MATES ED2MIT

Education and Training for Data Driven Maritime Industry

Tutorial A01.02

Cloud Computing Foundation: Reference Model and Use cases

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Cloud Computing Basics

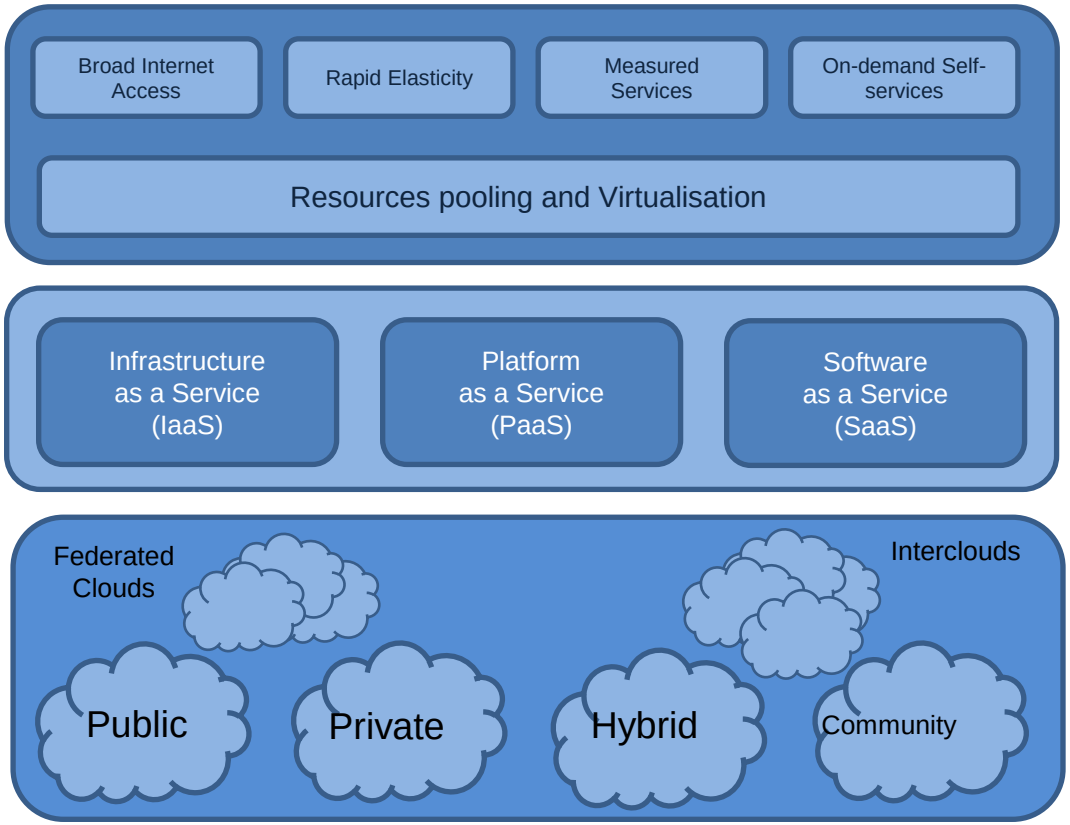
- Definition Cloud Computing
- Trends to Hybrid Clouds
- Virtual Machines and Containers
- Cloud Security and Compliance
- DevOps support

Cloud Computing as a key IT technology development factor

- Cloud Computing has entered a maturing stage and currently a commodity services
- Cloud Computing is powering modern business and powering new technologies development that require elastic computing resources on-demand
  - Mobile applications
  - Big Data and AI applications
  - Internet of Things (IoT)
  - Changes telecom market landscape
- In turn, other technologies demand accelerates Cloud Computing development
- Cloud Computing increases business agility and speeds up new services/products development to market
  - However still restrained by security concerns on business data protection

NIST Cloud Definition - Visualisation

Visual presentation of NIST Cloud Definition



Essential Characteristics

Service Models

Deployment Models

- New emerging cloud deployment and operation models
  - Intercloud/multicloud
  - Federated clouds

Cloud Deployment Models

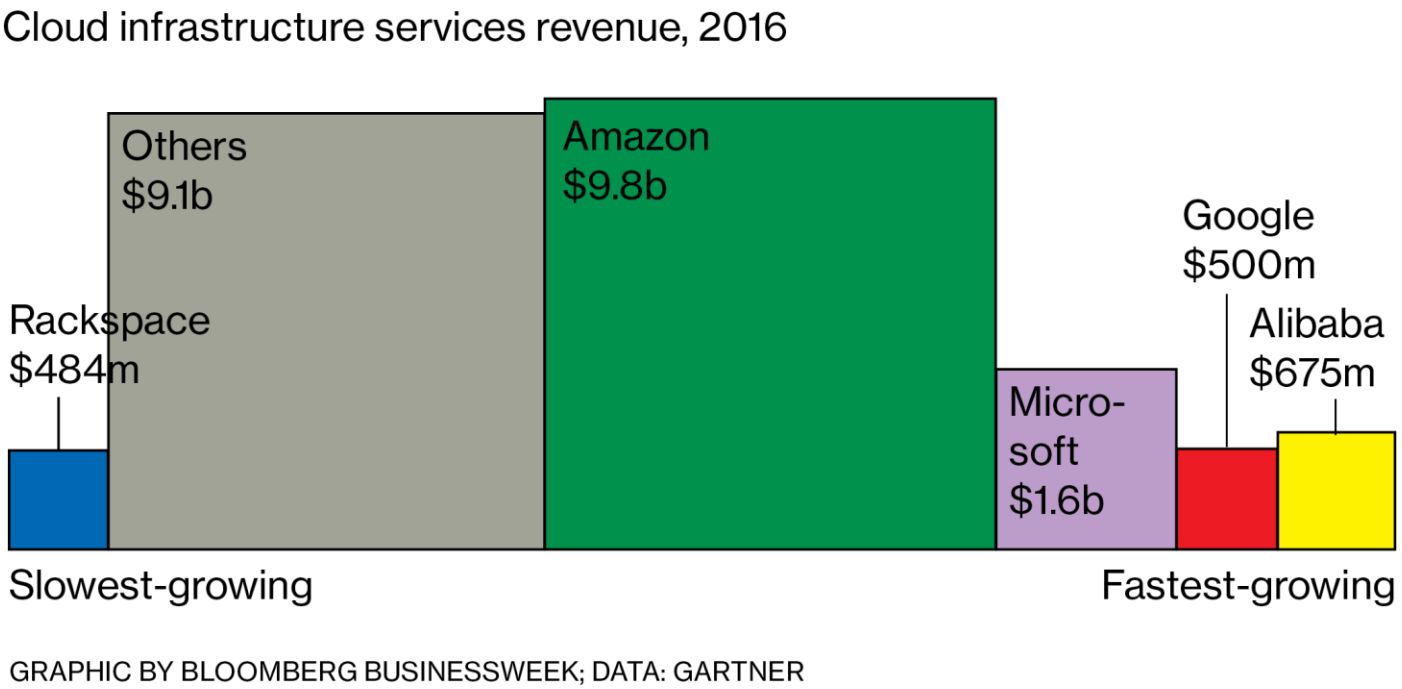
Private Cloud: The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

