# Advanced Networking and Distributed Systems

## Microservices and Communication Frameworks

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# What is a Distributed System? A recap

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# What is a Distributed System? A recap

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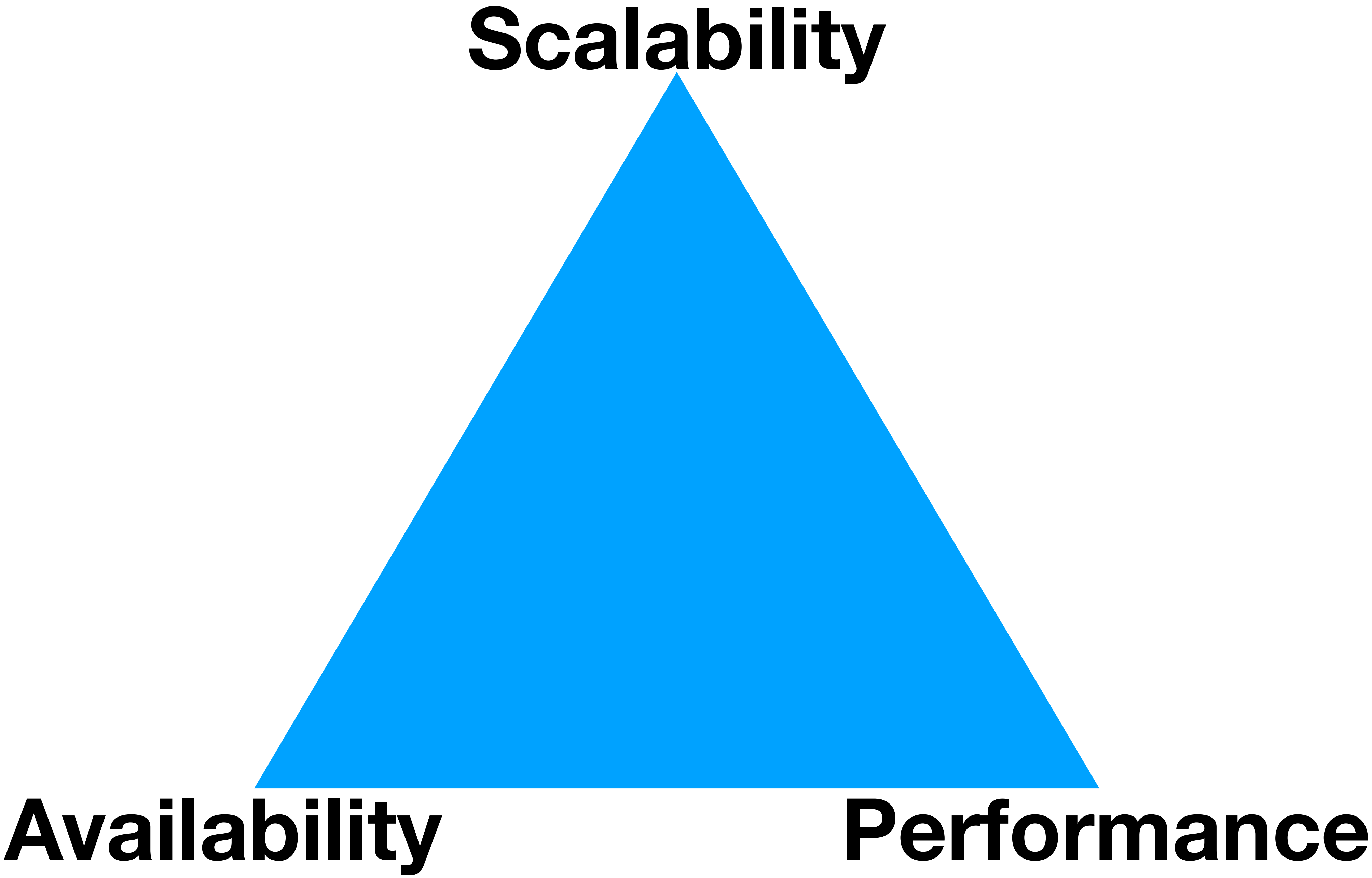
A distributed system is a collection of independent processes that appears to its users as a single coherent system.

-> Communication is key to collaboration!

How we establish and define this communication is critical.

# A guide for judging systems



Scalability

Availability

Performance

# Performance

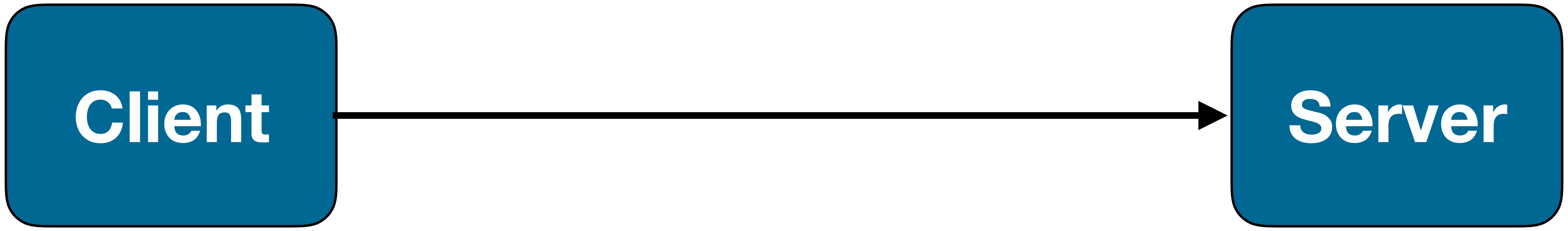
The amount of useful work accomplished by a computer system compared to time and resources used.

Examples of performance measures:

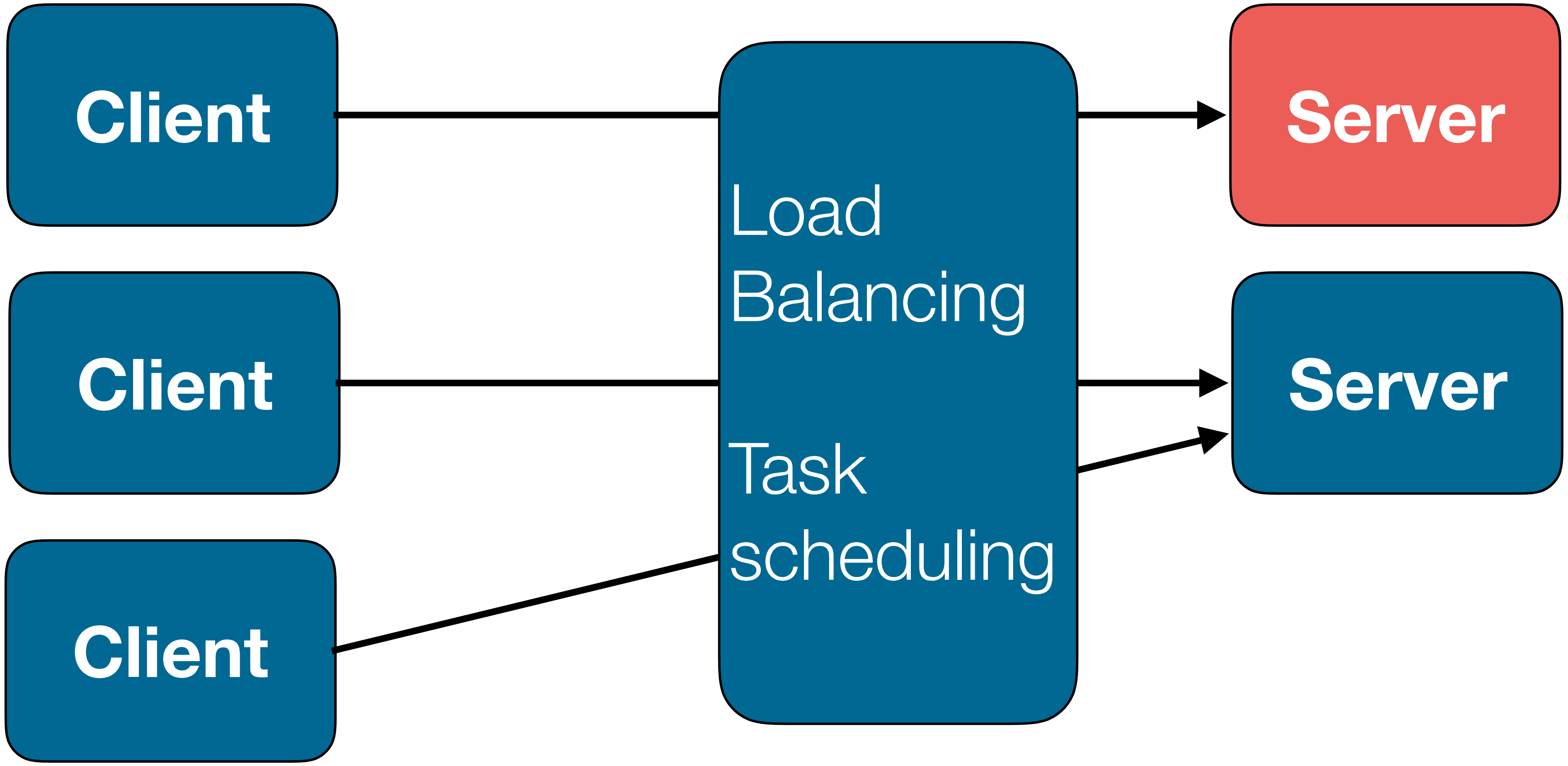
- Short response time aka Low Latency
- High Throughput
- Low Utilization of Resources

How is this different from the basic performance metrics we discussed in networking?

