



VIS 2022

VERTIGo

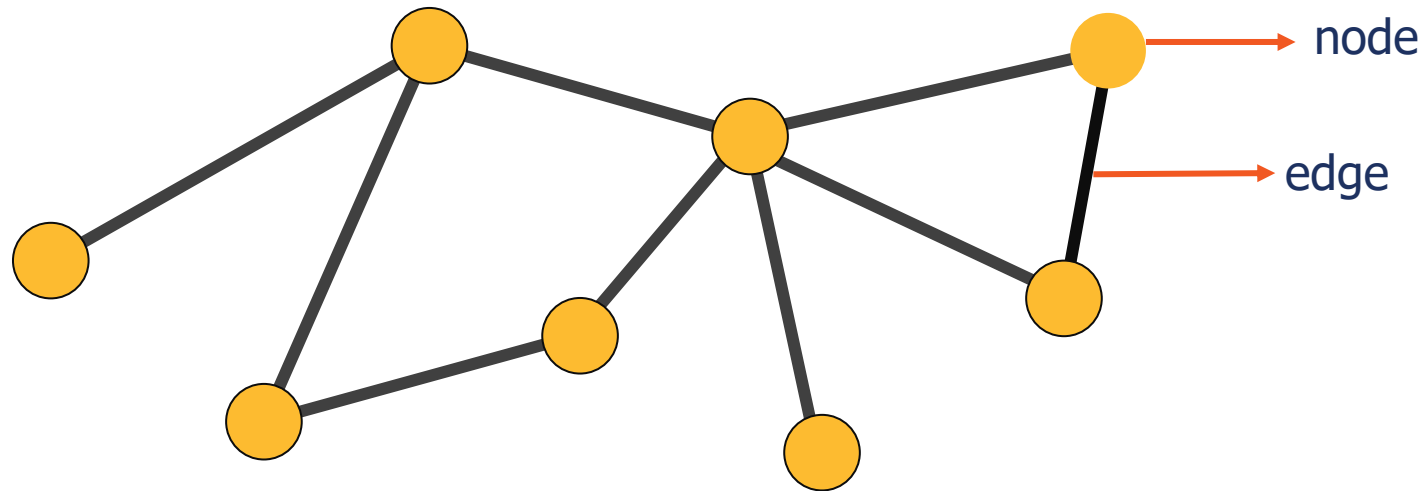
A Visual Platform for Querying and Exploring Large Multilayer Networks

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



Graphs (networks)

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



Graphs capture relations

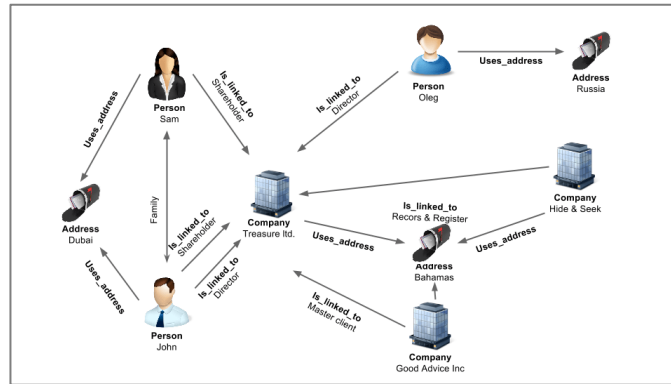
Graphs (networks) examples

Graphs in many domains

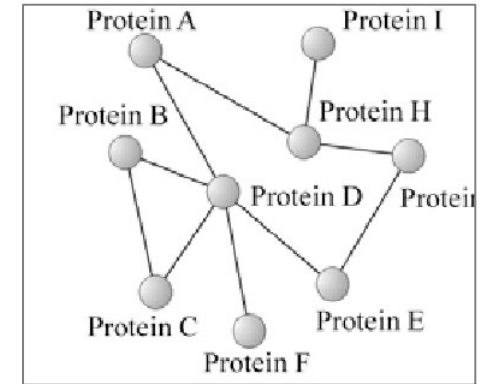
(1) Social network



(2) Offshore leak network

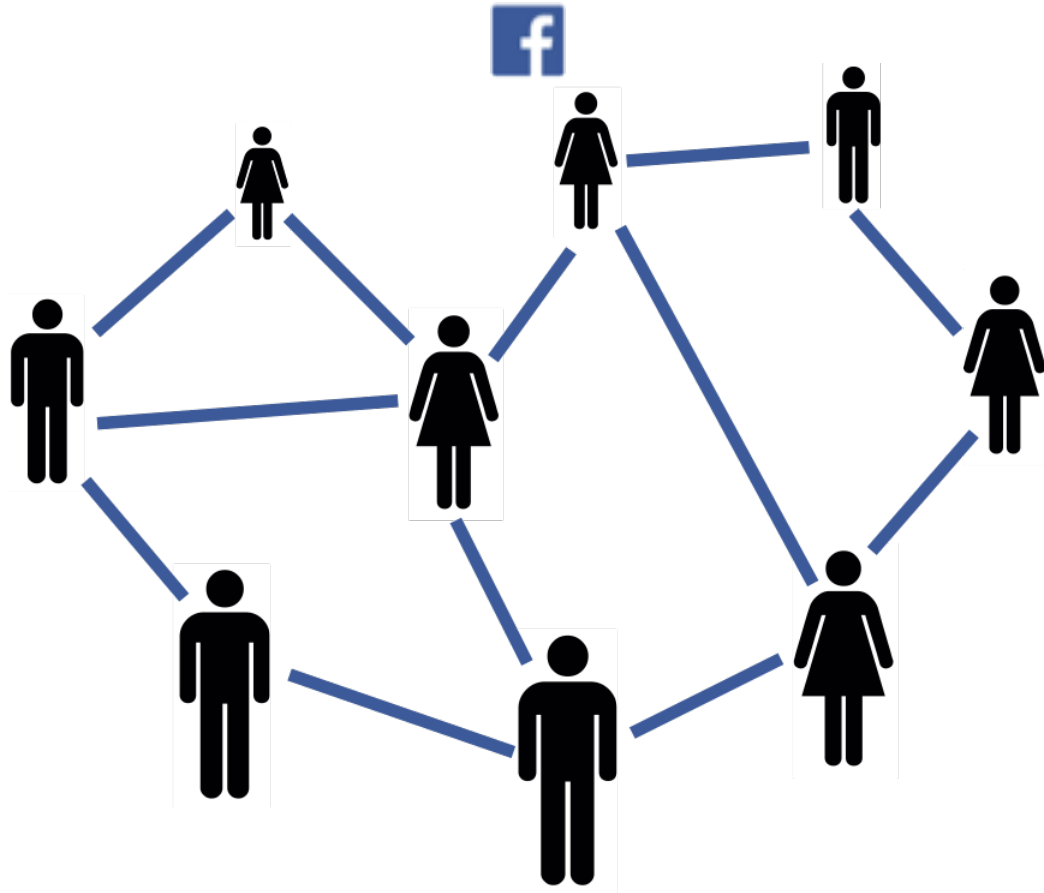


(3) Biological network



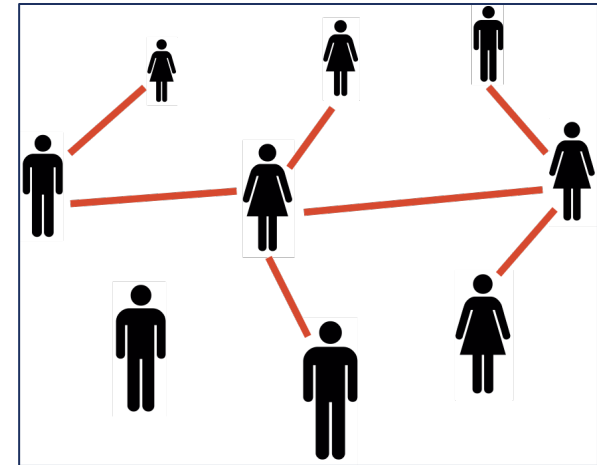
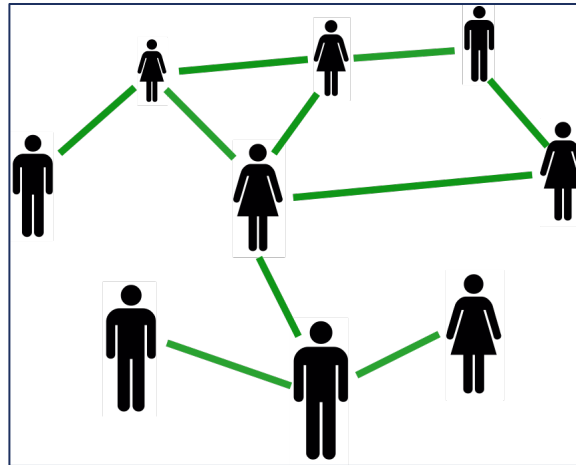
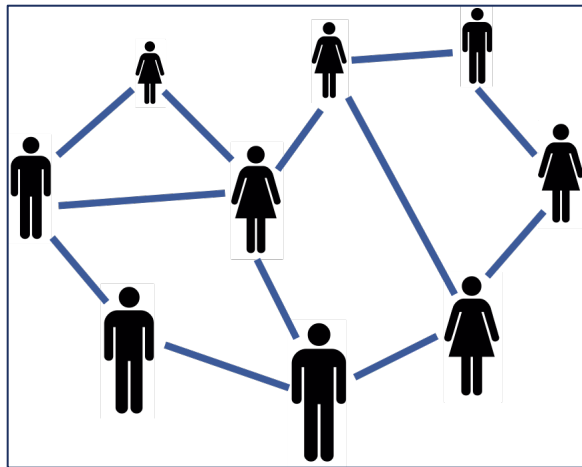
1. <https://medium.com/analytics-vidhya/social-network-analytics-f082f4e21b16>
2. <https://linkurious.com/blog/analysing-the-offshore-leaks-with-graphs/>
3. https://www.researchgate.net/publication/228925315_Complex_networks_The_key_to_systems_biology/figures?lo=1&utm_source=google&utm_medium=organic

