VIGOR: Interactive Visual Exploration of Graph Query Results (VAST 2017)

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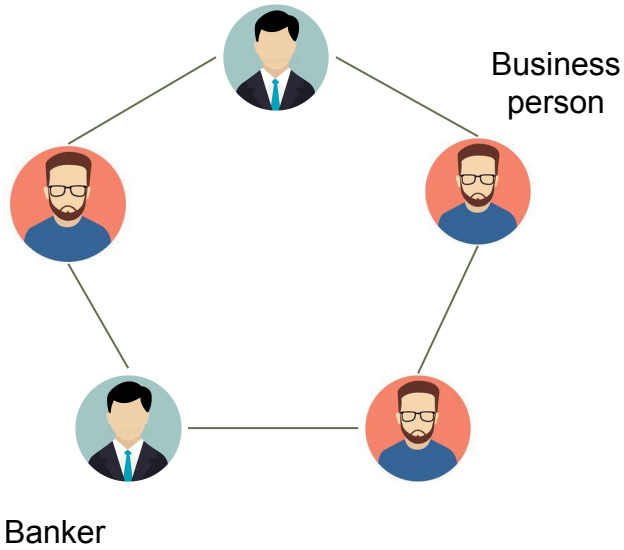
Outline

- Background
- Motivation
- VIGOR Interface Overview
- Design Rationale
- Methodology
- Experimental Results
- Pros/Cons
- Demo of the tool

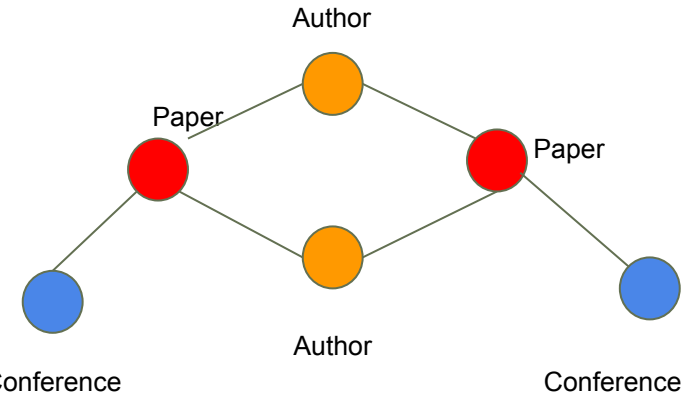
Background

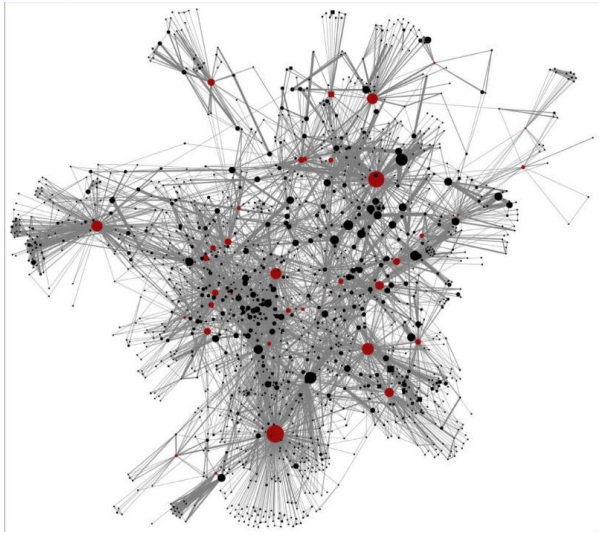
- What is graph querying?
- Why do we query graphs?
  - Detecting money laundering rings
  - Discovering near bipartite cores in auction fraud
  - Uncovering fraudulent near-clique reviews



Background

Analyst





Results: subgraph matches

Motivation

- Different node features
- Arbitrary user queries
- Large number of results
- Shared nodes and edges among the results

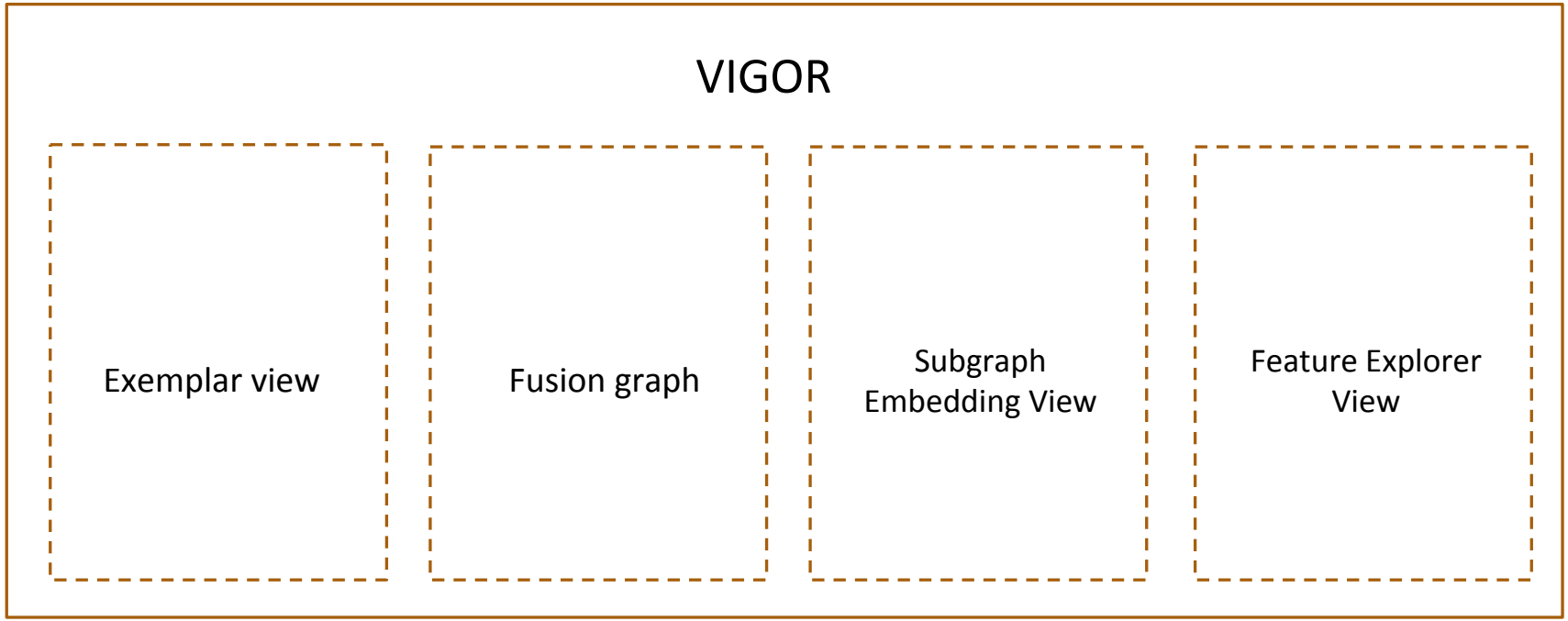
Cannot not help understand underlying patterns ⇒ Explainability

