	Leipzig

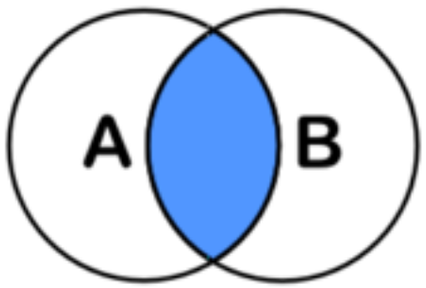
m:n Relationship

Join this way…

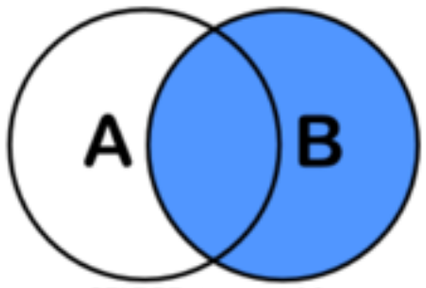



```
SELECT <auswahl>
FROM tabelleA A
LEFT JOIN tabelleB B
ON A.key = B.key
```

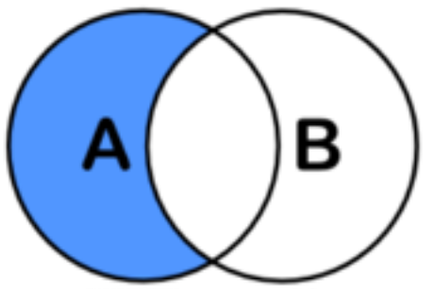
CHEATSHEET
SQL
JOINS



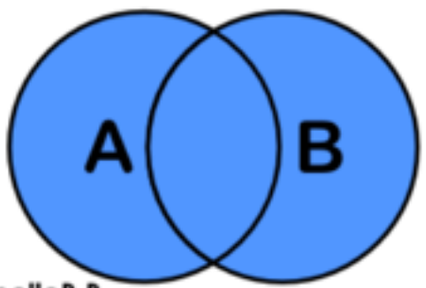

```
SELECT <auswahl>
FROM tabelleA A
INNER JOIN tabelleB B
ON A.key = B.key
```



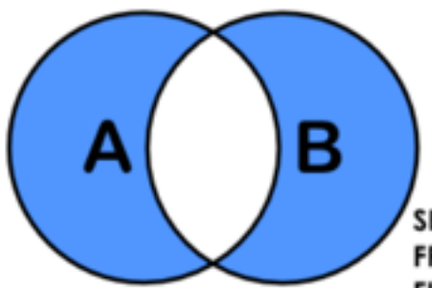

```
SELECT <auswahl>
FROM tabelleA A
RIGHT JOIN tabelleB B
ON A.key = B.key
```



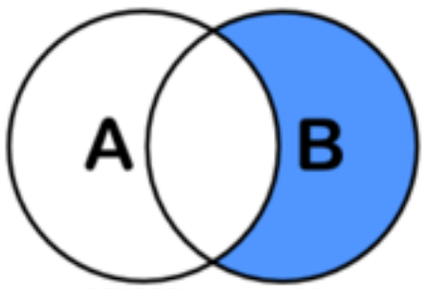

```
SELECT <auswahl>
FROM tabelleA A
LEFT JOIN tabelleB B
ON A.key = B.key
WHERE B.key IS NULL
```




```
SELECT <auswahl>
FROM tabelleA A
FULL OUTER JOIN tabelleB B
ON A.key = B.key
```



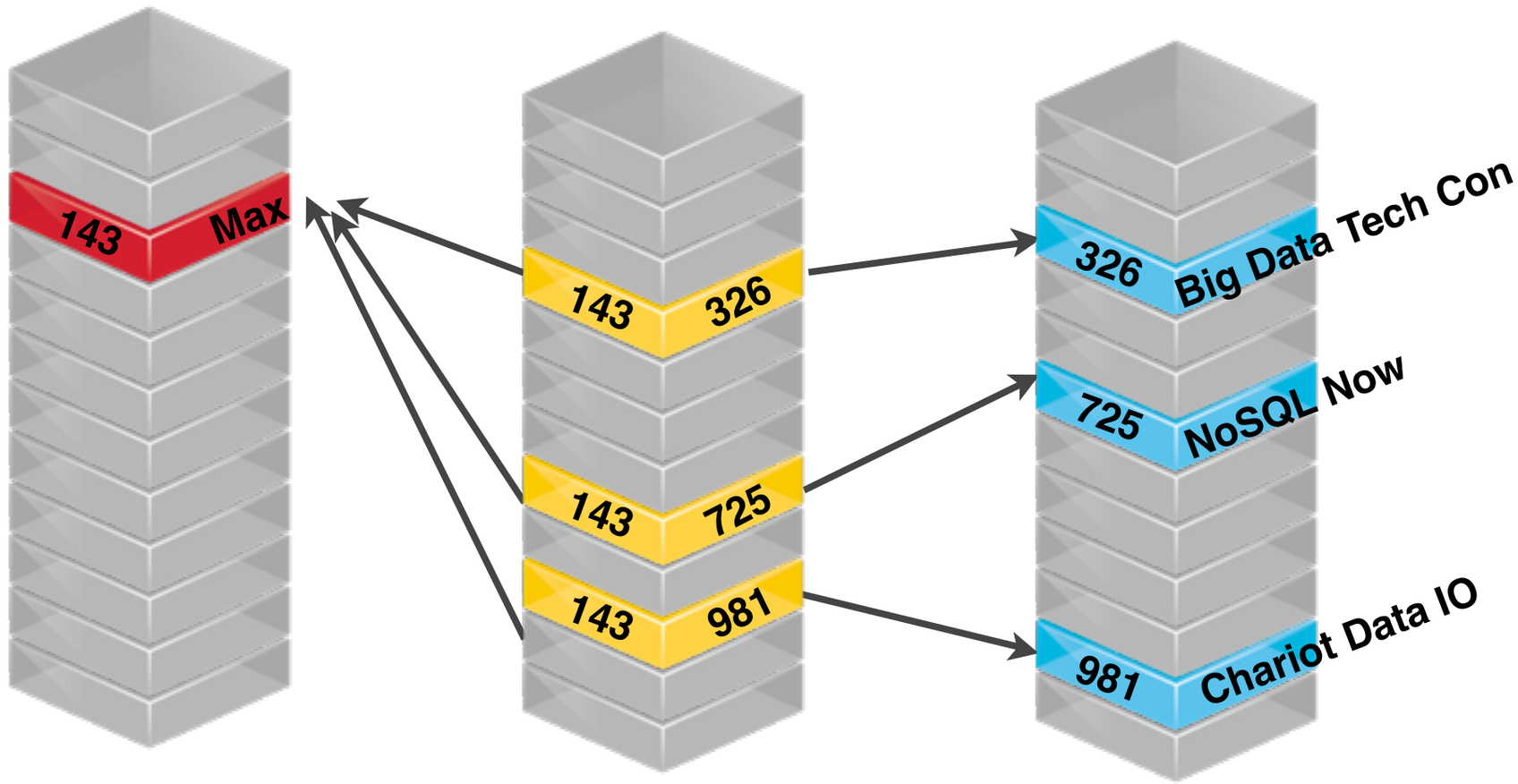

```
SELECT <auswahl>
FROM tabelleA A
FULL OUTER JOIN tabelleB B
ON A.key = B.key
WHERE A.key IS NULL
OR B.key IS NULL
```



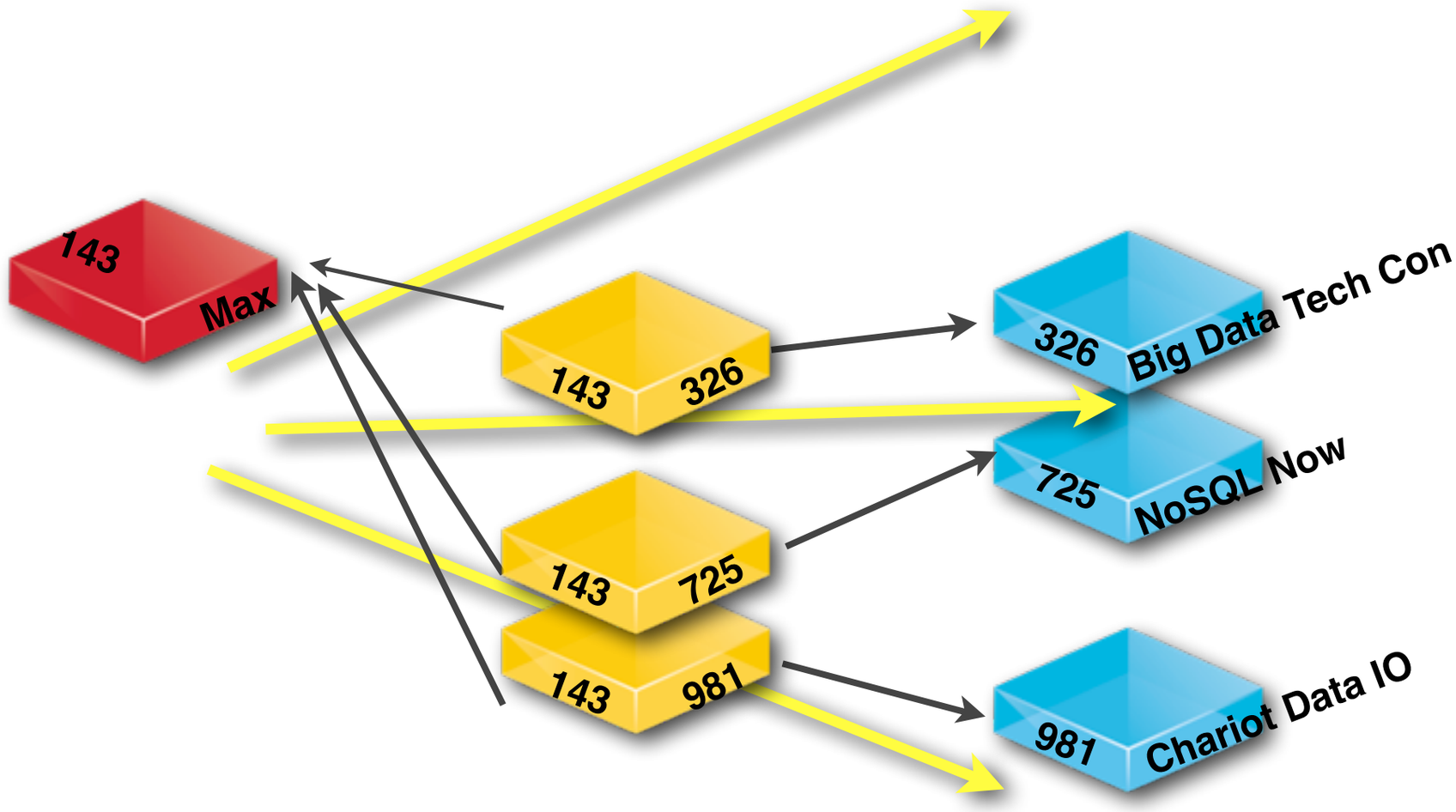

```
SELECT <auswahl>
FROM tabelleA A
RIGHT JOIN tabelleB B
ON A.key = B.key
WHERE A.key IS NULL
```

The Problem

- all JOINs are executed **every time** you query (traverse) the relationship
- executing a JOIN means to **search** for a key in another table
- with Indices executing a JOIN means to lookup a key
- B-Tree Index: O(log(n))
- more entries => more lookups => slower JOINs



People Attend Conferences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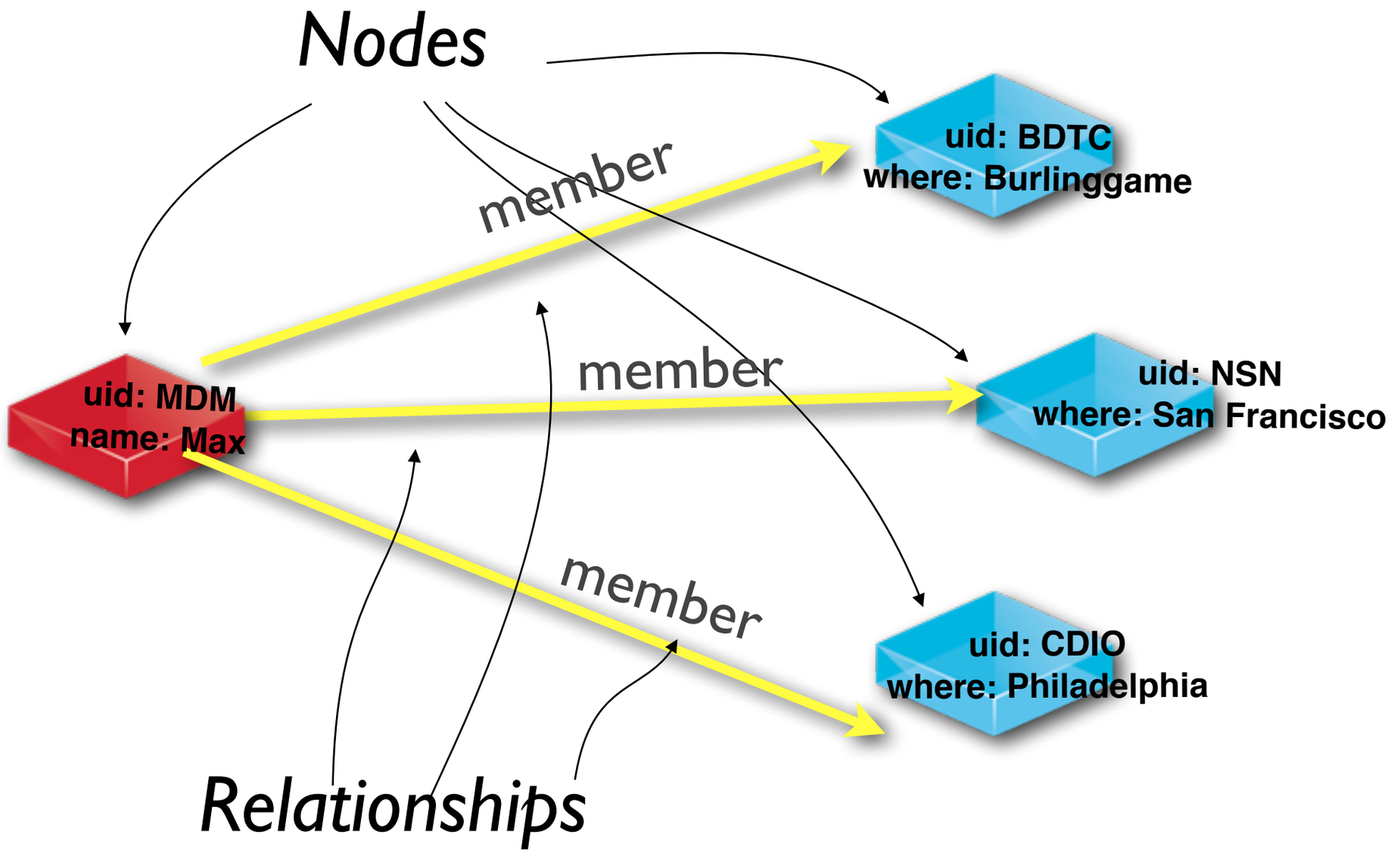
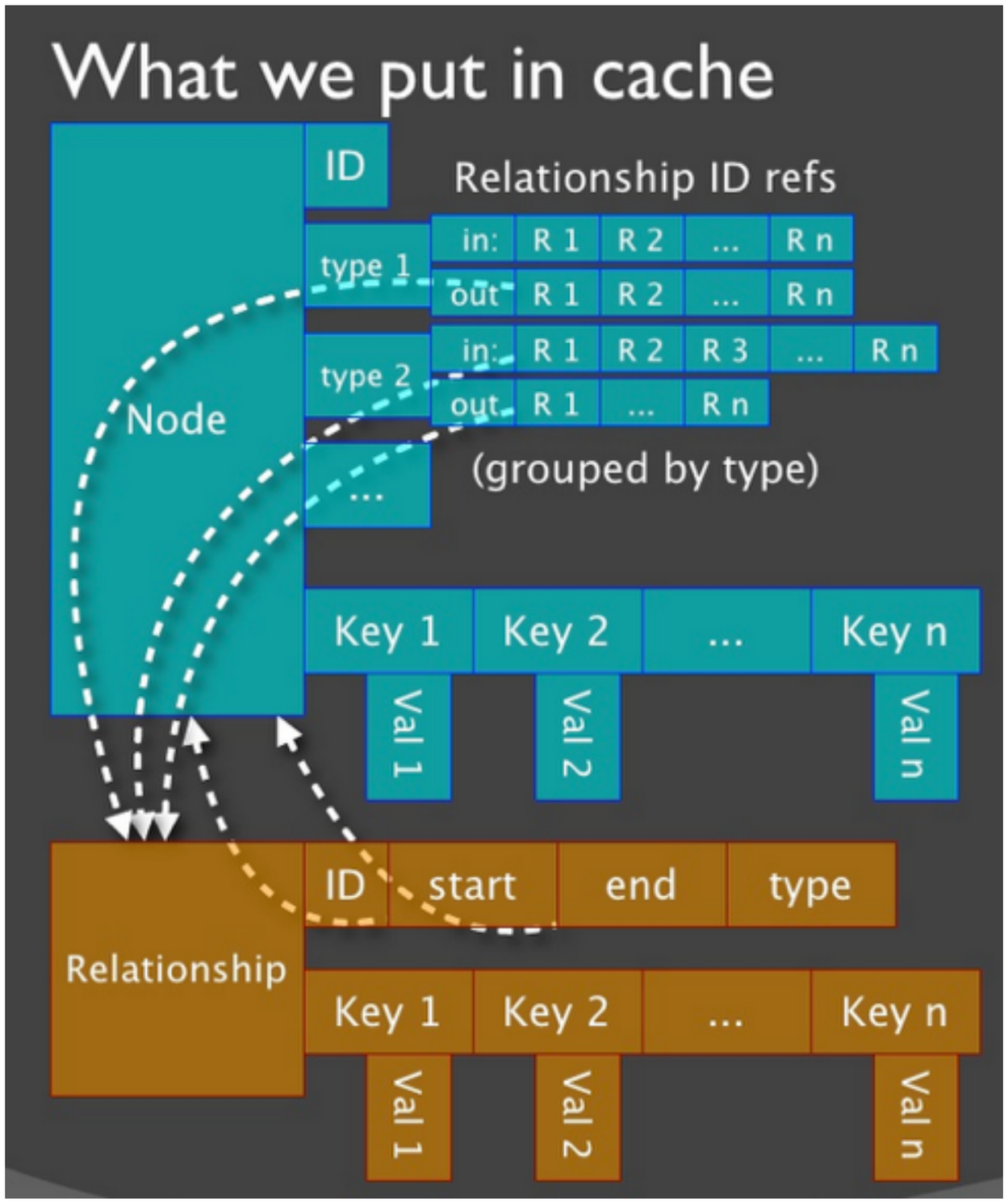
Chariot Data IO

A Property Graph



The Neo4j Secret Sauce



- Pointers instead of look-ups
- Do all your "Joining" on creation
- Spin spin spin through this data structure

Graph Buzz!