A social network



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

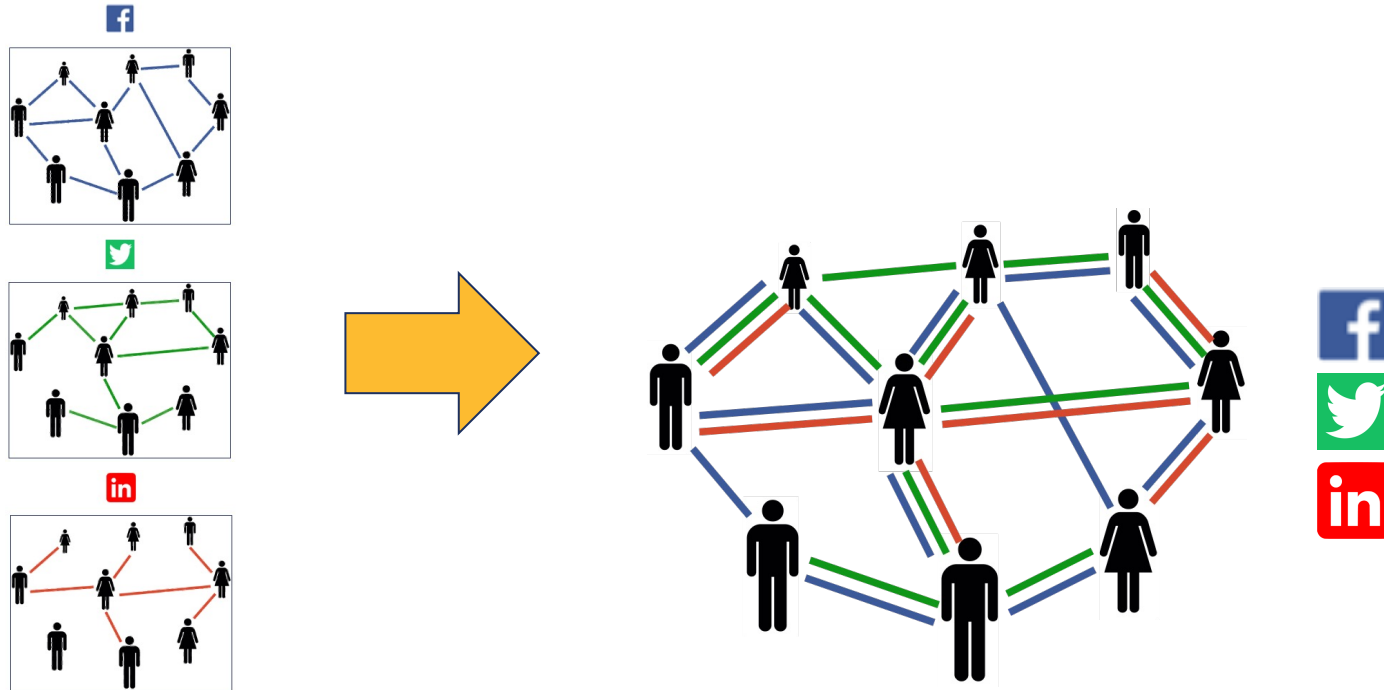
Various social networks



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

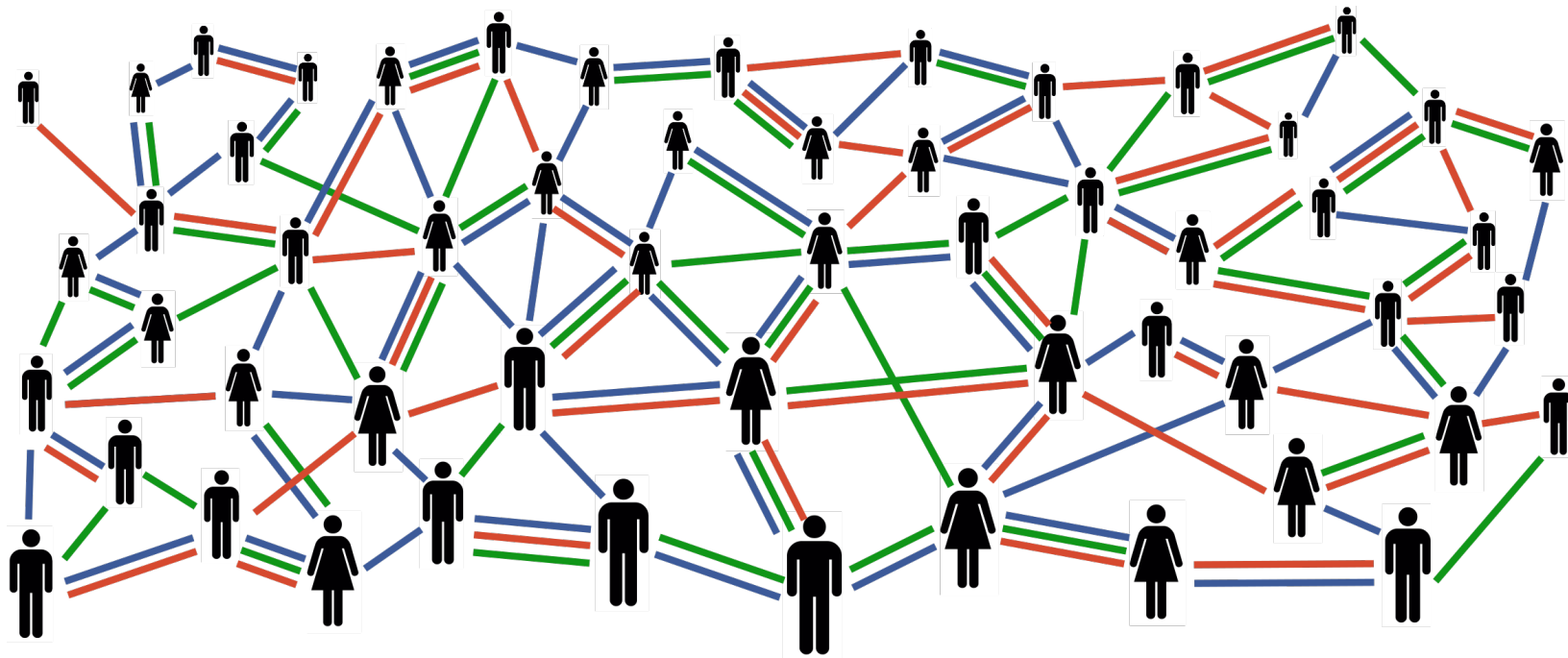
Multilayer graphs

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

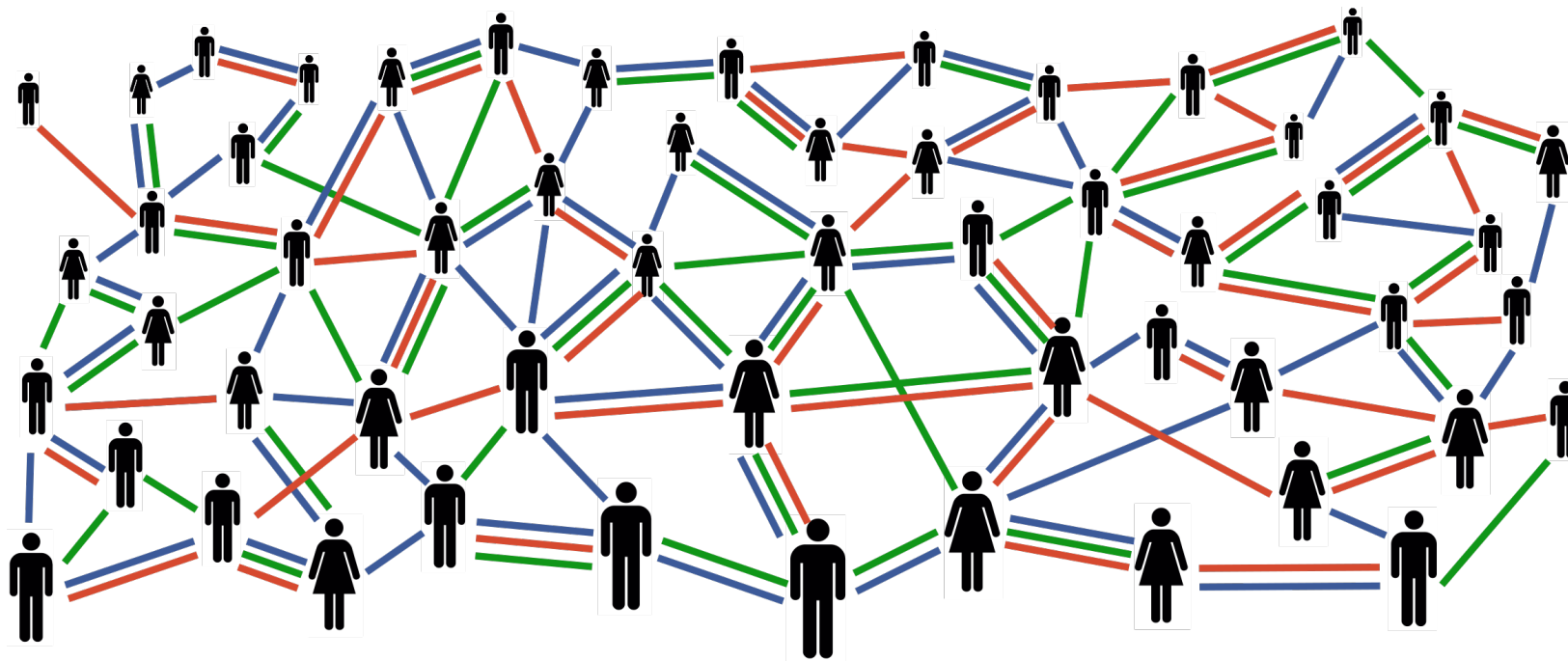


How to facilitate the **extraction** of knowledge from large multilayer graphs?

