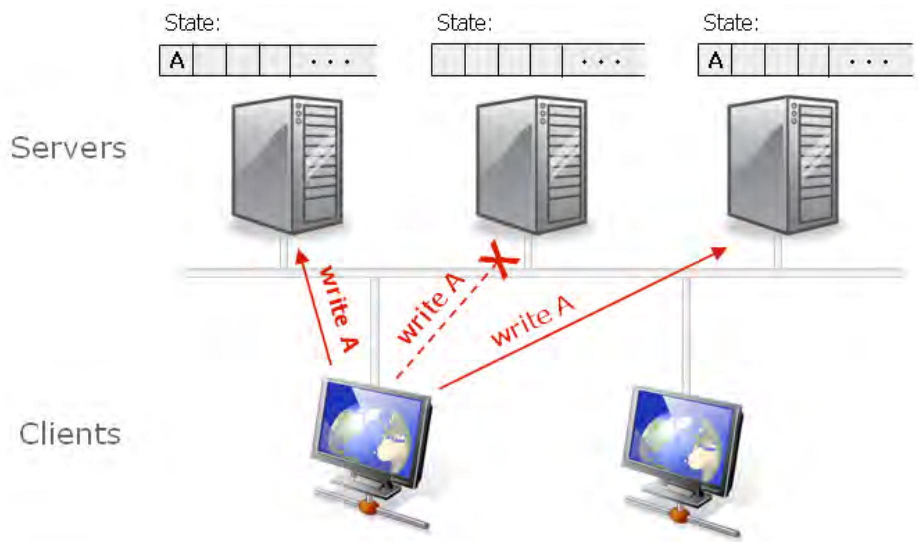

Security of Online Information

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MIT CSAIL

March 2009

The Vision

- All information of interest will be
  - Stored online
  - Accessible from anywhere
  - Persistent
  - Sharable
  - Easy to locate/query/use

Examples

- All your files
- Medical records
- Corporate data
- Scientific data

Scenario 1

- All my data from any device
  - Laptop, pc, telephone, kiosk, ...

- Saved automatically
- Uploaded as needed
- Automatic archive/backup
- Controlled sharing

Scenario 2

- Medical records
  - From many hospitals
  - Available everywhere
  - Access control and privacy

Storage System Requirements

- Scalability
- Performance
- Security, Security, Security

Security

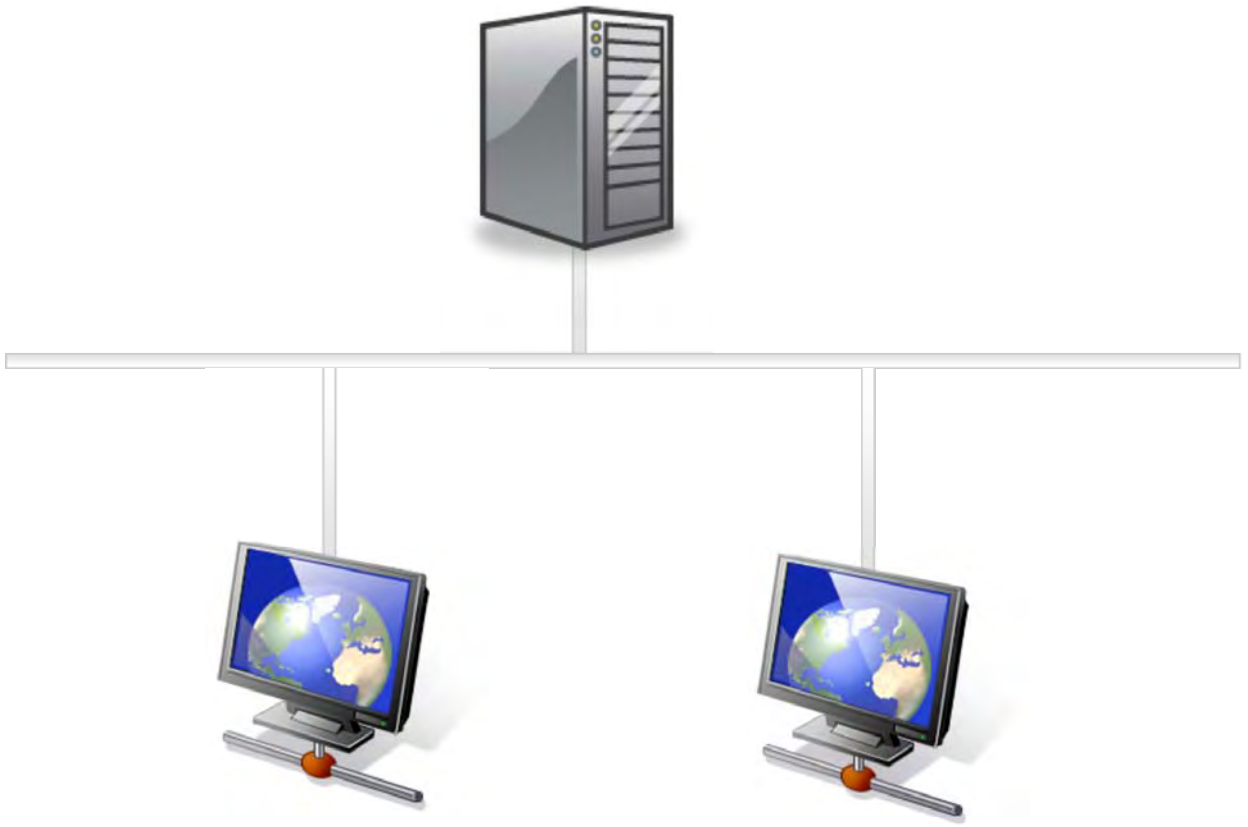
- Confidentiality
- Integrity

Security

- Confidentiality
- Integrity
- Reliability (information isn't lost)
- Availability (information available 24/7)

