

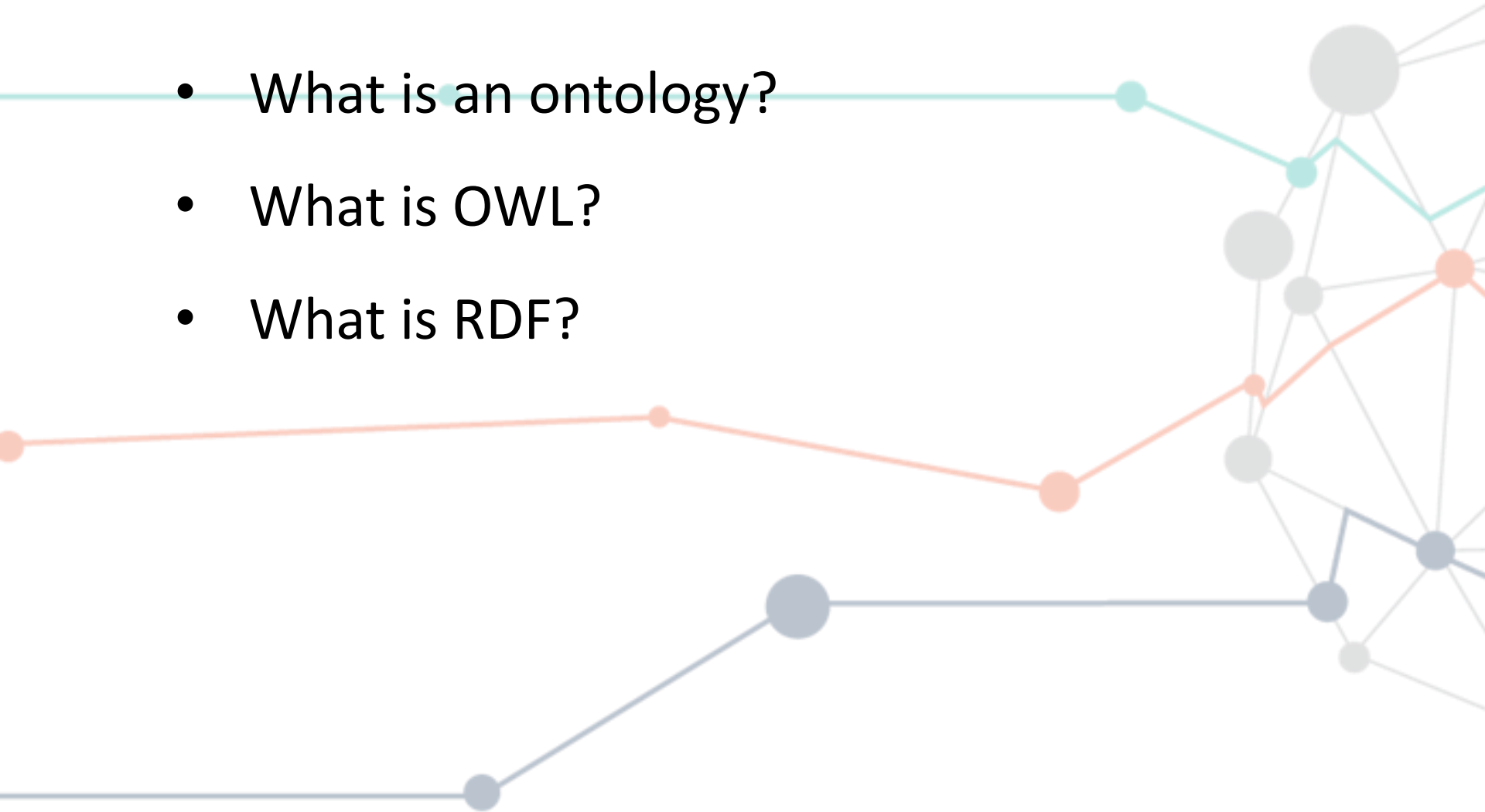
The background features a network of nodes and lines. A teal line with circular nodes runs horizontally across the top. An orange line with circular nodes runs horizontally across the middle. A blue line with circular nodes runs horizontally across the bottom. On the right side, there is a complex network of grey nodes connected by thin grey lines, with some nodes highlighted in teal, orange, and blue to match the lines. 

# Introduction to Graph Databases

Knowledge bases course  
Master program of AI  
Sofia University, Bulgaria

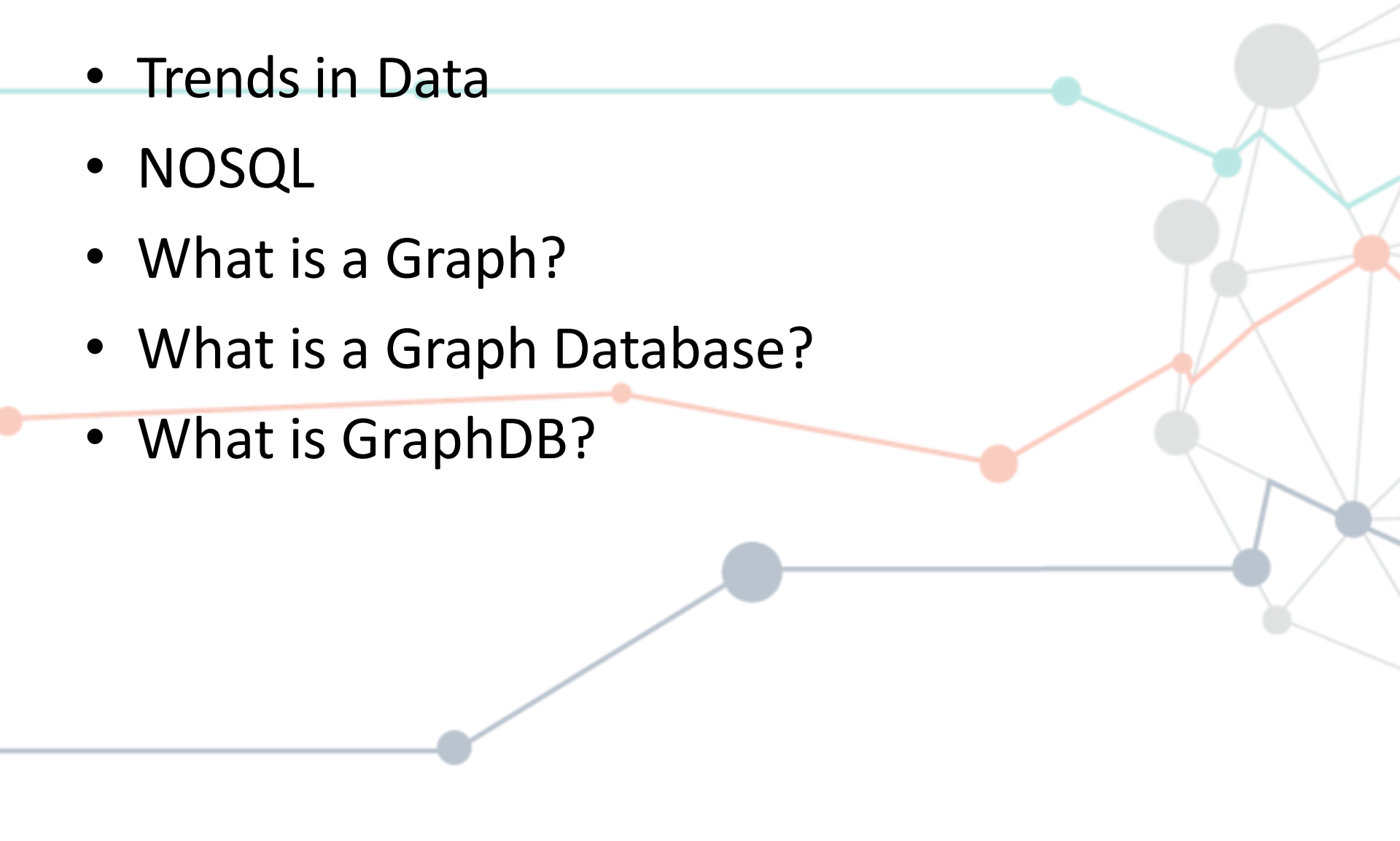
# From previous semester

- What is an ontology?
- What is OWL?
- What is RDF?



