

VIS 2022

VERTIGO

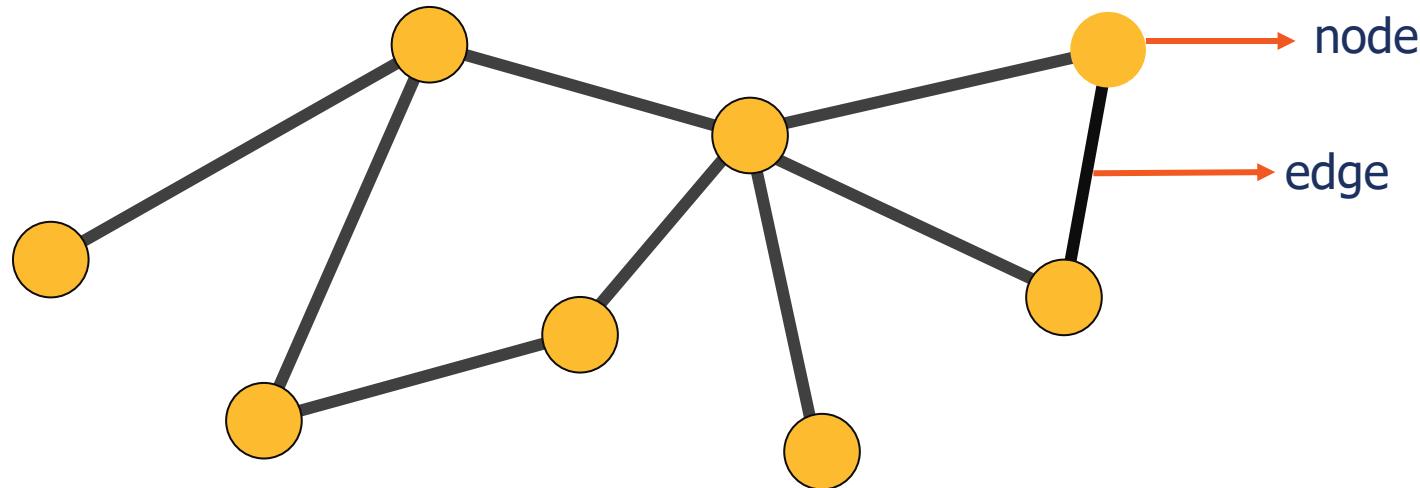
A Visual Platform for Querying and Exploring Large Multilayer Networks

Erick Cuenca, Arnaud Sallaberry, Dino Ienco, and Pascal Poncelet



Graphs (networks)

Graphs are structures that capture relationships (edges) among entities (nodes)



node

edge

Graphs capture relations

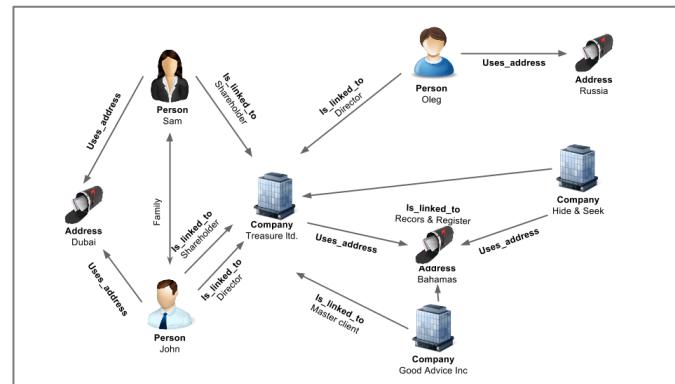
Graphs (networks) examples

Graphs in many domains

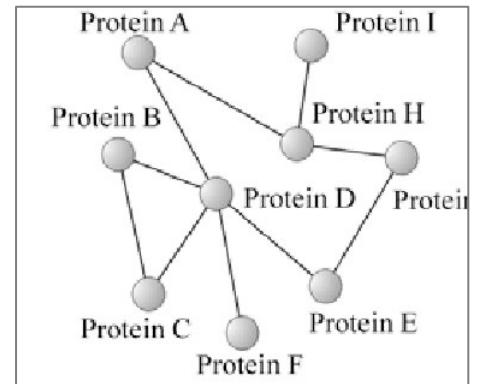
(1) Social network



(2) Offshore leak network

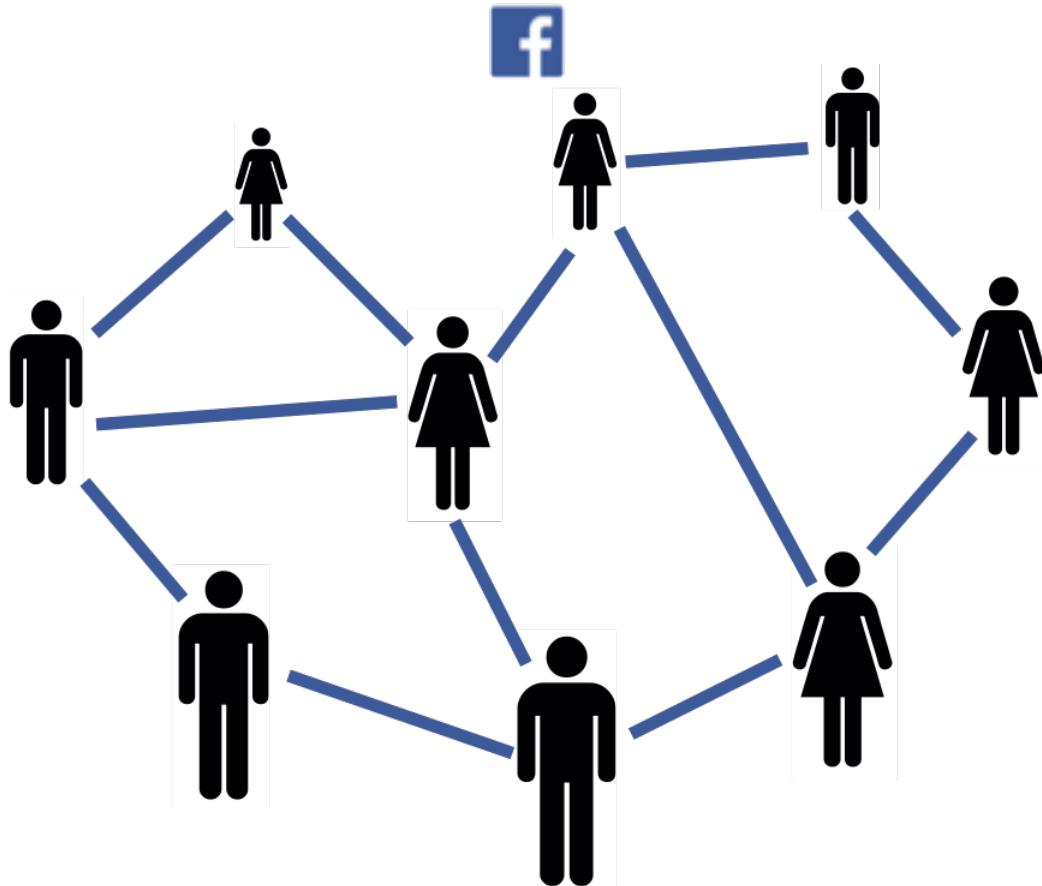


(3) Biological network



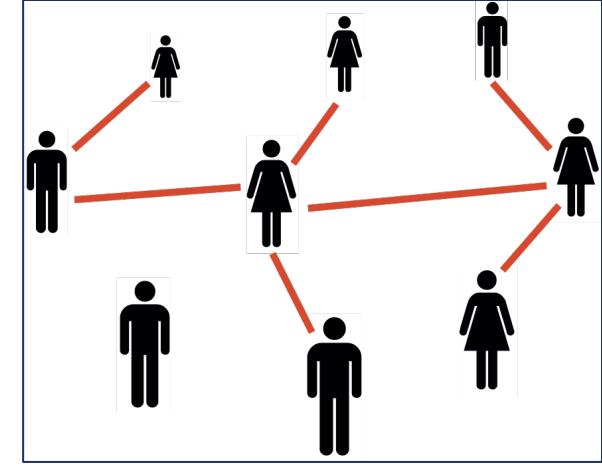
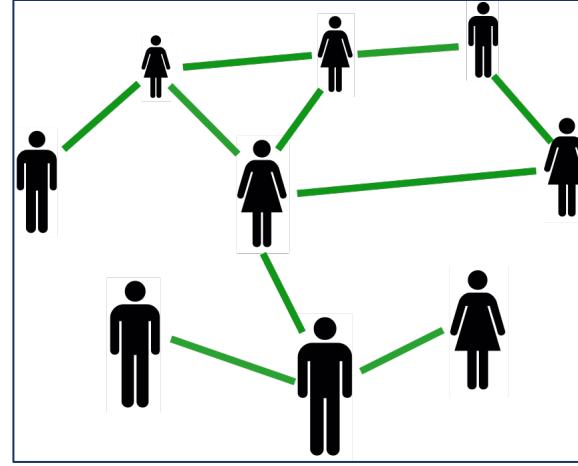
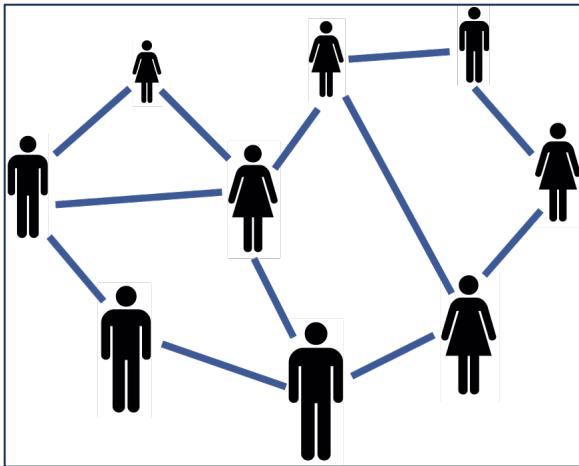
1. <https://medium.com/analytics-vidhya/social-network-analytics-f082f4e21b16>
2. <https://linkurious.com/blog/analysing-the-offshore-leaks-with-graphs/>
3. https://www.researchgate.net/publication/228925315_Complex_networks_The_key_to_systems_biology/figures?lo=1&utm_source=google&utm_medium=organic

