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Evidence for *a posteriori* security

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Evidence?

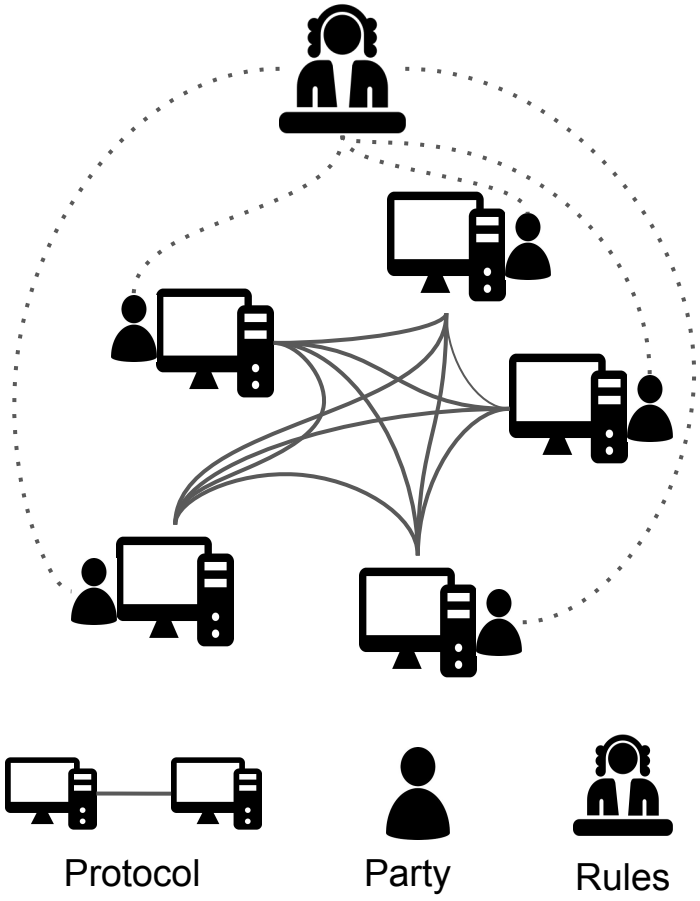
Liability Accountability Law

Due process Auditability

Verifiability Integrity Proof

Non-repudiation $P(A|E)>P(A)$

Some background



- **Ideal security goal: build secure systems that won't fail in any way, control information flow in systems**
- **Realistically, systems have many points of failure:**
  - **Protocol & human failures**
  - **Flawed rules**
- **Behaviour of the system cannot always be restricted to fit security goals**

Some background

- **Murphy's law/First axiom of infosec: anything that can go wrong will go wrong**

- **Impact of a failure varies from party to party**
  - **"Fail safe": party not responsible for a failure should not bear the costs**
  - **"Fail deadly": party responsible for a failure should bear the costs**

- **Accountability adds an incentive to avoid failures, but it requires an enforcing mechanism: evidence**

Some background

- Assume you have to deal with parties that can do anything e.g., law enforcement, kids
- Assume a trusted third party or a consensus mechanism that can make a decision and enforce it, it requires something to make the decision
- For our purpose, evidence is anything that can be used to make that decision i.e., assign liability
- Rather than help avoid failures, it helps deal with them after the fact
  - Security: identify the issue that caused a failure
  - Privacy: identify a privacy violation (typically policy)

Some examples

- Payment systems
  - Security Protocols and Evidence: Where Many Payment Systems Fail (Murdoch & Anderson, FC 2014)

- Access to data
  - VAMS: Verifiable Auditing of Access to Confidential Data (2018)
  - Ian Levy (NCSC Technical Director),on the privacy debate of data interception and surveillance: “My call is for more transparency, more openness and more evidence in this debate” (https://youtu.be/LRiAcbvSA3A?t=1h11m46s)

- Cryptocurrencies

- Many more, pick one related to your interests

Questions

- What's the correct model for the use of evidence?
- How should evidence be produced?
- What form should evidence take?

Threat model

- Threat modelling: want to account for parties that have “freedom”
- Compare to the “honest” ideal of what the party is doing, as specified by the system rules
- Deviation is realistic, but evidence allows evaluating the deviation and deciding if something was done wrong
- Goal: If someone deviates, there should be evidence so that they can be held accountable

Models

- Games are a standard way of modelling problems
  - Ideally: equilibrium that restricts deviations by ensuring detection

- Our setting has a few special attributes that aren't usually discussed:
  - Strategies have costs
    - What's the cost of deviating against the cost of auditing?
  - If the system is open, all players aren't necessarily known
    - Distribution over player types and computational capabilities?
  - Evidence adds new information to the system as it evolves

- Possible approach: Bayesian machine games (Halpern and Pass)
  - Bayesian game (incomplete information)
  - Takes into account machine types and a complexity function

Evidence principles

- **System independence: a system failure should not lead to failure of evidence production**

- **Reliability: Evidence should contain all information required to make a decision, but no more**
  - **Requires a clear definition of decision mechanism**
  - **Not possible to make liable an innocent party, no deniability for a guilty party**

- **Robustness: Evidence should be tamper-resistant**

- **Retention: Evidence collection and retention should not depend on a single party**

Evidence production

- **Logging actions**
  - **Merkle trees (Blockchains, Trillian)**
  - **Tamper-evident way of keeping records of actions**
  - **Is there a way of enforcing automatic logging of actions?**

- **Verifying computations**
  - **Existing cryptographic tools for verifying execution of programs**
  - **Generalising to things that aren’t programs?**

- **Proofs-of-X**
  - **Task specific proofs only**

- **Systems aspects: embedding the evidence production on top of a system**

Presenting evidence

- **Three settings for presentability**
- **Production level**
  - **Presented internally, no need for public presentability**
- **Expert witness:**
  - **Presented publicly to an expert witness, limited need for presentability but need for explainability**
- **Non-expert:**
  - **Presented to the public, convincing levels of presentability and explainability needed**

Forms of evidence

- Many trade-offs that have to be considered in context
  - Presentability
  - Verifiability
  - Privacy

- Evidence design should happen alongside system design

Questions

- What's the correct model for the use of evidence?
  - Unknown, varying participants
  - Computational costs
  - Evolving system

- How should evidence be produced?
  - Cryptographic evidence
  - Non-cryptographic evidence

- What form should evidence take?
  - Presentability
  - Privacy
  - Verifiability

Conclusion

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Questions?

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