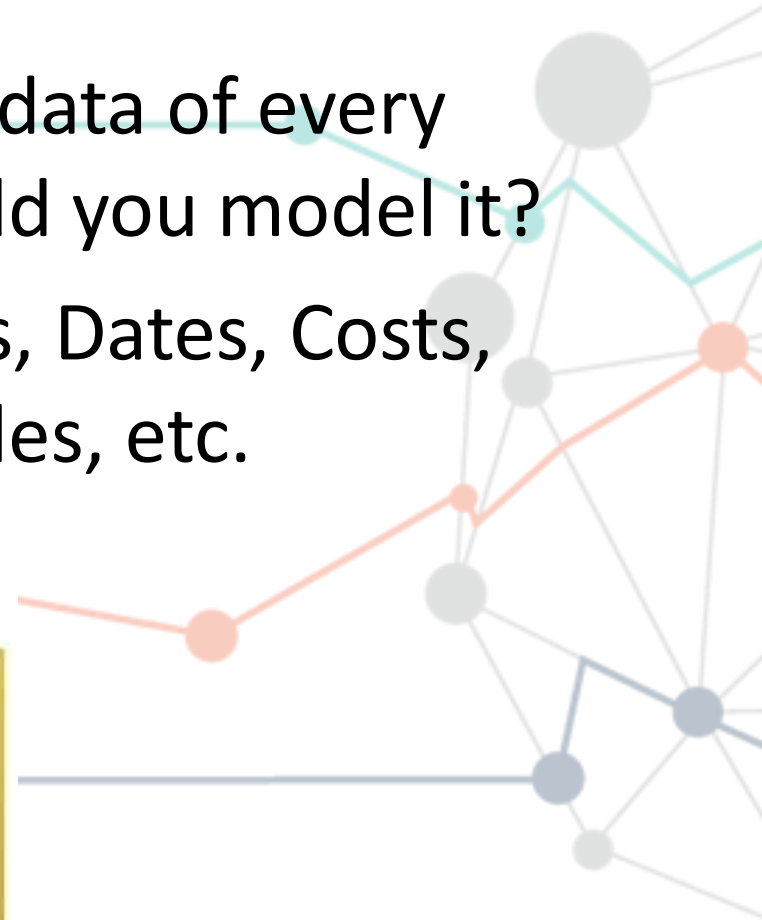
# Agenda

- Trends in Data
- NOSQL
- What is a Graph?
- What is a Graph Database?
- What is GraphDB?



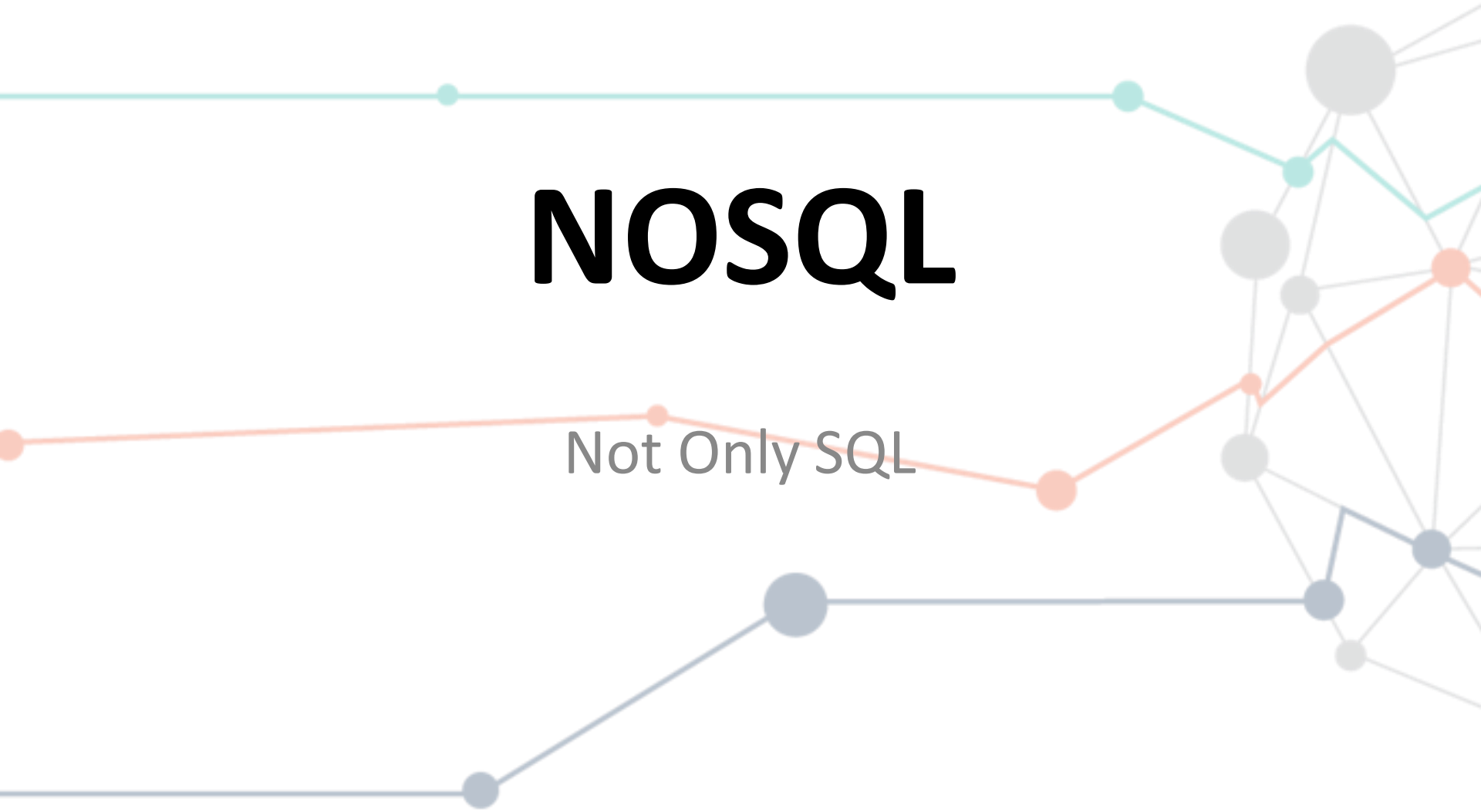
# Data is more Semi-Structured:

- If you tried to collect all the data of every movie ever made, how would you model it?
- Actors, Characters, Locations, Dates, Costs, Ratings, Showings, Ticket Sales, etc.



