Cross-domain Collaboration Recommendation

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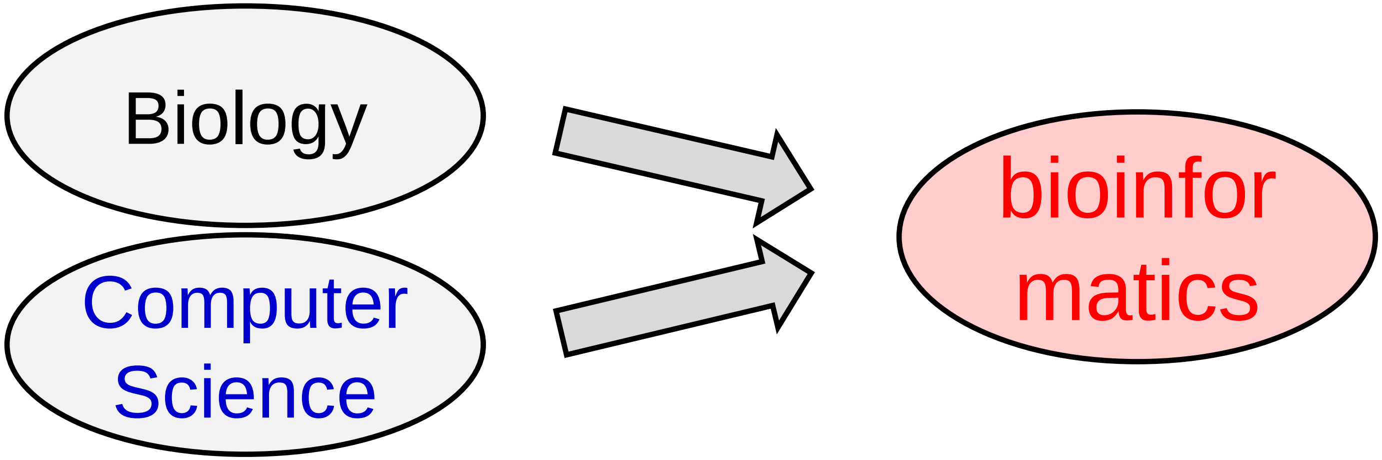
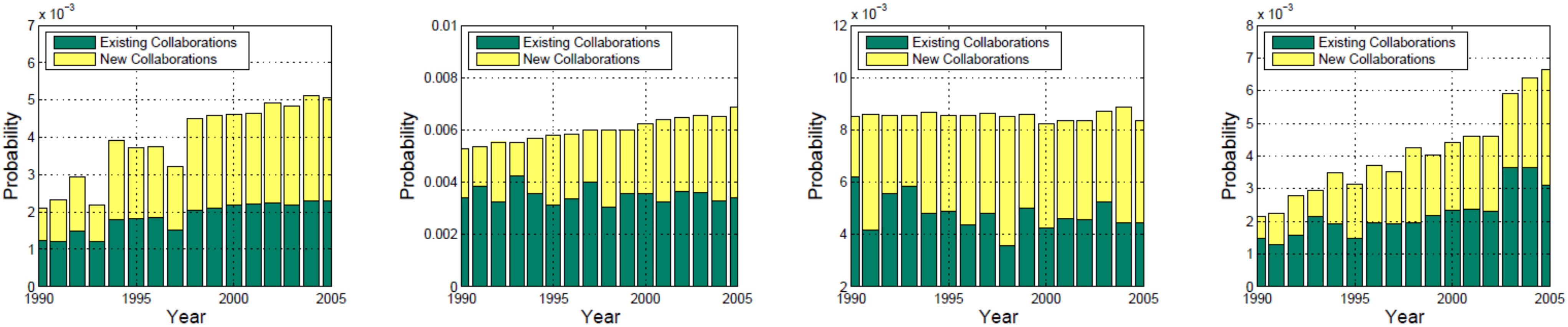
Cross-domain Collaboration

- Interdisciplinary collaborations have generated huge impact, for example,
  - 51 (>1/3) of the KDD 2012 papers are result of cross-domain collaborations between graph theory, visualization, economics, medical inf., DB, NLP, IR
  - Research field evolution



Cross-domain Collaboration (cont.)

