Cloud Computing Introduction and Foundations Concepts

Benefit analysis and business models examples

References:

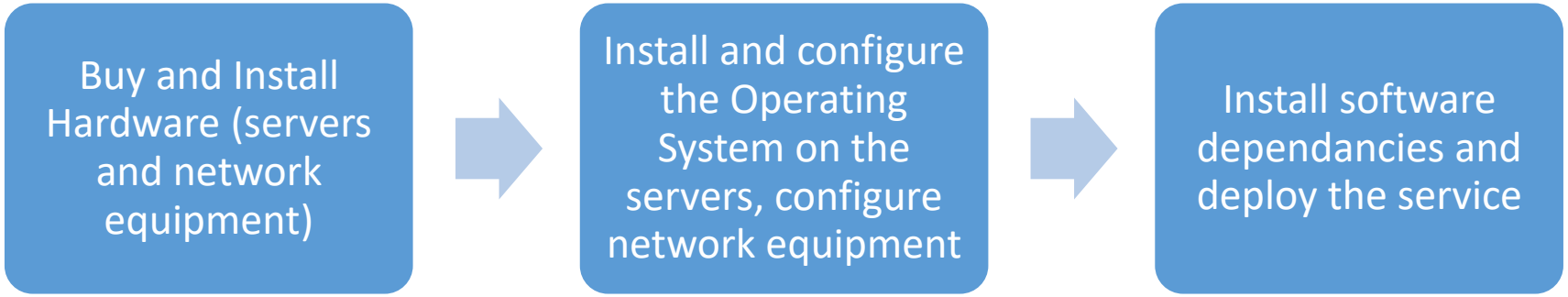
- [cam-san] Chapter 3

Cloud for Business

- Cloud computing radically changed the way IT systems are designed and deployed, introducing a real paradigm shift
- Unlike conventional computing paradigms, it provides a large number of advantages for businesses
- The technology and its opportunities changed the way the business is organized
- It also enabled new possible strategies and opportunities, unfeasible before

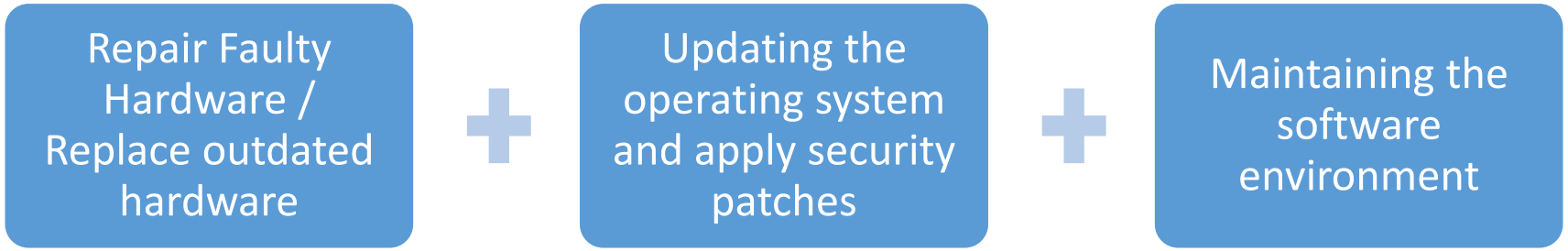
Conventional computing paradigm

- Traditional computing solutions for the implementation of business services required ***design and deployment of a complete IT infrastructure in-house***
- This can be performed with a significant initial investment for hardware and personnel
- This required to have the personnel to design and maintain all the aspects of the system, from the Operating System to Networking
- This requires the following workflow:



Keeping the system up and running

- After deploying the system, keeping it up and running smoothly is an additional significant effort, which – again – requires in-house personnel
- This results in a fixed cost for personnel and hardware repairs
- Specifically the company needs to take care of the following tasks:

