Secure Storage Systems and Key Technologies

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Outline

- Research Background
- Design Criteria of Secure Storage
- Basic Technologies
- Extended Technologies

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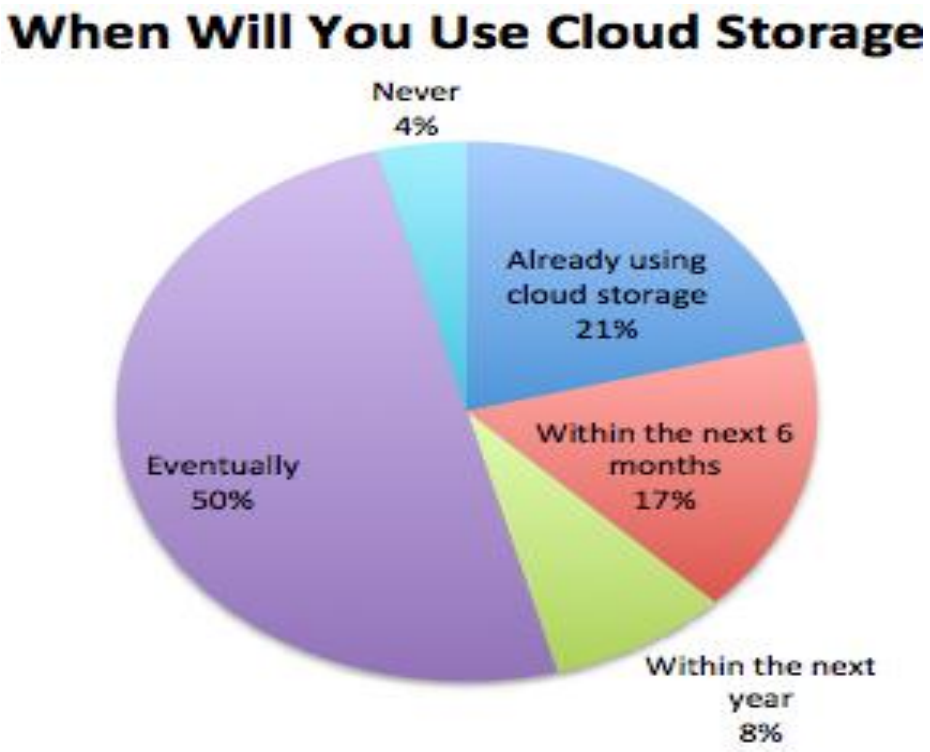
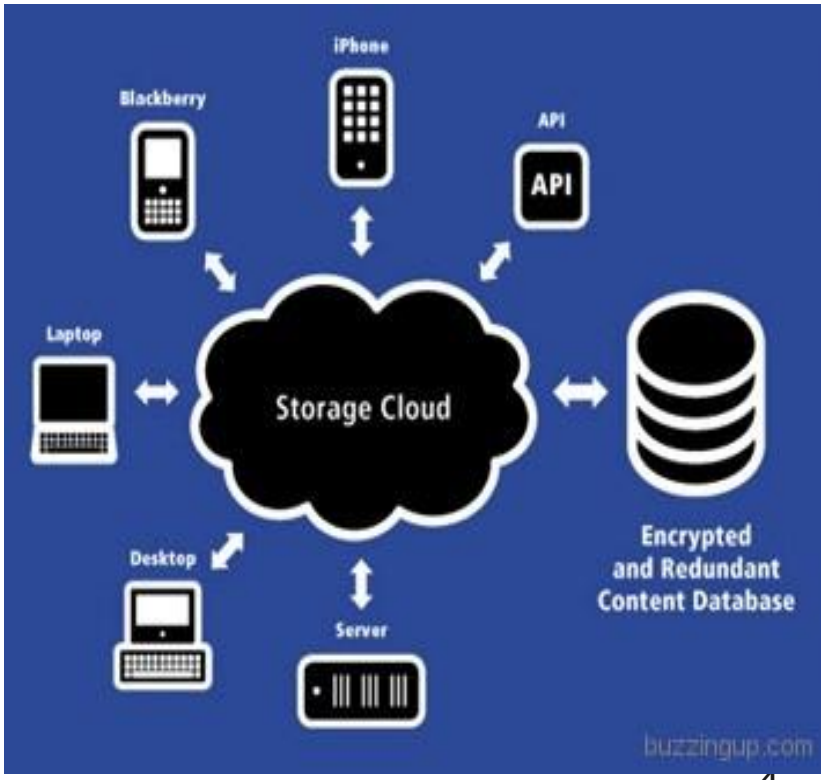
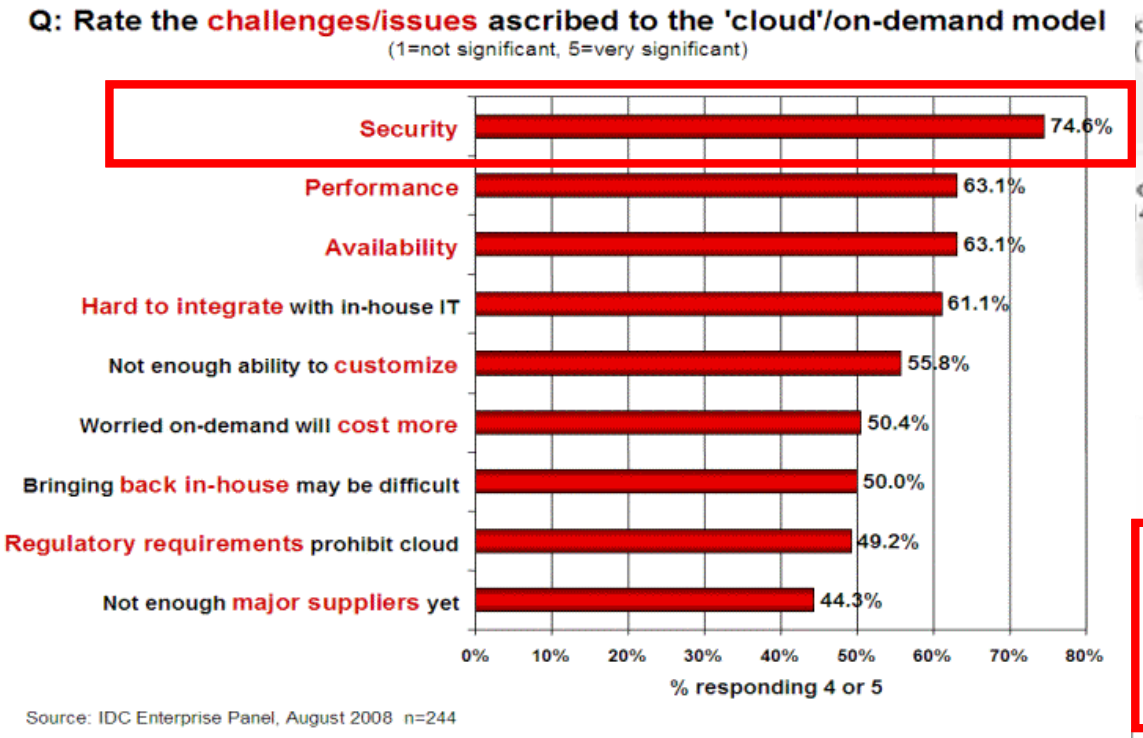
Research Background