Public Cloud: The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

Hybrid Cloud: The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

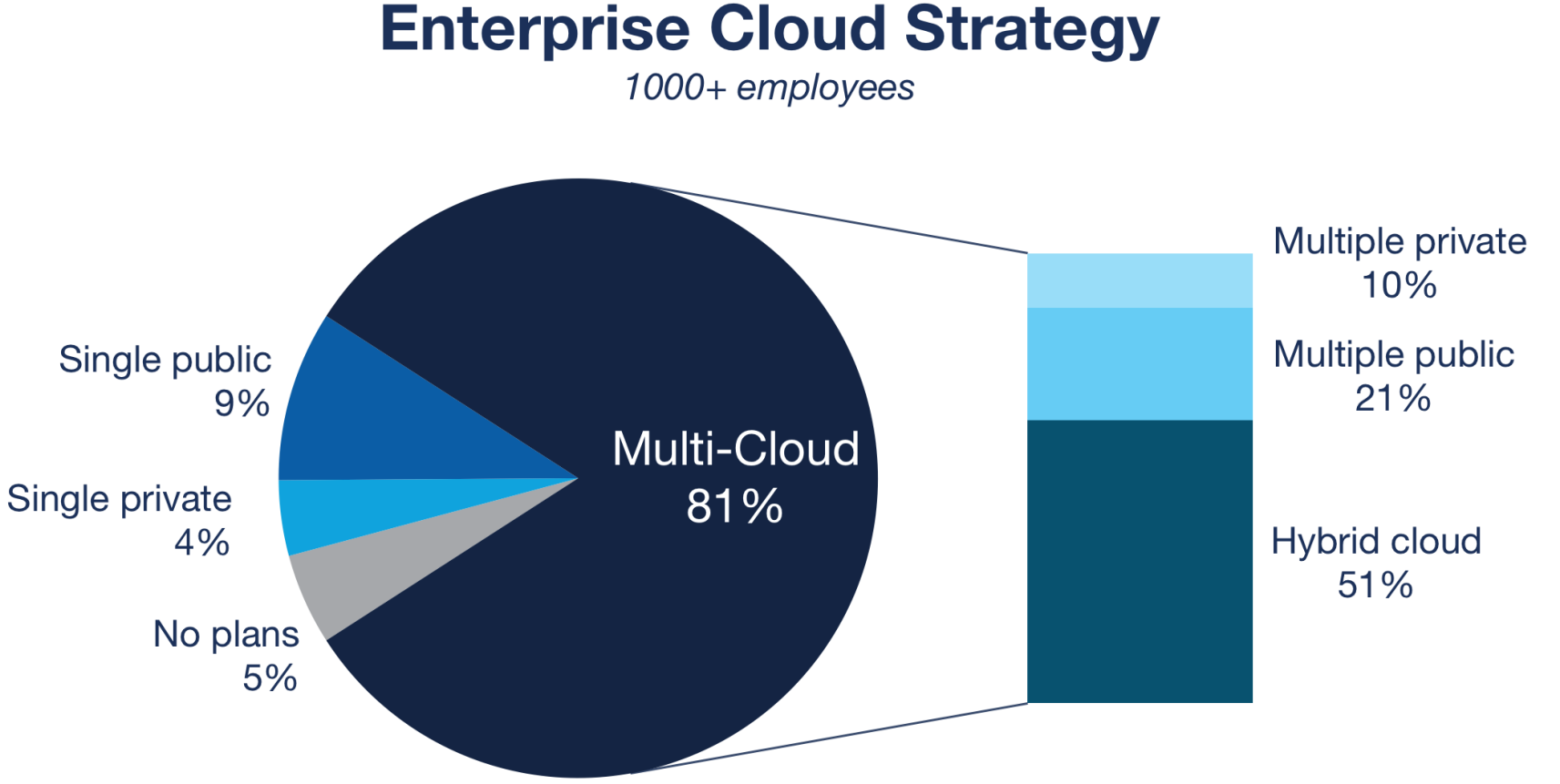
Community Cloud: The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

Cloud Services Market Trends

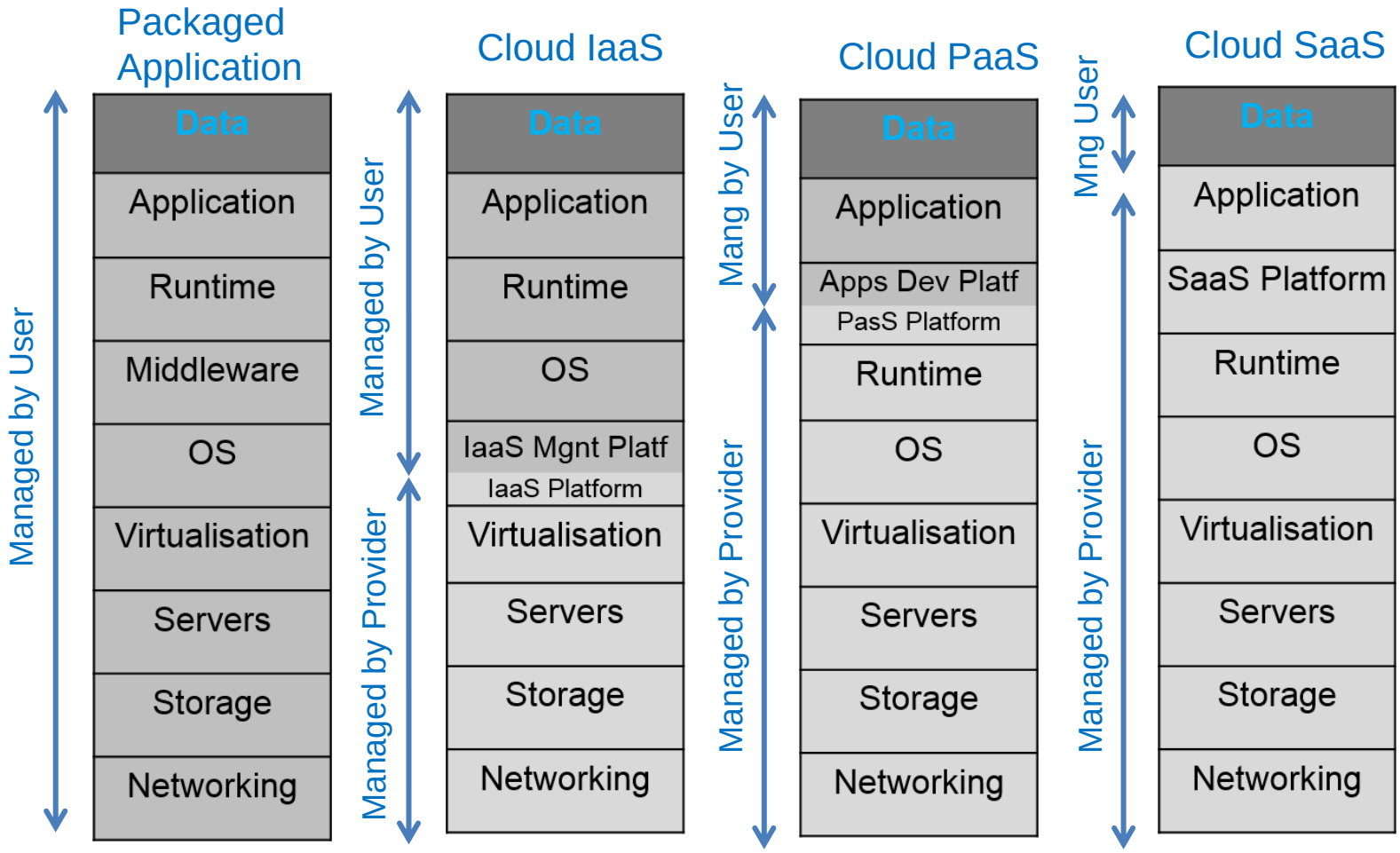


- https://www.bloomberg.com/news/articles/2017-11-10/microsoft-and-google-turn-to-ai-to-catch-amazon-in-the-cloud

Enterprise Cloud Strategy



Relation between IaaS, PaaS, SaaS



Note: Data always remain under user (cloud consumer or customer) responsibility, however it may be processe
Physically, they may be processed at each of S/P/IaaS level

Cloud Use Cases

Why do we need use cases analysis?

- Use cases analysis is an important component of the technology definition
- Use cases analysis gives examples how the technology is used and allows defining best practices
- Provide input for taxonomy
- Define requirements general and specific, functional and non-functional
- Provides a basis for architecture validation
- Help identifying the main stakeholders

General Cloud Use Cases

Use case 1:

- Moving part of workload to cloud in case of abrupt demand increase: cloudburst

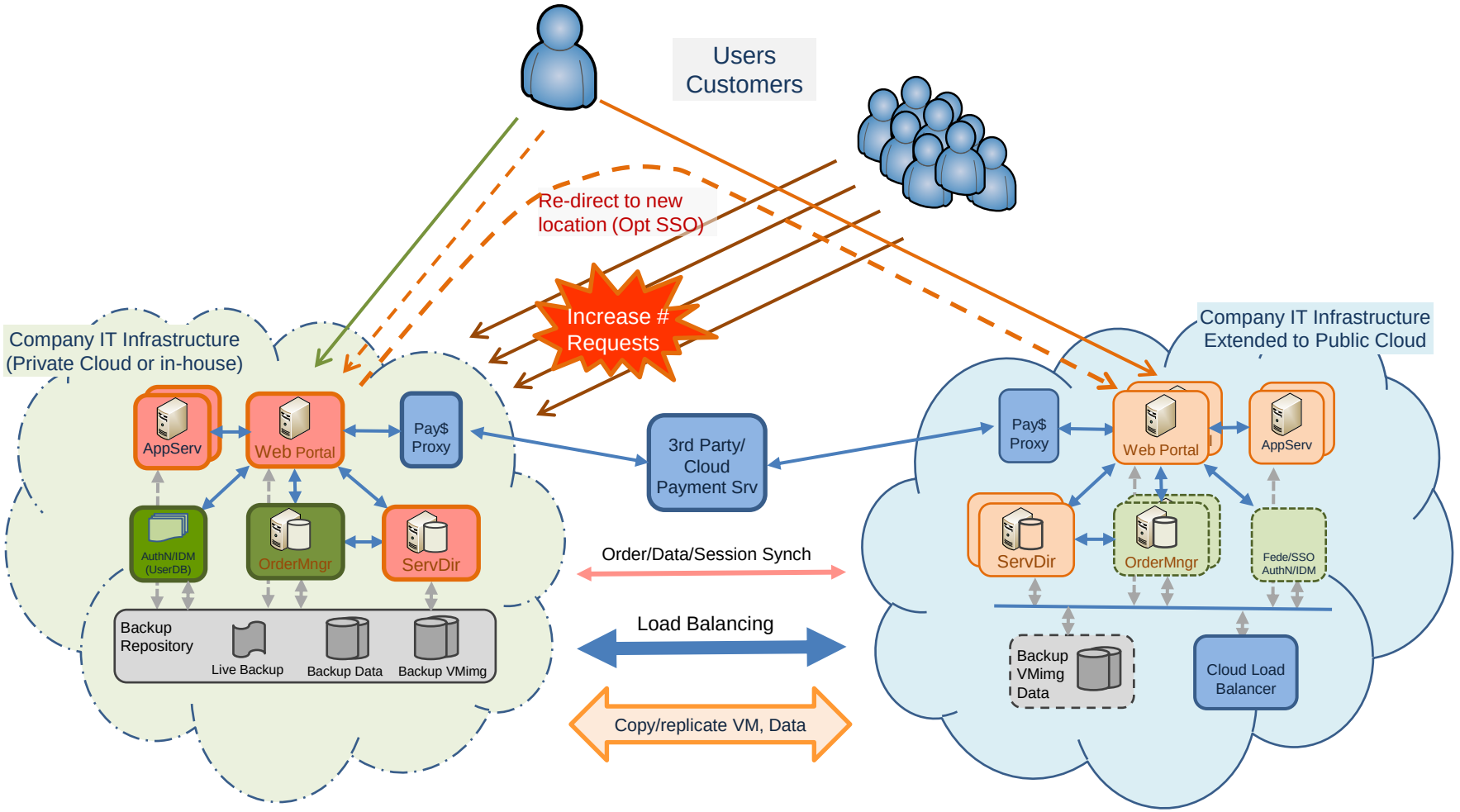
Use case 2:

- Disaster recovery
  - Moving/restoring emergency load in a partner cloud
  - Restoring own cloud based IT infrastructure

Use case 3:

- Service continuity when changing cloud provider

Cloudburst: Rapid load increase: seasonal, cyclical



Scenario: Abrupt demand increase for company's services: holiday shopping, seasonal, gaming, mobile Apps, ads campaign.

Cloudburst: Rapid load increase: seasonal, cyclical - Details

Scenario

- Webshops/eMarkets, entertainment sites have seasonal/holidays increase of load and users
- Surviving “disaster of success” when popular application or website attracts abrupt amount of users

Preconditions

- Company’s IT infrastructure is cloud based: private cloud or hosted on cloud
- Services and applications grouped to simplify services extension to cloud
  - Some 3rd party services (like payment systems) are already hosted on cloud
- The whole or part of IT infrastructure is backed up, including VM, Data, UserDB, topology, state/session

Sequence:

- Cloudburst scenario is triggered when increased number of requests causes services delay or interruption
- VM images and up-to-date order data (optionally UseDB) are backed up/replicated and transferred to suitable cloud provider (location, compatibility, cost)
- VMs and all necessary components are deployed in new cloud/location, data and states are synchronized
- Requests (all or part) are started to be re-directed to new location benefiting from elasticity of cloud resources
  - Additional capacity are automatically added to keep required Quality of Service (QoS), e.g. request processing time, downlowd sped, streaming quality
- Some services are typically not replicated to burst cloud, e.g. UserDB and order or payment processing
  - Initial client authentication can be done at the main site/portal and redirected using Singe Sign On (SSO) to new/cloud location
  - Data and processes synchronization must be in action
- External cloud resources and infrastructure stopped and de-commissioned, VM destroyed, after demand decrease (scale-down), all business related data are transferred back to company

Challenges

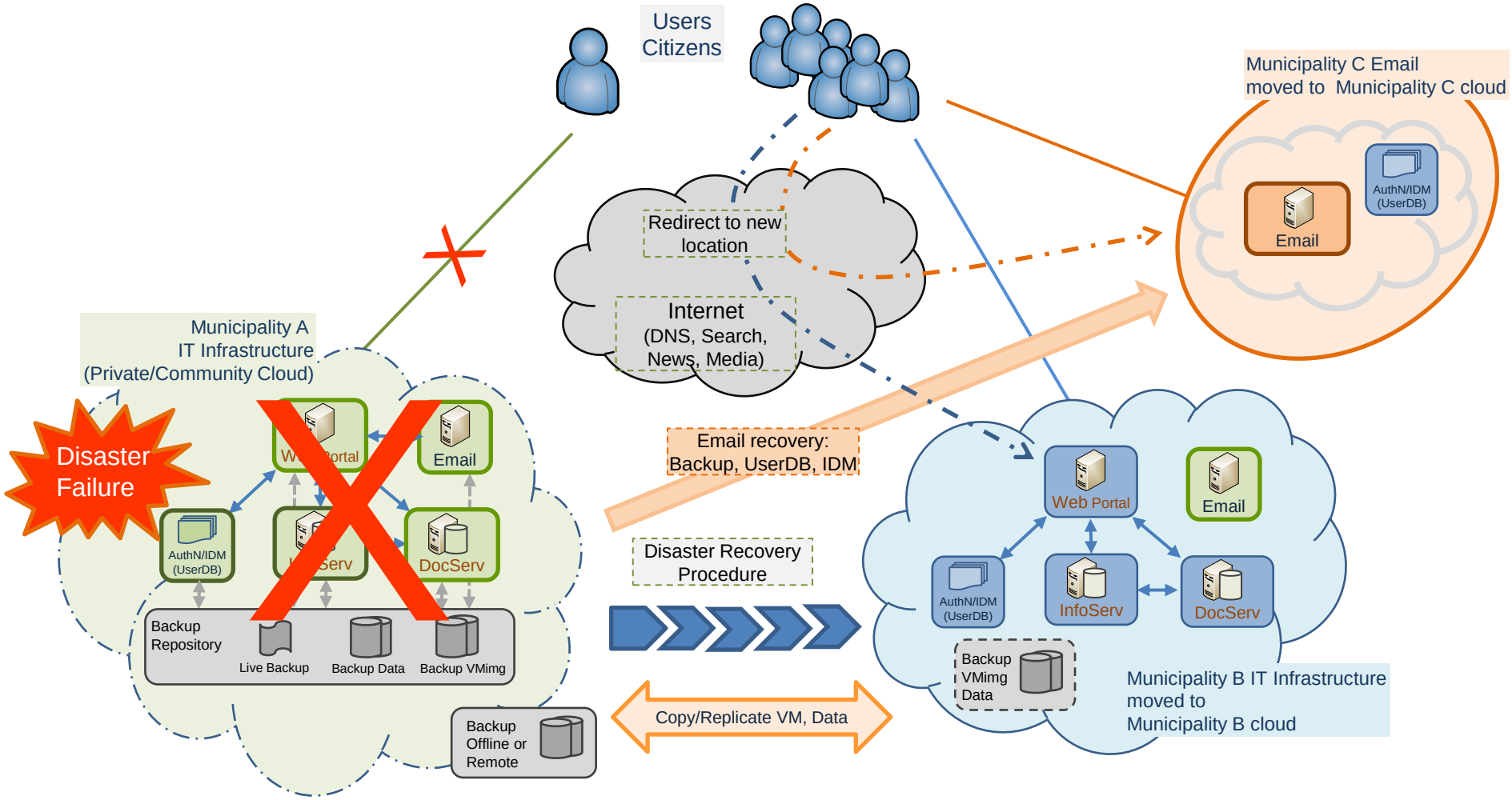
- Real time migration

Cloudburst: Design suggestions

- How will you launch your workloads? From a template, from a clone or from a dormant VM/instance?
- How will you connect, and how much data do you intend to push over this network connection?
  - Is it a point-to-point network, MPLS, EVPL or VPN, and is it production data, metadata, sensitive data or management traffic?
- How automated should this solution be? Is the cloud portal you have chosen easy enough to operate to take advantage of cloud bursting?
  - An API can provide full automation, but will require coding and additional business logic in your applications.
- How will the cloud handle your security policies? Does the cloud you have chosen have the governance and maturity you would expect for you data?
  - Can you even bring your own policies into the cloud? After all, the cloud holds your data, shouldn't it be able to support your existing IT policies?
- How will you handle load balancing? Will you need local and possibly global load balancing that can be dynamically updated to include the new workloads you have bursted into the cloud?
- How will you charge back in case of services outsourcing? Does your cloud bursting solution make it easy to charge back internal and external customers and set spend limits, controlling cloud sprawl and avoiding the auto-ballooning of cloud costs?