# NOSQL

Not Only SQL

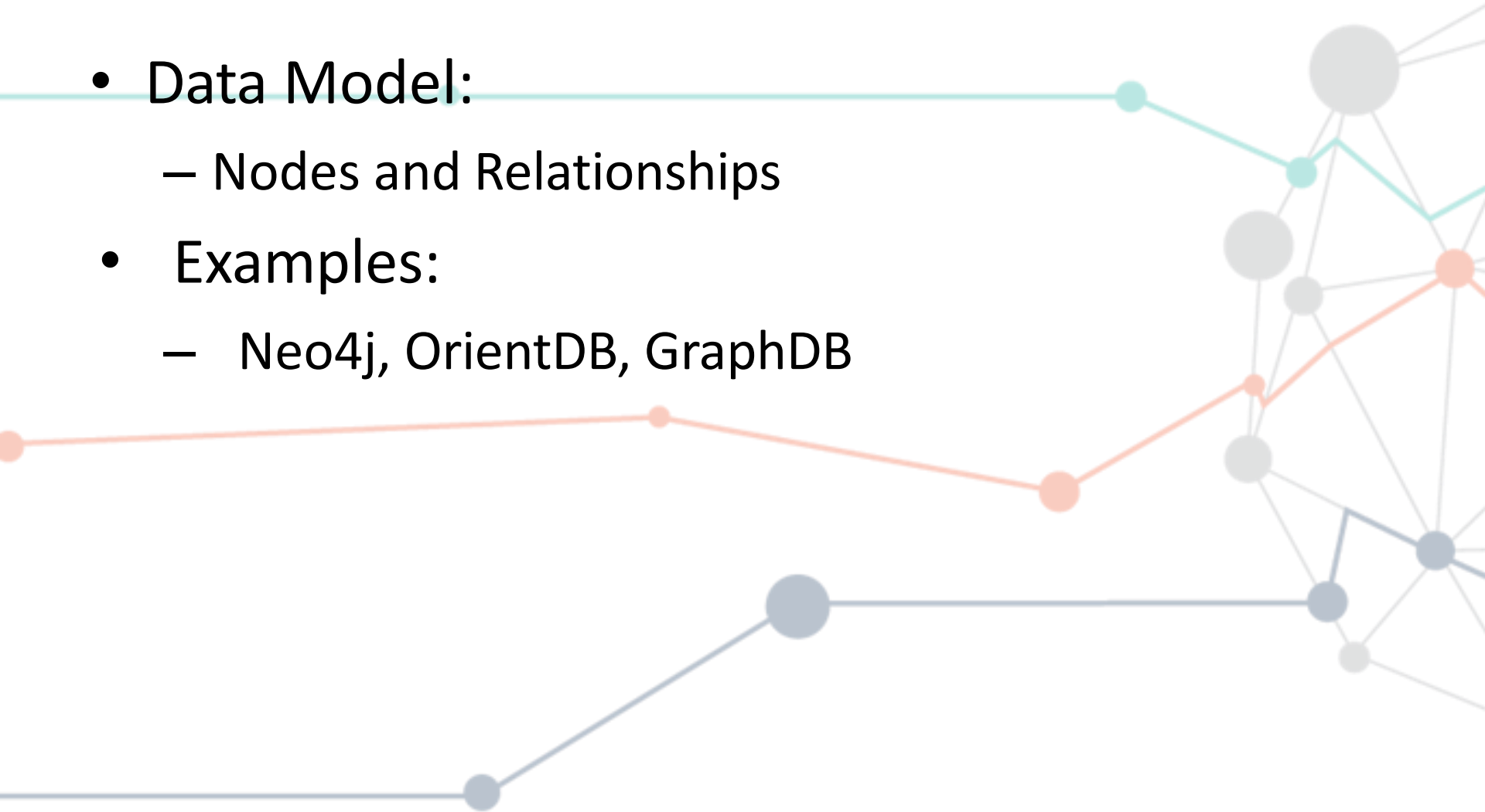


# NoSQL



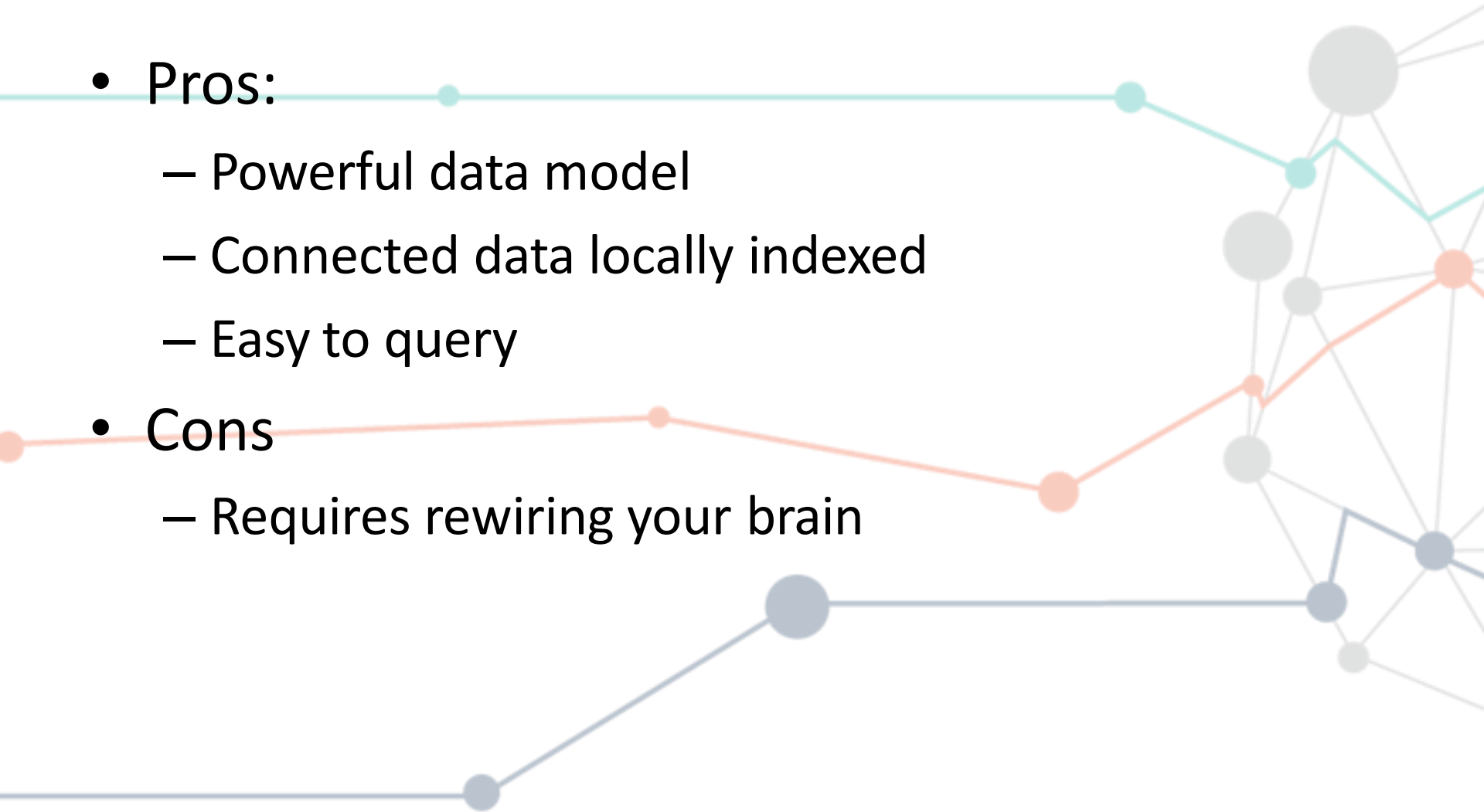
# Graph Databases

- Data Model:
  - Nodes and Relationships
- Examples:
  - Neo4j, OrientDB, GraphDB



