Accurate Autonomous Accounting in Peer-to-Peer Grids

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INTRODUCTION

Peer-to-peer grids

- Coordinate resources to execute resource-intensive applications
- Usually peers represent institutions with computational resources and can freely join the grid (no trust)
- Peers are both providers and consumers
  - occasionally need more computing power than they have
  - may also donate their idle resources to other peers

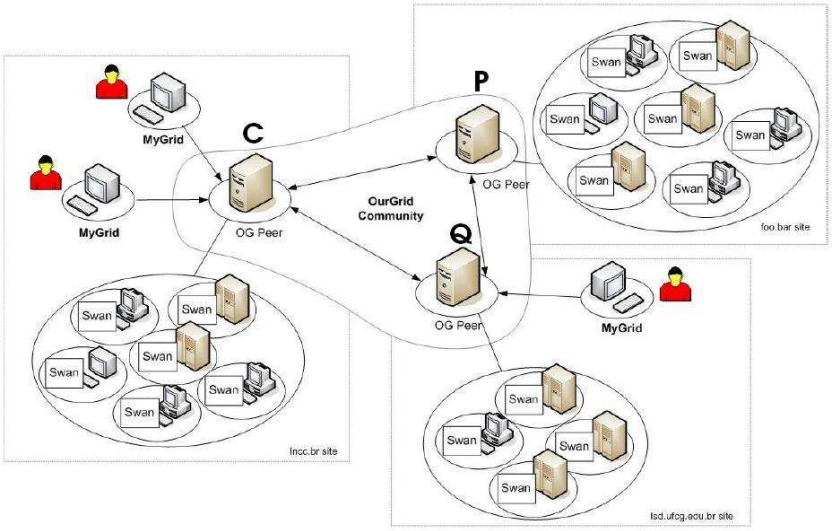
3

Peer-to-peer grids

- Non-zero cost for donating and no incentive leads to free-riders
  - solution: incentive mechanisms like the Network of Favors
    - reward best contributors
- Network of Favors:
  - each peer holds a ranking (balance of provided and consumed resource allocations)
  - depends on an accurate accounting mechanism

4

The OurGrid: a P2P grid



5

P2P grids: user's viewpoint

- User application is called a job and is comprised of tasks
  - task is a part of the application that can run in parallel
- Peers use both local and remote resources to execute local users' jobs
- Local users are prioritized
  - local jobs kill remote jobs

6

Agenda

- Issues related to accounting mechanisms in P2P grids
- Perfect and time-based accounting mechanisms
- Our relative accounting mechanism
- Performance evaluation
- Conclusions and future work

7

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ISSUES RELATED TO ACCOUNTING MECHANISMS IN PEER-TO-PEER GRIDS

8

Accurate Accounting Issue

- *P* wants to account its favors to peer *C*
  - to control resource usage (reward peers)
  - to charge for resource usage (money)
- Accuracy leads to fairness of the incentive mechanism
- How can peer *P* accurately account?
  - number of flops (vary with architecture)
  - CPU time (doesn't account amount of work)
  - benchmarks (application-specific)

9

Feasible Accounting Issue

- Peer-to-peer grids
  - peers can freely join the system
  - consumers have no control over providers' resources
- Should peer *C* trust peer *P*'s accounting?
  - human negotiation (doesn't scale)
  - auditing systems (complex deployment)
  - resource meter agents (trust issue)

10

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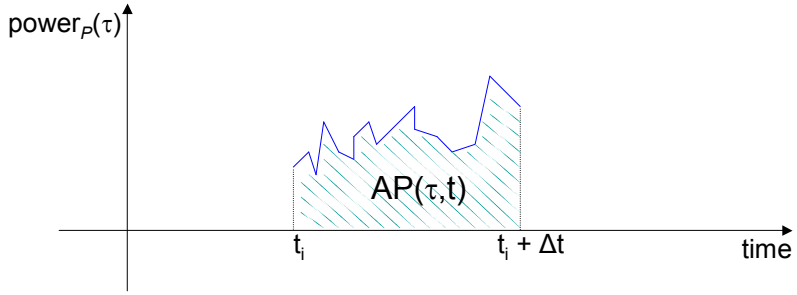
PERFECT AND TIME-BASED ACCOUNTING MECHANISMS

Perfect Accounting Mechanism

- For each task τ:



easily calculated

$$AP(\tau,P) = \int_{t_i}^{t_i+\Delta t} power_P(\tau,t)dt$$

difficult to estimate

Perfect Accounting Mechanism

- Totally accurate
- Very hard to deploy (if feasible)
  - hard to calculate the real power the resource delivers to the execution of a task
  - the consumer cannot trust the $power_P(\tau,t)$ informed by the provider of *P*

13

Time-based Accounting Mechanism

- Simple approximation
  - assumes all computing resources deliver the same power at any given time for any task

$$AT(\tau, p) = \Delta t$$

- Feasible
- Not accurate
  - does not take into account the amount of work done by the resource

14

We've seen...

