

ETAF: An Extended Trust Antecedents Framework for Trust Prediction

Guibing Guo, Jie Zhang, Daniel Thalmann
Neil Yorke-Smith*

School of Computer Engineering, NTU, Singapore

*American University of Beirut, Lebanon; and University of Cambridge, UK

Find me at <http://www.luckymoon.me/>

Introduction

- ▶ Trust in e-Commerce
 - ▶ Recommender systems
 - ▶ Security systems
 - ▶ Composite online services
- ▶ Trust types
 - ▶ Explicit trust
 - ▶ Epinions (WOT), ciao.co.uk (circle of trust)
 - ▶ **Implicit trust**
 - ▶ Trust labels, **trust values**

Introduction

- ▶ Trust inference
 - ▶ Social connections
 - ▶ **User behaviors**

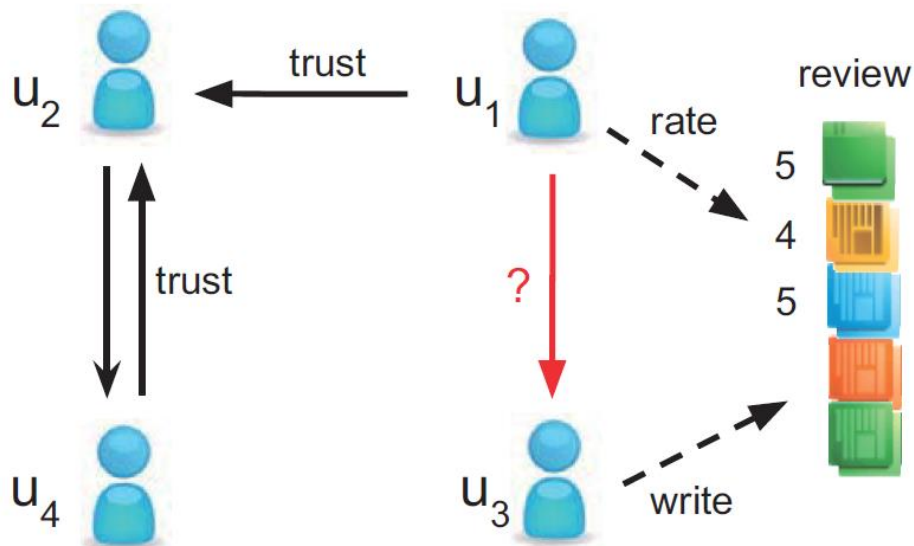


Fig. 1. A social rating network where users specify others as trustworthy and write (or rate) a number of reviews. Solid lines indicate the social trust relationships while dashed lines mean user behaviors (rating and writing).

- ▶ Our Contributions
 - ▶ ETAF: extending TAF w global trust
 - ▶ Formulation of ETAF
 - ▶ No social connections exist
 - ▶ Experimental evaluation
 - ▶ Epinions, CiaoDVDs*
 - ▶ All, cold start, warm start

* The data set is available at <http://www.librec.net/datasets.html>

Content

- 1 Introduction
- 2 Related Work
- 3 Our Proposal: ETAF
- 4 Evaluation
- 5 Conclusion

Related Work

- ▶ Trust prediction via trust connections
 - ▶ Guha et al. (2004): trust propagation
 - ▶ Golbeck (2005): TidalTrust
 - ▶ Massa & Avesani (2007): MoleTrust
 - ▶ Matrix factorization techniques:
 - ▶ Tang et al. (2012): mTrust
 - ▶ Yao et al. (2013): MATRI
- ▶ **Drawbacks**
 - ▶ Explicit trust required
 - ▶ Sparse trust problem

Related Work

- ▶ Trust prediction via user interactions
 - ▶ Liu et al. (2008): classification approach
 - ▶ Ma et al. (2009): user activity important
 - ▶ Matsuo & Yamamoto (2009)
 - ▶ Bidirectional trust
 - ▶ Product brand important
 - ▶ Nguyen et al. (2010): reciprocal trust
- ▶ **Drawbacks**
 - ▶ Hand-crafted features
 - ▶ Trust labels only

- ▶ Most relevant research
 - ▶ Guo et al. (2014)
 - ▶ Rating-based trust prediction
 - ▶ Indirect interactions not suffice
 - ▶ Nguyen et al. (2009): TAF
 - ▶ Prediction by ratings on item reviews
 - ▶ Local trustworthiness only, explicit trust needed
 - ▶ Kim & Phalak (2012): EPT
 - ▶ Both global and local expertise
 - ▶ Benevolence, integrity ignored

What is trust ?



Willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.



By Mayer et al. (1995)

Trust Antecedents Framework (TAF)

▶ TAF Framework

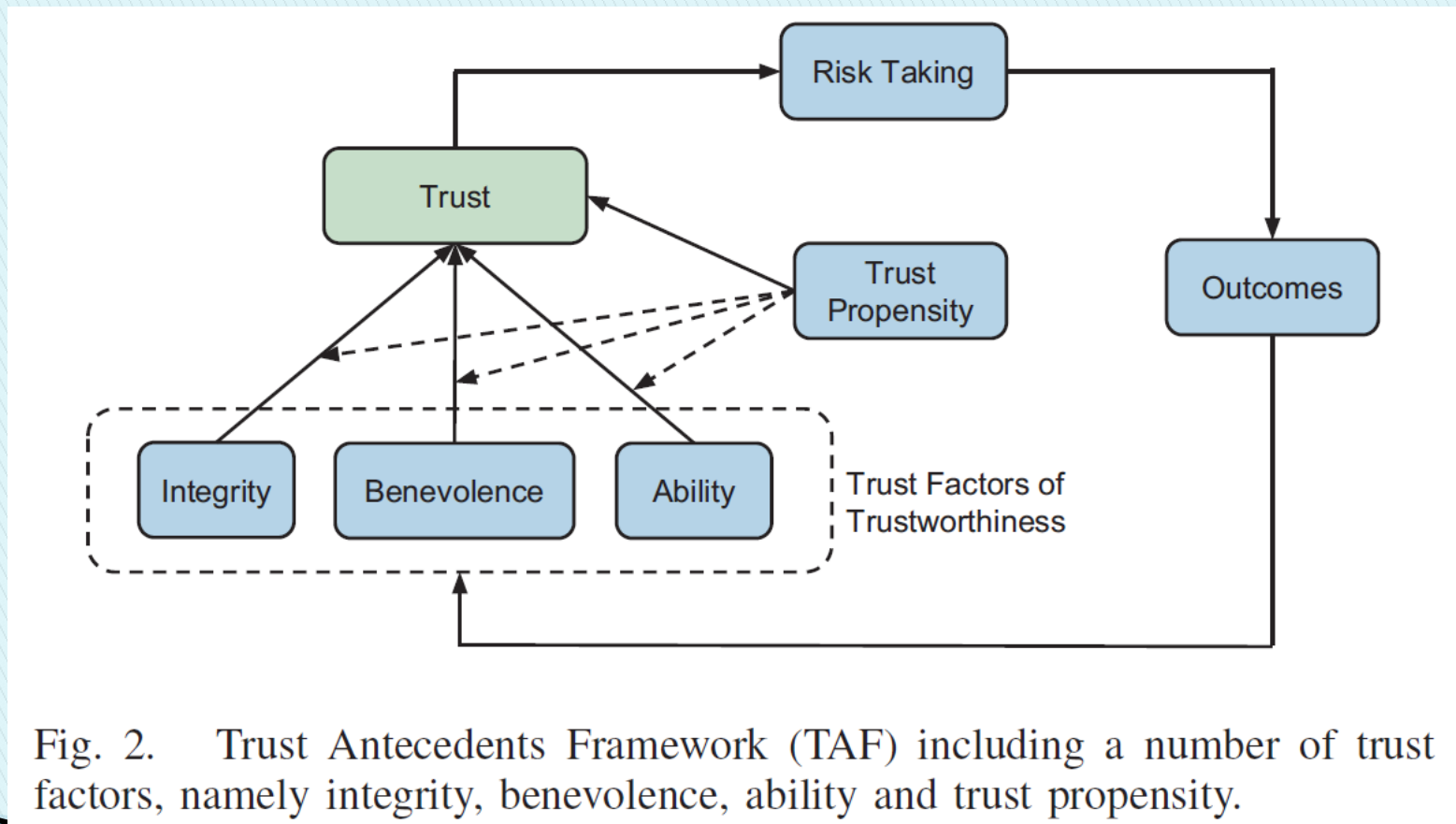


Fig. 2. Trust Antecedents Framework (TAF) including a number of trust factors, namely integrity, benevolence, ability and trust propensity.

