

Trusted Grid Computing with Security Assurance and Resource Optimization

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Presented by S. Song at PDCS-2004
San Francisco, September 15, 2004

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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

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Motivations

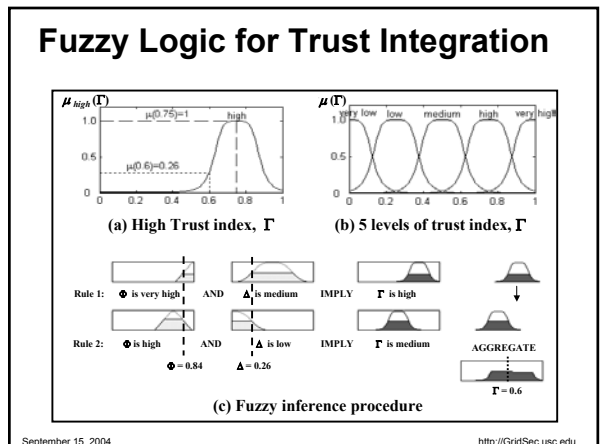
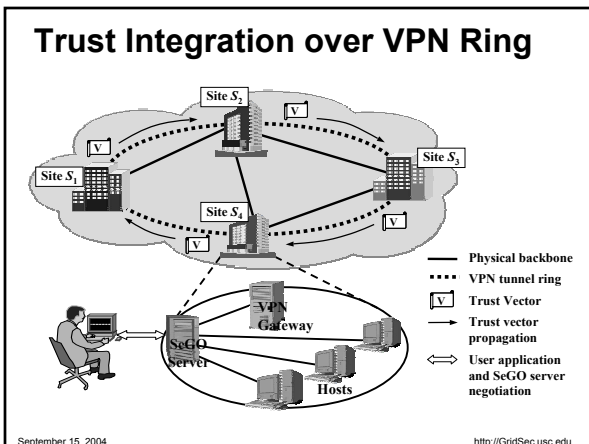
- Grid applications demand not only resources, but trusted resources to avoid application disasters in an open Grid environment
- Benefiting many security-sensitive Grid applications:
 - Scientific explorations, health-care
 - Public safety, cyberspace crime control, homeland security
 - Digital Government,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

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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)

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A Trust Integration Example

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

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

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

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

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

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

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

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

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

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

(e) Enhance $\Delta(S_3)$, $\Delta(S_2)$ and $\Delta(S_4)$ at first 3 rows using Eq.3

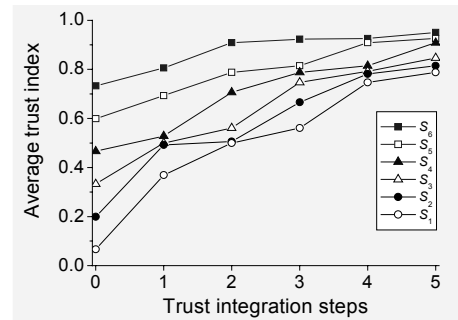
$$\begin{pmatrix} 0.6 & 0.6 & 0.6 & 0.6 \\ 0.7 & 0.7 & 0.7 & 0.7 \\ 0.8 & 0.8 & 0.8 & 0.8 \\ 0.9 & 1.0 & 1.0 & 0.9 \end{pmatrix}$$

(f) Enhanced matrix after update all trust vectors

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Effects of Trust Integration



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Trusted Resource Allocation

- Based on the fuzzy trust model, a *Secure Grid Outsourcing (SeGO)* scheduler was developed for Grid resource allocation:
 - $S_j = (P_j, V_j, C_j)$, 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*:

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

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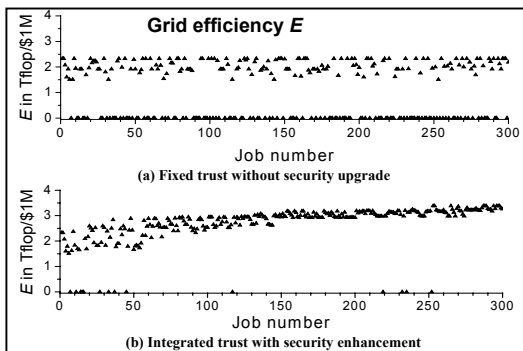
Performance Evaluation

- 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.

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Trust Integration Performance Gain



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Job Drop Rate and Average Waiting Time

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

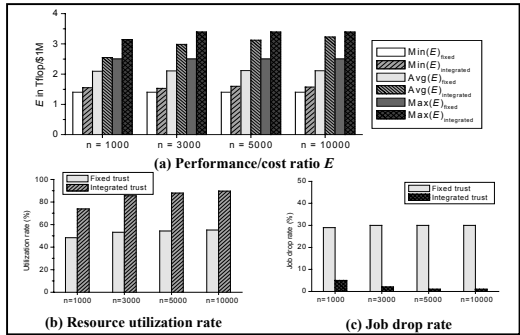
Job Number	Number of dropped jobs		Average waiting time in minutes	
	Fixed Trust	Trust Integration	Fixed Trust	Trust integration
1 - 50	20	9	28.33	16.05
51 - 100	22	0	30.67	3.87
101-150	19	1	27.90	2.51
151-200	21	0	35.33	1.00
201-250	28	3	34.11	3.31
251-300	20	1	20.86	1.82

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Scaling Effects of Job Number (n)

---- $n = 1000, \dots, 10000$ Jobs for Parallel Execution on 20 Grid Sites

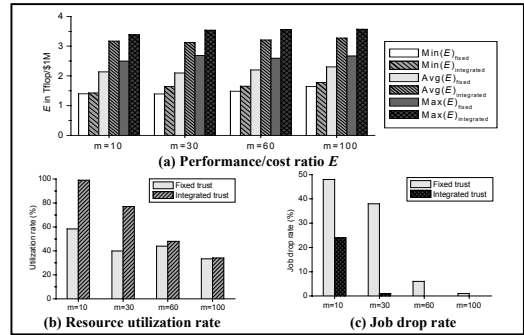


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Scaling Effects of Grid Size (m)

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



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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.

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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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