Trust in LargeScale Computational Grids: An SPKI/SDSI Extension for Representing Opinion

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Outline

Overview
Security

- Securing information access is a hard task
- Security technologies were created to make it difficult for unauthorized users to access information
- People and software agents that have legitimate rights could use their prerogatives to execute forbidden actions
- It would be important to consider the relationship between subjects, including the interation history

Overview
Security in Grids

- A Grid may encompass many institutions and different administrative domains
- It may also contains thousands of users and machines
- The environment is dynamic, with users and resources joining and leaving at any time
- Centralized solution is not desirable

Overview
Trust Chains

- Trust chains provide decentralized resource access control
- Based on mutual trust relations
- Each subject is a certification authority
- Can provide access rights to other subjects
- These rights can be delegated, creating a trust chain

Overview
SPKI/SDSI model

- SPKI/SDSI: implementation of trust chains
- Users can create authorization certificates in behalf of other users
- Users can delegate authorization certificates
- When a subject decides that another one is reliable, he has to have total certainty about this
- It would be better to have intermediate levels of trust

Outline

Jøsang model.

- Opinion ω about an statement
- $\omega = \{b, d, u\}$ where $b + d + u = 1, \quad \{b, d, u\} \in [0, 1]^3$
- b, d, and u represent belief, disbelief, and uncertainty
- There are 3 well defined states
- Operators to manipulate opinions

CONJUNCTION Operator

When need opinion about two independent statements

$\omega_p^A = \{b_p^A, d_p^A, u_p^A\}$ and $\omega_q^A = \{b_q^A, d_q^A, u_q^A\}$

$\omega_{p\Lambda q}^A = \omega_p^A \Lambda \omega_q^A = \{b_{p\Lambda q}^A, d_{p\Lambda q}^A, u_{p\Lambda q}^A\}$

where:

$$\begin{cases} b_{p\Lambda q}^A = b_p^A b_q^A \\ d_{p\Lambda q}^A = d_p^A + d_q^A - d_p^A d_q^A \\ u_{p\Lambda q}^A = b_p^A u_q^A + u_p^A b_q^A + u_p^A u_q^A \end{cases}$$

RECOMMENDATION Operator

Subject B recommends his opinion about an statement p to subject A

$$\omega_B^A = \{b_B^A, d_B^A, u_B^A\}$$

$$\omega_p^{AB} = \omega_B^A \otimes \omega_p^B = \{b_p^{AB}, d_p^{AB}, u_p^{AB}\}$$

$$\text{where:} \quad \begin{cases} b_p^{AB} = b_B^A b_p^B \\ d_p^{AB} = b_B^A d_p^B \\ u_p^{AB} = d_B^A + u_B^A + b_B^A u_p^B \end{cases}$$

CONSENSUS Operator

Combination of two subject beliefs about an statement

$\omega_p^A = \{b_p^A, d_p^A, u_p^A\}$ and $\omega_p^B = \{b_p^B, d_p^B, u_p^B\}$

$\omega_p^{A,B} = \omega_p^A \oplus \omega_p^B = \{b_p^{A,B}, d_p^{A,B}, u_p^{A,B}\}$

where:

$$\begin{cases} b_p^{A,B} = (b_p^A u_p^B + b_p^B u_p^A)/(u_p^A + u_p^B - u_p^A u_p^B) \\ d_p^{A,B} = (d_p^A u_p^B + d_p^B u_p^A)/(u_p^A + u_p^B - u_p^A u_p^B) \\ u_p^{A,B} = (u_p^A u_p^B)/(u_p^A + u_p^B - u_p^A u_p^B) \end{cases}$$