Trust Antecedents Framework (TAF)

- ▶ **Ability**
 - ▶ The expertise of performing an action
- ▶ **Benevolence**
 - ▶ The degree of doing good to the trustor
- ▶ **Integrity**
 - ▶ The consistency of adhering to moral norms
- ▶ **Trust propensity**
 - ▶ The degree of tending to trust others.

Extended Trust Antecedents Framework (ETAF)

▶ ETAF model

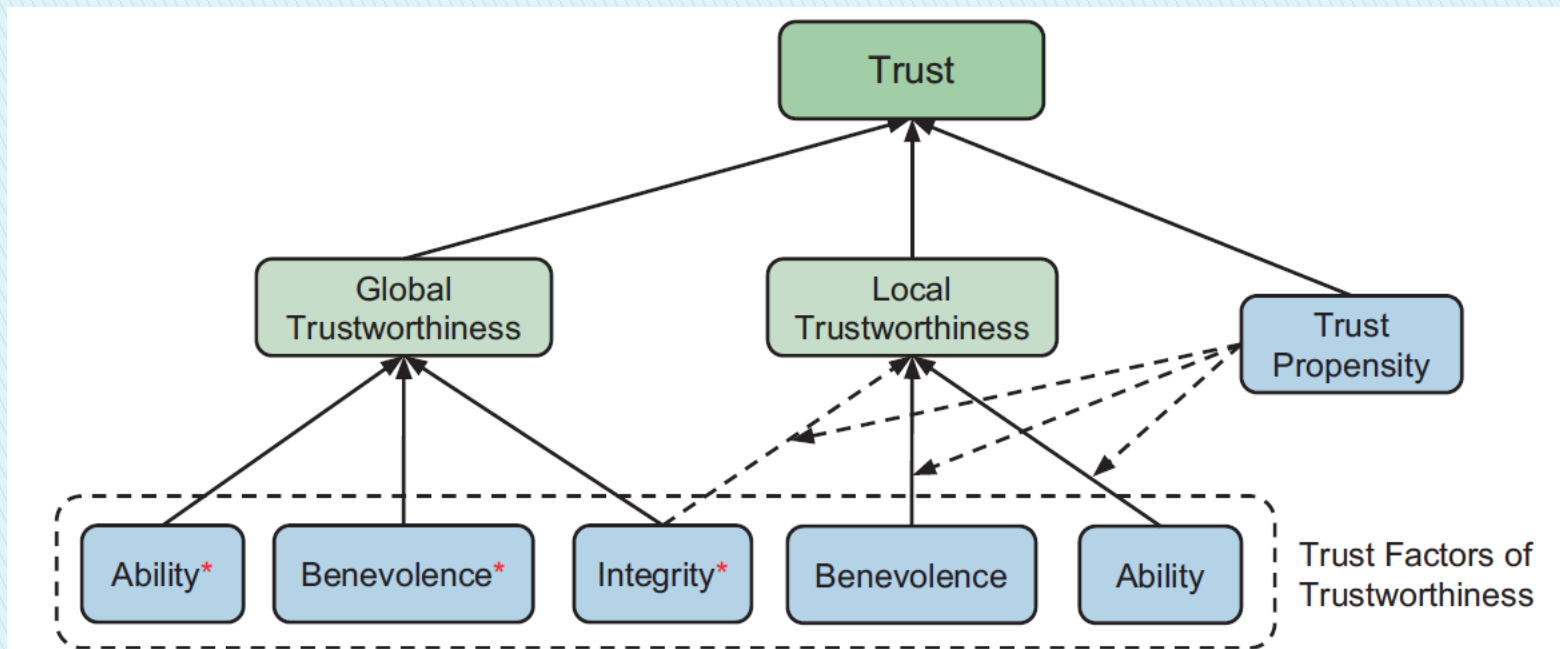


Fig. 3. Extended Trust Antecedents Framework (ETAF). Asterisks denote the global formalization of a trust factor; other factors are the local formalization of trust factors. Dashed lines indicate weak influence of a trust factor on the targets; solid lines strong influence.