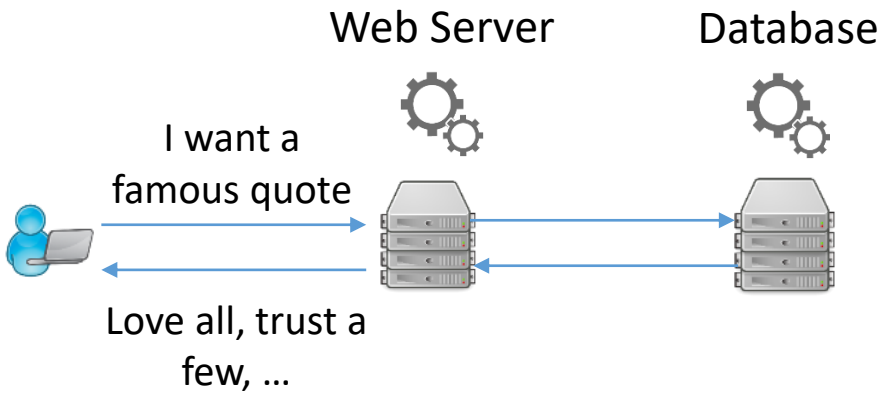


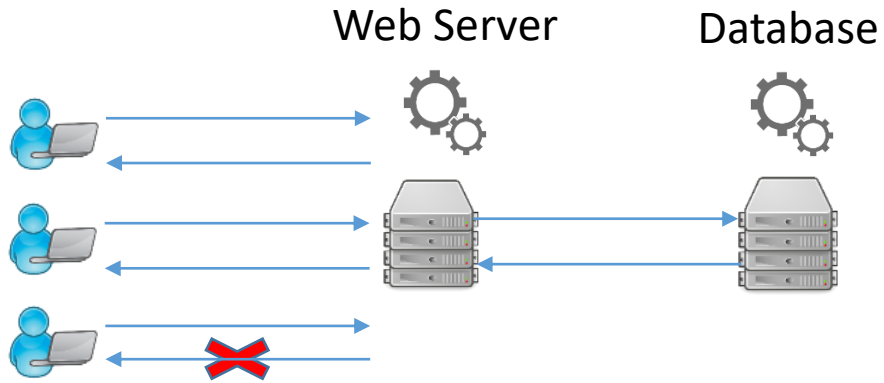
Scale the system

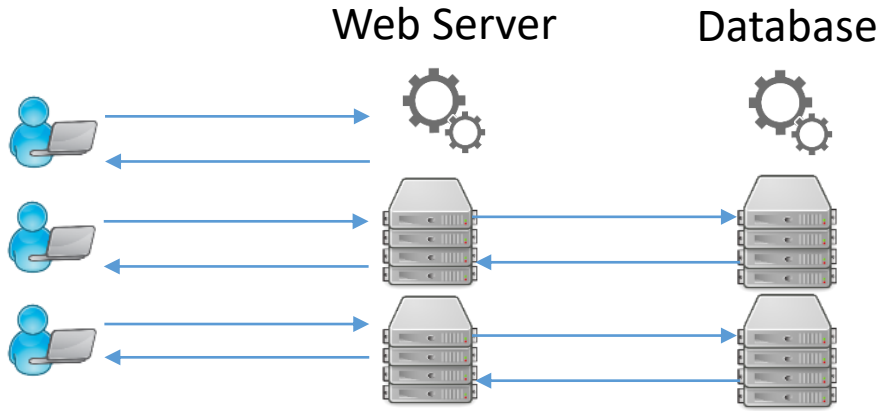
- The business can grows (even unexpectedly - overnight - in some cases)
  - The system must scale to accommodate a growing demand
  - Existing hardware must be updated with additional resources or additional hardware must be acquired and installed to handle the load -> additional cost
- The business can shrink (permanently or temporarely)
  - The load reduces
  - The system cannot scale down, acquired resources cannot be uninstalled and sold
  - Installed resources are not used -> waste of resources

Example

- SmartQuotes ltd is a small company that provides to its customers a ‘Famous Quotes as a Service’
- Through a website customers can request for personalized quotes based on quotes from famous people
- Using the conventional computing paradigm the company has to:
  - Hire 2 computer engineers to manage its small infrastructure
  - Buy two servers, one to host a database and one to host the web server that replies to the requests for quotes
- As the business expands, the number of requests from the customers increases, the current infrastructure cannot handle the load: responses are delayed or lost
- To handle the load, the company has to buy 2 more servers





