Trust-based Privacy Preservation for Peer-to-peer Data Sharing

Y. Lu, W. Wang, D. Xu, and B. Bhargava
yilu, wangwc, dxu, bb @ cs.purdue.edu
Department of Computer Sciences
Purdue University

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Problem statement

- Privacy in peer-to-peer systems is different from the anonymity problem
- Preserve privacy of requester
- A mechanism is needed to remove the association between the identity of the requester and the data needed

Proposed solution

- A mechanism is proposed that allows the peers to acquire data through trusted proxies to preserve privacy of requester
  - The data request is handled through the peer’s proxies
  - The proxy can become a supplier later and mask the original requester

Related work

- Trust in privacy preservation
  - Authorization based on evidence and trust, [Bhargava and Zhong, DaWaK'02]
  - Developing pervasive trust [Lilien, CGW'03]
- Hiding the subject in a crowd
  - K-anonymity [Sweeney, UFKS'02]
  - Broadcast and multicast [Scarlata *et al*, INCP'01]

Related work (2)

- Fixed servers and proxies
  - Publius [Waldman *et al*, USENIX'00]
- Building a multi-hop path to hide the real source and destination
  - FreeNet [Clarke *et al*, IC'02]
  - Crowds [Reiter and Rubin, ACM TISS'98]
  - Onion routing [Goldschlag *et al*, ACM Commu.'99]

Related work (3)

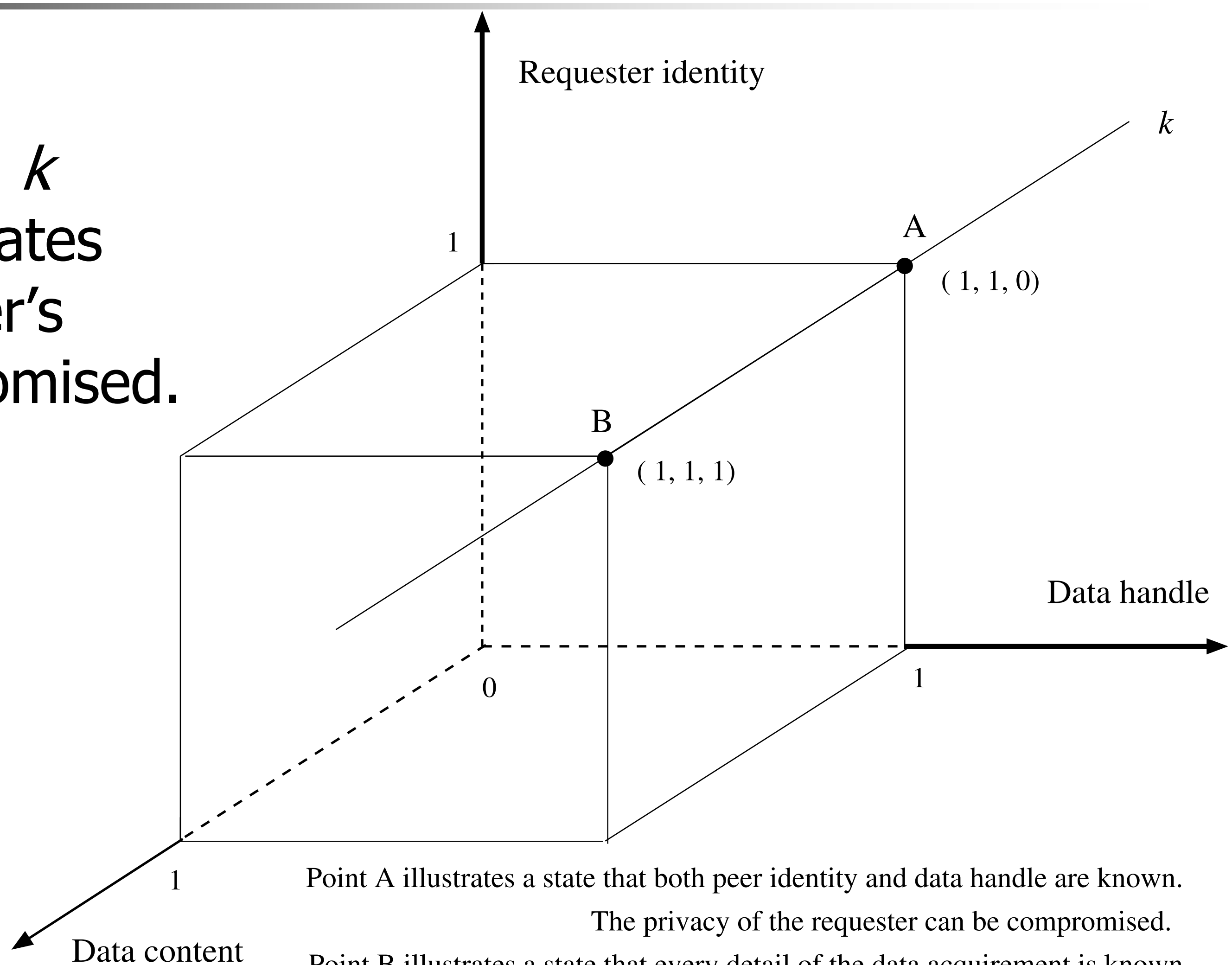
- p^5 [Sherwood *et al*, IEEE SSP'02]
  - p^5 provides sender-receiver anonymity by transmitting packets to a broadcast group
- Herbivore [Goel *et al*, Cornell Univ Tech Report'03]
  - Provides provable anonymity in peer-to-peer communication systems by adopting dining cryptographer networks

