Java, Peer-to-Peer, and Accountability: Building Blocks for Distributed Cycle Sharing

Ali Raza Butt

Xing Fang

Y. Charlie Hu

Samuel Midkiff

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The need for sharing compute-cycles

- Scientific applications
  - Complex, large data sets
- Dedicated resources
  - Expensive
- Modern workstation
  - Powerful resource
  - Available in large numbers
  - Underutilized

➔Harness idle-cycles of network of workstations

Current cycle-sharing schemes

- Examples: SETI@Home, Distributed.net, Entropia
- Use centralized application servers
  - Performance bottleneck
  - Single point of failure
- Applications are explicitly trusted
  - Introduce a plethora of security problems
- Users contribute compute-cycles
  - Individuals cannot utilize the shared cycles

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Cycles-sharing for All!

- Goal: all participants can utilize the system

Challenges:

- Resource discovery and management
- Portability
- Safety
- Security
- Fairness

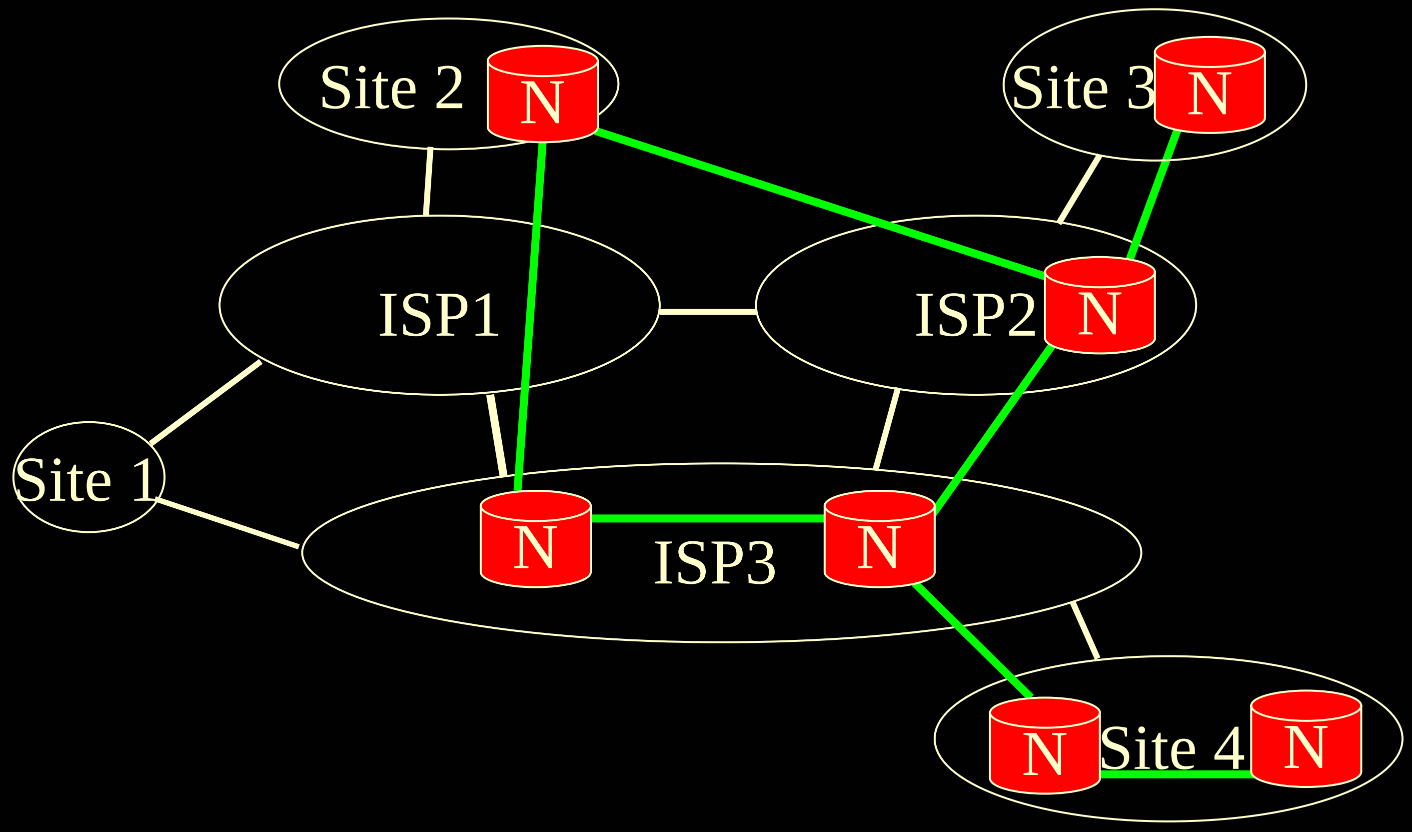
Our solution:

- Exploit existing peer-to-peer networking
- Leverage Java Virtual Machine Sandboxing
- Add the ability to remotely monitor Java program progress
- Develop distributed credit based accountability

Agenda

- Background
- Discovering resources
- Ensuring fairness
- Design & Implementation
- Evaluation
- Conclusions

Background: Overlay Networks



P2P networks are self-organizing overlay networks without central control

Background: structured p2p overlays

- Overlays with imposed structure
  - Each node has a unique random `nodeId`
  - Each message has a key
  - The `nodeId` and key reside in the same name space
- Routing: Takes a message with a key and sends it to a unique node
- Implements Distributed Hash Table (DHT) abstraction
- DHT abstraction is preserved in the presence of node failure/departure

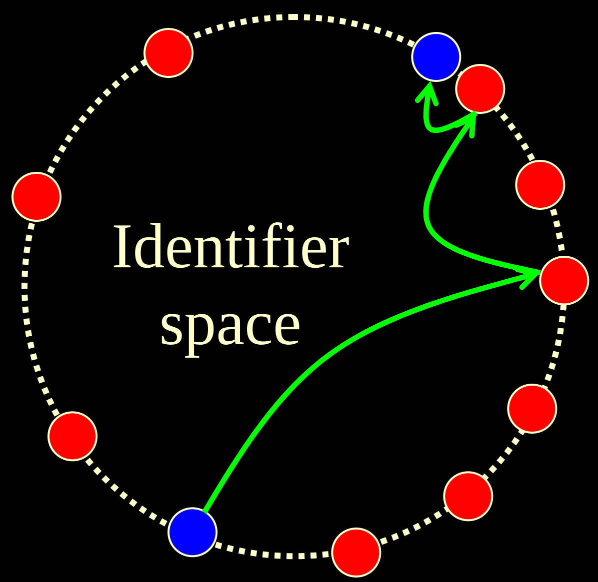
Properties of structured p2p networks

- Scalable
- Self-organizing
- Fault-tolerant
- Locality-aware
- Simple to deploy

- Many implementations available
  - E.g. Pastry, Tapestry, Chord, CAN…

Example: Pastry

- 128-bit circular identifier space
- Routing: A message is routed reliably to a node with `nodeId` numerically closest to the key
- Locality-aware
  - Routing table has *O(log N)* entries matching increasingly long prefix of local `nodeId`



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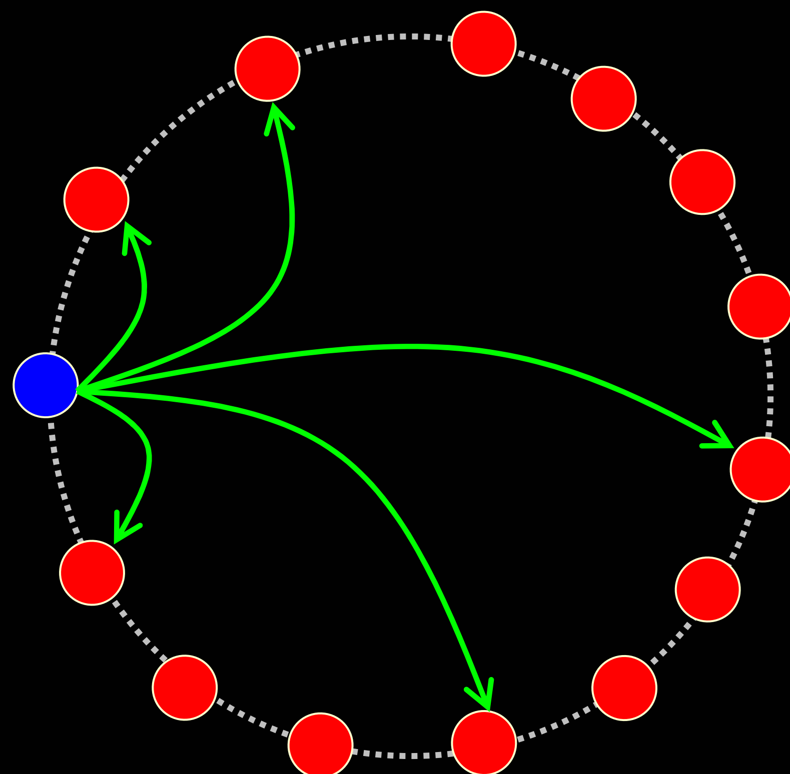
Resource availability information

