# Large-Scale and Multi-Structured Databases

# *Graph Databases Introduction*

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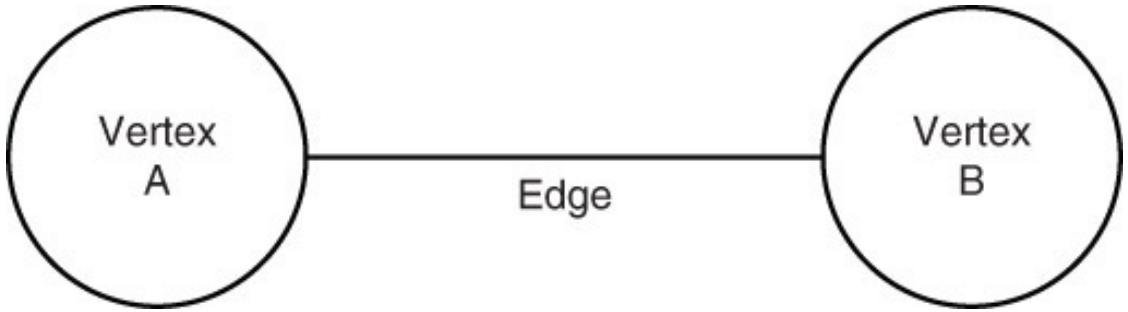
CROSSLAB Innovation for industry 4.0

# The Graph: Definition

In the image below, we show an example of a simple graph, namely a collection of Vertices and Edges.

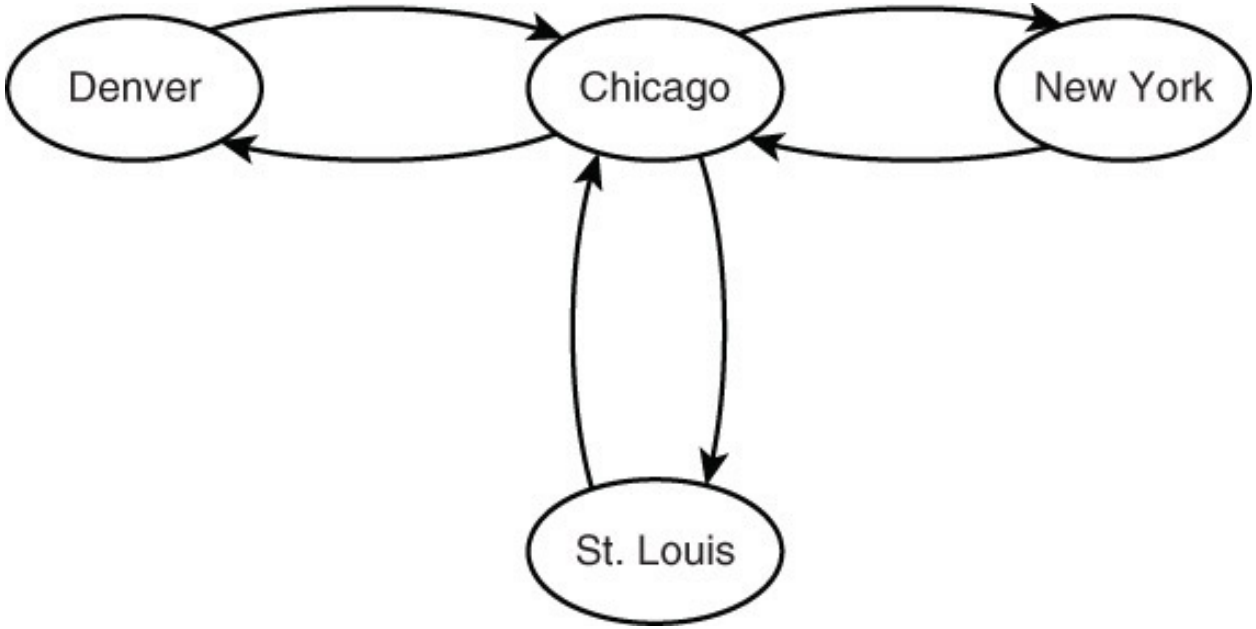



***Vertex***: specifies an entity. Usually, entities in a graph belongs to the same category.

***Edge***: specifies a relation between two vertices. Relations may be long terms or short terms.

Vertices and edges may have ***properties***.

