Infrastructure & Cloud Architecture

What's coming

- DCs
- Cloud architectures
  - on-premise
  - cloud (cloud-first)
  - hybrid
- From physical servers to serverless
- Cloud computing
- Cloud infrastructures
- Assignment

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Data Centres

Data Centres

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- In 1940s they were just large rooms filled with enormous computer machines
- The real turning point was between 1970s and 1990s during the boom of microcomputers
- The biggest change happened in 2000s during the dot-com bubble

Data Centres

NASA mission control computer room c. 1962

Data Centres: Major concerns

Energy efficiency and environmental sustainability

- DC components, mainly compute power and cooling system draw massive amounts of energy
- Power consumption can be up to 10% of total cost of ownership
- Major Cloud Providers Commit to maintain sustainability AWS, Azure, Google Cloud
- Heating / Cooling

Data Centres: Major concerns

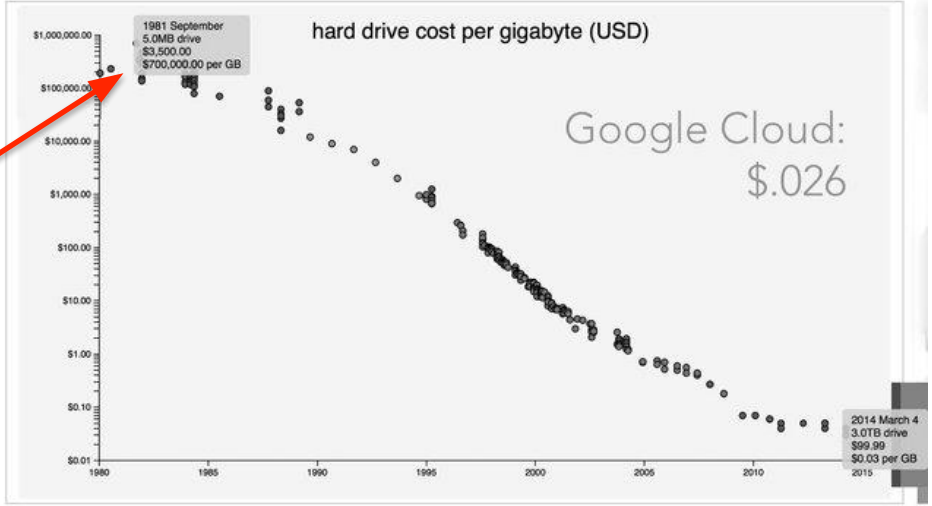
Costs and ageing of hardware

- Hardware (HW) has usually predetermined life-span and support provided by the vendor
- HW failures are not uncommon and must be accounted for, in fact, mathematical formulas can help predict failures depending on use and age
- over time some HW components may get cheaper, however most HW and SW keeps the value as vendors keep on adding new functionalities, provide better power efficiency, throughput or security hardening.

Data Centres: Major concerns

Costs and ageing of hardware

$700,000 per GB
in 1965



HDD cost over the time

Data Centres: Major concerns

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High Availability

- Ever-present requirement for High Availability is at the top of architects mind when designing a data centre
- Requirement for HA accounts one of the major costs of operating DC: every single component **must be doubled** -> racks, compute, networking, cabling, cooling system and internet and power supply must come from t**wo different** sources, which **must not be using the same routes** and backends.
- If any component should fail, immediately second must take its place
- DCs also maintain massive generators in case both power supplies fail

Data Centres: Major concerns

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Professionalism

- DCs require a number of highly trained professionals to design, setup and maintain smooth run od DC equipment
- Only staff required to enter DC location are those who physically operate with the Hardware and networking

