Introduction

Big Data Systems

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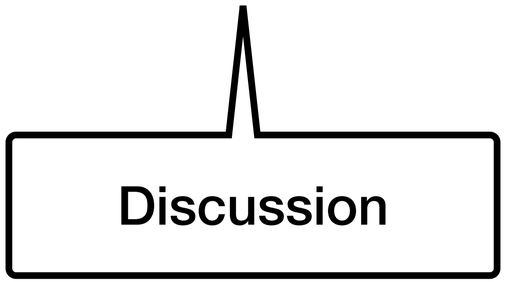
Agenda for today

- 5 V’s of Big Data
- Cloud computing
- Highly available / highly Scalable
- Managed vs Unmanaged services

When data is Big Data?



Big data

ערך שיחה

Big Data ("בִּיג דָּאטָה", לפי החלטת האקדמיה ללשון העברית: **נְתוּנֵי עָתֵק**[1]) הוא מונח המתייחס למאגר מידע הכולל נתונים מבוזרים, שאינם מאורגנים לפי שיטה כלשהי, שמגיעים ממקורות רבים, בכמויות גדולות, בפורמטים מגוונים, ובאיכויות שונות.

Data Lake

Big data

Article Talk

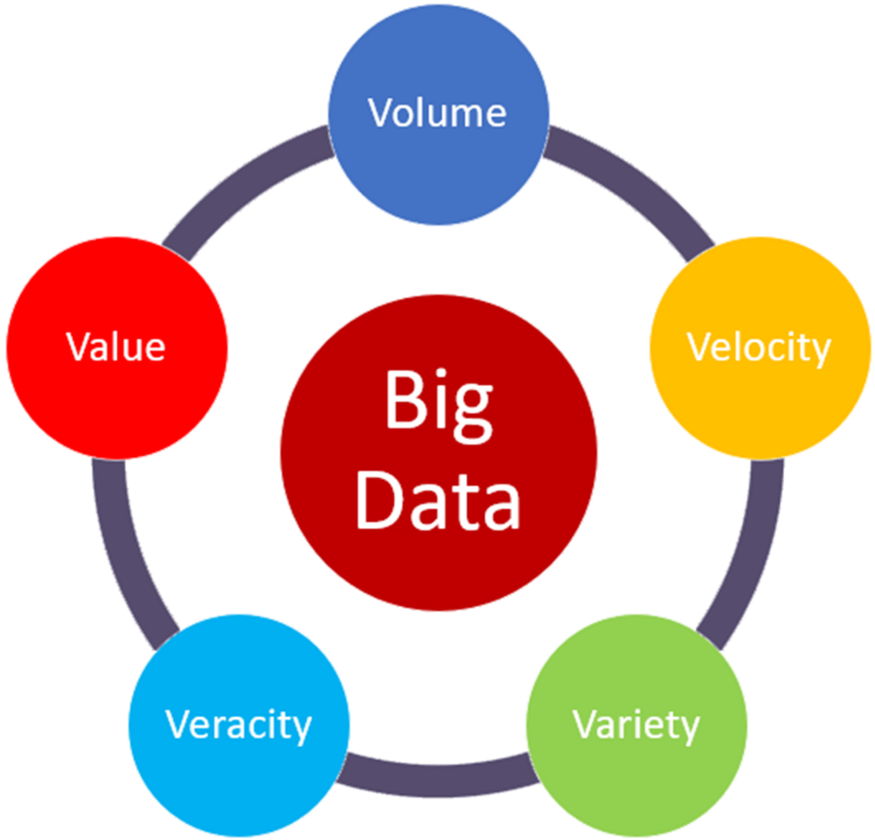
From Wikipedia, the free encyclopedia

This article is about large collections of data. For the band, see Big Data and consumer data, see Surveillance capitalism.

Big data primarily refers to data sets that are too large or complex to be dealt with by traditional data-processing software. Data with many entries (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate.[2] Though used sometimes loosely partly due to a lack of formal definition, the best interpretation is that it is a large body of information that cannot be comprehended when used in small amounts only.[3]

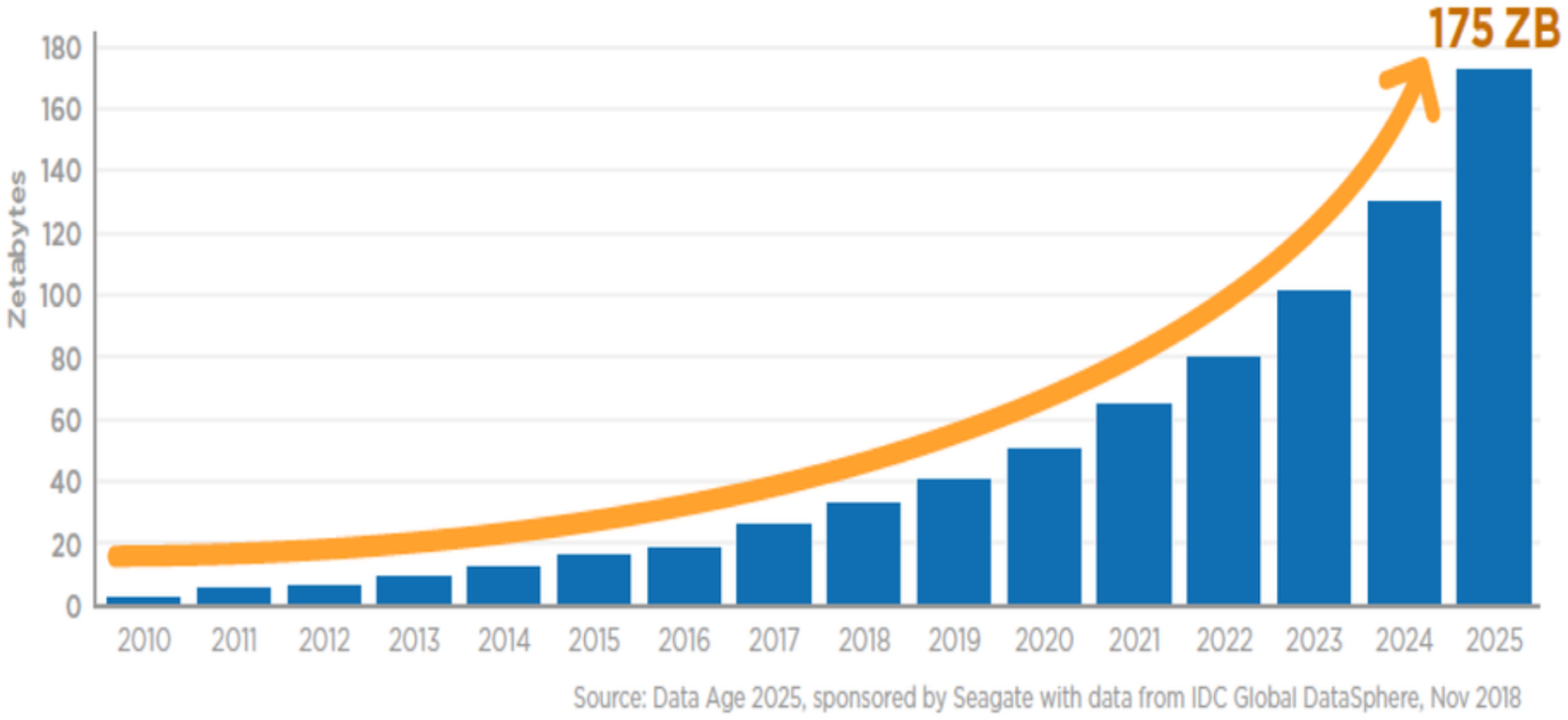
5 V’s of Big Data

- Volume
- Velocity
- Variety
- Veracity
- Value



Volume

- Data is rapidly increasing
  (due to cloud computing, mobile and more)



Value	Metric	
1000	kB	kilobyte
1000^2	MB	megabyte
1000^3	GB	gigabyte
1000^4	TB	terabyte
1000^5	PB	petabyte
1000^6	EB	exabyte
1000^7	ZB	zettabyte
1000^8	YB	yottabyte

Volume

- Data is rapidly increasing
  (due to cloud computing, mobile and more)

As of 2020, WhatsApp users send over 100 billion messages each day

Velocity

The speed at which data is generated

- Frequency of data generation (write)
  everything is measured
- Frequency of data processing (read)
  real time experience

Variety

- Structured data
  info, transactions…
- Semi structured data
  logs, sensor data…
- Unstructured data
  images, video, audio…

