VIGOR: INTERACTIVE VISUAL EXPLORATION OF GRAPH QUERY RESULTS

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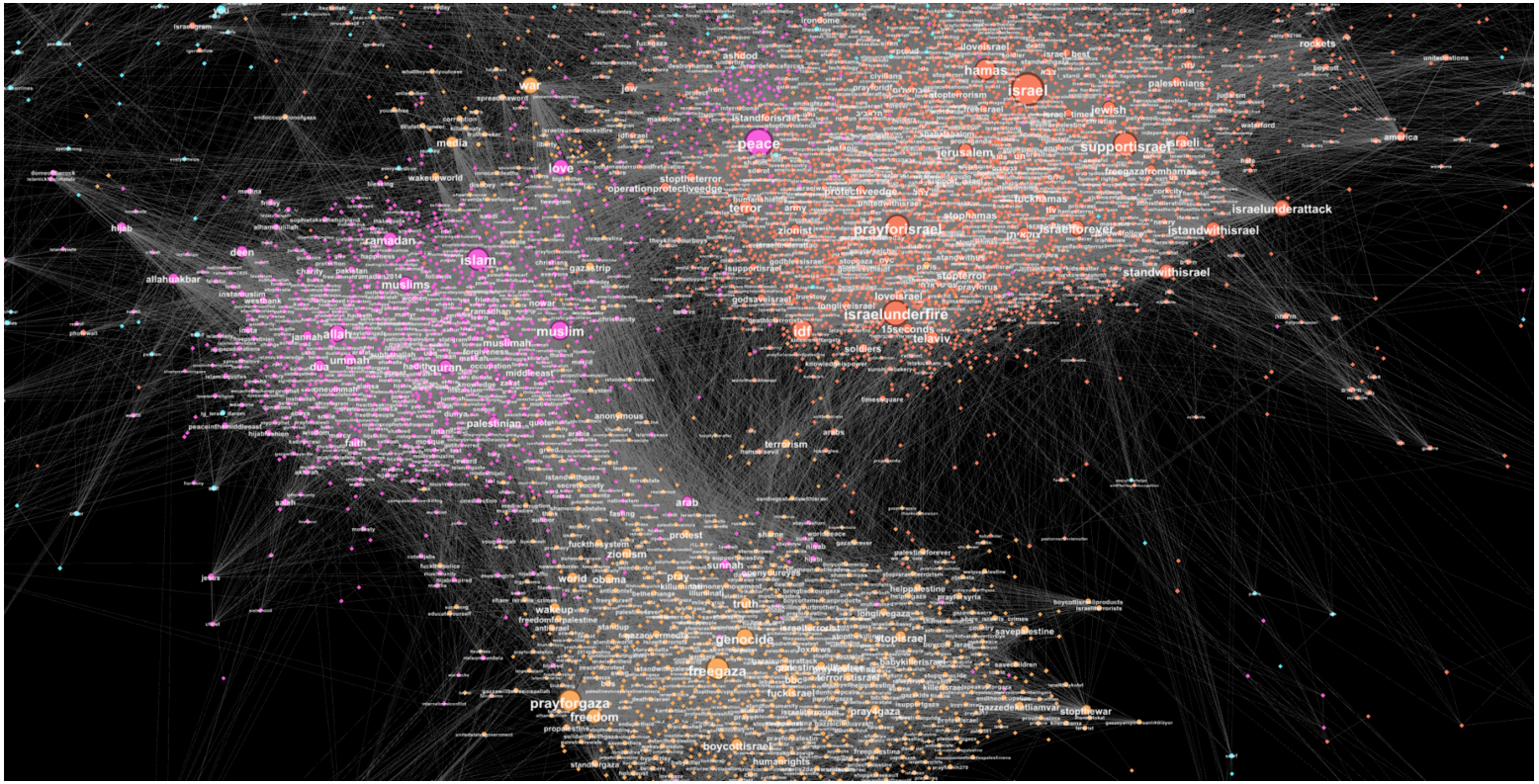
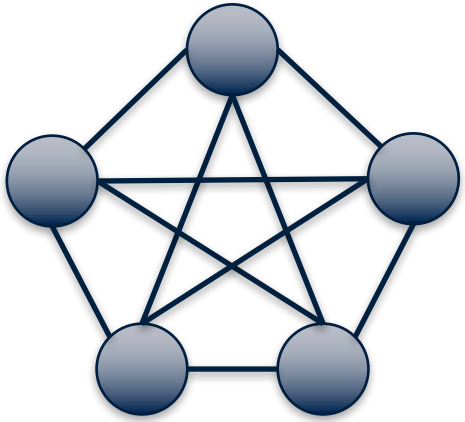
BACKGROUND



How can we extract useful information from large scale network?

