Cloud Computing

Cloud Services

- Cloud services divided into 3 main levels of abstraction:
  - Infrastructure-as-a-Service (IaaS)
  - Platform-as-a-Service (PaaS)
  - Software-as-a-Service (SaaS)

Cloud infrastructure

- Infrastructure-as-a-Service (IaaS):
  - provides virtualized hardware resources such as computing, storage and networking
  - resources are allocated on demand and in a pay-per-use fashion
  - an example of IaaS is Amazon EC2 (for computing) and Amazon S3 (for storage)

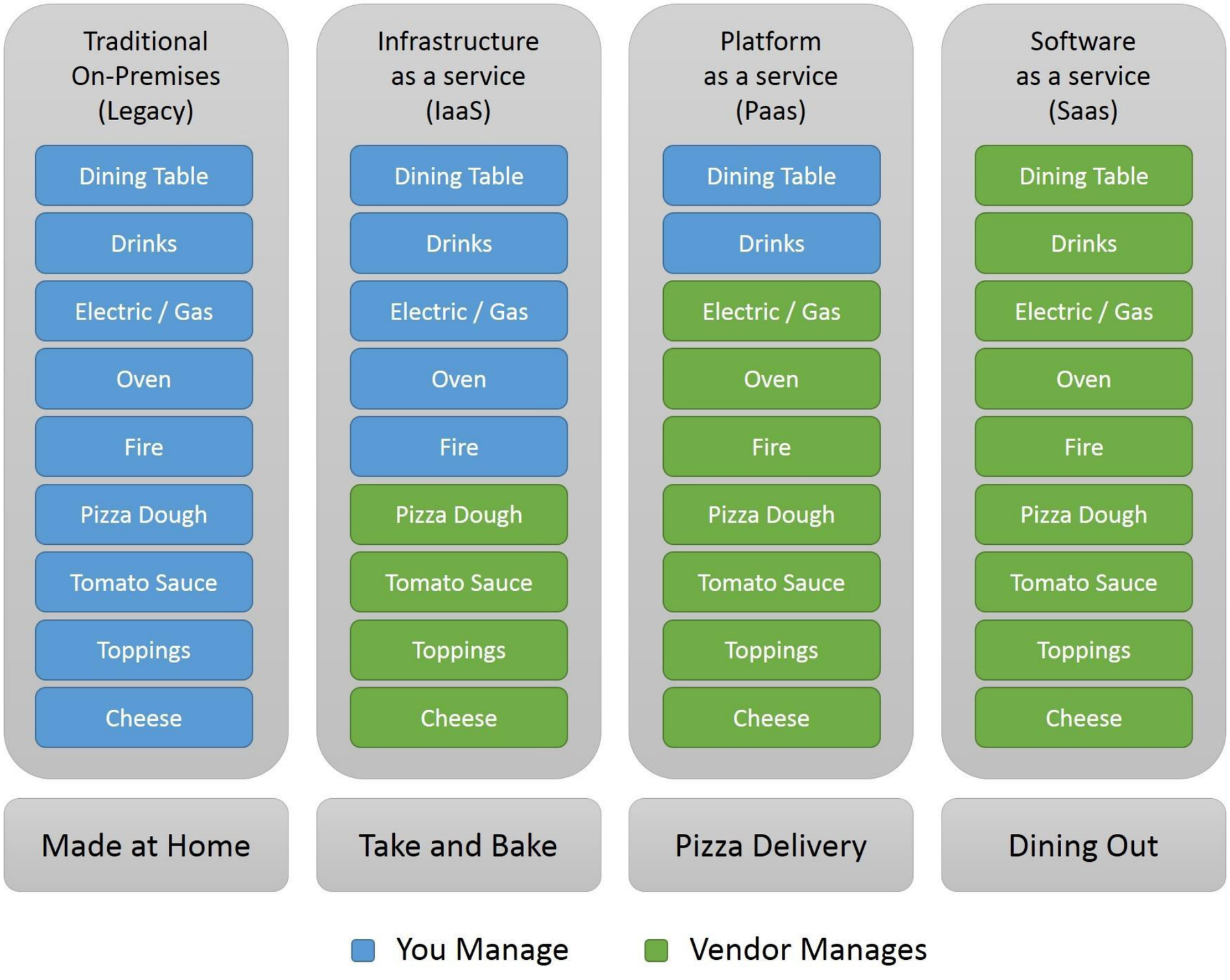
Cloud infrastructure

- Platform-as-a-Service (PaaS):
  - offers an encapsulation of a development environment abstraction that can be used to develop, deploy and run applications
  - examples include the Google App Engine