[ref] Cloudburst: Three steps for enterprise scaling into the cloud
http://blog.savvis.com/2012/04/cloud-burst-three-steps-for-enterprise-scaling.html /

Disaster Recovery (massive infrastructure failure)



Scenario: Due to natural disaster IT infrastructure of Municipality A destroyed; offline backup stored remotely is available; information service restored in the municipality B, email – in municipality C

Disaster Recovery: Services restored in a new location

Scenario

- Due to natural disaster IT infrastructure of Municipality A destroyed
- Offline backup stored remotely is available but cannot be used from Municipality A
- There is vital need for information both for citizens and for rescue team
- amount of users

Preconditions

- Municipalities' IT infrastructures are cloud based: using community cloud deployment model
- The whole IT infrastructure is backed up regularly, including VMs of all applications and services, Data, UserDB, topology
- Data and backups are replicated to/stored remotely

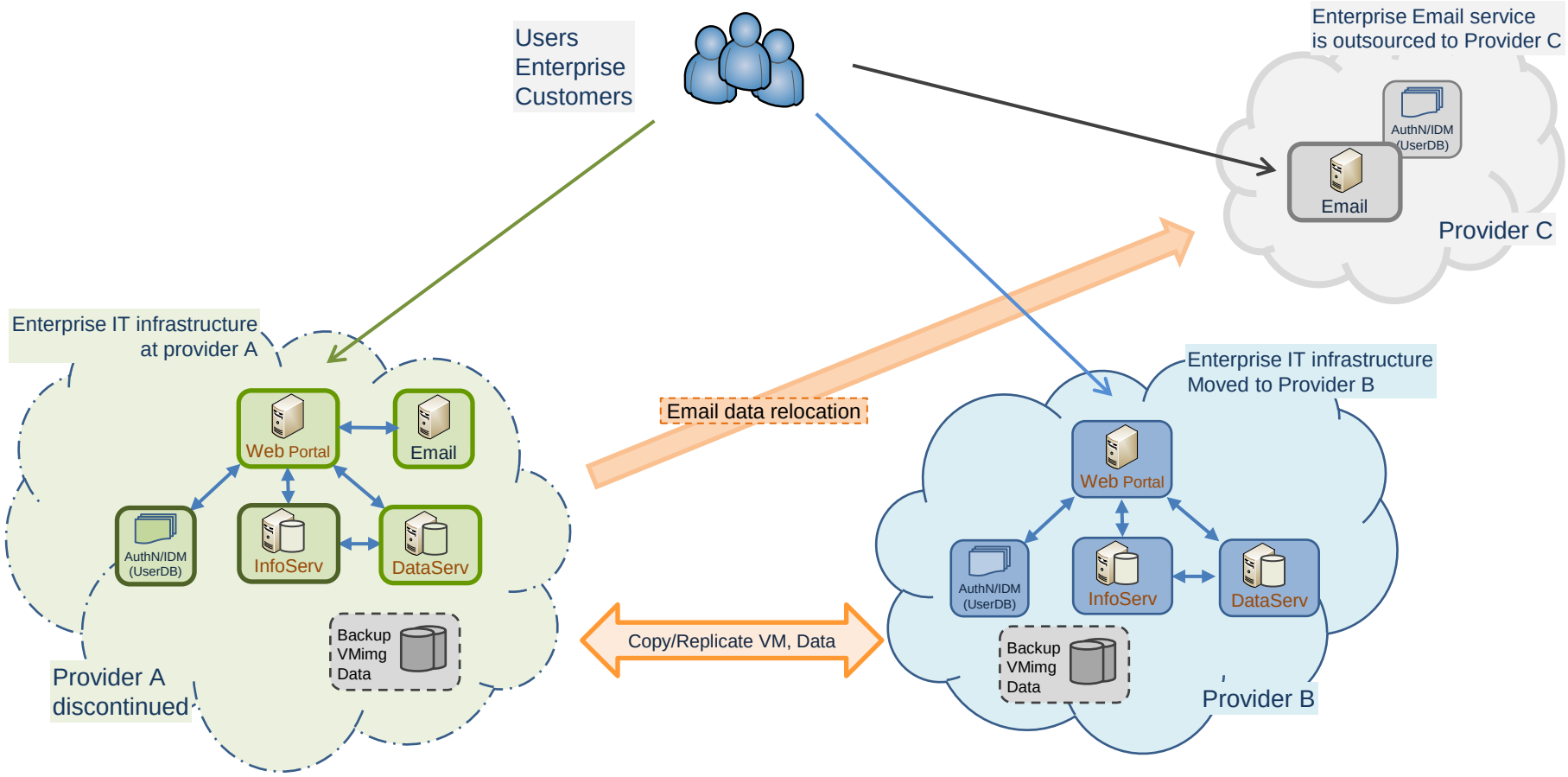
Sequence:

- Emergency Team (ET) starts working and following emergency response procedure
- ET accesses backup and transfers all files and images to previously defined location(s):
  - Information service is restored in the municipality B
  - Email service is restored in municipality C
  - Some services are provided by other municipalities
- New services location is registered in DNS and information is populated on Internet and on the web, by phone, newspapers
- Municipality A information services and email starting working on emergency mode; when original facility and datacenter are restored, services will be migrated to original location

Challenges:

- Full services backup and restoration must also include infrastructure and services topology
- Compatibility and standards for VM images, Data, service description and topology
- Compatible cloud platforms in Municipality A, B, C

Service continuity when changing Cloud provider



Scenario: Provider A discontinues its service; there is transition period; enterprise moves services to a new provider, assures services continuity, makes services optimisation

Service continuity when changing Cloud provider

Scenario

- Provider A discontinues its service; there is transition period; enterprise moves services to a new provider, assures services continuity

Preconditions

- Enterprise IT infrastructure is cloud based: private cloud or hosted on cloud
- The whole IT infrastructure is backed up, including VM, Data, UserDB, topology
- There is a transition period and a transition plan that also includes service/infrastructure optimization, some applications re-design

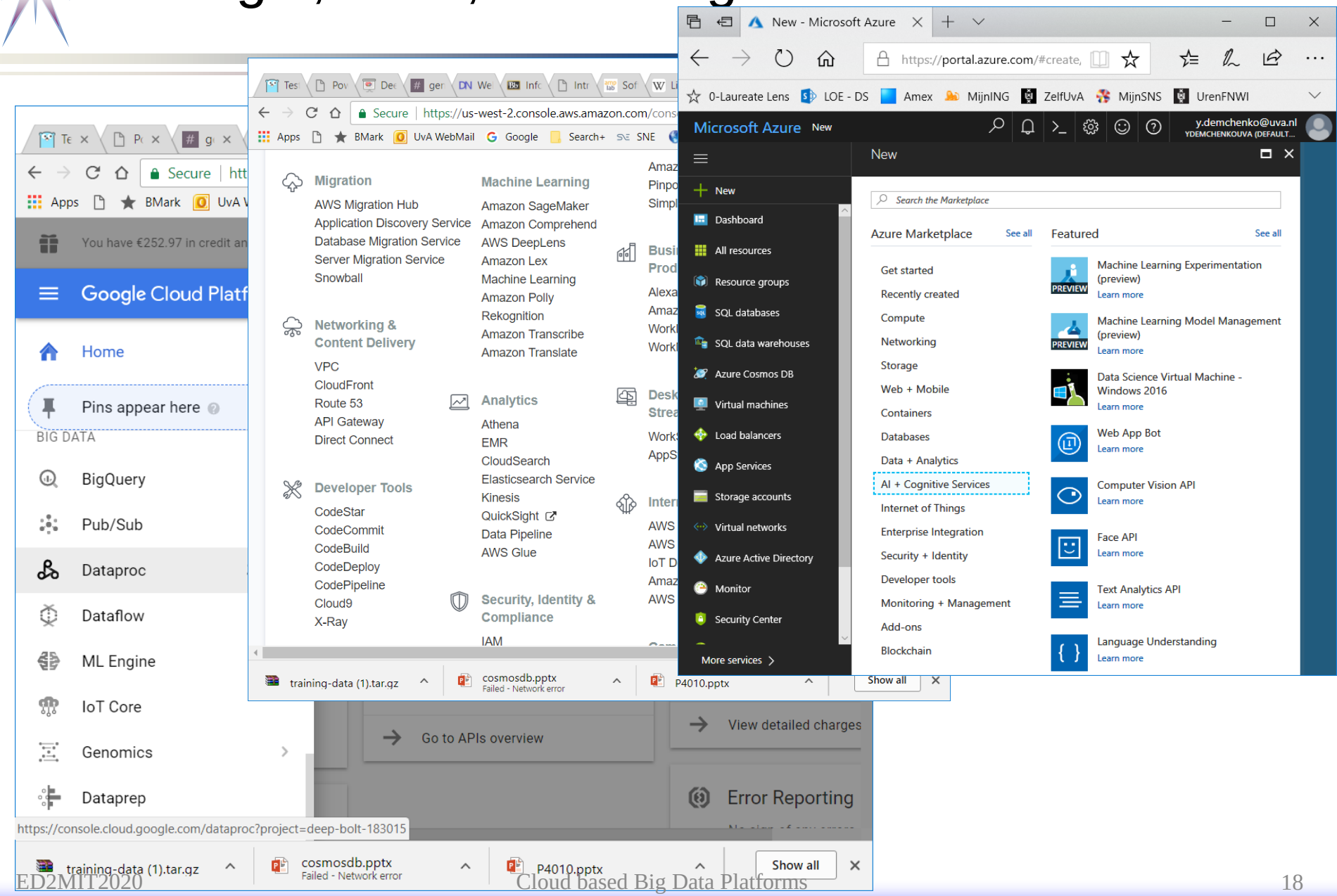
Sequence:

- Enterprise transfers/replicates either individual VM images or the whole infrastructure to new provider(s)
  - Main IT infrastructure is moved to provider B
  - Email service is moved to provider C
- Data are replicated to new location(s) and synchronised
- New services location is registered in DNS for correct Internet traffic forwarding; no other changes required
- Enterprise starts operating from a new location a new cloud provider as usual

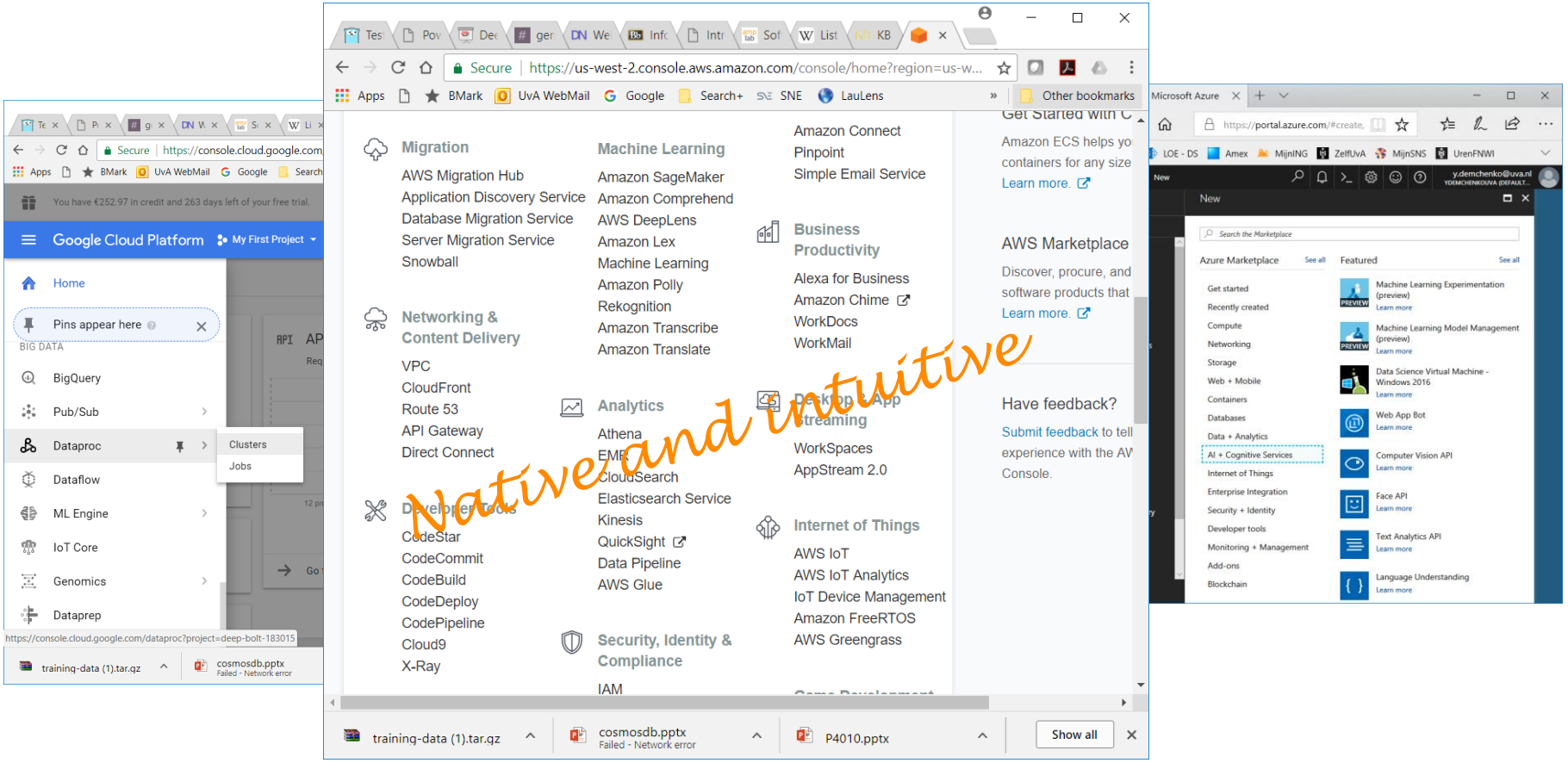
Challenges:

- Full services backup and migration must also include infrastructure and services topology
- Compatibility and standards for VM images, Data, service description and topology
- Compatibility of cloud platforms at providers A, B, C