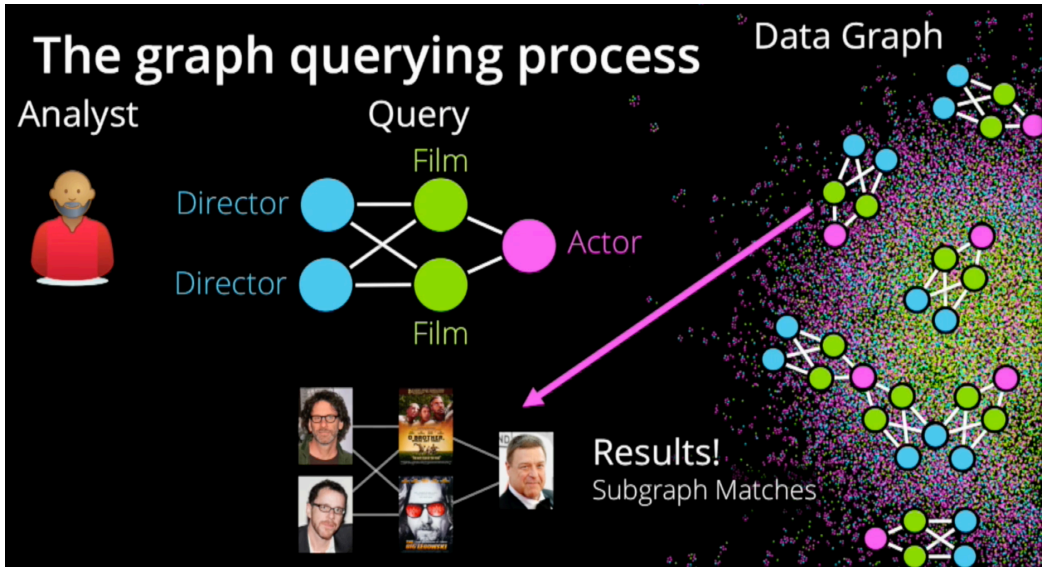
BACKGROUND

- Graph querying: locate entities with specific relationships among them
  - financial transaction networks
    - flag “near cliques” formed among company insiders
    - money-laundering
  - online auctions
    - uncover fraudsters and their accomplices
  - Bioinformatics
  - Social network analysis



BACKGROUND

- Few work focused on developing visualization system to help understand graph structure and rich data.
  - underlying data from the nodes
  - structure of each subgraph result
  - large number of results
  - potential overlap in node and edges among



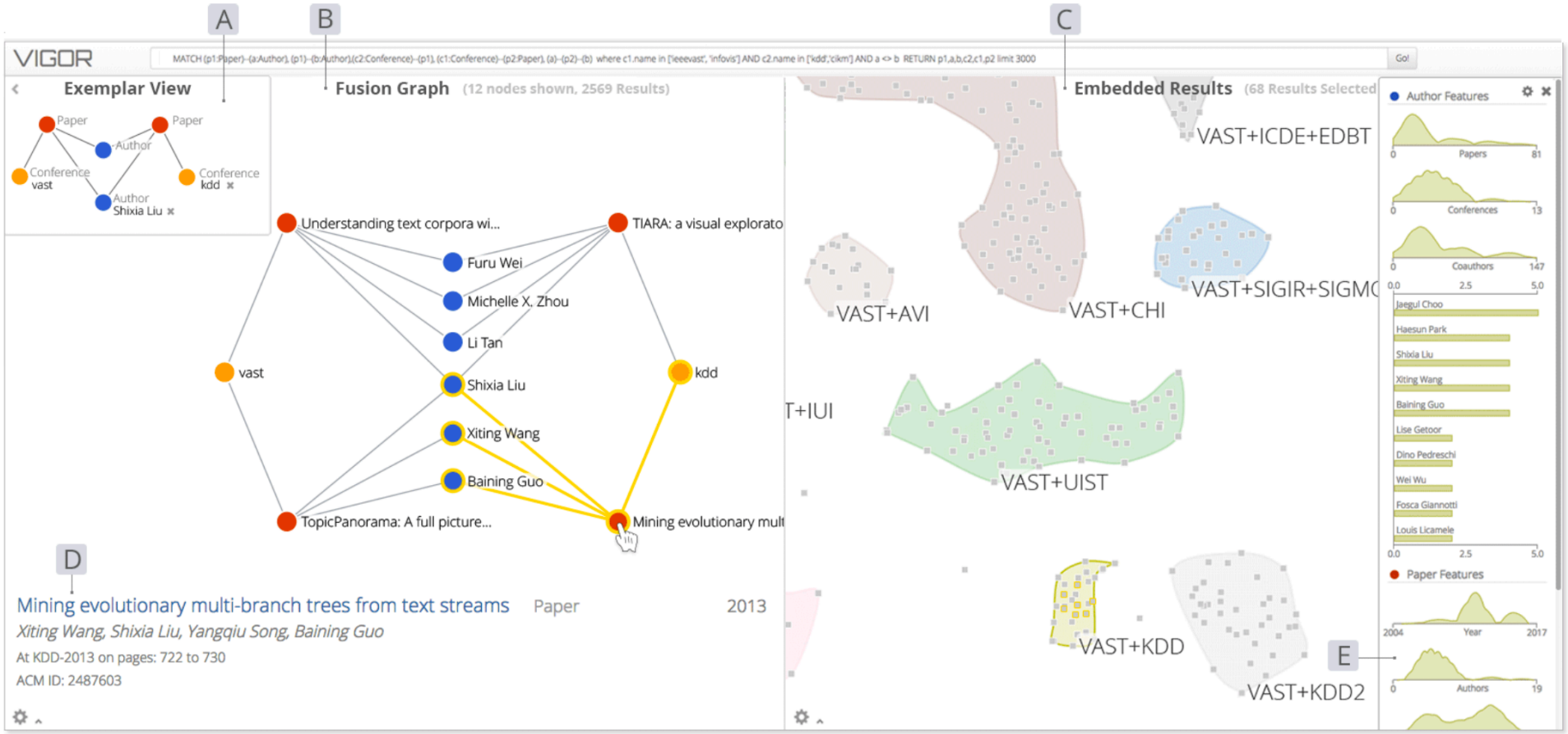
https://vimeo.com/237670479

DATA TO VIS AND DERIVED RESULTS

- DBLP Dataset.
- DBLP is a computer science bibliography website.
- Co-authorship network of DBLP's computer science bibliography data, focusing on the the data mining and information visualization communities
    - 59,655 authors; 48,677 papers; 7,236 sessions
    - 417 proceedings; 21 conferences;1,634,742 relations
- Derived results
    - a novel interactive visual analytics system, for exploring and making sense of query results

