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An Evaluation of BitTorrent's Performance In HPC Environments

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Motivation

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- Need scalable system services in large HPC systems
  - Example services: file systems, job launch, system monitoring
  - Communication bottlenecks; performance degradation
- Can we use recent distributed systems techniques here?
  - E.G. Peer-to-peer services developed for Internet systems
  - Must scale to large systems with complex topologies and bottlenecks
  - Not designed for HPC use-cases, networks, etc.

An Example Problem

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- Dynamic Shared Libraries distribution on HPC platforms
  - Read-only data-transfer
  - Many simultaneous downloaders
  - Looks a lot like a peer-to-peer problem
- Can we use BitTorrent?

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DYNAMIC SHARED LIBRARIES

The Problem

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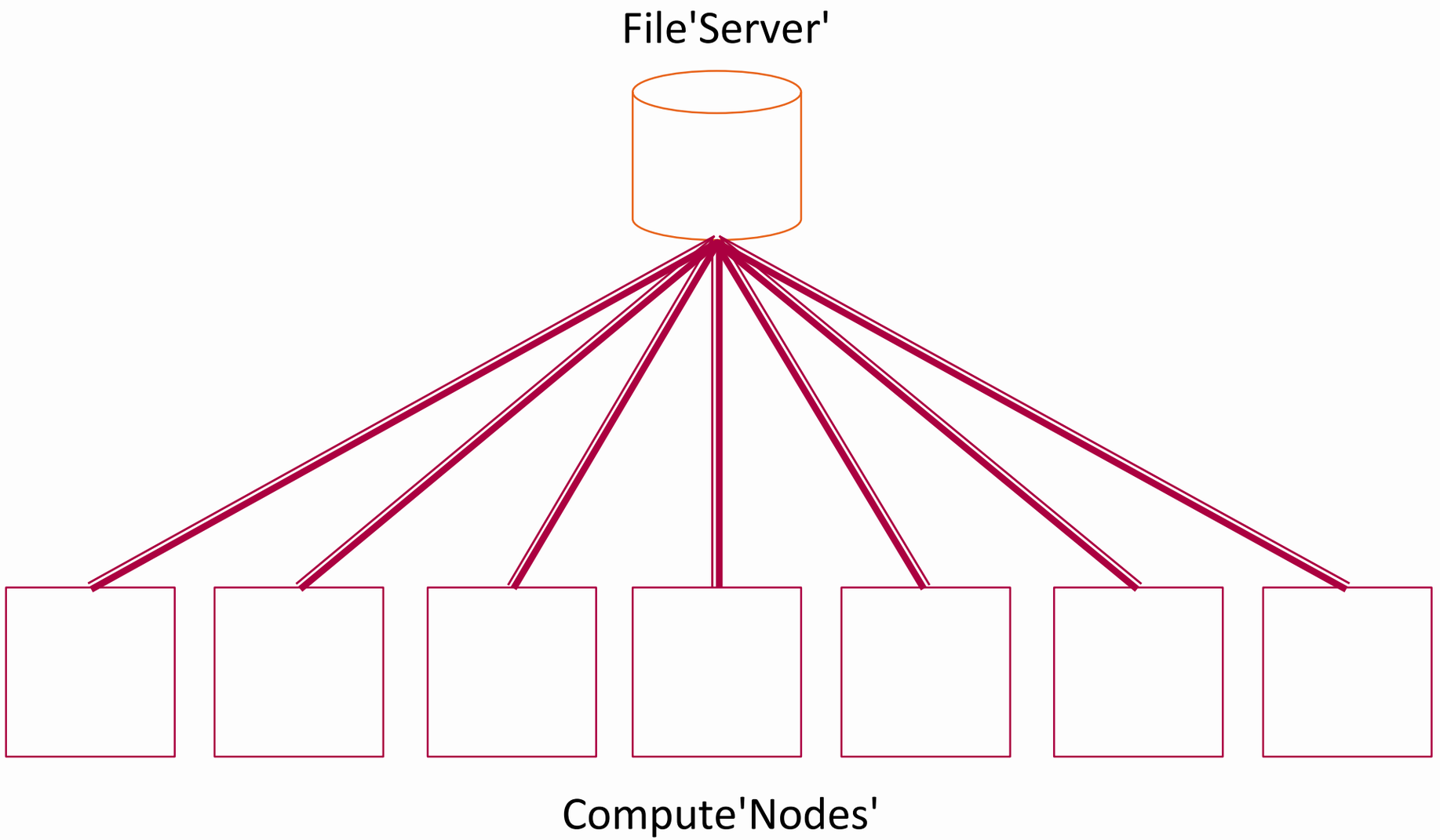
- Demand for Dynamic Shared Library support is increasing
- Two methods of use:
  - Linked at program launch
  - dlopen() during runtime