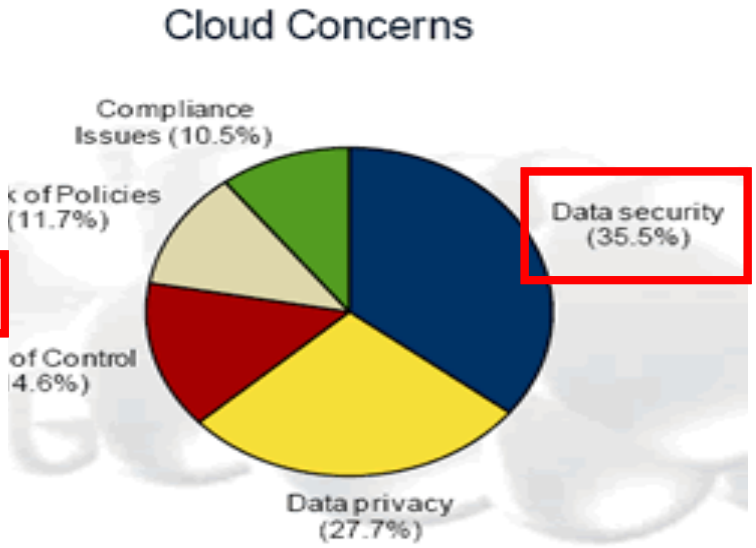




Cloud storage service is widely adopted.

Research Background





Concerns of data security in the cloud are aroused !!

Research Background

How to securely store data in the cloud?

