Trust Lifecycle Management in Ad-hoc Collaborations

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A Ubiquitous Computing Environment

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- **The characteristics of the environment**
  - A plethora of computational entities with a need for collaboration
  - Significant variation in the supporting infrastructure
  - A highly changeable set of potential collaborators
- **Ad-hoc collaborations become the norm**
  - Entities cannot rely on the availability of particular infrastructure
  - Entities need to collaborate with little known or even unknown entities
- **Entities need to decided who to collaborate with**
  - Collaborations are unavoidable and can be dangerous
    - Collaborations may have both costs and benefits
  - Decisions need to be taken autonomously and despite the lack of complete information about potential collaborators

Trust in Ad-hoc Collaborations (1)

- **The human notion of trust seems appealing as a basis for entity decision making**
  - Despite the difficulty in defining trust, certain characteristics are apparent and appealing
    - Trust is subjective in nature - disposition
    - Trust is situation specific
    - Trust evolves over time in the light of experience
  - Trust propagation is a desirable property

- **The goal is to use trust as the mechanism for managing the dangers / risks of collaboration**
  - Trust conveys information about likely behaviour
  - Virtual anonymity: identity conveys little information about likely behaviour
  - Entity recognition as a superset of authentication

Trust in Ad-hoc Collaborations (2)

- **Entity recognition versus authentication**

Authentication Process (AP)	Entity Recognition (ER)
A.1. Enrollment: generally involves an administrator or human intervention	
A.2. Triggering: e.g. someone clicks on a Web link to a resource that requires authentication to be downloaded	E.1. Triggering (passive and active sense): mainly triggering (as in A.2), with the idea that the recognizing entity can trigger itself
A.3. Detective work: the main task is to verify that the principal's claimed identity is the peer's	E.2. Detective work: to recognize the entity to-be recognized using the negotiated and available recognition scheme(s)
	E.3. Retention (optional): "preservation of the after effects of experience and learning that makes recall or recognition possible" [30]
A.4. Action: the identification is subsequently used in some ways. Actually, the claim of the identity may be done in steps 2 or 3 depending on the authentication solution (loop to A.2)	E.4. Action (optional): the outcome of the recognition is subsequently used in some ways (loop to E.1)

Trust in Ad-hoc Collaborations (3)

- **Credential-based versus evidence-based trust management**
  - Implicit view of trust as delegation of privileges to trusted entities
    - Avoid the issues of what trust is made of, how it is formed
    - Very restricted view of trust evolution – certificate revocation
  - Explicit view of trust as likely entity behaviour on the basis of the history of past interactions

- **Trust lifecycle management is key to a trust-based model for ad-hoc collaborations**
  - Need for explicit modelling of risk
  - Need for a trust model supporting trust formation, evolution and propagation
  - Need for a decision making process that relates the trust and risk models and incorporates entity recognition

The SECURE Collaboration Model (1)

- **A trust model**
  - A trust domain with a trustworthiness and an information ordering
    - An “unknown” trust value representing lack of information
  - A local trust policy that assigns trust to principals and may reference other principals
- **A risk model**
  - Trust mediated actions with a set of possible outcomes
  - Each outcome with an associated cost/benefit
  - Risk as the likelihood of an outcome occurring combined with its associated cost
- **The relationship between trust and risk**
  - Trust determines the likelihood of the outcomes
  - Trustworthy principals make beneficial outcomes more likely
  - Access right-based versus behaviour-based trust models

The SECURE Collaboration Model (2)

- **Collaboration decision making**
  - Collaboration request → Entity recognition → Entity trust assignment → Collaboration risk assessment → Collaboration policy application → Decision
- **Trust evaluation**
  - The result of multiple interactions with the same entity
  - Monitoring of collaboration → Production of evidence about entity's behaviour → Evidence processing → Update entity's trust value
- **Risk evaluation**
  - The result of multiple instances of similar interactions with different entities
  - Monitoring of collaborations → Production of evidence about outcome costs → Evidence processing → Update outcome costs/benefits

The SECURE Collaboration Model (3)

- **Evidence of entities' past behaviour**
  - Direct evidence results from a personal interaction with an entity - observations
    - Unquestionable in nature, treated as fact
  - Indirect evidence results from entities communicating their experiences from personal interactions with a particular entity to other entities – recommendations (trust values)
    - Subjective in nature, its value depends on the source
    - Trust in the recommender & recommendation adjustment
- **Evidence processing**
  - Evaluate evidence with respect to the current trust value → Evolve the current trust value in accordance to the evidence evaluation