VAD Idiom	VIGOR
What: Data	Network data with vertex and edges
What: Derived	Subgraph and feature clusters
Why: Tasks	Find subgraph according to query results and cluster features
Scale	Millions of relations and tens of thousands of co-authors

OVERVIEW


A
B
C
VIGOR
Exemplar View
Paper
Paper
Author
Conference
vast
Conference
kdd
Author
Shixia Liu
Fusion Graph
(12 nodes shown, 2569 Results)
Understanding text corpora wi...
TIARA: a visual explorato
Furu Wei
Michelle X. Zhou
Li Tan
vast
Shixia Liu
kdd
Xiting Wang
Baining Guo
TopicPanorama: A full picture...
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VAST+ICDE+EDBT
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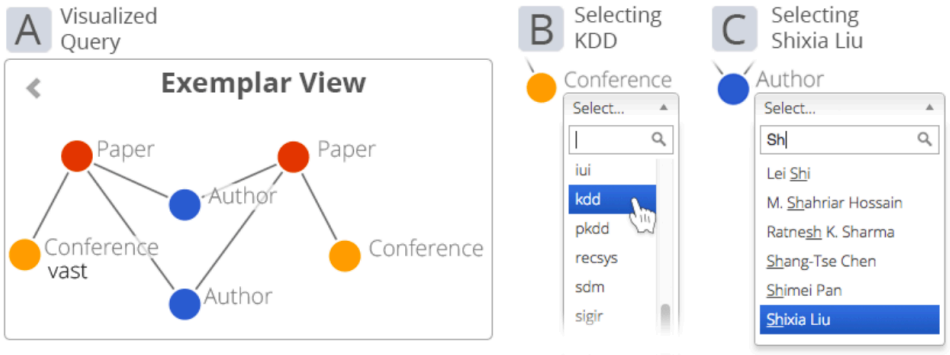
VAST+CHI
VAST+SIGIR+SIGMC
T+IUI
VAST+UIST
VAST+KDD
VAST+KDD2
Author Features
Papers
Conferences
Coauthors
Jaegul Choo
Haesun Park
Shixia Liu
Xiting Wang
Baining Guo
Lise Getoor
Dino Pedreschi
Wei Wu
Fosca Giannotti
Louis Licamele
Paper Features
Year
Authors
D
E
Mining evolutionary multi-branch trees from text streams
Paper
2013
Xiting Wang, Shixia Liu, Yangqiu Song, Baining Guo
At KDD-2013 on pages: 722 to 730
ACM ID: 2487603

ILLUSTRATIVE USAGE SCENARIO

Exemplar View

- The analyst starts with only the structure of the graph query, then incrementally adds node value constraints to narrow in on specific results
- Choose conference by name
- Narrows down the network by choosing mutual authors.

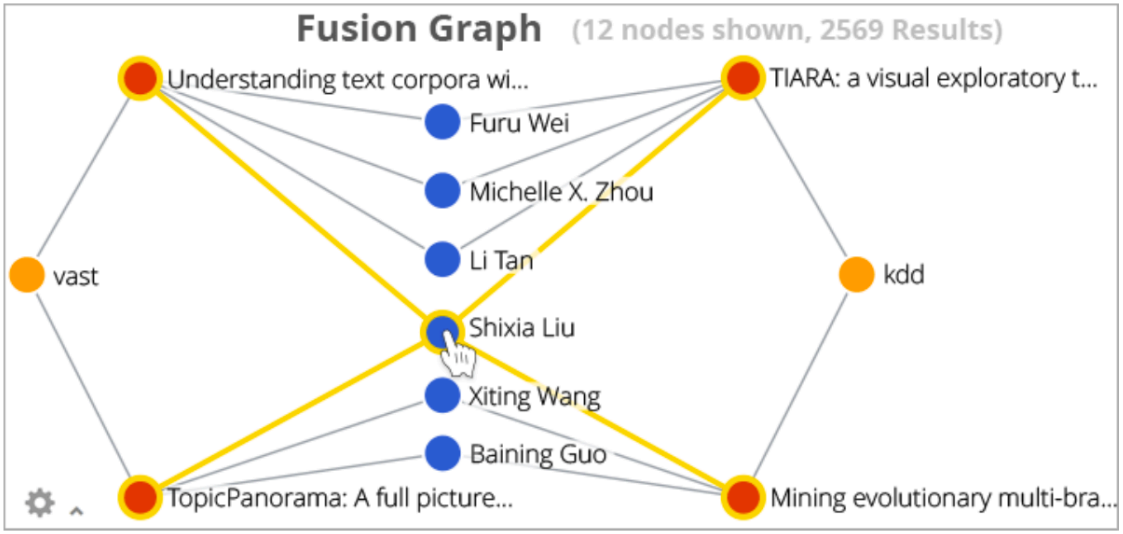


VAD Idiom	VIGOR
How: Encode	Use lines to show connected relationships; colors for different nodes
How: Reduce	Item filtering

