Cooperative Peer Groups in NICE

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Introduction

- **A distributed scheme for trust inference in peer-to-peer networks.**
  - **NICE system is a platform for implementing cooperative applications over the Internet.**
  - **We describe a technique for efficiently storing user reputation information in a completely decentralized manner.**
- We present a new decentralized trust inference scheme that can be used to infer across arbitrary levels of trust.

Cooperative System

- We define a cooperative application as one that allocates a subset of its resources, processing, bandwidth, and storage, for use by other peers.

- The goal is develop algorithms that will allow “good” users to identify other “good” users, and thus, enable *robust* cooperative groups.

Cooperative System

- Let the “good” nodes find each other quickly and efficiently: Good nodes should be able to locate other good nodes without losing resources interacting with malicious nodes.

- Malicious nodes and cliques should not be able to break up cooperating groups by spreading mis-information to good nodes.

NICE

- NICE is a platform for implementing cooperative distributed applications.

- Applications in NICE gain access to remote resources by bartering local resources.

- Transactions in NICE consist of secure exchanges of resource certificates.

NICE

- NICE provides the following services:
  - Resource advertisement and location
  - Secure bartering and trading of resources
  - Distributed "trust" valuation

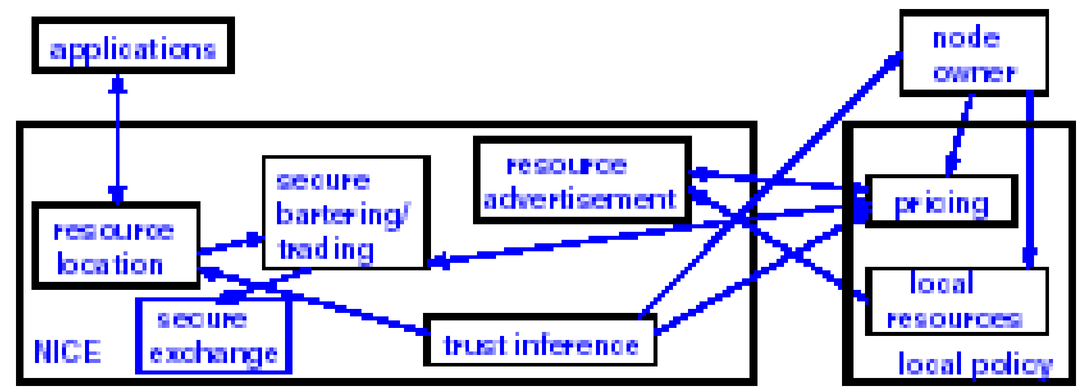


Fig. 1. NICE component architecture: the arrows show information flow in the system; each NICE component also communicates with peers on different nodes. In this paper, we describe the trust inference component of NICE.

NICE

- **Trust-based pricing:**
  - In trust-based pricing, resources are priced proportional to mutually perceived trust.
  - From Alice to Bob is $T_{Alice}(Bob) = 0.5$, and $T_{Bob}(Alice) = 1.0$
  - Alice trades with a principal with lower trust she incurs a greater risk of not receiving services in return.

Distributed Trust Compution

- Each involved user produces a signed statement (called a *cookie*) about the quality of the transaction.

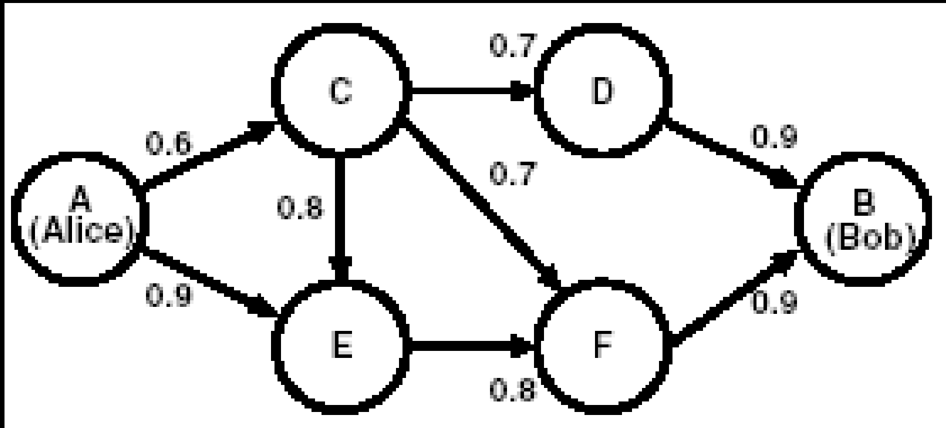
  - Consider a successful transaction *t* between users Alice and Bob in which Alice consumes a set of resources from Bob.

  - After the transaction completes, Alice signs a cookie *c* .

  - Each transaction creates new cookies which are stored by different users.