- Reliability and availability require replication

Single Server



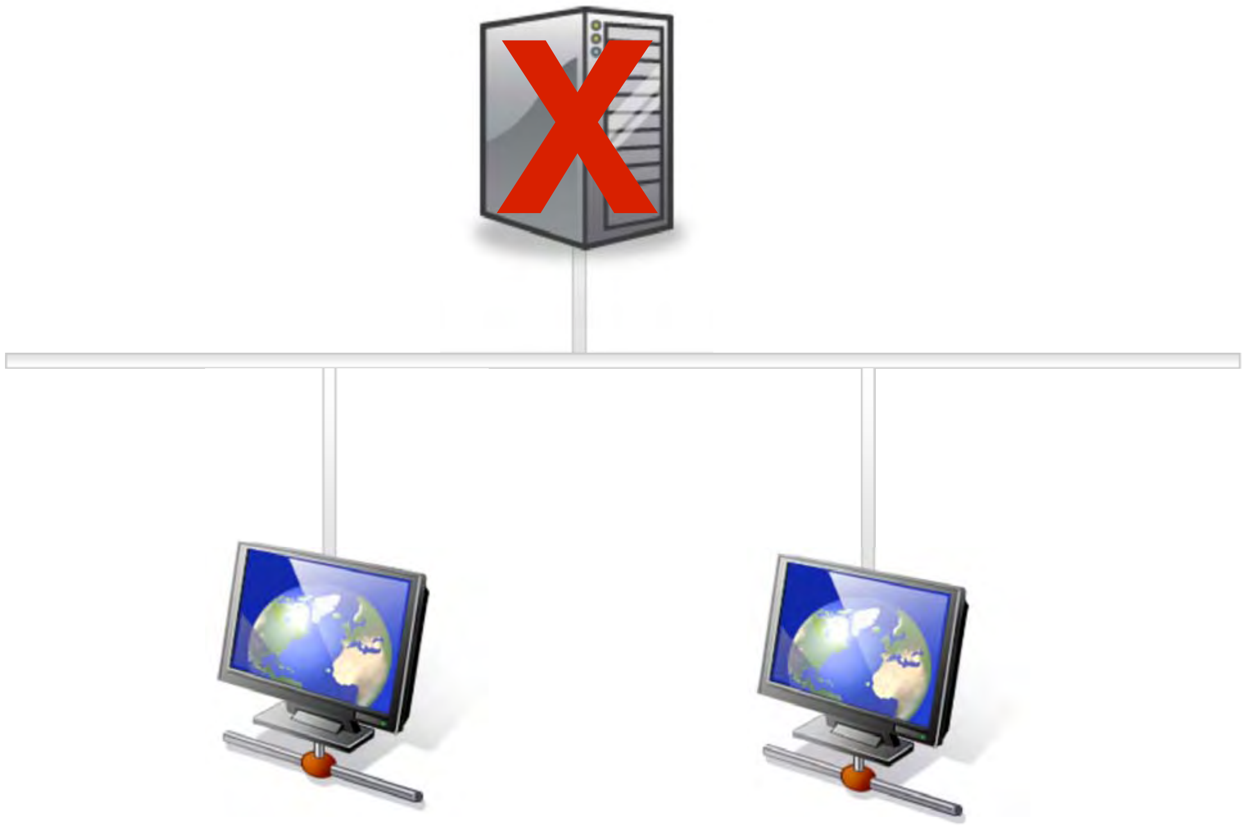
Server

Clients

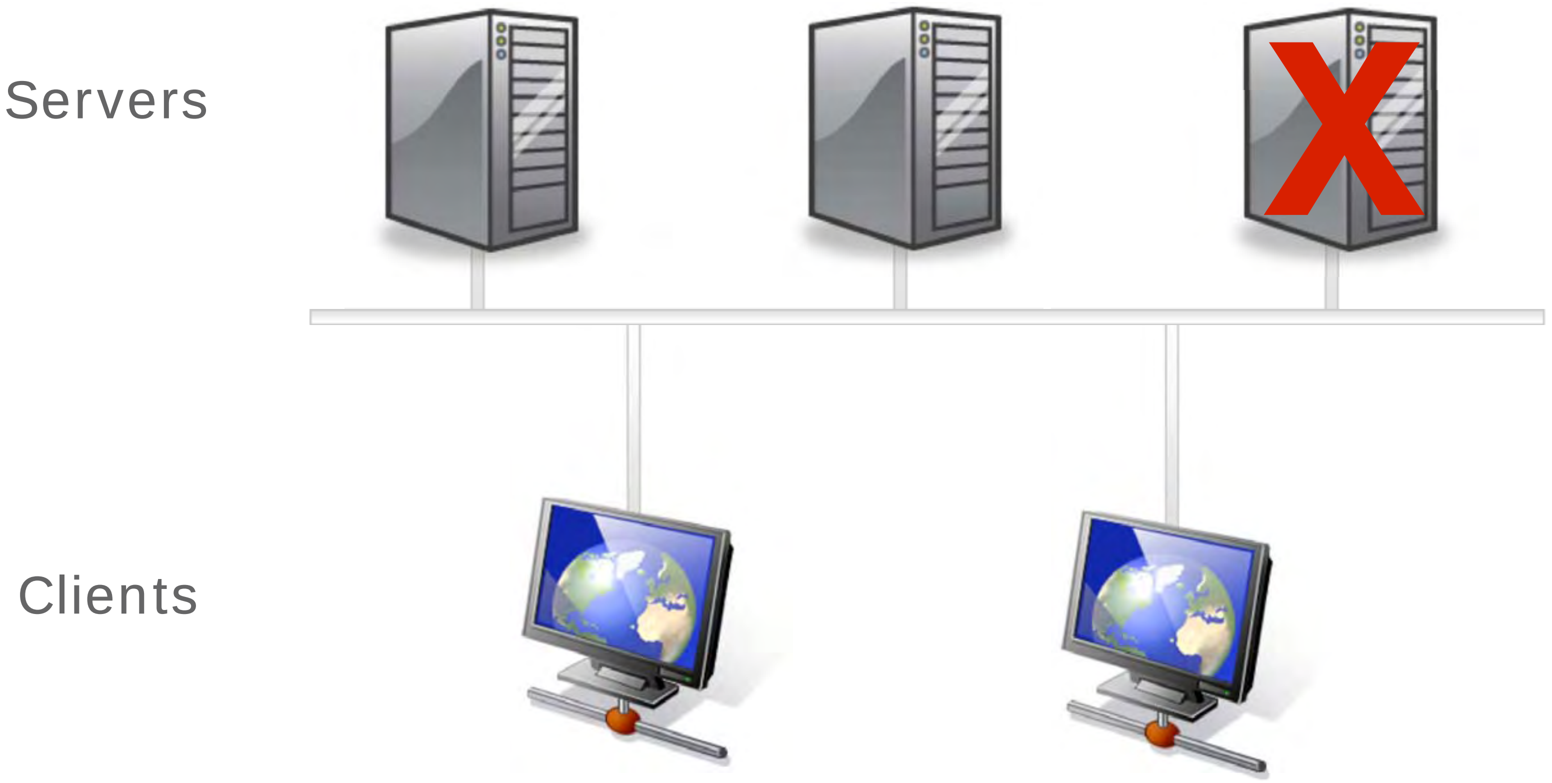
Single Server

