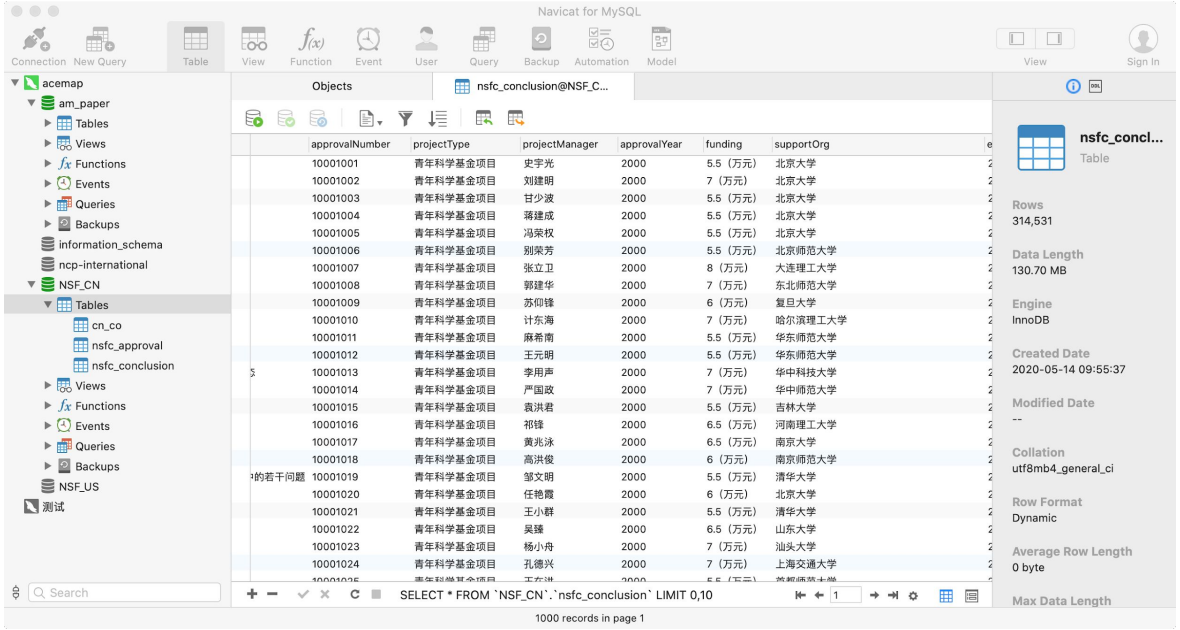
Mining collaboration in NSF grants

...with comparison between China & US

Crawler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am_paper
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Events
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Backups
information_schema
ncp-international
NSF_CN
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cn_co
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10001001 青年科学基金项目 史宇光 2000 5.5（万元） 北京大学
10001002 青年科学基金项目 刘建明 2000 7（万元） 北京大学
10001003 青年科学基金项目 甘少波 2000 5.5（万元） 北京大学
10001004 青年科学基金项目 蒋建成 2000 5.5（万元） 北京大学
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10001007 青年科学基金项目 张立卫 2000 8（万元） 大连理工大学