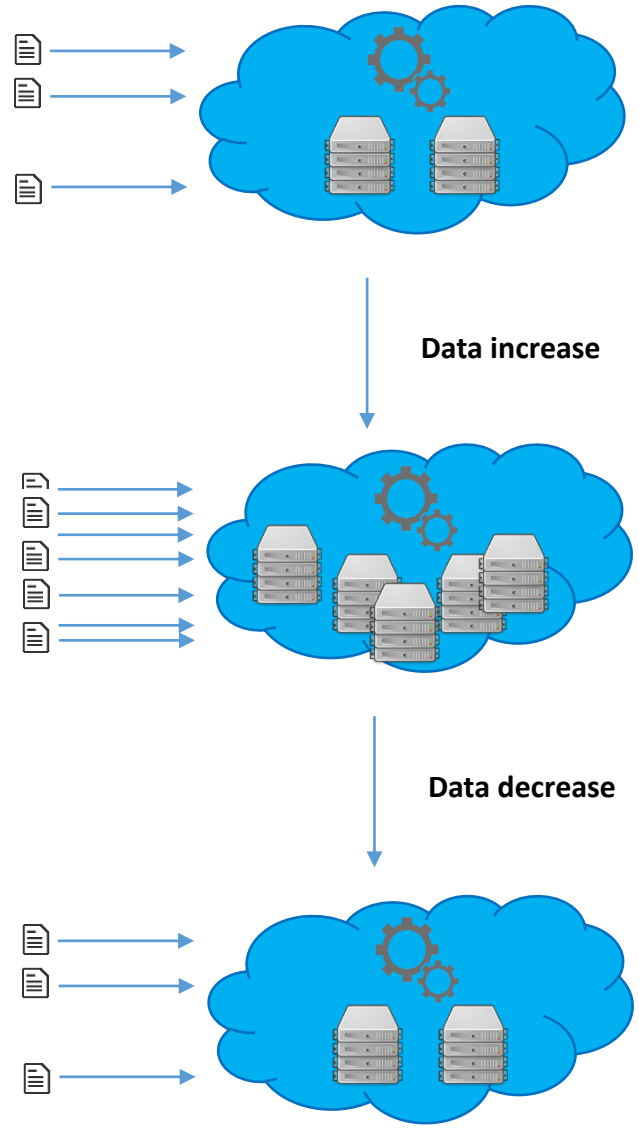


Cloud computing benefits

- Cloud computing with its utility based paradigm can be extremely helpful in this case (and in others)
- Utility-service means on-demand and metered service, in other words pay-per-use model
- You get computing resources on-demand and pay proportionally to what you get
- It allows to introduce dynamic **scalability** and **reduce costs, both initial and operational**

