Cyber Threats for IOT and Cloud

CSE2040

Module - 1

Introduction to IOT and Cloud Computing

Presidency University, Bengaluru

PRESIDENCY UNIVERSITY

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Introduction to IOT

Basic Definitions

- IoT stands for *Internet of Things*.
- It refers to the interconnectedness of ***Physical Devices***, such as *appliances and vehicles*, that are *embedded with Software, Sensors, and Connectivity* which enables these objects *to connect and exchange data*.
- This technology allows for the **collection** and **sharing of data** from a vast network of devices, creating opportunities for more efficient and automated systems.
- The **Internet of Things** describes **devices** *with sensors, processing ability, software* and other *technologies* that connect and **exchange data** with other devices and systems over the Internet or other communications networks.
- The **Internet of things** encompasses electronics, communication and computer science engineering.

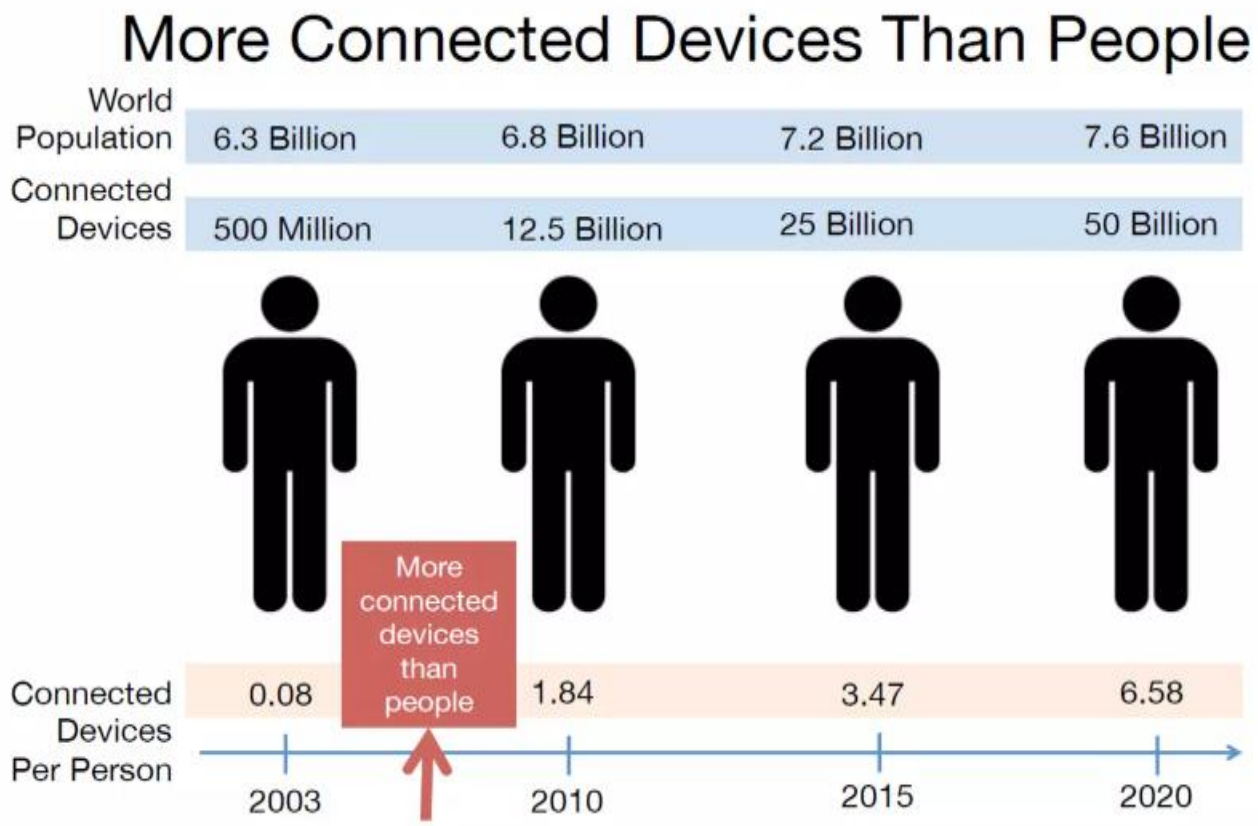
- IOT is a system of interrelated things, *computing devices, mechanical and digital machines, objects, animals, or people* that are provided with unique identifiers.
- In the upcoming years, IoT-based technology will offer advanced levels of services and practically change the way people lead their ***daily lives***.
- Advancements in *medicine, power, agriculture, smart cities, and smart homes* are just a few of the categorical examples where IoT is strongly established.

Unit 1.2 Genesis of IoT

Download

- Genesis of IoT: This section highlights IoT's place in the evolution and development of the Internet.
- The age of IoT is often said to have started between the years 2008 and 2009.
- During this time period, the number of devices connected to the Internet eclipsed the world's population.
- With more "things" connected to the Internet than people in the world, a new age was upon us, and the Internet of Things was born.
- The person credited with the creation of the term "Internet of Things" is Kevin Ashton.

- **Genesis of IoT:**
  - **The age of IoT is started in 2008 and 2009. In these years, more "things" connected to the Internet than people in the world.**



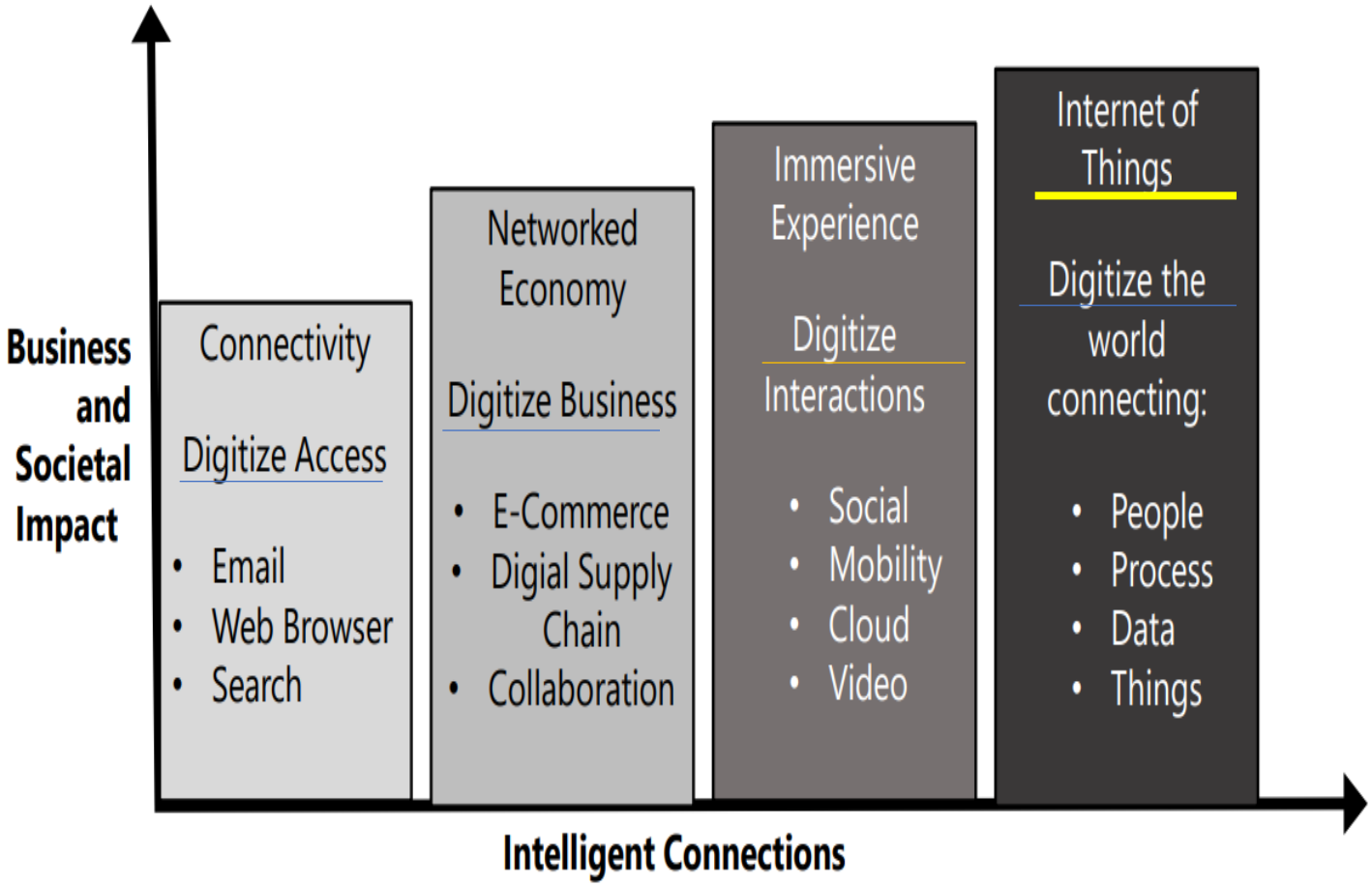
[Source: Cisco IBSG, April 2011]

- Kevin's Explanation:
- IoT involves the addition of senses to computers.
- *In the 20th centaury, computers were brains without senses.*
- *In the 21st centaury, computers are sensing* things for themselves.

1.2 Genesis of IoT

- While working for Procter & Gamble in 1999, Kevin used this phrase to explain a new idea related to linking the company's supply chain to the Internet.
- Kevin has subsequently explained that IoT now involves the addition of senses to computers. He was quoted as saying: "In the twentieth century, computers were brains without senses they only knew what we told them."
- Computers depended on humans to input data and knowledge through typing, bar codes, and so on. IoT is changing this paradigm; in the twenty-first century, computers are sensing things for themselves.

Evolutionary Phases of the Internet



History of IOT

- 1982- Vending machine
- 1990-Toaster
- 1999-IOT(Kevin Ashton)
- 2000-LG Smart Fridge
- 2004-Smart Watch
- 2007-Smart i phone
- 2009-Car Testing
- 2011-Smart TV
- 2013-Google Lens
- 2014-Echo
- 2015-Tesla autopilot

Four Key Components of IOT

- Device or Sensor
- Connectivity
- Data processing
- Interface

Characteristics of IoT

- **Intelligence**
- **Connectivity**
- **Dynamic Nature**
- **Architecture**
- **Sensing**
- **Heterogeneity**
- **Security**

What is a heterogeneous device?

This is a network where the devices are made by different manufacturers, or the computers run different operating systems. Two common examples of Heterogeneous Networks are the Internet, and the cell phone networks, both of which, you're likely familiar with.

Benefits of IoT

IoT offers a number of benefits to organizations, enabling them to:

1. Monitor their overall business processes;
2. Improve the customer experience;
3. Save time and money;
4. Enhance employee productivity;
5. Integrate and adapt business models;
6. Make better business decisions; and
7. Generate more revenue.