- Announcements to nearby nodes
  - Contain resource characteristics and availability information
  - Leverage locality-aware routing table
  - Soft state
    - Periodically refreshed

Resource announcements



are physically close to

Execution node selection

- Utilize local resource availability information
- Query nearby nodes for job execution
    - Proximity
    - Credit-worthiness
- Request remote execution

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Fairness in cycle-sharing

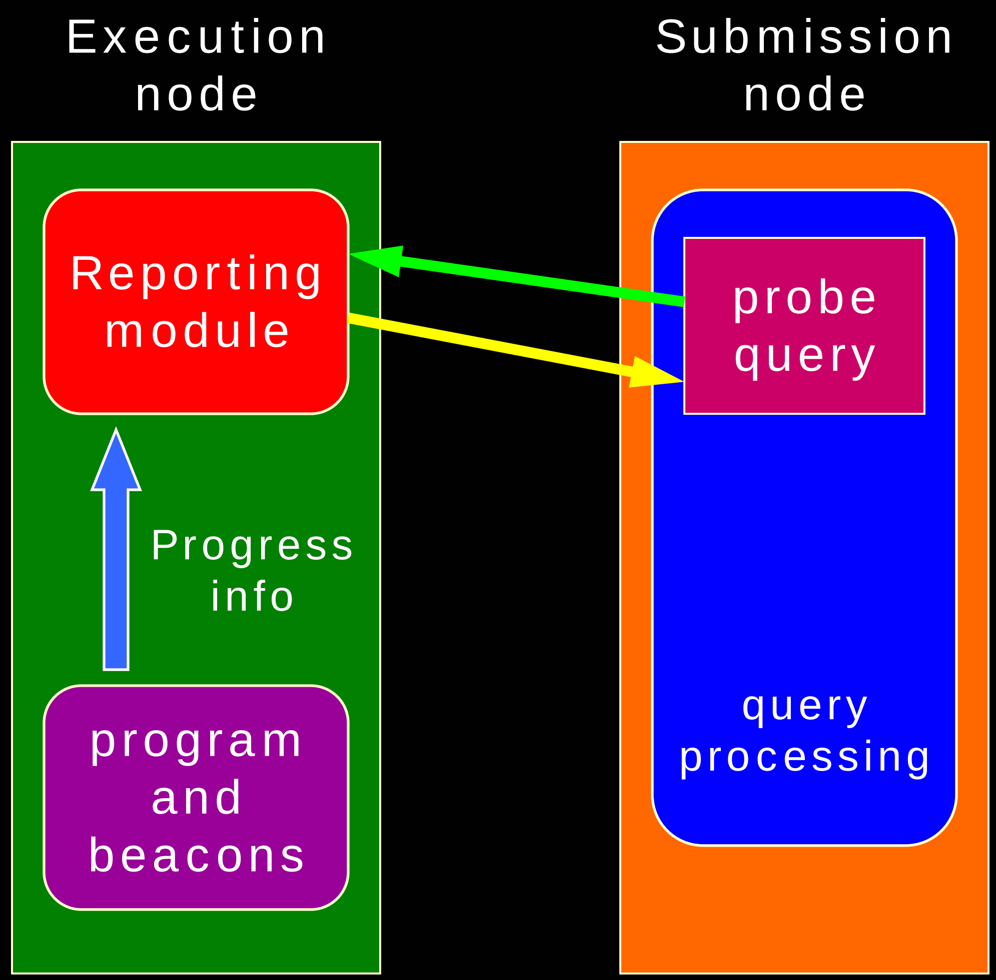
- More complex than fairness in storage sharing [Samsara: SOSP 2003]
  - Cycles are perishable resources
- Challenge
  - Mutual guarantees for submitting and contributing nodes
- Our Solution:
  - VM and compiler instrumented code for progress monitoring
  - DHT based feedback system to report unfair nodes
  - Assumption: nodes act in their own self-interest