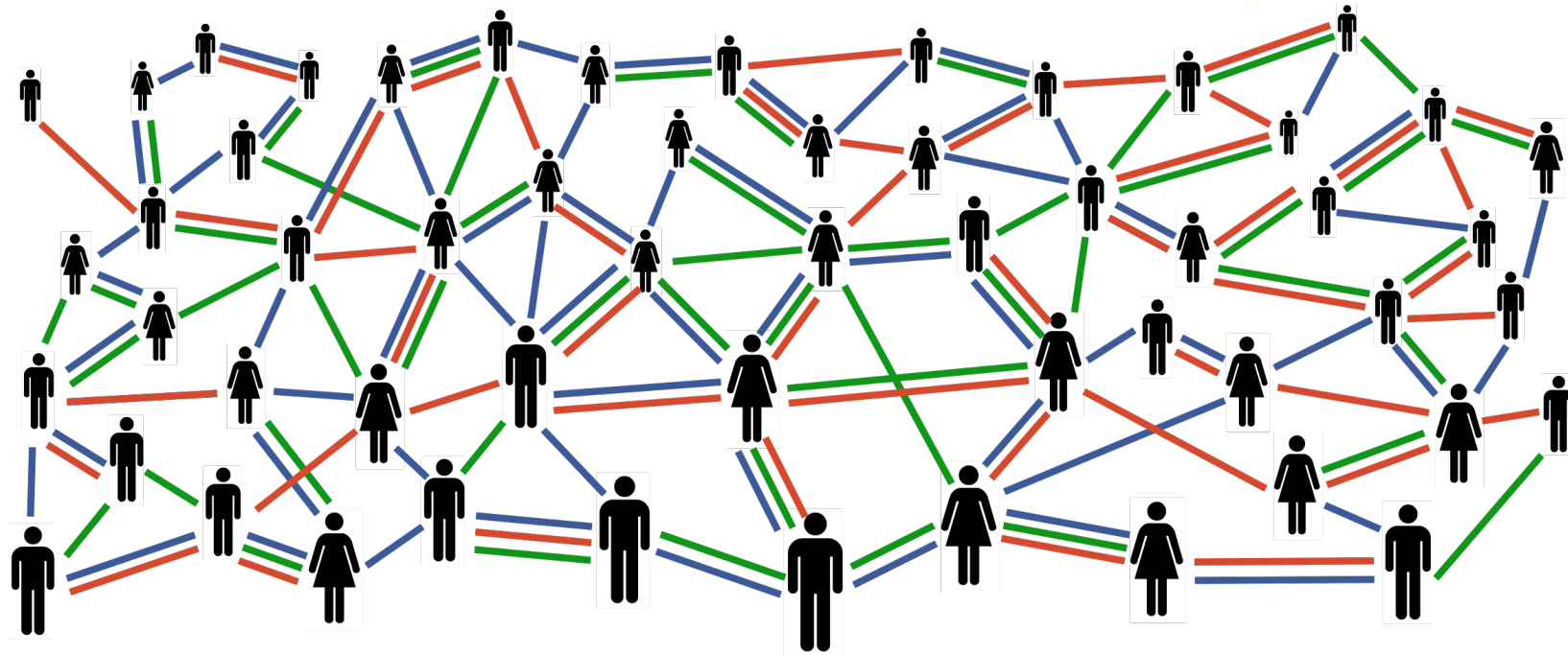
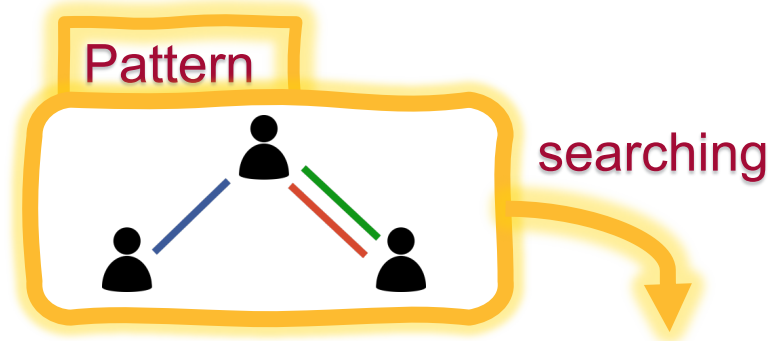


Subgraph matching (search a pattern)

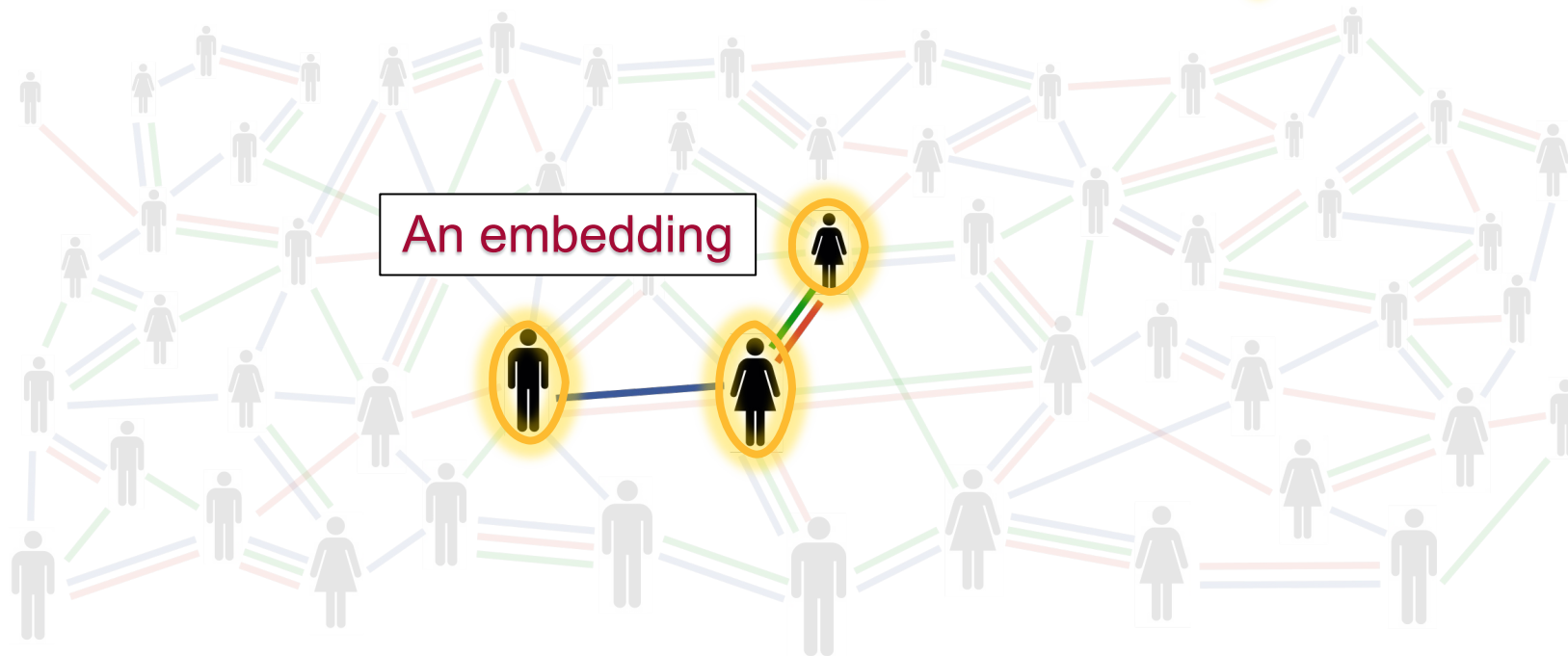
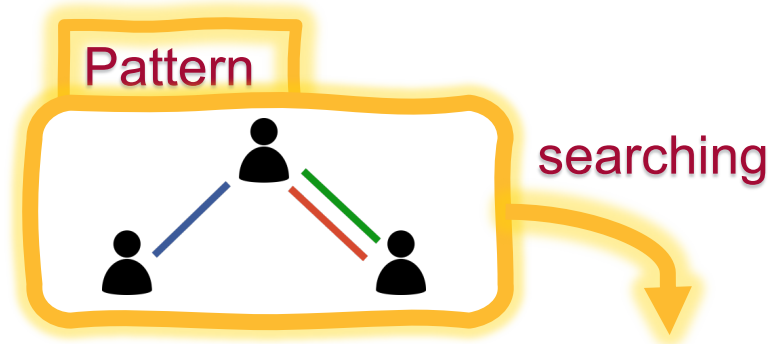
All occurrences of a subgraph are searched on the target multilayer graph



