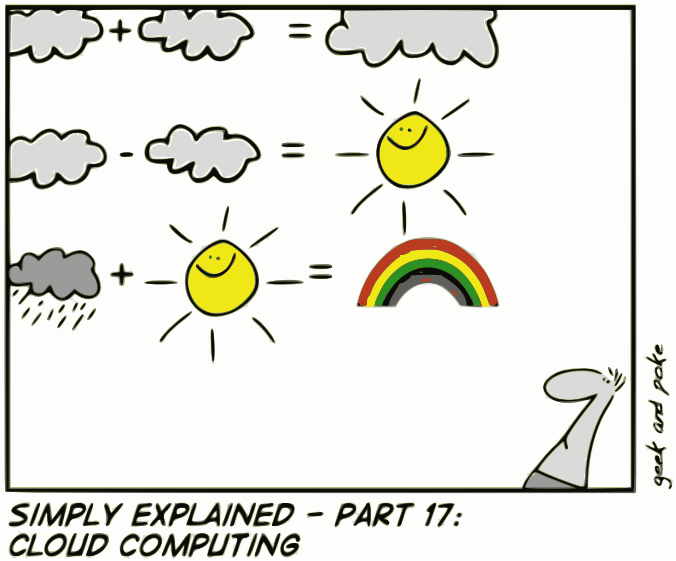
3rd Slide Set Cloud Computing

Prof. Dr. Christian Baun

Frankfurt University of Applied Sciences
(1971–2014: Fachhochschule Frankfurt am Main)
Faculty of Computer Science and Engineering
christianbaun@fb2.fra-uas.de

Agenda for Today

- Classic/Traditional IT
- What is Cloud Computing? $\Longrightarrow$ Definition
- Why using Cloud Computing?
- Cloud vs. (own physical) Servers
  - Chances and Risks



„*There is no cloud – it's just someone else's computer*“ (Source: unknown)

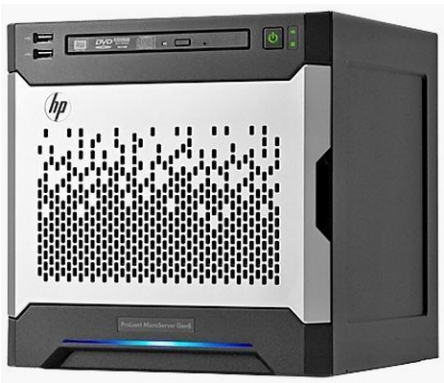
- Organizational types of Cloud services
  - Public / Private / Hybrid Cloud services
- Categories of Cloud systems
  - HuaaS / SaaS / PaaS / FaaS / IaaS
- Additional concepts (HuaaS, Cloud print, Cloud gaming, Cloud operating systems – DaaS)

What is Cloud Computing?

Image source: Pro7

Classic/Traditional IT

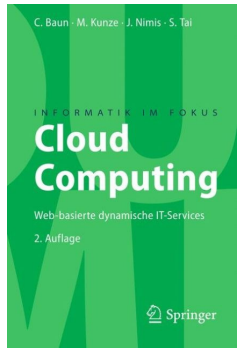
- On-site operation of physical server hardware („*on-premises*“) e.g. for:
  - data storage (memory)
  - archiving software
  - running industry software
  - running network services (e.g. mail server / web server / . . .)
  - financial accounting
  - Customer Relationship Management (CRM)



What is Cloud Computing?

Cloud Computing – Focal Points by Definition

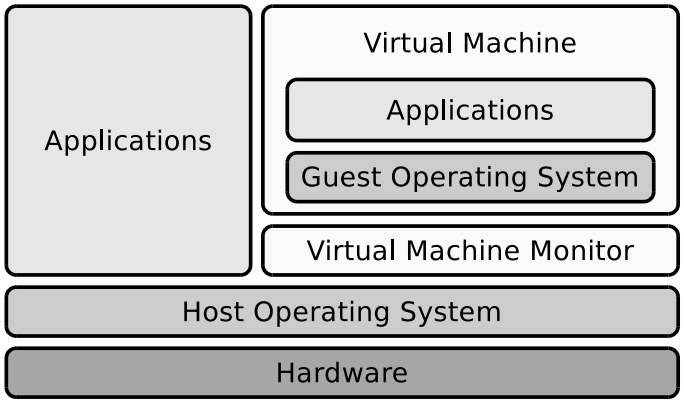
„*By using virtualized computing and storage resources and modern web technologies*, *Cloud Computing provides scalable, network-centric, abstracted IT infrastructures, platforms, and applications as on-demand services. These services are billed on a usage basis*.“

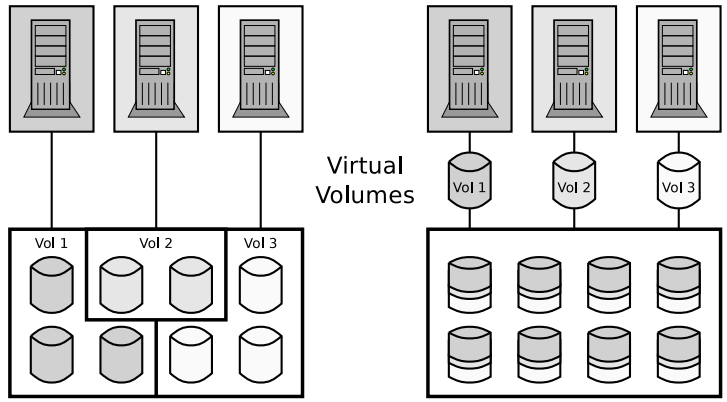


- Part 1: Fundamental technologies – basis of Cloud Computing
  - **Virtualization** for shared and efficient resource utilization
  - **Web Services** (REST/SOAP) for communicating with the services
- Part 2: Cloud services and their characteristics
  - **IaaS, PaaS, SaaS**
  - **scalable** $\Longrightarrow$ „elastic“
  - **network-centric** $\Longrightarrow$ services/resources are accessible over the internet
  - **abstracted** $\Longrightarrow$ independent of the concrete hardware
  - **on-demand** $\Longrightarrow$ prompt request completion
  - **pay as you go**

Fundamental Technologies – Virtualization

- Allows an abstract, logical perspective of physical resources
  - Servers, storage, networks
- Isolates (hides) the physical hardware
- With virtualization,. . .
  1. the physical hardware can be used in a shared and transparent way
  2. heterogeneous hardware resources can be combined to create a homogeneous resource pool





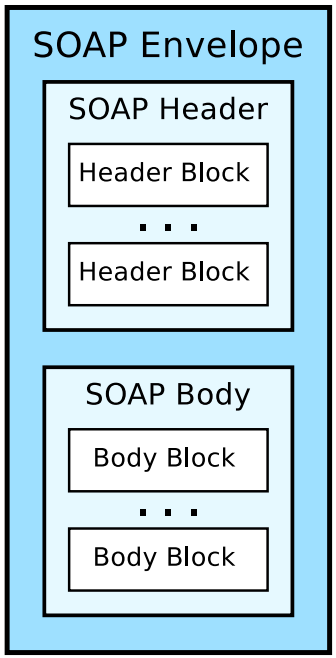
- Some advantages:
  - Server consolidation $\Longrightarrow$ cost reduction
  - Simplified (short-term) provisioning
  - Flexibility (different operating systems on the same hardware)

Fundamental Technologies – Web-Services

- Distributed systems often integrate heterogeneous resources
  - In theory, the these resources can be worldwide distributed
- Drawbacks of long distance connections compared to LANs
  - High response times
  - Low data transmission capacities
  - Potentially unreliable connections
- Web services enable **weakly coupled**, **asynchronous** and **messages-based** communication, based on HTTP and XML
- Most popular applications for web services:
  - Remote Procedure Calls
  - **SOAP** (originally defined as *Simple Object Access Protocol*)
  - **REST** (*REpresentational State Transfer*)

Web-Services – SOAP

- SOAP messages use the message format of the markup language XML
  - Usually, SOAP messages are stored in the body of a HTTP POST request and sent to an URL




```
<?xml version="1.0" encoding="UTF-8" ?>
<env:Envelope xmlns:env="http://www.w3.org/2001/09/soap-envelope">
  <env:Header>
    <n:alertcontrol xmlns:n="http://example.org/alertcontrol">
      <n:priority>1</n:priority>
      <n:expires>2001-06-22T14:00:00-05:00</n:expires>
    </n:alertcontrol>
  </env:Header>
  <env:Body>
    <m:alert xmlns:m="http://example.org/alert">
      <m:msg>Mary um 14 Uhr von der Schule abholen</m:msg>
    </m:alert>
  </env:Body>
</env:Envelope>
```

Source: Tanenbaum, van Steen. Verteilte Systeme. Pearson Studium (2008)

- The message sends a text to a web service
- The message has a specific priority (1) and will be discarded, if it arrives after 2:00 pm at the web service

RESTful Web Services

- Requested via the **HTTP interface**
  - More simple way of interaction in contrast to SOAP (XML-based)
- **Stateless communication**
  - Each HTTP message contains all information to understand it
  - The server doesn't hold any status or session information about the client
  - Each request is an transaction, independent from other transactions
- 4 HTTP methods are enough to work with different **resources**

HTTP	CRUD Actions	SQL	Description
`PUT/POST`	Create	`INSERT`	Create or replace a resource
`GET`	Read/Retrieve	`SELECT`	Request a resource
`PUT`	Update	`UPDATE`	Modify a resource
`DELETE`	Delete/Destroy	`DELETE`	Erase a resource

- Further useful HTTP methods:
  - `HEAD` – requests metadata about a resource
  - `OPTIONS` – requests, which methods are supported by a resource

Cloud Computing – Services

- Cloud computing is an umbrella term for different **services**
  - A service provider provides an IT service to one or more customers
    - Service provider = external provider or in-house department
  - Typical scenario: **Outsourcing** $\Longrightarrow$ Outsourcing of IT services
  - Functionality and quality of service should be defined by a **Service-Level-Agreement** (SLA)

How can Cloud services be distinguished in an **organizational** way?

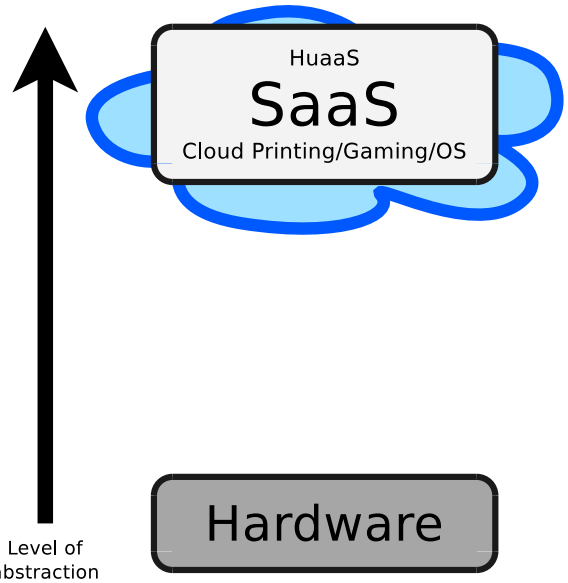
Organizational Distinction of the Services

- **Public Cloud**
  - Customer and provider belong to different organizations
    $\Longrightarrow$ **Outsourcing**
  - (Almost) no costs for purchasing, operating and maintaining your own hardware
  - Resources are immediately ready for use and (almost) unlimited available
- **Private Cloud**
  - Customer and provider belong to the same organization
  - Costs are similar to a non-Cloud-based architecture
  - Based on classic/traditional IT
- **Hybrid Cloud**
  - Public and private Clouds are used together
  - Application examples
    - Manage load peaks with public Cloud services
    - Store backup data in public Clouds,

How can Cloud services be distinguished according to their **functionality**?

Functional Distinction of the Services – SaaS

- **Software as a Service** (SaaS)
  - Provider runs web applications
    - **This also includes storage services** such as Dropbox, MEGA, iCloud, OneDrive,...
  - Customers only need a browser
  - Scalable solution
    - Also in terms of data storage
  - Can be used from any place



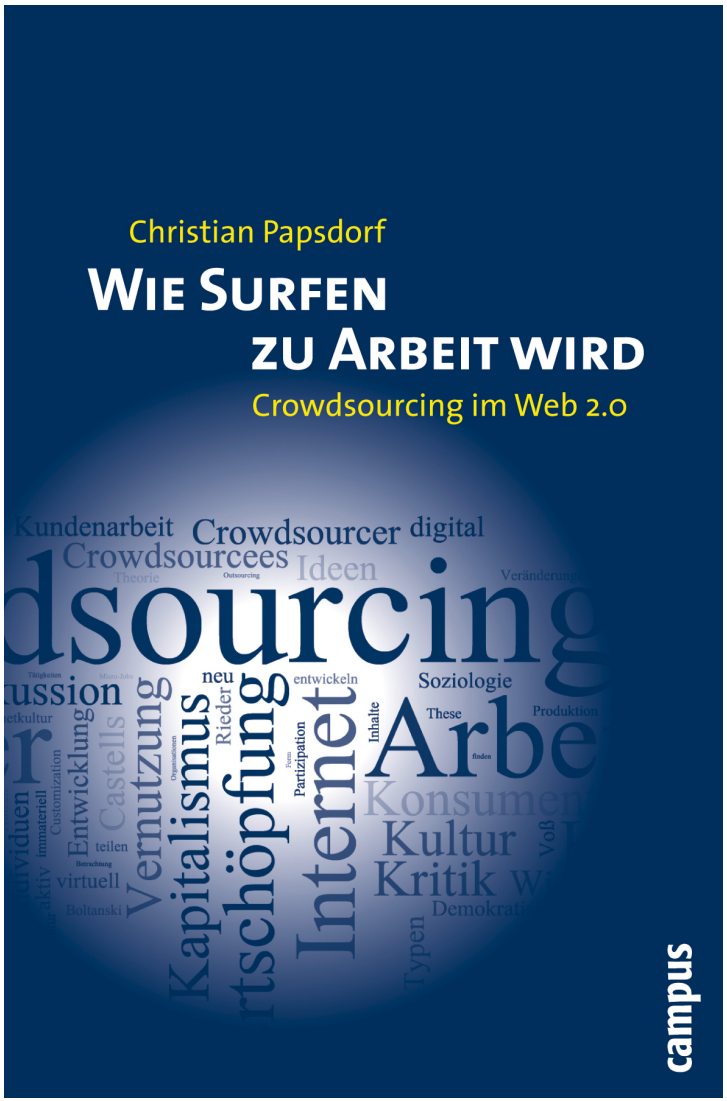
Softwaredienste gibt es schon länger als den Begriff „Cloud Computing“

- (Free) solutions for building software services exist since more than 15 years
- Web server: Apache HTTP server, nginx,...
- Application server for web applications: Apache Tomcat (Java), JBoss (Java), Zope (Python)
- Scripting language for dynamic web pages: PHP, JavaScript (NodeJS)

Humans as a Service (HuaaS)

- Principle of crowdsourcing
- Human creativity is offered for low cost or donated from volunteers
- Interesting for...
  - Low-skilled jobs
  - Activities, which a computer cannot do, or requires an unreasonably high development time
- Possible applications are among others:
  - Image recognition
  - Personal Perspective (subjective) reviews for products
  - Translations
  - (Product) assignments to (product) categories
- Examples of public Cloud HuaaS
  - Investigation of the British expenses scandal by The Guardian in 2009
  - GutenPlag, VroniPlag
  - Marketplace for HuaaS: Amazon Mechanical Turk
- In the private Cloud area: HuaaS does not take place

Recommended literature to Crowdsourcing



- Christian Papsdorf. *Wie Surfen zu Arbeit wird*. Campus (2009)
- Consumer Write reviews, develop ideas, create logos,. . .
- These value-adding activities are of high economic significance
- Companies use the internet culture (participation, engagement, self-realization,. . .) to let the users mostly work for free
- Why do the consumers accept this and work for free?

Pril Competition

- On April 1st 2011, Henkel launched a crowdsourcing campaign
  - Despite the date, it was no joke!
- Everyone was able to crate a new design proposal for the 600ml bottle at `http://mein.pril.de`
- There were material prizes to win
- The two best designs should go on sale for a short time
- Users of Facebook were able to vote their favorite
- Huge feedback: $>$ 30,000 proposals were submitted

Pril Competition – Outcome

- Not all proposals matched Henkel's expectation

- After a short time, 2 proposals of Peter Breuer (a professional advertising copywriter) became favorites
- The *chicken* proposal was ranked 1st place with several thousand votes ahead 2nd place
- Reaction of Henkel: They changed the rules
  - Now, proposals needed to be previously evaluated and release by a jury
  - Only after the jury evaluation, the users were allowed to vote for the proposal
- Result: Wave of anger

Pril Competition – Manipulation of the Outcome

- Things got even worse
  - Henkel erased comments of angry users
  - Henkel massively reduced the number of votes of several designs
  - Henkel stated they just „cleaned up“ the results
- From this time, the affair went through the press
  $\Longrightarrow$ Bad public relations work

Source: Jörg Breithut. Virale Werbefallen – Pril schmeckt nach Hähnchen. 12.4.2011
`http://www.spiegel.de/netzwelt/web/0,1518,756532,00.html`

Things do not necessarily need to end like this...

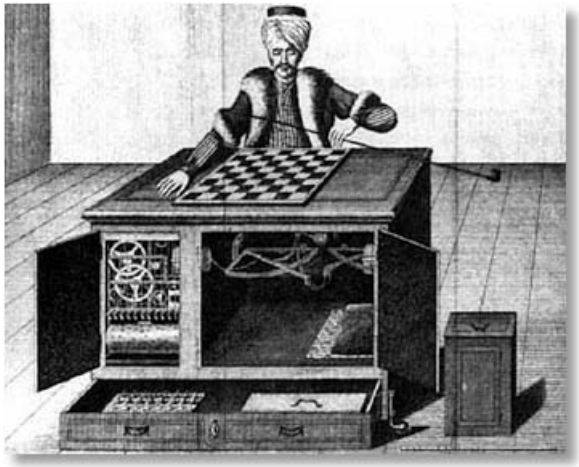
Otto Competition

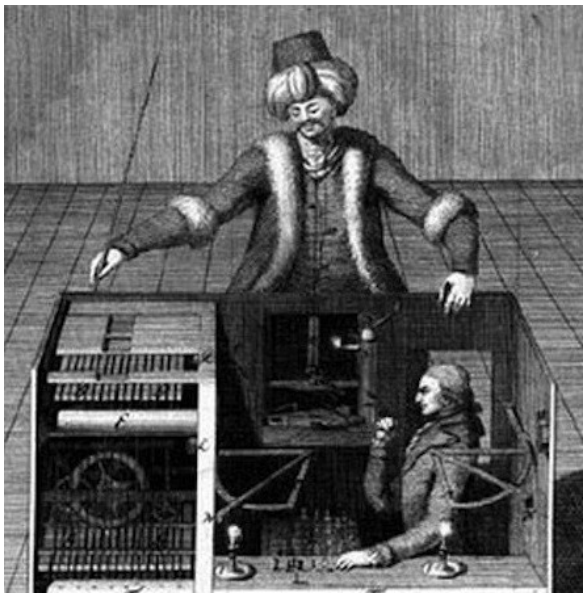
- Otto organized a „model montest“ in 2010
  - The winner with the most votes was planned to become the new face of the Facebook fan page

- Winner against 48,488 other participants: „Der Brigitte“ (Sascha Mörs)
  - A 22 years old business administration student from FH Koblenz
- Otto was not unhappy about the result
  - Approximately 1.2 million votes were submitted

$\Longrightarrow$ Great public relations work

Amazon's Mechanical Turk – Cloud Marketplace





- March 8th, 2006 - Sam Williams
- **Pennies for Web Jobs**

Speaking to a room filled with Internet developers at the O'Reilly Emerging Technology Conference in San Diego this week, Luis Felipe Cabrera, Amazon's vice president of software development, outlined a project to **harness human intelligence for tasks that computers can't handle well**, such as recognizing objects in images.