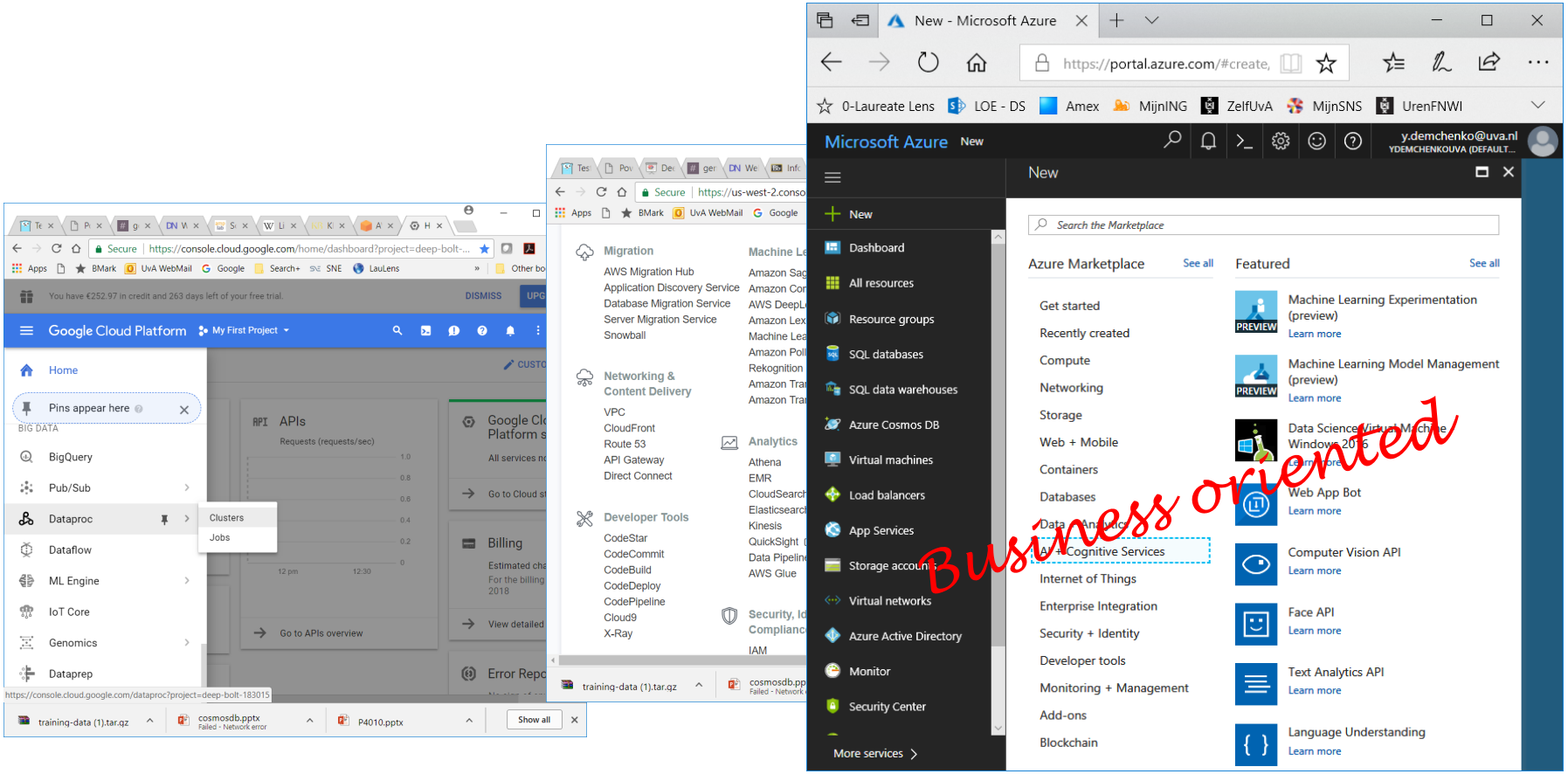
Google, AWS, Azure Big Data Stacks



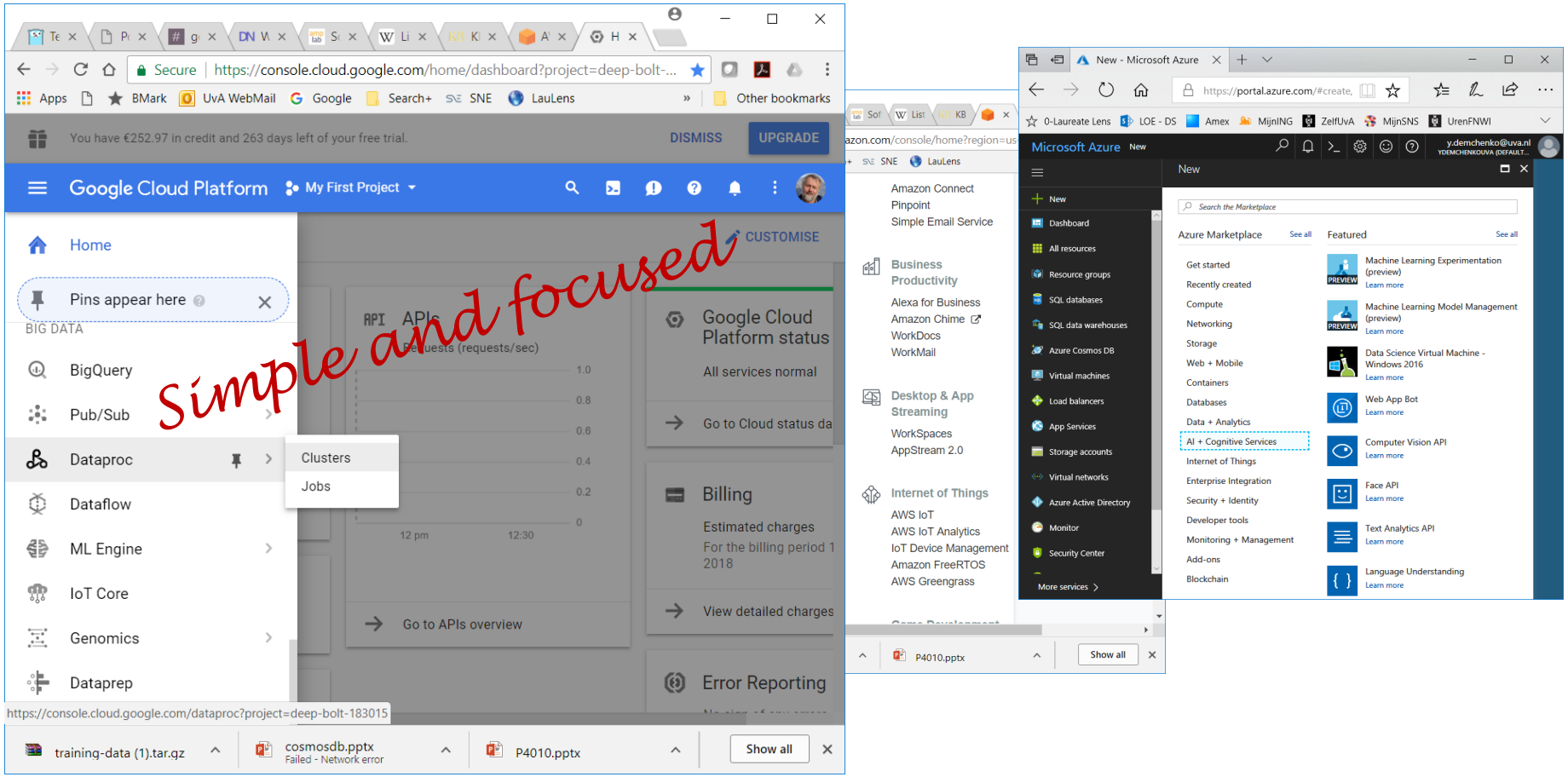
AWS, Azure, Google Big Data Stacks



AWS, **Azure**, Google Big Data Stacks



AWS, Azure, **Google** Big Data Stacks



AWS Cloud – Basic Services

- EC2 (Elastic Cloud Computing) – VMs, Container,
- S3 (Simple Storage Service) – buckets
- Lambda (functions – serverless computing)
- Network – Virtual Private Cloud, Virtual Private Network, dedicated connectivity
- Database – SQL, NoSQL
- IoT, Edge Computing
- Identity management, Federated Access Control
- Data Analytics, Business Intelligence
- Machine Learning

AWS Cloud Big Data Services

AWS Cloud offers the following services and resources for Big Data processing:

- EC2 Virtual Machine (VM) instances for HPC optimized for computing (with multiple cores) and with extended storage for large data processing.
- **Amazon Elastic MapReduce (EMR)** provides the Hadoop framework on Amazon EC2 and offers a wide range of Hadoop related tools.
- **Amazon Kinesis** is a managed service for real-time processing of streaming big data (throughput scaling from megabytes to gigabytes of data per second and from hundreds of thousands different sources).
- **Amazon DynamoDB** highly scalable NoSQL data stores with sub-millisecond response latency.
- Amazon Aurora scalable relational database
- Amazon Redshift fully-managed petabyte-scale **Data Warehouse** in cloud at cost less than $1000 per terabyte per year.
- **Amazon Machine Learning**
- Machine Learning (Artificial Intelligence) based services (Lex, Translate, Recognition, etc.)

Selecting Cloud Service Provider

- Type of VM instance
- Compute resource: VM, Container, Function or Lambda
- Storage resources and Content Distribution Network (CDN)
- Region and availability zone
  - Local compliance and certification, e.g. GDPR for Europe
- Cost of services and billing scheme
  - Note: VM cost is calculated per core
  - Note: Database cost is calculated by transactions and I/O operations + used VM instances

Amazon Web Services (AWS) Cloud

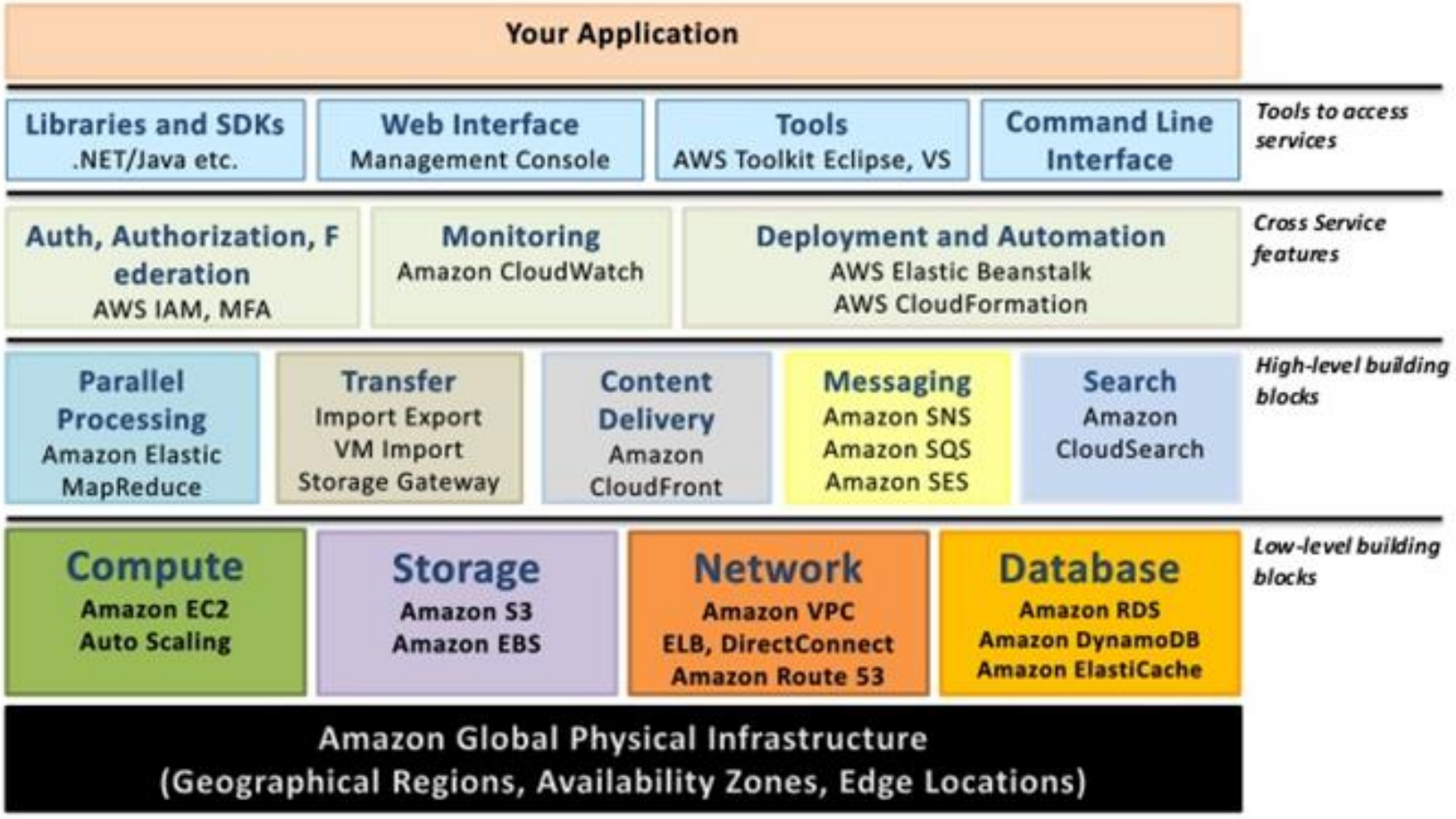
- AWS service groups
  - Compute: Elastic Compute Cloud (EC2) and EC2 Container service
  - Storage and Content Delivery: Simple Storage Service (S3), CloudFront, Glacier, etc.
  - Database: RDS, Dynamo, ElastiCache, Redshift
  - Networking: VPC, Direct Connect, Rout 53
  - Security and Identity Management: IAM (Identity and Access management), Directory, etc.
  - Developer tools
  - Management and Governance
  - Analytics and Machine Learning
  - Mobile Services
  - Applications Integration
  - Enterprise Applications
  - Internet of Things