Cannot explore the result set ⇒ Interactive query expansion/filtering

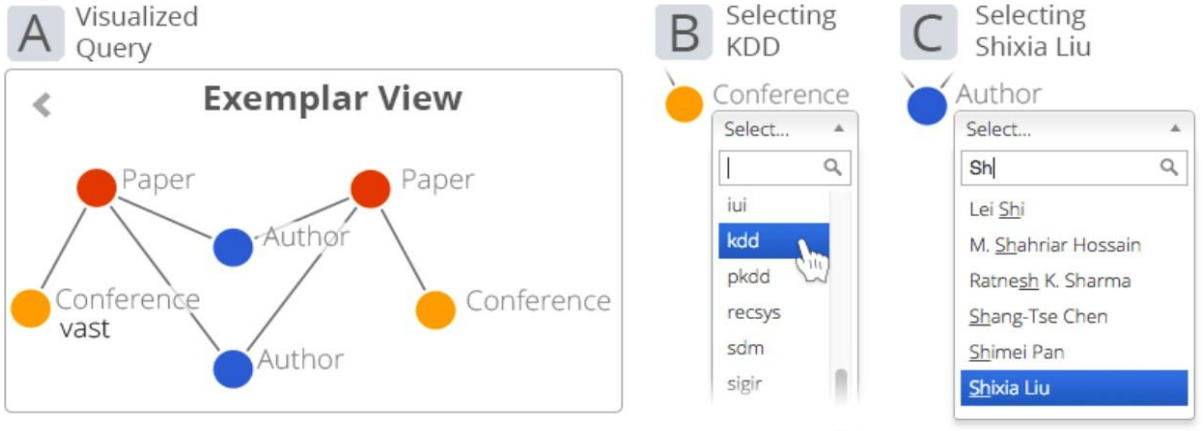
Solution: **VIGOR** **Graph Query Visualization and Exploration System**