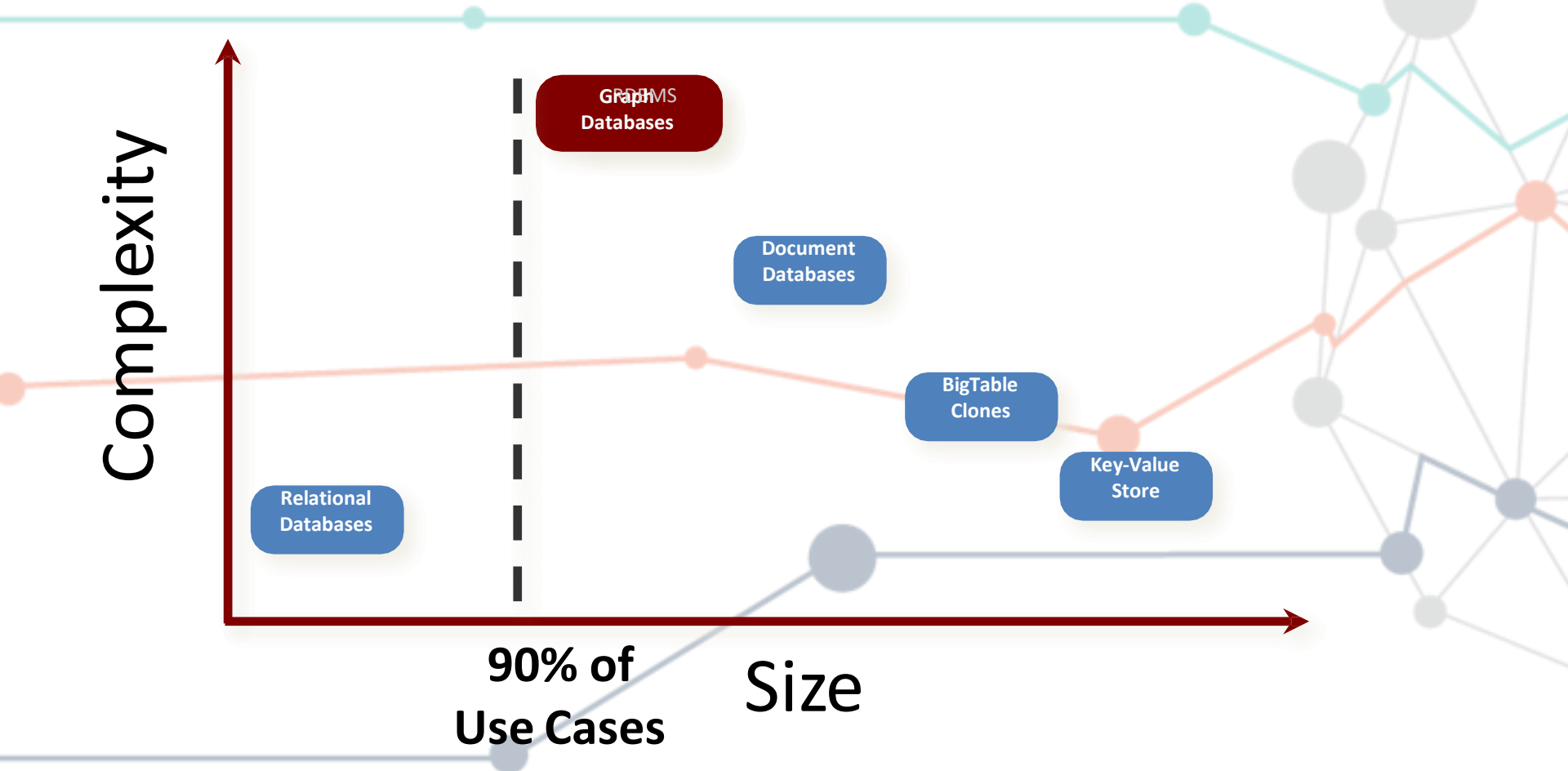
# Graph Databases: Pros and Cons

- Pros:
  - Powerful data model
  - Connected data locally indexed
  - Easy to query
- Cons
  - Requires rewiring your brain