Data Centres: Major concerns

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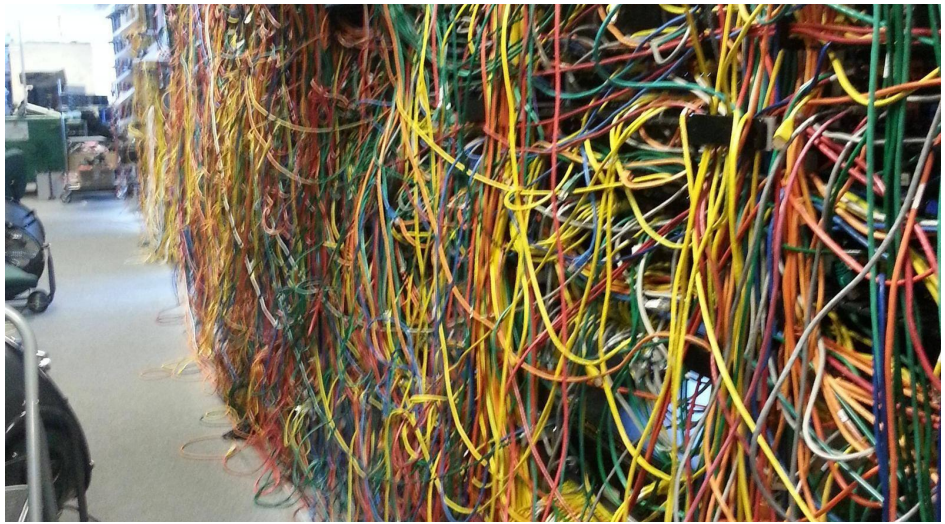
Professionalism



DON’T try this at home…

Infrastructure components

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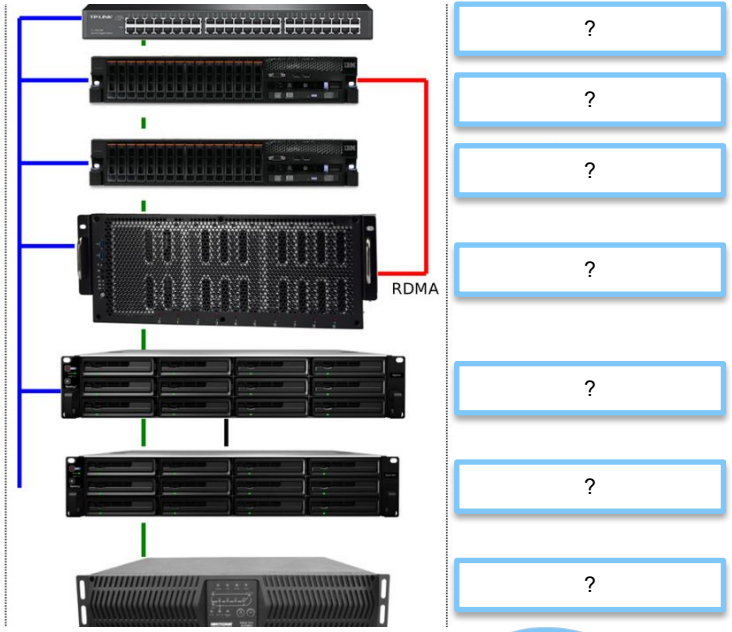
- physical topology:
  - networking
  - compute nodes
  - security devices
  - HVAC

  or virtual topology (VMs) — physical devices logically combined in clusters

Infrastructure components



Server rack components

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Cloud architectures

Cloud architectures

Private cloud (on-premise)

- Legacy solution for most companies nowadays
- Most companies build DCs usually to meet legal requirements (Banks)
- It is important for company to calculate yearly Data Center "Cost of Ownership”
- With Cloud Providers offering now so many services with reasonable pricing, on-premise solutions are used more and more scarcely

Cloud architectures

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Private cloud (on-premise)

- **Pros**
  - You own all components and processes
  - Best if you have specific security or procedural requirements Cloud Providers don’t yet adhere to

Cloud architectures

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Private cloud (on-premise)

- **Cons**
  - Double each DC component to maintain High Availability
  - Maintain 2nd DC in separate location as backup and Disaster Recovery
  - Constant maintenance and change of components
  - Maintaining enterprise level backup SW and HW including storage for tapes
  - Maintaining 24/7 operations to ensure DCs and Infrastructure are running properly
  - Ensuring 3rd party SW and HW providers and vendors deliver (eg internet providers)
  - Finite resources -> constant need to invest in more resources in growing companies

Cloud architectures

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Public cloud

- Public cloud is the go-to strategy for most modern companies
- Enables to start small, play around and grow into large infrastructure as needed
- Allows clients to benefit from "Economy of Scale"
- Cloud Providers are constantly working "under the hood" to develop their own HW components and optimize processes and production costs
- Today some services are at such level of integration that a professional Solutions Architect can interlink several services together and form entire applications that are secure, reliable and fast