Amazon EC2 and S3 API became a standard-de-facto interfaces for accessing and managing cloud services

- Majority of existing cloud management platforms offer EC2 and S3 interfaces

- AWS has 14+ availability zones to choose from:
  - US Standard (default), US West (Oregon), US West (Northern California)
  - Europe: Ireland, Frankfurt, London, Paris
  - Asia Pacific (Singapore), Asia Pacific (Tokyo), Asia Pacific (Sydney), Asia Pacific (Mumbai)
  - South America (Sao Paulo)
  - **GovCloud (US) Regions**. The US Standard Region automatically routes requests to facilities in Northern Virginia or the Pacific Northwest using network maps

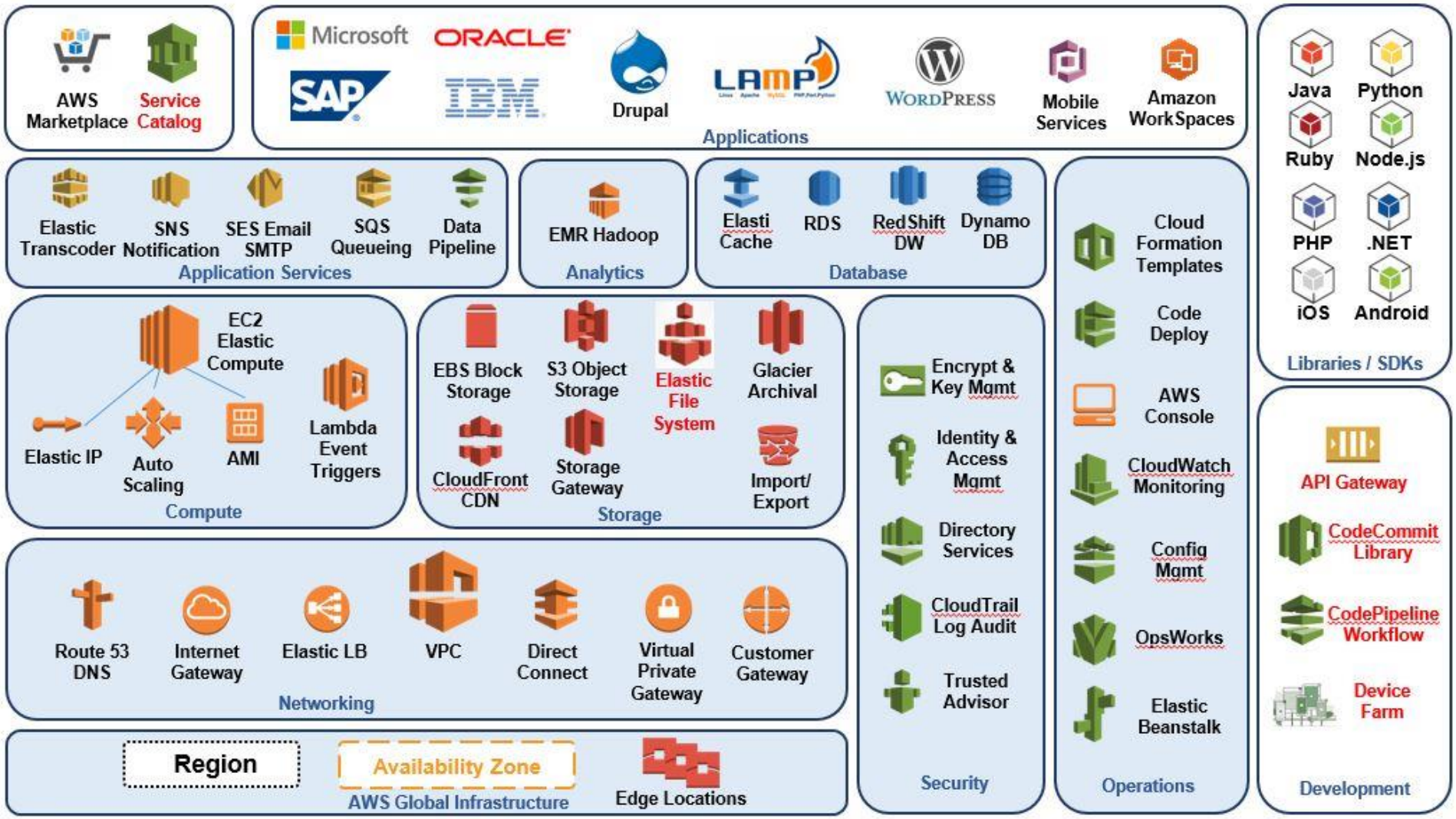
Amazon AWS Cloud Architecture (est 2011)



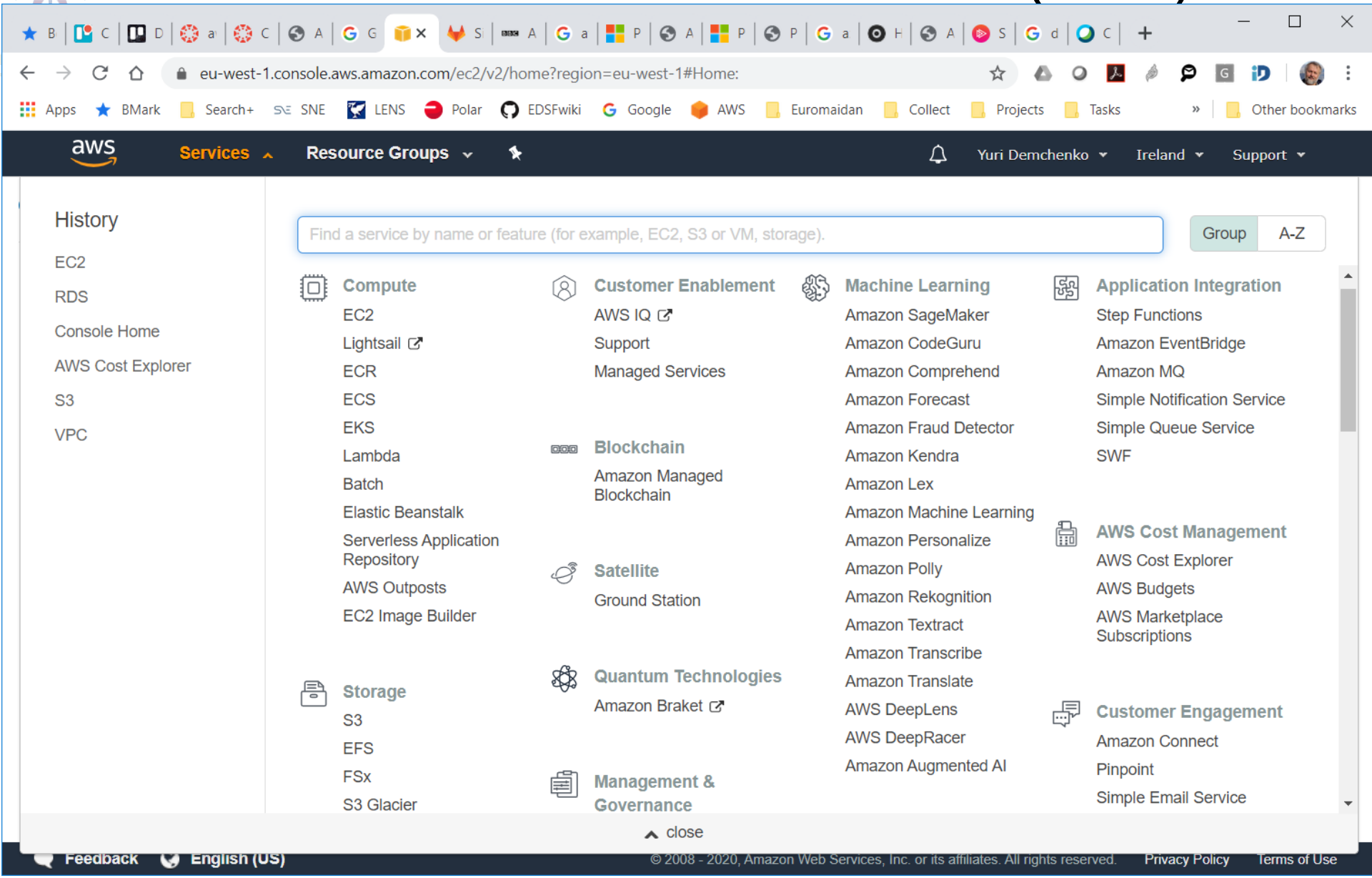
AWS Architecture Overview: Services (2018) - https://d1.awsstatic.com/whitepapers/aws-overview.pdf