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MacArthur 'Genius Grant' Winner Maria Chudnovsky on Graph Theory

Wednesday, October 03, 2012

Bright Launches Bright Packed With Jobs Data Seeking Tips

InfoWorld Home / InfoWorld Tech Watch / Buzz grows around graph databases

The First Word on Tech
INFOWORLD TECH WATCH

AUGUST 29, 2012

Buzz grows around graph databases

Interest in graph databases will continue to grow, given its ability to analyze data delivered in a non-relational format, such as social networking data

By Paul Krill | InfoWorld

Follow @pjkrill

Graph Databases: The New Way to Access Super Fast Social Data

September 26, 2012 by **Emil Eifrem**

1

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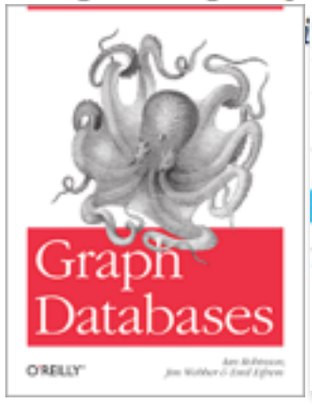
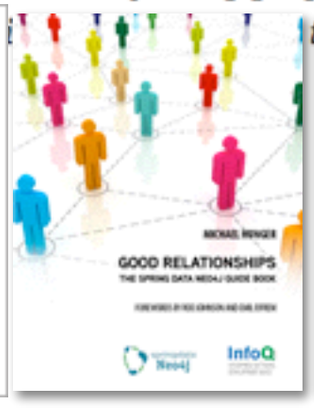
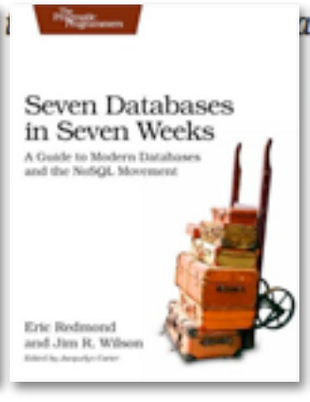
173 Share

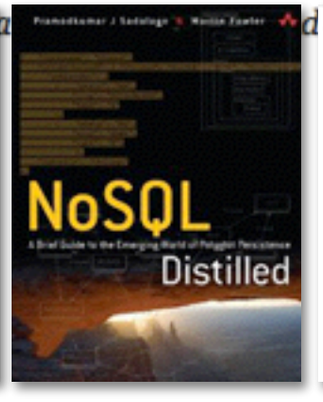
Facebook's Social Graph, Neo4j show rising use of graph databases

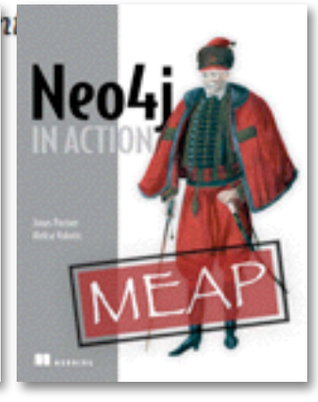
Summary: *Facebook's Social Graph -- the database underlying its Graph Search engine unveiled yesterday-- is just one of many graph databases being employed for complex, connected data. Neo4j*











I saw my own Interest Graph and it's scary-accurate. We'd certainly pay for the ability to use the Gravity personalization technology I saw today at TechCrunch to help target content to users.

TC **Michael Arrington, TechCrunch**

The Neo4j Graph Database

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- Neo4j is the **leading graph database** in the world today
  - Most widely deployed: **500,000+ downloads**
  - **Largest ecosystem**: active forums, code contributions, etc
  - Most mature product: in development since 2000, **in 24/7 production since 2003**

Early Adopters of Graph Tech

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facebook

Google™

Survival of the Fittest

Evolution of Web Search

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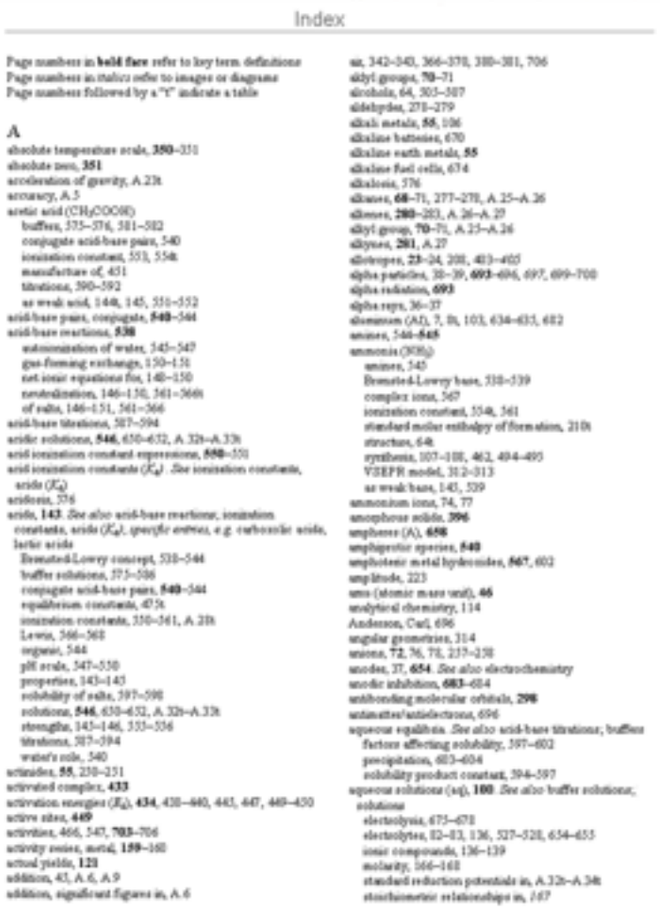
Pre-1999

WWW Indexing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Page numbers in *italics* refer to images or diagrams
Page numbers followed by a "t" indicate a table

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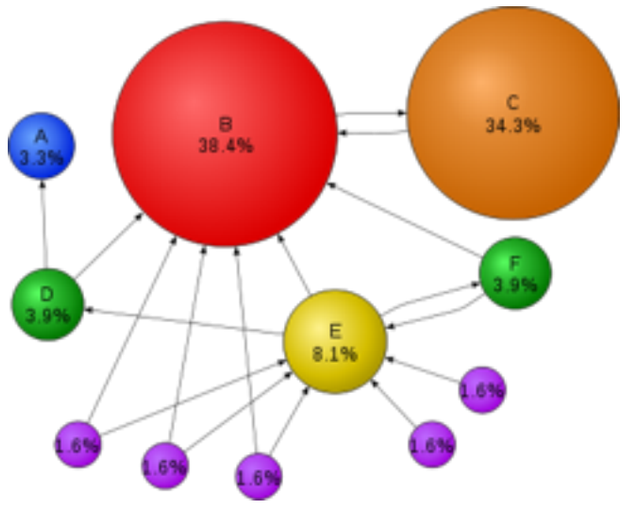
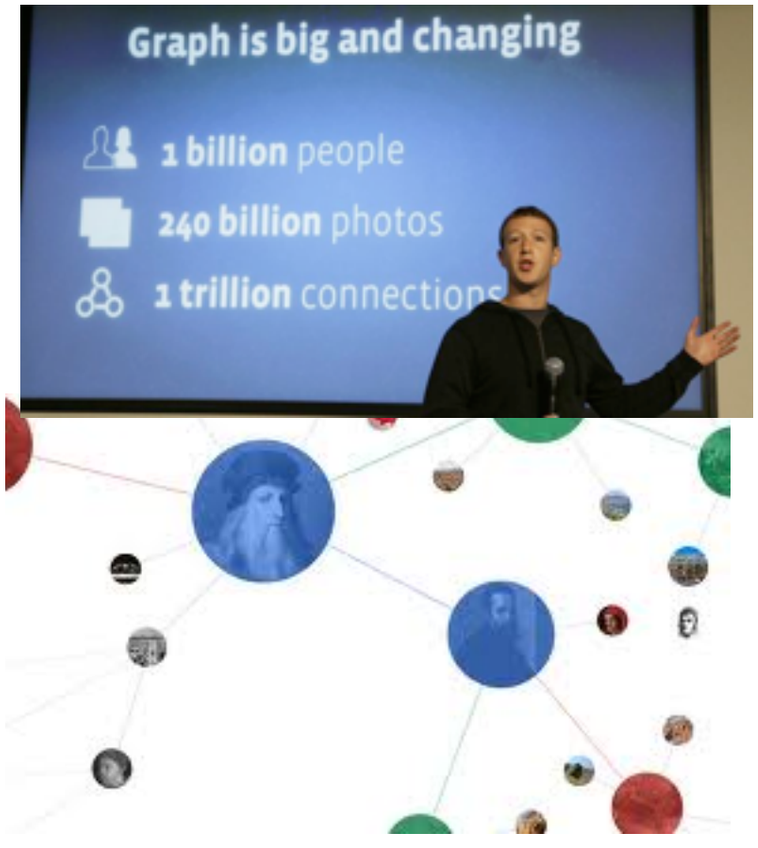
1999 - 2012

Google Invents PageRank



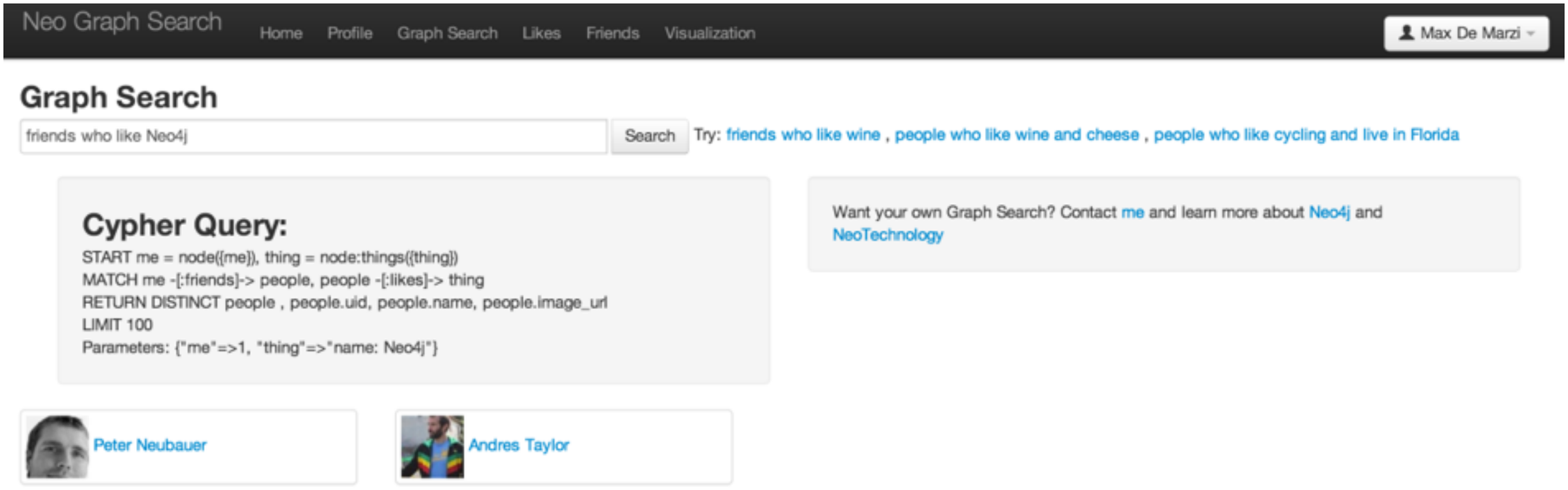
2012-?

Google Knowledge Graph, Facebook Graph Search



Discrete Data + Connected Data (Simple) + Connected Data (Rich)

Open Source Example



http://maxdemarzi.com/2013/01/28/facebook-graph-search-with-cypher-and-neo4j/

Survival of the Fittest

Evolution of Online Recruiting

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1999

Keyword Search

Home > **Job Search**

Search over **150,000** U.S. jobs.
Perform your search below or get tips on searching.

Location Search:

-------- Select a location --------
Alaska-Anchorage
Alaska-Fairbanks
Alaska-Juneau
Alaska-Valdez
Alabama-Anniston

Category Search:

-------- Select a category --------
Accounting/Finance/Banking
Administrative/Clerical
Creative Arts/Media
Education/Training
Engineering/Architecture/Design

Keyword Search:

Search Jobs | Clear

2011-12

Social Discovery

glassdoor careerbuilder viadeo CareerArcGroup

Most jobs are found through an inside connection
Each friend that joins Glassdoor allows you to see more connections at more companies

9 friends on glassdoor	3,905 inside connections	3,882 companies

Invite more friends — ask them to share their connections

Jobs with Connections

Sr. Statistical Analyst, Product Innovation
Netflix – Los Gatos, CA
From: Job.com – 1 days ago

Creative Director
frog design – San Francisco, CA
From: Experteer – 8 days ago

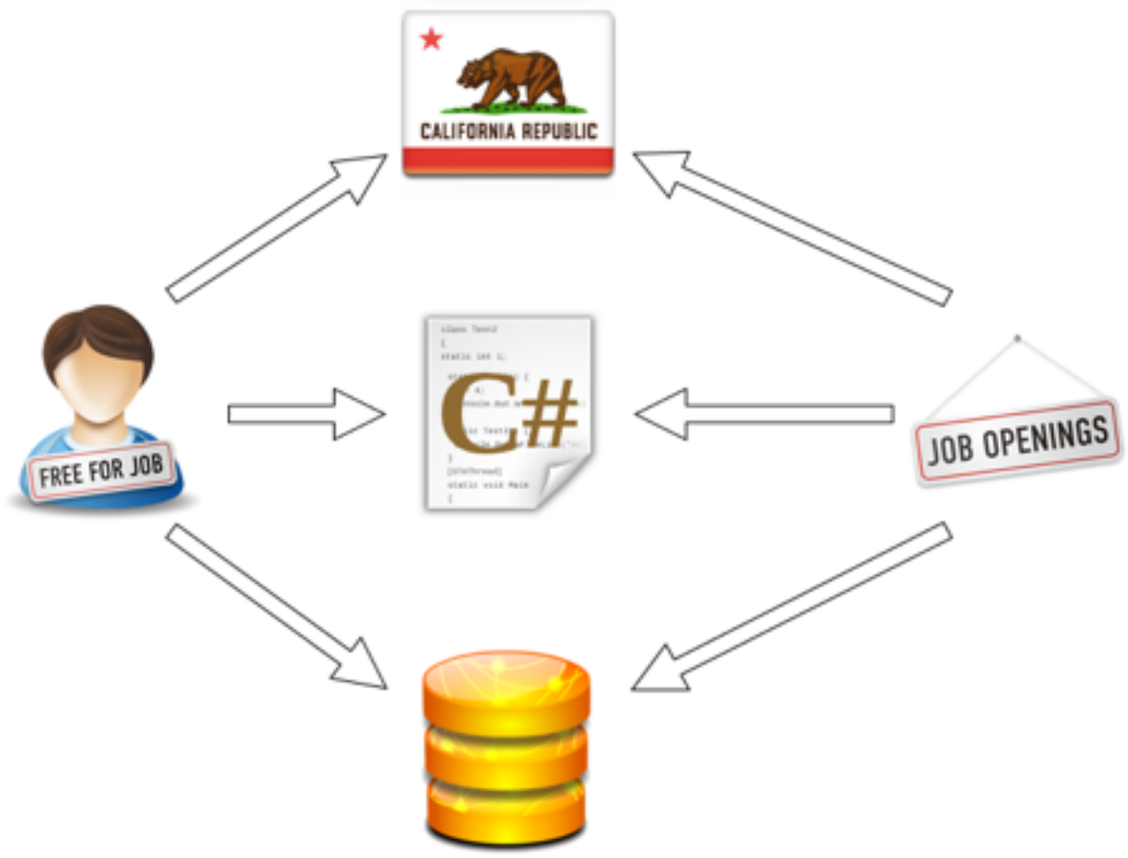
Java Server Software Engineer
Electronic Arts – Redwood City, CA
From: Experteer – 3 days ago

EMERGENCY MEDICAL TECH
U. S. NAVY – Fremont, CA
From: Monster – 14 days ago

Want better jobs? Tell us your current job title

Discrete Data + Connected Data

Open Source Example



http://maxdemarzi.com/2012/10/18/matches-are-the-new-hotness/

Open Source Example

```
START me=node:users_index(name={user})
MATCH skills<-[:has]-me-[:lives_in]->city<-[:in_location]-job-[:requires]->requirements
WHERE me-[:has]->()<-[:requires]-job
WITH DISTINCT city.name AS city_name,
     job.name AS job_name,
     LENGTH(me-[:has]->()<-[:requires]-job) AS matching_skills,
     LENGTH(job-[:requires]->()) AS job_requires,
     COLLECT(DISTINCT requirements.name) AS req_names,
     COLLECT(DISTINCT skills.name) AS skill_names
RETURN city_name, job_name,
FILTER(name IN req_names WHERE NOT name IN skill_names) AS missing
ORDER BY matching_skills / job_requires DESC, job_requires
LIMIT 10
```

http://maxdemarzi.com/2012/10/18/matches-are-the-new-hotness/

Open Source Example

Matching Jobs for Daniel

Reload the page or click Match Another User

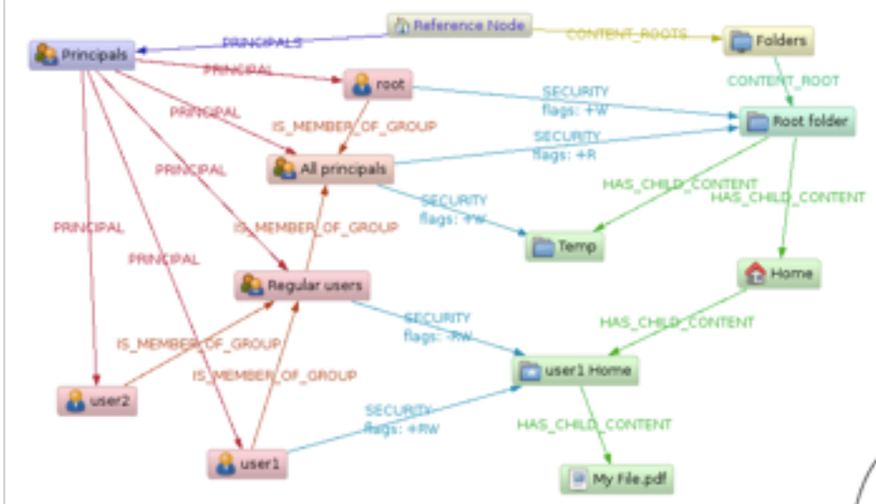
Job	Match	Missing
Spring-C-Django-SQL in *Dallas*	100% Match	
Neo4j-C-CSS in *Dallas*	Partial Match	+ CSS
C-Spring-Java in *Dallas*	Partial Match	+ Java
Java-Redis-C-Neo4j in *Dallas*	Partial Match	+ Java + Redis

http://maxdemarzi.com/2012/10/18/matches-are-the-new-hotness/

Emergent Graph in Other Industries

(Actual Neo4j Graphs)