Server

Clients



Replicated Servers



Servers

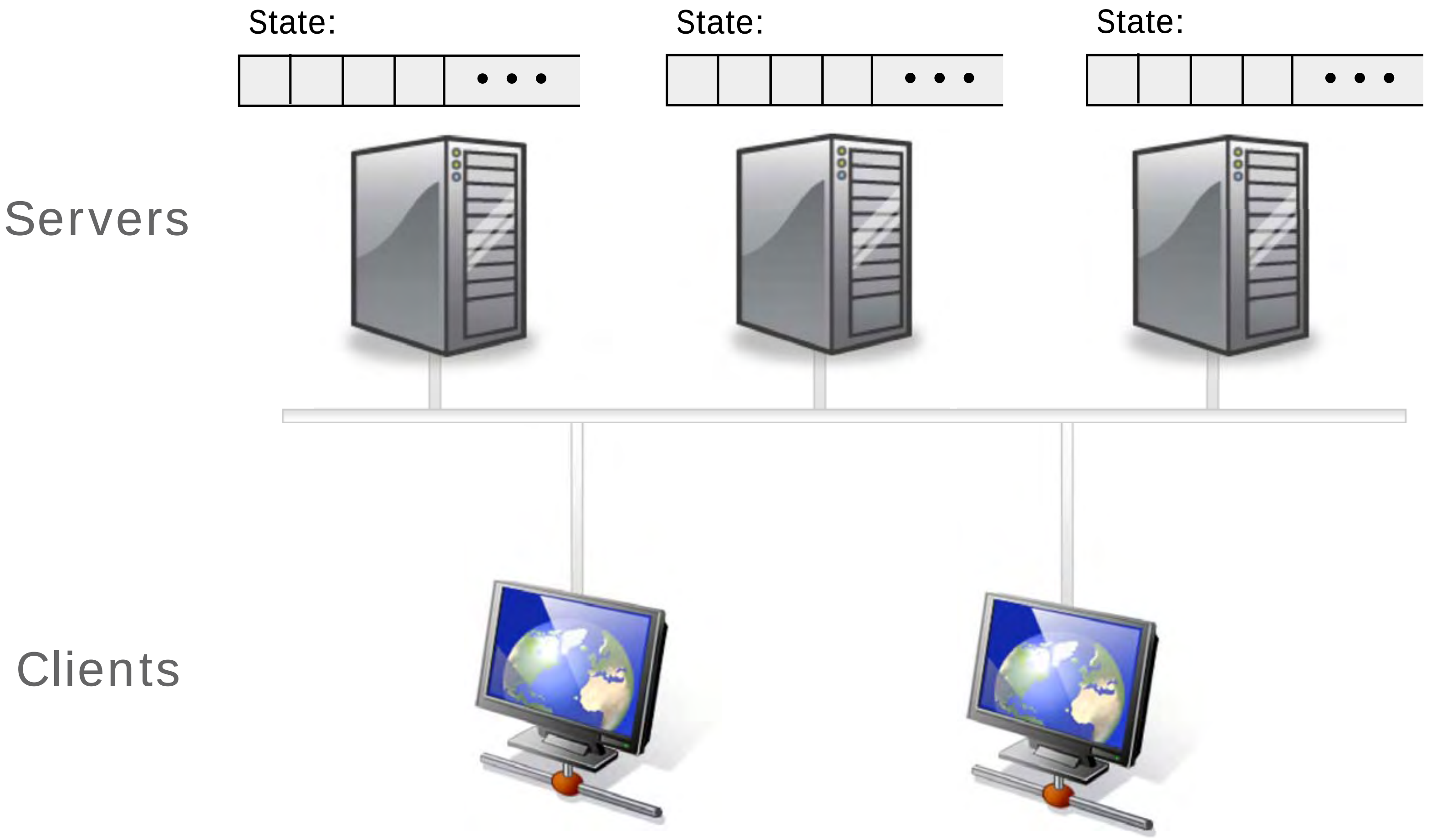
Clients

Replication Protocols

- Goal: information is preserved and accessible in spite of failures