Veracity

The truthfulness or reliability of the data

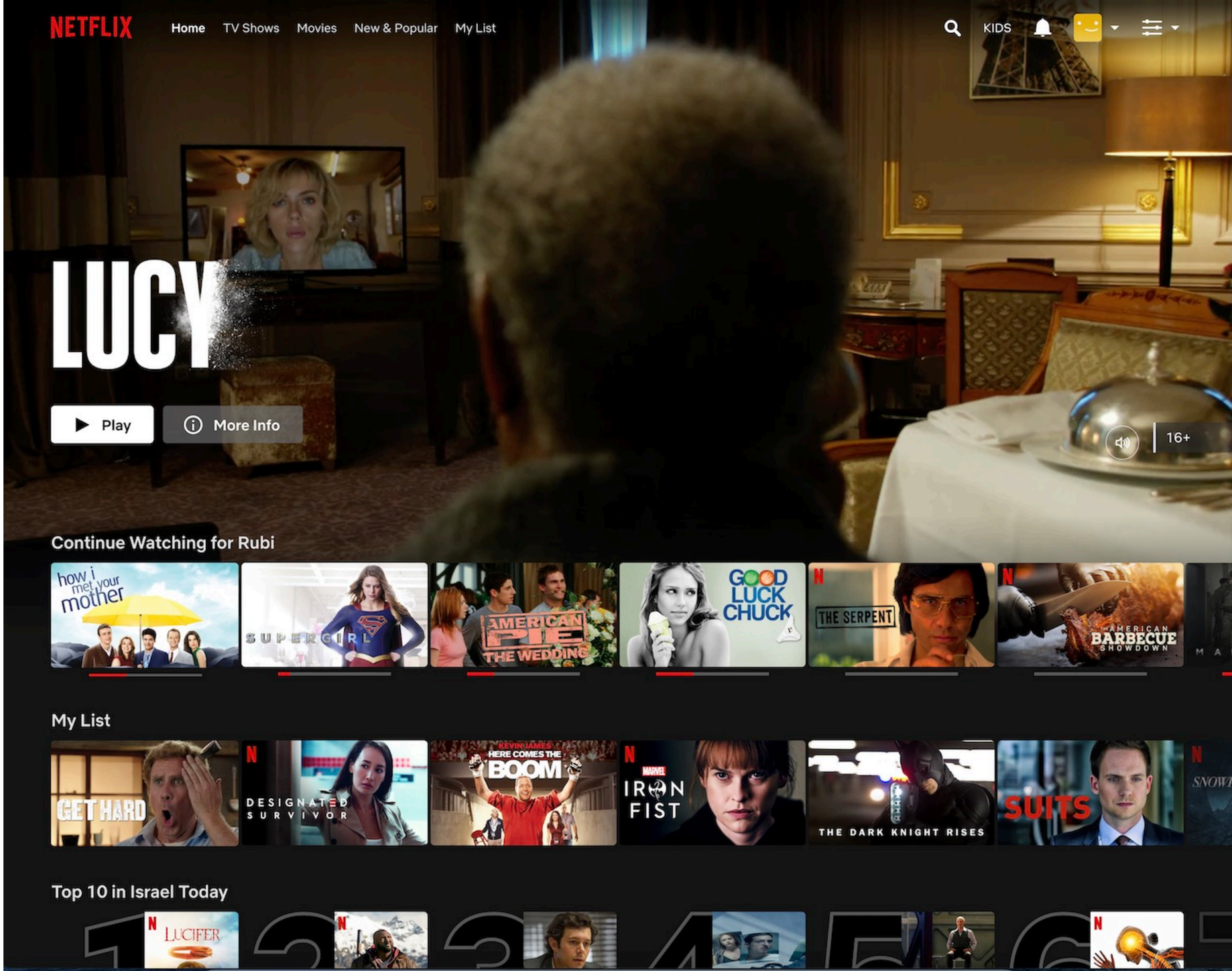
- data quality of captured data can vary greatly
  - bias
  - abnormalities
  - inconsistencies
  - duplication

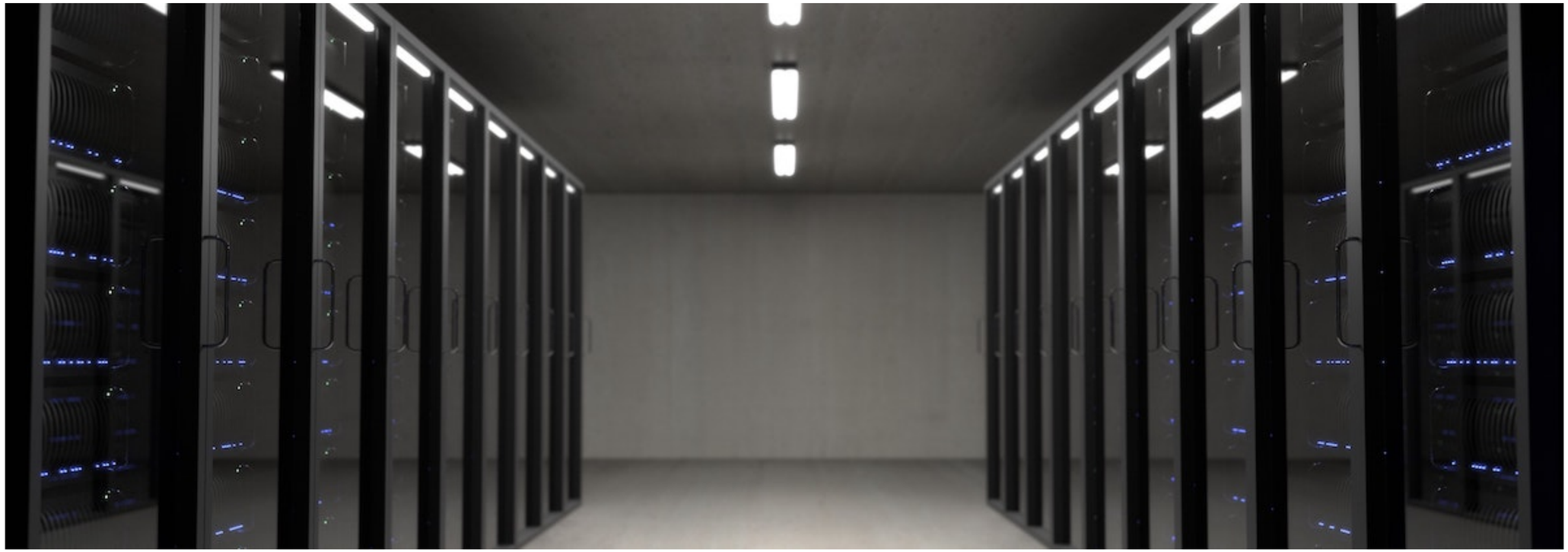
Value

The final result.

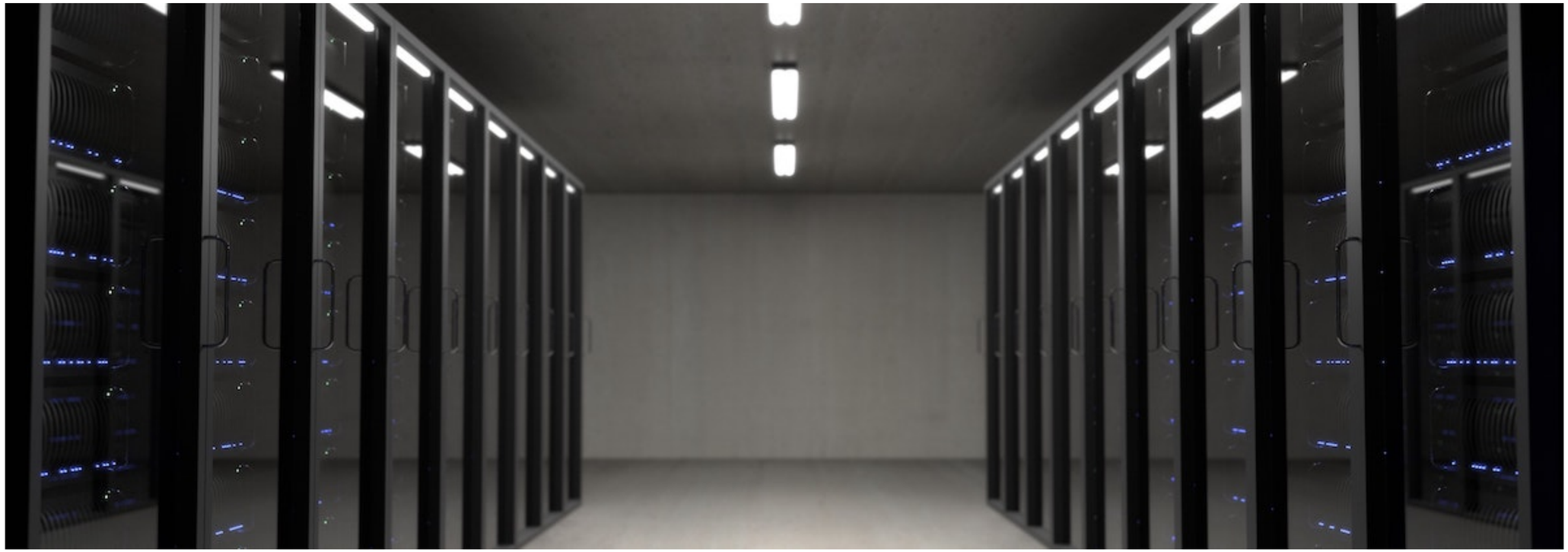
- which questions were answered
- hidden insights (machine learning)
- collecting data without use is, well, useless

