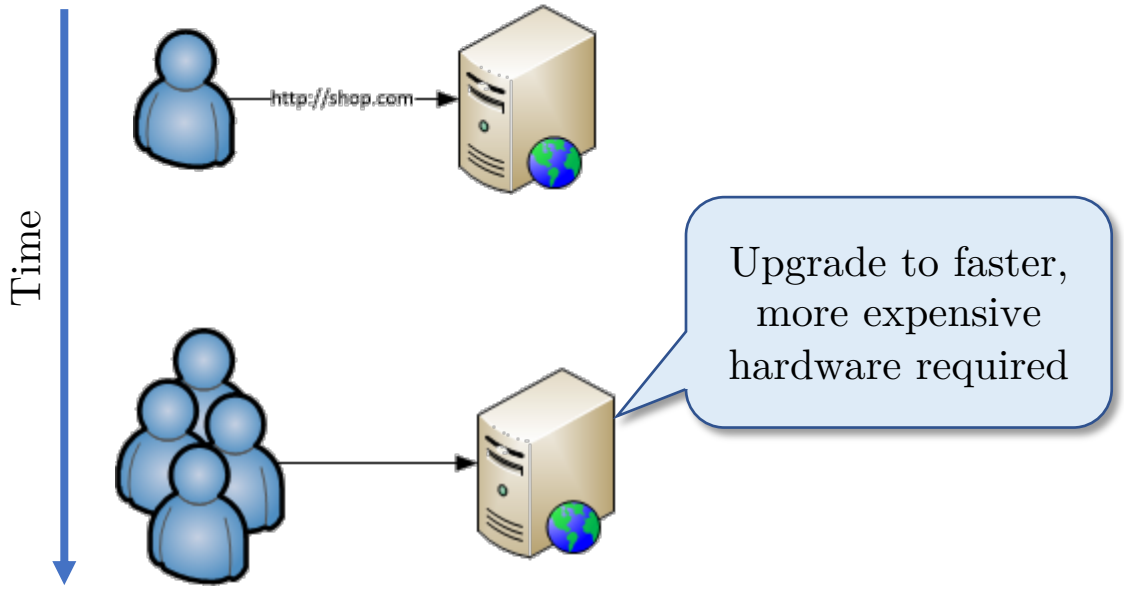
Concepts of Distributed Systems

Agenda

- 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.

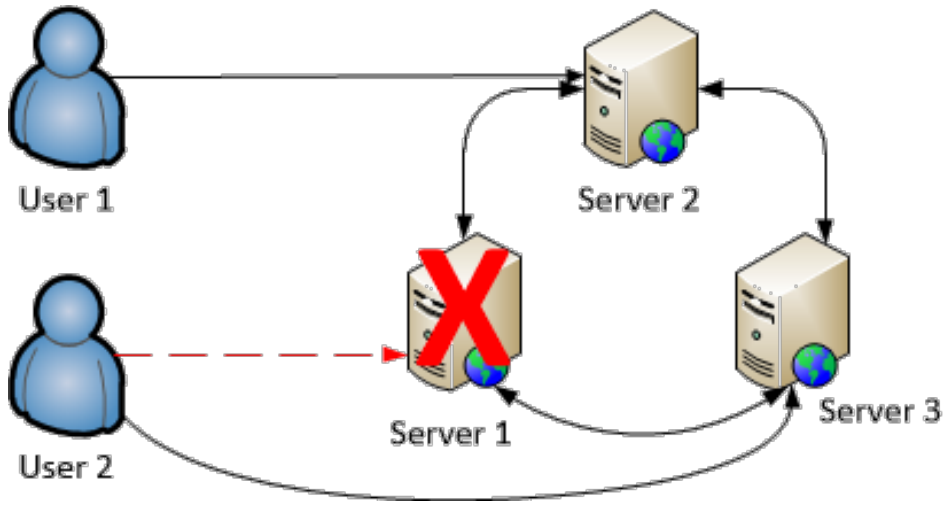


Disadvantages:

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

Definition

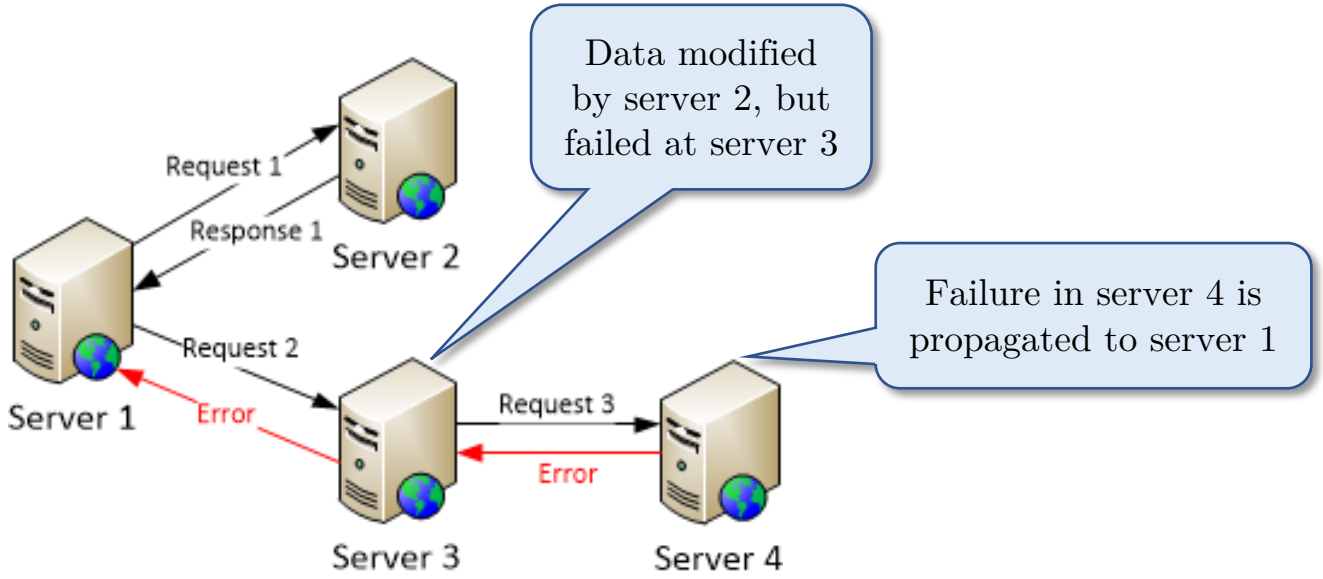
Distributed system is a computing environment, where multiple processes running on different machines, communicate through the network and coordinate actions in order to appear to the end-user as a single coherent system.



