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Introduction. CAP. Base

Course: Real-Time Backend

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Contents

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01

Distributed systems

In this section we will discuss what is “Distributed system” and why do we need it.

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What is a distributed system?

A distributed system is a system whose components are located on different networked computers, which communicate and coordinate their actions by passing messages to one another

M. van Steen and A.S. Tanenbaum, Distributed Systems, 3rd ed.

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Features

- Parallelism
  - More users / more data - solve tasks faster
- Fault tolerance
  - Continue working even a part of a system fails
- Physical distribution
  - 2 users in different countries
- Security / Isolation
  - Admin access/Regular access
- Separation
  - Premium users/Regular users

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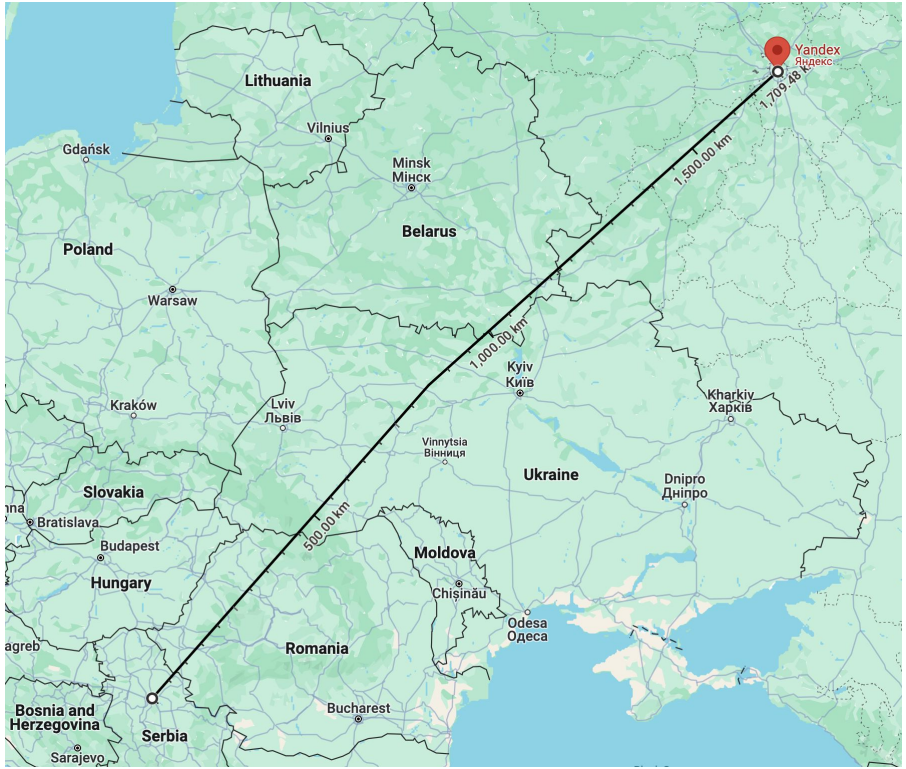
Internet



299792 km/s - speed of light
200000 km/s - real speed
dist = 2000 km
min_time = 2000 / 200000 = 10 ms
both_ways = 10 * 2 = 20

```
64 bytes from 188.35.21.10: icmp_seq=0 ttl=54 time=59.026 ms
64 bytes from 188.35.21.10: icmp_seq=1 ttl=54 time=57.408 ms
64 bytes from 188.35.21.10: icmp_seq=2 ttl=54 time=56.451 ms
64 bytes from 188.35.21.10: icmp_seq=3 ttl=54 time=56.620 ms
64 bytes from 188.35.21.10: icmp_seq=4 ttl=54 time=70.777 ms
64 bytes from 188.35.21.10: icmp_seq=5 ttl=54 time=58.574 ms
64 bytes from 188.35.21.10: icmp_seq=6 ttl=54 time=57.659 ms
```

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Challenges

- Resources
- Partial failures
- Performance

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Infrastructure

- Storage (GFS, S3, SQL db, NoSQL db, Clickhouse)
- Communication (Message brokers, GRPC, HTTP)
- Computation (Flink, MapReduce, Spark)

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02

Performance. Scalability

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Scalability

Task 1

Task 3

Task 2

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Scalability

Task 1

Task …

Task 3

Task 2

Task 4

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Scalability

Task 1

Task …

Task 3

Task 2

Task 4

Vertical scaling

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Scalability

Task 1

Task 2

Task 3

Task 4

Task …

Horizontal scaling

2x machines = 2x times faster?

