Data-Intensive Distributed Computing

CS 451/651 (Fall 2018)

The Final Part

November 29, 2018

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These slides are available at http://lintool.github.io/bigdata-2018f/

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The datacenter *is* the computer!
"Big ideas"

Scale "out", not "up"*

Limits of SMP and large shared-memory machines

Assume that components will break*

Engineer software around hardware failures

Move processing to the data*

Cluster have limited bandwidth, code is a lot smaller

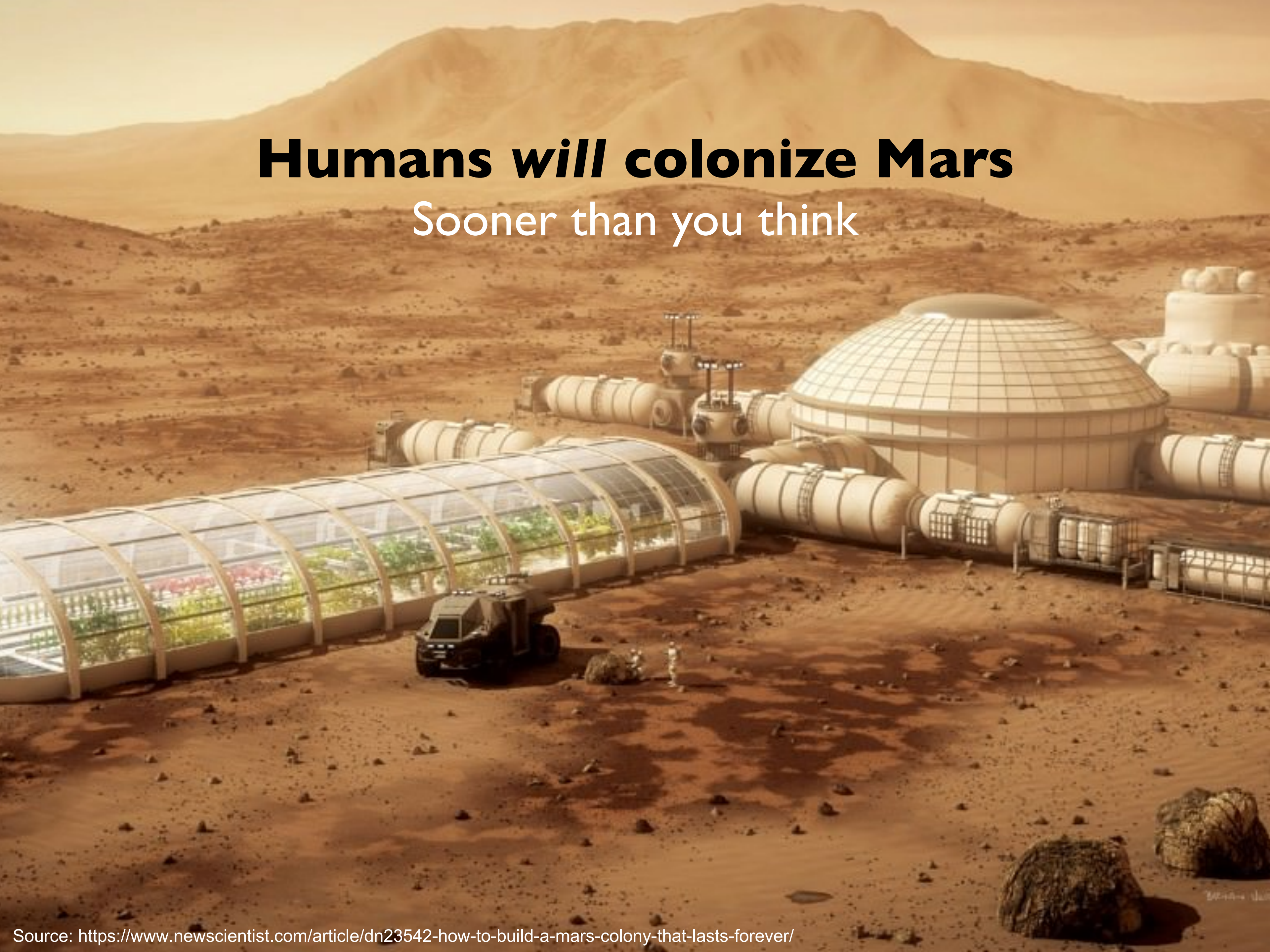
Process data sequentially, avoid random access