ILLUSTRATIVE USAGE SCENARIO

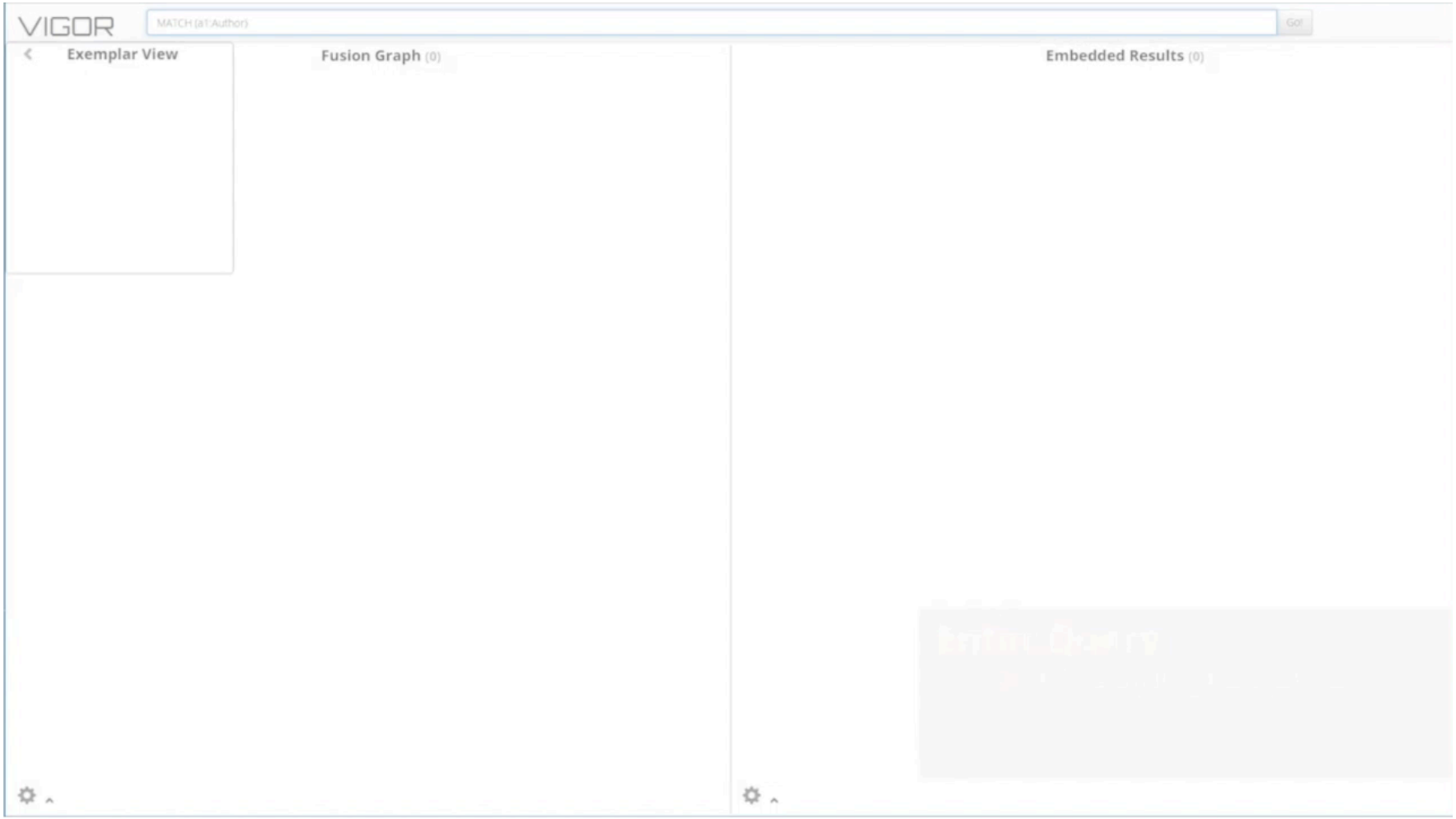
Fusion Graph

- After adding Exemplar View filters, induced subgraph of all the combined results from the original query will be generated in Fusion Graph.
- Shixia Liu's papers and co-authors who have published papers together at VAST and KDD.



VAD Idiom	VIGOR
How: Manipulate	Reorder, realign, hovering highlight

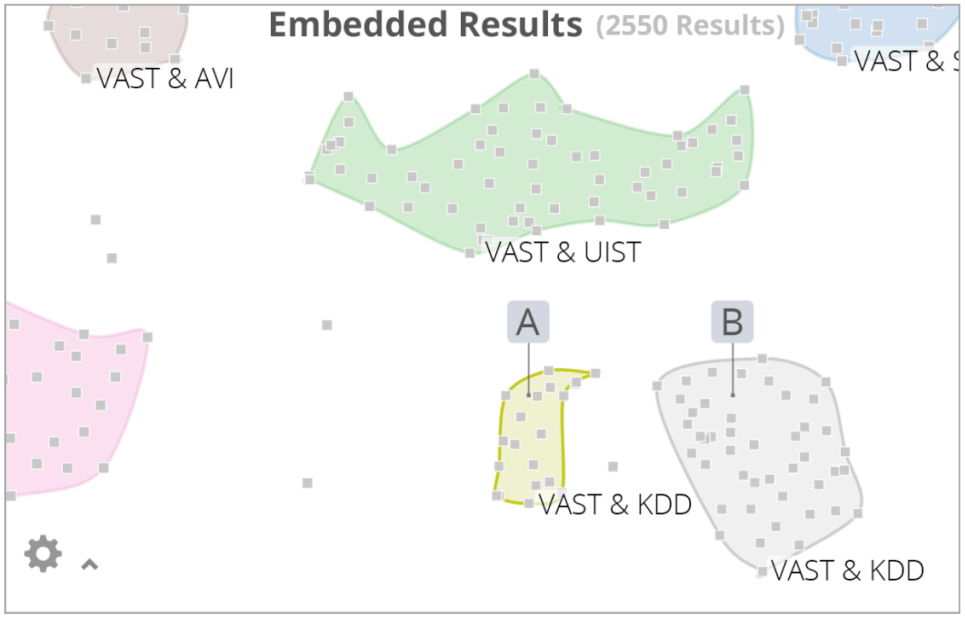
ILLUSTRATIVE USAGE SCENARIO



ILLUSTRATIVE USAGE SCENARIO

Subgraph Embedding

- Query: an author who has published two papers with a co-author, where the papers were published to VAST and another conference will return 2550 results.
- Subgraph Embedding view provides an overview of all results by clustering