- Introduction to peer-to-peer grids
  - a peer is both a provider and a consumer
  - incentive mechanism
- Some accounting mechanisms' issues
  - accuracy
  - feasibility
- Two accounting mechanisms
  - perfect (accurate, but not feasible)
  - time-based (feasible, but not accurate)

15

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OUR RELATIVE ACCOUNTING MECHANISM

16

Accurate and Feasible Mechanism

- Accounting by peer
- Assumption
  - peers use both local and remote resources to accomplish tasks
- Relative power between peers:

$$rpower_B(A) = \frac{mean\{exectime(\tau_B B)\}}{mean\{exectime(\tau_B A)\}}$$

local execution

remote execution

- Note that $rpower_A(A) = 1$

17

Accurate and Feasible Mechanism

- Accounting per task perceived by provider A:

$$AR_A(\tau, B, A) = \Delta t \times rpower_A(A)$$

- Accounting per task perceived by consumer B:

$$AR_B(\tau, B, A) = \Delta t \times rpower_B(A)$$

18

Accurate and Feasible Mechanism

- Advantages
  - no negotiation or complex deployment (scalable)
  - no exchange of information among peers (autonomous)
- Disadvantages
  - based on mean execution times of tasks
    - heterogeneity in the size of tasks or few local resources may introduce errors

19

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PERFORMANCE EVALUATION

20

Performance Evaluation

- Event-based simulator for P2P grid
- 3 accounting mechanisms (perfect, relative, time)
- 3 scenarios
  - most common (heterogeneous resources and tasks)
  - disadvantageous (heterogeneous tasks)
  - accounting attack (half of the peers run 2 tasks per resource simultaneously)
- 2 metrics
  - response time (end time – submission time)
  - favor ratio: $fr(A) = \frac{resourcesConsumed(A)}{resourcesDonated(A)}$
- 280 instances (confidence level: 95%)

21

Scenario 1: Common Case

- 5 peers: mean resource power U(2,6)
- 5 peers: mean resource power U(5,15)
- 5 peers: mean resource power U(8,24)
- Sum of resource powers in each peer: 250
- 1,000 jobs with 250 tasks of size U(200,600)
- Inter-arrival time of jobs: U(1,799)

22

Scenario 1: Common Case

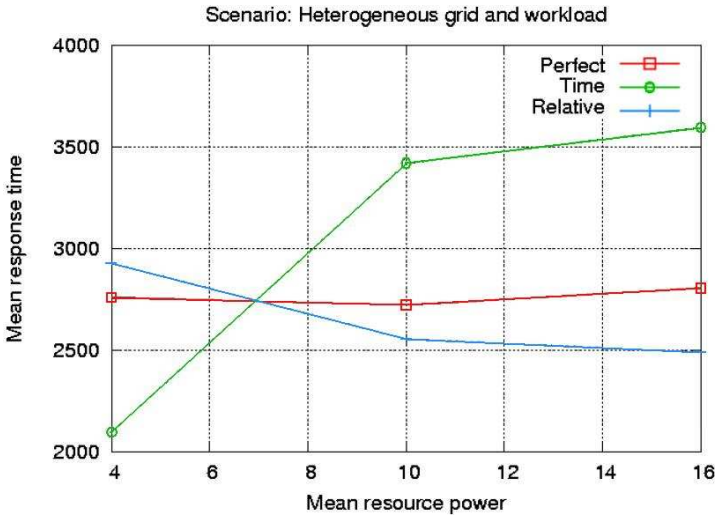

Figure 1. Power vs. mean response time for scenario 1

23

Scenario 1: Common Case

Table 1. Favor ratio (*fr*) for peers in scenario 1

	Mean *fr* (Std Deviation of *fr*)		
	Power 4	**Power 10**	**Power 16**
Perfect	0.908 (0.114)	0.981 (0.099)	0.994 (0.101)
Relative	0.872 (0.122)	0.995 (0.079)	1.020 (0.075)
Time	1.051 (0.084)	0.866 (0.095)	0.830 (0.100)