10001008 青年科学基金项目 郭建华 2000 7（万元） 东北师范大学
10001009 青年科学基金项目 苏仰锋 2000 6（万元） 复旦大学
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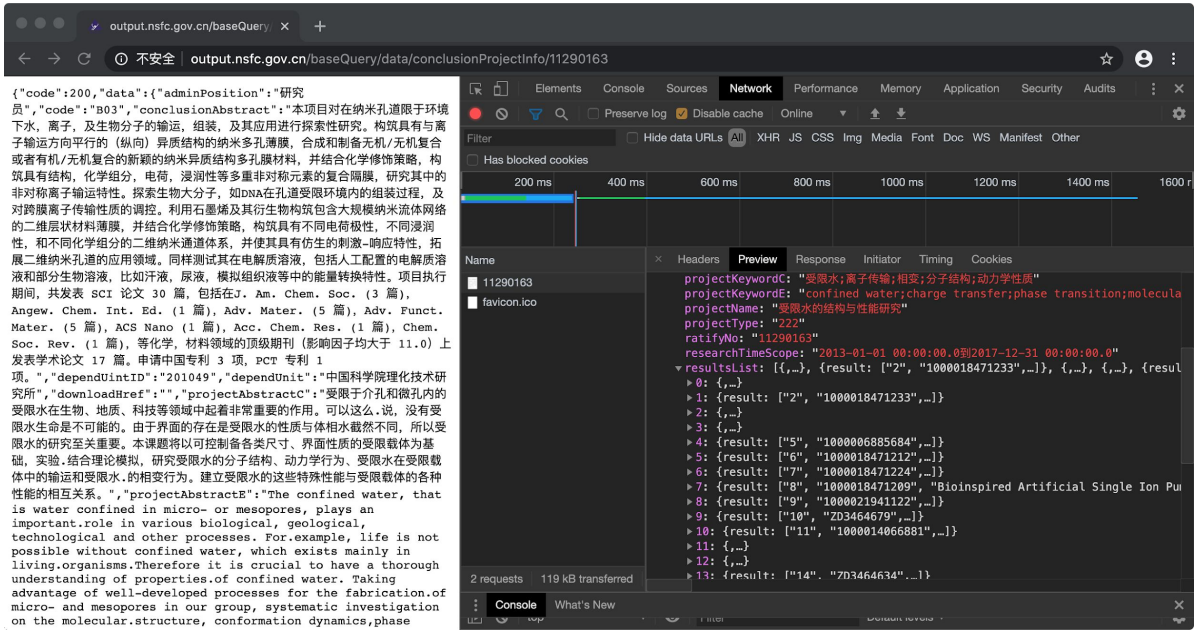
Crawler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Elements Console Sources Network Performance Memory Application Security Audits
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projectKeywordC: "受限水;离子传输;相变;分子结构;动力学性质"
projectKeywordE: "confined water;charge transfer;phase transition;molecula
projectName: "受限水的结构与性能研究"
projectType: "222"
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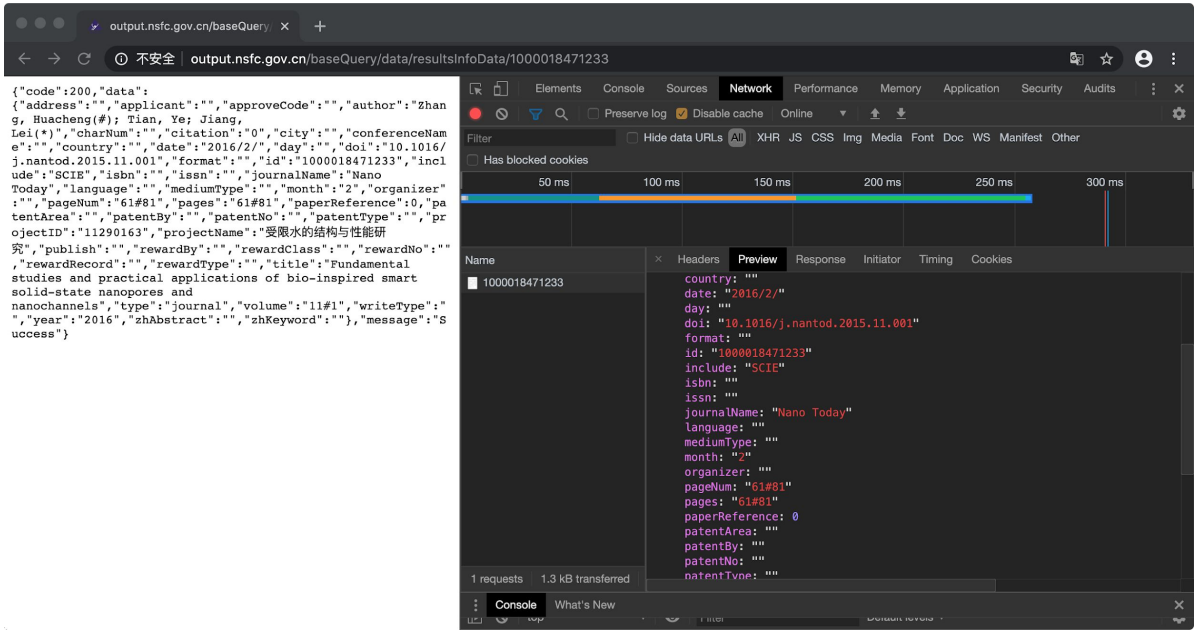
Console What's New