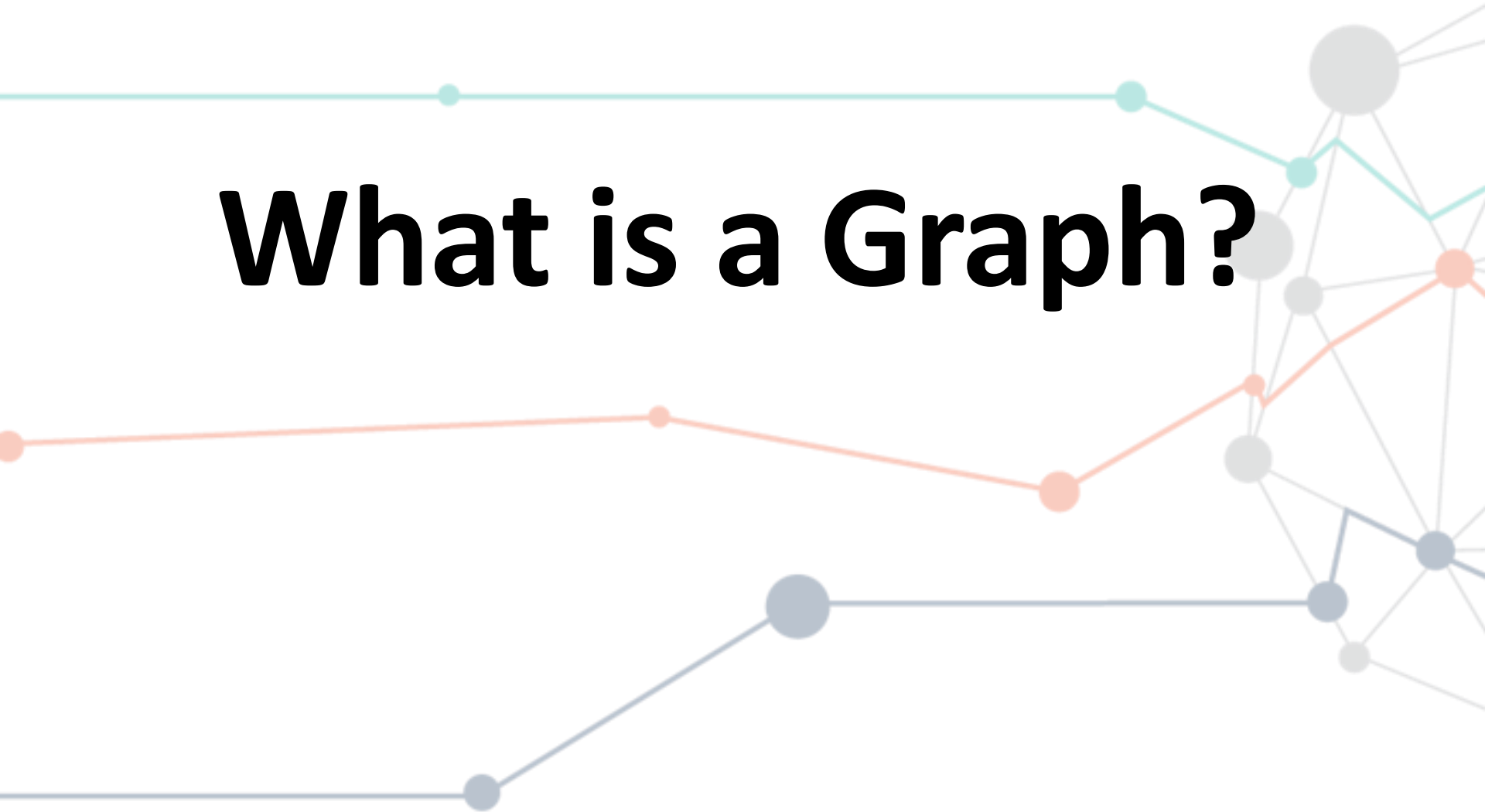




# Living in a NOSQL World



# What is a Graph?



# What is a Graph?

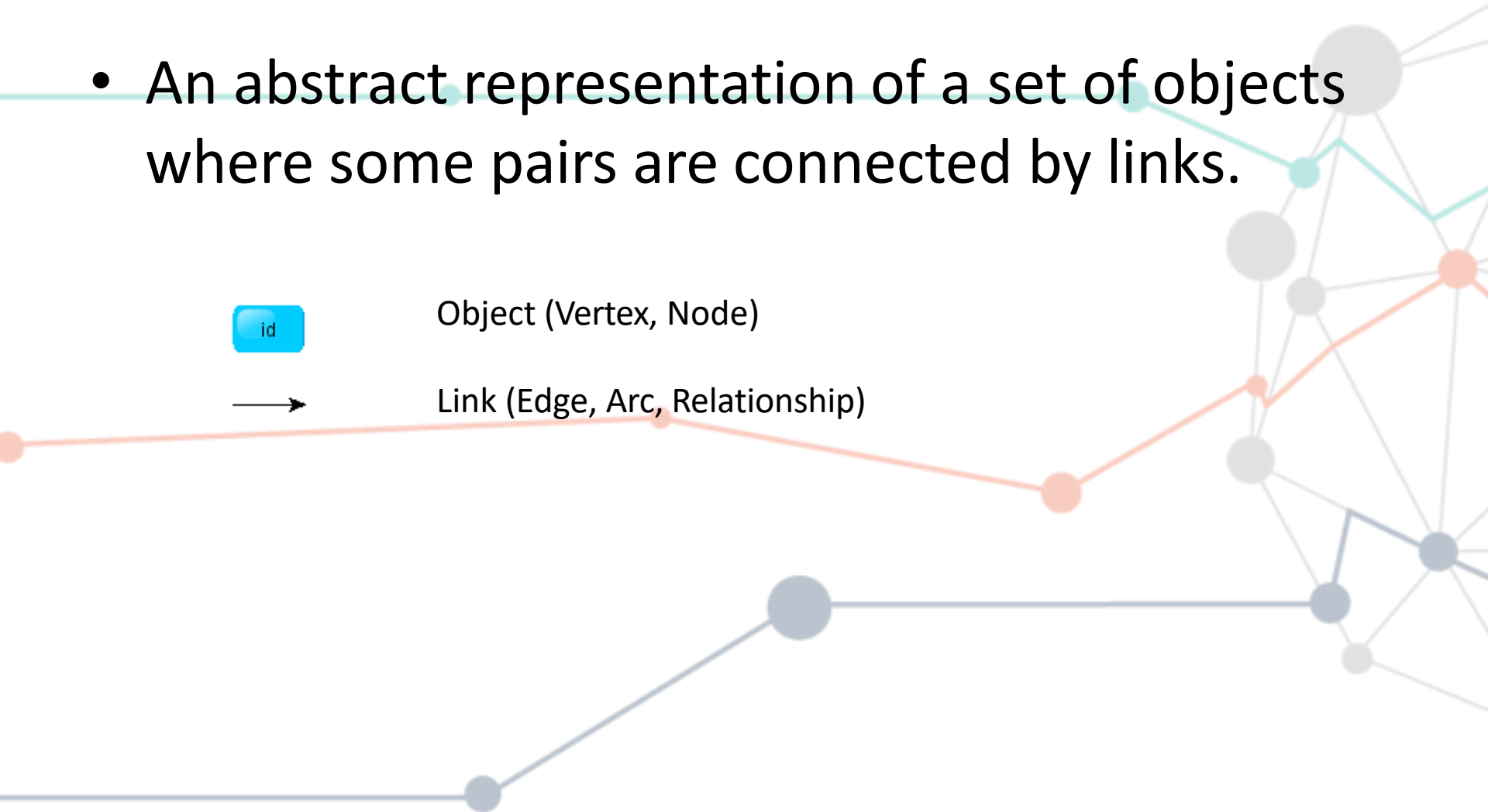
- An abstract representation of a set of objects where some pairs are connected by links.



Object (Vertex, Node)

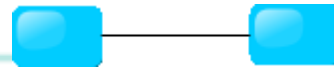


Link (Edge, Arc, Relationship)

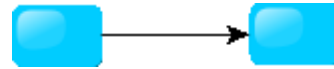


# Different Kinds of Graphs

- Undirected Graph



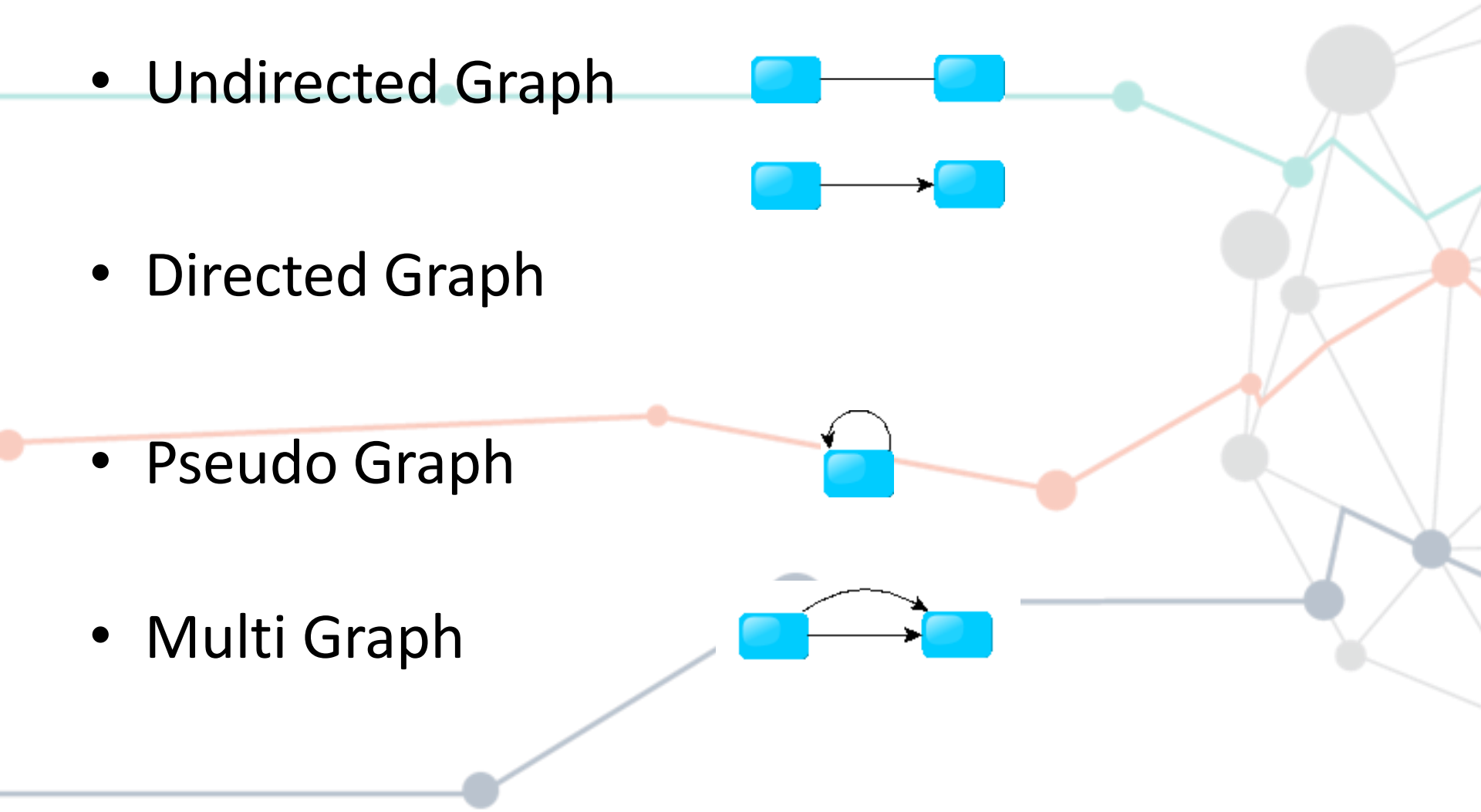
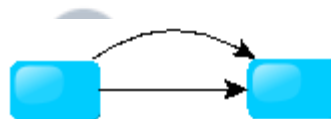
- Directed Graph



