FALCON – A System for Reliable Checkpoint Recovery in Shared Grid Environments

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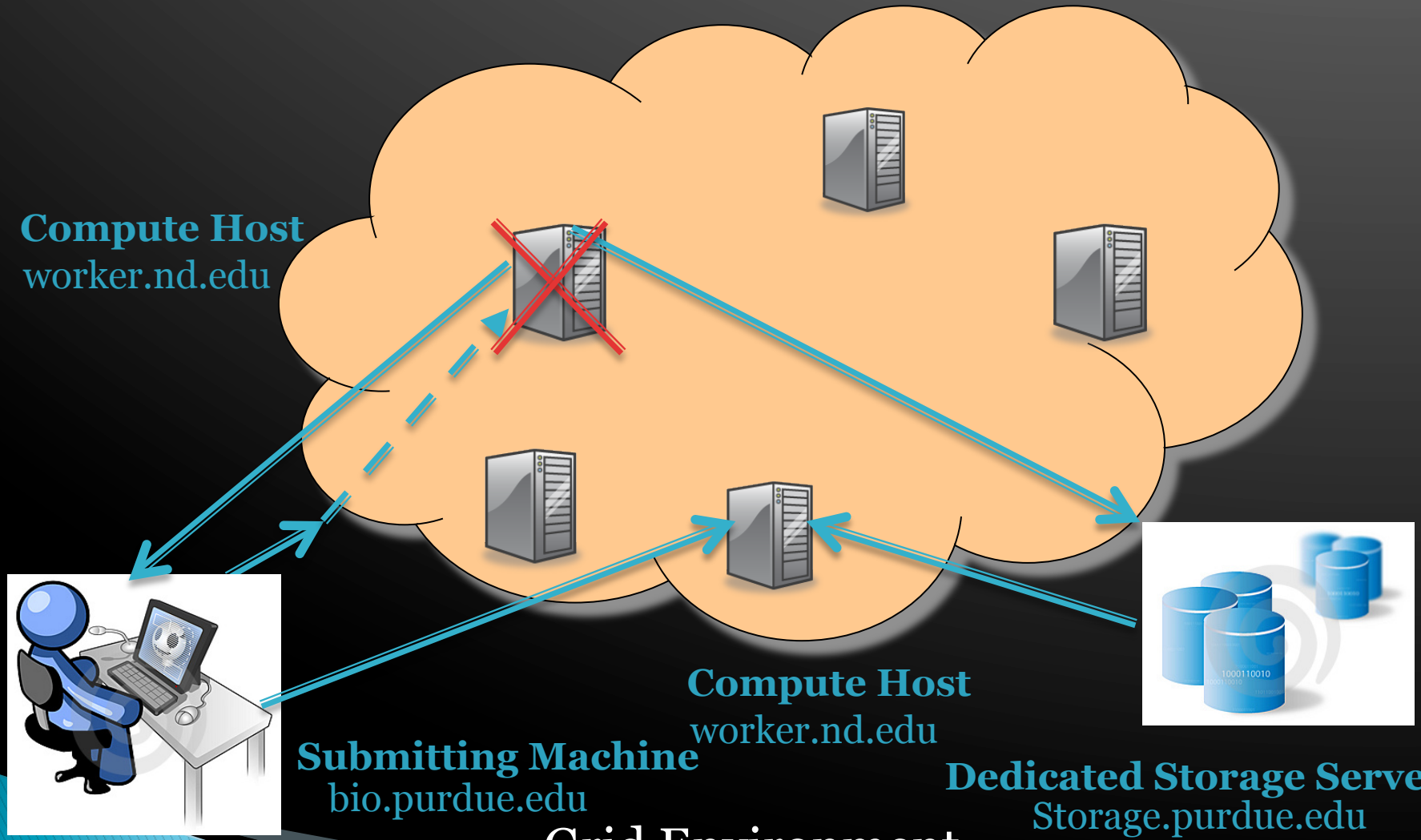
Background

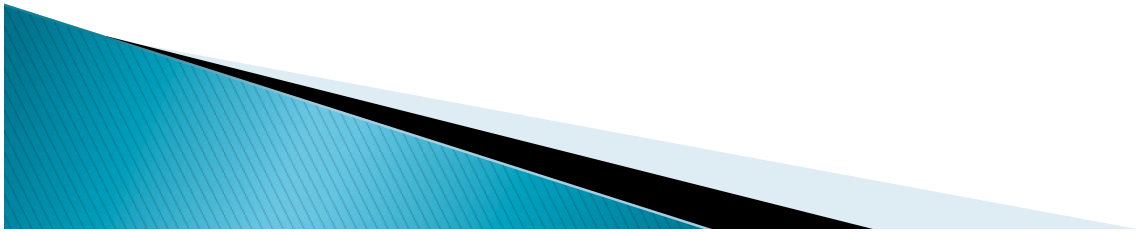
- What is a grid or cycle sharing (CS) system
  - Machines share their unused computation cycles
- What is a Fine-Grained CS (FGCS)?
  - Guest and host jobs can coexist
  - Example: Condor
- Resources are extremely volatile
  - In BoilerGrid (DiaGrid), eviction rate – 1.3 per job per hour on average
  - Checkpoint-recovery provides fault-tolerance