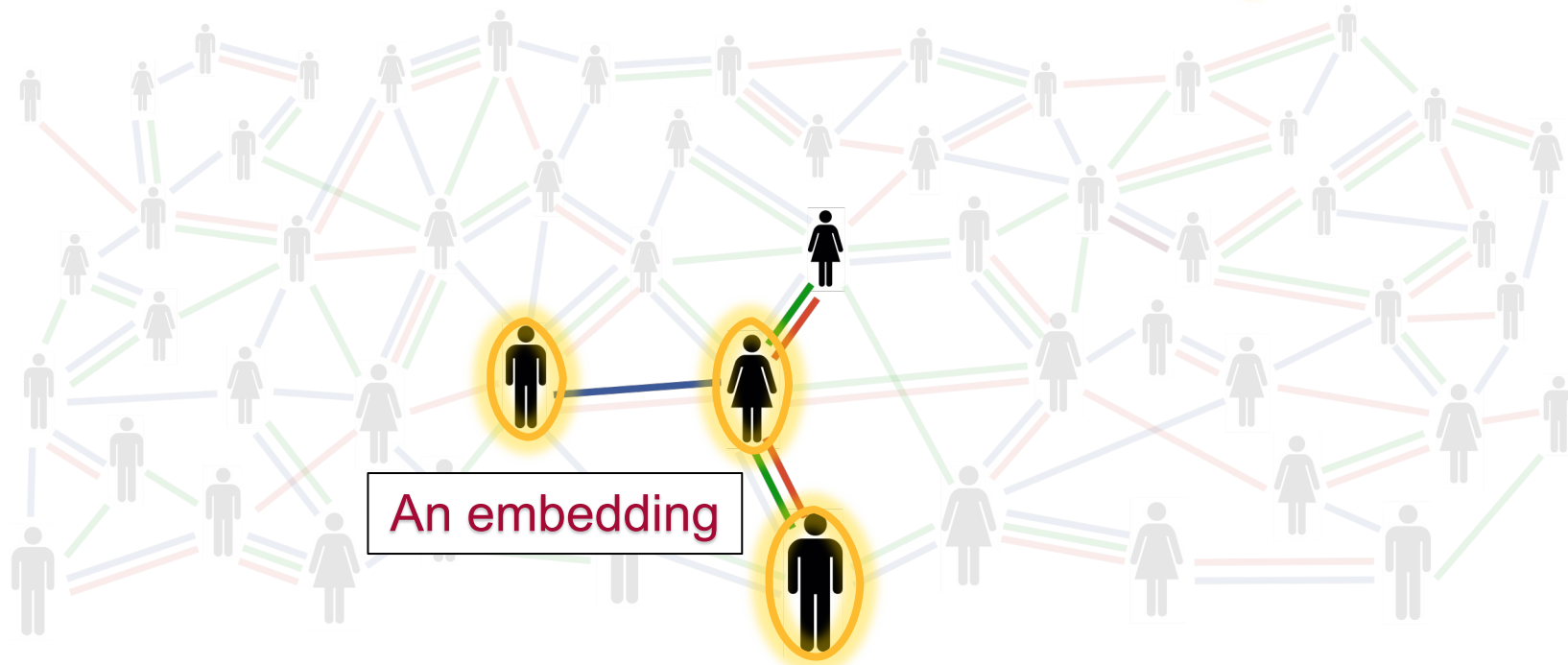
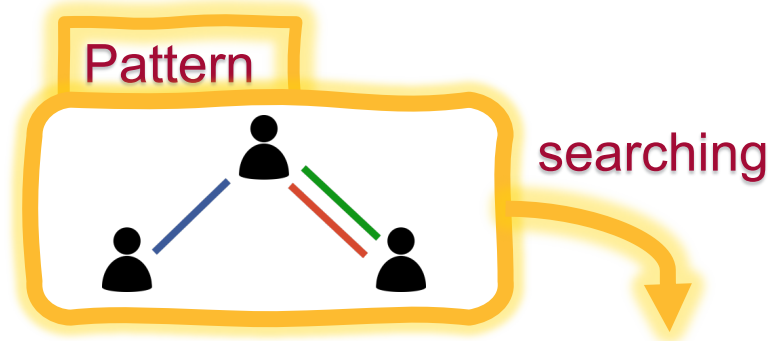
Subgraph matching



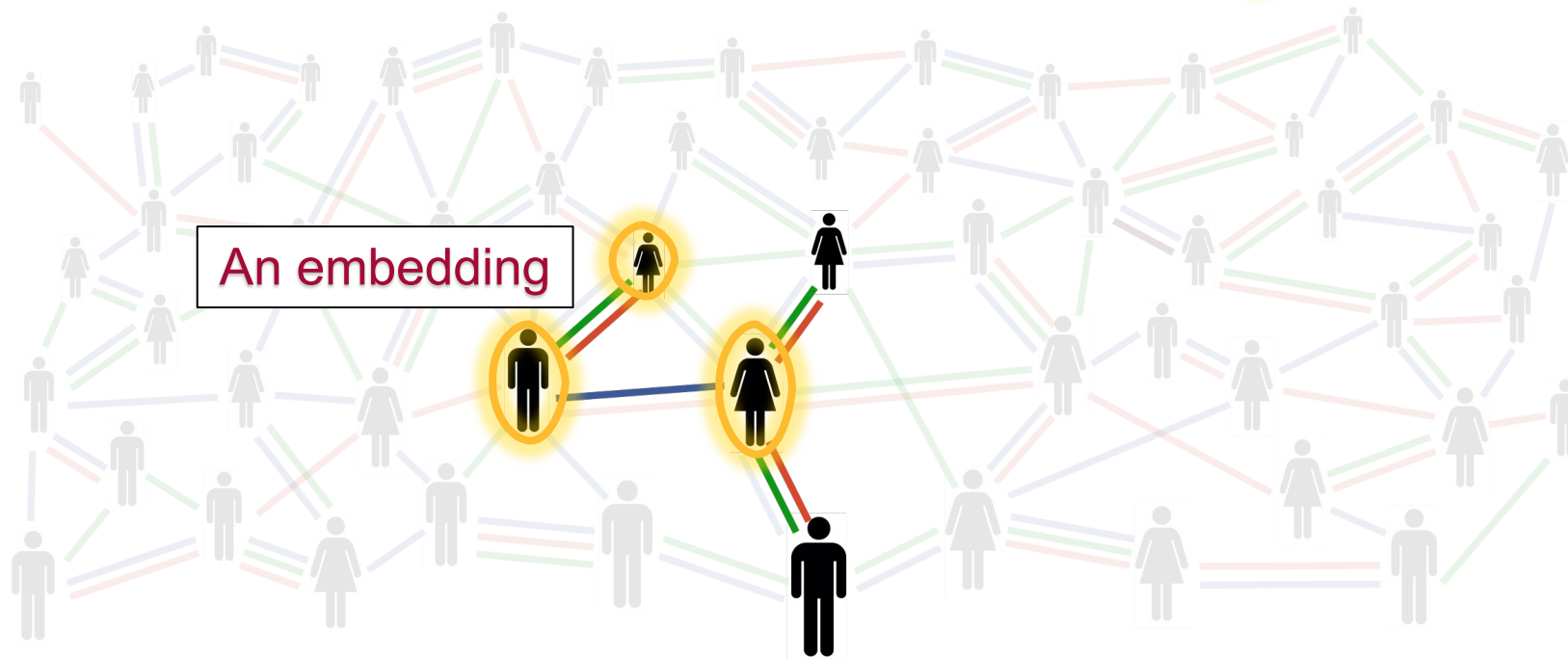
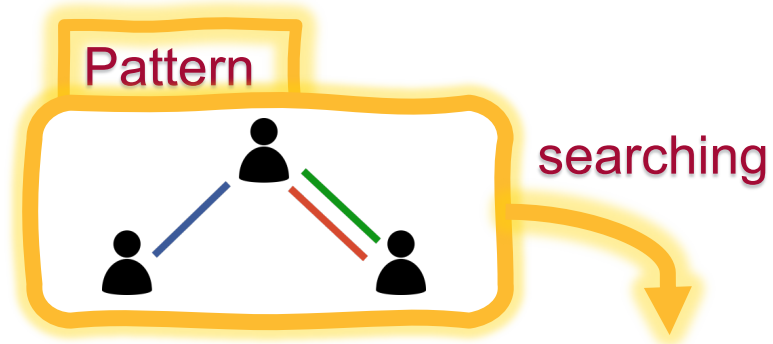
Subgraph matching