Formalization of the ETAF model

▶ Ability*

▶ Review quality

$$q_i = w(|U_{i,p}|) \cdot \frac{\sum_{v \in U_{i,p}} ab_v^r \cdot r_{v,i,p} (1 - \beta l_{v,p})}{\sum_{v \in U_{i,p}} ab_v^r}, \quad (1)$$

▶ Local Leniency

$$l_{v,p} = \frac{1}{|I_{v,p}|} \sum_{i \in I_{v,p}} \frac{r_{v,i,p} - q_i}{r_{v,i,p}}. \quad (3)$$

- ▶ $l_{v,p} < 0$: user v tends to give lower ratings than review quality
- ▶ Similarly if $l_{v,p} > 0$ or $l_{v,p} = 0$

Formalization of the ETAF model

▶ Ability*

▶ Rater ability

$$ab_v^r = w(|I_{v,\cdot}|) \left(1 - \frac{\sum_{i \in I_{v,\cdot}} |r_{v,i,a(i)} - q_i|}{|I_{v,\cdot}|} \right), \quad (2)$$

▶ Writer ability

$$ab_v^w = w(|I_{\cdot,v}|) \frac{\sum_{i \in I_{\cdot,v}} q_i}{|I_{\cdot,v}|},$$

▶ Ability

$$ab_v^* = \gamma \cdot ab_v^w + (1 - \gamma) \cdot ab_v^r, \quad (4)$$

Formalization of the ETAF model

► Ability*

Algorithm 1: Global Computation of Trust Factors

Input : Users U , Reviews I , Ratings R

Output: Users' rater ability ab_v^r , review quality q_i and local leniency $l_{v,p}$

```
1 randomly initialize rater ability  $ab_v^r$  and local leniency
   $l_{v,p}$  with small values in  $(0, 1)$ ;
2 while not converged do
3   foreach  $i \in I$  do
4     | compute review quality  $q_i$  by Equation 1;
5   foreach  $v \in U$  do
6     | update rater ability  $ab_v^r$  by Equation 2;
7   foreach  $v \in U$  do
8     | foreach  $p \in U \setminus \{v\}$  do
9       | | update local leniency  $l_{v,p}$  by Equation 3;
10 return  $ab_v^r, q_i, l_{v,p}$  for all users, reviews, and user pairs;
```

Formalization of the ETAF model

- ▶ Benevolence*
 - ▶ Global leniency

$$ln_v = \frac{1}{|U_{v,\cdot}|} \sum_{p \in U_{v,\cdot}} \frac{l_{v,p} - \min l}{\max l - \min l},$$

- ▶ Normalization

$$be_v^* = \frac{ln_v - \min ln}{\max ln - \min ln}, \quad (5)$$

Formalization of the ETAF model

▶ Integrity*

- ▶ Social norms: ratings given by majority users
- ▶ Rater integrity

$$in_v^r = \frac{w(|I_{v,\cdot}|)}{2} \left(1 + \frac{\sum_{i \in I_{v,\cdot}} (r_{v,i,a(i)} - \bar{r}_v)(q_i - \bar{q})}{\sqrt{\sum_{i \in I_{v,\cdot}} (r_{v,i,a(i)} - \bar{r}_v)^2} \sqrt{\sum_{i \in I_{v,\cdot}} (q_i - \bar{q})^2}} \right),$$

▶ Writer integrity

$$in_v^w = w(|I_{v,\cdot}|) \cdot \mu_v \cdot (1 - \sigma_v).$$

▶ Integrity

$$in_v^* = \eta \cdot in_v^w + (1 - \eta) \cdot in_v^r, \quad (6)$$

- ▶ Ability
 - ▶ Average rating
 - ▶ Interaction intensity

$$ab_v^u = \psi(|I_{u,v}|; \alpha, \mu) \cdot \frac{\sum_{i \in I_{u,v}} r_{u,i,v}}{|I_{u,v}|}, \quad (7)$$

where

$$\psi(x; \alpha, \mu) = \frac{1}{1 + e^{-\alpha(x-\mu)}},$$

Formalization of the ETAF model

▶ Benevolence

$$be_v^u = \frac{l_{u,v} - \min l}{\max l - \min l}. \quad (8)$$

▶ Trust propensity

$$tp_u = ln_u.$$

► Personalized Trust

$$t_{u,v} = \left(\alpha \cdot lt_{v,u} + (1 - \alpha) \cdot gt_v \right) \cdot tp_u, \quad (9)$$

where

$$lt_{v,u} = ab_v^u \cdot be_v^u \cdot 0.5, \quad gt_v = ab_v^* \cdot be_v^* \cdot in_v^*,$$