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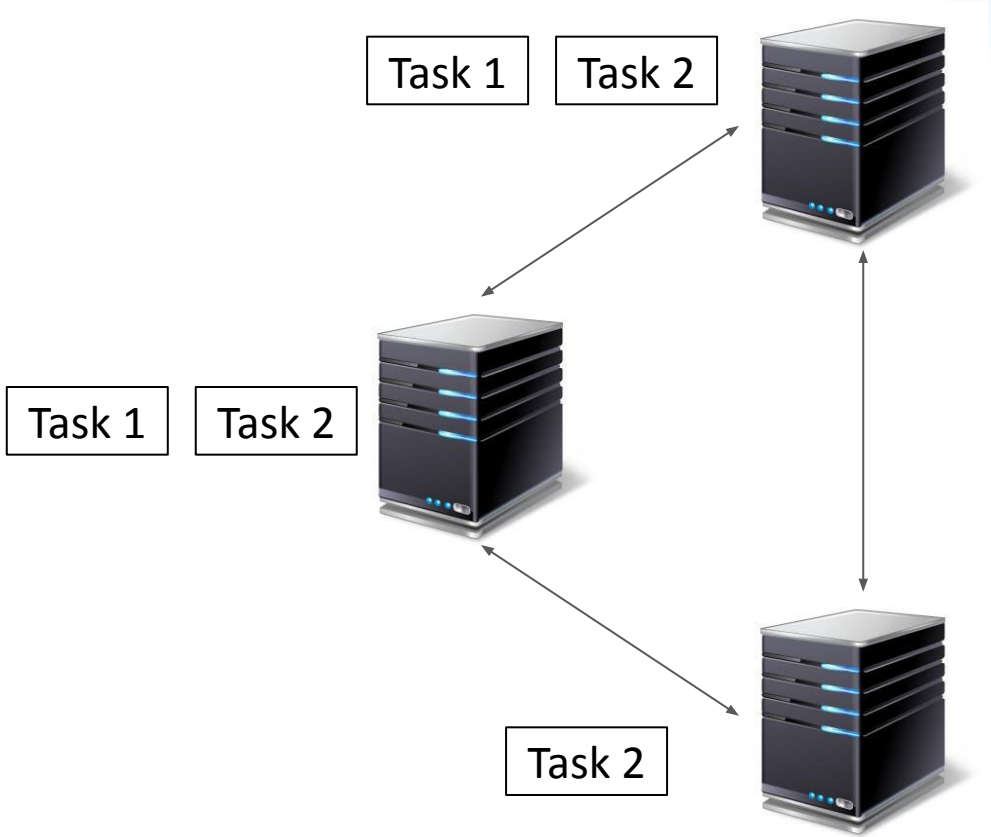
Not all computations are independant



