A Result-Data Offloading Service for HPC Centers

Henry Monti, Ali R. Butt

VirginiaTech
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Sudharshan S. Vazhkudai

OAK RIDGE
National Laboratory

HPC Center Data Offload Problem

- Supercomputer serviceability affected by data offloading errors
  - Offloading is a large data job prone to failure
    - End resource unavailability
    - Transfer errors
  - Delayed offloading
    - From a center standpoint
      - Wastes scratch space
      - Renders result data vulnerable to purging
    - From a user job standpoint
      - Increased turnaround time if part of the job workflow depends on offloaded data
      - Potential resubmits due to purging
- Upshot: Timely offloading can help improve center performance
  - HPC acquisition solicitations are asking for stringent uptime and resubmission rates **(NSF06-573)**

Current Methods For Data Offloading

- Home grown solutions
  - Every center has its own
- Utilize point-to-point transfer tools:
  - GridFTP
  - HSI
  - scp
  - …

Limitations of Direct Transfers

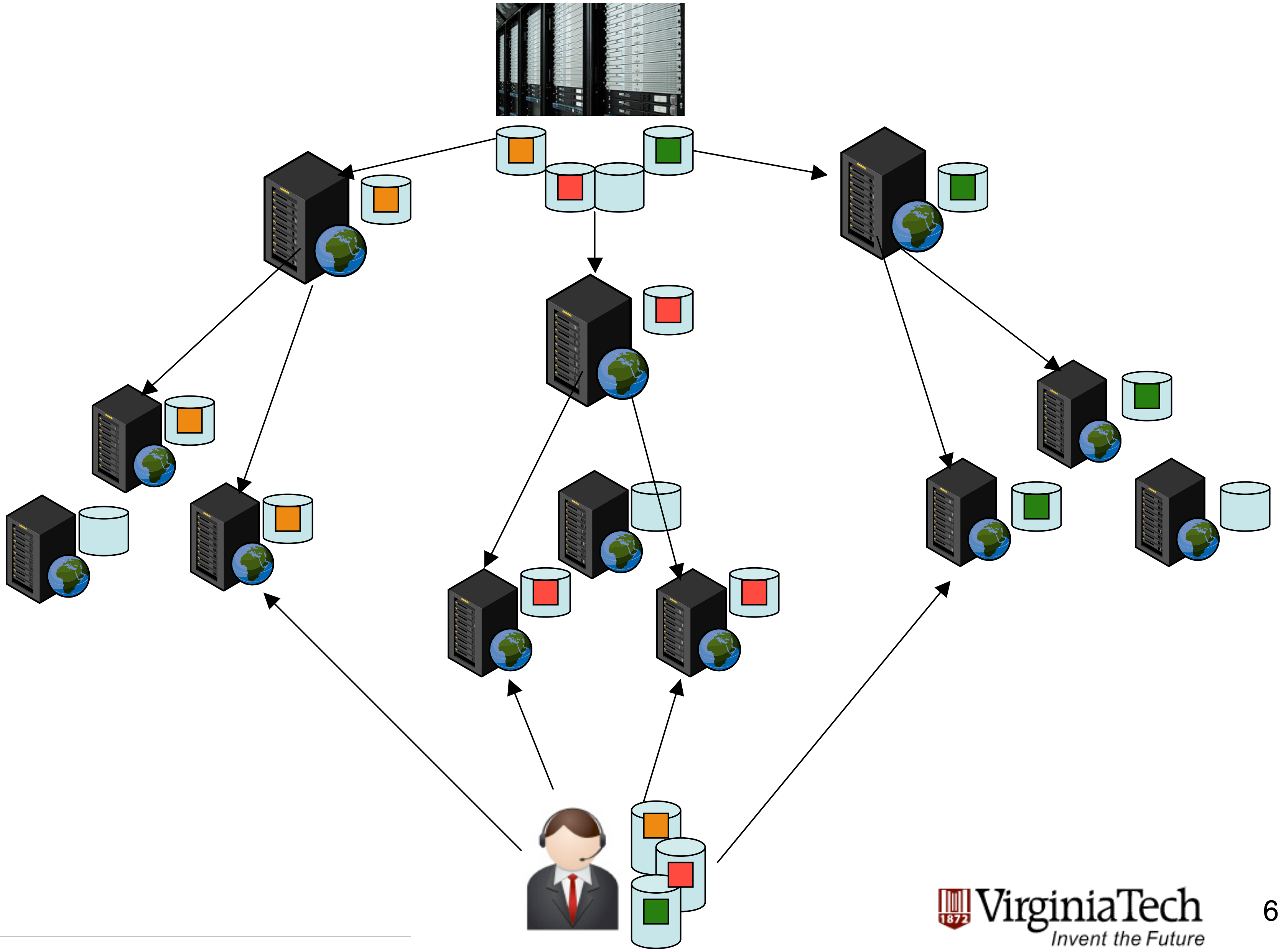
- Require end resources to be available
- Do not exploit orthogonal bandwidth
- Do not consider SLAs or purge times

