Cepheus: A New Encrypted File System with Group Sharing and Integrity Protection

Kevin Fu

Course VI-3A   April 26, 1999

On-Campus Thesis Advisor: Ron Rivest
Bellcore Company Supervisor: S. Rajagopalan

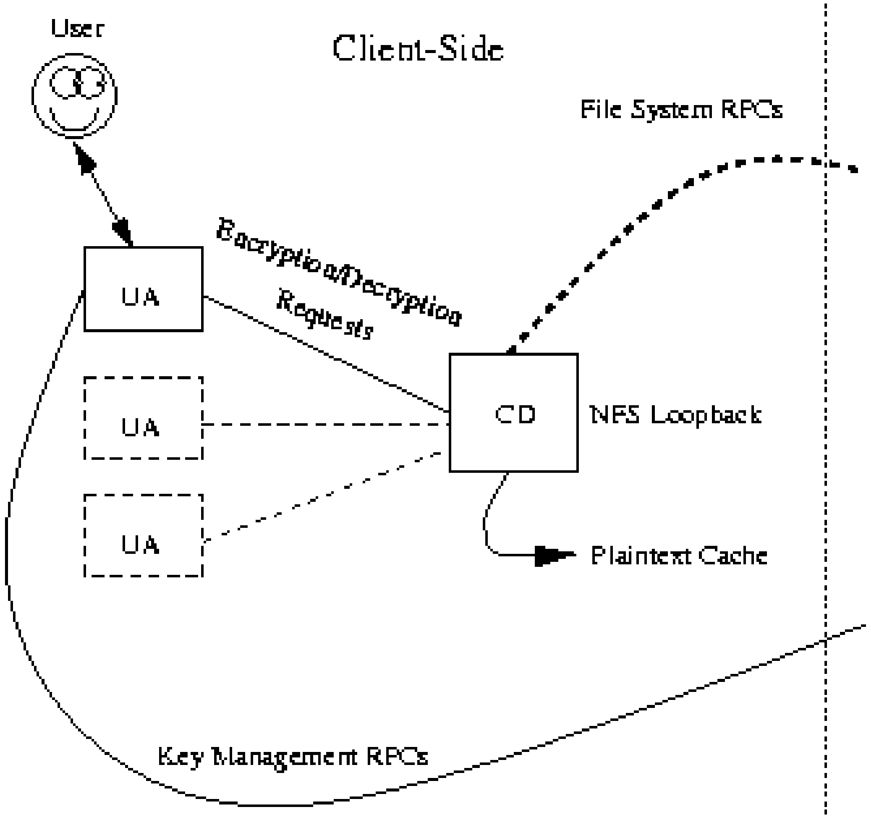
What is Cepheus?

- Confidentiality and integrity protection of data stored on a network file system
- Securely maintain UNIX semantics (file sharing, random access)
- NFS drop-in replacement

Key Problems for Secure Storage

- Problems:
  - Manual encryption cumbersome
  - Protection against malicious system administrators
- Solution: Encrypt stored data
- Side effects:
  - Loss of random access to data
  - No guarantee of integrity