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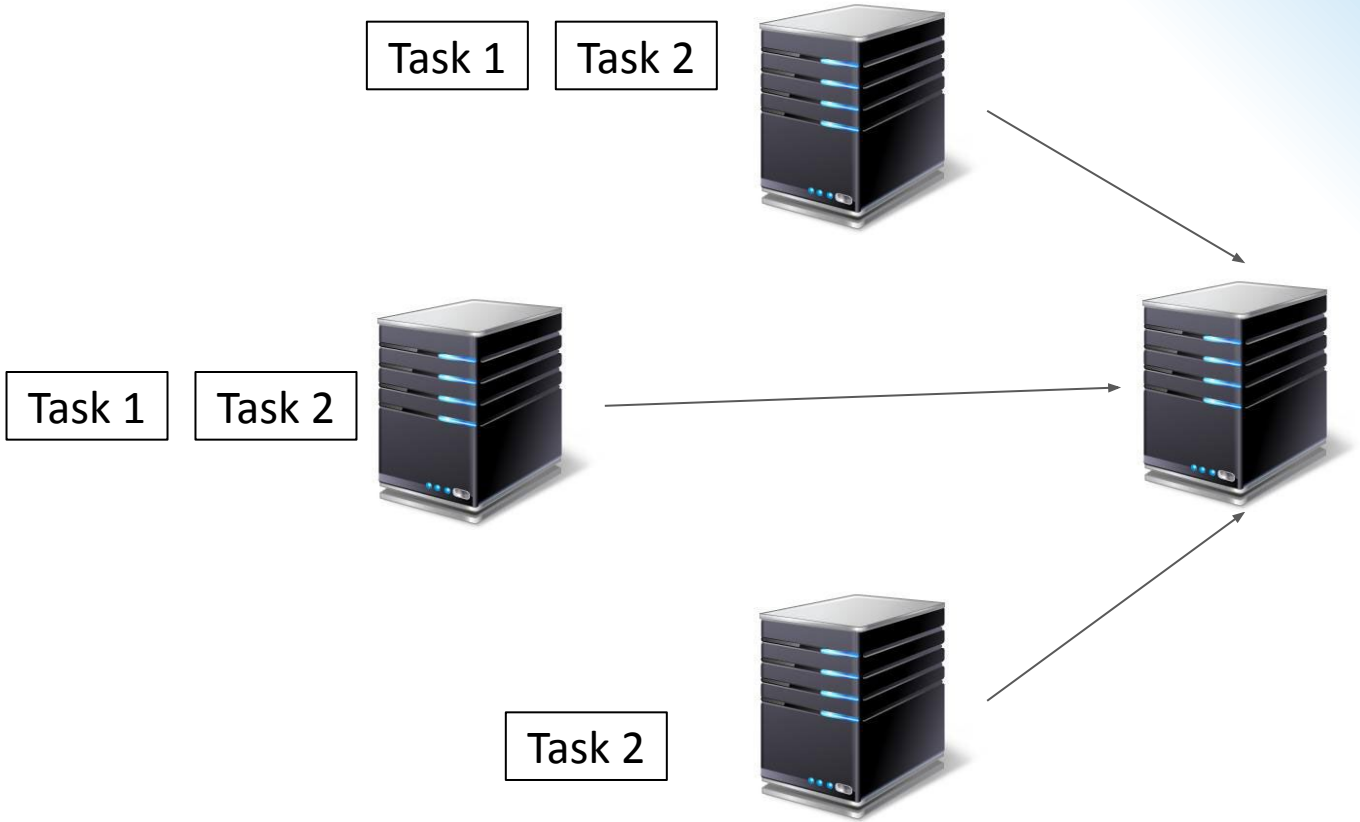