- Not an ideal solution for data-offloading

Our Contribution: Decentralized Data-Offloading Service

- Utilize army of intermediary storage locations
- Offload data to nearby nodes
- Support multi-hop data migration to end user
- Allow end user to retrieve data as necessary

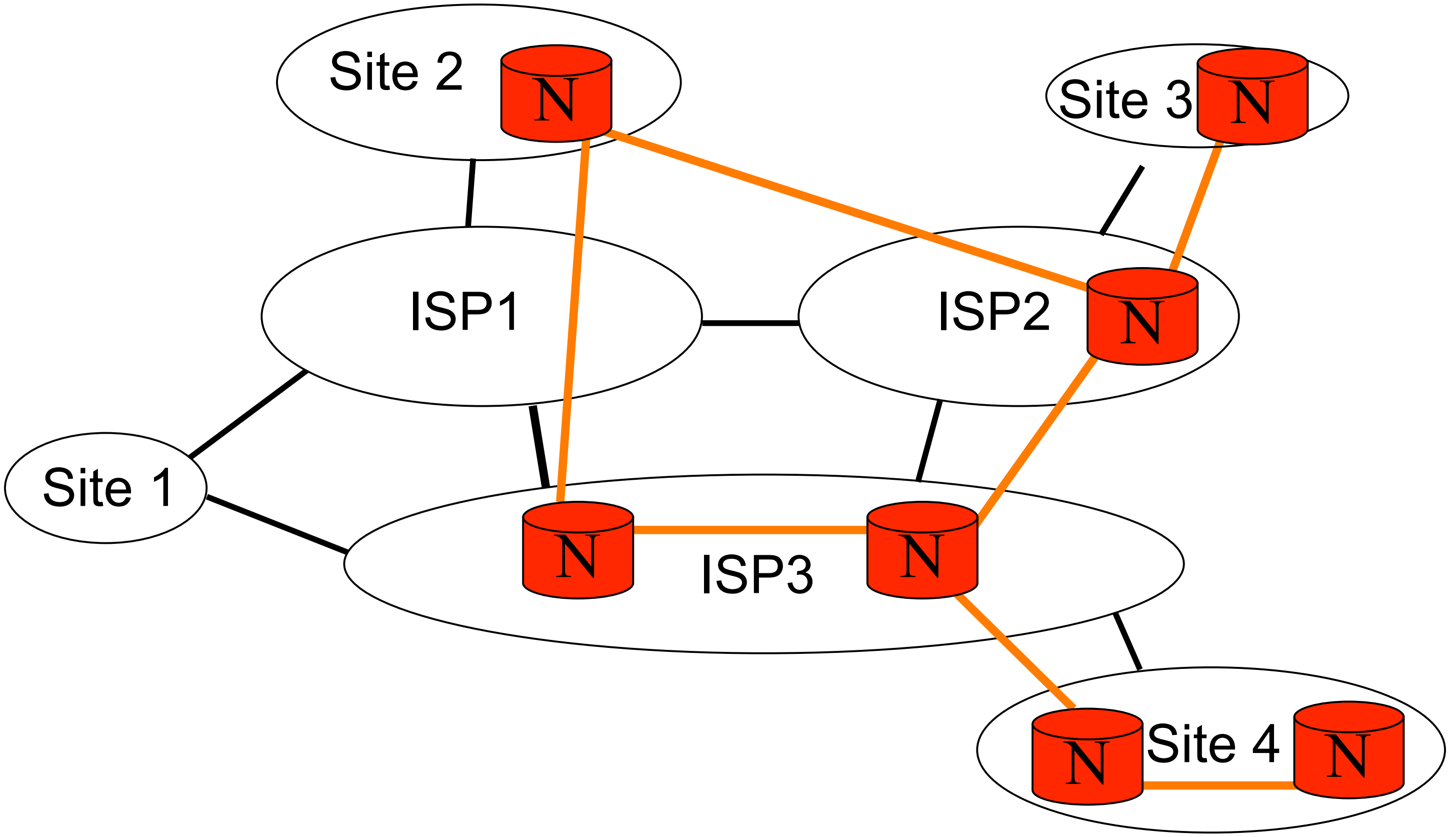
- Provide multiple fault-tolerant data flow paths from the center to the end user