The backbone of the plan is a Web-services platform called Mechanical Turk. It uses an **auction-style system** to **farm out complex tasks – complex for a computer**, that is – such as **recognizing the difference** between a human face and a nearby bush, or **accurately transcribing** an audio recording. Cabrera likes to call the platform „artificial artificial intelligence" – it's **computers asking humans to do tasks, rather than the other way around**.

. . .

Image source: Google image search

Source: `http://m.technologyreview.com/web/16519/`

Another Crowdsourcing Marketplace – Samasource

- `http://www.samasource.org`
- Founded in 2008
- Nonprofit project, which gives digital work to people in developing countries
  - *Workers* are in Haiti, India, Kenya, Pakistan, South Africa and Uganda
    - In these countries, school education includes for historical reasons a good basic education in the English language
    - But these countries don't have enough jobs
- Infrastructure is financed from donations
  - Donors are among others the Rockefeller Foundation and Google
- Wages of about $300 are low from a European perspective, but in developing countries this is a desirable monthly income
- Example for a customer: Ask.com
  - Up to 50,000 requests from Ask.com are processed per month

Google Cloud Print

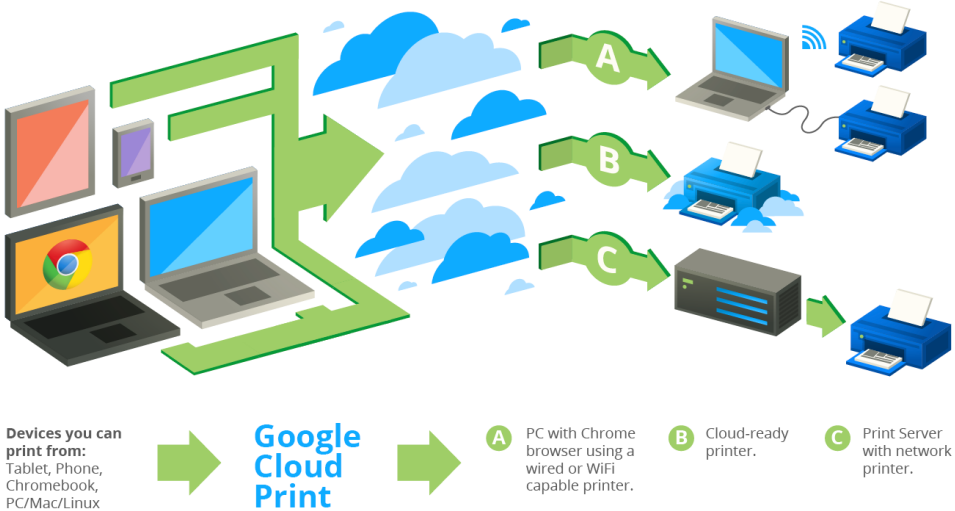
Image source: Google

- Provides printing via the Cloud
- Internet enabled devices such as netbooks, touchpads and mobile phones get more and more popular
- Connection of local printers is difficult
  - Printer drivers are missing
  - Some devices lack enough resources
  - Several operating systems (iOS, Android, Windows, Linux...) exist
- Solution: Google Cloud Print (`https://developers.google.com/cloud-print/`)
- HP and Samsung offer compatible printers
  - Via an e-mail address, the devices can be identified and added as a Cloud printer inside Chrome OS
- The user sends his document to be print to the service, sets the printer settings and receives a feedback about the successful job execution

Google Cloud Print (2 Types of Printers)

Image source: Google

- **Google Cloud Print compatible network printer**
  - The printer is registered at the service
  - Print jobs are sent to a service
  - The service prepares the print job and forwards it to the printer
- **Legacy printer** (not compatible with Google Cloud Print)
  - Locally attached printer (USB) or network printer
  - A proxy is installed on a local PC
    - The proxy registers the printer and sends print jobs to the service
    - Prepared print jobs are sent via the proxy to the printer
  - Drawback: The proxy computer must be switched on for printing



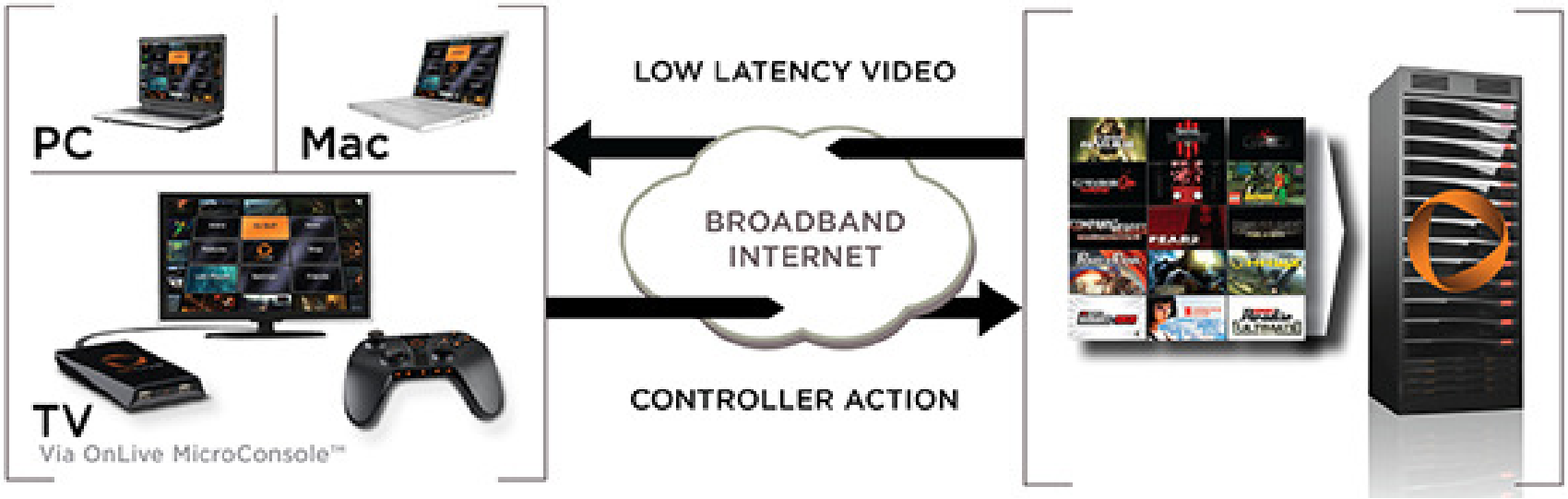
Google will terminate the Google Cloud Print service on December 31, 2020 after a decade for no reason

:-(

Cloud Gaming (1/6)

Image source: OnLive

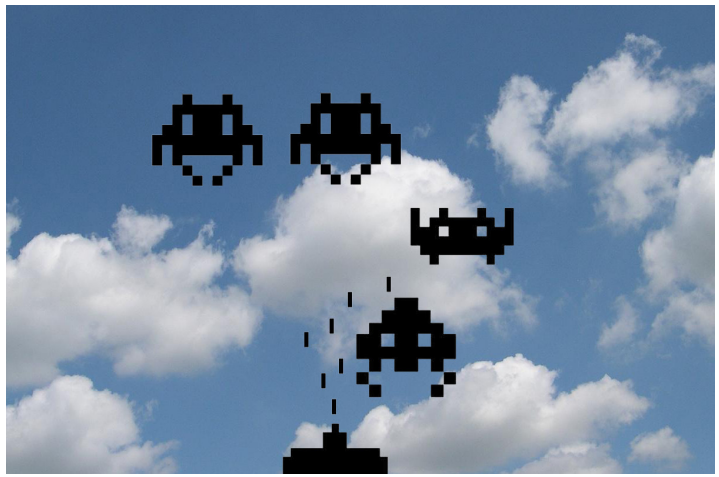
- Cloud gaming services make high-end video games available on low-end devices (older PCs, TVs, mobile phones)
  - The video games run at the servers of the provider
  - The users' devices are only used to display the games
  - The video output is transmitted as a compressed video stream
  - User input is sent to the provider and processed there



Cloud Gaming (2/6)

Image source: computerlearnhow.com and gamelitist.com

- Drawback: The required compression reduces the optical quality
- Problem: The network latency must be low because the user input is transmitted to a remote server and processed there
  - Period between the user input and results on the local display must be small in order not to disrupt the game flow
- Positive side effect for the providers: Pirate copies are impossible



Cloud Gaming (3/6) – Providers

Image source: Onlive and Gaikai

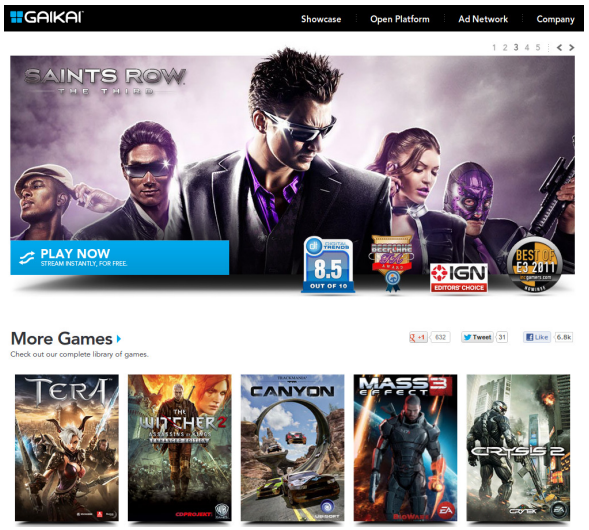
onLive®

Free your games.
Free yourself.

OnLive delivers top-tier video games on demand to your TV, PC, Mac® or tablet —whatever you have on hand. Sign in. Play. It's that simple.

- `http://www.onlive.com`
- Available in the U.S. between June 17th 2010 and April 30th 2015
- Requirements:
  - Network link with low latency and $< 1000\,\text{km}$ distance to the OnLive data center used
- The service itself is no longer available

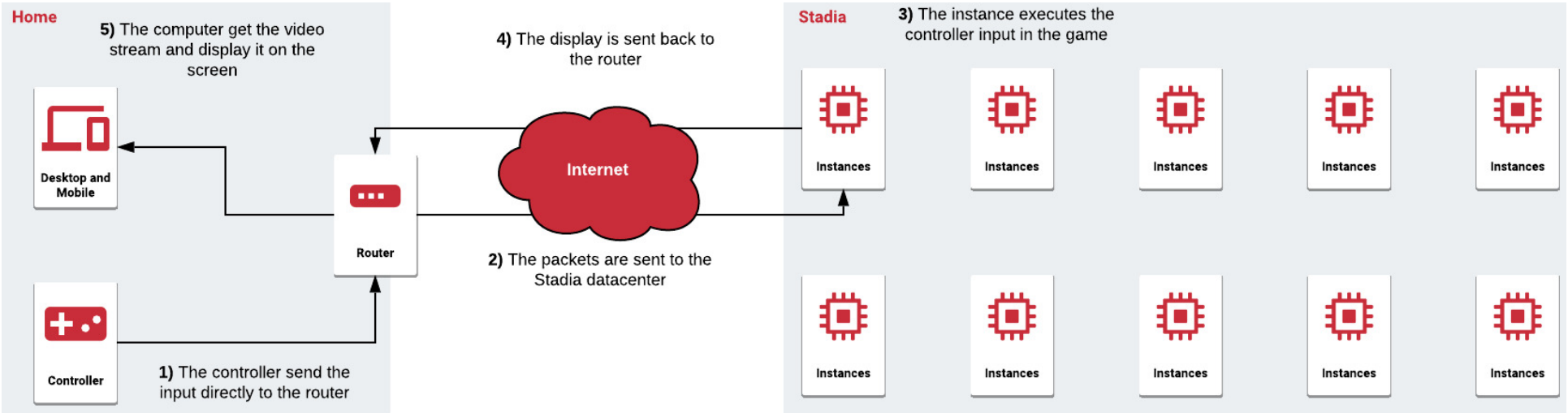
- `http://www.gaikai.com`
- Available since February 27th 2011
- July 2012: Sony buys Gaikai for $380 million
- Is used to stream PS3 games to the PS4 and PC $\Longrightarrow$ PlayStation Now
- The service itself is no longer available



Cloud Gaming (4/6) – Google Stadia

Image source: Google

- Available since November 19th 2019. `https://stadia.google.com`
- Supports (almost) all terminal devices with the Google Chrome browser



- Games run on Linux servers and are developed to run on Stadia
- A Customer, starting a game, gets a Linux instance with the build already available on it
- The Stadia controller sends input directly to the WiFi router
  - This avoids one additional hop

Quelle: `https://medium.com/@kevinp11/cloud-gaming-stadia-vs-nvidia-geforce-now-2789c4575826`

Cloud Gaming (5/6) – Google Stadia

Image source: Google

Resolution	Data usage
4K	Up to 20 GB/hr
1080p	Up to 12.6 GB/hr
720p	Up to 4.5 GB/hr

Stadia Streaming Tech: A Deep Dive (Google I/O'19)

`https://www.youtube.com/watch?v=9Htdhz6Op1I`

The Verge

Google is shutting down Stadia in January 2023

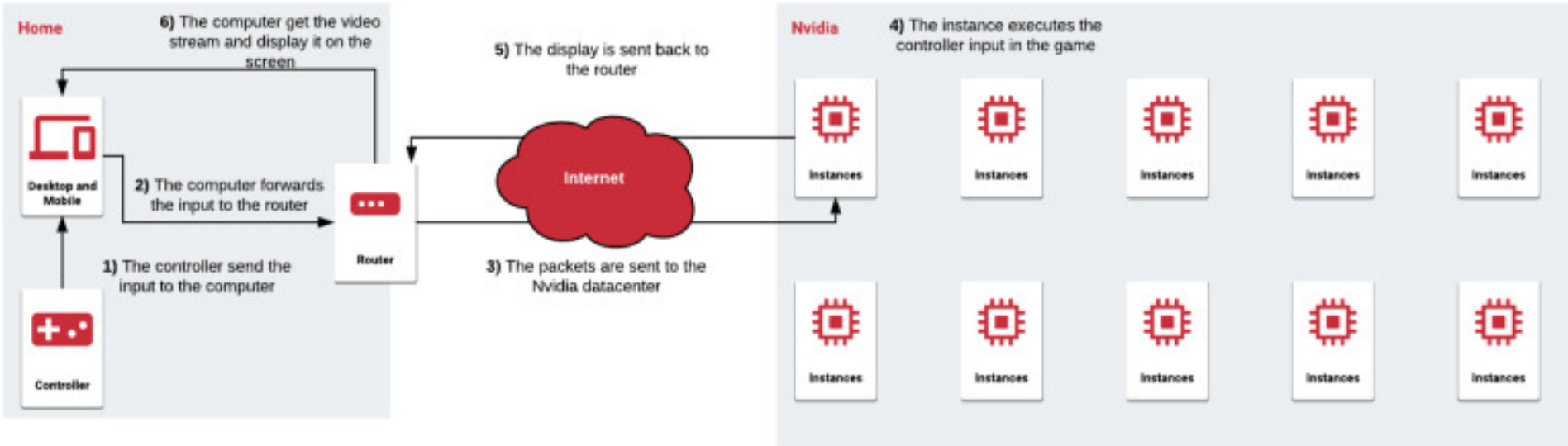
Google is shutting down Stadia, its cloud gaming service. The service will remain live for players until January 18th, 2023. Google will be refunding all...

29.09.2022

Cloud Gaming (6/6) – Nvidia GeForce Now

Image source: Nvidia

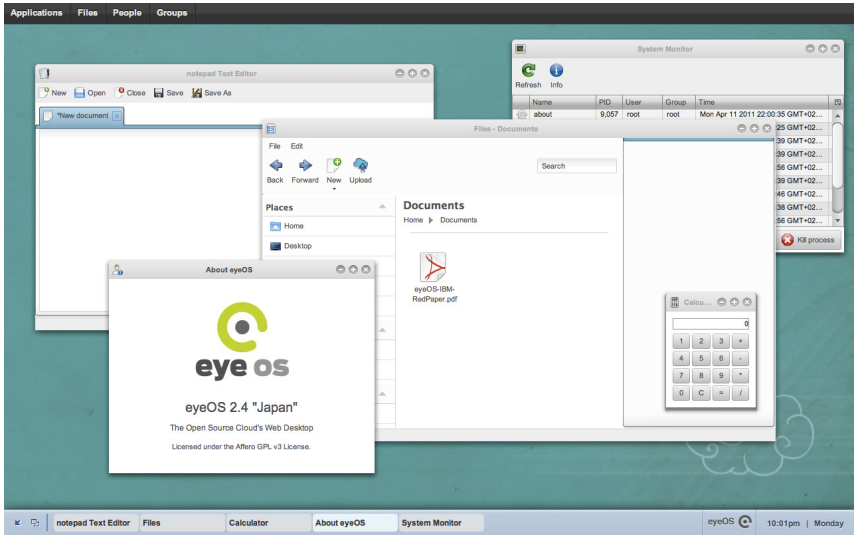
- In development since 2013
- `https://www.nvidia.com/en-us/geforce-now/`
- Available since February 2020 for Windows, Mac OS and Android
- Is a streaming wrapper around Steam, Uplay, Epic,...
- A Customer, starting a game, gets a Windows server instance with Steam/Uplay/Epic/... and the game is launched there
- Requires 15 Mbps for 720p (60 fps) and 25 Mbps for 1080p (60 fps)



`https://medium.com/@kevinp11/cloud-gaming-stadia-vs-nvidia-geforce-now-2789c4575826`

Cloud Operating Systems = DaaS

Image source: Wikimedia (GPL)



- Web desktops, „Cloud operating systems“, Desktop-as-a-Service (DaaS)
  - Popular products: eyeOS + oneye

Last free software version (AGPL license): v2.5 (2011)
`https://github.com/nawawi/eyeOS`
`https://github.com/jonrandoem/eyeos`
`https://github.com/cloudspaces/eyeos-u1db`
Since 2014 a part of Telefónica
Successor project: **oneye**. `https://github.com/oneye/oneye`

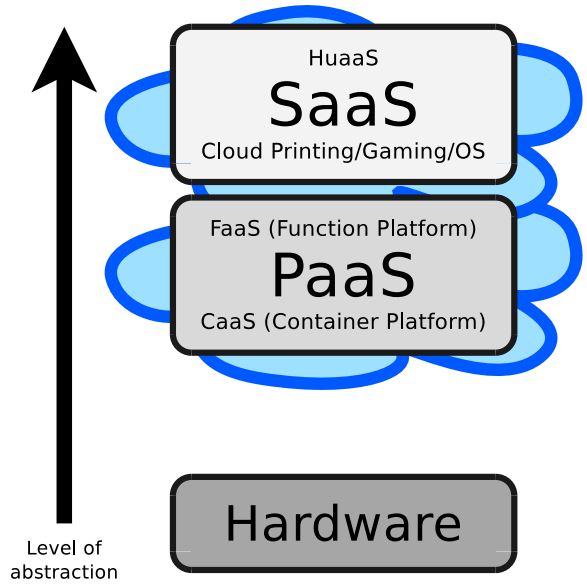
- The operating system, all installed applications and the user data are located on the servers of the provider
  - The users only need a browser and internet access
- The term Cloud operating system is misleading here (DaaS is better!)
  - For using a Cloud operating system, a computer with a browser and therefore with an operating system too is required
  - The native operating system is not replaced
    - Only the applications and user data are outsourced

Cloud Cooking – the Future ?!