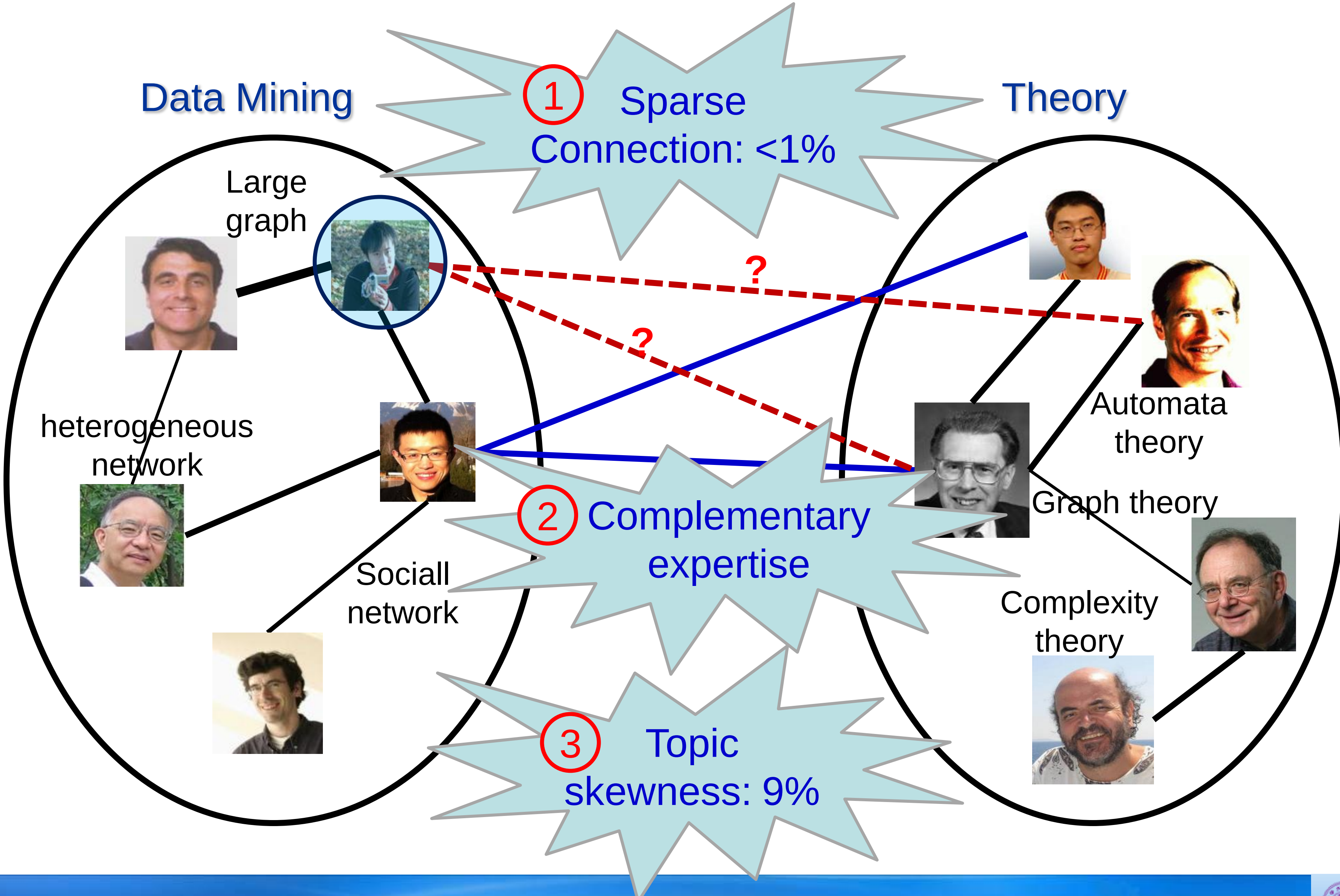
- Increasing trend of cross-domain collaborations



(a) DM - TH (b) DM - MI (c) DM - VIS (d) MI - DB

Data Mining(DM), Medical Informatics(MI), Theory(TH), Visualization(VIS)

Challenges



Data Mining
1 Sparse Connection: <1%
Theory
Large graph
heterogeneous network
Sociall network
Automata theory
Graph theory
Complexity theory
?
?
2 Complementary expertise
3 Topic skewness: 9%

Related Work-Collaboration recommendation

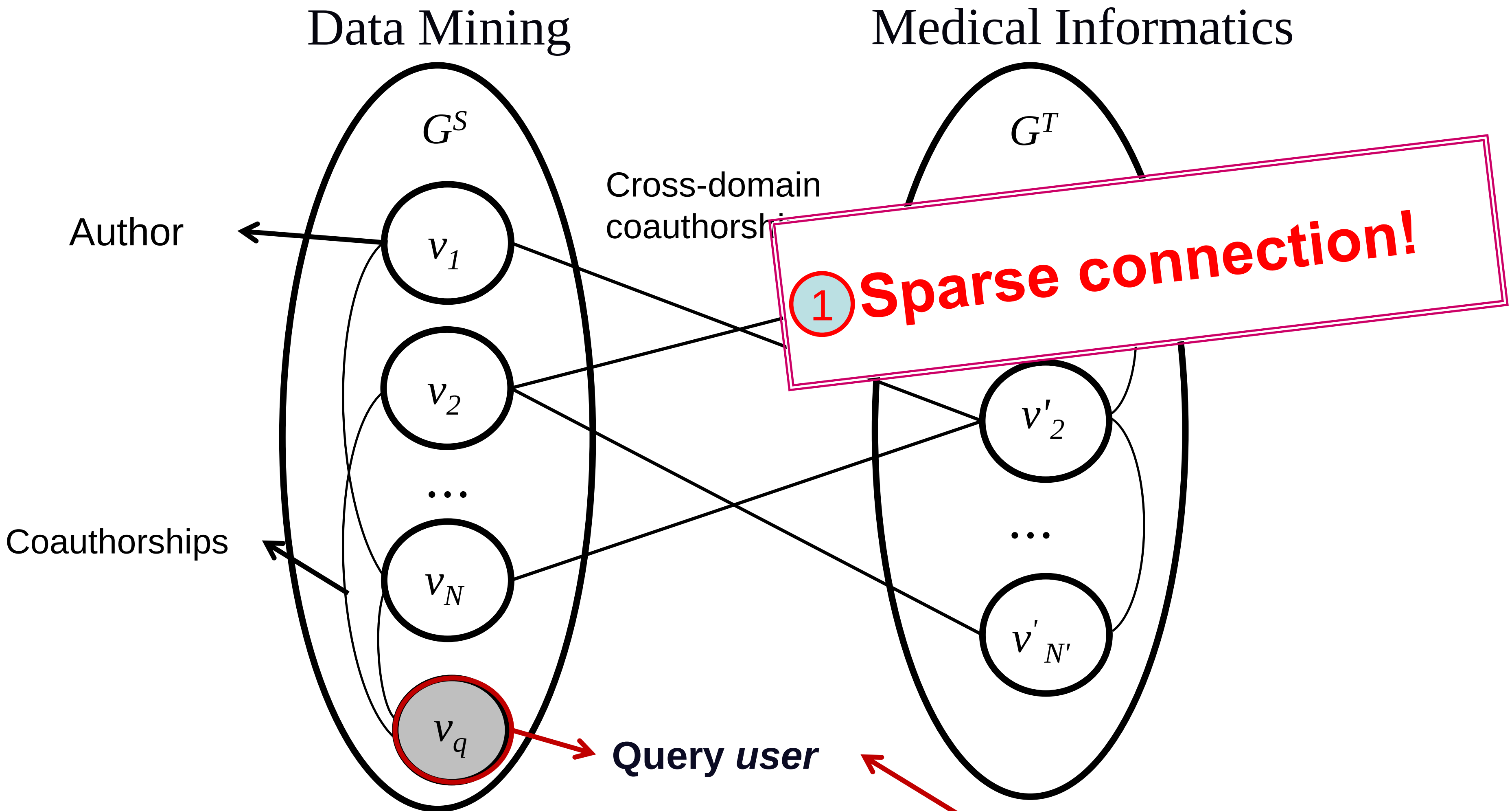
- Collaborative topic modeling for recommending papers
  - C. Wang and D.M. Blei. [2011]
- On social networks and collaborative recommendation
  - I. Konstas, V. Stathopoulos, and J. M. Jose. [2009]
- CollabSeer: a search engine for collaboration discovery
  - H.-H. Chen, L. Gou, X. Zhang, and C. L. Giles. [2007]
- Referral web: Combining social networks and collaborative filtering
  - H. Kautz, B. Selman, and M. Shah. [1997]
- Fab: content-based, collaborative recommendation
  - M. Balabanovi and Y. Shoham. [1997]