Challenges Faced in Our Approach

- Discovering intermediary nodes
- Addressing insufficient participants
- Adapting to dynamic network behavior
- Ensuring data reliability and availability

Overlay Networks



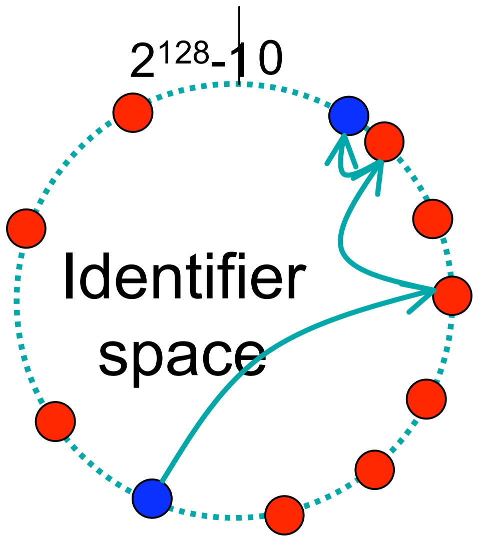
P2P networks are self-organizing overlay networks without central control

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

Intermediary Node Discovery

- Utilize DHT abstraction
- Nodes advertise their availability to others
- Receiving nodes *discovers* the advertiser



- Discovered nodes utilized as necessary

What if there aren't enough participants?

- Use Landmark Nodes
  - Nodes that are always available
  - Willing to store data
- Leverage out-of-band agreements
  - Other researchers who are also interested in the data
  - Data warehouses
    - cheaper option than storing at the HPC center
- These nodes are a safety net!

Adapting Data Distribution To Dynamic Network Behavior

- Available bandwidth can change
  - A simple random distribution may not be effective
  - Utilize network monitoring
- Network Weather Service (NWS)
  - Provides bandwidth Measurement
  - Predicts future bandwidth
- Choose dynamically changing data paths
- Select enough nodes to satisfy a given SLA

Protecting Data from Intermediate Storage Location Failure

- Use data replication
  - Achieved through multiple data flow paths

- Employ Erasure coding
  - Can be done at the Center or intermediaries
  - End user may pay for coding at the Center

Evaluation: Experimental Setup

- PlanetLab test bed
  - 22 PlanetLab nodes

    center + end user + 20 intermediary nodes

- Experiments:
  Compare point-to-point with the proposed method
  1. Random distribution
  2. Bandwidth measurement based
  3. Bandwidth forecasts based