Client-Side



User Agent

•Encryption/decryption

•Integrity check

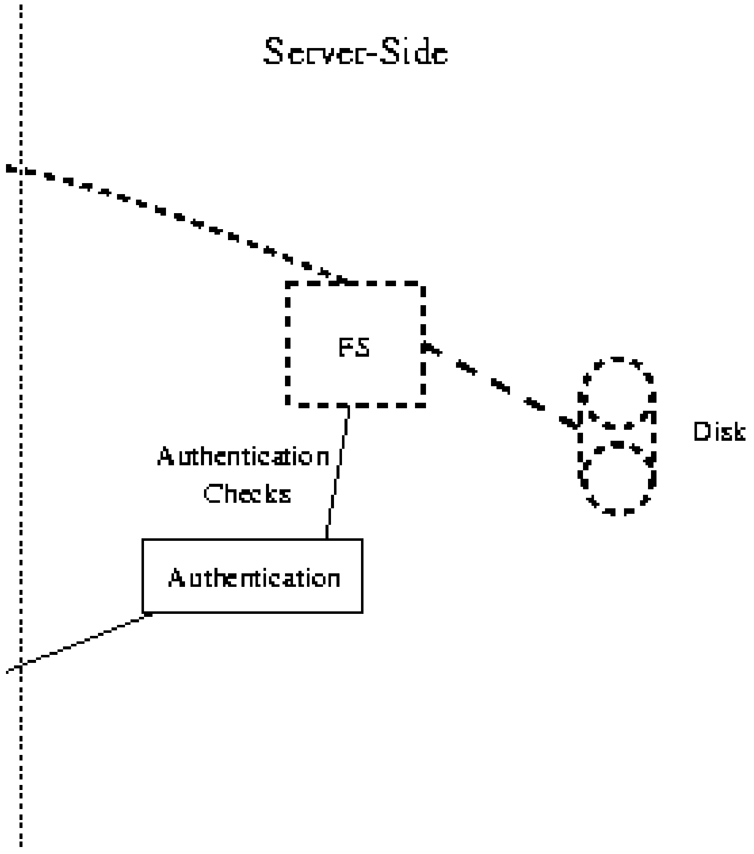
Client Daemon

•Cache per user agent

•Delayed-write-encryption policy for caching

•Delayed re-encryption for distributed re-encryption

Server-Side



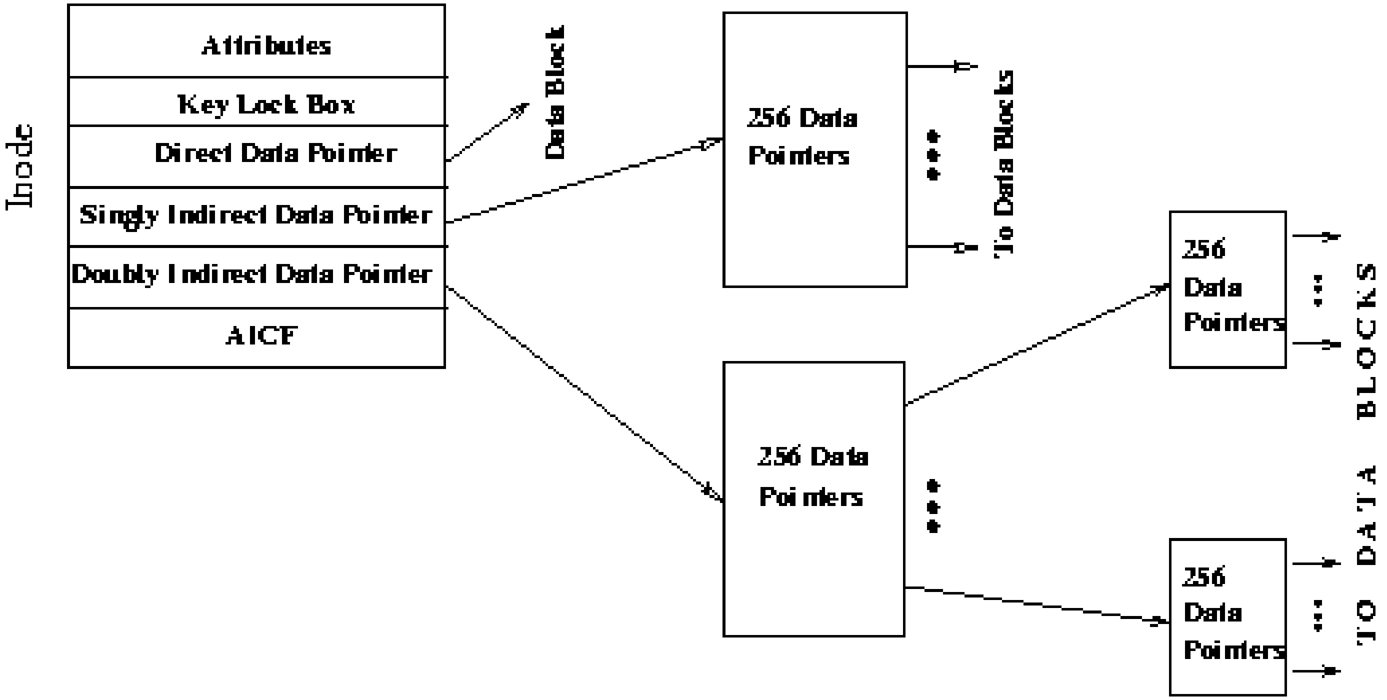
File Server

- Encrypted storage
- Hash tree structure beneath the inode for integrity

Authentication Server