Related Work-Expert finding and matching

- Topic level expertise search over heterogeneous networks
  - J. Tang, J. Zhang, R. Jin, Z. Yang, K. Cai, L. Zhang, and Z. Su. [2011]
- Formal models for expert finding in enterprise corpora
  - K. Balog, L. Azzopardi, and M.de Rijke. [2006]
- Expertise modeling for matching papers with reviewers
  - D. Mimno and A. McCallum. [2007]
- On optimization of expertise matching with various constraints
  - W. Tang, J. Tang, T. Lei, C. Tan, B. Gao, and T. Li. [2012]

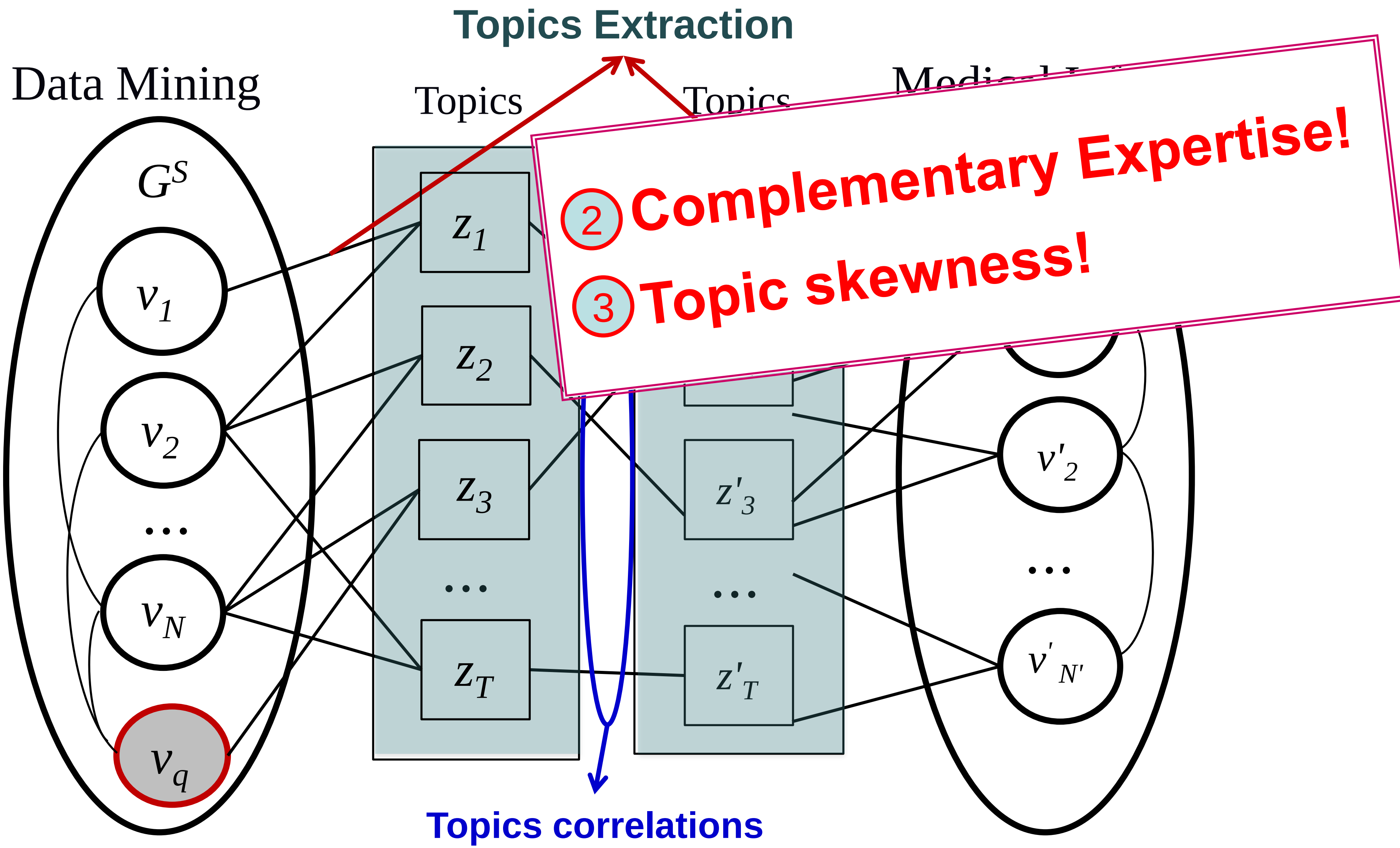
Approach Framework
—Cross-domain Topic Learning