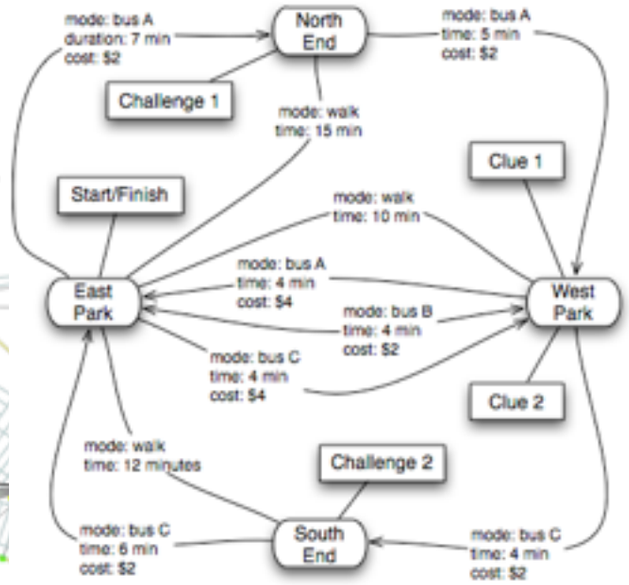
Content Management & Access Control



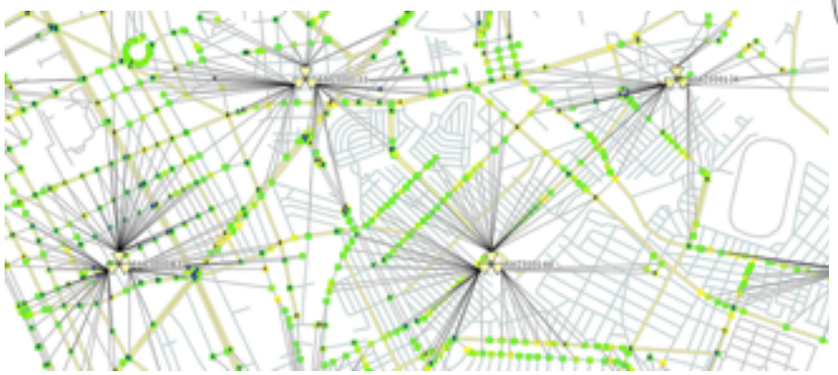
Insurance Risk Analysis

Geo Routing

(Public Transport)



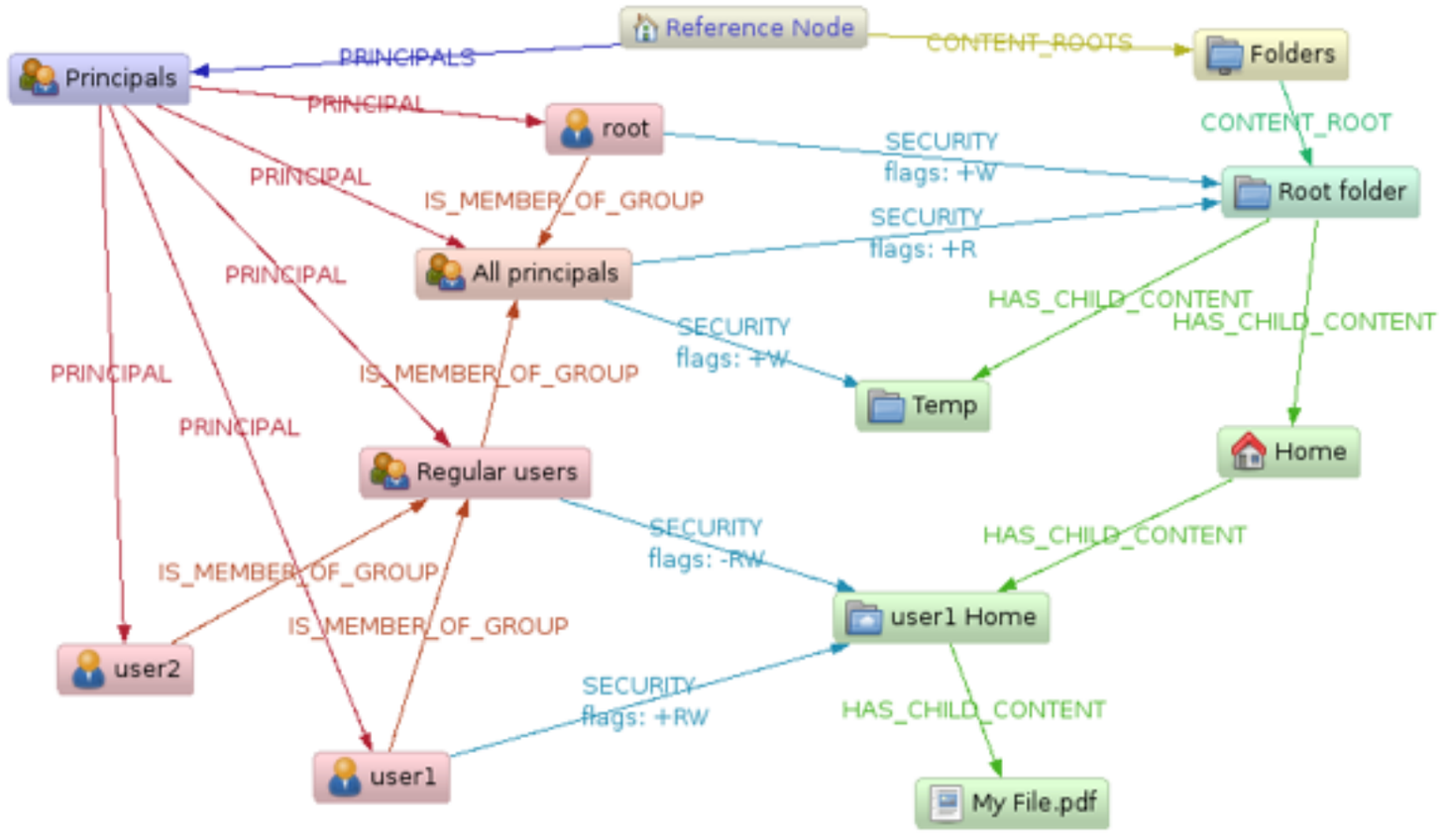
Network Cell Analysis



Network Asset Management

BioInformatics

Open Source Example



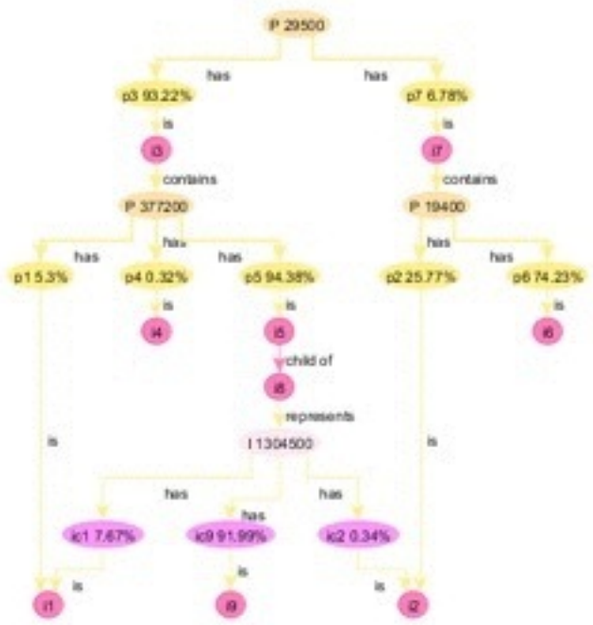
http://maxdemarzi.com/2013/03/18/permission-resolution-with-neo4j-part-1/

Emergent Graph in Other Industries

(Actual Neo4j Graphs)

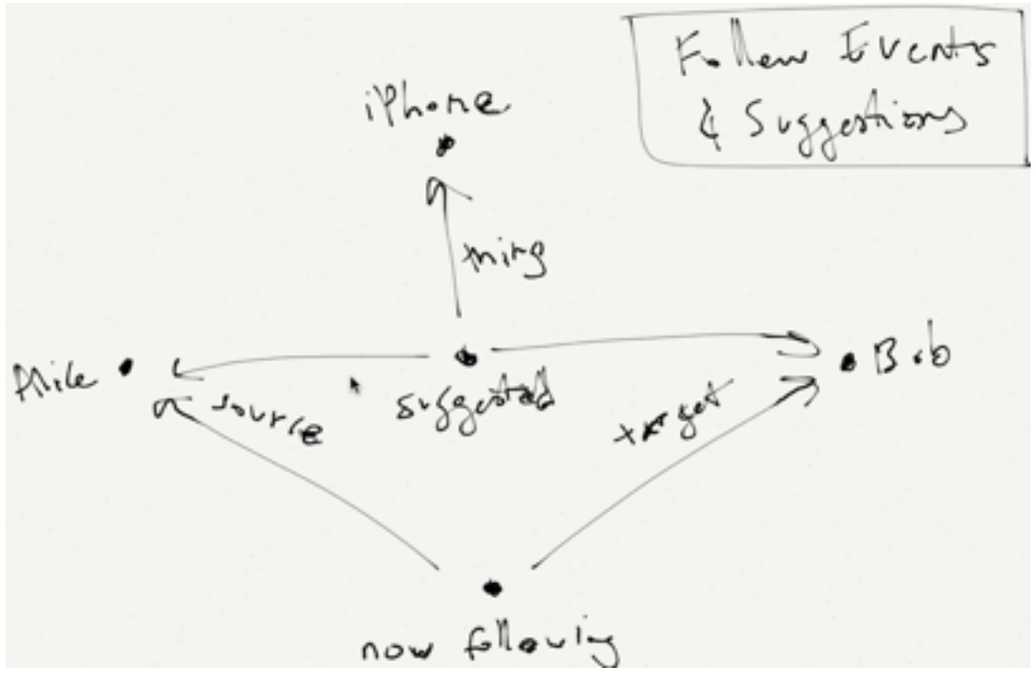
Web Browsing

Portfolio Analytics

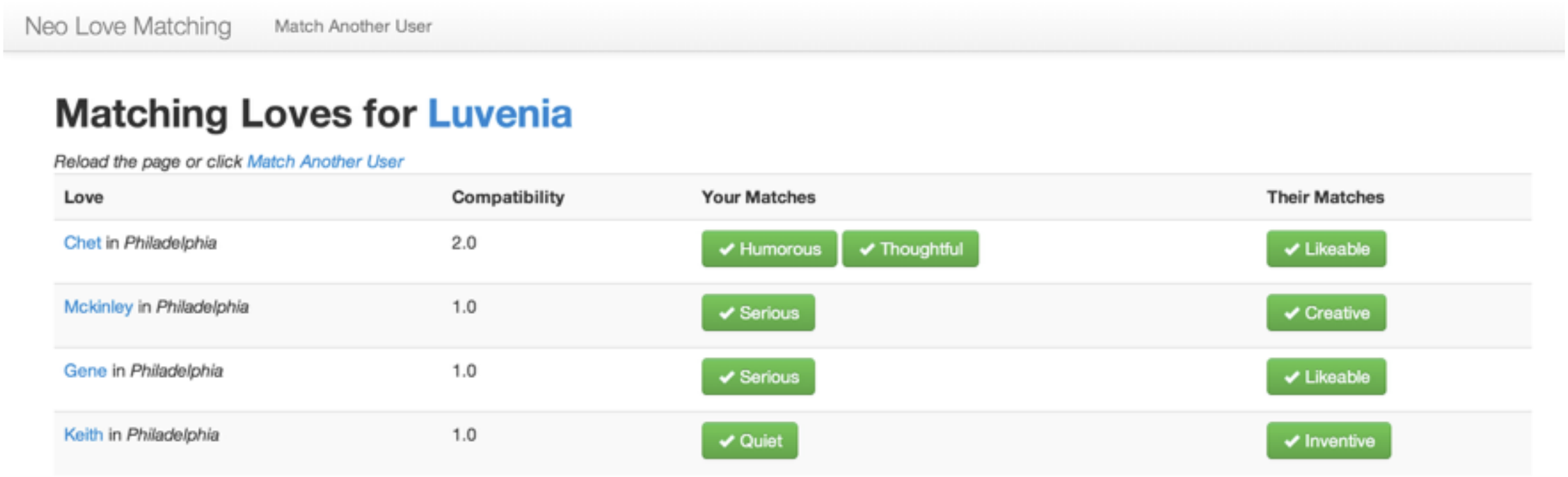


Gene Sequencing

Mobile Social Application



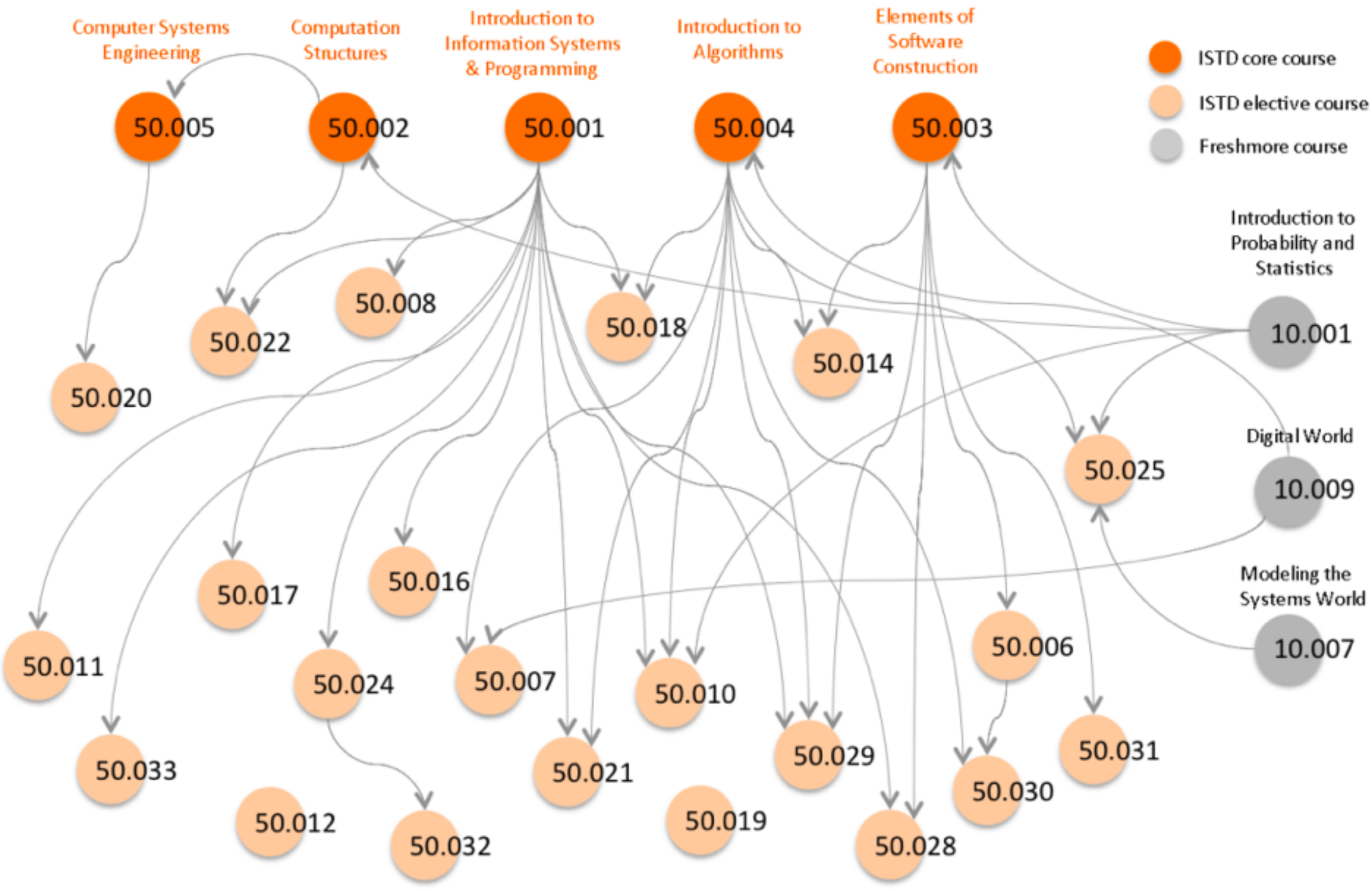
Open Source Example



http://maxdemarzi.com/2013/04/19/match-making-with-neo4j/

Curriculum Graph

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT



Early Adopter Segments

(What we expected to happen - view from several years ago)

Core Industries & Use Cases:	Web / ISV	Finance & Insurance	Datacom / Telecom
Network & Data Center Management			
MDM			
Social			
Geo			

Neo4j Adoption Snapshot

Select Commercial Customers (Community Users Not Included)

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Core Industries & Use Cases:	Software	Financial Services	Telecommunications	Web Social, HR & Recruiting	Health Care & Life Sciences	Media & Publishing	Energy, Services, Automotive, Gov't, Logistics, Education, Gaming, Other
Network & Data Center Management	Zenoss, Juniper, NetApp, Serena, gen, Virtual Instruments		HP, SFR				
MDM / System of Record			Cisco, Deutsche Telekom	Wooz, Equilar, viadeo, glassdoor	Zephyr Health, HealthUnlocked		Juice Plus+, onefinestay
Social	Glowbl	ICE	maaii		SharePractice	LifeChurch.tv, Squidoo, indiatimes	teachscape
Geo	DingLicom		Justdial	CareerArcGroup, classmates.com			gamesys, Accenture, Global 500 Logistics, shuti
Identity & Access Mgmt	aikux.com, id entropy	Global 500 Finance	telenor				
Content Management	springcm, Adobe, Liquid Common			Dshini, SHRM, SevenBridges, hinge		zeebox, LifeWay, decibel, <fuseworks/>, Perigee, CHIP, DOSB New Media GmbH	
Recommend-ations	kitedesk, Axon Active			careerbuilder, InfoJobs, moviepilot	Curaspan Healthgroup, Janssen		research now, compete
BI, CRM, Impact Analysis, Fraud Detection, Resource Optimization, etc.	SODIFRANCE, idmission, Humanvest.co, NexLP, DRW Trading Group	Global 500 Telecommunication					DRAKER, Impact Technologies, Lockheed Martin, Global 500 Energy, Global 500 Aerospace

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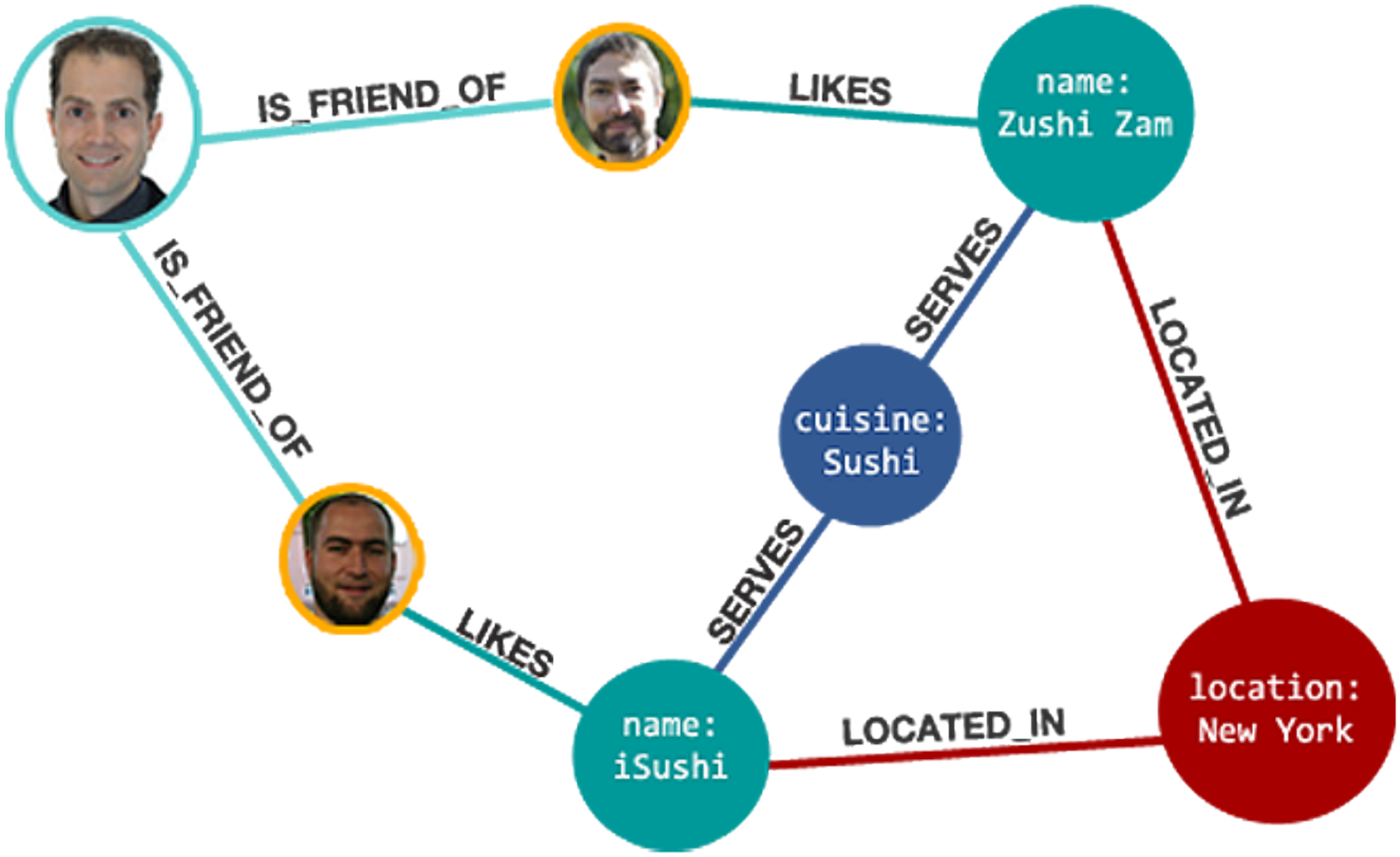
What Can You Do With Graphs?