Advantages of IoT

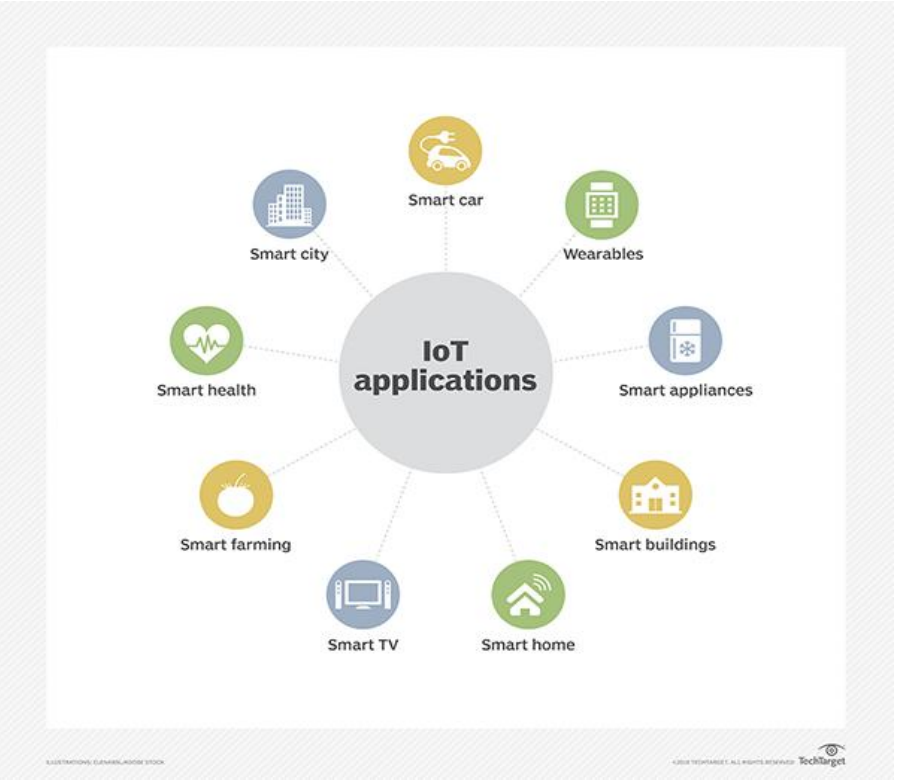
- Improved efficiency and automation of tasks.
- Increased convenience and accessibility of information.
- Better monitoring and control of devices and systems.
- Greater ability to gather and analyze data.
- Improved decision-making.
- Cost savings.

Disadvantages of IoT

- Security concerns and potential for hacking or data breaches.
- Privacy issues related to the collection and use of personal data.
- Dependence on technology and potential for system failures.
- Limited standardization and interoperability among devices.
- Complexity and increased maintenance requirements.
- High initial investment costs.
- Limited battery life on some devices.
- Concerns about job displacement due to automation.
- Limited regulation and legal framework for IoT, which can lead to confusion and uncertainty.

Modern Applications

- Smart Grids and energy saving
- Smart cities
- Smart homes/Home automation
- Healthcare
- Earthquake detection
- Radiation detection/hazardous gas detection
- Smartphone detection
- Water flow monitoring
- Traffic monitoring
- Wearables
- Smart door lock protection system
- Robots and Drones
- Healthcare and Hospitals, Telemedicine applications
- Security
- Biochip Transponders (For animals in farms)
- Heart monitoring implants (Example Pacemaker, ECG real time tracking)
- Agriculture
- Industry



List of Commonly used Sensors in the Internet of Things (IoT) Devices

1. Temperature Sensor
2. Pressure Sensor
3. Proximity Sensor
4. Accelerometer and Gyroscope Sensor
5. IR Sensor
6. Optical Sensor
7. Gas Sensor
8. Smoke Sensor

Alcohol Sensor

Ultrasonic Sensor

IR optical Sensor

LDR Sensor

Gas Sensor

Gyroscope Sensor

Different types of Sensors

Iot4beginners

Rain Sensor

Sense Hat

Photo Diode

IR proximity Sensor

Proximity Sensor

PIR Sensor

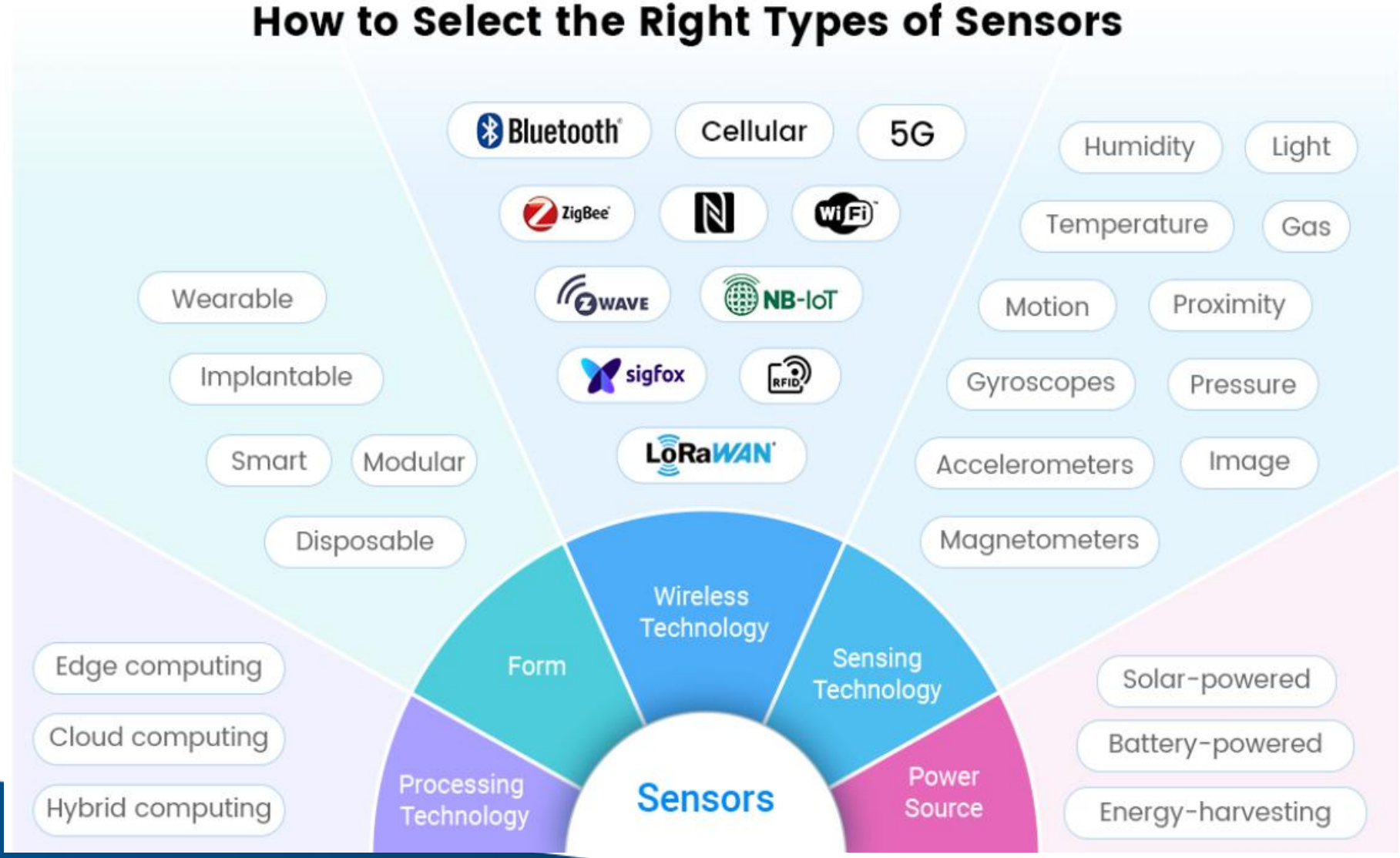
https://www.mokosmart.com/types-of-sensors-in-iot/

https://iot4beginners.com/commonly-used-sensors-in-the-internet-of-things-iot-devices-and-their-application/

Different types of Sensors

- **Temperature Sensors** – A temperature sensor is a device that detects and measures hotness and coolness and converts it into an electrical signal.
- **Image Sensors** – An **image sensor** or imager is a sensor that detects and conveys information used to form an image.
- **Gyro Sensors** – also known as angular velocity sensors, can detect changes in rotation angle per unit of time.
- **Obstacle Sensors** – An obstacle detection system uses ultrasonic sensors mounted on the front and/or rear bumpers.
- **RF Sensor** – Radio frequency sensors are devices that are wired to meters and display power measurements.
- **IR (Infrared) Sensor** – IR sensors are now widely used in motion detectors, which are used in building services to switch on lamps or in alarm systems to detect unwelcome guests.
- **LDR Sensor** – Light Dependent Resistor - An LDR is a resistor whose resistance changes as the amount of light falling on it changes.
- **Ultrasonic Distance Sensor** – As the name indicates, ultrasonic / level sensors measure distance by using ultrasonic waves.

How to Select the Right Types of Sensors



TYPE	FEATURE	APPLICATIONS
Temperature	High accuracy, wide measurement range, easy to use	HVAC systems, food processing, medical equipment
Pressure	Accurate, reliable, suitable for various applications	Aviation, industrial processes
Humidity	Accurate, suitable for various environments	HVAC systems, food processing
Light	High sensitivity, fast response time, low power consumption	Consumer electronics, security systems, automotive lighting
Motion	Accurate	Gaming, security systems
Gas	Sensitive, detect multiple gases simultaneously	Environmental monitoring, safety systems
Proximity	High accuracy	Automotive, robotics
Flow	Accurate, reliable	Industrial processes, automotive fuel systems
Position	Accurate, reliable	Aerospace, navigation systems
Image	High resolution, wide field of view, can capture both still images and video	Photography, surveillance, medical imaging
Accelerometer	Accurate, low power consumption, detect linear acceleration	Motion sensing in consumer electronics, automotive safety systems
Gyroscope	High accuracy, detect angular velocity and orientation	Robotics, navigation systems, gaming
Magnetometer	Accurate, detect magnetic fields	Navigation systems, aerospace

IoT and Digitization

- At a high level, IoT focuses on connecting "things" such as objects and machines, to a computer network, such as the Internet.
- Digitization encompasses the connection of "things" with the data they generate and the business insights that result.

Example: Wi-Fi devices in Malls detecting customers, displaying offers, based on the spends, mall is segregated, changes the location of product displays and advertising.

- Digitization: It is the conversion of information into a digital format.

- **IoT and Digitization**

Example:

1. Digital camera- No films used, mobile phones with camera.

Digitization of photography changed experience of capturing images.

2. Video rental industry and transportation , no one purchases video tapes or DVDs.

With digitization, everyone is streaming video content or purchasing the movies as downloadable files.

3. Transportation- Taxi Uber,Ola use digital technologies.

4.Home Automation – Popular product: Nest – sensors determine the climate and connects to other smart objects like smoke alarm, video camera and various third party devices.

Ex: Nest Learning Thermostat, Nest Protect and Nest Cam enable users to set heating, check in-house cameras and smoke levels from their smartphone or another Wi-Fi device.