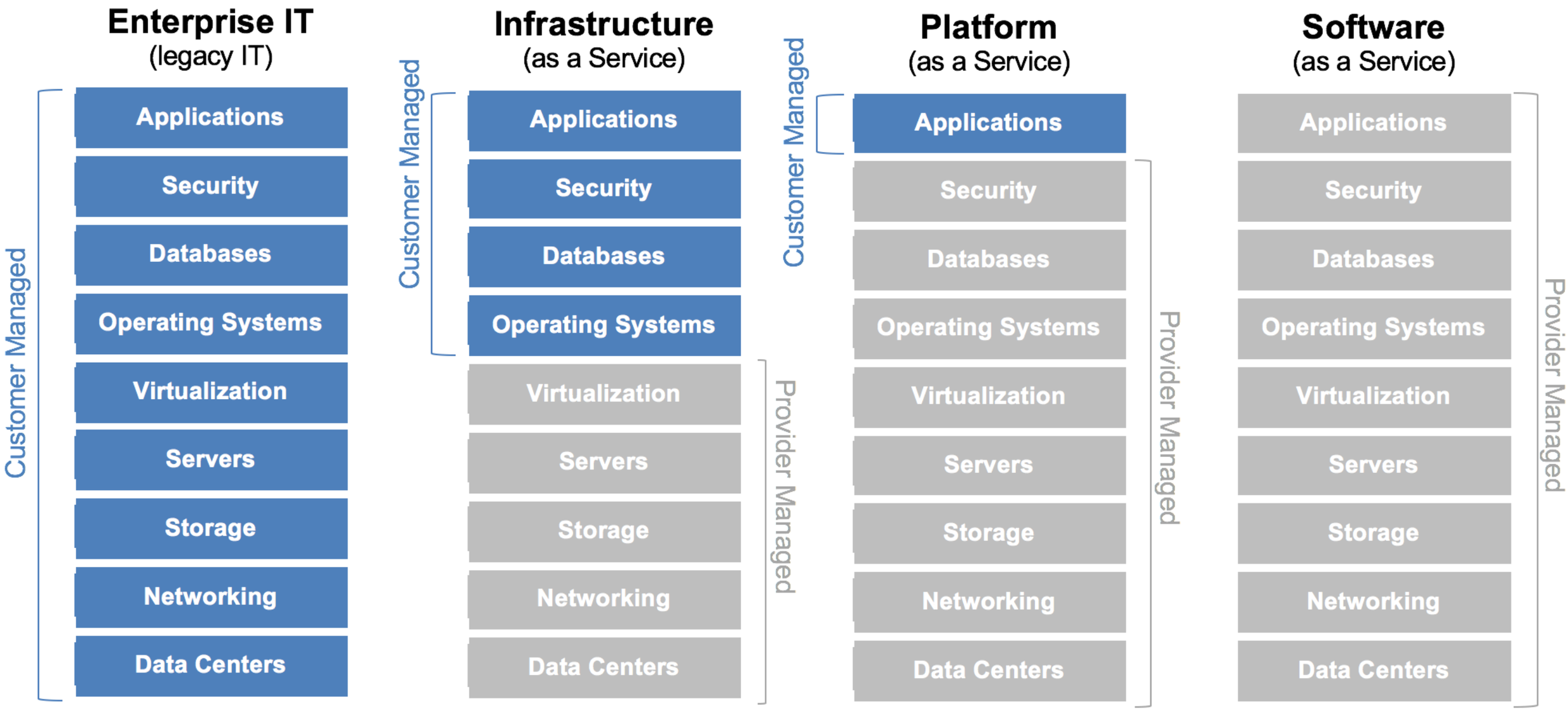
Cloud infrastructure

- Software-as-a-Service (SaaS):
  - features full applications or generic software like databases
  - offered as a service and accessible as a web service or through a web browser
  - SalesForce.com and the Google Apps like Gmail are some well known instances of this type

Pizza as a Service



https://m.oursky.com/saas-paas-and-iaas-explained-in-one-graphic-d56c3e6f4606



https://mycloudblog7.wordpress.com/2013/06/19/who-manages-cloud-iaas-paas-and-saas-services/

Infrastructure-as-a-Service

- Datacenters scattered around the world (Asia, Europe and, North and South America)

- Each with around 80 000 servers

- Top main players: Google, Amazon and Microsoft

Infrastructure-as-a-Service

- How can we manage many datacenters each with thousands of servers?
  - Virtualization