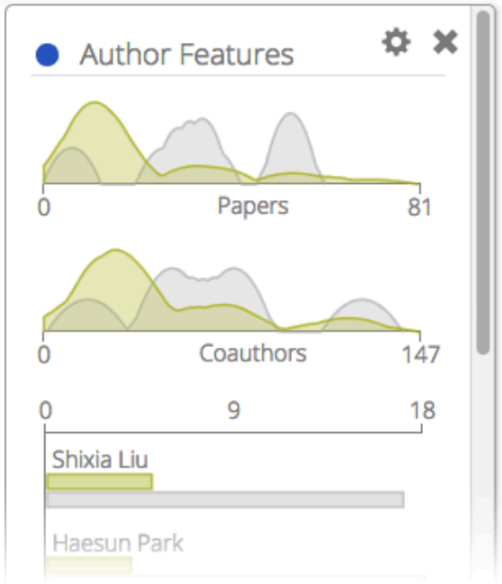


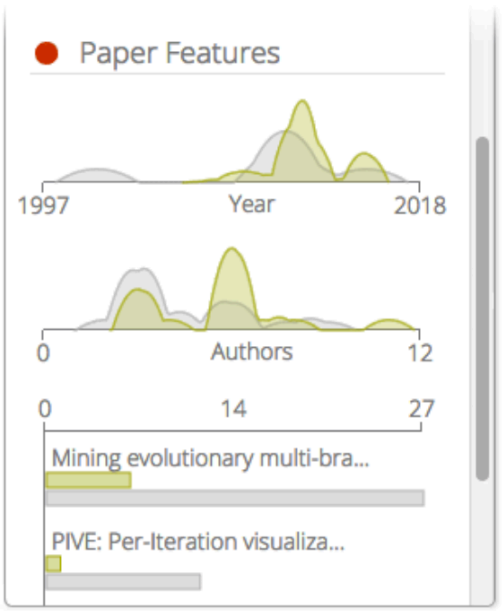
VAD Idiom	VIGOR
How: Facet	Linked highlighting
How: Encode	colors for different clusters

ILLUSTRATIVE USAGE SCENARIO

Feature Explorer

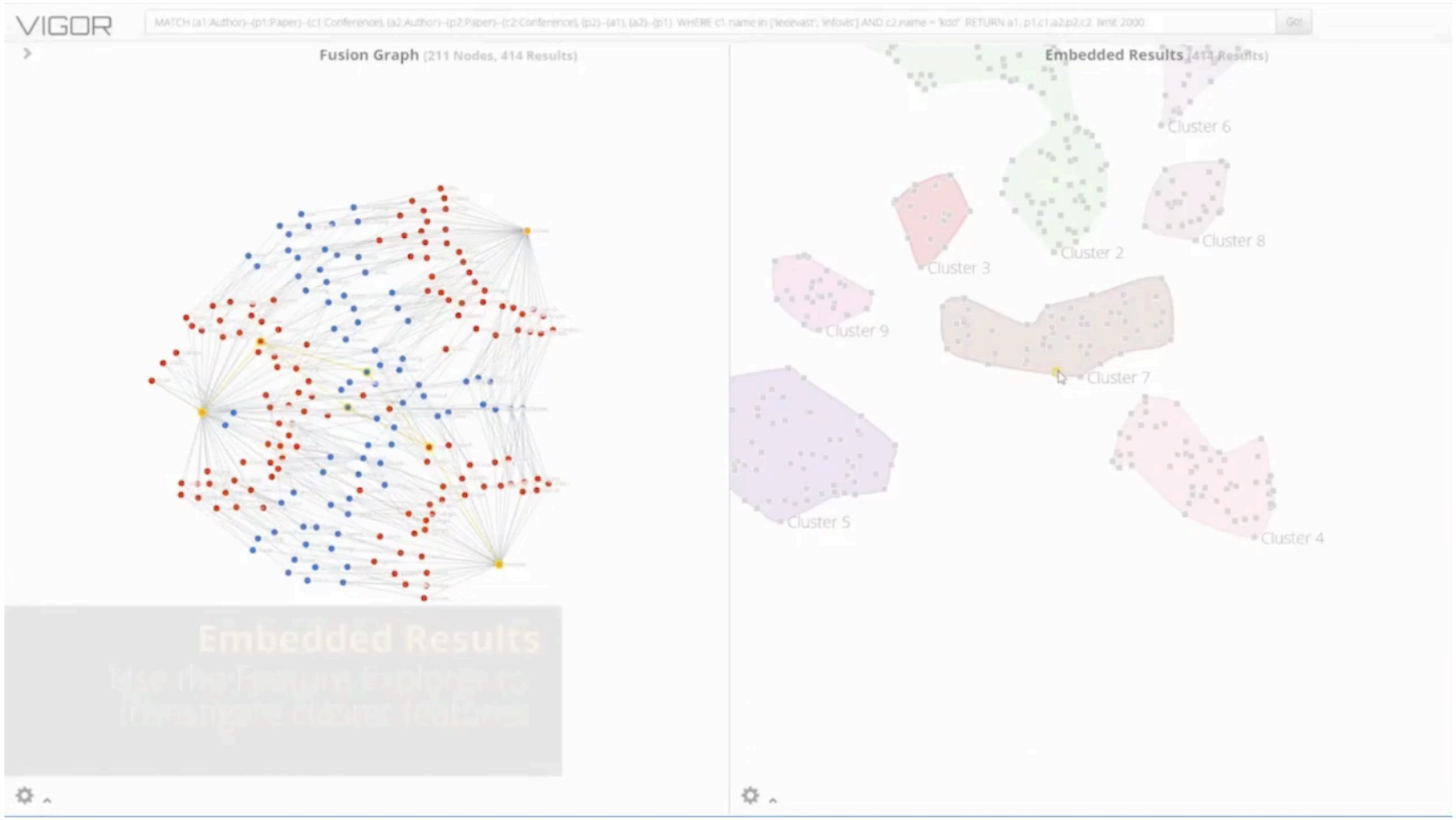
- Compare two cluster in the Feature Explorer
- Color: same as the cluster color
- X-axis: # Papers/ # co-authors/publication year/ # authors
- Y-axis: number of papers
- The bar chats show the top-k most common values,