Credits “Building Powerful Web Applications in the AWS Cloud” by Louis Columbus
http://softwarestrategiesblog.com/2011/03/10/building-powerful-web-applications-in-the-aws-cloud/

AWS Products (est. 2015)



Amazon AWS Console – Products (2020)



Amazon EC2: Amazon Machine Instances (AMI)

EC2 AMIs (Amazon Machine Instances) forms the basic infrastructure on which applications can be deployed just as any other server

- ***Reserved* instances**, which can be purchased with a one time payment for a long term reservation and are available at considerably lower prices
- ***On-Demand* instances**, which are for immediate demands but with comparatively higher prices
- ***Spot* instances**, which is unused capacity for which users can bid for

AMI allows the following controls over the provisioned infrastructure:

- Location of the AMIs and management of static IP addresses
  - Using one of eight availability zones for a user to choose from:
- Network management and access control to the AMI configuration
- Use of a Web based management console
- For professional use, developers have an option to use **AWS command line tools** which allows them to write scripts to automate this management (e.g., Ruby, bash, python)

Amazon EC2 Machine Instances Types

VM instances are optimised for different types of applications and use cases (Amazon EC2 Instances http://aws.amazon.com/ec2/instance-types/):

- M3 - General Purpose
- C3 - Compute Optimized
- R3 - Memory Optimized
- G2 - GPU
- I2 - Storage Optimized
- HS1 - High storage density
- T1 - Low cost micro instances

Name	vCPUs	Baseline Perf	RAM (GiB)	CPU Cred/Hrr	Price/Hr (Linux)	Price/ Month
t2.micro	1	10%	1.0	6	$0.013	$9.50
t2.small	1	20%	2.0	12	$0.026	$19.00
t2.medium	2	40%	4.0	24	$0.052	$38.00

Example 1: M3 instance provides a balance between compute, memory, and network resources:

- High Freq. Intel Xeon E5-2670 (Sandy Bridge) Processors
- SSD-based instance storage for fast I/O performance
- Balance of compute, memory, and network resources

M3 instances come in configurations:

- m3.medium (1 core, 3.75 GB, SSD 1 x 4 GB)
- m3.large (2 core, 7.5 GB, SSD 1 x 32 GB)
- m3.xlarge (4 core, 15 GB, SSD 2 x 40 GB)
- m3.2xlarge (8 core, 30 GB, SSD 8 x 30 GB)

C3 instances are compute-optimized, using highest performing processors

- High Frequency Intel Xeon E5-2680 v2 (Ivy Bridge) Processors
- Support for Enhanced Networking
- Support for clustering
- SSD based instances storage

C3 instances come in configurations:

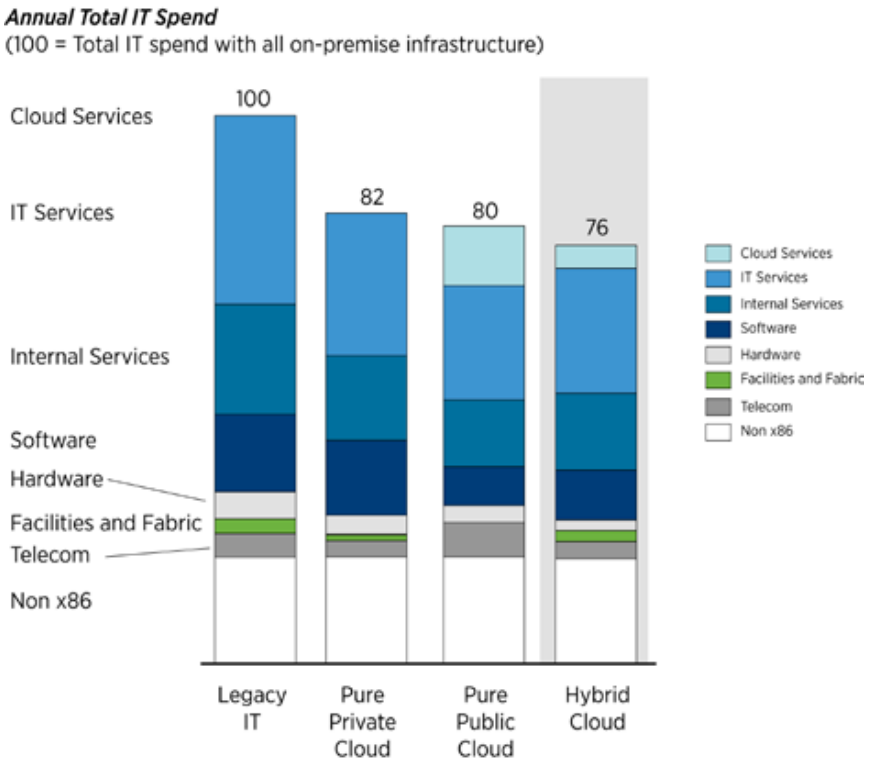
- c3.large (2 core, 3.75 GB, SSD 2 x 16 GB)
- c3.xlarge (4 core, 7.5 GB, 2 x 40 GB)
- c3.2xlarge (8 core, 15 GB, 2 x 80 GB)
- c3.4xlarge (16 core, 30 GB, 2 x 160 GB)
- c3.8xlarge (32 core, 60 GB, 2 x 320 GB)

Optimizing Cost and Billing Options

On-demand Instances	Reserved Instances	Spot Instances	Dedicated Instances
• Pay as you go • Zero commitment	• One time low upfront fee + discounted hourly costs • Upto 71% savings over on-demand	• Requested Bid Price and Pay as you go • Price change every hour based on EC2 capacity	• Standard and Reserved • Multi-tenant Single Customer • Ideal for compliance and regulatory workload

- EC2 AMIs offers the following resources provisioning and billing options
  - *Reserved* instances, which can be purchased with a one time payment for a long term reservation and are available at considerably lower prices
  - *On-Demand* instances, which are for immediate demands but with comparatively higher prices
  - *Spot* instances, which is unused capacity for which users can bid for
  - Dedicated instances (can be standard and reserved) created and deposited for special user needs

Cloud and Total IT Spending



[ref] Business Agility and the True Economics of Cloud Computing. Business White Paper, VMware 2011.

VMware and EMC research [ref]

- The hybrid cloud is more economical than pure public cloud or pure private cloud models
- Hybrid cloud deployment would reduce typical total IT spending by approximately **20 to 30 percent**

- Hybrid clouds combine benefits of public clouds elasticity and on-demand resource provisioning with the benefits of private clouds
  - Legacy applications
  - Operational control
  - Sensitive applications and data
- Hybrid clouds require **standardisation and interoperability** between private and public platforms to achieve applications portability
  - Common platform
  - Common management
  - Security
  - Compliance

Amazon Elastic MapReduce (EMR)

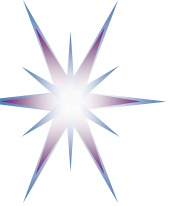
- Amazon Elastic MapReduce (EMR) provides the Hadoop framework on Amazon EC2 and offers a wide range of Hadoop related tools.
- MapReduce and Spark
- Graphical user interface

Self-check Questions

- Dropbox: What type of cloud service or application?
- You run/setup accountants company. What type of cloud service you would use?
- You are a researcher using unique (old) software for your data processing.
  - What type of cloud service you will use?
- You need to setup a summer school on (agile) programming techniques.
  - Will you use cloud? What type?
- You need to support a project group that besides writing reports needs also regular project calls (voice, video)

Demo: Services deployment on AWS

- AWS VM launch (deployment)
  - Important aspects
- EMR deployment
  - Cluster configuration suggestion
- Secure remote access
  - SSH client, secret key configuration



Curiously Asked Questions (CuAQ)

- What is minimum viable knowledge of cloud?
- Is cloud secure enough? What about GDPR?
- Do I need to use SSH?

Summary: Cloud Computing

- Cloud is an ultimate technology for Big Data
  - Big Data storage and Data processing
- Cloud Computing has many benefits as a new technology and as IT infrastructure design and management transformation factor
- At the same time Cloud Computing has a number of restraining factors, main of which is security of data and services or infrastructure in clouds
  - New services based on Confidential Computing platform

Reflection and discussion

- What would be your estimation for SME in the known to you business domain of the pros and cons factors to move to cloud?
- What form of cloud services is more economically efficient for big, medium, small company?

References

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- Use Cases and Functional Requirements for Inter-Cloud Computing, GICTF White Paper. August 9, 2010 - http://www.gictf.jp/doc/GICTF_Whitepaper_20100809.pdf

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