State of the Art Checkpoint-Recovery Scheme



Problem Motivation

- High overhead for application users
  - Submitting machine
    - If the submitter is behind a slow network (say, DSL modem)
  - Central storage server
    - High latency of transferring checkpoints back and forth between different university campuses (12% of the time)
    - High overhead when multiple machines are sending data to a single server
    - High overhead of sending data to a loaded server
- Stress on shared network resource
  - Transferring large amount of checkpoint data (gigabytes)
  - Transferring data across distant points in the network



Potential Solution and Challenges

Submitting Machine
bio.purdue.edu

Compute Host
worker.nd.edu

Compute Host
worker.nd.edu

Storage Host
worker.nd.edu

No Checkpoint available

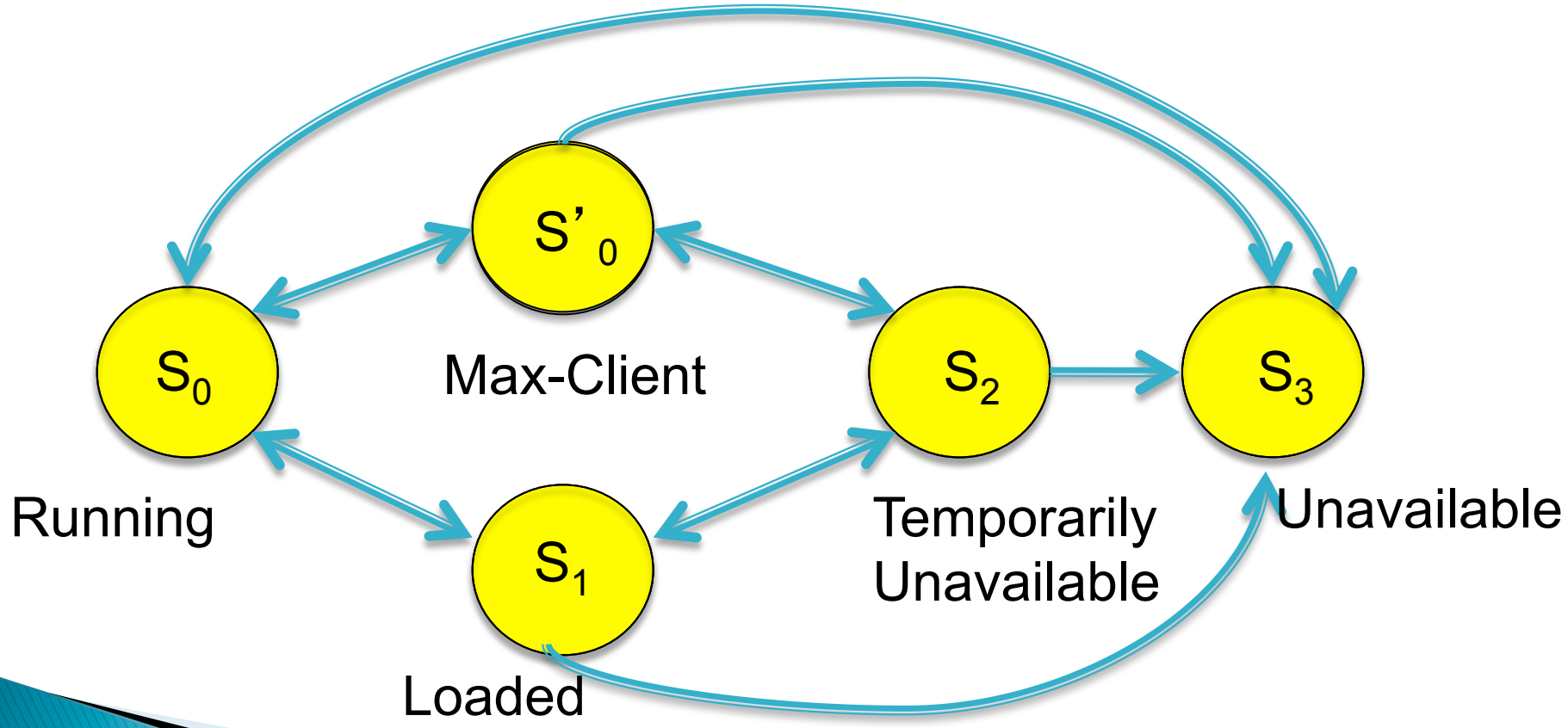
Shared Grid Environment

Contribution

- Goal: Can we improve the performance of the guest jobs by storing checkpoints in shared grid environment?
- Developed a reliable checkpoint-recovery system FALCON
  - Provides fault-tolerance through "Erasure Coding"
  - Selects reliable storage hosts which are nearby
    - Builds a failure model for storage hosts
  - Stores and retrieves checkpoints in efficient manner
- Deployed FALCON in BoilerGrid (DiaGrid)
  - Performance improvement of benchmark applications in production grid is between 11% to 44%

