When Trust Does Not Compute

The Role of Trust in Ubiquitous Computing

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Time for Trust!

- Pervasive Computing Systems Require a Security Architecture Based on Trust Rather Than Just User Authentication and Access Control
  - Kagal/Finin/Joshi, IEEE Computer 12/01
- Old Model Based on Verification of Credentials (Authentication) and Delegation Not Suitable
  - Ubicomp 2002 Security Workshop (Summary)
- [We Need] Security and Trust Technologies in Support of Privacy, Safety, and Dependability
  - Scenarios for Ambient Intelligence 2010, ISTAG

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Why (Computational) Trust?

- Simplify Authentication
  - No Passwords!
- Natural Form of Interaction
  - Ideally Suited for Ubiquitous Computing
- Improve Cooperation
  - More Flexibility
- Strengthen Security
  - 'Better' Evidence

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Step 1: What to Solve

- Starting Point: Scenarios
  - Allow Authors to Illustrate Problems and Solutions
- Examples
  - Gray et al: "Commuter-Train Black-Jack"
    (iTrust 2003)
  - Shand et al: "Trusted Phone Numbers"
    (PerCom 2003)
- Issues
  - Described Scenario Does Not Solve a Problem, or
  - Solves a Problem That Does Not Exist

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Step 2: How to Solve

- Compute Trust Value
  - Based on Prior Experience, Recommendations, Risk
  - Allow Exchange/Access if Above Threshold
  - Take Cues from Psychology, Sociology
- Examples
  - English et al.: "Trust Information Structure" (iTrust 2003)
  - Shand et al.: "Transparent Collaboration" (PerCom 2003)
  - Gray et al.: "Trust-Based Admission Control" (iTrust 2003)

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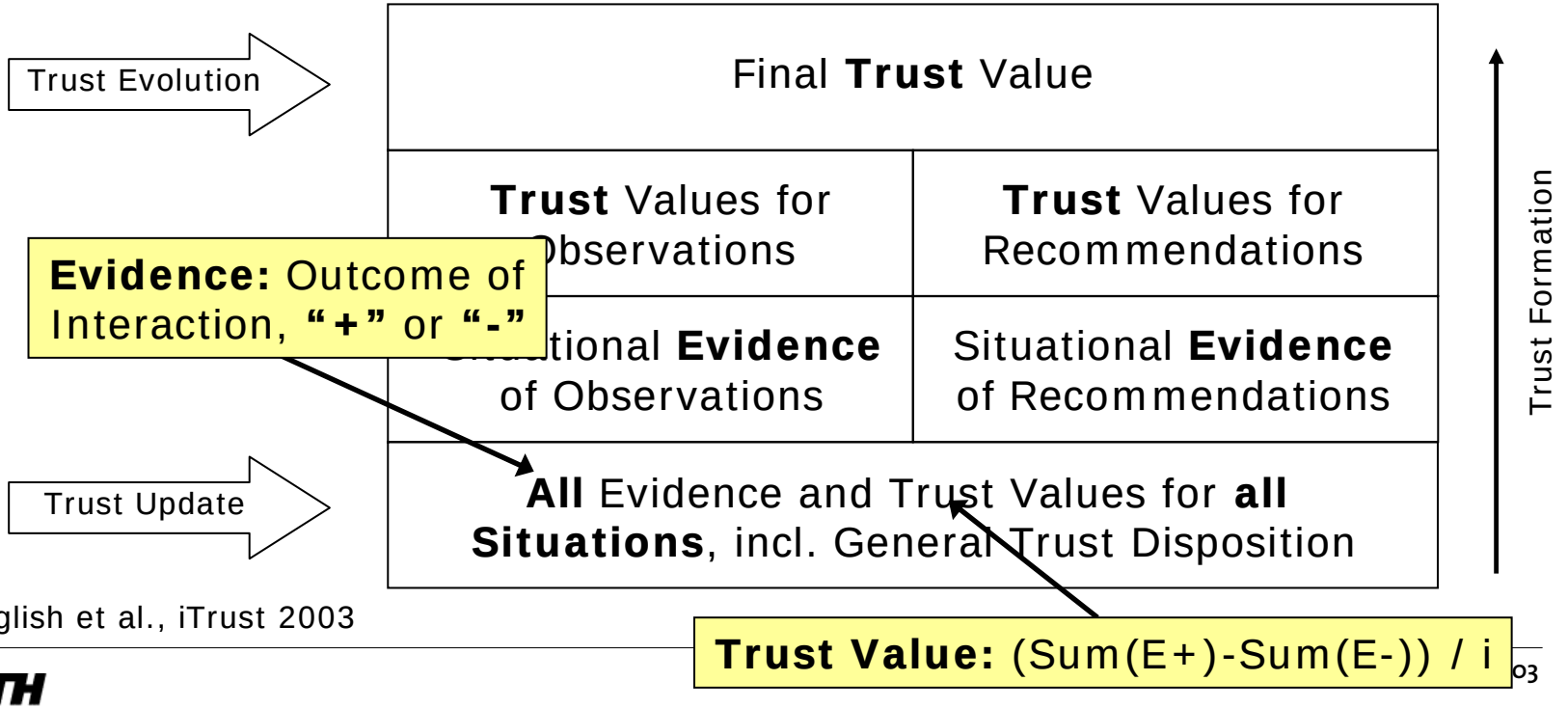
Trust Information Structure