Image source: Heise Zeitschriften Verlag

Functional Distinction of the Services – PaaS + FaaS

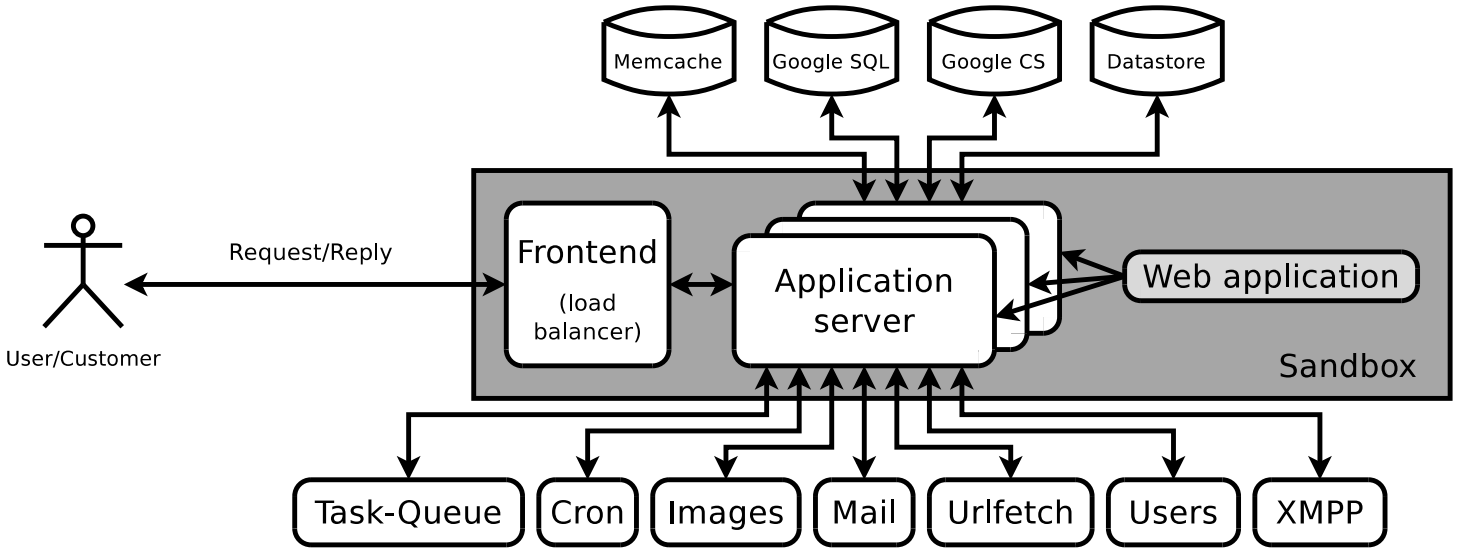
- **Platform as a Service** (PaaS)
  - Provider run scalable runtime environment(s)
  - Customers run their own web applications in the infrastructure of the service provider
    - Applications can use various infrastructure and storage services
  - Target group: **developers and operators of web applications**



Function as a Service (FaaS) are a subcategory of PaaS

- Customers can run their own functions (scalable) on the infrastructure of the service provider
- Typically, the services support JavaScript (Node.js), Python and/or Java
- Functions are triggered by external requests or events (e.g. HTTP request, reception of an Email,...)
- The backend is *invisible* for the customers $\Longrightarrow$ **serverless architecture/computing**

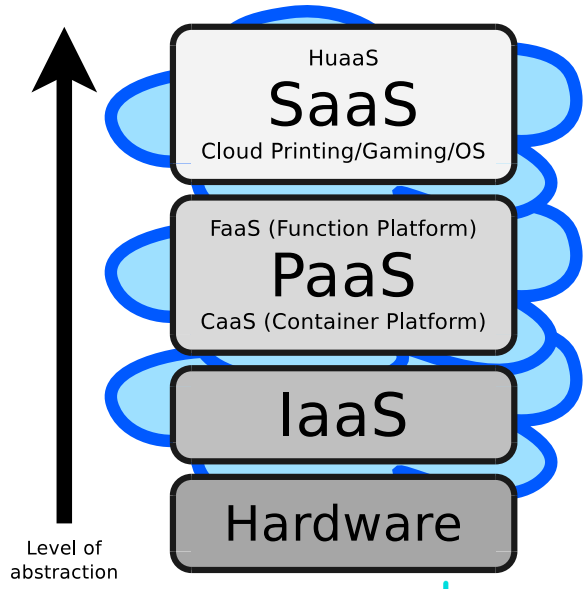
Platform Service Examples – App Engine



- Customers run their own web applications (Python, Java, Go, PHP,...) in the Google infrastructure
- Automatically scales on demand
- Applications can use different infrastructure and storage services
- The image shows the 1st generation of App Engine runtimes
- The 2nd generation is more integrated into other Google Cloud services
- Free reimplementations (unique selling point of the GAE):
  - AppScale GTS (†), typhoonAE (†), CapeDwarf (†)

Functional Distinction of the Services – IaaS

- **Infrastructure as a Service** (IaaS)
  - Provider runs physical servers
  - Customers run **virtual maschines** (VM) with (almost) any operating systems and unmodified applications
    - Customers have administrator privileges in their VMs and specify the firewall rules themselves



amazon web services™ Google Compute Engine Microsoft Azure rackspace the open cloud company IBM Cloud

Amazon EC2 Amazon S3 ORACLE Cloud Infrastructure DigitalOcean linode

In an IaaS service offering, an entire data center can be virtually replicated

- IaaS offerings from major service providers typically include various services for VMs, storage (object storage and block storage), databases, virtual networks, IP addresses, firewalls, load balancing, and more.

Infrastructure Service Example – Amazon Web Services

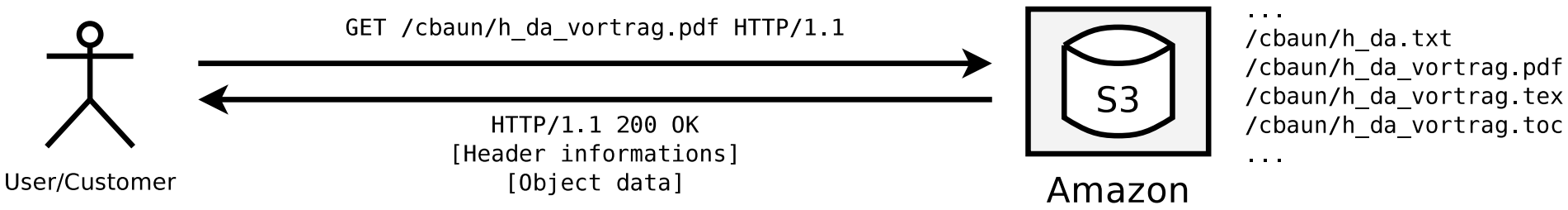
- The AWS is a collection of different public cloud services
- Billed according to consumption
- Services of the AWS are among others

Elastic Compute Cloud (EC2)	$\Longrightarrow$	Infrastructure service for virtual servers
Simple Storage Service (S3)	$\Longrightarrow$	Storage service for web objects
Elastic Block Store (EBS)	$\Longrightarrow$	Storage service for virtual storage volumes
Elastic Load Balancing (ELB)	$\Longrightarrow$	Service for virtual load balancers
CloudWatch	$\Longrightarrow$	Service for monitoring AWS resources
Auto Scaling	$\Longrightarrow$	Service for scaling EC2 capacities
SimpleDB	$\Longrightarrow$	Service for distributed database
Amazon Simple Queue Service (SQS)	$\Longrightarrow$	Service for message queues
Amazon Mechanical Turk	$\Longrightarrow$	HuaaS/Crowdsourcing marketplace

- Application examples:
  - Implementation of virtual data centers
  - Building up an elastic infrastructure (e.g. for a startup)
  - Acquire resources within a short time

Infrastructure Service Example – Amazon S3

- Simple Storage Service (S3)
- Data is stored as **(web-)objects** (1 byte to 5 TB)
- Each object is assigned to a **bucket**
  - Buckets have unique names and contain no other buckets
    $\Longrightarrow$ Folders are impossible
- Objects are accessible online
  - `http://s3.amazonaws.com/bucket/objekt`
- Access to buckets and objects is done via REST or SOAP



- April 2013: 2 trillion objects stored in S3, 1.1 million requests per second

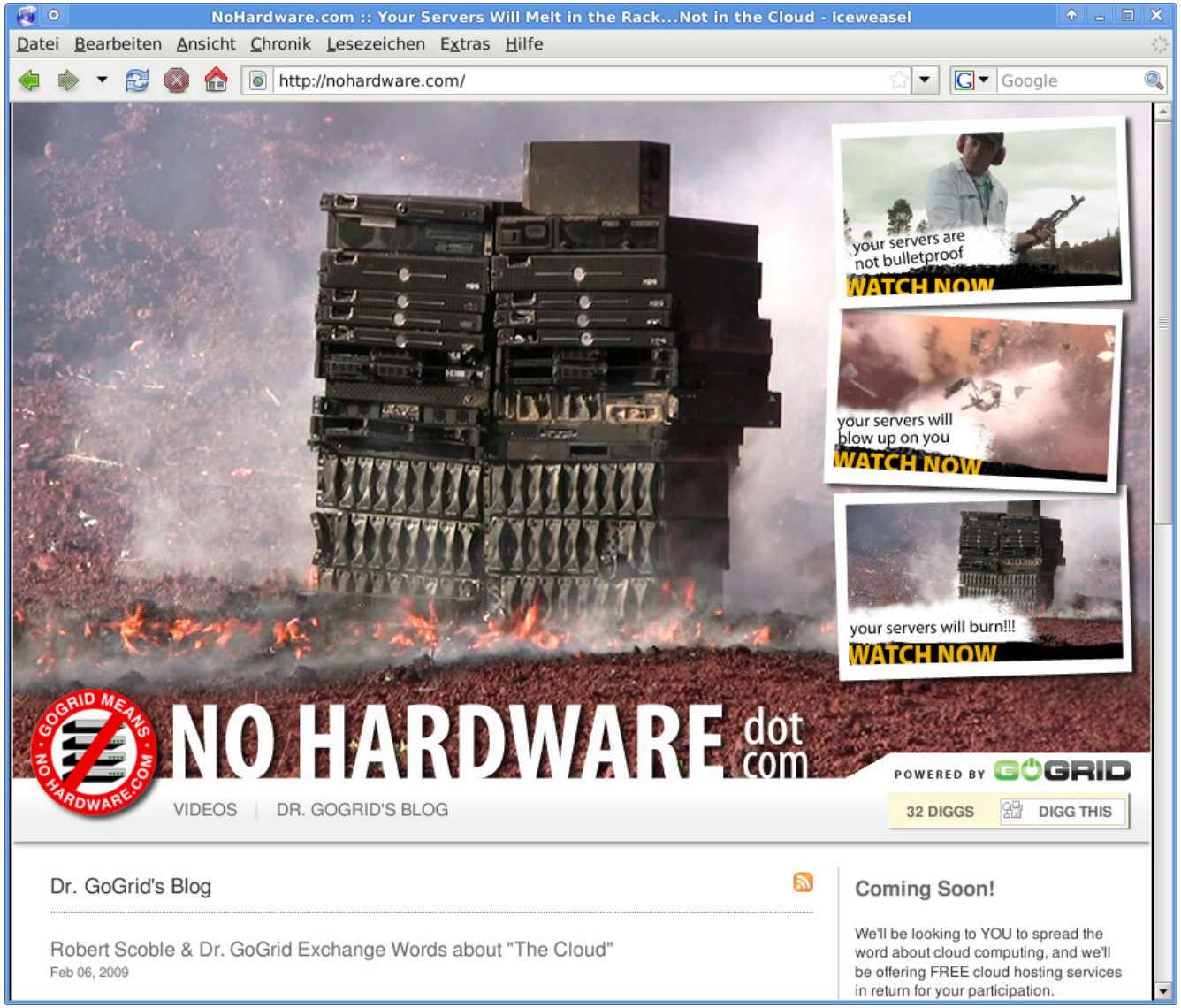
(`https://aws.amazon.com/de/blogs/aws/amazon-s3-two-trillion-objects-11-million-requests-second/`)

Performance Computing as a Service (HPCaaS)

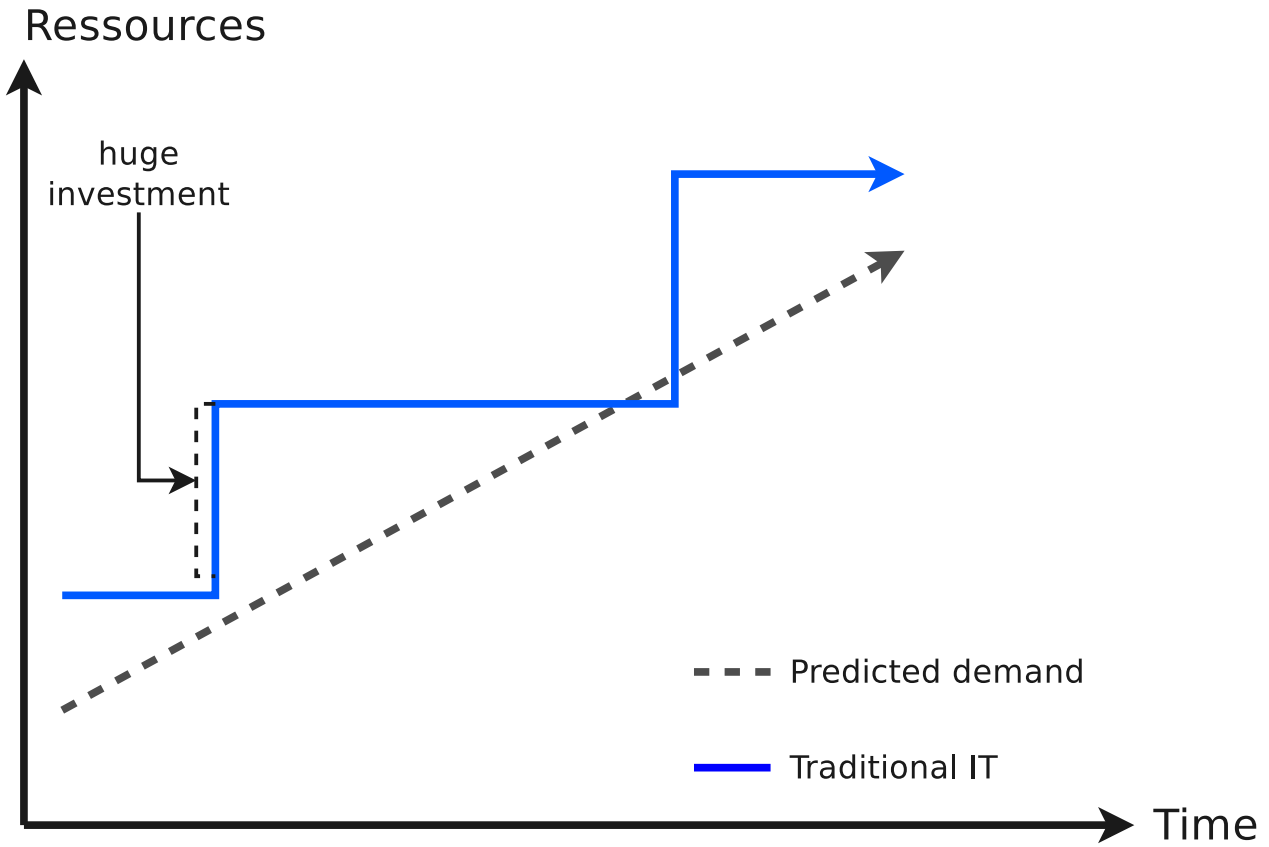
- Belongs to the infrastructure services too
- For HPCaaS, the network latency between the virtual machines, and thus the physical location of the nodes is important
- Only few private Cloud solutions support the grouping of nodes
  - OpenNebula and CloudStack
- Some private Cloud solutions offer absolutely no localization of the virtual machines
  - Eucalyptus
- Public Cloud HPCaaS offerings exist
  - Cluster Compute Instances inside Amazon EC2
- HPCaaS is not suited for all HPC problems
  - It is suited just for trivial parallel problems

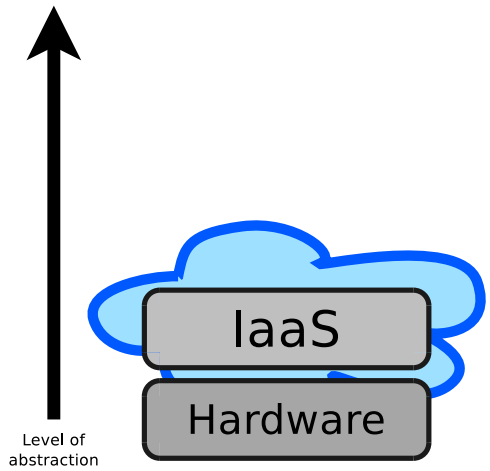
Do we still need own Server Hardware?

Dr. GoGrid said no!



Opportunities: IaaS vs. own physical infrastructure (1/3)

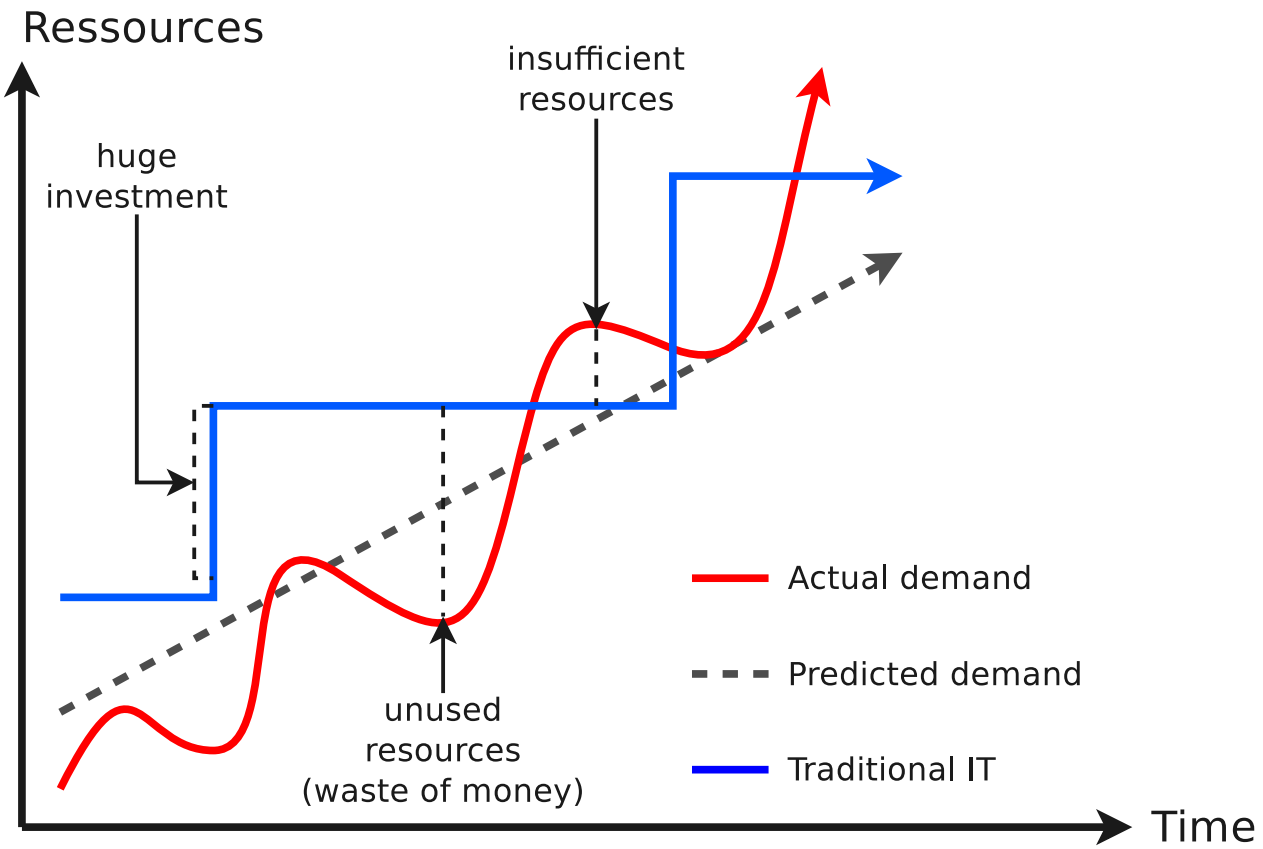


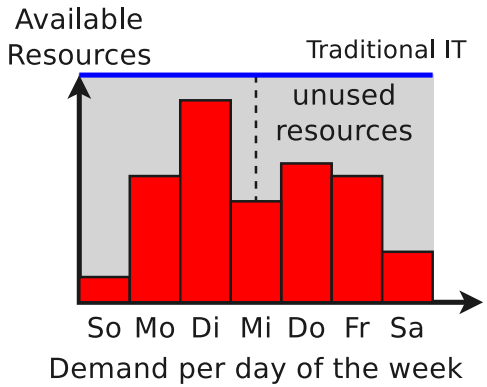


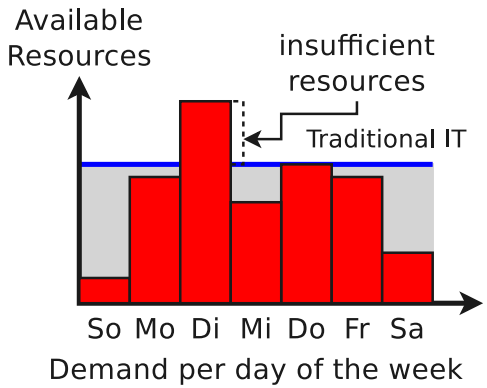
Challenge 1: Predicting resource requirements is difficult