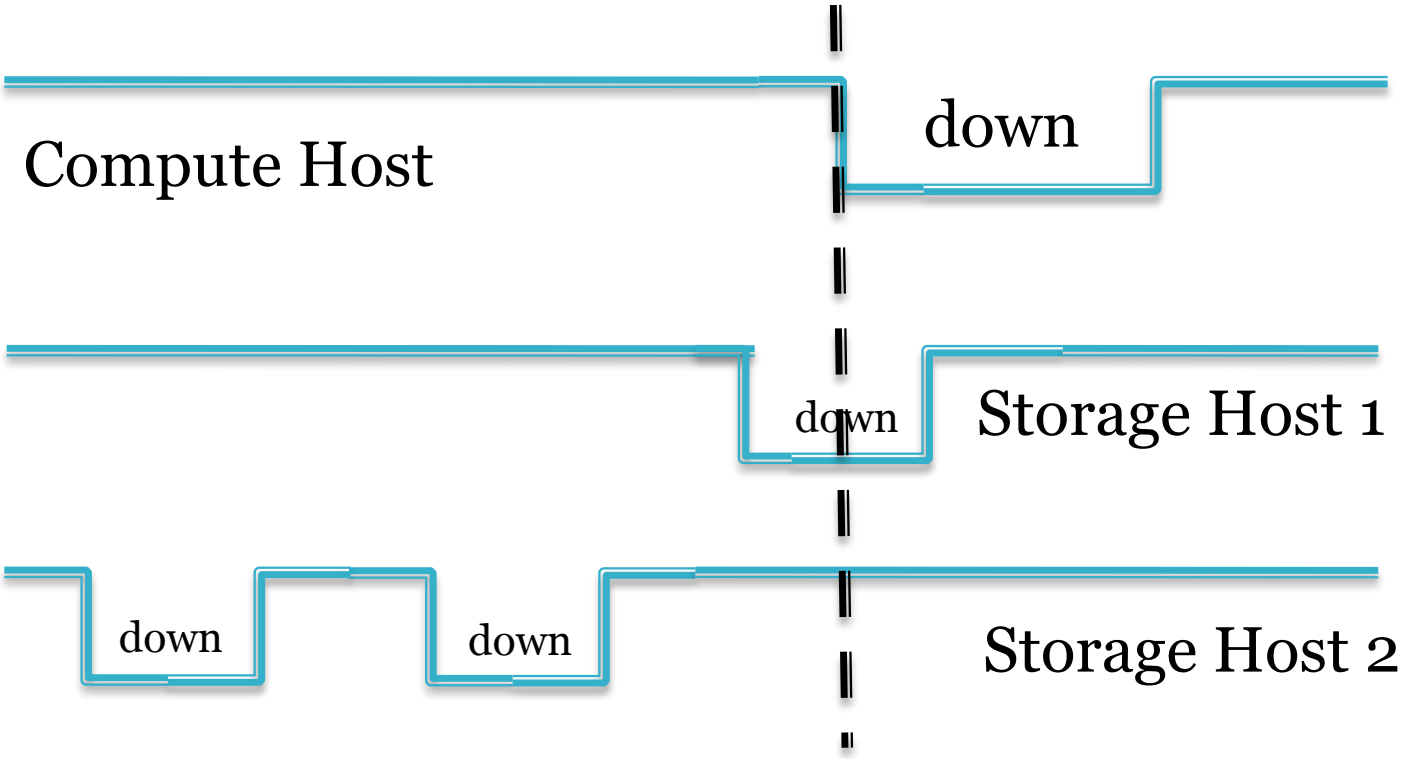
Failure Model

- Aids in predicting availability of the storage nodes
- Load: %utilization of I/O