- Volume
- Velocity
- Variety
- Veracity
- Value





Cloud computing

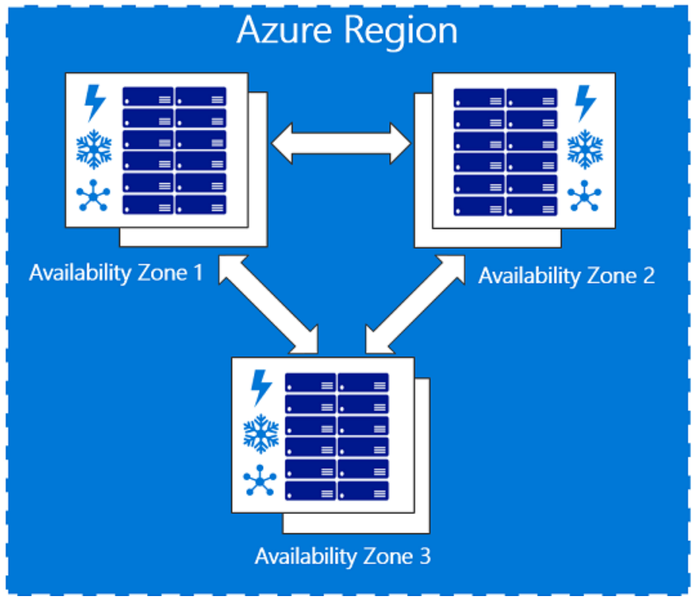


Cloud computing

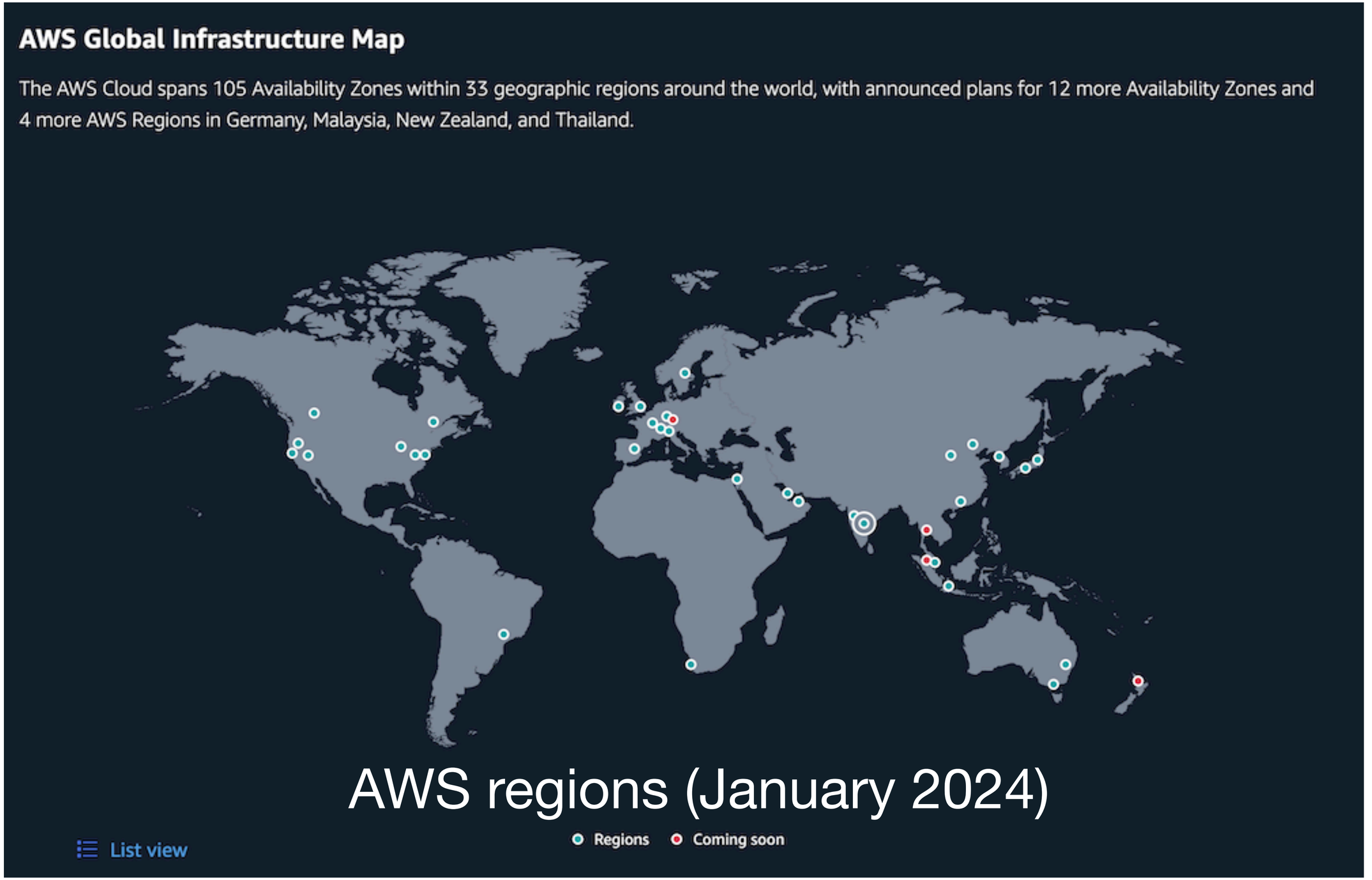
Not so relevant for the “regular Database course”, but for Big Data it is crucial

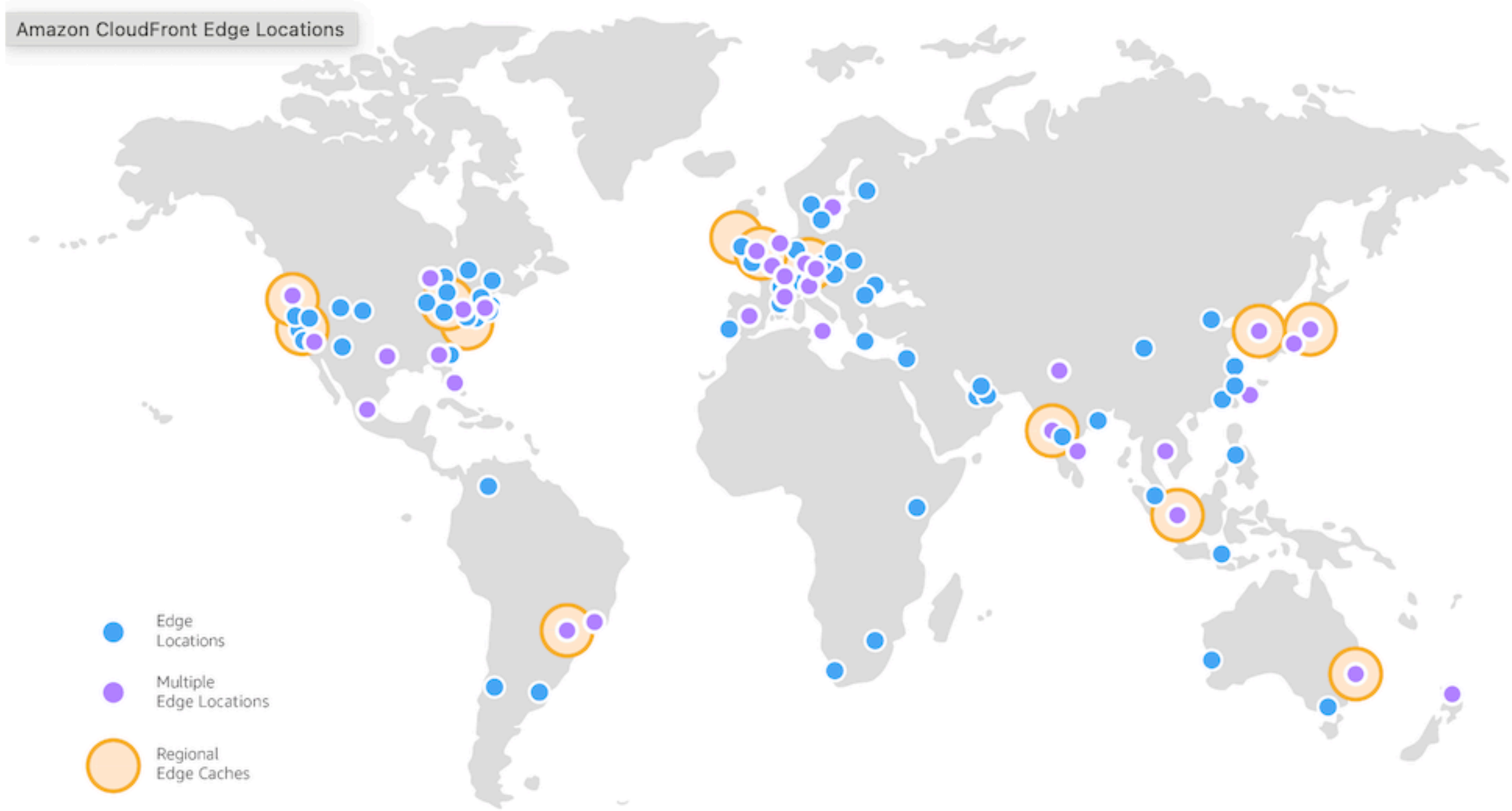
Region / AZ / EL

- Region
  Cluster of data centers in a physical location
- Availability Zone
  a discrete data center with redundant power, networking, and connectivity in a Region
- Edge Location
  access to the network with limited services (usually CDN)