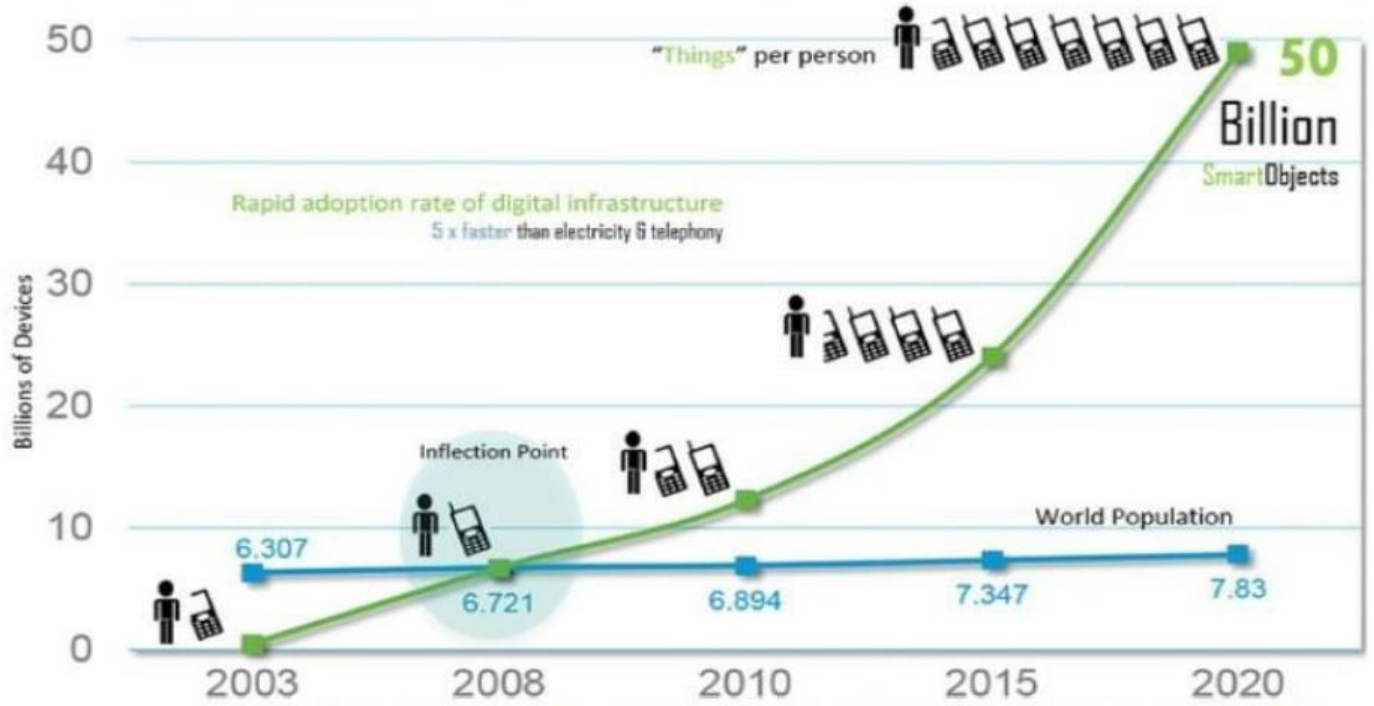
Unit - 1 : IoT Impact

IoT Impact

- About 14 billion or 0.06% of "things" are connected to the internet today.
- Cisco predicts in 2020 , it may go upto 50 billion and says this new connection will lead to $19 trillion in profit and cost savings.
- UK government says 100 billion objects may connected
- Managing and monitoring smart objects using real –time connectivity enables a new level of data-driven decision making.
- This results in optimization of systems and processes and delivers new services that save time for both people and business while improving the overall quality of life.

Unit - 1 : IoT Impact

- **IoT Impact**



Devices

The Rapid Growth in the Number of Devices Connected to the Internet

Year →

Unit - 1 : IoT Impact

- Connected Roadways- Google's Self Driving Car
- Connected Roadways is a term associated with both the drivers and driverless cars fully integrating with the surrounding transportation infrastructure.
- Basic sensors reside in cars monitor oil Pressure,tire pressure, temperature and other Operating conditions, provide data around Core car functions.

Google's Self-Driving Car

Unit - 1 : IoT Impact

- Connected Roadways

Current challenges being addressed by Connected Roadways

Challenge	Supporting Data
Safety	• 5.6 million crashes in 2012, 33,000 fatalities – US department of Transportation • IoT and enablement of connected vehicle technologies significantly reduces the loss of lives each year.
Mobility	• More than a billion cars on road worldwide. • Connected vehicle mobility application will give drivers more informed decisions which may reduce travel time. • Communication between mass transit, emergency response vehicle and traffic management help optimizing the routing of vehicle resulting in reducing in travel delays further.

Unit - 1 : IoT Impact

- Connected Roadways

Current challenges being addressed by Connected Roadways

Challenge	Supporting Data
Environement	• Each year, Transit System will reduce CO_2 emission s by 16.2 million metric tons by reducing private vehicle miles- American Public Transportation Association • Connected Vehicle Environmental Application will give all travels the real time information to make "green transportation" choice.

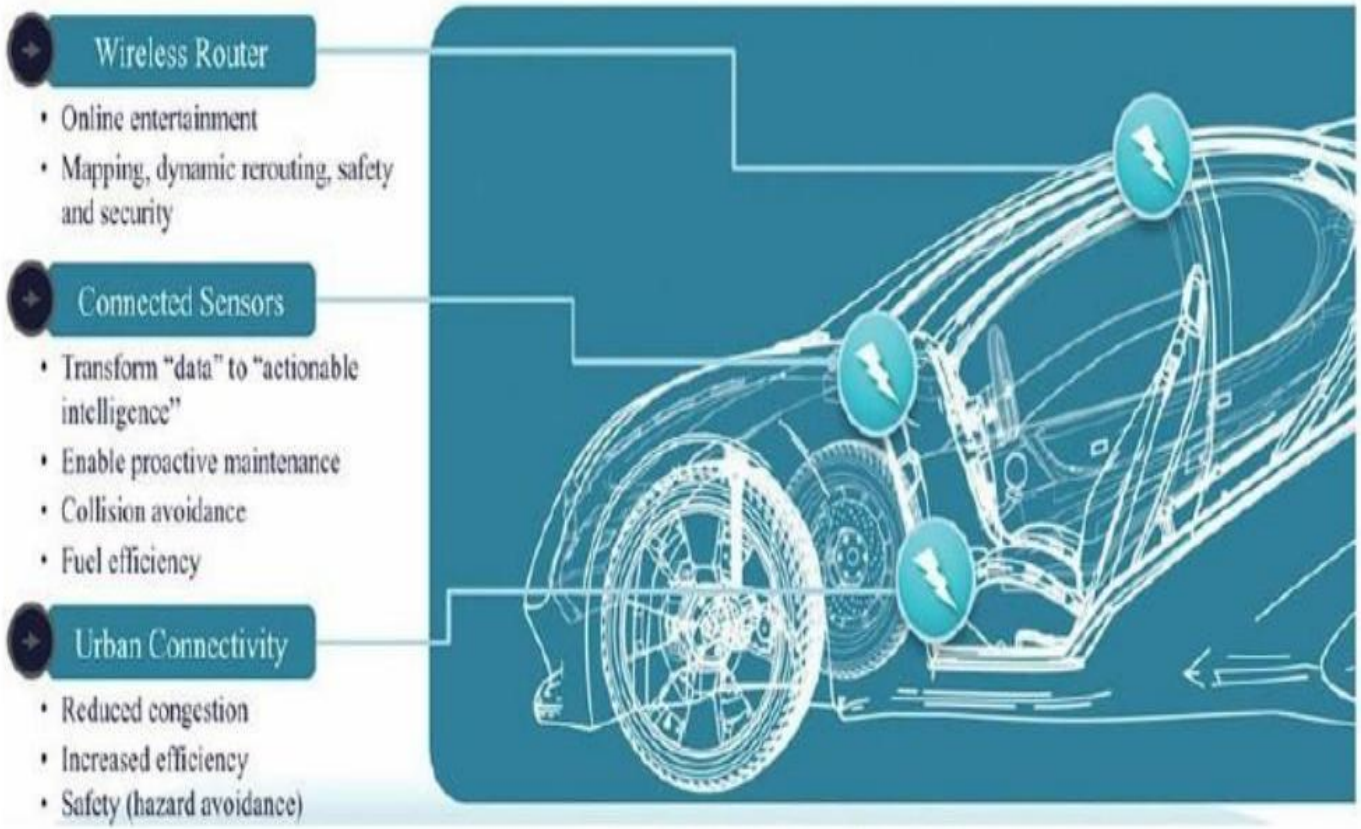
Unit - 1 : IoT Impact

- **The Connected Car**

With automated vehicle tracking, a vehicle 's location is used for notification of arrival times, theft prevention or high way assistance.

-Cargo Management

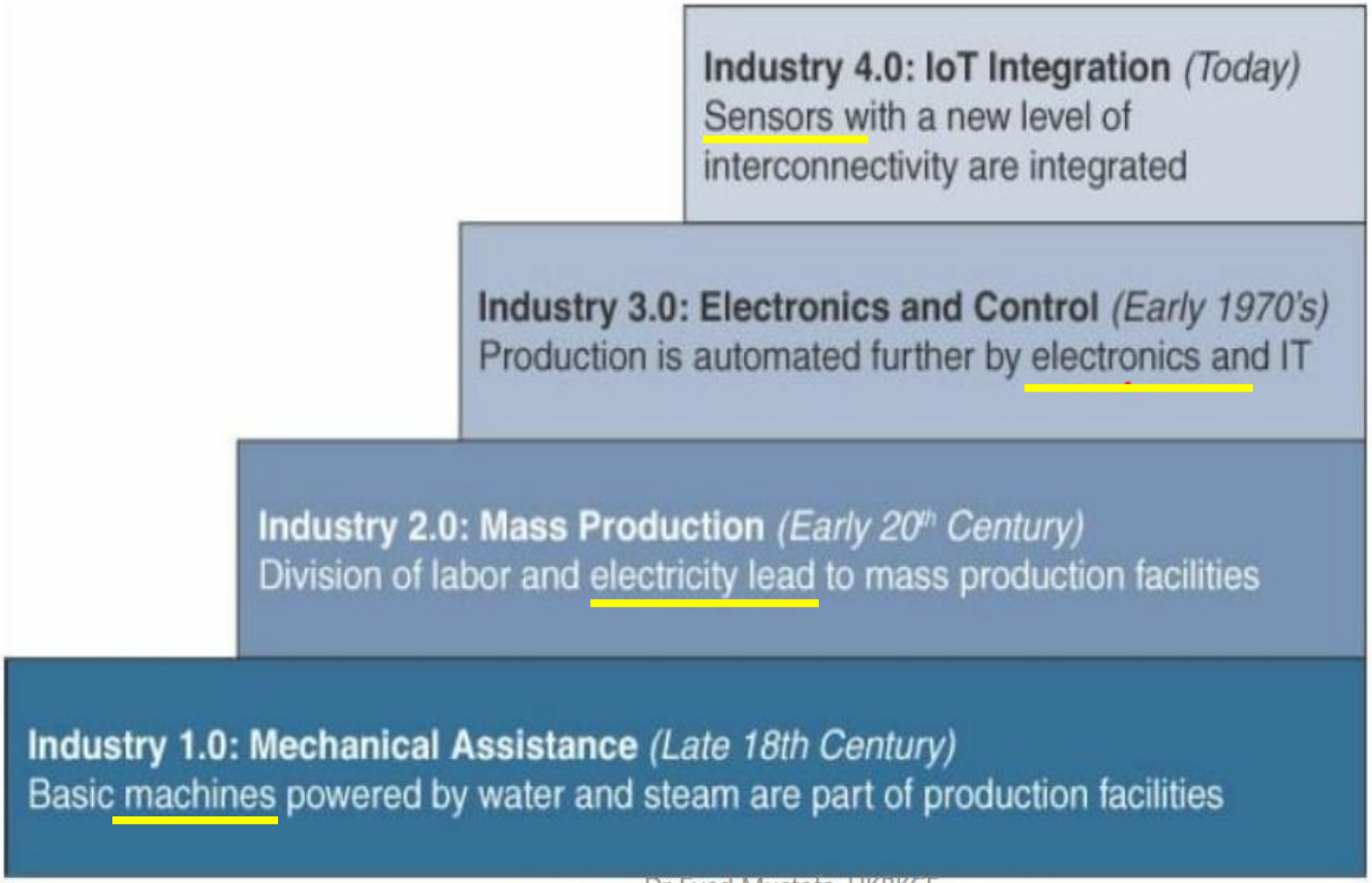
-fully connected car will generate >25GB data/hour