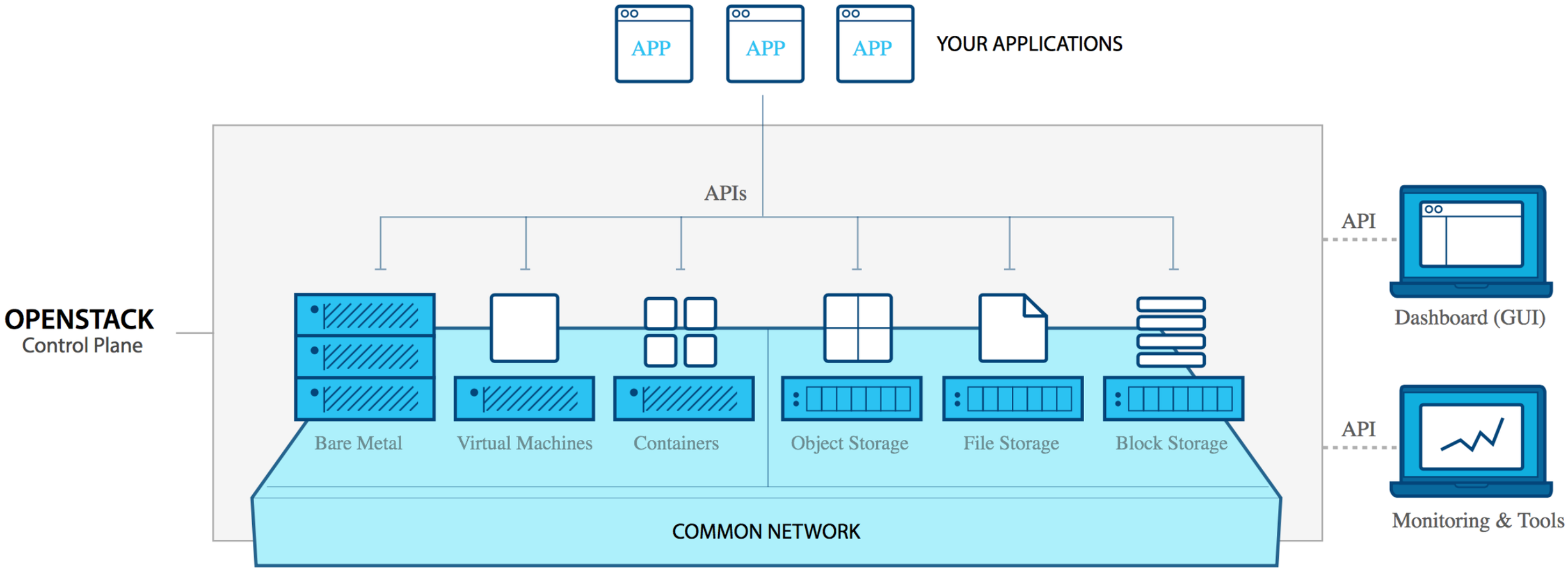
OpenStack

- Open source software for creating private and public clouds

- Controls large pools of compute, storage, and networking resources throughout a datacenter

- Managed through a dashboard or via the OpenStack API

OpenStack


APP
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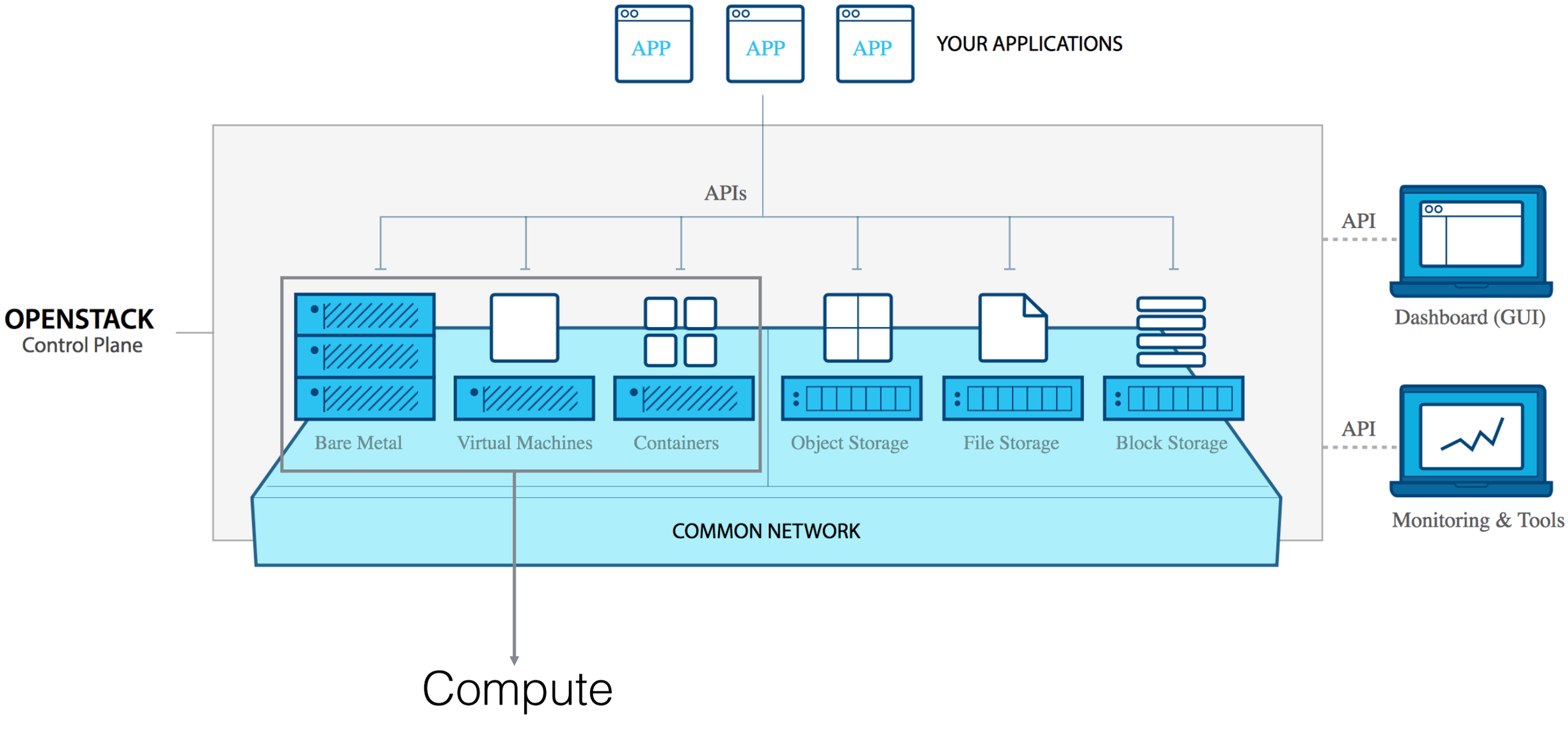
YOUR APPLICATIONS
APIs
OPENSTACK
Control Plane
Bare Metal
Virtual Machines
Containers
Object Storage
File Storage
Block Storage
COMMON NETWORK
API
Dashboard (GUI)
API
Monitoring & Tools