The Naïve Approach



Current Solutions

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- There are a number of current solutions to this problem
  - Cache nodes
  - Bulk pre-distribution
  - Tree-based overlay networks
- These solutions look like peer-to-peer networks
  - Can we use an off-the-shelf peer-to-peer technology?

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BITTORRENT

Why BitTorrent?

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- One of the more popular peer-to-peer protocols
- Open-source implementations
- Private networks
- Extensible protocol
  - Peer Exchange
  - Magnet Links

Preparation

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- Tracker
  - Daemon listens for incoming peers
  - Maintains a list of peers
- Description File
  - User specified file or directory
  - Splits file(s) into smaller pieces
  - Lists tracker information
- Initial Seeder
  - Starts with a full set of data
  - Registers with tracker

Starting a Client

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- Reads description file
- Connects to tracker
  - Registers as a peer
  - Gets a list of peers
- Connects to other peers

Data Distribution

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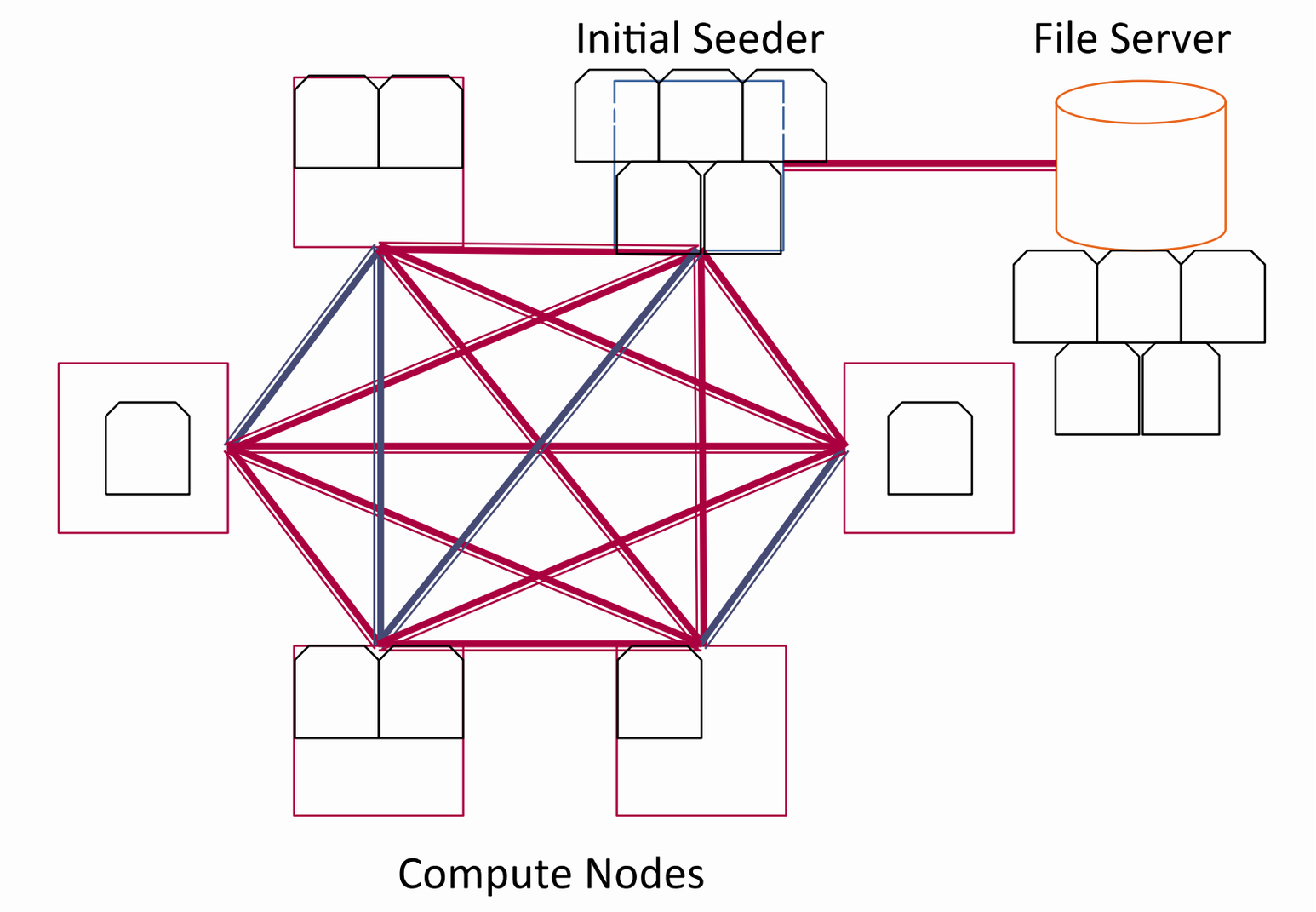
- Leechers
  - Keep a list of piece availability
  - Request pieces they don’t have
- Seeders and Leechers
  - Respond to requests
  - Distributes Data according to fairness algorithm
- Fairness algorithm
  - Leechers use Tit-for-tat
  - Seeders try to push complete copies

