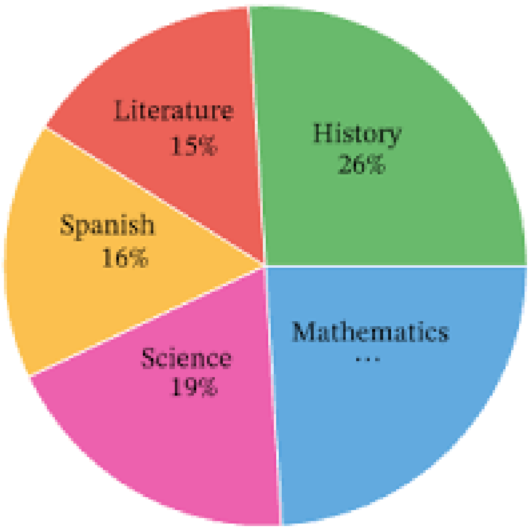
Mahidol University
Wisdom of the Land

BIG DATA PROCESSING

Graph Network

What is Graph

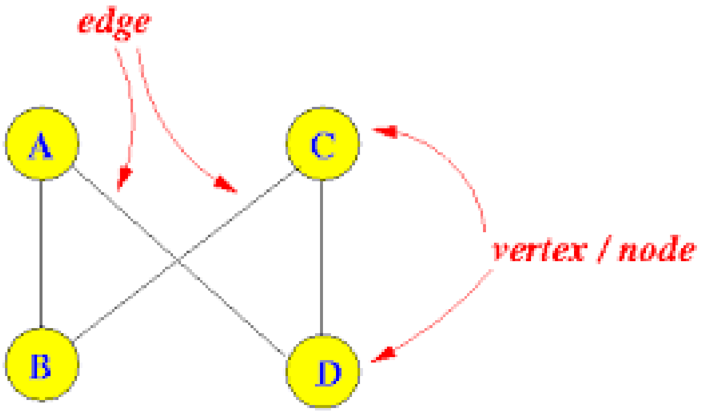
- Graph is not a chart!!



- Graph
  - Vertices
  - Edges

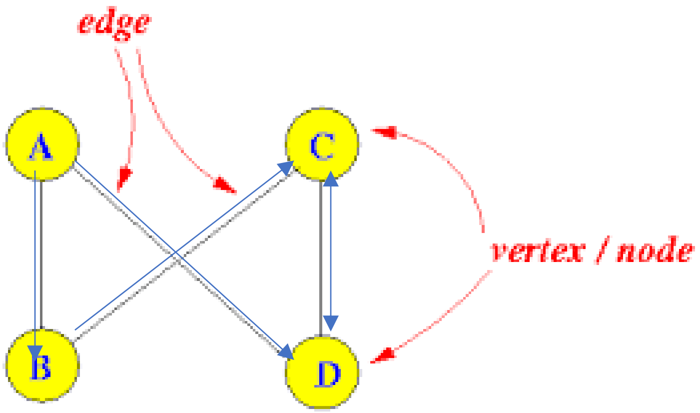
V={A,B,C,D}

E={(A,D),(A,B),(C,D),(C,B)}



Data structure operation

- Add edge
- Add vertex
- Get neighbor (and etc)



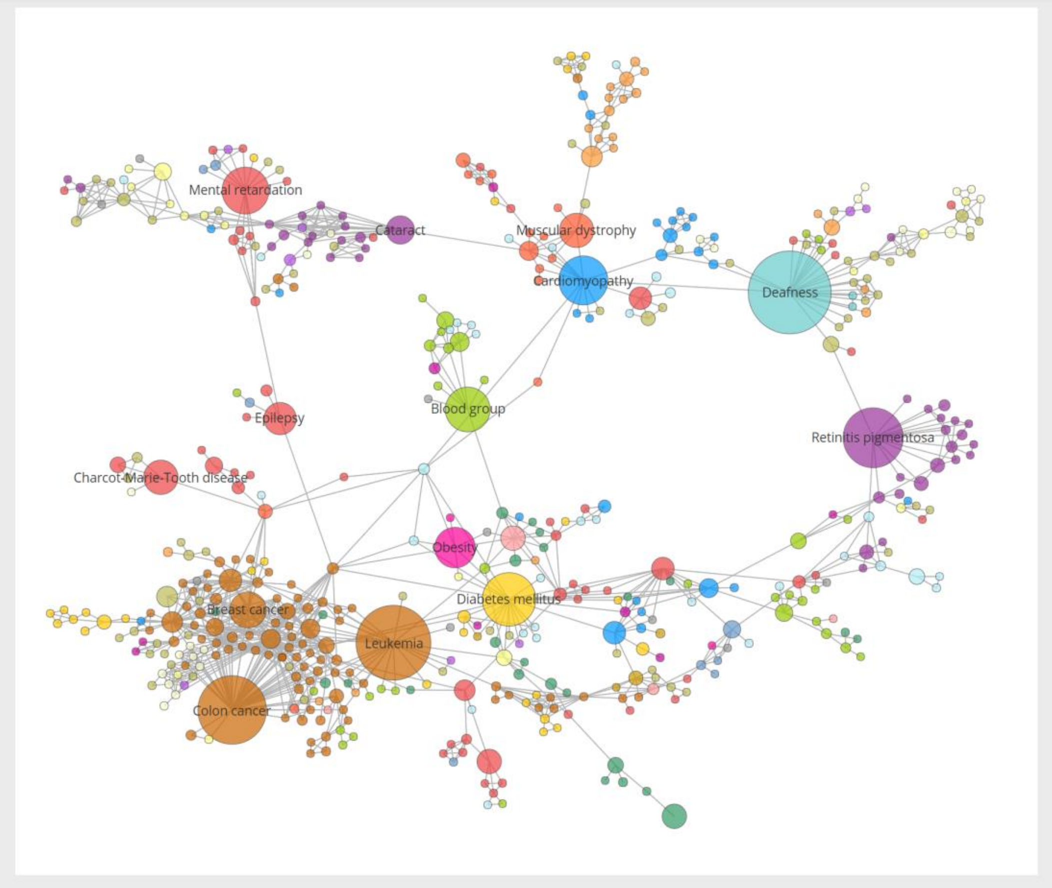
	A	B	C	D
A	0	1	0	1
B	0	0	1	0
C	0	0	0	1
D	0	0	1	0