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Design Criteria of Secure Storage

- **Confidentiality**
  - Data information are secret against the unauthorized access
- **Integrity**
  - Unpermitted Modification Prevention
  - Unpermitted Modification Detection
- **Availability**
  - An authorized user can execute a data operation within an acceptable period of time
- **Performance and Others**

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Basic Technologies- Secret Key Distribution

Data are encrypted, how to distribute keys?

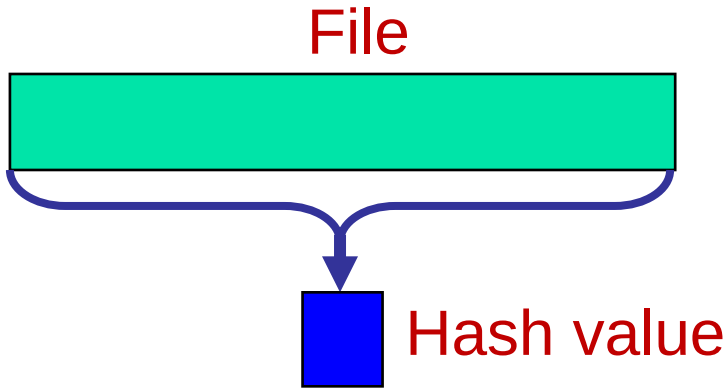
- **Servers-dominated schemes**
  - Need to fully trust servers
  - Inadequate when servers are untrusted
- **Owner-dominated schemes**
  - Owners should always online
  - Incur huge management burden
- **Trusted-third-party-dominated schemes**
  - Avoid putting complete trust on servers
  - Save data owners from burdensome management

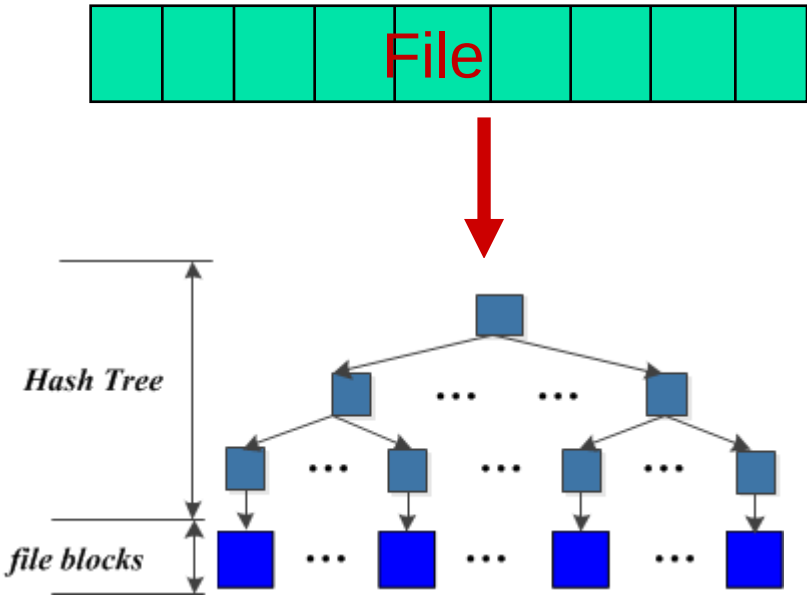
Basic Technologies- Access Control

- **Public/private keys**
  - Writer- private key, reader- public key
  - Asymmetric operations, cost expensive
- **ACL + symmetric keys**
  - Writer gets more keys to append signature
  - ACL recodes all users and is stored in metadata file
- **ACL + public/private keys**
  - Employ user's public key to encrypt file block key
  - Reduce the amount of keys to manage for clients
  - E.g., ACL only recodes the writers in FARSITE