Crawler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patentType: ""
1 requests
1.3 kB transferred
Console
What's New

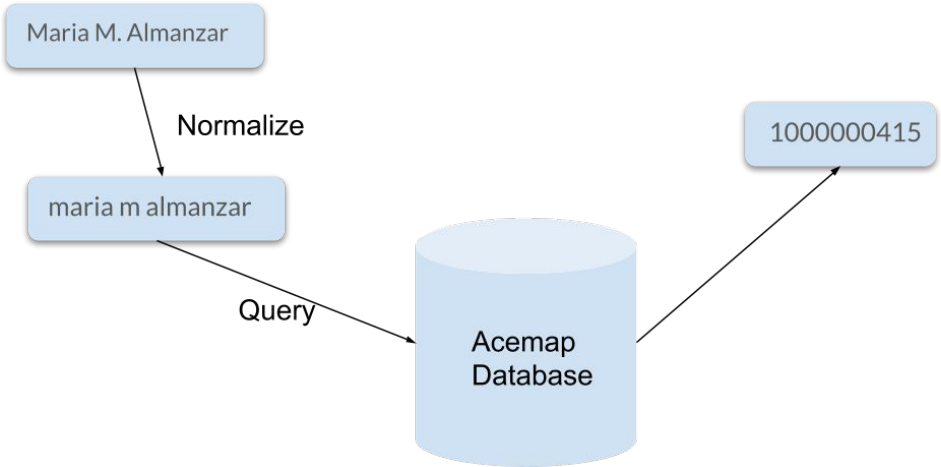
Author Mapping

Mapping from name to Acemap-ID: **Name** (Maria M. Almanzar) -> **AuthorID** (1000000415)

- Large volume of data: **91,458,238** authors in total, took almost **2 min** to traverse, over **8 GB** dump;
- Confusion between duplicate names: more than **10** authors with name ‘A. A. A. Mohamed’;
- Ambiguity rising from degeneracy: ‘张三’ or ‘San Zhang’ or ‘San ZHANG’ or ‘Zhang San’;
- Multiple Institutions: Geoffrey Hinton worked for Google and the University of Toronto at the same time;
- Typo: ‘Keith Ross’ (NYU Professor) and ‘Keith Rose’ (surgeon) and ‘Keith Ros’ (nobody);

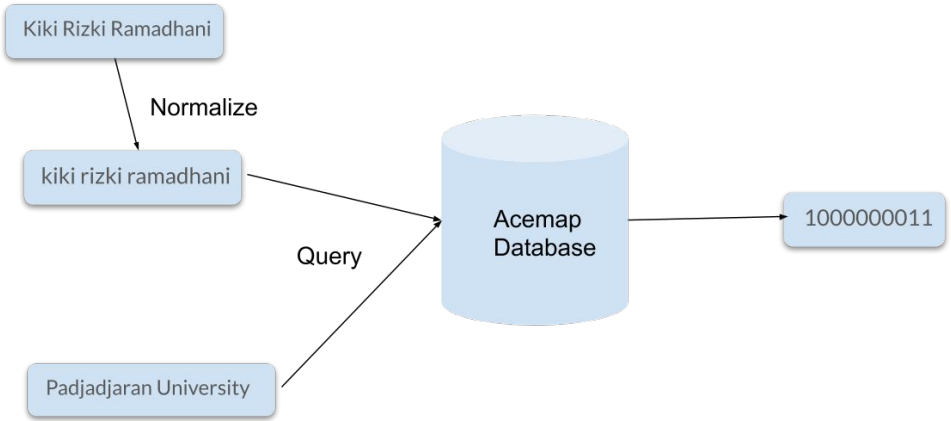
Author Mapping

Strategy One: Direct Matching of Name.



Author Mapping

Strategy Two: Direct Matching of Name + Affiliation.