Sushi restaurants in **New York, New York** that my friends like
Sushi restaurants in **New York, New York** that my friends like


IS_FRIEND_OF
LIKES
name:
Zushi Zam
IS_FRIEND_OF
SERVES
LOCATED_IN
cuisine:
Sushi
LIKES
SERVES
name:
iSushi
LOCATED_IN
location:
New York


```
MATCH (me:Person)-[:IS_FRIEND_OF]->(friend),
    (friend)-[:LIKES]->(restaurant),
       (restaurant)-[:LOCATED_IN]->(city:Location),
       (restaurant)-[:SERVES]->(cuisine:Cuisine)

WHERE me.name = 'Philip' AND city.location='New York' AND
      cuisine.cuisine='Sushi'

RETURN restaurant.name
```

http://maxdemarzi.com/?s=facebook

** Cypher query language example*


Sushi restaurants in **New York, New York** that my friends like
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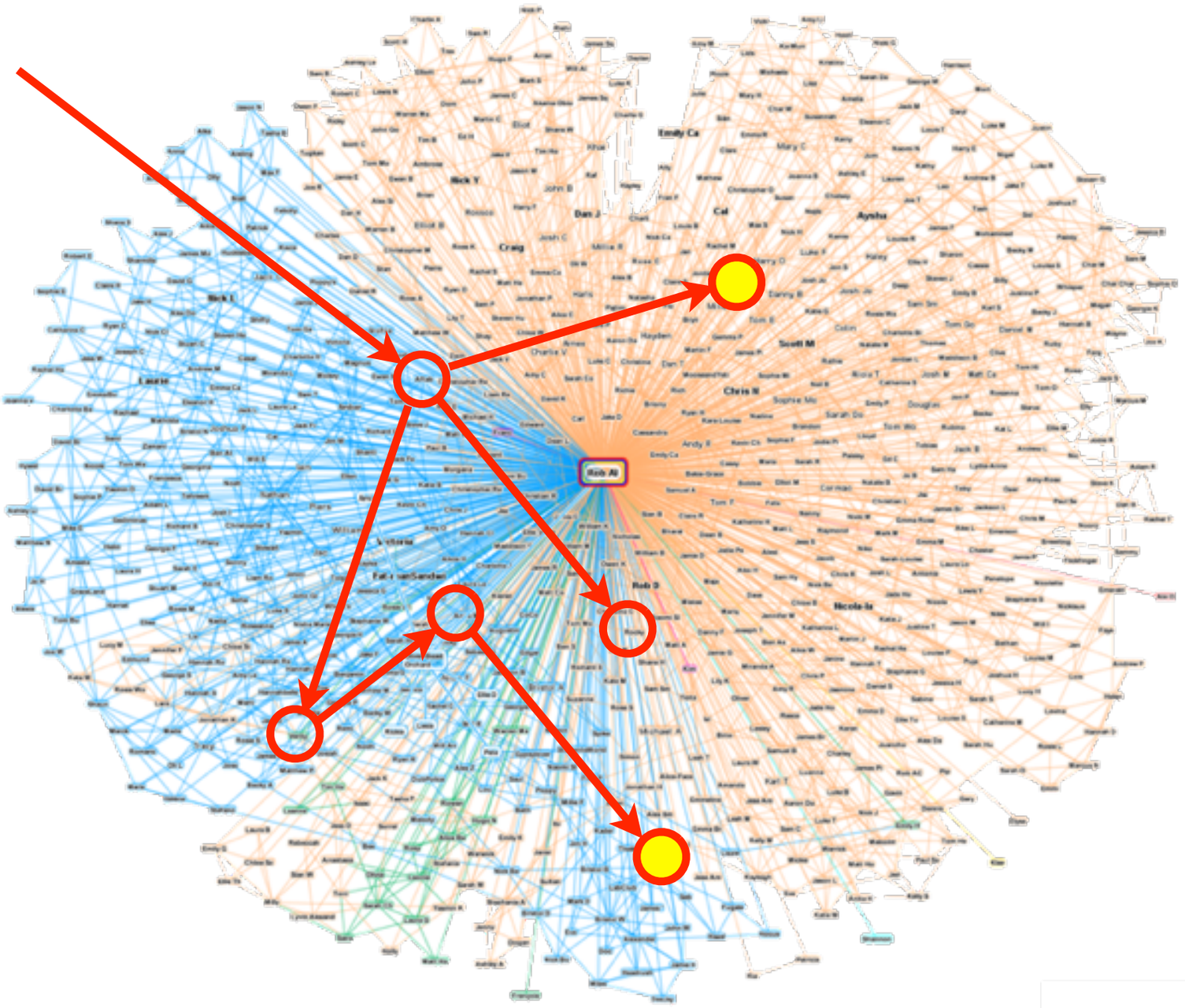
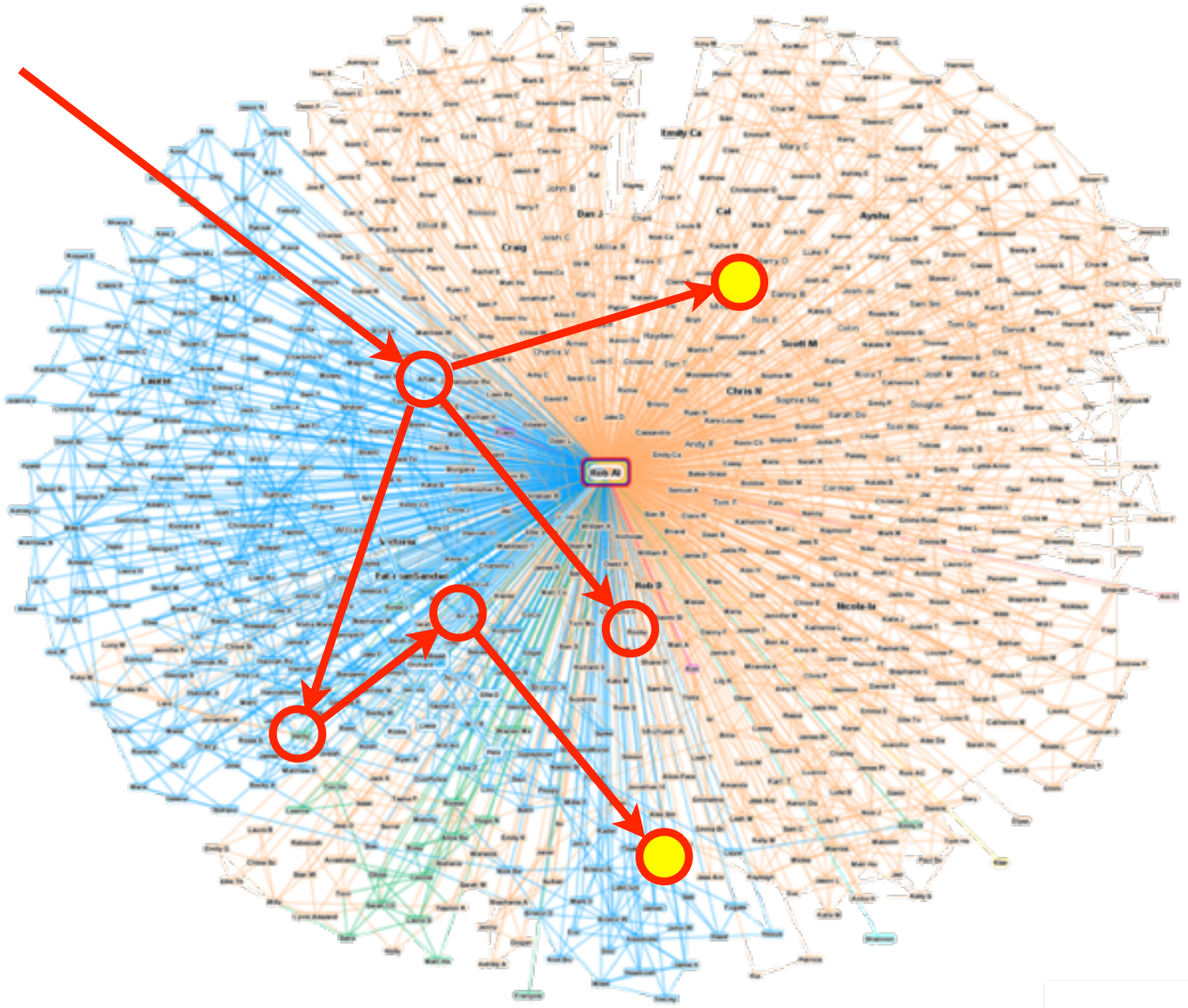


Of course.. a graph is a graph is a graph

What drugs will bind to protein X and not interact with drug Y?



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Connected Query Performance

Connected Query Performance

Query Response Time =*
f(graph density, graph size, query degree)

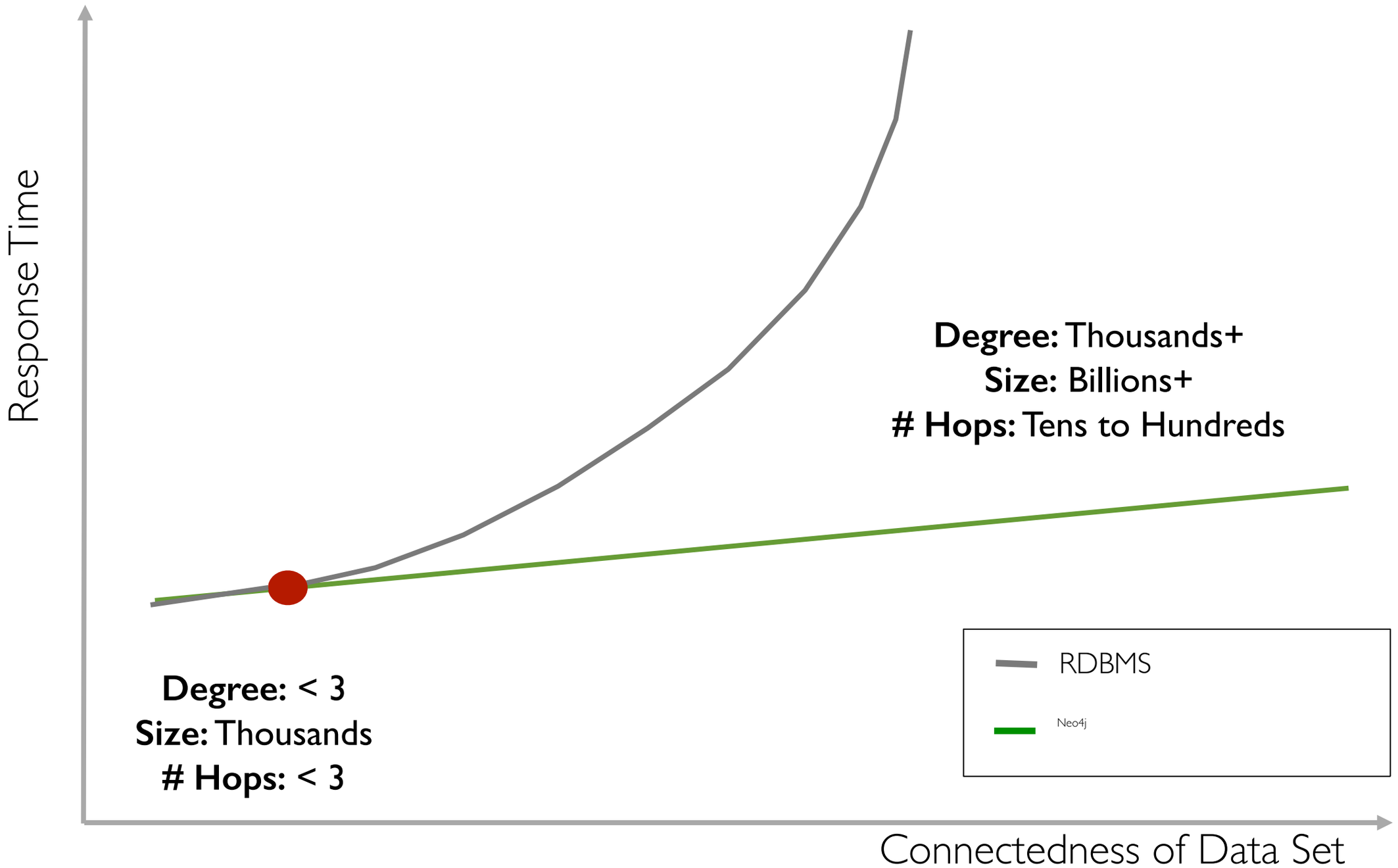
- **Graph density** (avg # rel's / node)
- **Graph size** (total # of nodes in the graph)
- **Query degree** (# of hops in one's query)

RDBMS:
>> exponential slowdown as each factor increases

Neo4j:
>> Performance remains constant as graph size increases
>> Performance slowdown is linear or better as density & degree increase

Connected Query Performance

RDBMS vs. Native Graph Database



Graph db performance

- a sample social graph
  - with ~1,000 persons
- average 50 friends per person
- pathExists(a,b) limited to depth 4
- caches warmed up to eliminate disk I/O

Database	# persons	query time
MySQL		
Neo4j		
Neo4j		

Graph db performance

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Database	# persons	query time
MySQL	1,000	2,000 ms
Neo4j		
Neo4j		

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Neo4j	1,000	2 ms
Neo4j		

Graph db performance

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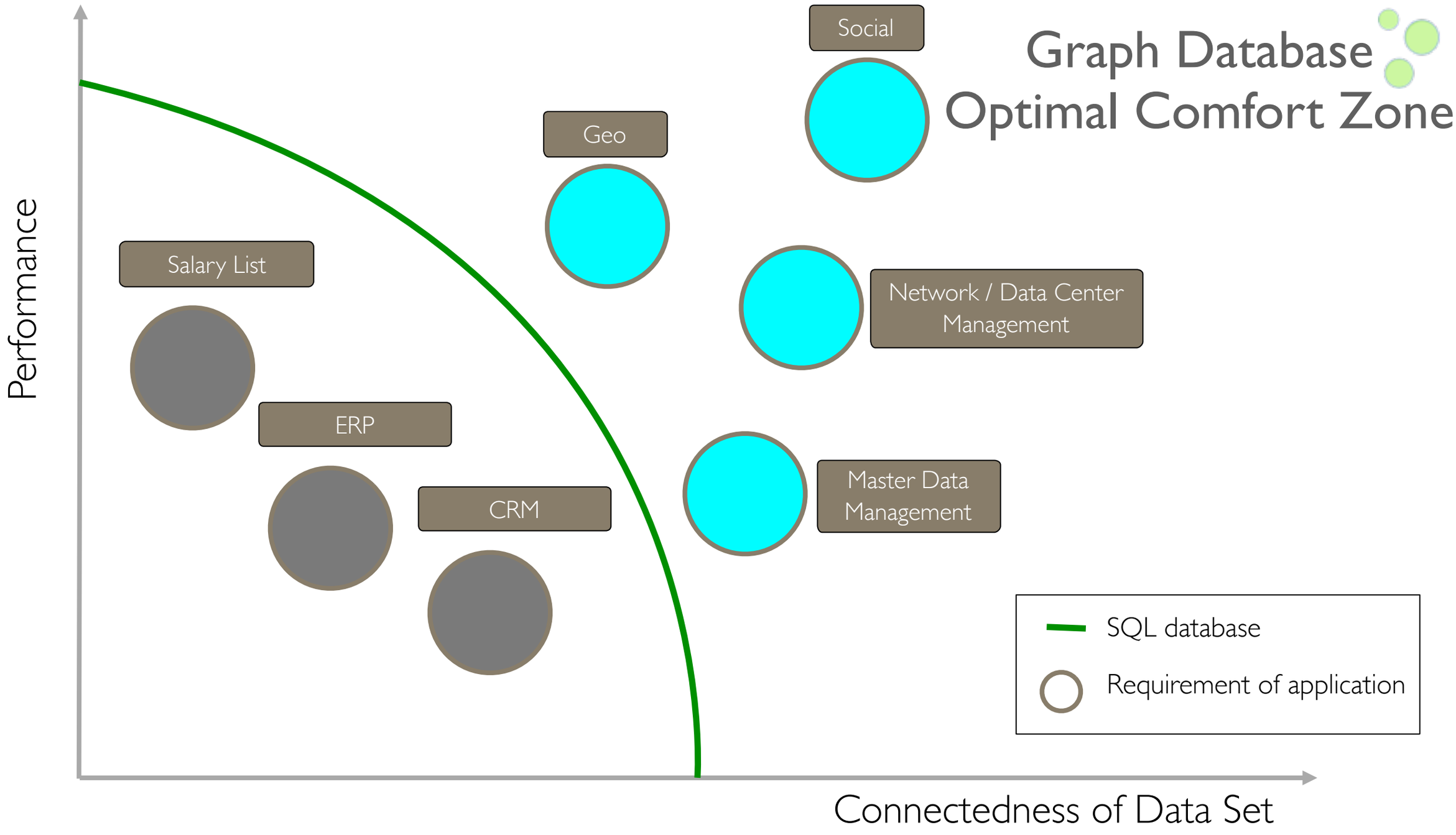
Database	# persons	query time
MySQL	1,000	2,000 ms
Neo4j	1,000	2 ms
Neo4j	**1,000,000**	2 ms

*Additional Third Party Benchmark Available in *Neo4j in Action*: http://www.manning.com/partner/