The Connected Car

Unit - 1 : IoT Impact

➢ The Four Industrial Revolution



The Four Industrial Revolutions

Unit - 1 : IoT challenges

➢ IoT challenges

Challenge	Description
Scale	• IT networks scale is larger, The scale of OT is several orders of magnitude larger. • Example: Electrical Company has deployed tons of millions meters in service area where they employed tens of thousands of employees for acting as IP Node using IP v6. • i.e the scale of network, the utility is managing has increased by more than 1000 fold.
Security	• With more "things" connected with other "things" and people security is an increasingly complex issue for IoT. Threat surface is greatly expanded and if device gets hacked, its connectivity is a major concern. • A Compromised device can serve as a launching point to attack other devices and systems.
Privacy	• A sensor become more prolific in every day lives, the data what they gather will be specific to individuals and their activities. • Example: Health information , Shopping patterns, transactions at retail establishments. • For Businesses, the data has monetary value. • Organization discusses about who owns the data and how individuals can control whether it is shared and with whom.

https://www.youtube.com/watch?v=WTHK6SRMLoo

Unit - 1 : IoT challenges

➢ IoT challenges

Challenge	Description
Big Data and Data Analytics	• IoT and large number of sensors are going to trigger deluge of data that must be handled. • This data will provide critical information and insights if it can be processed in an efficient manner. • Challenge is evaluating massive amounts of data arriving from different sources in various forms and doing so in a timely manner.
Interoperability	• As with nascent technology, various protocols and architectures are jockeying for market share and standardizations within IoT. • Some of these protocols and architectures are based on proprietary elements and others are open. • Recently IoT Standards are helping minimize this problem, but there are often various protocols and implementations available for IoT networks.

IOT Architecture and protocols

- The architecture of IoT depends upon its functionality and implementation in different sectors. Still, there is a basic process flow based on which IoT is built.

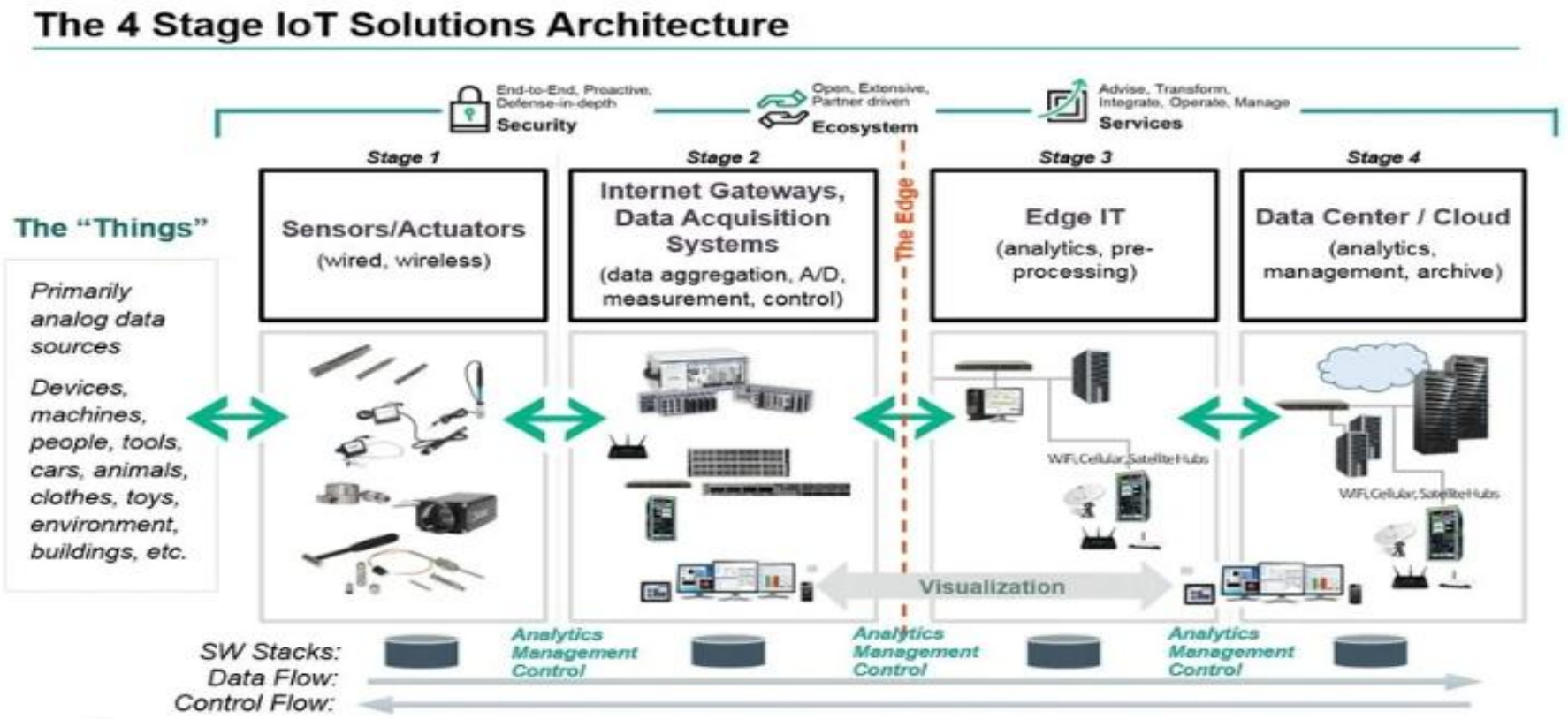


Fig: 4 Stage IoT architecture

https://forgeahead.io/blog/what-are-the-4-stages-of-iot-architecture/

4 Stages of IOT Architecture

1. **Sensing Layer –**

   The sensing layer is the first layer of the IoT architecture and is responsible for collecting data from different sources. This layer includes sensors and actuators that are placed in the environment to gather information about temperature, humidity, light, sound, and other physical parameters. These devices are connected to the network layer through wired or wireless communication protocols.

2. **Network Layer –**

   The network layer of an IoT architecture is responsible for providing communication and connectivity between devices in the IoT system. It includes protocols and technologies that enable devices to connect and communicate with each other and with the wider internet. Examples of network technologies that are commonly used in IoT include WiFi, Bluetooth, Zigbee, and cellular networks such as 4G and 5G. Additionally, the network layer may include gateways and routers that act as intermediaries between devices and the wider internet, and may also include security features such as encryption and authentication to protect against unauthorized access.

An actuator is a device that converts energy into motion.

3. **Data processing Layer –**

The data processing layer of IoT architecture refers to the software and hardware components that are responsible for collecting, analyzing, and interpreting data from IoT devices. This layer is responsible for receiving raw data from the devices, processing it, and making it available for further analysis or action.The data processing layer includes a variety of technologies and tools, such as data management systems, analytics platforms, and machine learning algorithms. These tools are used to extract meaningful insights from the data and make decisions based on that data.**Example** of a technology used in the data processing layer is a data lake, which is a centralized repository for storing raw data from IoT devices.