# Distributed Performance

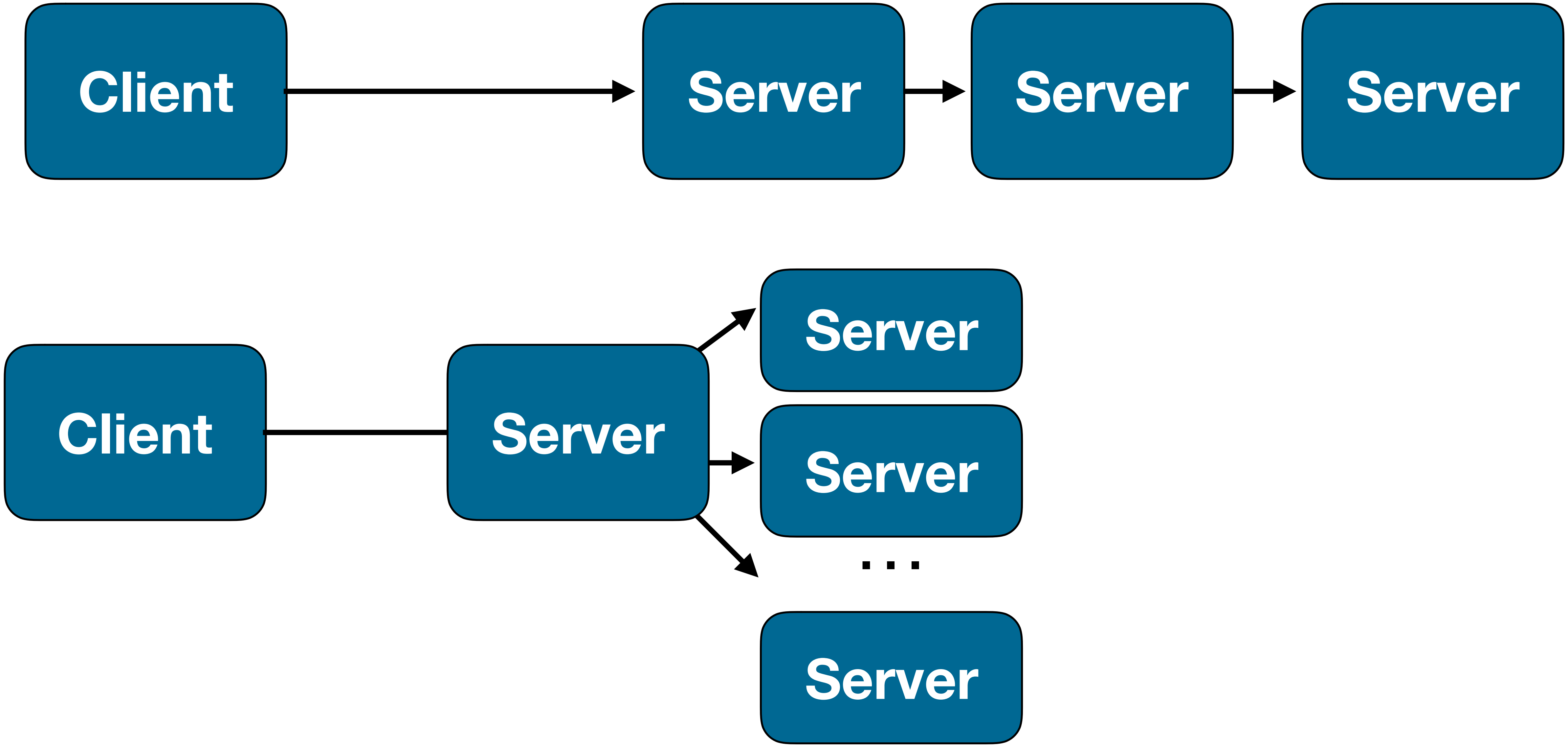


# Distributed Performance



# Distributed Performance

Communication and interacting components can compound performance problems



# Distributed Performance

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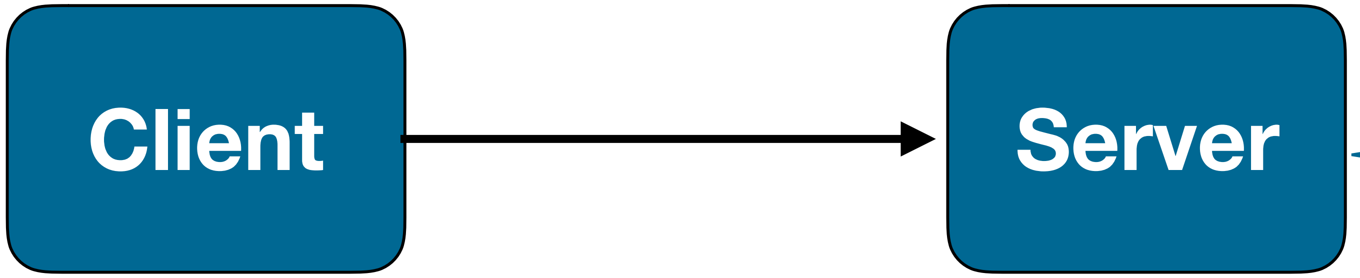
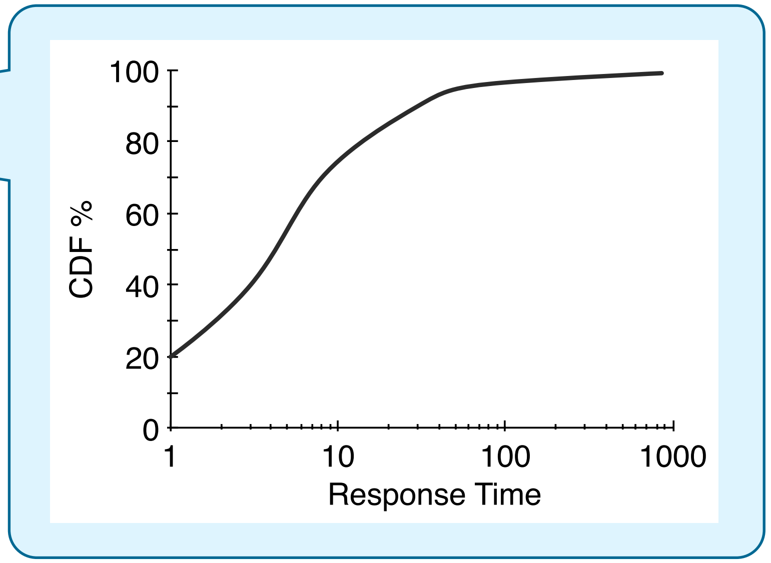
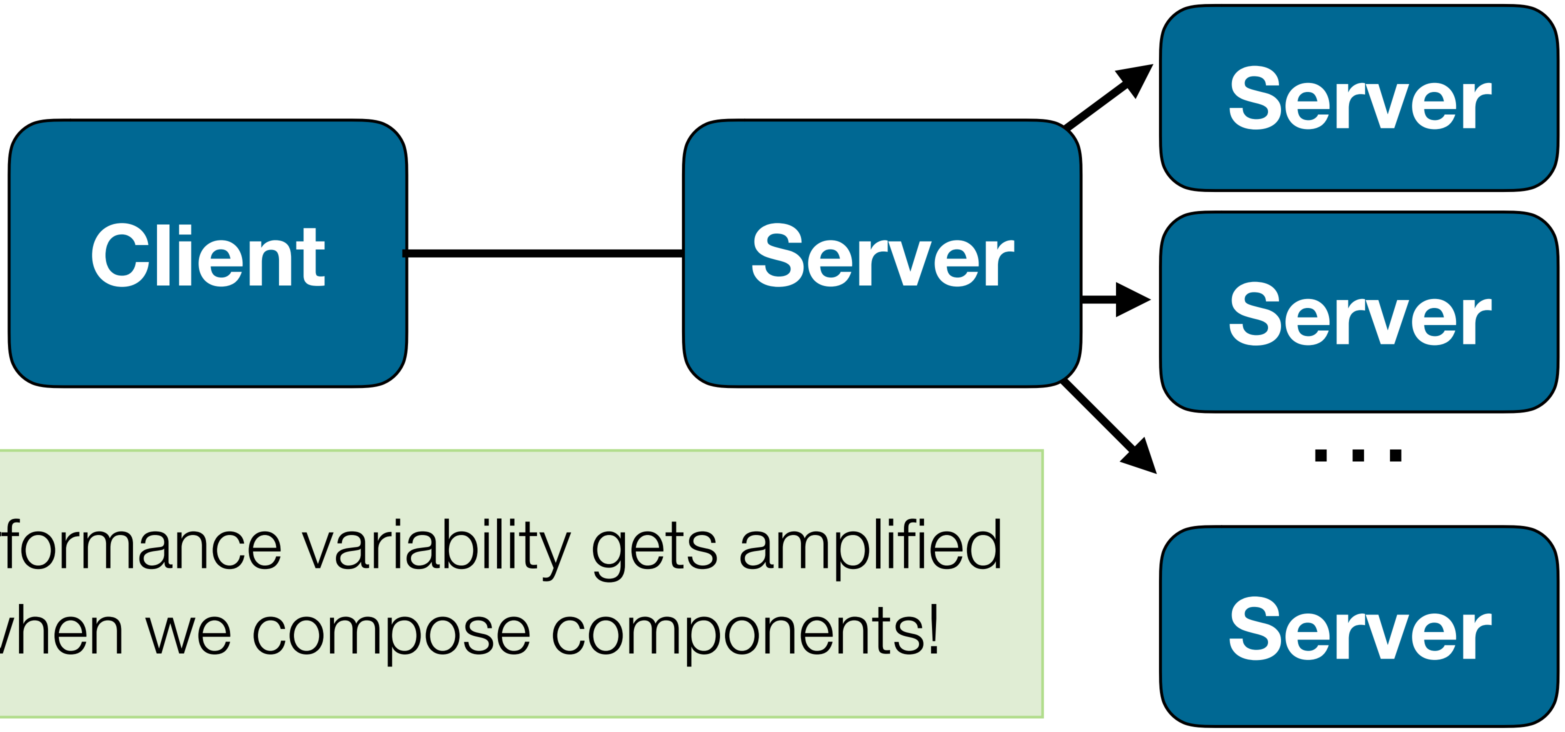