OpenStack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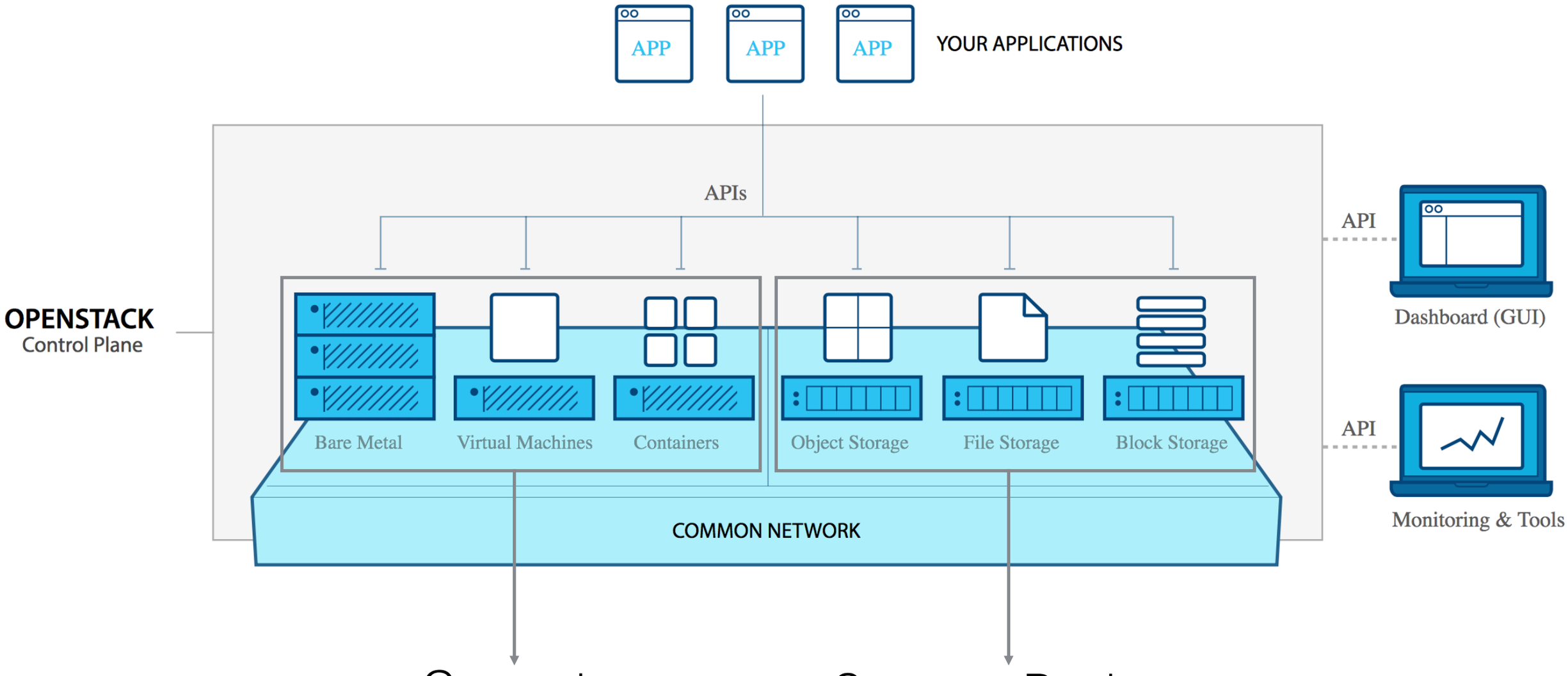
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Monitoring & Tools
Compute
Storage, Backup
& Recovery (SDS)

OpenStack - Cinder

- Block storage
  - virtualizes the management of block storage devices
  - provides end users with a self service API to request and consume those resources without requiring any knowledge of where their storage is actually deployed or on what type of device

OpenStack - Swift

- Highly available, distributed, eventually consistent object/blob store

- Ideal for storing unstructured data that can grow without bound

Ephemeral storage vs Cinder vs Swift

	Ephemeral storage	Block storage	Object storage
Used to…	Run operating system and scratch space	Add additional persistent storage to a virtual machine (VM)	Store data, including VM images
Accessed through…	A file system	A block device that can be partitioned, formatted and mounted (such as, /dev/vdc)	REST API
Accessible from…	Within a VM	Within a VM	Anywhere
Managed by…	OpenStack Compute (Nova)	OpenStack Block Storage (Cinder)	OpenStack Object Storage (Swift)
Persists until…	VM is terminated	Deleted by user	Deleted by user
Sizing determined by…	Administrator configures size settings, known as *flavors*	Specified by user in initial request	Amount of available physical storage
Example of typical usage…	10 GB first disk, 30GB second disk	1 TB disk	10s of TBs of dataset storage

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OpenStack - Neutron

- Software-Defined-Network (SDN)
  - focused on delivering networking-as-a-service (NaaS) in virtual compute environments
  - abstracts the network topology and addressing

OpenStack - Telemetry

- Monitoring service collects data on the utilization of the physical and virtual resources
- Efficiently collect, normalise and transform data
- Persist data for subsequent retrieval and analysis
- Trigger actions when defined rules are met

