On interoperable trust negotiation strategies

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Context

In Trust Negotiation Frameworks such as
TRUST BUILDER, RT, PEER TRUST, PROTUNE

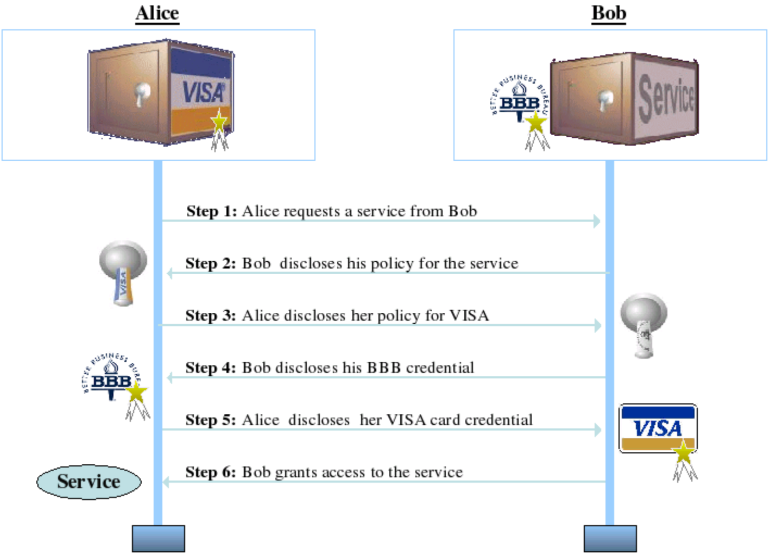
Transactions require

Access Control + **Controlled Sensitive Disclosures**

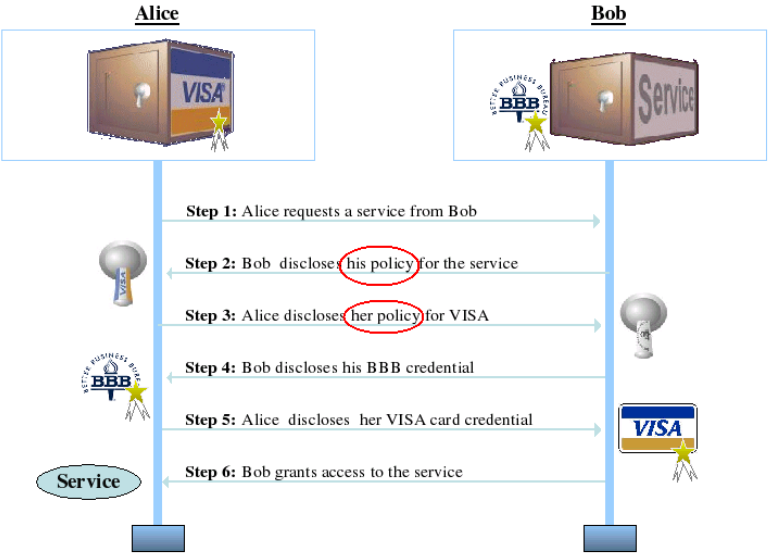
$\Downarrow$

Trust Negotiations

Context


Alice
Bob
VISA
BBB
Service
Step 1: Alice requests a service from Bob
Step 2: Bob discloses his policy for the service
Step 3: Alice discloses her policy for VISA
Step 4: Bob discloses his BBB credential
Step 5: Alice discloses her VISA card credential
Step 6: Bob grants access to the service
Service

Context



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Context

Many Trust Negotiation Frameworks protect peers' policies:

Example

- a bank grants special treatments to rich customers
- many other customers would not appreciate such privileges

Context

A negotiation may fail

- because peers' negotiation strategies don't release all of the policy
- even if the peers' policies permit a successful transaction

Our Goal

Guidelines for Negotiation Strategies that

1. make transactions succeed keeping partially secret both policies and sensitive information

Another goal:

2. reduce the amount of sensitive information released

Previous approches

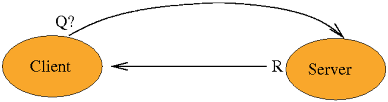
Previous approches:

- start from desirable ”good” properties for negotiation strategies for *designing* a family of strategies that work well together.

Our Approch

Our approch:

- starts from the motivations that drive peers in releasing information for *deriving* negotiation strategies:
  - Servers want to publish services
  - Client want to access to services
  - *making transactions succeed*



As side effect we obtain a ”good” property:

Interoperability: strategies yield a successful negotiation whenever the policies of the involved peers permit it.