Author Matching

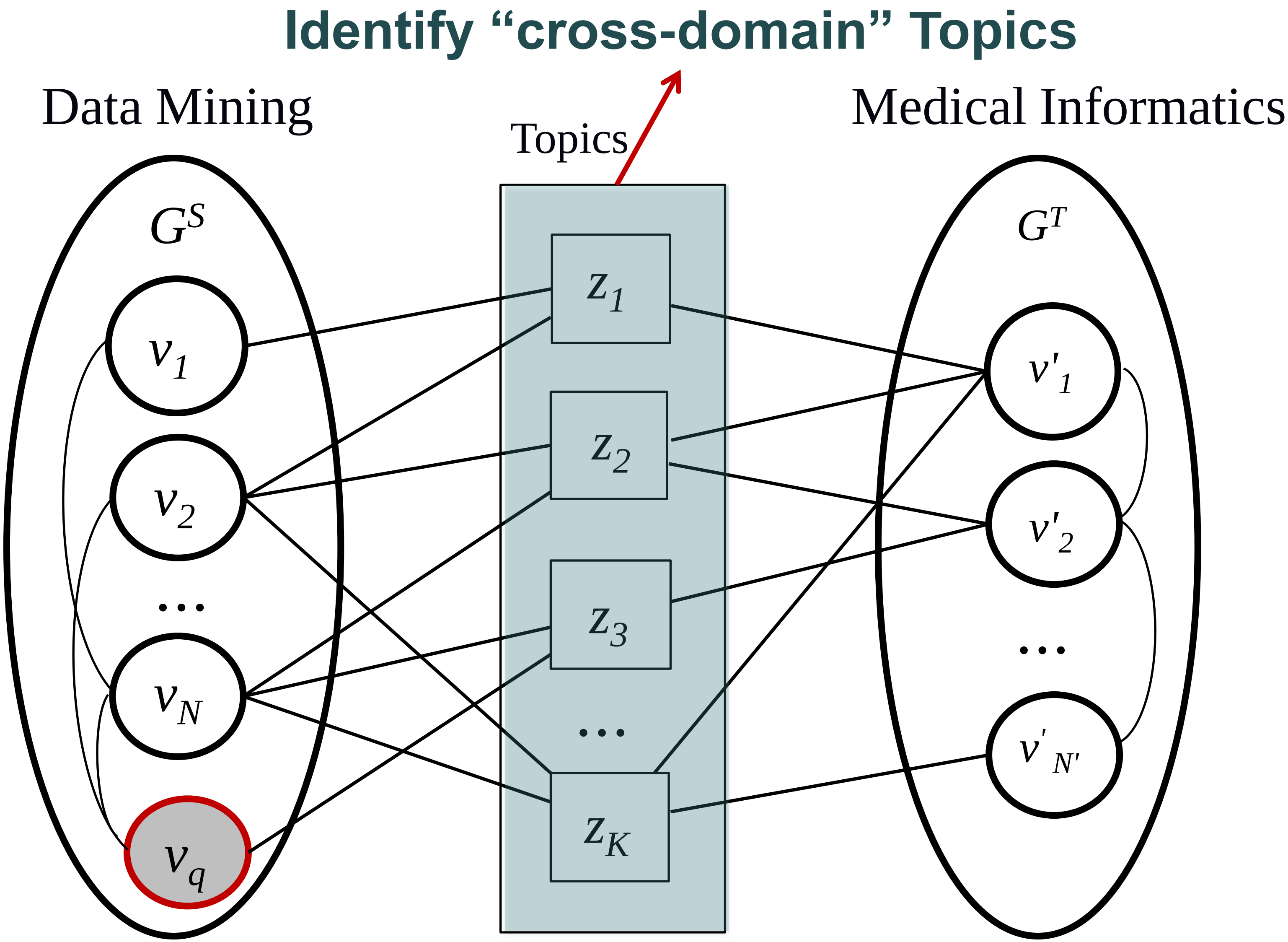


$$\mathbf{r}^{(t+1)} = (1-\tau)\mathbf{S}\cdot\mathbf{r}^{(t)} + \tau\boxed{\mathbf{q}}$$

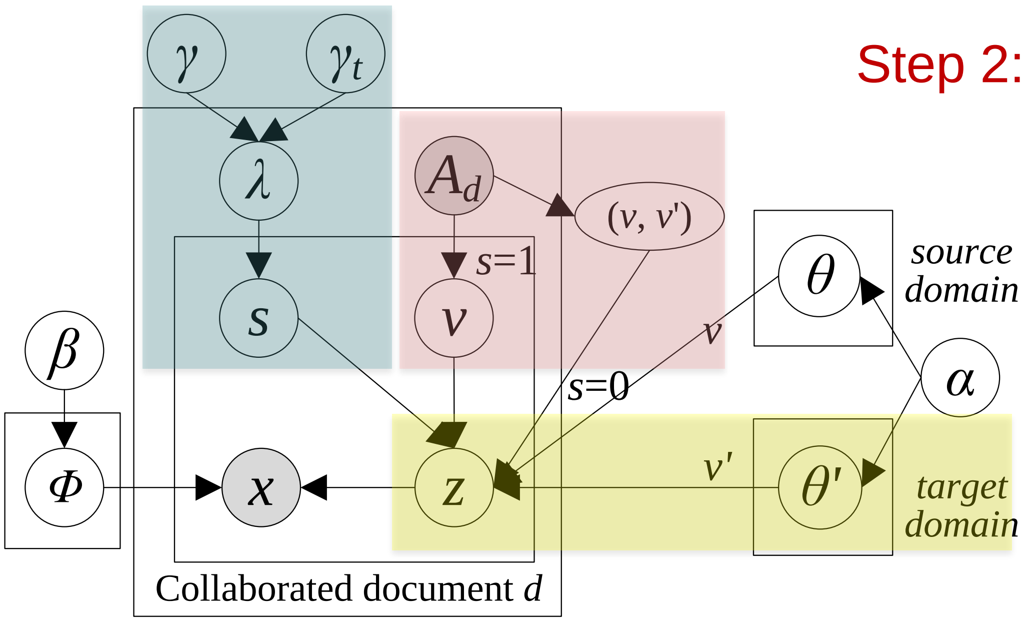
Topic Matching



Cross-domain Topic Learning



Collaboration Topics Extraction



Input: a source domain G^S and a target domain G^T
Output: estimated parameters θ,θ',ϕ, ϑ, and λ