Privacy measurement

- A tuple <requester ID, data handle, data content> is defined to describe a data acquirement.
- For each element, "0" means that the peer knows nothing, while "1" means that it knows everything.
- A state in which the requester's privacy is compromised can be represented as a vector <1, 1, y>, ($y \in [0,1]$) from which one can link the ID of the requester to the data that it is interested in.

Privacy measurement (2)

For example, line *k* represents the states that the requester's privacy is compromised.



Point A illustrates a state that both peer identity and data handle are known. The privacy of the requester can be compromised.

Point B illustrates a state that every detail of the data acquirement is known.

Mitigating collusion

- An operation "*" is defined as:

$$<c_1, c_2, c_3> = <a_1, a_2, a_3> * <b_1, b_2, b_3>$$

$$c_i = \begin{cases} \max(a_i, b_i), & a_i \neq 0 \ \ and \ \ b_i \neq 0; \\ 0, & otherwise. \end{cases}$$

- This operation describes the revealed information after a collusion of two peers when each peer knows a part of the "secret".
- The number of collusions required to compromise the secret can be used to evaluate the achieved privacy

Trust based privacy preservation scheme

- The requester asks one proxy to look up the data on its behalf. Once the supplier is located, the proxy will get the data and deliver it to the requester
  - Advantage: other peers, including the supplier, do not know the real requester
  - Disadvantage: The privacy solely depends on the trustworthiness and reliability of the proxy