A social network



A set of people
linked by a relationship
(*e.g.*, friendship)

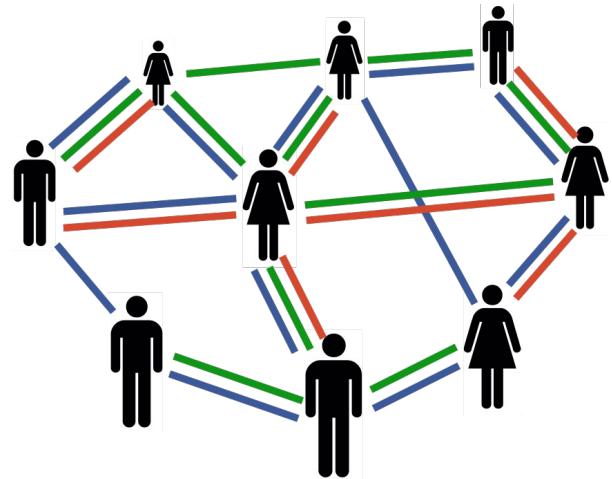
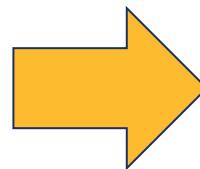
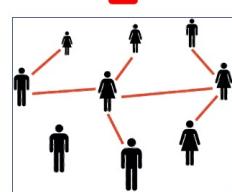
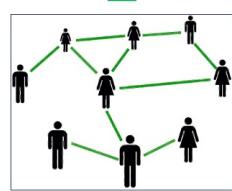
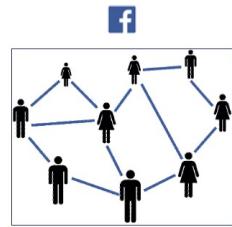
Various social networks



A different graph is used to represent the same people on various social networks.