Step 1:

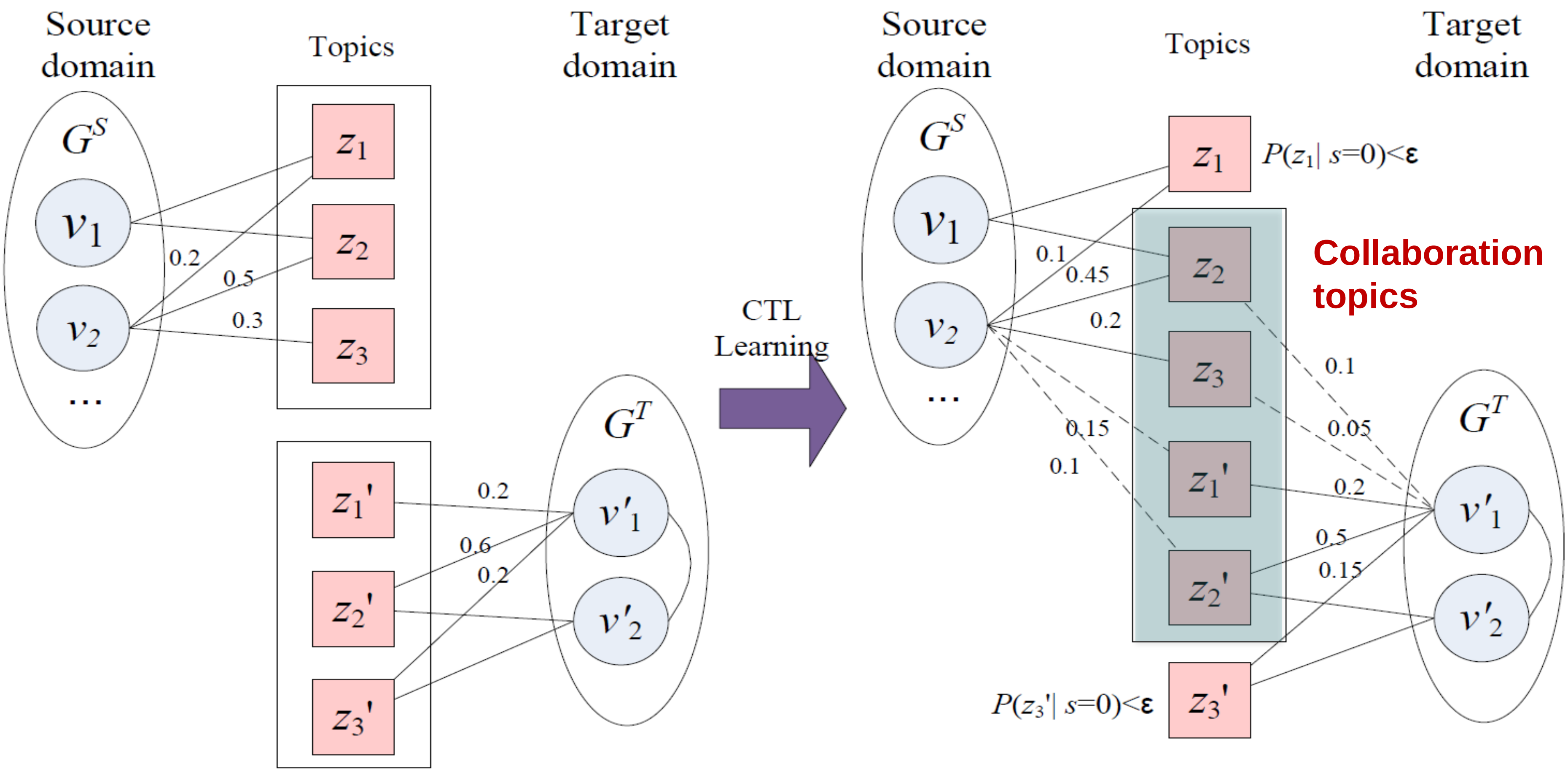
Initialize an ACT model in G^S by learning from documents written by authors only from G^S;
Similarly, initialize an ACT model for target domain G^T;

foreach *collaborated document* d **do**

Step 2:

  foreach *word* $x_{di} \in d$ **do**
    Toss a coin s_{di} according to $bernoulli(s_{di}) \sim beta(\gamma_t, \gamma)$, where $beta(.)$ is a Beta distribution, and γ_t and γ are two parameters;
    if $s_{di} = 0$ **then**
      Randomly select a pair (v, v') from d's authors, where v is an author from G^S and v' from G^T;
      Draw a topic $z_{di} \sim multi(\vartheta_{vv'})$ from the topic mixture $\vartheta_{vv'}$ specific to (v, v');
    end
    if $s_{di} = 1$ **then**
      Randomly select a user v;
      Draw a topic $z_{di} \sim multi(\theta_v)$ from the topic model of user v;
    end
  end
  Draw a word $x_{di} \sim multi(\phi_{z_{di}})$ from z_{di}-specific word distribution;
end

Intuitive explanation of Step 2 in CTL



Experiments

Data Set and Baselines

- Arnetminer (available at http://arnetminer.org/collaboration)

Domain	Authors	Relationships	Source
Data Mining	6,282	22,862	KDD, SDM, ICDM, WSDM, PKDD
Medical Informatics	9,150	31,851	JAMIA, JBI, AIM, TMI, TITB
Theory	5,449	27,712	STOC, FOCS, SODA
Visualization	5,268	19,261	CVPR, ICCV, VAST, TVCG, IV
Database	7,590	37,592	SIGMOD, VLDB, ICDE