99th %ile -> 1 second



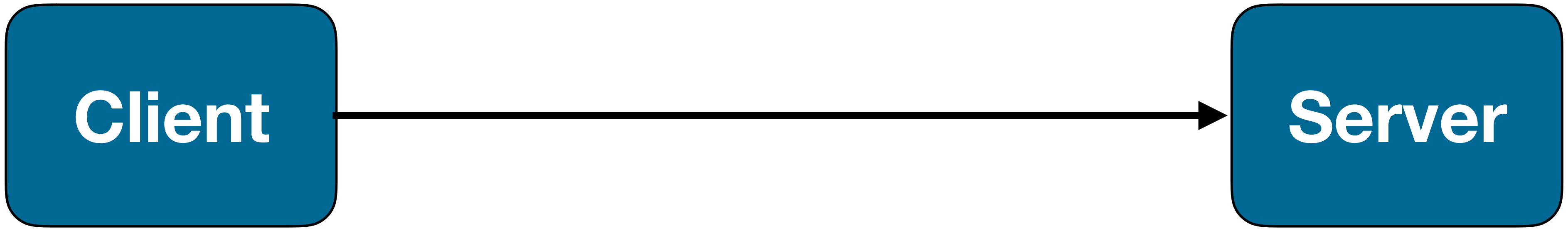
Performance variability gets amplified when we compose components!

# Availability

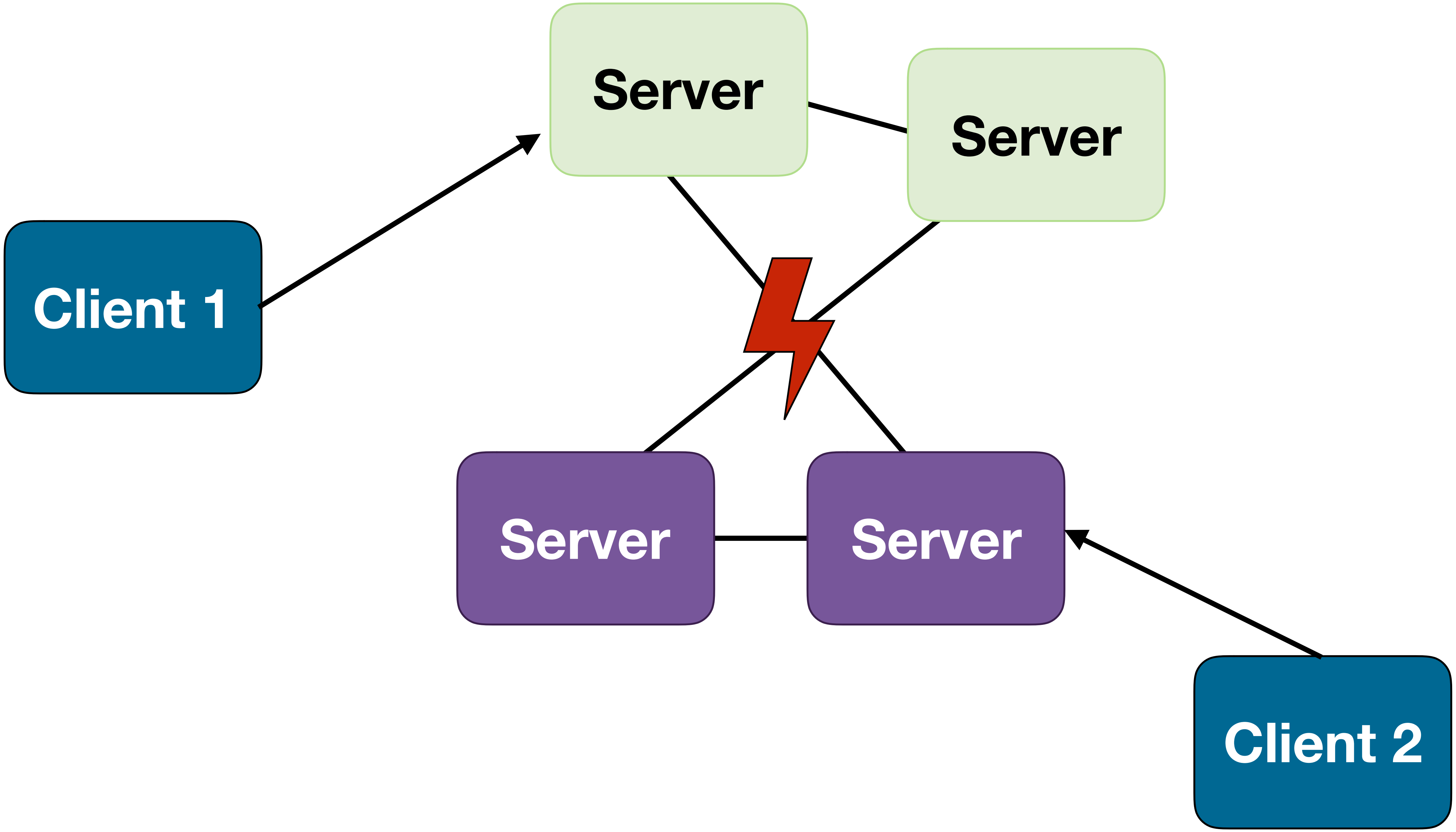
Availability: The proportion of time a system is running and able to do its job.

Fault Tolerance: Ability of a system to behave in a well defined manner once faults occur.