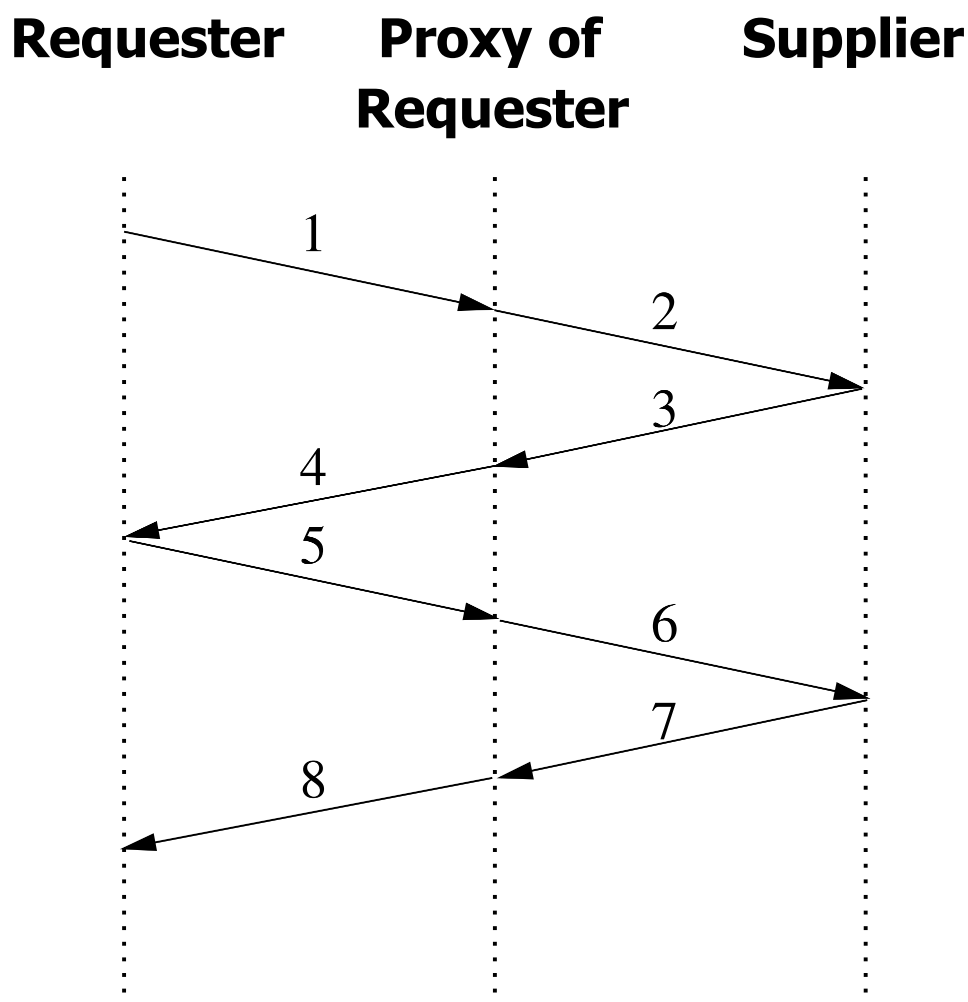
Trust based scheme – Improvement 1

- To avoid specifying the data handle in plain text, the requester calculates the hash code and only reveals a part of it to the proxy.
- The proxy sends it to possible suppliers.
- Receiving the partial hash code, the supplier compares it to the hash codes of the data handles that it holds. Depending on the revealed part, multiple matches may be found.
- The suppliers then construct a bloom filter based on the remaining parts of the matched hash codes and send it back. They also send back their public key certificates.

Trust based scheme – Improvement 1

- Examining the filters, the requester can eliminate some candidate suppliers and finds some who may have the data.
- It then encrypts the full data handle and a data transfer key k_{Data} with the public key.
- The supplier sends the data back using k_{Data} through the proxy
- Advantages:
  - It is difficult to infer the data handle through the partial hash code
  - The proxy alone cannot compromise the privacy
  - Through adjusting the revealed hash code, the allowable error of the bloom filter can be determined

Data transfer procedure after improvement 1



R: requester *S*: supplier

Step 1, 2: *R* sends out the partial hash code of the data handle

Step 3, 4: *S* sends the bloom filter of the handles and the public key certificates