Storage Repository Selection

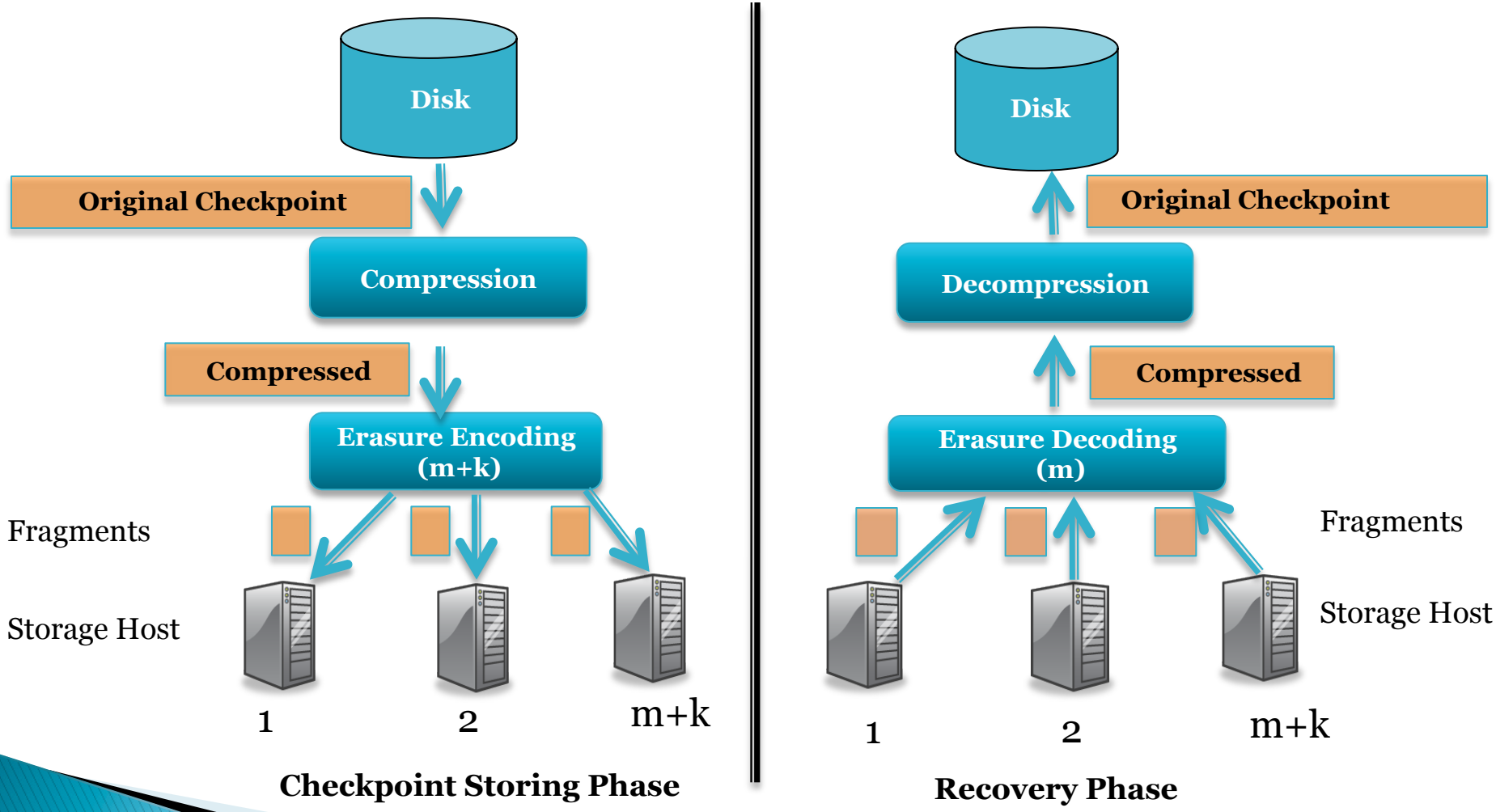
- Predict availability of storage nodes
  - Correlated temporal reliability