Job progress monitoring

- System leverages existing *Instrumentation Sampling Framework*
- A thread periodically retrieves contents of Method Invocation Counters
- VM communicates progress (using *beacons*) asynchronously to the *Reporting Module*

Monitoring setup

- Reporting module
  - Provides submitter with job monitoring capability
  - Decouples design of beacons from that of query
  - Provides asynchronous job monitoring



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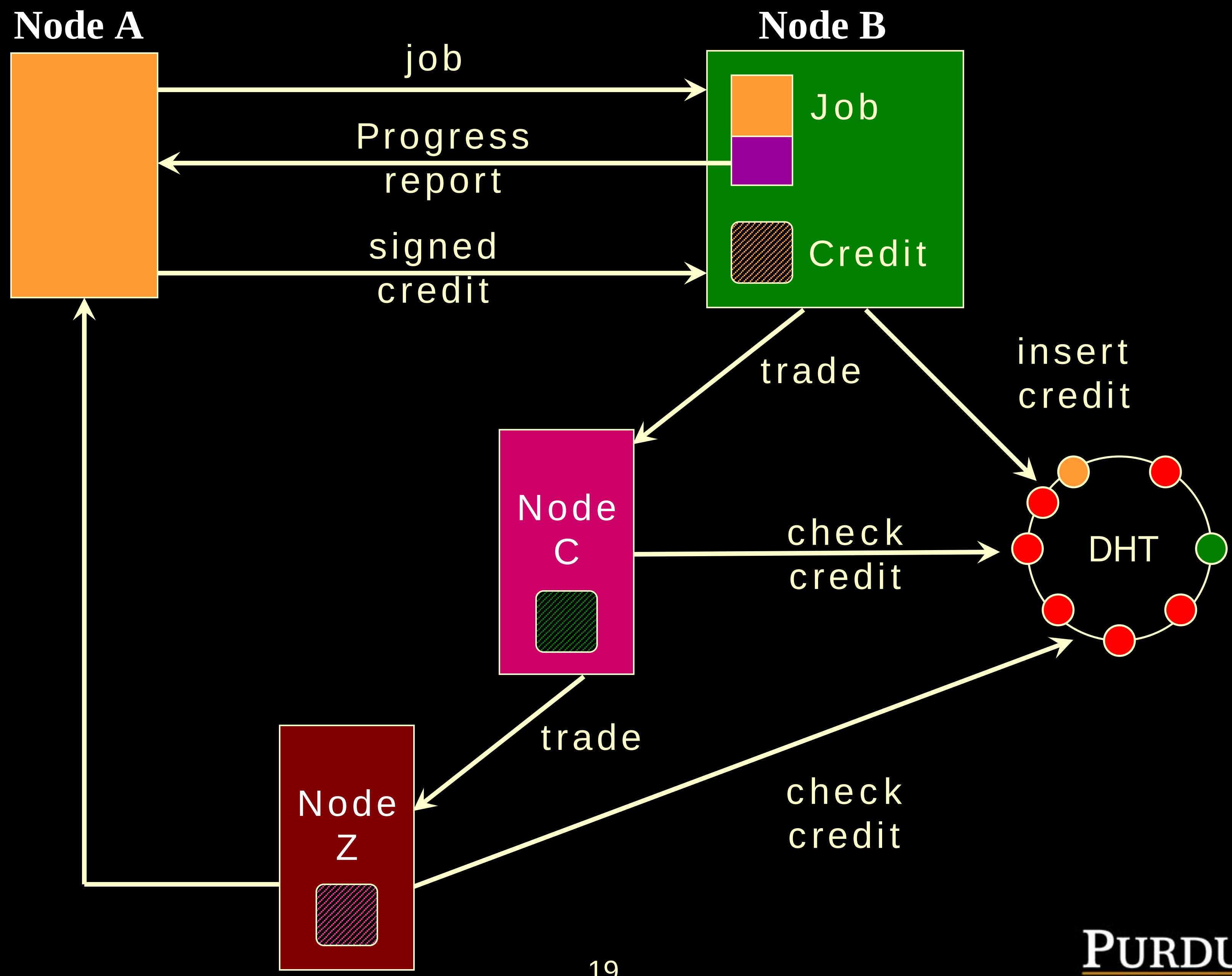
Distributed credit feedback system