Cloud architectures

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Public cloud

- **Pros**
  - Absolute control over your billing and resources used
  - Can save up to 60% of billing via well-architected design and use of reserved instances
  - Fully disposable architecture = scale the entire infrastructure up or tier it down in minutes
  - Nearly unlimited resources available at your disposal
  - Agile development = build complexity by adding resources and services to meet new business requirements and feature requests
  - Large selection of provided services which can easily be interlinked to form large, scalable and cost-effective solutions
  - With pay-as-you-go billing model, you are not limited to using a single Cloud Provider = no vendor-locking

Cloud architectures

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Public cloud

- **Cons**
  - Design, implementation and maintenance require specially trained staff
  - Inadequate knowledge may compromise security and cost-effectiveness
  - Migrating entire infrastructure at once may be costly and time-consuming
  - Not all 3rd party licensing for on-premise can be seamlessly migrated to use in cloud
  - Estimating cloud usage is very difficult to calculate correctly and requires highly experienced cloud Solutions Architect knowledge

Cloud architectures

Hybrid

- Best for combining their on-premise DCs with public cloud solutions
- Companies usually start small, with several Proof of Concepts (POC) to prove that the cloud complies with all projects' requirements
- Most customers start by managing cloud as backup and new projects are preferably built on the cloud, while older applications may be still being served from the on-premise infrastructure

Cloud architectures

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Hybrid

- **Pros**
  - Benefit from best of both worlds
  - possibility to decouple private and sensitive components of the infrastructure (like databases) from the compute infrastructure
  - savings on the private DCs
- **Cons**
  - maintenance costs

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Cloud architecture: Case study

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From physical servers to serverless

From physical servers to serverless

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As time progressed, the IT industry has gone through number of eras that have changed the way we design infrastructure and applications.

Physical servers

- Remain popular for running business-critical applications such as Oracle Databases on Banking systems
- Designed and setup to do one function non-stop
- Complying with business needs for growing number of applications quickly becomes overwhelming challenge.
- High waste of unused resources when the application isn't fully used

From physical servers to serverless

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As time progressed, the IT industry has gone through number of eras that have changed the way we design infrastructure and applications.

The progression went from physical servers, to virtual servers (VMs) and containers to serverless (lambdas).

From physical servers to serverless

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From physical servers to serverless

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Virtual servers

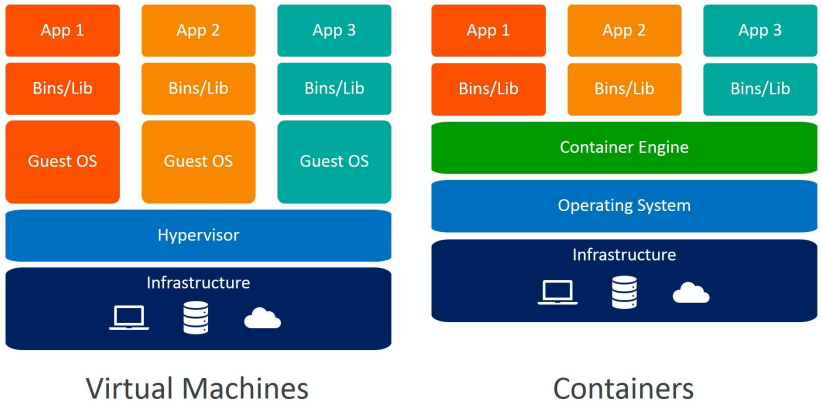
- Abstraction of resources opens wide range of possible use-cases including virtual networking, virtual machines, virtual firewalls etc.

- Virtualisation has played a major part in shaping modern structure and rapid growth of IT and is at heart of cloud providers' core stack.

From physical servers to serverless

Containerization

- Containerised applications are “isolated” in that they do not bundle in a copy of the operating system
- Instead, an open source runtime engine (such as the Docker runtime engine) is installed on the host’s operating system and becomes the conduit for containers to share an operating system with other containers on the same computing system



From physical servers to serverless

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Serverless

- Is an implementation of Function as a Service (FaaS)
- Allows to develop, run, and manage application functionalities without the complexity of building and maintaining the infrastructure
- Typically provided under pay-as-you-go billing model
- Some serverless services can run locally or even in embedded devices
- Many Cloud providers' services leverage serverless architecture underneath

From physical servers to serverless

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Serverless: Stateful and Stateless applications

- Serverless applications may be **stateful**:
  - store their **state**
  - long-lived applications
  - require data storage (volumes)

$$f(x_t) = x + f(b_t)$$

$$f(b_t) = b_{t-1} + 1$$

The b is a stateful variable and it depends on time t – it is itself a function of time.