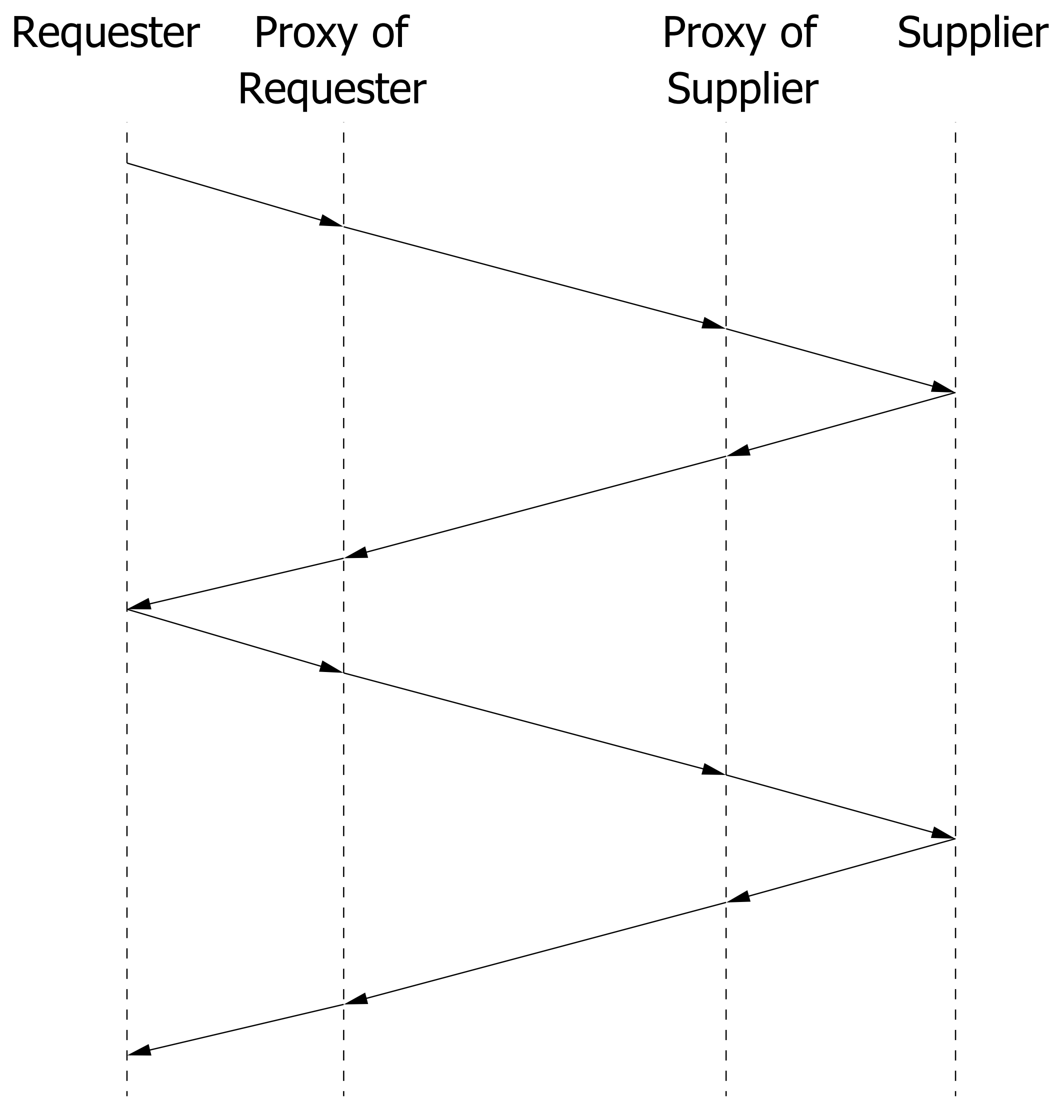
Step 5, 6: *R* sends the data handle and k_{Data} encrypted by the public key

Step 7, 8: *S* sends the required data encrypted by k_{Data}

Trust based scheme – Improvement 2

- The above scheme does not protect the privacy of the supplier
- To address this problem, the supplier can respond to a request via its own proxy