# Graphs: Examples




Modeling Highways between Cities

# Modeling Highways between Cities

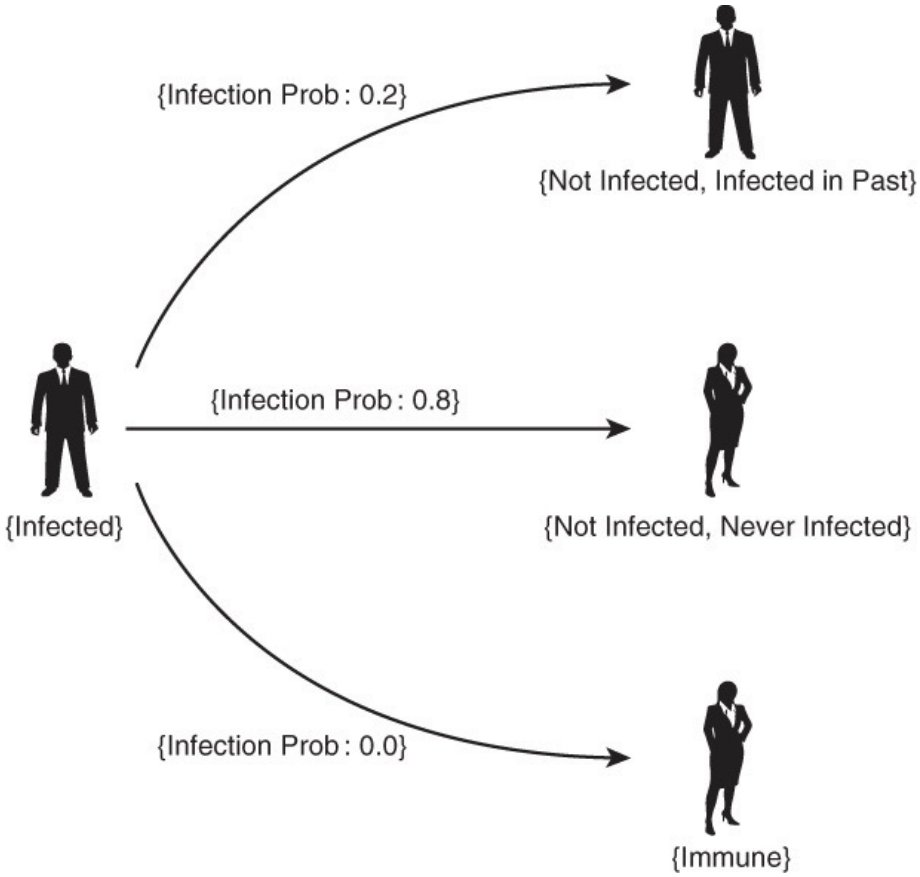
A highway could be a single edge between two cities, in which case it models the road traffic in both directions.

Alternatively, a graphical representation could use two edges, one to represent travel in each direction (for example, east to west and west to east).

**Issue:** Which is the "right way" to model highways?
**Answer:** It depends!

- ✓ If the goal is to model distance and approximate travel times between cities, then a single edge might be sufficient.
- ✓ If we are interested in more detailed descriptions of highways, such as direction, number of lanes, current construction areas, and locations of accidents, then using two edges is a better option