Basic Technologies- Integrity Checking

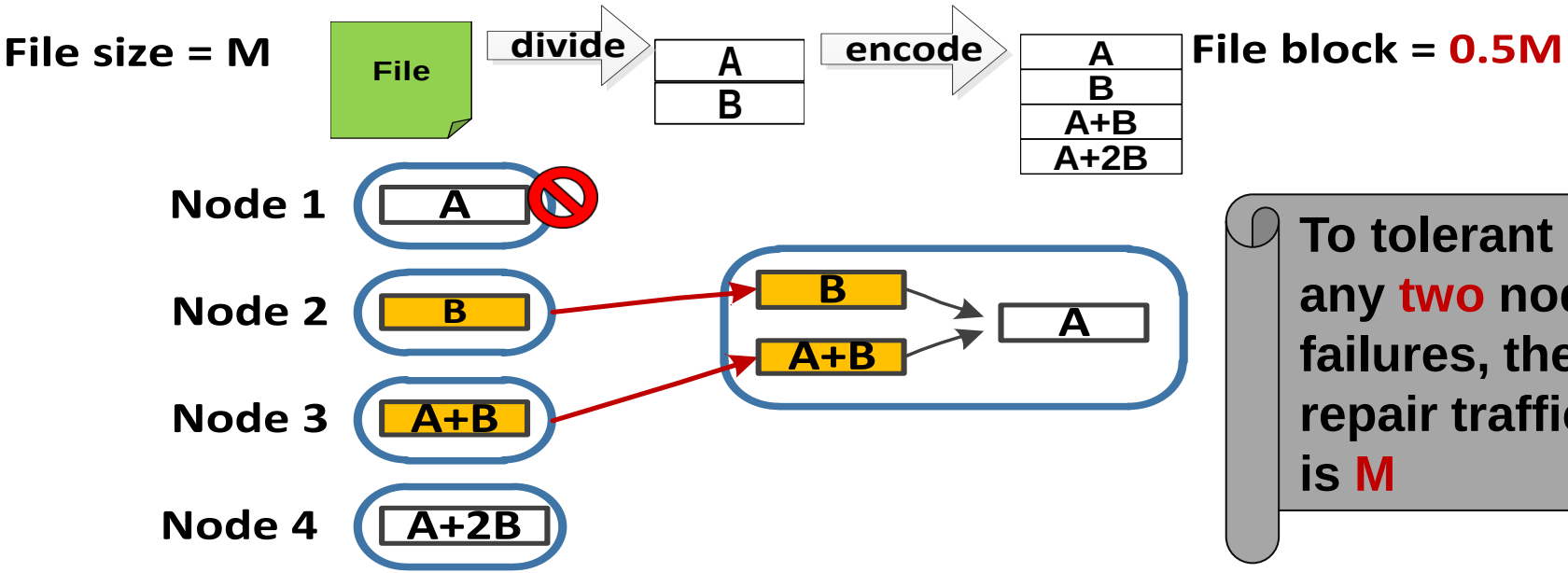
- **Calculate the hash value H_i for file F_i**
  - Convenient but not efficient
  - Every access demands the re-calculation of H
- **Construct Hash Tree**
  - Partition the files into many file blocks
  - Construct Hash Tree based on the integrity information of file blocks
  - Access/Update Complexity is O(log N)





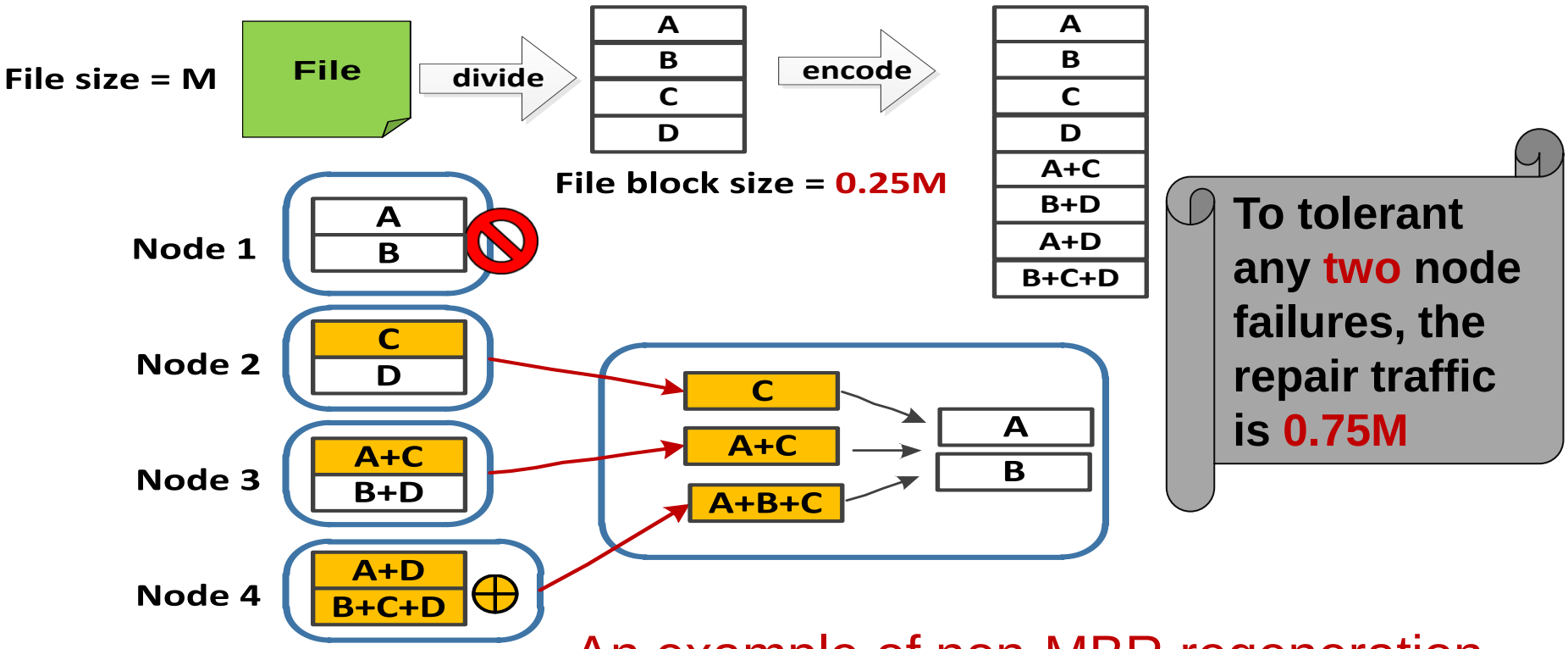
Basic Technologies- Availability Assurance