From physical servers to serverless

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Serverless: Stateful and Stateless applications

- or they may be **stateless**:
  - do not store their **state**
  - scale out easily
  - omnipotent

$$f(x) = x + b$$

The b is a *constant*.

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Serverless:
When would you use it?

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Cloud computing

Cloud computing

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Definition

Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing.

Instead of buying, owning, and maintaining physical data centres and servers, you can access technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider like Amazon Web Services (AWS).

Cloud computing

Models

Infrastructure as a Service (IaaS)

Infrastructure as a Service, sometimes abbreviated as IaaS, contains the basic building blocks for cloud IT and typically provide access to networking features, computers (virtual or on dedicated hardware), and data storage space. Infrastructure as a Service provides you with the highest level of flexibility and management control over your IT resources and is most similar to existing IT resources that many IT departments and developers are familiar with today.

Platform as a Service (PaaS)

Platforms as a service remove the need for organizations to manage the underlying infrastructure (usually hardware and operating systems) and allow you to focus on the deployment and management of your applications. This helps you be more efficient as you don't need to worry about resource procurement, capacity planning, software maintenance, patching, or any of the other undifferentiated heavy lifting involved in running your application.

Software as a Service (SaaS)

Software as a Service provides you with a completed product that is run and managed by the service provider. In most cases, people referring to Software as a Service are referring to end-user applications. With a SaaS offering you do not have to think about how the service is maintained or how the underlying infrastructure is managed; you only need to think about how you will use that particular piece of software. A common example of a SaaS application is web-based email where you can send and receive email without having to manage feature additions to the email product or maintaining the servers and operating systems that the email program is running

Cloud computing models

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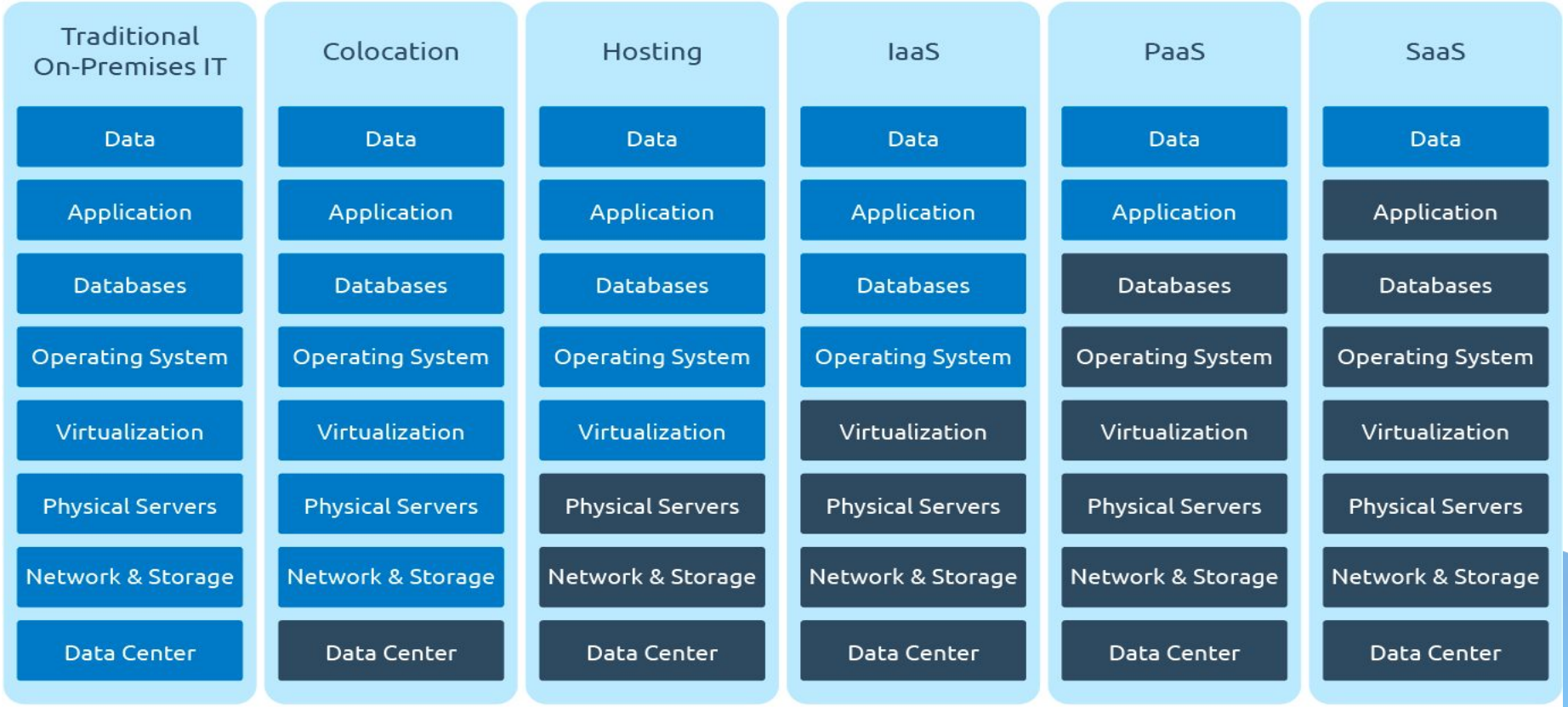
Traditional On-Premises IT
Data
Application
Databases
Operating System
Virtualization
Physical Servers
Network & Storage
Data Center
Colocation
Data
Application
Databases
Operating System
Virtualization
Physical Servers
Network & Storage
Data Center
Hosting
Data
Application
Databases
Operating System
Virtualization
Physical Servers
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PaaS
Data
Application
Databases
Operating System
Virtualization
Physical Servers
Network & Storage
Data Center
SaaS
Data
Application
Databases
Operating System
Virtualization
Physical Servers
Network & Storage
Data Center
Provider-Supplied
Self-Managed