- ▶ Datasets
 - ▶ CiaoDVDs & Epinions

| Features | CiaoDVDs | Epinions |
|---------------------|----------|-----------|
| Writers | 920 | 6,167 |
| Reviews | 20,469 | 429,093 |
| Reviews/Writer | 22.25 | 69.58 |
| Raters | 3,951 | 6,028 |
| Reviews | 20,455 | 230,891 |
| Review Ratings | 641,810 | 6,512,699 |
| Ratings/Rater | 162.44 | 1080.41 |
| Trustors | 1,438 | 1,500 |
| Trustees | 4,299 | 6,156 |
| Trust Ratings | 40,133 | 11,310 |
| Density | 0.65% | 0.12% |
| Direct Interactions | 5.65 | 7.67 |
| Total Users | 4,658 | 7,551 |

▶ Experimental Settings

▶ Baselines

- ▶ EPT: Kim and Phalak (2012)
- ▶ TAF: Nguyen et al. (2009)
- ▶ ETAF: our approach
- ▶ ETAF*: our approach wo global trust

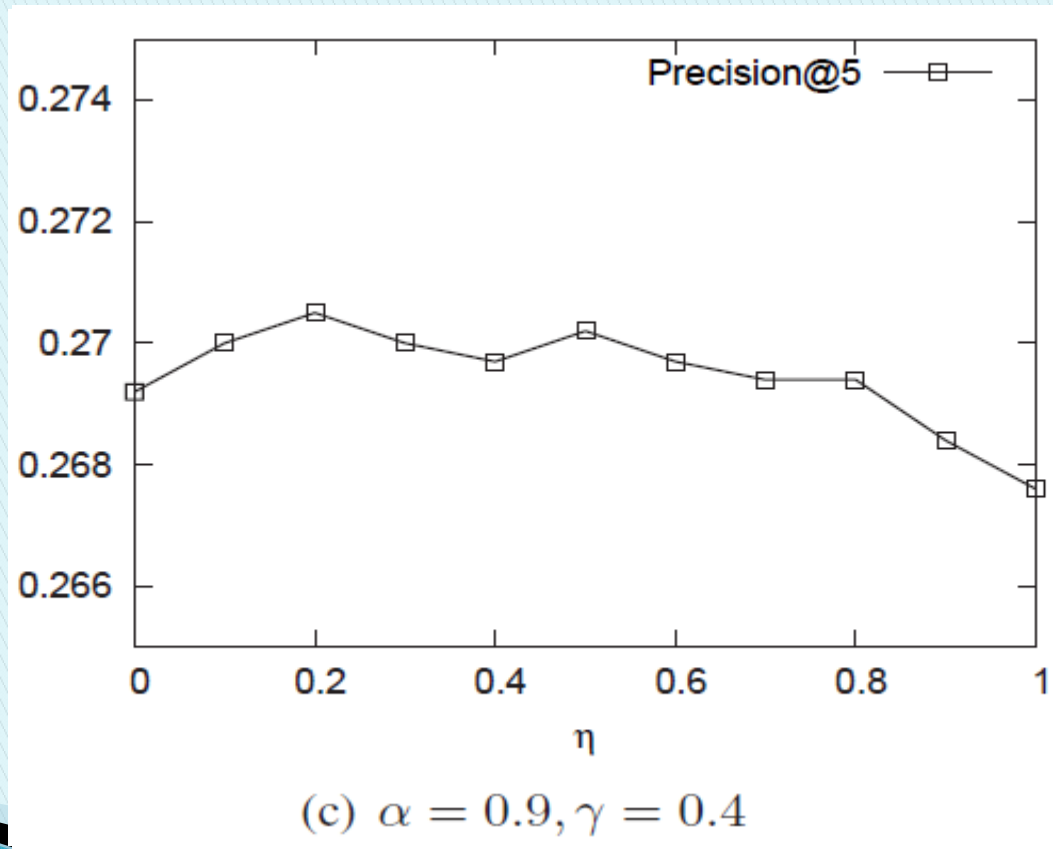
▶ Views

- ▶ All users, Cold start, Warm start

▶ Measures

- ▶ Precision@5/10, Recall@5/10, MAP, NDCG, MRR

- ▶ Case Study 1: CiaoDVDs
 - ▶ Sensitivity analysis

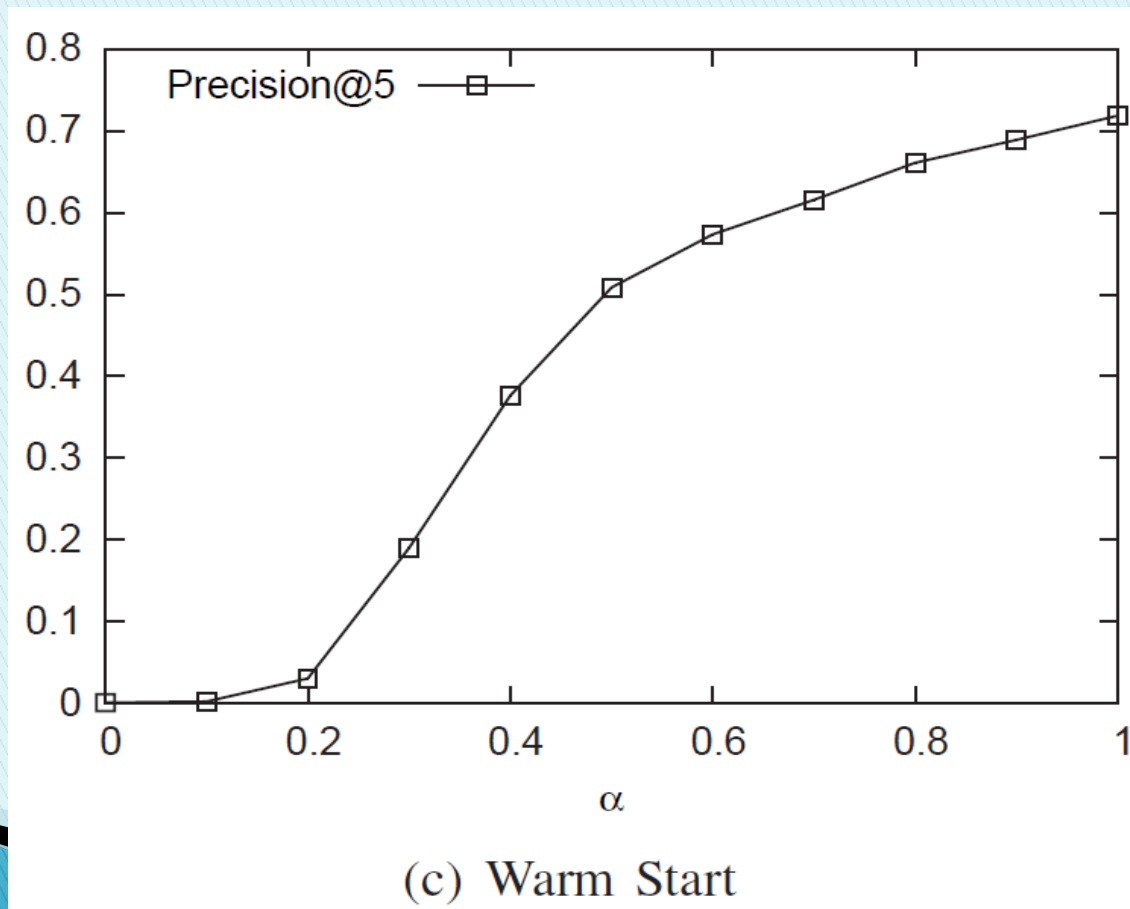


Evaluation

► Performance comparison

| View | Method | Pre@5 | Pre@10 | Rec@5 | Rec@10 | MAP | NDCG | MRR |
|------------|-------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| All Users | EPT | 0.1270 | 0.1080 | 0.0236 | 0.0358 | 0.0247 | 0.0662 | 0.2577 |
| | Improve | 113% | 102% | 219% | 185% | 221% | 147% | 92% |
| | TAF | 0.2529 | 0.2067 | 0.0733 | 0.0992 | 0.0757 | 0.1550 | 0.4614 |