Overview of VIGOR

Interface Overview



Exemplar view

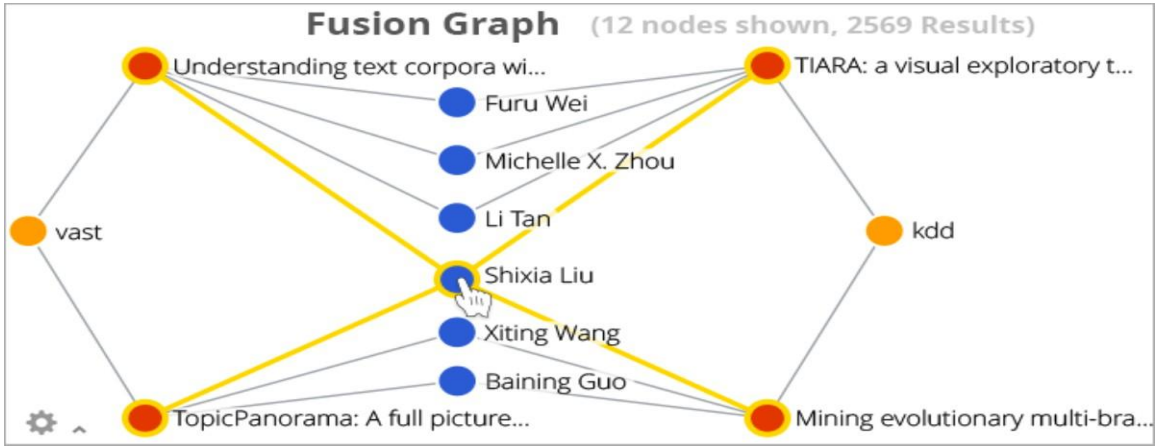


Alice enters a graph query

Cypher QL transforms query to a graph

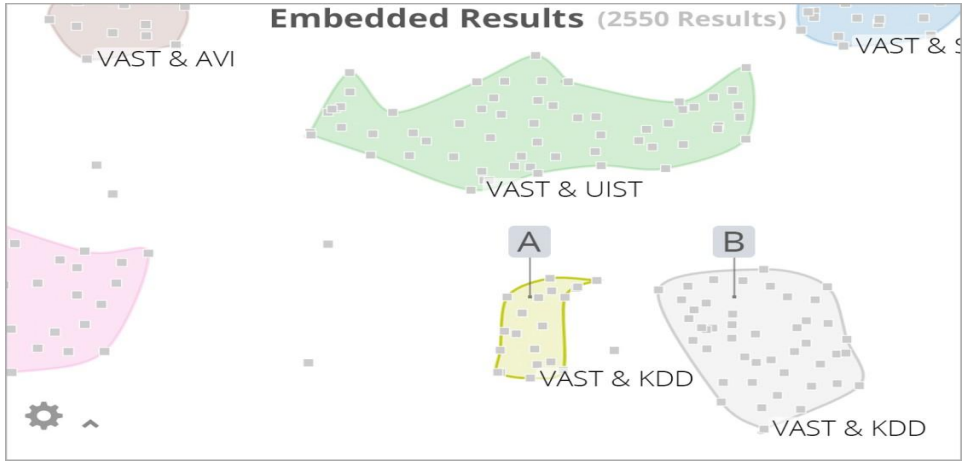
"Find authors who have papers both in VAST and KDD"

Fusion graph



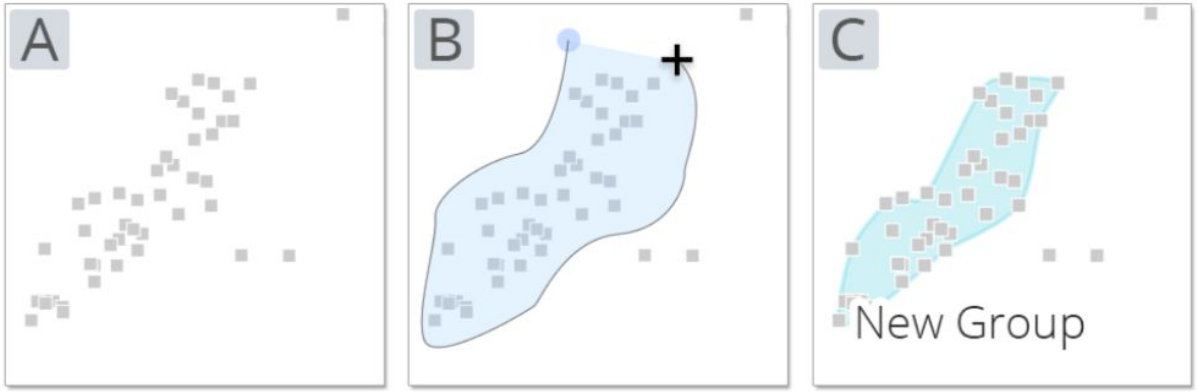
- VIGOR provides a hybrid view of how the query results match up with the input query
- Selecting a result node highlights the relevant attributes related to that tuple

Subgraph Embedding View



- Each square point represents a node in result-subgraph
- Similar results are spatially close in embedding space
- Points in same cluster are bounded by a concave hull

Subgraph Embedding View



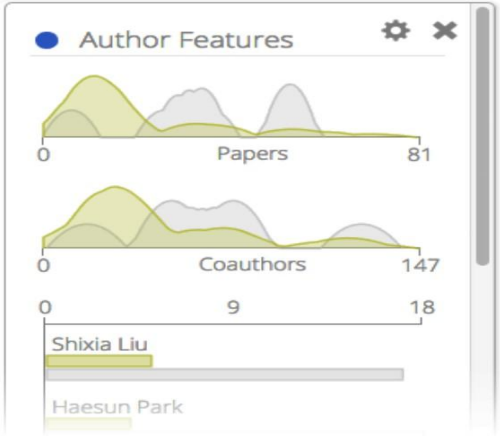
Alice's graph query on DBLP

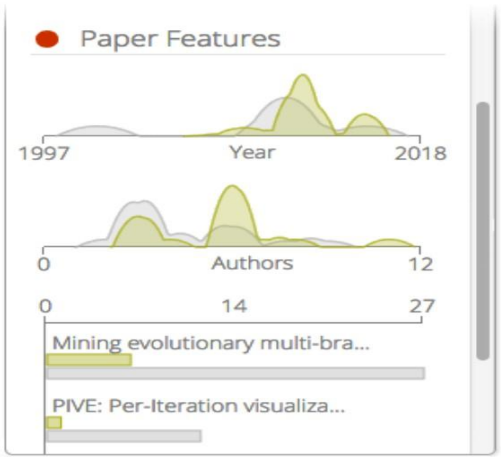
~ 2500 results of (paper, author-list)

Result subgraphs clustered in a feature aware space

Considers all possible combinations of features and PCA to a two-dimensional space

Feature Explorer View





- VIGOR provides the feature-level flexibility
- Subgraph Embedding changes based on modified features
- Supports both continuous and discrete feature values