  - Network failures
  - Machine failures

- Benign failures
- Byzantine failures

Replication



State:

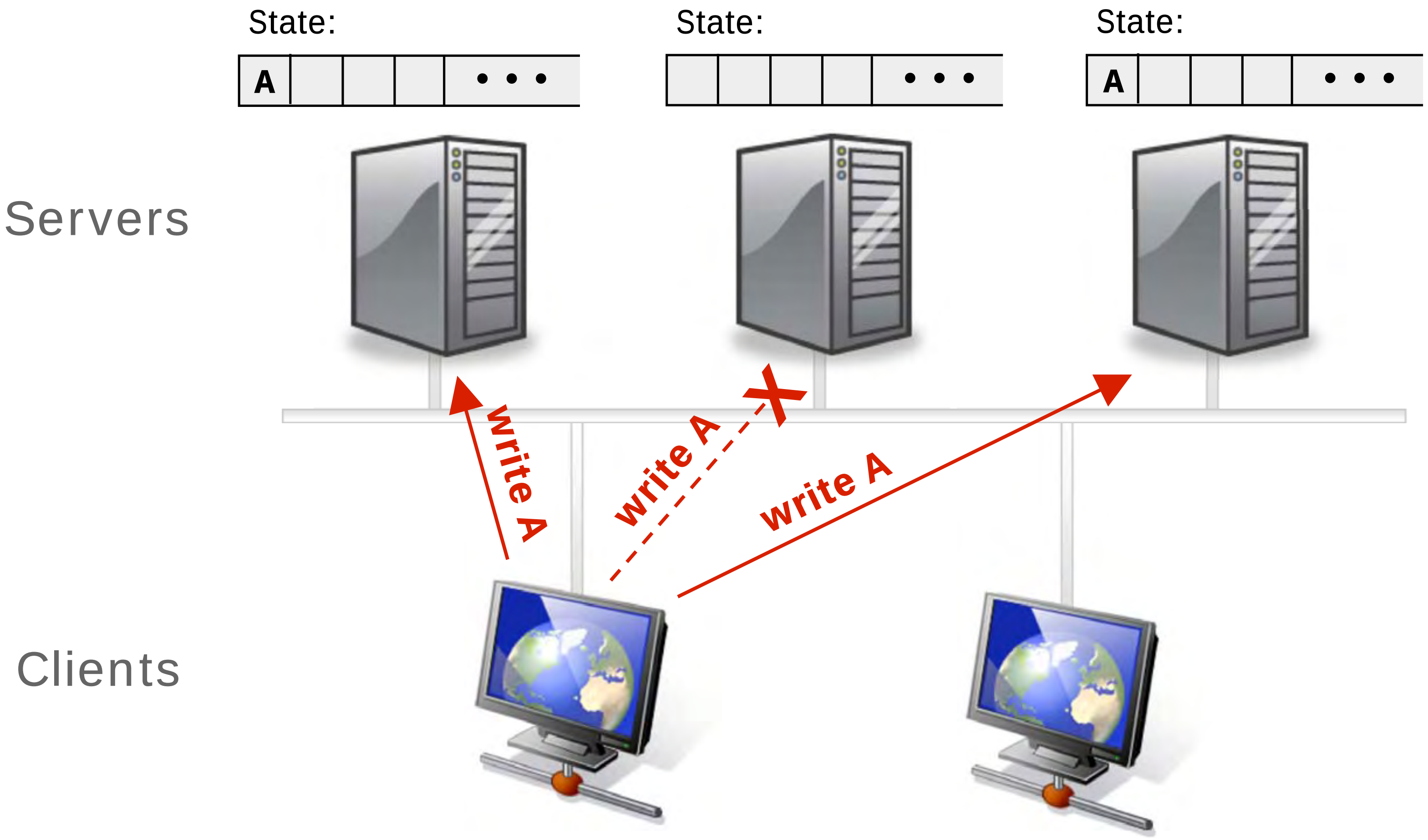
State:

State:

Servers

Clients

Replication



State:

A				• • •

State:

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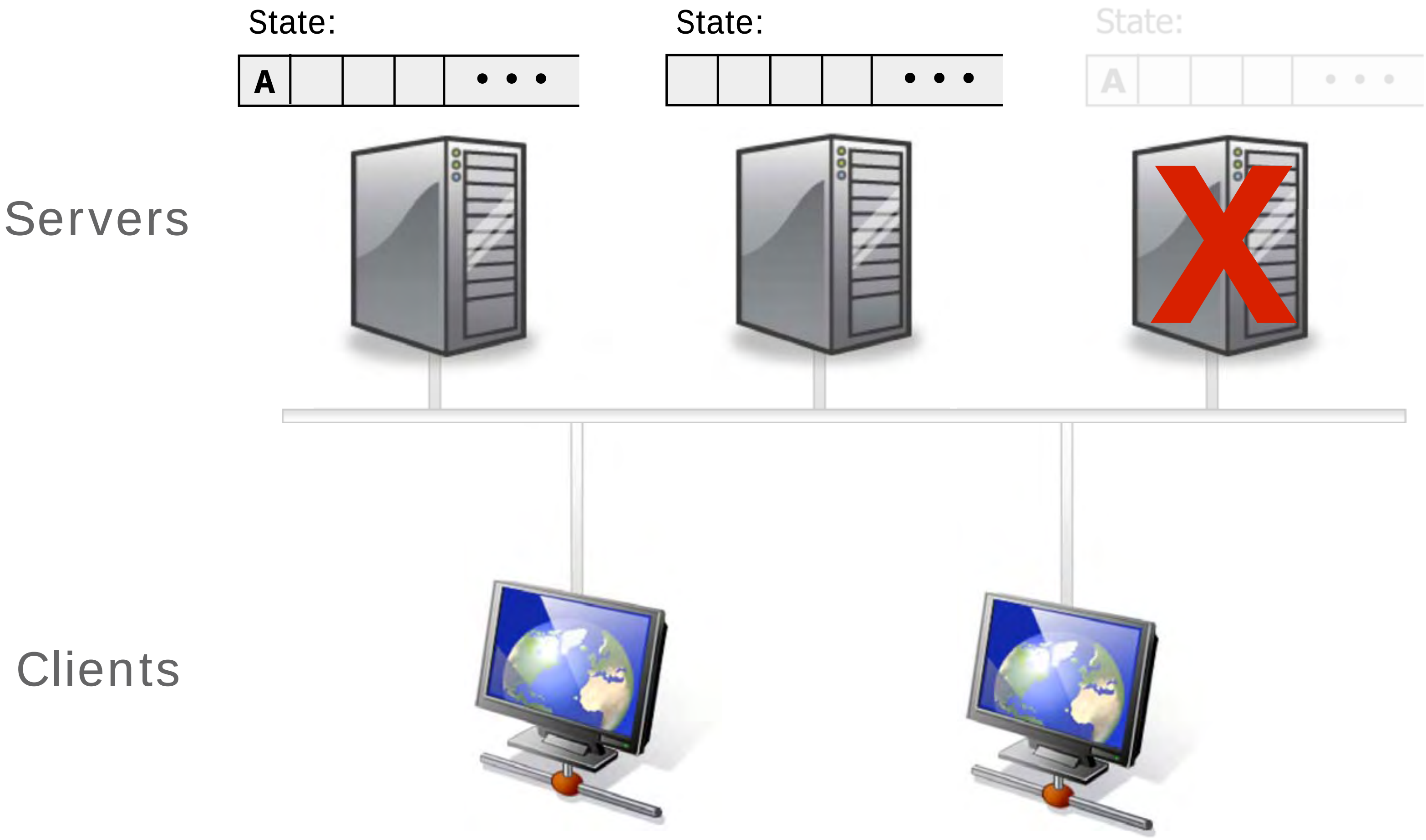
State:

A				• • •

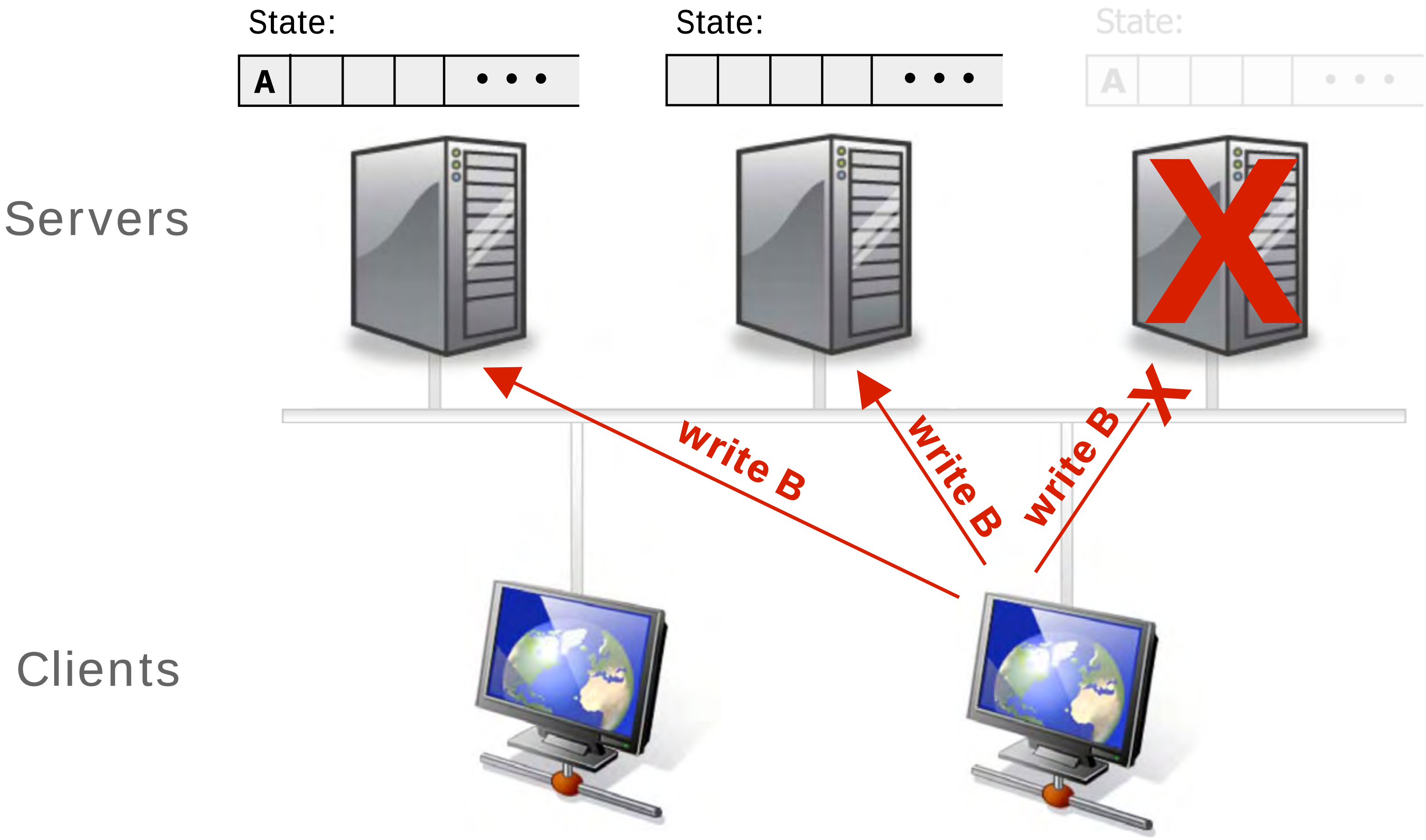
Servers

Clients

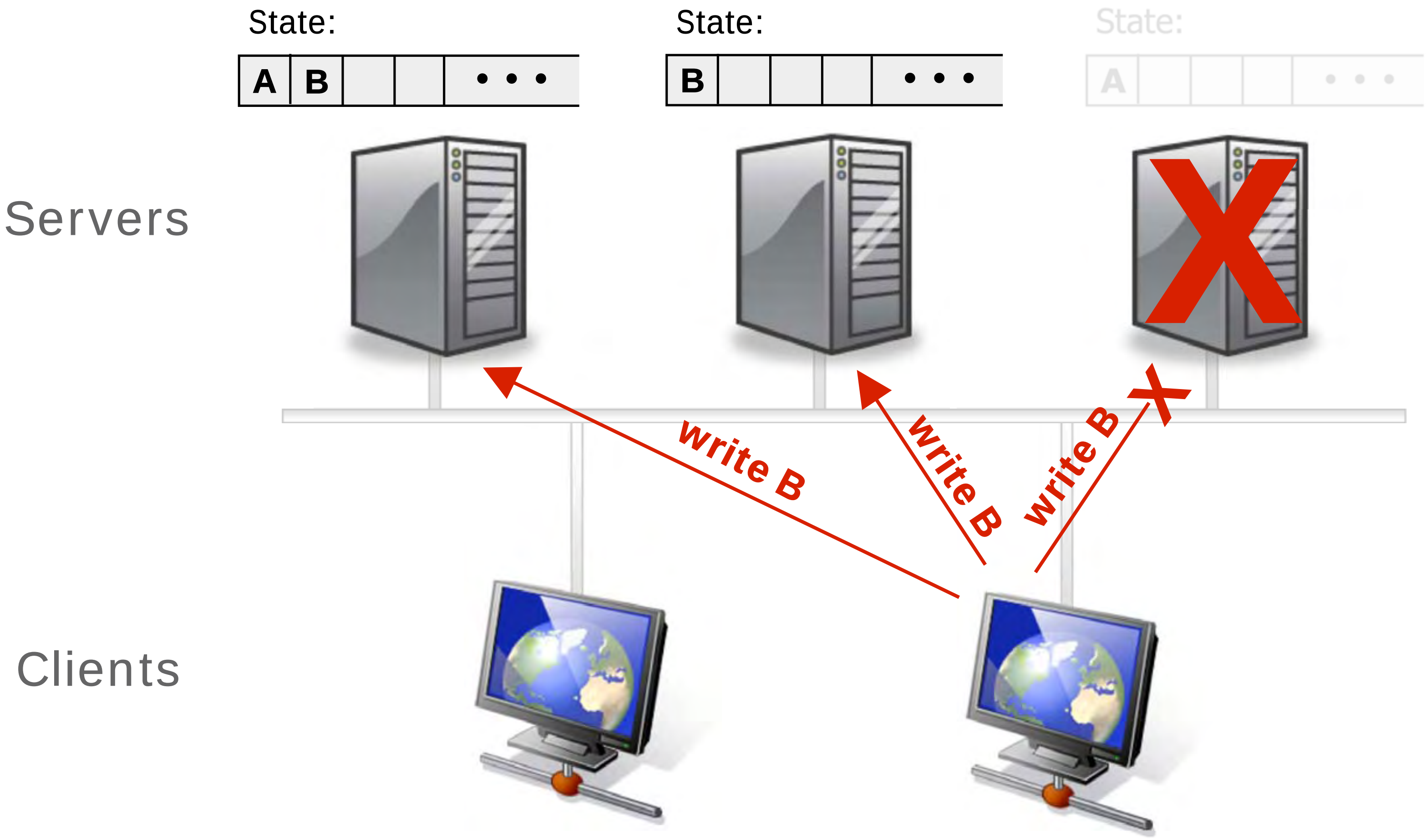
Replication



Replication



Replication



State: A B • • •

State: B • • •

State: A • • •

Servers

Clients

Ordering Solution

- Use a primary
  - It orders the operations
  - Other replicas obey this order

Ordering Solution

- Use a primary
  - It orders the operations
  - Other replicas obey this order