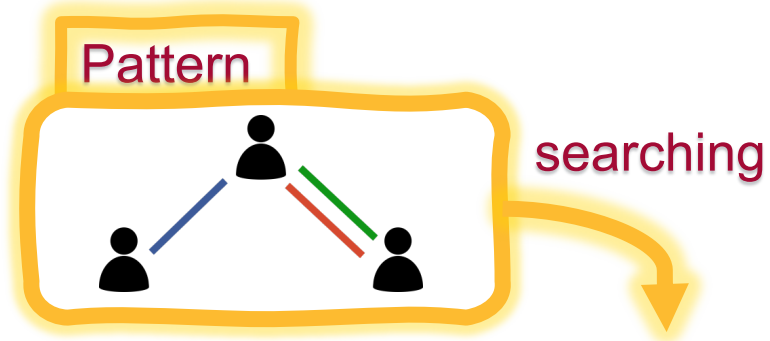
Subgraph matching



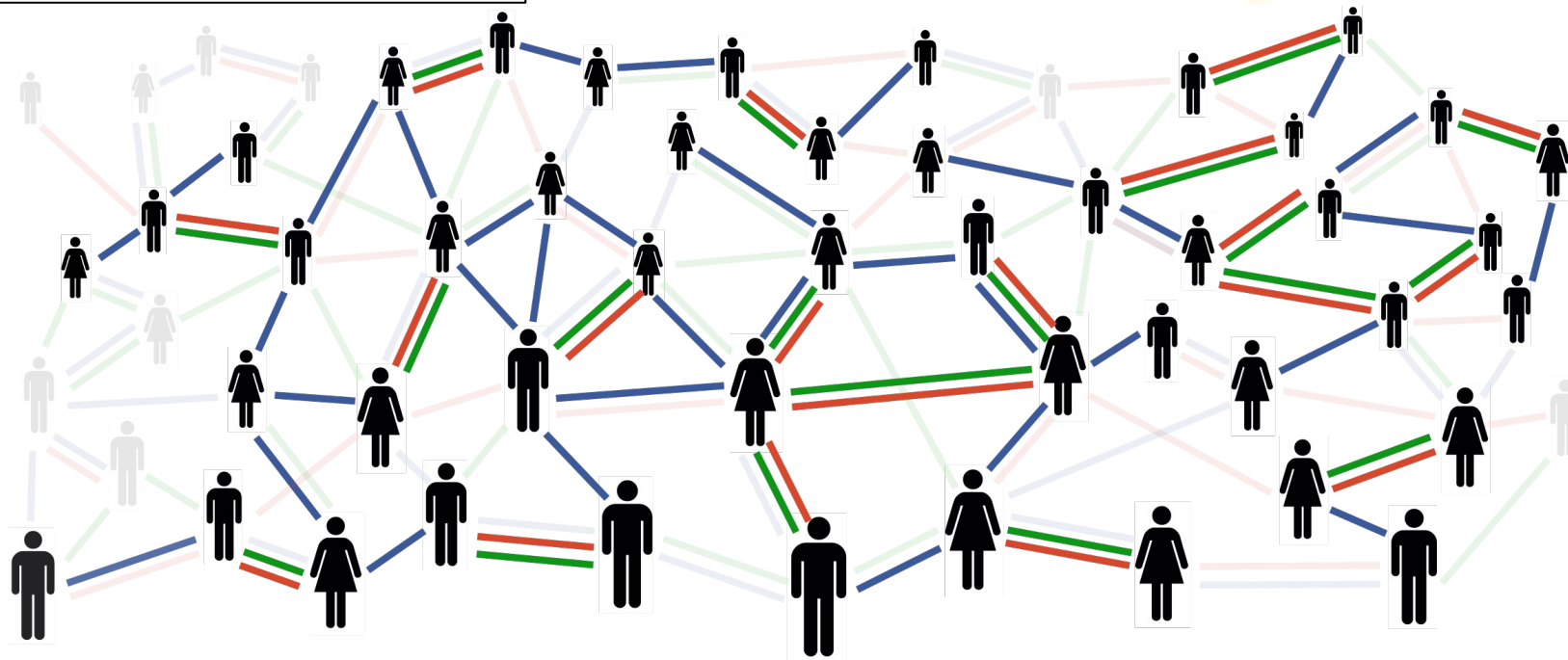
Subgraph matching



Subgraph matching



Several embedding results



Visual Graph Query Processing Tasks

Task

Query construction

How to design the query?

Results visualization

How to visualize the results of
the query?

Results exploration

How to explore the query
results?

Query suggestion

How to suggest new queries?

Visual Graph Query Processing Tasks

Task

Query construction

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How to visualize the results of the query?

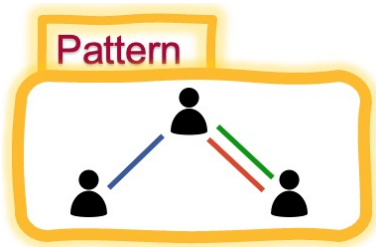
Results exploration

How to explore the query results?

Query suggestion

How to suggest new queries?

- Visual interface



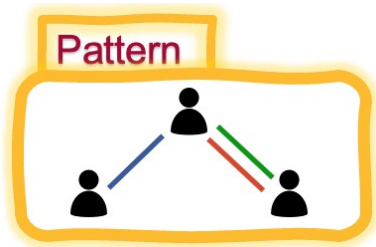
Visual Graph Query Processing Tasks

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How to design the query?

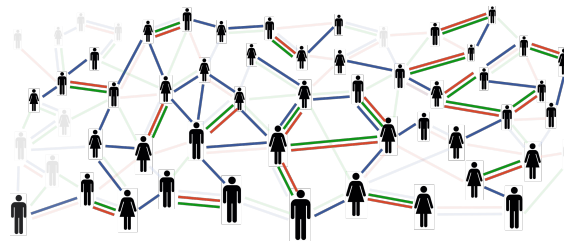
- Visual interface



Results visualization

How to visualize the results of the query?

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



Results exploration

How to explore the query results?

Query suggestion

How to suggest new queries?

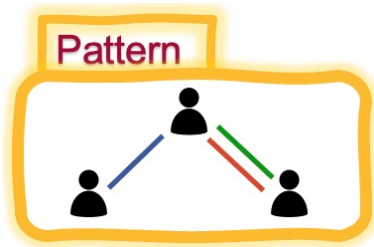
Visual Graph Query Processing Tasks

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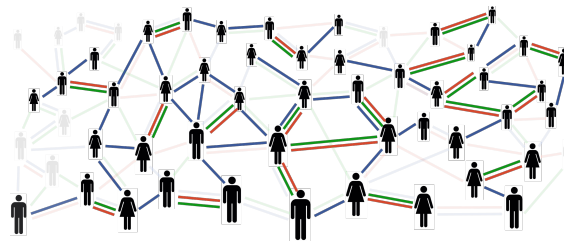
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Results visualization

How to visualize the results of the query?

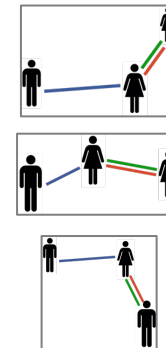
- Suitable graph visualization and multilayer query engine
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Results exploration

How to explore the query results?

- Visualizations and interactions to explore the results at different levels of details: overview -> details



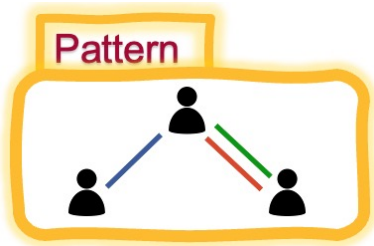
Visual Graph Query Processing Tasks

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Query construction

How to design the query?

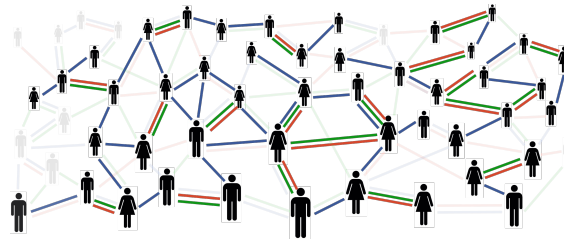
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Results visualization

How to visualize the results of the query?

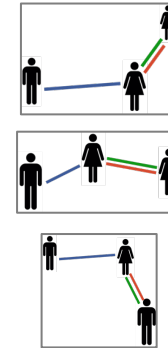
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Results exploration

How to explore the query results?

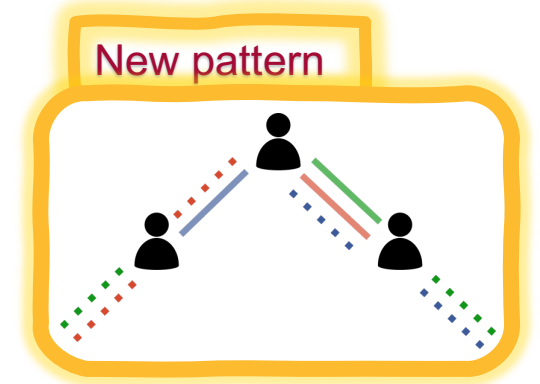
- Visualizations and interactions to explore the results at different levels of details: overview -> details



Query suggestion

How to suggest new queries?

