Privacy-Preserving Trust Negotiations

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Project info

- Collaborators (Ph.D. students):
  - Keith Frikken
  - Jiangtao Li
- Publications
  - NDSS ‘06
  - WPES ‘04

Access control

- Access control decisions are often based on requester *characteristics* rather than identity
  - Access policy stated in terms of attributes to be satisfied
- Digital credentials, e.g.,
  - Citizenship, age, physical condition (disabilities), employment (government, healthcare, FEMA, etc), credit status, group membership (AAA, AARP, …), security clearance, …

Scenario

- Requester ("Alice") sends request to resource owner ("Bob")
- Bob sends policy for access
- Alice sends appropriate credentials
- Bob verifies credentials and grant access if they satisfy policy

Problem: Sensitive info

- Treat credentials as sensitive
  - Better individual privacy
  - Better security
- Treat access policies as sensitive
  - Hide business strategy (fewer unwelcome imitators)
  - Less “gaming”

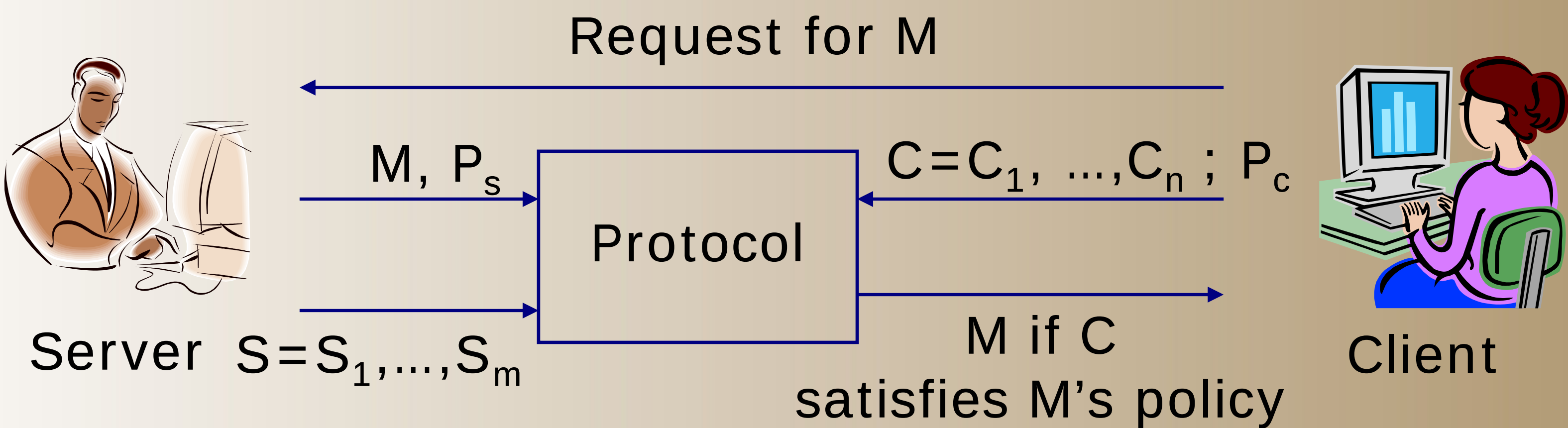
Previous work

- Mostly on sensitive credentials
- Minimizing credential disclosure
- Introduced "use-policies" for credentials
- Multiple rounds in a negotiation
  - A round makes more credentials usable
  - Stop when no change occurs in a round

Ideal Solution Requirements

- Neither side learns anything about the other's credentials
- Neither side learns anything about the other's policies
- Neither side learns which of their own credentials caused were relevant to successful negotiaton
- No off-line probing (e.g., by requesting an M once and then trying various subsets of credentials)

Model



- M = message ; P_c , P_s = Policies ; C, S = credentials
  - Credential sets C and S are issued off-line, *and can have their own "use policies"* (included in P_s and P_c)
- Client gets M iff her usable C_j's satisfy access policy for M
- Cannot use a trusted third party

Credentials

- Generated by certificate authority (CA), using Identity Based Encryption
- E.g., issuing Alice a student credential:
  - Use Identity Based Encryption with ID = Alice||student
  - Credential = private key corresponding to ID
- Simple example of credential usage:
  - Send Alice M encrypted with public key for ID
  - Alice can decrypt only with a student credential
  - Server does not learn whether Alice is a student or not

Policy

- A Boolean function $p_M(x_1, ..., x_n)$
  - x_i corresponds to attribute $attr_i$
- Policy is satisfied iff
  - $p_M(x_1, ..., x_n) = 1$ where x_i is 1 iff there is a usable credential in C for attribute $attr_i$
- E.g.,
  - Alice is a senior citizen and has low income
  - Policy=(disability$\vee$senior-citizen)$\wedge$low-income
  - Policy $= (x_1 \vee x_2) \wedge x_3 = (0 \vee 1) \wedge 1 = 1$

Dependencies

- Credentials' "use policies" can depend on each other
  - Arbitrarily deep nesting of dependencies
  - Cycles are possible
  - Cycles can overlap
- Trust negotition process is iterative

Iterative negotiation

- Eager strategy
  - Policy-usability determination is done by a “forward flooding” process that determines which credentials are usable
  - Works for DAG only
- We use a “Reverse-Eager” Strategy
  - Can handle cycles
  - Use doubly-blinded policy evaluation

Iteration

- Phase 1: Credential and Attribute Hiding
- Phase 2: Blinded Policy Evaluation

Iteration overview

- For each $attr_i$ A generates 2 randoms $r_i[0]$, $r_i[1]$
- Engages with B in sub-protocol the outcome of which is that B learns n values $k_1, k_2, ..., k_n$
  - $k_i = r_i[1]$ if B *has and can use* a credential for $attr_i$, otherwise $k_i = r_i[0]$

Iteration overview (cont'd)

- Above hiding stage makes use of equality test for array elements
  - "Is there are index at which the array items are equal?"
  - Answer is split: A knows the randoms that encode "yes" and "no", B learns one of those randoms
- Blinded policy evatuation
  - Uses the k_1, k_2, ..., k_n and the n pairs $r_i[0]$, $r_i[1]$ computed in the hiding stage
  - Results in A's usable credential set being *implicitly* updated according to whether policies evaluate to true

Other access control result

- Key-derivation
  - In access hierarchies [CCS 05, SACMAT 06]
  - New:
    - Time-based (discrete time units)
    - Geo-spacial based (planar regions)
    - Combinations of above
- In all of the above: 1 key, O(1) time derivation, almost-linear public storage

For more details ...

... on the trust negotiations result:

http://homes.cerias.purdue.edu/~jtli/paper/ndss06.pdf

or

http://www.cs.purdue.edu/homes/kbf/publications/NDSS06tn.pdf