# Distributed Availability



# Distributed Availability



# Scalability

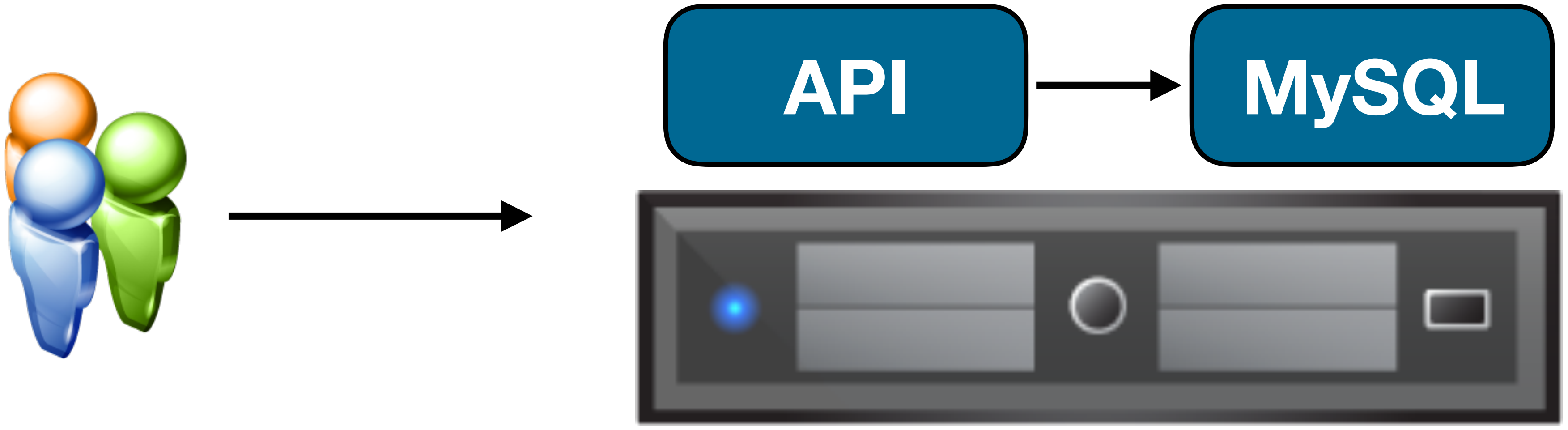
Capability of a system, network or process to handle a growing amount of work in a capable manner.

Considerations in scaling:

- **Size**: Adding more resources should make a system faster.
- **Geographic**: Adding more resources in more regions should decrease response time for users.
- **Administration**: Adding more resources should not make it harder to administer the system.

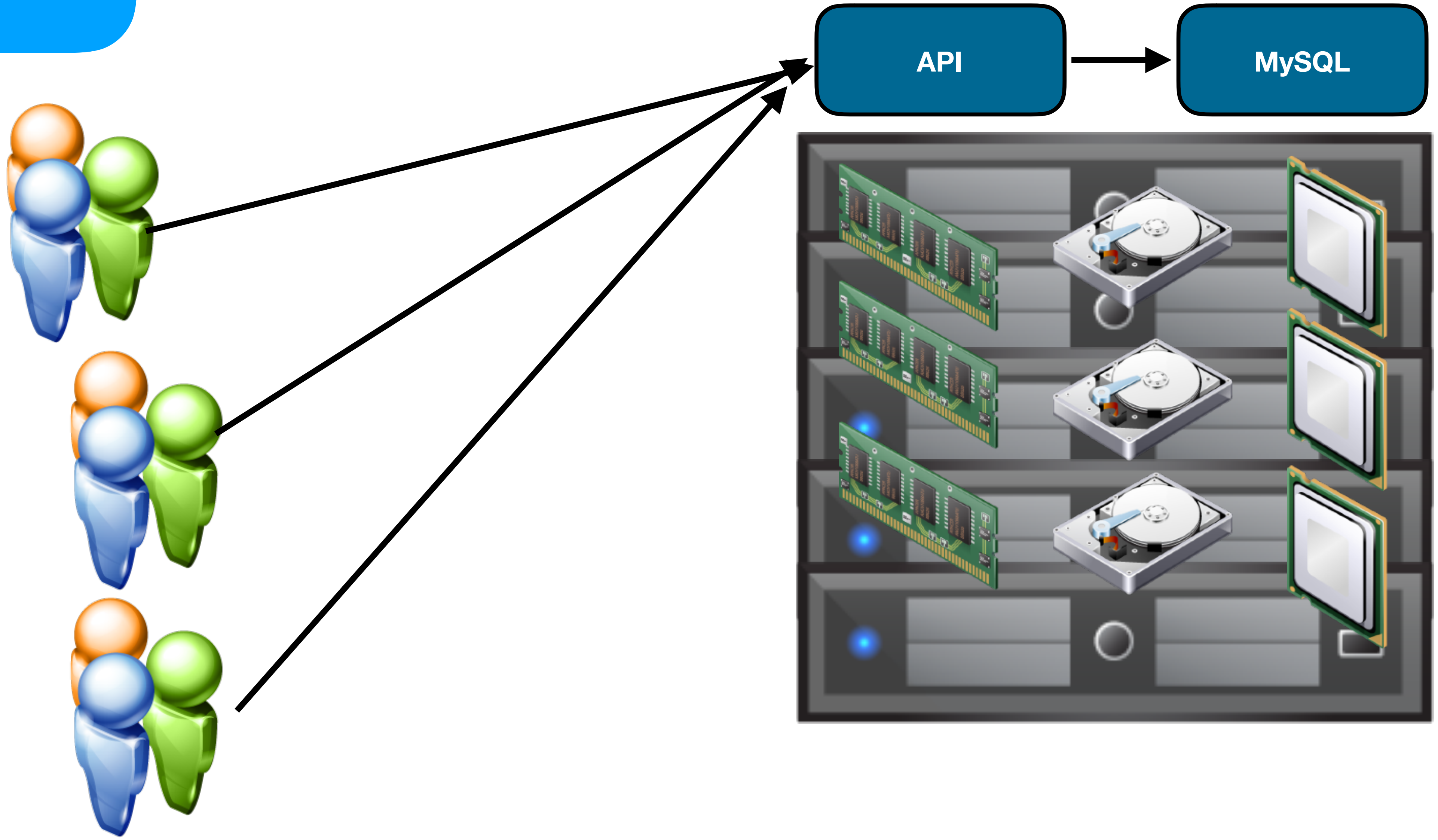
# The Monolith

How can we scale as a monolith?



# Scale Up

Let's just add more compute resources!