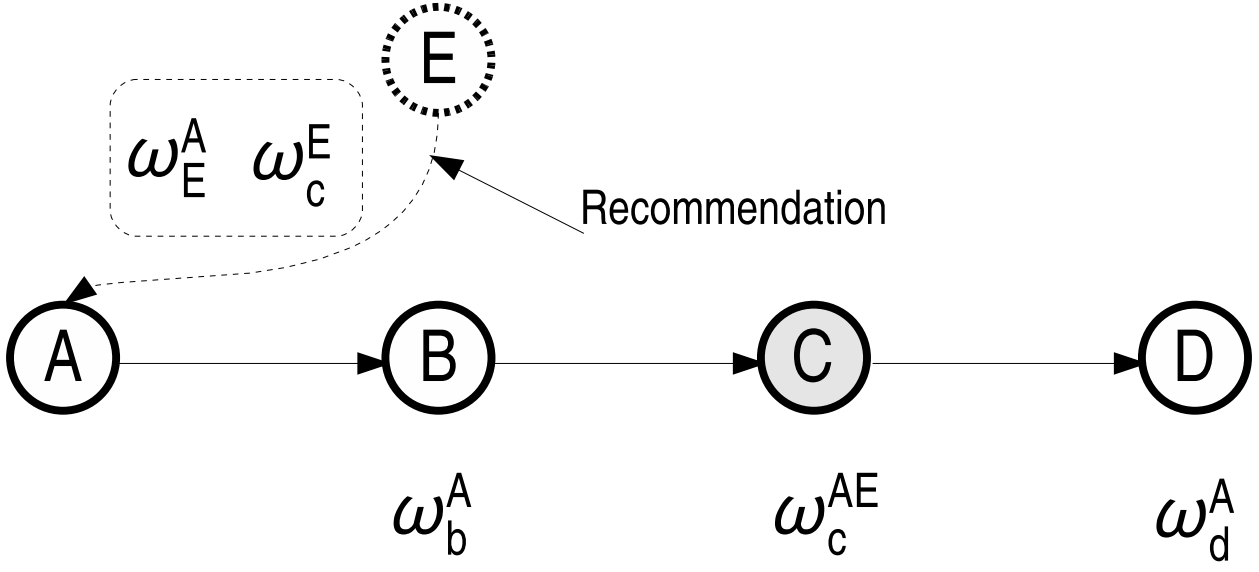
Outline

Using the model with trust chains

- Introduce the concept of opinions in trust chains
- Opinions are used to determine trust between subjects
- A subject can validate a trust chain using the consensus of its opinion about all the subjects in the chain

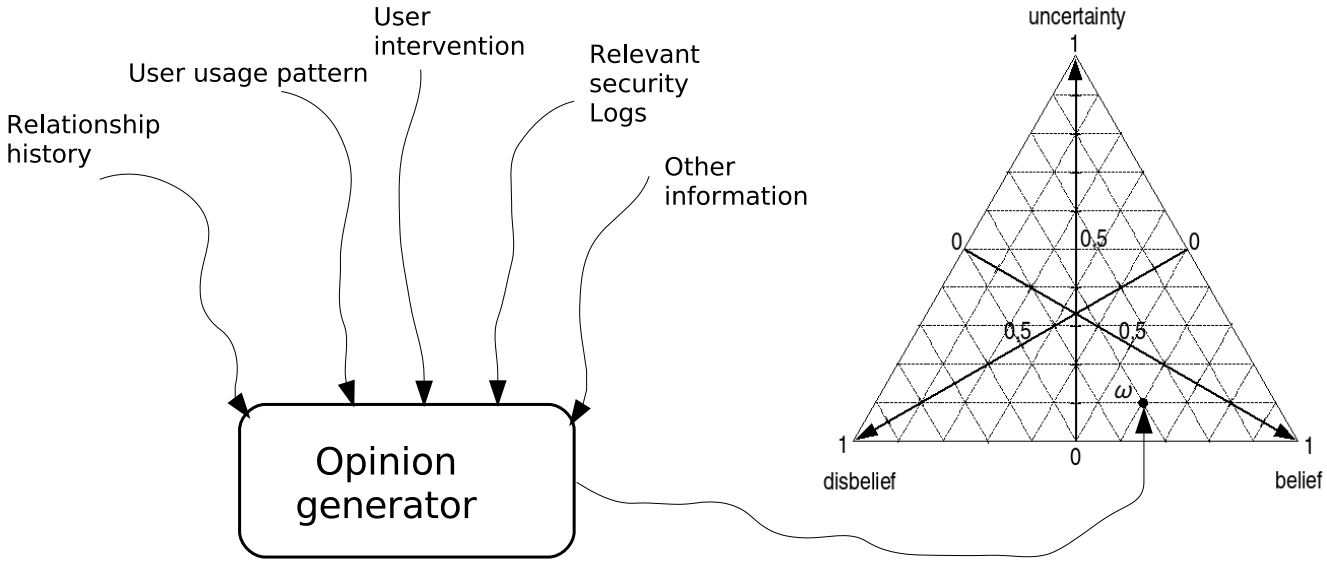
Subject E recommends C to A

- Subject A needs to validate the trust chain but his opinion about C is uncertain
- Subject E recommends his opinion about C to A