Design Rationale

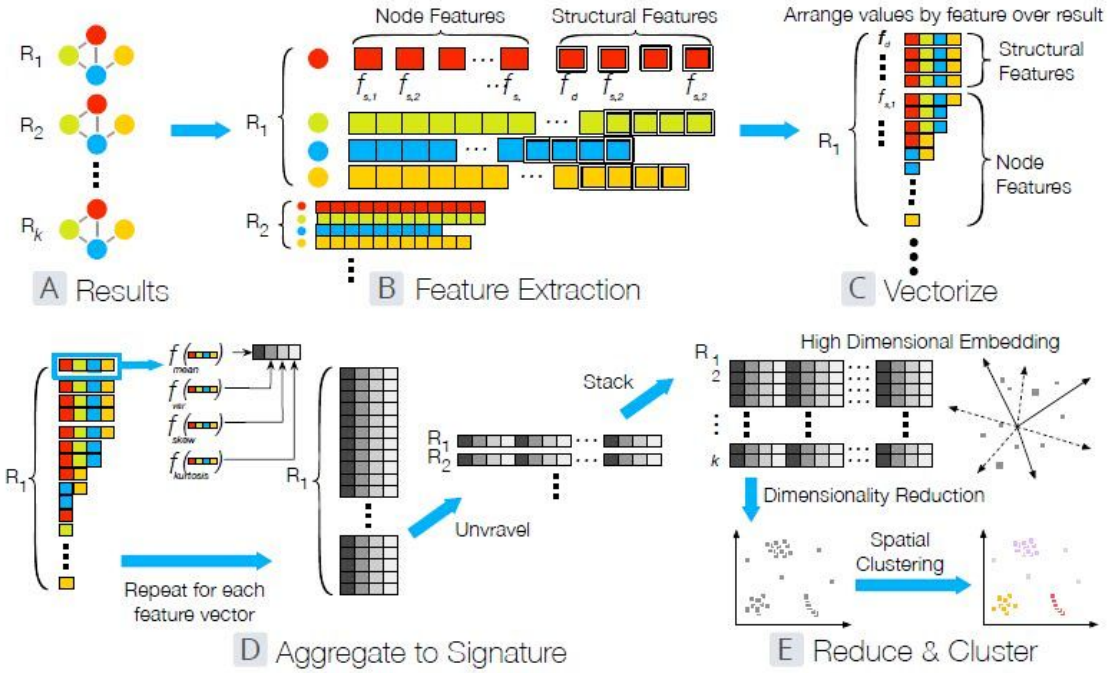
- Exemplar View provides:
  - ✓ Fast error-checking for input query
  - ✓ Bottom-up exploration of result-set
  - ✓ Ability to start from a familiar result and on the fly query expansion or filtering

- Subgraph Embedding provides:
  - ✓ Top-down exploration of the result-set
  - ✓ Global view of the result set
  - ✓ Clustering similar results together help analysts get a macro-view

Design Rationale

- ❑ Feature-centric sense-making by Feature Explorer View
- ❑ VIGOR provides coordination among multiple views
  - ✓ Fusion graph combines top-down and bottom-up views of result set
  - ✓ Clicking on the node explains why that result was included
  - ✓ Hovering over the squares on Subgraph Embedding View shows detailed values

Methodology



Methodology contd.

1. **Extract - Structural/Node features for each node**

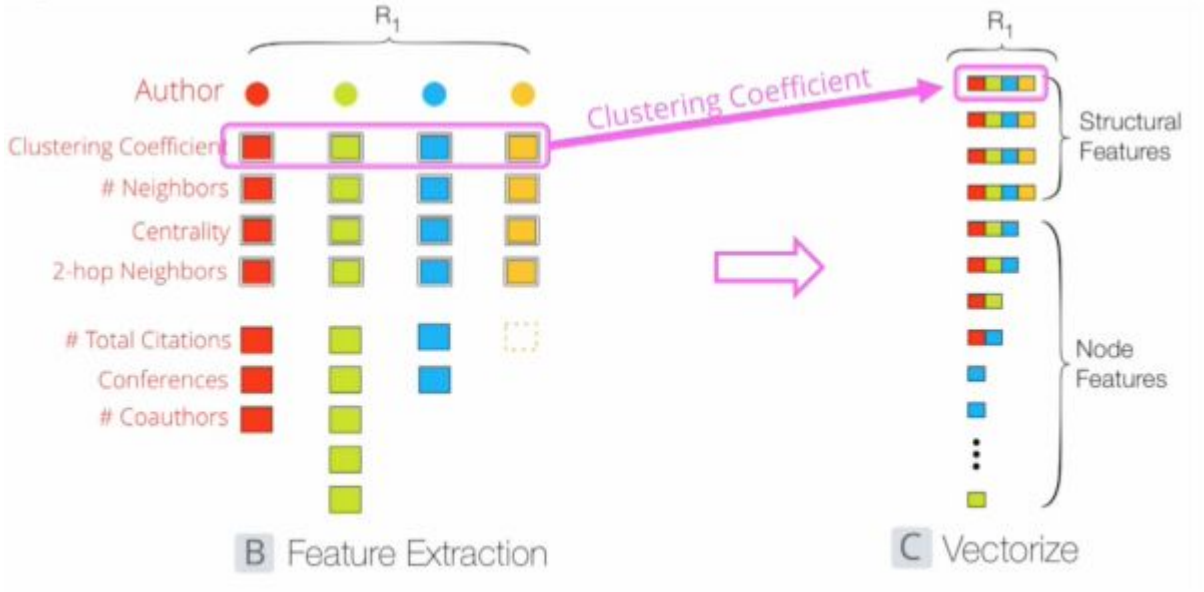
   ✓ **Structural features:**
   - Node degree
   - Egonet edges
   - Egonet neighboring nodes
   - Clustering coefficients

   ✓ **Node features:**
   - For author: number of co-authors, number of conferences

2. **Vectorize - Merge the common features into per-result vectors**

3. **Aggregate & Normalize into Signature- by computing mean, variance, skewness and kurtosis for each feature for each node .**

Merge common feature



Methodology contd.