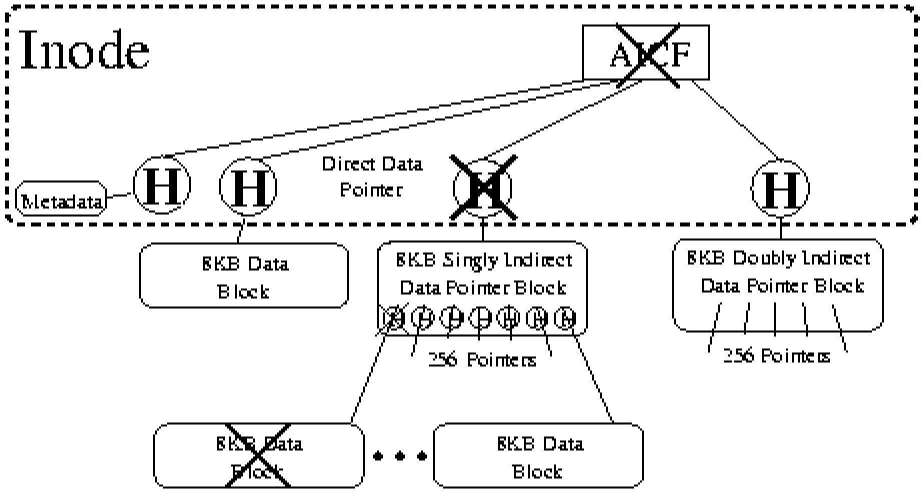
- Key distribution
- Key recovery

File Structures



Contents of a Data Pointer	4-Byte Disk Address	8-Byte Initialization Vector	20-Byte Cryptographic Hash

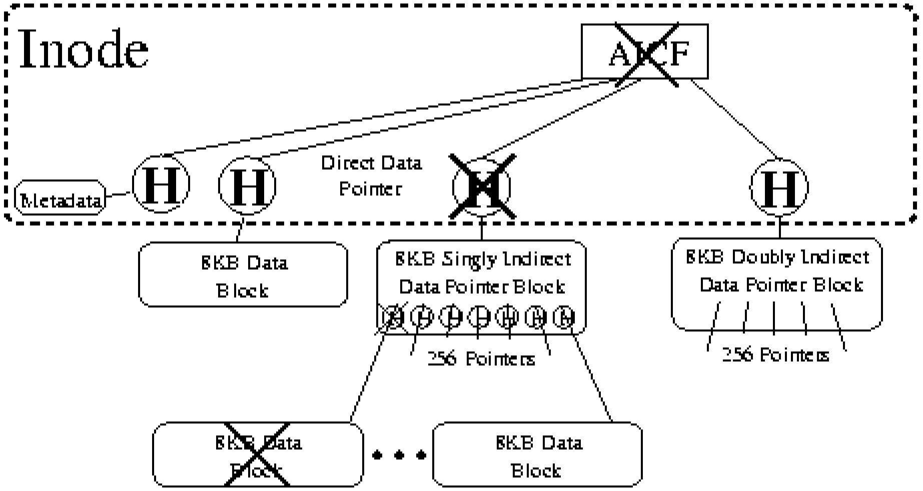
O(1) Sequential Read of a Block



- If block not cached, CD obtains ciphertext block from SD
- If block not decrypted, request UA to decrypt
- If hash path unauthenticated, compute hashes and AICF