Real World graph problem

- Social Media
  - Vertext/ Node : User
  - Edges: Tweet/post
  - Benefits
    - What are the interactions?
    - Who is the influencer?
    - Does it show violent behaviour?
    - Is this person addicted to onlin social media?

Real World graph problem 2

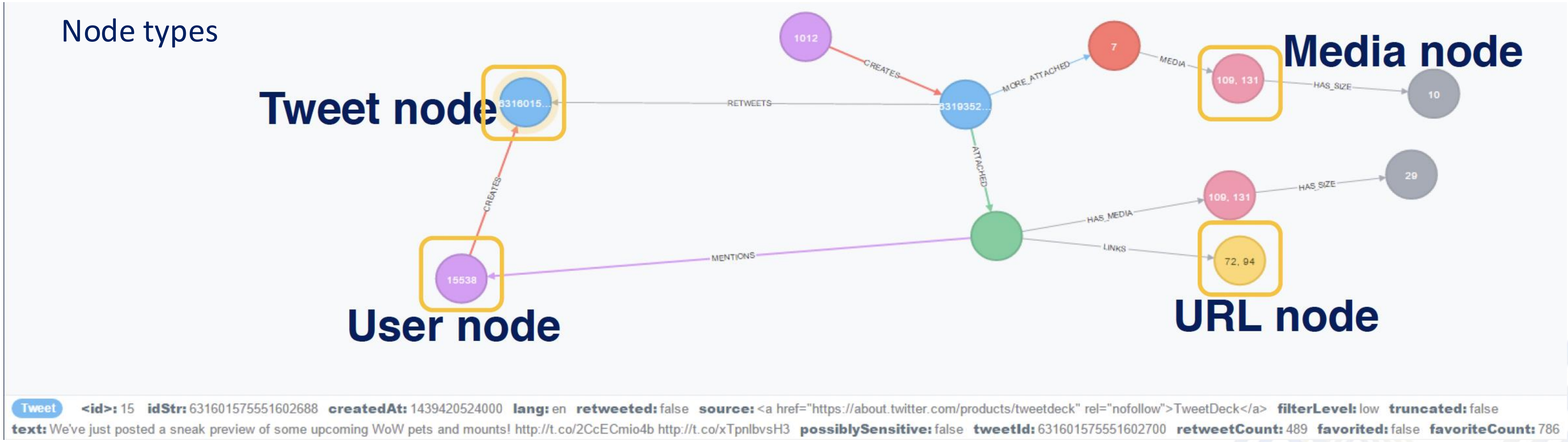
- Biology Network
    - Gene-Protein relationship
    - Gene-gene interaction
    - cell-cell signaling
    - Genen-disease relationship
    - Human knowledges
- Discovery unknow connection
    - Gene → 1 disease



Real World graph problem3

- Human Connection
  - Connection connectivity
  - Example of information can be added
    - LinkIn
    - Telephone network
    - using Calendar Event
    - Business transaction
    - GPS signals
  - Benefits
    - Influencer analysis
    - Match making (job,interest, so on)
    - Thread detection

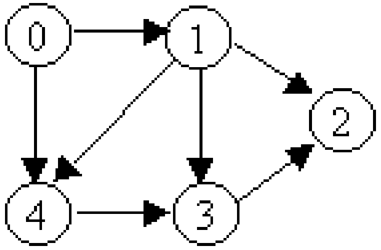
Graph Analytics



V: a set of vertices
E: a set of edges
TN: a set of node types
f (TN-> V): type assignment to nodes

