

# Concepts of Distributed Systems

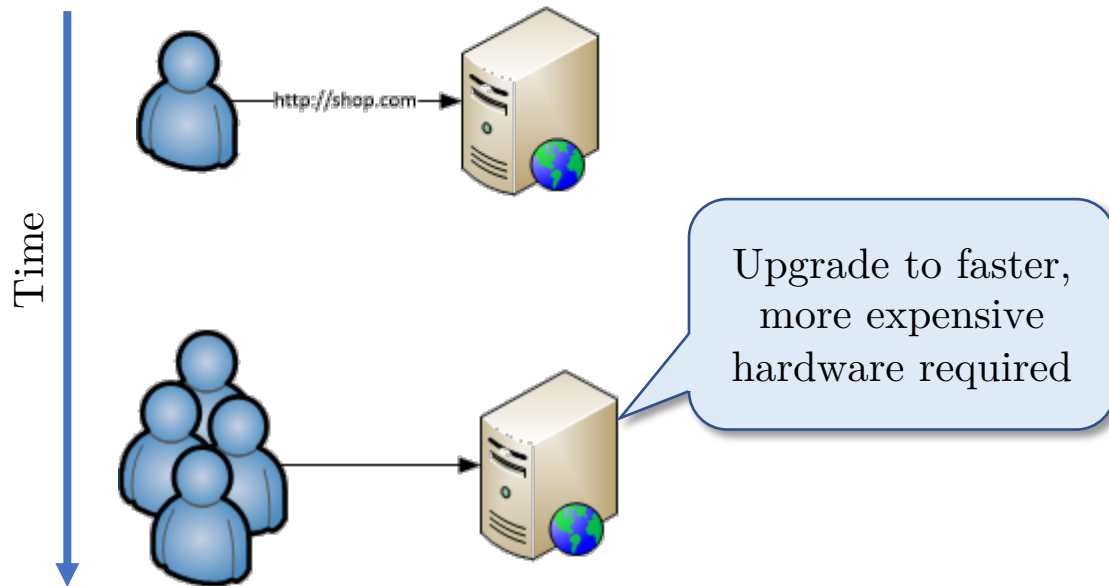
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- Evolution of computer system's architecture
  - Centralized system
  - Distributed system
- Definition of distributed computing and its challenges
- Describe use-case of course application

## Definition

Centralized systems leverage client-server architecture, where multiple clients are directly connected to a single server, which handles all their requests.

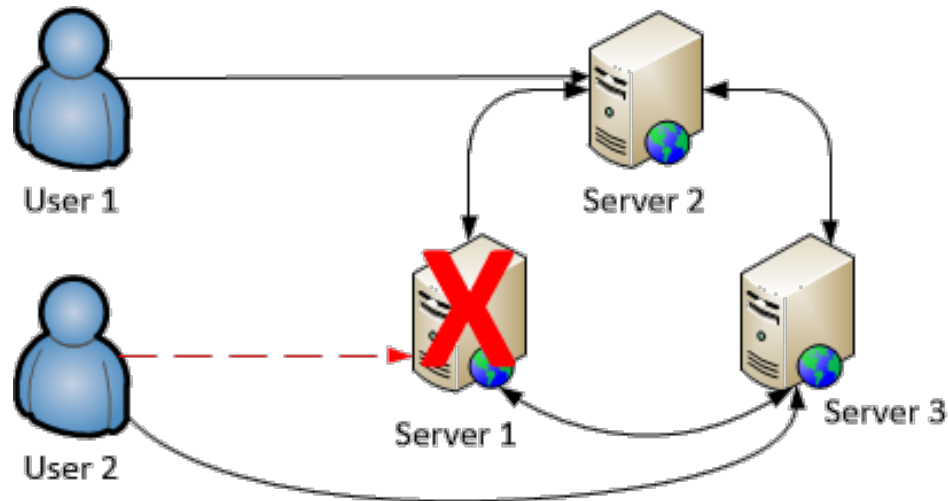


## Disadvantages:

- Performance improvement limited to vertical scalability
- Single point of failure
- Hard to achieve 99,999% availability

## Definition

Distributed system is a computing environment, where **multiple processes** running on **different machines**, **communicate through the network** and **coordinate actions** in order to appear to the end-user as a single coherent system.