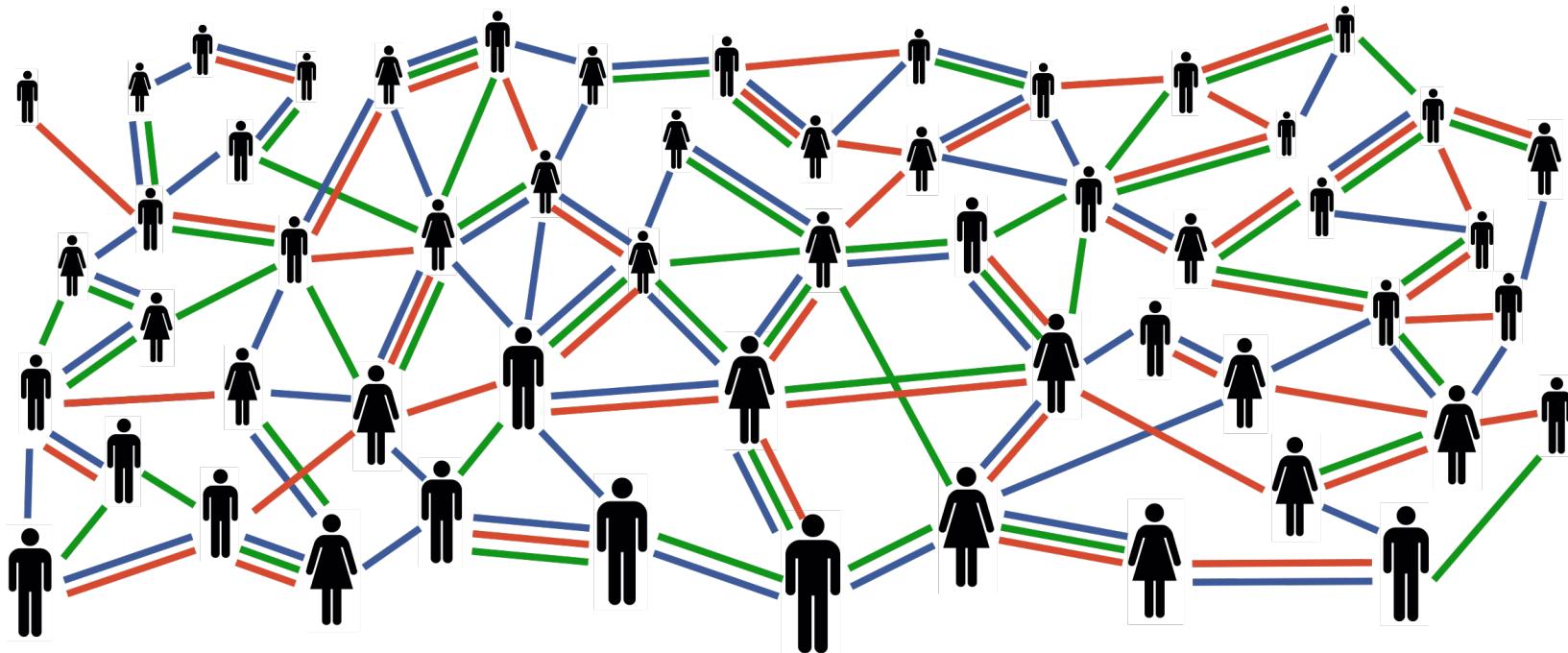
Multilayer graphs

Multilayer graphs allow the definitions of **multiple** types of nodes and edges

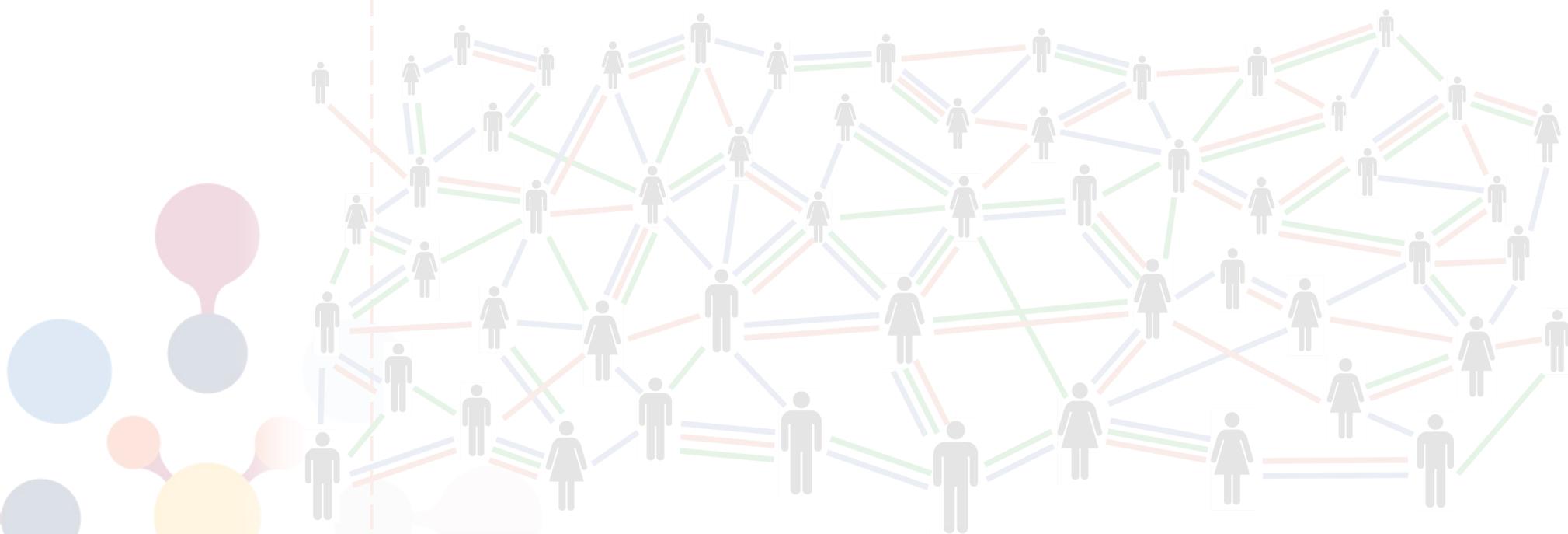


Multilayer graphs can be large

Multilayer graphs can be composed of thousand of nodes/edges

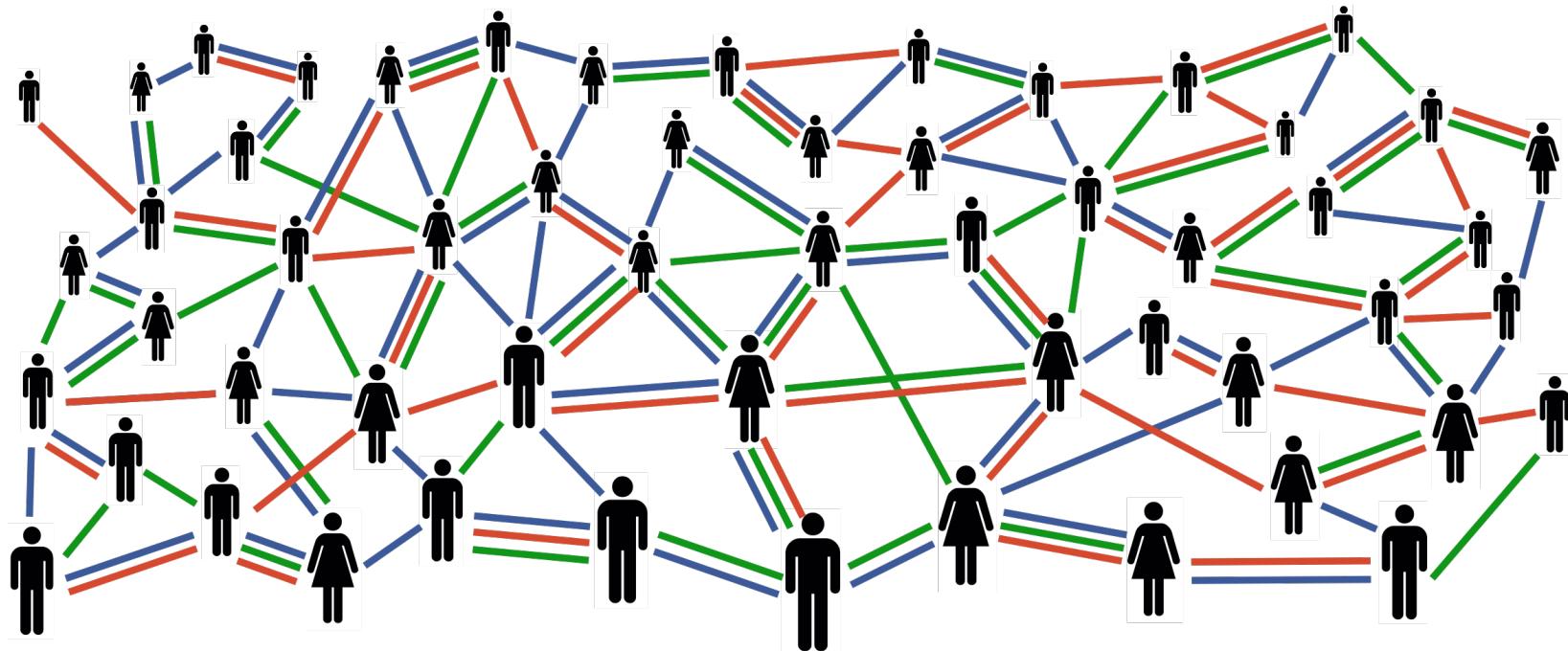


How to facilitate the **extraction** of knowledge from large multilayer graphs?

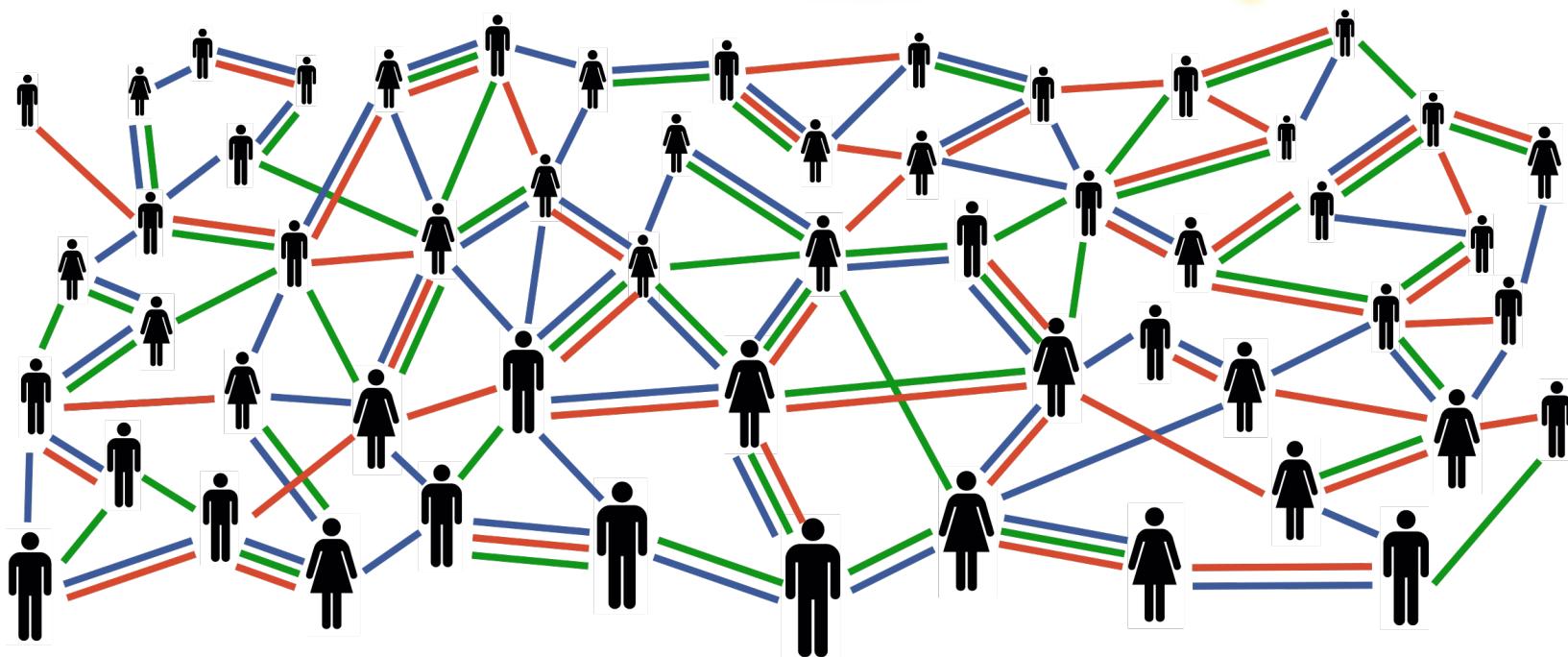
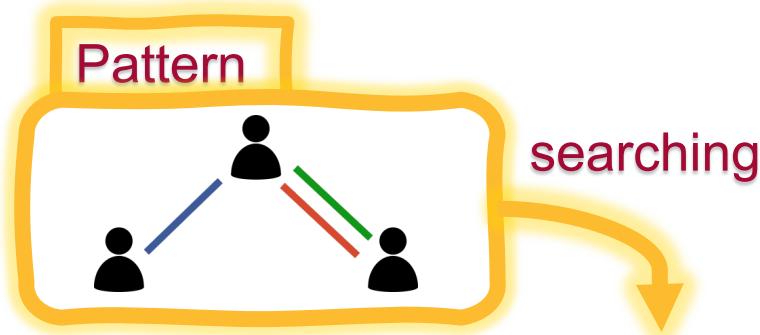


Subgraph matching (search a pattern)

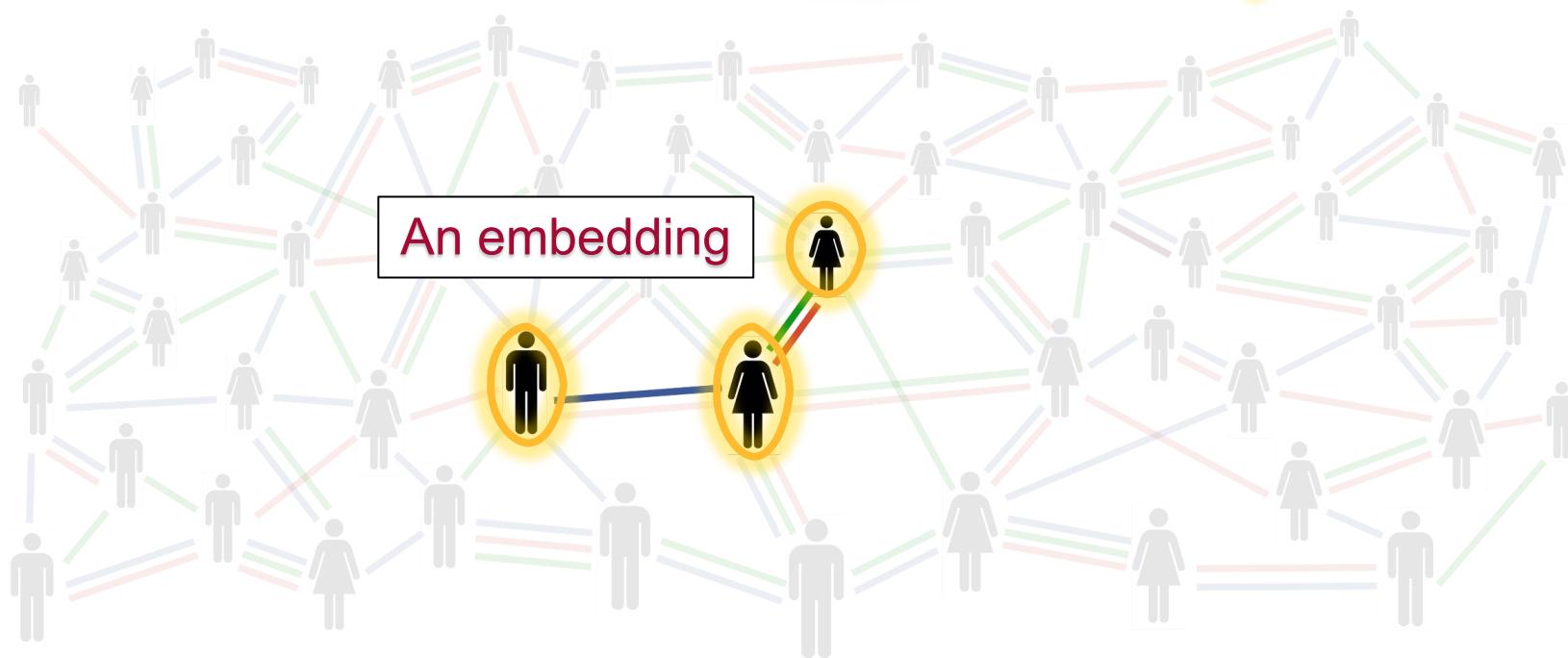
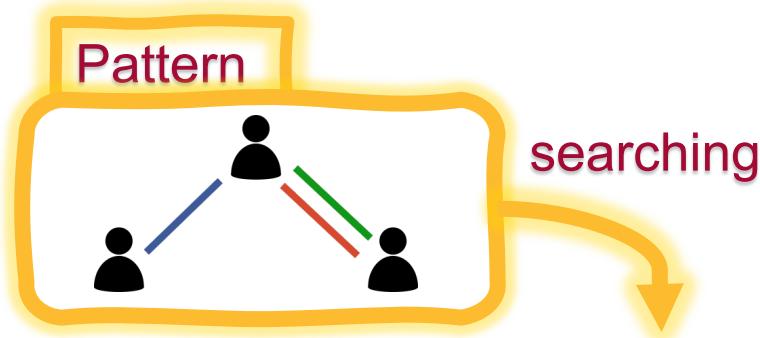
All occurrences of a subgraph are searched on the target multilayer graph