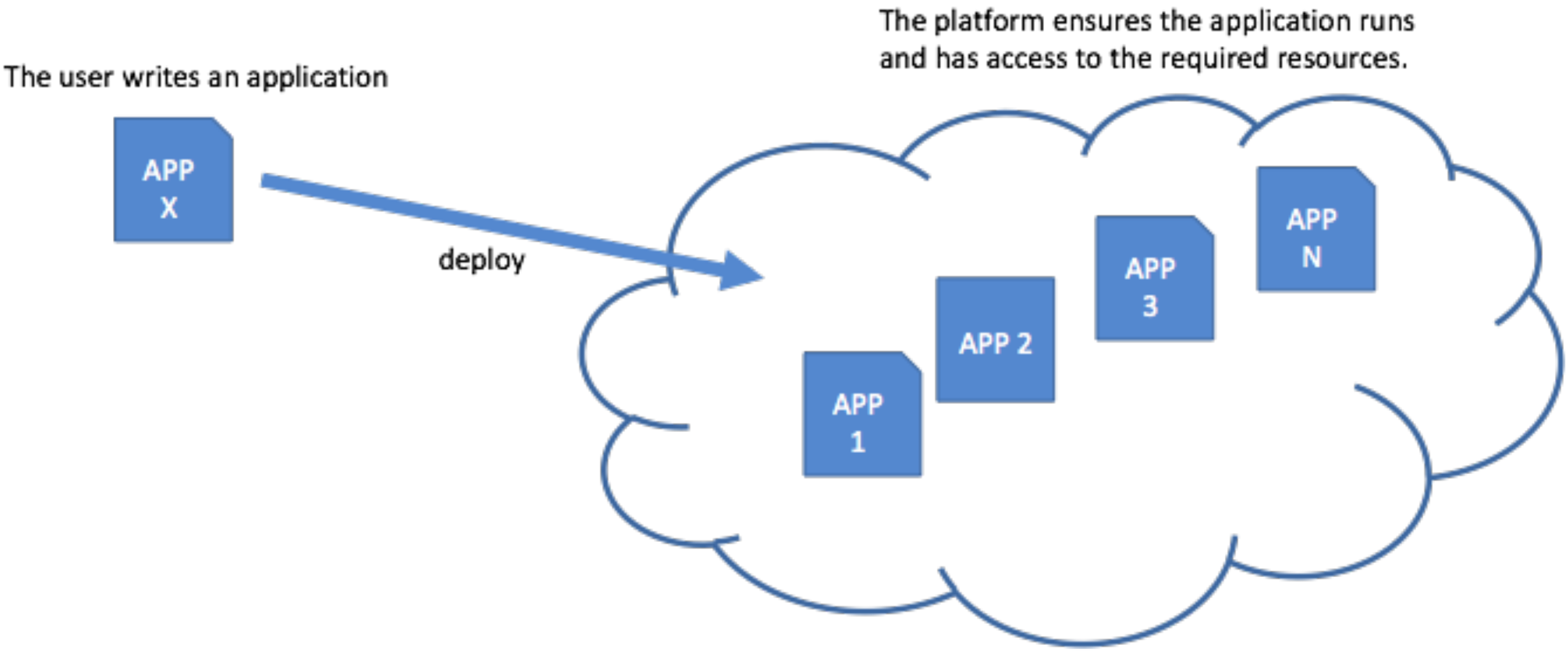
Counterparts in other services

OpenStack	Amazon WebServices	Google Cloud Platform
Nova Compute	EC2	Google Compute Engine
Cinder	EBS (Elastic Block Storage)	Persistent disks
Swift	S3 (Simple Storage Service)	Cloud Storage
Neutron	Networking	Google Cloud Virtual Network
Telemetry	CloudWatch	Google Stackdriver

From IaaS to PaaS

- From managed allocation and provision of resources to managed infrastructure
- Actual resources become transparent
- Focus on the application, which is the deployment item
- The interface is a programming environment, with APIs to IaaS/SaaS services
- The user can focus on the functionality to deploy instead on what are the resource requirements to support it
- Fast prototyping, easy deployment, managed elasticity and load balancing

PaaS


The user writes an application
APP
X
deploy
The platform ensures the application runs
and has access to the required resources.
APP
1
APP 2
APP
3
APP
N