The Zone of SQL Adequacy



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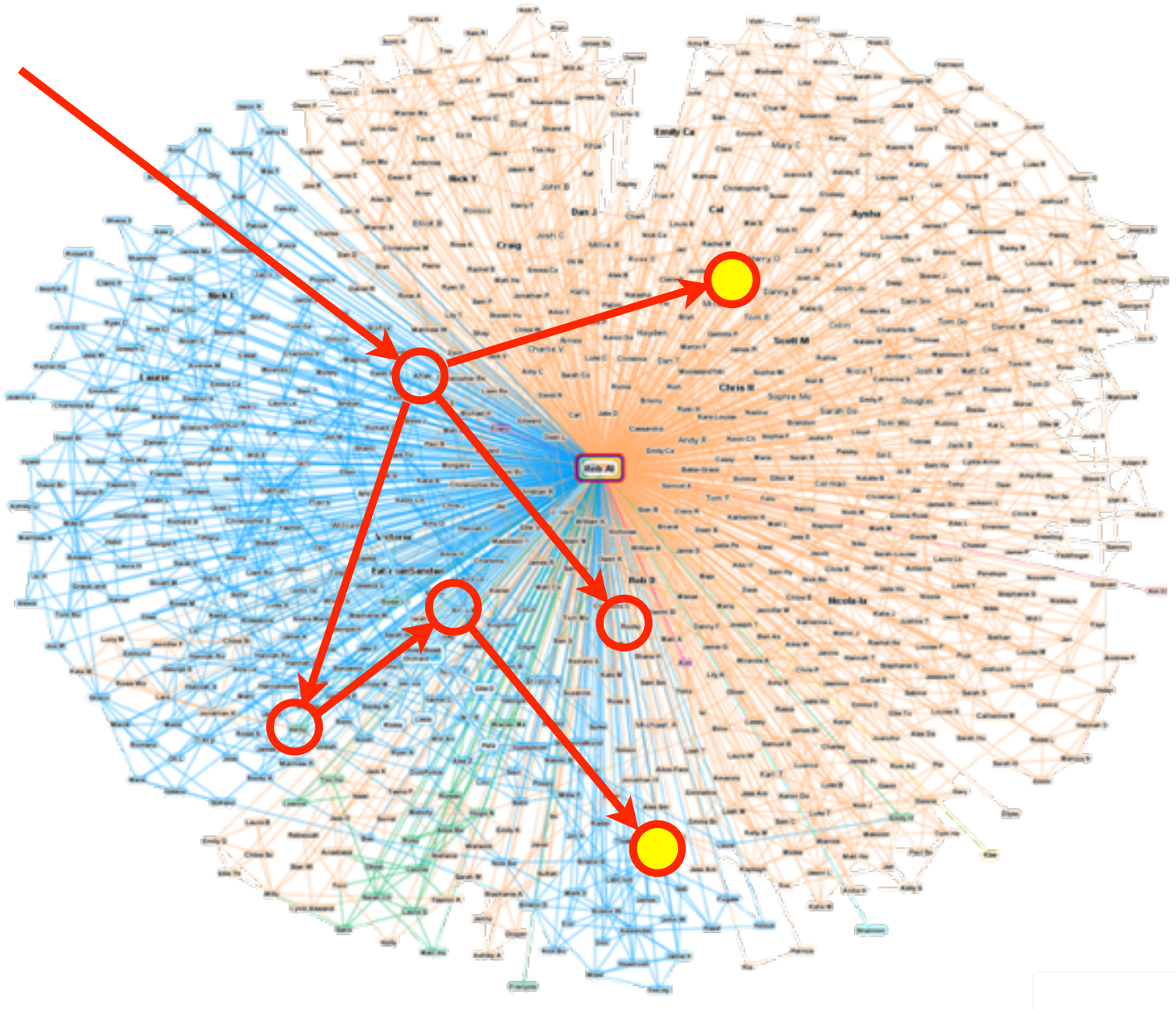
Graph Technology Ecosystem

#1: Graph Local Queries



e.g. Recommendations, Friend-of-Friend, Shortest Path

What is a Graph Database

"A **graph database**... is an online database management system with CRUD methods that expose a graph data model"[1]

- Two important properties:
  - **Native graph storage** engine: *written from the ground up to manage graph data*
  - **Native graph processing**, including *index-free adjacency* to facilitate traversals

1] Robinson, Webber, Eifrem. *Graph Databases*. O'Reilly, 2013. p. 5. ISBN-10: 1449356265

Graph Databases are Designed to:

1. Store inter-connected data
2. Make it easy to make sense of that data
3. Enable extreme-performance operations for:
    - Discovery of connected data patterns
    - Relatedness queries > depth 1
    - Relatedness queries of arbitrary length
4. Make it easy to evolve the database

Top Reasons People Use Graph Databases

1. **Problems with Join performance.**
2. **Continuously evolving data set** (often involves wide and sparse tables)
3. The **Shape of the Domain** is naturally a graph
4. **Open-ended business requirements** necessitating fast, iterative development.

ABOUT THE VIADEO GROUP

The Viadeo Group forms the world's second largest professional social network with over 50 million members.

- N°1 in France with over 7 million members,
- N°1 in China with over 14 millions members.
- Strong presence in Europe and in emerging markets, strong growth in South America
- Presence in Russia since December 2011 through a joint venture with leading media group : Sanoma Independent Media
- April 2012 : record funding of 24 million euros (FSI, historical shareholders and new entrants)
- Headquarters in Paris and local offices on 5 continents
- 400 employees

- The Viadeo Group consists of:

viadeo ApnaCircle.com 天際網 www.tianji.com

viadeo

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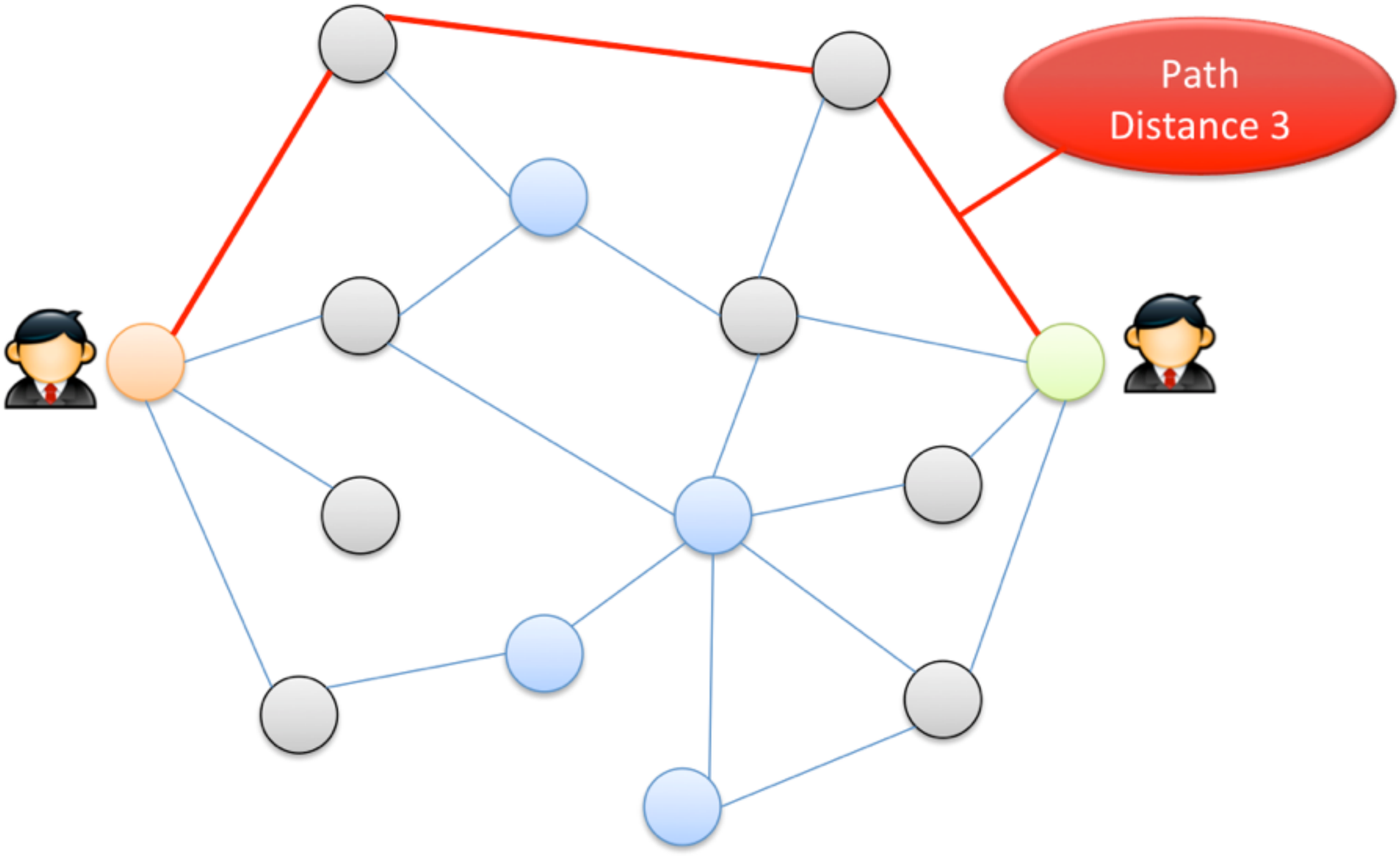


viadeo

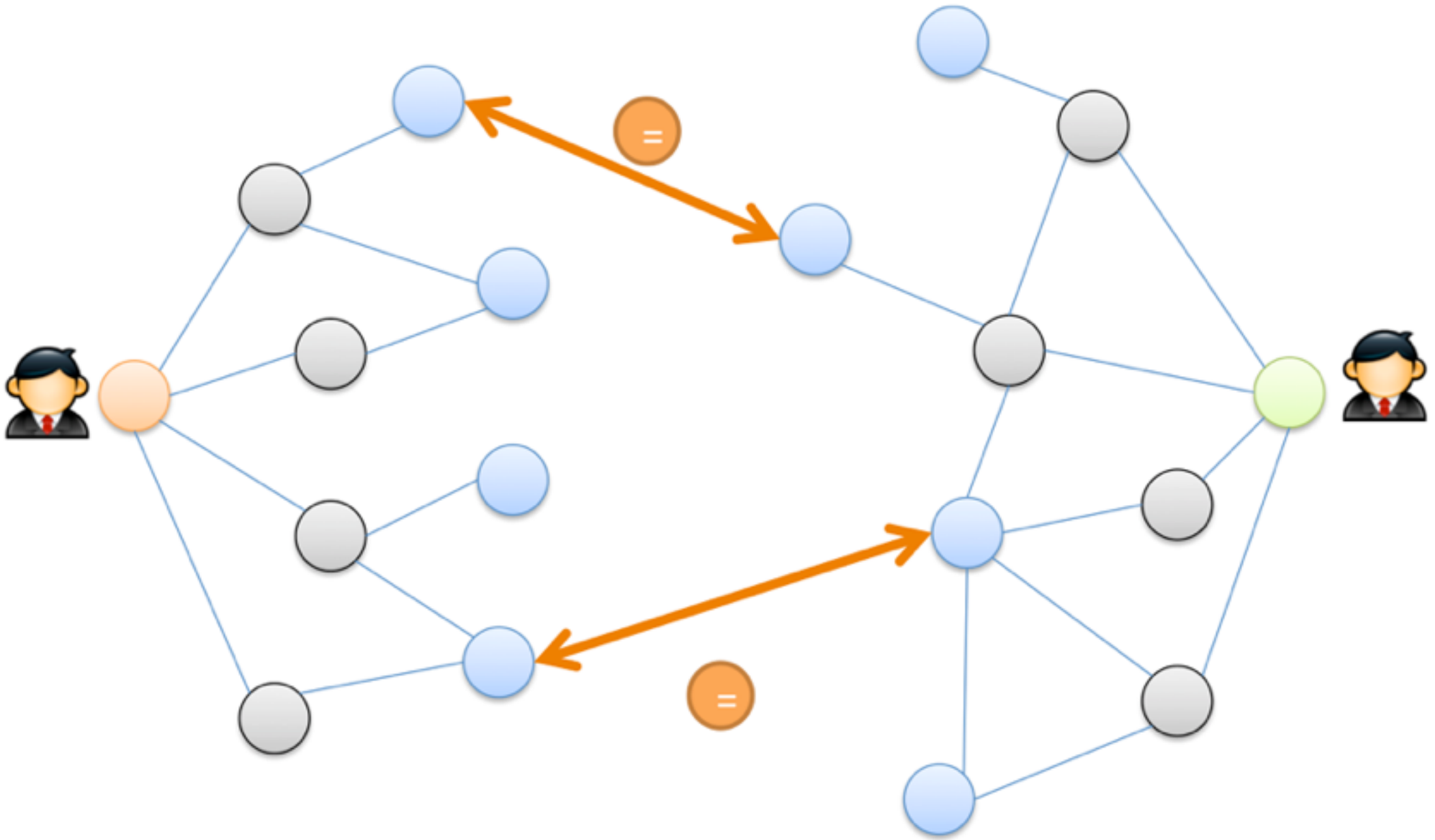
PREHISTORY 2006-2011

- In-house algorithm
- Network storage in **MySQL Database**

```
CREATE TABLE `Network` (
  `memberId` int(11) NOT NULL DEFAULT '0',
  `L1` mediumblob NOT NULL,
  `L2` mediumblob NOT NULL,
  PRIMARY KEY (`memberId`)
) ENGINE=InnoDB;
```

viadeo

PREHISTORY 2006-2011



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PREHISTORY 2006-2011

LIMITATIONS

1) Important latency for complete update

2) Massive bandwidth impact for internal network

3) 48 hours to restart from scratch

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PREHISTORY 2006-2011

Update the network (old-fashioned style)

Member A and Member B are now in contacts

- Update of A.L1 + B.L1 and A.L2 + B.L2
- Retrieving A.L1 + B.L1 and update *.L2

Example:

- A has 500 contacts
- B has 150 contacts

➔ 500 + 150 + 2 = **652 updates!**

GRAPH DATABASE

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APACHE
GIRAPH

Wait what?

New Users?
Real Time Updates?

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WHY Neo4J

BENEFITS

Instantaneous
graph updates

Very easy to integrate
(less than 2 months)

Backup /
Restore

High Availability

Graph Database Deployment

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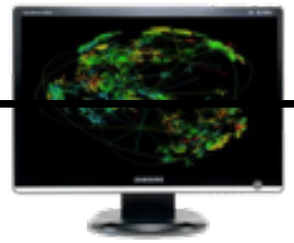
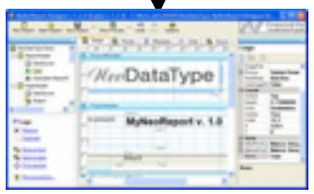
End User



Ad-hoc visual navigation & discovery

Graph Visualization

Graph-Dashboards & Ad-hoc Analysis



Reporting

Application

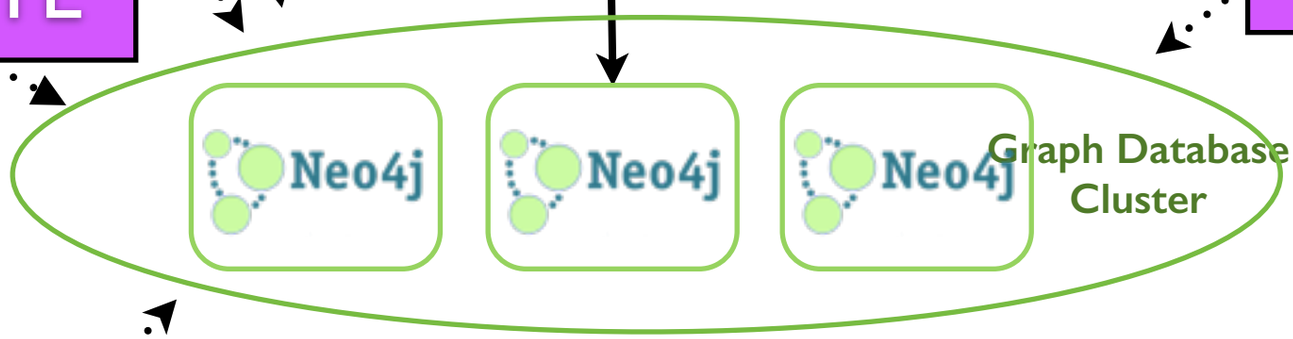
Other Databases

Bulk Analytic Infrastructure

(e.g. Graph Compute Engine)