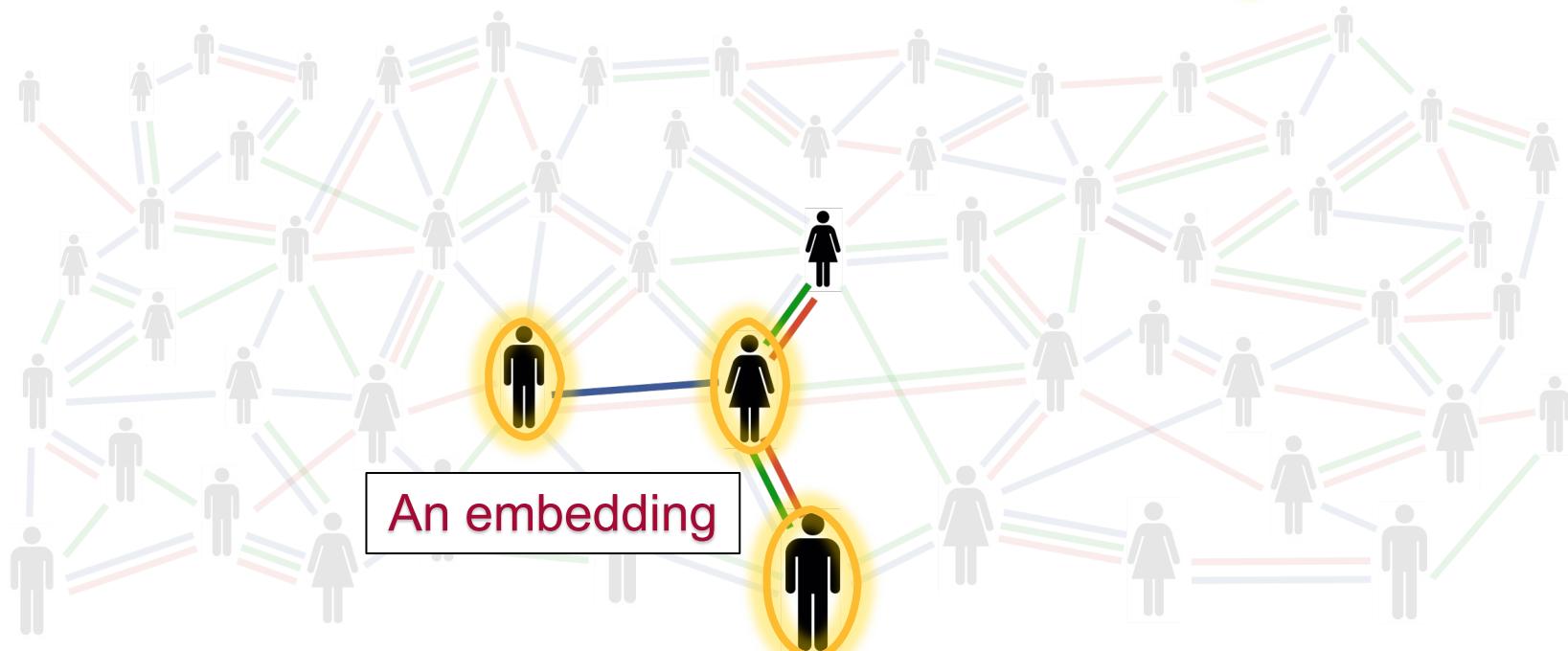
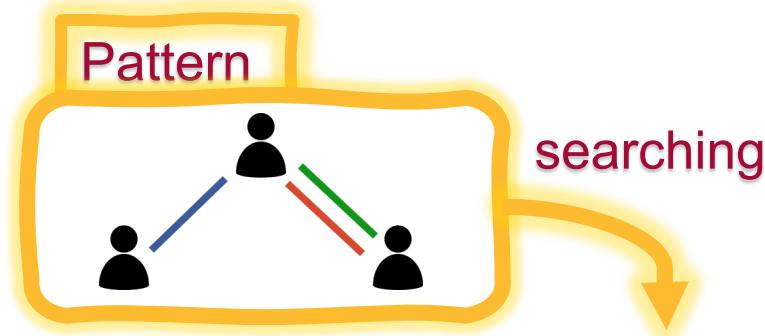
Subgraph matching



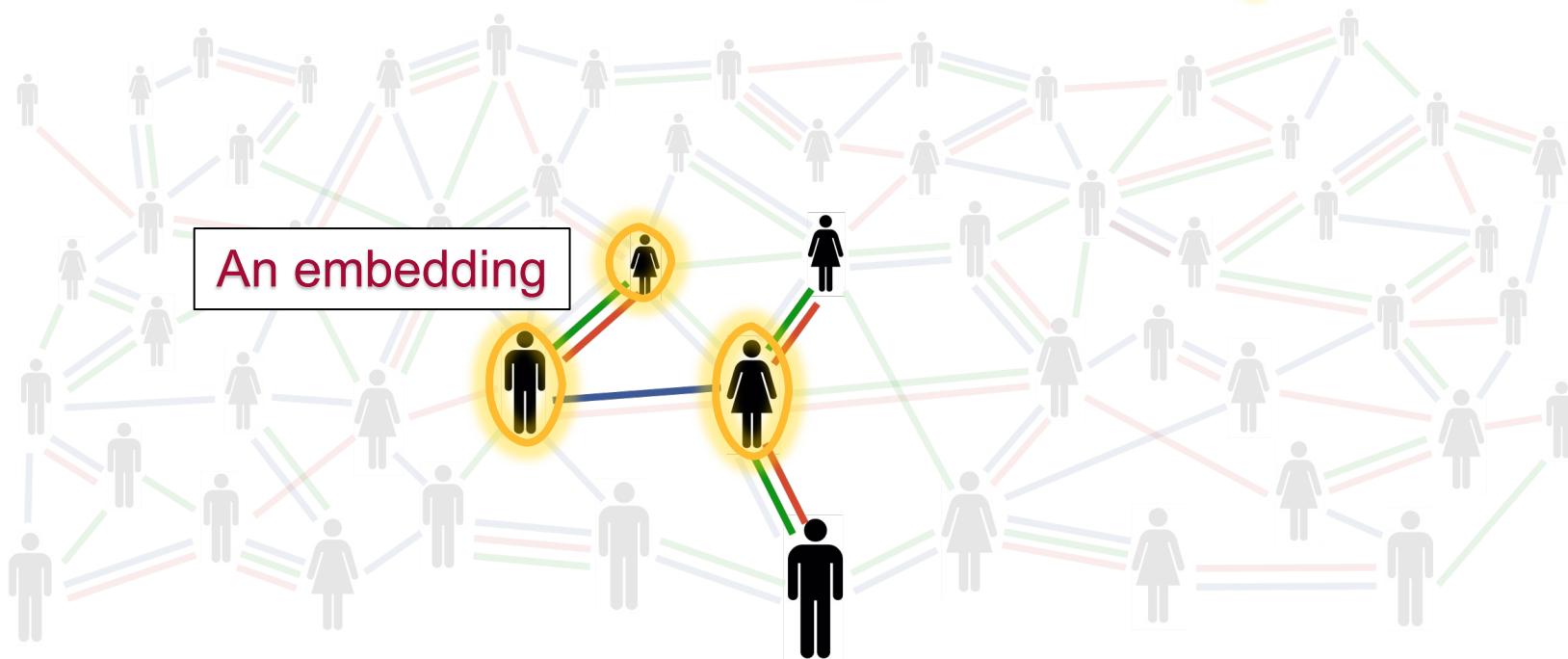
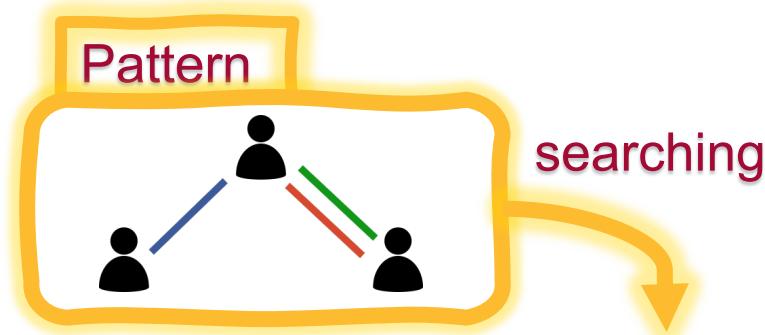
Subgraph matching