- Pseudo Graph

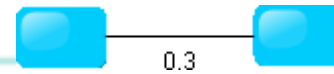


- Multi Graph

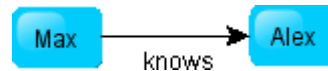


# More Kinds of Graphs

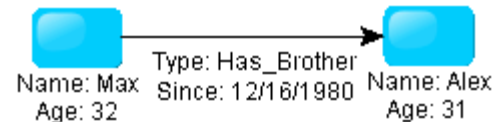
- Weighted Graph



- Labeled Graph

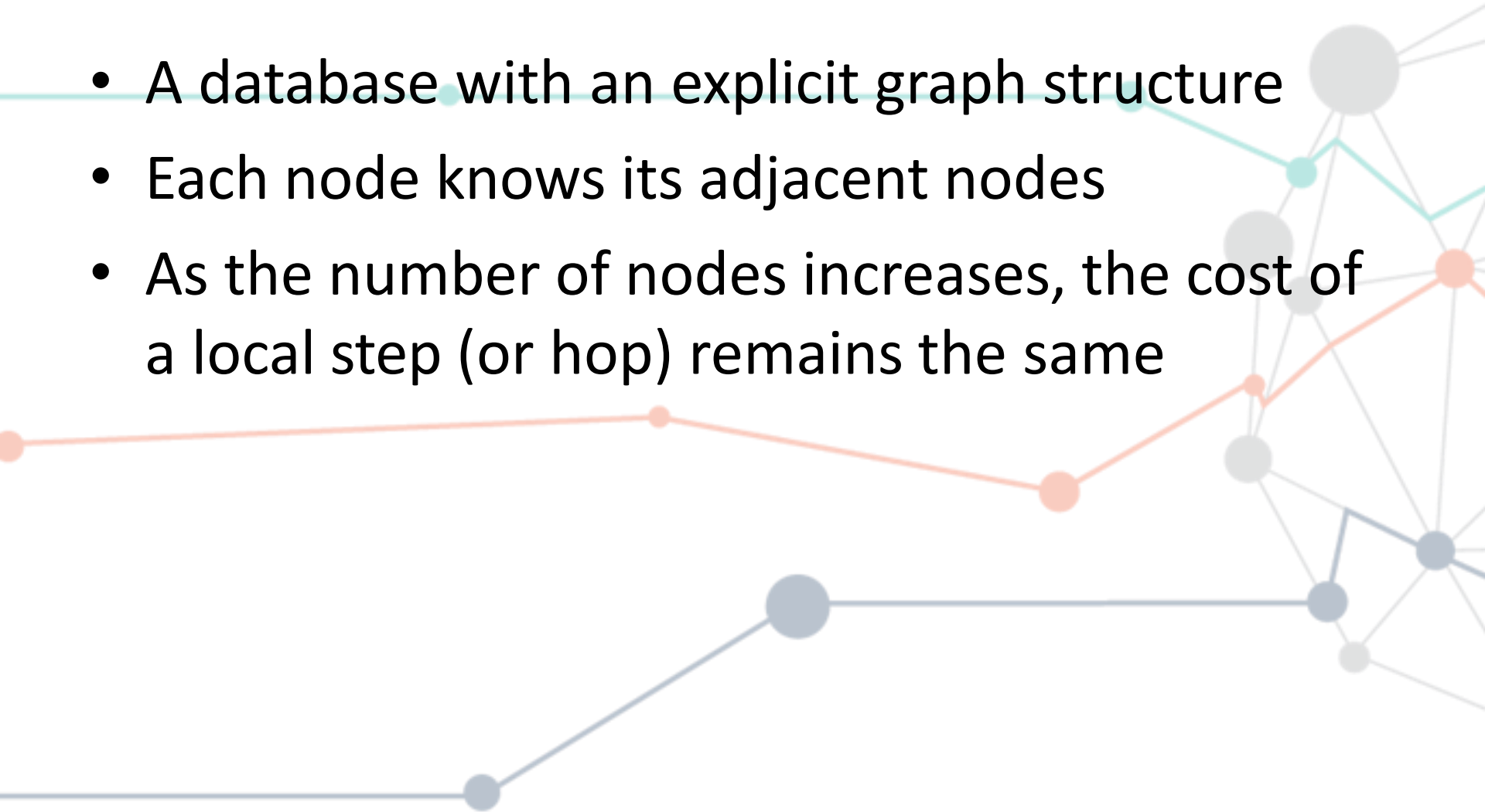


- Property Graph

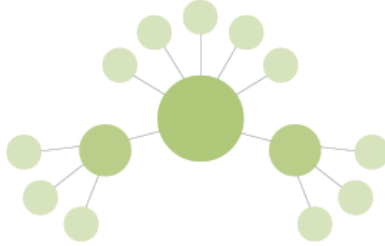
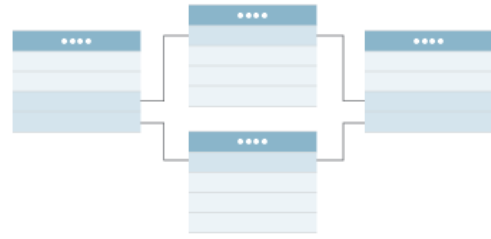


# What is a Graph Database?

- A database with an explicit graph structure
- Each node knows its adjacent nodes
- As the number of nodes increases, the cost of a local step (or hop) remains the same

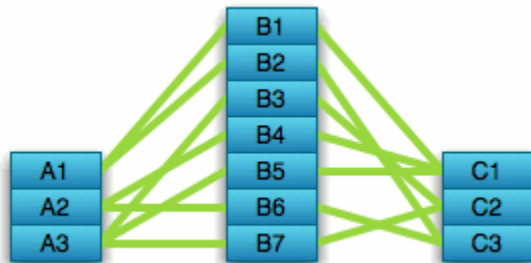


# Graph database vs. relational database

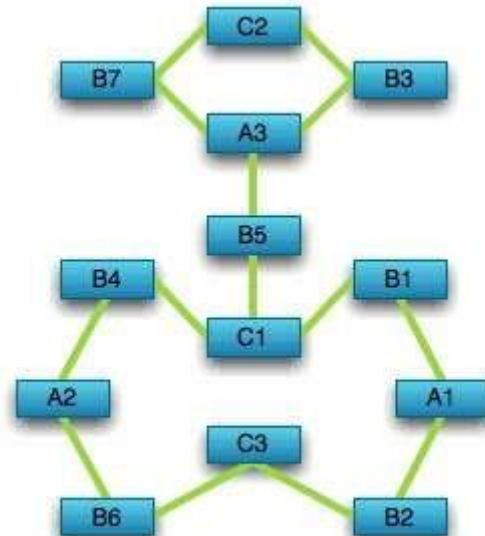
	Graph database	Relational database
FORMAT	Nodes and edges	Tables with rows and columns
RELATIONSHIPS	Considered data, represented by edges between nodes	Related across tables, established using foreign keys between tables
COMPLEX QUERIES	Run quickly and do not require joins	Require complex joins between tables
TOP USE CASES	Relationship-heavy use cases, including fraud detection and recommendation engines	Transaction-focused use cases, including online transactions and accounting
EXAMPLE		