Data Distribution



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ARCHITECTURE

Added Actions

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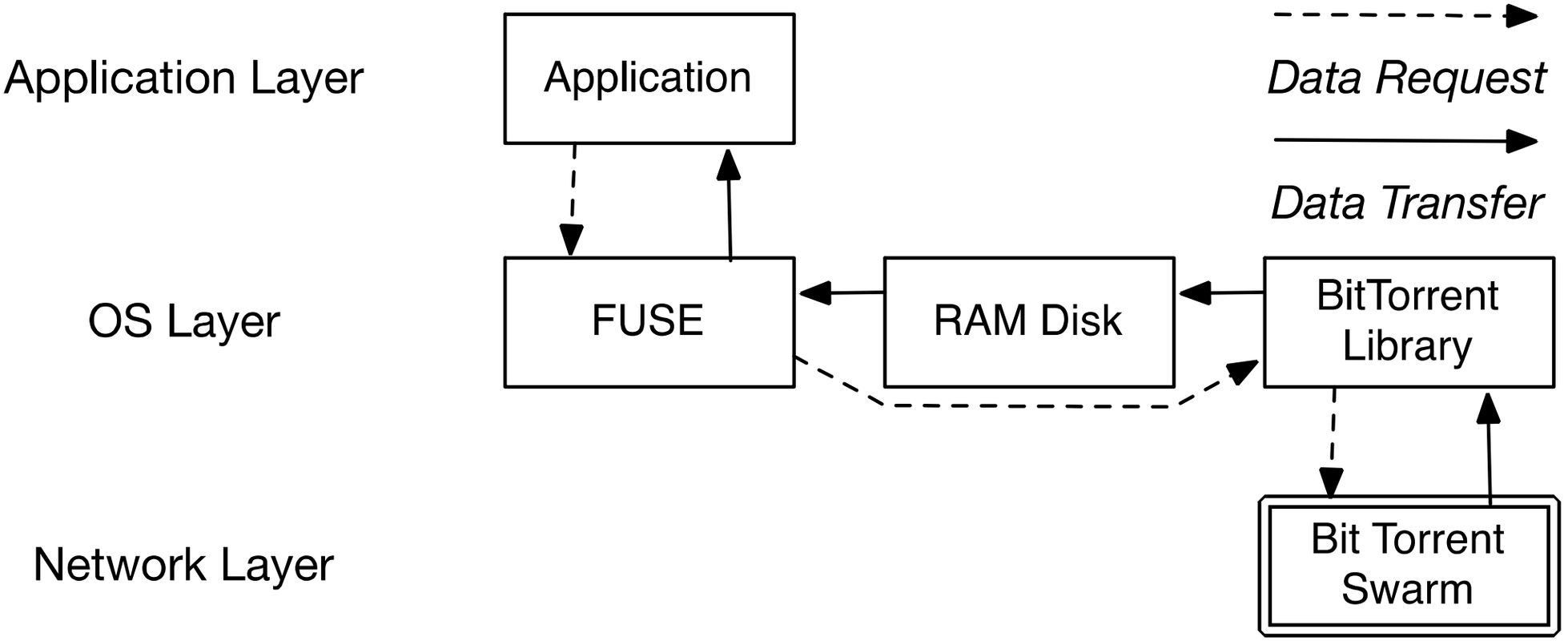
- Before Job Launch
  - Create the description file
  - Start Tracker & Initial Seeder
- During Job Launch
  - Distribute the description file
  - On each node
    - Start FUSE client
    - Add directory to LD_LIBRARY_PATH
- During Runtime
  - DL requests first search the FUSE directory
  - If a file isn't downloaded yet, request it from the BitTorrent swarm
  - If a file is downloaded, pass through to a local RAMDisk