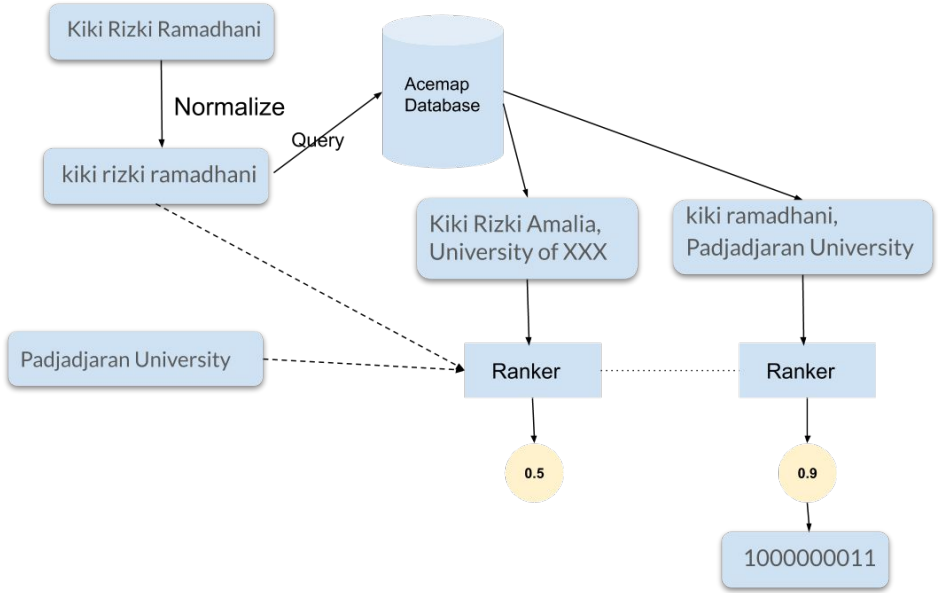


Author Mapping

Strategy Three: similarity ranking of Name + Affiliation (based on Levenshtein distance).

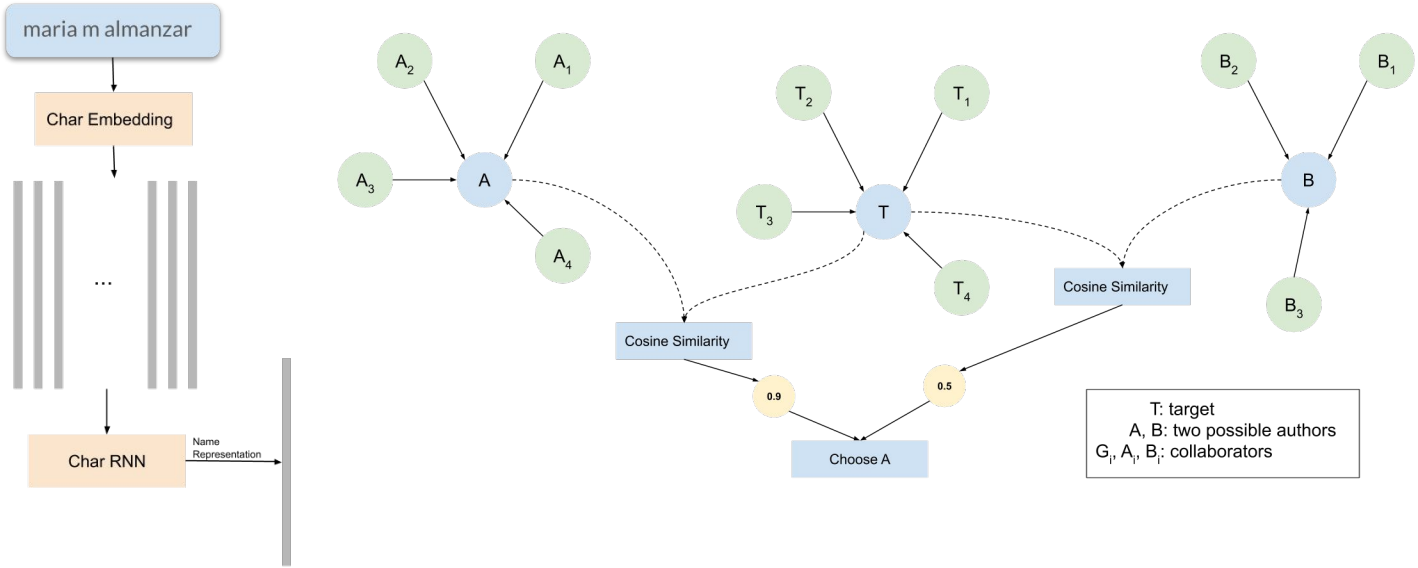
- The Levenshtein distance between two string is the minimum number of single-character edits (insertions, deletions or substitutions) required to change one word into the other.