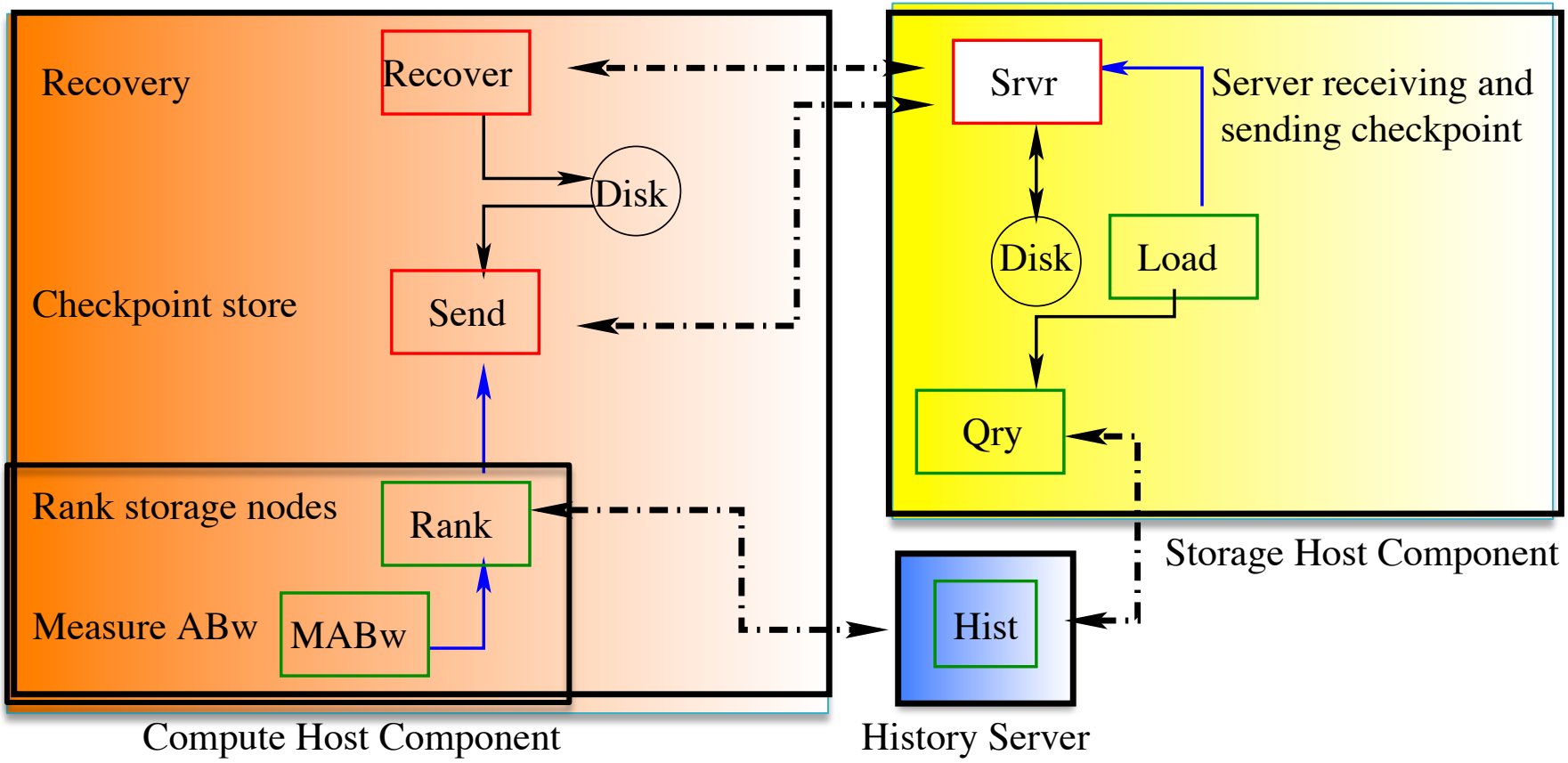
Storage Repository Selection

- Calculate network transfer overhead
  - Network Overhead = Amount of data to send (MB) / Available Bandwidth between a storage host and a compute host
- Minimize an objective function
  - Objective function: checkpoint storing overhead – benefit from the fact that a job can restart from the last saved state
  - Overhead includes network overhead
  - Benefit computed using the correlated temporal reliability
- Select a set of $m+k$ storage nodes that minimizes this objective function