- (Names may vary between cloud providers)

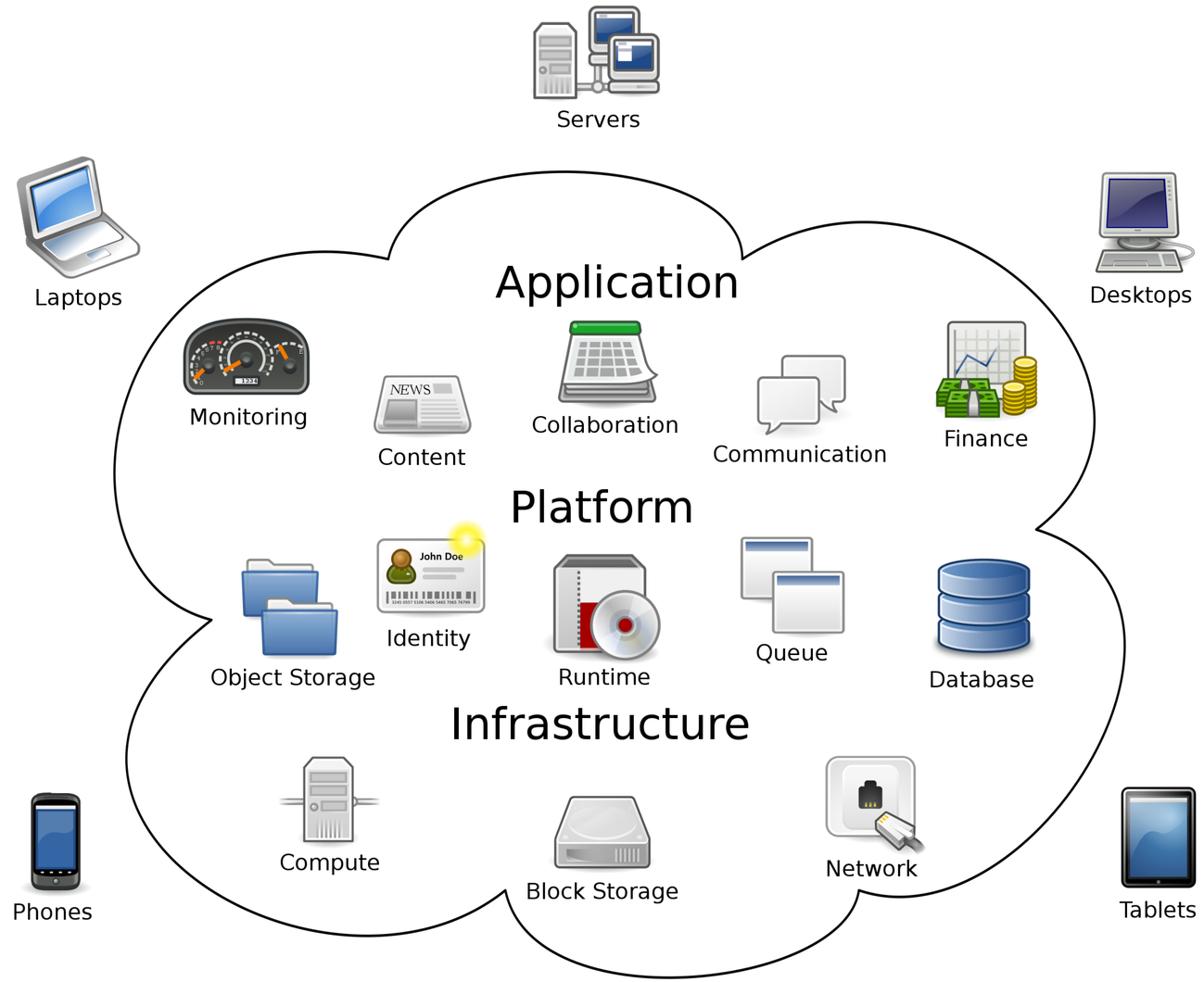

AWS Global Infrastructure Map
The AWS Cloud spans 105 Availability Zones within 33 geographic regions around the world, with announced plans for 12 more Availability Zones and 4 more AWS Regions in Germany, Malaysia, New Zealand, and Thailand.
AWS regions (January 2024)
List view
Regions
Coming soon



AWS edge locations (January 2024)

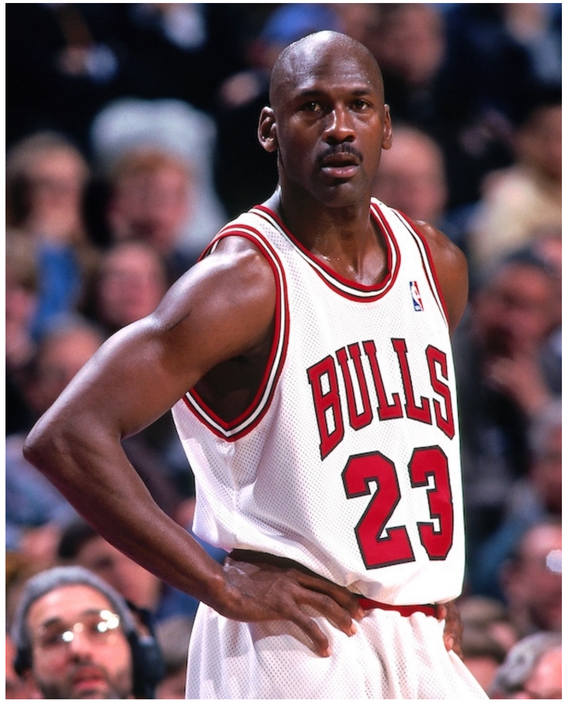
Cloud computing

- SaaS
  software as a service
- PaaS
  platform as a service
- IaaS
  infrastructure as a service



Highly Available / Highly Scalable

Mike orders a a basketball



Once clicked “order"

- Create order
- Check inventory
- Process payment
- Approve order
- Send to warehouse
- …

System error
fire / flood / electricity / hardware malfunction / software update…

Availability problem

Possible outcomes

- Service disruption
- Data loss
- Data consistency
- Money lost (direct / reputation)
- A hard problem to solve for Databases
  disaster recovery:
  RTO (Recovery time) / RPO (Recovery point object)

Possible outcomes

- Service disruption
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  disaster recovery:
  RTO (Recovery time) / RPO (Recovery point object)

How long would it take the database server to reset and “recover”?

High availability

- “Nines”

Availability	Downtime per day	Downtime per year
90%	2.40 hours	36.53 days
95%	1.20 hours	18.26 days
99%	14.40 minutes	3.65 days
99.9%	1.44 minutes	8.77 hours
99.99%	8.64 seconds	52.60 minutes
99.999%	864.00 milliseconds	5.26 minutes
99.9999%	86.40 milliseconds	31.56 seconds

Can you think of a faster solution?

Can you think of a faster solution?

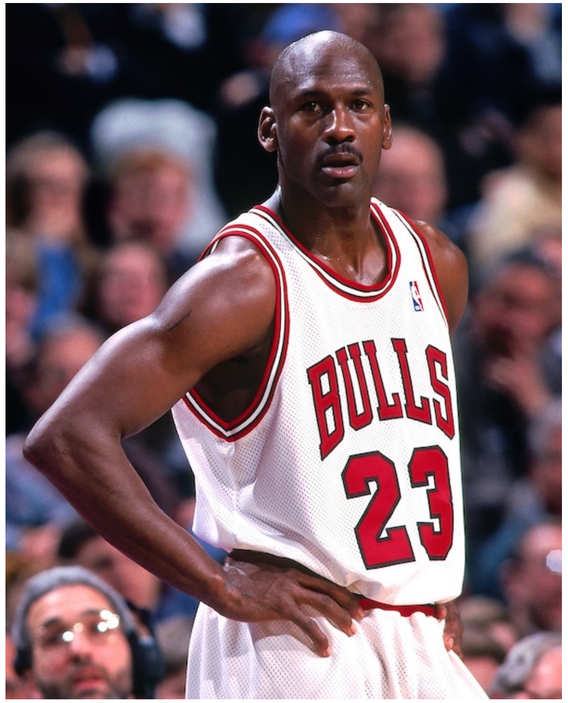
- Have a backup server on standby
  - How long would it take it to resume?
  - How to keep the backup server's data up to date?