Distributed Trust Compution

- **Strongest path:**
  - Alice chooses the *strongest* path, and uses the minimum trust value on the path as the trust value for Bob.
  - The strongest path is *AEFB*, and Alice infers a trust level of 0.8 for Bob.
- **Weighted sum of strongest disjoint paths:**
  - *ACDB* is the other disjoint path (with strength 0.6), and the inferred trust value from Alice to Bob is 0.72.



Distributed Trust Inference:Basic Algorithm

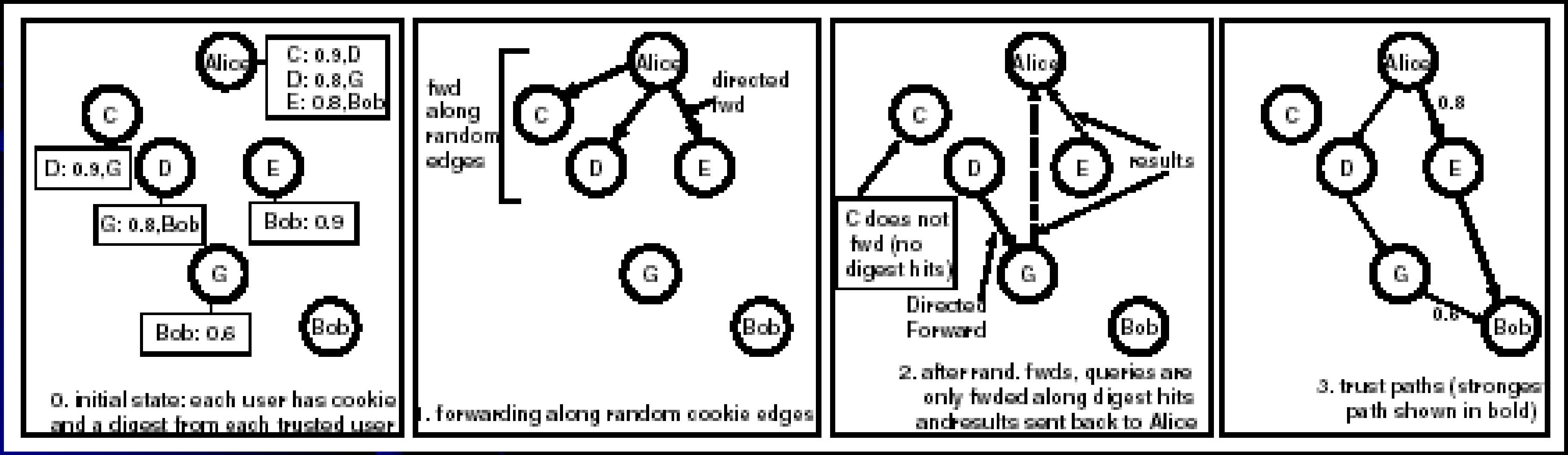
- Each user stores a set of signed cookies that it receives as a result of previous transactions.

- Suppose Alice wants to use some resources at Bob's node.
  - Either Alice already has cookies from Bob, or Alice and Bob have not had any transactions yet.

  - When Alice has no cookies from Bob.
    - Alice initiates a search for Bob's cookies at nodes from whom she holds cookies.
    - Suppose Alice has a cookie from Carol, and Carol has a cookie from Bob.
    - Carol gives Alice a copy of her cookie from Bob.
    - Alice presents two cookies to Bob: one from Bob to Carol, and one from Carol to Alice.

Refinements

- Whenever node receives a cookie from some other node, it also receives a digest of all other cookies at the remote node.
- Each node keeps a digest of recently executed searches and uses this digest to suppress duplicate queries.