# Compared to Relational Databases

Optimized for aggregation



Optimized for connections



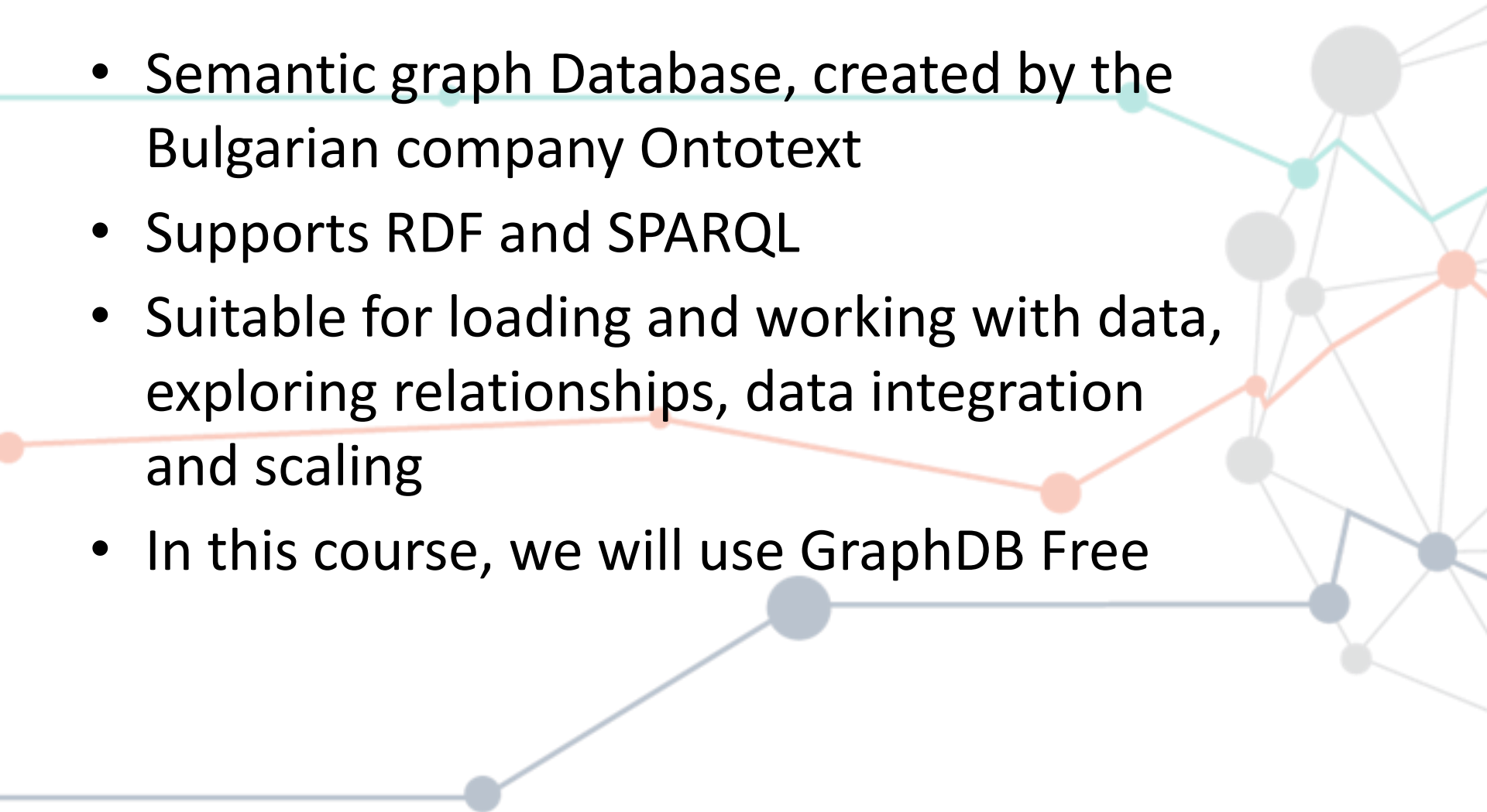


# What is GraphDB?

The background features a complex network of nodes and edges. On the right side, there is a dense cluster of nodes, some of which are larger than others, connected by thin grey lines. Several distinct paths are highlighted with thicker lines in teal, orange, and blue. These paths consist of nodes connected by straight line segments, extending from the left and bottom edges of the frame towards the central cluster.

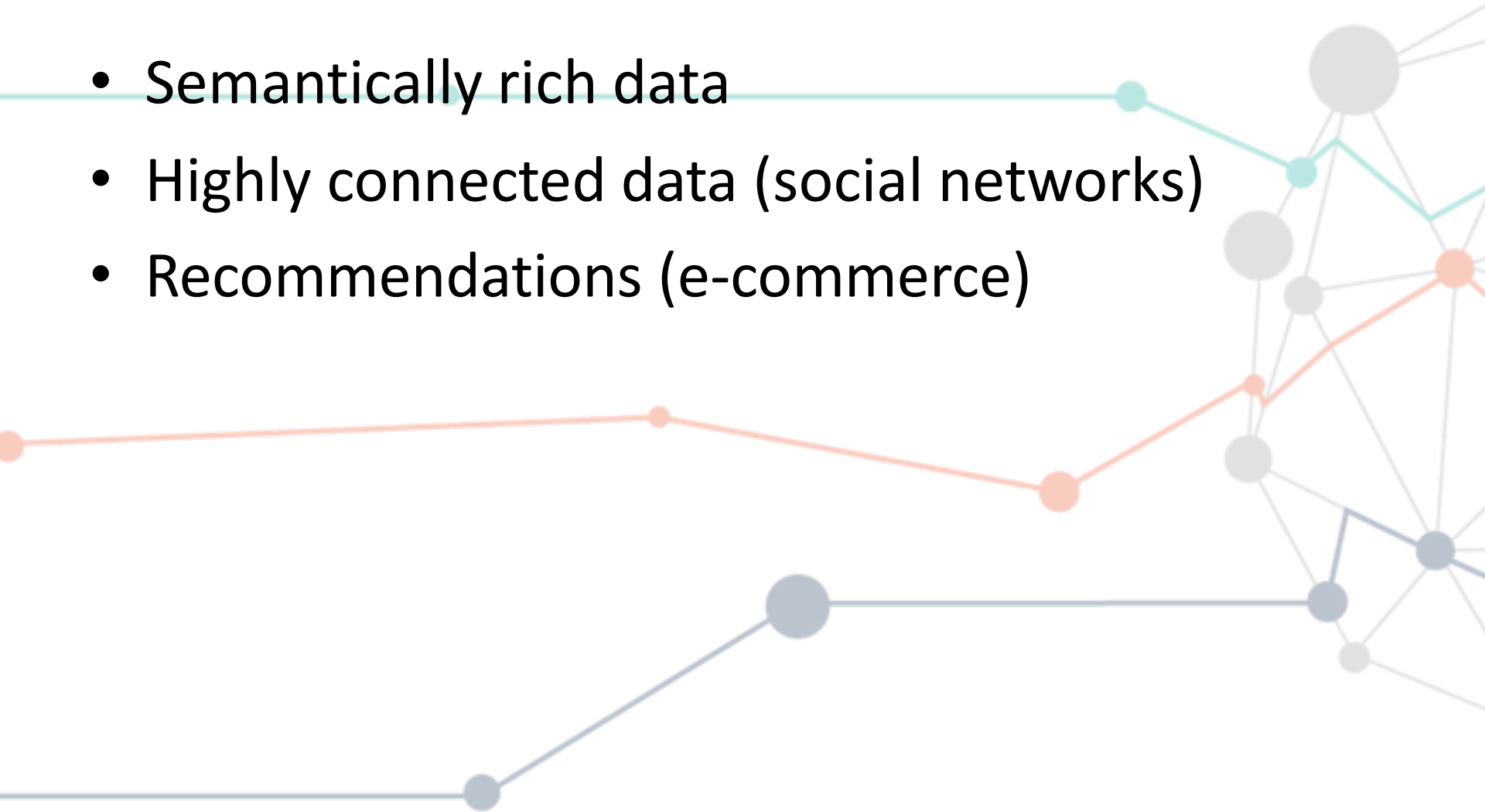
# What is GraphDB?

- Semantic graph Database, created by the Bulgarian company Ontotext
- Supports RDF and SPARQL
- Suitable for loading and working with data, exploring relationships, data integration and scaling
- In this course, we will use GraphDB Free



Good for

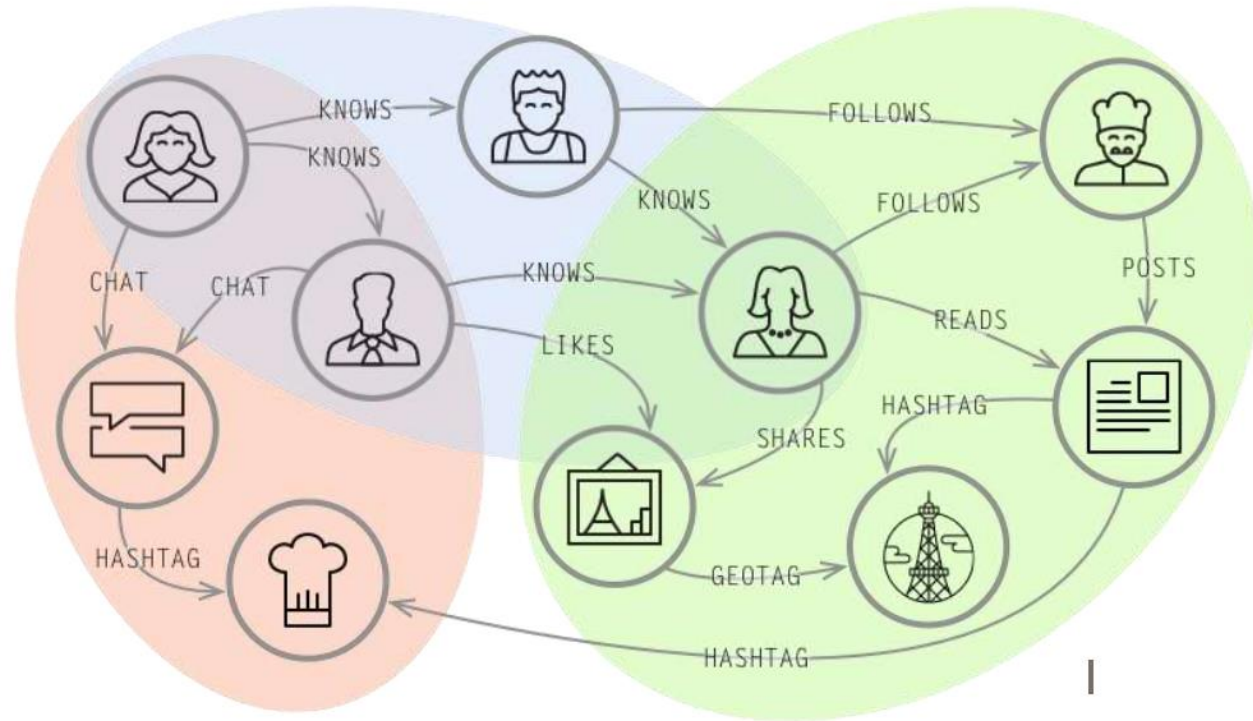
- Semantically rich data
- Highly connected data (social networks)
- Recommendations (e-commerce)