- Models Human "Trust Lifecycle"
  - Trust Formation, Evolution, Exploitation
  - Uses Personal Observations and Recommendations



Transparent Collaboration

- Access Based on One's Own and External Recommendations (Trust Value)
  - Each Trust Value is (Belief, Disbelief)-Pair
  - Access Granted if Benefits > Risks
- Issues
  - User Must Specify Trust as "Weight of Evidence For and Against a Particular Trust Assignment" (Complexity?)
  - Risk-Assessment Required: "Maximum Benefit of Trusting *P* With *N*; Cost of *P* Ignoring Our Recommendations; Cost of Owner Being Asked for Guidance; ..." (Complexity?)

Shand et al., PerCom 2003

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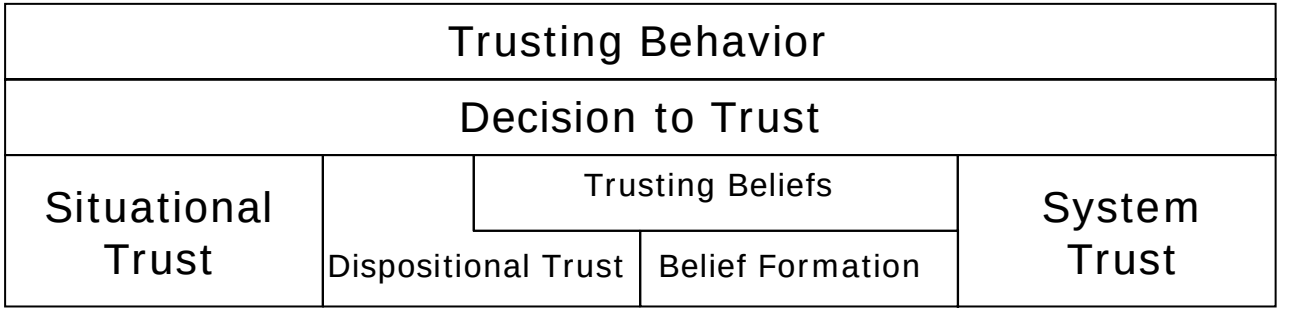
Trust-Based Admission Control

- Uses Psychological Trust-Framework
  - Based On: Situational Trust, Dispositional Trust, System Trust, Beliefs, Intentions
  - Access Granted if Majority of Entities Agree



McKnight and Chervany's Trust Framework (1996)

Step 2: How to Solve

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- Examples
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  - Gray et al.: "Trust-Based Admission Control"
  - Shand et al.: "Transparent Collaboration"
- Issues
  - High Complexity, High Dynamics (Unpredictable?)
  - Unrealistic Scaling Assumptions (AI Revisited?)

Scaling Assumptions

- Total/Partial Ordering of Trust Values
  - Can Trust-Comparisons be Chained?
- Humans can Rate/Rank Their Beliefs
  - How to Quantify "Gut Feeling"?
- Beliefs can be Inferred From Observation
  - Too Many Variables (Dispositions, Beliefs, ...)
- System or User can Identify Situations
  - How Consistent are Humans? (Exceptions!)