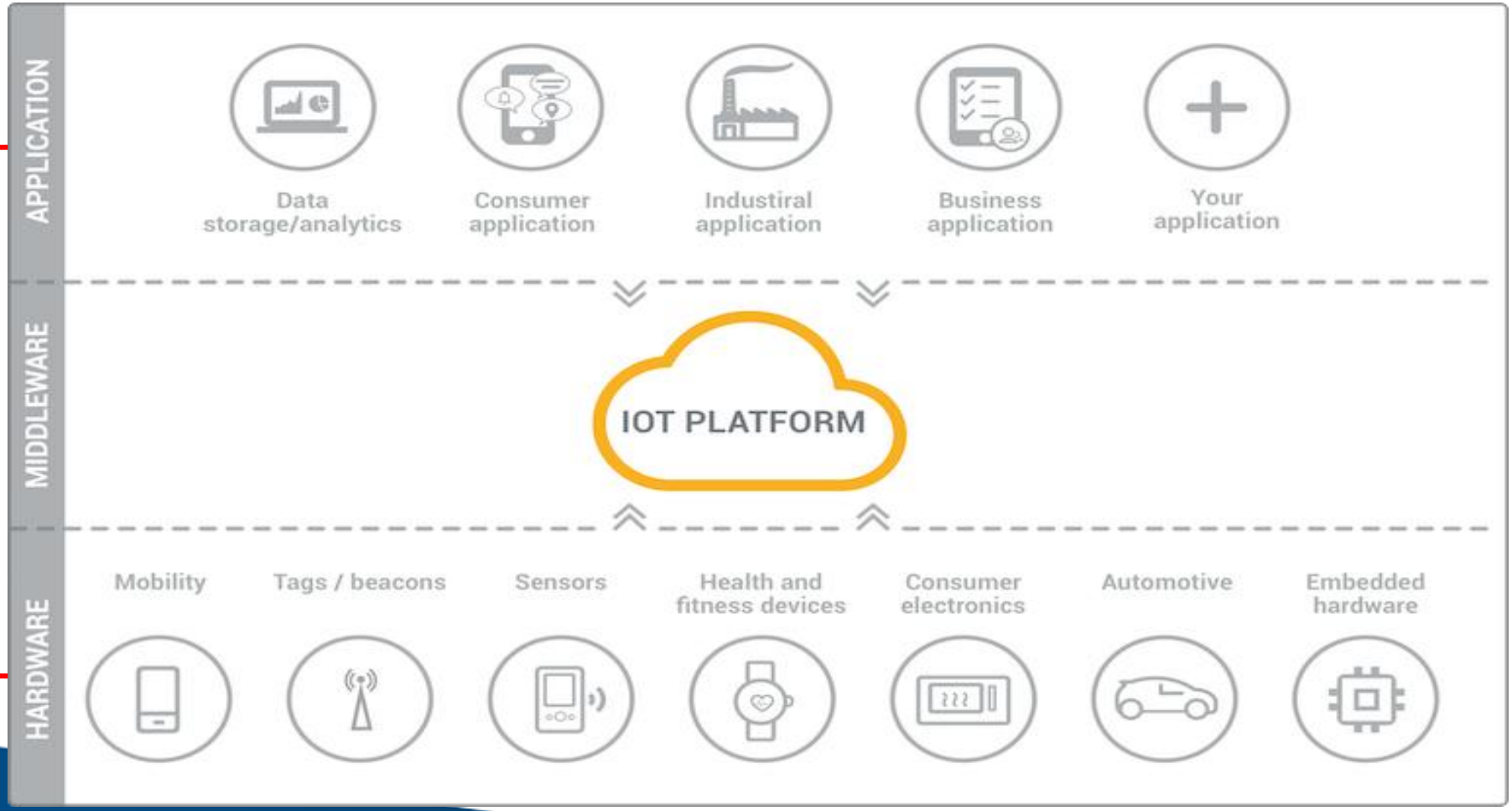
4. **Application Layer –**

The application layer of IoT architecture is the topmost layer that interacts directly with the end-user. It is responsible for providing user-friendly interfaces and functionalities that enable users to access and control IoT devices.This layer includes various software and applications such as mobile apps, web portals, and other user interfaces that are designed to interact with the underlying IoT infrastructure. It also includes middleware services that allow different IoT devices and systems to communicate and share data seamlessly.The application layer also includes analytics and processing capabilities that allow data to be analyzed and transformed into meaningful insights. This can include machine learning algorithms, data visualization tools, and other advanced analytics capabilities.

IoT - Platform

- An IoT Platform fills the *gap between the Devices (sensors) and Application (network).*
- As in IoT, all the IoT devices are connected to other IoT **devices** and **Application** *to transmit* and *receive information* using protocols. There is a gap between the IoT device and IoT application.

IOT Platforms



- **Amazon Web Services (AWS) IoT platform:** Amazon Web Service IoT platform *offers a set of services* that *connect to several devices* and *maintain the security* as well. This platform collects data from connected devices and performs real-time actions.

- **Microsoft Azure IoT platform:** Microsoft Azure IoT platform *offers strong security mechanism*, *scalability* and *easy integration* with systems. It uses standard protocols that support bi-directional *communication between* **connected devices** and **platform**. Azure IoT platform has an Azure Stream ***Analytics that processes a large amount of information*** in real-time generated by sensors.

- **Google Cloud Platform IoT:** Google Cloud Platform is a global cloud platform that ***provides*** a solution **for IoT devices and applications**. It handles a ***large amount of data using Cloud IoT Core by connecting various devices***. It allows to apply BigQuery analysis or to apply Machine learning on this data.

Some of the **features** provided by Google Cloud IoT Platform are:

- Cloud IoT Core
- Speed up IoT devices
- Cloud publisher-subscriber
- Cloud Machine Learning Engine

- **IBM Watson IoT platform:** The IBM Watson IoT platform enables the ***developer to deploy*** the ***application*** and ***building IoT solutions*** quickly. This platform provides the **following Services as;**
- Real-time data exchange, Device management, Secure Communication, Data sensor and weather data services

- **Artik Cloud IoT platform:** Artik cloud IoT platform is **developed by Samsung** to enable devices *to connect to cloud services*.
- It has a set of ***services*** that continuously **connect devices to the cloud** and start gathering data. It stores the incoming data from connected devices and combines this information.
- This platform contains a set of connectors that connect to third-party services.

Real-Time examples of IoT

Real life examples of IoT

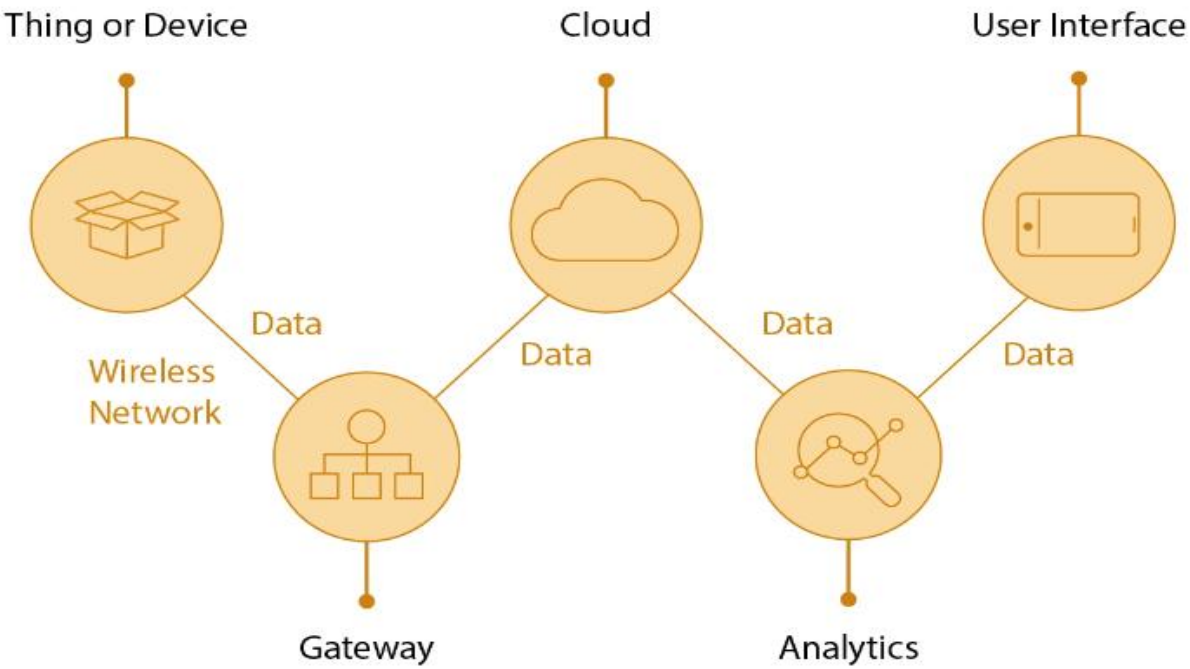
From sources across the web

- Smart cities
- Smart homes
- Connected car
- Home security
- Transportation
- Industrial Internet
- Autonomous vehicles
- Agricultural IoT
- Wearables
- Smart home
- Agriculture
- Smart cars
- Automation
- Predictive maintenance
- Mimo monitor
- Industrial Safety
- Healthcare
- Retail
- Energy
- Smart grid
- Healthcare IoT
- Smart supply chain
- Smart lights
- IoT data analytics

https://www.google.com/search?q=Real-Time+examples+of+IoT&sca_esv=602274207&sxsrf=ACQVn08mrGN62Y96h6wwnzO2PlRMnlFs8w%3A1706515301510&source=hp&ei=ZVu3ZZHxHPqovr0Pxpi-UA&iflsig=ANes7DEAAAAAZbdpdQ7uvGEi-0FV5f6Qqs6hXZHmpqZT&ved=0ahUKEwjRt-TykIKEAxV6lK8BHUaMDwoQ4dUDCA0&uact=5&oq=Real-Time+examples+of+IoT&gs_lp=Egdnd3Mtd2l6IhlSZWFsLVRpbWUgZXhhbXBsZXMgb2YgSW9UMgQQIxgnMgYQABgWGB4yBhAAGBYYHjIEAAYFhgeGA8yBhAAGBYYHjILEAAYgAQYigUYhgMyCxAAGIAEGIoFGIYDSLwJUABYAHAAeACQAQCYAYIBoAGCAaoBAzAuMbgBA8gBAPgBAvgBAQ&sclient=gws-wiz

IoT Components

Major Components of IoT



Things or Devices

- The key physical items being tracked are Things or Devices. Smart sensors are connected to things/devices which further continues ***to collect data from the device and send it to the next layer***, which is the portal or also called as the gateway, small smart sensors for a variety of applications are now possible because of new advancements in microelectronics.

Some commonly used Sensors are:

- **Temperature sensors and thermostats sensors**
- **Pressure sensors**
- **Humidity / Moisture level sensors**
- **Light intensity detectors sensors**
- **Moisture sensors**
- **Proximity detection sensors**
- **RFID tags sensors**

User Interface (UI)

- User interface also termed as UI is nothing but, a user-facing program that **allows** the user to monitor and manipulate data.
- The user interface (UI) is the visible, tangible portion of the IoT device that people can interact with. Developers must provide a well-designed user interface that *requires the least amount of effort from users* and promotes additional interactions.

Cloud

- **Cloud** storage is **used** ***to store the data*** *which has been collected from different devices or things.*
- **Cloud computing is simply a set of connected servers that** operate continuously(24*7) over the Internet.
- IoT devices, applications, and users generate massive amounts of data, which must be managed efficiently. Data collection, processing, management, and archiving are among the responsibilities of IoT clouds. The data can be accessed remotely by industries and services, allowing them to take critical decisions at any time.

Analytics

- After receiving the data in the cloud, that ***data is processed***.
- Data is analyzed here with the help of various algorithms like machine learning algorithms and all.
- Analytics is the conversion of analog information via ***connected sensors and devices into actionable insights that can be processed, interpreted, and analyzed in depth.***
- Analysis of raw data or information for further processing is a prerequisite for the monitoring and enhancement of the Internet of things (IoT).

IOT Communication

IoT communication

From sources across the web

WiFi

Bluetooth

Zigbee is a standards-based wireless technology developed to enable low-cost, low-power wireless machine-to-machine (M2M) and internet of things (IoT) networks.

LoRaWAN

Long Range Wide Area Network

wireless networks to connect low-power objects such as electricity meters and smartwatches,

RFID

Radio-frequency identification uses electromagnetic fields to automatically identify and track tags attached to objects. An RFID system consists of a tiny radio transponder, a radio receiver and transmitter.

Cellular

Message Queuing Telemetry Transport

Sigfox

Z-Wave

Z-Wave is a wireless communications protocol used primarily for residential and commercial building automation.

MQTT

It is designed for connections with remote locations that have devices with resource constraints or limited network bandwidth, such as in the Internet of Things.

Constrained Application ...

Ethernet

Ethernet is a family of wired computer networking technologies commonly used in local area networks, metropolitan area networks and wide area networks.

Intelligent devices

NFC

Near-field communication is a set of communication protocols that enables communication between two electronic devices over a distance of 4 cm or less.

IoT Communication

- **IoT is the connection** of devices over the internet, where these smart devices communicate with each other , exchange data , perform some tasks without any human involvement.
- These devices are embedded with **electronics, software, network** and **sensors** which help in communication.
- Communication between smart devices is very important in IOT as it enables these devices to gather, exchange data which contribute in success of that IOT product/project.