4.Reduction and Clustering

- ✓ **Reduce dimensionality to 2 using PCA / kernel-PCA / t-SNE**
- ✓ **Cluster results based on feature combinations using OPTICS**
  - **Canberra distance (weighted version of manhattan distance)**

$$d(\mathbf{p}, \mathbf{q}) = \sum_{i=1}^{n} \frac{|p_i - q_i|}{|p_i| + |q_i|}$$

where

$$\mathbf{p} = (p_1, p_2, \ldots, p_n) \text{ and } \mathbf{q} = (q_1, q_2, \ldots, q_n)$$

  - **Canberra distance is sensitive to small changes near zero, which helps preserves small distances in the final reduction.**

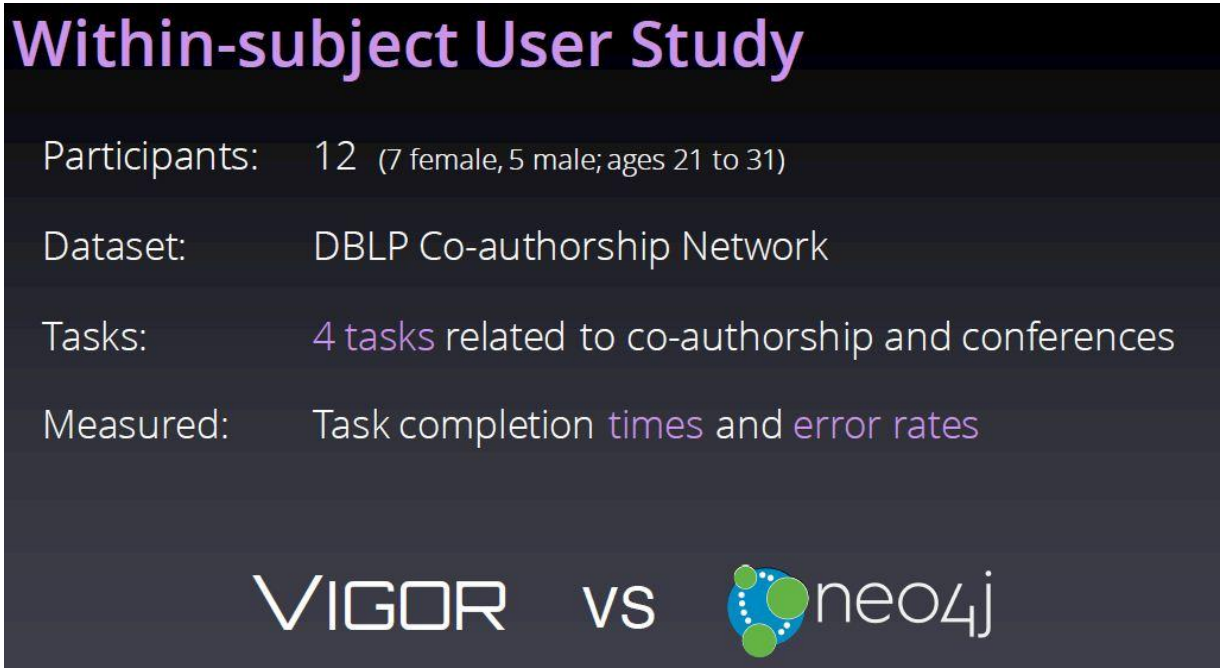
Architecture

- Client-server architecture using D3 and jQuery
- Backend in python

Experimental results

- User study
- Think-aloud explorative study

User Study 1: DBLP



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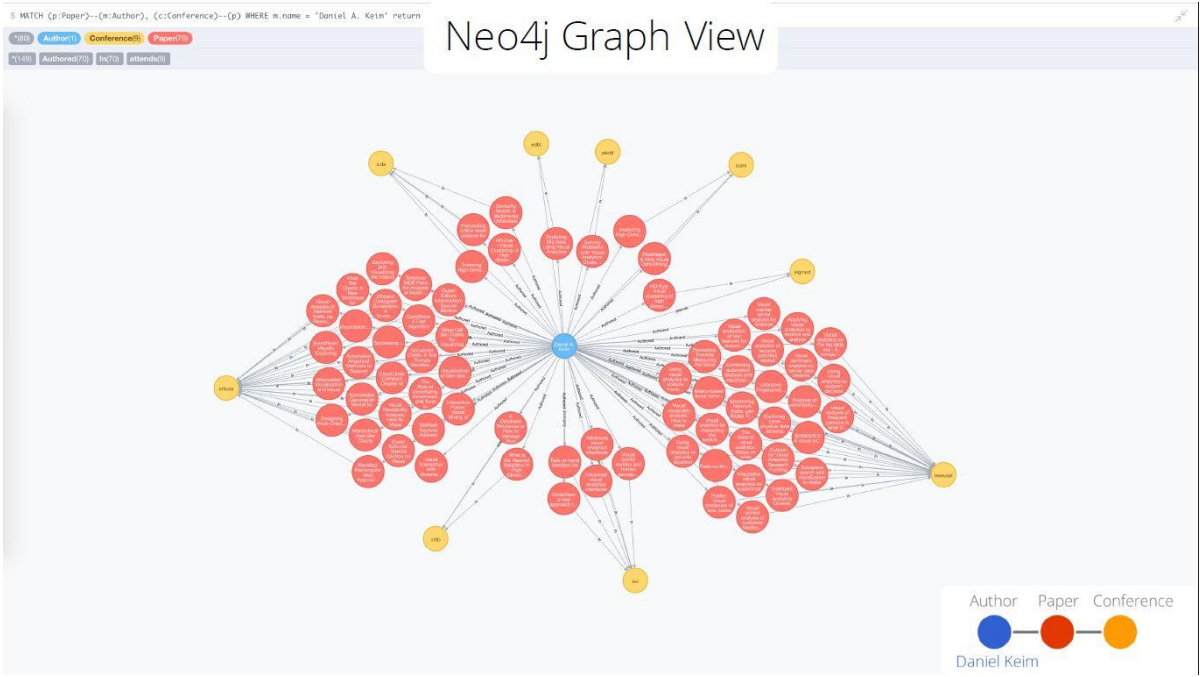
Experimental results (contd.)