Writes O(log n)

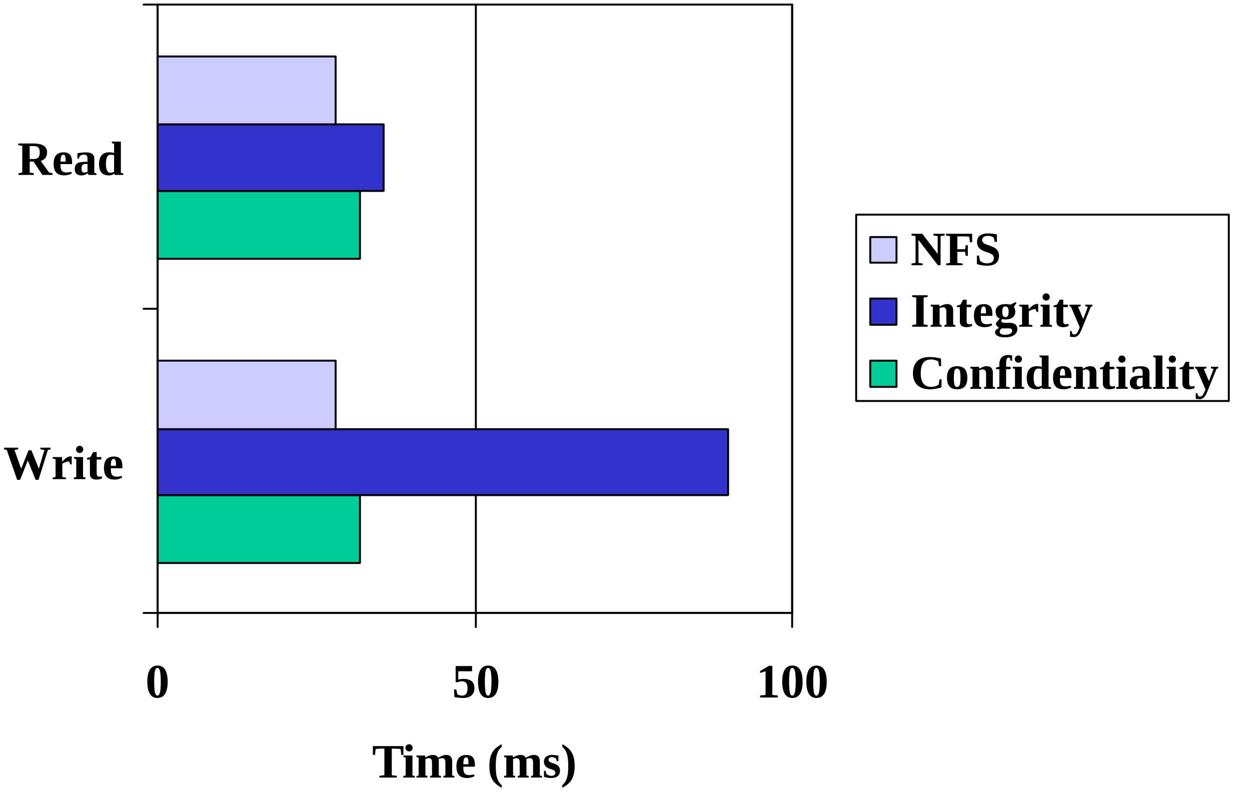
- CD writes plaintext block to cache, not SD
- When cache flushed:
  - Compute hash paths of dirty blocks.
  - Compute AICF
  - Write changed hash paths and AICF to SD
  - Encrypt, send to SD.



Integrity Failures

- When an integrity check fails, the client daemon refuses to serve the file (returns NFS_ERR_IO)
- User agent notified of integrity check failure
- Can attempt recovery of file via user agent

Performance Results



Conclusions

- Provides efficient random access to confidential, integrity-protected data
- Enables secure group sharing
- Uses a well-understood file system interface
- Surveys a wide range of cryptographic storage file systems

Anticipated Q/A