# Scale Up

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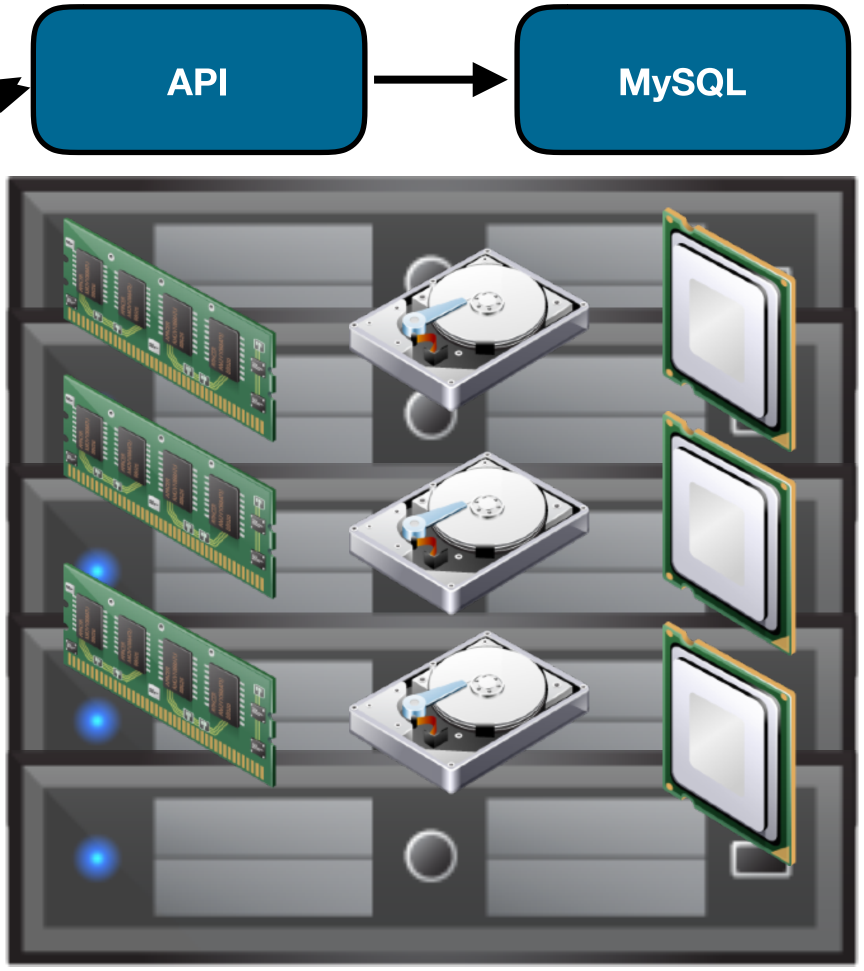
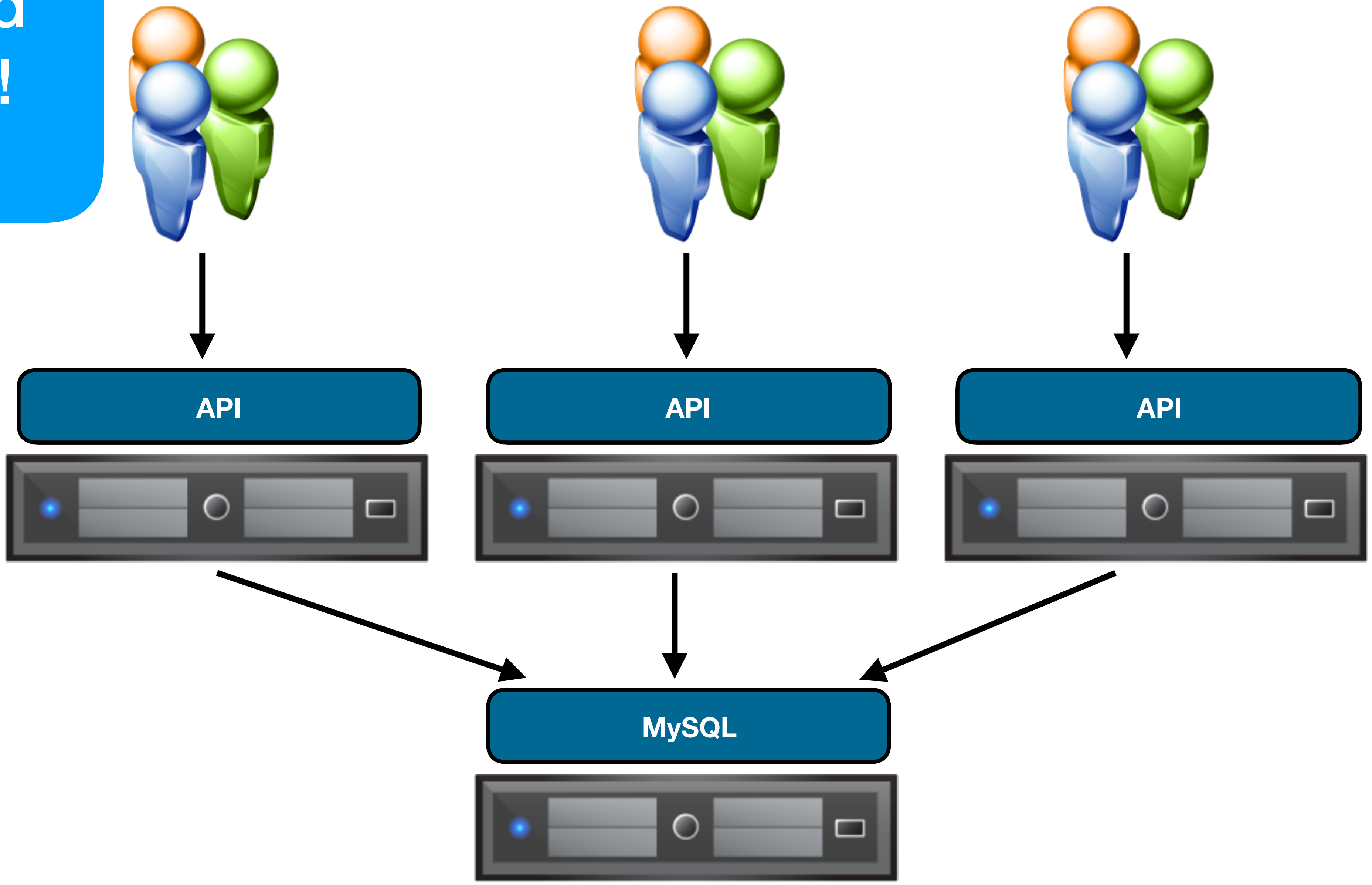


Scaling UP adds more resources to an existing system to reach a desired state of performance.

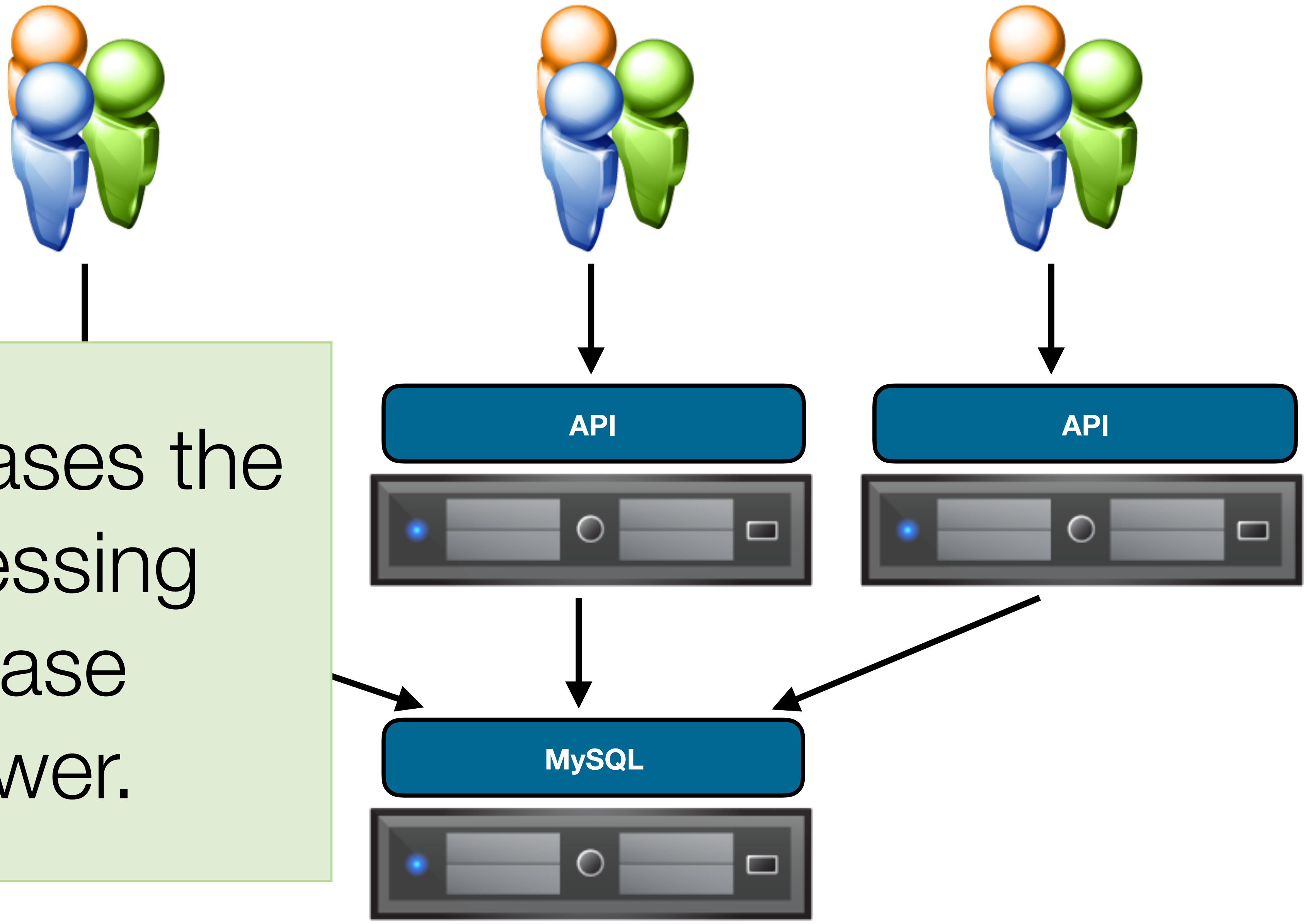
# Scale Out

Let's just add more nodes!