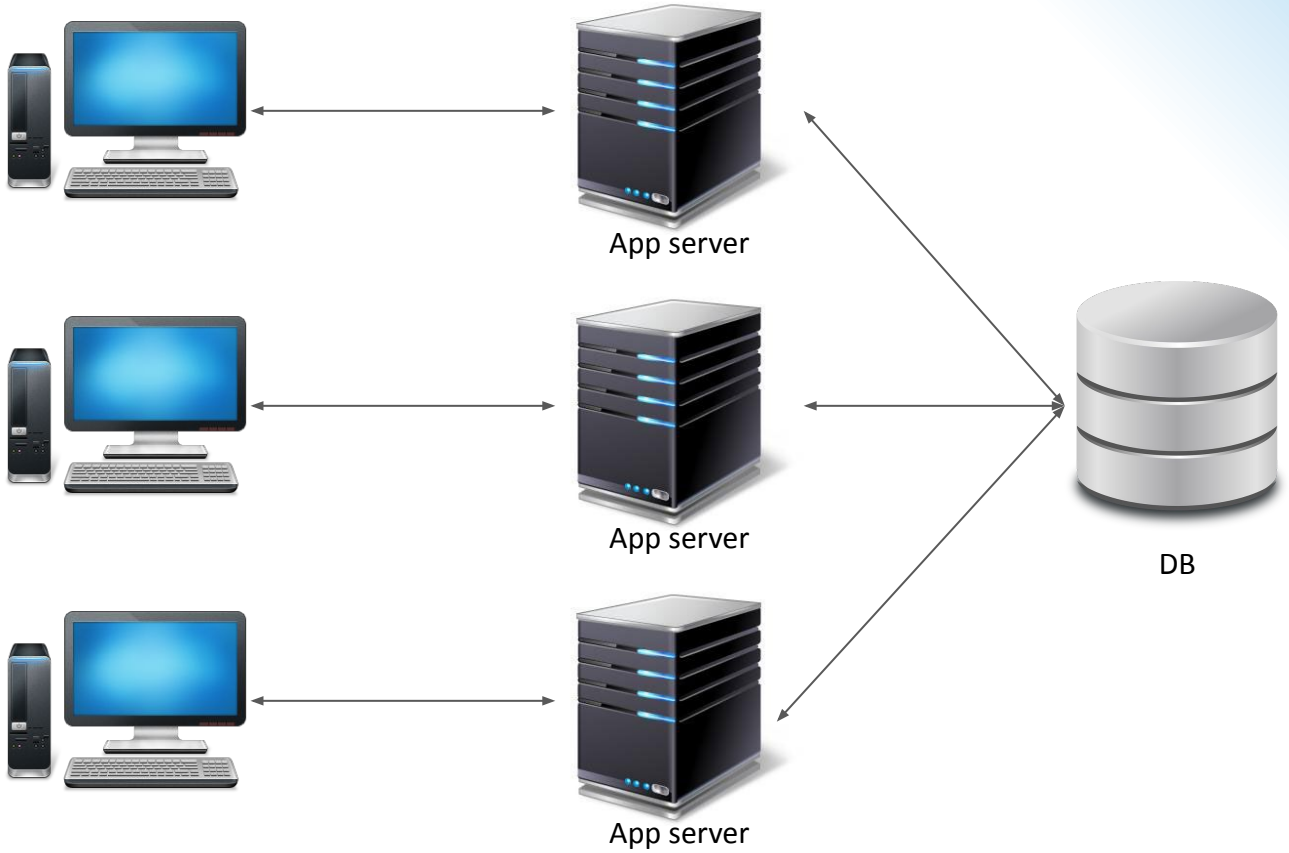
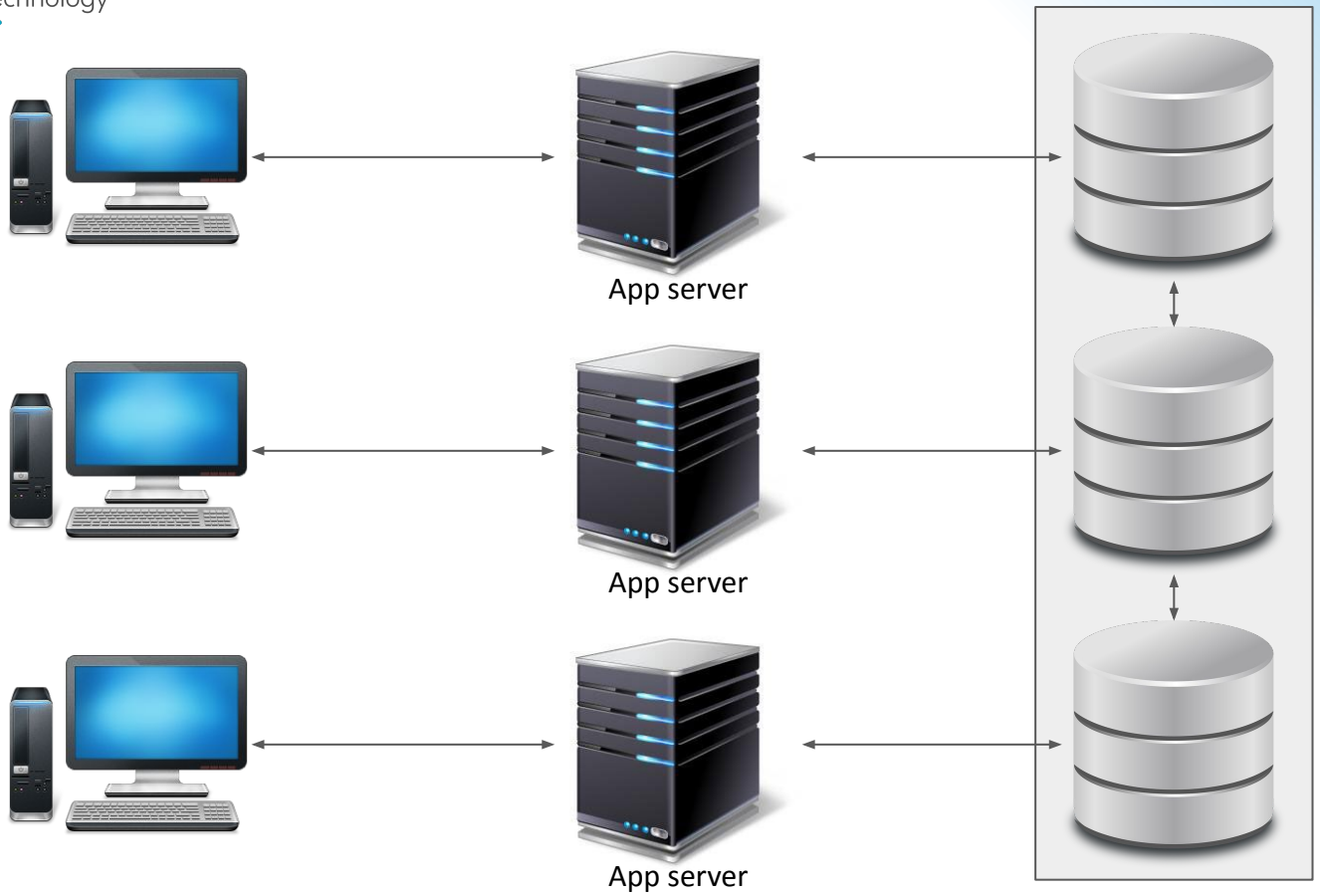
or maybe even harder