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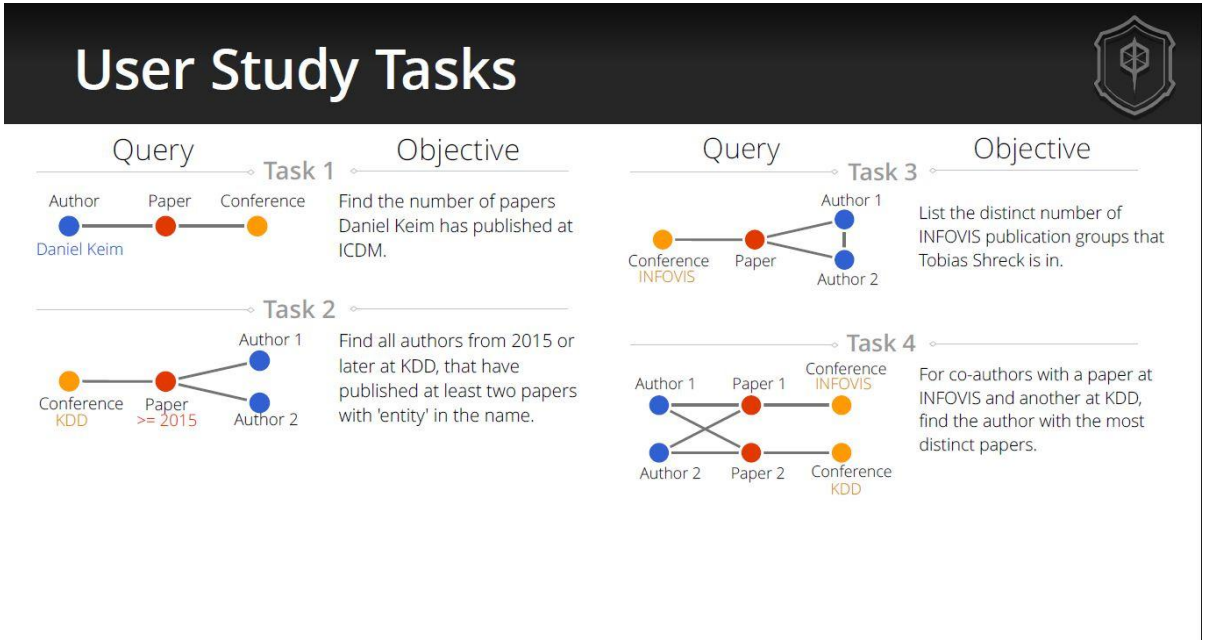

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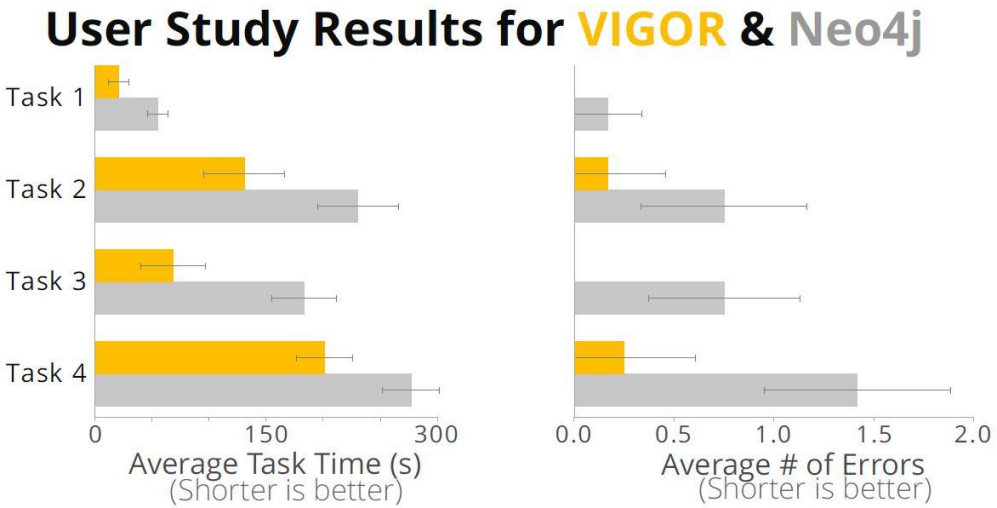
Experimental results (contd.)

- Confounding factors:
  - ✓ Software (VIGOR or Neo4j)
  - ✓ Complexity of the task
  - ✓ Software Order (VIGOR or Neo4j going first)

- ANOVA results show only varying the software produced significant improvement.

Experimental results (contd.)