- BUT: the primary might fail
  - Replicas watch the primary and elect a new one if it fails

Issues

- Insuring correct behavior
  - Dealing with all possibilities
- Handling node recovery
- Providing competitive performance

Timeline

- 1987-1992: protocols developed
- > 2000: use in industry

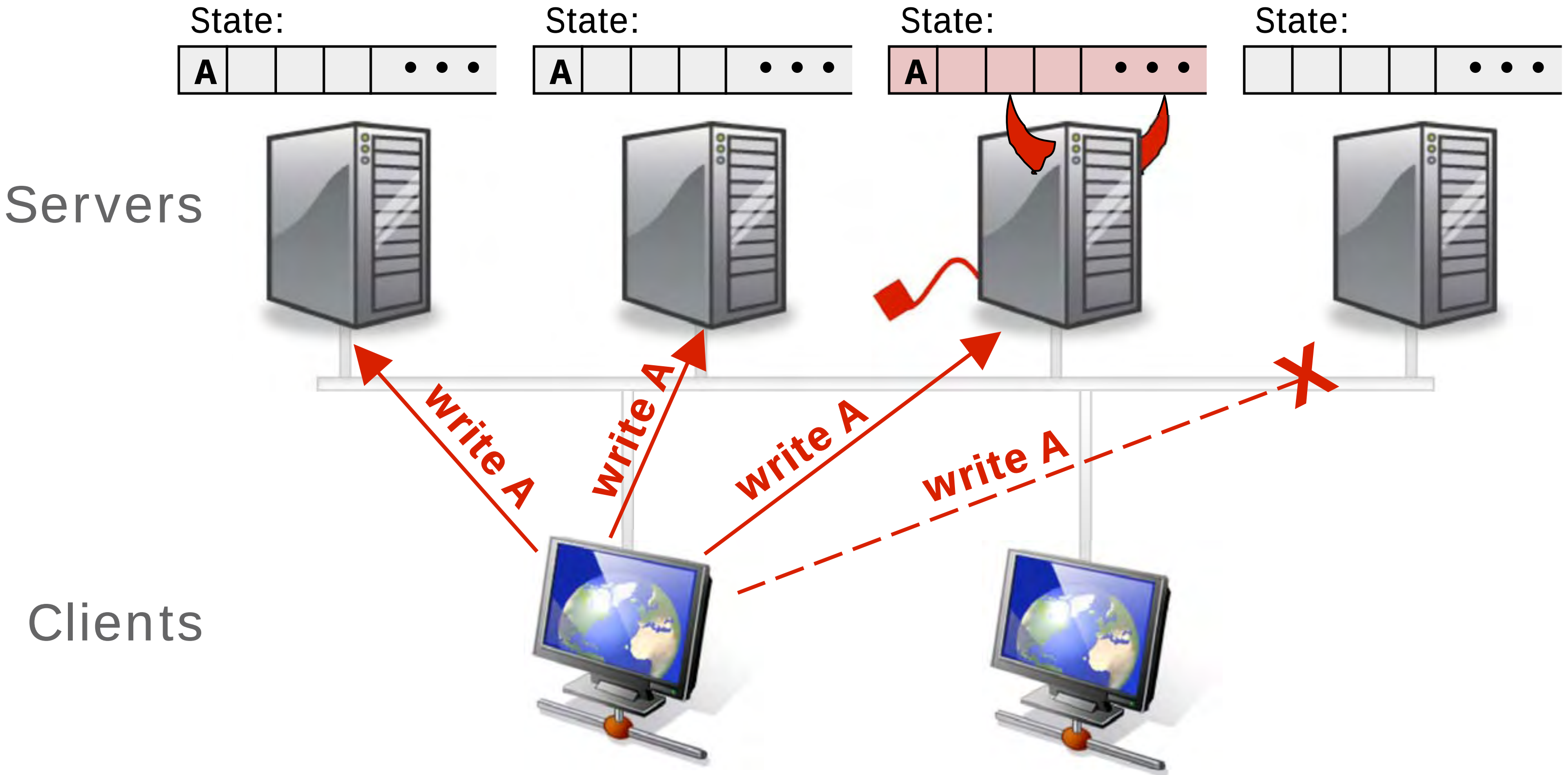
- 1996 approximately: more challenging failure models