| | Improve | 6.96% | 5.66% | 2.73% | 2.82% | 4.89% | 5.55% | 7.11% |
| | ETAF* | 0.2577 | 0.2107 | 0.0702 | 0.0950 | 0.0733 | 0.1547 | 0.4678 |
| Improve | 4.97% | 3.65% | 7.26% | 7.37% | 8.32% | 5.75% | 5.64% | |
| | ETAF | 0.2705 | 0.2184 | 0.0753 | 0.1020 | 0.0794 | 0.1636 | 0.4942 |
| Cold Start | EPT | 0.0072 | 0.0042 | 0.0142 | 0.0179 | 0.0116 | 0.0167 | 0.0314 |
| | Improve | 949% | 883% | 686% | 552% | 762% | 696% | |
| | TAF | 0.0663 | 0.0332 | 0.1057 | 0.1057 | 0.0968 | 0.1208 | 0.2509 |
| | Improve | 13.88% | 24.40% | 5.58% | 10.41% | 3.31% | 10.02% | |
| | ETAF* | 0.0663 | 0.0332 | 0.1057 | 0.1057 | 0.0973 | 0.1206 | 0.2487 |
| Improve | 13.88% | 24.40% | 5.58% | 10.41% | 2.77% | 10.20% | | |
| | ETAF | 0.0755 | 0.0413 | 0.1116 | 0.1167 | 0.1000 | 0.1329 | 0.2616 |
| Warm Start | EPT | 0.2849 | 0.2411 | 0.0327 | 0.0504 | 0.0397 | 0.1159 | 0.4785 |
| | Improve | 55.77% | 52.26% | 109% | 91.07% | 103% | 66.70% | 40.15% |
| | TAF | 0.3836 | 0.3281 | 0.0654 | 0.0922 | 0.0771 | 0.1852 | 0.6081 |
| | Improve | 15.69% | 11.89% | 4.34% | 4.45% | 4.67% | 4.32% | 10.28% |
| | ETAF* | 0.4301 | 0.3651 | 0.0664 | 0.0972 | 0.0810 | 0.1938 | 0.6583 |
| Improve | 3.19% | 0.55% | 2.86% | -0.93% | -0.37% | -0.31% | 1.87% | |
| | ETAF | 0.4438 | 0.3671 | 0.0683 | 0.0963 | 0.0807 | 0.1932 | 0.6706 |