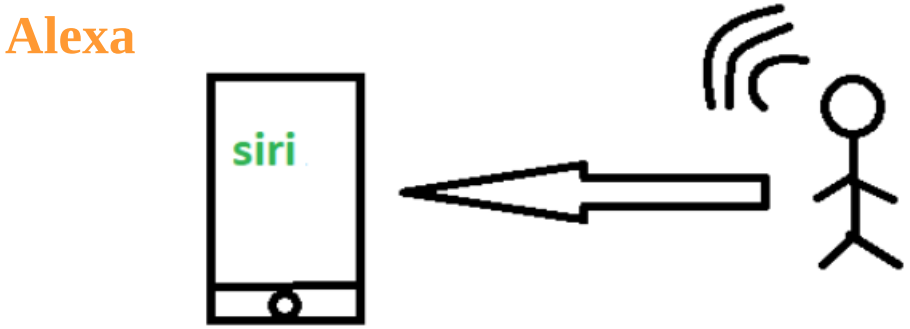
Types of Communications in IOT:

The following are some communication types in IoT:-

1. Human To Machine (H2M)
2. Machine To Machine (M2M)
3. Machine To Human (M2H)
4. Human To Human (H2H)

1. Human to Machine (H2M):

In this human gives input to IOT device i.e as speech/text/image etc. IOT device (Machine) like sensors and actuators then understands input, analyses it and responds back to human by means of text or Visual Display. This is very useful as these machines assist humans in every everyday tasks. It is a combo of software and hardware that includes human interaction with a machine to perform a task.



H2M communication

Merits: This H2M has a user-friendly interface that can be quickly accessed by following the instructions. It responds more quickly to any fault or failure. Its features and functions can be customized.

Examples:

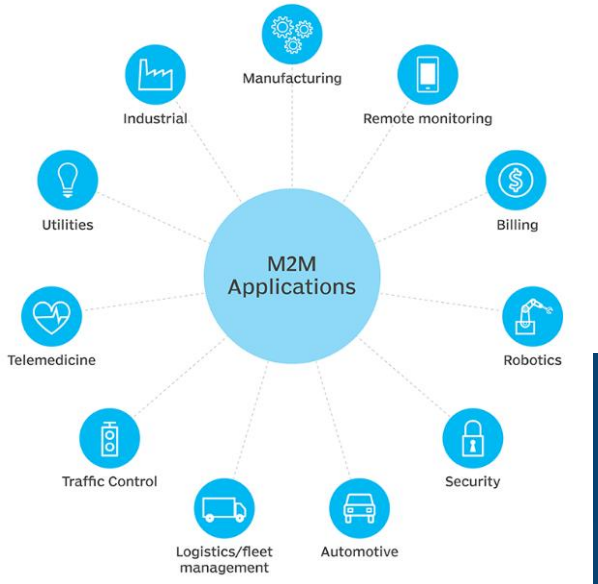
- Facial recognition.
- Bio-metric Attendance system.
- Speech or voice recognition.

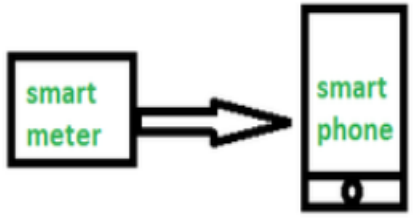
2. Machine to Machine (M2M):

The process of exchanging information or messages between two or more machines or devices is known as Machine to Machine (M2M) communication.

It is the communication among the physical things which do not need human intervention.

M2M communication is also named as Machine Type communication in 3GPP(3rd Generation Partnership Project). In this the interaction or communication takes place between machines by automating data/programs. In this machine level instructions are required for communication. Here communication takes place without human interaction. The machines may be either connected through wires or by wireless connection. An M2M connection is a point-to-point connection between two network devices that helps in transmitting information using public networking technologies like Ethernet and cellular networks. IoT uses the basic concepts of M2M and expands by creating large "cloud" networks of devices that communicate with one another through cloud networking platforms.



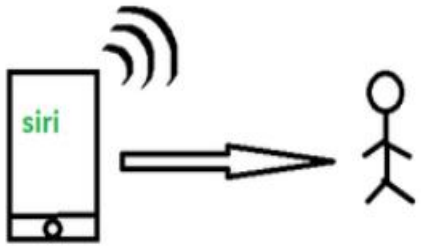


M2M communication

1.Common examples include ATM, smart home meters, vehicle telemetry services, asset tracking, wearable technologies, and automated supply chain management (SCM), Telemedicine.

3. Machine to Human (M2H) :

In this machine interacts with Humans. Machine triggers information(text messages/images/voice/signals) respective / irrespective of any human presence. This type of communication is most commonly used where machines guide humans in their daily life. It is way of interaction in which humans co-work with smart systems and other machines by using tools or devices to finish a task.



M2H communication

Examples

Examples:

- Fire Alarms
- Traffic Light
- Fitness bands
- Health monitoring devices

4. Human to Human (H2H) :

This is generally how humans communicate with each other to exchange information by speech, writing, drawing, facial expressions, body language etc. Without H2H, M2M applications cannot produce the expected benefits unless humans can immediately fix issues, solve challenges, and manage scenarios.

The process of exchanging information
or messages between two or more people is known as human to human (H2H) communication. This can be done through various means such as verbal,
non-verbal, or written communication.

H2H communication

Assignments

https://www.studocu.com/in/document/maharshi-dayanand-university/computer-science/assignment-1-internet-of-things-notes/30382718

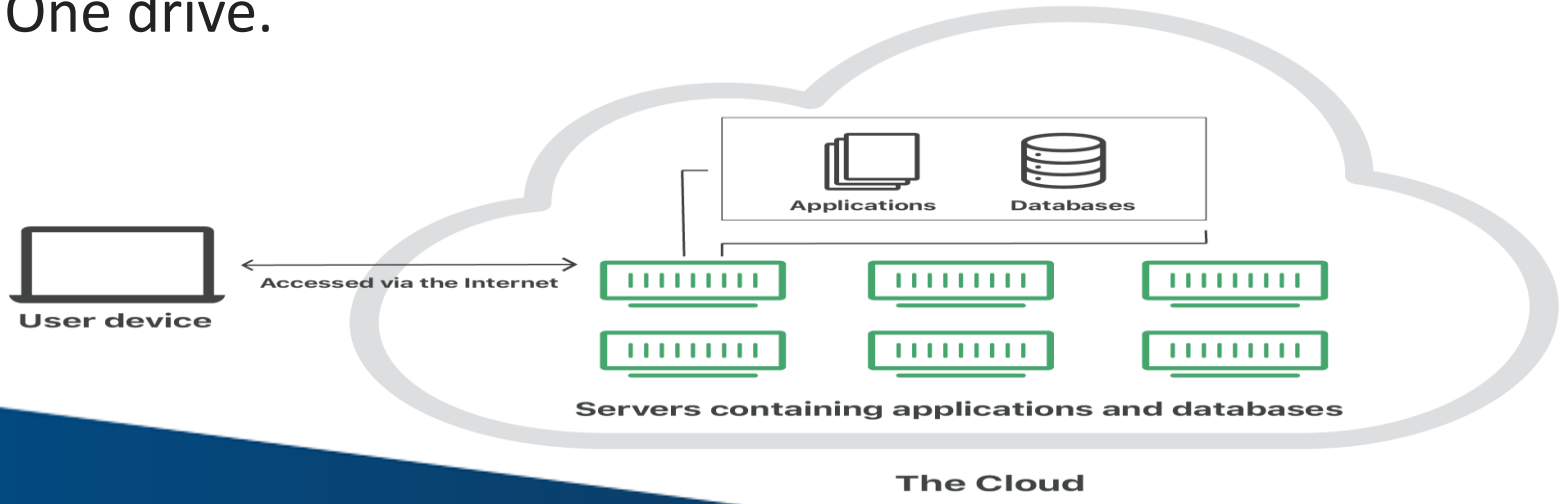
https://www.studocu.com/in/document/chaitanya-bharathi-institute-of-technology/basic-electronics/cloud-computing-assignment-questions/71586001

https://www.studocu.com/in/document/panjab-university/computer-science-and-engineering/cloud-computing-assignment/53564550

Introduction to Cloud Computing

Cloud

- "The **cloud" refers to servers** that are *accessed over the Internet,* and the *software* and *databases* that run on those servers.
- **Cloud Servers** are located in data centers all over the world.
- **Cloud storage** providers like Dropbox or Google Drive or One drive.



What is Cloud Computing

- Cloud Computing is the ***on-demand*** *availability of computer system resources*, especially ***data storage*** and ***computing power***, without direct active management by the user. Large clouds often have functions distributed over multiple locations, each of which is a data center.
- **Cloud Computing** is the delivery of different services through the ***Internet, including*** ***Data storage, Servers, Databases, Networking, and Software***.
- **Cloud storage** has grown increasingly popular among individuals ***who needs larger storage space*** and for businesses seeking an efficient off-site data back-up solution.

What Is Cloud Computing?

- **Cloud Computing** means **storing and accessing** the data and programs on remote servers that are hosted on the internet instead of the computer's hard drive or local server.
- Cloud computing is also referred to as Internet-based computing, it is a technology where the resource is provided as a service through the Internet to the user. The data that is stored can be files, images, documents, or any other storable document.

The following are some of the **Operations** that can be performed with **Cloud Computing**:

- Storage, backup, and recovery of data
- Delivery of software on demand
- Development of new applications and services
- Streaming Videos and Audio

What are Cloud Services?

- The **Resources** available in the Cloud are known as "*Services*," since they are actively managed by a Cloud Provider.

- **Cloud Services** include Infrastructure, Applications, Development Tools, and Data Storage among other products.
- These services are sorted into several different categories, or ***service models*.**

What is Cloud Computing Reference Model?

The cloud computing reference model is an abstract model that divides a cloud computing environment into abstraction layers and cross-layer functions to characterize and standardize its functions. This reference model divides cloud computing activities and functions into three cross-layer functions and five logical layers.

Each of these layers describes different things that might be present in a cloud computing environment, such as computing systems, networking, storage equipment, virtualization software, security measures, control and management software, and so forth. It also explains the connections between these organizations. The five layers are the Physical layer, virtual layer, control layer, service orchestration layer, and service layer.