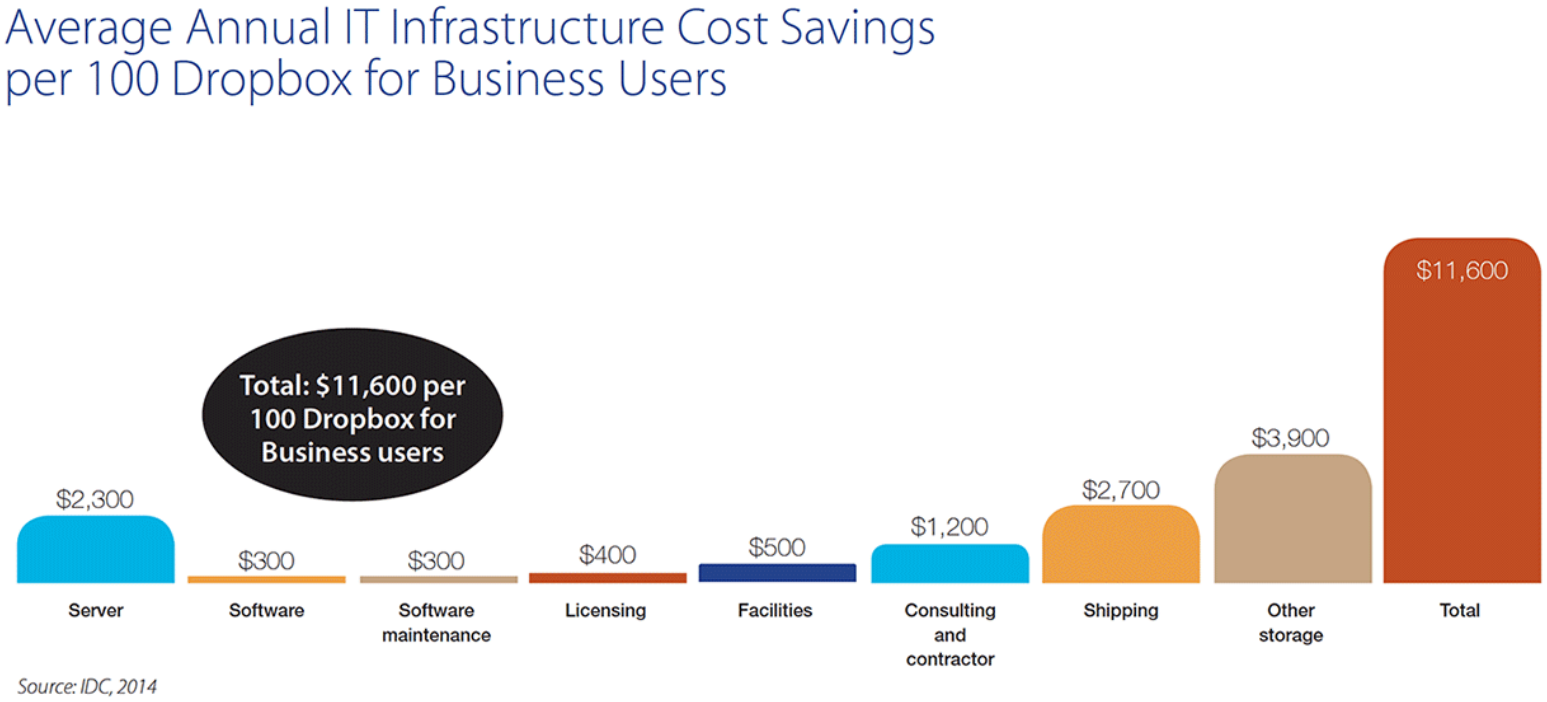
Scalability

- *High scalability*: provision of services can be based on **current demand requirements**
- Such **dynamic provisioning** can be done *automatically* using software automation for dynamic scaling
- This results is the possibility of dynamically expand/contract the resources associated with a service



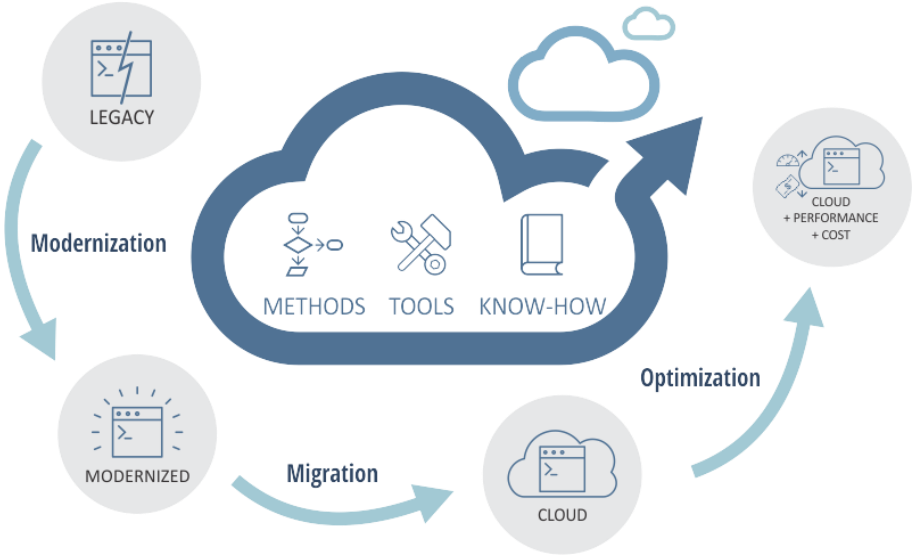
No fixed costs

- *No Infrastructure*: services can be created without owning a computing infrastructure or IT resources
  I. No initial investment is needed
  II. No maintenance costs
- No need for specialized personnel to maintain and manage the infrastructure