- Own server hardware:
  - High purchase costs
  - Deployment is time-intensive

Opportunities: IaaS vs. own physical infrastructure (2/3)



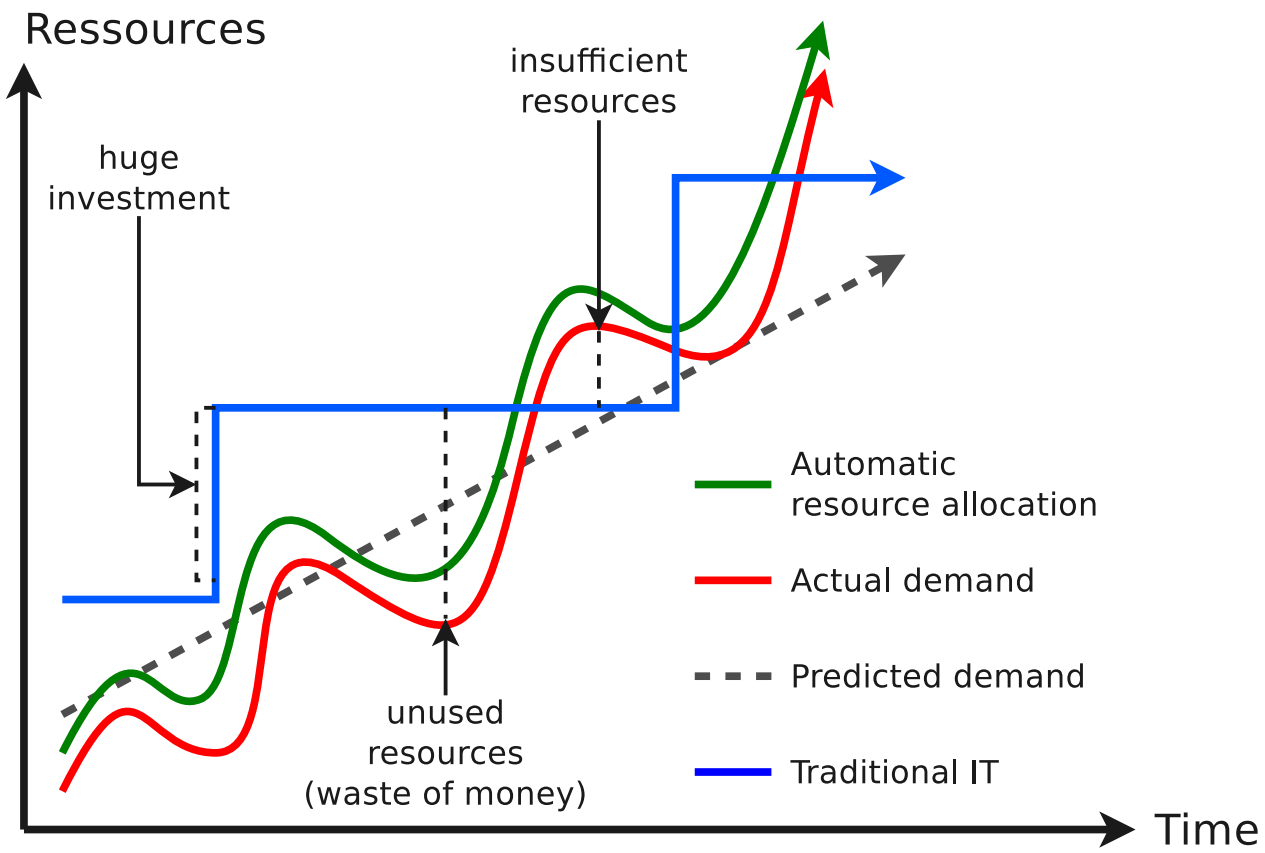


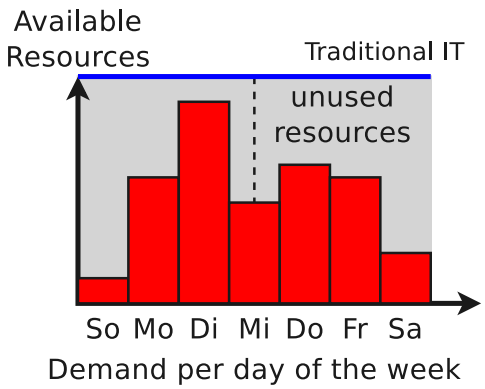


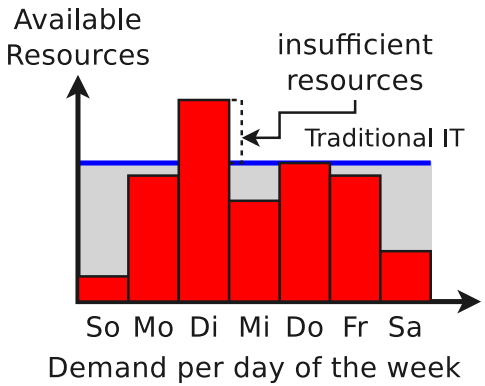
Challenge 2: Predicted demand ≠ actual demand

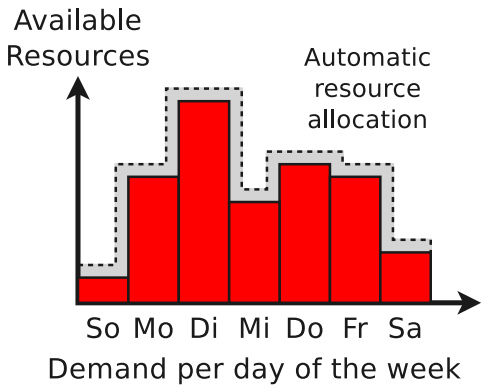
- Unused resources in the traditional IT model
- Resources may become insufficient if demand increases unexpectedly fast

Opportunities: IaaS vs. own physical infrastructure (3/3)







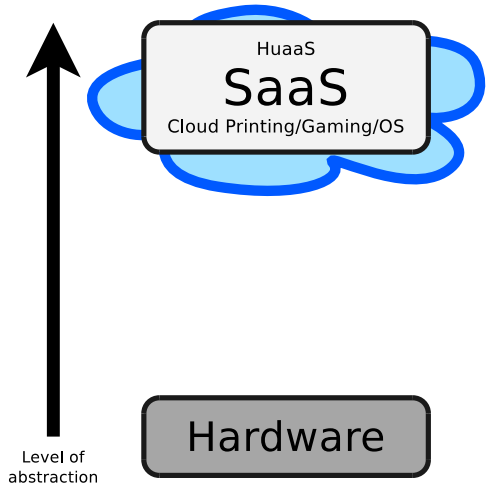


Ziel: Virtuelle Infrastruktur

- No high investment costs
- Always enough resources available
- Scales up and down on demand

Opportunities: SaaS vs. locally installed Applications

- Benefits for customers
  - Only a browser is required for use
  - operating system independent
  - No installation effort
  - No maintenance effort (updates)
  - can be used from any location



Major service providers have a huge competence due to the number of employees and experience.

- Benefits for service providers:
  - No pirate copies
  - All customers automatically have the latest software version
  - Reduced support effort

Opportunities: Lower costs

- Cloud services cause (almost) no purchase costs and (possibly) lower operating costs than own physical resources

There is no general rule that cloud computing is always the cheapest alternative!

- Using a **SaaS** instead of purchased software causes **usually** significantly lower acquisition costs
  - Further statements on SaaS are not possible in a generalized manner
- Using an **IaaS** instead of your own physical servers on premises causes **always significantly lower** purchase costs
  - With flexible use („pay-as-you-go principle“) the operating costs are usually very high (perhaps IaaS is then even the most expensive alternative!)
  - With rental agreements (1-3 years), the costs are reduced, but customers are bound $\Longrightarrow$ no longer a true „pay-as-you-go principle!“

Anyone who is aware of their resource requirements can calculate the exact costs of using an IaaS

Amazon AWS Simple Monthly Calculator: `https://calculator.s3.amazonaws.com/index.html`
Microsoft Azure Price Calculator: `https://azure.microsoft.com/de-de/pricing/calculator/`

What about the Risks?

Image Source: Pixabay (CC0)

- Questions that everyone must ask themselves before deciding against own physical hardware on premises and in favor of outsourcing:
  1. What is the **availability** of data and services?
     - What is the consequence if the availability falls below the guaranteed level?
     - What if the service provider modifies or terminates the service?
  2. Can **data loss** occur?
     - What is the consequence of data loss?
  3. Is your own data **protected against unauthorized access**?
     - What is the consequence of a theft?
  4. Are the Cloud service providers **trustworthy**?
     - Who has access to customer data?
  5. Can customers **leave a service provider**?
     - Do similar offerings/solutions exist?

(1) Availability of Cloud Services

Es war die schlimmste Erfahrung seines Berufslebens. „**Zwei Tage lang war unsere Firma komplett lahmgelegt**“ . . . „Sie können sich gar nicht vorstellen, was hier los war!“ . . . Niemand in der ganzen Firma konnte mehr auf irgendein internes Dokument zugreifen; Kunden wunderten sich, dass ihre E-Mails unbeantwortet blieben; **48 Stunden lang war die Firma ohne Daten und Büro-Software**. Dabei war . . . technisch alles in Ordnung, die Computer liefen, die Datenleitungen funktionierten. Der Grund für den Totalausfall . . . ein **Fehler im Bezahlsystem von Google**.

Weil ein Rechnungsbetrag von wenigen Hundert Euro nicht abgebucht werden konnte, hatte der kalifornische Gigant der deutschen Firma kurzerhand den Zugang zu ihrer Büro-Software und den zugehörigen Unterlagen gesperrt. Ohne Vorwarnung. „Am liebsten hätte ich das Geld in einen Umschlag gepackt und persönlich hingetragen“ . . . Aber er habe nicht einmal gewusst, wohin. Für mittelständische europäische Kunden ist die Google-Niederlassung in Dublin zuständig, **telefonisch erreichbar ist sie jedoch nicht**. Und jene Hilferufe, die der . . . per E-Mail schickte und ins Formular auf der Google-Website eintrug, blieben zunächst unerhört.

Source: Dirk Asendorpf, Die Zeit, 17. February 2011, S.39
`https://www.zeit.de/2011/08/Cloud-Computing`

- It can always happen that locally installed software does not work or becomes unavailable
- But with cloud services, customers are completely dependent on the availability and helpfulness of the provider

What can you expect when something goes wrong?

(1) Availability of Cloud Services (Example: AWS S3)

- For S3, Amazon guarantees 99.9% availability per month

	Downtime (HH:MM:SS)		
Availability	per day	per month	per year
99.9%	00:01:26	00:43:49	08:45:56
99%	00:14:23	07:18:17	87:39:29
95%	01:12:00	36:31:27	438:06:27

- If availability falls below that, the customer gets a **refund**
  - `http://aws.amazon.com/s3-sla/`

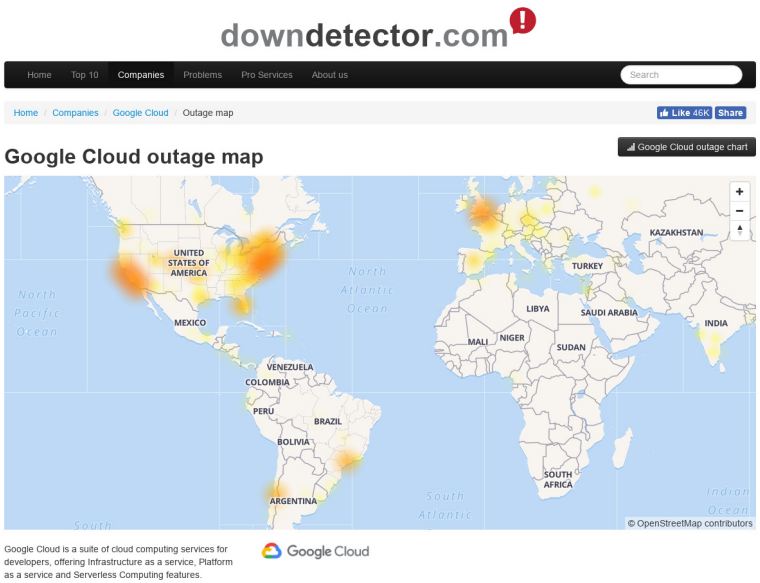
Monthly Uptime Percentage	Service Credit Percentage
Less than 99.9% but greater than or equal to 99.0%	10%
Less than 99.0% but greater than or equal to 95.0%	25%
Less than 95.0%	100%

When using services from IBM or Microsoft, the numbers are almost the same

- `https://azure.microsoft.com/de-de/support/legal/sla/storage/v1_5/`
- `https://www-03.ibm.com/software/sla/sladb.nsf/sla/bm-7857-04`

Will a refund help any further, if the service fails and thus the own data is not available (or gone)?

(1) If the Cloud goes down, you House goes down



June 2nd 2018
http://www.zdnet.com/article/google-cloud-goes-down-taking-youtube-gmail-snapchat-and-others-with-it/

A mysterious outage has hit Google Cloud... and thousands of sites have gone down as a result, including both Google and non-Google services.

Affected companies include ... Snapchat, Vimeo, ... YouTube, Gmail, Google Search, G Suite, Hangouts, Google Drive, Google Docs, Google Nest...

Image: Public Domain

http://www.fastcompany.com/90358396/that-major-google-outage-meant-some-nest-users-couldnt-unlock-doors-or-use-the-ac

... But an especially annoying side effect of Google Cloud's downtime was that Nest-branded smart home products for some users just failed to work. According to reports from Twitter, many people were unable to use their Nest thermostats, Nest smart locks, and Nest cameras during the downtime. This essentially meant that because of a cloud storage outage, people were prevented from getting inside their homes, using their AC, and monitoring their babies...

(1) People Can't Vacuum Or Use Their Doorbell...

People Can't Vacuum Or Use Their Doorbell Because Amazon's Cloud Servers Are Down

November 26th 2020

https://eminetra.com.au/people-cant-vacuum-or-use-their-doorbell-because-amazons-cloud-servers-are-down/74505/

There is a problem with Amazon Web Services (AWS). And unfortunately, for those who own AWS-dependent vacuums or doorbells, many of the so-called "smart" objects will stop working.

Many of the services you know and love (Adobe Cloud Software, 1Password, Flickr) are all having problems due to outages.

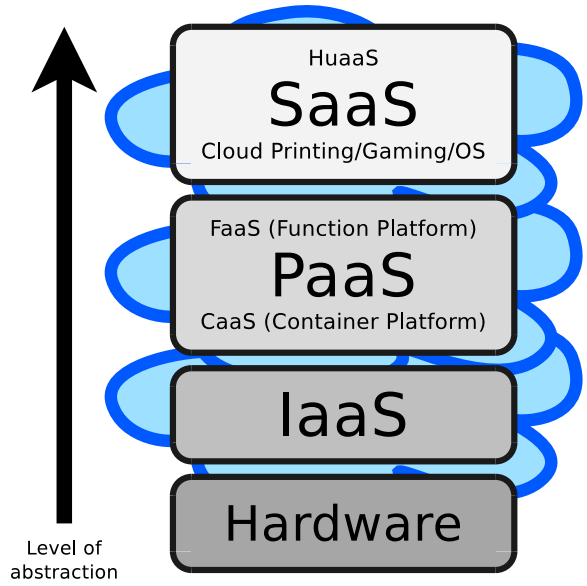
However, there were some unexpected issues as well. In short, many began to realize that they didn't realize that the cloud computing they needed was really very dependent.

What we can do now is probably not a good idea to rely on the same company for half of our Internet infrastructure.

Brave new world? Do your devices work even without a connection to the cloud service provider or without an Internet connection?

(1) Service Modifications happen almost every Day

- In **SaaS** service offerings, the features and the GUI often change
  - If a software is installed locally, it is up to the customer to decide when to „migrate“
- In **PaaS** and **IaaS** service offerings, the features and the tools often change
  - Modifications made by the service providers normally require adjustments to be made by the customer
    - Customers must continuously monitor the service offering and be able to react to modifications
- Difference between **Parental Computing** and **Personal Computing**



This source is very worth reading: **The Cloud's My-Mom-Cleaned-My-Room Problem**

Welcome to the era of parental computing, or how the cloud makes children of us all
`https://www.theatlantic.com/technology/archive/2011/09/the-clouds-my-mom-cleaned-my-room-problem/245648/`

Modifications by service providers, as described here, are not the worst scenario (see next slide).

(1) What happens if the Provider terminates the Service?

- Temporary service interruptions can always occur
  - It can also happen at any time, that a provider modifies a service offering or terminates the service

- Public Cloud IaaS service offering from Hewlett-Packard (HP)
- 30.10.2015: Announcement that the service will be switched off on 31.10.2016

- 09/2016: Together with T-Systems as data trustee, Microsoft offers an IaaS service for privacy aware customers

> Why an independent data trustee is relevant here will be explained on slide 55.

- 08/2018: Microsoft announces the termination of the service and refuses to accept new customers
- 08/2019: Microsoft integrates two new data centers in Germany with „very high privacy levels“ into its IaaS service offering – but without an independent data trustee

---

- Public Cloud storage service from Nirvanix
- 16.9.2013: Notification that the service will be switched off on 30.9.2013

> How long does it actually take to export data from a cloud service (see next slide)?