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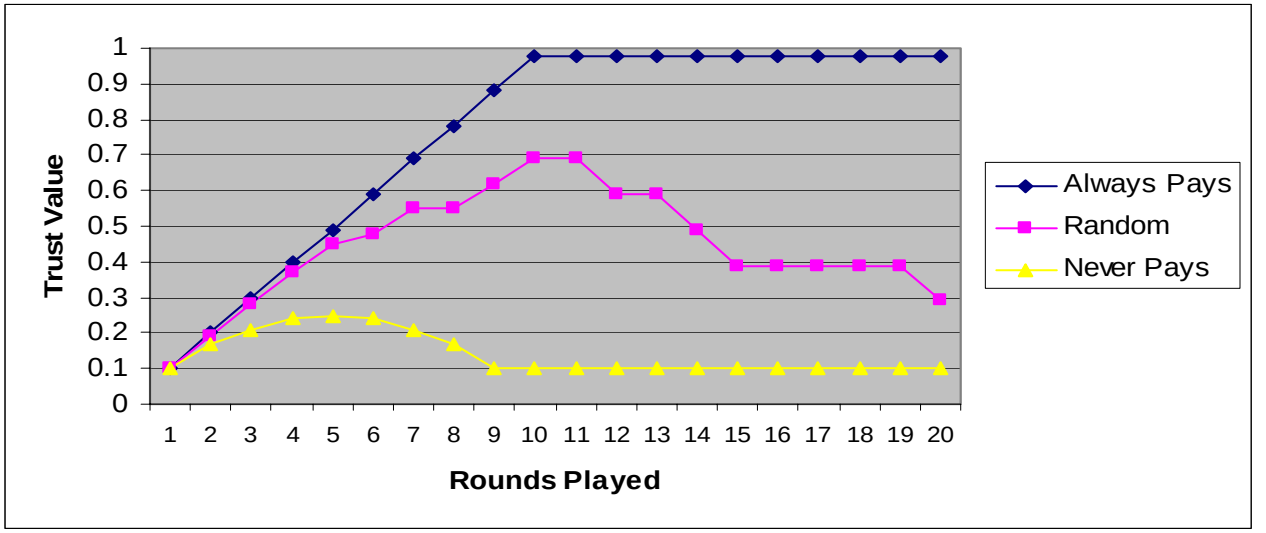
Step 3: How to Validate

- When Does it Work?
  - Research Needs Evaluations Methods
  - Most Trust-Frameworks Lack Verification Step
- Example



  - Gray et al.: "Trust-Based Admission Control" (iTrust 2003)

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Goal 1: Do as I Think

- Emulate Human (Me!)
  - So I Can Delegate Decisions
  - Test: Compare Decisions on Range of Interactions
- Do I Always Know What I Want?
  - Split Decisions ("Near Miss" Tolerance)
  - Important vs. Unimportant Decisions
  - Wanting to Trust vs. Trusting

Goal 2: Do What is Best

- Maximize Expected Payoff
  - So I can Improve (Profits/Fun/Health/...)
  - Test: Compare With "Optimal" Decisions
- Needs Detailed Risk Assessment
  - Based on User- or 3rd-Party-Input?
  - Hindsight Argument: All Successful Decisions Seem to Have Been "Good"
  - How Much Disagreement is Tolerable?

Conclusions

- Problems with Ubicomp Trust
  - Don't Know What to Solve (Focus)
  - Don't Know How to Solve (Implementation)
  - Don't Know How to Verify (Validation)
- Automation Issues
  - Context Identification (Precise Enough?)
  - Quantification Possible? (Manual/Auto)
  - Computation Possible? (Expectations?)

Conclusions

- Support, Not Replace
  - Location-based Authentication
  - Reputation Display, Interaction History
  - Simplified Sharing, Temporary Overrides
- Trust as a Human Trait
  - Analyze When and Why Humans Trust
  - Create Systems that Humans can Trust!
  - Create Systems that can be Used to Trust!