24

Scenario 1: Common Case

- Conclusions
  - time-based accounting encourages peers to donate slower resources
  - relative accounting performs well in the most common scenario

25

Scenario 2: Disadvantageous Case

- 15 peers with 25 resources of power 10
- 1,000 jobs with 250 tasks of size varying according to an exponential distribution with mean 400
- Inter-arrival time of jobs: U(1,799)
- Large variation in the size of tasks
- Homogeneous grid

26

Scenario 2: Disadvantageous Case

Table 2. Response time and favor ratio for peers in scenario 2

	Mean (Std Deviation)	
	Response Time	**Favor Ratio**
Perfect	2,921.6 (2,783.6)	0.9524 (0.125)
Relative	2,951.2 (2,879.4)	0.9193 (0.175)
Time	2,922.1 (2,782.6)	0.9523 (0.125)

27

Scenario 2: Disadvantageous Case

- Conclusions
  - relative accounting makes the incentive mechanism less fair when there is heterogeneity in the size of tasks
  - standard deviation of the favor ratio is only 40% worse for the relative accounting

28

Scenario 3: Accounting Attack

- 10 peers with 25 resources of mean power U(4,16) (named faster)
- 10 peers with 50 resources of mean power U(2,8) (named slower)
- 1,000 jobs with 250 tasks of size U(200,600)
- Inter-arrival time of jobs: U(1,799)
- Half of the peers pretend to have twice the actual number of resources

29

Scenario 3: Accounting Attack

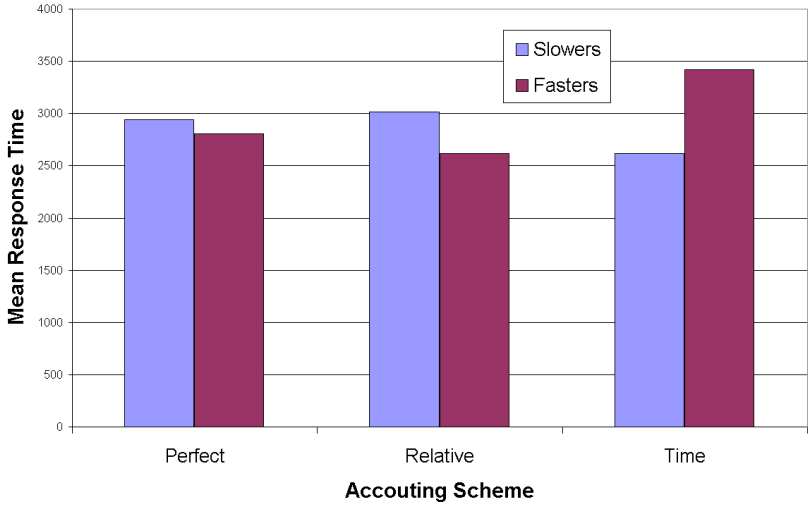

Figure 2. Mean response time for setting 3

30

Scenario 3: Accounting Attack

Table 3. Mean favor ratio (*fr*) for peers in scenario 3

	Mean *fr* (Std Deviation of *fr*)		
	Slower Peers	**Faster Peers**	**All Peers**
Perfect	0.931 (0.122)	0.976 (0.111)	0.953 (0.119)
Relative	0.911 (0.132)	0.989 (0.107)	0.950 (0.126)
Time	1.003 (0.117)	0.833 (0.117)	0.918 (0.145)

31

Scenario 3: Accounting Attack

- Conclusions
  - relative accounting gives incentive for peers to donate faster resources
  - relative accounting is less vulnerable to accounting attacks than the time-based

32

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CONCLUSIONS AND FUTURE WORK

33

Conclusions

- Perfect mechanism is very hard to be implemented
  - no trust between consumer and provider
  - consumers have no control over providers' resources
- Time-based mechanism is vulnerable to accounting attacks and biased towards slower peers
- Relative mechanism is simple to be deployed and performs close to the perfect mechanism

34

Future Work

- Evaluate the relative accounting performance in a real system like the OurGrid
- Consider data transfers and network links for the relative accounting evaluation

35

Thank you all!

Questions? Suggestions?

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36