- Ensure compensation for consumed cycles
- Tradable credit-reports
  - Digitally signed
  - Un-forgeable
- DHT based distributed credit tracking
  - Allows a node's transactions to be checked by other nodes
  - Allows determination of a node's credit-worthiness
- Credit-worthiness used to punish and reward nodes


Node A
Node B
job
Job
Progress
report
signed
credit
Credit
trade
insert
credit
Node
C
check
credit
DHT
trade
Node
Z
check
credit

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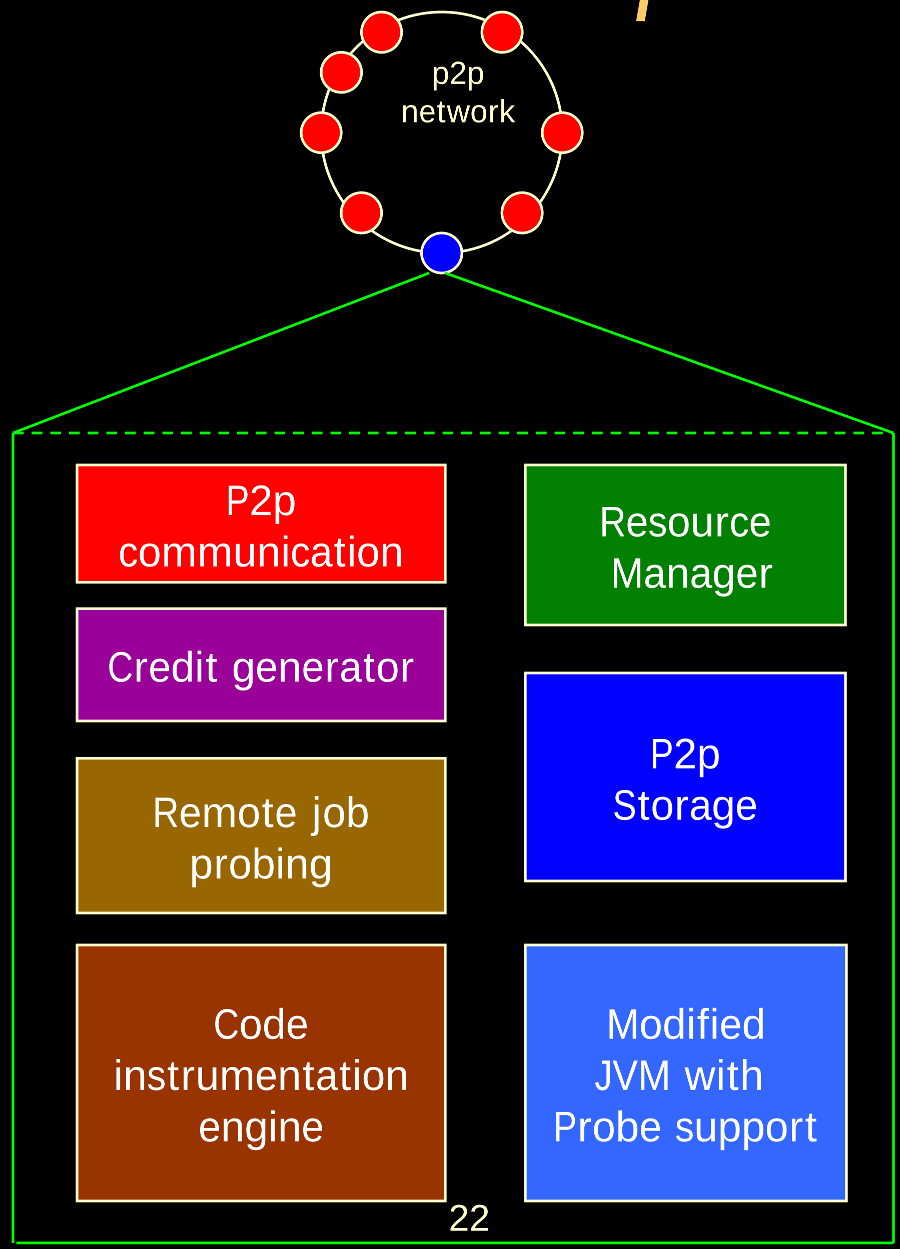
Implementation

- Prototype implementation:
  - P2p functionality using FreePastry 1.3
  - DHT feedback built on PAST
- Augmented Jikes RVM
  - Added new VM thread to use adaptive compiler information to monitor progress