Seeks are expensive, disk throughput is good

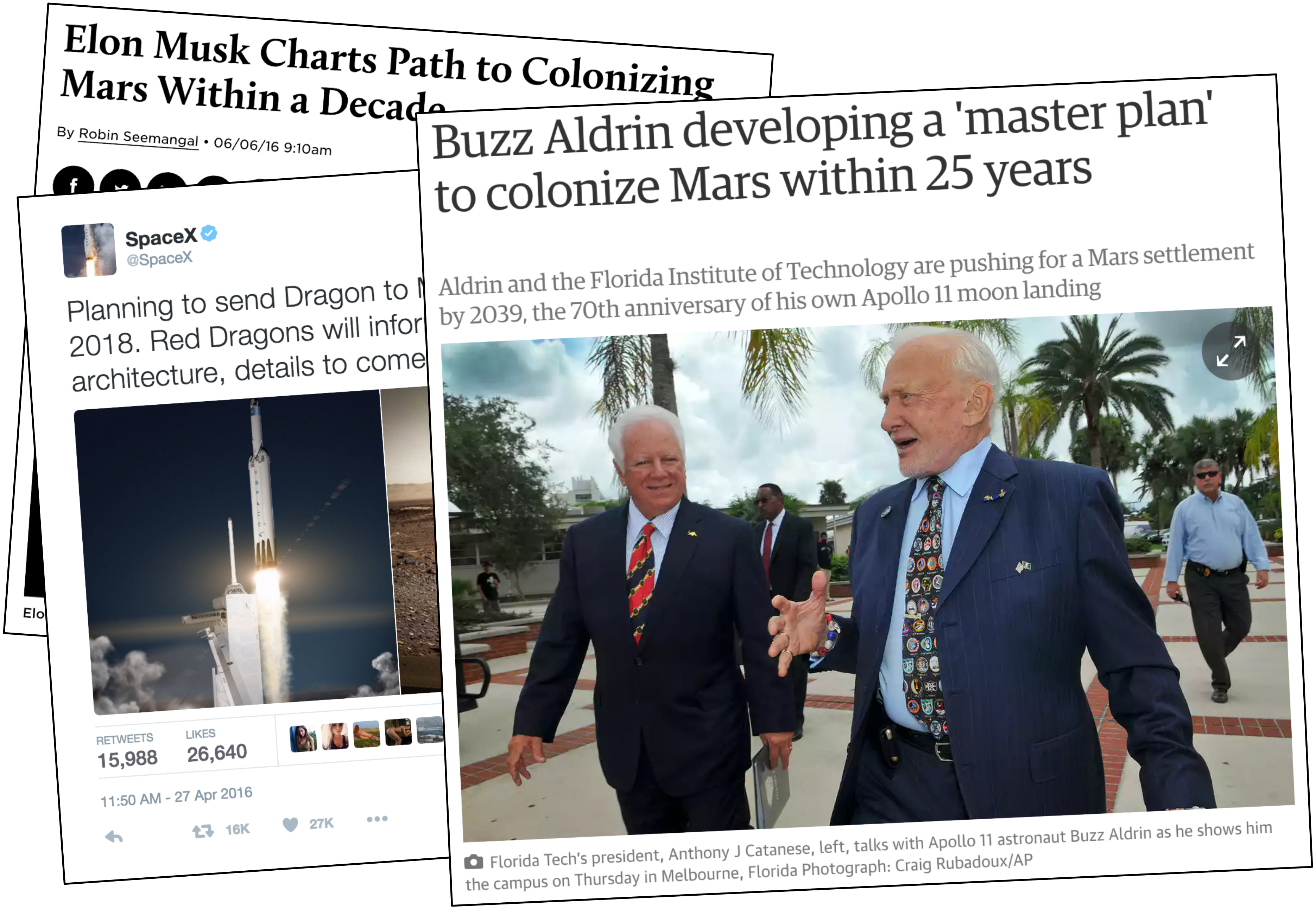
Source: NASA/JPL

Humans *will* colonize Mars

Sooner than you think



Source: https://www.newscientist.com/article/dn23542-how-to-build-a-mars-colony-that-lasts-forever/


Elon Musk Charts Path to Colonizing Mars Within a Decade

By Robin Seemangal • 06/06/16 9:10am

SpaceX
@SpaceX

Planning to send Dragon to M
2018. Red Dragons will infor
architecture, details to come

RETWEETS 15,988
LIKES 26,640

11:50 AM - 27 Apr 2016

16K 27K

Buzz Aldrin developing a 'master plan' to colonize Mars within 25 years

Aldrin and the Florida Institute of Technology are pushing for a Mars settlement by 2039, the 70th anniversary of his own Apollo 11 moon landing

Florida Tech's president, Anthony J Catanese, left, talks with Apollo 11 astronaut Buzz Aldrin as he shows him the campus on Thursday in Melbourne, Florida Photograph: Craig Rubadoux/AP

Source: https://www.theguardian.com/science/2015/aug/27/buzz-aldrin-colonize-mars-within-25-years
Source: https://twitter.com/SpaceX/status/725351354537906176
Source: http://observer.com/2016/06/elon-musk-charts-path-to-colonizing-mars-within-a-decade/

“Mars can’t just be a one-shot mission” – Buzz Aldrin

“The Pilgrims on the Mayflower came here to live and stay. They didn’t wait around Plymouth Rock for the return trip, and neither will people building up a population and a settlement [on Mars].”

Source: *Mayflower in Plymouth Harbor* by William Halsall (1882)

Needs

Produce breathable air

Grow food

Build shelter

Mine fuel and materials

"Staying alive"

Conduct science

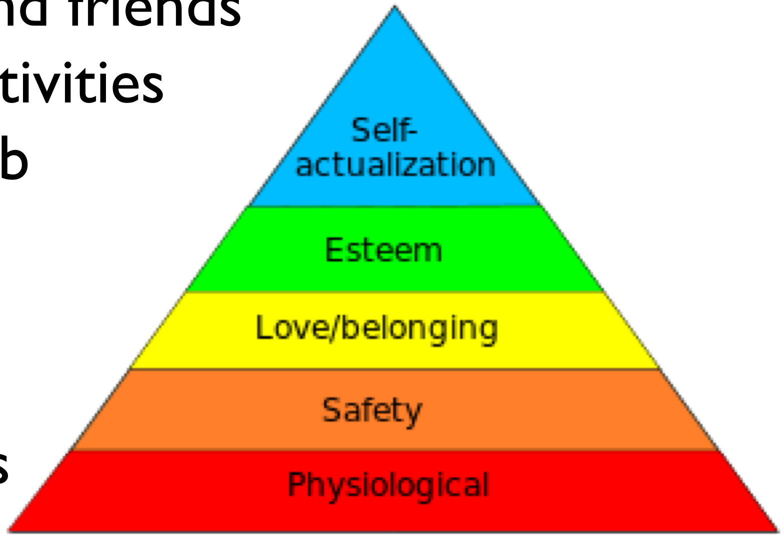
Connect with family and friends

Engage in leisure activities

Search the web

"Staying sane"

Maslow's hierarchy of needs



Searching the web should be as easy
from Mars as it is from Marseille!

The fundamental problem: Latency

speed of light: 2-24 minutes

rockets: 5-10 months

Bandwidth is “reasonable”

Lunar Laser Communications Demonstration:
622-Mbps downlink, 20-Mbps uplink

SneakerNet on rockets: Easily PBs

What's doable, what's not?

Example: How do I grow potatoes in recycled organic waste?

Source: 20th Century Fox

Search from Mars: Implementation

Step 1. Rocket SneakerNet

Step 2. Beam the diffs

We know exactly how to do this!

Step 3. User model activate!

We have a good idea how to do this!

It's a caching problem!

We've worked out some simulations already…

C. Clarke, G. Cormack, J. Lin, and A. Roegiest. Ten Blue Links on Mars. WWW 2017.
J. Lin, C. Clarke, and G. Baruah. Searching from Mars. IEEE Internet Computing, 20(1):78-82, 2016.

For the truly skeptical…

Search from Mars ~
Search from regions on
Earth with poor connectivity

Easter Island
Canadian Arctic
Villages in rural India

More "down to Earth" applications!

Source: Wikipedia (Everest)

What’s growing faster?

Big Data

What do I mean here?

Moore’s Law

What do I mean here?

Big Data > Moore’s Law

Big Data < Moore’s Law

Big Data ~ Moore’s Law

First, a story…

J. Lin. Is Big Data a Transient Problem? IEEE Internet Computing, 19(5):86-90, 2015.

What’s growing faster?

Big Data

Let’s restrict to
Human-generated data

Moore’s Law

Bounds?

Human population
Data generation per unit time

Big Data > Moore’s Law

Big Data < Moore’s Law

Big Data ~ Moore’s Law

Implications?