- ▶ Case Study 2: Epinions
 - ▶ Sensitivity analysis

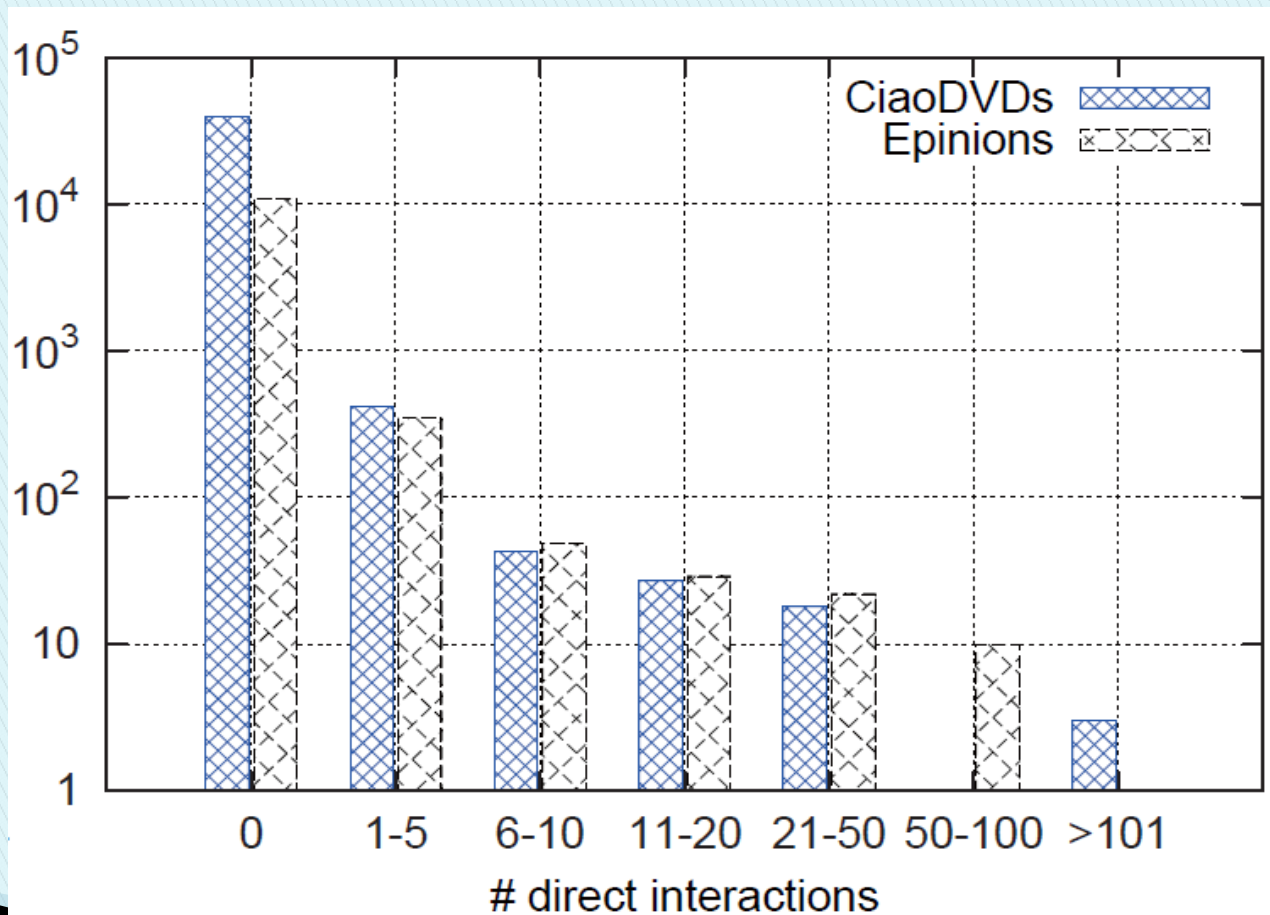


Evaluation

► Performance comparison

| View | Method | Pre@5 | Pre@10 | Rec@5 | Rec@10 | MAP | NDCG | MRR |
|------------|-------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| All Users | EPT | 0.1700 | 0.1164 | 0.2840 | 0.3124 | 0.2753 | 0.3267 | 0.4203 |
| | Improve | 109% | 105% | 94.37% | 87.04% | 105% | 95.81% | 97.69% |
| | TAF | 0.3509 | 0.2361 | 0.5478 | 0.5824 | 0.5599 | 0.6361 | 0.8275 |
| | Improve | 1.34% | 1.23% | 0.77% | 0.33% | 0.75% | 0.57% | 0.41% |
| | ETAF | 0.3556 | 0.2390 | 0.5520 | 0.5843 | 0.5641 | 0.6397 | 0.8309 |
| Cold Start | EPT | 0.0471 | 0.0235 | 0.1933 | 0.1933 | 0.1895 | 0.2011 | 0.2216 |
| | Improve | 246% | 246% | 245% | 245% | 243% | 234% | 243% |
| | TAF | 0.1629 | 0.0814 | 0.6660 | 0.6660 | 0.6529 | 0.6799 | 0.7651 |
| | Improve | 0.00% | 0.00% | 0.00% | 0.00% | -0.46% | -0.35% | -0.55% |