$$\operatorname{lev}_{a,b}(i,j) = \begin{cases} \max(i,j) & \text{if } \min(i,j) = 0, \\ \min \begin{cases} \operatorname{lev}_{a,b}(i-1,j) + 1 \\ \operatorname{lev}_{a,b}(i,j-1) + 1 \\ \operatorname{lev}_{a,b}(i-1,j-1) + 1_{(a_i \neq b_j)} \end{cases} & \text{otherwise.} \end{cases}$$



Author Mapping

Strategy Four: similarity ranking of Name + Collaborators (based on Graph Neural Network).



Author Mapping

Design of Experiments:

- Use authors from NSF_US as dataset, randomly extract 10% of it as test set;
- Manually create typos at rate **α** in test set (insertions, deletions or substitutions);
- Set a drop rate **β** of affiliation and collaborators;

Author Mapping

	Training Time	Inference Time	Acc*	Acc**
Name	-	0.01 s/item	0.93	0.42
Name + Affiliation	-	0.02 s/item	0.98	0.53
Levenshtein	-	0.42 s/item	**0.99**	0.89
GNN	2 hours	1.98 s/item	0.97	**0.95**

* : with $\alpha = 0$ and $\beta = 0$
**: with $\alpha = 0.2$ and $\beta = 0.8$

Author Mapping

Deployment:

- We will deploy our algorithms on Acemap server and provide an API for users;

Contribution Ⅰ: NSF-CN DataBase

Intuition and Contribution:

- Acemap NSF-CN database contains the principal investigator and the grant information;
- We built a table (NSF_CN.grants), using ‘grants.projectManager’ as foreign key;
- We built a table (NSF_CN.cn_nnsf_participants),

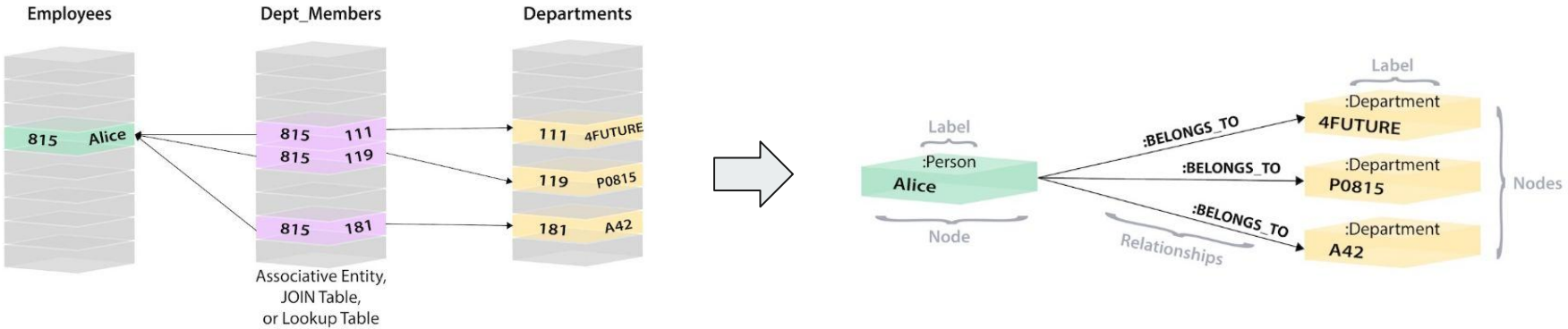
Contribution Ⅱ: NSF-US Grant Table

Intuition and Contribution:

- Acemap NSF-US database contains the principal investigator and the grant information;
- We built a table (NSF_US.grants) providing detailed information about grants;
- We built a table (NSF_US.participants) providing all investigators in the grants.