Back to my story…

AWS News Blog

X1 Instances for EC2 – Ready for Your Memory-Intensive Workloads

by Jeff Barr | on 18 MAY 2016 | in Amazon EC2* | Permalink | Share

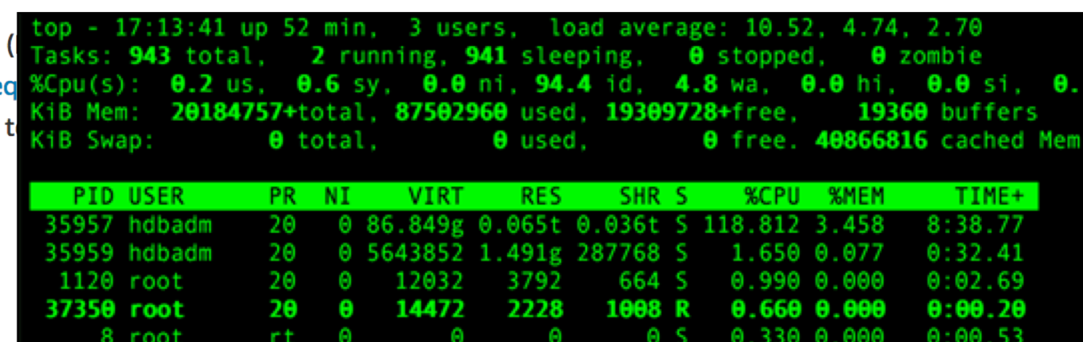
Many AWS customers are running memory-intensive big data, caching, and analytics workloads and have been asking us for EC2 instances with ever-increasing amounts of memory.

Last fall, I first told you about our plans for the new X1 instance type. Today, we are announcing availability of this instance type with the launch of the **x1.32xlarge** instance size. This instance has the following specifications:

- Processor: 4 x Intel™ Xeon E7 8880 v3 (Haswell) running at 2.3 GHz – 64 cores / 128 vCPUs.
- Memory: 1,952 GiB with Single Device Data Correction (SDDC+1).
- Instance Storage: 2 x 1,920 GB SSD.
- Network Bandwidth: 10 Gbps.
- Dedicated EBS Bandwidth: 10 Gbps (EBS Optimized by default at no additional cost).

The Xeon E7 processor supports Turbo Boost 2.0 (up to 3.1 GHz), AVX 2.0, AES-NI, and the very interesting (to me, anyway) TSX-NI instructions. AVX 2.0 (Advanced Vector Extensions) can improve performance on HPC, database, and video processing workloads; AES-NI improves the speed of applications that make use of AES encryption. The new TSX-NI instructions support something cool called transactional memory. The instructions allow highly concurrent, multithreaded applications to make very efficient use of shared memory by reducing the amount of low-level locking and unlocking that would otherwise be needed around each memory access.

If you are ready to start using the X1 instances in the US East (
Pacific (Singapore), or Asia Pacific (Sydney) Regions, please req
instances available in other Regions and in other sizes before t



What's growing faster?

Big Data

Let's restrict to
Human-generated data

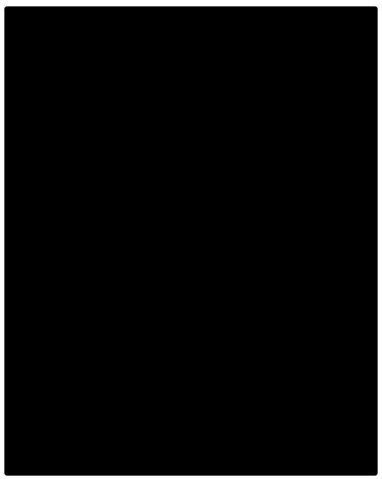
Moore's Law

What am I forgetting?

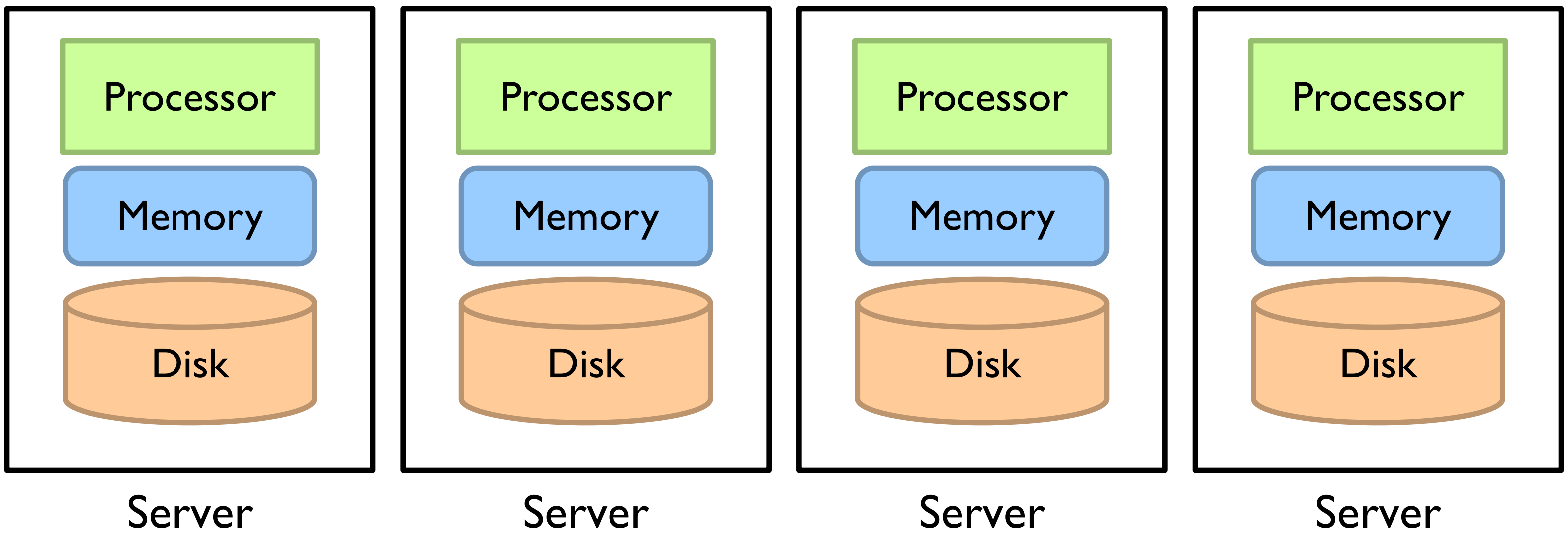
Bounds?

