NCCloud: Applying Network Coding for the Storage Repair in a Cloud-of-Clouds

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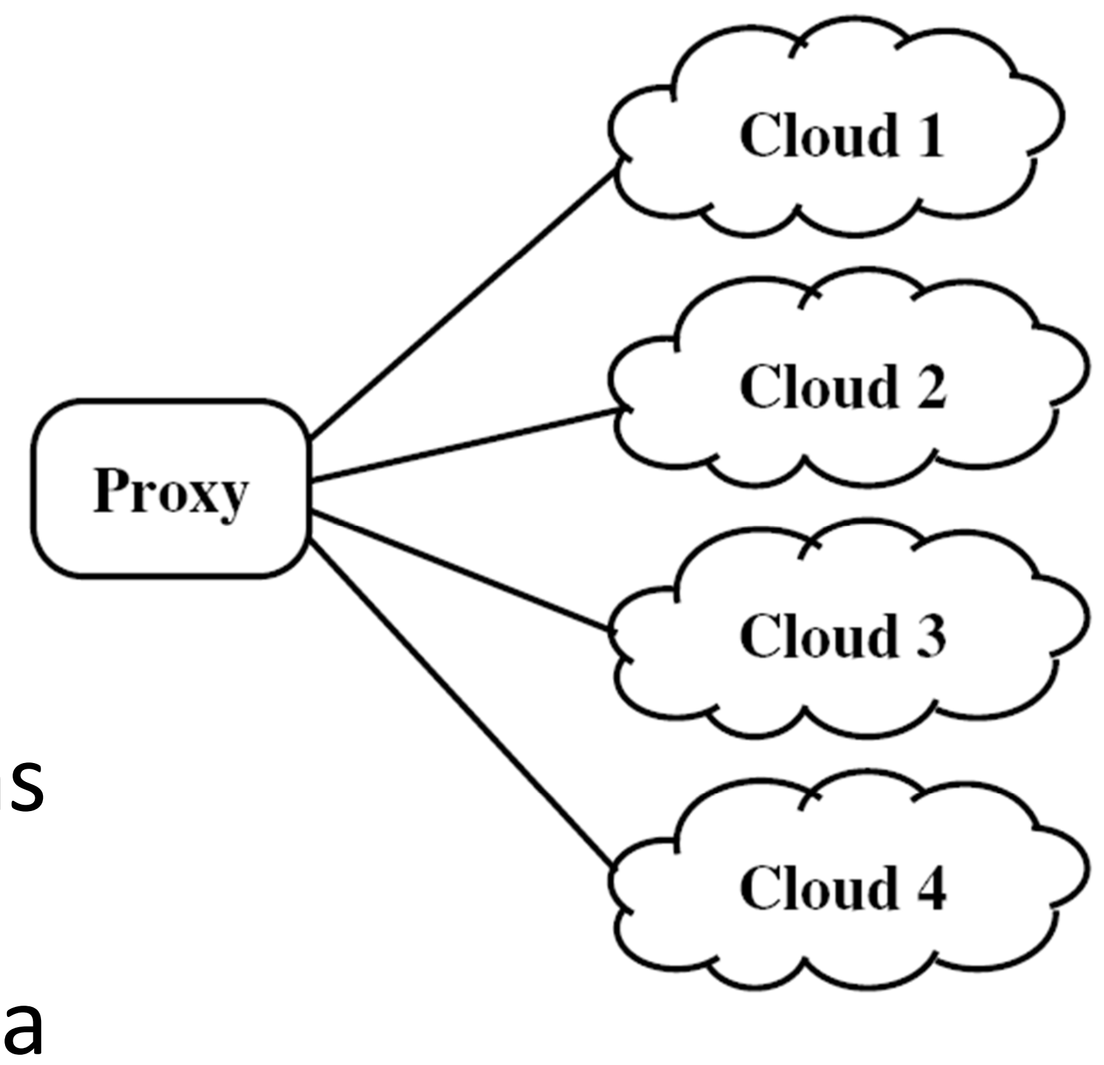
Source code available at http://ansrlab.cse.cuhk.edu.hk/software/nccloud