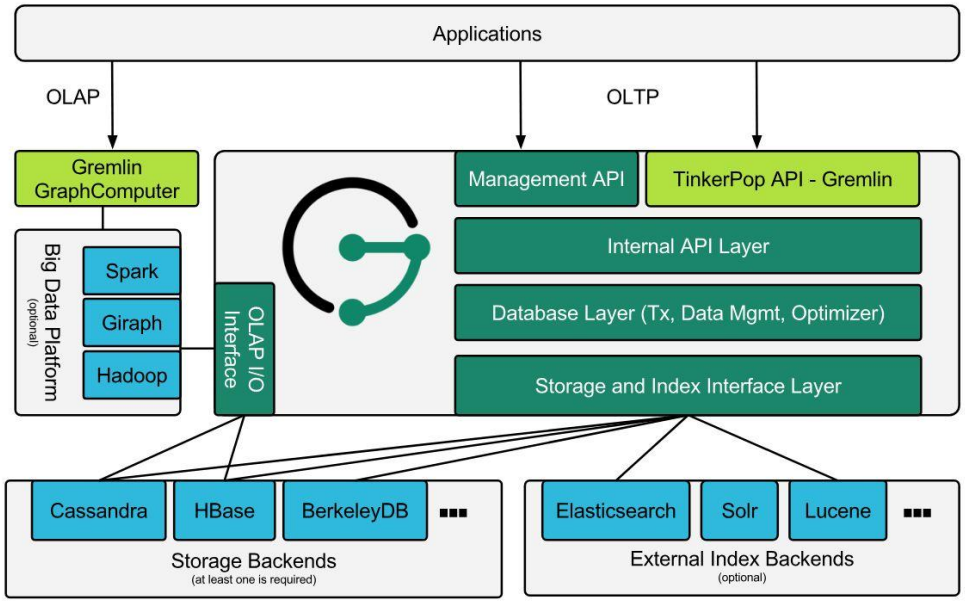
Graph Database

- A type of NoSQL database.
- Uses graph structures for semantic queries with nodes, edges, and properties to represent and store data.
- Flexible & Extensible.

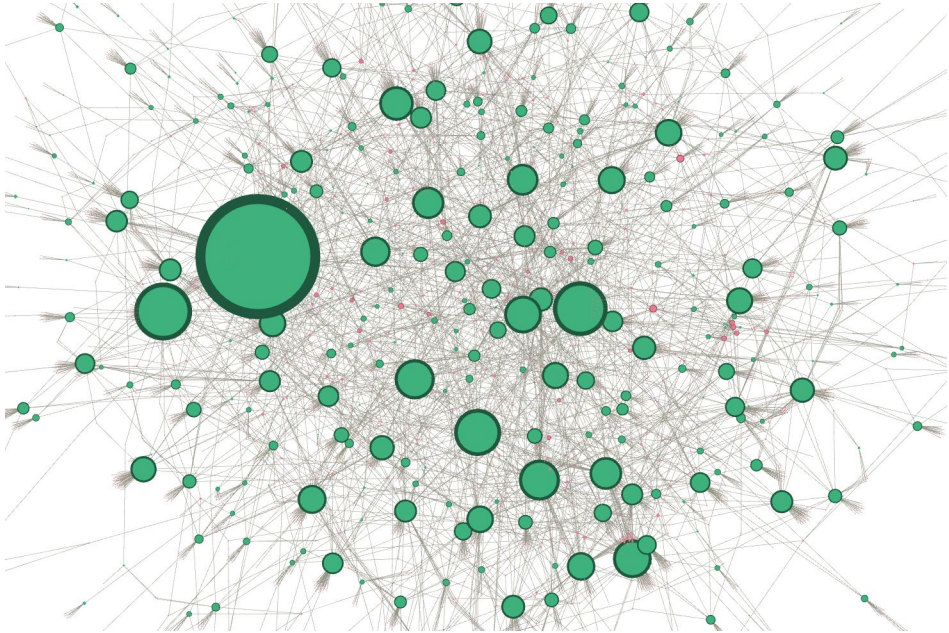


JanusGraph

- Deployment
  - Hbase as storage backend.
  - Solr as external index backend.
  - Gremlin as graph traversal language.
- Performance Test
  - 5.75s for finding the US scholar with most collaborations. .