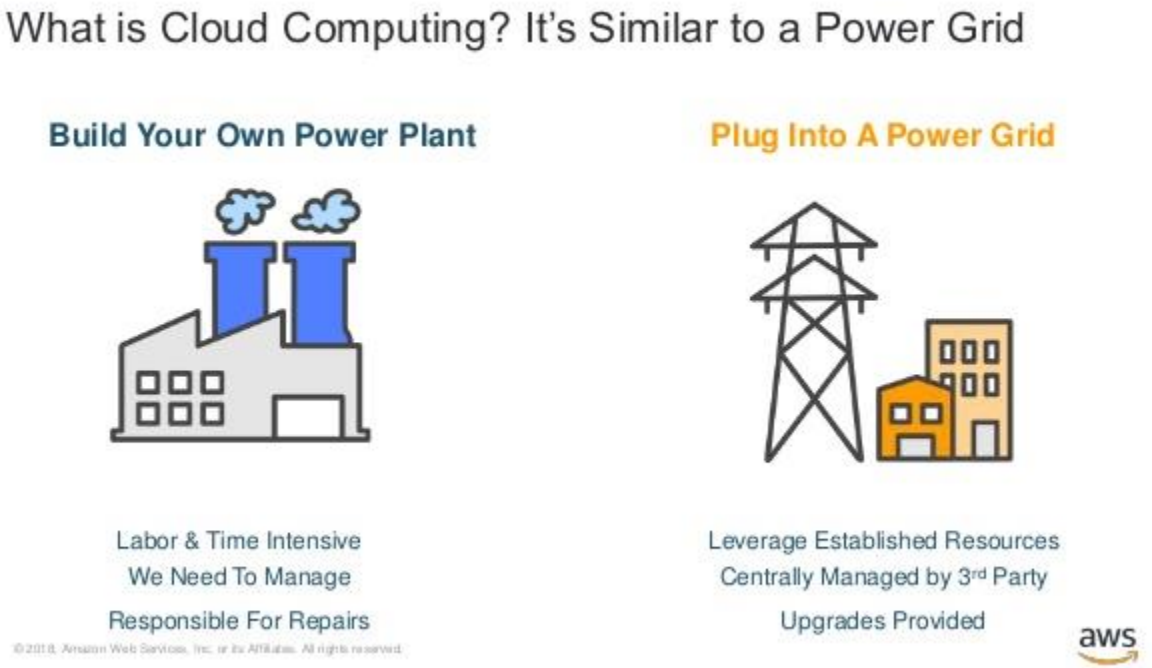
Cost reduction

- Cloud Computing providers in general offer IT resources **<u>at very low cost</u>**
- This is guaranteed by creating an infrastructure that is:
  - **Large**: buying IT hardware in bulk reduces the costs
  - **Shared**: different customers share the same infrastructure, *resources are fully exploited* (no dead periods)
  - **Fixed costs are shared**: know-how and personnel are also shared so their costs are further reduced



Utility Market

- Cloud computing advantages are the same of all the utility systems, would you rather build your own power plant or plug into the power grid?



Other indirect advantages

- **Minimal Management Responsibility**: Managing the IT infrastructure is a (even legal) responsibility for a company. Cloud shifts majority of the infrastructure management tasks towards the cloud provider. Dedicated teams at the provider's end take care of all these activities. As those teams are dedicated to these tasks they apply best practices for management reducing risks.
- **Higher Quality of Service**: In traditional computing enterprises the infrastructure was managed by a team that was not completely focused on the task or offloaded to third parties. The quality of the infrastructure, was broadly dependent on the expertise of the team or the third party, or dependent on the amount of additional tasks they had. Cloud computing providers have dedicated expert teams that are well-trained staffs and are dedicated completely to ensure a high quality of service.