Checkpoint-Recovery Scheme



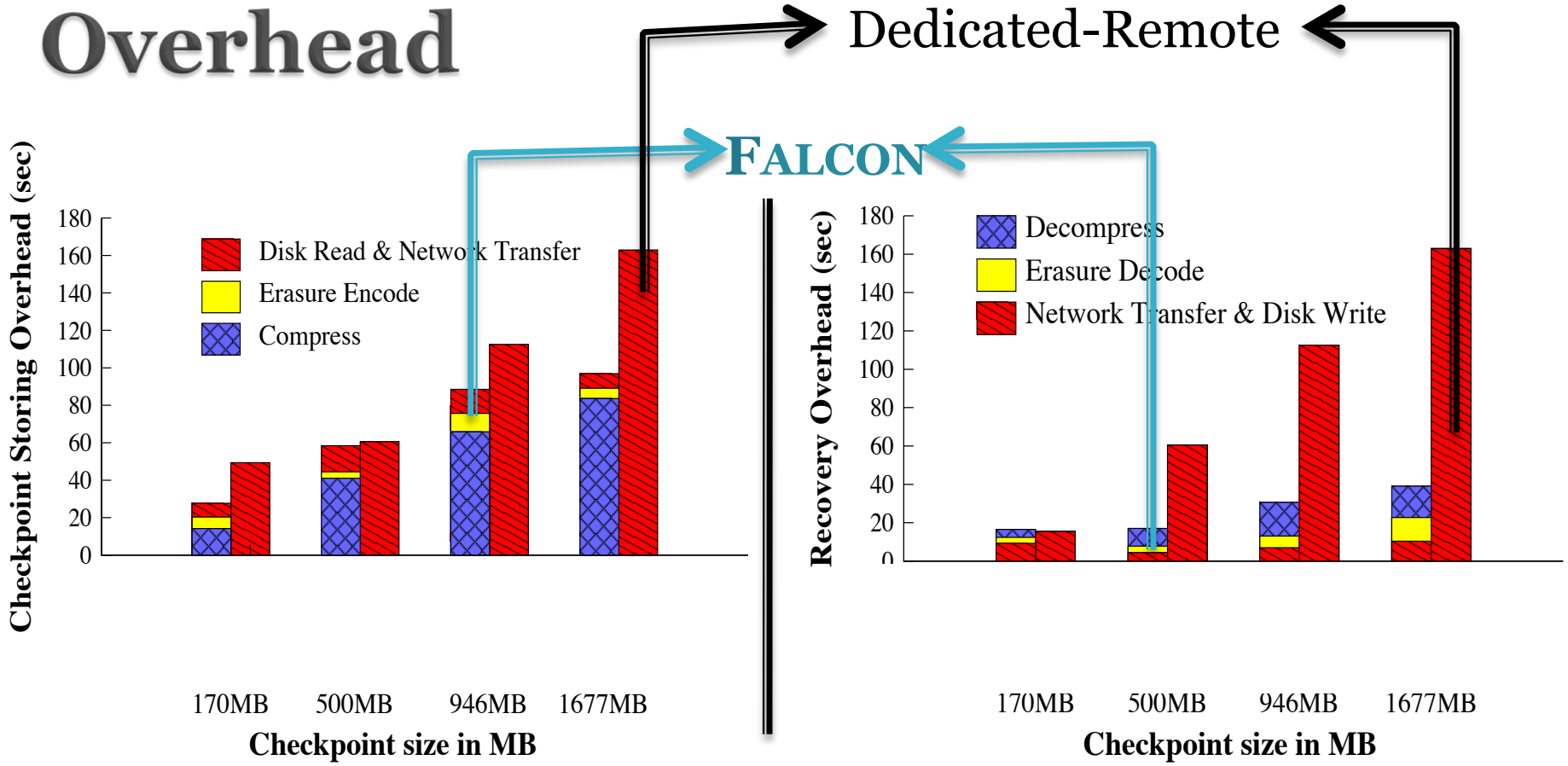
Structure of FALCON



Evaluation

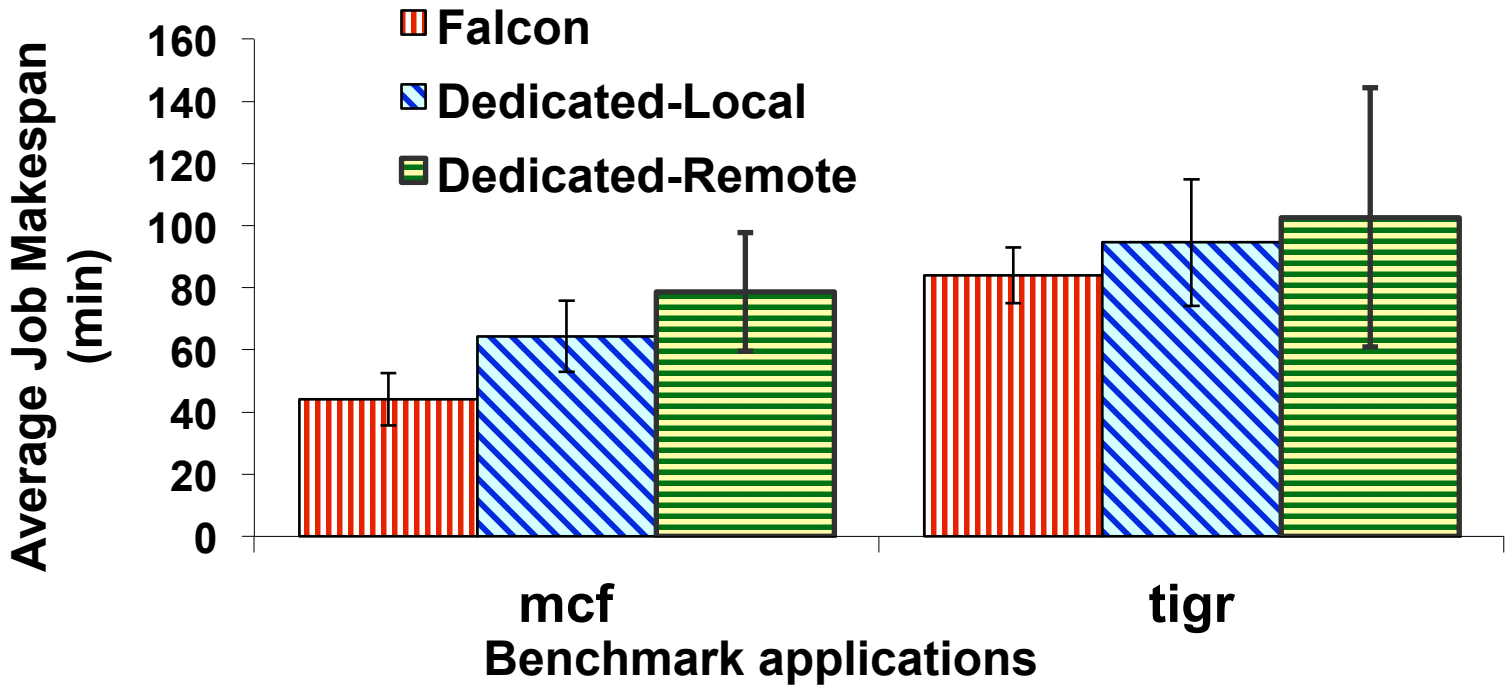
- Overall performance evaluation:
  - Average job makespan – the time a job takes to complete
- Efficiency of the checkpoint-recovery schemes:
  - Checkpoint storing overhead
  - Recovery Overheads
- Setup:
  - Submitted jobs to BoilerGrid
  - Applications – MCF (SPEC CPU 2006), TIGR (BioBench)
  - Erasure encoding parameters: m=3, k=2