Data Request Path



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MAKING BITTORRENT WORK FOR HPC

BitTorrent Assumptions Get in the Way

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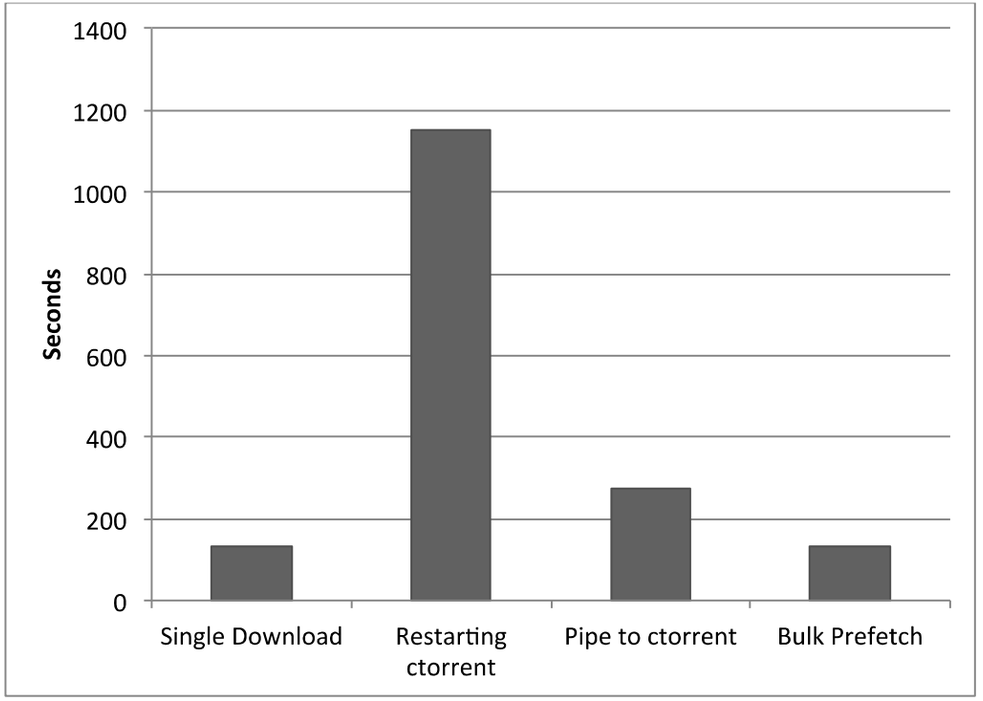
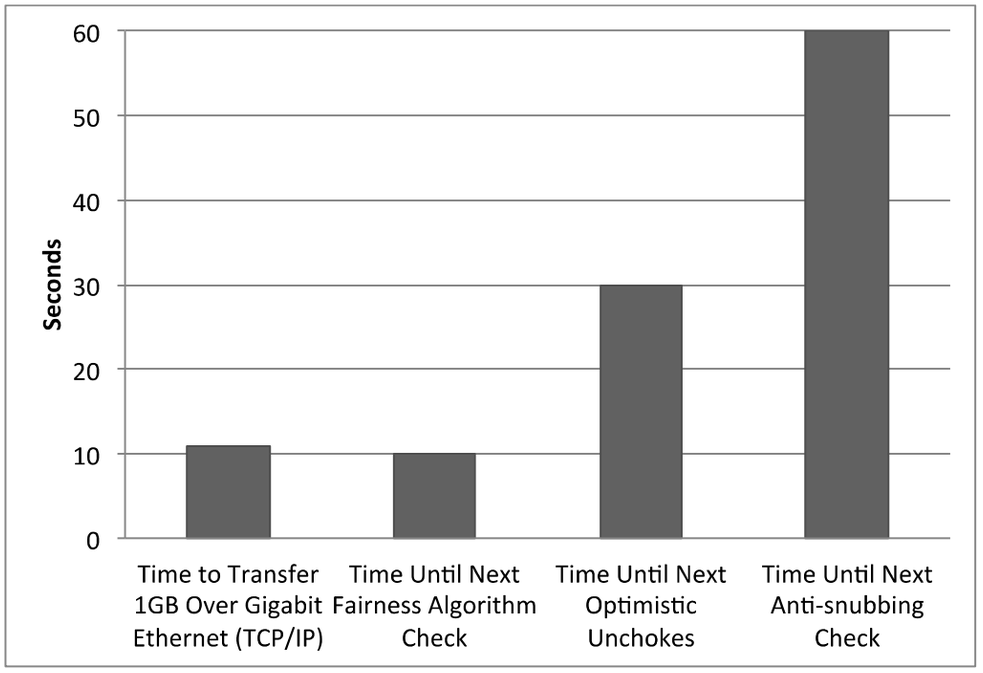
- Basic approach: Downloads individual files on-demand
- Problem: Violates basic BitTorrent usage assumption