    …

- Have two servers operate simultaneously
  - How to decide which server accept which request?
  - How to sync their data?

    …

Mike tweets about a basketball he bought



- Reach millions of users
- Millions of users try to buy the same basketball at the same time

System error
Too many requests

Scalability problem

How can you support millions of users?

How can you support millions of users?

- “Easy” - lets “use” much more servers
- But how would they “work” together?
- Do we need all servers 24h?

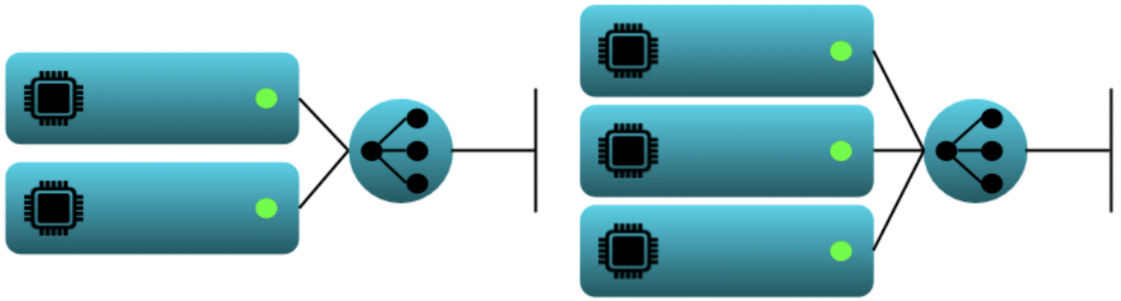
High scalability - key properties

- Scale up vs scale out
  commodity computing
- **Microservices**
- **Stateless**
  amazon’s shopping cart is stateless?
- **Data Sharding**

Scale up vs Scale out

- Commodity hardware

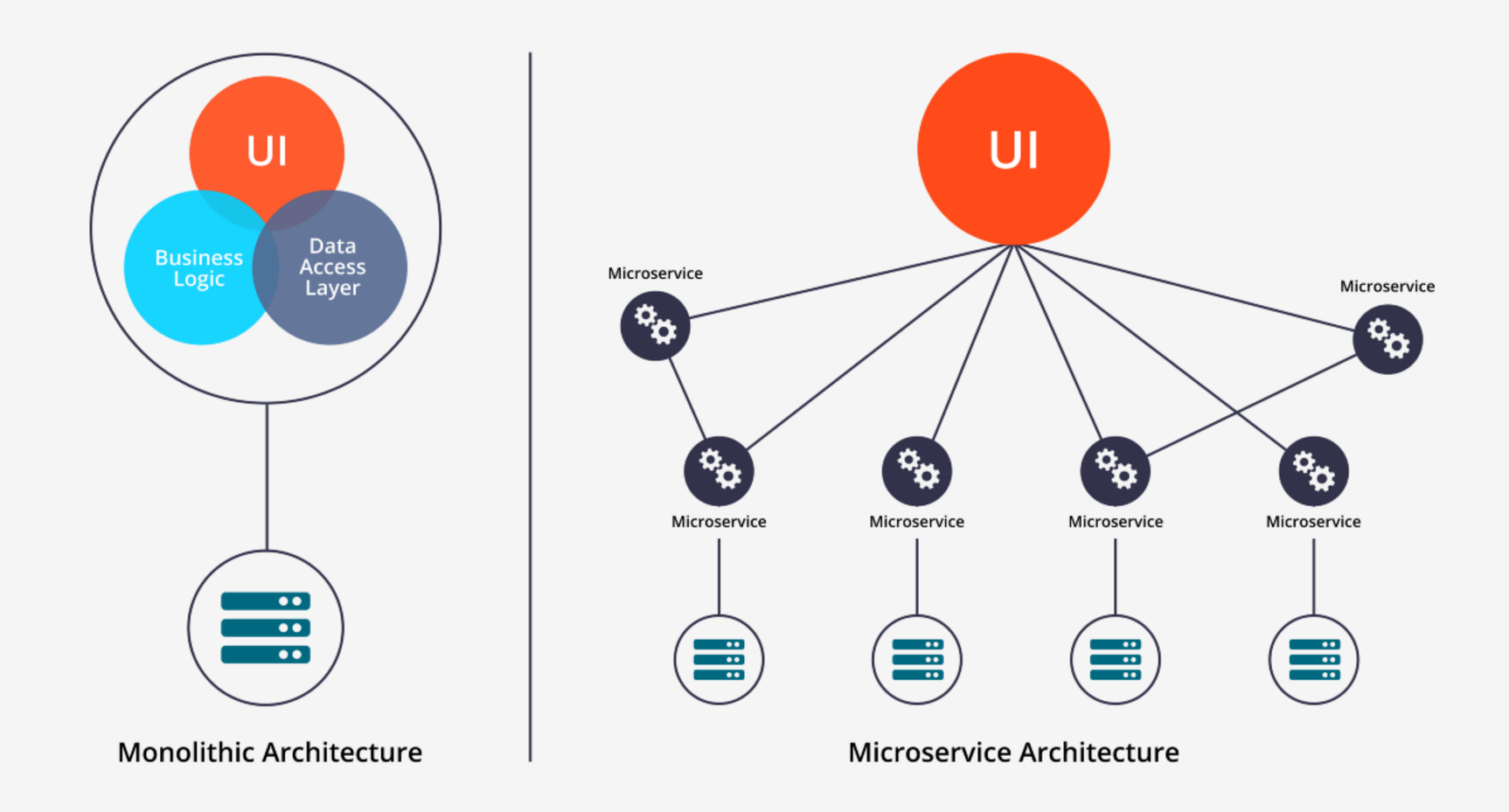
Scaling up from two to three CPUs



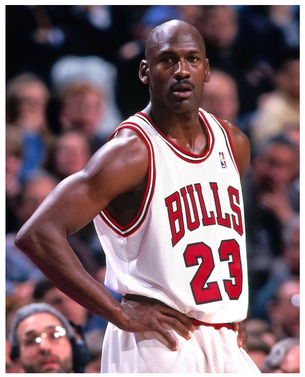
Scaling out from two to three CPUs

Microservices

- Split a big task into **loosely coupled** services



Example


BULLS
23

Clicked order
Order creation
Inventory check
Process payment
Send to warehouse
Order approve
microservice
highly scalable
highly available
microservice
highly scalable
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Example - inventory check

- Ok so we have a smaller task - how to support millions of users?

Example - inventory check

- Ok so we have a smaller task - how to support millions of users?

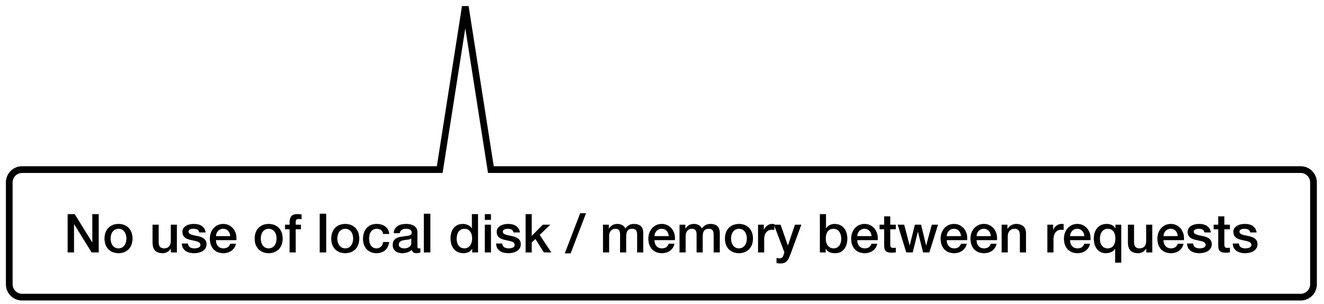
—> Stateless logic + load balancer + auto scaling