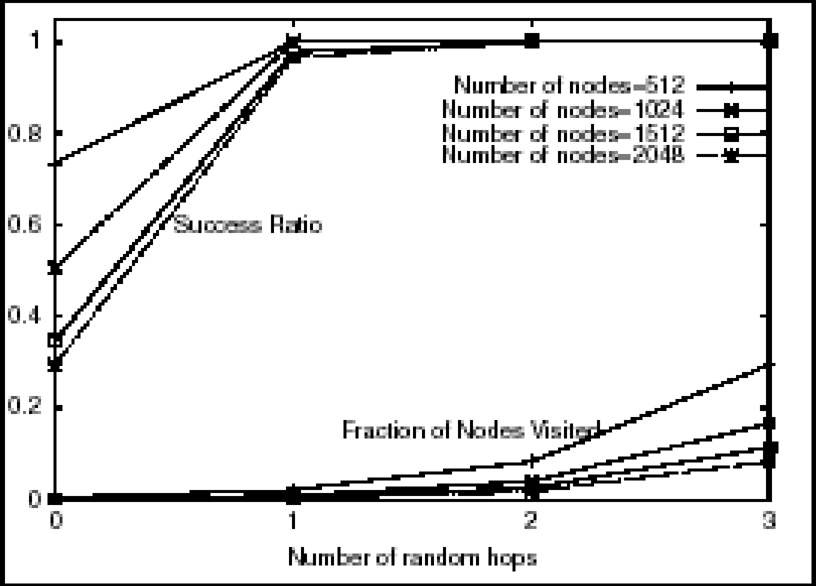


Negative Cookies

- It follows high trust edges out of Bob and terminates when it reaches a negative cookie for Eve.
- The search returns a list of people whom Bob trusts who have had negative transactions with Eve in the past.
- If Bob discovers a sufficient set of negative cookies for Eve, he can choose to disregard Eve's credentials, and not go through with her proposed transaction.

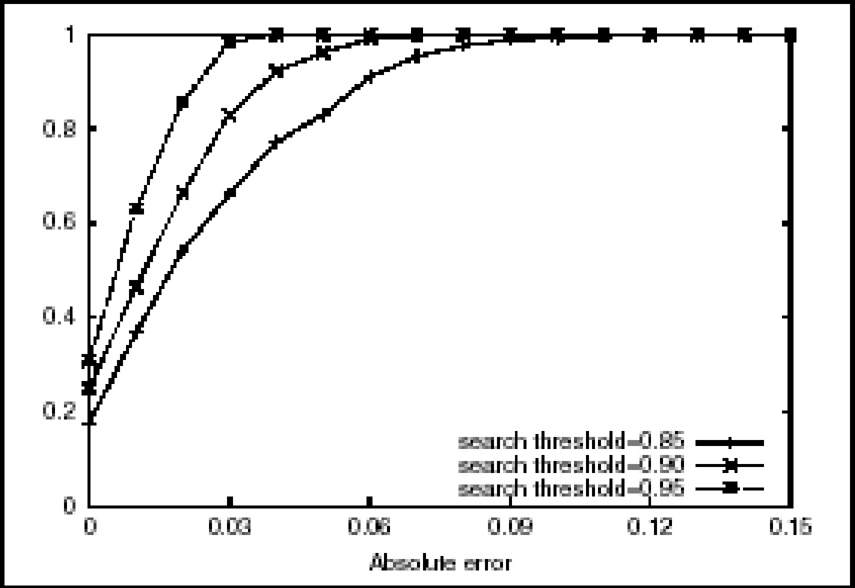
Simulations

- We simulate a stable system consisting of *only* good users.
- we assume that all users implement the entire search protocol correctly.
- Each query starts at a node *s* chosen uniformly at random and specifies a search for cookies of another node *t* chosen uniformly at random.



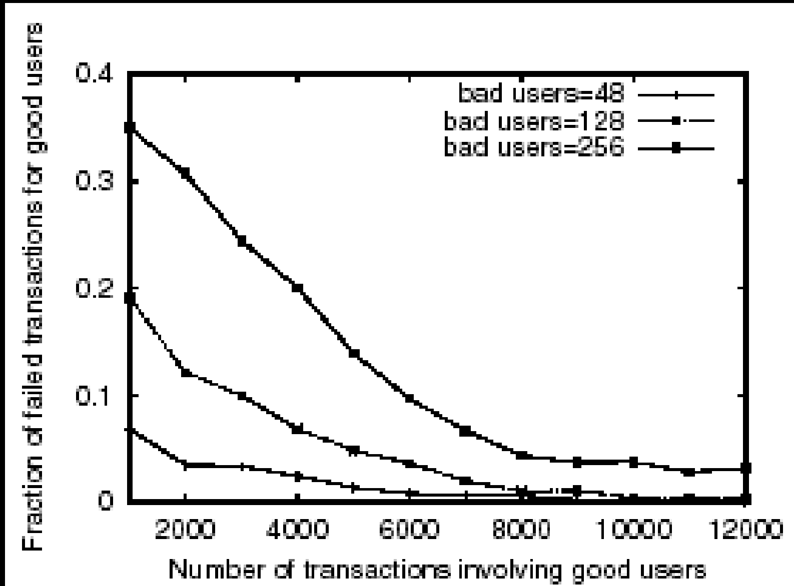
Simulations

- The higher threshold searches have a less possible absolute margin of error, and thus produce the best paths.
- However, very high threshold searches are also more likely to produce no results.



Simulations

- The number of failed transactions are proportional to the number of bad users in the system.
- Bad nodes rapidly fill the preference lists of good nodes, but are quickly identified as malicious.



Conclusions

- A low overhead trust information storage and search algorithm is used in the NICE system to implement a range of trust inference algorithms.
- We have presented a scalability study of our algorithms, and have shown that our technique is robust against a variety of attacks by malicious users.

Comment

- Cache
- QoS
- Routing