# Scale Out

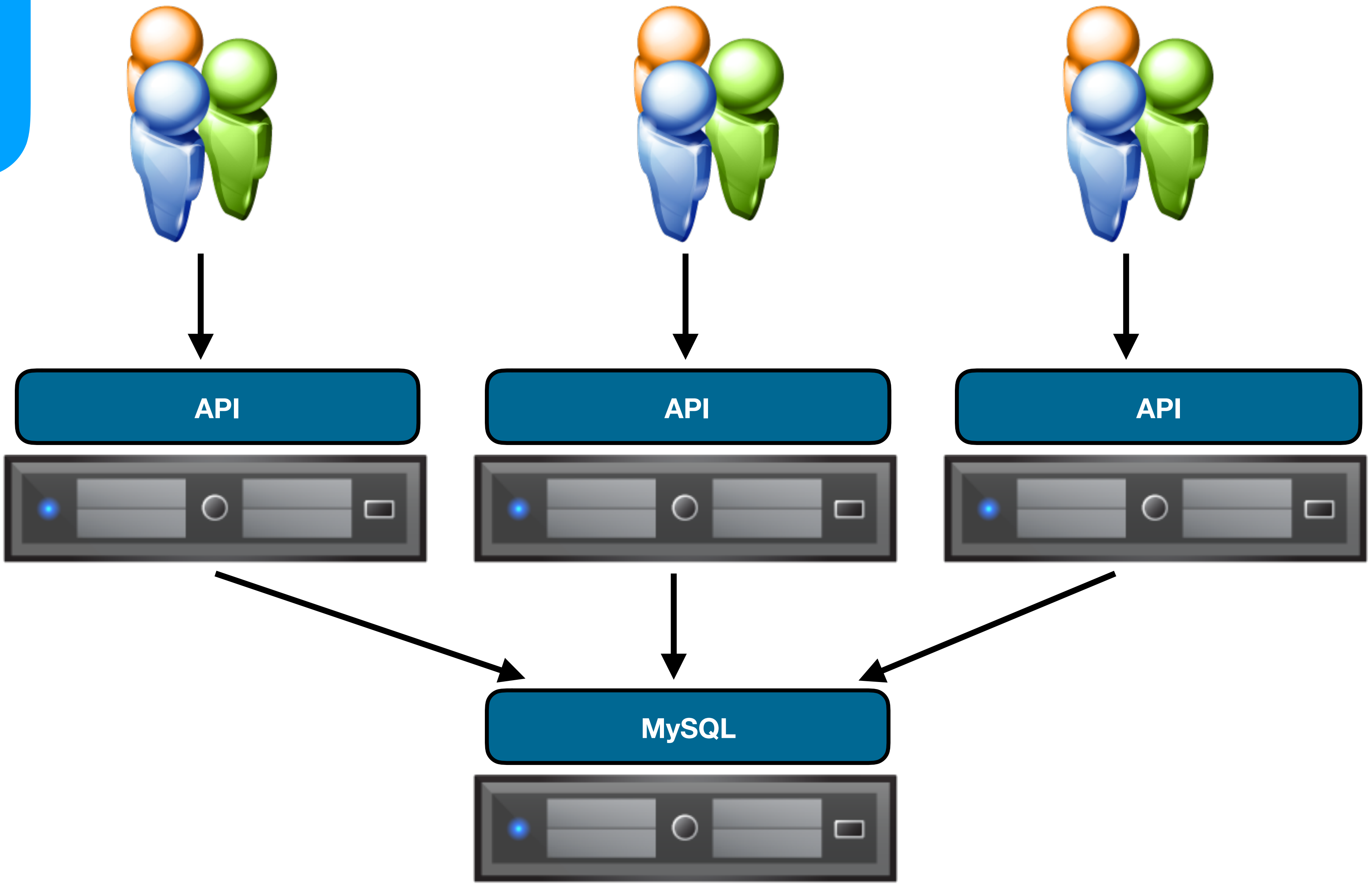
Let’s just add more nodes!



Scaling OUT increases the number of processing nodes to increase processing power.

# Distributed Monolith

What problems arise from this?



# Monolithic Challenges

- **Scalability:** Need to possibly use both up and out to reach performance goals. Hard to scale things like databases.
- **Reliability:** A fault/memory leak in a single place can crash the entire app.
- **Orchestration:** You need to rebuild and deploy the entire application every time you make a change.
- **Code Complexity:** Code turns into spaghetti due to too many things happening at once. Hard to refactor features.
- **Upgradeability**: Moving to newer tech stacks requires converting the entire app at once.

There must be a better way….

# What is a Microservice?

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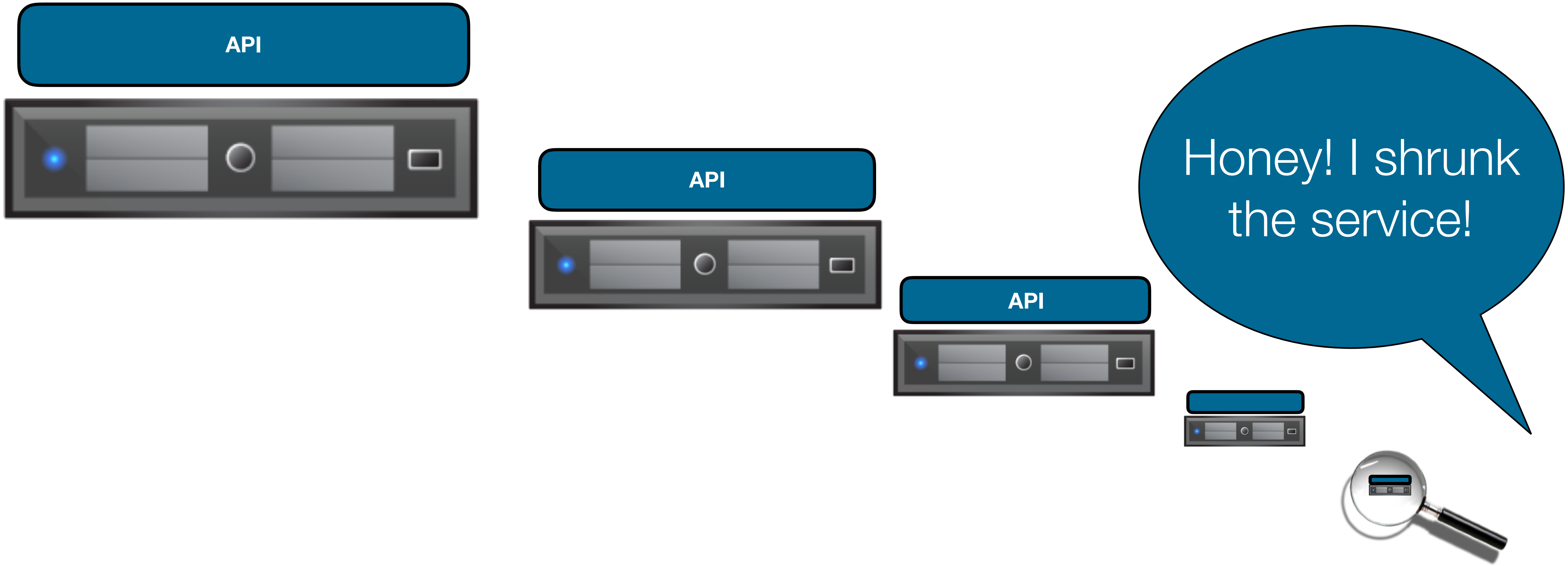
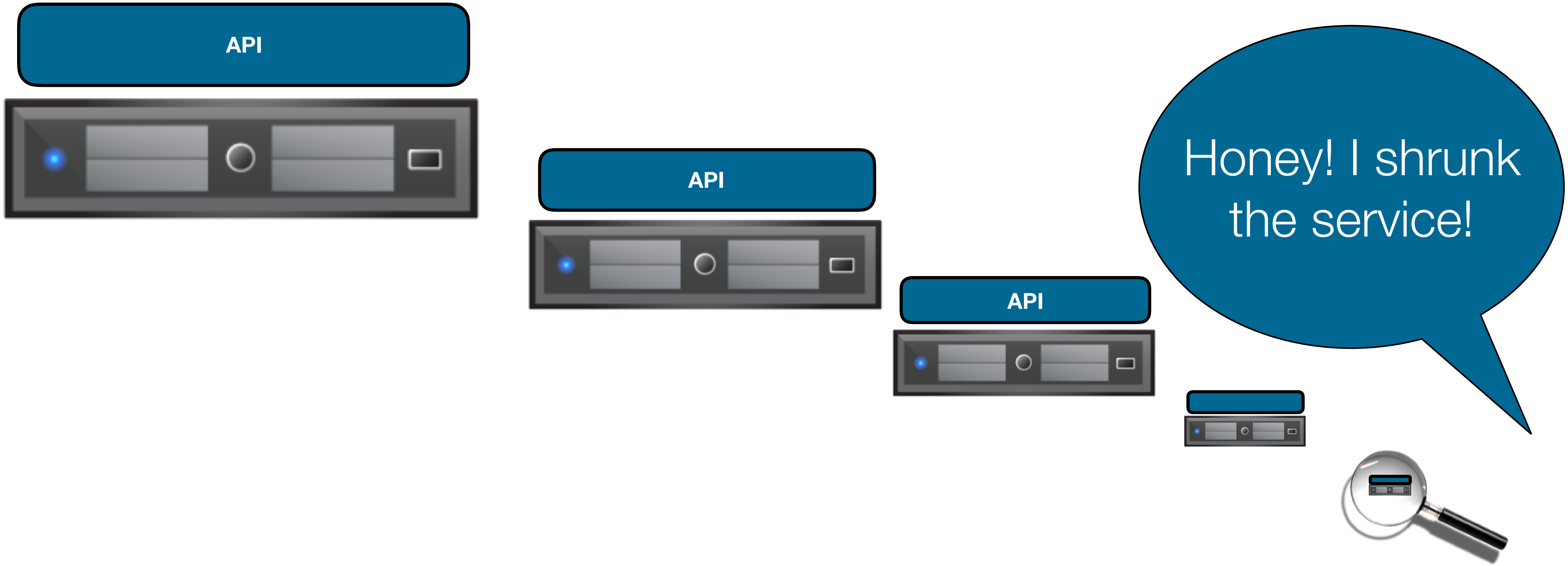