Goals

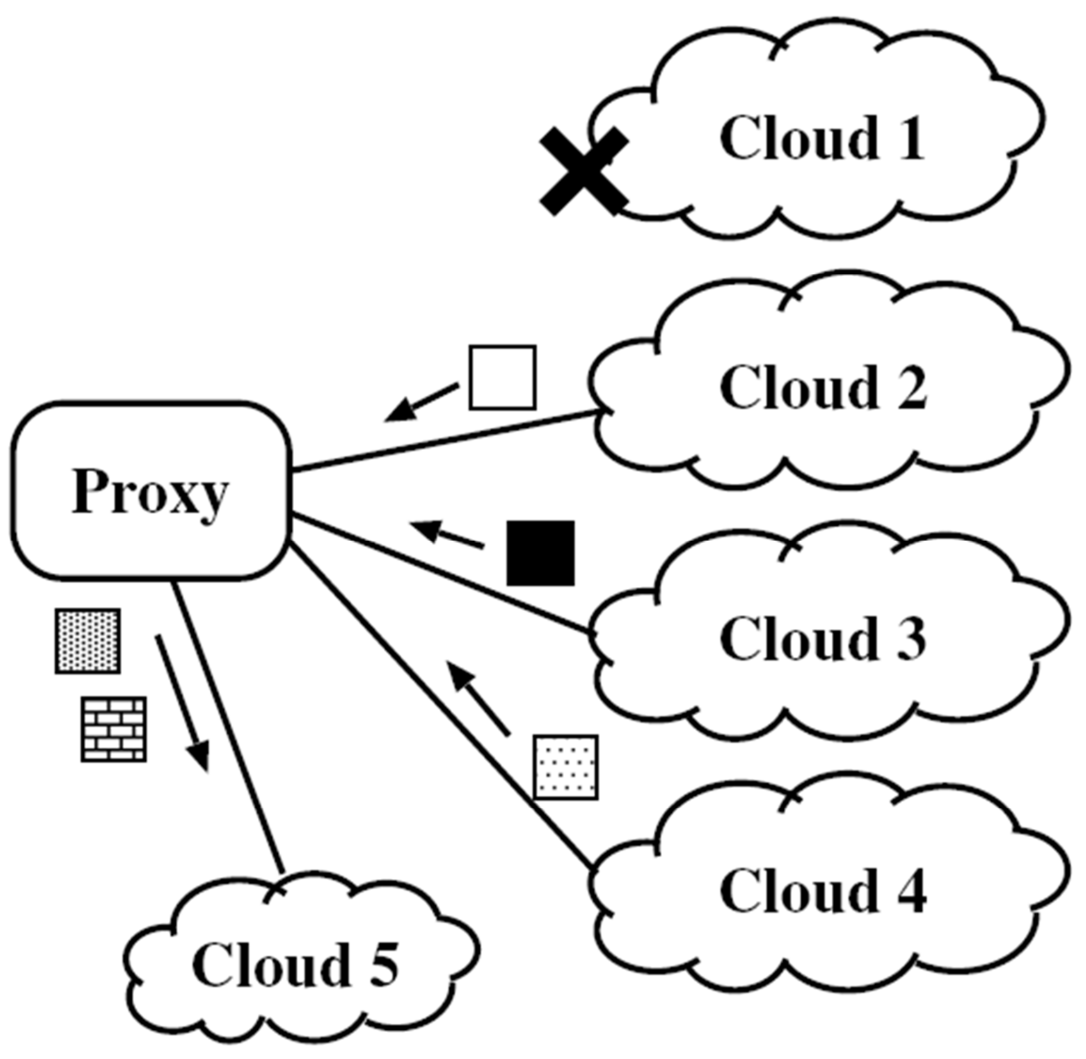
- Design NCCloud a proxy-based file system for long-term archival using multiple cloud storage providers.
- Propose an implementable design of functional minimum storage regenerating code (F-MSR), which adapts the benefits of network coding in minimizing the cost of repairing a single-cloud failure, while preserving storage overhead as in erasure codes.