Statless

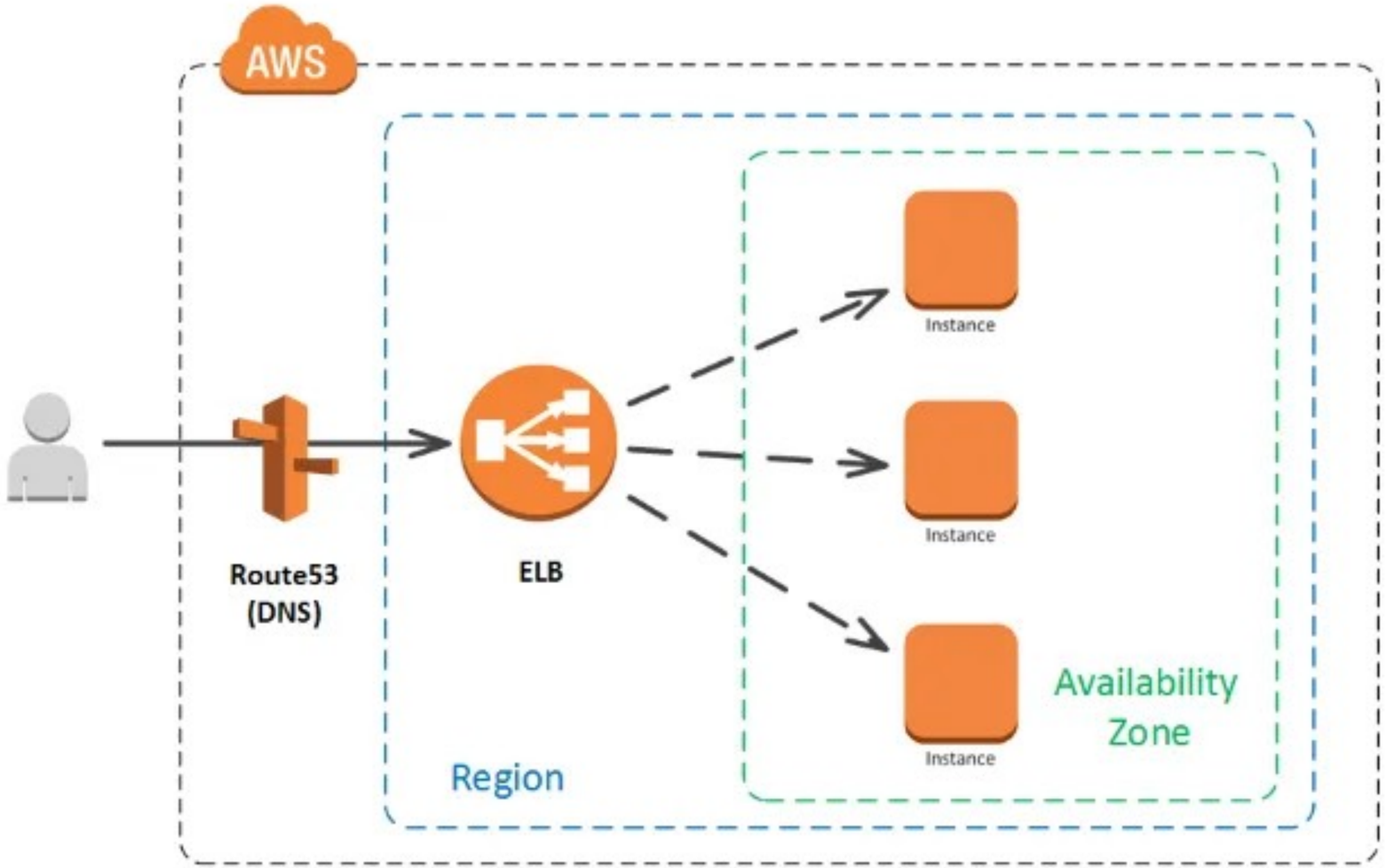
- Similar to “Model of computation” course
- Intuition:
  - Do not store anything on **local** disk or memory
  - Any server can handle any request

Example - inventory check - stateless

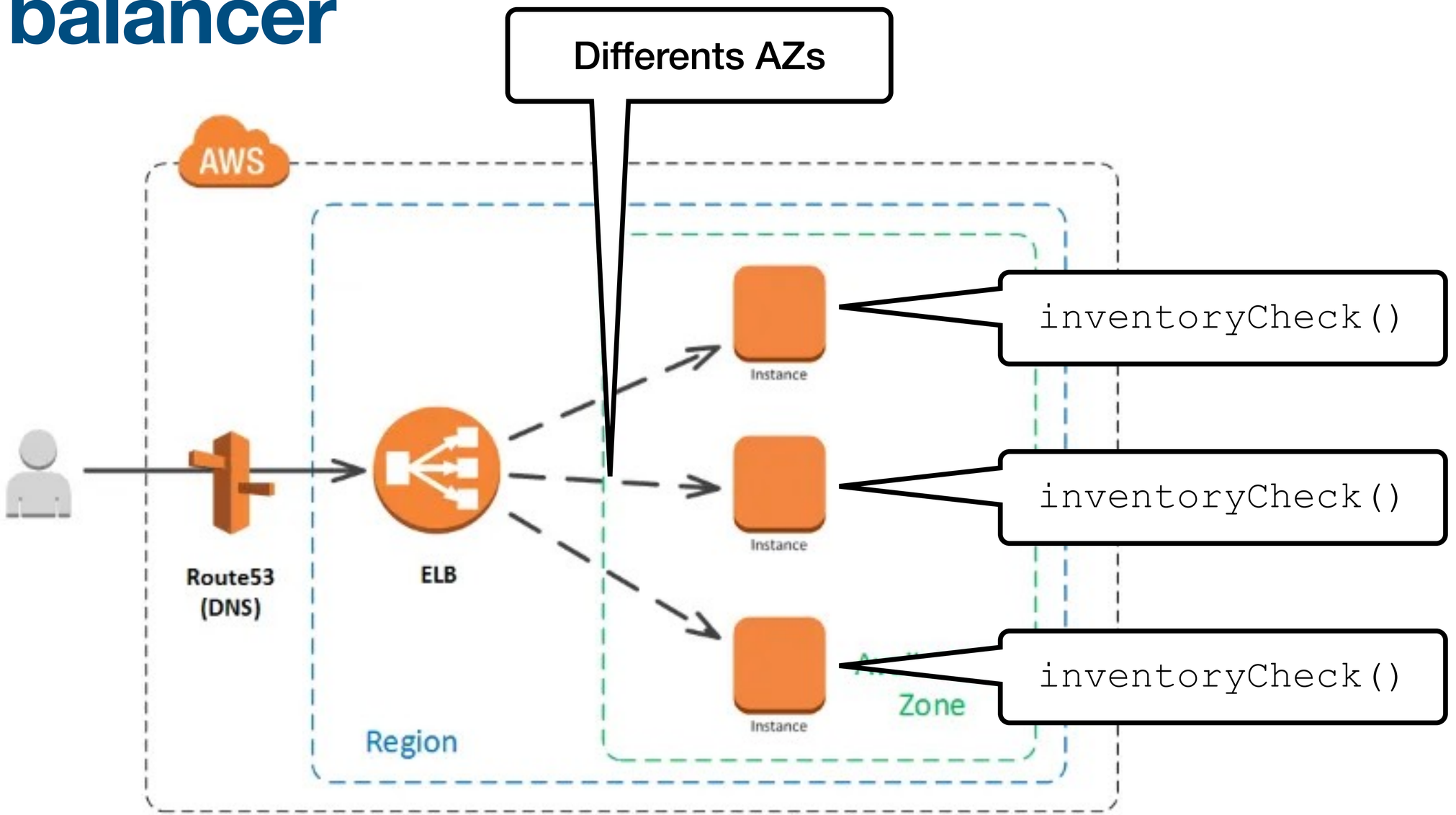
```
private boolean inventoryCheck(String[] itemIDs) {
   // checks with the db (different service)
   for (String itemID : itemIDs)
      if (db.inventoryCheck(itemID) == false)
         return false;
   return true;

}
```