Software modules



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Methodology

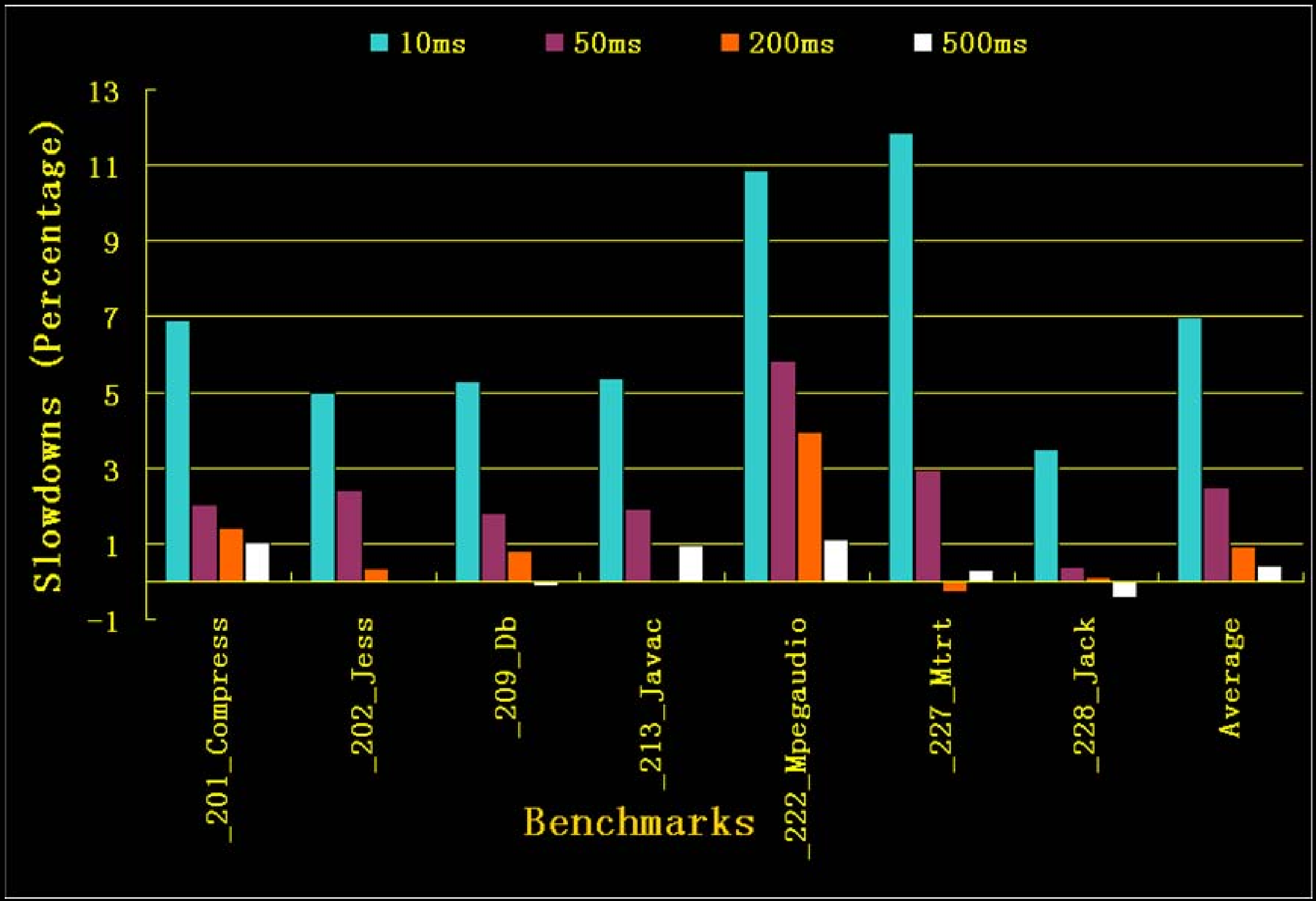
- Overhead measurement in a real implementation
  - Overhead of beacons
  - Overhead of reporting module

- Effectiveness of catching thieves in a large scale simulation

Implementation Setup

- Hardware
  - Pentium 4, 2 GHz, 512MB RAM
  - Linux kernel 2.4.18
  - Connected via 100 Mb/s Ethernet

