Trusted Grid Computing
with Security Assurance and Resource Optimization

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Presentation Outline

- Motivations
- Fuzzy Logic based Trust Integration
- The SeGO Scheduler for Resource Optimization - (Secure Grid Outsourcing)
- Grid Performance with Trust Integration
- Lessons Learned and Future Research

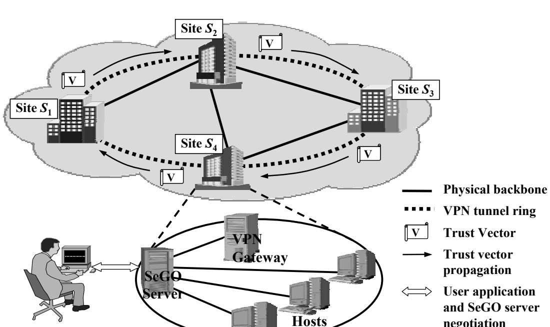
Motivations

- Grid applications demand not only resources, but trusted resources to avoid application disasters in an open Grid environment
- Benefiting many security-sensitive Grid applications:
  - Scientific explorations, health-care
  - Public safety, cyberspace crime control, homeland security
  - Digital Government, distance education, social community, national services
  - Grids for Business, enterprises, and e-commerce

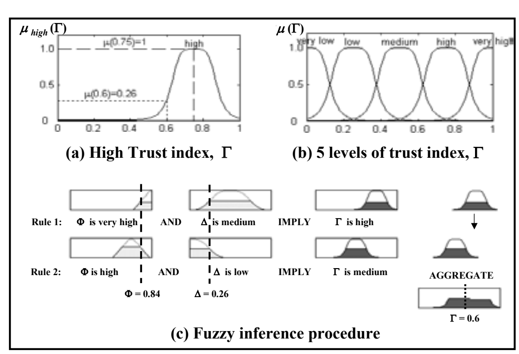
Trusted Grid Computing Requirements

- Trusted resource allocation, sharing, and scheduling
- Secure communications among Grid sites, clusters, and protected download operations among peer machines
- Intrusion resistance, attack repelling, etc
- Fortification hardware/software (firewalls, packet filters, VPN gateways, traffic monitors, etc.)
- Self-defense toolkits/middleware (Distributed IDSs, risk assessment, response automation)

Trust Integration over VPN Ring



Fuzzy Logic for Trust Integration



(a) High Trust index, Γ (b) 5 levels of trust index, Γ

(c) Fuzzy inference procedure

Questions? Contact with Shanshan Song at shanshas@usc.edu

A Trust Integration Example

Eq. 1 $t_{ij}^{new} = \alpha t_{ij}^{old} + (1-\alpha)s_{ij}$

Eq. 2 $\Delta(S_j) = \Delta(S_j) + \varepsilon(\Delta)$

Eq. 3 $V_j^{new} = \frac{m-1}{m} V_j^{old} + \frac{1}{m} V_i$

$$\begin{pmatrix} 0.3 & 0.2 & 0.3 & 0.4 \\ 0.5 & 0.4 & 0.5 & 0.5 \\ 0.7 & 0.7 & 0.6 & 0.7 \\ 0.8 & 0.8 & 0.9 & 0.8 \end{pmatrix}$$

(a) Initial trust matrix

$$\begin{pmatrix} 0.3 & \mathbf{0.2} & 0.3 & 0.4 \\ 0.5 & \mathbf{0.4} & 0.5 & 0.5 \\ 0.7 & \mathbf{0.8} & 0.6 & 0.7 \\ 0.8 & \mathbf{0.9} & 0.9 & 0.8 \end{pmatrix}$$

(b) Update V_2 at column 2 using Eqs. 1 and 2

$$\begin{pmatrix} \mathbf{0.4} & \mathbf{0.3} & \mathbf{0.4} & \mathbf{0.5} \\ \mathbf{0.6} & \mathbf{0.5} & \mathbf{0.6} & \mathbf{0.6} \\ 0.7 & 0.8 & 0.6 & 0.7 \\ 0.8 & 0.9 & 0.9 & 0.8 \end{pmatrix}$$

(c) Enhance $\Delta(S_1)$ and $\Delta(S_2)$ at rows 1 and 2 using Eq.3

$$\begin{pmatrix} 0.4 & 0.3 & 0.4 & \mathbf{0.5} \\ 0.6 & 0.5 & 0.6 & \mathbf{0.5} \\ 0.7 & 0.8 & 0.6 & \mathbf{0.6} \\ 0.8 & 0.9 & 0.9 & \mathbf{0.8} \end{pmatrix}$$

(d) Update V_4 at column 4 using Eqs.1 and 2

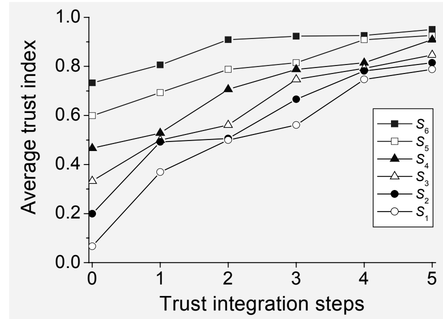
$$\begin{pmatrix} \mathbf{0.5} & \mathbf{0.4} & \mathbf{0.5} & \mathbf{0.6} \\ \mathbf{0.6} & \mathbf{0.6} & \mathbf{0.6} & \mathbf{0.6} \\ \mathbf{0.7} & \mathbf{0.8} & \mathbf{0.7} & \mathbf{0.7} \\ 0.8 & 0.9 & 0.9 & 0.8 \end{pmatrix}$$

