An effective approach for accurate estimation of trust of distant information sources in the Semantic Web

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Overview

- Introduction and Problem Definition
- Related Work: End-to-End Approaches
- Our Approach: FACiLE
- Experimental Results
- Conclusions and Future Work
Introduction and Problem Definition
Introduction

- Trust metrics to access the trustworthiness of information sources’ referrals are often employed
  - E.g. in the World Wide Web, mobile ad-hoc networks

- Direct own experience rarely suffices for sites visited only occasionally

- Accuracy of inferred trust for “distant” sources may considerably deteriorate due to
  - “noise”
  - the intervention of malicious nodes

This gets worse with distance
In the Semantic Web...

- Transaction \( \rightarrow \) exchange of information

- All referrals and query responses are information

- Objective: Access the trustworthiness of distant nodes
  - Our approach is based on path algebra ...
  - yet, in a more effective way
Related Work

- Simple aggregation functions
  - E.g. sum +1, -1 votes

- Linear algebra
  - Matrix multiplication of direct trust values, probabilistic interpretation

- Path algebra:
  - Directed weighted graph, algebra on the path

- Multi-dimensional trust metrics, e.g. context factors, interests etc.
FACiLE vs. End-to-End Approaches
End-to-End Approaches

- Path algebra treats trust networks as directed weighted graphs
- Trust → a link’s weight in range [0, 1]
  - Results from direct experience with the node
  - No link ⇔ unawareness of trust
- **End-to-end trust inference**
  - Find alternative paths terminating to information source
  - **Concatenate** trust values along path
    - max, min, harmonic mean
  - **Aggregate** calculated trust values along different paths
    - sum, average, max
The FACiLE Approach

For trust inference on a distant node:
1. Ask neighbors for their trust assessment
2. and adopt them based on their own relative inferred trust

Neighbor’s trust is inferred based on
- Concatenation and aggregation

Innovative last step: combination
- Direct trust values of to the distant node are combined based on their own inferred trust
Example

End-to-end inferred trust from q to s
- Maximum: 0.4096, Minimum: 0.3072

FACiLE’s inferred trust from q to s
- 0.8 or above
Experimental Results
The Model (I)

- 100-node power-law graph with some shortcuts ensuring small-word properties
- Three node types: “Good”, “Bad”, “Ugly”
The Model (II)

- Ideal- and Real-World models
- Ideal World: Good always honest, Bad always dishonest
- Real World: Inverted response with probability 0.1, or "Noisy" observation
  - Ugly give random response with probability 0.5
- Efficiency criteria: hit ratio
  - Count a "hit" if inferred trust matches true type
Operators Considered for Each Function (I)

- **Concatenation**
  - Multiplication (MULTI): \( t_{qs} = t_{qc} \cdot t_{cs} \)
  - Harmonic Mean (HARM): \( t_{qs} = \frac{t_{qc} \cdot t_{qc}}{t_{qc} + t_{cs}} \)
  - **Hybrid** Mean (HYBRID): If \( t_{qc} + t_{cs} < 1 \) then HARM else MULTI
Operators Considered for Each Function (II)

- **Aggregation**
  - Maximum: Path with max inferred trust

- **Combination**
  - Maximum(Max): if \( t_{qb} > t_{qc} \) then \( t_{qs} = t_{bs} \) else \( t_{qs} = t_{cs} \)
  - Weighted Average (WeiAvg):
    \[
    t_{qs} = \frac{t_{qb} \cdot t_{bs} + t_{qc} \cdot t_{cs}}{t_{qb} + t_{qc}}
    \]
Performance of End-to-End

Ideal World

- Low performance in **all interesting cases**, i.e.
- “Good” nodes over 50%

Real World
Best End-to-End Combination vs. FACiLE in Ideal World

- WeiAvg and Max perform better than end-to-end approaches for all interesting cases
Best End-to-End Combination vs. FACiLE in Real World

- WeiAvg and Max perform better than end-to-end approaches for all interesting cases
FACiLE with “Ugly” Nodes too

FACiLE achieves high hit ratios, provided that Bad nodes are fewer than 50% of the system

- MULTI concatenation, Max combination
- Real-world model
Incorporate Direct Trust

Trust to distant nodes is given as weighted sum:

$$\lambda \cdot \text{direct\_trust} + (1-\lambda) \cdot \text{inferred\_trust}$$

![Graph showing the number of transactions with the same distant node vs. lambda (\(\lambda\))](image-url)
Effect of Direct Trust to FACiLE

Direct trust is beneficial for FACiLE only if the system has few “Good” nodes.
Conclusions
Conclusions

- Developed a new approach for **trust inference** over **occasionally visited** nodes in the Semantic Web.
- FACiLE reveals that referrals from “trustworthy” nodes “near” the target-node for trust inference are:
  - more informative, and
  - more resistant to “noise” and malicious collectives.
- FACiLE has **high hit ratios** and performs better than end-to-end approaches in all interesting cases:
  - I.e. systems with more trustworthy nodes.
- FACiLE is as effective as direct trust for trust graphs with more than half of the nodes being trustworthy.
Future Work

- Apply FACiLE to other specific contexts
  - e.g. mobile ad-hoc networks, grid

- Use different concatenation and aggregation operators
  - e.g. max-flow