Human population
Data generation per unit time

Source: Google



Server


Processor
Memory
Disk
Server
Processor
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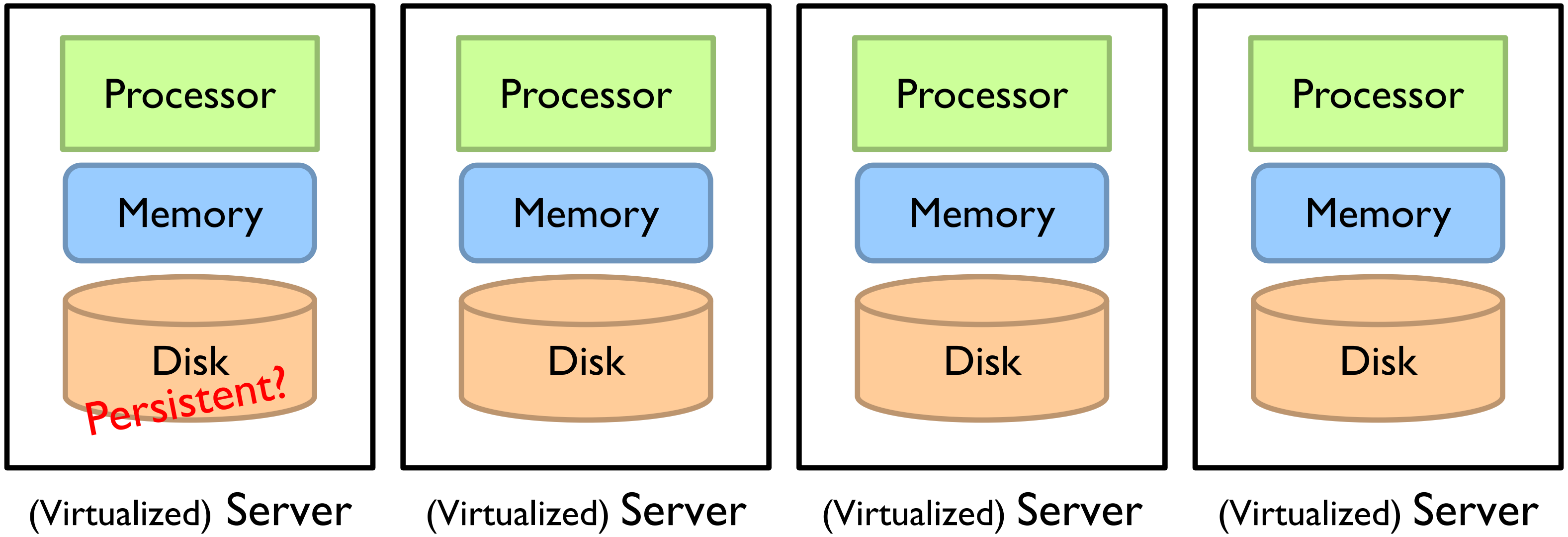
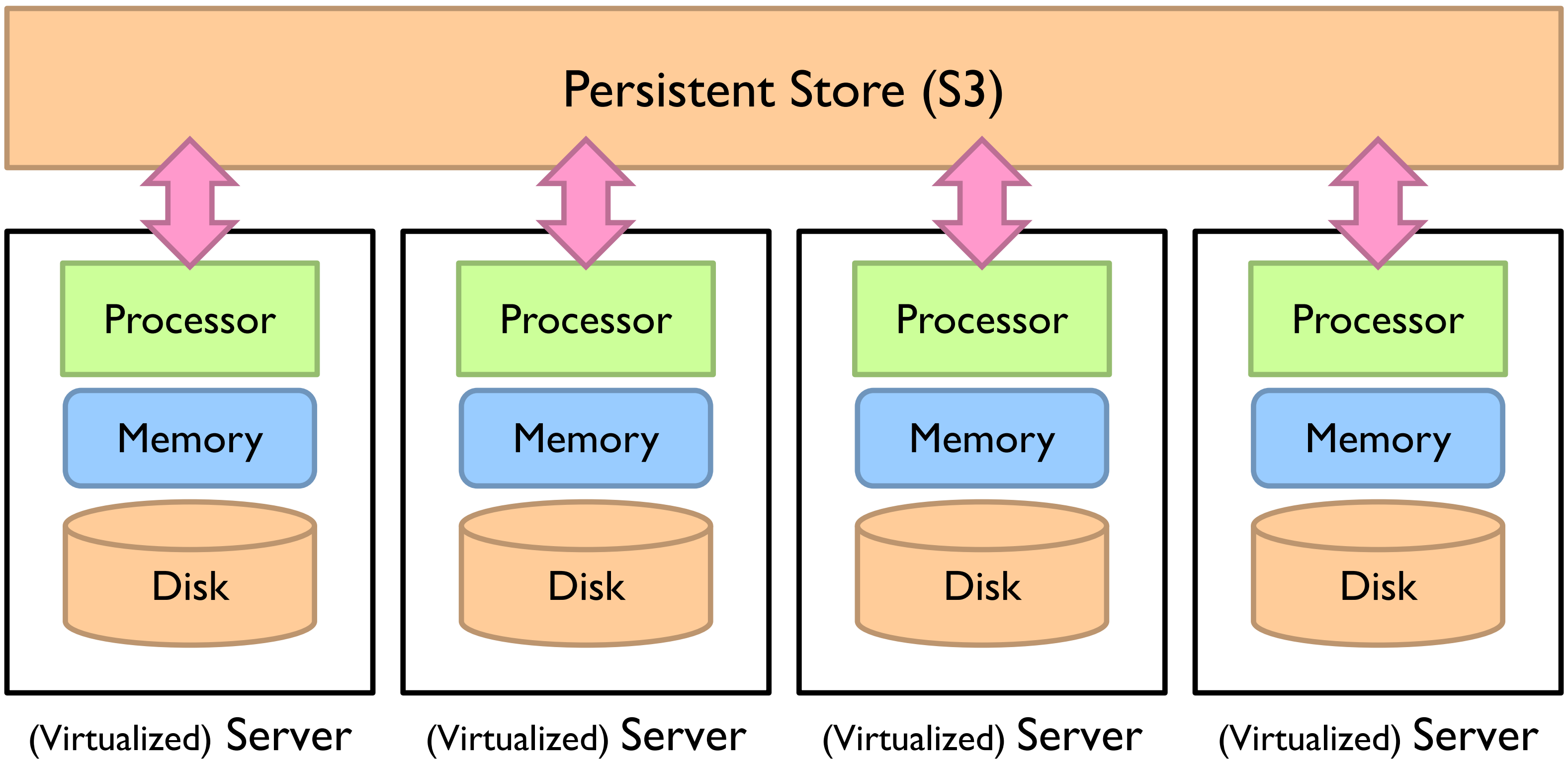
Server
Processor
Memory
Disk
Server



Cloud (I'm going to illustrate with AWS)