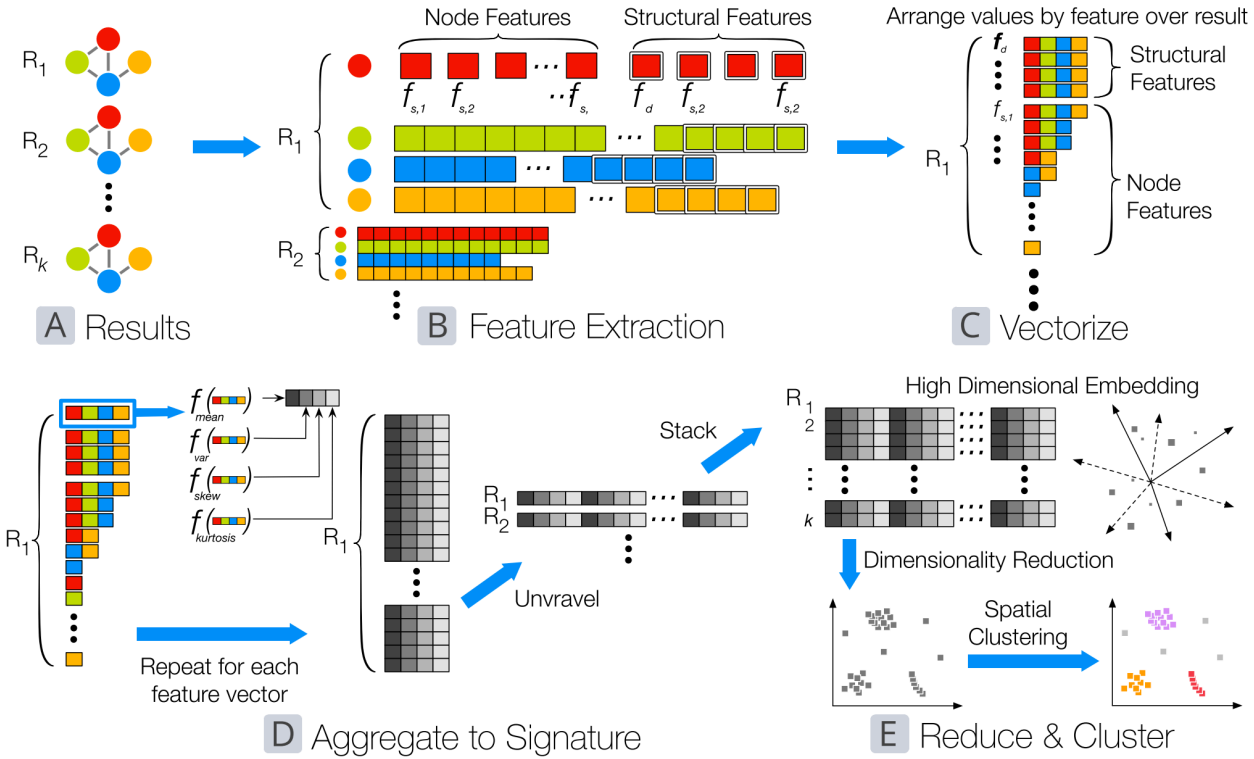
VAD Idiom	VIGOR
How: Encode	colors for different clusters

ILLUSTRATIVE USAGE SCENARIO



METHODOLOGY & ARCHITECTURE

- Extract Features - Calculate the topological- and node-features.
- Vectorize - Merge the common features into per-result vectors.
- Aggregate & Normalize into Signature - Reduce the large input vectors into uniform signatures.
- Reduce & Cluster - Reduce the signatures using dimensionality reduction.