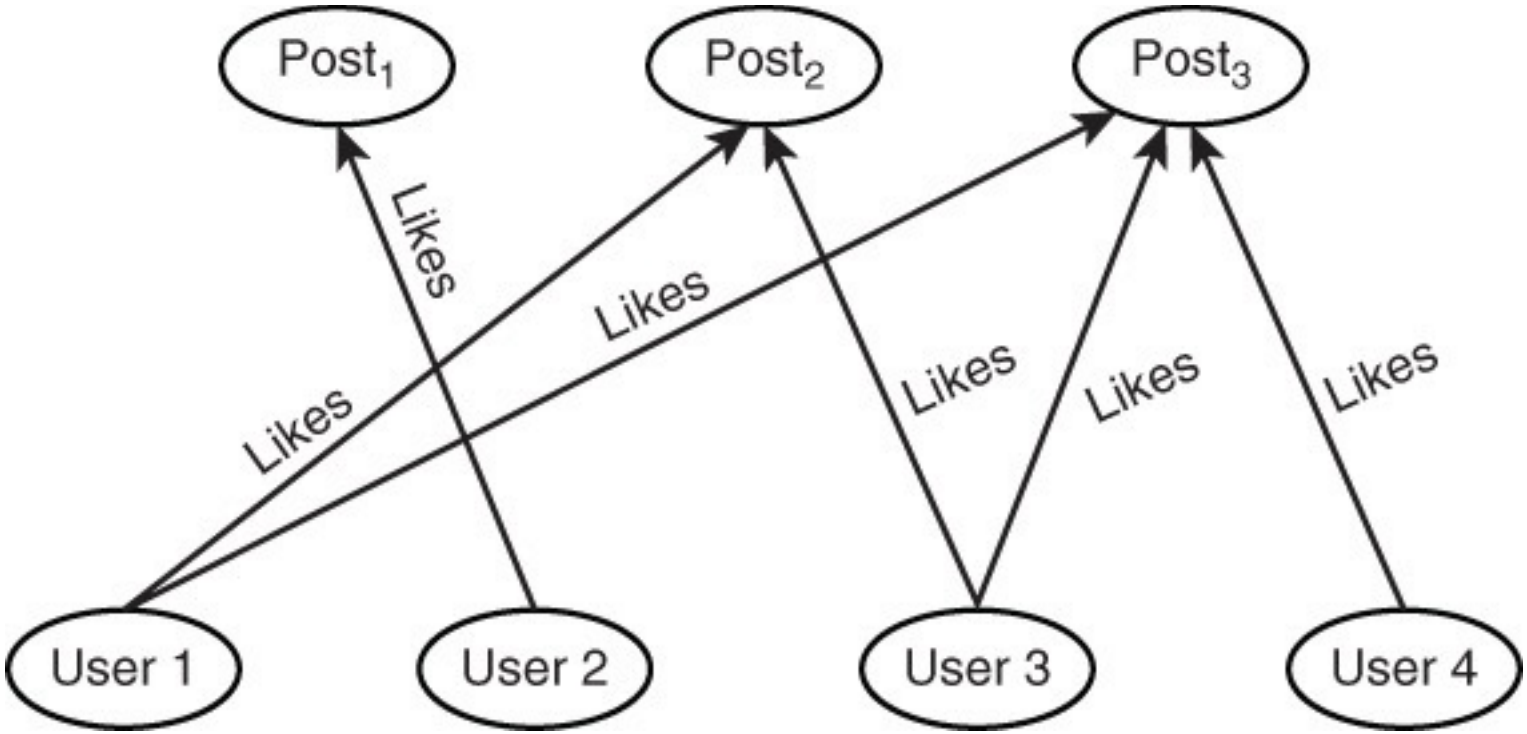
# Graphs: Examples




Watch the video:
https://www.youtube.com/watch?v=lJHcg5rRAJQ

Modeling Infectious Diseases

# Graphs: Examples




Modeling Social Media

# Graph Databases

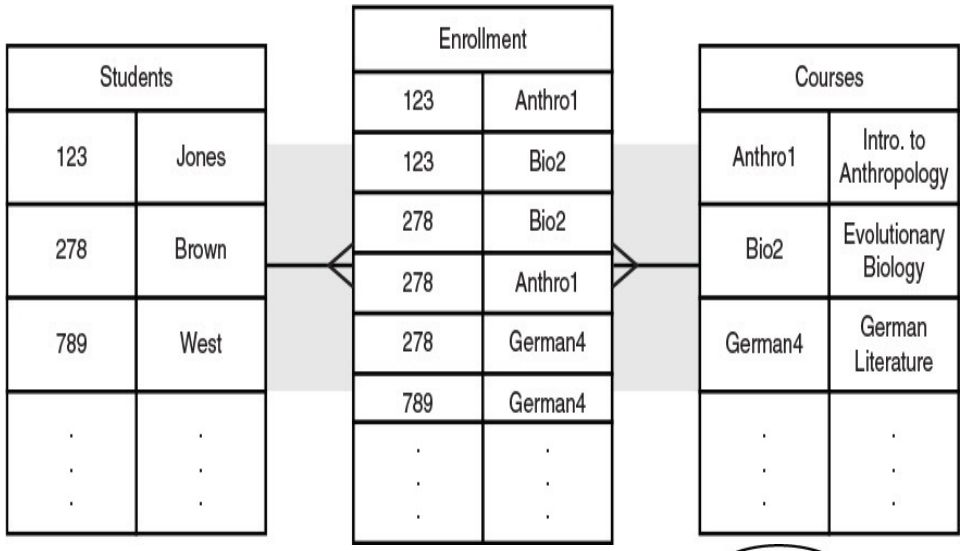
- Graph databases adopt vertices and edges to ***store*** explicit ***relations*** between ***entities***.