Connect to Gephi

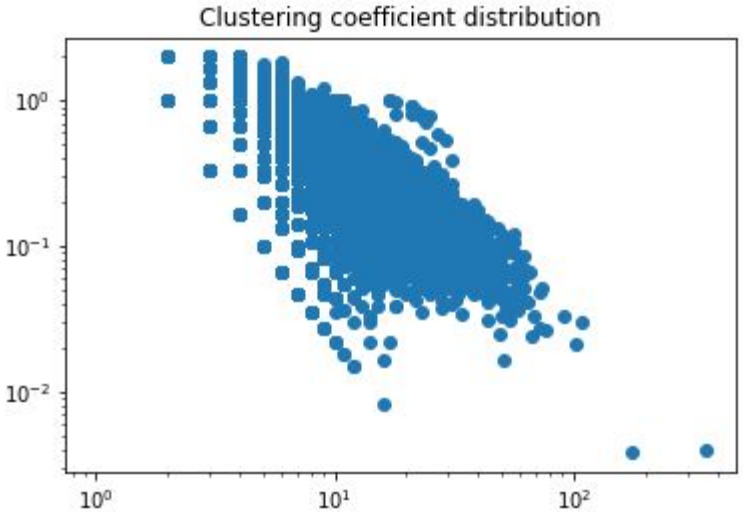


Complex Network Analysis

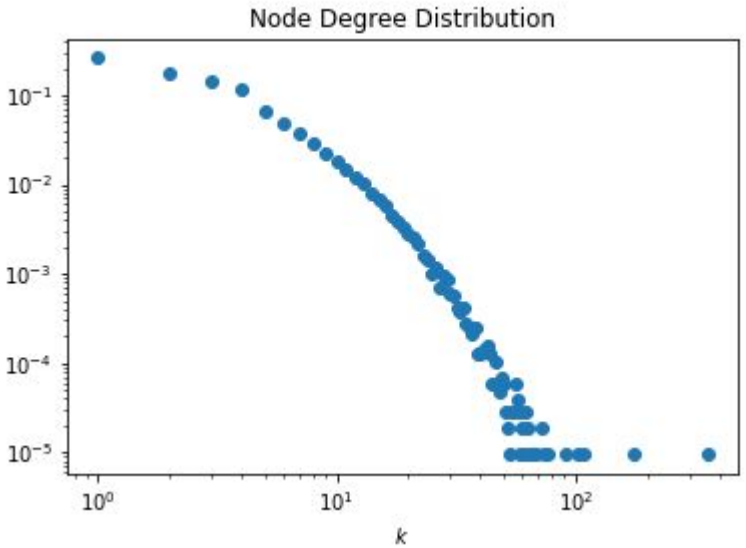
- Qualitative methods for understanding network characteristics
- Metrics we look at
  - Size
  - Degree distribution, average node degree
  - Diameter
  - Assortativity coefficient: Do connected nodes have similar degrees - rich club?
  - Clustering coefficient: Tendency for nodes to cluster together
  - Rich club coefficient: Are well-connected nodes connected?
- Cross-comparison between US, CN and US + CN