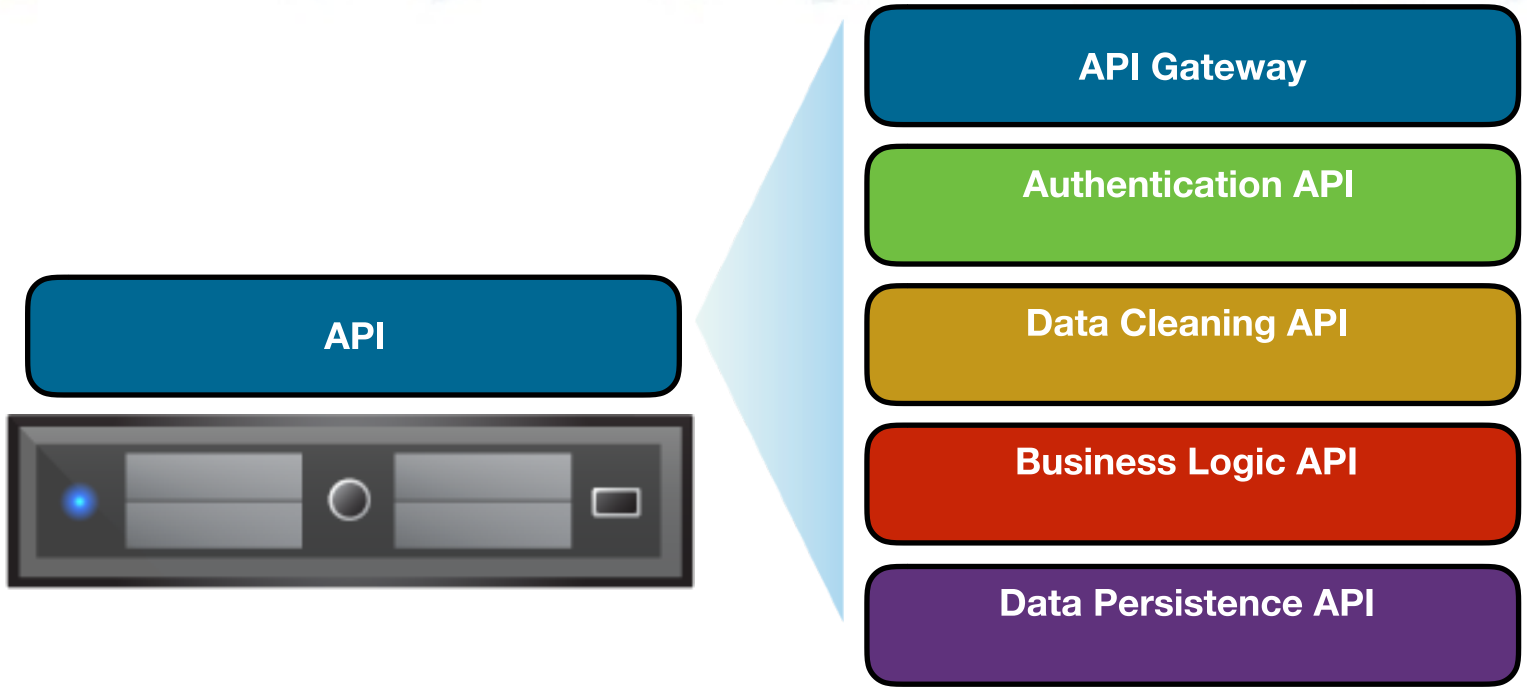
# What is a Microservice?

A system built out of many different components running in different processes and communicating over well defined API's.

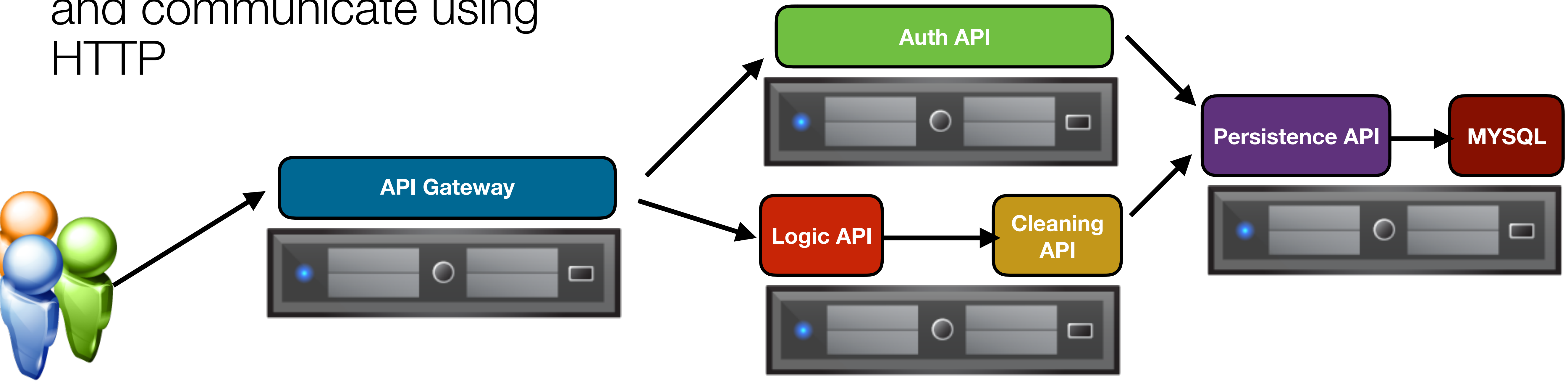


# Microservices

Take your api and split it into smaller components based on function.



API's are then distributed across many machines and communicate using HTTP



# Microservice Benefits?

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# Microservices Benefits?

- Source Code Complexity is lower. Each component responsible for smaller duty.

- Reliability. If a single service fails the rest of the application can keep running and even possibly recover.

- Services can be scaled independently and scaled up with tailored resources.

- Deploying changes only requires redeploying the single service. Can upgrade to new features independently.

- Development time is less. Ideal metric is every service can be redeployed in two weeks!

# Challenges?

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# Microservices Challenges

**Discovery**: how to find a service you want?

**Scalability**: how to replicate services for speed?

**Openness**: how to agree on a message protocol?

**Fault tolerance**: how to handle failed services?

**Data Consistency:** how do you pass data around?

**Coordination**: how do you coordinate tasks?

**The Big Picture:** how do all the pieces fit together?

All distributed systems face these challenges, microservices just increases the scale and diversity…

# Communication is Key

Microservices (and all distributed systems) need an easy way to communicate

Building custom protocols over raw sockets is messy

Most services are Request/Response

- Ask for a service or piece of data from server
- Send a piece of data to server