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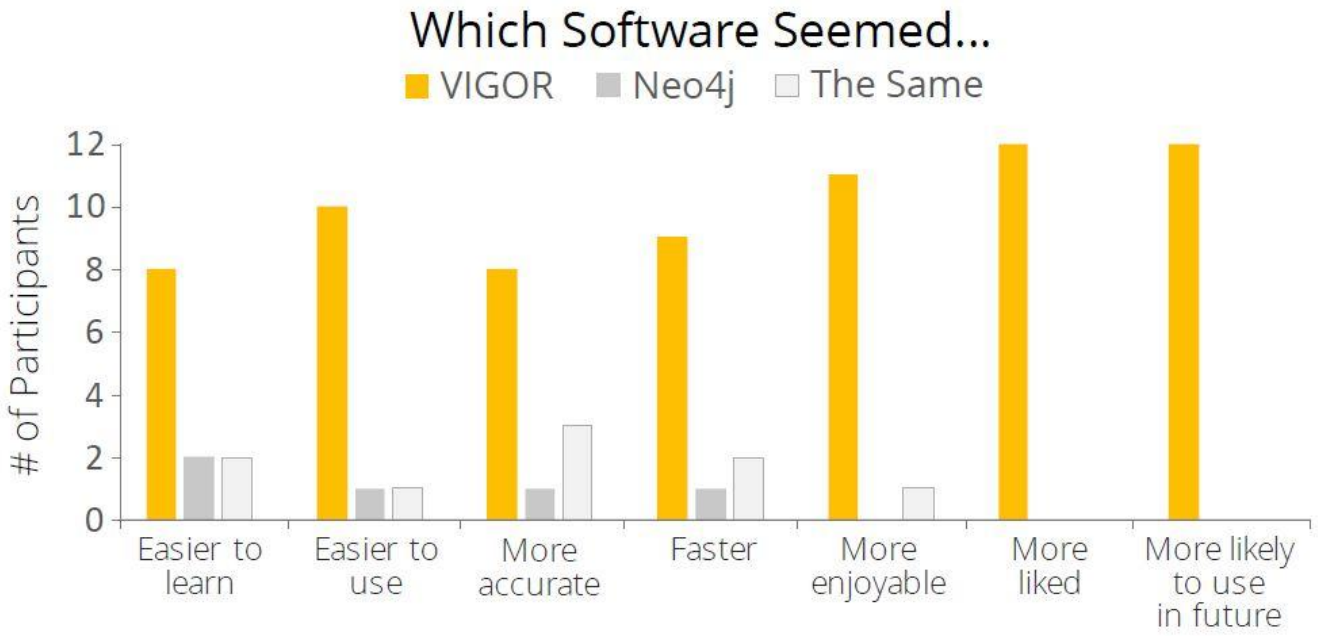
Experimental results (contd.)



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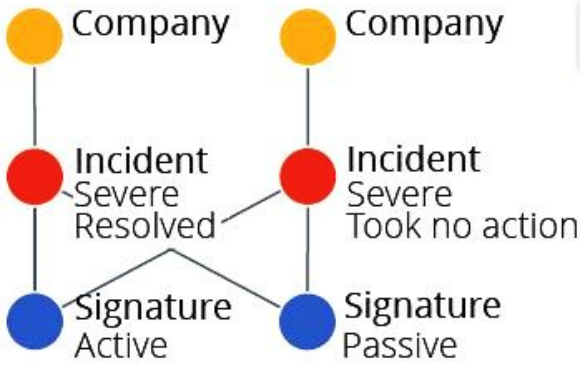
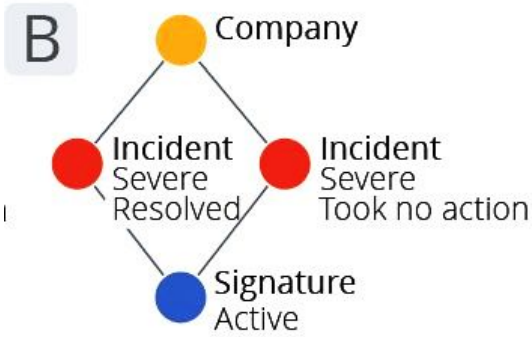
User Study 2: Cyber Security

- Network: Cyber Security network with 7,651 nodes and 384,182 edges
- Nodes connect clients of Symantec with Security incidents
  - ✓ Active signature
  - ✓ Passive signature
- Dataset contains > 11,000 incidents
- Participants: 3 Cyber Security experts from Symantec
- Number of queries: 2

Experimental results

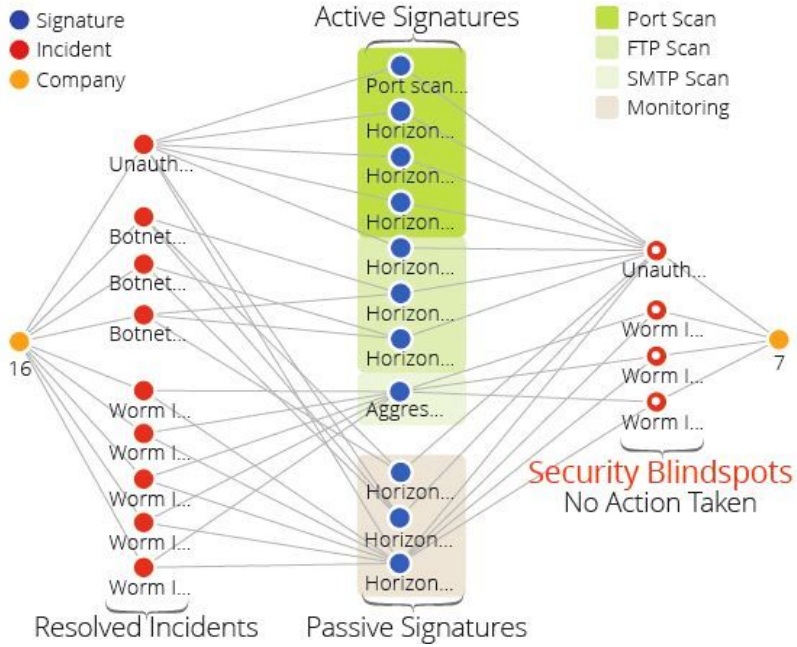


Query 1: *Compare two companies with at least one active and one passive signature where one took actions to every threat detected and one did not*