Advantages (when "done right"):

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

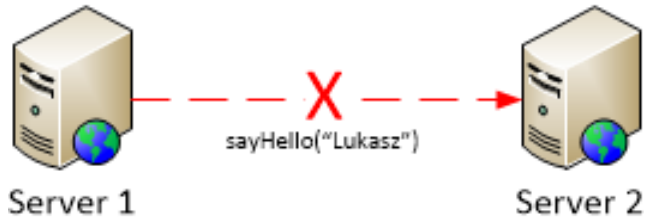
- Failure handling
  - Any remote procedure call can fail at runtime for different reasons
  - Failure propagation from distant parts of the system
  - Partial failure vs. data consistency



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

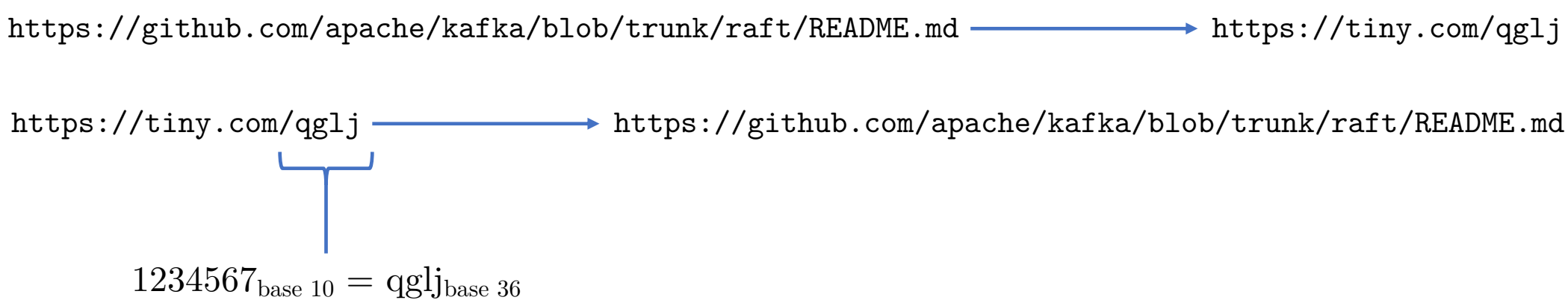
- Development and bug reproduction
  - Time as a variable factor
  - Number of software and hardware components involved

"You have to design distributed systems with the expectation of failure."

K. Arnold

Task

Design and implement URL shorten service.



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

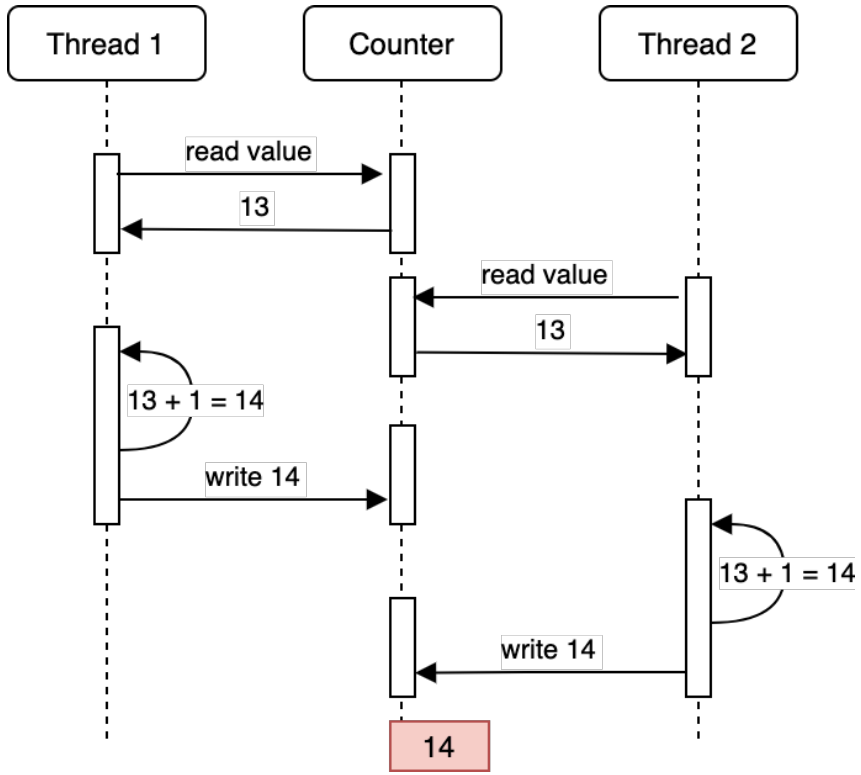
```
private long lastGeneratedId = 0;

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;
}

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

Generate next ID and format short URL

Insert mapping to database and return result



Scale up:

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

Summary

- 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