Abstract Negotiation Framework

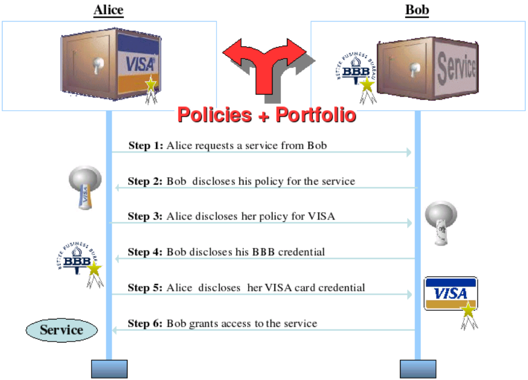
Policy language $\mathcal{L}$:

- a set of policy items
  - policy rules
  - portfolio: digital credentials, declarations

Abstract Negotiation Framework

Policies + Portfolio :

- finite subsets of $\mathcal{L}$
- all the information that a peer has for negotiating a resource



Abstract Negotiation Framework

The semantics of policies is modelled by

$$\text{unlocks} \subseteq \wp(\mathcal{L}) \times \mathcal{L}$$

P unlocks x iff P allows x to be released

Monotonicity : if we add more policy rules and credentials to a policy then the set of unlocked policy items increases [K. Seamons et al., *Requirements for policy languages for trust negotiation*.]

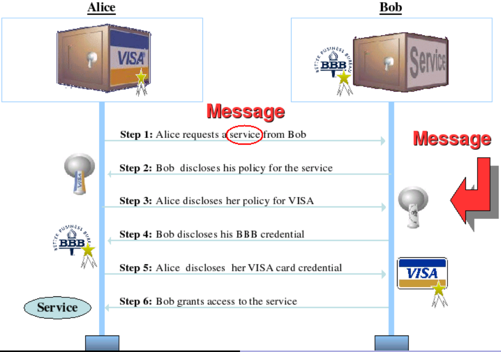
Expressiveness :

$\forall\, q \in \mathcal{L}$ *there exists a finite* $P \subseteq \mathcal{L}$ *s.t.* P unlocks q

Abstract Negotiation Framework

Messages :

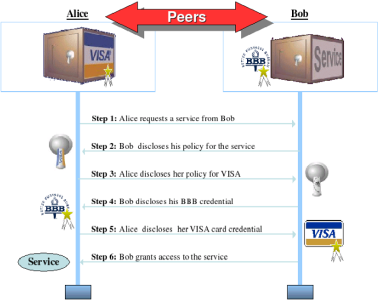
- a finite subset of $\mathcal{L}$
- information exchanged between a client and a server for negotiating a resource
- client's requests for a resource



Abstract Negotiation Framework

Peer : a pair $A = (P_A, R_A)$

- P_A: *policy + portfolio*
- $R_A : Msgs^* \rightarrow Msgs$ is a *release strategy*



- Given the past history of negotiation, a release strategy prescribes the next *"move"* of a peer.

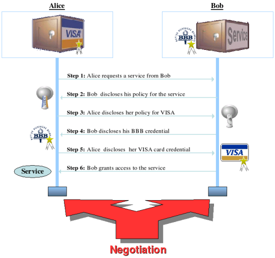
Abstract Negotiation Framework

Transaction $T = \langle A, B, \mathrm{res}, F \rangle$

- A (client) and B (server) are peers;
- $\mathrm{res} \in \mathcal{L}$ is a policy item (the *initial request*, $\mathrm{res} \in P_B$);
- $F \subseteq Msgs^*$ is a *failure criterion*, i.e. the set of all possible failed negotiations.

Abstract Negotiation Framework

Negotiation nego(T) induced by T, R_A and R_B



- the finite or infinite sequence of messages $\mu = \mu_0\mu_1 \ldots \mu_k \ldots$ mutually exchanged between A and B
- $\mu_0 = \{\text{res}\}$
- nego(T) terminates when
  - nego(T) $\in F$ (negotiation is *failed*)
  - res $\in \bigcup_{i=1}^{|\mu|} \mu_i$ (negotiation is *successful*)

Abstract Negotiation Framework

- To get our results we have
  - to restrict the class of peers that we study
  - to fix a failure criterion

Negotiation Framework

$$\boxed{\Psi = (\mathcal{C}, F)}$$

- $\mathcal{C}$: a class of peers;
- F: a failure criterion.

Peers classification

Truthful: for all *hist*, $R_A(hist) \subseteq P_A$

- No item is ”invented”.

Secure: for all *hist*, $R_A(hist) \subseteq \text{unlocked}(P_A, hist)$

- The disclosure policy is preserved.

Monotonic: if $\text{released}(hist) \subseteq \text{released}(hist')$
$R_A(hist) \subseteq R_A(hist')$

- The more information is received, the more information is released

Monotonic servers are of practical interest

- A better characterization of the client lets the server present a wider range of choices to get the desired resource.

Failure Criteria and Termination

Vacuous Messages

- equivalent to empty message;
- it carries no new information.

Failure criteria F_k

- a negotiation fails after k consecutive *vacuous messages*.

Negotiation Framework

Next we focus on the negotiation framework

$$\boxed{\Psi = (\mathcal{C}, F_k)}$$

F_k: a failure criterion with $k > 0$

$\mathcal{C}$:

- monotonic servers
- canonical (truthful and secure) peers
  - If A and B are truthful, termination is guaranteed.