- The company declared itself bankrupt on October 1st, 2013

(1) Transfer Time of large Amounts of Data

- A HDD with 10 TB storage capacity currently costs about 300 €
  - 10 TB are today (2020) a quite moderate amount of data
- Scenario:
  - A customer stores 10 TB of data in a cloud storage service he is no longer satisfied with or will soon be shut down
- Exercise: Calculate the transfer time for 10 TB for these data rates: 10 MBit/s, 100 MBit/s and 1000 MBit/s

$$10\,\text{TB} = 10 * 2^{40}\,\text{Byte} = 10{,}995{,}116{,}277{,}760\,\text{Byte} = 87{,}960{,}930{,}222{,}080\,\text{Bit}$$

- For 10 MBit/s data rate:

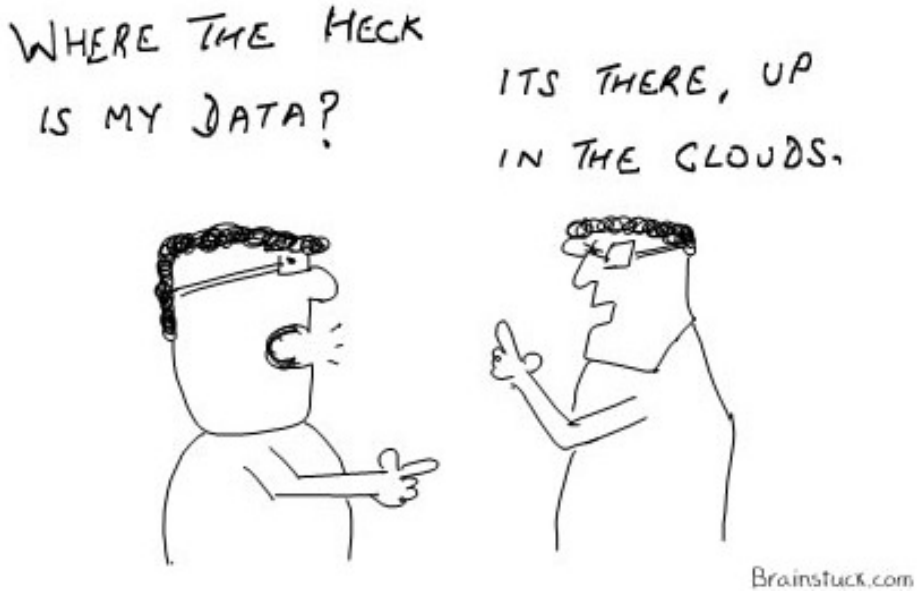
$$\frac{87{,}960{,}930{,}222{,}080\ \text{Bit}}{10{,}000{,}000\ \text{Bit/s}} \approx 8{,}796{,}093\ \text{s} \approx 2443.3\ \text{h} = \text{more than 100 days}$$

- For 100 MBit/s data rate: about 10 days
- For 1000 MBit/s data rate: about 1 day

Transferring large amounts of data has never been trivial.
When using cloud services, a „plan B“ always makes sense.

(2) Consider and prevent the potential loss of your Data

- Data loss can always occur when using **own physical hardware on premises**
  - Reasons: User errors, technical issues, malware (viruses and trojans), natural disasters, theft (vandalism)...



- **The exact same threats exist for cloud service providers**
  - These companies have a lot of manpower and experience, but 100% security cannot be achieved
  - There are numerous examples of data loss in cloud services

Data loss in cloud services is not just a theoretical scenario!

(2) Data Loss . . . is not just a theoretical Scenario

- **Microsoft 365 and Azure SQL (January 2019)**
- Some services were not available for one day (disturbed)
- Some customer data (SQL databases) permanently lost

- **Salesforce (May 2016)**
- One server site of the SaaS was down for one day
- Some customer data permanently lost

- **Amazon AWS (April 2011)**
- Thousands of websites offline for days
- Some customer data permanently lost
- Affected customers got **ten days free usage** (see slide 46)

- **Google Gmail (February 2011)**
- Emails/calendar entrys/contacts of 150,000 customers (some permanently!) erased

Migration into a cloud service cannot replace a local backup!

(3) Protection of own Data against unauthorized Access

- If a customer runs virtual servers in an IaaS, he must take care of their security himself – just like with physical servers on premises
  - Only the security of the building is no longer in the hands of the customer
- Passwords are no more/less secure when a server runs at a cloud service provider
  - Operating systems and network services need to be updated regularly!
    - In case of new security vulnerabilities even very quickly

There can also be security Issues with SaaS

Dropbox was chosen as an example here because this provider communicates security vulnerabilities very transparently.

- 2011: Dropbox accepted any password for all user accounts for 4 hours
- 2012: 68 million customer credentials were stolen
- 2016: The credentials from 2012 were offered for sale on Darknet and already circulated in the four years before

There is no 100% security against the theft of your own data.
But two-factor authentication and using encryption when possible helps!

(4) Data Access by Foreign Authorities and Agencies

- Companies in the US have to comply with the **Patriot Act** (2001) and **CLOUD Act** (2018)
  - Companies must provide US authorities access to data even if it is not stored in the US
  - Companies may be prohibited by the requesting authority from informing their customers about a data request

Microsoft already clarified in June 2011 that US companies must hand over all customer data to US authorities upon their request. Customers would be informed wherever possible, but no US company can guarantee that the requesting authority will allow the customer to be informed.
`http://www.zdnet.com/blog/igeneration/microsoft-admits-patriot-act-can-access-eu-based-cloud-data/11225`

- Some large cloud service providers exist that are not US companies
- A popular example is the Alibaba Cloud from China
- China is a „single-party socialist system“
  $\Longrightarrow$ no independent justice system, intransparent authorities, surveillance...

- Solution: Use service offerings from Germany/Europe
- However, our service providers are rather small (we have no technology leaders!)

(5) Risk of Lock-in

- If a customer decides to use a public Cloud service, he also decides to use a specific interface
- Potential issue: **Lock-in**
  - A dependency between the user and the provider of the service exists
- Scenarios: Price increases, provider bankruptcy, change of service offering (functionality),. . .
- A consequence of switching the provider is the **loss** of the infrastructure (**services**) and possibly even the own **data**
  - Consequences for customers (especially companies) may be fatal
- If a customer uses a service for long term, he **invests** is in this service
  - The own business model is focused on the service
  - Employees are trained
  - Services are *refined*

It is good to always have a „plan B“. . .

(5) Avoiding lock-in (by example of the AWS S3)

- **Competitors**
  - Offer public services with the same functionality and API
    - For S3: Google Cloud Storage, HP Cloud Object Storage, (†2016) , Connectria CS, Host Europe CS (†2014), Nirvanix (†2013), Dunkel Cloud Storage, Cloudian, IBM Cloud Object Storage...

- **(Free) implementations**
  - Running private Cloud services with the same functionality and API
    - For S3: Eucalyptus Walrus, Nimbus Cumulus, OpenStack Swift, Riak CS, Ceph Object Storage, Minio...


Competitors and/or free reimplementations often exist. However, the market is not static and free software projects appear and disappear. Getting familiar working with competitive offerings and free reimplementations is seldom trivial but it offers interesting opportunities like developing exciting software projects $\Longrightarrow$ see KOALA and the Octopus Cloud Storage System

Karlsruhe Open Application for cLoud Administration

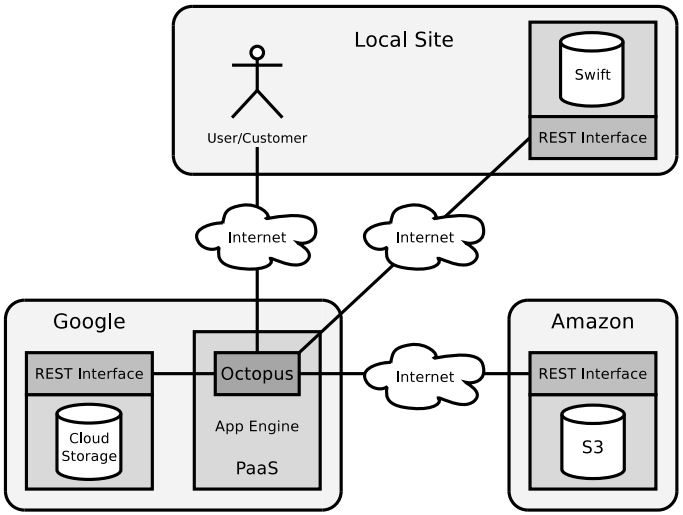
- Users interact directly with infrastructure and storage services
  - Tools of providers normally only support few services
    $\Longrightarrow$ Services are mostly isolated solutions
    - Wanted: **Marketplace portal** $\Longrightarrow$ KOALA
      - Service, which integrates public and private services from different providers
    - Developed for the Google App Engine
      - Runs in a private context too
    - Challenges during the development:
      - Features of the (private) services
      - Quality of documentation

Project: `https://github.com/christianbaun/koalacloud`

The KOALA Cloud Manager - Cloud Service Management the Easy Way. *Christian Baun, Marcel Kunze, Viktor Mauch*. Proceedings of the IEEE Cloud 2011 4th International Conference on Cloud Computing in Washington. ISBN:978-0-7695-4460-1

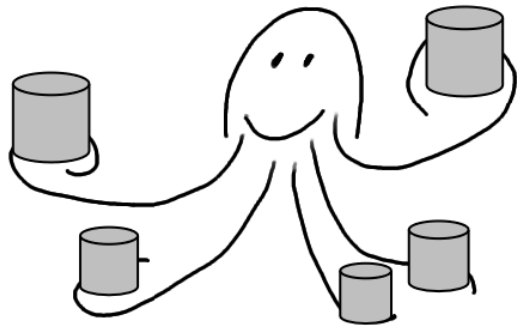
The KOALA Cloud Management Service - A Modern Approach for Cloud Infrastructure Management. *Christian Baun, Marcel Kunze*. Proceedings of the 1st International Workshop on Cloud Computing Platforms (CloudCP) that was part of the EuroSys 2011 in Salzburg. The Association for Computing Machinery (ACM). ISBN:978-1-4503-0727-7

Octopus Cloud Storage System



- Service, which connects S3-compatible storage service to a RAID 1
- Benefits:
  - Better availability of the data
  - Independence of individual providers
- Developed for the Google App Engine

- Copies files to the storage services and monitors the synchronicity via MD5 checksums
- Challenges of the development:
  - Behavior of services is not 100% identical



Project: `https://github.com/christianbaun/octopuscloud`

Octopus - A Redundant Array of Independent Services (RAIS). *Christian Baun, Marcel Kunze, Denis Schwab, Tobias Kurze*. Proceedings of the 3rd International Conference on Cloud Computing and Services Science (CLOSER 2013) in Aachen. SCITEPRESS. ISBN: 978-989-8565-52-5, P.321-328

Conclusion

- This presentation demonstrated **some risks** of cloud computing
  - But it is an **exciting technology with a lot of potential** regarding
    - Automation, flexibility, purchase and operating costs,. . .
- Some basic rules:
  1. Define own requirements $\Longrightarrow$ Market analysis
     - find a matching service offering and avoid a Lock-In!
     - Do competitive offerings and/or free reimplementations exist?
     - Have a „Plan B“ and try it out before it becomes necessary
  2. Determine the background of the service provider and the legal situation
     - Estimate the reliability of the service provider
     - Communication with providers from Germany is potentially simpler
     - Major providers usually stay in business for a longer period of time
  3. Always have a second backup
     - Either stored locally or stored in another service provider
  4. Use encryption and strong passwords
     - Using two-factor authentication is more secure than passwords

The installation of a server in a company takes several weeks. Deploying a virtual server in an IaaS takes less than 5 minutes.

Transition IT into the Era of Industrialization

- Carr describes the changes in IT, caused by inexpensive and highly available Cloud services and compares this changes with the industrial revolution 100 years ago
- Change in the economy and society have been caused by always available electrical energy
- Energy production in large power plants was cheaper than building bigger water wheels to self produce the energy

- A power grid arose and the transport of energy over long distances became possible
- This allowed to build up factories everywhere and not only near rivers
- Incorporating a companies became simplified by inexpensive energy. In Cloud Computing, it is similar
- Until now, most companies and universities operate their IT services themselves
- The consolidation in large-scale computing and data centers is less expensive and will become standard in the long term
- New business segments arise
- The impact on the business models of current IT market leaders such as Microsoft, IBM and SAP is immense

Industry reacts by offering specialized Services

gigaom.com/2011/08/16/amazon-targets-u-s-government-with-govcloud/

Amazon targets U.S. government with GovCloud

by Derrick Harris AUG. 16, 2011 - 2:38 PM PDT

A▼ A▲

SUMMARY: *Amazon Web Services has rolled out a new region, called GovCloud, designed specifically for federal government workloads. The region is designed to meet the myriad regulations that government agencies must meet when deploying new infrastructure, which have proven a hindrance in terms government cloud adoption.*

Amazon Web Services has rolled out a new offering, called GovCloud, designed specifically to run federal government workloads. The AWS region is designed to meet the myriad regulations that government agencies must meet when deploying new infrastructure, which have proven something of a hindrance in terms of letting the government adopt cloud computing services. And the timing couldn't be better.

The GovCloud site explains that government agencies have had trouble processing and storing data in the cloud, which the government says can be accessible only by U.S. persons. But because AWS GovCloud "is physically and logically accessible by U.S. persons only, government agencies can now manage more heavily regulated data in AWS while remaining compliant with strict federal requirements." Of course, GovCloud will feature high-level security for all this data.

U.S. government closes nearly half of their Data Centers

Interview of the NYT with Vivek Kundra, Chief Information Officer of the Obama administration

...The federal government is the largest buyer of information technology in the world, spending about $80 billion a year. The Obama administration, in plans detailed Wednesday, is taking aim at some of that by closing 800 of its sprawling collection of 2,000 data centers. The savings, analysts say, will translate into billions of dollars a year and acres of freed-up real estate....

... the data center consolidation was part of a broader strategy to embrace more efficient, Internet-era computing. In particular, the government is shifting to cloud computing, in which users use online applications like e-mail remotely, over the Internet. These cloud services can be provided by the government to many agencies or by outside technology companies....

...But government officials say the federal agencies are moving faster than the initial plans, with a total of 195 closings now scheduled by the end of 2011. That would help lift the total to 373 data centers by the end of 2012.....

...„In an era of massive deficits, the federal government has to figure out ways to get more efficient. The data center consolidation is part of that process.“

„The shift to modernized computer services has already started. For example, nearly 140,000 employees at the General Services Administration and Department of Agriculture have moved to cloud-based e-mail, Mr. Kundra said, saving about $42 million a year. Google provides the cloud e-mail for the G.S.A, while a Microsoft cloud service is used by the Agriculture Department.

Source: `http://www.nytimes.com/2011/07/20/technology/us-to-close-800-computer-data-centers.html`

Interesting Example: Dropbox

- Web service, started in 2007
- Provides a network file system for the synchronization of files between different computers and users
- Stores the users' files inside S3 (**see latest news on slide 65**)

Where does Dropbox store everyone's data?

Once a file is added to your Dropbox, the file is then synced to Dropbox's secure online servers. All files stored online by Dropbox are encrypted and kept securely on Amazon's Simple Storage Service (S3) in multiple data centers located across the United States.

Source: `https://www.dropbox.com/help/7/en/`

- Business model: **Refine a Cloud service**

- Interesting business model.
- But is it also the best model when the company continues to grow?

Dropbox left the Amazon Cloud

- *The Epic Story of Dropbox's Exodus From the Amazon Cloud Empire*

  Cade Metz, March 14th, 2016

  Source: `https://www.wired.com/2016/03/epic-story-dropboxs-exodus-amazon-cloud-empire/`

Over the last two-and-a-half years, Dropbox built its own vast computer network and shifted its service onto a new breed of machines designed by its own engineers, all orchestrated by a software system built by its own programmers with a brand new programming language.

. . . some companies get so big, it actually makes sense to build their own network with their own custom tech and, yes, abandon the cloud. Amazon and Google and Microsoft can keep cloud prices low, thanks to economies of scale. But they aren't selling their services at cost. . . . „There is some margin somewhere." If you're big enough, you can save tremendous amounts of money by cutting out the cloud. . . Dropbox says it's now that big.

The irony is that in fleeing the cloud, Dropbox is showing why the cloud is so powerful. It too is building infrastructure so that others don't have to. It too is, well, a cloud company.

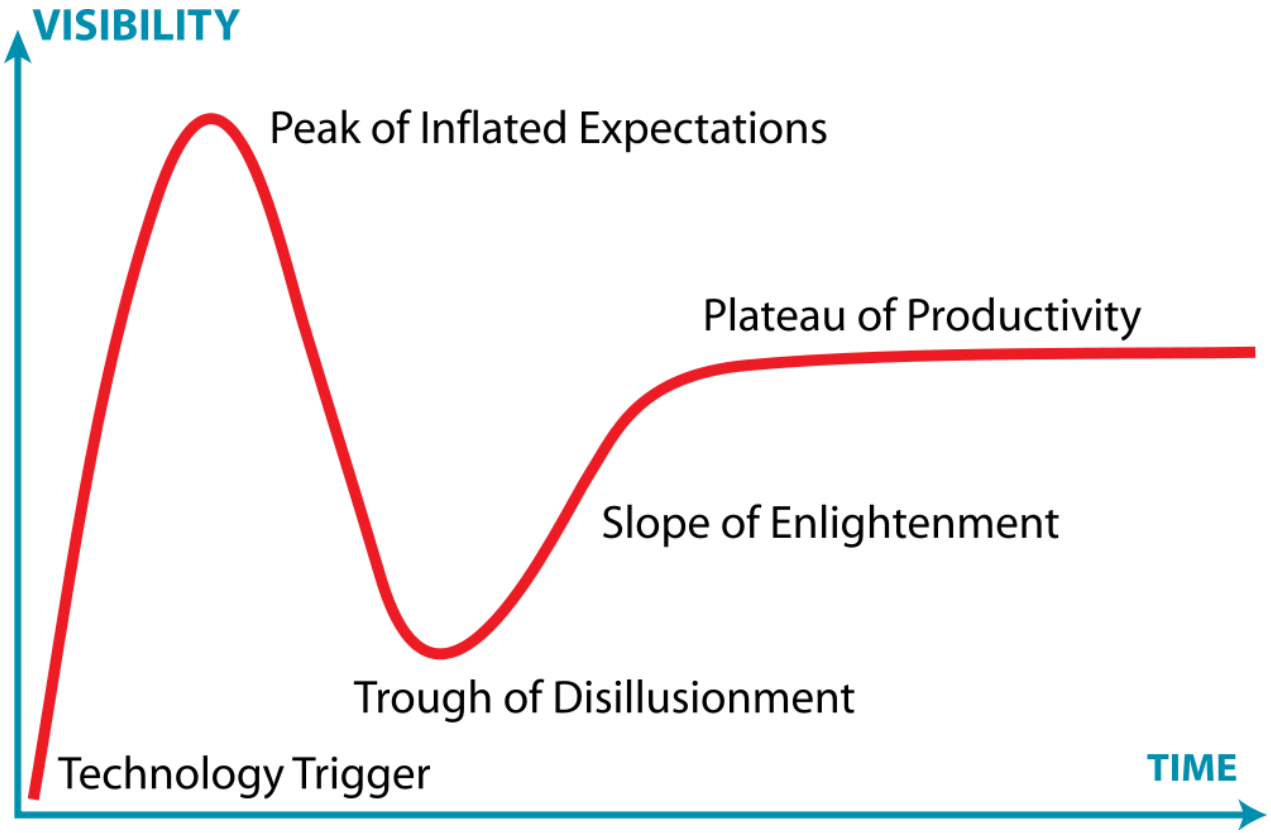
- Here's How Much Money Dropbox Saved by Moving Out of the Cloud (2018)
  `https://www.datacenterknowledge.com/cloud/here-s-how-much-money-dropbox-saved-moving-out-cloud`
- Dropbox saved almost $75 million over two years by building its own tech infrastructure (2018)
  `https://www.geekwire.com/2018/dropbox-saved-almost-75-million-two-years-building-tech-infrastructure/`
- The only thing more challenging than building a multi-exabyte distributed storage system is scaling it (2020)
  `https://builtin.com/hardware/dropbox-magic-pocket-distributed-storage-system`

Is Cloud Computing still a Hype?