- In ***relational databases***, connections are not represented as links. Instead, two entities share a ***common attribute*** value, which is known as a ***key***.

- ***Join operations*** are used in relational databases to find connections or links.

- When dealing with huge amount of data (several tables with too much rows) join operation became ***computationally expensive.***

# Graph Databases vs Relational Databases



| Students | |
|---|---|
| 123 | Jones |
| 278 | Brown |
| 789 | West |

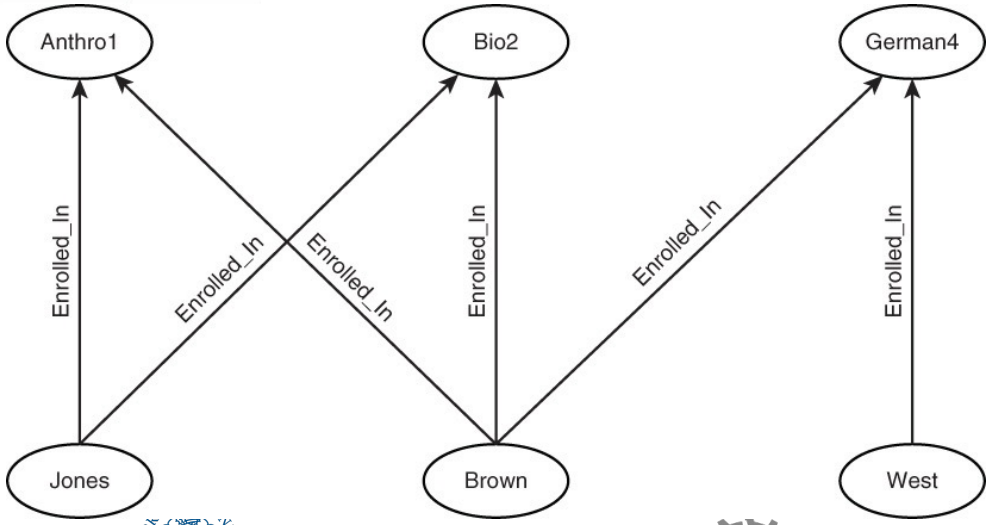
| Enrollment | |
|---|---|
| 123 | Anthro1 |
| 123 | Bio2 |
| 278 | Bio2 |
| 278 | Anthro1 |
| 278 | German4 |
| 789 | German4 |

| Courses | |
|---|---|
| Anthro1 | Intro. to Anthropology |
| Bio2 | Evolutionary Biology |
| German4 | German Literature |

***Example of query***: list all the course a particular student is enrolled in.

In relational models, we need a join procedure.

The edges between students and courses allow us to ***quickly*** query the databases.



# Many-to-Many Relations

Graph databases allows to modeling ***many-to-many relations*** in a easier way than relational databases.

People

| | |
|---|---|
| U1 | User1 |
| U2 | User2 |
| U3 | User3 |
| . | . |
| . | . |
| . | . |
| . | . |
| UN | UserN |