Other indirect advantages

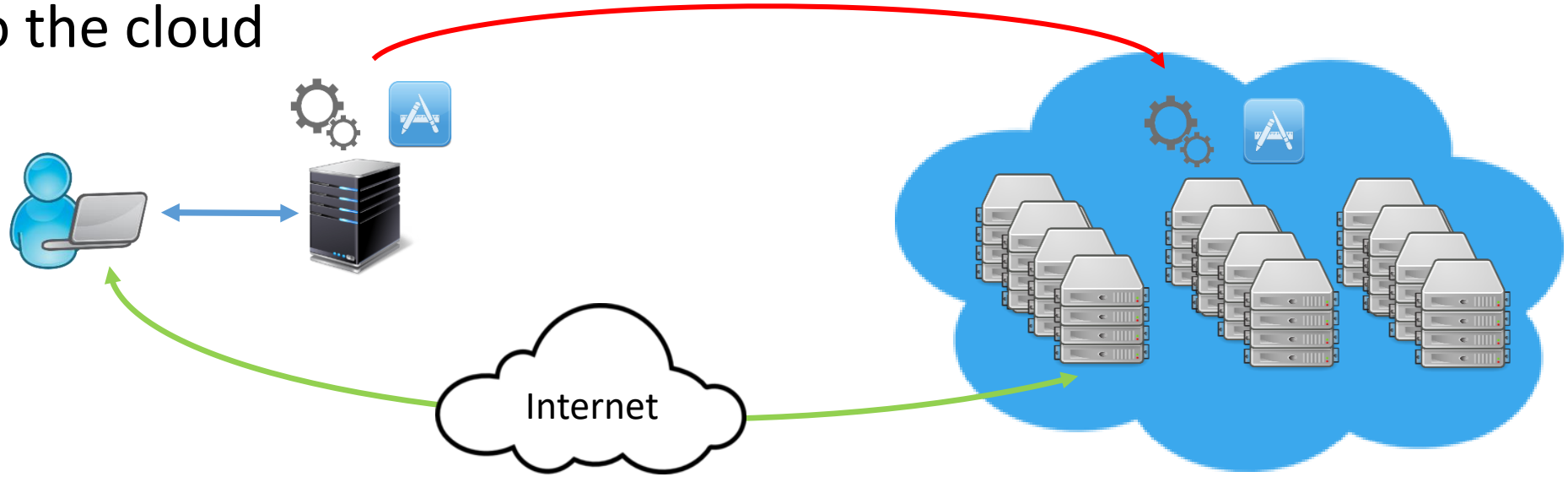
- **Reliability**: Higher quality of management helps to increase reliability significantly. The adoption of techniques for high availability, like load balancing, backup practices and recovery procedures, allows to ensure maximum reliability or ensure quick recovery from hardware failures. Consumers do not have to take care of those issues anymore as the cloud provider takes care of creating an environment that is safe from hardware failures or disasters.
- **Continuous availability**: Cloud providers assure almost 24 x 7 service availability, by employing state of the art redundancy mechanisms

Other indirect advantages

- **Minimal software management**: License procurement and software management is one of the task in creating an IT infrastructure. Cloud computing, in some of its service types, takes care not only of the infrastructure but also of the software. This eliminates the need for licensing (it's on the cloud provider) and software management, such as updates and patches (they are managed by the cloud provider)
- **Location independent**: Cloud services are accessed via Internet. This means that such services can be accessed from anywhere, anytime.
- **Companies are focused on their business**: ***System developers*** can focus on ***developing the business logic*** rather than maintaining the infrastructure

Cloudification

- Advantages of cloud computing are leading to ‘cloudification’
- Cloudification is a term coined to refer to moving *application and services from local computing deployments to somewhere* into the Cloud
- Local infrastructures are dismantled to move services and applications to the cloud



Use-Cases (i) - Cloudification

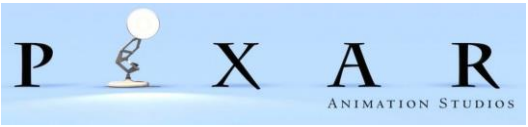
- ***Large enterprises*** offload some of their activity to cloud systems to ***reduce fixed costs***
  - ***Expedia*** moved 80% of their critical infrastructure from local servers to AWS in 2017. They got the following benefits:
    - Reduced infrastructure costs
    - Minimized response latency (from 700ms to 50ms) thanks to a more efficient infrastructure
  - https://aws.amazon.com/solutions/case-studies/expedia/