# Social Networks

Used for:

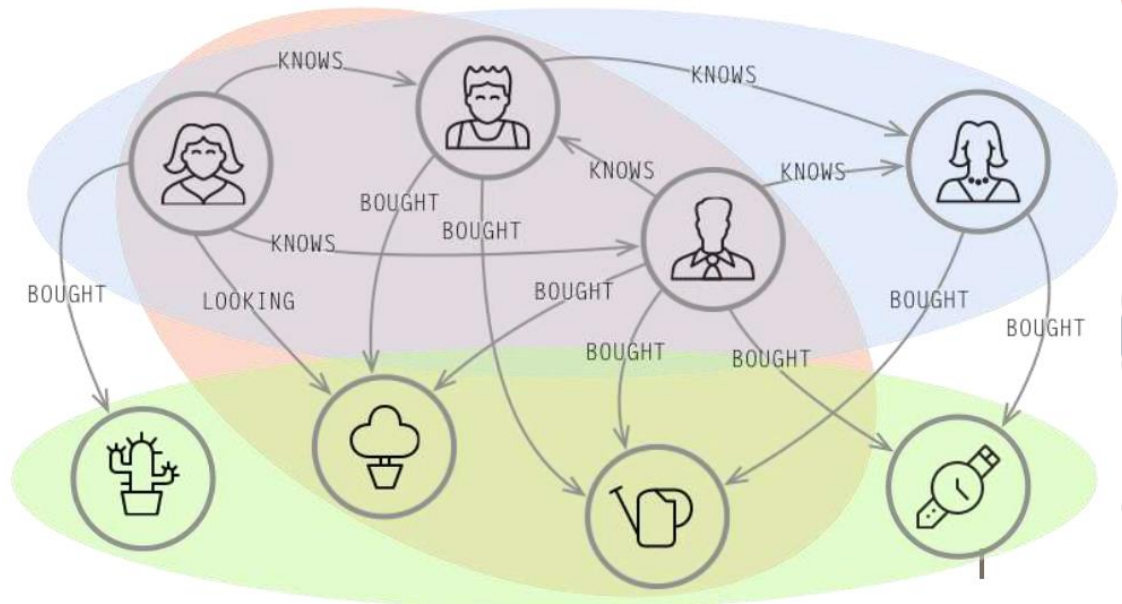
- Recommendation of friends
- Analysis of influence
- Implicit user clusters



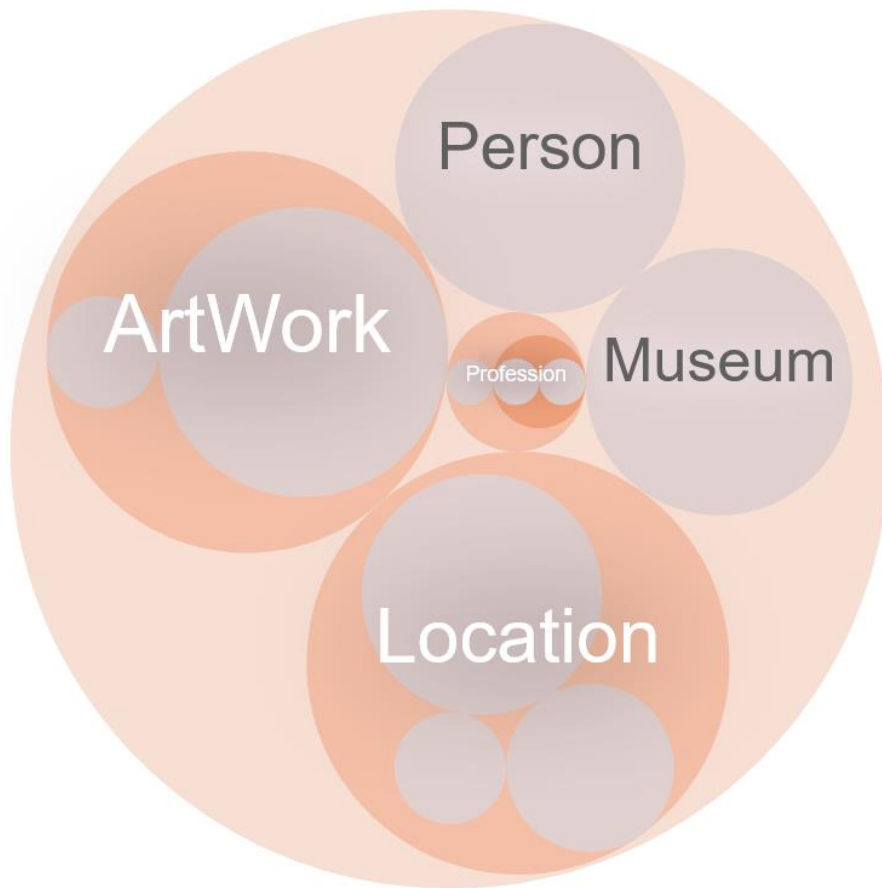
# Recommendations

Used for:

- Recommendation of products, services and content



# Example: The art ontology



# Example: The art ontology

	subject ↕	predicate ↕	object ↕	context ↕
1	<a href="#">art:AdolpheMonticelli</a> 🔗	<a href="#">art:firstName</a>	"Adolphe"	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
2	<a href="#">art:AdolpheMonticelli</a>	<a href="#">art:hasProfession</a>	<a href="#">art:Painter</a>	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
3	<a href="#">art:AdolpheMonticelli</a>	<a href="#">art:lastName</a>	"Monticelli"	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
4	<a href="#">art:AdolpheMonticelli</a>	<a href="#">rdf:type</a>	<a href="#">art:Person</a>	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
5	<a href="#">art:ArtWork</a>	<a href="#">rdf:type</a>	<a href="#">owl:Class</a>	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
6	<a href="#">art:ArtWork</a>	<a href="#">rdfs:comment</a>	"A work of art, artwork, art piece, piece of art or art object is an aesthetic physical item or artistic creation"@en	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
7	<a href="#">art:ArtWork</a>	<a href="#">rdfs:label</a>	"ArtWork"@en	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>
8	<a href="#">art:Artist</a>	<a href="#">rdf:type</a>	<a href="#">owl:Class</a>	<a href="http://www.ontotext.com/explicit">http://www.ontotext.com/explicit</a>

# Questions?





The background features a network of thin grey lines connecting various circular nodes. Some nodes are larger than others. Three distinct paths are highlighted: a teal line at the top, an orange line in the middle, and a blue line at the bottom. The teal line starts on the left, goes right, and then angles down towards a cluster of nodes on the right. The orange line starts on the left, goes right, dips down, and then angles up towards the same cluster. The blue line starts on the left, goes right, dips down, and then angles up towards the cluster. The text 'Thank you!' is centered in the upper half of the image.

Thank you!