- Is Cloud Computing still a topic, which is helpful to apply for funding?
- Is Cloud Computing still a Hype?
  - Or is it an established and fully developed technology?
- 2 ways to check the „hype status“ of a technology
  - **Gartner Hype Cycle** for Emerging Technologies
  - **Google Trends** (`http://www.google.de/trends/`)

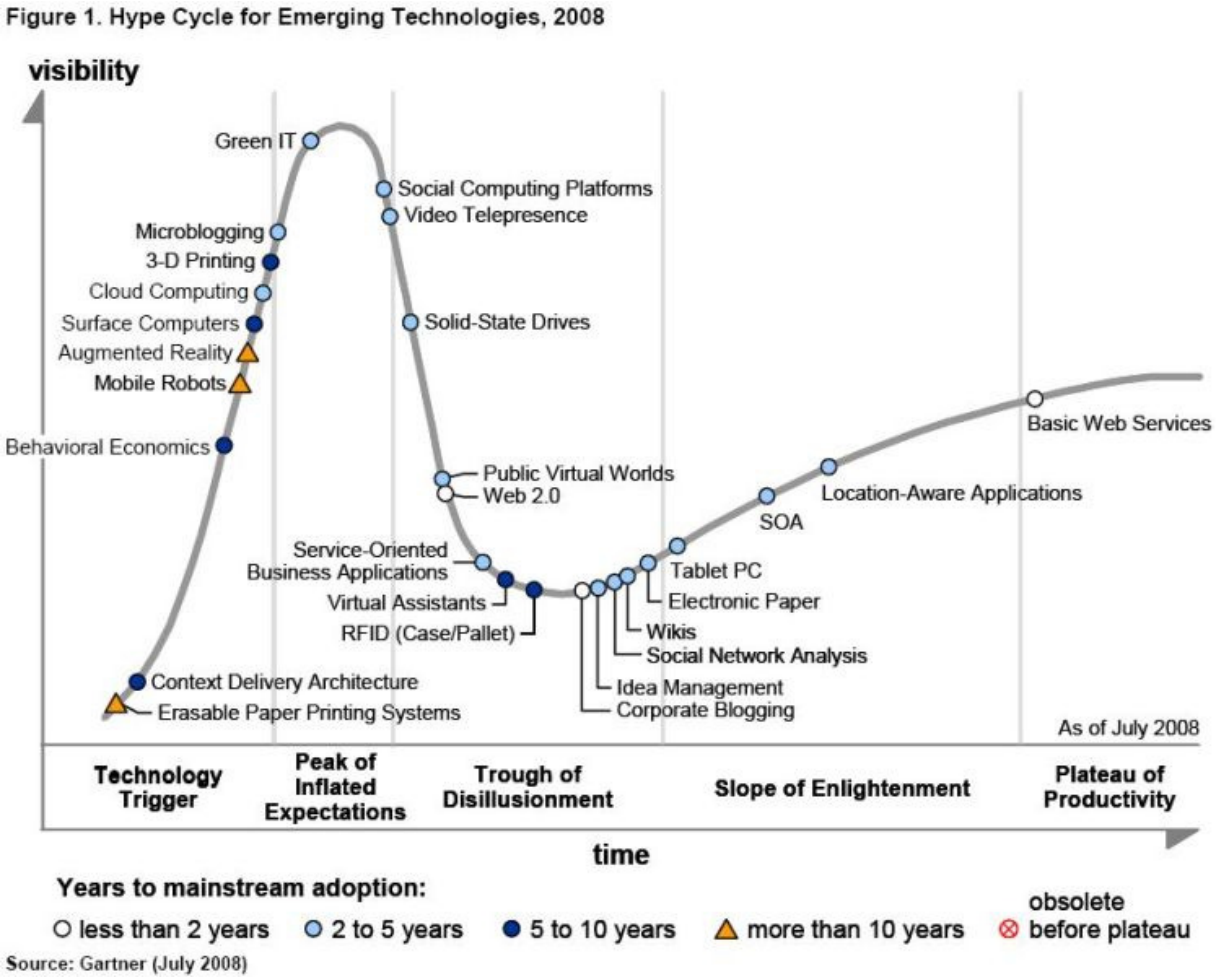
Gartner Hype Cycle

Image source: Wikipedia



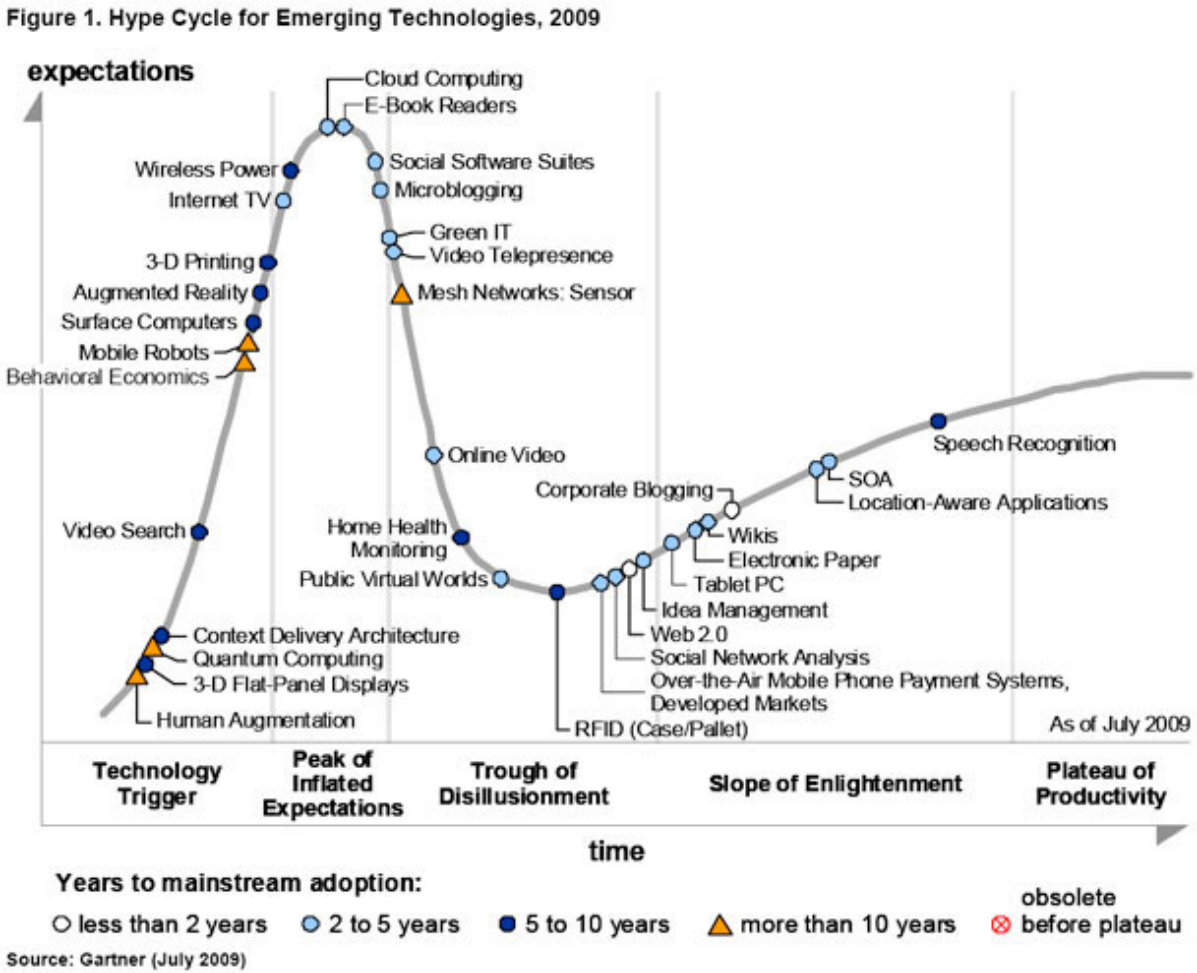
- Phases of public attention during the introduction of a new technology

Gartner Hype Cycle 2008



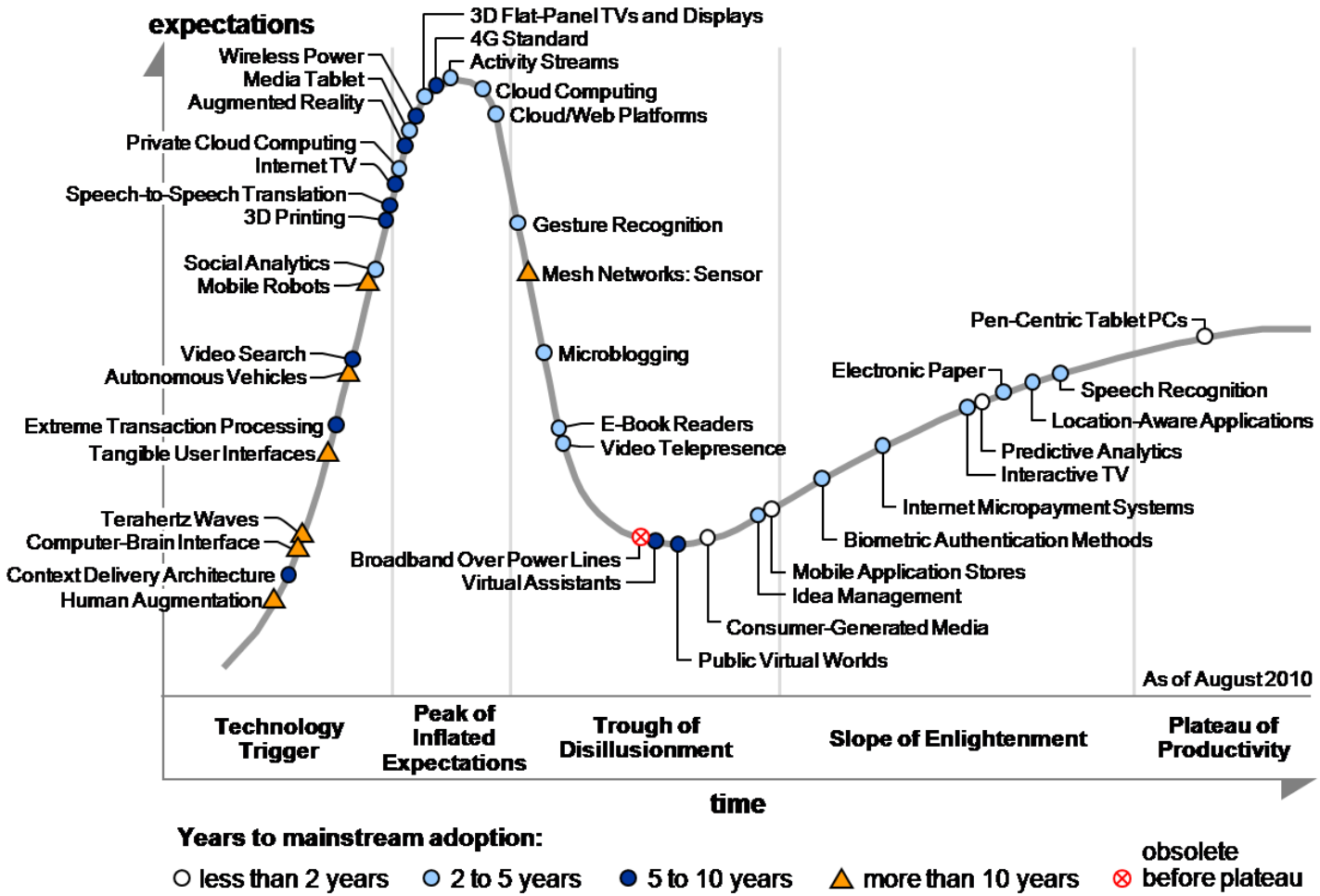
Cloud Computing $\Longrightarrow$ trigger

Gartner Hype Cycle 2009



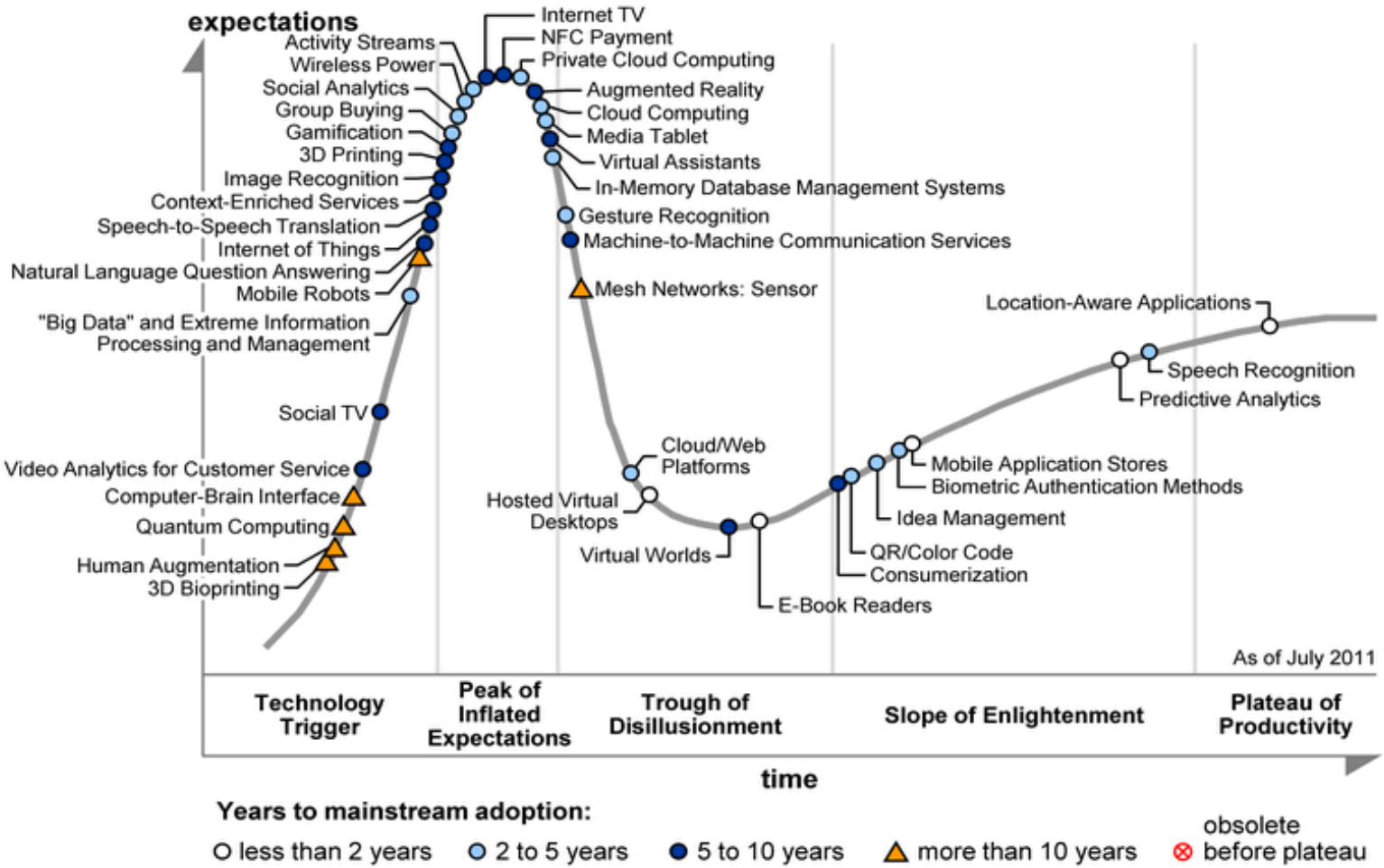
Cloud Computing $\Longrightarrow$:-)

Gartner Hype Cycle 2010



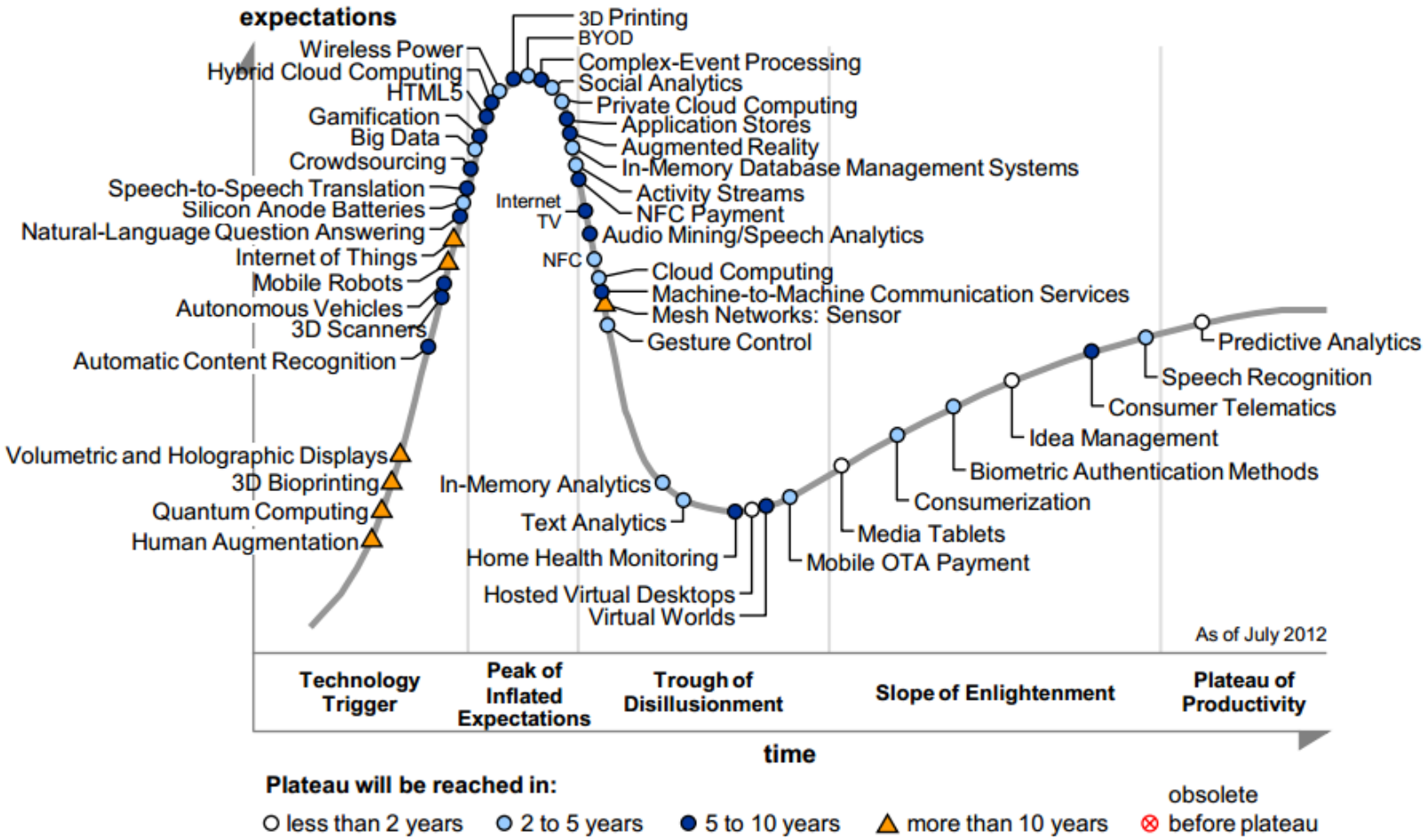
Private Cloud Computing, Cloud Computing, Cloud/Web Platforms $\Longrightarrow$:-)