Use-Cases (ii) - Startup

- ***Small enterprises or startups*** can afford to translate their ideas into business ***without excessive front-up costs***
  - ***Airbnb:*** The San Francisco-based Airbnb began operation in 2008
  - When the company was launched its entire infrastructure was based on AWS
  - AWS scalability and flexibility allowed the company to grow considerably in short time, currently it has hundreds of employees across the globe supporting property rentals in nearly 25,000 cities in 192 countries
  - https://aws.amazon.com/solutions/case-studies/airbnb/

Use-Cases (iii) - Sporadic HPC

- ***Companies that require sporadic very high performance computing (HPC) capabilities only for a very short amount of time*** can rent for a short time a large amount of resources ***without maintaining their own infrastructure***
  - ***Pixar:*** rendering an animation movie needs for each frame between 10 and 100 hours of CPU time. Multiply that by between 24 and 60 frames per second, and then multiply again for a circa ninety minute movie, render a movie on a single machine could hit between 10 and 100 million processing hours (or between 100 and 1000 years)
  - Use cloud resources only for the time needed to render the movie reduces costs and time needed for the process
  - https://www.fasthosts.co.uk/blog/cloud/cloud-pixar-and-hollywood-computing



Global-scale Services

- With the conventional computing paradigm is unfeasible to implement and run global-scale services, i.e. services available world wide with ***billions*** of users scattered across different continents
  - Deploying a global-scale service on a single location will result in network scalability issues, data has to be transfer across the globe over the Internet, thus resulting in bottlenecks or high latencies. Data to be stored for such systems will require ad-hoc storage solutions, that can be hardly implemented on a single location
  - A company would have to deploy different IT infrastructures on different locations (e.g. one for each continent or nation) to deploy different instances of the Cloud service to route requests from users to the nearest location. The service will have to be re-engineered to spread the data (big data) on multiple locations and distribute the computing effort

Global-scale Infrastructure

- Cloud providers deploy their infrastructure on different datacenters placed all over the world, thus to cover different areas efficiently
- They also offer cloud consumer ad-hoc solutions to replicate cloud services on different data centers

Use-case (iv) – Global Service

- **Google Search**, the most popular web search service (91.63% share of the market)
- *Google Search handles about 15 exabytes of data, according to some estimates. That's 15 billion gigabytes, basically more than 30 million household HDDs*
- *Google handles more than 65,000 search queries a SECOND! That's 3.9 million a minute, 234 million an hour, 5.6 billion a day, and more than 2 TRILLION a year*
- 16% of the searches are is new search terms never seen before. That means that about 896 million unique keywords are searched for every day!
- The most searched term on Google is 'facebook' with a monthly search volume of 2520000000
- *Do you think it is feasible the implementation of such service on a single location?*

2018 DATA

Use-case (v) – Data Collection

- GE Power is the largest energy company in the world. In 2018, General Electric power plants produced one-third of the world's electricity
- GE Power has sensors embedded in their equipment (gas/steam turbines, electric generators, etc) to collect telemetry data to monitor equipment behavior to optimize their settings and detect malfunctioning
- A cloud-based data collection infrastructure allows GE Power to collect 500,000 data records per second, and scale to support the ingestion of 20 billion sensor-data tags from devices installed all over the world

- https://aws.amazon.com/solutions/case-studies/ge-power/

Global-scale content distribution

- Particular case of global-scale service is ***content distribution***
- Content distribution is a specific service that requires to distribute a set of data to a large number of users rapidly and in an efficient manner
- The content can be heterogeneous, e.g. video, music, web pages, software updates
- Some of the content could have specific latency/bandwidth requirements, e.g. the packets of a video must be transmitted with a certain maximum latency, otherwise the user experience is impaired

Use-case (v) – Content Distribution

- King is a web gaming company funded in 2003. Now they produce web or mobile app games (Candy Crush)
- The company has the need to deliver game content to a global user base, with different network connectivity, from fast new networks (4G) to old mobile user networks (e.g. 2G or 3G). Regardless of location and technology, players need fresh content to use the game
- They exploit cloud providers for global content distribution in order to have an optimal and scalable global reach
- https://aws.amazon.com/blogs/aws/king-using-amazon-cloudfront-to-deliver-mobile-games-to-over-200-countries/