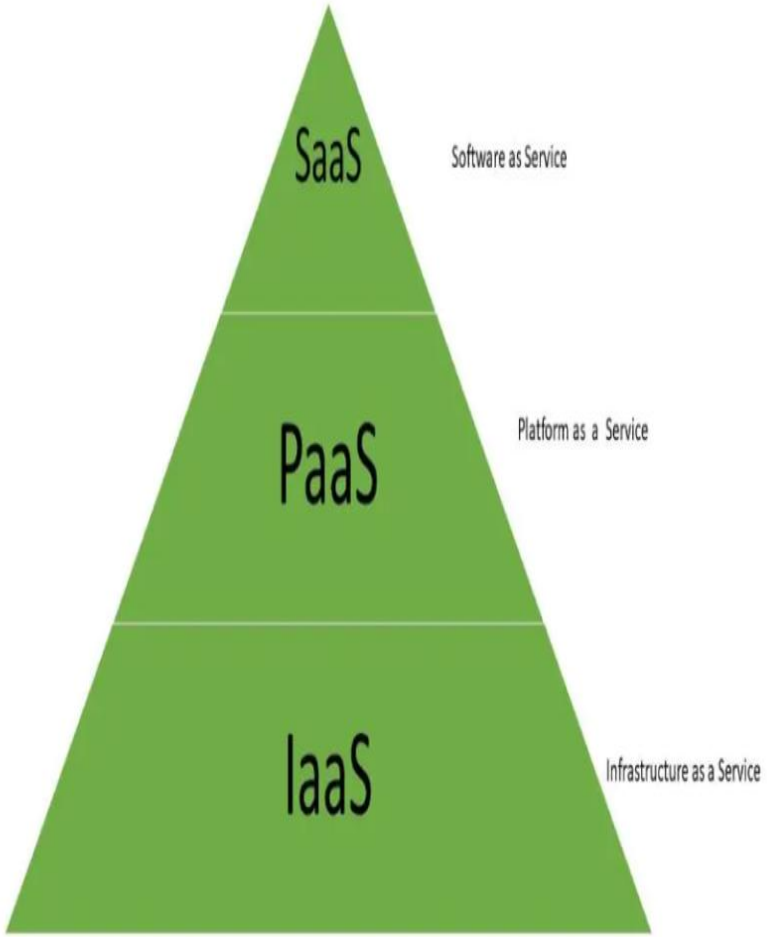
Cloud Computing reference model is divided into 3 major service models:

Types of Cloud Computing:

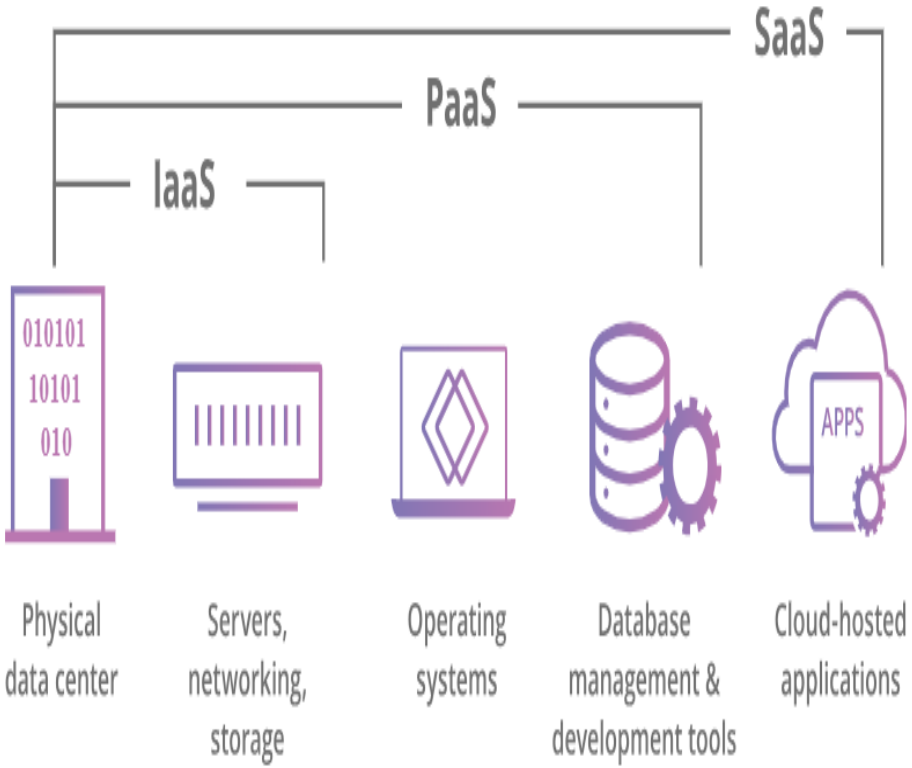
1. Software as a Service (SaaS)
2. Platform as a Service (PaaS)
3. Infrastructure as a Service (IaaS)

https://www.cloudflare.com/learning/cloud/what-is-the-cloud/

The below diagram explains the cloud computing reference model:



What are the main service models of cloud computing?



Software-as-a-Service (SaaS)

- Software-as-a-Service (SaaS) is a way of delivering services and applications over the Internet. Instead of installing and maintaining software, we simply access it via the Internet, freeing ourselves from the complex software and hardware management.

- It removes the need to install and run applications on our own computers or in the data centers eliminating the expenses of hardware as well as software maintenance.

- SaaS provides a complete software solution that you purchase on a **pay-as-you-go** basis from a cloud service provider. Most SaaS applications can be run directly from a web browser without any downloads or installations required.

- The SaaS applications are sometimes called **Web-based software, on-demand software, or hosted software.**

- **Advantages of SaaS**

1. **Cost-Effective:** Pay only for what you use.
2. **Reduced time:** Users can run most SaaS apps directly from their web browser without needing to download and install any software. This reduces the time spent in installation and configuration and can reduce the issues that can get in the way of the software deployment.
3. **Accessibility:** We can Access app data from anywhere.
4. **Automatic Updates:** Rather than purchasing new software, customers rely on a SaaS provider to automatically perform the updates.
5. **Scalability:** It allows the users to access the services and features on-demand.

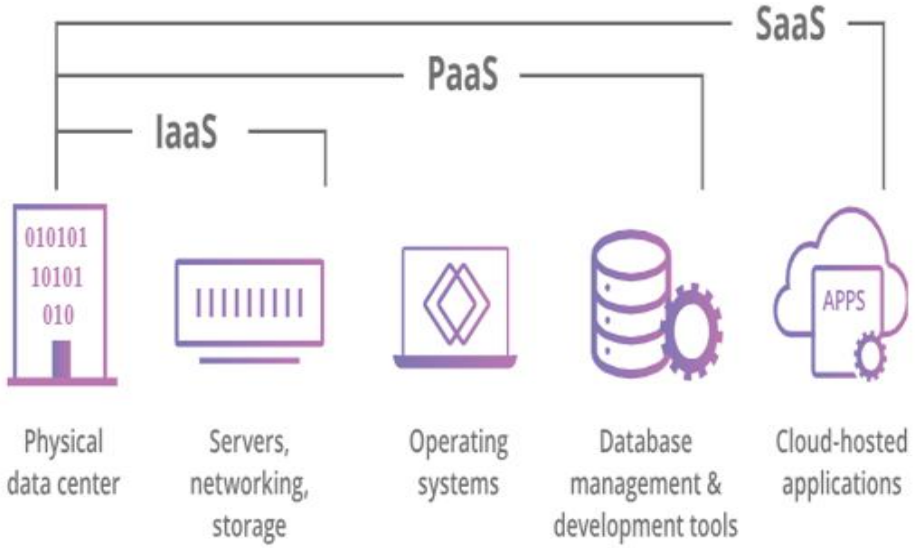
- **Disadvantages of Saas**

1. **Limited Customization**: SaaS solutions are typically not as customizable as on-premises software, meaning that users may have to work within the constraints of the SaaS provider's platform and may not be able to tailor the software to their specific needs.
2. **Dependence on Internet Connectivity**: SaaS solutions are typically cloud-based, which means that they require a stable internet connection to function properly. This can be problematic for users in areas with poor connectivity or for those who need to access the software in offline environments.
3. **Security concerns:** SaaS providers are responsible for maintaining the security of the data stored on their servers, but there is still a risk of data breaches or other security incidents.
4. **Limited control over data:** SaaS providers may have access to a user's data, which can be a concern for organizations that need to maintain strict control over their data for regulatory or other reasons.

Platform as a Service

- PaaS is a category of cloud computing that provides a platform and environment to allow ***developers to build applications and services*** over the internet. PaaS services are hosted in the cloud and *accessed by users* simply via their web browser.

- A PaaS provider hosts the hardware and software on its own infrastructure. As a result, PaaS frees users from having to install in-house hardware and software to develop or run a new application. Thus, the development and deployment of the application take place **independent of the hardware**.



- **Advantages of PaaS**

1. **Simple and Convenient for users:** It provides much of the infrastructure and other IT services, which users can access anywhere via a web browser.
2. **Cost-Effective:** It charges for the services provided on a per-use basis thus eliminating the expenses one may have for on-premises hardware and software.
3. **Efficiently managing the lifecycle:** It is designed to support the complete web application lifecycle: building, testing, deploying, managing, and updating.
4. **Efficiency:** It allows for higher-level programming with reduced complexity thus, the overall development of the application can be more effective.

- **Disadvantages of Paas**

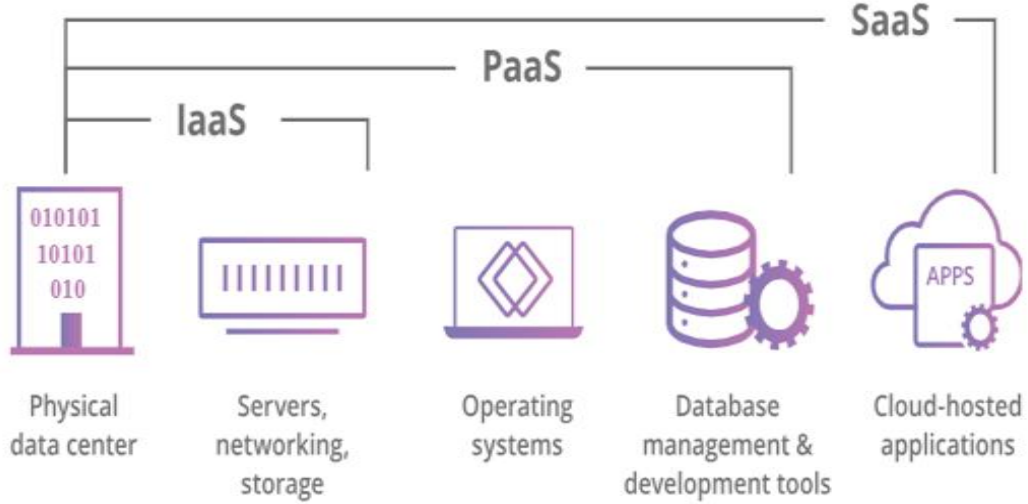
1. **Limited control over infrastructure:** PaaS providers typically manage the underlying infrastructure and take care of maintenance and updates, but this can also mean that users have less control over the environment and may not be able to make certain customizations.
2. **Dependence on the provider**: Users are dependent on the PaaS provider for the availability, scalability, and reliability of the platform, which can be a risk if the provider experiences outages or other issues.
3. **Limited flexibility:** PaaS solutions may not be able to accommodate certain types of workloads or applications, which can limit the value of the solution for certain organizations.

Infrastructure as a Service

- Infrastructure as a service (IaaS) is a **service model** that delivers, computer infrastructure on an outsourced basis to support various operations.
- Typically, IaaS is a service where *infrastructure is provided* as outsourcing to enterprises such as;; **networking equipment, devices, database, and web servers**.