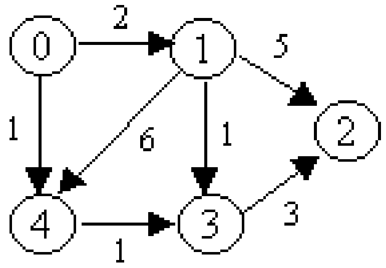
Weight

- Edge Property
  - Distance



$$A = \begin{bmatrix} 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

  - Strenght of connection



$$A = \begin{bmatrix} \infty & 2 & \infty & \infty & 1 \\ \infty & \infty & 5 & 1 & 6 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & 3 & \infty & \infty \\ \infty & \infty & \infty & 1 & \infty \end{bmatrix}$$

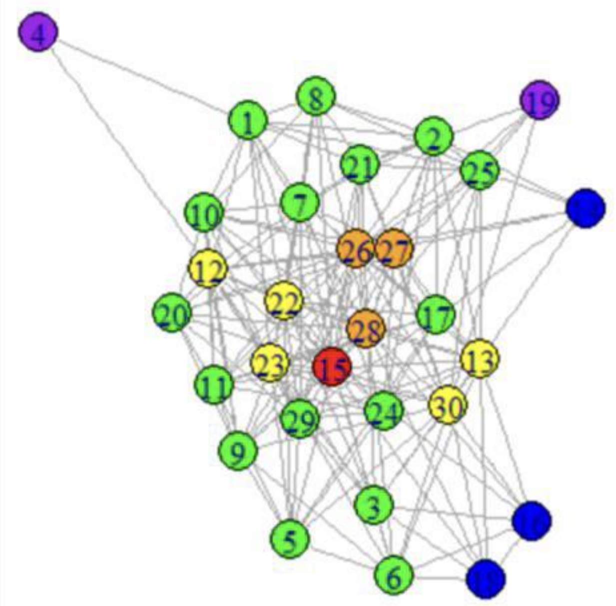
  - Likelihood of interaction (Biology)
  - Certainty of information (knowledge network)

Degre Centrality

- Count of the number of edges **incident,** normalized by the possible number of edges

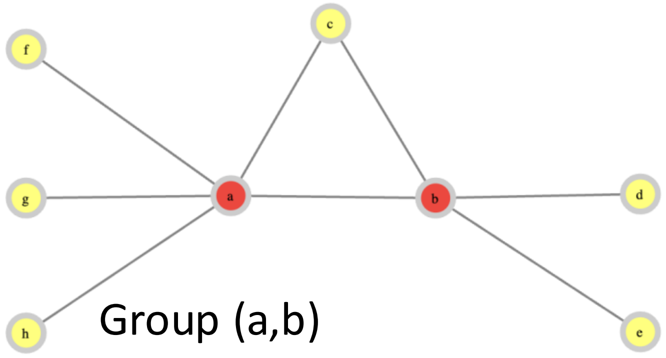
$$(\#\ of\ edges)/(N{-}1)$$

- “hub” (maximally-connected) nodes



Group Degre Centrality

- Consider a group as a single entity



Group (a,b)
group degree centrality=1

- Count of the number of edges incident within group, normalized by non group

$$\frac{\#edges\ in\ the\ group}{\#non-group}$$

Closeness Centrality

Average of shortest-path distances from all other nodes

- Low raw closeness means node has short distance from other nodes

For an information flow network

- Low closeness nodes receive information sooner than other nodes
- Same for other flows *if the flow happens through shortest paths*
- A low closeness can influence many others, directly and indirectly

Node	Shortest Path from A
B	1
C	2
D	3
E	4
F	5
G	5
H	4

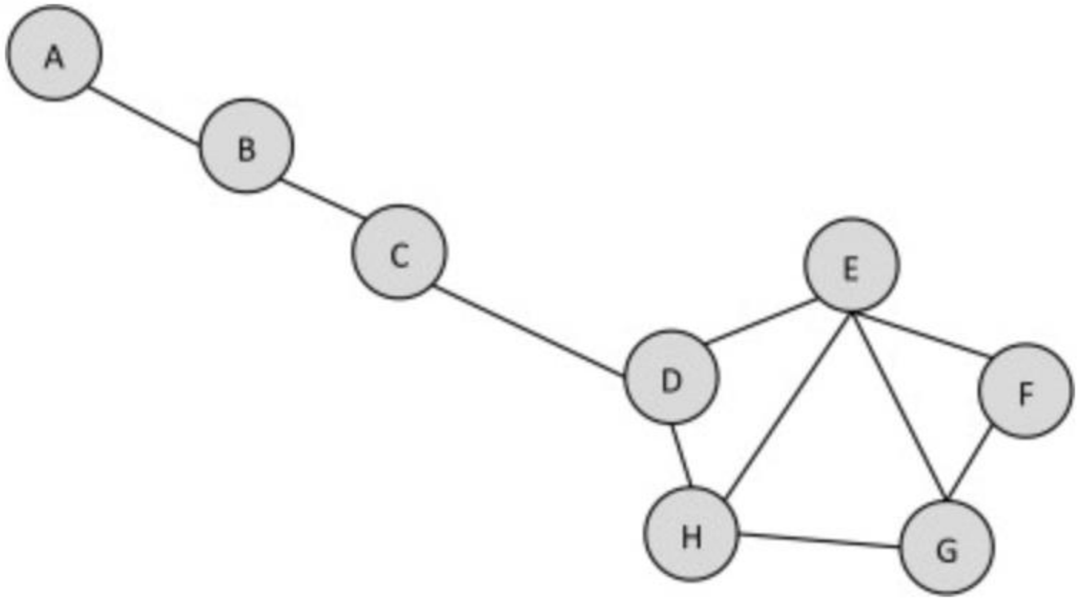
Here, the average shortest path length is:

$(1+2+3+4+5+5+4) \div 7 = 24 \div 7 = \mathbf{3.43}.$

Node	Shortest Path from D
A	3 (D–C–B–A)
B	2
C	1
E	1
F	2
G	2
H	1

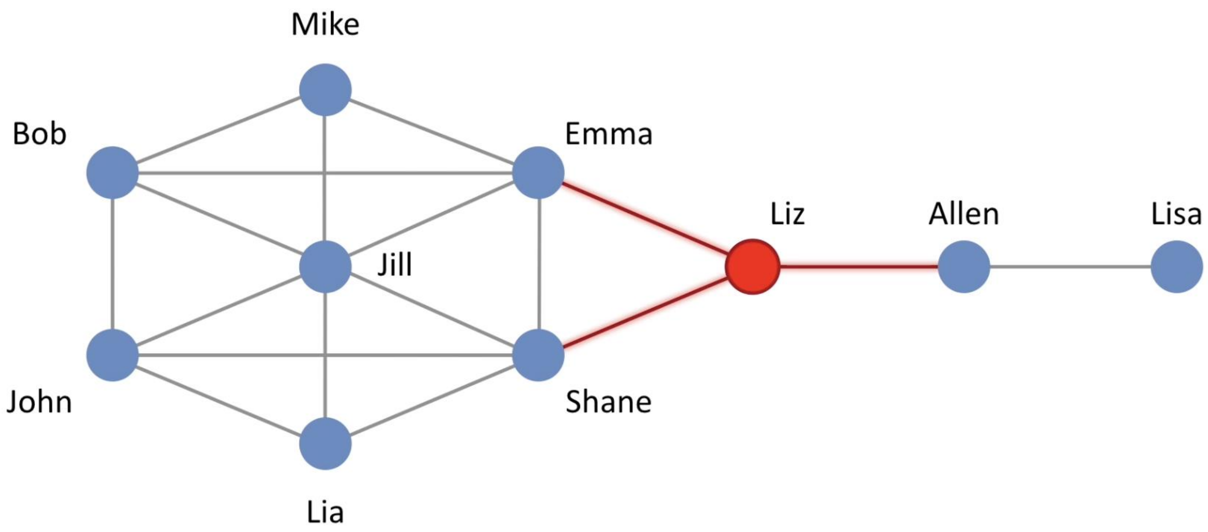
The average of those shortest path lengths is:

$(3+2+1+1+2+2+1) \div 7 = 12 \div 7 = \mathbf{1.71}.$



To inject a new piece of information into the network with the idea
that it should read every other node quickly

Betweenness Centrality



- Ratio of pairwise shortest path that pass through that node
- Measures fraction of shortest-path commodity flow passing through a node
- Junction path in the network
- high betweenness centrality is often **controllers** of power or information