- **Replication**
  - Storage Cost: tM, Repair Traffic: *M*
  - Fault tolerance: any (t-1) failures of files
- **(n-k) Erasure-Code**
  - Storage Cost: nM/k, Repair Traffic: *M*
  - Fault tolerance: any k failures of file blocks



Basic Technologies- Availability Assurance

- **Regenerating Codes (MBR)**
  - Storage Cost = Repair Traffic = [(2n-2)M]/[(2n-k-1)k]
  - Fault tolerance: any k failures of file blocks
  - Balance storage cost and network traffic

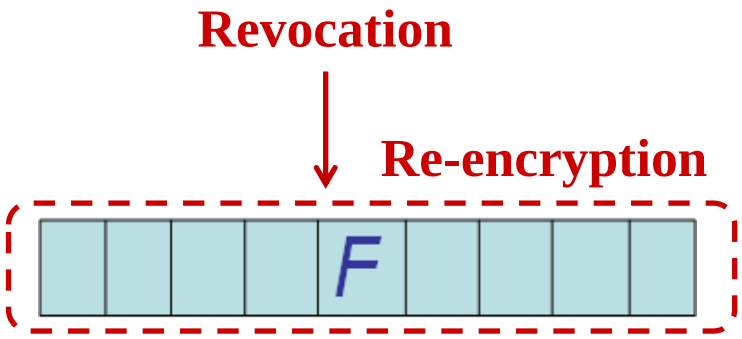


An example of non-MBR regeneration

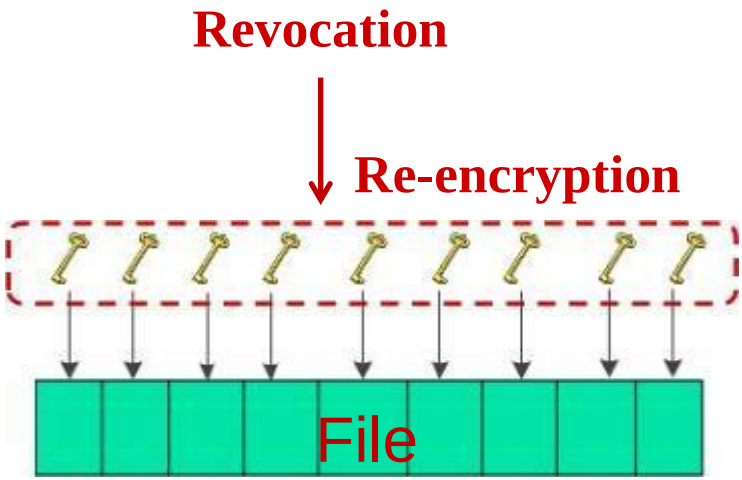
Basic Technologies- Permission Revocation

When a user's permission is revoked…

- **Aggressive revocation**
  - Regenerate new keys and perform re-encryption for the involved files
  - Timely but expensive