Subgraph matching

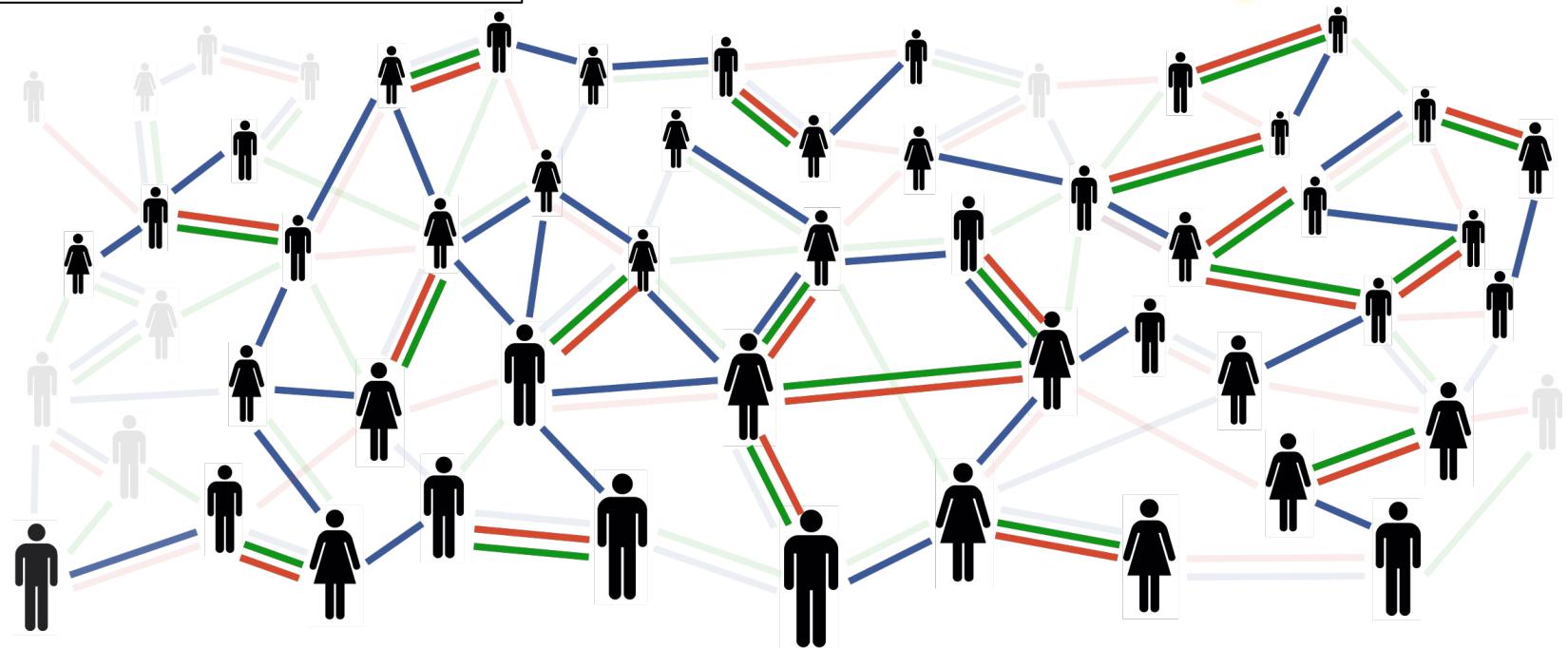
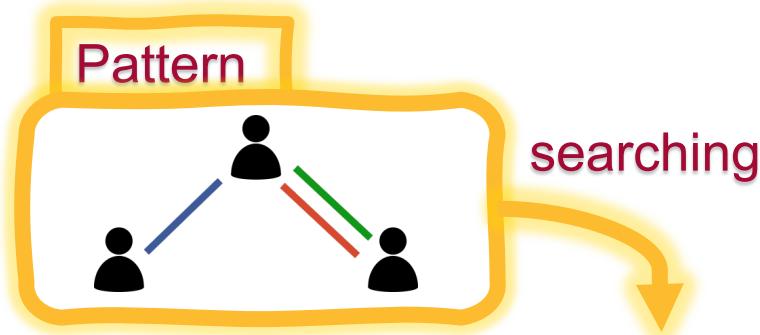


Subgraph matching



Subgraph matching

Several embedding results



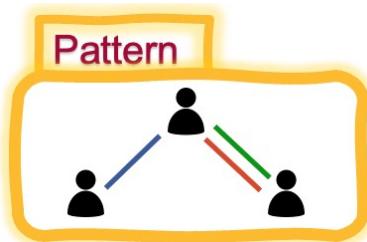
Visual Graph Query Processing Tasks

Task			
Query construction	Results visualization	Results exploration	Query suggestion
How to design the query?	How to visualize the results of the query?	How to explore the query results?	How to suggest new queries?

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- Visual interface

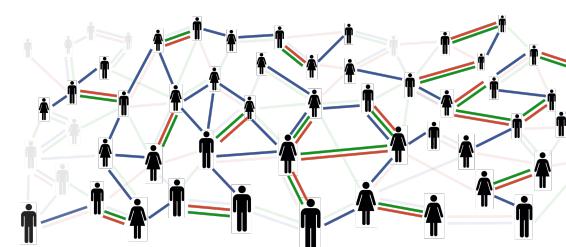
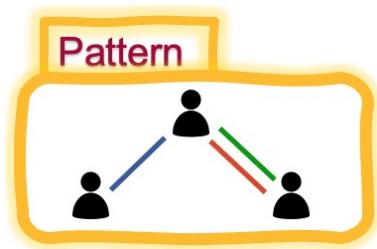


Visual Graph Query Processing Tasks

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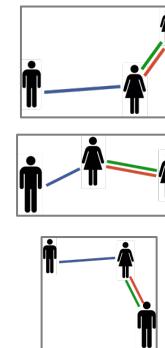
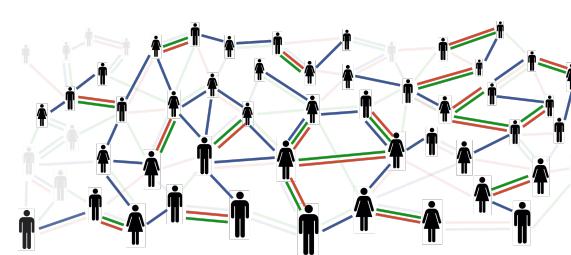
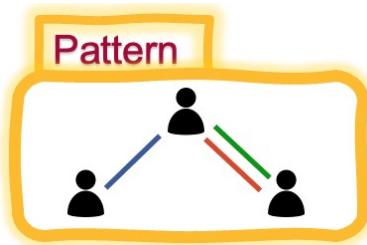
- Visual interface

- Suitable graph visualization and multilayer query engine
- Improve the System Response Time when dealing with the subgraph isomorphism problem



Visual Graph Query Processing Tasks

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How to design the query?	How to visualize the results of the query?	How to explore the query results?	How to suggest new queries?
<ul style="list-style-type: none">• Visual interface	<ul style="list-style-type: none">• Suitable graph visualization and multilayer query engine• Improve the System Response Time when dealing with the subgraph isomorphism problem	<ul style="list-style-type: none">• Visualizations and interactions to explore the results at different levels of details: overview -> details	



Visual Graph Query Processing Tasks

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<ul style="list-style-type: none">• Visual interface	<ul style="list-style-type: none">• Suitable graph visualization and multilayer query engine• Improve the System Response Time when dealing with the subgraph isomorphism problem	<ul style="list-style-type: none">• Visualizations and interactions to explore the results at different levels of details: overview -> details	<ul style="list-style-type: none">• Suggest new edges to the initial query• Refine the query iteratively

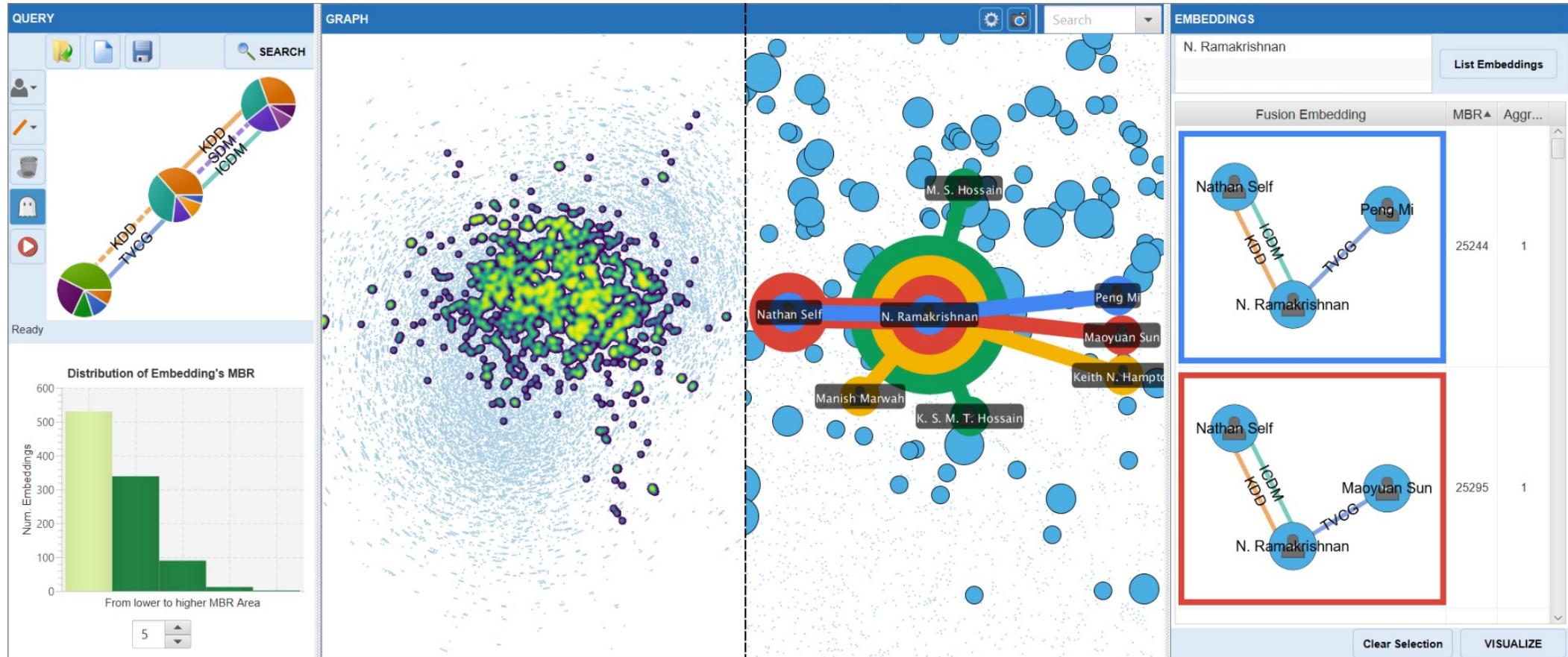
The diagram illustrates the four tasks of visual graph query processing. It features four main components: 1) Query construction, represented by a small graph pattern labeled 'Pattern' enclosed in a yellow box. 2) Results visualization, represented by a large, dense graph with many nodes and edges of various colors (blue, green, red). 3) Results exploration, represented by three smaller boxes showing different zoomed-in views of the graph, illustrating how to explore results at different levels of detail. 4) Query suggestion, represented by a graph pattern labeled 'New pattern' enclosed in a yellow box, showing how to refine or suggest new queries.