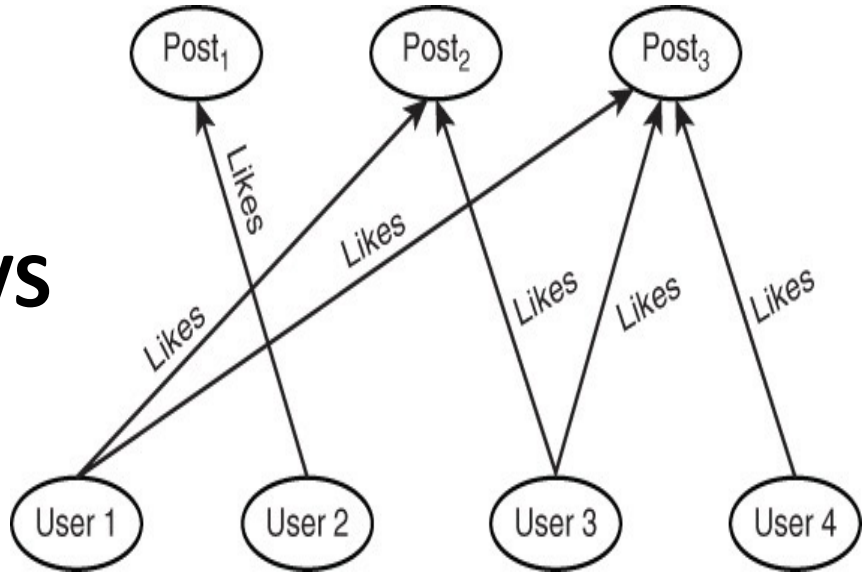
Likes

| | |
|---|---|
| U1 | P1 |
| U1 | P2 |
| U1 | P3 |
| U2 | P3 |
| U3 | PN |
| U3 | P2 |
| UN | P1 |
| UN | P2 |

Posts

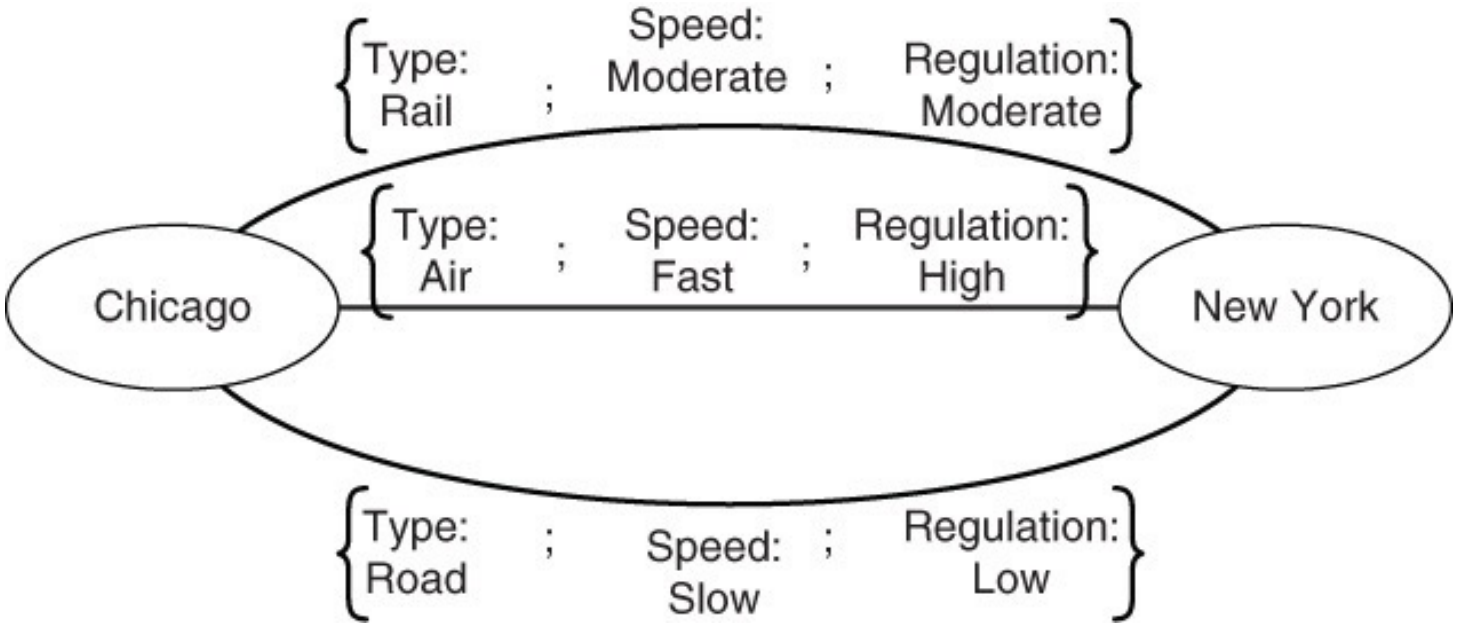
| | |
|---|---|
| P1 | Post1 |
| P2 | Post2 |
| P3 | Post3 |
| . | . |
| . | . |
| . | . |
| . | . |
| PN | PostN |