Persistent Store (S3)
Processor
Memory
Disk
(Virtualized) Server
Processor
Memory
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(Virtualized) Server
Processor
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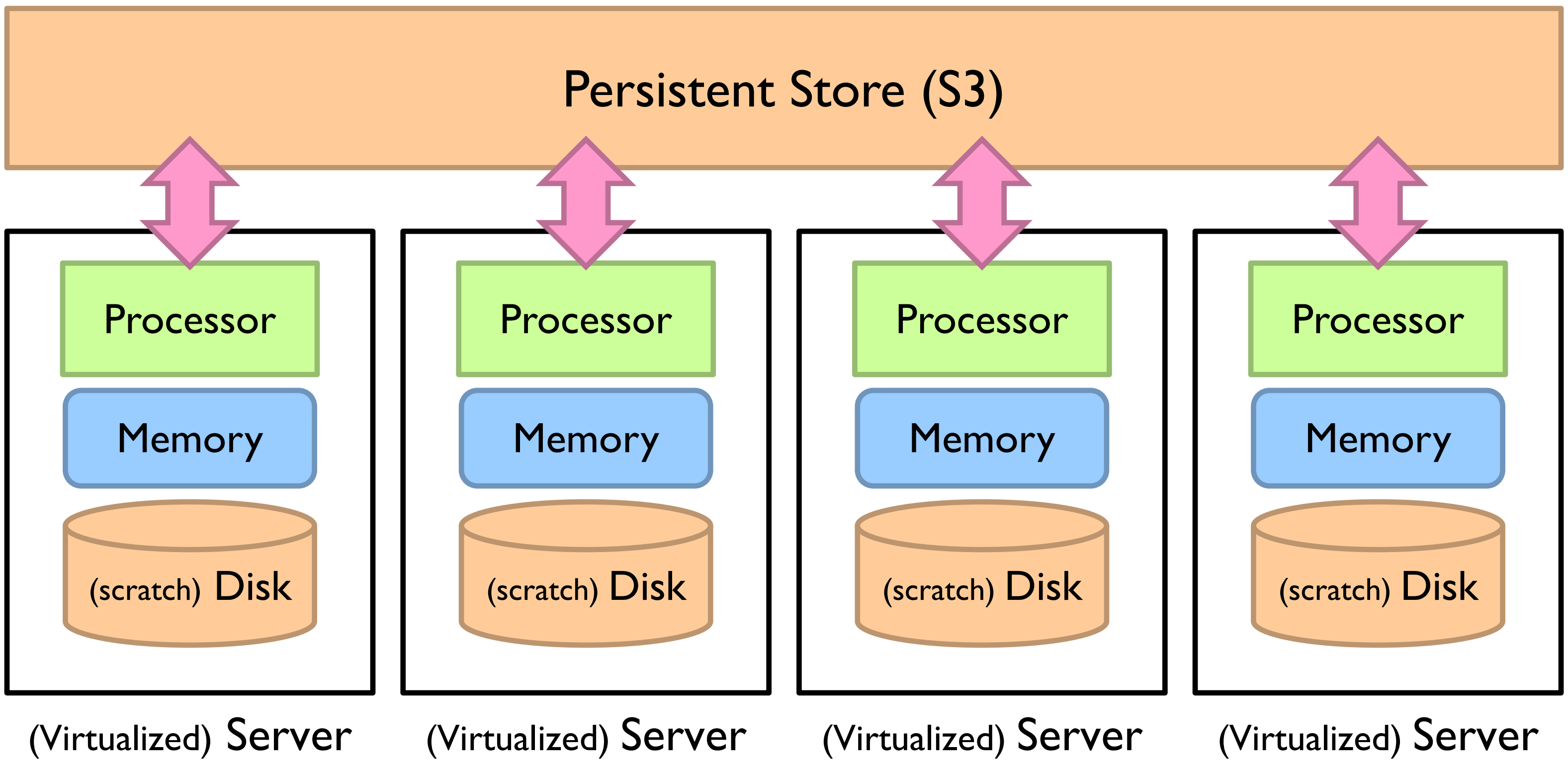
(Virtualized) Server
Processor
Memory
Disk
(Virtualized) Server