Gartner Hype Cycle 2011



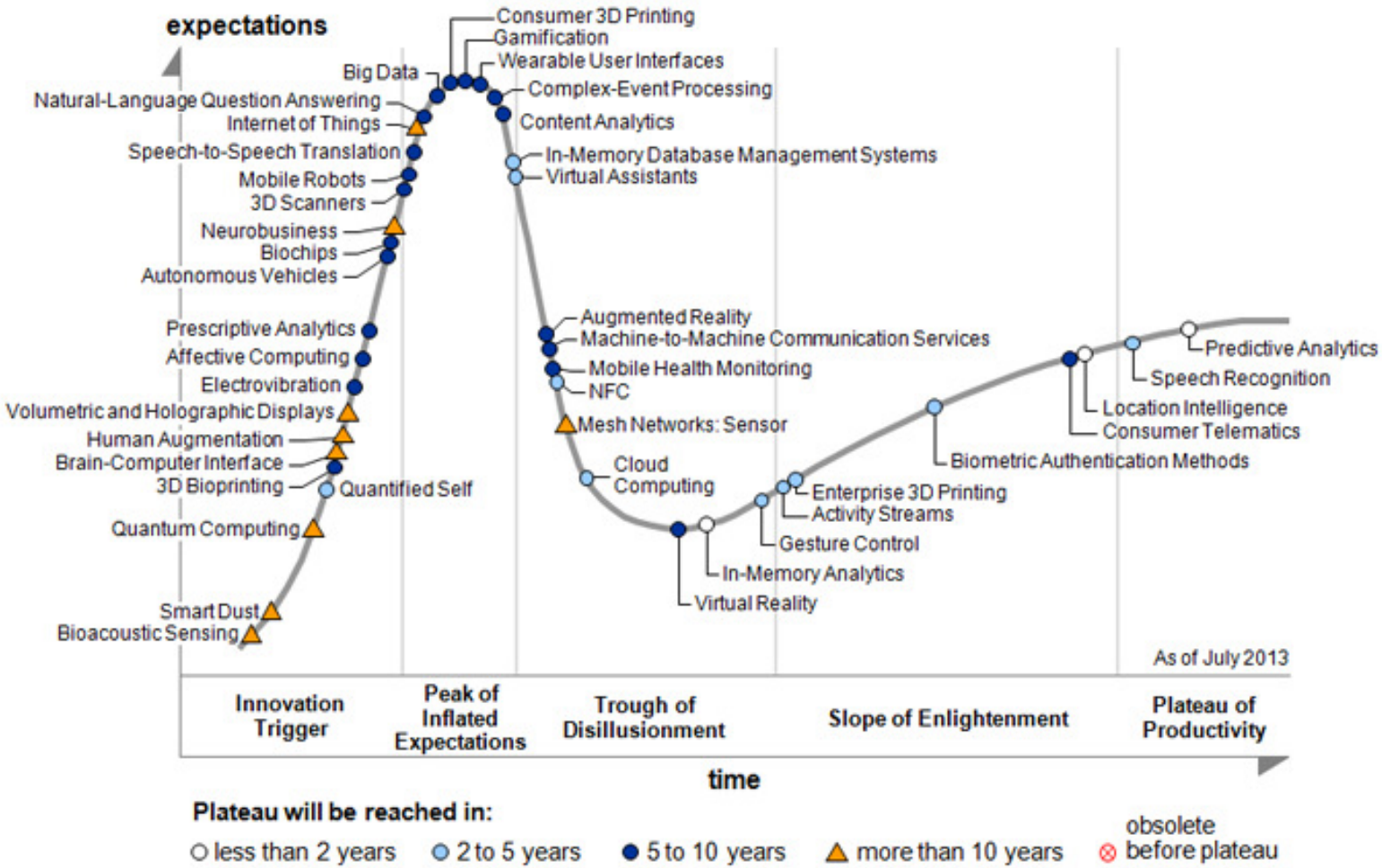
Big Data $\Longrightarrow$ trigger
Private Cloud Computing, Cloud Computing $\Longrightarrow$:-)
Cloud/Web Platforms $\Longrightarrow$:-(

Gartner Hype Cycle 2012



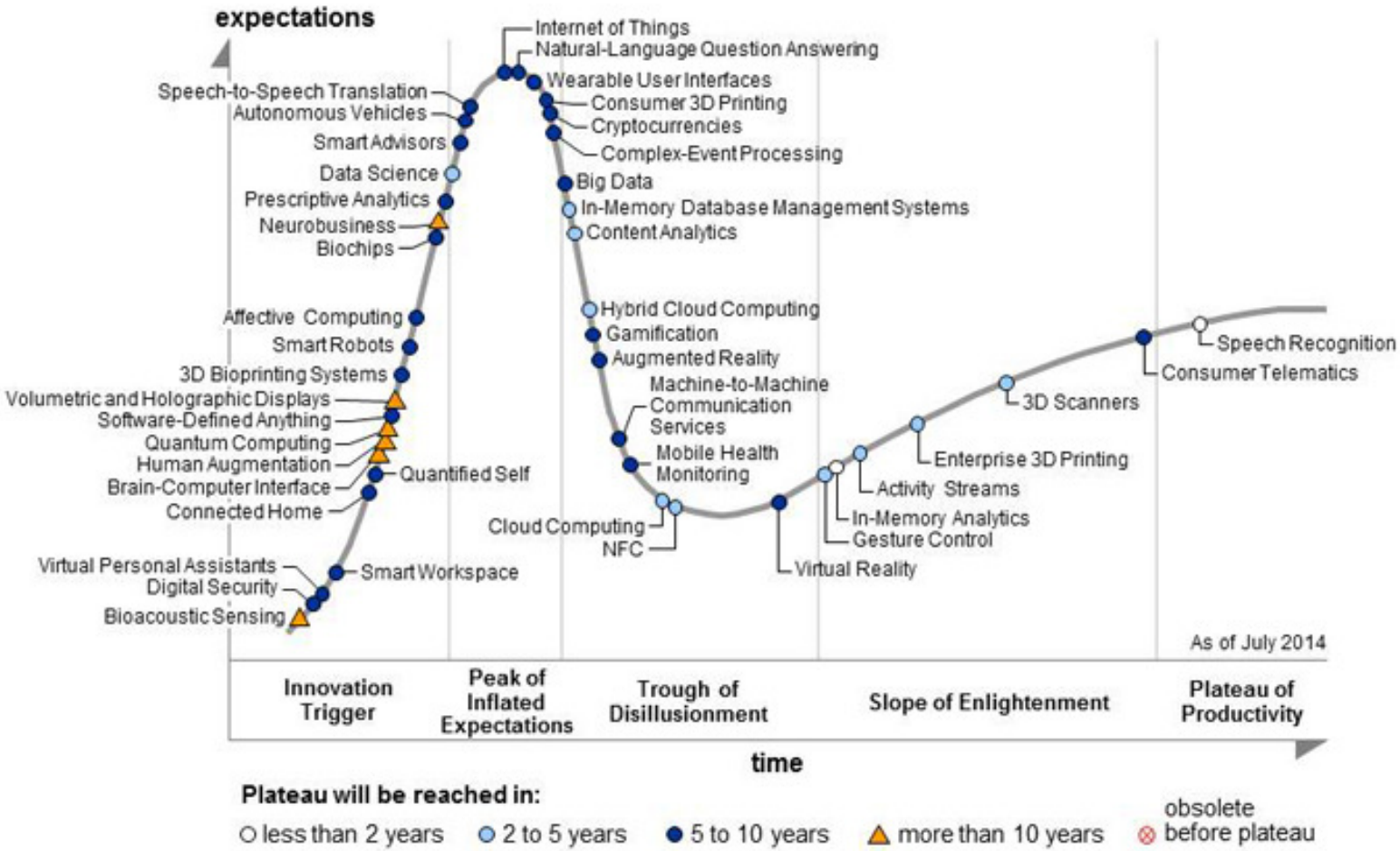
Crowdsourcing, Big Data, Hybrid Cloud Computing, Private Cloud Computing $\Longrightarrow$:-)
Cloud Computing $\Longrightarrow$:-|

Gartner Hype Cycle 2013



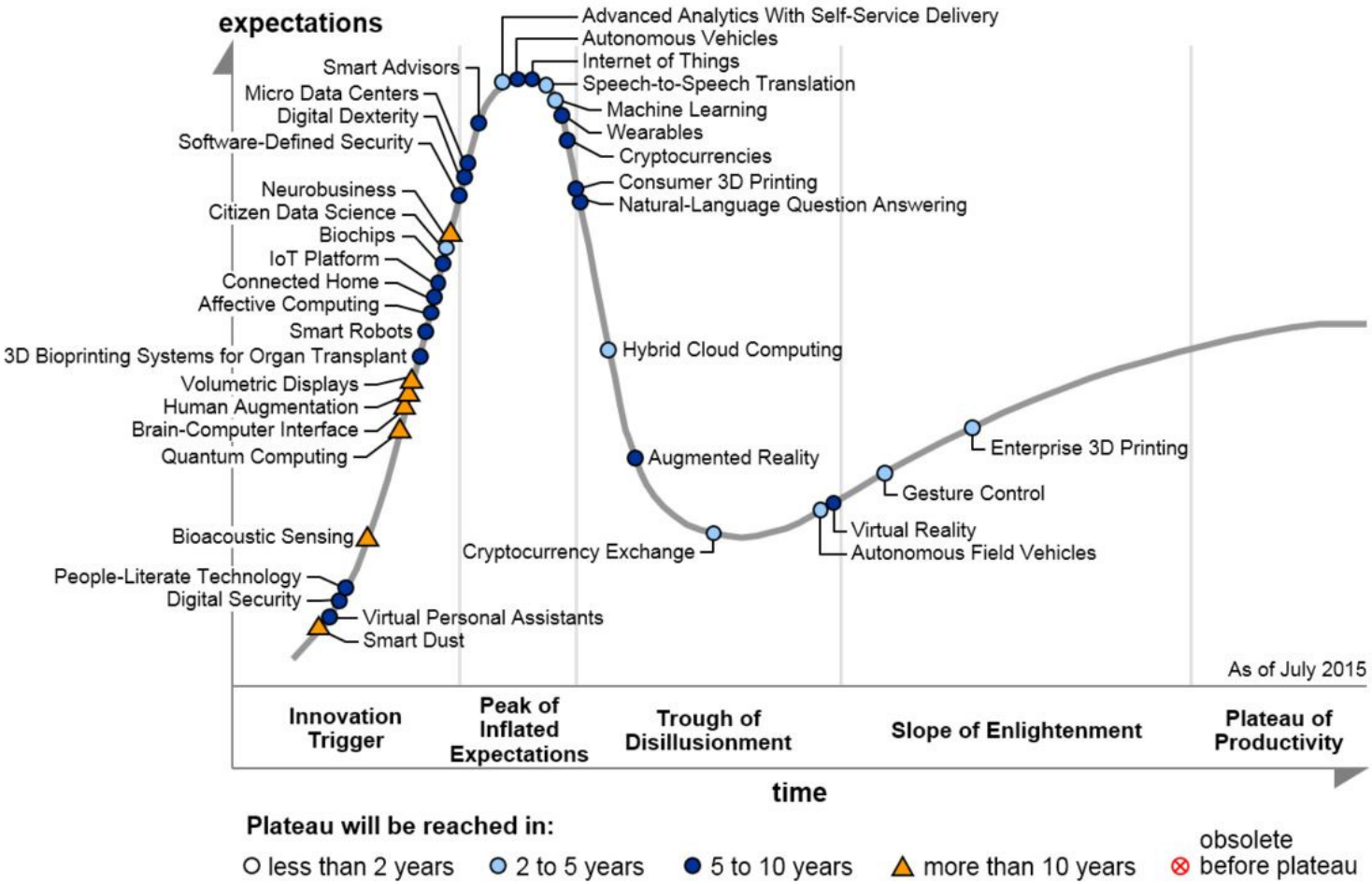
Big Data $\Longrightarrow$:-)
Cloud Computing $\Longrightarrow$:-(

Gartner Hype Cycle 2014



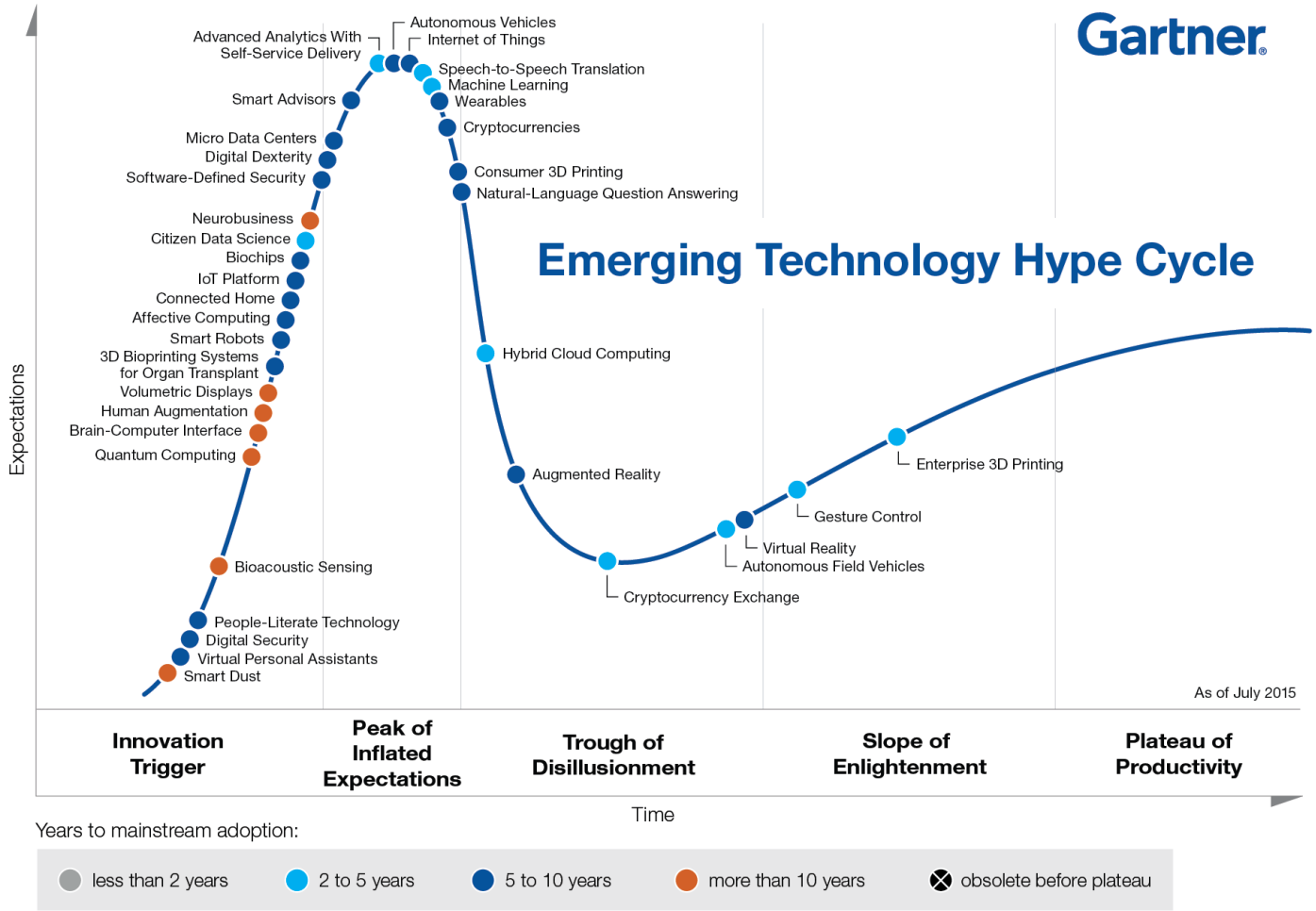
Big Data, Hybrid Cloud Computing, Cloud Computing $\Longrightarrow$:-(

Gartner Hype Cycle 2015



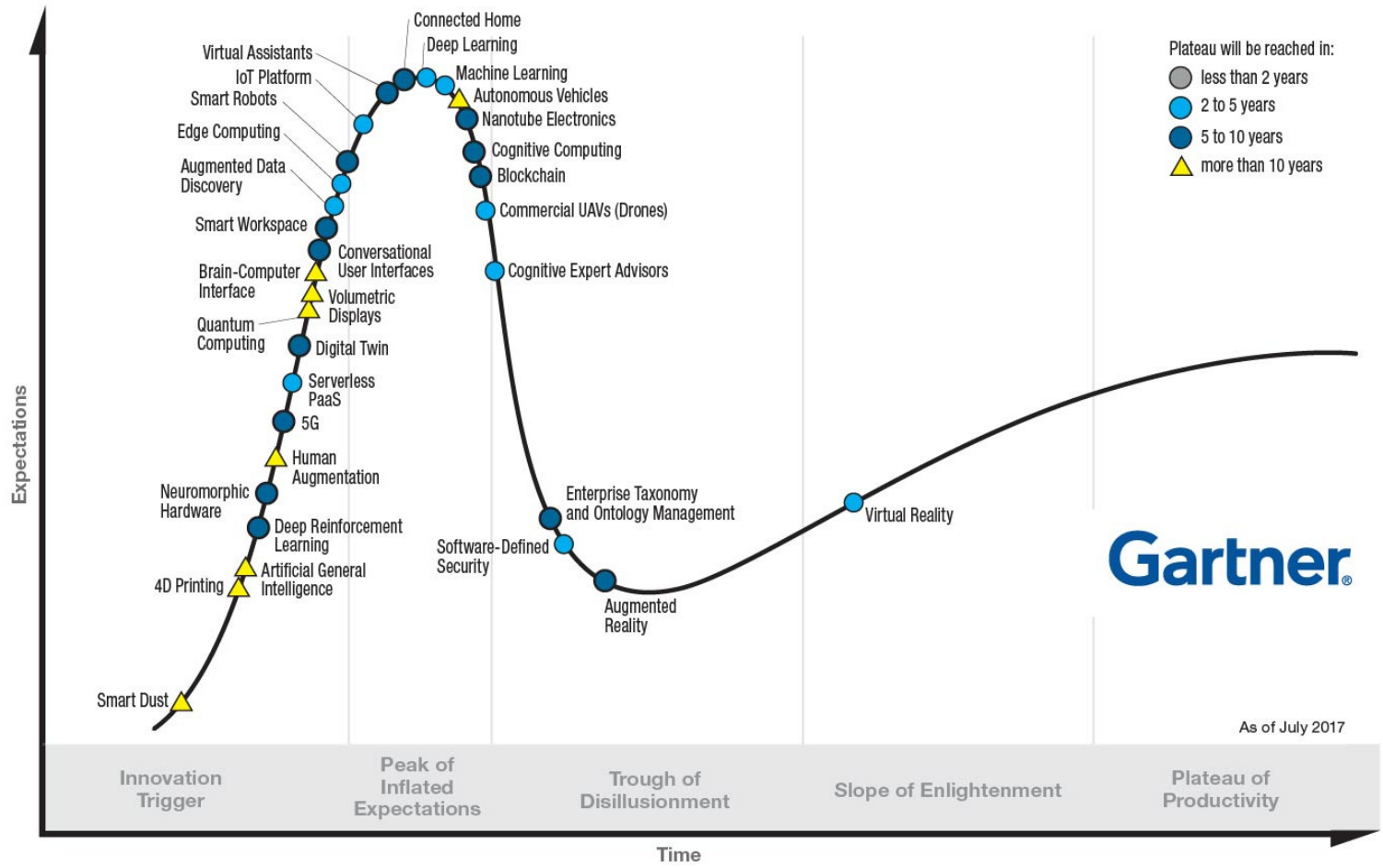
Hybrid Cloud Computing $\Longrightarrow$:-(