Not suitable for

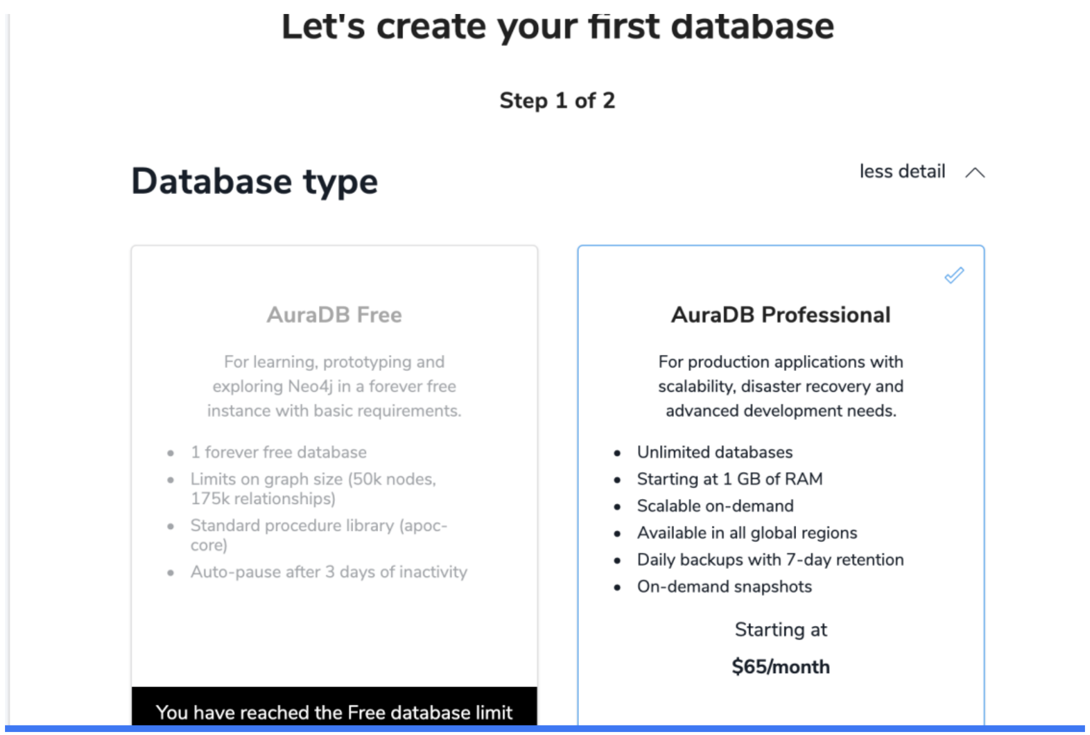
- Any quantity that does not flow in shortest path channels like **infection** or **rumor** on the internet doesn't work well with betweeness centrality.

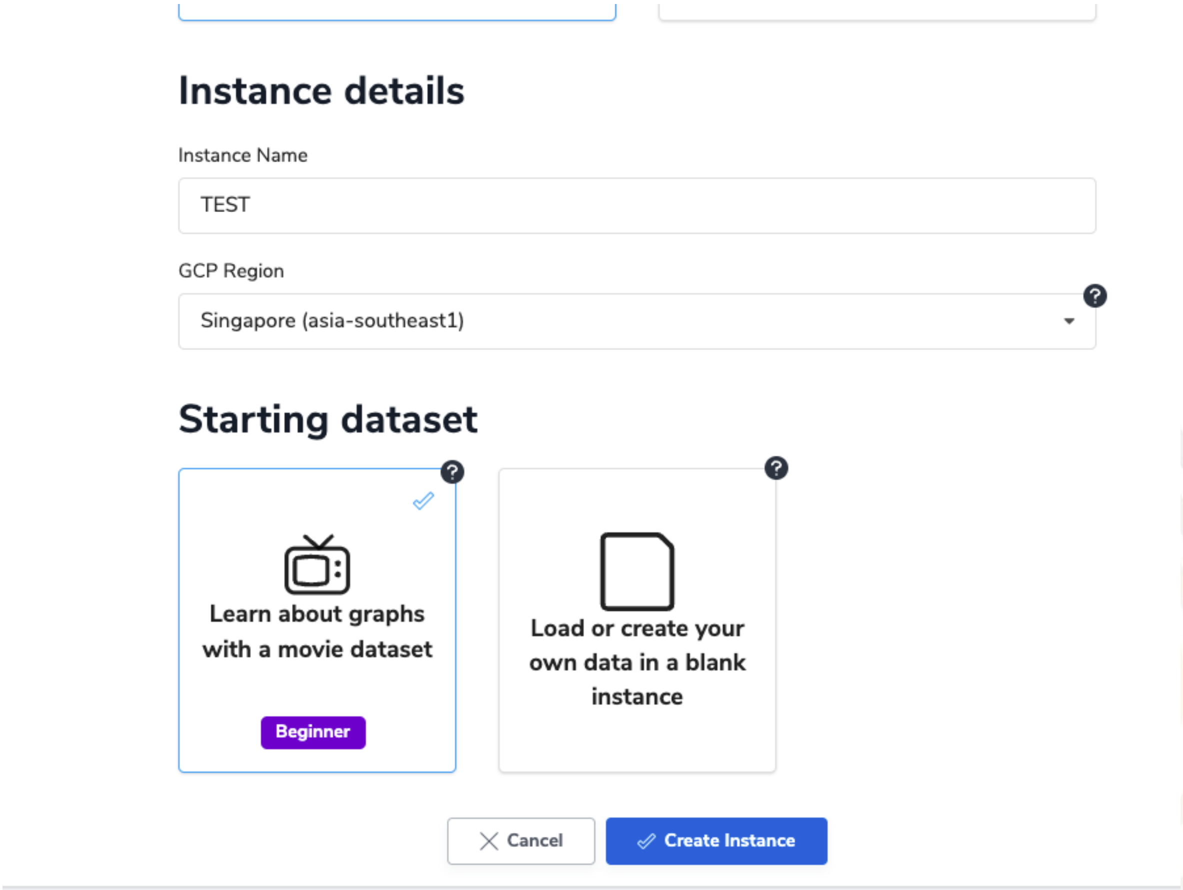
Community Analytics

- Static Analyses
  - What are the communities at time T?
  - Who belong to a community?
  - How closely knit is this community?
- Temporal/Evolution Analyses
  - How did this community form?
  - Which communities are stable?
  - Find strong *transient* communities – why did they form or dissolve?
- Predictive Analyses
  - Is this community likely to grow?
  - Will these nodes continue as a community in future?
  - Are dominant roles emerging in this community?