| | ETAF | 0.1629 | 0.0814 | 0.6660 | 0.6660 | 0.6499 | 0.6775 | 0.7609 |
| Warm Start | EPT | 0.5775 | 0.4739 | 0.1633 | 0.2264 | 0.2293 | 0.3689 | 0.7946 |
| | Improve | 24.38% | 28.99% | 33.31% | 36.35% | 48.89% | 34.05% | 12.90% |
| | TAF | 0.7085 | 0.6042 | 0.2108 | 0.3040 | 0.3307 | 0.4846 | 0.8994 |
| | Improve | 1.38% | 1.18% | 3.27% | 1.55% | 3.24% | 2.04% | -0.26% |
| | ETAF | 0.7183 | 0.6113 | 0.2177 | 0.3087 | 0.3414 | 0.4945 | 0.8971 |

► Distribution of user interactions



(c) Histogram

Conclusion

- ▶ Extended TAF
 - ▶ Incorporating global trust
 - ▶ Four general trust factors
- ▶ Formulation of ETAF
 - ▶ No explicit trust required
- ▶ Empirical evaluation
 - ▶ global trust leads to better performance
 - ▶ and indirect influence on local trust

Future Work

- ▶ More behavior features
 - ▶ Interaction duration
 - ▶ Interaction frequency
 - ▶ ...

Thank You!
&
Questions?