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Challenges for a data-driven society

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

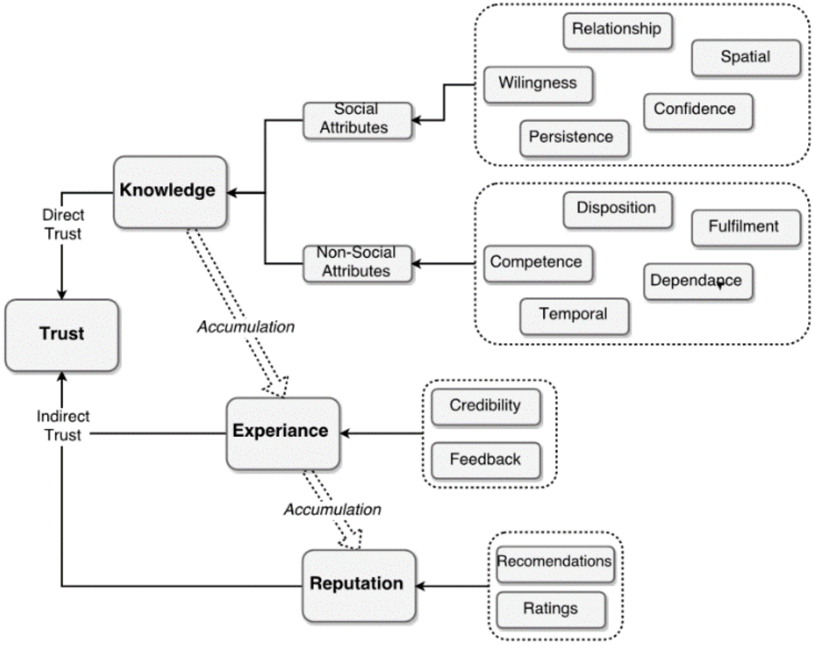
- Trust Definition (Computer Science)
  – Qualitative or Quantitative property of trustee, measured by trustor as a belief, in subjective or objective manner, for a given task, in a specific context, for a specific time period

Trust in IoT

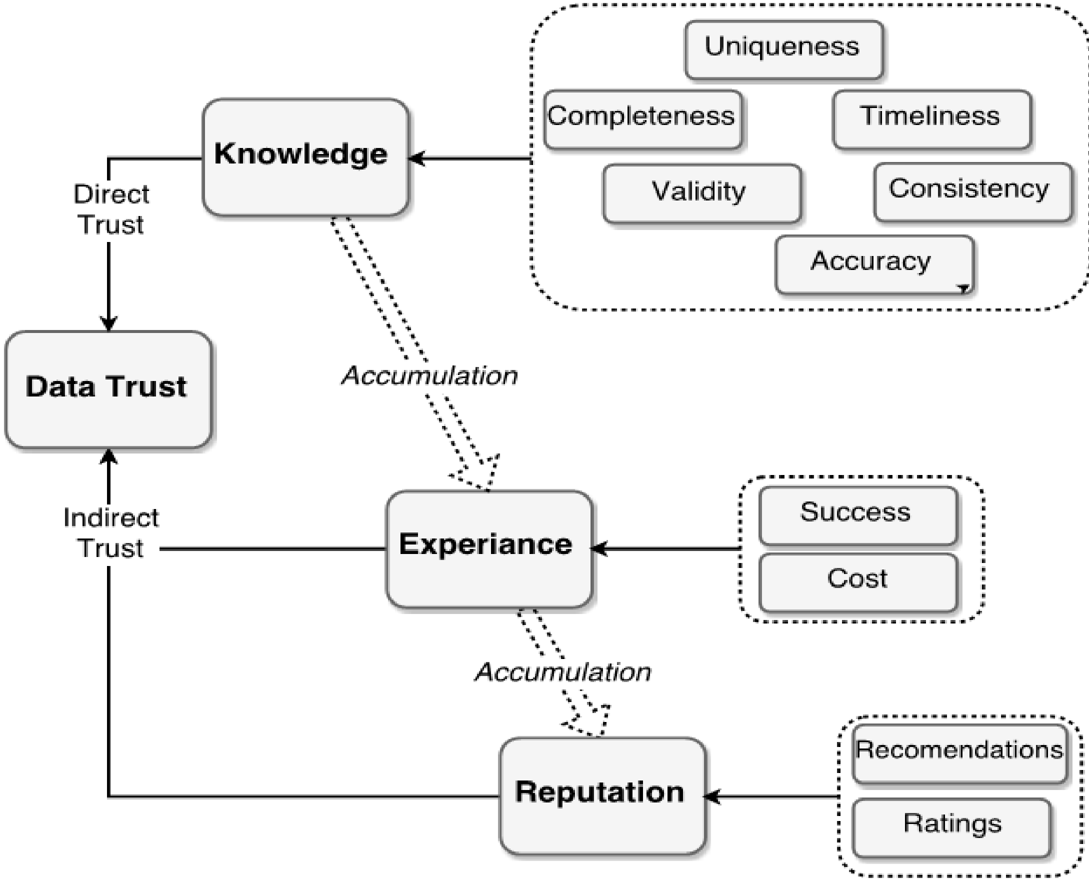
- Problems
  - Risks involved in Cyber, Physical and Social World
  - Entity based trust vs Data Trust
- Data centric trust evaluation and prediction
  - Extend research on entity based trust towards data centric trust
  - Hybrid trust framework (Entity and Data)
  - Trust prediction in the absence of 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