Design

- Maintain redundancy with Maximum Distance Separable (MDS) property
- Focus on double fault tolerance
- Proxy-based design: NCCloud serves as an interface between client & clouds
- Repair operation: The proxy reads data from survival clouds, reconstructs new data, and writes them to a new cloud



Normal operation

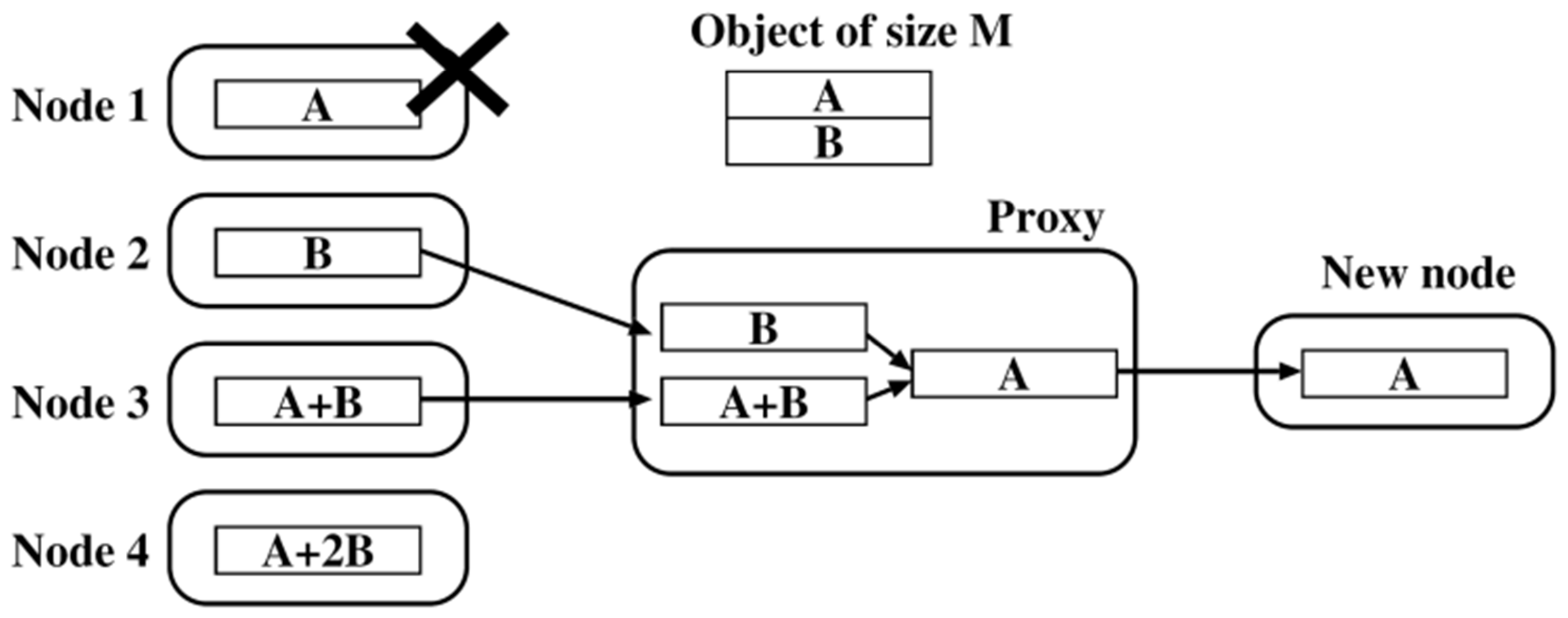


Repair operation

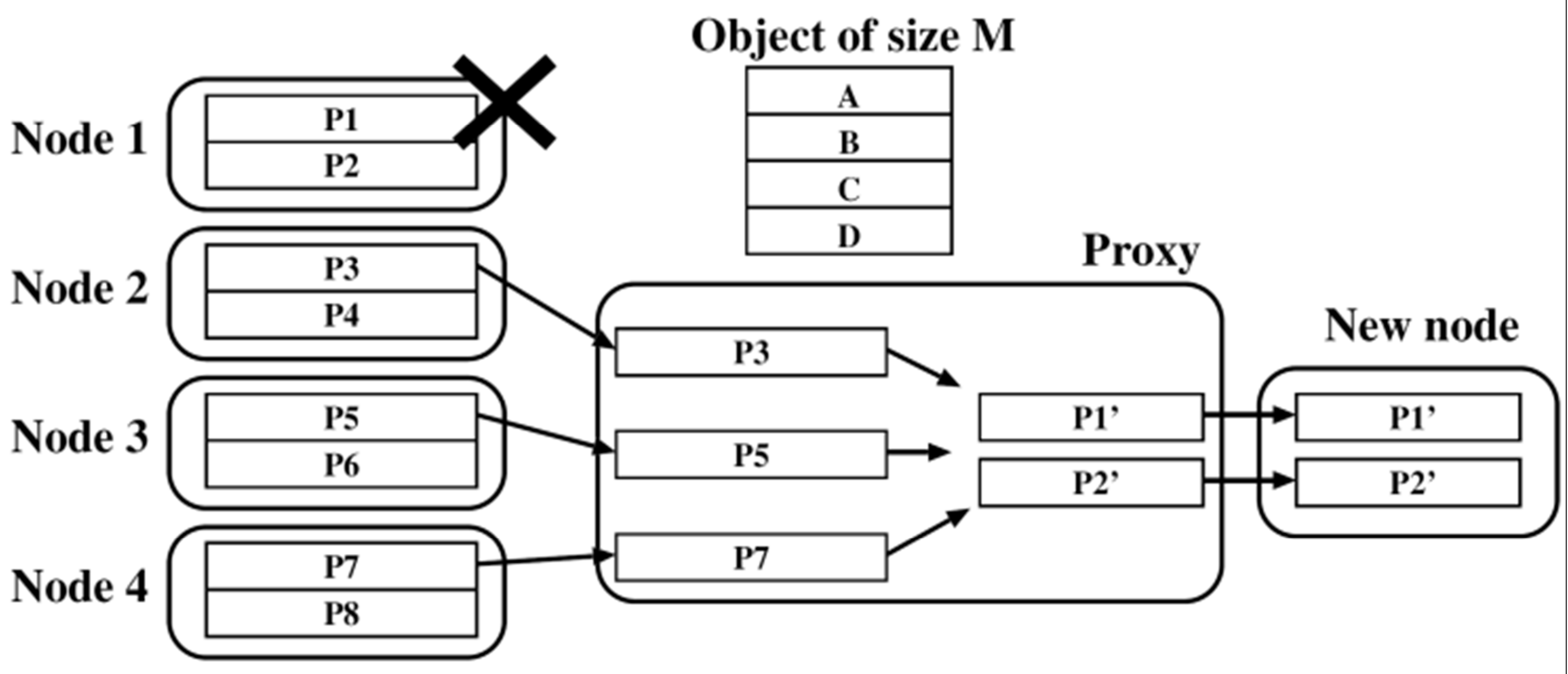
repair traffic = □+■+▨

Goal: minimize repair traffic

Reed-Solomon code vs. F-MSR



Repair Traffic $_{\text{Reed-Solomon Code}}$ = M



Repair Traffic $_{\text{F-MSR}}$ = 0.75M

- Conventional repair method: recovers the whole file
- F-MSR's repair method: recovers only chunks in the failed node
- Both RS and F-MSR have same storage size, but F-MSR reduces repair traffic (up to 50% for large n)
- F-MSR is non-systematic, in return for less repair traffic than systematic codes
- Key technique: a two-phase checking heuristic to make iterative repairs sustainable.