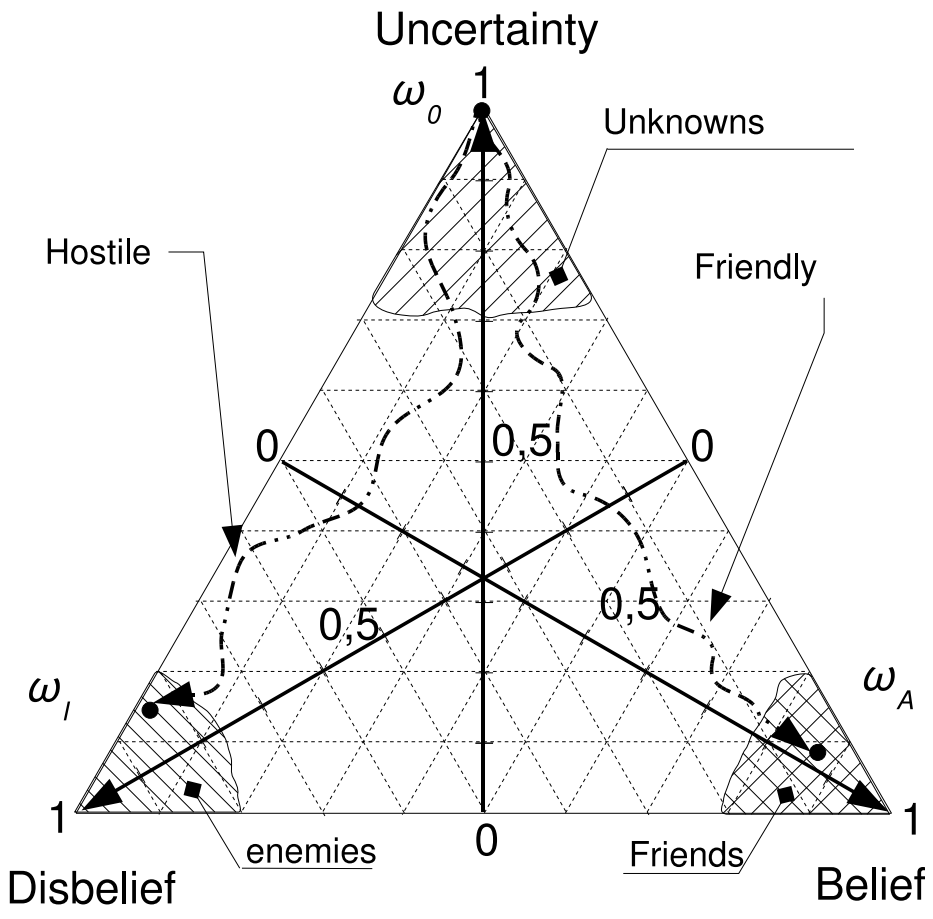


Opinion generator

- Need some mechanism to automatically generate opinions between subjects
- Should also allow manual user intervention



Opinion changing



Outline

Opinion Certificate

- Added new kind of certificate: *opinion certificate*
- *issuer* - is the subject that gave the opinion, he is the certificate owner
- *subject* - is the entity that received the opinion
- *opinion* - is the opinion represented using the model
- *validity specification* - represents the validity of the certificate