ETL

ETL



Graph Database Cluster

Graph Mining & Aggregation

Ad-Hoc Analysis

Data Storage & Business Rules Execution

Data Scientist

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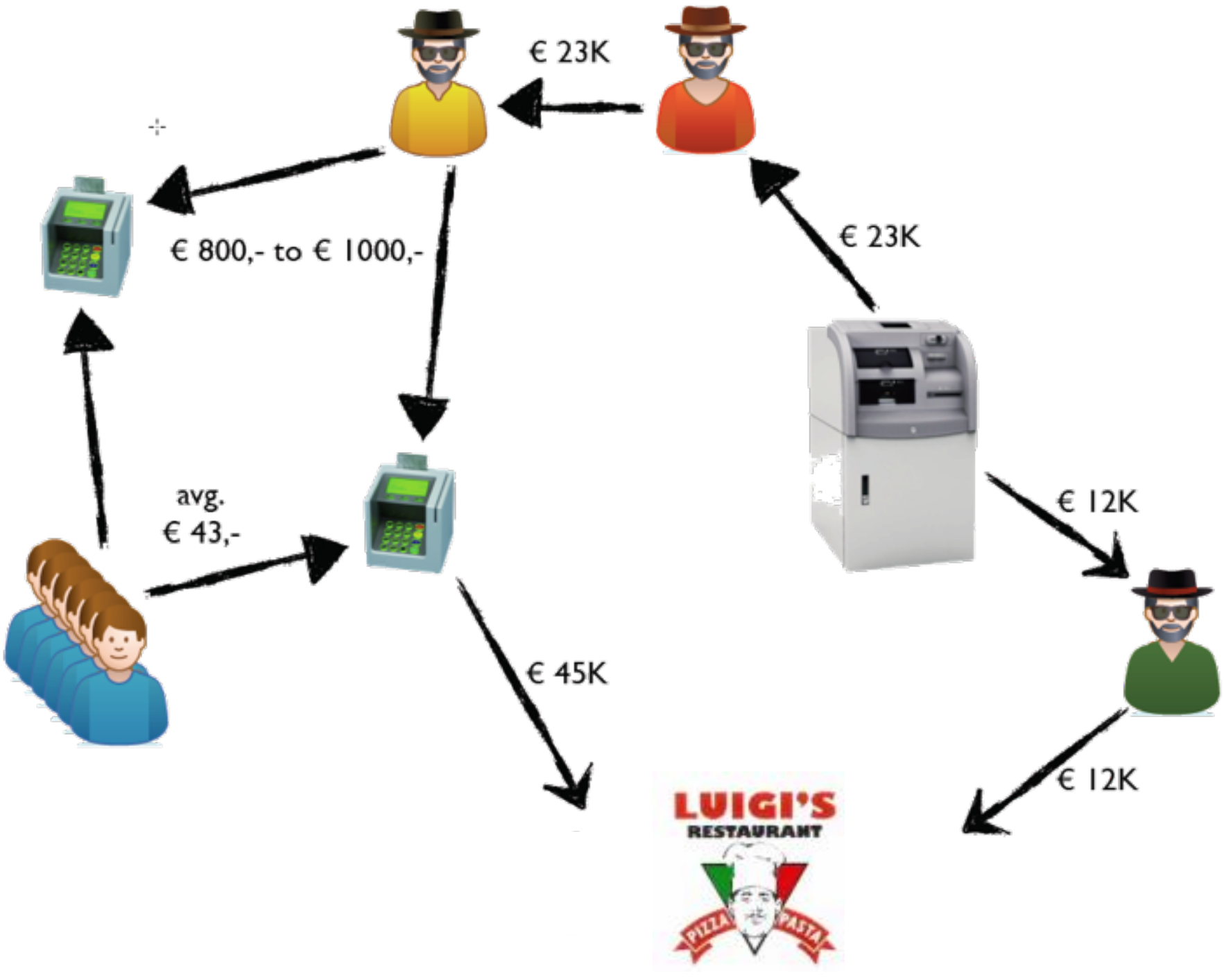
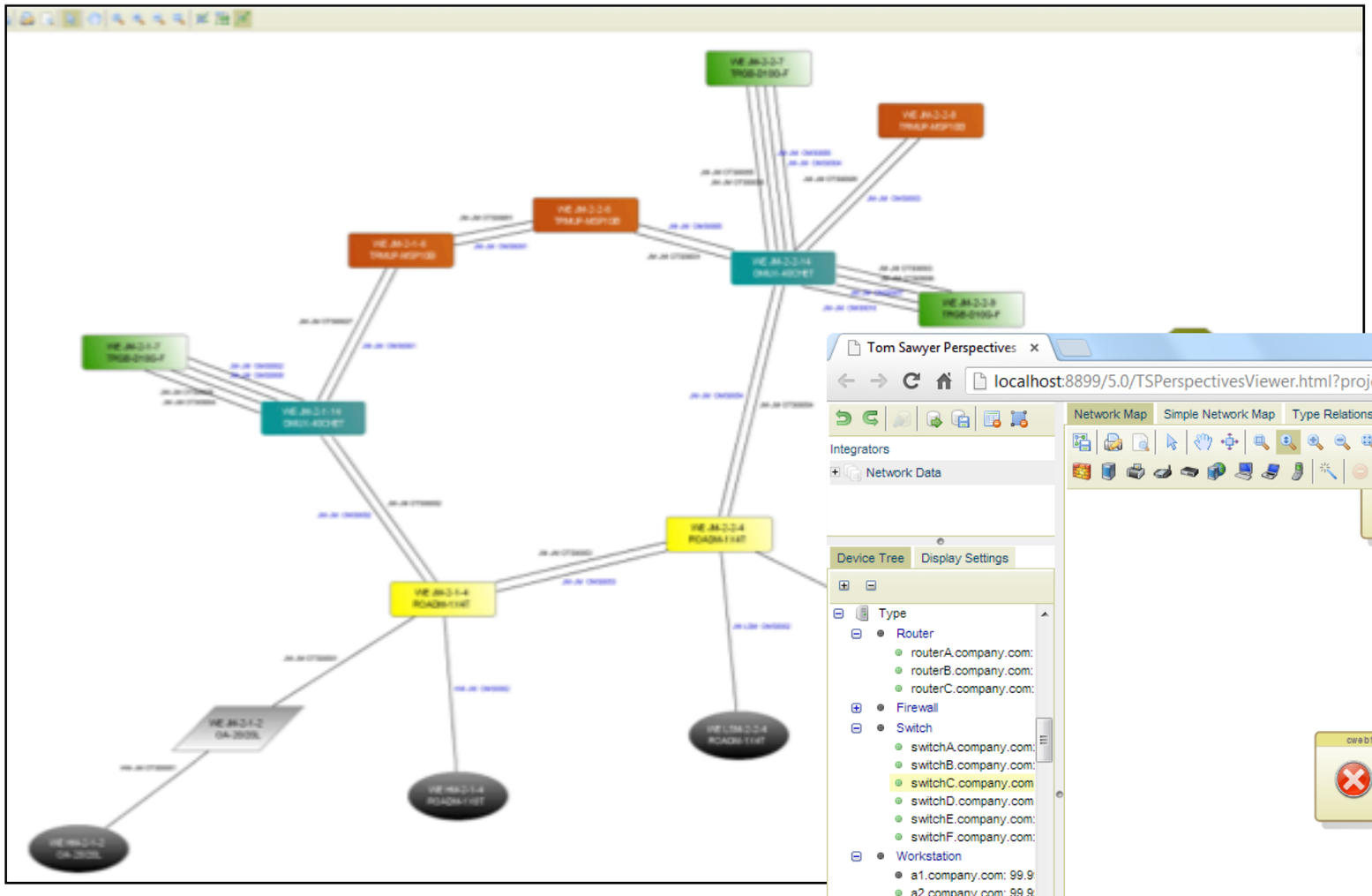
Graph Dashboards

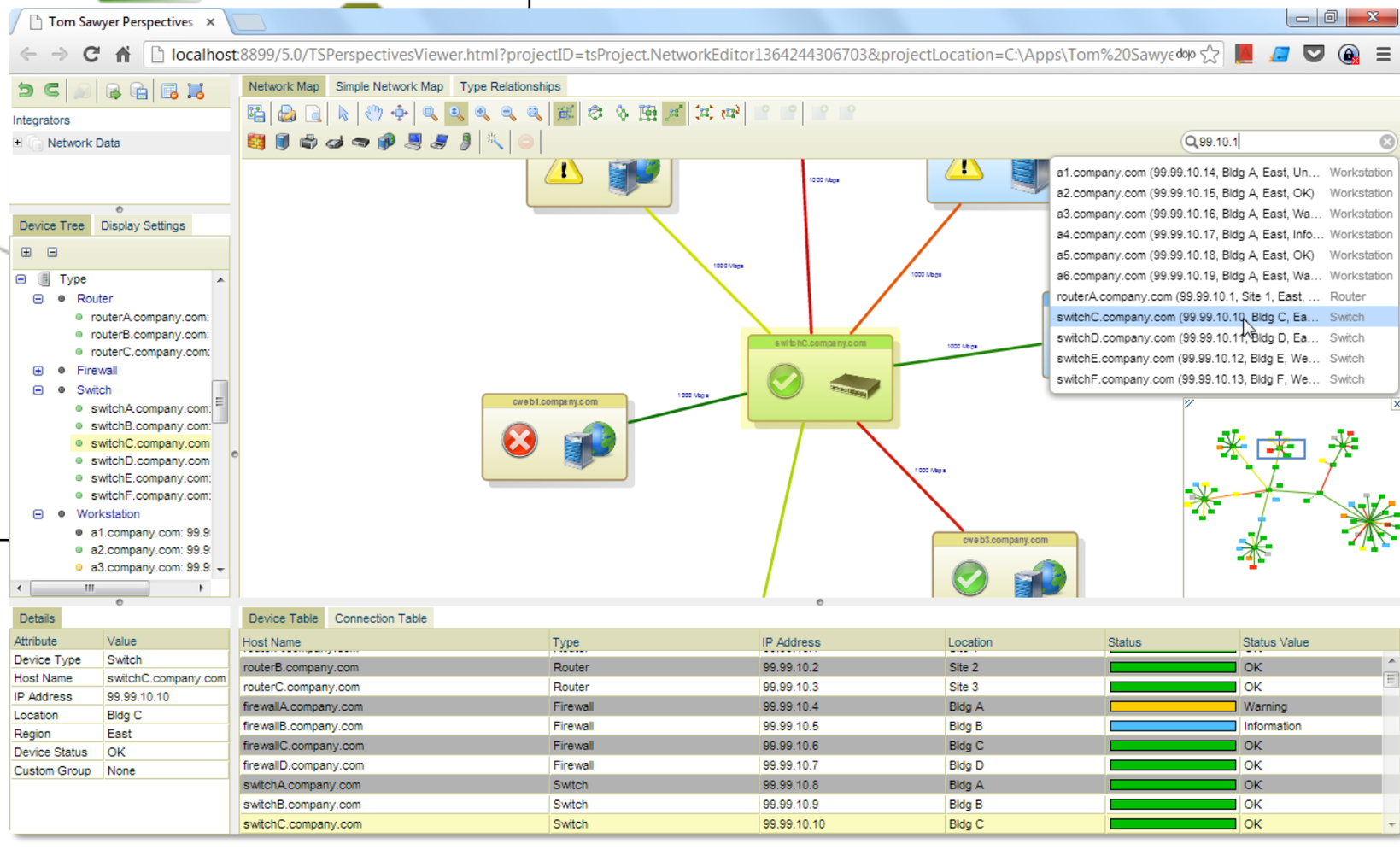
The Power of Visualization

Fraud Detection & Money Laundering



IT Service Dependencies





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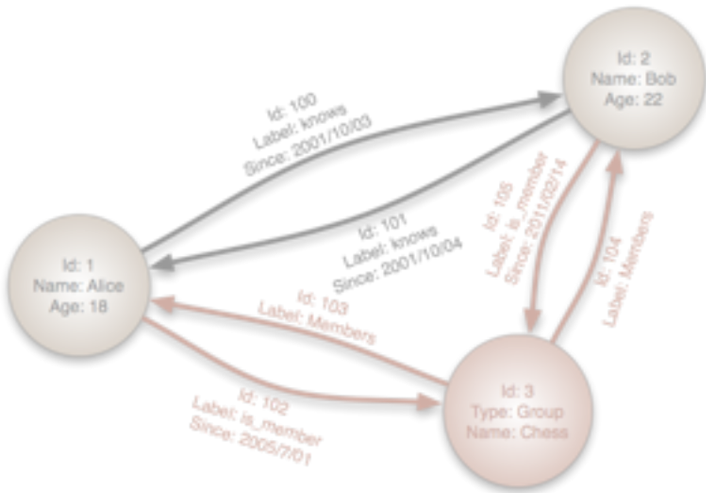
Working with Graphs

Case Studies & Working Examples



Cypher

ASCII art Graph Patterns

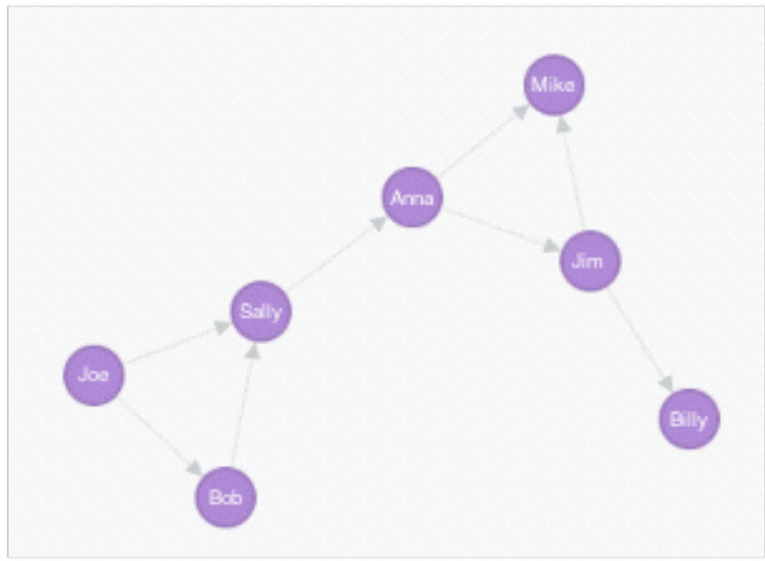

```
MATCH (A) -[:LOVES]-> (B)
  WHERE A.name = "A"
  RETURN B as lover
```

Social Example

Practical Cypher

Social Graph - Create

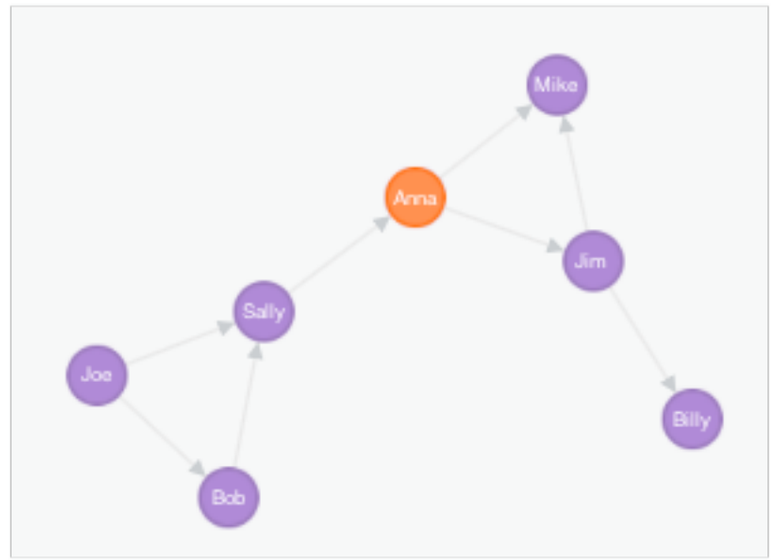
```
CREATE
    (joe:Person {name:"Joe"}),
    (bob:Person {name:"Bob"}),
    (sally:Person {name:"Sally"}),
    (anna:Person {name:"Anna"}),
    (jim:Person {name:"Jim"}),
    (mike:Person {name:"Mike"}),
    (billy:Person {name:"Billy"}),

    (joe)-[:KNOWS]->(bob),
    (joe)-[:KNOWS]->(sally),
    (bob)-[:KNOWS]->(sally),
    (sally)-[:KNOWS]->(anna),
    (anna)-[:KNOWS]->(jim),
    (anna)-[:KNOWS]->(mike),
    (jim)-[:KNOWS]->(mike),
    (jim)-[:KNOWS]->(billy)
```



Practical Cypher

Social Graph - Friends of Joe's Friends

```
MATCH (person)-[:KNOWS]-(friend),
      (friend)-[:KNOWS]-(foaf)
WHERE person.name = "Joe"
  AND NOT(person-[:KNOWS]-foaf)
RETURN foaf
```

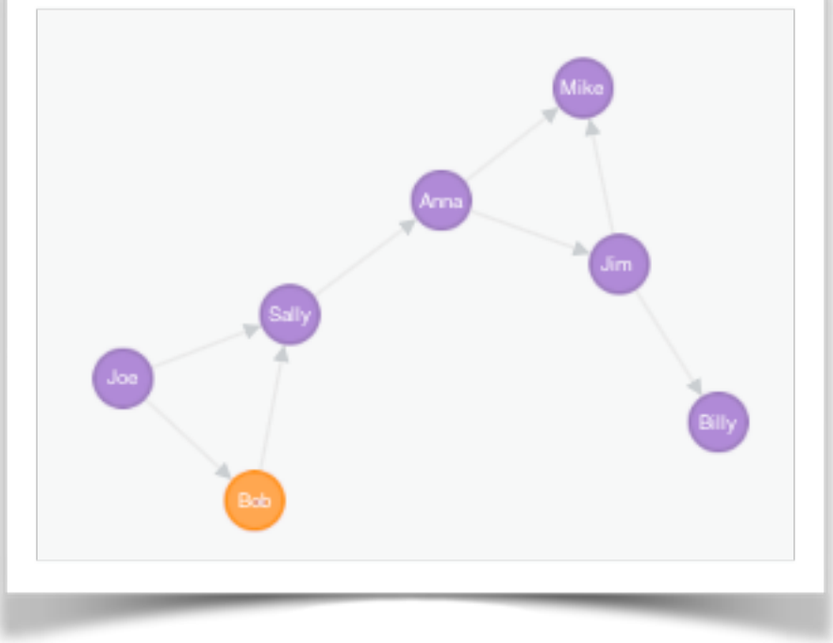


foaf
{name:"Anna"}

Practical Cypher

Social Graph - Common Friends

```
MATCH (person1)-[:KNOWS]-(friend),
  (person2)-[:KNOWS]-(friend)
WHERE person1.name = "Joe"
  AND person2.name = "Sally"
RETURN friend
```

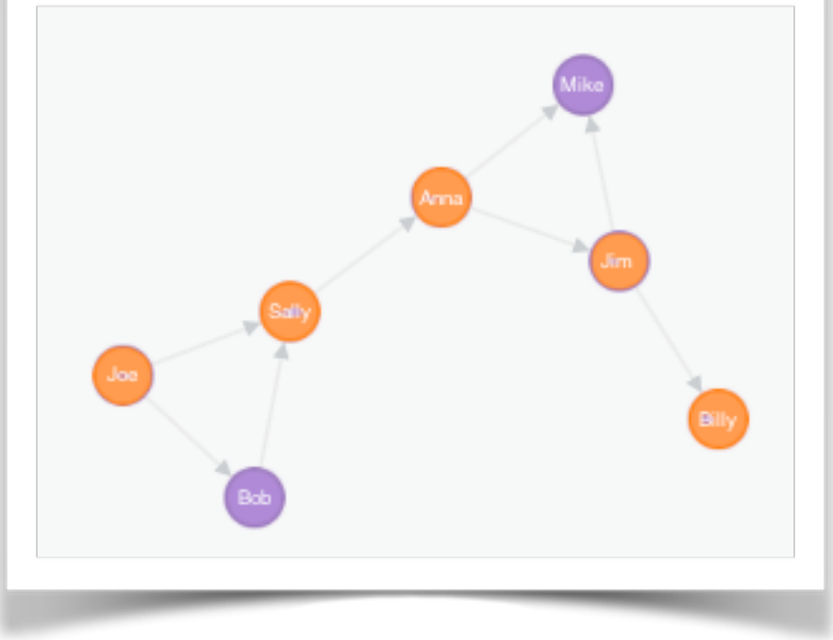


friend
{name:"Bob"}

Practical Cypher

Social Graph - Shortest Path

```
MATCH path = shortestPath(
  (person1)-[:KNOWS*..6]-(person2)
)
WHERE person1.name = "Joe"
   AND person2.name = "Billy"
RETURN path
```



path
{start:"13759", nodes:["13759","13757","13756","13755","13753"], length:4, relationships:["101407","101409","101410","101413"], end:"13753"}

glassdoor™ *Industry: Online Job Search*
Use case: Social / Recommendations
Sausalito, CA

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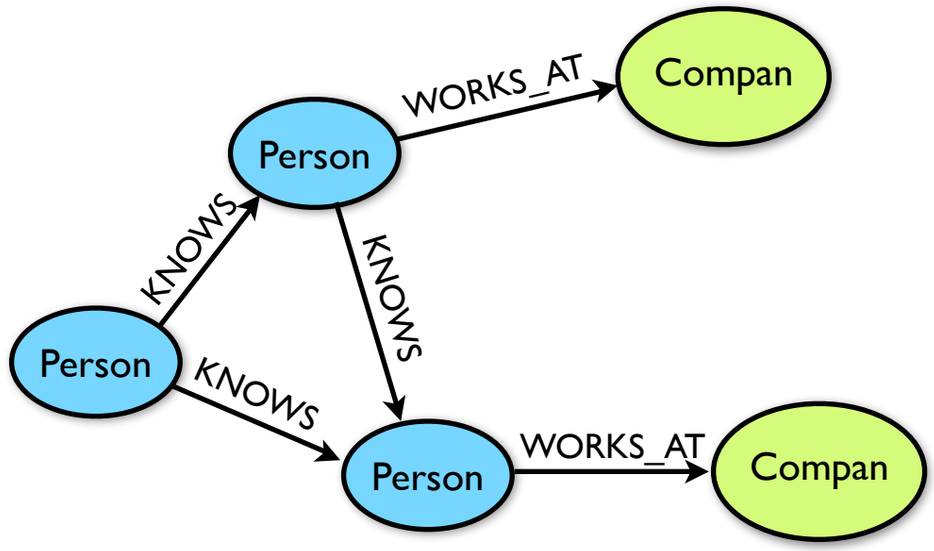
Background

- Online jobs and career community, providing anonymized inside information to job seekers



Business problem

- Wanted to leverage known fact that most jobs are found through personal & professional connections
- Needed to rely on an existing source of social network data. Facebook was the ideal choice.
- End users needed to get instant gratification
- Aiming to have the best job search service, in a very competitive market

Solution & Benefits

- First-to-market with a product that let users find jobs through their network of Facebook friends
- Job recommendations served real-time from Neo4j
- Individual Facebook graphs imported real-time into Neo4j
- Glassdoor now stores > 50% of the entire Facebook social graph
- Neo4j cluster has grown seamlessly, with new instances being brought online as graph size and load have increased