Visual Graph Query Processing Tasks

Approach	Task			
	Query construction	Results visualization	Results exploration	Query suggestion
GRAPHITE [1]	✓	✓		
VOGUE [2]	✓	✓		
GraphVista [3]	✓	✓		
VISAGE [4]	✓	✓		
VIGOR [5]	✓	✓	✓	
VIIQ [6]	✓			✓
VERTIGO [7]	✓	✓	✓	✓

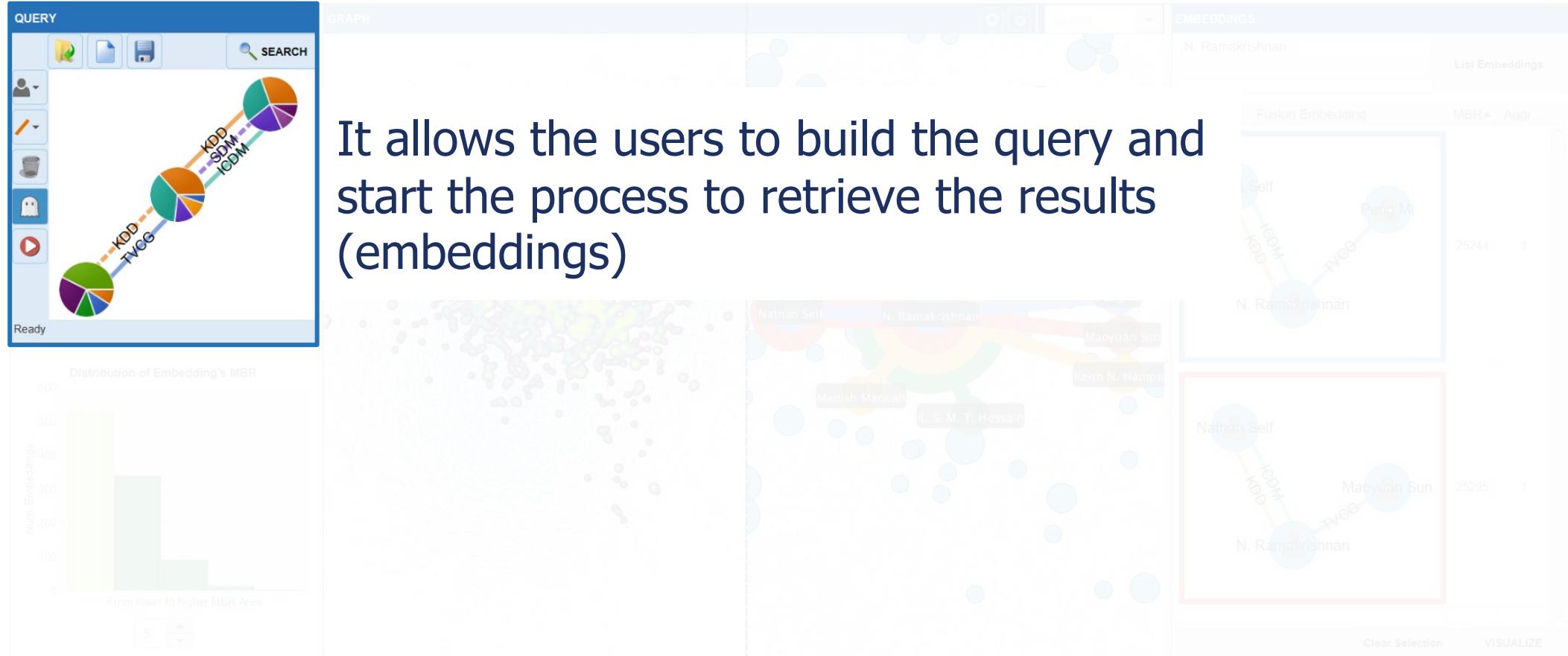
1. D. H. Chau, C. Faloutsos, H. Tong, J. I. Hong, B. Gallagher, and T. Eliassi-Rad, "Graphite: A visual query system for large graphs," in Proceedings of the International Conference on Data Mining (ICDM), 2008, pp. 963–966.
2. S. S. Bhowmick, B. Choi, and S. Zhou, "VOGUE: Towards A Visual Interaction-aware Graph Query Processing Framework," in Proceedings of the Biennial Conference on Innovative Data Systems Research (CIDR), 2013.
3. M. Paradies, M. Rudolf, and W. Lehner, "GraphVista: Interactive Exploration of Large Graphs," Cornell University Library, 2015.
4. R. Pienta, F. Hohman, A. Tamersoy, A. Endert, S. Navathe, H. Tong, and D. H. Chau, "VISAGE: Interactive Visual Graph Querying," in Proceedings of the International Working Conference on Advanced Visual Interfaces (AVI), 2016, pp. 272–279.
5. R. Pienta, F. Hohman, A. Endert, A. Tamersoy, K. Roundy, C. Gates, S. Navathe, and D. H. Chau, "VIGOR: Interactive Visual Exploration of Graph Query Results," IEEE Transactions on Visualization and Computer Graphics, vol. 24, no. 1, pp. 215–225, 2018.
6. N. Jayaram, S. Goyal, and C. Li, "VIIQ: Auto-Suggestion Enabled Visual Interface for Interactive Graph Query Formulation," Very Large Data Base, vol. 8, no. 12, pp. 1940–1943, 2015.
7. E. Cuenca, A. Sallaberry, D. Ienco, and P. Poncelet, "VERTIGO: a Visual Platform for Querying and Exploring Large Multilayer Networks," IEEE Transactions on Visualization and Computer Graphics, vol. 28, no. 3, pp. 1634–1647. 2022.