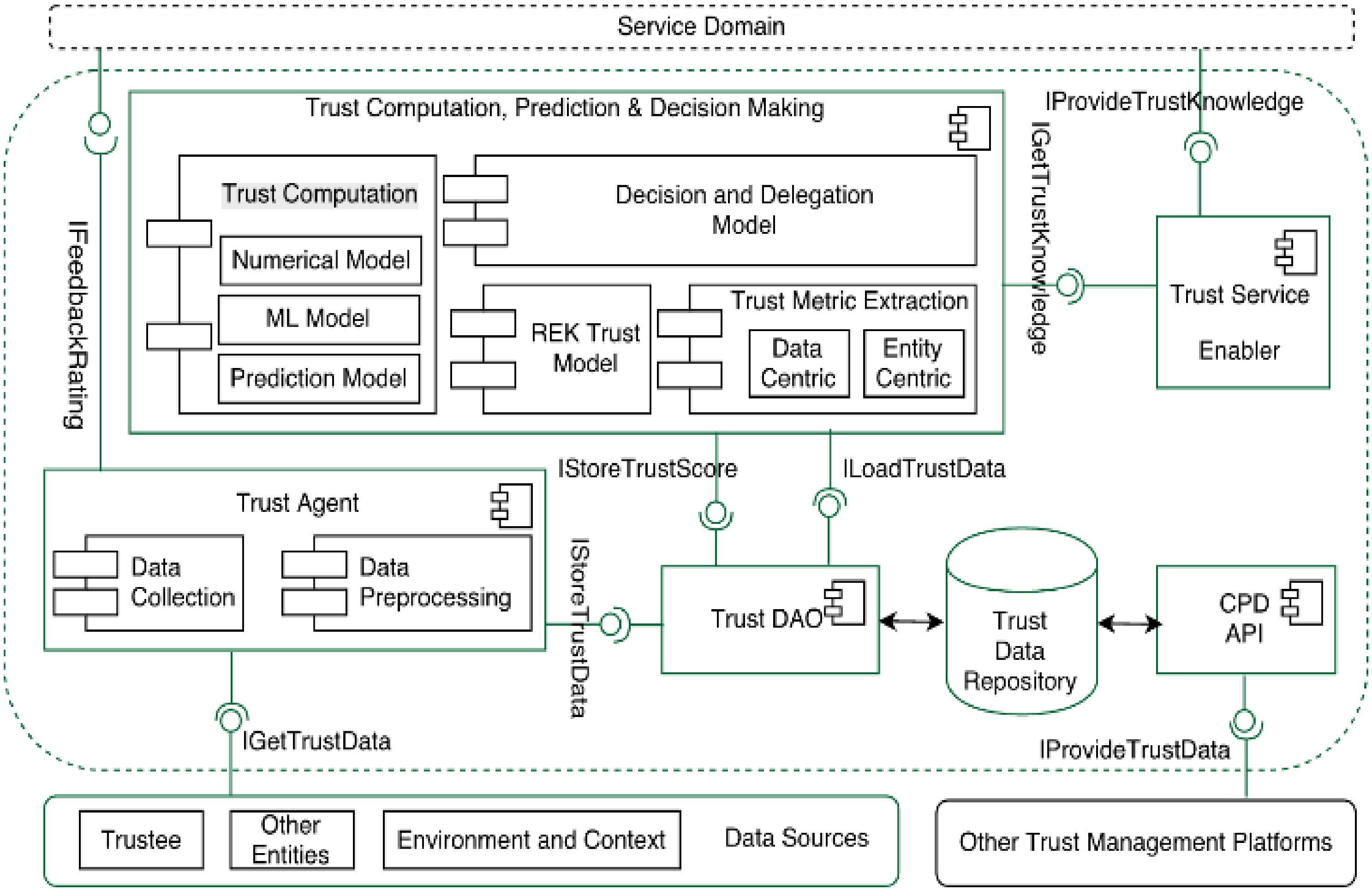
- REK Model



Data Trust Model



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 $\alpha+\beta+\gamma+\delta+\in+\varepsilon=1$
- 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})

	Trustors (Users)				Features					
Trustees (DS)	u_1	u_2	…	u_{nu}	T^{cm}	T^{uq}	T^{tm}	T^{vl}	T^{ac}	T^{cn}
i_1	◬		◬		◈	◈	◈	◈	◈	◈
⋮		◬		◬	◈	◈	◈	◈	◈	◈
j_{nm}		◬	◬		◈	◈	◈	◈	◈	◈

Data Trust Prediction II

- Algorithm

Inputs

- trustors or users (n_u), number of Trustees or DSs (n_m) and six features (T^x)
- △ : users already having trust relationships → $y^{(i,j)}$:Trust Value
- ◈ : values of each six features → $\boldsymbol{T}^{(i)}$: Feature Vector for each DS

Outputs

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

	Trustors (Users)				Features					
Trustees (DS)	u_1	u_2	…	u_{nu}	T^{cm}	T^{uq}	T^{tm}	T^{vl}	T^{ac}	T^{cn}
i_1	△		△		◆	◆	◆	◆	◆	◆
⋮		△		△	◆	◆	◆	◆	◆	◆
j_{nm}		△	△		◆	◆	◆	◆	◆	◆