Cloud


Persistent Store (S3)
Processor
Memory
(scratch) Disk
(Virtualized) Server
Processor
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(scratch) Disk
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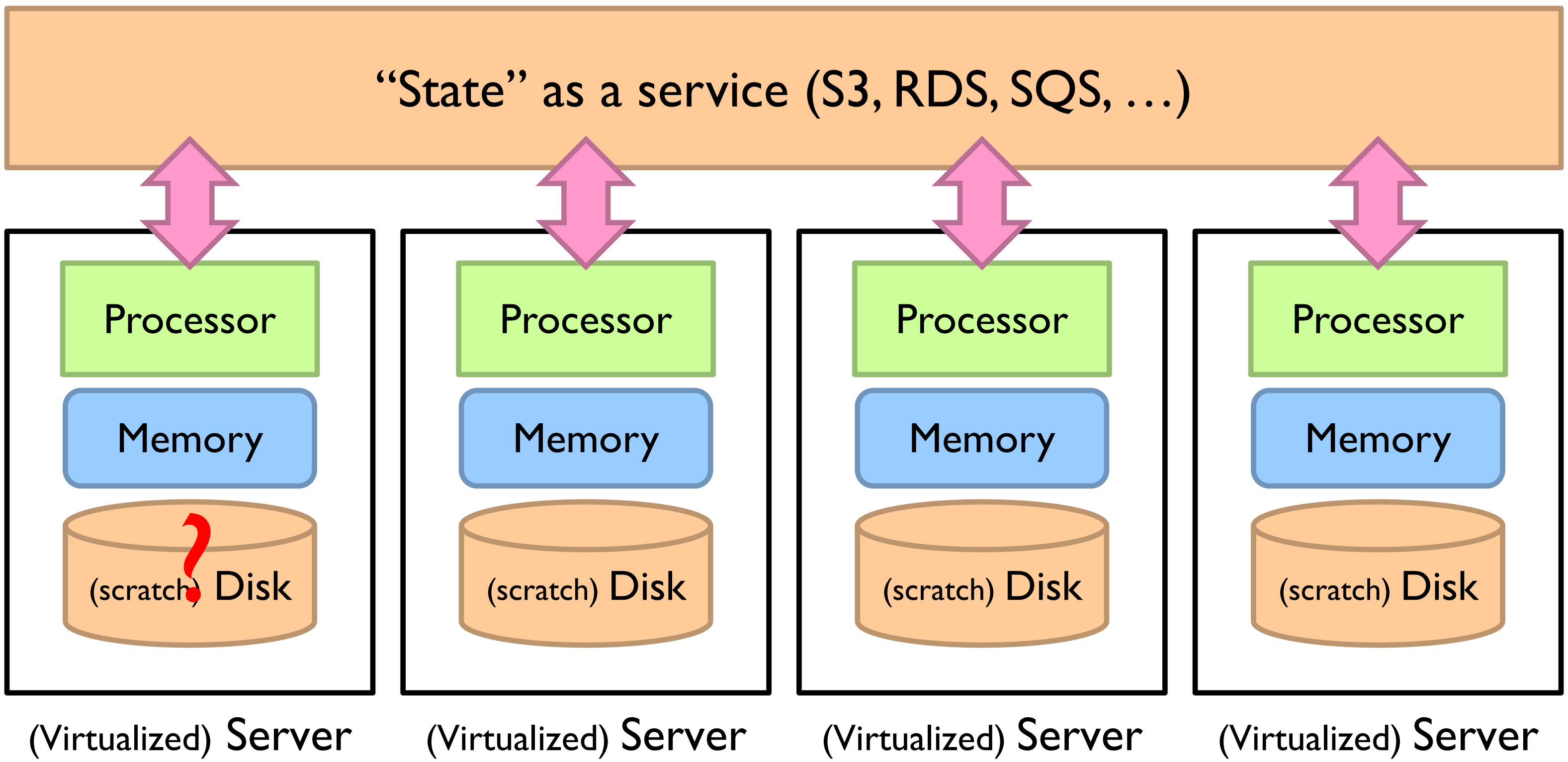
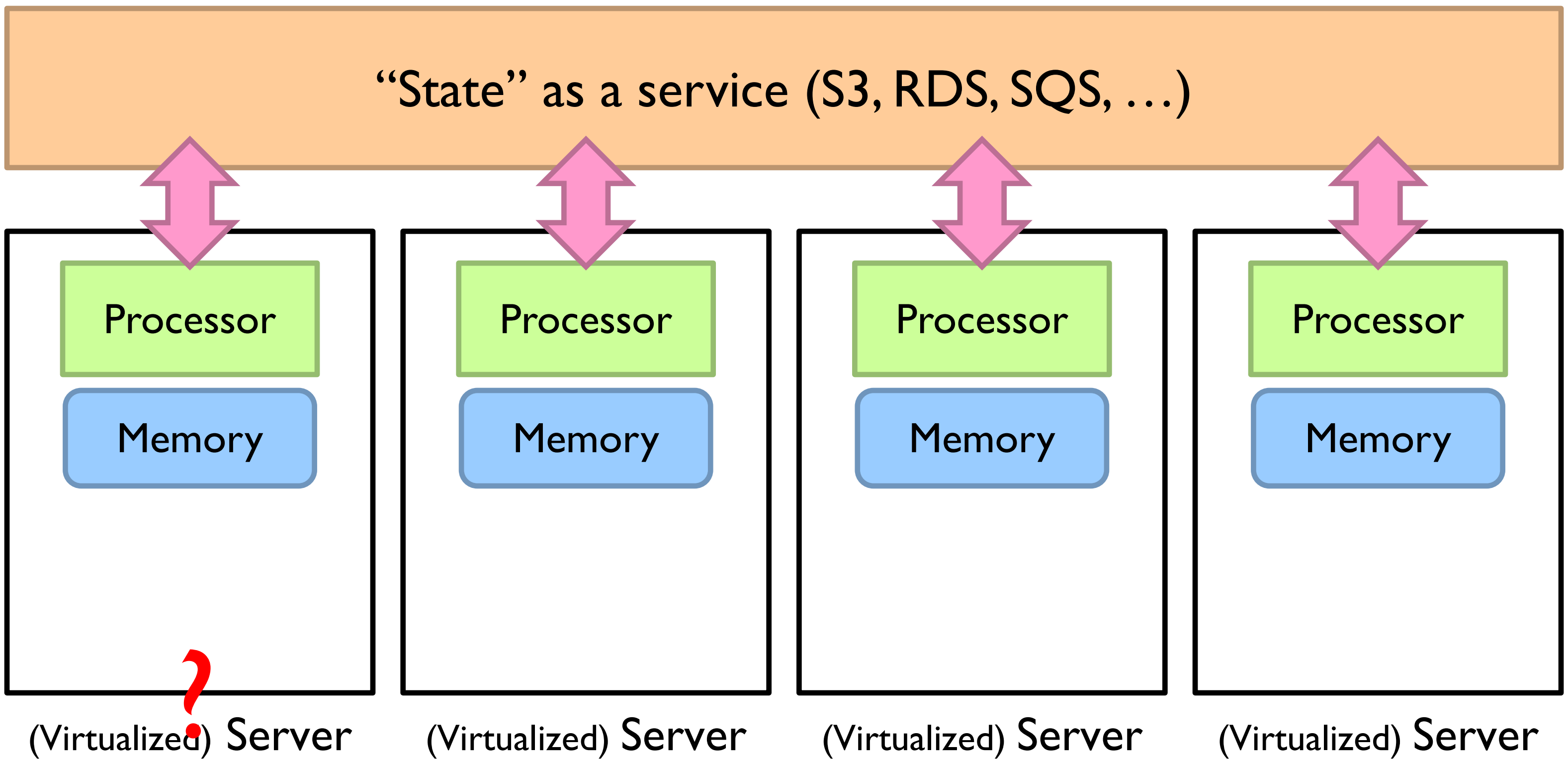
Processor
Memory
(scratch) Disk
(Virtualized) Server

Cloud



“State” as a service (S3, RDS, SQS, …)
Processor
Memory
(scratch) Disk
(Virtualized) Server
Processor
Memory
(scratch) Disk
(Virtualized) Server
Processor
Memory
(scratch) Disk
(Virtualized) Server
Processor
Memory
(scratch) Disk
(Virtualized) Server
?