Evaluation under 4 nodes: RS (RAID-6) vs. F-MSR

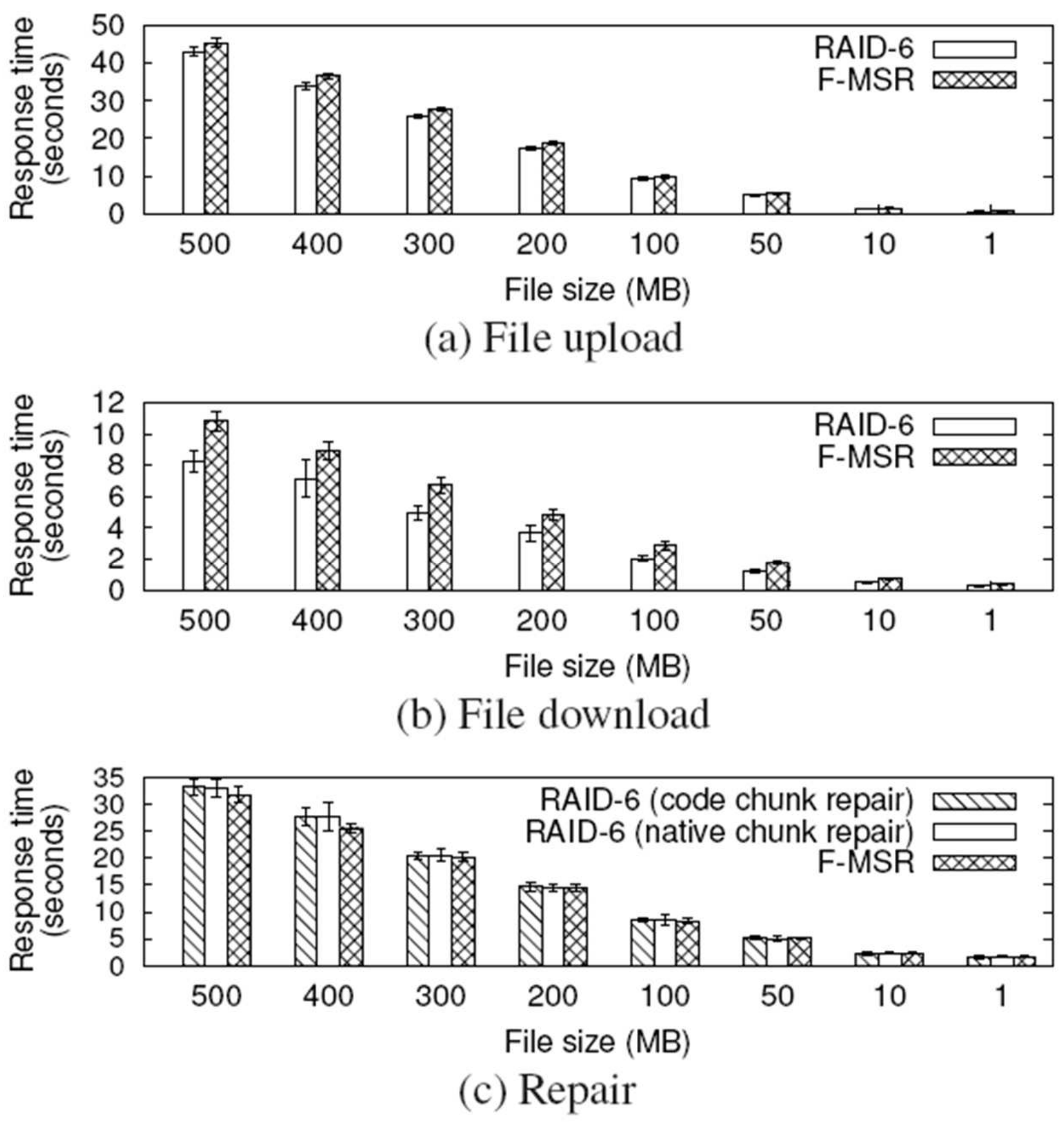
Cost

- **Repair traffic cost**
  F-MSR saves 25% over RS for 4-node case
- **Metadata of F-MSR**
  metadata size = 160 B; chunk size = 4MB.
- **Overhead due to GET request during repair**
  RAID-6: 0.427%
  F-MSR: 0.854%

Response time

F-MSR has small coding overhead, which will be masked by transmission fluctuations over the Internet