VERTIGO: a Visual Platform for Querying and Exploring Large Multilayer Networks

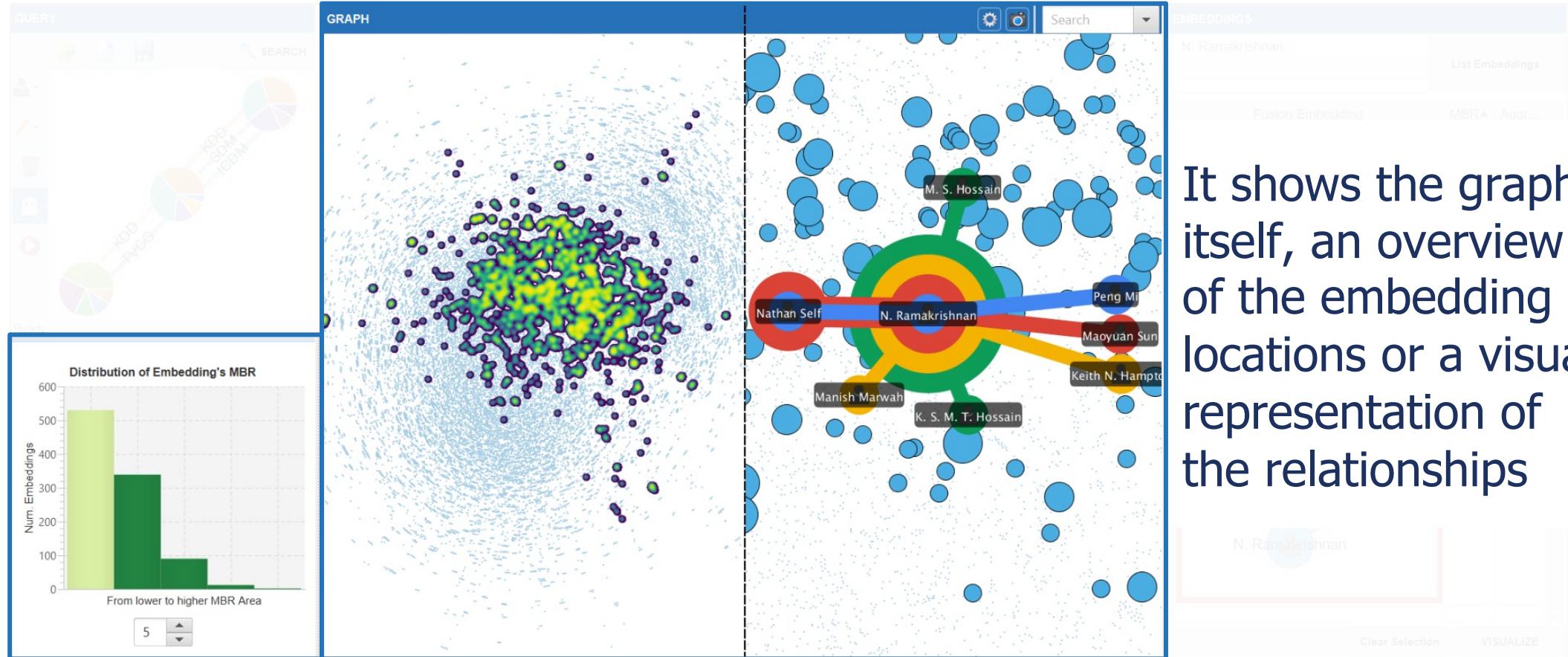


VERTIGO

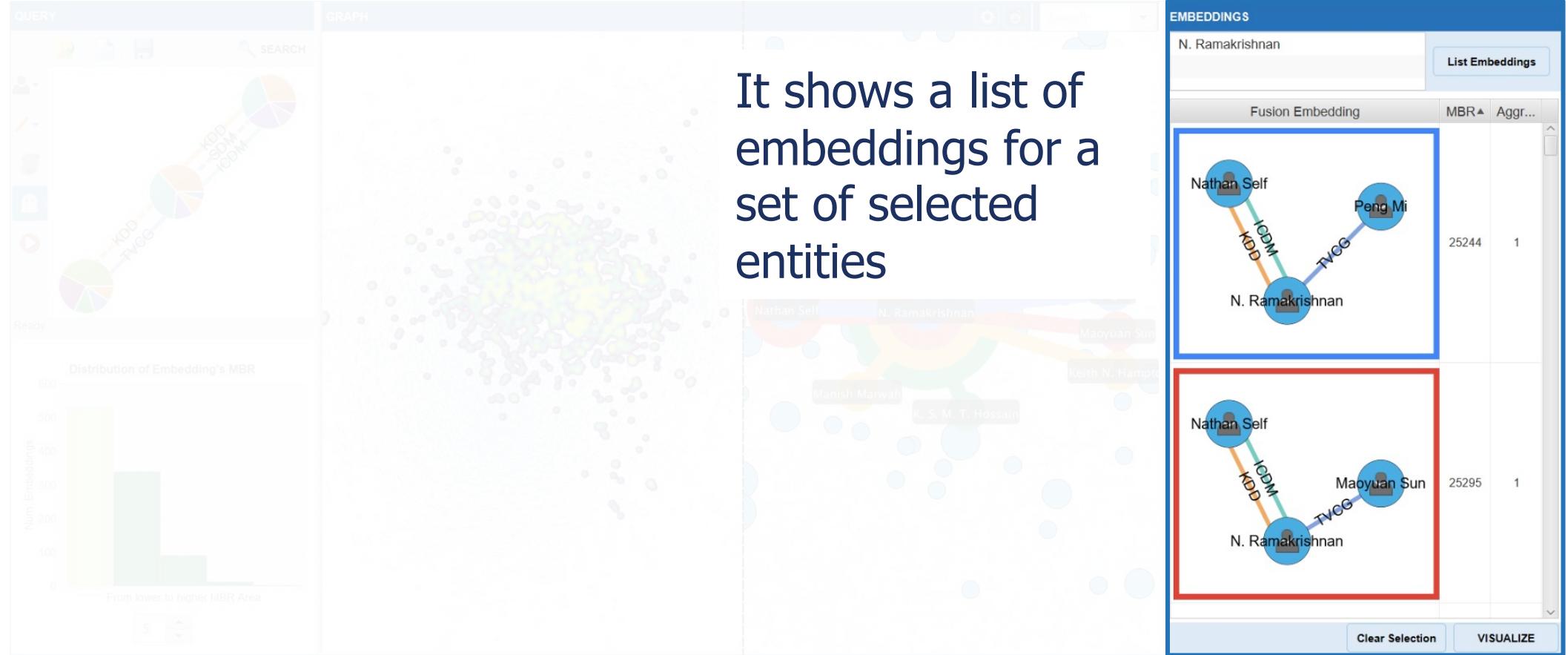
The query view



The graph view



The embeddings view



Demonstration

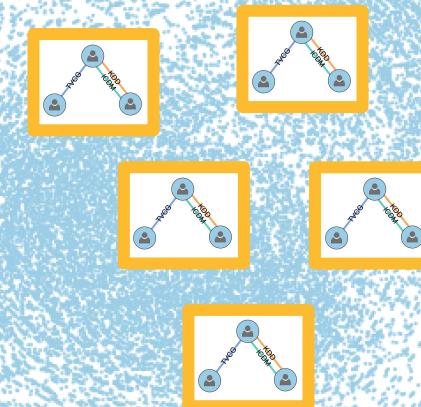
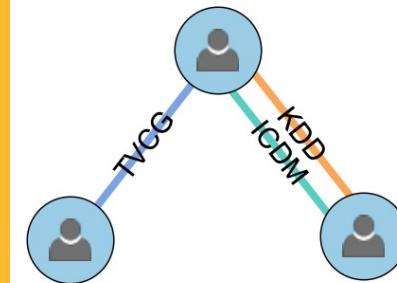
Co-authorship multilayer network (dblp)

- $\approx 38k$ nodes (authors)
- $\approx 130k$ edges (co-authorship)
- 18 layers (edges types)
 - Venues of VIS and DM fields



Pattern

Authors who act as links between the VIS and DM communities

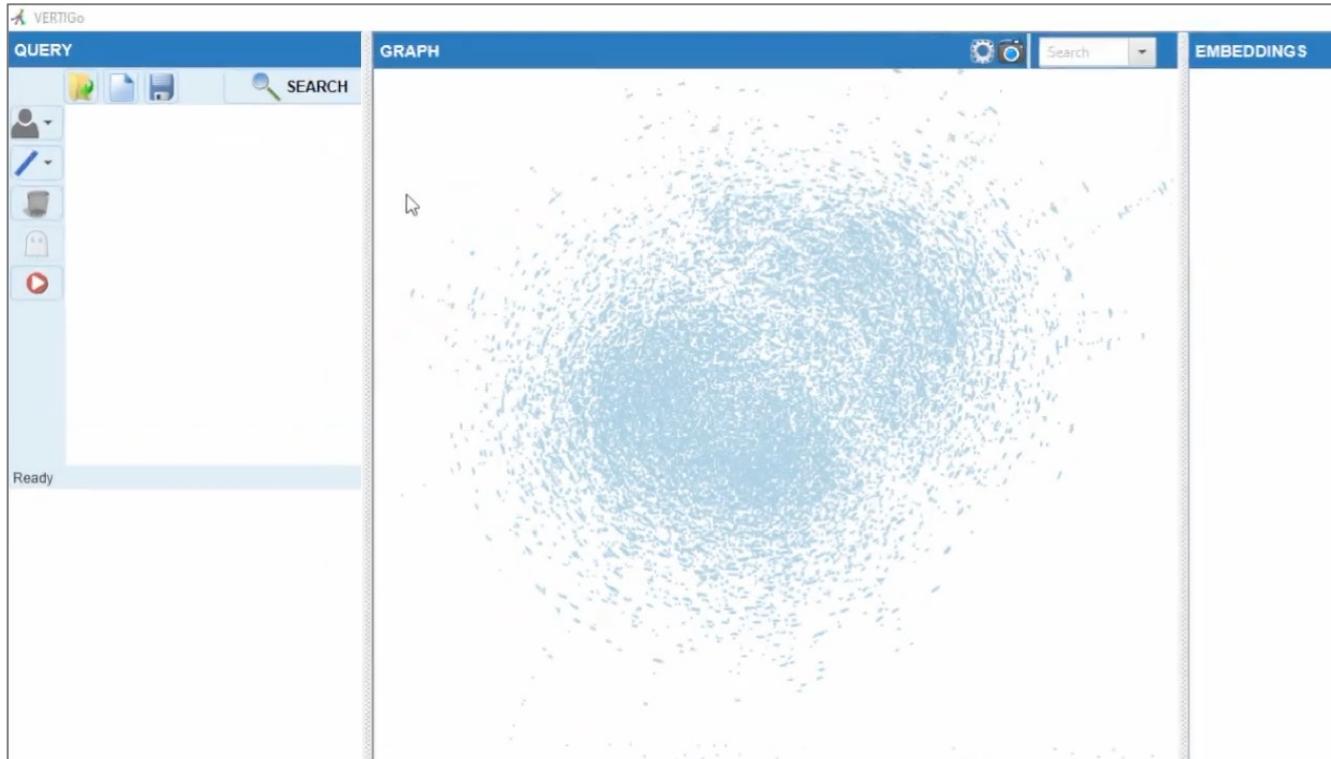


Query construction

Results visualization

Results exploration

Query suggestion



The **query view** supports:

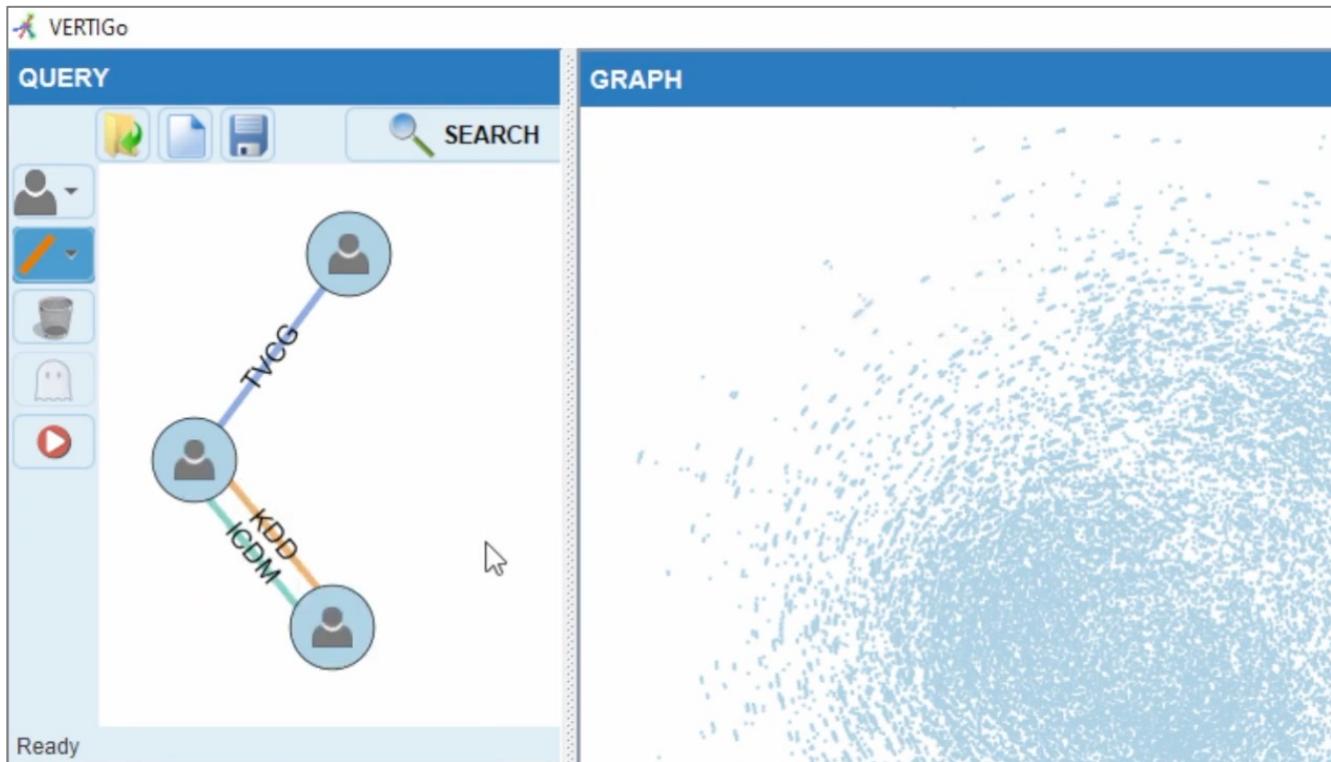
- Add multiple node types
- Add multiple edge types
- Specify a node attribute value
- Build standard and multilayer graph structures