- Baselines
  - Content Similarity(Content)
  - Collaborative Filtering(CF)
  - Hybrid
  - Katz
  - Author Matching(Author), Topic Matching(Topic)

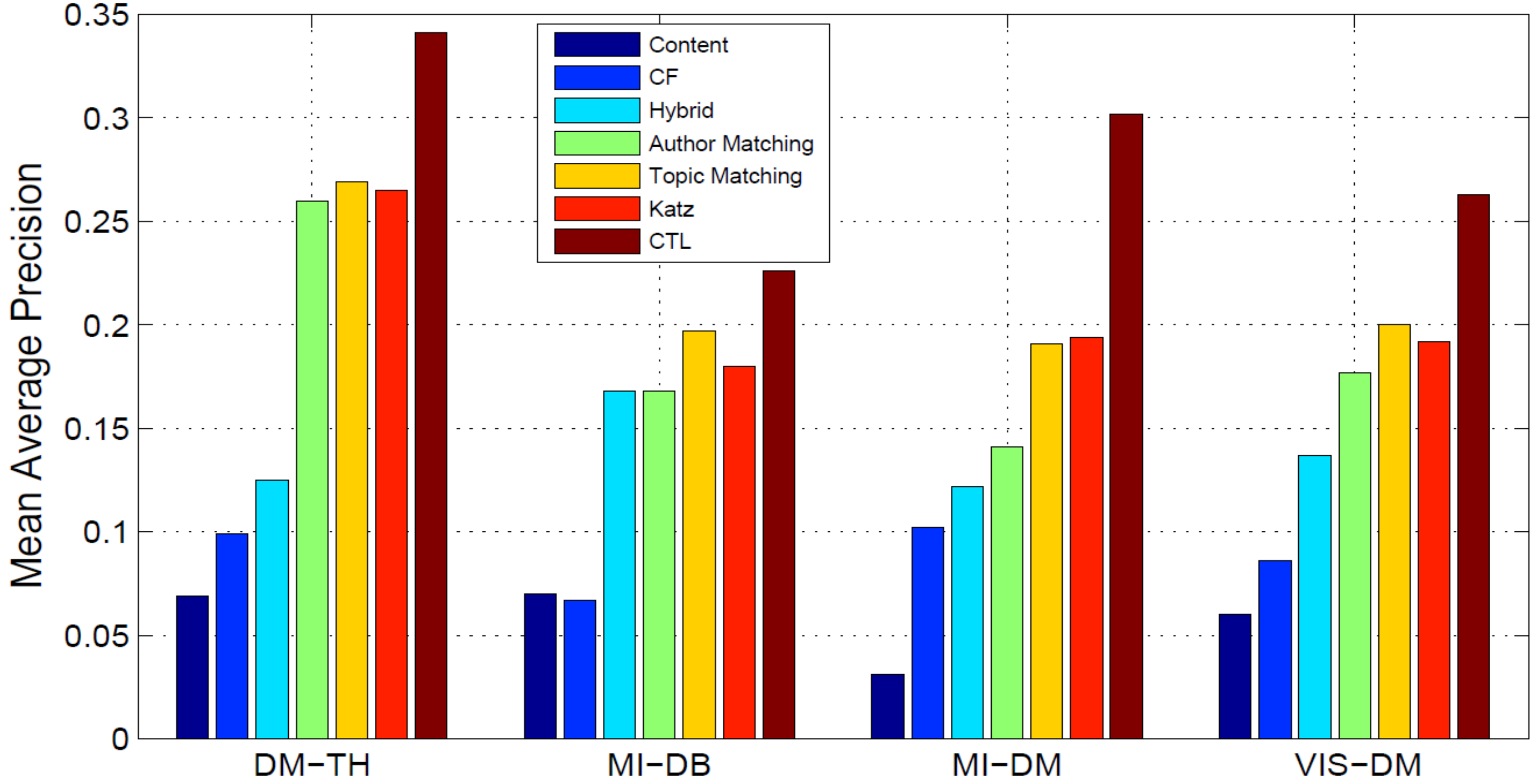
Performance Analysis

Training: collaboration before 2001 Validation: 2001-2005

Cross Domain	ALG	P@10	P@20	MAP	R@100	ARHR -10	ARHR -20
Data Mining(S) to Theory(T)	Content	10.3	10.2	10.9	31.4	4.9	2.1
	CF	15.6	13.3	23.1	26.2	4.9	2.8
	Hybrid	17.4	19.1	20.0	29.5	5.0	2.4
	Author	27.2	22.3	25.7	32.4	10.1	6.4
	Topic	28.0	26.0	32.4	33.5	13.4	7.1
	Katz	30.4	29.8	21.6	27.4	11.2	5.9
	CTL	37.7	36.4	40.6	35.6	14.3	7.5

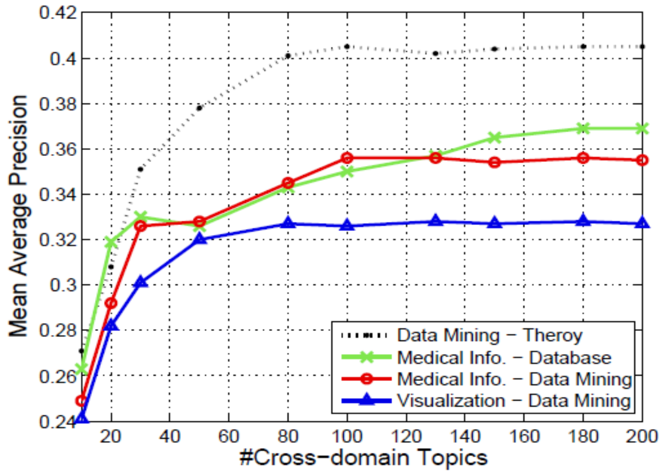
Content Similarity(Content): based on similarity between authors' publications
Collaborative Filtering(CF): based on existing collaborations
Hybrid: a linear combination of the scores obtained by the Content and the CF methods.
Katz: the best link predictor in link-prediction problem for social networks
Author Matching(Author): based on the random walk with restart on the collaboration graph
Topic Matching(Topic): combining the extracted topics into the random walking algorithm