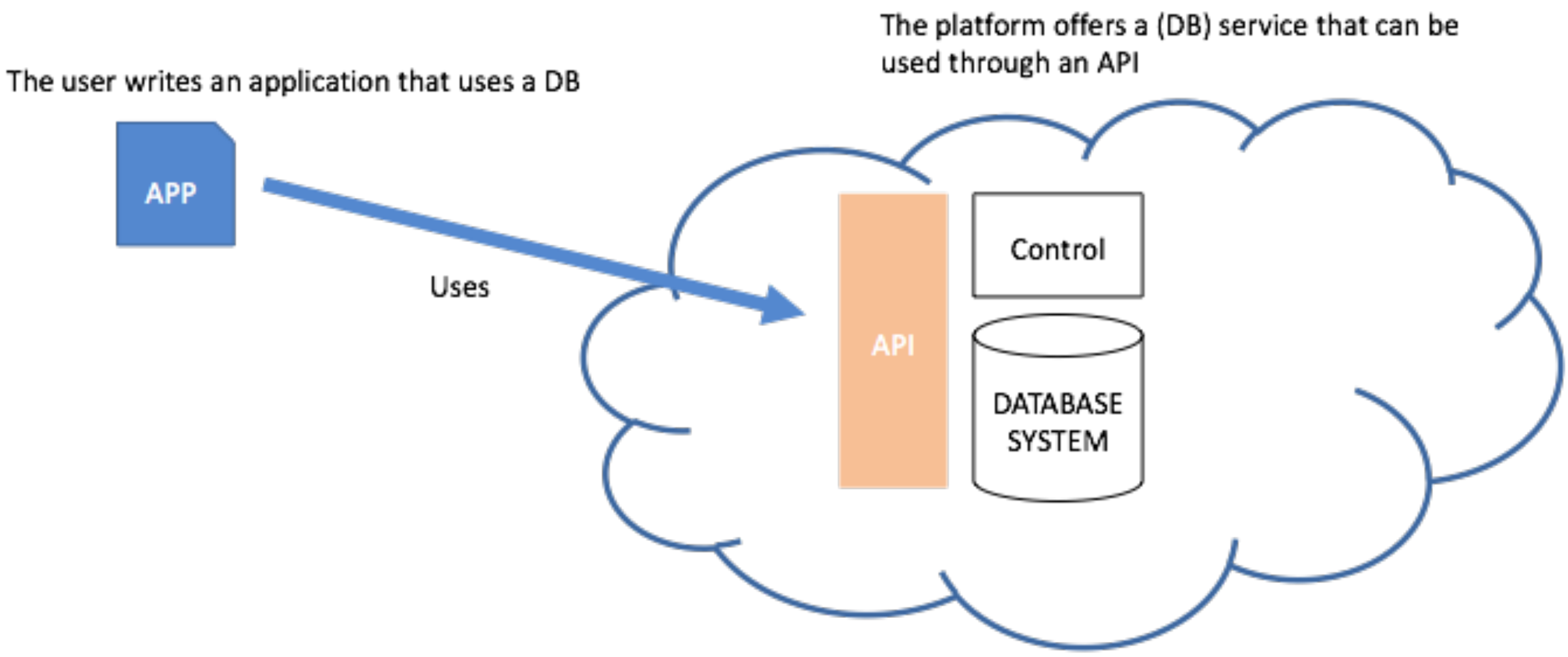
PaaS

- Example: Google App Engine
  - based on container instances
  - supports multiple languages (Java, Python, PHP, …)
  - and tools (Cloud SDK, IntelliJ IDEA, …)
  - and APIs (Google Cloud Storage, …)
  - versioning, testing, monitoring, logging, and security features
  - automatic elasticity and fault-tolerance

From PaaS to SaaS

- Specific services are provided
- Managed software components that export their traditional APIs
- Examples are database management systems
- There is no deployment item – the DB is exposed through a client and used as a traditional DB but with minimal configuration needed and with remote access
- Transparent management, elasticity and fault-tolerance

SaaS



Example: Amazon DynamoDB

IaaS, PaaS and SaaS: complex distributed systems

- Virtualization
- Provisioning
- Monitoring
- Reporting
- Billing
- Interoperability between all of the above

Advantages

IaaS, PaaS and SaaS

Convenience

- From IaaS:
  - avoid upfront costs on infrastructure management and hardware
  - “easily” deploy legacy applications
- to PaaS
  - focus on the application development itself and its requirements
  - powerful development, deployment, debugging, and benchmarking tools already in place
  - transparent elasticity and fault-tolerance
- to SaaS
  - leverage existing components (databases, web/application servers)
  - transparent elasticity and fault-tolerance

Speed

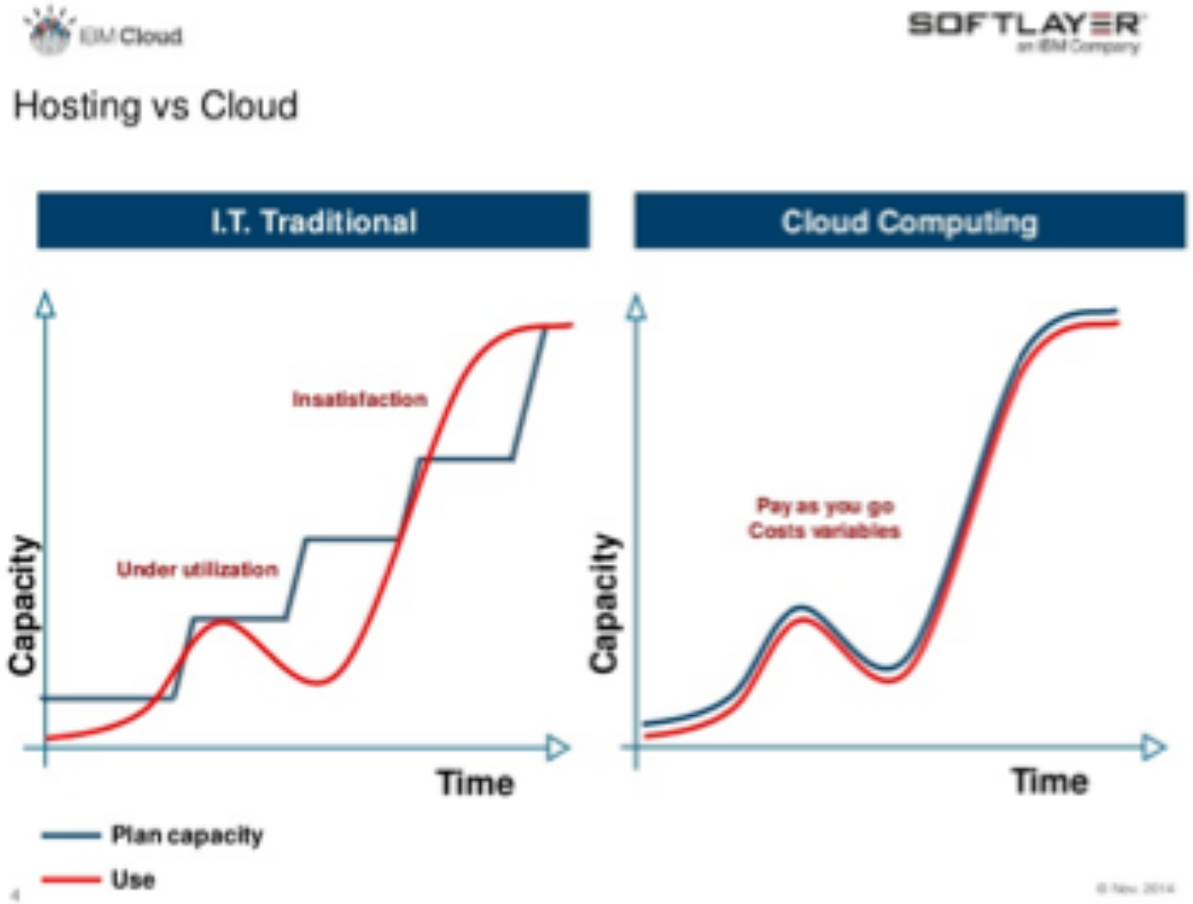
- From IaaS:
  - infrastructure is already installed and configured
- to PaaS
  - a development framework is already installed and configured
  - High degree of automation for deployment allows quick enhancement and bug fixing deploy
- to SaaS
  - Quick integration of different cloud software solutions