- Suggest new edges to the initial query
- Refine the query iteratively



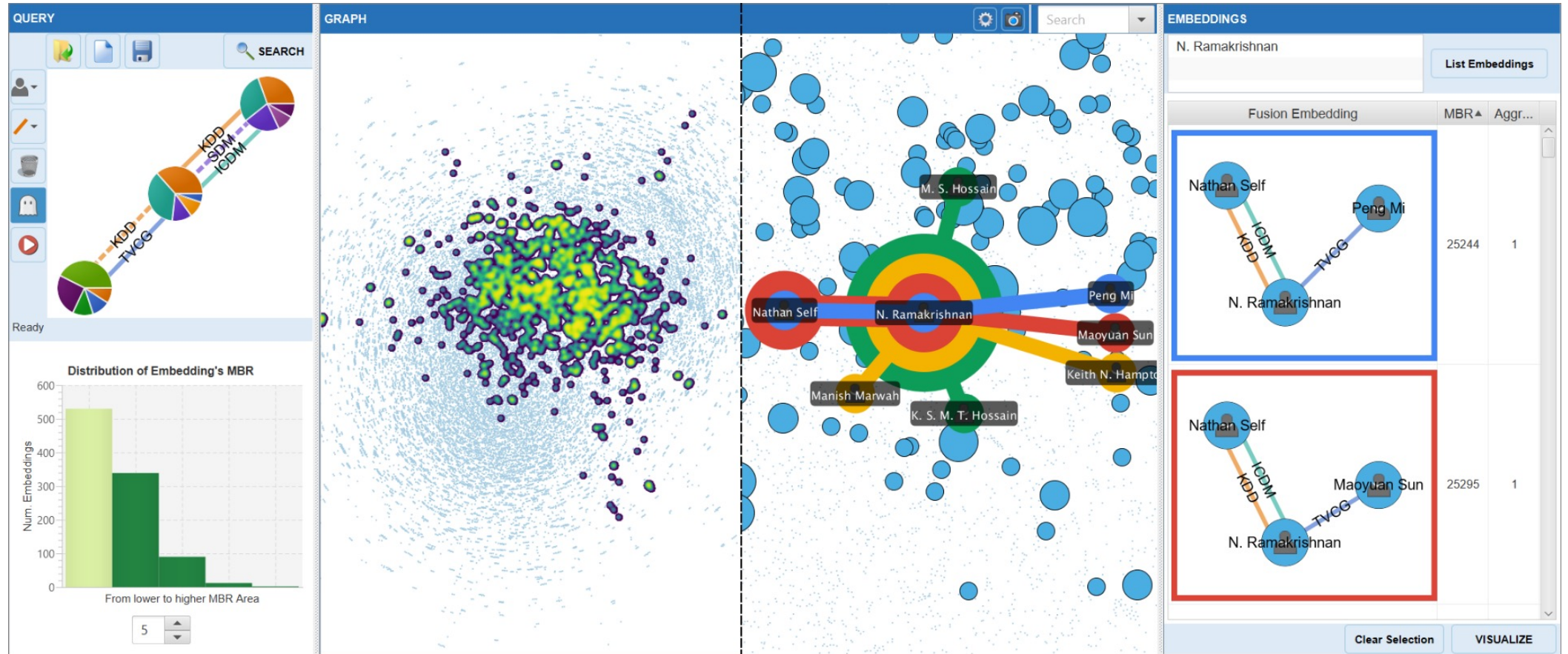
Visual Graph Query Processing Tasks

Task

Approach	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

It allows the users to build the query and start the process to retrieve the results (embeddings)

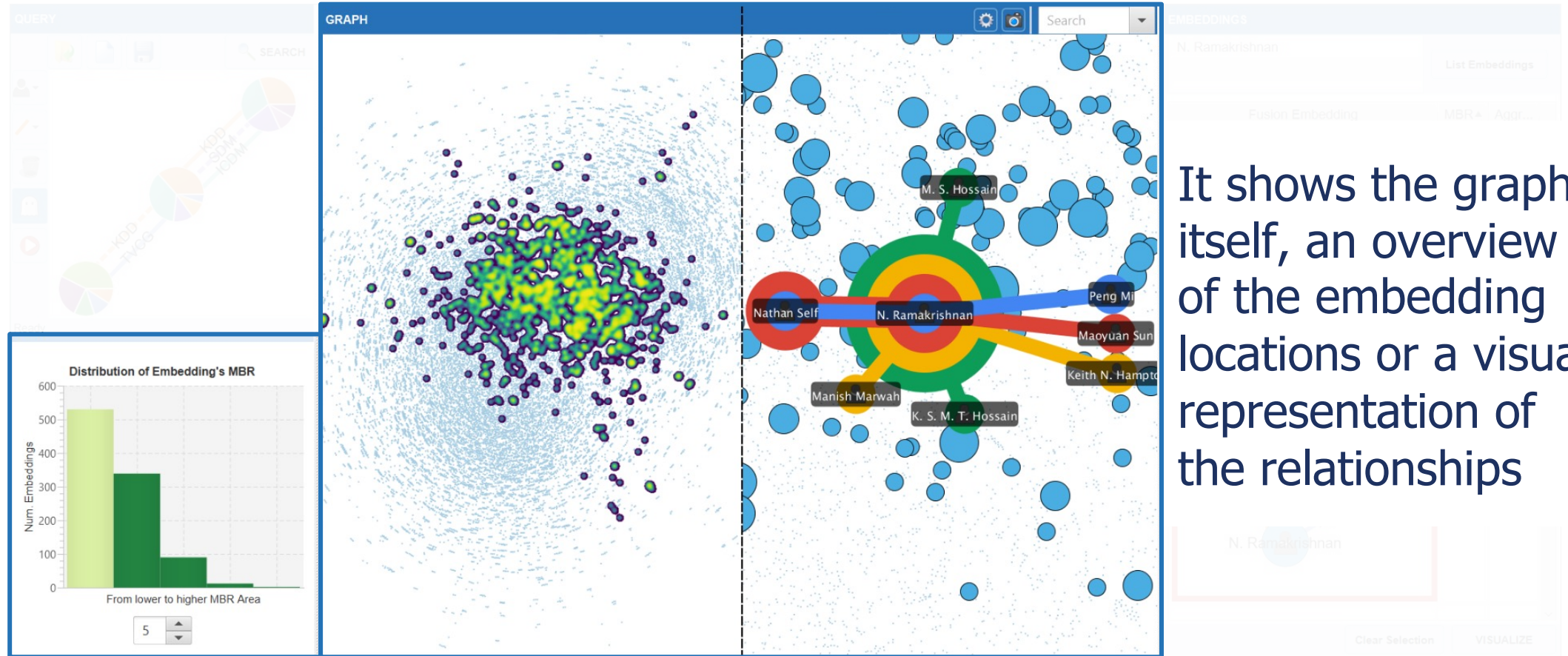
The screenshot displays the VERTIGo interface with three main panels:

- QUERY:** A panel on the left with a toolbar (SEARCH, icons for home, file, save, user, edit, trash, ghost, play) and a query graph. The graph shows a sequence of nodes: KDD, TWGG, KDD, SDM, ICDM, KDD. Below the graph is a histogram titled "Distribution of Embedding's MBR" showing the number of embeddings (0 to 600) across different MBR areas. A dropdown menu is set to "5".
- GRAPH:** A central panel showing a network graph with nodes and edges. Nodes are labeled with names like Nathan Self, N. Ramakrishnan, Manyuan Sun, Keith N. Hampt, Manish Marwal, and S. S. M. T. Hossain.
- EMBEDDINGS:** A panel on the right showing a table of embeddings. The table has columns for "Fusion Embedding", "MBR+", and "Aggr...". Two rows are visible, each with a graph visualization of the query path and corresponding MBR and Aggr values.

Fusion Embedding	MBR+	Aggr...
	25244	1
	25295	1

VERTIGo

The graph view



It shows the graph itself, an overview of the embedding locations or a visual representation of the relationships

The embeddings view



Demonstration

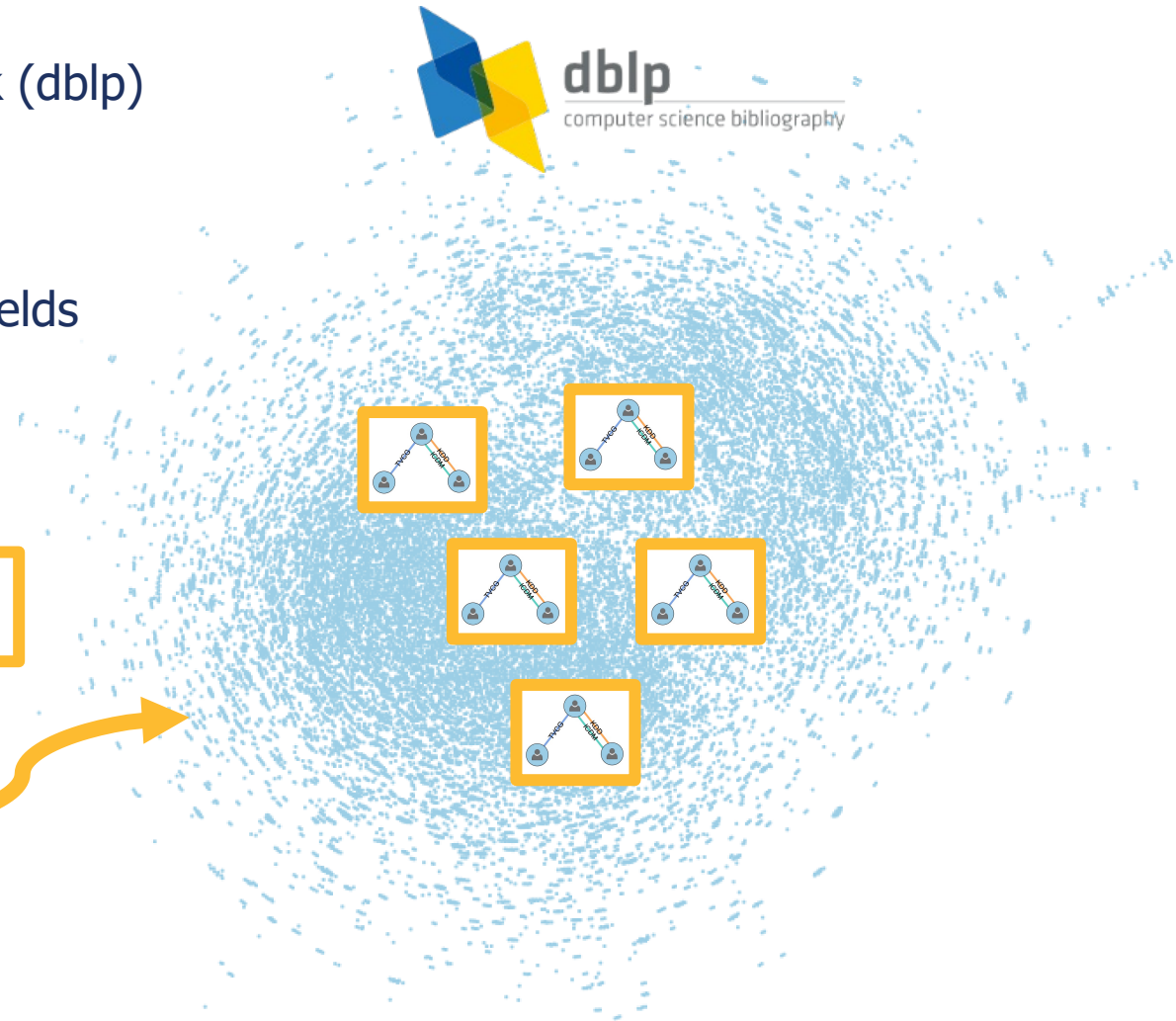
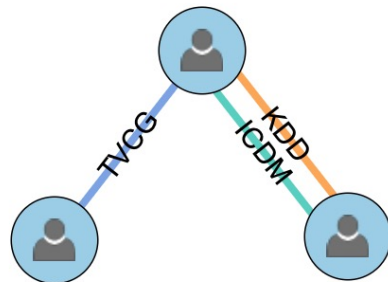
Co-authorship multilayer network (dblp)