Load balancer

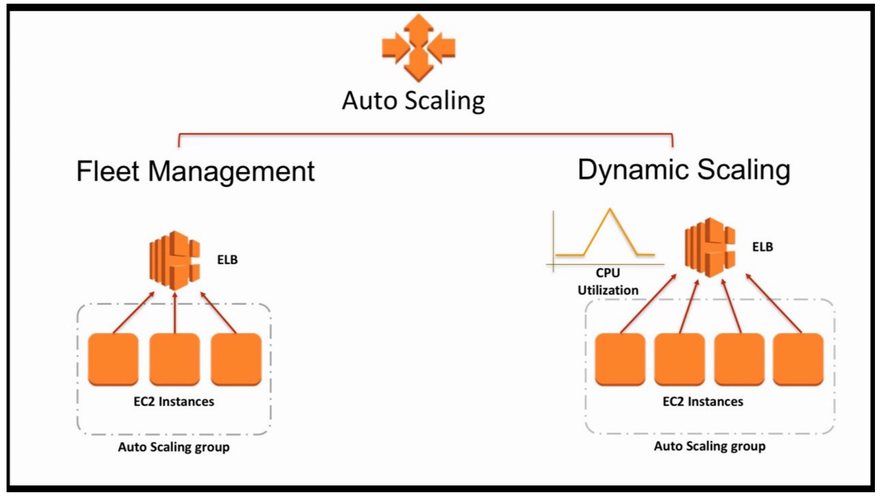


Load balancer



Auto scaling

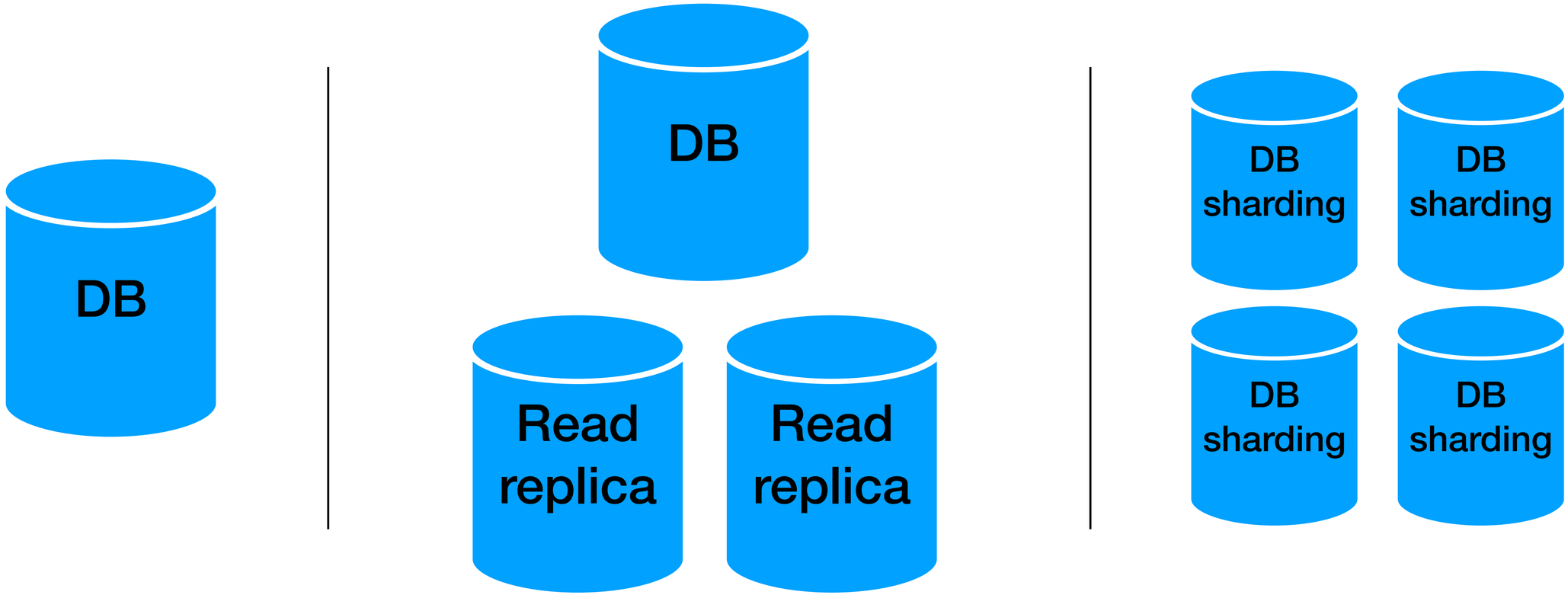
- When threshold occurs (hits / traffic / CPU…), create a new instance with the same logic and add it to the load balancer
- When threshold drops, remove the instance from the load balancer and terminate it
- Usually requires stateless logic
  can Cassandra work with auto scale?



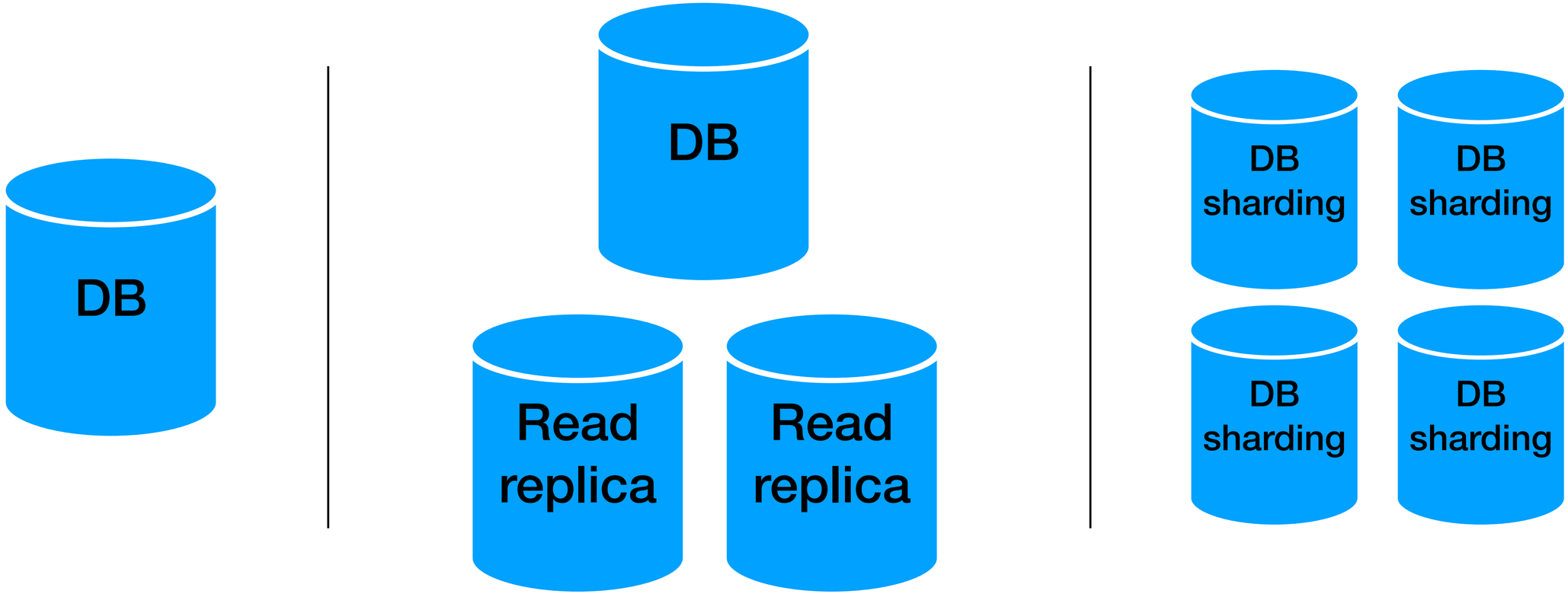
Auto scaling - compute + storage?

- Some applications use both compute and storage (for example the db service in the example)
- Stateless?
- What happens when we scale down?

