DATA CENTRIC TRUST EVALUATION AND PREDICTION FRAMEWORK FOR IOT

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Trust Overview

• “Firm belief in the reliability, truth, or ability of someone or something” -- Oxford Dictionary

• Trustor : Evaluating the trust
• Trustee : Who is being evaluated
• Trust Value : Trustee’s trustworthiness in trustor’s perspective

• Trust Definition (Computer Science)
  – Qualitative or Quantitative property of trustee, measured by trustor as a belief, in subjective or objective manner, for a given task, in a specific context, for a specific time period
Trust in IoT

• Problems
  – Risks involved in Cyber, Physical and Social World
  – Entity based trust vs Data Trust

• Data centric trust evaluation and prediction
  – Extend research on entity based trust towards data centric trust
  – Hybrid trust framework (Entity and Data)
  – Trust prediction in the absence of previous encounters
  – Implementation Scenario based on an user case

• Standardization activities ITU-T SG13
  – ITU-T SG13/Q16 - Recommendation on trust
  – ITU-T FG-DPM - Data quality & trust
Generic Trust Model

- REK Model

Data Trust Model

- Knowledge
  - Uniqueness
  - Completeness
  - Timeliness
  - Validity
  - Consistency
  - Accuracy

- Data Trust
  - Direct Trust
  - Accumulation

- Experience
  - Success
  - Cost
  - Recommendations
  - Ratings

- Reputation
  - Recommendations
  - Ratings

- Knowledge
  - Relationship
  - Spatial
  - Willingness
  - Confidence
  - Persistence
  - Disposition
  - Fulfillment
  - Dependence
  - Competence
  - Temporal

- Experience
  - Credibility
  - Feedback

- Reputation
  - Recommendations
  - Ratings
Data Trust Framework
Data Trust Computational Model

- **Knowledge DTM** \( T_{AB}^K \)
  \[- T_{AB}^K = \alpha T_B^{cm} + \beta T_B^{uq} + \gamma T_B^{tm} + \delta T_B^{vl} + \varepsilon T_B^{ac} + \epsilon T_B^{cn} \]
  where \( \alpha + \beta + \gamma + \delta + \varepsilon + \epsilon = 1 \)

- **Experience DTM** \( T_{AB}^E \)
  \[- T_{AB}^E = \sigma T_B^{su} + \varphi \frac{1}{T_B^{ct}} \]

- **Reputation DTM** \( T_{AB}^R \)
  \[- T_{AB}^R = T_{1B}^R + T_{2B}^R + \cdots + T_{nB}^R \]

- **Final data trust value**
  \[- T_{AB}^d = \rho T_{AB}^K + \tau T_{AB}^E + \omega T_{AB}^R \]
Data Trust Prediction

- Collaborative filtering (CF) to predict the unknown trust values between the user and specific data source.
- Over six different data centric features:
  - Completeness ($T_{cm}$), Uniqueness ($T_{uq}$), Timeliness ($T_{tm}$), Validity ($T_{vl}$), Accuracy ($T_{ac}$) and Consistency ($T_{cn}$).

<table>
<thead>
<tr>
<th>Trustees (DS)</th>
<th>Trustors (Users)</th>
<th>Features</th>
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<tbody>
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<td>$u_1$</td>
<td>$u_2$</td>
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<td>$i_1$</td>
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<td>$j_{nm}$</td>
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- $T_{cm}$, $T_{uq}$, $T_{tm}$, $T_{vl}$, $T_{ac}$ and $T_{cn}$.
Data Trust Prediction II

• Algorithm

Inputs

– trustors or users \((n_u)\), number of Trustees or DSs \((n_m)\) and six features \((T^x)\)
– \(\triangleleft\): users already having trust relationships \(\rightarrow y^{(i,j)}\): Trust Value
– \(\blacklozenge\): values of each six features \(\rightarrow T^{(i)}\): Feature Vector for each DS

Outputs

– \(\theta^{(j)}\): parameter that describes the profile of users
– \(T^{dp}_{ij}\): predicted data trust value

\[
T^{dp}_{ij} = (\theta^{(j)})^T (T^{(i)})
\]
Data Trust Prediction III

- $T_{ij}^{dp} = (\theta^{(j)})^T (T^{(i)})$
  - $T^{(i)} = [T_{cm}^u T_{mq}^m T_{vl}^l T_{ac}^l T_{cn}]^T$

- $\theta^{(j)}$: profile of users

  - Using MSE method, $J$: $\min_{\theta^{(j)}} \frac{1}{2} \sum_{i:r(i,j)=1} (\theta^{(j)})^T (T^{(i)}) - y^{(i,j)})^2 + \frac{\lambda}{2} \sum_{k=1}^{6} (\theta_k^{(j)})^2$
  
  - Find the best parameter using gradient decent

\[
\theta_k^{(j)} = \begin{cases} 
\theta_k^{(j)} - \alpha \sum_{i:r(i,j)=1} (\theta^{(j)})^T (T^{(i)}) - y^{(i,j)})^2 T_k^{(i)} , k = 0 \\
\theta_k^{(j)} - \alpha (\sum_{i:r(i,j)=1} (\theta^{(j)})^T (T^{(i)}) - y^{(i,j)})^2 T_k^{(i)} + \lambda \theta_k^{(j)} , k \neq 0
\end{cases}
\]

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<td>$u_{nu}$</td>
<td>$T_{ac}^l$</td>
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<td>$T_{cn}$</td>
<td>$T_{vl}^l$</td>
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Trustors (Users) Features

- $\theta_{ij}$: profile of users
Implementation Model

- **Use Case**: Air pollution crowd sensing
Conclusion and Future Work

• Extended entity based trust assessment towards data
  – Identify relevant data trust metrics, evaluation and prediction
  – Hybrid Trust Framework
  – Implementation scenario based on publish-subscribe architecture

• Increase autonomous capabilities and decision making abilities with improved accuracy

• Future work
  – Intelligent trust evaluation using machine learning and AI techniques
  – Application of Reinforcement techniques to improve the REK trust model
  – Develop the prediction algorithm based on advanced recommendation algorithms (E.g. Content and Contextual information)
  – Stimulate the standardization on data trust
Thank you!

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