Query 2: *Find companies that are inconsistent in taking actions when a threat is detected*

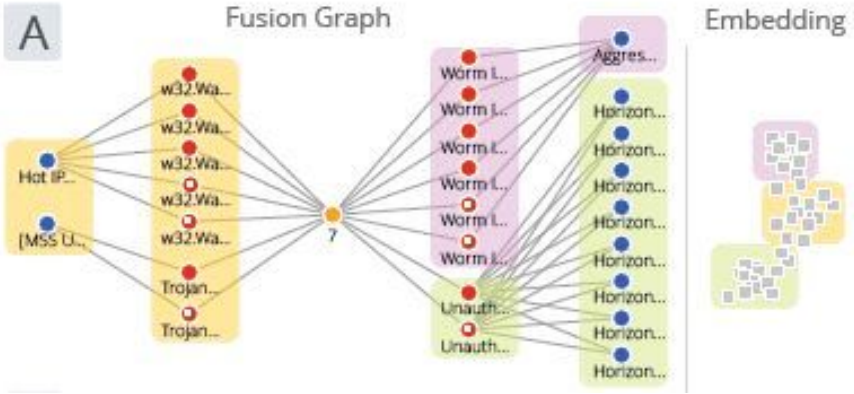
Experimental results (contd.)



Visualization of Query 1 results:

Security blindspots for Company “7” is detected using Fusion Graph

Experimental results (contd.)



Visualization of Query 2 results:

A company with inconsistent behavior when an incident is reported

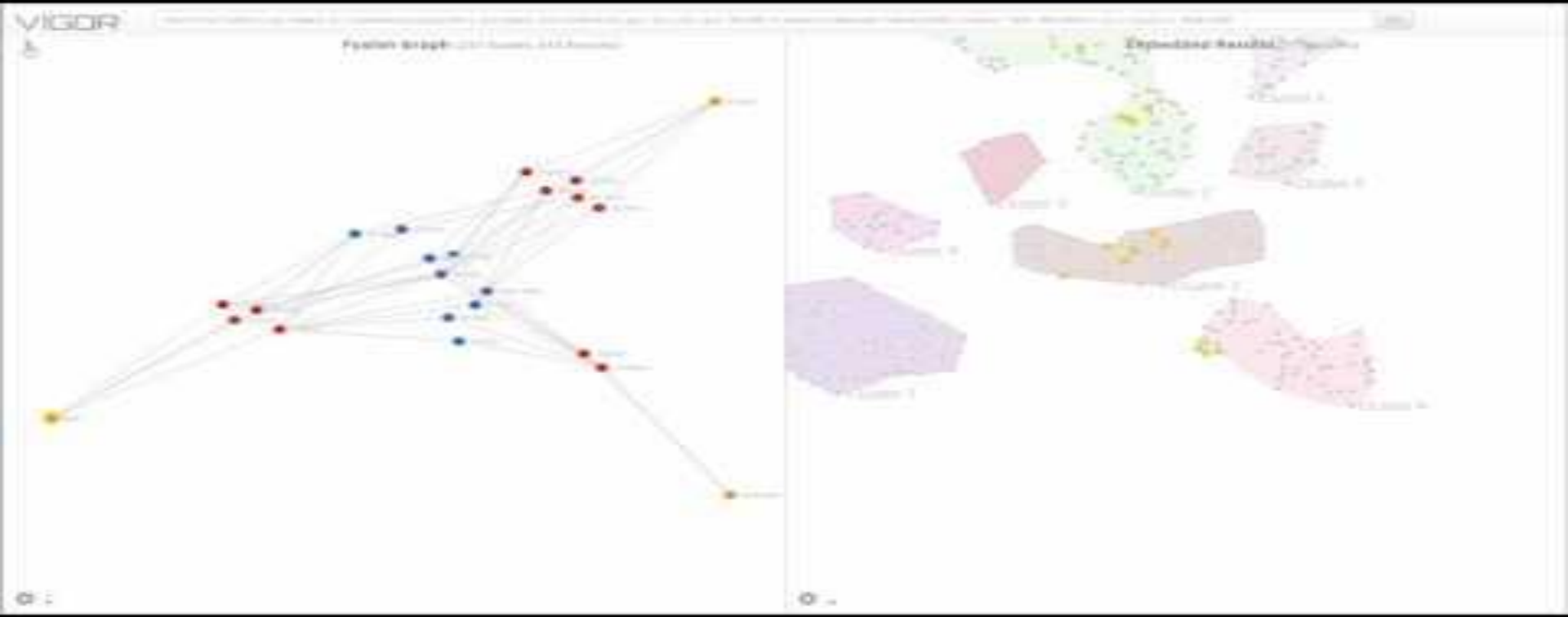
Pros/Cons

Pros:

- Exemplar-based interaction technique
- Feature-aware subgraph result summarization

Cons:

- User study only with few professional participants
- Users should be familiar with Cypher QL
- No arguments are provided for used structural features
- Insufficient analysis on clustering quality
- No evaluation on query creation and refinement
- Some information loss in the embedding process
- No information about the scope of the graph results that can be visualized (directed?, weighted?)
- User cannot filter based on the features in the feature explorer view


VIGOR

Thank You!