Advantages of Opinion Certificate

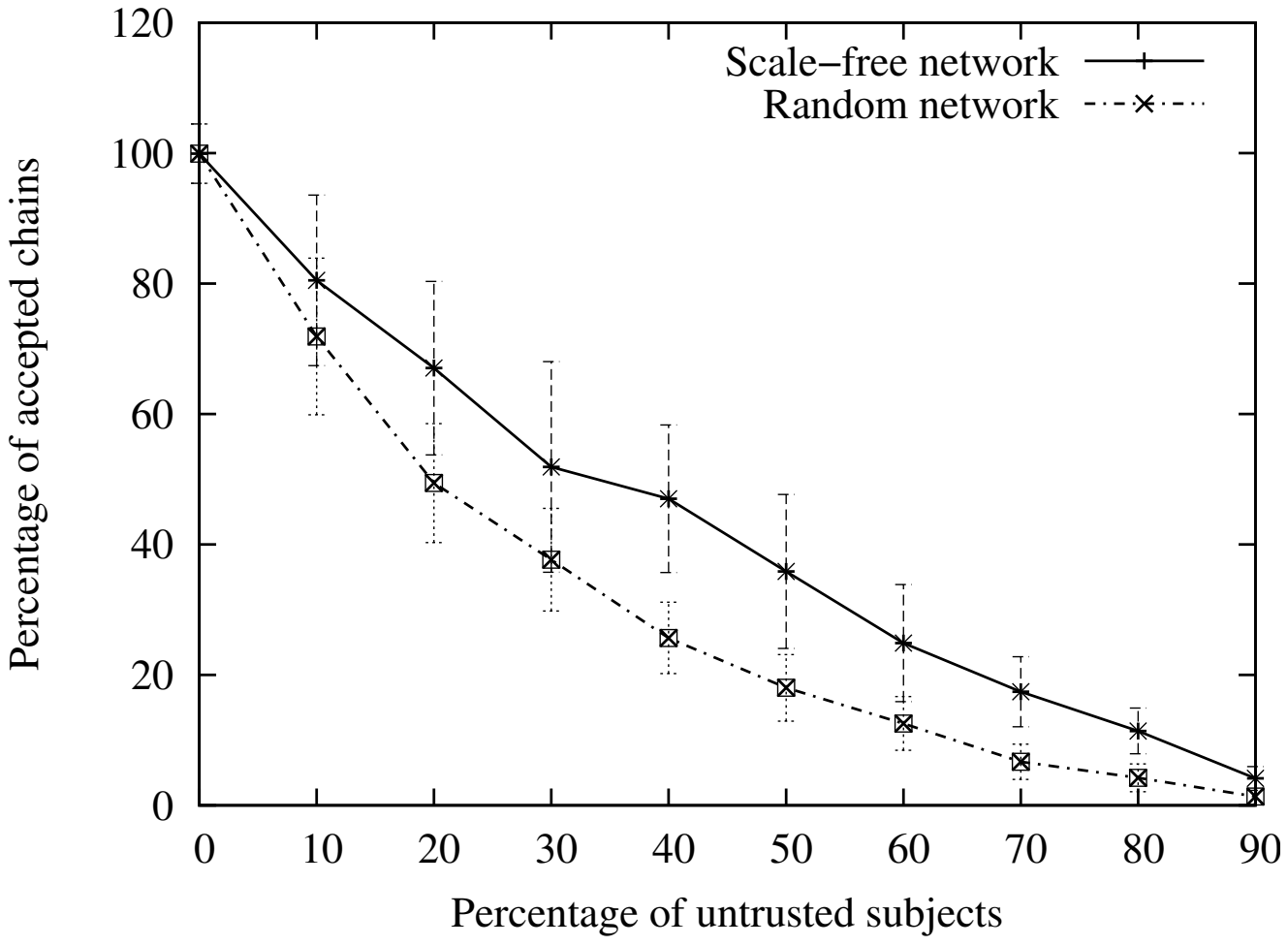
- Opinion composition allows chains to be verified considering non-binary opinions of all related subjects.
- Long chains could usually results in unfavorable opinions
- Non-binary opinions may be used to have an access control list with fine granularity.