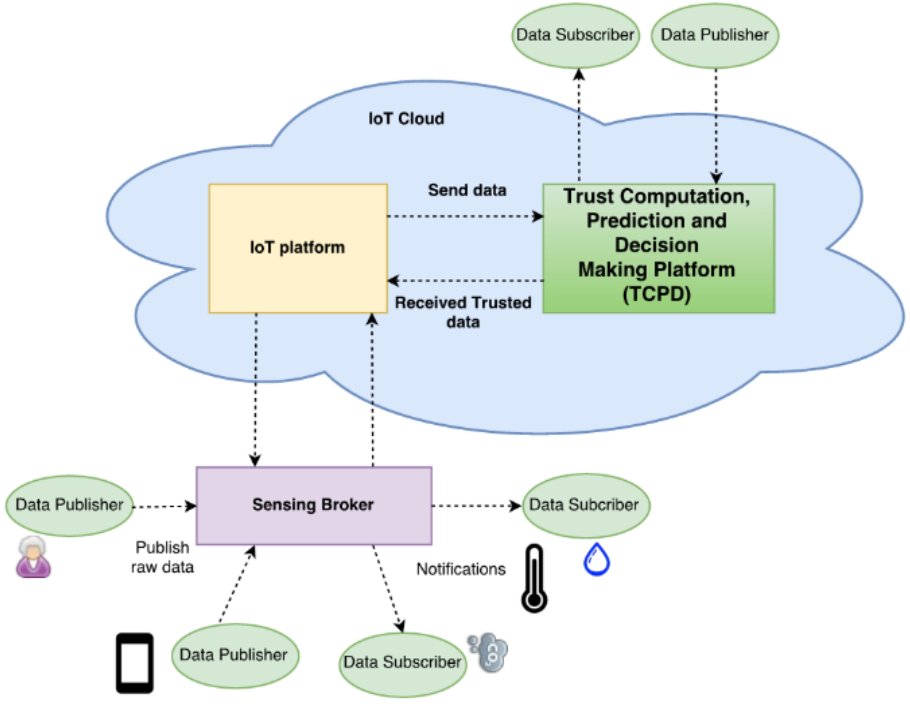
Data Trust Prediction III

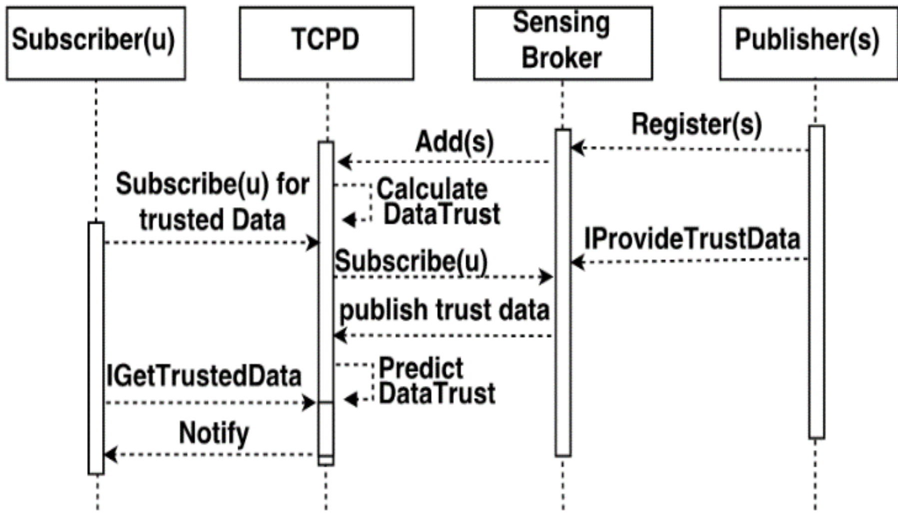
Trustees (DS)	Trustors (Users)				Features					
	u_1	u_2	…	u_{nu}	T^{cm}	T^{uq}	T^{tm}	T^{vl}	T^{ac}	T^{cn}
i_1	△		△		◆	◆	◆	◆	◆	◆
⋮		△		△	◆	◆	◆	◆	◆	◆
j_{nm}		△	△		◆	◆	◆	◆	◆	◆

- $T_{ij}^{dp} = \left(\boldsymbol{\theta}^{(j)}\right)^T \left(\boldsymbol{T}^{(i)}\right)$
  - $\boldsymbol{T}^{(i)}=[T^{cm}\ T^{uq}\ T^{tm}\ T^{vl}\ T^{ac}\ T^{cn}]^{\mathrm{T}}$
- $\boldsymbol{\theta}^{(j)}$: profile of users
  - Using MSE method, J: $\min_{\theta(j)} \frac{1}{2} \sum_{i:r(i,j)=1} \left(\left(\boldsymbol{\theta}^{(j)}\right)^T \left(\boldsymbol{T}^{(i)}\right) - y^{(i,j)}\right)^2 + \frac{\lambda}{2} \sum_{k=1}^{6} (\theta_k^{(j)})^2$
  - Find the best parameter using gradient decent
    - $\min_{\boldsymbol{\theta}^{(1)},\boldsymbol{\theta}^{(2)},\ldots,\boldsymbol{\theta}^{(n_u)}} \mathrm{J}(\boldsymbol{\theta}^{(1)}, \boldsymbol{\theta}^{(2)}, \ldots, \boldsymbol{\theta}^{(n_u)})$
    - $$\theta_k^{(j)} = \begin{cases} \theta_k^{(j)} - \alpha \sum_{i:r(i,j)=1} \left(\left(\boldsymbol{\theta}^{(j)}\right)^T \left(\boldsymbol{T}^{(i)}\right) - y^{(i,j)}\right)^2 T_k^{(i)} &, k = 0 \\ \theta_k^{(j)} - \alpha (\sum_{i:r(i,j)=1} \left(\left(\boldsymbol{\theta}^{(j)}\right)^T \left(\boldsymbol{T}^{(i)}\right) - y^{(i,j)}\right)^2 T_k^{(i)} + \lambda \theta_k^{(j)}) &, k \neq 0 \end{cases}$$

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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