Cloud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Memory
(Virtualized) Server
Processor
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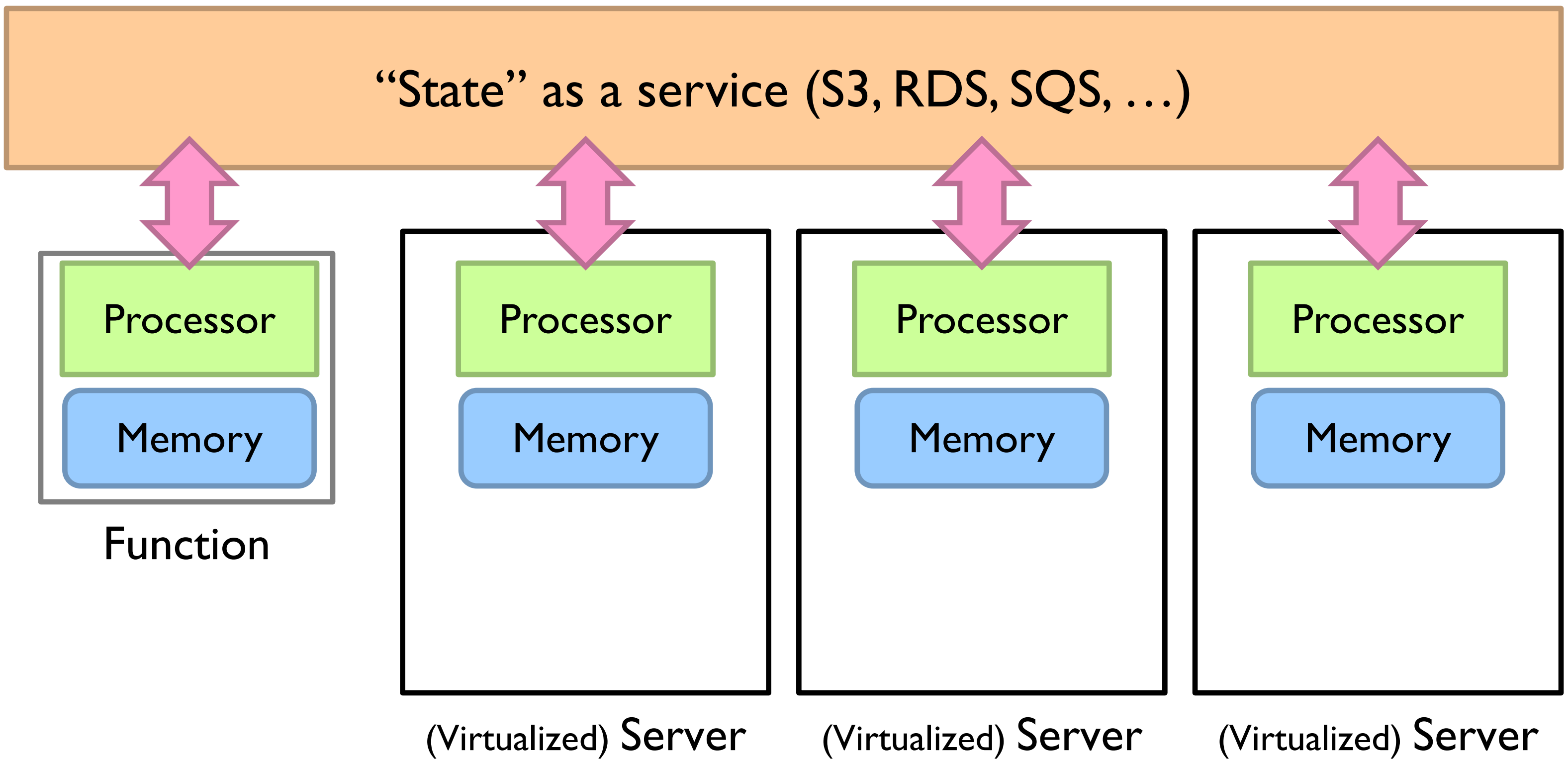
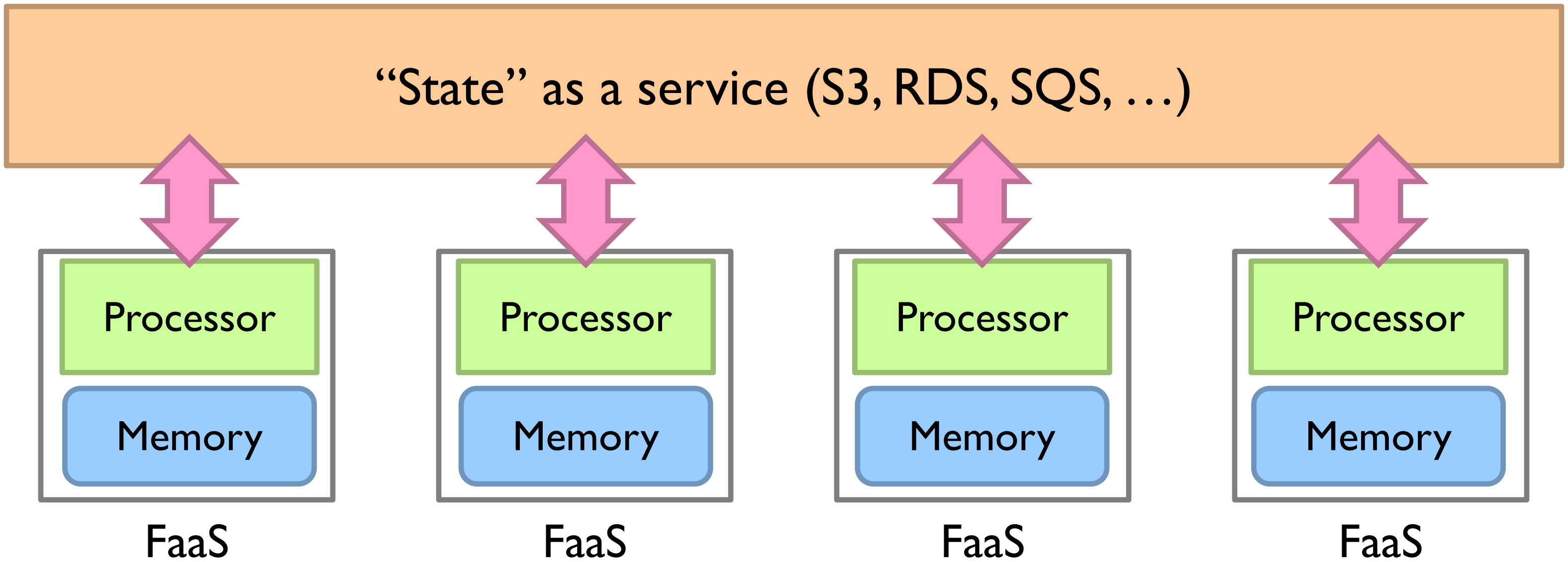
Memory
(Virtualized) Server

Cloud



"State" as a service (S3, RDS, SQS, …)
Processor
Memory
Function
Processor
Memory
(Virtualized) Server
Processor
Memory
(Virtualized) Server
Processor
Memory
(Virtualized) Server

Cloud


"State" as a service (S3, RDS, SQS, …)
Processor
Memory
FaaS
Processor
Memory
FaaS
Processor
Memory
FaaS
Processor
Memory
FaaS