Local cloud

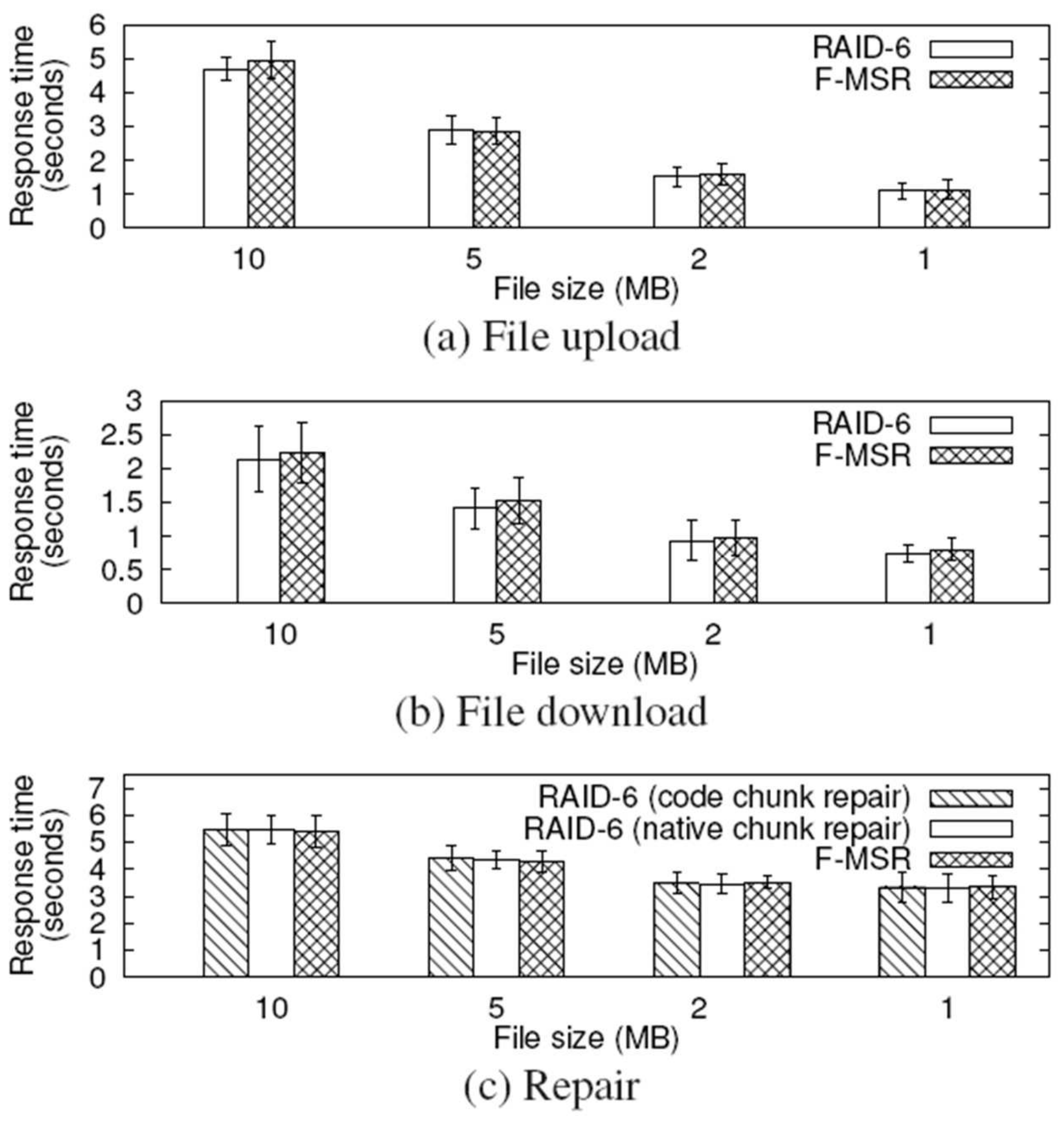


(a) File upload

(b) File download

(c) Repair

Commercial cloud



(a) File upload

(b) File download

(c) Repair