**Cloud Computing:**

**Bit of history:**

Cloud computing is an evolution in technologies. In 1960s to 1980 we experienced the rise of time sharing, which allowed the user to use the resources more conveniently [1]. And then we experienced the distributed computing at around 1980s [2]. Client server was introduced late 1980s and then the next step towards the evolution was the introduction of cloud computing. The term cloud computing was popularized by Amazon.com around 2006 [3]. After that many big companies started to invest in it.

Cloud computing is the revolution in IT which changed the way we consume computer services. For the past few years cloud computing has made computing to be much more efficient and cost effective. Many companies have saved millions of money by using the services of the cloud computing. Cloud computing leverage the services of the remote systems.

Users don’t need to pay any more than the services that they are using. It helps the companies to minimize the cost for computing and use that capital in other areas.

**Categories:**

By the National Institute for Standards in Technology (NIST) cloud computing has these characteristics:

* On-demand self-service.
* Ubiquitous network access.
* Resource pooling.
* Rapid elasticity.
* Pay-per-use.

Additionally they define these delivery models:

* SaaS (Software as a service).
* PaaS (Platform as a service).
* IaaS (Infrastructure as a service).

Three different deployment model:

* Private Cloud.
* Public Cloud.
* Hybrid Cloud. [4]

**Internet of Things (IOT):**

**Bit of history:**

It was early 1970s when the idea of IOT was began. At that time scientists saw the potential in the field of inter connected things. They used the phrase “pervasive computing”. It was 1999 when Kevin Ashton who was working with radio frequency identification, those were small chips that someone could place to any item or animals, and could track that item. He realized the potential in using RFID. He then used the phrase “Internet of Things”, it was the concept of a huge structure where things on the internet interconnect over sensors.

Internet of Things or IOT is simply an addition to the present Internet which is furthered into the physical world, into things. IOT has been a buzz word among the industries and researchers since it was officially published in 2005. [5]

IOT is now taking over all the technology departments. The amount of devices are increasing at a huge number. It is estimated that by the year 2020 there will be around 50 billion devices [6]. The global market value of IOT is to reach 7.1 trillion dollar by the year of 2020 [7]. As we can see that this technology is changing the world rapidly. In every sectors of our civilization is now touched by this technology. From medical to transportation and to logistics IOT is used everywhere.

IOT can be fragmented into two sections, B2C- business to consumer IOT and B2B- business to business IOT. B2C is customer IOT, where B2B is commercial IOT. In IOT there are three types of products. Namely- smart, connected, and IOT products. In IOT there is a front end. That is for the users. There is a back end for admin touch points. And in between, we have enabling infrastructure.

**IOT components:**

**People**: People who energies the Internet of Things

**Infrastructure**: It is the backbone of internet.

**Things**: These are sensors, home automation, cameras etc.

**Data**: Other devices receive data after all the data collection.

**Processes**: It bring about the way all these components work together.

**Fog Computing:**

**Bit of history:**

The necessity for extend cloud computing with the help of fog computing appeared around 2012, for coping with increasing number of IOT devices and big data volumes in order to support real-time and low-latency applications. [8]

In 2015, Cisco Systems, [Princeton University](https://en.wikipedia.org/wiki/Princeton_University), [Microsoft](https://en.wikipedia.org/wiki/Microsoft), [Intel](https://en.wikipedia.org/wiki/Intel), [ARM Holdings](https://en.wikipedia.org/wiki/ARM_Holdings) and [Dell](https://en.wikipedia.org/wiki/Dell) founded the “[OpenFog Consortium](https://en.wikipedia.org/wiki/OpenFog_Consortium)”, for promoting interests and development in the field of fog computing. [Helder Antunes](https://en.wikipedia.org/wiki/Helder_Antunes), Cisco Sr. Managing-Director is the consortium's chairman and from Intel, its Chief IOT Strategist Jeff Fedders is the first president. [9]

The term fog in computer science is an architecture that extends services offered by the cloud to edge devices. Fog is seen as a new cloud and many believe it is here to replace the cloud but really it's just an evolution or an extension of cloud. One thing, the term edge devices these are routers, switches WAN and LAN devices basically these are the entry point into the network. Fog allows us to carry out our storage communication and application services at a distributed level. If we want to put it in simpler terms fog is cloud plus Internet of Things.

In cloud we have some issues like dependency on the internet causing latency, limited bandwidth causing delays, security issues due to failing data protection mechanisms and requirement of high-speed Internet connectivity and that is where fog comes in. Fog doesn't work on a cloud it works on a network edge so it's faster. In cloud architecture devices were directly connected to the data center or cloud. Now we have fog in the middle to bring the

Internet of Things to life by delivering distributed computing capabilities and enabling creation of an intermediate layer between the things and the cloud. Fog basically supports Internet of Things applications and in today's world of cutting edge technology we have integrated Internet of Things into our lives. Every aspect of our lives is now monitored by this technology.

Cloud storage is the backbone of Internet of Things and now we are storing gigantic amount of expanded data, the future of big data is proceeding towards edge computing. Behind this new technology is to build a better operational connectivity between a server core and remote application reader sitting at the farthest point which we call the edge.

Fog supports Internet of Things applications that demand real-time response, especially as fog is closer to the end-user and it supports mobility at the same time. Fog has less demand for internet bandwidth because data is aggregated at certain points instead of sending over cloud channels so it's faster. It has location awareness it supports stability and there's very low delay.

We can also use distribute sensors or activator networks like the ones used for smart cities. Fog also allows for environmental and monitoring control. The best thing about fog is it adds security to the cloud so there is very low probability that an attack on data can occur.

**\*\*\* this section is needed, as it goes with the main concept.\*\*\***

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The internet of things is expanding and creating opportunities in many different areas and will shape new business models that meet customers' needs. Opportunities, productivity and growth all rely on data. Devices in the IOT are constantly gathering data. After collection, they send the data to the cloud, which is a network of servers in another location providing centralized resources such as computation and storage.

Businesses use a good deal of the data gathered for statistical analysis, forecasting and data analytics. The cloud is a resource somewhere else, and the problem with the cloud is simply distance. Cloud servers have the power to process and mine large data sets but are too far away to process data and respond in real time. Because of the distance, the cloud model can be a problem in environments where operations are mission-critical or internet connectivity is less than ideal.

An optimal solution is to distribute the computing requirements and bring processing closer to the edge of the network, reducing the amount of data that is sent to the cloud for processing and analysis. There is a huge value in having access to real-time information and analytics from device-generated data, which helps businesses to make critical split-second decisions. Bringing computing resources and application services closer to the edge is fog computing.

Fog computing is the combination of hardware and software solutions that decentralizes the cloud, monitors and analyzes real-time data from network-connected things and then takes action. The fog reduces data-analysis time from minutes to seconds. Situations where milliseconds can have fatal consequences require high-speed data processing such as diagnosis and treatment of patients or vehicle-to-vehicle communication to prevent collisions and accidents.

I'm at the OpenFog Consortium, which is a group of developers, manufacturers and software companies that share ideas on how to expand the use of the fog for the internet of things ecosystem. Fog computing supplements the cloud and will continue to expand as it improves efficiency and reduces the amount of data processed by the cloud.