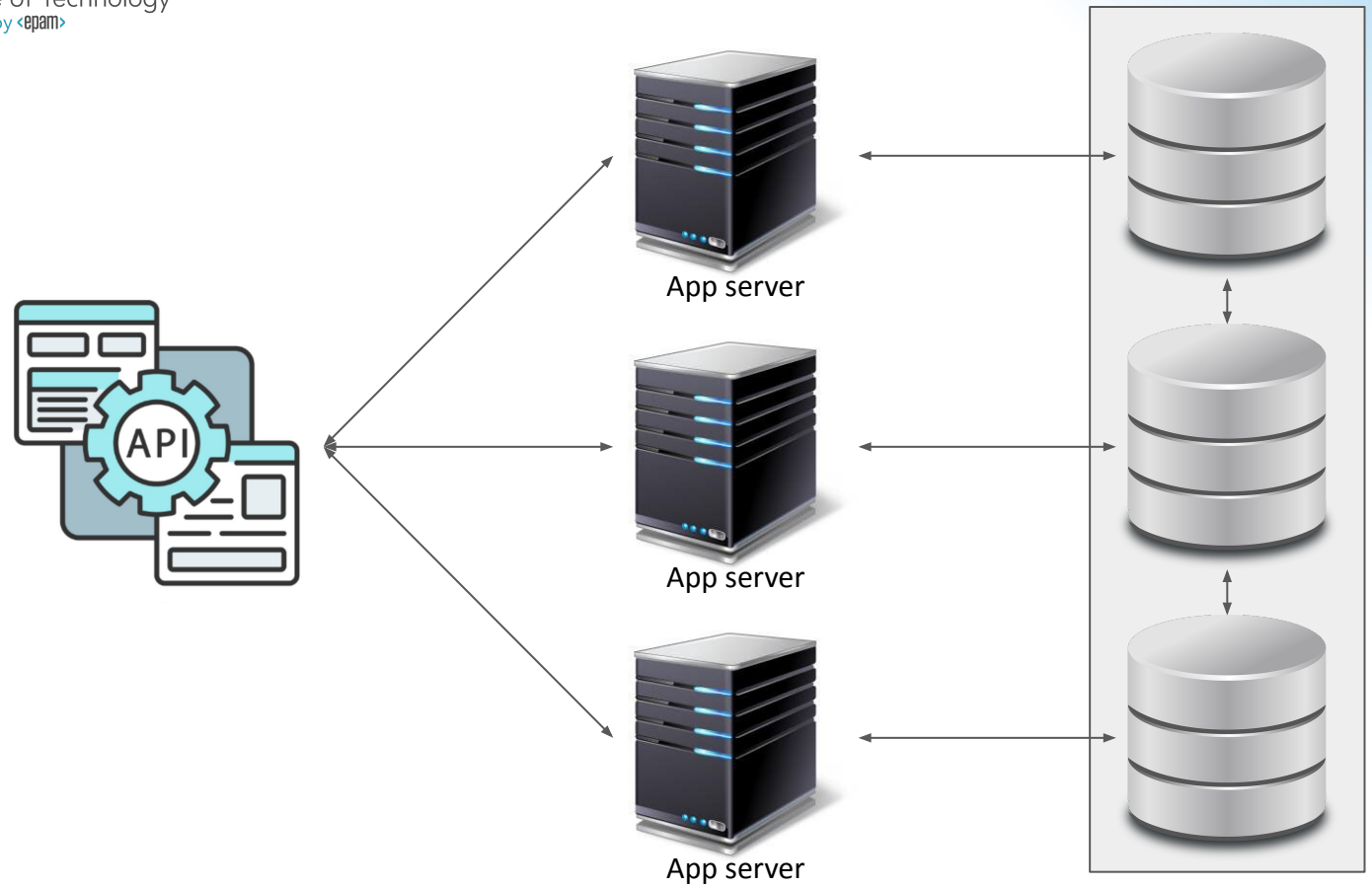


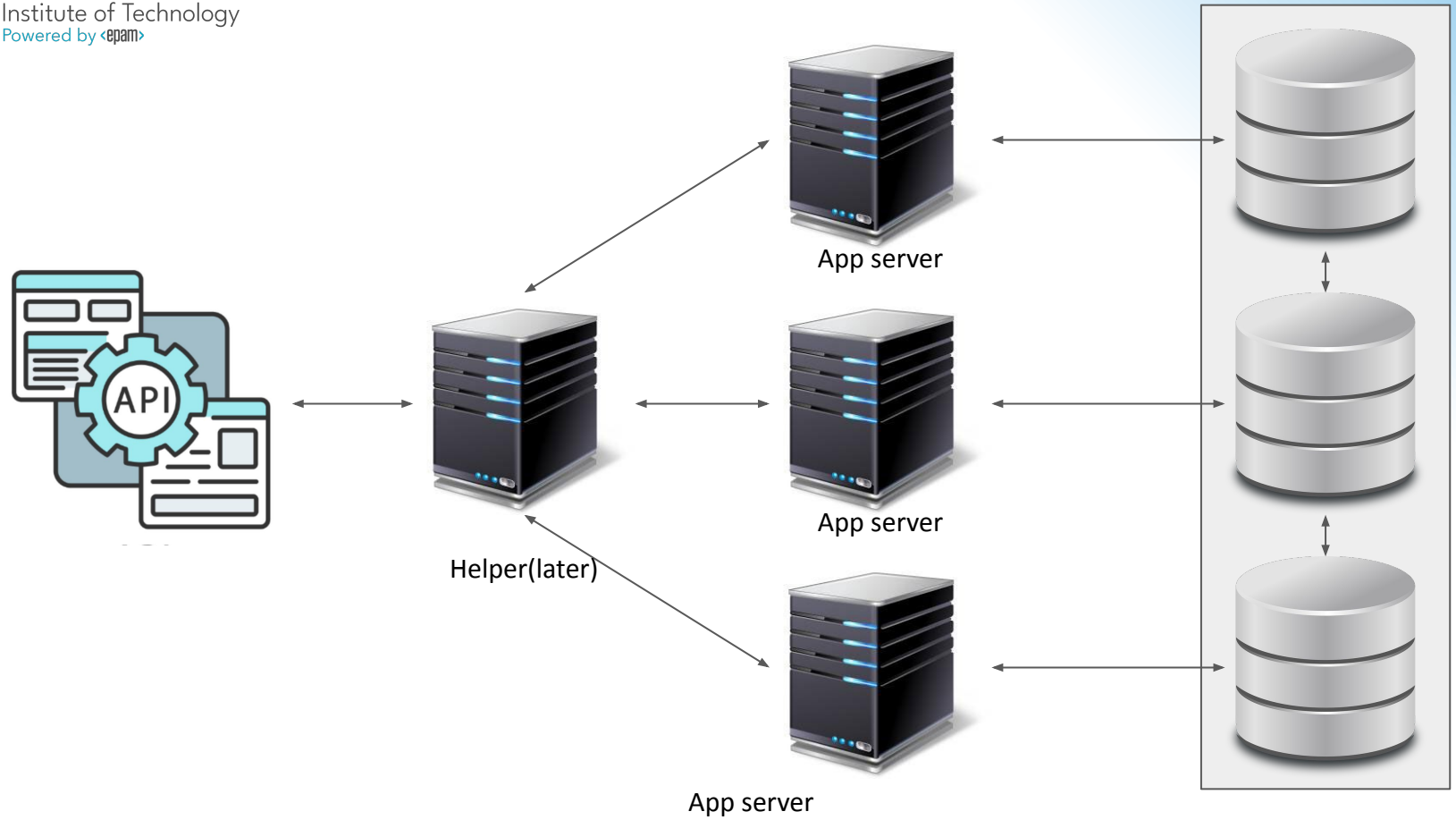
Having storage also makes things more complicated


App server
App server
App server
DB


App server
App server
App server

We also want to provide abstractions so client can work with distributed system conveniently


API
App server
App server
App server


API
Helper(later)
App server
App server
App server

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03

Fault tolerance and consistency

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Fault tolerance

What we mean by fault tolerance

- Availability
  - Under certain set of failures we still provide service
- Recoverability
  - Can recover from a failed state