- $\approx 38k$ 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

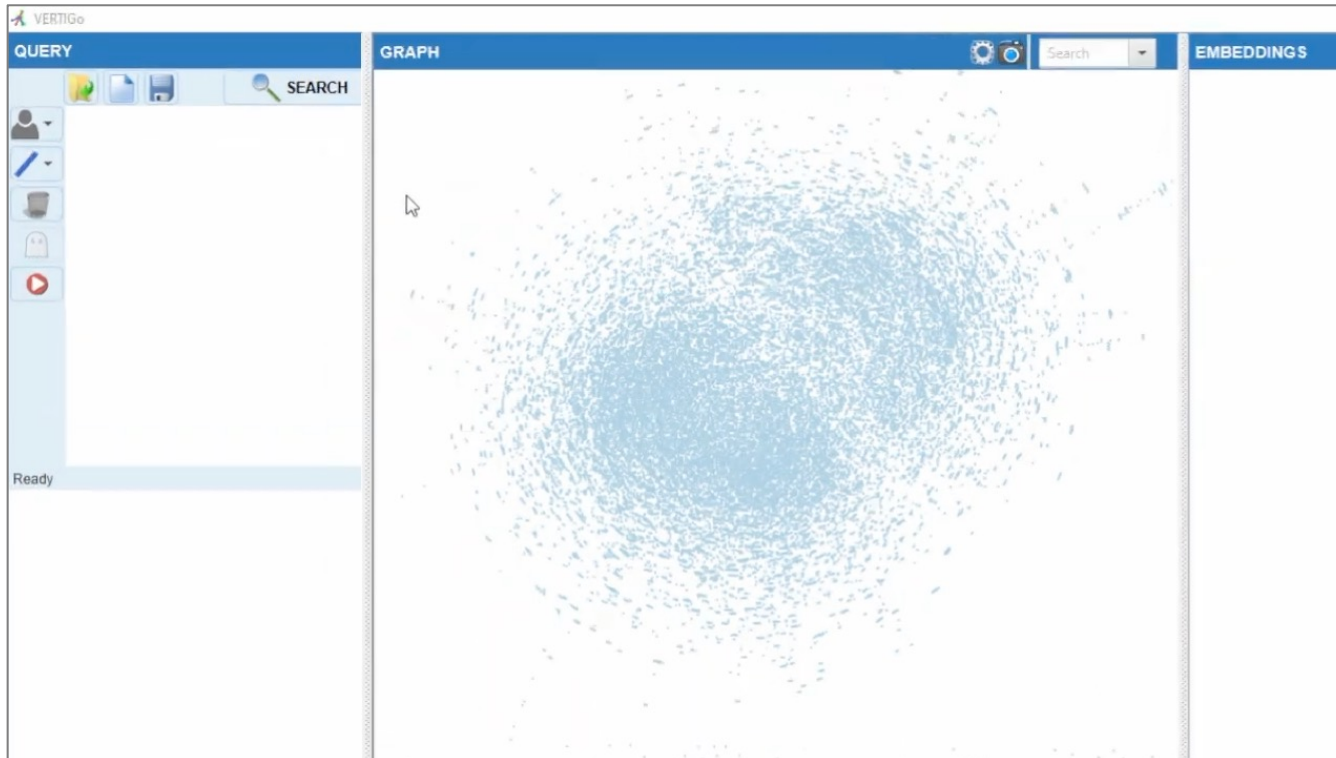


Query
construction

Results
visualization

Results
exploration

Query
suggestion



The **query view** supports:

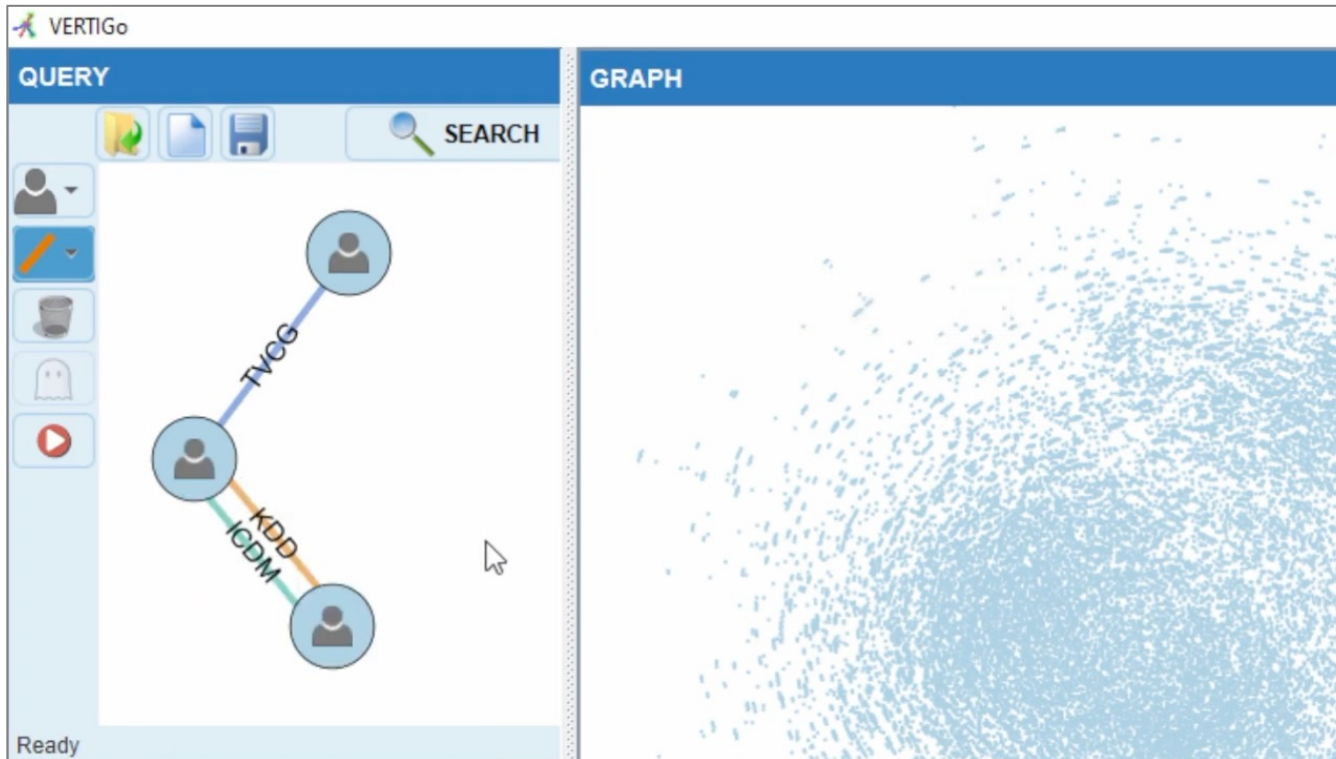
- Add multiple node types
- Add multiple edge types
- Specify a node attribute value
- Build standard and multilayer graph structures