Query construction

Results visualization

Results exploration

Query suggestion



- VERTIGO interacts with the query engine (SuMgra*) to explore the results (embeddings)
- The process can be **started, paused, and resumed** at any time

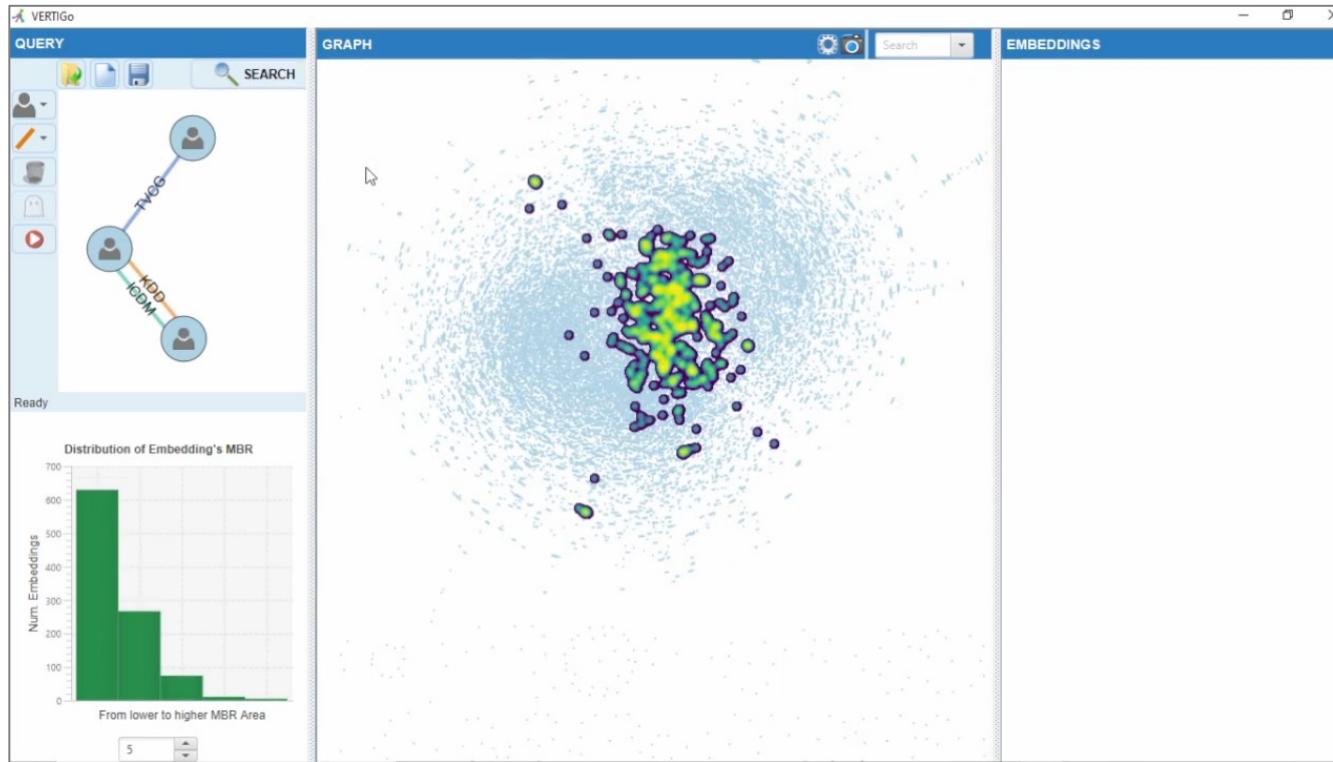
* [Vijay Ingallali, Dino Ienco, and Pascal Poncelet. SuMgra: Querying Multigraphs via Efficient Indexing. In Proceedings of the International Conference on Database and Expert Systems Applications (DEXA), pages 1-15. Springer, 2016]

Query construction

Results visualization

Results exploration

Query suggestion



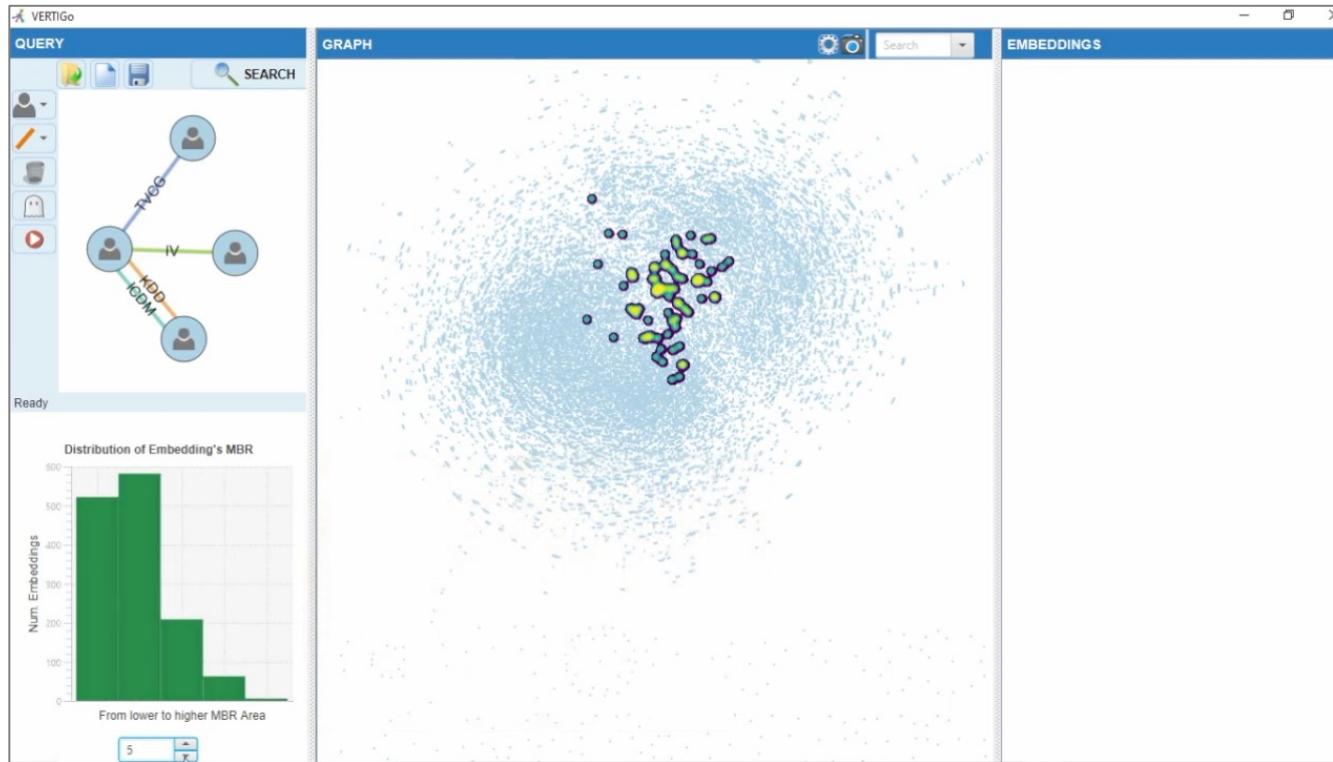
- VERTIGO suggests extensions of the query from the underlying graph
 - It guides the user in the incremental construction of a query
- Suggested edges:
 - Internal: dashed lines
 - External: slices pie charts

Query construction

Results visualization

Results exploration

Query suggestion



- A histogram shows the distribution of embeddings by n ranges of their Minimum Bounding Rectangle (MBR)
 - Filter embedding results by MBR values
- The **graph view** allows users to focus on a selected area

Query construction

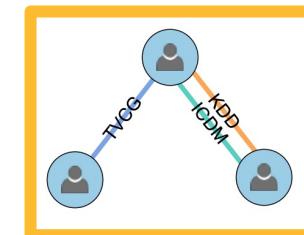
Results visualization

Results exploration

Query suggestion

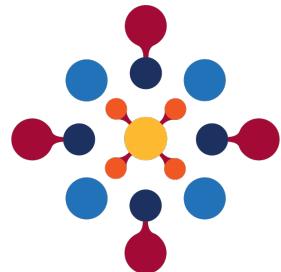


- The **embedding view** shows the *fusion embeddings* associated with the selected nodes:
- **Kelp-based visualization** associated with the selected fusion embeddings



In summary

- VERTIGO supports tasks commonly involved in the visual query process
 - Query Construction, Visualization and Exploration of Query Results, and Query suggestion
- VERTIGO interacts with the search engine
 - Allows to start, pause, and resume the query engine
- VERTIGO combines visual component and interactions to analyze the results at different levels of detail



VIS2022

VERTIGO 

<http://advanse.lirmm.fr/vertigo/>



Video, source code

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