How to achieve

- Using permanent storage
- Replication

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Consistency

Example: KV service

- Set(k, v)
- Get(k) -> v

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Consistency

Example: KV service

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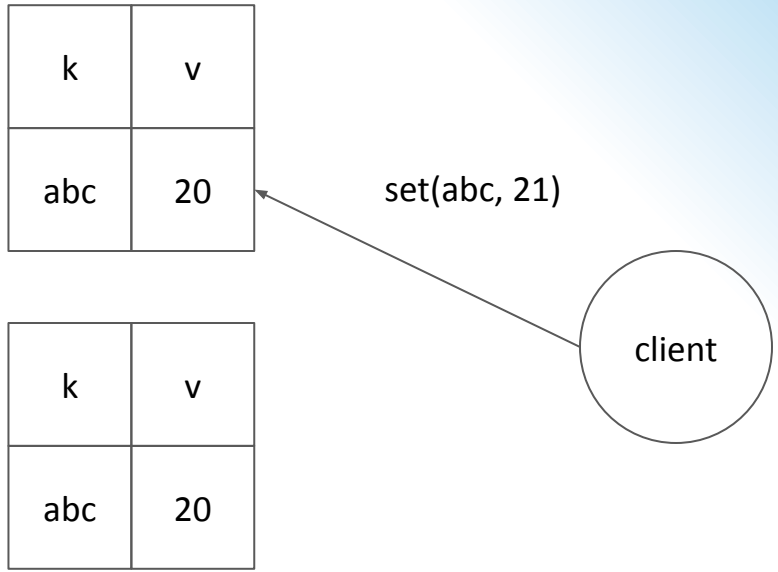

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Consistency

Example: KV service

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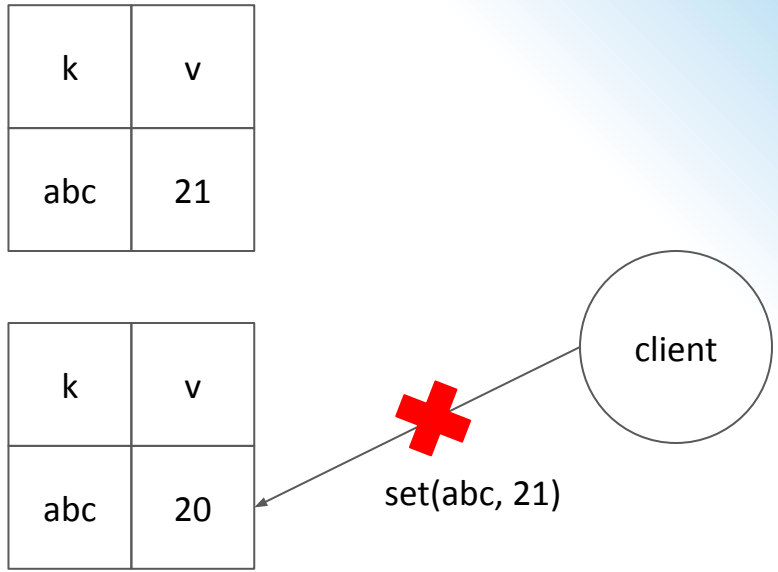

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Consistency

Example: KV service

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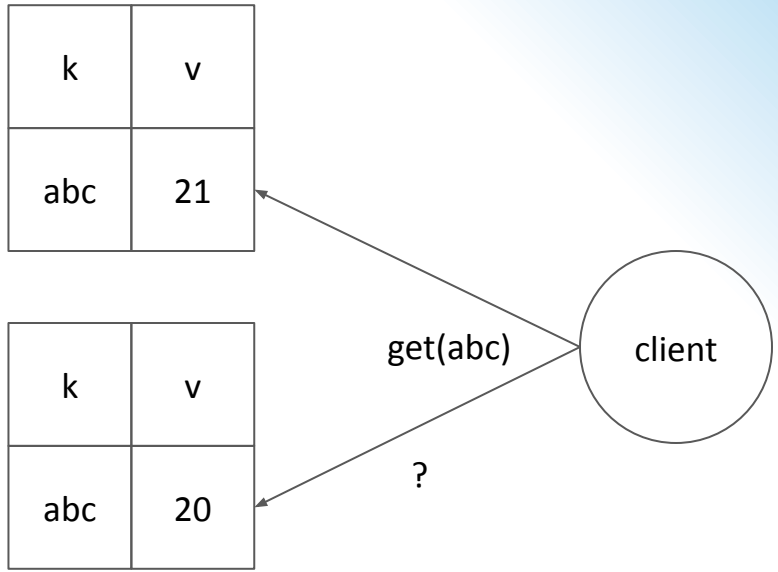

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Consistency

Example: KV service

- Set(k, v)
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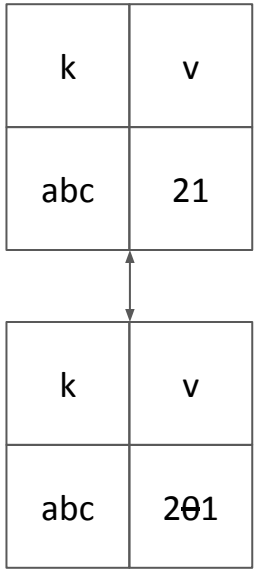