Performance on New Collaboration Prediction

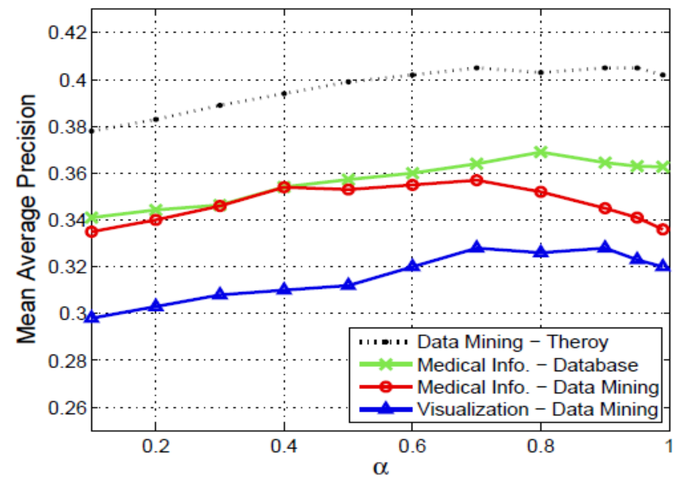


CTL can still maintain about 0.3 in terms of MAP which is significantly higher than baselines.

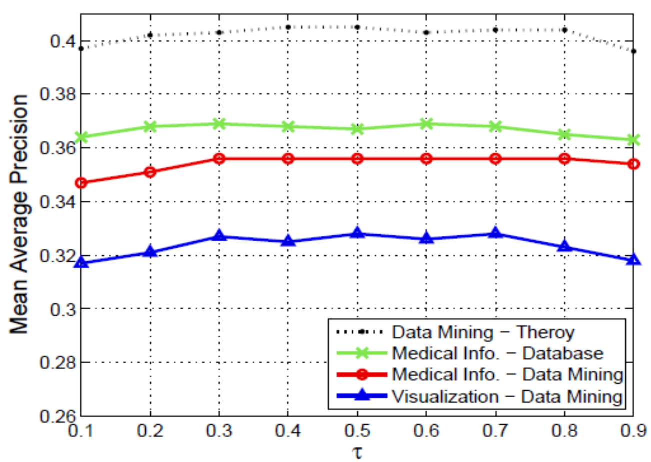
Parameter Analysis



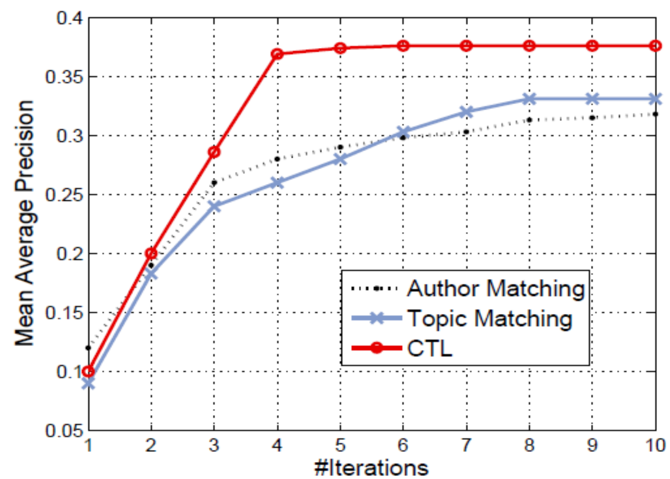
(a) number of topics T



(b) Hyperparameter α



(c) RWR parameter τ



(d) Convergence analysis

(a) varying the number of topics T

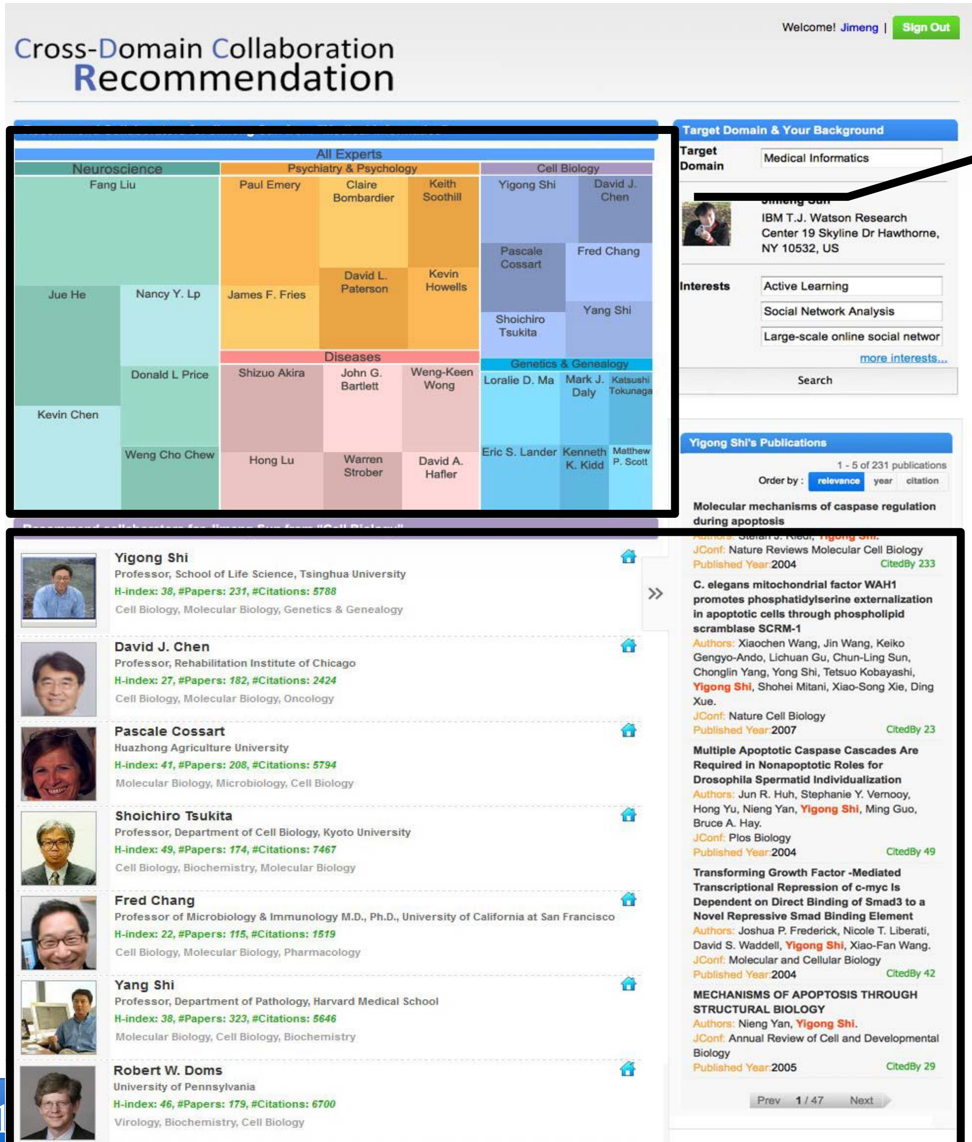
(b) varying α parameter

(c) varying the restart parameter τ in the random walk

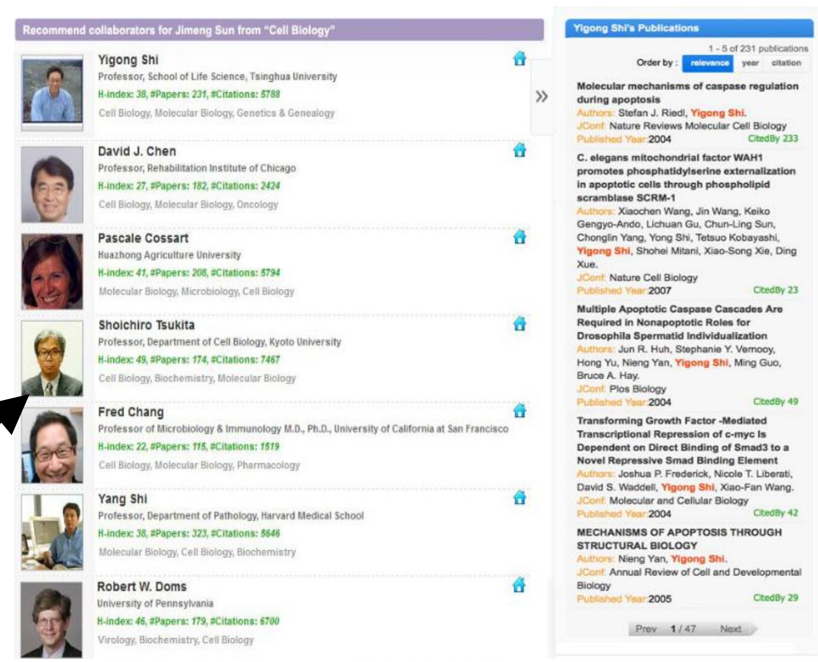
(d) Convergence analysis

Prototype System

http://arnetminer.org/collaborator



Treemap: representing subtopic in the target domain



Recommend Collaborators & Their relevant publications

Conclusion

- Study the problem of cross-domain collaboration recommendation
- Propose the cross-domain topic model for recommending collaborators
- Experimental results in a coauthor network demonstrate the effectiveness and efficiency of the proposed approach

Future work

- Connect cross-domain collaborative relationships with social theories (e.g. social balance, social status, structural hole)

- Apply the proposed method to other networks

Thanks!

System: http://arnetminer.org/collaborator

Code&Data: http://arnetminer.org/collaboration