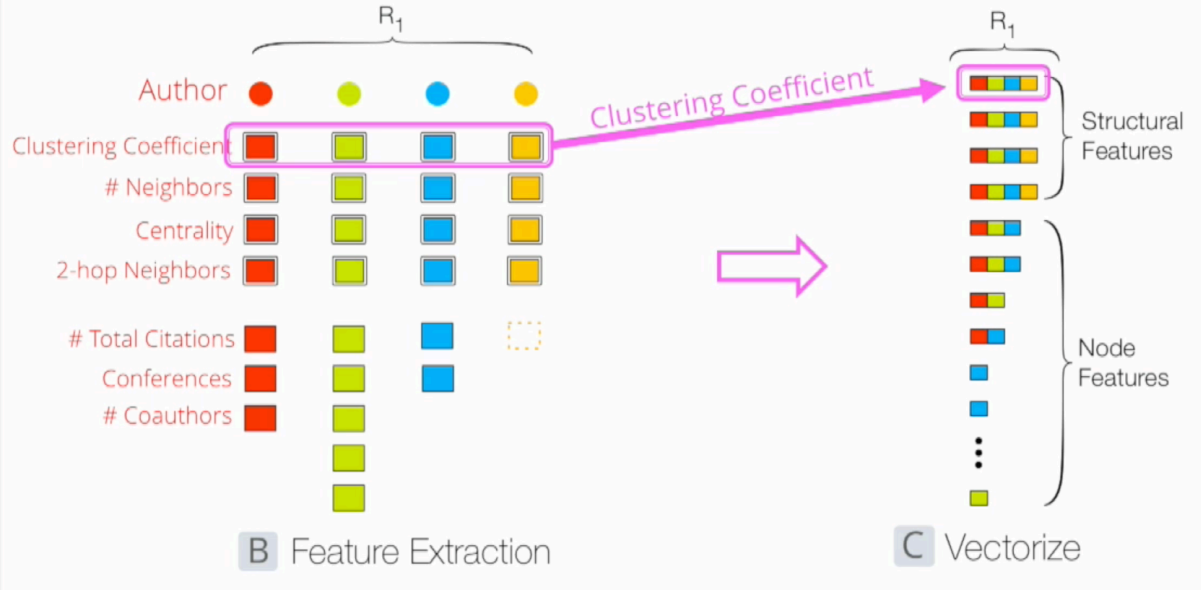


METHODOLOGY & ARCHITECTURE (CONT'D)

- **Extract Features.**
- Structural features
  - Subgraph neighborhood and egonet information
  - An egonet of a node, i, is (a) the neighbor nodes of i, (b) the edges to these neighbors and (c) all the edges among neighbors.
- Node degree – number of neighbors
  - $d_i = |N(i)|$, $N(i)$ is the neighboring nodes of node i
- Egonet edges - a unweighted graph, simply counting the number of edges
  - $E\big(ego(i)\big) = \sum_{j \in N(i)} (\sum_{e_{jk} \in E(j)} \delta_{ik})$
  - $\delta_{ik} = \begin{cases} 1, if\ k \in N(i) \\ 0, if\ k \notin N(i) \end{cases}$
- Egonet neighboring nodes - the number of neighbor nodes of neighbor nodes
  - $|N(ego(i))| = |\cup_{j \in N(i)} N(j)|$
- Clustering coefficient – ratio of closed loop subgraph and total number of edges
  - $c_i = \frac{2|e_{jk} \in E(i): j,k \in N(i)|}{|N(i)| \cdot (|N(i)| - 1)}$

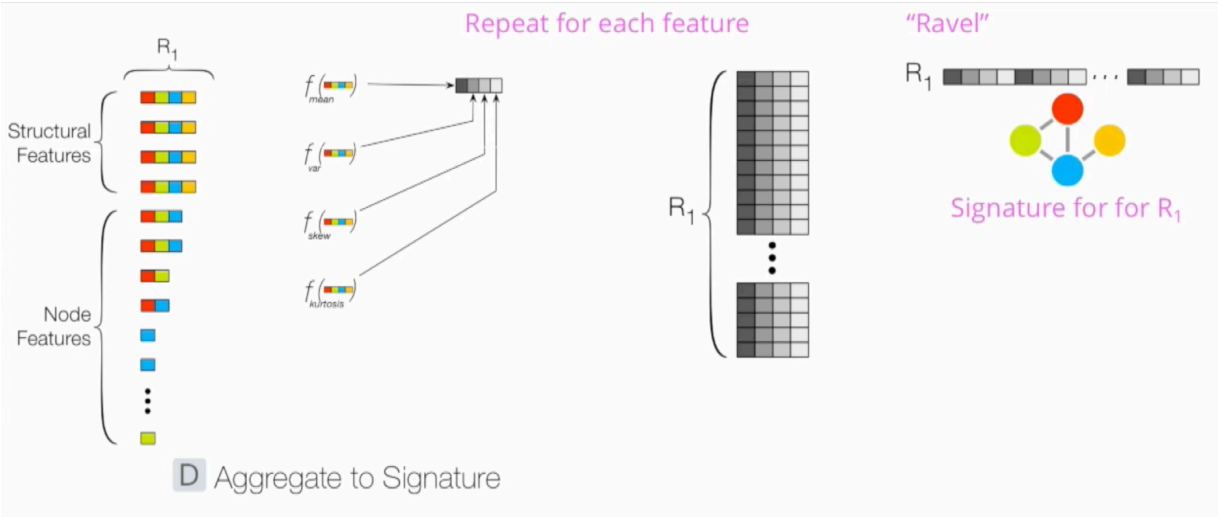
METHODOLOGY & ARCHITECTURE (CONT'D)

- **Vectorize**
  - Nodes feature
    - Author name
    - Number of co-authors
    - Number of conference
  - Merge common feature



METHODOLOGY & ARCHITECTURE (CONT'D)

- **Aggregate & Normalize**
- For each feature, statistic charateristics are extracted: mean, variance, skewness, and kurtosis
- Generate feature at same length: $4 \cdot (|f_s| + |f_t|)$
- **Reduce & Cluster**
- Dimensionality reduction reduces the feature dimension to 2D, which helps to vis.