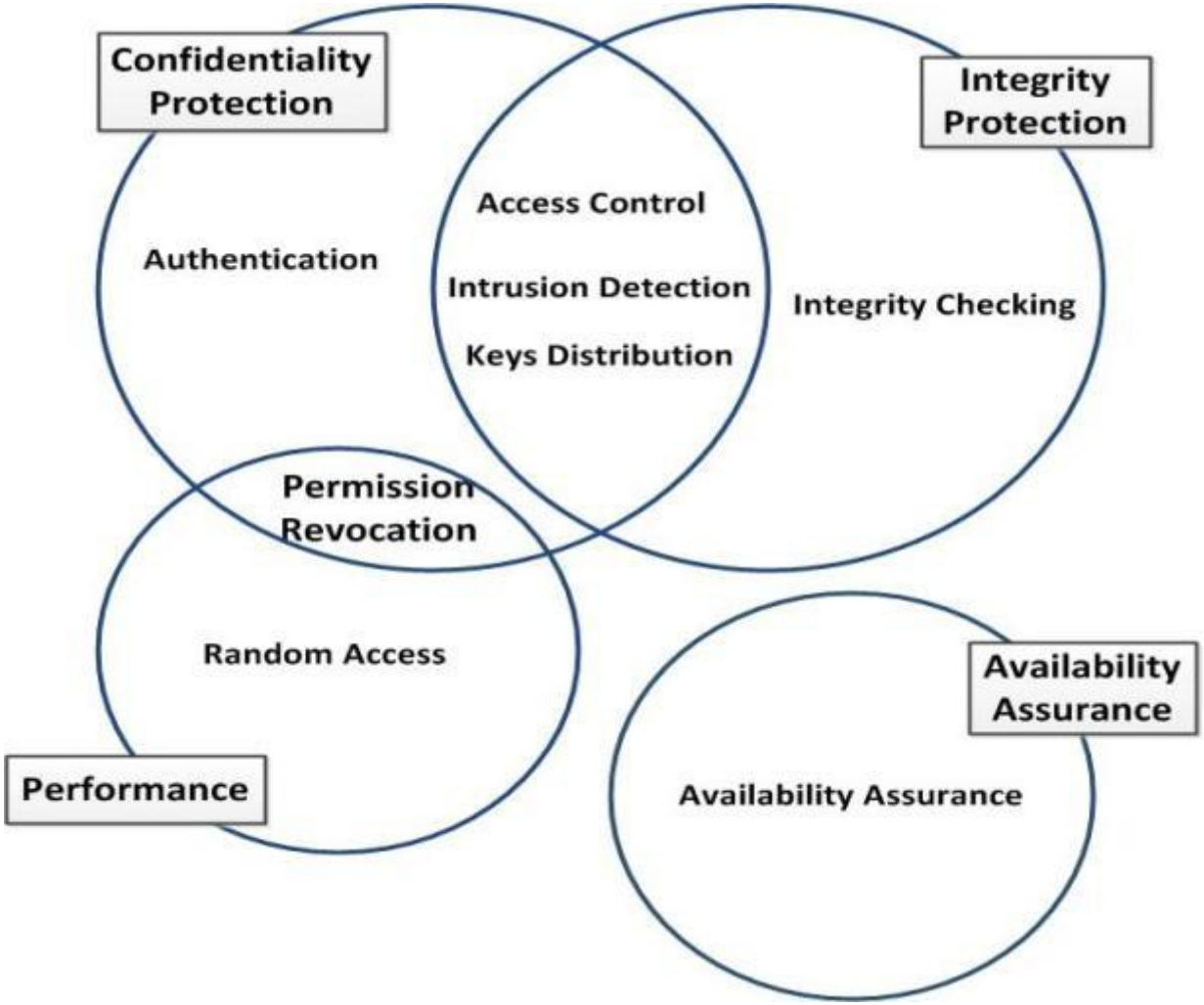
- **Lazy Revocation**
  - The revoked user can still read the unchanged files after the revocation
  - Defer the re-encryption to the update of the involved files
  - Complex management: e.g., key versions



Basic Technologies- Others

- **Authentication**
  - Authentication is the first guard to prevent unauthorized user's illegal operations
  - Authentication in cloud storage system can simply classify as public-key-infrastructure-based and user ID with authentication-key-pairs-based authentication
- **Storage-based Intrusion Detection System**
  - Storage-based intrusion detection system (SIDS) is a significant part of intrusion detection system (IDS)
  - SIDS usually deploy in storage device
  - SIDS is usually workable even if the host is invaded, it is very suitable for cloud storage server