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

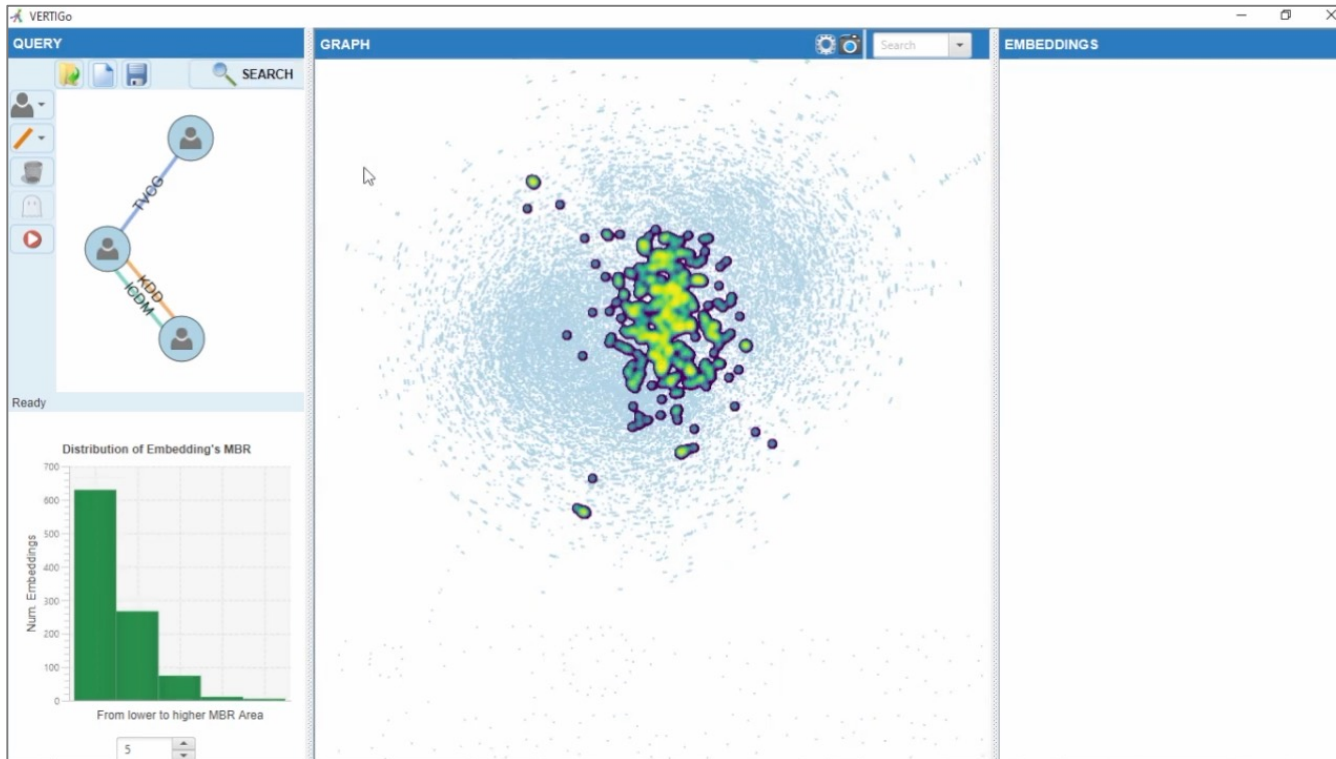
* [Vijay Ingallli, Dino Ienco, and Pascal Poncelet. SuMGra: Querying Multigraphs via Efficient Indexing. In Proceedings of the International Conference on Database and Expert Systems Applications (DEXA), pages 1-15. Springer, 2016]

Query
construction

Results
visualization

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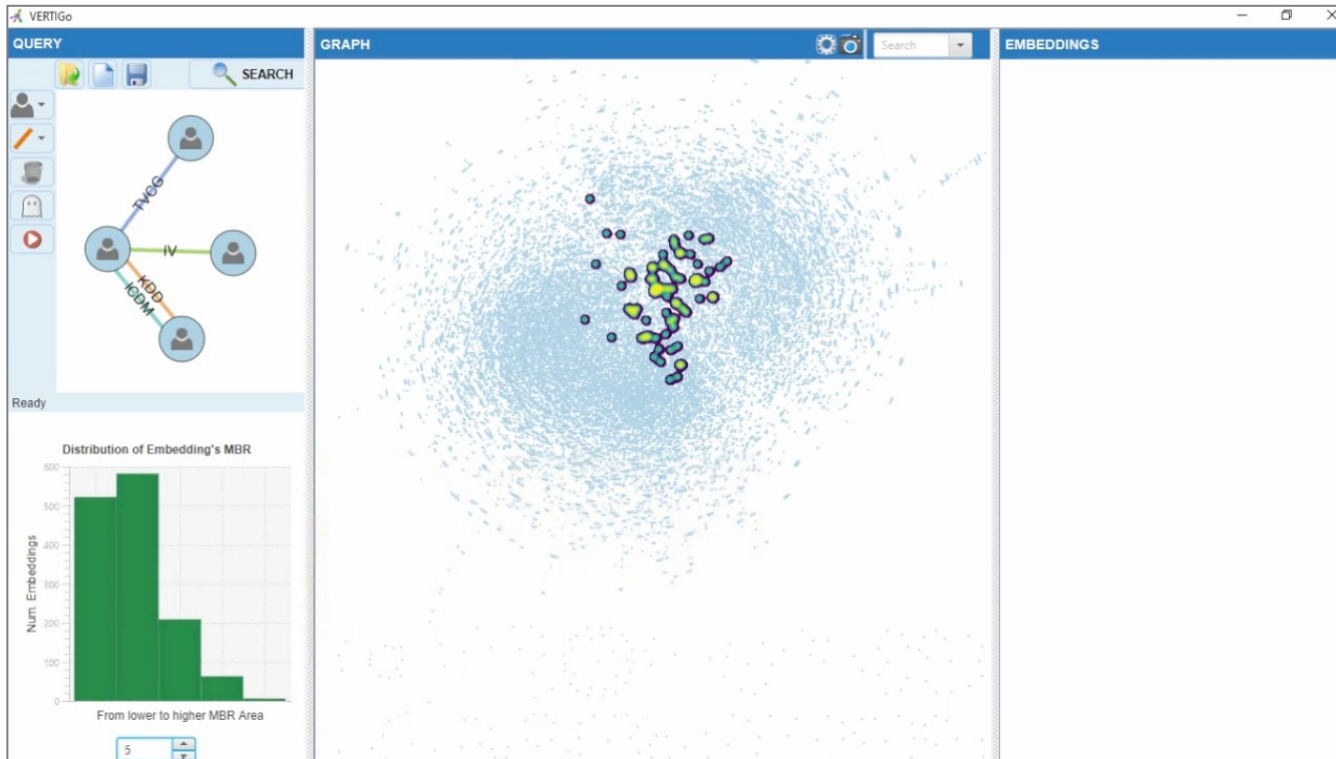
- VERTIGo suggests extensions of the query from the underlying graph
 - It guides the user in the incremental construction of a query
- Suggested edges:
 - Internal: dashed lines
 - External: slices pie charts

Query
construction

Results
visualization

Results
exploration

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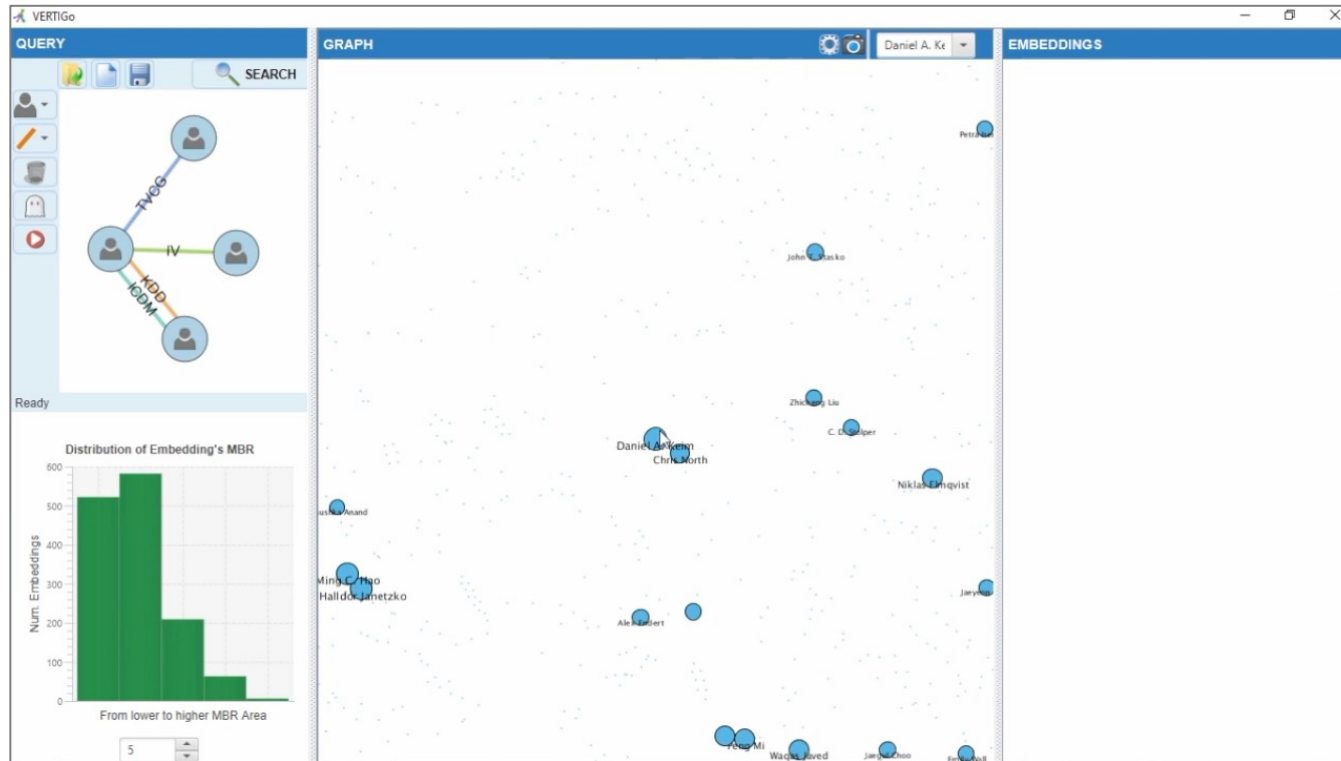
- A histogram shows the distribution of embeddings by n ranges of their Minimum Bounding Rectangle (MBR)
 - Filter embedding results by MBR values
- The **graph view** allows users to focus on a selected area

Query
construction

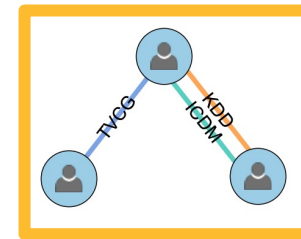
Results
visualization

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



VIS 2022

VERTIGo 

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



Video, source code

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[@erickedu85](https://twitter.com/erickedu85)