Gartner Hype Cycle 2016



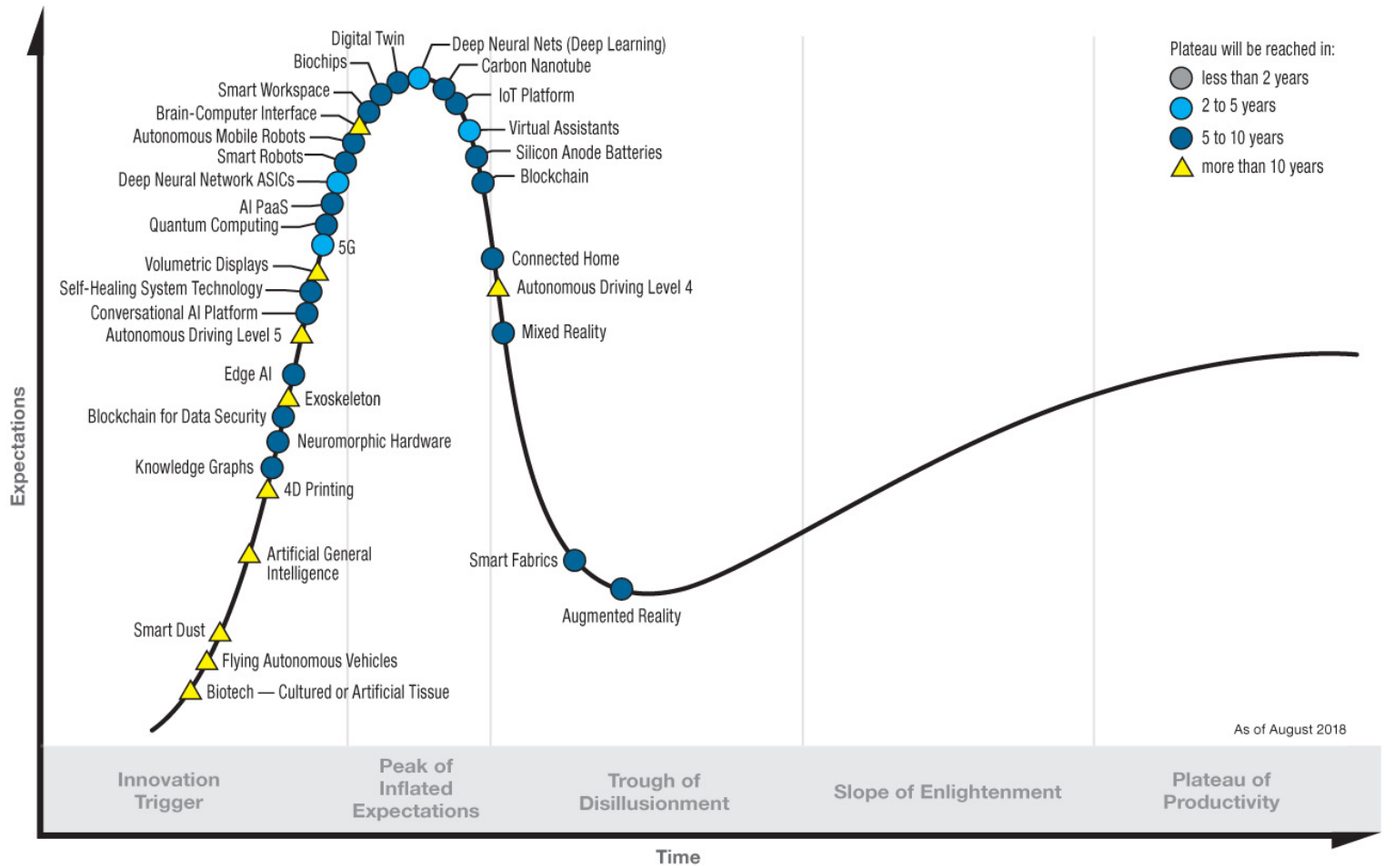
Hybrid Cloud Computing $\Longrightarrow$:-(

Gartner Hype Cycle 2017



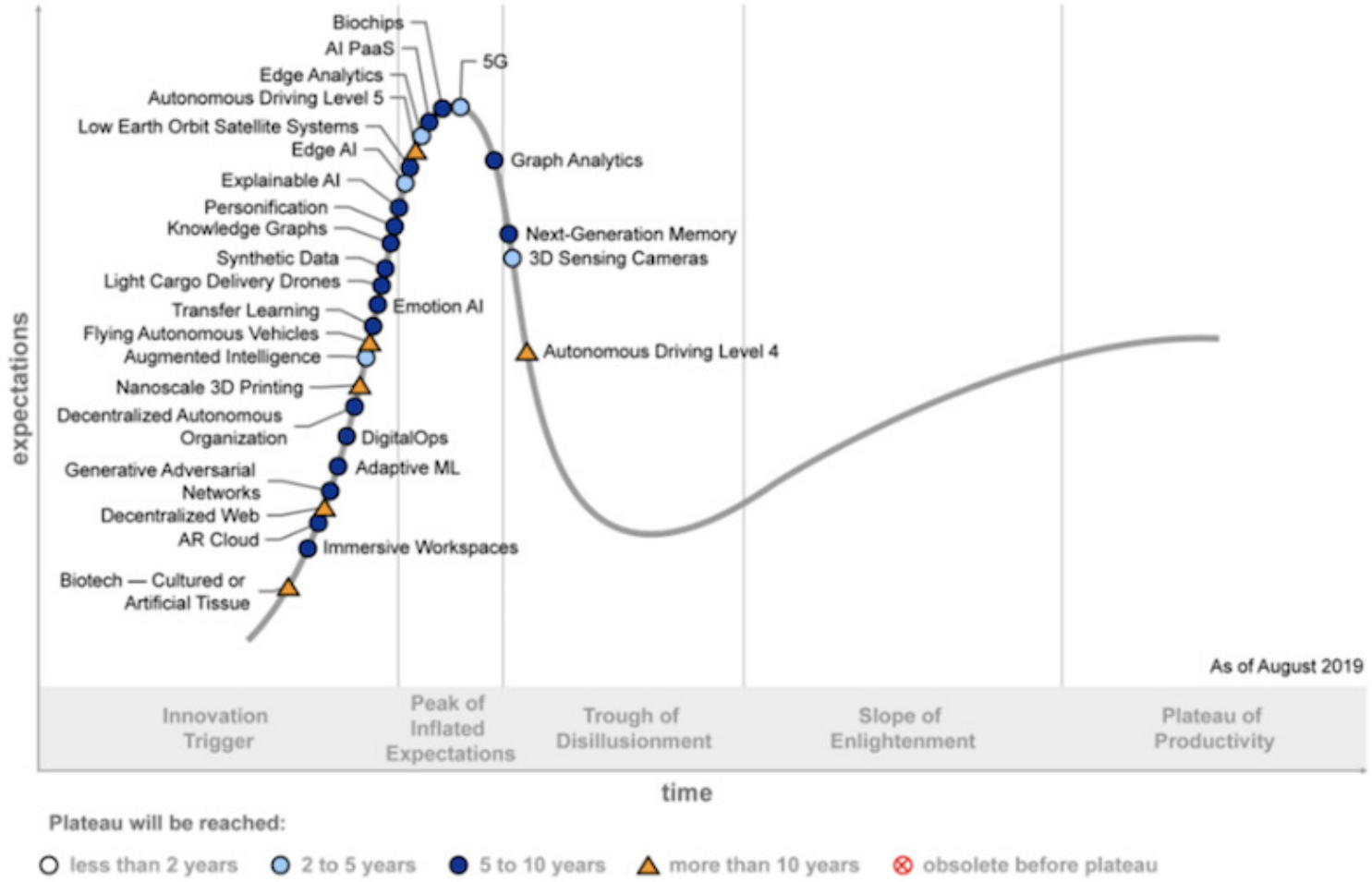
Serverless PaaS $\Longrightarrow$ trigger
Edge Computing $\Longrightarrow$:-)

Gartner Hype Cycle 2018



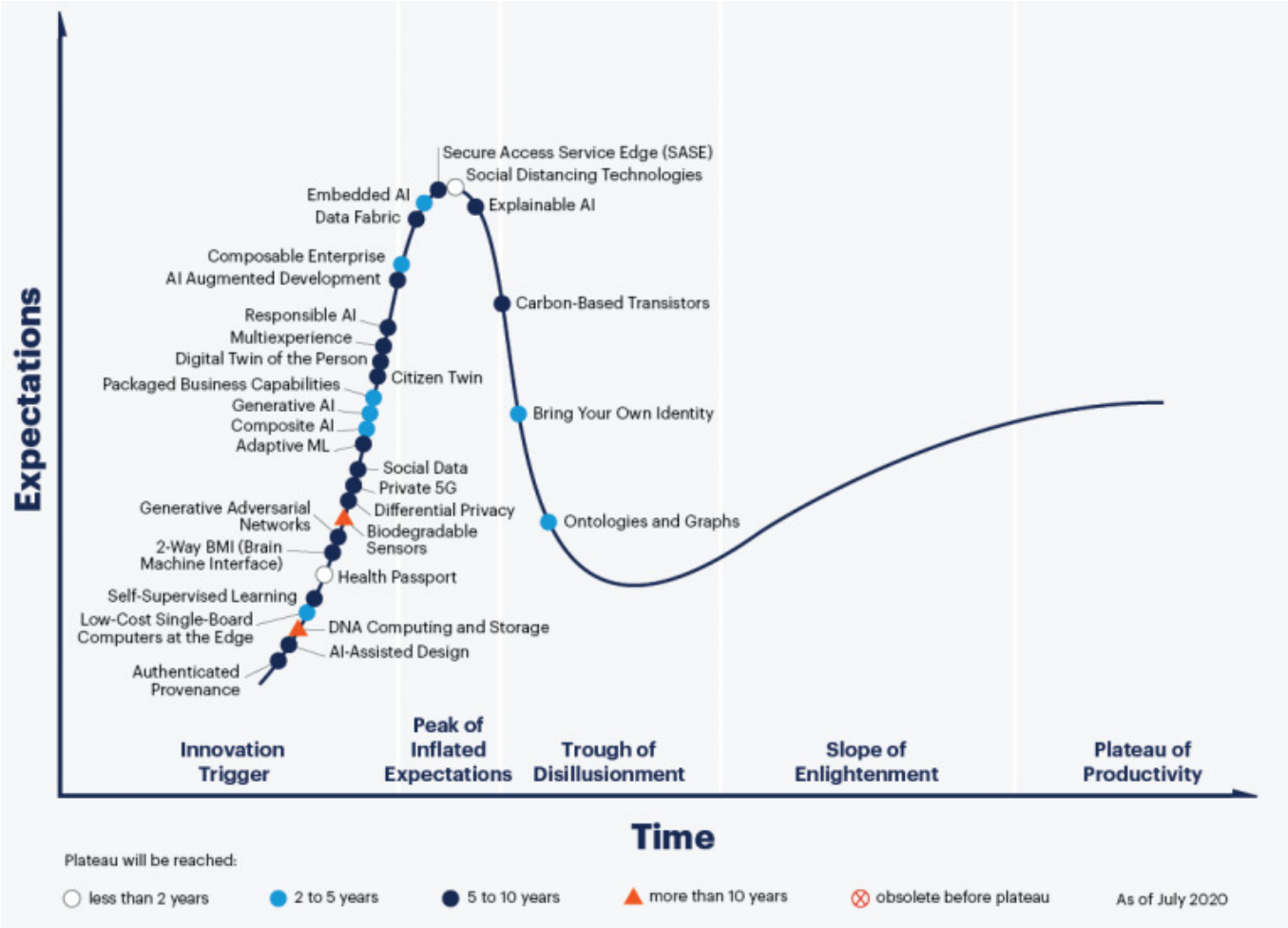
Edge AI, AI PaaS $\Longrightarrow$ trigger

Gartner Hype Cycle 2019



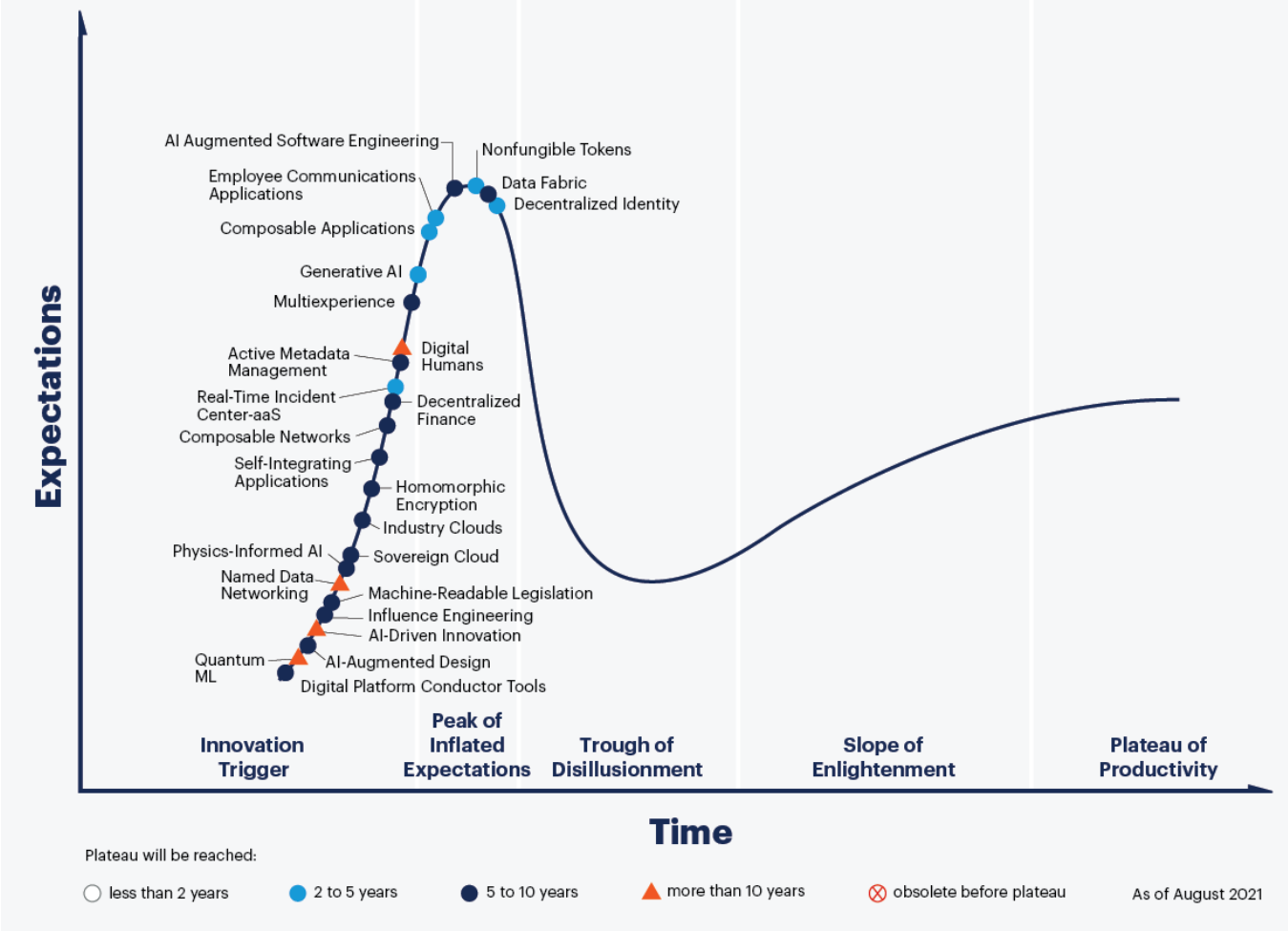
AR Cloud $\Longrightarrow$ trigger
Edge AI, Edge Analytics, AI PaaS $\Longrightarrow$:-|

Gartner Hype Cycle 2020



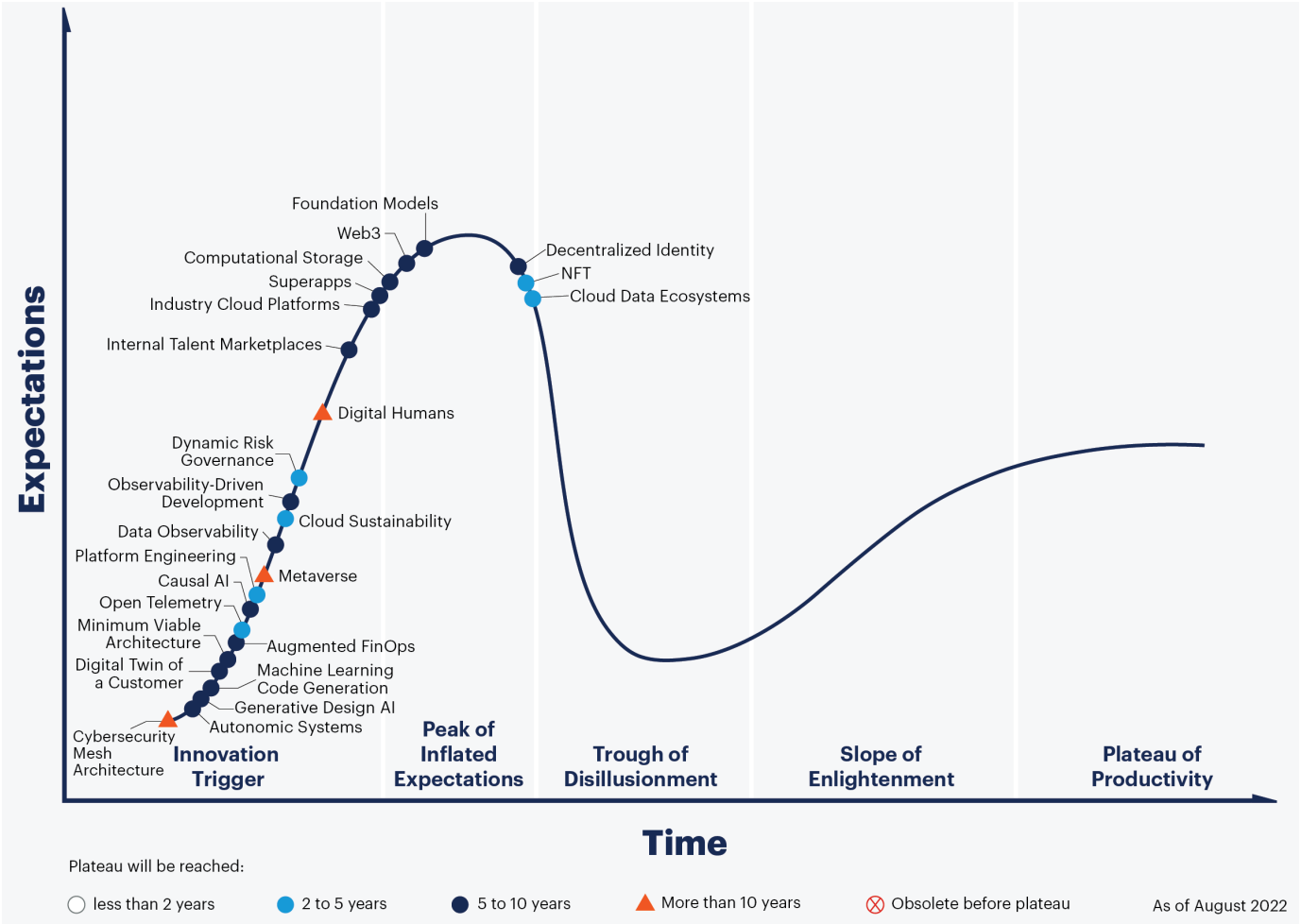
AR Cloud $\Longrightarrow$ trigger
Edge AI, Edge Analytics, AI PaaS $\Longrightarrow$:-|

Gartner Hype Cycle 2021



Souvereign Cloud, Industry Cloud $\Longrightarrow$ trigger

Gartner Hype Cycle 2022



Cloud Sustainability $\Longrightarrow$ trigger
Industry Cloud, Cloud Data Ecosystems $\Longrightarrow$:-)

Conclusion and Outlook

- Cloud Computing is not an IT hype any more
  - but some cloud-related technologies are still IT hypes
- Cloud Computing helped to industrialize (parts of) the IT
- Opportunities and risks exist – as with all IT solutions