Elasticity

- From IaaS
  - illusion of virtually infinite resources
  - increase and decrease computational power, storage space and other resources according to demand
    - needs to be done manually or by resorting to third-party tools
- to PaaS and SaaS
  - no need to manually manage elasticity

Flexible pricing model

- IaaS, PaaS and SaaS
  - no upfront costs
  - pay as you go allows to quickly correct possible over and under estimations with respect to system sizing
  - costs of infrastructure management and maintenance are included in the service



Disadvantages

IaaS, PaaS and SaaS

Loss of control

- From IaaS
  - no control over specific hardware and virtualizarion software
  - no possibility of fine tuning and optimizing the infrastructure
- to PaaS
  - no control over specific hardware and the PaaS platform software
  - some performance bottlenecks are out of the control of the application owner
  - management and monitoring is reduced to the tools provided by the platform
- to SaaS
  - third-party black-box cloud applications

Security

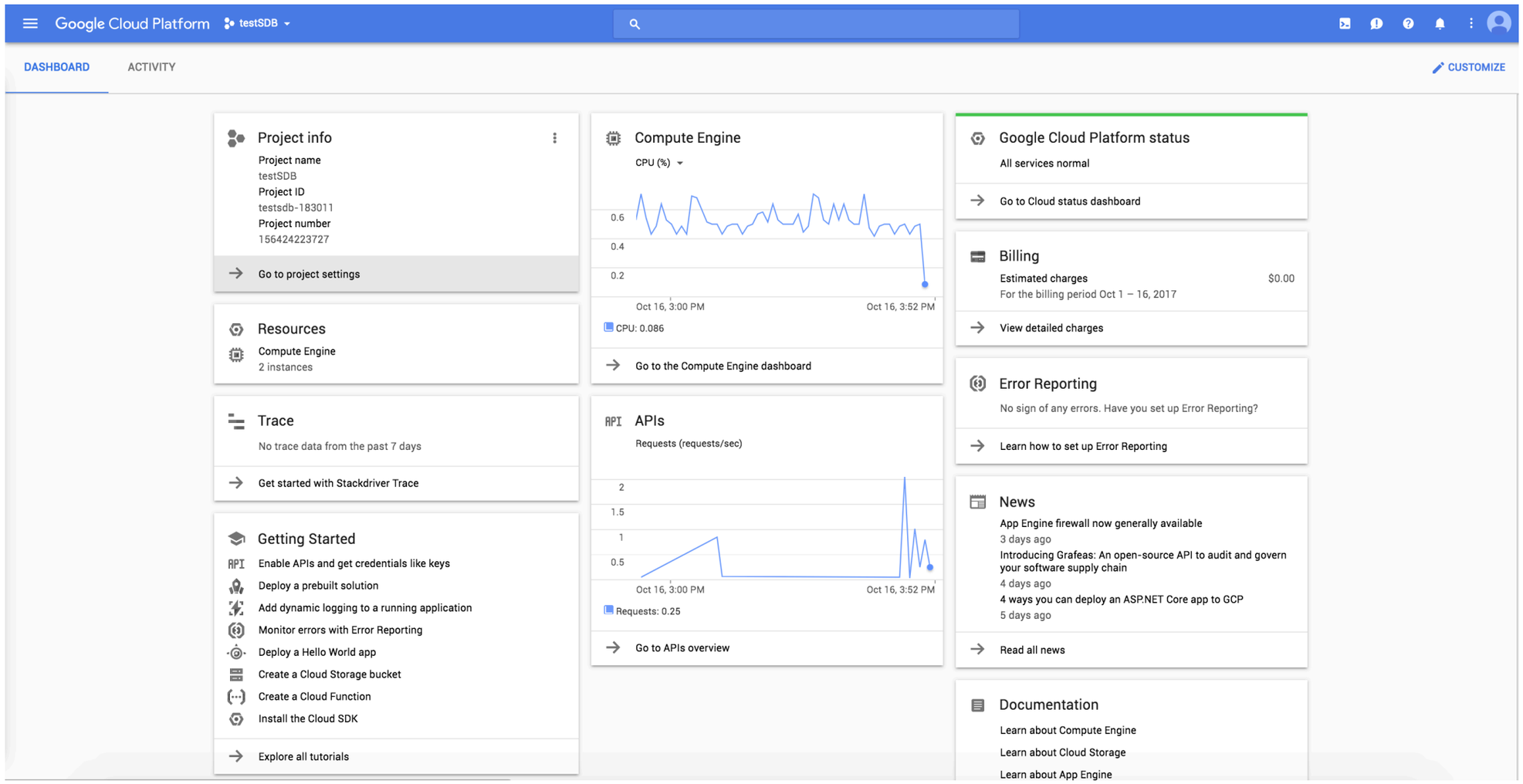
- IaaS, PaaS and SaaS
  - as secure as the provider – any vulnerability of the provider is a vulnerability of the application
  - fixes to vulnerabilities must be done by the provider
  - if (even if unlikely) the provider fails, the application fails and recovery is out of the control of the application owner