Starting point: what do peers want?

Peers are selfish :

- their only goal is to make transactions succeed

Cooperativeness:

- Cooperative peers are those whose strategies maximize the set of successful transactions.

Towards guidelines

n-cautious peers

- after *n* vacuous messages
- if *A* has something to release

$$\mathrm{unlocked}(P_A, hist) \not\subseteq \mathrm{released}(hist)$$

- then *A* releases something

$$R_A(hist) \not\subseteq \mathrm{released}(hist)$$

weakly n-cautious peers

- after *n* vacuous messages
- if *A* has something to release that *could be useful*
- then *A* releases something.

Interacting with monotonic servers

Theorem

A peer A is cooperative w.r.t. monotonic peers iff A is $(k-2)$-cautious.

- To make a client *A* cooperative with monotonic servers, it is necessary and sufficient to program *A*'s strategy in a $(k-2)$-cautious way.
- But how to make a monotonic server cooperative w.r.t. a $(k-2)$-cautious client?

Interacting with $(k-2)$-cautious peers

Theorem

A peer B is cooperative with all $(k-2)$*-cautious peers iff B is weakly* $(k-2)$*-cautious.*

- To make a server B cooperative with $(k-2)$-cautious clients, it is necessary and sufficient to program B's strategy in a weakly $(k-2)$-cautious way.

  Note: for efficiency it might be preferrable to adopt cautiousness as an approximation of weak cautiousness.

Summary

In any negotiation framework

- $\Psi = (\mathcal{C}, F_k)$
- monotonic servers
- selfish peers (cooperative)

strategies must be

- $(k-2)$-cautious on clients
- weakly $(k-2)$-cautious on servers

Implications

Unexpected side effects

- *each client is INTEROPERABLE with each server*
- *each client is INTEROPERABLE with each client*

Interoperability:

- whenever a successful transaction is possible, the strategies find some
- even if the policies are partially kept secret

Further Guidelines

How to choose a value for parameter k of F_k:

- k even (to avoid exploits)
- preferrably $k = 2$

See the paper.

Future Work

Sensitivity Minimizing

- guidelines to program release strategies that minimize the amount of sensitivity of information disclosed during a negotiation

More on k in F_k - Even k vs. Odd k

Odd values of k allow exploits even
if both A and B are $(k-2)$-cautious

- *A* may send vacuous messages until *B* is forced to disclose something 2 steps before failure
- If *B* sends a vacuous message 2 steps before failure, then it really means it can't release anything else
- *A* can still disclose something at the last step and keep the negotiation alive
- Very bad for privacy – deprecated

More on k in F_k - Even k vs. Odd k

Even values are ok

- The peer that starts the vacuous sequence is also the peer that must release something 2 steps before failure
- Optimal value: $k = 2$
- No vacuous messages unless a peer really can't release anything new

Negotiations

Negotiation nego(T) induced by $T = \langle A, B, \text{res}, F_k \rangle$, R_A and R_B

- the finite or infinite sequence of messages $\mu = \mu_0 \mu_1 \ldots \mu_k \ldots$ s.t.
  - $\mu_0 = \{\text{res}\}$;
  - for all even $i \in \mathbb{N}$, $\mu_{i+1} = R_B(\mu_{\leq i})$;
  - for all odd $i \in \mathbb{N}$, $\mu_{i+1} = R_A(\mu_{\leq i})$;
  - for all $i \in \mathbb{N}$, if res $\in \mu_i$ or $\mu_{\leq i} \in F$, then $\mu = \mu_{\leq i}$.

Cooperativeness

A peer A is *cooperative* w.r.t. a class of peers $\mathcal{C}$, if no A' is s.t.

- A and A' have the same policy P,
- for all $B \in \mathcal{C}$ and all Ψ-transactions T involving A and B, $val(T) \leq val(T[A'/A])$,
- for some $B \in \mathcal{C}$ and some Ψ-transaction T involving A and B, $val(T) < val(T[A'/A])$.

n-cautiouness

A peer A is *n-cautious* if

- for all transactions T involving A
- and all prefixes μ of $nego(T)$,
- if μ has a vacuous tail whose length is $\geq n$
- then

$$\text{unlocked}(P_A, \mu) \not\subseteq \text{released}(\mu) \Rightarrow R_A(\mu) \not\subseteq \text{released}(\mu)$$

(i.e., $R_A(\mu)$ is not vacuous)

weak *n*-cautiouness

A peer A is *weakly n-cautious* if

- for all transactions T involving A
- and all prefixes μ of $nego(T)$,
- if μ has a vacuous tail whose length is $\geq n$ and
- if $R_a(\mu)$ is vacuous then T fails while
- T can be successful,
- then

$$\text{unlocked}(P_A, \mu) \not\subseteq \text{released}(\mu) \Rightarrow R_A(\mu) \not\subseteq \text{released}(\mu)$$

(i.e., $R_A(\mu)$ is not vacuous)