Network Management Example

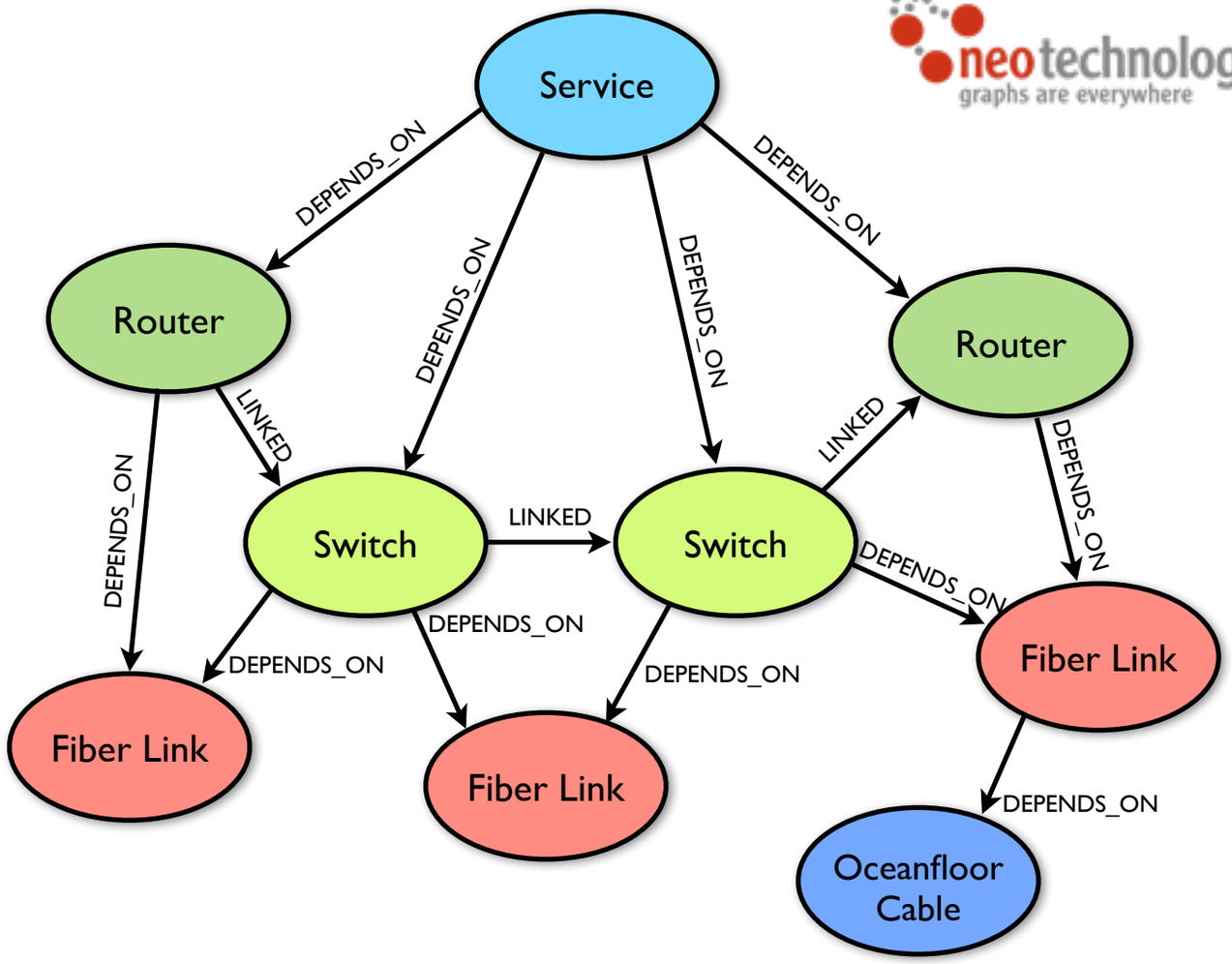
vivendi

SFR

Industry: Communications
Use case: Network Management
Paris, France

Background

- Second largest communications company in France
- Part of Vivendi Group, partnering with Vodafone



Business problem

- Infrastructure maintenance took one full week to plan, because of the need to model network impacts
- Needed rapid, automated "what if" analysis to ensure resilience during unplanned network outages
- Identify weaknesses in the network to uncover the need for additional redundancy
- Network information spread across > 30 systems, with daily changes to network infrastructure
- Business needs sometimes changed very rapidly

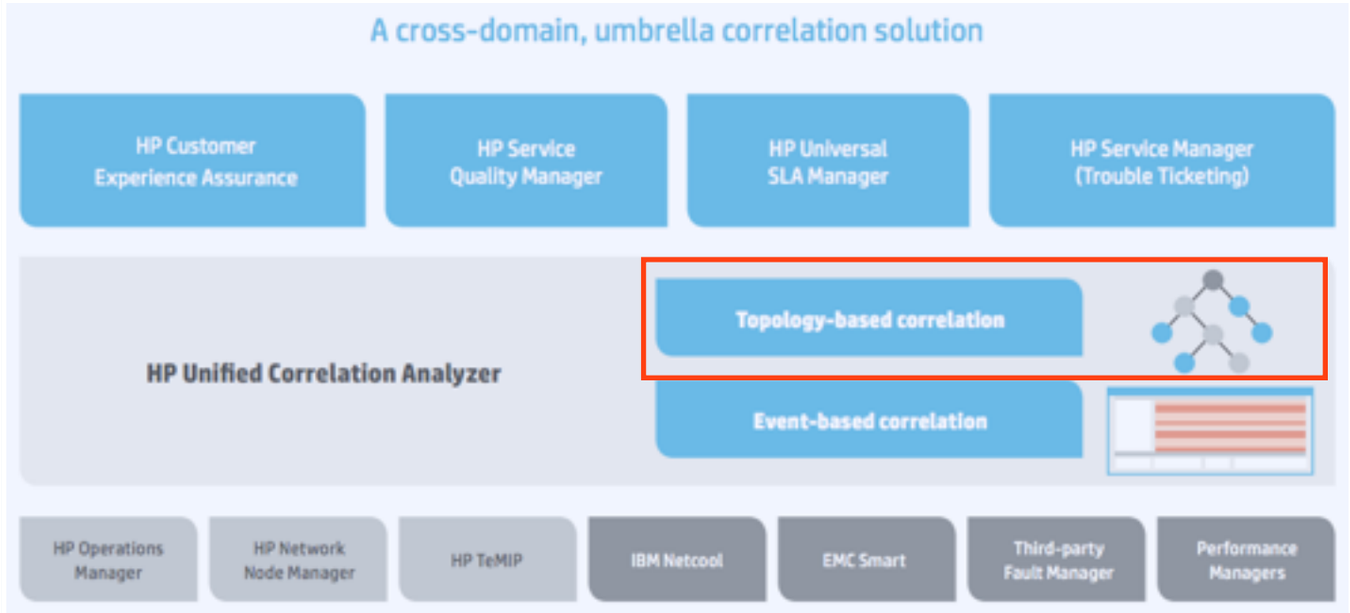
Solution & Benefits

- Flexible network inventory management system, to support modeling, aggregation & troubleshooting
- Single source of truth (Neo4j) representing the entire network
- Dynamic system loads data from 30+ systems, and allows new applications to access network data
- Modeling efforts greatly reduced because of the near 1:1 mapping between the real world and the graph
- Flexible schema highly adaptable to changing business requirements

Industry: Web/ISV, Communications
Use case: Network Management
Global (U.S., France)

Background

- World's largest provider of IT infrastructure, software & services
- HP's *Unified Correlation Analyzer* (UCA) application is a key application inside HP's OSS Assurance portfolio
- Carrier-class resource & service management, problem determination, root cause & service impact analysis
- Helps communications operators manage large, complex and fast changing networks



Business problem

- Use network topology information to identify root problems causes on the network
- Simplify alarm handling by human operators
- Automate handling of certain types of alarms Help operators respond rapidly to network issues
- Filter/group/eliminate redundant Network Management System alarms by event correlation

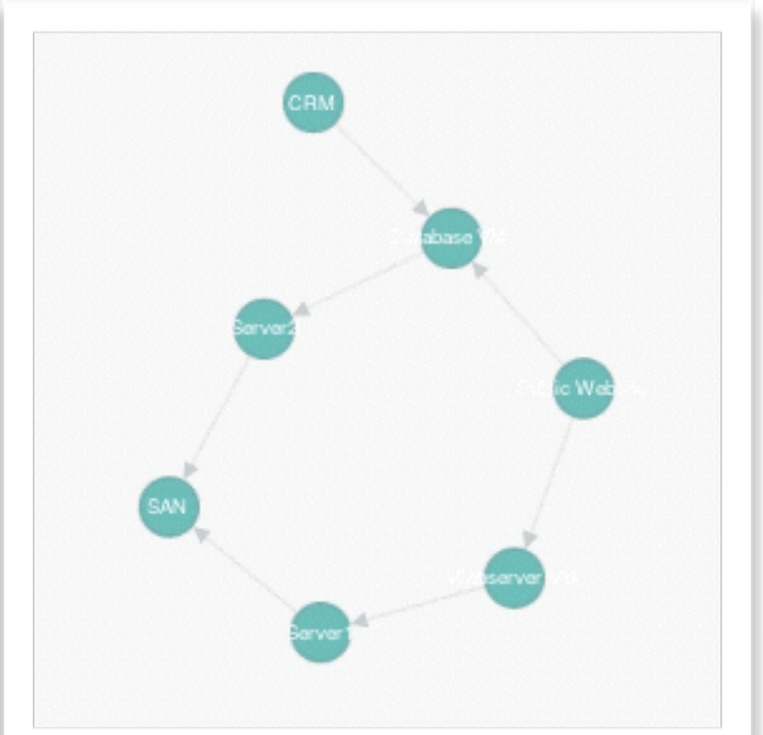
Solution & Benefits

- Accelerated product development time
- Extremely fast querying of network topology
- Graph representation a perfect domain fit
- 24x7 carrier-grade reliability with Neo4j HA clustering
- Met objective in under 6 months

Practical Cypher

Network Management - Create

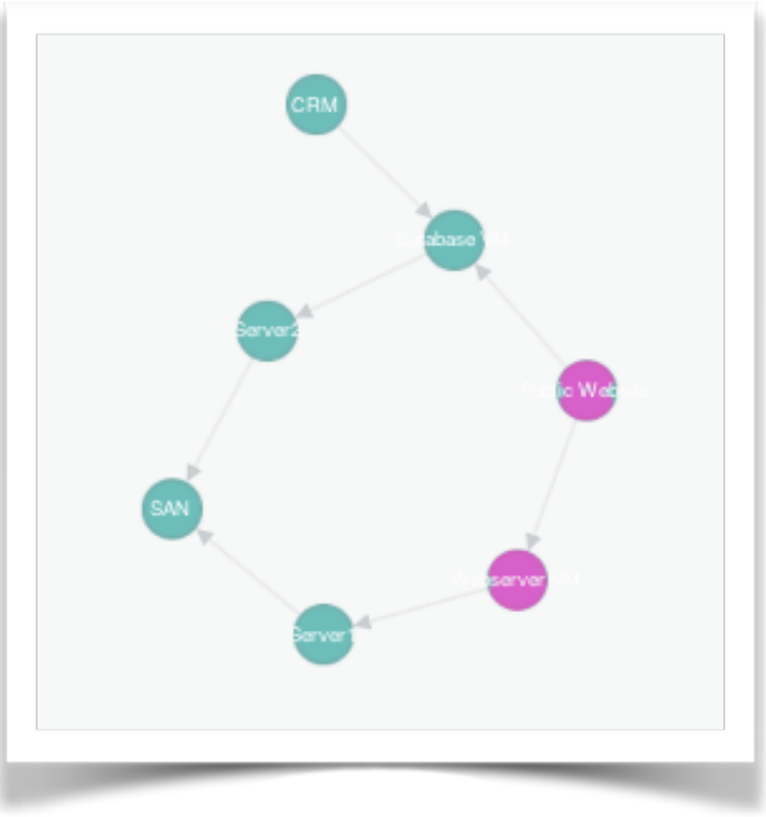
```
CREATE
    (crm {name:"CRM"}),
    (dbvm {name:"Database VM"}),
    (www {name:"Public Website"}),
    (wwwvm {name:"Webserver VM"}),
    (srv1 {name:"Server 1"}),
    (san {name:"SAN"}),
    (srv2 {name:"Server 2"}),

    (crm)-[:DEPENDS_ON]->(dbvm),
    (dbvm)-[:DEPENDS_ON]->(srv2),
    (srv2)-[:DEPENDS_ON]->(san),
    (www)-[:DEPENDS_ON]->(dbvm),
    (www)-[:DEPENDS_ON]->(wwwvm),
    (wwwvm)-[:DEPENDS_ON]->(srv1),
    (srv1)-[:DEPENDS_ON]->(san)
```



Practical Cypher

Network Management - Impact Analysis

```
// Server 1 Outage
MATCH (n)<-[:DEPENDS_ON*]-(upstream)
WHERE n.name = "Server 1"
RETURN upstream
```

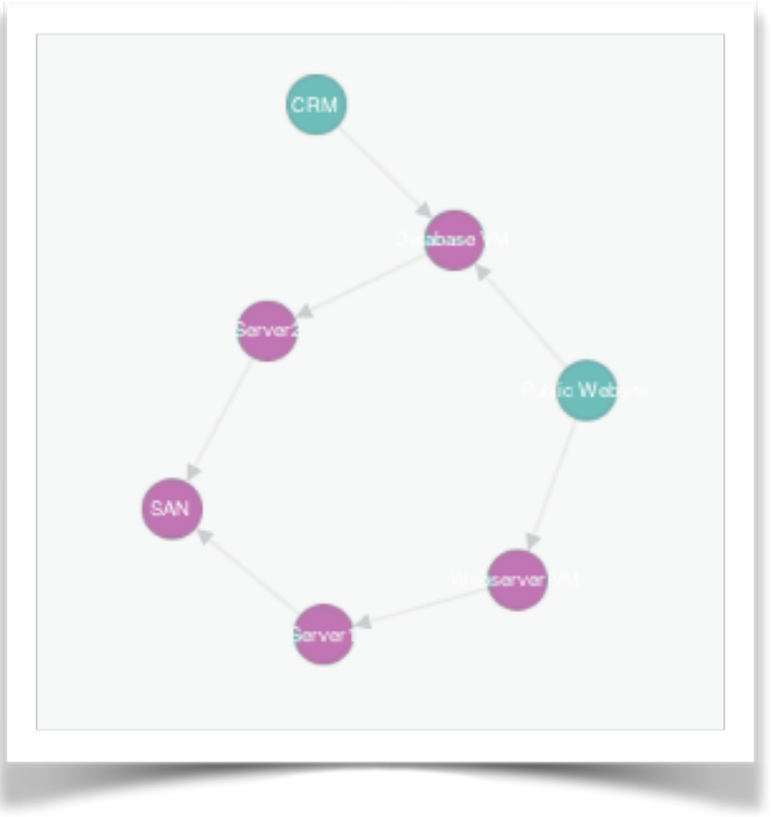


upstream
{name:"Webserver VM"}
{name:"Public Website"}

Practical Cypher

Network Management - Dependency Analysis

```
// Public website dependencies
MATCH (n)-[:DEPENDS_ON*]->(downstream)
WHERE n.name = "Public Website"
RETURN downstream
```



downstream
{name:"Database VM"}
{name:"Server 2"}
{name:"SAN"}
{name:"Webserver VM"}
{name:"Server 1"}

Practical Cypher

Network Management - Statistics

```
// Most depended on component
MATCH (n)<-[:DEPENDS_ON*]-(dependent)
RETURN n,
  count(DISTINCT dependent)
    AS dependents
ORDER BY dependents DESC
LIMIT 1
```

n	dependents
{name:"SAN"}	6

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More Graphs in the Real World

accenture *Industry: Logistics*
Use case: Parcel Routing

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Background

- One of the world's largest logistics carriers
- Projected to outgrow capacity of old system
- New parcel routing system
  - *Single source of truth for entire network*
  - *B2C & B2B parcel tracking*
  - *Real-time routing: up to 5M parcels per day*

Business problem

- 24x7 availability, year round
- Peak loads of 2500+ parcels per second
- Complex and diverse software stack
- Need predictable performance & linear scalability
- Daily changes to logistics network: route from any point, to any point

Solution & Benefits

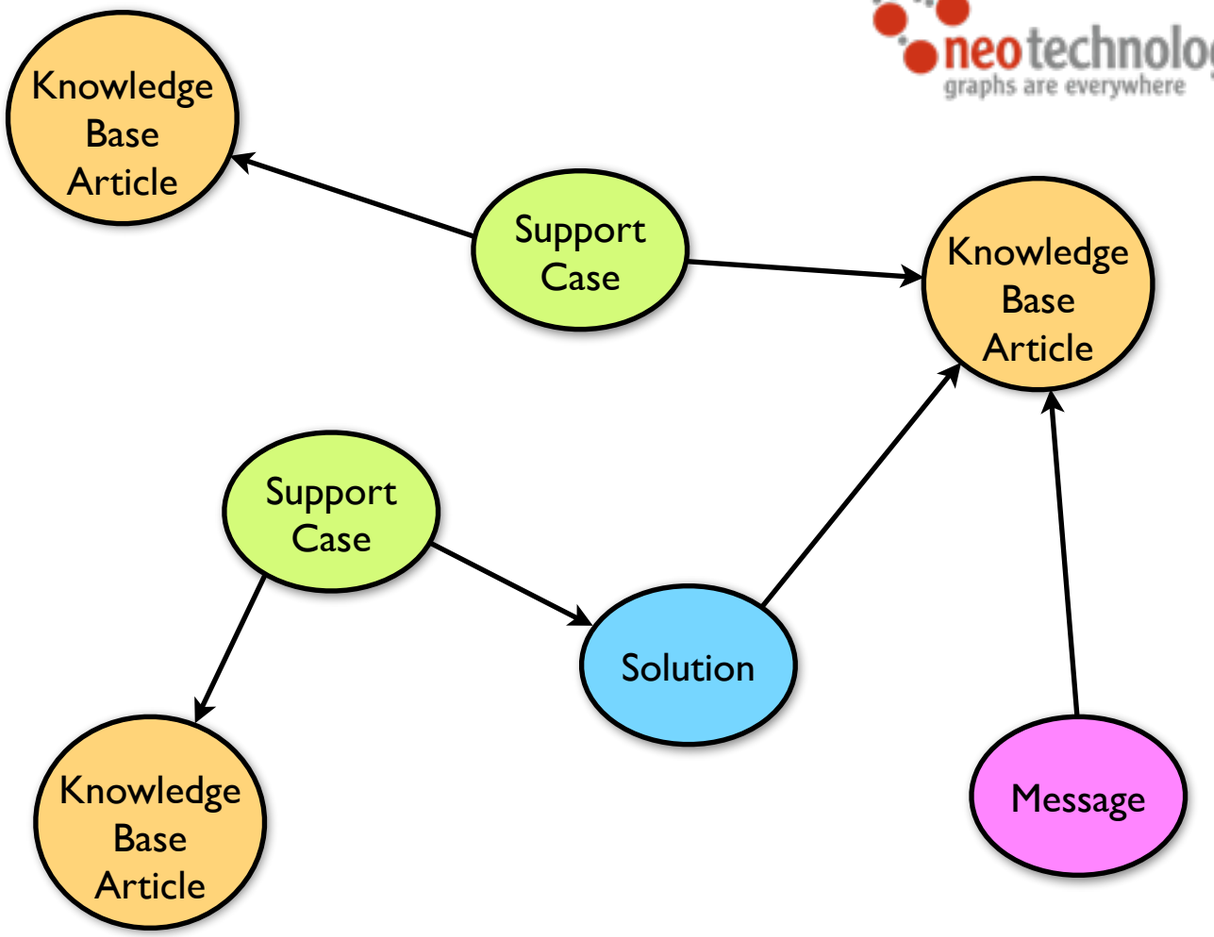
- Neo4j provides the ideal domain fit:
  - a logistics network is a graph
- Extreme availability & performance with Neo4j clustering
- Hugely simplified queries, vs. relational for complex routing
- Flexible data model can reflect real-world data variance much better than relational
- "Whiteboard friendly" model easy to understand