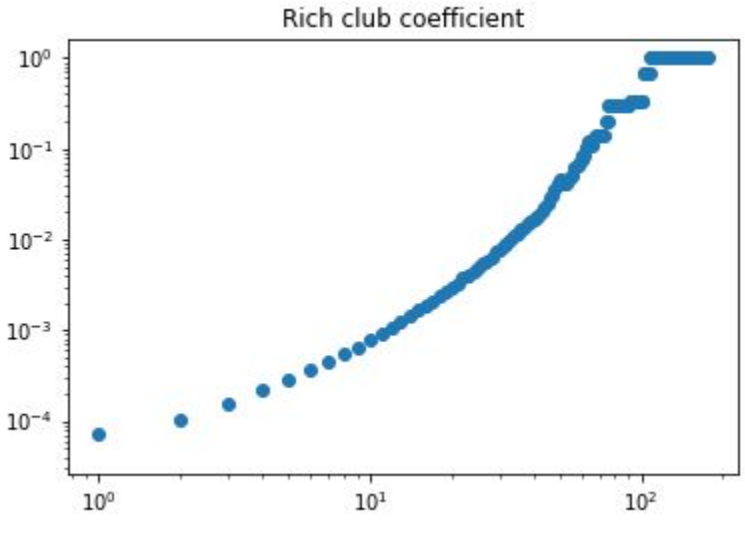
Example: US NSF

- Size: |V| = 104524, |E| = 235320
- Average degree: 4.50
- (Pseudo) Diameter: 20
- Assortativity: 0.07
  - Close to 0, not assortative
- Average clustering coefficient: 0.46 (High)



Example: US NSF

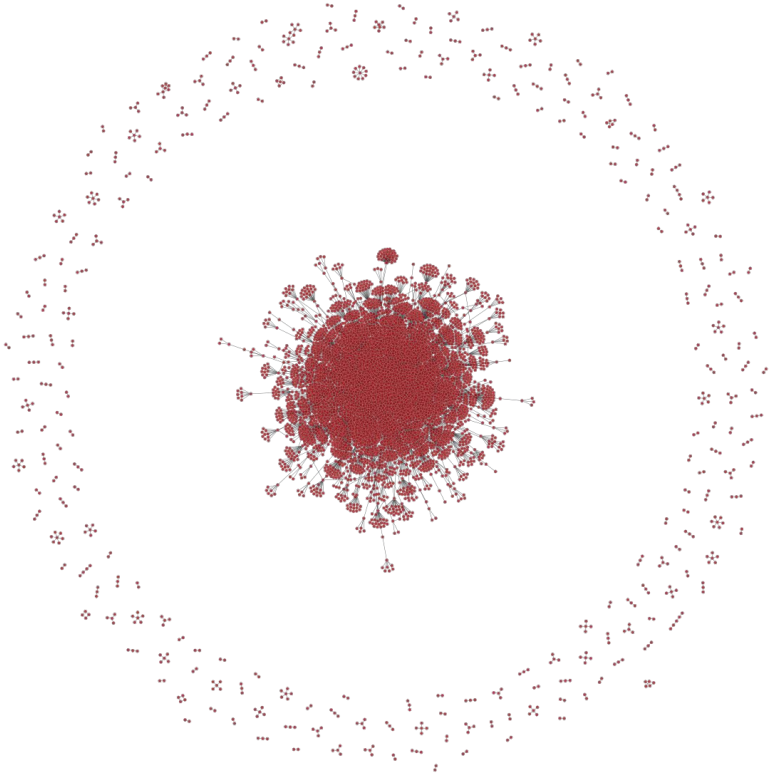




Does NOT follow power law

Cross-comparison

Data	Diameter	Assortativity	Average clustering coefficient	Rich club coefficient
US	20	0.07	0.45	< 1
CN	18	0.13	0.56	< 1
CN + US	15	-0.25	0.32	< 1



The Final CN-US collaboration (not coronavirus)

Thanks

Notable Metrics

- Assortativity
  - Two connected nodes imply their similarity.
  - Assortativity coefficient, with regard to a property, measures the overall similarity on this property between two connected nodes?
  - Actually Pearson'r, so falls in [-1, 1]
- Clustering coefficient
  - For each node, the number of edges in its neighborhood / the number of edges if its neighborhood is complete
  - Understood w.r.t a comparable random graph
- Rich club coefficient
  - For degree k, the number of edges in the subgraph formed by nodes with degree >= k / complete graph

Computing the Metrics

- Select a network-analysis framework
  - Strike the right balance between speed and ease of use
  - Contenders: networkx, igraph, graph-tool, SNAP, networkkit
- Networkx
  - The most-feature complete
  - Written in pure Python = extremely slow
  - Benchmarks[1] show that it is 10 times slower than the *slowest* library
- Graph-tool
  - C++ with Python interface = fast (like Numpy)
  - We have to implement the rich club coefficient ourselves
- Why not Gephi
  - Not well-maintained
  - Lack many metrics

1 https://www.timlrx.com/2020/05/10/benchmark-of-popular-graph-network-packages-v2/