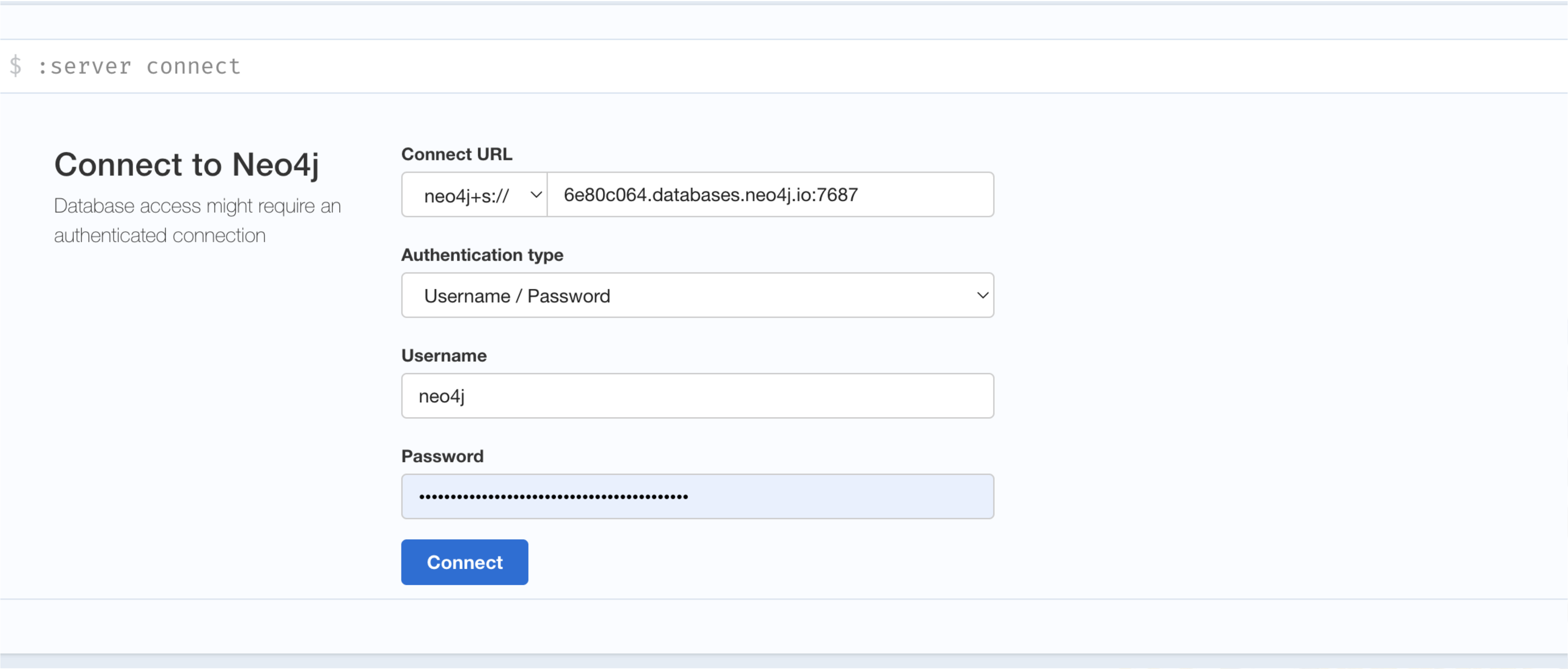
Neo4J

- **https://console.neo4j.io/#databases**





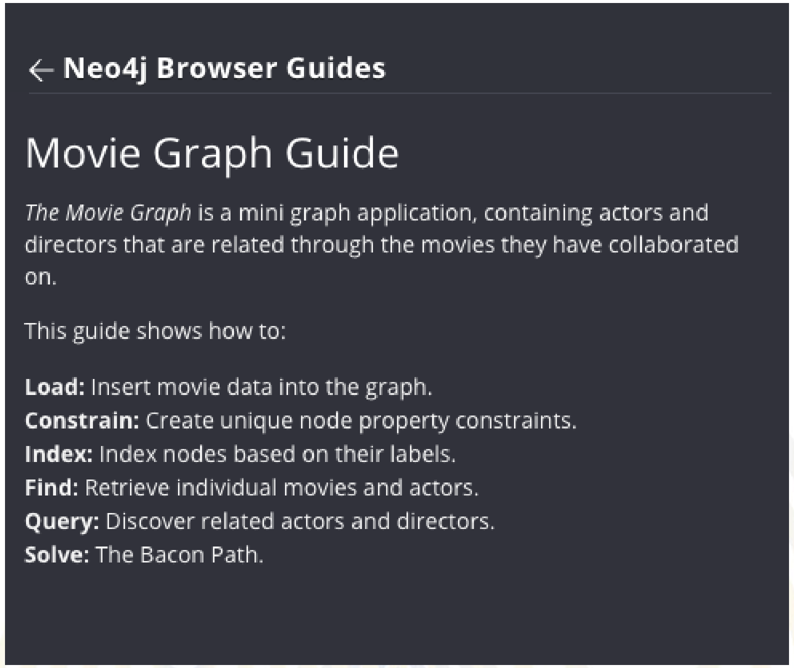
Database connection



Creating Nodes: Cypher

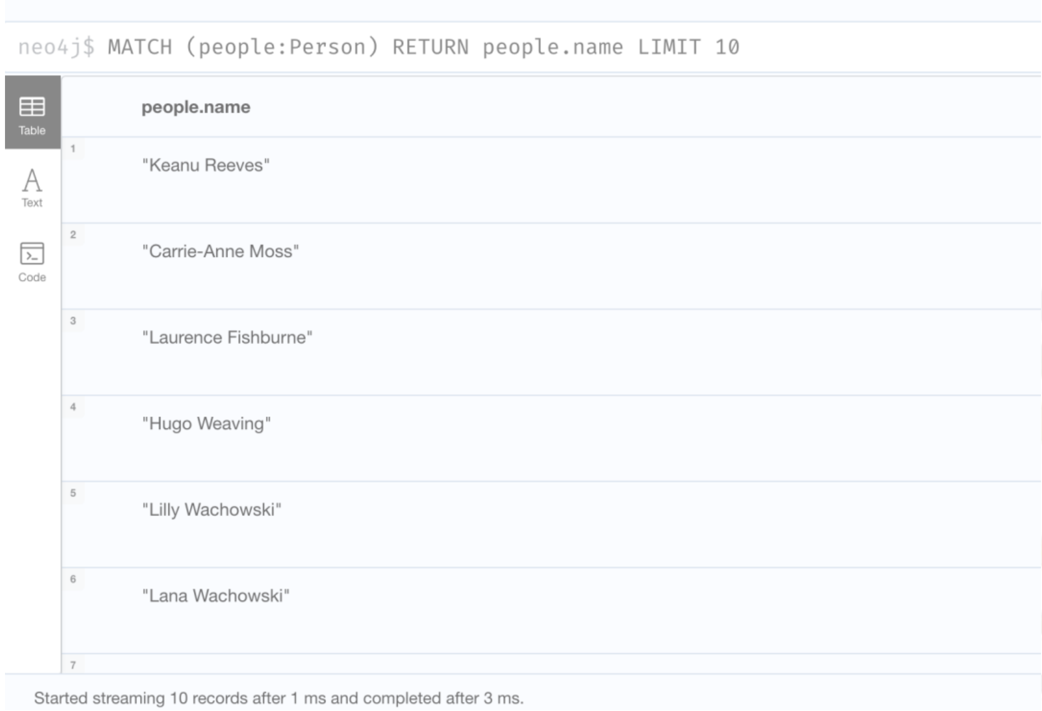
`:guide movie-graph`

- CREATE (TheMatrix:Movie {title:'The Matrix', released:1999, tagline:'Welcome to the Real World'})
- CREATE (Keanu:Person {name:'Keanu Reeves', born:1964})
- CREATE (Carrie:Person {name:'Carrie-Anne Moss', born:1967})
- CREATE (Keanu)-[:ACTED_IN {roles:['Neo']}]->(TheMatrixReloaded),
- (Carrie)-[:ACTED_IN {roles:['Trinity']}]->(TheMatrixReloaded),
- (Laurence)-[:ACTED_IN {roles:['Morpheus']}]->(TheMatrixReloaded),
- (Hugo)-[:ACTED_IN {roles:['Agent Smith']}]->(TheMatrixReloaded),
- (LillyW)-[:DIRECTED]->(TheMatrixReloaded),
- (LanaW)-[:DIRECTED]->(TheMatrixReloaded),



Query some data

- // Get some data
- MATCH (n1)-[r]->(n2) RETURN r, n1, n2 LIMIT 25
- MATCH (tom {name: "Tom Hanks"}) RETURN tom



Deleting

- **Delete all nodes and edges**
  - match (n)-[r]-() delete n, r
- **Delete all nodes which have no edges**
  - match (n) delete n
- **Delete all edges**
  - match (n)-[r]-() delete r
- **Delete only ToyRelation edges**
- match (n)-[r:ToyRelation]-() delete r

