Interact with Strangers...
RATE: Recommendation-aware Trust Evaluation in Online Social Networks

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RATE: Recommendation-aware Trust Evaluation in Online Social Networks
Introduction
- Online Social Networks

Facebook  Twitter  Google+  Tencent QQ  Sina WeiBo  Renren

Epinions 😊😊😊😊😊
Introduction

- Trust Issues & Trust Evaluation

Trust issues exist in any application whenever a person (e.g., source $s$) needs to estimate the trust level of another (e.g., target $t$), so as to decide whether or not to conduct further interactions.

Trust Evaluation is a process to predict the trust worthiness of a target $t$, from the perspective of $s$. 
Motivation
- From Social Graph to Trusted Graph

(a) Social Graph

\[ N_s = \{ u_1, \ldots, u_n \} \]

(b) Trusted Graph

\[ R = \{ r_1, \ldots, r_m \} \]
Motivation

- Select Whom As Recommenders?

The direct trust?
Social relationships?
Possible cost?
Risk (uncertainty)?
The Problem

- Recommender Selection Problem

**Given:** a social network $G = (V, E)$; Two nodes, $s$ and $t$, $s$ is the source and $t$ is the target.

**Find:** the best recommenders $R = \{r_1, \ldots, r_m\}$

**Objectives:** making a proper decision (to trust or not to trust $t$), meeting the optimal requirements of higher accuracy, lower risk (uncertainty), and less cost.
**RATE Scheme**

- **Metrics Identification**

**Trustworthiness** ($t_{uv}$): Honesty, and the capability to provide real information.

**Influence** ($i_{uv}$): The closer the relationship exists between two persons, the larger the possibility that one’s opinion will influence the other’s.

**Uncertainty** ($u_{uv}$): It is lower, when the evidence for success/failure dominates, and it is larger when there is little or no evidence.

**Cost** ($c_{uv}$): Just as in daily life, the source wants to contact the target. Regardless of whether it contacts directly or indirectly, some cost will be charged.

$$M_{uv} = \langle t_{uv}, i_{uv}, u_{uv}, c_{uv} \rangle$$

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RATE Scheme

- Utility Functions And The Objective

\[ F = w_t \times t + w_i \times i \quad (1) \]
\[ G = w_u \times u + w_c \times c \quad (2) \]

where \( w_t, w_i, w_u, w_c \) are the weights of the four metrics \( t, i, u, \) and \( c \), respectively (determined by the source \( s \));
\[ 0 < w_t, w_i, w_u, w_c < 1, \quad w_t + w_i = 1, \quad w_u + w_c = 1. \]

The objective: maximize \( F \) and minimize \( G \)

Normalized Utility: \( \lambda \times F + (1 - \lambda) \times (1 - G) \) where \( 0 < \lambda < 1. \)
RATE Scheme

- 1-hop Recommender Selection

Issue 1: How to measure the quality of a recommender?

measure the quality of a recommender

Issue 2: How many recommenders are enough, and are efficient for, decision-making?

decide the size of the optimal recommender set
RATE Scheme

- Measure The Quality Of A Recommender

*Quality of Recommender (QoR)* comprises requirements on a recommender, taking trustworthiness, influence, uncertainty, and cost, as attributes.

Users can set multiple quality constraints $Q^t$, $Q^i$, $Q^u$, $Q^c$ (e.g., thresholds)
RATEx Scheme

- Example

\[ Q^t > 0.5, Q^i > 0.5, \]
\[ Q^u < 0.3, Q^c < 0.5 \]

Qualified recommenders: \( u_1, u_2 \)
**RATE Scheme**

- The Size Of The Recommender Set

- Selecting all qualified neighbors.

- Selecting a fixed number of qualified neighbors
  
  e.g., 3, 6, etc.

- Selecting a fixed proportion of qualified neighbors
  
  e.g., 1/3, 1/6, etc.
RATE Scheme
- The Size Of The Recommender Set

Flexibly selecting some top \( m \) qualified neighbors, \( m \leq n \).

We continue to select qualified recommenders until the number of next hop neighbors is no less than the current ones.
RATE Scheme

- The Effects Of RATE

By comparing the performance of sorting or not sorting the neighbors with QoR, the effects of RATE scheme can be analyzed.
Extension
- Multiple Hop Scenario

Trustworthiness
\[ t_{p(a_1,\ldots,a_n)} = \prod_{e(a_j,a_{j+1}) \in p(a_1,\ldots,a_n)} t_{a_j,a_{j+1}} \]

Influence
\[ i_{p(a_1,\ldots,a_n)} = \prod_{e(a_j,a_{j+1}) \in p(a_1,\ldots,a_n)} i_{a_j,a_{j+1}} \]

Uncertainty
\[ u_{p(a_1,\ldots,a_n)} = 1 - \prod_{e(a_j,a_{j+1}) \in p(a_1,\ldots,a_n)} (1 - u_{a_j,a_{j+1}}) \]

Cost
\[ c_{p(a_1,\ldots,a_n)} = \sum_{e(a_j,a_{j+1}) \in p(a_1,\ldots,a_n)} c_{a_j,a_{j+1}} \]
Experimental Evaluation
- Dataset Epinions (www.epinions.com)

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Experimental Evaluation
- Method: Leave-One-Out

If there is an edge between two nodes, that edge is masked, and trust is calculated through algorithms; then, we compare the calculated value with the masked value.
Experimental Evaluation
- Metrics: Precision, Recall, Fscore

\[
\text{Precision} = \frac{A_t \cap B_t}{B_t}
\]

\[
\text{Recall} = \frac{A_t \cap B_t}{A_t}
\]

\[
\text{Fscore} = \frac{2 \times \text{Recall} \times \text{Precision}}{\text{Recall} + \text{Precision}}
\]

where \(A_t\) is the number of edges on which \(s\) trusts \(t\) directly, and \(B_t\) is the number of edges on which \(s\) trusts \(t\), by trust calculated through an algorithm.
Experimental Evaluation
- Trust Evaluation Strategies

AveR-MaxT
AveR-WAveT
MaxR-MaxT
MaxR-WAveT
Experimental Evaluation - Results (Accuracy)
Evaluation
- Results (Cost & Uncertainty)
Summary & Conclusion

We propose a recommendation-aware trust evaluation scheme: RATE.

We take a new perspective on the selection of good recommenders, to help people make proper decisions.

We evaluate RATE using a real trust network, Epinions.

The results demonstrate how each metric can impact the performance of RATE, and show that RATE can predict trust with higher accuracy (at least 22.4% higher), lower risk, and less cost.
Future Work

- The theoretical bounds of the size of an optimal recommender subset.
- The probability of success to make a proper trust decision.
- The extension of multiple targets scenario.
Thank you for your attention!

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