Checkpoint Storing & Recovery Overhead



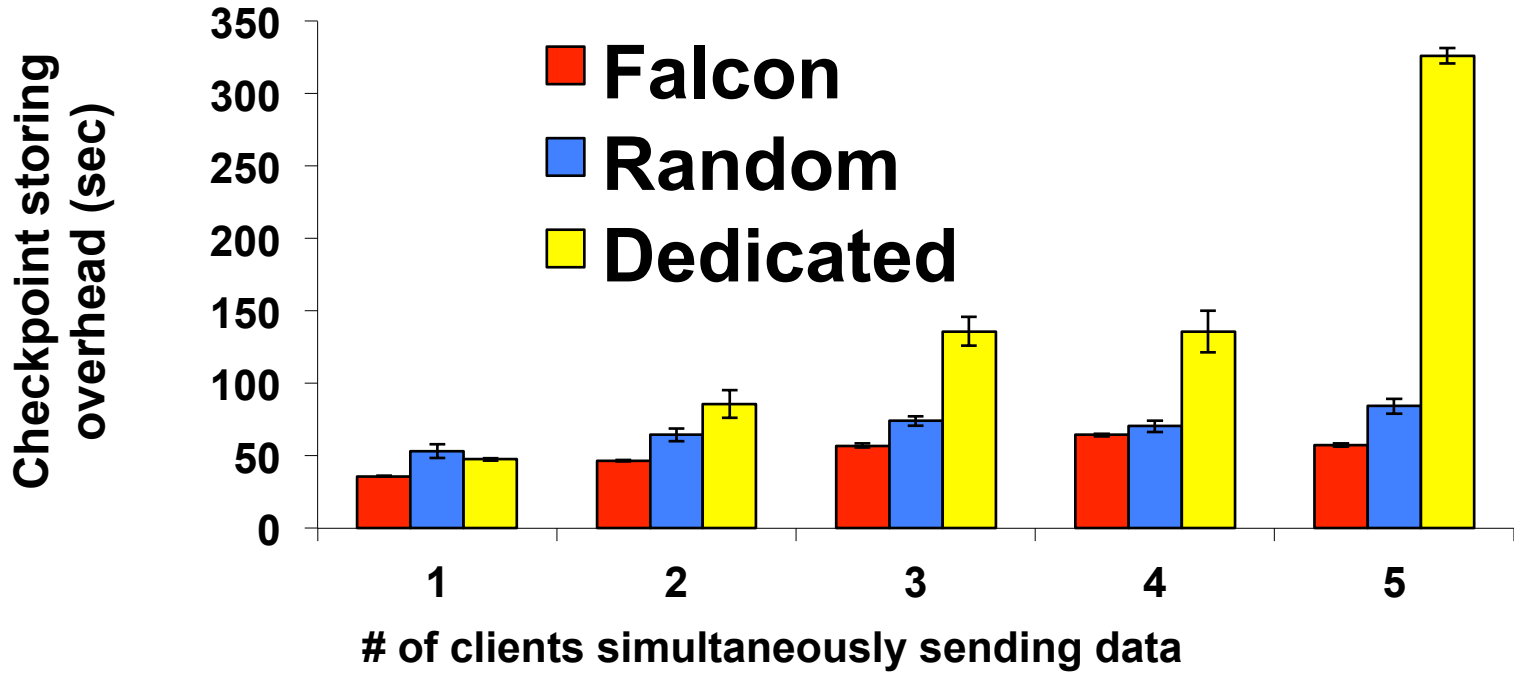
- Performance of Falcon scales with the increase in the checkpoint sizes
- Lower network transfer overhead and lower utilization of shared network bandwidth

Overall Performance Comparison



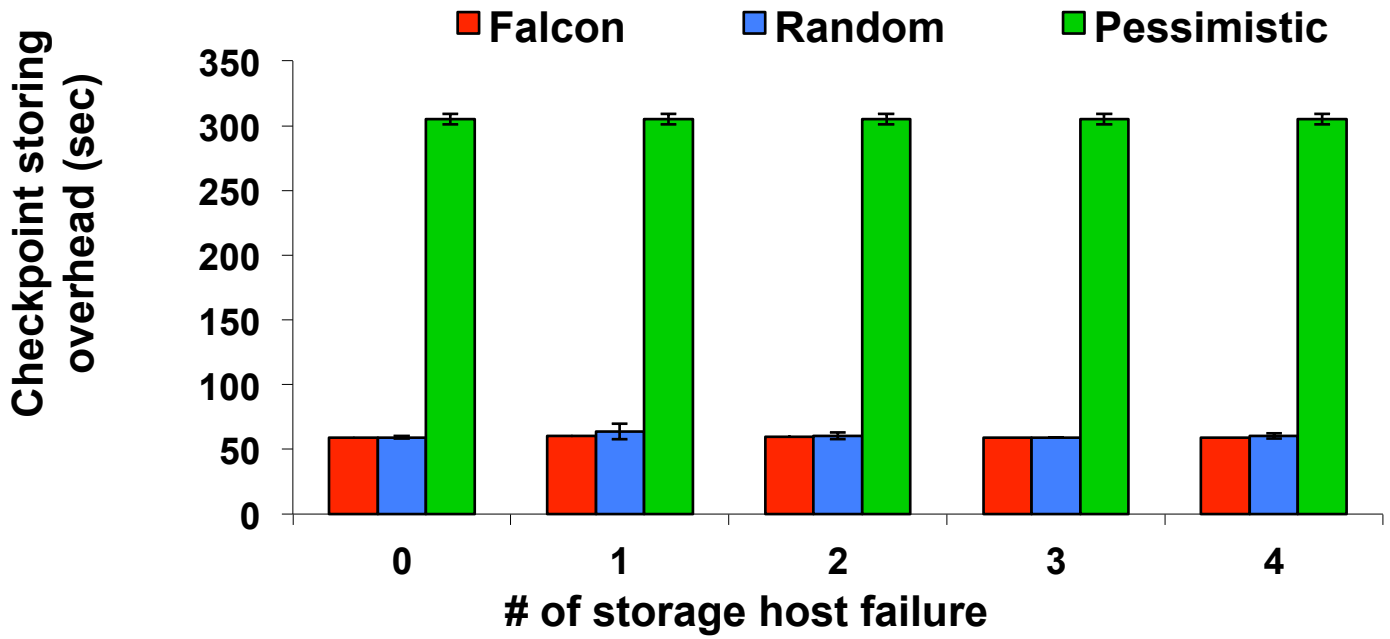
- Performance improvement of the applications are between 11% and 44%