Cloud

Serverless Architectures

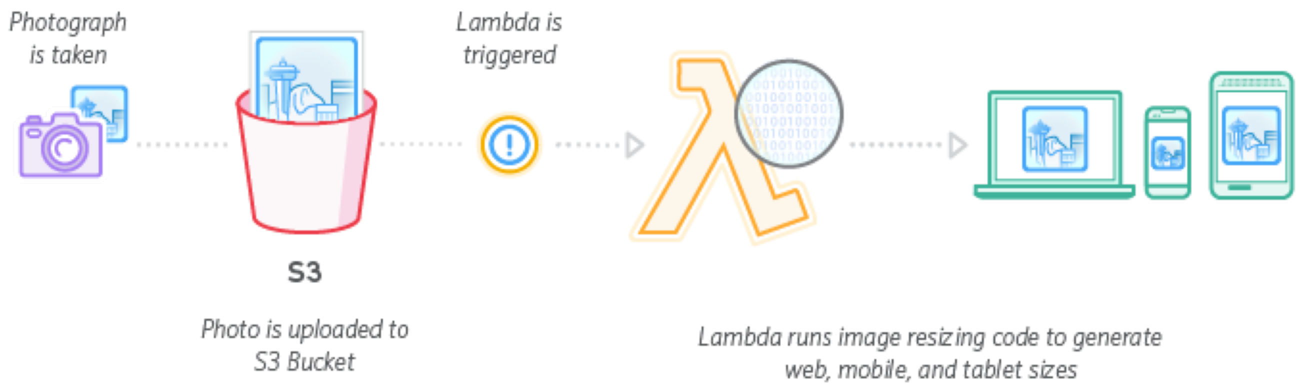
Doesn’t mean you don’t have servers

Just that managing them is the cloud provider’s problem

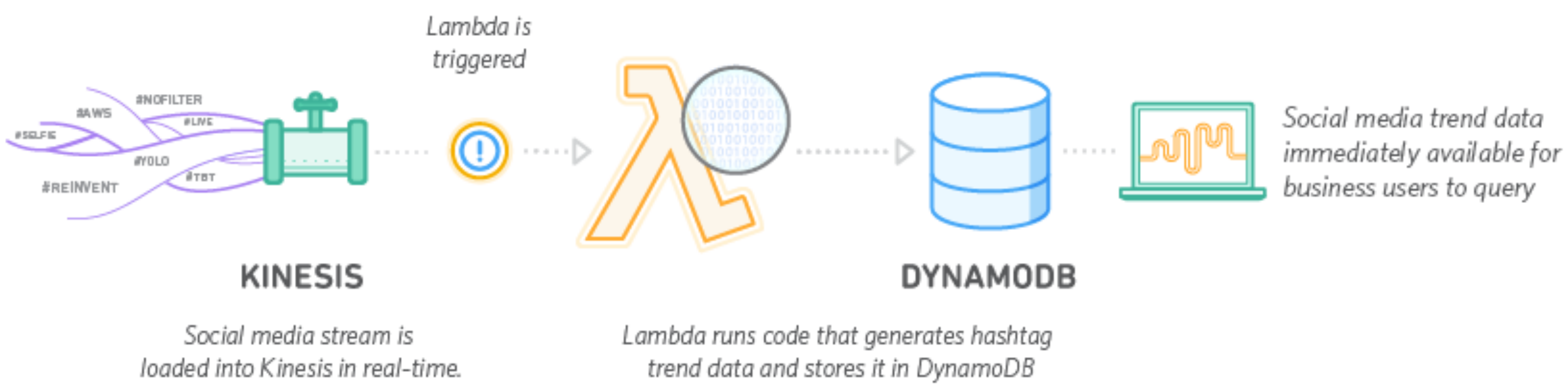
Write functions with well-defined entry and exit points

Cloud provider handles all other aspect of execution

Example: *Image Thumbnail Creation*



Example: *Analysis of Streaming Social Media Data*



Source: Amazon Web Services

(Current) Serverless Architectures

Asynchronous, loosely-coupled, event-driven

Functions touch relatively little data

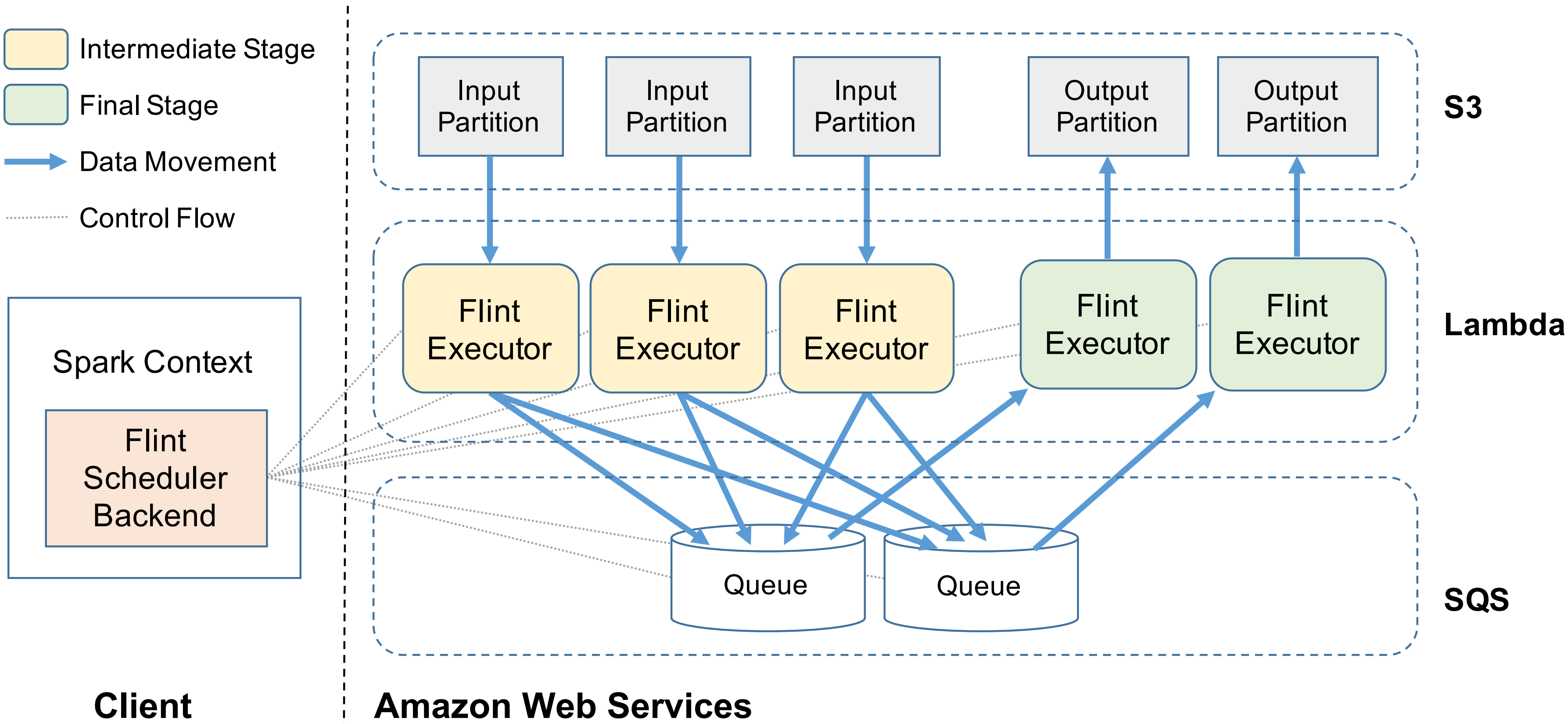
What about serverless data analytics?

Design goal: pure pay-as-you-go, zero costs for idle capacity

Compared to current options?

Flint

PySpark execution backend



Youngbin Kim and Jimmy Lin. Serverless Data Analytics with Flint. IEEE Cloud 2018.

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Source: flickr (https://www.flickr.com/photos/39414578@N03/16042029002)