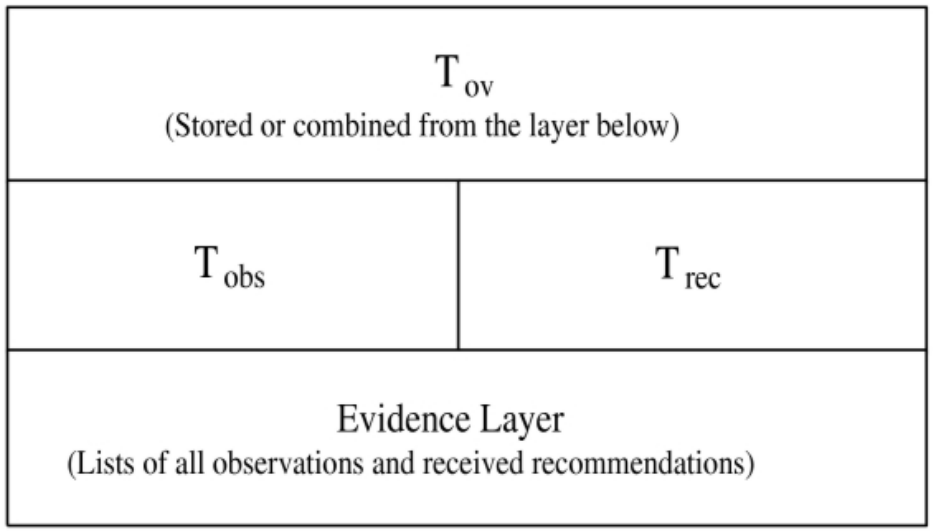
The SECURE Collaboration Model (4)

- **Evidence evaluation in terms of *Attraction***
  - Attraction is a measure of the effect evidence has to the current trust value
  - The trust domain determines the direction of the attraction
    - In terms of trustworthiness can either be positive or negative
    - In terms of information can either be reinforcing or contradicting
  - The risk domain determines the measure of the attraction
    - The more different the associated profiles of likely behaviour the stronger the attraction

- **Trust value evolution**
  - In the form of a trust evolution or trust update function
  - Encodes dispositional characteristics: trusting disposition & trust dynamics

The SECURE Collaboration Model (5)

- **Operational issues**
  - An architecture with the following component
    - Trust Lifecycle Manager
    - Collaboration Monitor
    - Evidence Gatherer
    - Evidence Store
  - Trust Information Structure



The SECURE Collaboration Model (6)

- **The formation of trust**
  - The “unknown” trust value
    - We always have an initial trust value
  - References in local trust policies
  - Recommendations
    - When using recommendations formation is the same to evolution with “unknown” as the current trust value
    - Approaches to evidence gathering
      - Initial list of recommenders, authorisation hints, ask neighbours for good recommenders, recommender brokers, broadcast

Food for Thought

- **Context as a situational modifier of trust**
  - Who and what are already elements of the decision making process
  - Explicit modelling of relationships between contexts are crucial
  - Different aspects of trust
    - Keep in mind the need for trust propagation
- **System trust**
  - Trust in the underlying infrastructure (e.g. recognition mechanism)
  - Taking into account available (security) infrastructure
- **The role of the user**
  - Introducing user into the trust loop
- **Trust and obscurity**
  - Security by obscurity should be avoided
  - Openness of trust policies opens the possibility of trust scams

Final Word

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SECURE
Secure Environments for Collaboration among Ubiquitous Roaming Entities

- SECURE is an EU FET project (IST-2001-32486)
  http://secure.dsg.cs.tcd.ie

itrust

- iTrust is an EU FET working group on Trust Management in Dynamic Open Systems (IST-2001-34810)
  http://www.itrust.uoc.gr

The e-purse scenario (1)