Fairness Algorithm Problems

- BitTorrent tries to tolerate adversarial peers
- Fairness algorithm tuned for Internet speeds and timescales
- Sequential requests interfere with tit-for-tat choking algorithm



Working Around Fairness

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- Solution: Bulk prefetching of launch loaded libraries
- Libraries can be loaded two ways
  - On launch
  - On demand (dlopen)
- List of launch-loaded libraries provided by ldd
- Downloading these together, we match BitTorrent's use case
- We still support on-demand requests

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RESULTS

Experimental Setup

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- The Pynamic benchmark
  - Test case has 495 libraries totaling ~1.1GB
  - Test case based on an LLNL scientific code
- Three Machines
  - Teller – 100 node, AMD Fusion with Infiniband
  - Muzia – 20 node, Cray XE6
  - Cielo - 8,944 Node, Cray XE6

Small Scale

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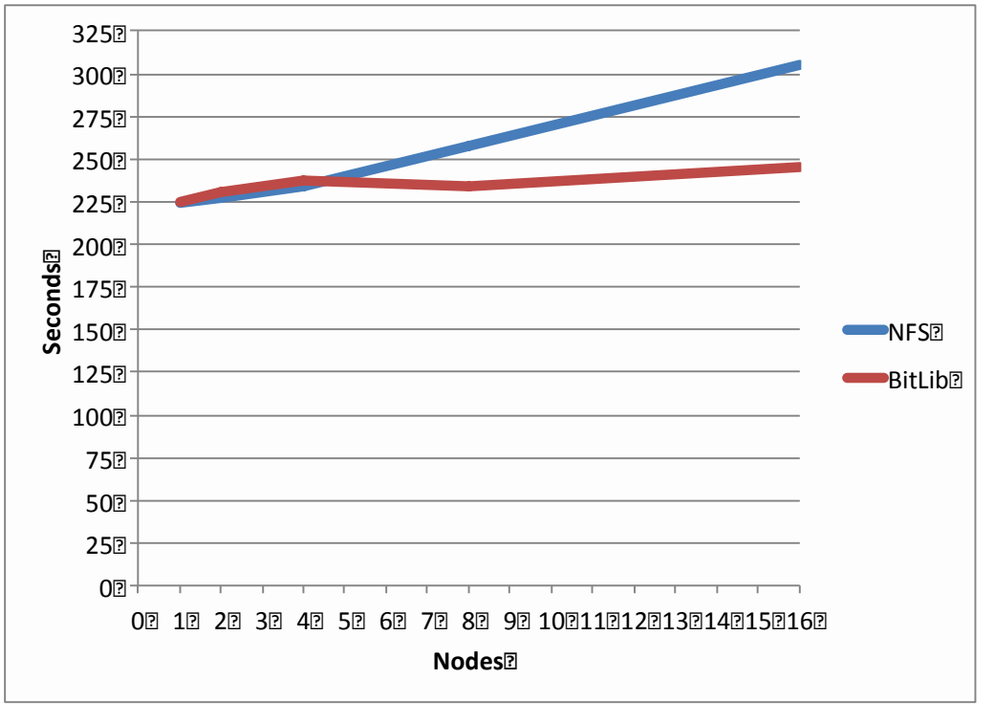
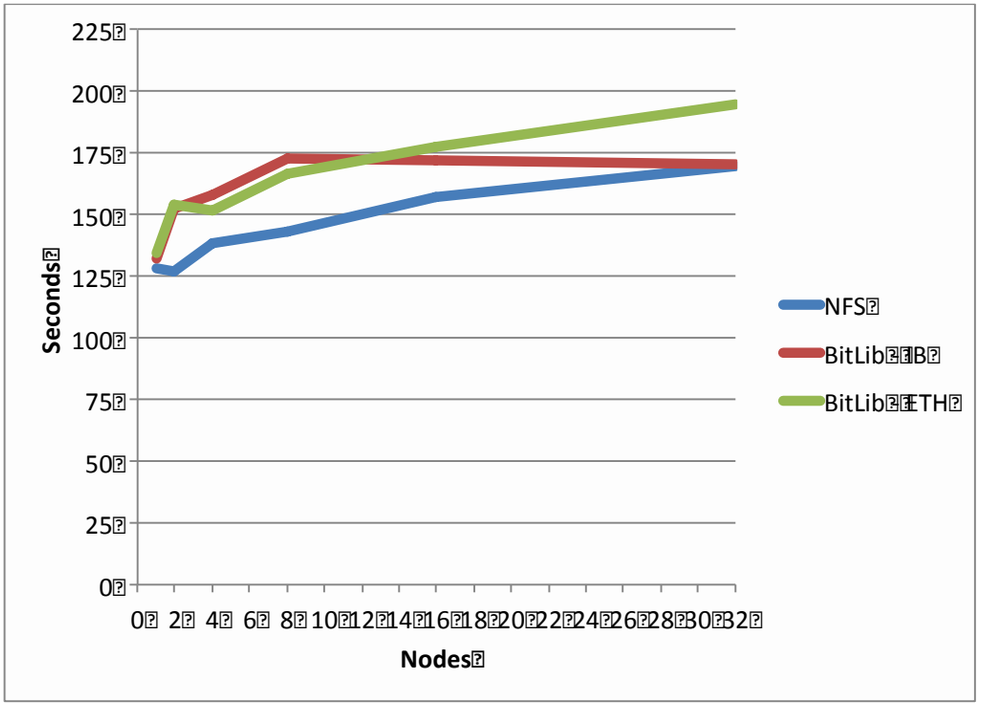