Scaling databases



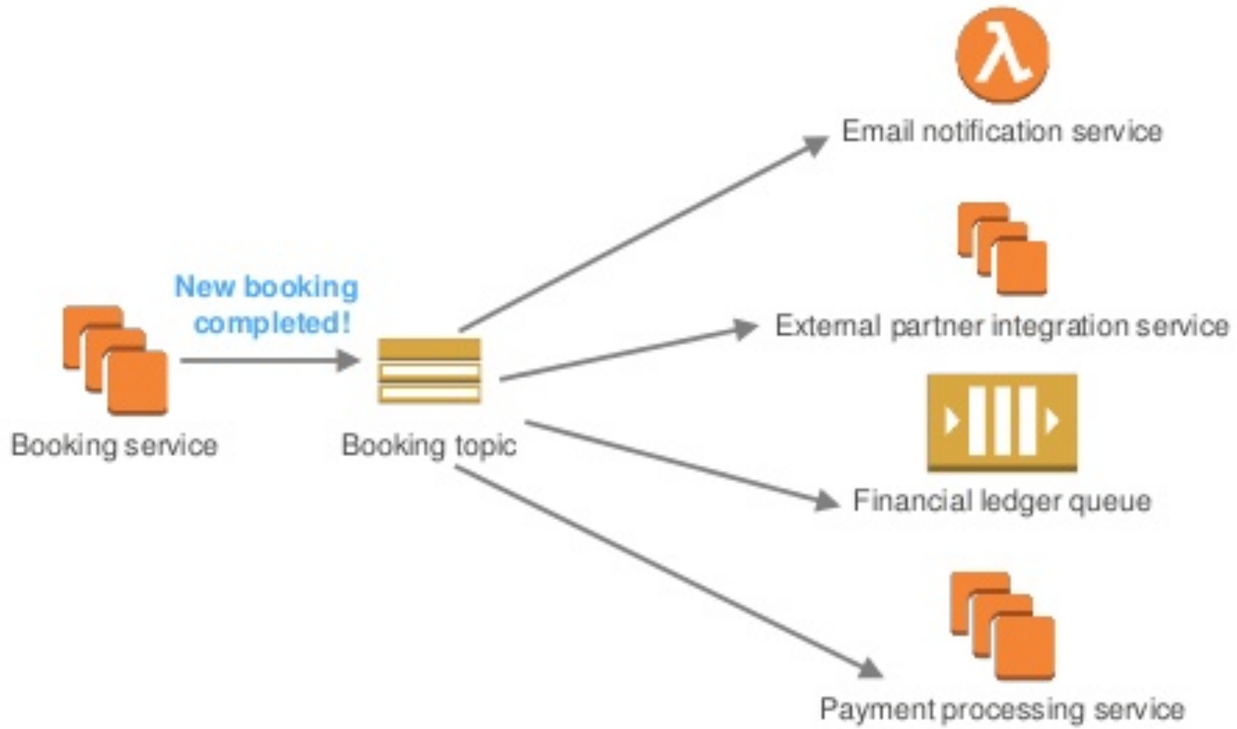
Scaling databases



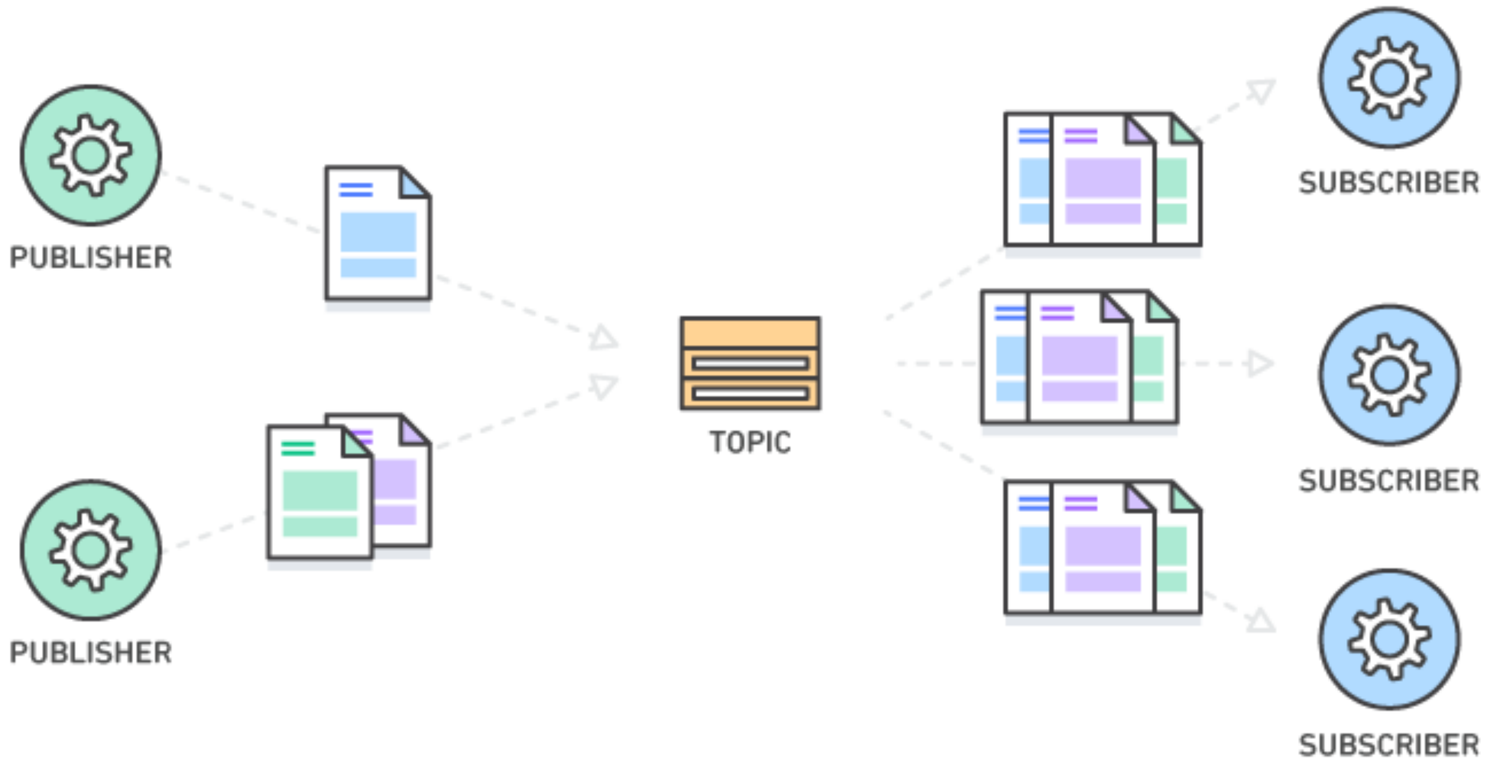
Warning - we will talk about this a lot :)

Decoupling + event based services

- autonomous and unaware of each other services



Pub sub


PUBLISHER
PUBLISHER
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Managed vs Unmanaged services

Unmanaged service

You are responsible for everything!

- Choosing CPUs, storage, network…
- Installing OS, Java, core software, dependencies…
- Patches, updates
- Security
- Backup
- Monitoring
- Availability

Unmanaged service (2)

Requires different skills

- System
- DevOps
- …

Managed service

- All the stuff we talked about before are managed for you out of the box
- Hardware utilization
- Focus on stuff that really matters for you
- Cost?

Managed service cons

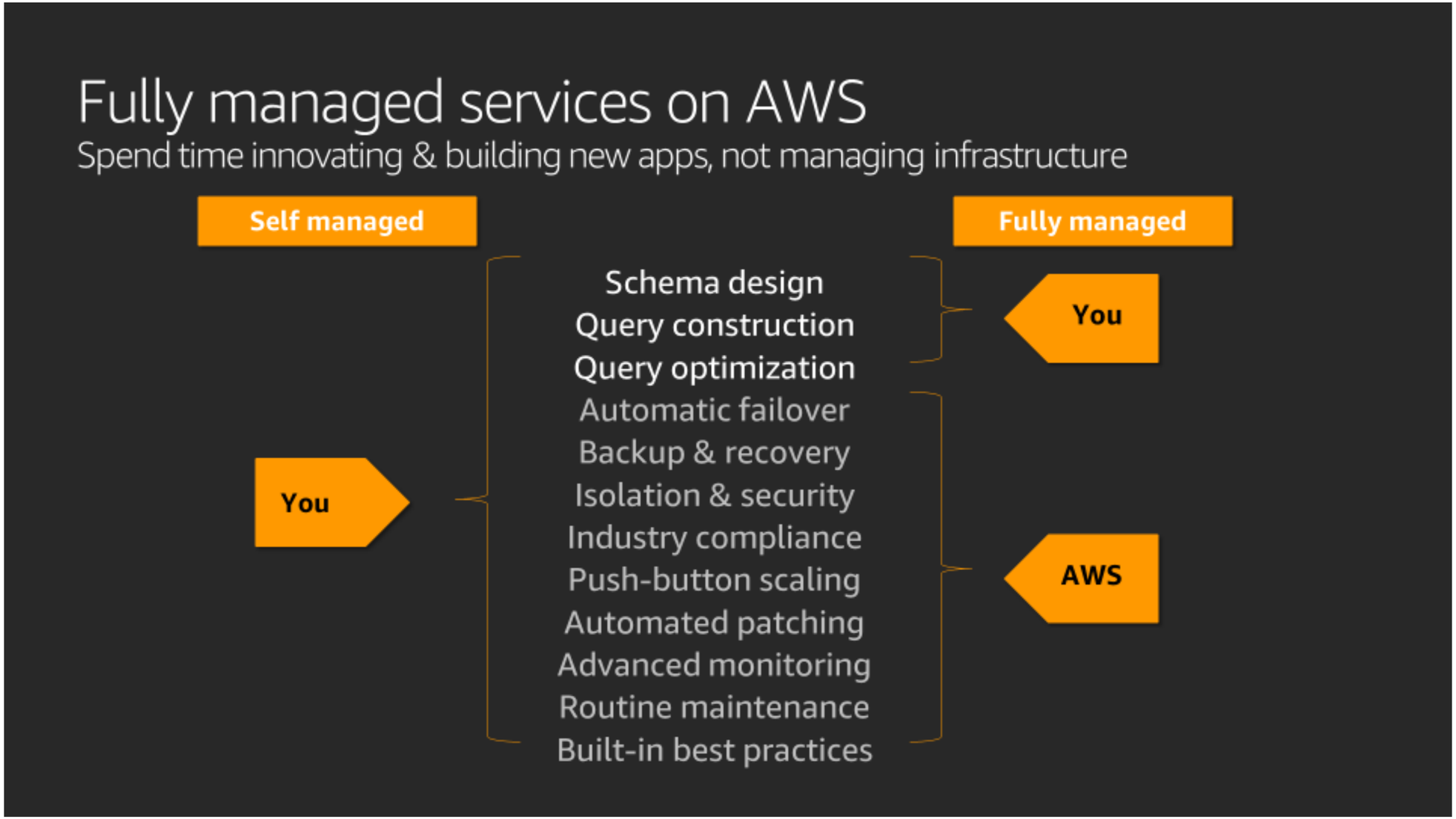
- **Cloud locked in**
- Slightly limited functionality
- Works only in the cloud
- Cost?
  (cheaper to go unmanaged on large scale, but a lot of headaches)

In practice

- Some will be managed and some not
  VMs
  load balancers
  network stuff
  …

- **To go managed or unmanaged with databases is a good question**

Managed vs Unmanaged Databases



But how managed service work?

- It is just someone else's software…

- Do we need to understand how it works behind the scenes?

For databases, YES!

Big Data databases

- Managed big data databases are built on, well, big data databases
- **Data modeling is crucial.**
  (with bad modeling, nothing will work)

To model data correctly,
we need to understand the technology
(it is not just reading the API docs)