Challenge always be side with opportunity!

- Sparse connection:
  - cross-domain collaborations are rare;
- Complementary expertise:
  - cross-domain collaborators often have different expertise and interest;
- Topic skewness:
  - cross-domain collaboration topics are focused on a subset of topics.

How to handling these patterns?

Performance Analysis

Cross Domain	ALG	P@10	P@20	MAP	R@100	ARHR-10	ARHR-20
Medical Info.(S) to Database(T)	Content	10.1	10.9	12.5	45.9	3.6	2.1
	CF	18.3	20.2	21.4	47.6	5.3	3.9
	Hybrid	25.0	26.5	28.4	59.1	6.4	4.2
	Author	26.2	29.6	32.2	54.8	10.5	5.4
	Topic	29.4	26.3	34.7	59.3	11.5	5.2
	Katz	27.5	28.3	30.7	57.2	10.5	5.0
	CTL	32.5	30.0	36.9	59.8	11.4	5.4

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Cross Domain	ALG	P@10	P@20	MAP	R@100	ARHR -10	ARHR -20
Medical Info.(S) to Data Mining(T)	Content	5.8	5.7	9.5	19.8	1.9	0.9
	CF	13.7	17.8	18.9	34.3	2.7	1.3
	Hybrid	18.0	19.0	19.8	36.7	3.4	1.3
	Author	20.1	23.8	29.3	64.4	5.3	2.1
	Topic	26.0	25.0	33.9	48.1	10.7	5.6
	Katz	21.2	23.8	32.4	48.1	10.2	4.8
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Performance Analysis

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Visual.(S) to Data Mining(T)	Content	9.6	11.8	13.2	18.9	3.1	1.8
	CF	14.0	20.8	26.4	29.4	6.9	4.3
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