Privacy

- IaaS, PaaS and SaaS
- Data is uploaded to third-party infrastructures
- Unauthorised government or third-party access to private and sensitive data
- Data is no longer fully controlled by its rightful owner

Google Cloud Platform

- https://cloud.google.com

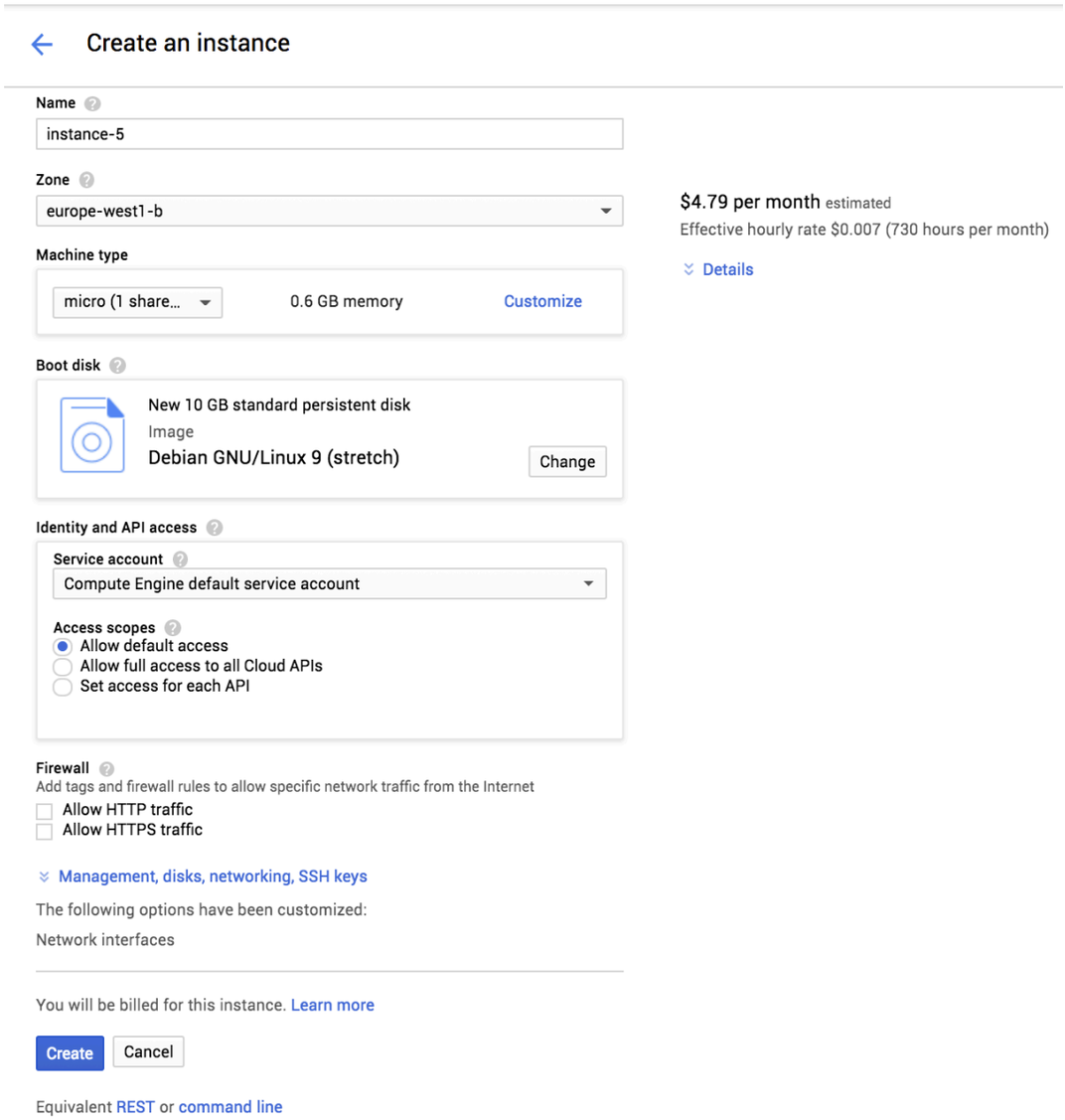


Google Cloud Platform

- Create project
  - associate billing account (check e-mail for coupon)
    - each account has 50$
- Add team members (as Owners)
  - Side Bar -> IAM

Google Cloud Platform
Create VM instance

- Side Bar -> Compute Engine -> VM instances
- Create Instance
- Configure SSH Key (Metadata)



Google Cloud Platform
Create VM instance

- Budget of 150$ for each group
- Each Zone has different prices
- Manage the budget wisely!!
- Advice: for testing purposes use micro instances, for the demo use small or 1vCPU instances
- **Never forget to turn off/ STOP the VMs** when not using them to save money…