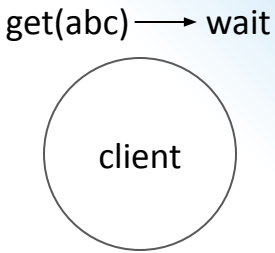

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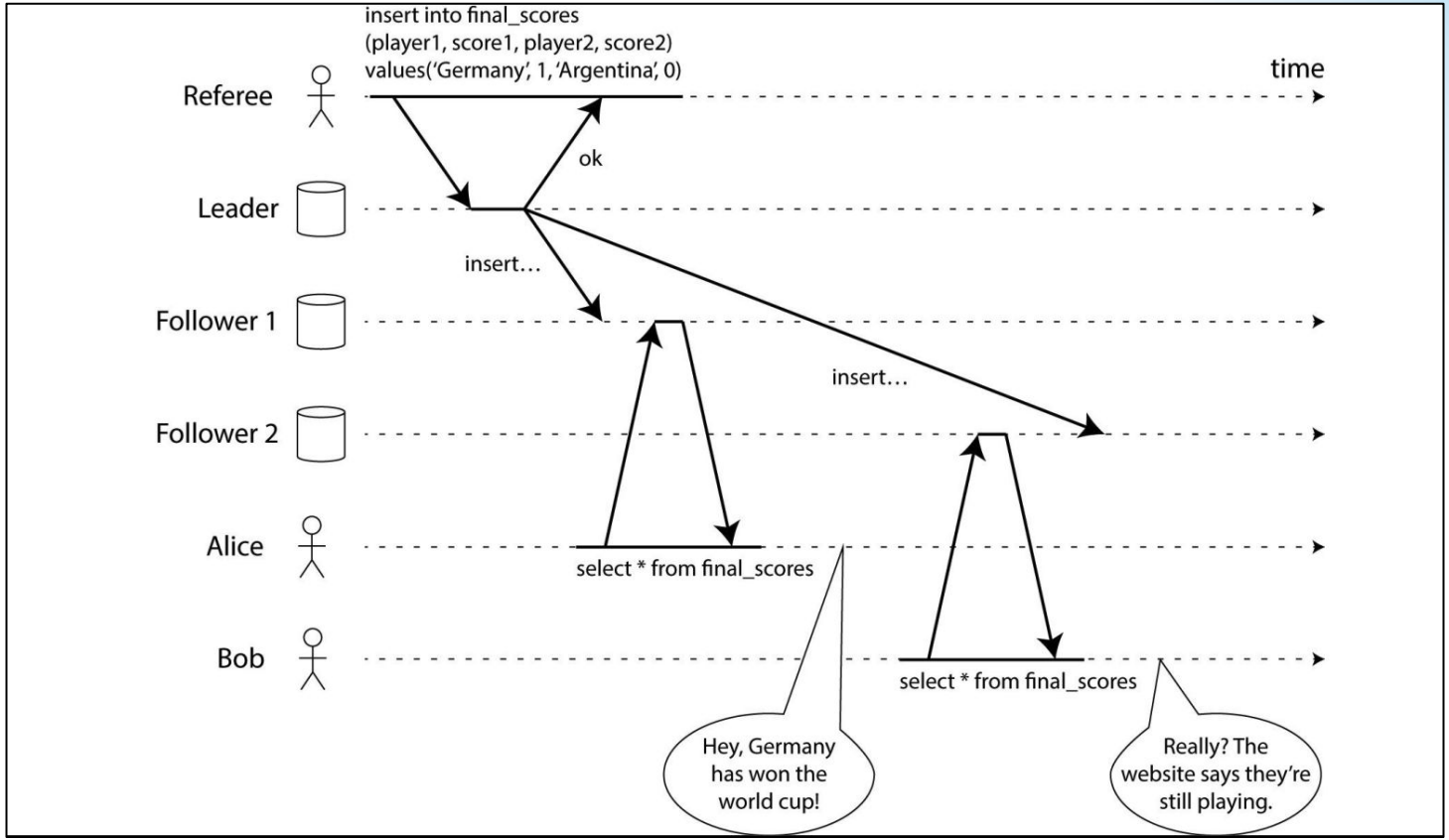
Example



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04

CAP theorem

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CAP theorem

A shared-data system can have at most two of the three following properties: **C**onsistency, **A**vailability, and tolerance to network **P**artitions

Brewer (2000)

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On Consistency

Atomic, or **linearizable**, consistency is the condition expected by most web services today. Under this consistency guarantee, there must exist a total order on all operations such that each operation looks as if it were completed at a single instant. This is equivalent to requiring requests of the distributed shared memory to act as if they were executing on a single node, responding to operations one at a time.

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On Availability

For a distributed system to be continuously available, every request received by a non-failing node in the system must result in a response. That is, any algorithm used by the service must eventually terminate ... [When] qualified by the need for partition tolerance, this can be seen as a strong definition of availability: even when severe network failures occur, every request must terminate.

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On Partition tolerance

In order to model partition tolerance, the network will be allowed to lose arbitrarily many messages sent from one node to another. When a network is partitioned, all messages sent from nodes in one component of the partition to nodes in another component are lost.

You can’t sacrifice partition tolerance!

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Examples

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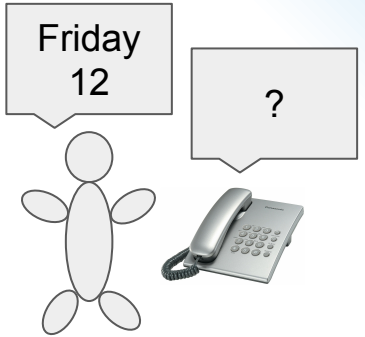
No partition tolerance



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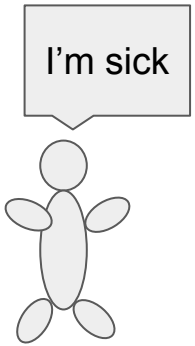
No partition tolerance