**vs**



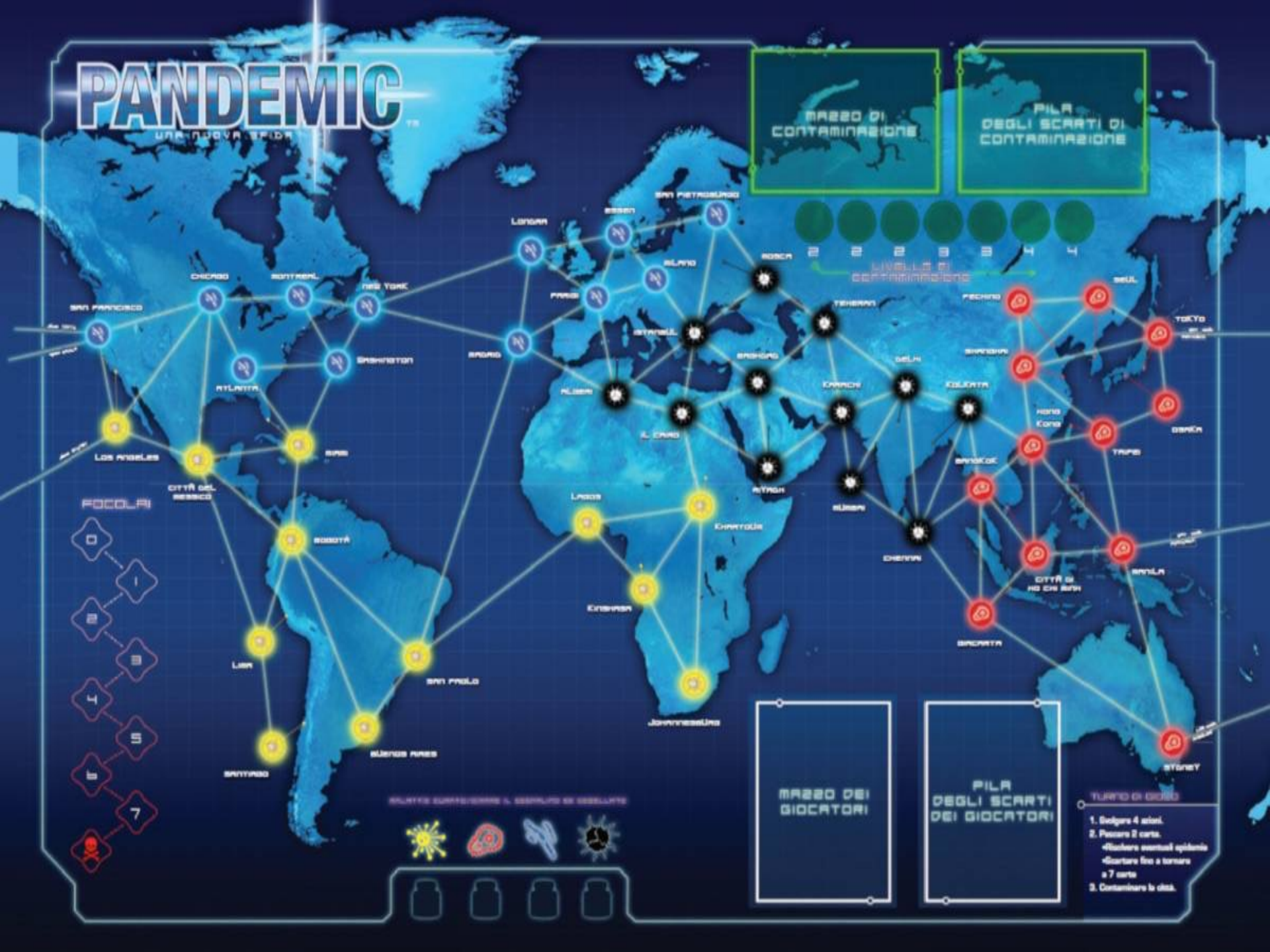

Edges allow us to ***explicitly*** modeling many-to-many relations, rather than using tables.

# Modeling Multiple Relations between Entities




***Different*** type of ***relations*** between entities may be handled exploiting ***multiple*** type of edges.

Multiple type of edges can be simply obtained specifying ***different values*** of edge ***properties***


PANDEMIC
UNA NUOVA SFIDA
MAZZO DI CONTAMINAZIONE
PILA DEGLI SCARTI DI CONTAMINAZIONE
2 2 2 3 3 4 4
LIVELLO DI CONTAMINAZIONE
FOCOLAI
0 1 2 3 4 5 6 7
MAZZO DEI GIOCATORI
PILA DEGLI SCARTI DEI GIOCATORI
TURNO DI GIOCO
1. Eseguire 4 azioni.
2. Pescare 2 carte.
• Risolvere eventuali epidemie
• Scartare fino a tornare a 7 carte
3. Contaminare le città.

# Suggested Readings

Chapter 12 of the book "*Dan Sullivan, NoSQL For Mere Mortals, Addison-Wesley, 2015*".

*Watch the Pandemic Game video:*

*https://www.youtube.com/watch?v=63Ha1ktxvoY&ab_channel=Geek%26Sundry*

# Images

If not specified, the images shown in this lecture have been extracted from:

*"Dan Sullivan, NoSQL For Mere Mortals, Addison-Wesley, 2015"*