Challenges/Risks

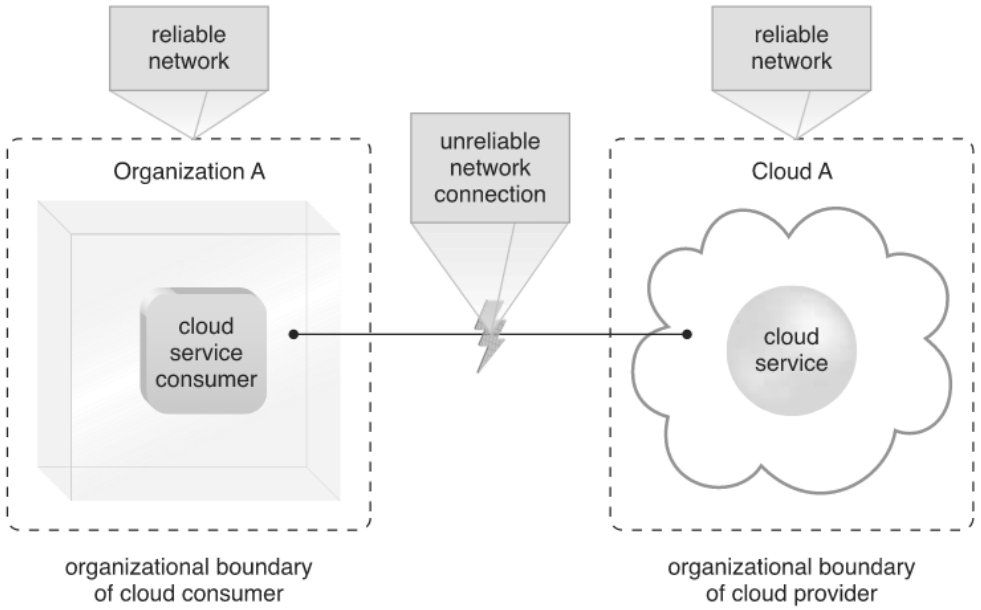
- The cloud approach might have disadvantages, when compared with the traditional approach
- Such disadvantages represent, on one side, challenges for cloud providers to support a wider range of use-cases, on the other, risks for cloud consumers
- **Network cost**: cloud computing requires constant network connectivity to access the service. This introduces an additional cost for network bandwidth.
- **Network Bandwidth**: Although the cost of network access can be affordable, network bandwidth can be limited. When applications that deal with critical and huge volume or data sets are considered, the network might represent a bottleneck, thus limiting the adoption of the cloud in such use-cases.

Challenges/Risks

- **Limited Portability**: standardization of cloud computing technologies is still limited. We are far from having a broad and well-recognized standard. Different cloud computing providers have different solutions that are proprietary and interoperable each other. A service developed to run on the infrastructure of a cloud provider can hardly run on a different infrastructure. Such vendor lock-in limits portability of cloud applications.
- **Legal Issues**: Cloud computing providers build their data centers at locations of their convenience, both geographical and economical. The storage location of cloud consumer's data might be outside their country region. Since privacy or compliance rules generally differ from country to country, multi-regional legal issues can arise. For instance, some countries require that sensitive data (e.g. medical records) are stored in the same country of users, thus arising multi-regional legal issues when this type of data is involved.

Data Security

- In cloud computing users and enterprises need to offload and store their data outside their organizational boundaries
- Data is **transmitted** over a network potentially unreliable/untrusted (the internet) and eventually is **stored** in the infrastructure of the cloud provider that is usually considered reliable/trusted
- *Different trust boundaries* are involved, compared with the traditional approach that involved only one single organizational boundaries



Data Security

- The transmission of the data over an unreliable network connection requires security mechanisms (e.g. data encryption) to be employed
- Building confidence among consumers about the security of user/enterprise data stored outside their own network boundary is a big challenge for cloud providers
- Reduced control over cloud governance may also bother cloud computing consumers