Trust based scheme – Improvement 2



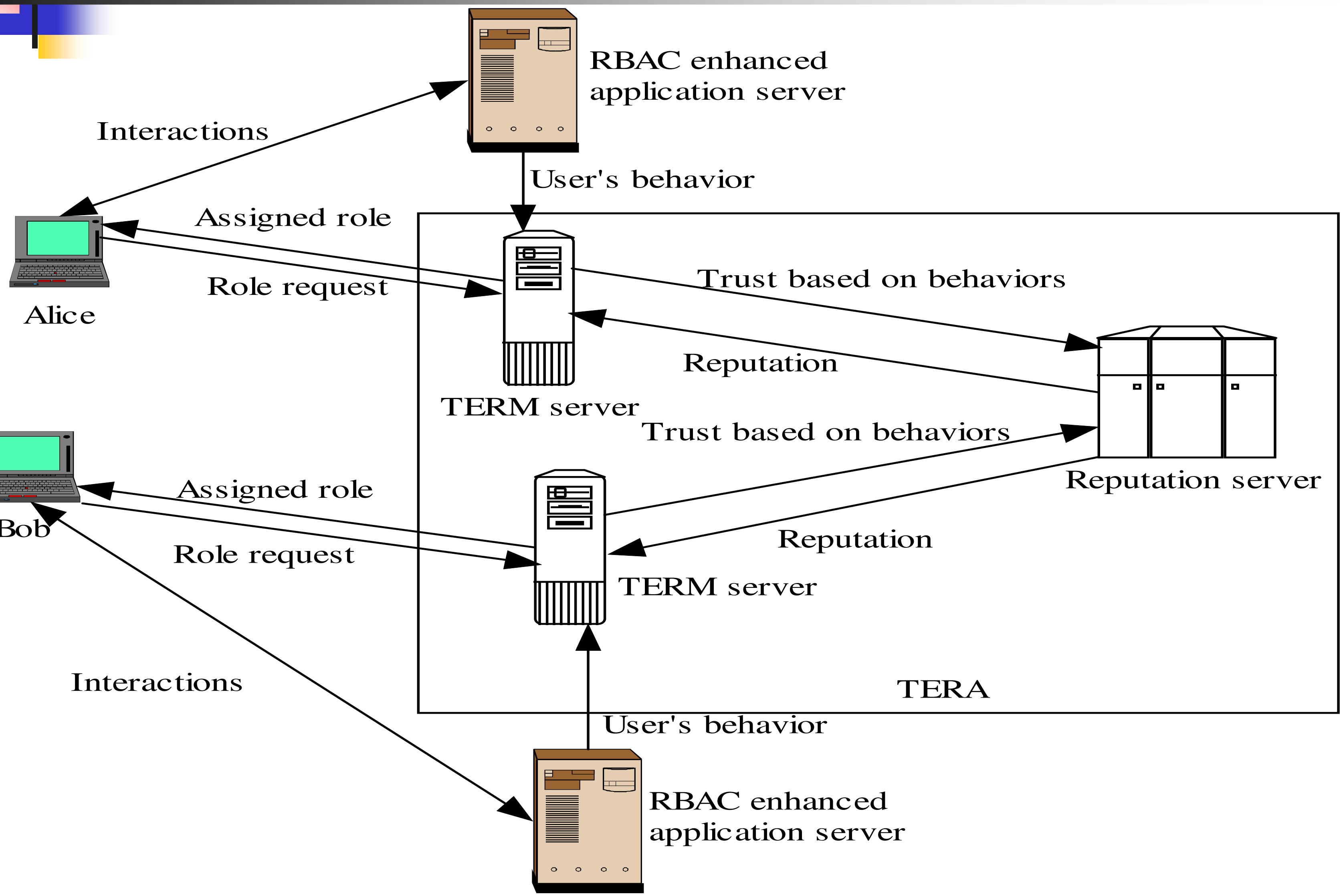
Trustworthiness of peers

- The trust value of a proxy is assessed based on its behaviors and other peers' recommendations
- Using Kalman filtering, the trust model can be built as a multivariate, time-varying state vector

Experimental platform - TERA

- Trust enhanced role mapping (TERM) server assigns roles to users based on
  - Uncertain & subjective evidences
  - Dynamic trust
- Reputation server
  - Dynamic trust information repository
  - Evaluate reputation from trust information by using algorithms specified by TERM server

Trust enhanced role assignment architecture (TERA)



Conclusion

- A trust based privacy preservation method for peer-to-peer data sharing is proposed
- It adopts the proxy scheme during the data acquirement
- Extensions
  - Solid analysis and experiments on large scale networks are required
  - A security analysis of the proposed mechanism is required

Related publication

- B. Bhargava and Y. Zhong, "Authorization based on evidence and trust," in *Proc. of International Conference on Data Warehousing and Knowledge Discovery (DaWaK),* 2002
- B. Bhargava, "Vulnerabilities and fraud in computing systems," in *Proc. of International Conference on Advances in Internet, Processing, Systems, and Interdisciplinary Research (IPSI)*, 2003.
- L. Lilien and A. Bhargava, "From vulnerabilities to trust: A road to trusted computing," in *Proc. of International Conference on Advances in Internet, Processing, Systems, and Interdisciplinary Research (IPSI)*, 2003.
- L. Lilien, "Developing pervasive trust paradigm for authentication and authorization," in *Proc. of Third Cracow Grid Workshop (CGW)*, 2003.