Handling Simultaneous Clients



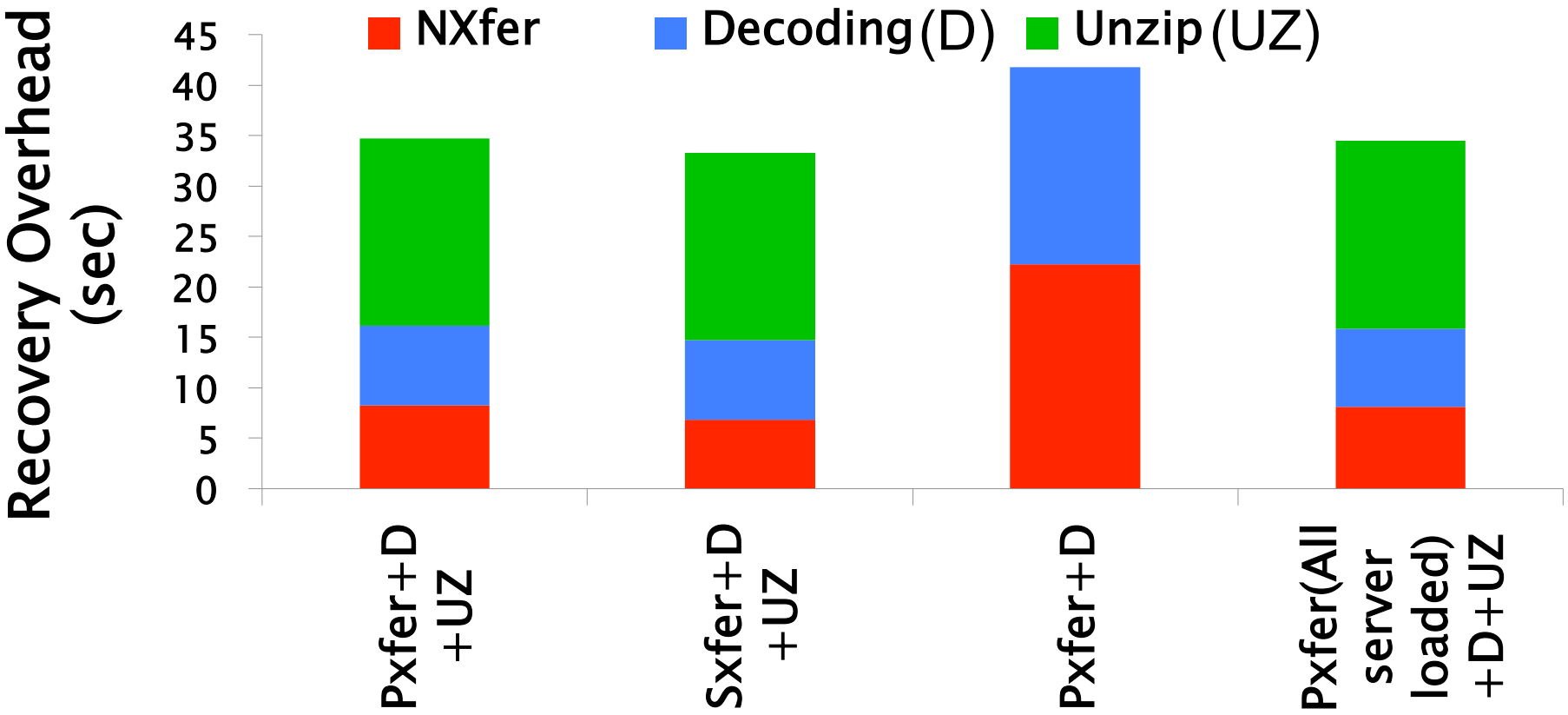
- Performance of dedicated scheme suffers
- Performance of Random scheme suffers because of choosing machine behind slow network

Handling Storage Failures



- Robustness at no extra cost for Falcon
- Pessimistic incurs large overhead

Contributions of Components



- Pxfer – parallel network transfer, Sxfer – serial network transfer
- Largest contribution comes from compression

Conclusion

- Developed a multi-state failure model for storage nodes
  - Also provides load balancing
- Developed a failure-aware storage selection technique
- Checkpoint-recovery scheme
  - Fault-tolerant
  - Scalable
  - Robust
- All the components are user level applications
- No simulation, no synthetic checkpoint
- User level checkpoint
- Question: Can we improve the performance of the guest jobs by storing checkpoints in a shared grid environment?
  - Answer: Yes FALCON can

Thank You