Basic Technologies- Summary



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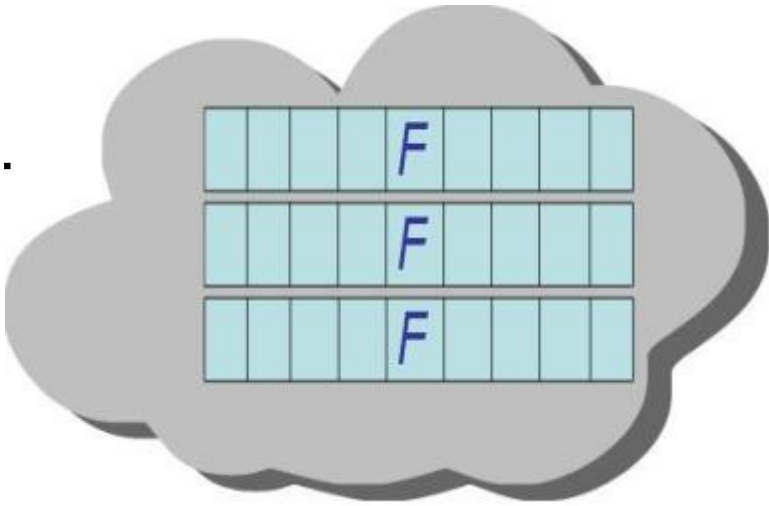
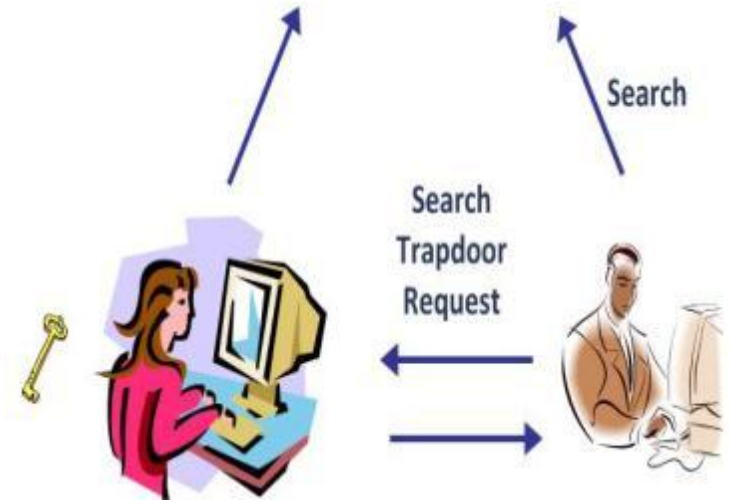
Extended Technologies- Searchable Encryption

Data are stored in encrypted form, when a user plans to find some files…

- **A Straight Forward Way**
  - Download and decrypt all the files
  - Perform search on plaintext
  - Huge cost for unneeded files



- **Searchable Encryption**
  - Users ask owner for search trapdoor
  - Cloud server performs search based on the trapdoor
  - Efficient and secure



File Sharing

Extended Technologies- Searchable Encryption

- **Research status of Searchable Encryption**
  - Single keyword search support

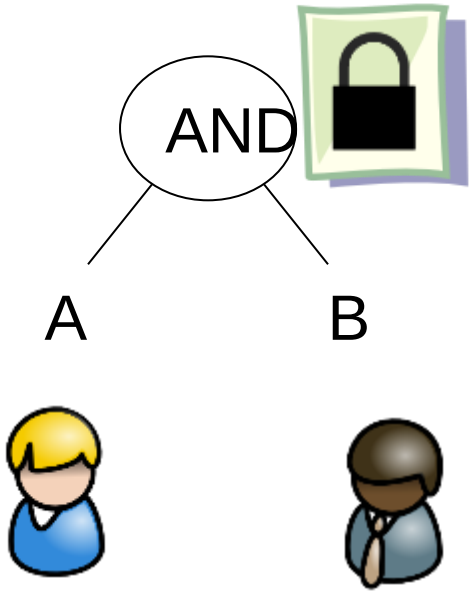
    “conference=A”
  - Conjunctive query support:
    “(name=Alice)and(age=20)”
  - Logical query support over multiple keyword fields:
    “(name=Alice or Bob)and(age=20or16)”
  - Ranked keyword search

    return the top-k relevant results
  - Similar keyword search

    “*lice”→”Alice”,”Blice”,…,”Zlice”,”lice”