Cloud computing

Economy of scale

- The larger the scale of cloud provider's infrastructure the more active role in investing into enhancing DC efficiency
    - power consumption
    - Processors
    - routers and switches, racks, HVAC systems
    - Custom versions of security-hardened operating systems
    - proprietary network cables all over the world. [TIP: Story of first transatlantic cable installation]
- All clients benefit in having enhanced security, lower latency and improved up-time of all services provided

Cloud computing

Security

Prevent

Define user permissions and identities, infrastructure protection and data protection measures for a smooth and planned AWS adoption strategy.

Detect

Gain visibility into your organization's security posture with logging and monitoring services. Ingest this information into a scalable platform for event management, testing, and auditing.

Respond

Automated incident response and recovery to help shift the primary focus of security teams from response to analyzing root cause.

Remediate

Leverage event driven automation to quickly remediate and secure your AWS environment in near real-time.

Cloud computing

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Pros

- Trade capital expense for variable expense
- Benefit from massive economies of scale
- Stop guessing capacity
- Increased speed and agility
- Hardware and operations savings
- Global in minutes

Cloud computing

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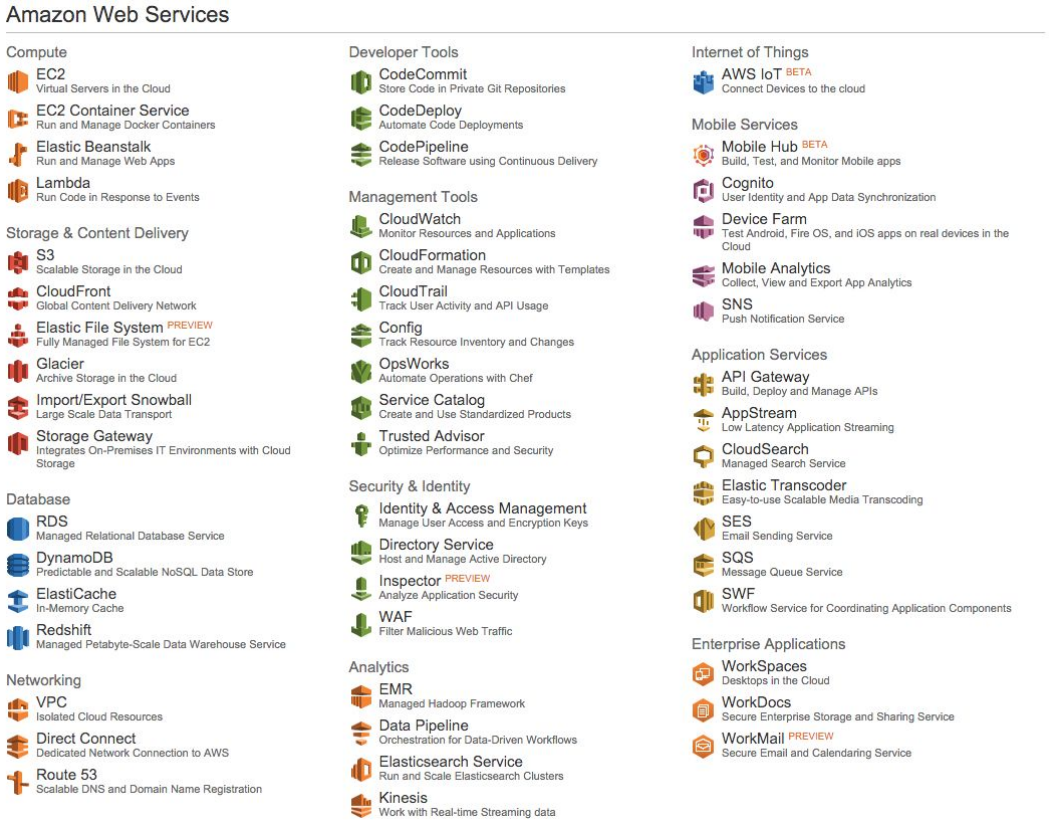
Cons

- Bad habits (i.e. application and infrastructure architecture) may be extremely costly
- Steeper learning curve -> “cloud thinking”
- A greater amount of knowledge of the application is required, including service limitations
- Security considerations

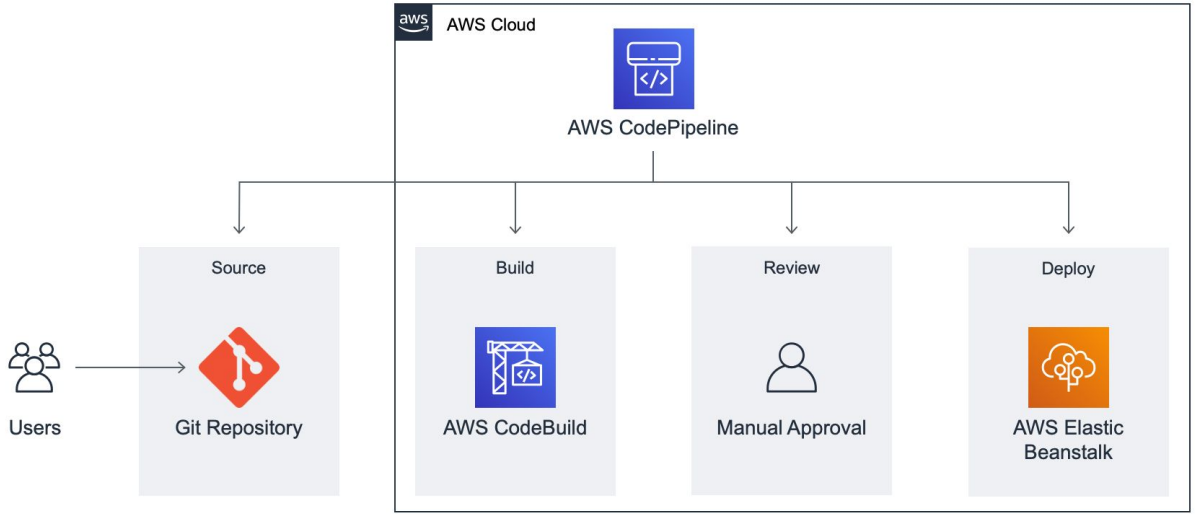
Cloud computing

AWS stack



Cloud computing

AWS Example: Pipelines



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AWS stack: Demo

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Assignment