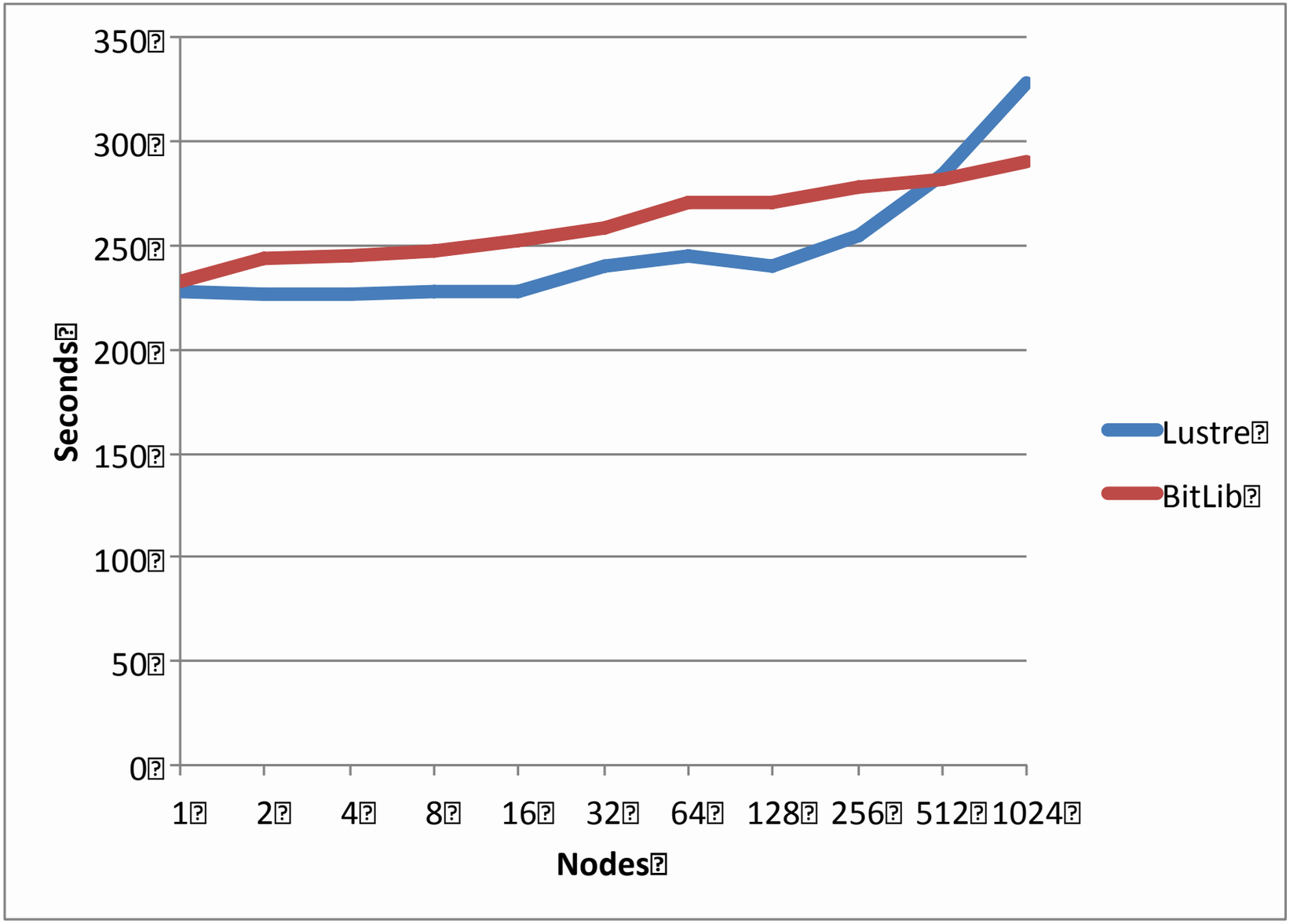
Muzia: a Gemini system



Teller: an Infiniband system



Cielo


350
300
250
200
150
100
50
0
Seconds
1
2
4
8
16
32
64
128
256
512
1024
Nodes
Lustre
BitLib

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ISSUES AND FUTURE WORK

Network Features

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- Can we use HPC network features to enhance and optimize BitTorrent?
- Multicast
- Topology-aware
- Multiple-paths

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QUESTIONS?