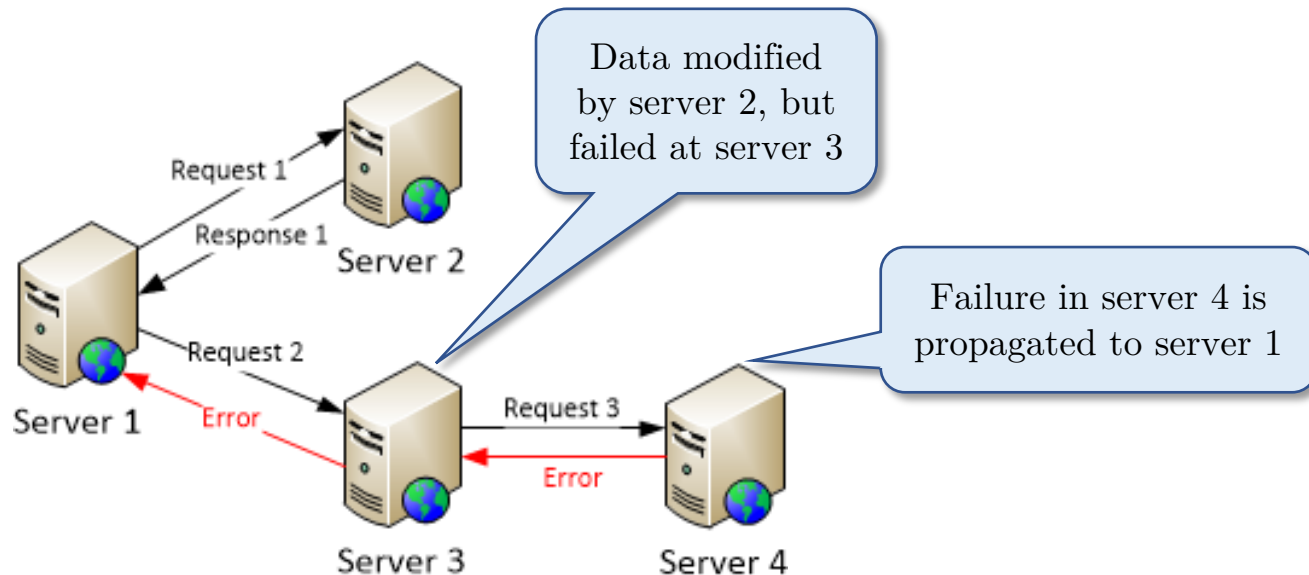


Advantages (when “done right”):

- Infinite performance due to horizontal scalability
- Resilient and fault-tolerant
- 24/7/365 availability

# Distributed System's Challenges

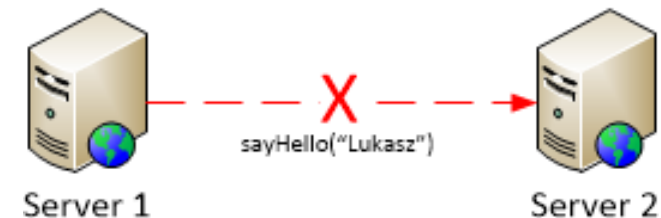
- Failure handling
  - Any remote procedure call can fail at runtime for different reasons
  - Failure propagation from distant parts of the system
  - Partial failure vs. data consistency



Local function call returns response or exception. Remote function call can timeout

```
sayHello("Lukasz");
```

```
private String sayHello(String name) {  
    return String.format(  
        "Greetings %s!", name  
    );  
}
```



# Distributed System's Challenges


- Concurrent resource access
  - Synchronize local threads and remote processes
  - Inconsistent state across servers
- Development and bug reproduction
  - Time as a variable factor
  - Number of software and hardware components involved


*“You have to design distributed systems with the expectation of failure.”*


*K. Arnold*

## Task

Design and implement URL shorten service.

`https://github.com/apache/kafka/blob/trunk/raft/README.md`  `https://tiny.com/qglj`

`https://tiny.com/qglj`  `https://github.com/apache/kafka/blob/trunk/raft/README.md`

  
  
 $1234567_{\text{base } 10} = \text{qglj}_{\text{base } 36}$

# Single-Threaded vs. Multi-Threaded vs. Distributed System

```
private long lastGeneratedId = 0;
```

```
public String shortenUrl(String longUrl) {  
    long id = generateNextId();  
    String shortUrl = String.format(  
        "http://tiny.com:8080/%s",  
        Long.toString(id, 36));  
    insertMapping(shortUrl, longUrl);  
    return shortUrl;  
}
```

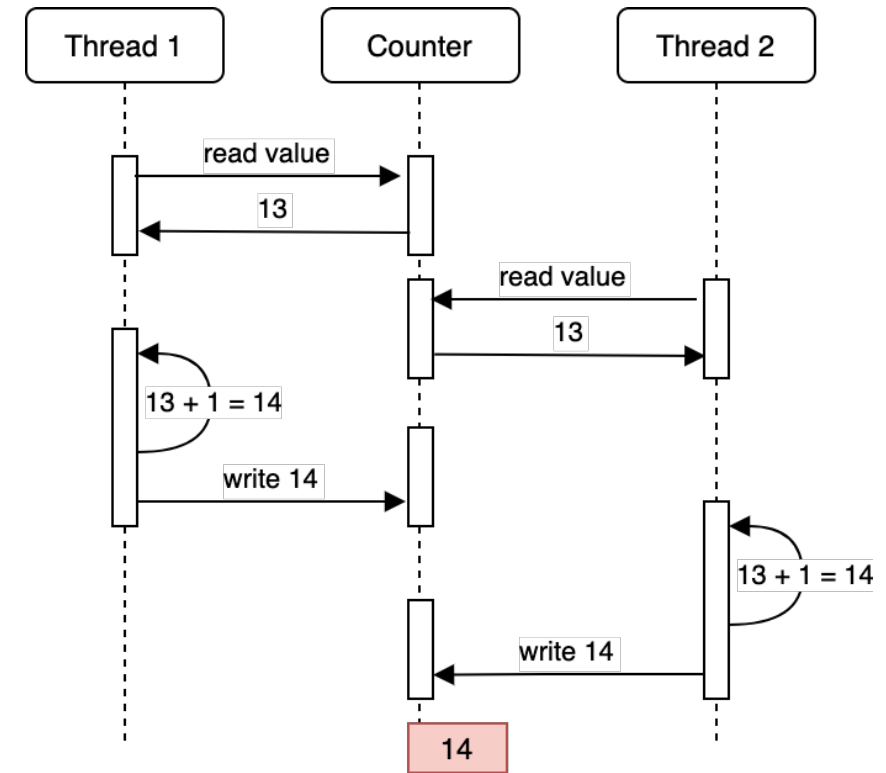
Generate next ID  
and format short URL

Insert mapping to  
database and return  
result

```
private synchronized long generateNextId() {  
    long id = ++lastGeneratedId;  
    return id;  
}
```

Scale up:

- Single-threaded → Multi-threaded
- Multi-threaded → Distributed System





- Disadvantages of Centralized System
- Definition of distributed computing
- Challenges of Distributed System

*“You know you have [a distributed system] when the crash of a computer you’ve never heard of stops you from getting any work done.”*

*L. Lamport*