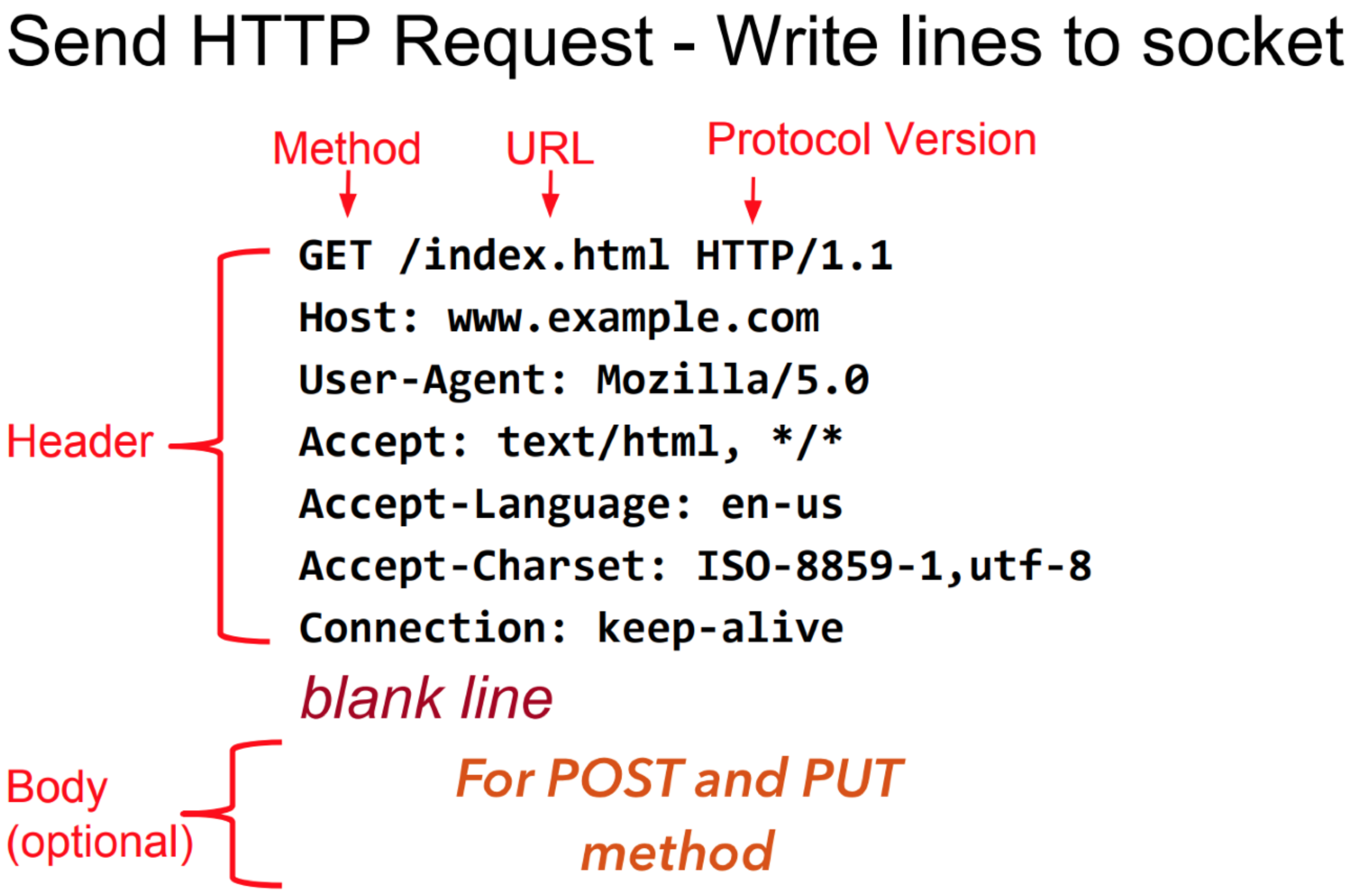
- What does this sound like?

# HTTP

https://tools.ietf.org/html/rfc2616

Versatile request/response communication standard

Client sends:



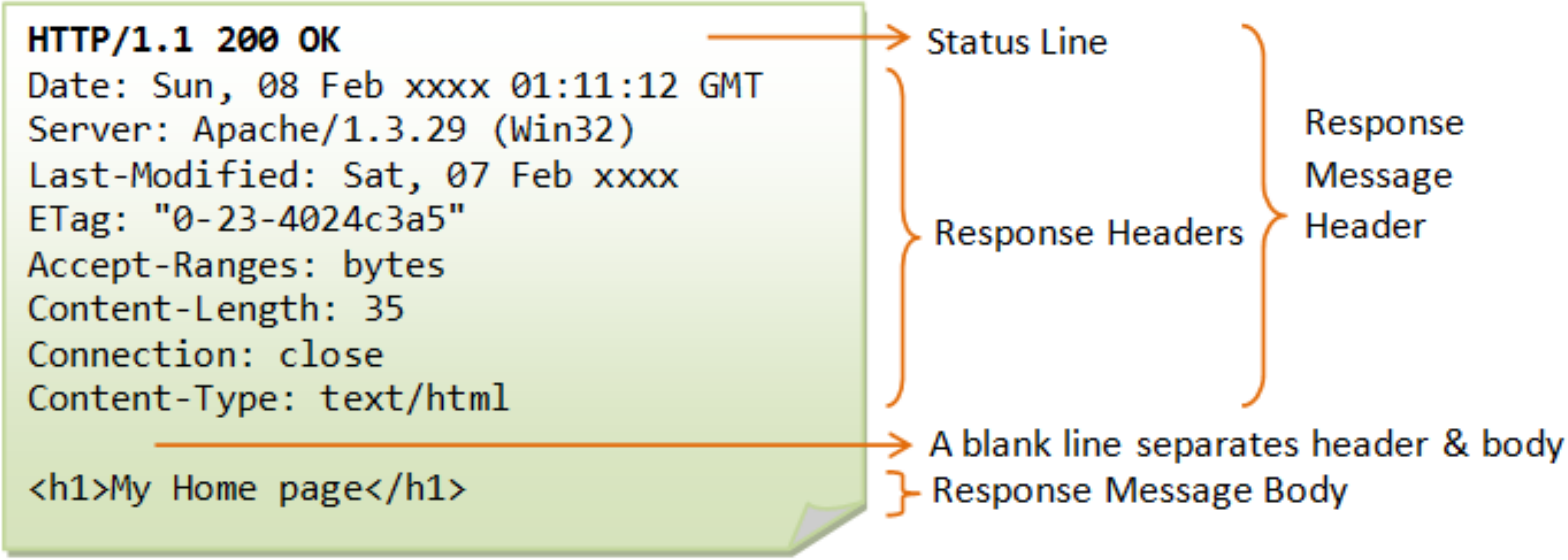
Send HTTP Request - Write lines to socket

```
GET /index.html HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0
Accept: text/html, */*
Accept-Language: en-us
Accept-Charset: ISO-8859-1,utf-8
Connection: keep-alive
```

Image Source: https://medium.com/from-the-scratch/http-server-what-do-you-need-to-know-to-build-a-simple-http-server-from-scratch-d1ef8945e4fa

# HTTP

Server responds with



```
HTTP/1.1 200 OK
Date: Sun, 08 Feb xxxx 01:11:12 GMT
Server: Apache/1.3.29 (Win32)
Last-Modified: Sat, 07 Feb xxxx
ETag: "0-23-4024c3a5"
Accept-Ranges: bytes
Content-Length: 35
Connection: close
Content-Type: text/html

<h1>My Home page</h1>
```

Image source: https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html

# HTTP Request Types

Standard defines HTTP Methods

- **GET**
- HEAD
- **POST**
- **PUT**
- PATCH
- DELETE
- TRACE
- CONNECT

https://tools.ietf.org/html/rfc2616#section-9

# RESTful Services

**Re**presentational **s**tate **t**ransfer (REST)

- Software architecture for web services
- Typically use HTTP as communication mechanism

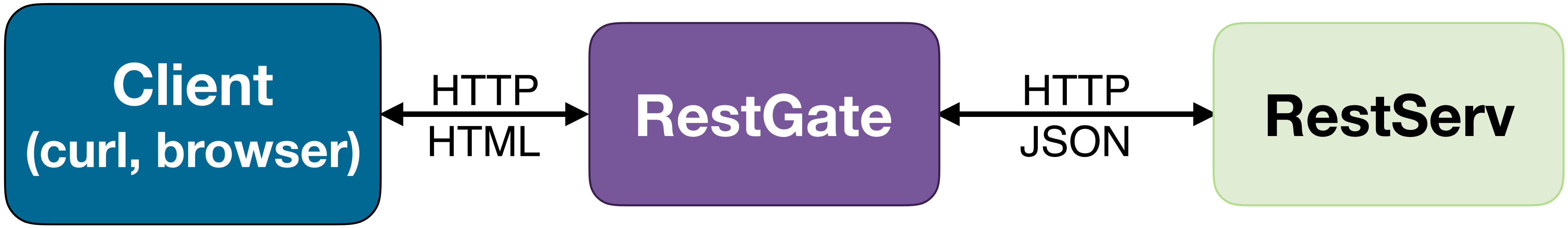
Stateless

- No per-client state stored on server between requests
- Each request must contain all information needed to process it
- Application can still have state (e.g., a database), but each request should be treated independently

Basic idea: use web technologies (e.g., HTTP, JSON) to make application interfaces (as opposed to ones directly viewed by clients on web browsers)

# Let's REST!

We will build a RESTful service that interacts with another RESTful service


Client
(curl, browser)
HTTP
HTML
RestGate
HTTP
JSON
RestServ