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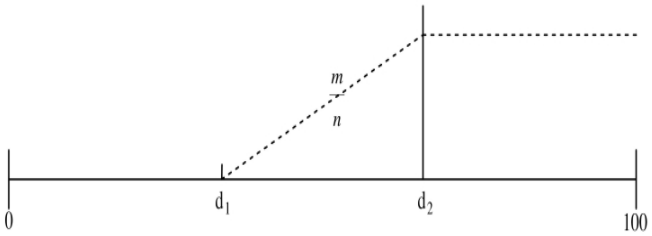
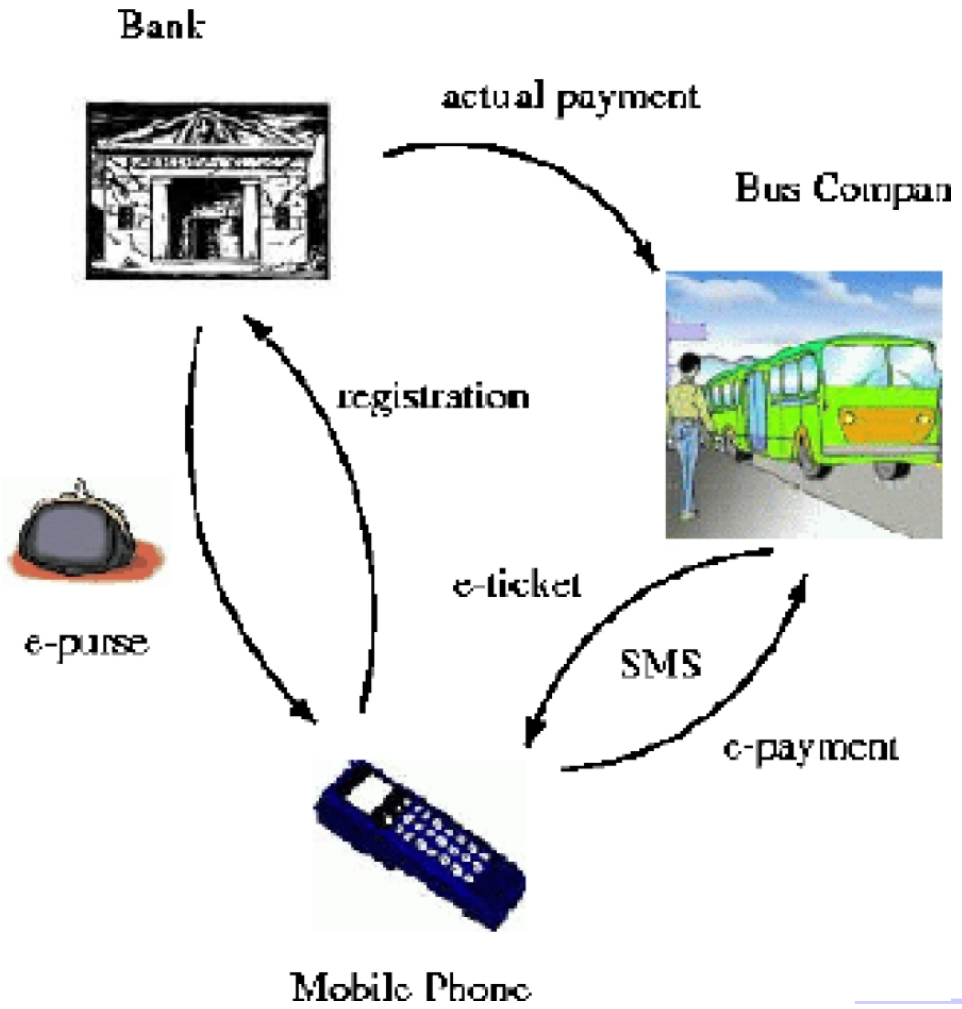
- The focus is on the bus company – passenger interaction
- The trust values are intervals (d1, d2)
- The risk analysis





The e-purse scenario (2)

- **Trust evolution in the light of observations**
  - Observation – validity of e-cash
  - Observations adjust the boundaries of the intervals
    - Valid e-cash ⇒ positive attraction
    - Invalid e-cash ⇒ negative attraction
    - Expected outcome (i.e. probability > 50%) ⇒ reinforcing
    - Unexpected outcome ⇒ contradicting

attraction direction	direction of boundary movement	interval size
positive, reinforcing	$\longrightarrow$	$m_1 > m_2$
positive, contradicting	$\longrightarrow$	$m_1 < m_2$
negative, reinforcing	$\longleftarrow$	$m_1 > m_2$
negative, contradicting	$\longleftarrow$	$m_1 < m_2$

  - If the amount of money is less than d1 and the e-cash is valid we don't really change the trust value
  - We consider the level of positive and negative adjustment as dispositional parameters