Industry: Communications
Use case: Recommendations
San Jose, CA

Cisco.com

Background

- Cisco.com serves customer and business customers with Support Services
- Needed real-time recommendations, to encourage use of online knowledge base
- Cisco had been successfully using Neo4j for its internal master data management solution.
  - *Identified a strong fit for online recommendations*



Business problem

- Call center volumes needed to be lowered by improving the efficacy of online self service
- Leverage large amounts of knowledge stored in service cases, solutions, articles, forums, etc.
- Problem resolution times, as well as support costs, needed to be lowered

Solution & Benefits

- Cases, solutions, articles, etc. continuously scraped for cross-reference links, and represented in Neo4j
- Real-time reading recommendations via Neo4j
- Neo4j Enterprise with HA cluster
- The result: customers obtain help faster, with decreased reliance on customer support

Deutsche Telekom

Industry: Communications
Use case: Social gaming
Frankfurt, Germany

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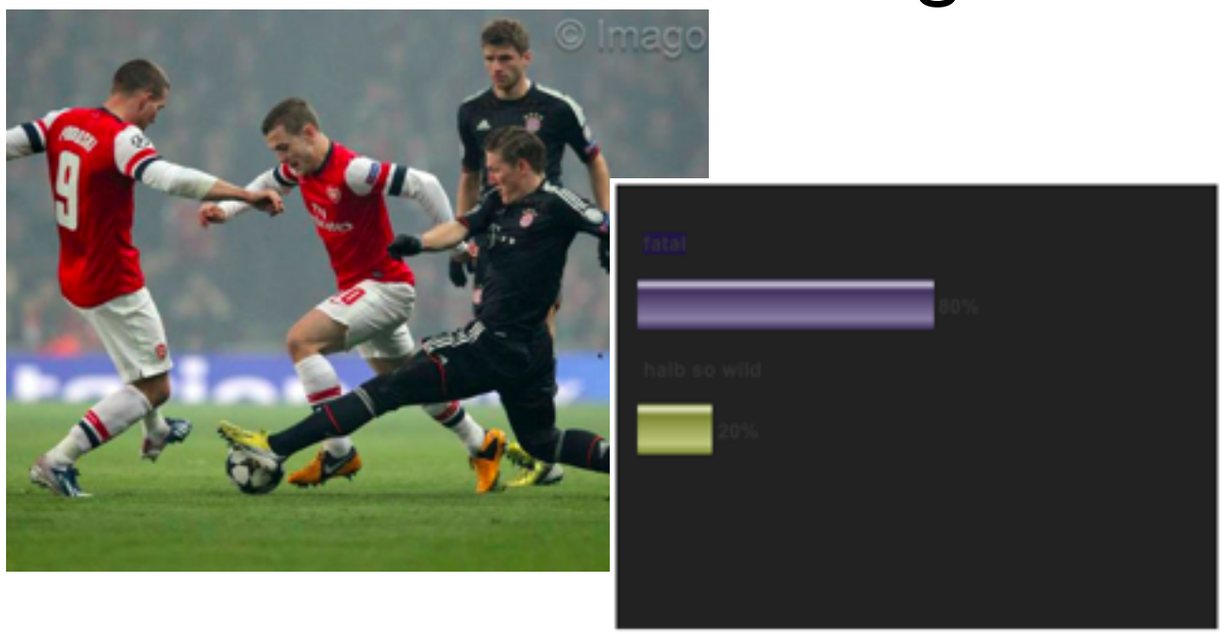
Background

- Europe's largest communications company
- Provider of mobile & land telephone lines to consumers and businesses, as well as internet services, television, and other services

> 236,000	50	> 58 bn. €
Employees worldwide in 2011	Countries	Revenue in 2011

Interactive Television Programming



Business problem

- The Fanorakel application allows fans to have an interactive experience while watching sports
- Fans can vote for referee decisions and interact with other fans watching the game
- Highly connected dataset with real-time updates
- Queries need to be served real-time on rapidly changing data
- One technical challenge is to handle the very high spikes of activity during popular games

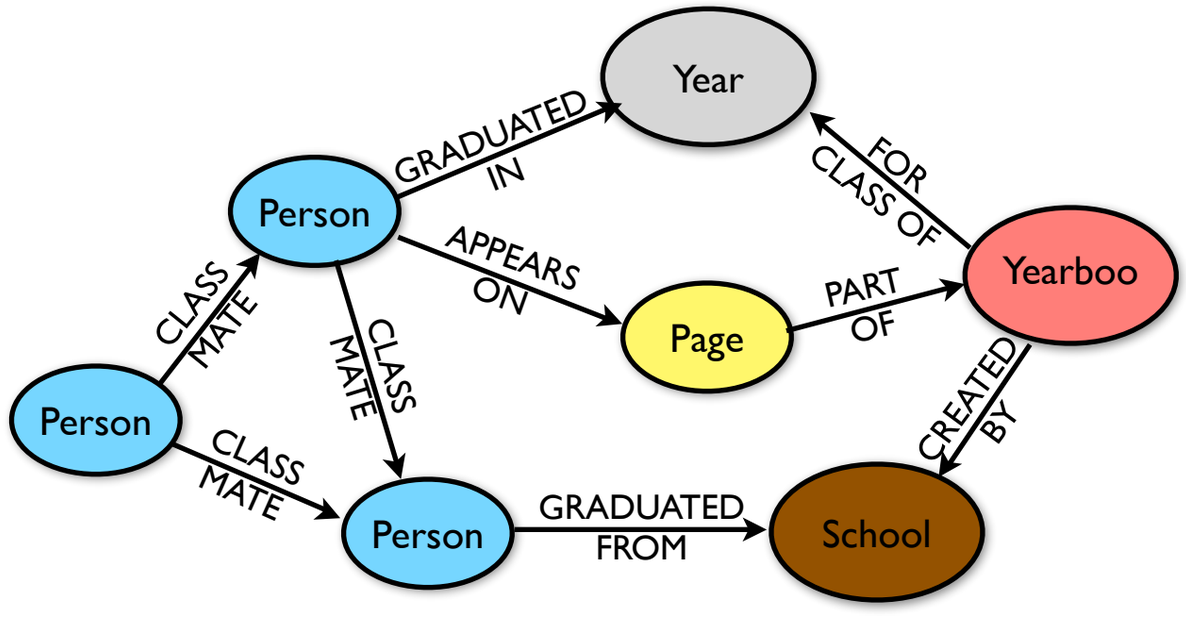
Solution & Benefits

- Interactive, social offering gives fans a way to experience the game more closely
- Increased customer stickiness for Deutsche Telekom
- A completely new channel for reaching customers with information, promotions, and ads
- Clear competitive advantage

Industry: Social Network
Use case: Social / Recommendations
Seattle, WA

Background

- Memory Lane, Inc. was founded in 1995 and based in Seattle, Washington. Subsidiary of United Online, Inc.
- Classmates.com, operates an online yearbook that connects members in the United States and Canada with friends and acquaintances from school, work, and the military.
- Evolving toward more sophisticated social networking capability



Business problem

- Develop new Social capabilities to help monetize Yearbook-related offerings
  - Show me all the people I know in a yearbook
  - Show me yearbooks my friends appear in most often (i.e. "Top yearbooks to look at")
  - Show me sections of a yearbook that your friends appear most in (i.e. "8 of your friends are on page 12 with the football team)
  - Show me other high schools that my friends went to (i.e. friends you made in other schools)

Solution & Benefits

- 3-Instance Neo4j Cluster with Cache Sharding + Disaster-Recovery Cluster
- Neo4j provides18 ms response time for the top 4 queries
- Initial graph size:100M nodes and 600M relationships
  - People, Images, Schools, Yearbooks, Yearbook Pages
- Projected to grow to 1B nodes & 6B relationships

teachscape

Industry: Education
Use case: Resource Authorization & Access Control
San Francisco, CA

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Background

- Teachscape, Inc. develops online learning tools for K-12 teachers, school principals, and other instructional leaders.
- Teachscape evaluated relational as an option, considering MySQL and Oracle.
- Neo4j was selected because the graph data model provides a more natural fit for managing organizational hierarchy and access to assets.

Business problem

- Neo4j was selected to be at the heart of a new architecture.
- The user management system, centered around Neo4j, will be used to support single sign-on, user management, contract management, and end-user access to their subscription entitlements.

Solution & Benefits

- Domain and technology fit
  - simple domain model where the relationships are relatively complex. Secondary factors included support for transactions, strong Java support, and well-implemented Lucene indexing integration
- Speed and Flexibility
  - The business depends on being able to do complex walks quickly and efficiently. This was a major factor in the decision to use Neo4j.
- Ease of Use
  - accommodate efficient access for home-grown and commercial off-the-shelf applications, as well as ad-hoc use.
  - Extreme availability & performance with Neo4j clustering
  - Hugely simplified queries, vs. relational for complex routing
  - Flexible data model can reflect real-world data variance much better than relational
  - “Whiteboard friendly” model easy to understand

Industry: Online Job Search
Use case: Social, Mobile
Cambridge, Massachusetts

Background

- Own several job search properties, including Internships.com, TweetMyJobs, and CareerBeam
- CareerArc Group ecosystem now serves 30 million annual visitors, 40,000 companies (including more than 50% of the Fortune 100), and over 350 universities

Business problem

- Launching new application: "Who do you know on Facebook"
- Existing SQL Server application difficult to develop against, and slowing down as user volumes increased
- Looking for a solution that could easily manage a large amount of interrelated data

Solution & Benefits

- Neo4j's was a natural fit for the social graph underlying CareerArcGroup's professional social network
- Significantly accelerated R&D, overcoming the agility problems the team had been facing
- Strong, reliable performance on EC2, running reliably inside of existing EC2 architecture
- Initial go-live included 10 million nodes, 30 million relationships and 235 million properties

maaii™
Let's connect

Industry: Communications
Use case: Social, Mobile
Hong Kong

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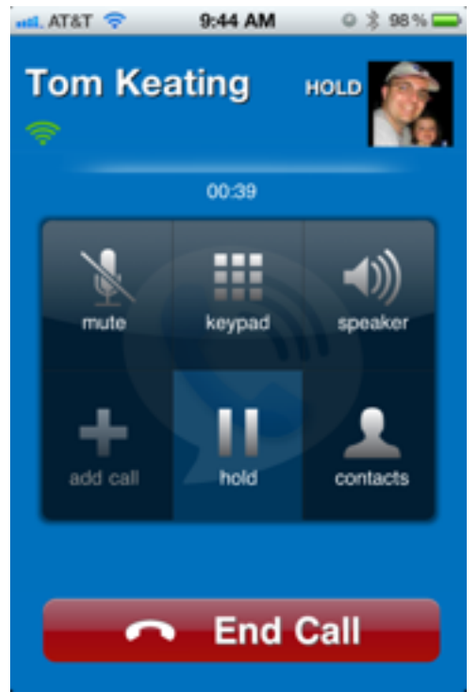
Background

- Hong Kong based telephony infrastructure provider (aka M800 aka Pop Media)
- Exclusive China Mobile partner for international toll-free services. SMS Hub & other offerings
- 2012 Red Herring Top 100 Global Winner



Business problem

- Launched a new mobile communication app "Maaii" allowing consumers to communicate by voice & text (Similar to Line, Viber, Rebtel, VoxOx...)
- Needed to store & relate devices, users, and contacts
- Import phone numbers from users' address books. Rapidly serve up contacts from central database to the mobile app
- Currently around 3M users w/200M nodes in the graph

Solution & Benefits

- Quick transactional performance for key operations:
  - friend suggestions ("friend of friend")
  - updating contacts, blocking calls, etc.
  - etc.
- High availability telephony app uses Neo4j clustering
- Strong architecture fit: Scala w/Neo4j embedded

onefinestay

Industry: Hospitality
Use case: Social Mobile
London, England

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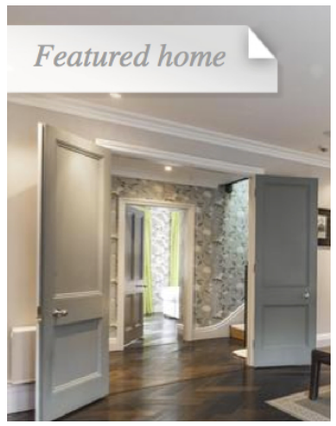
Background

- London-based 'A-list' home listing & booking
- Web & mobile app w/visible floor plans
- Luxury benefits & home convenience in international cities (NYC, London) 24/7 phone services, suggested eateries/events/hot spots
- Travel agency partners
- 2010 had 6 apts - 2012, = 700 & growing
- Bloomberg Business "Like living in a catalog"



Business problem

- Needed to serve up structure & floor plan details, and related spatial uses: "where's linen?"
- Relational database couldn't unlock the power of data & balance features with support a
- Needed complex structural data modeling with speed, accuracy and flexibility
- Serving thousands of listings & rapidly growing

Solution & Benefits

- 6-week implementation, integrated w/framework
- optimized workflow w/user interface = easy entry
- adds operation speed/efficiency, saves time/money
- scales easily, supports growth, strong community
- Best NoSQL alternative, w/Neo4j query performance & admin interface

Curaspan HEALTH GROUP

Industry: Health Care
Use case: Recommedatations
Newton, Massachusetts

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Background

- Founded in 1999. Widely considered the industry leader in patient management for discharges & referrals
- Manage patient referrals for more than 4600 health care facilities
- Connects providers, payers and suppliers via secure electronic patient-transition networks, and web-based patient management platform

Business problem

- Satisfy complex "Graph Search" queries by discharge nurses and intake coordinators, e.g.: *"Find a skilled nursing facility within n miles of a given location, belonging to health care group XYZ, offering speech therapy and cardiac care, and optionally Italian language services"*
- Real-time Oracle performance not satisfactory
- New functionality called for more complexity, including granular role-based access control

Solution & Benefits

- Fast real-time performance needs now satisfied
- Queries span multiple hierarchies, including provider graph & employee permissions graph
- Graph data model provided a strong basis for adding more dimensions to the data, such as insurance networks, service areas, and ACOs (Accountable Care Organizations)
- Some multi-page SQL statements have been turned into one simple function with Neo4j

GoodStart™ Genetics

Industry: Health Care
Use case: Bioinformatics
Cambridge, Massachusetts

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Background

- Clinical diagnostics company specializing in genetic carrier screening for inherited diseases
- Founded in 2008 by Harvard Business School & Harvard Medical School graduates
- Two sides of the business: Clinical and R&D
- Particularly strong in the detection of rare alleles and measuring frequency in the population

Business problem

- Clinical data split across several operational databases that are not structured for discovery
- Needed an easy query mechanism for scientists who are not data scientists. "Graph search" for bioinformatics.
- Much in Bioinformatics remains unknown: having to specifying a schema ahead of time can range from difficult to impossible.

Solution & Benefits

- New R&D database build atop Neo4j to support information discovery by scientists
- Lightweight web front end allows simple Cypher queries to be constructed ad hoc
- Raw VCF sequence data imported into Neo4j, along with clinical data from Oracle database
- Time to answer new questions went from days of ad-hoc information gathering to hours or minutes

Gartner's "5 Graphs"

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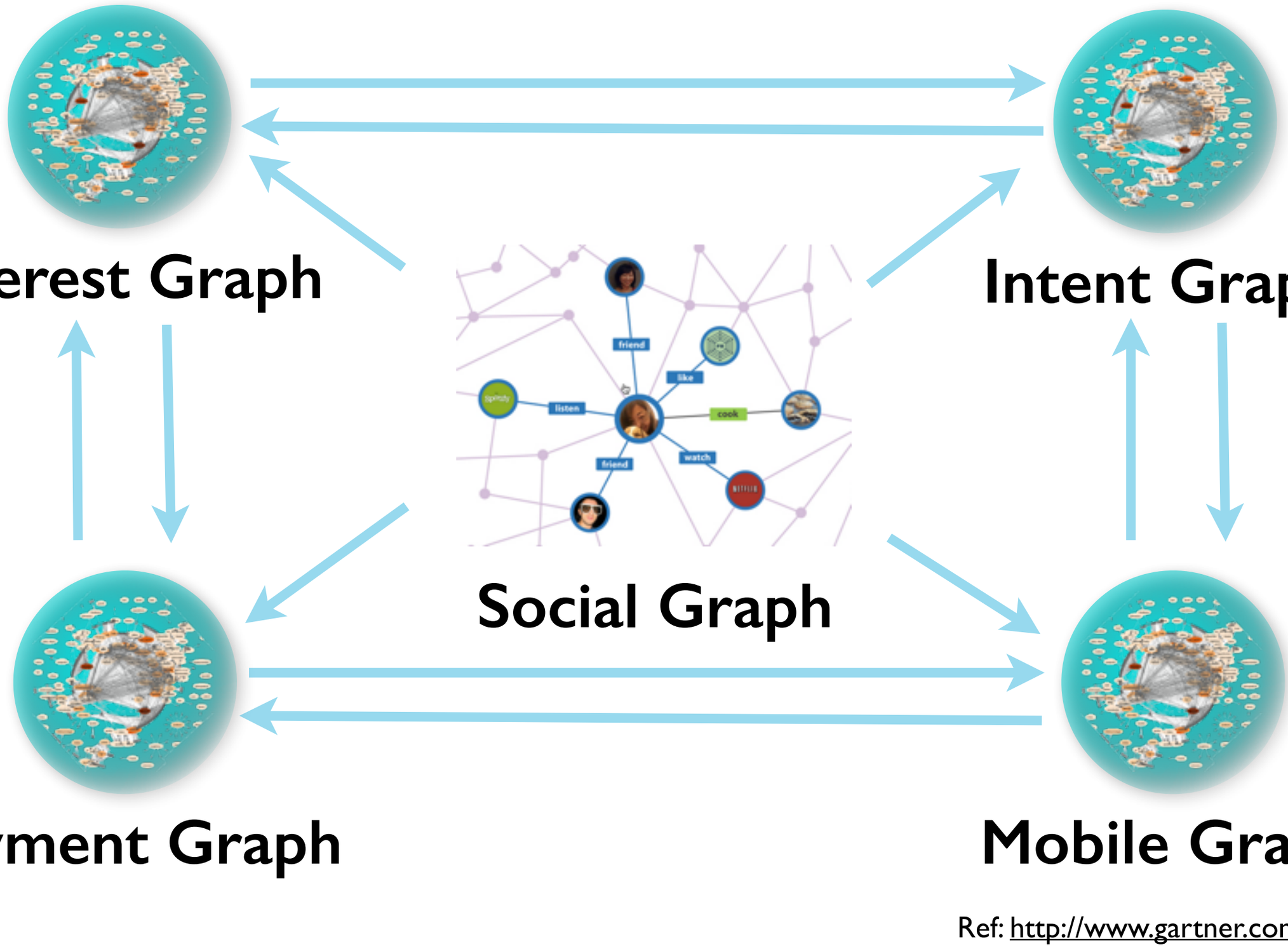
Consumer Web Giants Depends on Five Graphs



Ref: http://www.gartner.com/id=2081316

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Questions ?