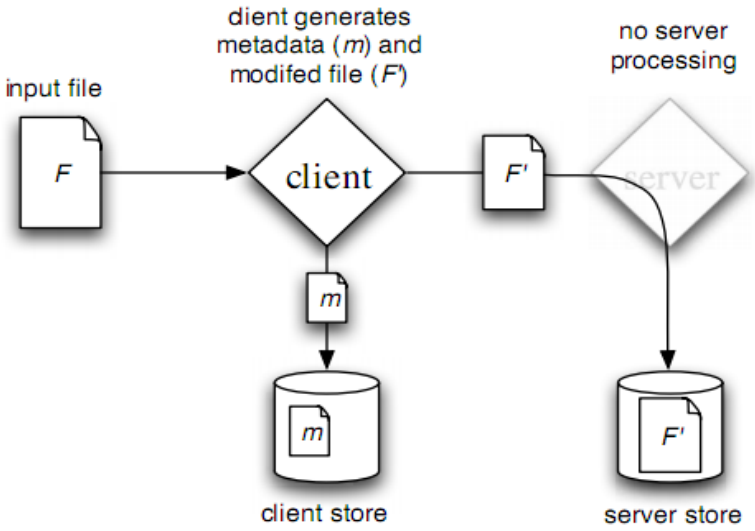
Extended Technologies- Attribute-based Encryption

- **Motivation**
  - Every user has to manage massive keys in the cloud
  - Neither flexible (number of keys), nor convenient (online distribute keys)
- **Use attributes as the keys**
  - Attribute: age, profession, etc
  - Flexible (only attribute keys), convenient (offline access)
  - Flexible access control mechanism: ‘and’, ‘or’, ‘in’ gates

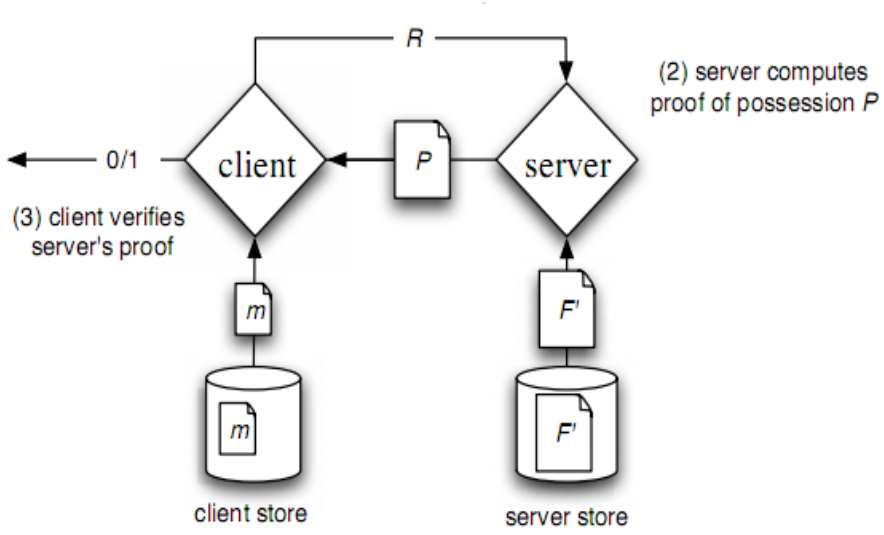


Extended Technologies- Data Audit

- **Provable Data Possession (PDP)**
  - PDP scheme enable users to checking outsourced data's integrity with low computation and communication cost
  - PDP can category as basic PDP, DPDP, and MR-PDP
  - Use Third-Part Auditor (TPA) to provide public verifiability and batch verifiability mechanism



(a) Pre-process and store



(b) Verify server possession

Extended Technologies- Data Audit

- **Proof of Retrievability (POR)**
  - POR scheme can simple consider as two parts: verification and recover
  - POR's verification part is assemble as PDP's
  - POR's recover part usually utilize reliability technologies, such as replication, erase code, network code, and so on
- **Data Provenance Auditing**
  - Provenance can be consider as the information that helps cloud storage to describe the derivation history of data
  - Auditing provenance could analysis the origin of the cloud data, which is crucial in multiple user cooperative work system

Extended Technologies- Data Assured Deletion

- **Data Assured Deletion**
  - Assured Deletion is that cloud data would become completely unretrievability after the certain condition
  - Fade utilizing a third party to manage keys and provide policy-based assured deletion mechanism
  - Vanish utilizing the special feature of DHT network, implement a time-based assured delete mechanism on the email scenario
- **Secure Data Deduplication**
  - Traditional data deduplication mechanisms may cause some security problems
  - Data encryption has increased the difficulty of data deduplication

Thank you!