Outline

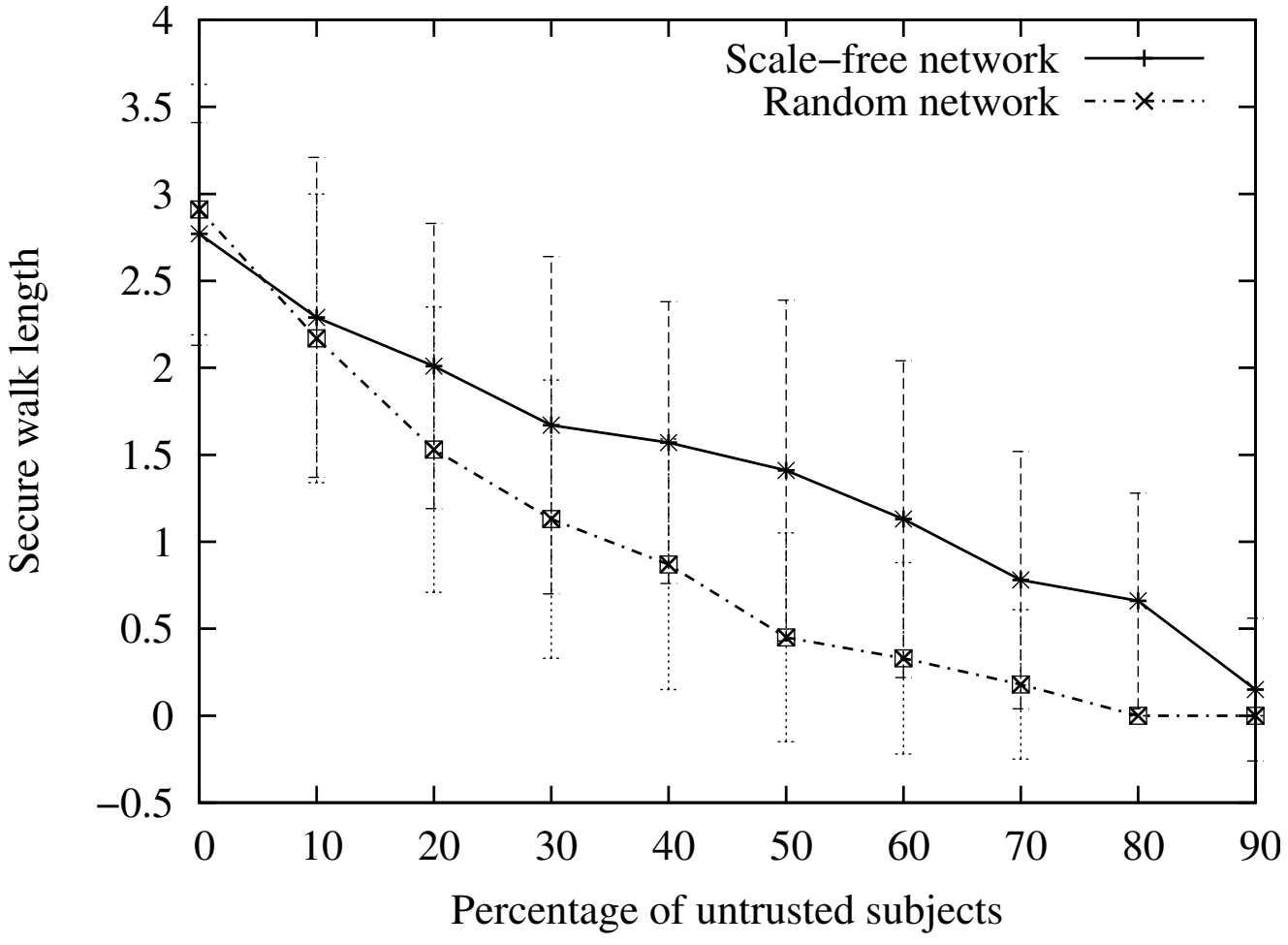
- Bamboo Simulator
- 100 subjects, each controlling a single shared resource
- Random and Free-scale network topologies
  - Free-scale contain high-connectivity hubs
  - Present in web pages, power grids, social interactions
- Simulation have subjects performing legitimate and ilegitiamate action
  - Actions change the opinion of one subject about another

- Steps
  - Initial opinions of 100% uncertainty
  - Subjects delegate their resources randomly
  - Subjects perform resource accesses, modifying opinions
  - Subjects delegates their resources again, creating new trust chains
  - Trust chains are verified to check which ones are acceptable
- Accepted chains versus percentage of untrusted subjects
- Secure chain length versus percentage of untrusted subjects

Accepted chains versus percentage of untrusted subjects



Secure chain length versus percentage of untrusted subjects



Concluding Remarks

- New concept to the initial SPKI/SDSI model: the subjectivity.
- Subjectivity allows SPKI/SDSI to be used in highly dynamic environments such as computational grids
- Jøsang's model seems adequate for represeting opinions

- Need to verify whether the mathematical operations are sufficient
- Implementation of a grid security middleware using the SPKI/SDSI extension
- Finer granularity in security policy definitions

Questions

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