(e) Enhance $\Delta(S_1)$, $\Delta(S_2)$ and $\Delta(S_3)$ at first 3 rows using Eq.3

$$\begin{pmatrix} \mathbf{0.6} & \mathbf{0.6} & \mathbf{0.6} & \mathbf{0.6} \\ \mathbf{0.7} & \mathbf{0.7} & \mathbf{0.7} & \mathbf{0.7} \\ \mathbf{0.8} & \mathbf{0.8} & \mathbf{0.8} & \mathbf{0.8} \\ \mathbf{0.9} & \mathbf{1.0} & \mathbf{1.0} & \mathbf{0.9} \end{pmatrix}$$

(f) Enhanced matrix after update all trust vectors

Effects of Trust Integration



Trusted Resource Allocation

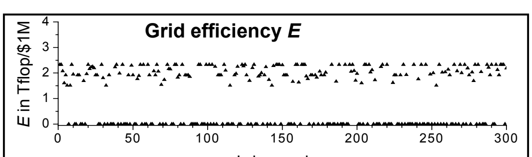
- Based on the fuzzy trust model, a *Secure Grid Outsourcing* (*SeGO*) scheduler was developed for Grid resource allocation:
  - $S_i = (P_i, V_i, C_i)$, representing the *computing power*, *trust vector*, and *unit service cost*.
  - *Job* = (*W*, *D*, *T*, *B*), representing the *workload*, *execution deadline*, *minimum trust requirement*, and *budget limit*.
- The optimization process is modeled as a nonlinear programming problem, with the objective to maximize the *Grid Efficiency*:

$$E = \sum_{i=1}^{m} W_i t_{ij} \Big/ \sum_{i=1}^{m} W_i C_i = \sum_{i=1}^{m} x_i P_i L t_{ij} \Big/ \sum_{i=1}^{m} x_i P_i L C_i$$

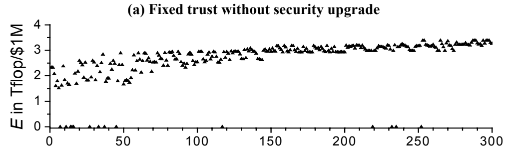
Performance Evaluation

- In a computational Grid environment, we execute mainly coarse-grain supercomputing applications.
- The performance of the SeGO scheme was evaluated by a discrete event-driven Grid simulator developed at USC to model the trust integration and the resource optimization processes.
- We use typical workload parameters measured at USC Center for High Performance Computing and Communications. Both user jobs and resource parameters are configured to reflect real-world situations.

Trust Integration Performance Gain



(a) Fixed trust without security upgrade



(b) Integrated trust with security enhancement

Job Drop Rate and Average Waiting Time

---- 300 Jobs for Parallel Execution on 6 Grid Sites

Job Number	Number of dropped jobs		Average waiting time in minutes	
	Fixed Trust	Trust Integration	Fixed Trust	Trust integration
1 - 50	20	9	28.33	16.05
51 - 100	22	0	30.67	3.87
101-150	19	1	27.90	2.51
151-200	21	0	35.33	1.00
201-250	28	3	34.11	3.31
251-300	20	1	20.86	1.82

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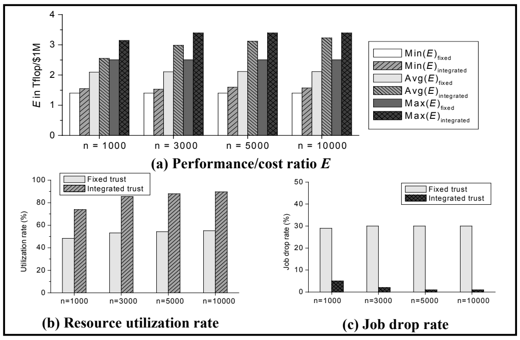
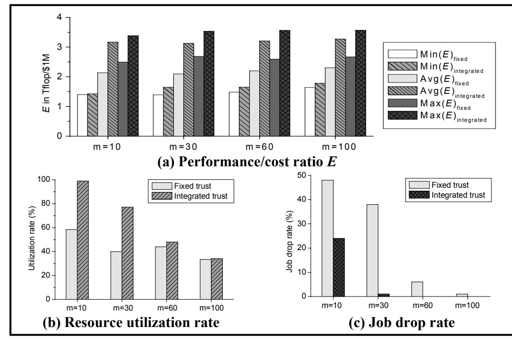
Scaling Effects of Job Number (n)

---- n = 1000, …, 10000 Jobs for Parallel Execution on 20 Grid Sites



Scaling Effects of Grid Size (m)

---- 5000 Jobs Parallel Execution on m = 10, 30, 60, 100 sites



Conclusions

- Fuzzy trust integration reduces platform vulnerability: our fuzzy trust integration guides the defense deployment across distributed Grid sites. This lays the foundation of distributed security enforcement in Grids.
- Trusted Grid resource allocation and configuration: the SeGO scheduler can be applied to upgrade the AppLeS and NimRod/G schedulers in security reinforcement.
- Our work will benefit many Grid applications in scientific explorations, health-care, public safety, national security, digital government, etc.

Further Research Challenges

- Currently, a simulator is implemented to validate the proposed fuzzy trust integration process and to obtain some simulated performance results.
- Real-life Grid applications will be tested on a real Grid test bed scattered at USC, ISI, and several Grid sites contributed by our international collaborators in China, France, and Australia.
- A production SeGO scheduler will be converted from the simulator using fuzzy trust integration.

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