Byzantine Failures

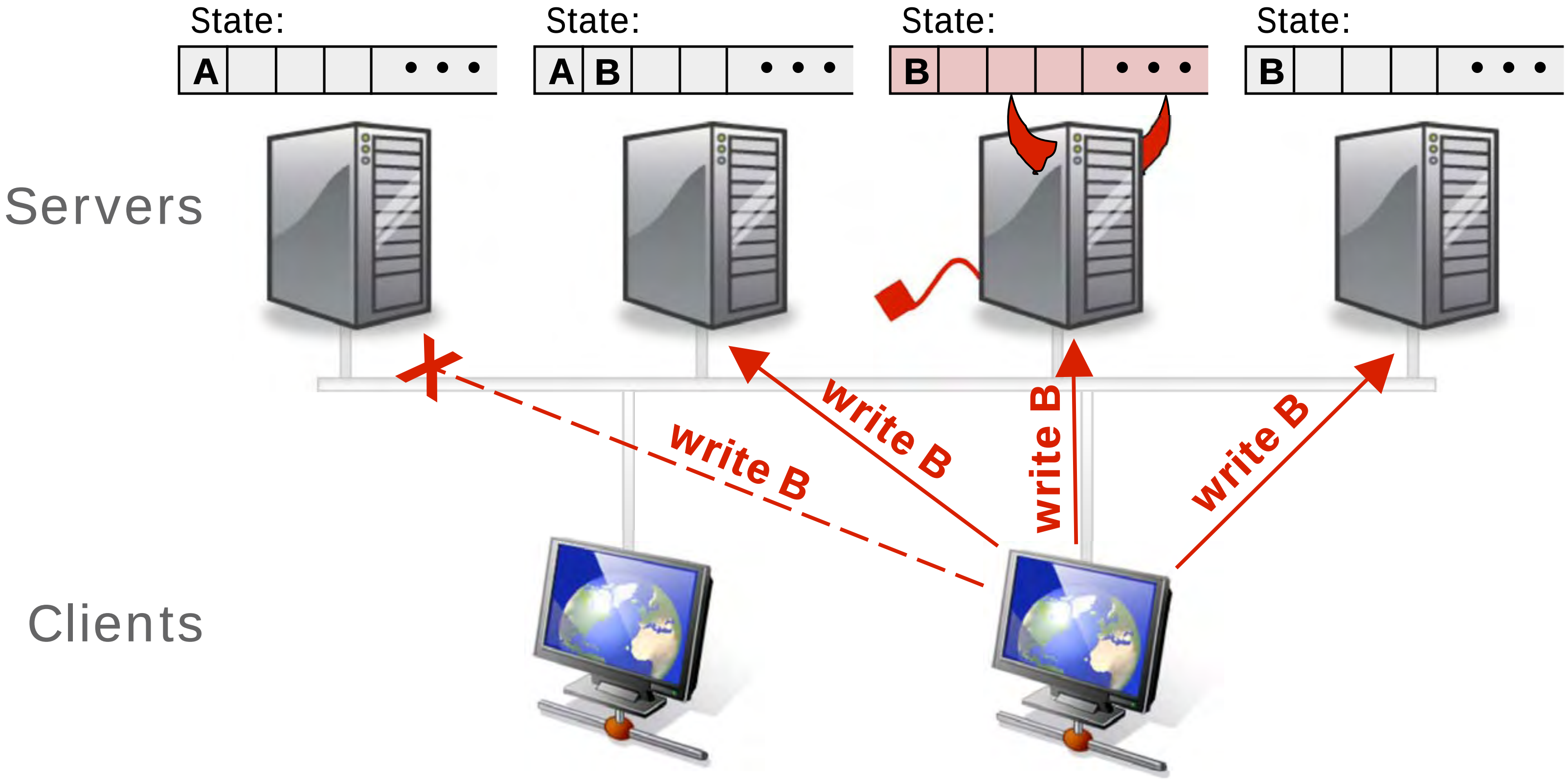
- Machines fail arbitrarily
  - They lie
  - They collude

- Causes
  - Malicious attacks
  - Software errors

Byzantine Behavior



Byzantine Behavior



Strategy

- The same!

- Key difference: replicas might lie
  - More replicas
  - More messages

Where next?

- 1996-2002: BFT
- Replication
  - Better protocols
  - Scaling up
- Other security issues
  - Integrity
  - Confidentiality