How Certain is Recommended Trust-Information?

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How Far Can Recommended Trust Be The Base of a Trust Decision?

- One expects that part of the information is given by malicious participants
- Trust-information given by a recommender may be reliable or not
- Condensing recommended trust-information of different sources to one value is not reasonable
Strategy for a Trust-Decision

- Keep recommended trust-information untouched
- X builds a network of relations, using recommended and direct information
- If X performs a trust-decision towards Y, the network of relations is transformed into a decision tree
- X chooses a path by random to reduce the influence of malicious nodes
- Passing a node, X chooses by random if it trusts the recommended information or not
- With higher chance paths are chosen, where it is more certain not to end in an un-trusted node
- At the end, the trust-decision is done on the base of a direct-trust-information or on the base of no information
Network of Reliability and Trust

- **Trust**: Complex structure, not a probability
- **Reliability**: probability that given information is reliable
Transformation of the Network Into a Decision Tree
Transformation of the Network Into a Decision Tree
Transformation of the Network Into a Decision Tree

Diagram showing nodes A, B, C, D, E, and Y with relationships and trust values as follows:
- A to B: 0.7
- B to C: 0.8
- C to D: 0.5
- A to E: 0.9
- E to Y: 0.4
- C to E: 0.6
- E to Y: 0.4
- Y to X: 0.4

Arrows indicate the direction of trust or reliability flows, with values for each connection.

Trust and Reliability

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Transformation of the Network Into a Decision Tree
Transformation of the Network Into a Decision Tree

A 0.6 0.4
C 0.7

X

0.9 0.4

B 0.8

0.6

E 0.7

0.4

Reliability

Trust

0.7 0.3

Y

D 0.5

T_Y^D

E

C

A

0.6

0.4

0.7

T_Y^E

T_Y^E

⊥

⊥
Transformation of the Network Into a Decision Tree

A  0.7  C  0.5
   \downarrow 0.8
   B  0.6  D
       \downarrow 0.7
       X  0.9

\begin{align*}
\text{Reliability} & \rightarrow T_Y^E \\
T_Y & \rightarrow \text{Trust}
\end{align*}

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Weighs of the Edges
Certainty

- **Certainty**: Probability to reach a trust information
- **Certainty** refers to the sub-tree if a node has been reached
- **Certainty** at a given node is the weight for the edge, pointing to the node
Weighs of the Edges

Certainty

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Weighs of the Edges

Certainty

\[ C_Y^X = C_Y^{X \setminus \{X,Y\}} \]

\begin{align*}
 C_Y &= C_Y^{X \setminus \{X,Y\}} \\
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Weighs of the Edges
Certainty

\[ C_{Y|C}^{X,(X,Y)} \]

\[ C_{Y|E}^{X,(X,Y)} \]

\[ C_{Y|A}^{X,(X,Y)} \]

\[ C_{Y}^{X,(X,Y)} = C_{Y}^{X,(X,Y)} \]

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Weighs of the Edges

Certainty

\[ C_Y^X = C_Y^{X \{x,y\}} \]

\[ C_{Y|C}^{X\{x,y\}} \]

\[ C_{Y|E}^{X\{x,y\}} \]

\[ C_{Y|A}^{X\{x,y\}} \]

\[ C_Y^{C\{x,c,y\}} \]

\[ C_Y^{C\{x,c,y\}} \]

\[ C_Y^{C\{x,c,y\}} \]

\[ 0.6 \]

\[ 0.4 \]

\[ 0.7 \]

\[ 0.3 \]

\[ 0.5 \]

\[ 0.5 \]

\[ 0.5 \]
Weighs of the Edges

Certainty

\[ C_{Y} = C_{Y,Y} \]

\[ C_{Y}^{X,Y} \]

\[ C_{Y|C}^{X,Y} \]

\[ C_{Y|E}^{X,Y} \]

\[ C_{Y|A}^{X,Y} \]

\[ T_{Y}^{D} \]

\[ \bot \]

\[ T_{Y}^{E} \]

\[ \bot \]
Weighs of the Edges

Certainty

\( C_Y = C^X_{\{x,y\}} \)

\( C^X_{Y|C} \)

\( C^X_{Y|E} \)

\( C^X_{Y|A} \)

\( C^X_{\{x,y\}} \)

\( C_{C|\{x,c,y\}} \)

\( T^D_Y \)

\( T^E_Y \)

\( 0.5 \)

\( 0.5 \)

\( 0.5 \)

\( 0.5 \)

\( 0.7 \)

\( 0.7 \)

\( 0.3 \)

\( 0.6 \)

\( 0.4 \)

\( \bot \)
Weighs of the Edges
Certainty

\[
\frac{0.5^2 + 0.7^2}{0.5 + 0.7} = 0.617
\]
Weighs of the Edges
Certainty

\[
\begin{align*}
C_Y &= C_Y^{X,\{X,Y\}} \\
C_Y^{X,\{X,Y\}} &= C_Y^{X,\{X,Y\}} \\
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C_Y^{X,\{X,Y\}} &= C_Y^{X,\{X,Y\}}
\end{align*}
\]

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Weighs of the Edges
Certainty

\[ 0.6 \times 0.617 = 0.37 \]
Weighs of the Edges Certainty
Results So Far

- **Simulation** with networks of 20 nodes with reliability 50% - 100% shows
  - 3 hops: certainty < 50%
  - 7 hops: certainty < 25%
- The building of a decision-tree has **exponential complexity**
- Two trials to reduce its complexity:
  - Restricting hops to destination
  - Limiting the **minimal certainty** of a sub-tree
Simulation with Hop-Restricion
Simulation with Certainty-Restriction

![Simulation Graph]

- Without limitation
- Min. certainty 0.5
- Min. certainty 0.4
- Min. certainty 0.3
- Min. certainty 0.2
- Min. certainty 0.1
- Unlimited

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Influence of Malicious Participants

![Graph showing the influence of malicious participants on trust information certainty.](image)

-0.2
+0.1

- without attack
- 2 bad nodes giving bad values
- 4 bad nodes giving bad values
- 6 bad nodes giving bad values
- 2 bad nodes giving good values
- 4 bad nodes giving good values
- 6 bad nodes giving good values

hops to target

certainty
Results

- **Influence of malicious participant** lies in the percentage-magnitude like the percentage of malicious participants.
- **Limiting the tree** to 6-8 hops or 0.3-0.4 minimal certainty gives **acceptable results** compared to the unrestricted values (up to 107x faster).
- **Hop-restriction** is more **effective** than certainty-restriction (up to 3.1x faster).
- Still **exponential** complexity in **worst case**.
- Decision on the base of recommended trust-information of distance > 8 hops are getting **unreasonable**.
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