Simple Query

Counting the number of nodes

```
match (n:MyNode)
return count(n)
```

Counting the number of edges

```
match (n:MyNode)-[r]->()
return count(r)
```

Finding the types of a node:

```
match (n)
```

Finding root nodes:

```
match (m)-[r:TO]->(n:MyNode)
where not (()-->(m))
return m
```

Simple Query

Finding leaf nodes:

```
match (n:MyNode)-[r:TO]->(m)
where not ((m)-->())
return m
```

Finding triangles:

```
match (a)-[:TO]->(b)-[:TO]->(c)-[:TO]->(a)
return distinct a, b, c
```

Finding 2nd neighbors of D:

```
match (a)-[:TO*..2]-(b)
where a.Name='D'
return distinct a, b
where n.Name = 'Afghanistan'
return labels(n)
```

Analytics

- **Viewing the graph**
  - match (n:MyNode)-[r]->(m) return n, r, m
- **Finding paths between specific nodes*:**
  - match p=(a)-[:TO*]-(c) where a.Name='H' and c.Name='P’ return p limit 1
  - match p=(a)-[:TO*]-(c) where a.Name='H' and c.Name='P' return p order by length(p) asc limit 1
- **Finding the length between specific nodes:**
  - match p=(a)-[:TO*]-(c) where a.Name='H' and c.Name='P’ return length(p) limit 1

Analytics

- **Finding a shortest path between specific nodes:**
  - match p=shortestPath((a)-[:TO*]-(c)) where a.Name='A' and c.Name='P' return p, length(p) limit 1
- **All Shortest Paths:**
  - MATCH p = allShortestPaths((source)-[r:TO*]-(destination)) WHERE source.Name='A' AND destination.Name = 'P’ RETURN EXTRACT(n IN NODES(p)| n.Name) AS Paths
- **All Shortest Paths with Path Conditions:**
  - MATCH p = allShortestPaths((source)-[r:TO*]->(destination)) WHERE source.Name='A' AND destination.Name = 'P' AND LENGTH(NODES(p)) > 5 RETURN EXTRACT(n IN NODES(p)| n.Name) AS Paths,length(p)

Example

- match p=shortestPath((a:Person)-[:ACTED_IN*]-(c:Person)) where a.name='Hugo Weaving' and c.name='Keanu Reeves' return p, length(p)

Small data

- Experiment
- Import
- Check nodes/edges
- Shortest Path

Deleting networks

- MATCH (n) DETACH DELETE n
    - Deleted 178 nodes, deleted 259 relationships, completed after 70 ms.

Experiment

Create 5 Nodes & relationship

- create (N1:ToyNode {name: 'Tom'}) - [:ToyRelation {relationship: 'knows'}] -> (N2:ToyNode {name: 'Harry'}),
- (N2) - [:ToyRelation {relationship: 'co-worker'}] -> (N3:ToyNode {name: 'Julian', job: 'plumber'}),
- (N2) - [:ToyRelation {relationship: 'wife'}] -> (N4:ToyNode {name: 'Michele', job: 'accountant'}),
- (N1) - [:ToyRelation {relationship: 'wife'}] -> (N5:ToyNode {name: 'Josephine', job: 'manager'}),
- (N4) - [:ToyRelation {relationship: 'friend'}] -> (N5);

Querying

- **Five Nodes**
  - N1 = Tom, N2 = Harry,N3 = Julian,N4 = Michele,N5 = Josephine
- **Five Edges**
  - e1 = Harry ‘is known by’ Tom
  - e2 = Julian ‘is co-worker of’ Harry
  - e3 = Michele ‘is wife of’ Harry
  - e4 = Josephine ‘is wife of’ Tom
  - e5 = Josephine ‘is friend of’ Michele
- **View the resulting graph**
  - match (n:ToyNode)-[r]-(m) return n, r, m
- **Selecting an existing single ToyNode node**
  - match (n:ToyNode {name:'Julian'}) return n

Modifying nodes

Adding a Node Correctly

- match (n:ToyNode {name:'Julian'})
- merge (n)-[:ToyRelation {relationship: 'fiancee'}]->(m:ToyNode {name:'Joyce', job:'store clerk'})

Adding a Node Incorrectly

- create (n:ToyNode {name:'Julian'})-[:ToyRelation {relationship: 'fiancee'}]->(m:ToyNode {name:'Joyce', job:'store clerk'})

Modifying nodes

Correct your mistake by deleting the bad nodes and edge

- match (n:ToyNode {name:'Joyce'})-[r]-() delete n, r
- MATCH (n) WHERE size((n)--())=0 DELETE (n)

Modify a Node's Information

- match (n:ToyNode) where n.name = 'Harry' set n.job = 'drummer'
- match (n:ToyNode) where n.name = 'Harry' set n.job = n.job + ['lead guitarist']

Connecting to spark

- import org.neo4j.spark._
- import org.apache.spark.graphx._
- import org.apache.spark.graphx.lib._

To connect to the Neo4j database, we need to create Neo4j instance:

Spark-shell:

- val neo = **Neo4j**(sc)