Overhead of beacons



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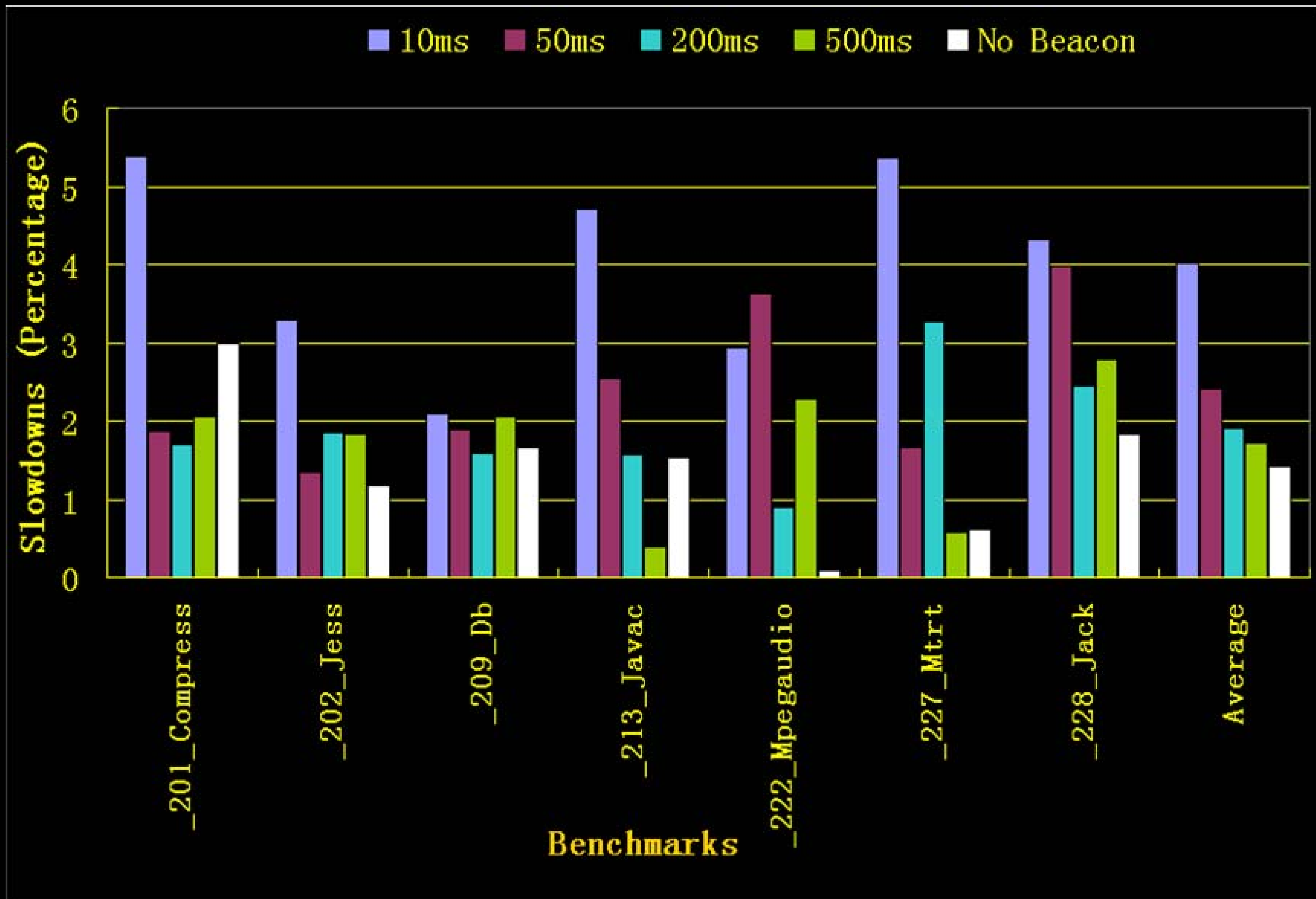
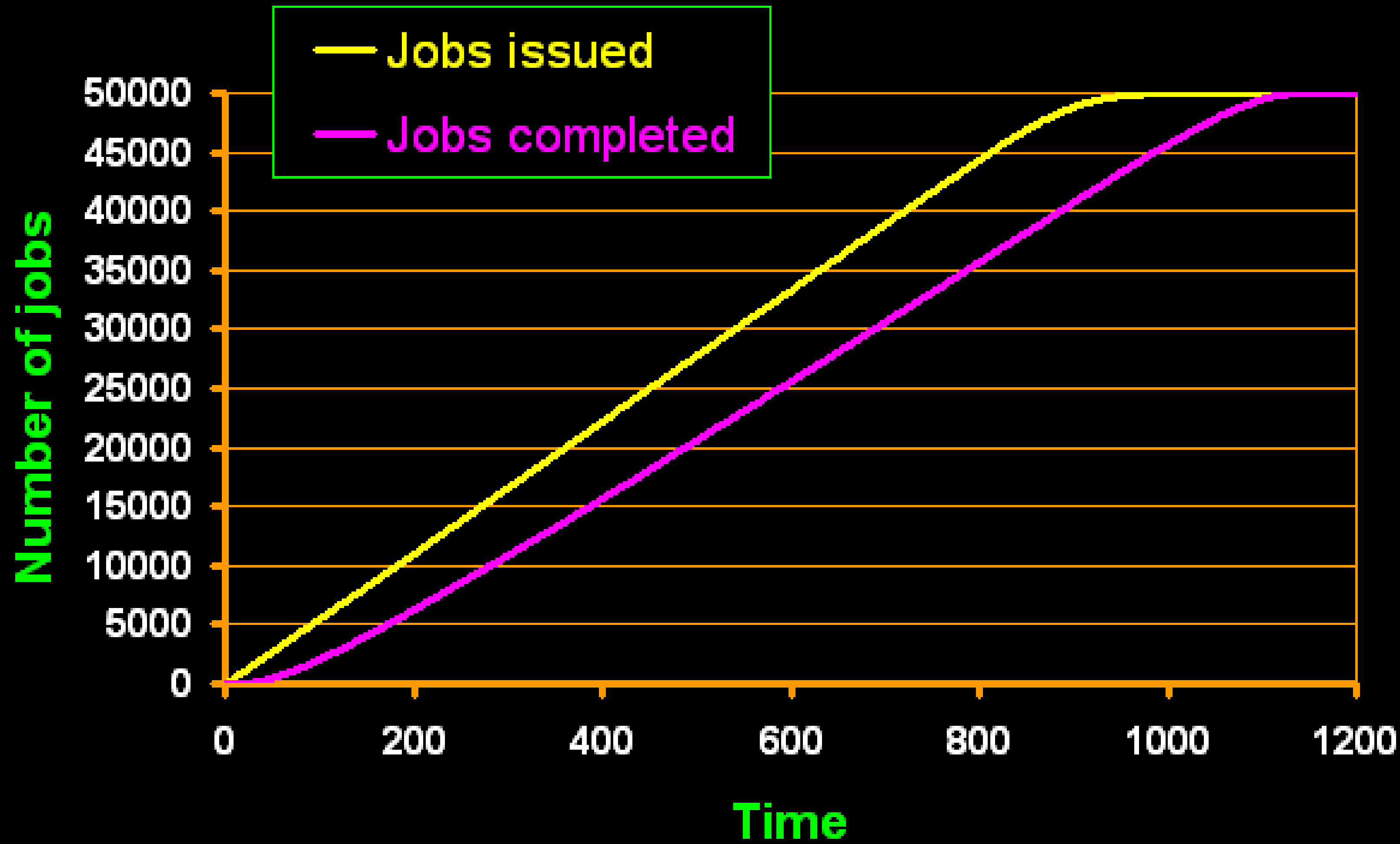
Overhead of the reporting module



Simulations

- 1000 Nodes setup
- Georgia Tech-Internet Topology Models (GT-ITM)
  - Transit-stub model
  - 100 transit domains
  - 10 stub domains
- Sequence
  - 100 (issue time: T, job length: L) pairs
  - Interval ($T_n – T_{n-1}$), L uniform distribution [1,17]
  - Random overload/idle periods

Jobs issued and completed: No cheaters



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Jobs issued and completed: cheaters

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Jobs issued and completed: cheaters caught

Evaluation conclusion

- The overhead of monitoring code is insignificant

- The accounting system effectively recognizes cheating nodes and restricts them

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Conclusions

- Building blocks for cycle-sharing
  - Peer-to-peer networks
  - Java based progress monitoring and security
  - Credit-based accountability mechanisms

- Ideal system for inter-organizational networks of pooled resources

Questions?