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Trust in IoT and Its Applications

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Trust and Knowledge

• Future trust and knowledge infrastructure

ICT is a Basis of Knowledge Society

Potential Risks

Y.3052 – “Overview of trust provisioning in ICT infrastructures and services” Feb. 2017
Increasing Intelligence in IoT

Control and Trust

- Behave intelligently and rationally to
  - **Sense** real-world behaviour
  - **Perceive** the world using information models
  - **Adapt** to different environments and changes
  - **Learn** and **build** knowledge
  - **Act** to control their environments
Barrier to growth of IoT market

Data and Trust

Who are we comfortable sharing personal data from smart devices with?

- 63% Spouse/Significant Other
- 41% Close Friends
- 40% Health Professionals
- 30% Police
- 28% Insurance Companies
- 26% Boss
- 22% Supermarkets
- 14% Ad Companies
- 14% Government

Source: 2014 Internet of Things Privacy Infographic

Volume – Data at Rest

Variety – Data in Many Forms

Velocity – Data in Motion

Variability – Data in Change

Veracity – Data in Doubt
Towards Internet of Value

Data is Value – How to measure Value?

Security, Privacy and Trust

IoPTS – Internet of People, Things & Services
Understanding of Trust

Trust of a party A to a party B for a given task S is the measurable belief of A in that B accomplishes S dependably for a specified period P within a particular trust context T (in relation to the task S).

Trust is relative to a specific task (a service). Different trust relationships appear in different business contexts.

The measurement may be absolute (e.g., probability) or relative (e.g., Level of Trust).

This period may be in the past (history), the duration of the service (from now and until end of service), future (a scheduled or forecasted critical time slot), or always.

Dependability is deliberately understood broadly to include availability, reliability, safety, confidentiality, integrity and serviceability.
Direct Trust vs. Indirect Trust

**Indirect Trust** (Experience and Third-party Opinions)

- Direct TrustLinks (Trust Context)
- Direct TrustLinks (other Context)
- Global TrustLinks (Trust Context)
- Global TrustLinks (other Context)

**Personal Observation as Experience**

**Experience**

**Reputation**

**Global Opinion as Reputation**

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**Direct Trust** (Knowledge as Direct Observation)

- **P** Reliability
- **C** Confidentiality
- **S** Serviceability (Maintainability)
- **P** Safety
- **C** Cyber
- **S** Social

P: Physical
C: Cyber
S: Social
Computational Trust

- **Trust** components:
  - Ability / Capability:
    - Stability
    - Reliability
    - Scalability
    - Safety
    - Robustness
  - Integrity / Honesty:
    - Completeness
    - Accuracy / Correctness
    - Consistency
    - Certainty
    - Recency
  - Benevolence / cooperative:
    - Assurance
    - Availability
    - Credibility
    - Relevance

- **Computational Trust**
  - Direct Observation (Knowledge)
  - Third Party Information
  - Reputations

- **System Dependability**
  - Experience

- **Social Trust**
Key Design Principles

Consider Trust as a Key Component for IoT

• Interactions and relationships among Social/Cyber/Physical worlds
• Ensuring IoT data quality
• Trustable intelligent services based on data convergence and mining
• Trustworthy environment for correct operations
• Enhanced security and privacy
Challenges for Trust in general

1. Understanding of trust
2. Trust relationships
3. Trust management
4. Measure & calculate
5. Decision making
6. Autonomy
7. Constraint environment
8. T-SCPI architecture
9. New business models
10. Standardization

NOTE - T-SCPI: Trustworthy Social-Cyber-Physical Infrastructure

Challenges for Trust in IoT

• Highly interconnected IoT infrastructure
  – A new kind of complex system
• Assuring continuous trustworthiness
  – Trust is situation-specific and trust changes over time
• Data transparency
  – Promote transparency about what data is collected and how it will be processed and handled
• Trust, security and privacy become tightly coupled
  – A unified approach towards trust, security and privacy co-analysis, design, implementation and verification
• The integration of the physical, cyber, and social worlds
  – Social-cyber-physical trust relationships
Technical Issues

• Identification of entities
• Trustworthy data collection and aggregation
• Trustworthy data process and analysis
• Trust modelling and measuring
• Trust computation and trust evaluation/validation
• Dissemination of trust information
• Trust establishment and provisioning
• Trustworthy system lifecycle management
Trust Relationship Model

Legend

- Virtual Social Object
- Cyber Object
- Virtual Physical Object

Social Entities

- Social-societal Trust relationship
- Social-cyber Trust relationship
- Social-physical Trust relationship

Stakeholders

- Social Trust Component
- Cyber Trust Component
- Physical Trust Component

Individuals Communities

Physical Things
Trust Computation Procedure

DIKW Pyramid

Data → Information → Knowledge → Wisdom

Decision Making → Reasoning Level of Trust → Building Trust Knowledge-base → Formalizing of Semantic Information → Collecting and Annotating Data

Understanding of Trust

V A L U E

Dependability

Low → High

Decision Risk
Trust Index

Data from various sources

Trust Attributes
- Qualitative Attributes
- Quantitative Attributes

Trust Indicators
- Subjective Trust Indicators
- Objective Trust Indicators

Objectify
Calculate

Trust Index

Trustor
Decision
Trustworthy Smart City Crowdsensing

Smart Citizen – collective monitoring of the city

- Smart transportation, smart metering and public safety
  - Benefits to public, business and government
  - Ensuring Trustworthiness
A New Paradigm – Blockchain

“*It is a machine for creating trust.*”
(Source: The Economist)

• The currency in the IoT is data.
• Revolutionizes how transactions are recorded
  – a decentralized digital ledger that records transactions
  – building trust, reducing costs and accelerating transactions
“Trust is the oxygen which will breathe life into the IoT. Industry needs to show data is safe and that it is properly treated.” (source: www.techuk.org.)

Trust is an essential element for value added business models in the IoT.