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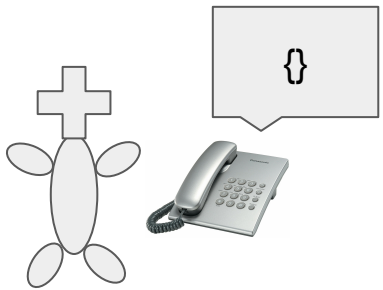
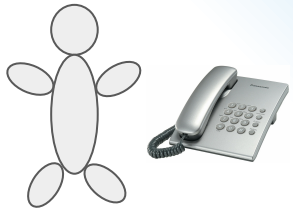
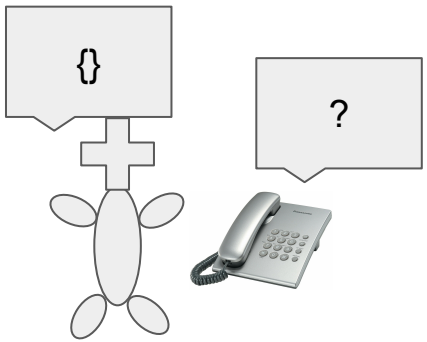
No consistency







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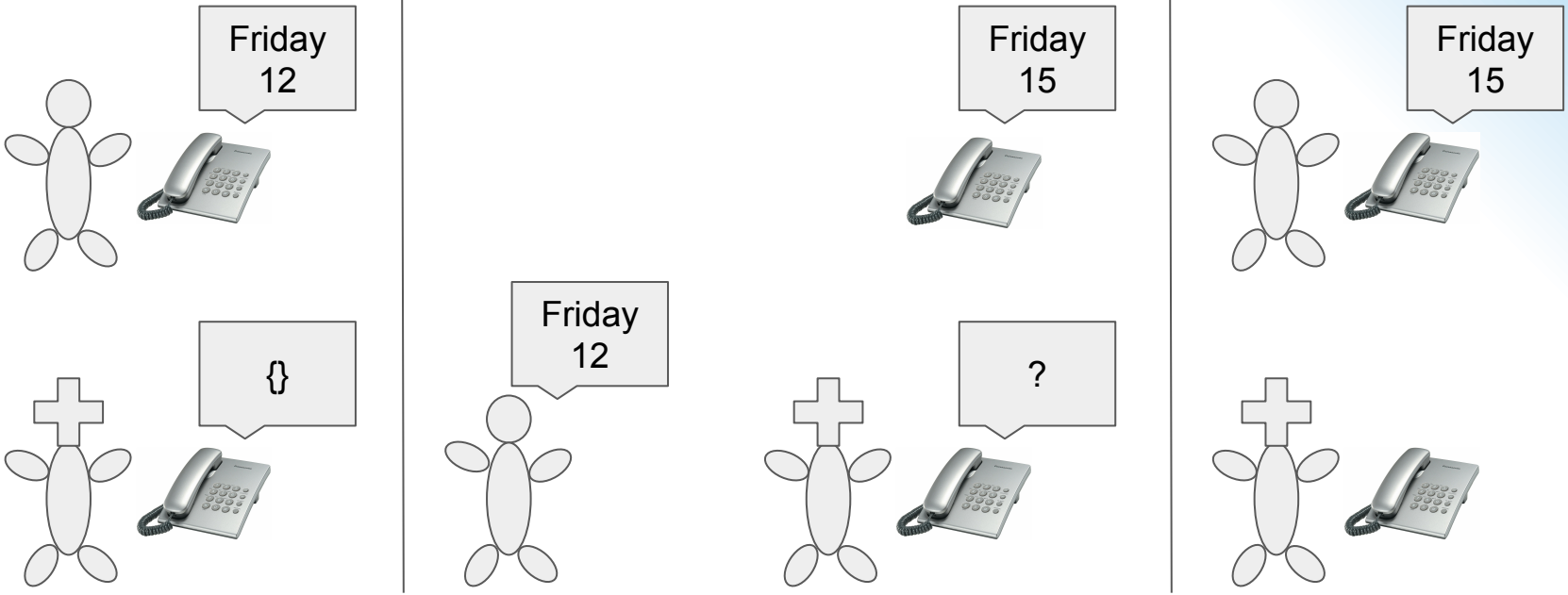
No availability



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06

What next?

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Next steps

- PACELC
- BASE
- ACID

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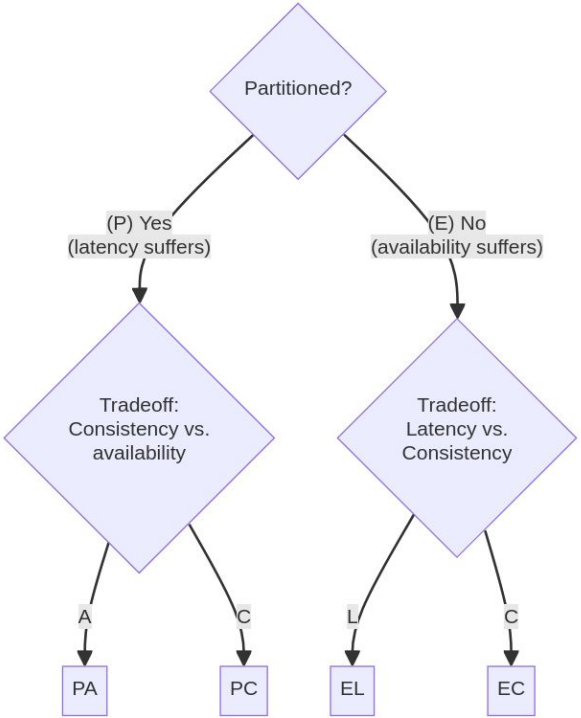
PACELC



if (**P**, then **A** or **C**, **e**lse **L** or **C**)

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That's All Folks!