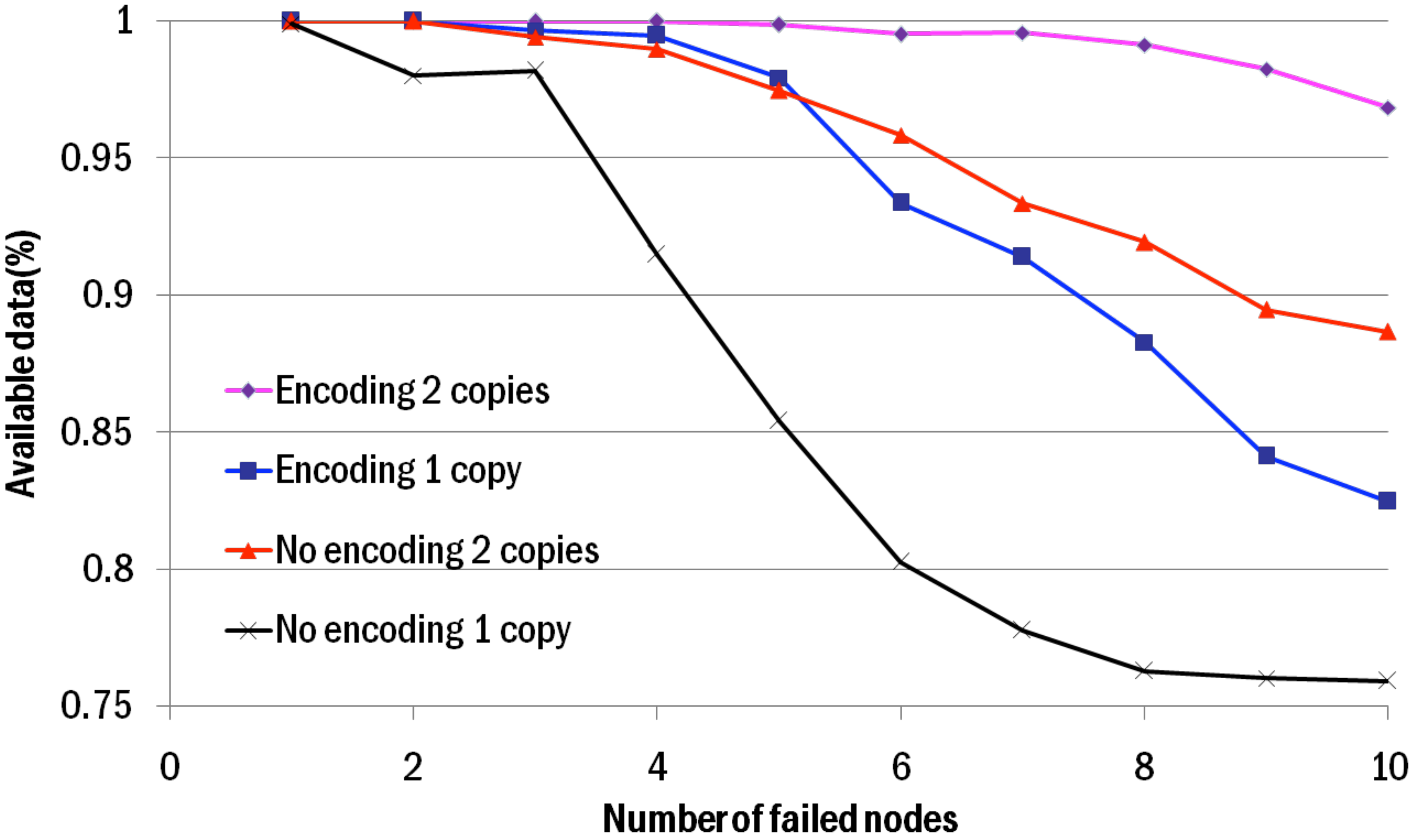
Results: Data Transfer Times

	Direct	Random	Measurement Based	Forecast Based
Offload	739	245	214	210
Push	N/A	431	393	370
Pull	739	665	663	663

Times are in seconds

Transfer of a 95 MB file

Replication vs. Erasure Coding



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Conclusion

- A fresh look at Offloading
  - Decentralized approach
  - Monitoring-based adaptation
- Considers SLAs and purge policies
- Provides high reliability for data
- Outperforms direct transfer by **72%**

Future Work

- Strategically placed Landmark nodes
- Schedule offload to coincide job completion
- Eager offloading
- Integration with job script

- Contact
  - Virginia Tech.
    - Distributed Systems and Storage Lab. http://research.cs.vt.edu/dssl/
    - {hmonti, butta}@cs.vt.edu
  - ORNL
    - http://www.csm.ornl.gov/~vazhkuda/Storage.html
    - vazhkudaiss@ornl.gov