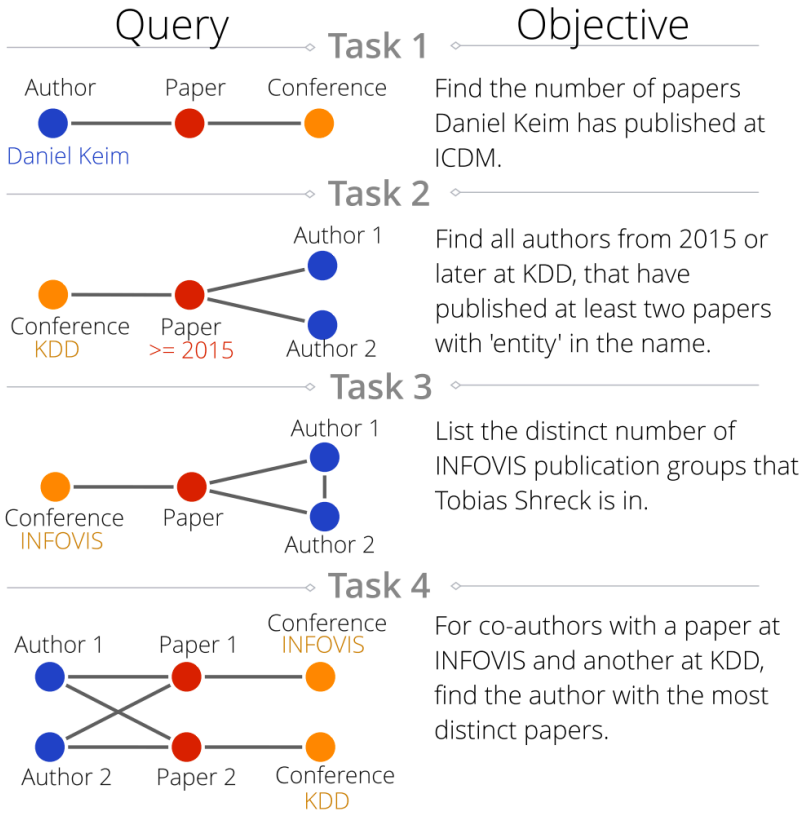
VAD Idiom	VIGOR
How: Encode	Attribute aggregation

EVALUATION

- User Study
  - 12 participants from computing related majors.
    - 7 female, 5 male
    - age 21 to 31
  - Paid $10 for 70 minutes test.
  - Dataset: DBLP co-authorship network
- Real World Application: Discovering Cybersecurity Blindspots

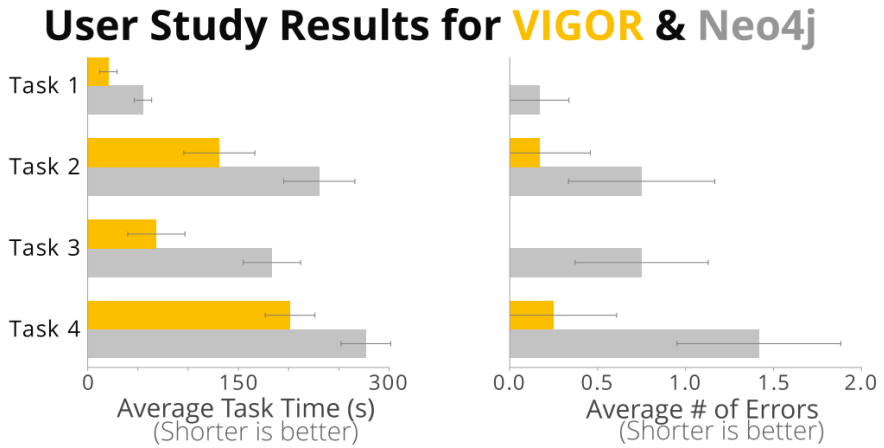
USER STUDY

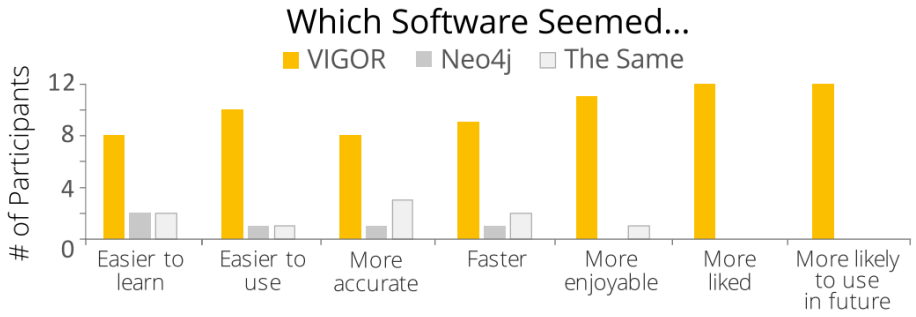
- Tasks 1:Find the count of ICDM conference papers by Daniel Keim.
- Task 2: From the last two years of KDD publications, find and list the authors who are on more than one paper with “entity” in the name.
- Task 3: Find the number of distinct groups of researchers that Tobias Shreck is in from INFOVIS publications.
- Task 4: Among coauthors of at least two papers together at INFOVIS and KDD, who has the most publications.



USER STUDY

- Quantitative Results
  - Tasks: find out the software affect by executing four task and exam the average task time, and average # of errors.
- Observations and Subjective Results
  - Participants rate various aspects comparing both systems





CONTRIBUTIONS OF VIGOR

- Novel visual analytics system, VIGOR
- Exploring and making sense of graph querying results
- Exemplar-based interactive exploration
    - bottom-up: how many similar values are matched to each query-node
    - top-down: how a particular node value filters the results from the whole structure
- Novel result summarization through feature-aware subgraph result embedding and clustering.
    - VIGOR provides a top-down, high-level overview
    - Clustering node-feature and structural result similarity
- An integrated system fusing multiple coordinated views
    - Brushable linked views among Exemplar View, Subgraph Embedding View, and the Fusion Graph

CRITIQUE

- The number of people for user study might not enough and they are all professional users.
- Query sentence is hard to generate for non-professionals.
- The co-authorship is limited to one-hop

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Thank you!