- It is also known as **Hardware as a Service (HaaS).** IaaS customers pay on a per-user basis, typically by the **hour, week, or month**. Some providers also charge customers based on the amount of virtual machine space they use.

- It simply provides the underlying *operating systems, security, networking, and servers* for developing such applications, and services, and deploying development tools, databases, etc.



- **Advantages of IaaS**

1. **Cost-Effective:** Eliminates capital expense and reduces ongoing cost and IaaS customers pay on a per-user basis, typically by the hour, week, or month.
2. **Website Hosting:** Running websites using IaaS can be less expensive than traditional web hosting.
3. **Security:** The IaaS Cloud Provider may provide better security than your existing software.
4. **Maintenance:** There is no need to manage the underlying data center or the introduction of new releases of the development or underlying software. This is all handled by the IaaS Cloud Provider.

- **Disadvantages of IaaS**

1. **Limited control over infrastructure:** IaaS providers typically manage the underlying infrastructure and take care of maintenance and updates, but this can also mean that users have less control over the environment and may not be able to make certain customizations.
2. **Security concerns**: Users are responsible for securing their own data and applications, which can be a significant undertaking.
3. **Limited access:** Cloud computing may not be accessible in certain regions and countries due to legal policies.

Characteristics of Cloud Computing

1. **On-demand self-services:** The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.
2. **Broad network access:** The Computing services are generally provided over standard networks and heterogeneous devices.
3. **Rapid elasticity:** The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.
4. **Resource pooling:** The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.
5. **Measured service:** The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.
6. **Multi-tenancy:** Cloud computing providers can support multiple tenants (users or organizations) on a single set of shared resources.
7. **Virtualization:** Cloud computing providers use virtualization technology to abstract underlying hardware resources and present them as logical resources to users.
8. **Resilient computing:** Cloud computing services are typically designed with redundancy and fault tolerance in mind, which ensures high availability and reliability.
9. **Flexible pricing models:** Cloud providers offer a variety of pricing models, including pay-per-use, subscription-based, and spot pricing, allowing users to choose the option that best suits their needs.
10. **Security:** Cloud providers invest heavily in security measures to protect their users' data and ensure the privacy of sensitive information.
11. **Automation:** Cloud computing services are often highly automated, allowing users to deploy and manage resources with minimal manual intervention.
12. **Sustainability:** Cloud providers are increasingly focused on sustainable practices, such as energy-efficient data centers and the use of renewable energy sources, to reduce their environmental impact.

What are the different types of cloud deployments?

In contrast to the models discussed above, which define how services are offered via the cloud, these different cloud deployment types have to do with where the cloud servers are and who manages them.

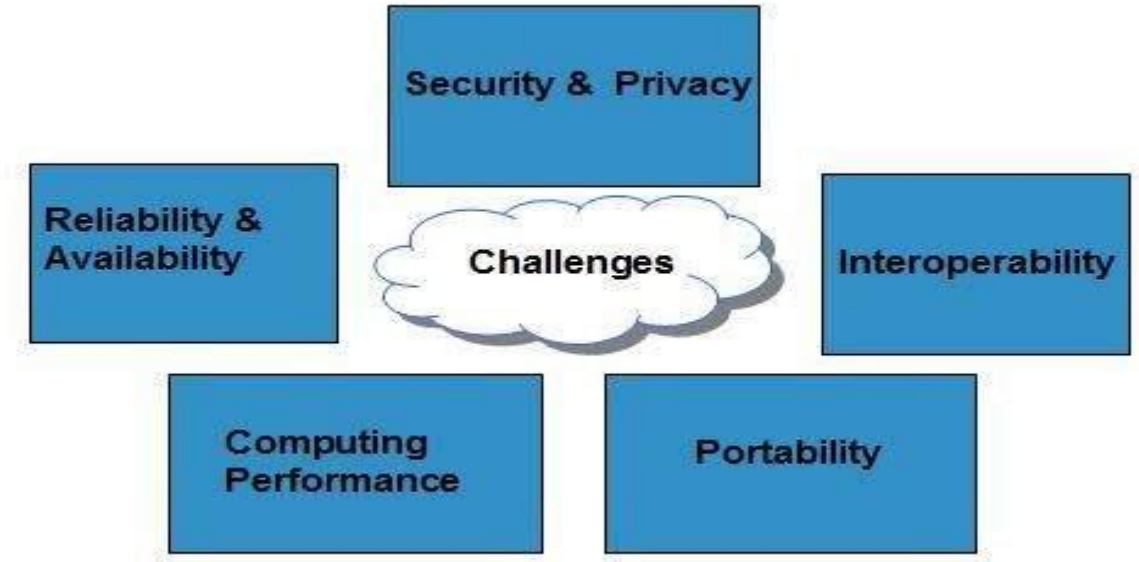
The most common cloud deployments are:

- **Private cloud**: A private cloud is a server, data center, or distributed network wholly dedicated to one organization.
- **Public cloud**: A public cloud is a service run by an external vendor that may include servers in one or multiple data centers. Unlike a private cloud, public clouds are shared by multiple organizations. Using virtual machines, individual servers may be shared by different companies, a situation that is called "multitenancy" because multiple tenants are renting server space within the same server.
- **Hybrid cloud**: hybrid cloud deployments combine public and private clouds, and may even include on-premises legacy servers. An organization may use their private cloud for some services and their public cloud for others, or they may use the public cloud as backup for their private cloud.
- **Multi-cloud**: multi-cloud is a type of cloud deployment that involves using multiple public clouds. In other words, an organization with a multi-cloud deployment rents virtual servers and services from several external vendors — to continue the analogy used above, this is like leasing several adjacent plots of land from different landlords. Multi-cloud deployments can also be hybrid cloud, and vice versa.

Multicloud is when an organization uses cloud computing services from ***at least two cloud providers*** to run their applications. Instead of using a single-cloud stack, multicloud environments typically include a ***combination of two or more Public clouds, two or more Private clouds, or some combination of both***.

Cloud Computing Challenges

- Cloud computing, an emergent technology, has placed many challenges in different aspects of data and information handling.
- Some of these are shown in the following diagram:



Security and Privacy

Security and Privacy of information is the biggest challenge to cloud computing. Security and privacy issues can be overcome by employing encryption, security hardware and security applications.

Portability

This is another challenge to cloud computing that applications should easily be migrated from one cloud provider to another. There must not be vendor lock-in. However, it is not yet made possible because each of the cloud provider uses different standard languages for their platforms.

Interoperability

It means the application on one platform should be able to incorporate services from the other platforms. It is made possible via web services, but developing such web services is very complex.

Computing Performance

Data intensive applications on cloud requires high network bandwidth, which results in high cost. Low bandwidth does not meet the desired computing performance of cloud application.

Reliability and Availability

It is necessary for cloud systems to be reliable and robust because most of the businesses are now becoming dependent on services provided by third-party.

Architecture Of Cloud Computing

Cloud computing architecture refers to the components and sub-components required for cloud computing. These components typically refer to:

- Front end (Fat client, Thin client)
- Back-end platforms (Servers, Storage)
- Cloud-based delivery and a network (Internet, Intranet, Intercloud)

Thin clients rely on a network connection for computing and don't do much processing on the hardware itself.

Thick clients don't need the constant network connection and can do much of the processing for client/server applications.

Front End (User Interaction Enhancement)

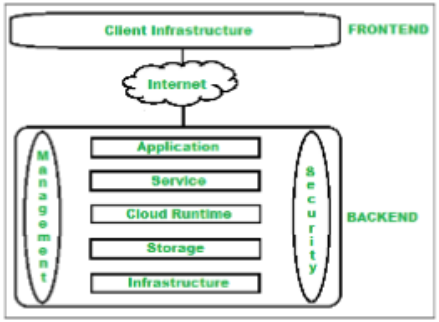
The User Interface of Cloud Computing consists of 2 sections of clients. The Thin clients are the ones that use web browsers facilitating portable and lightweight accessibilities and others are known as Fat Clients that use many functionalities for offering a strong user experience.

Back-end Platforms (Cloud Computing Engine)

The core of cloud computing is made at back-end platforms with several servers for storage and processing computing. Management of Applications logic is managed through servers and effective data handling is provided by storage. The combination of these platforms at the backend offers the processing power, and capacity to manage and store data behind the cloud.

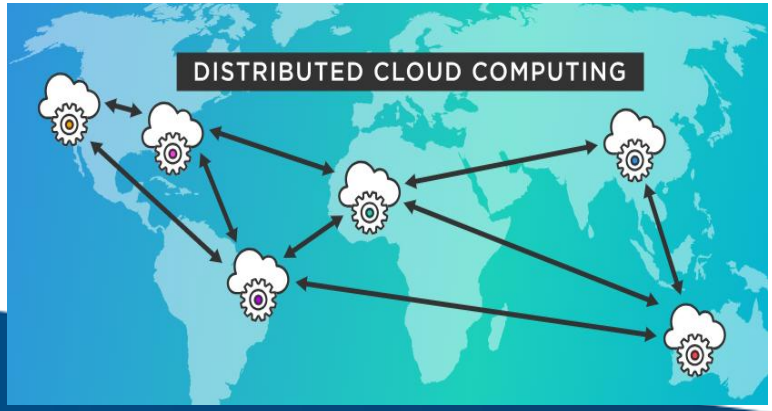
Cloud-Based Delivery and Network

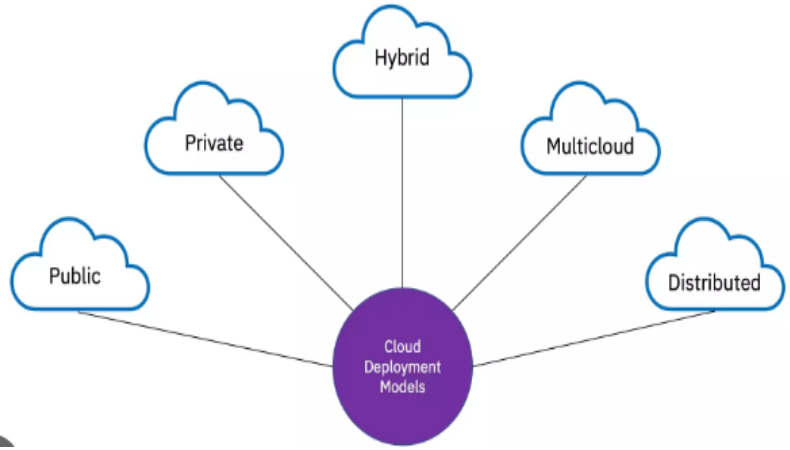
On-demand access to the computer and resources is provided over the Internet, Intranet, and Intercloud. The Internet comes with global accessibility, the Intranet helps in internal communications of the services within the organization and the Intercloud enables interoperability across various cloud services. This dynamic network connectivity ensures an essential component of cloud computing architecture on guaranteeing easy access and data transfer.



What is Distributed Cloud Computing?

- **Distributed cloud computing** is the *distribution of public cloud services across multiple Geographic locations.*
- In **distributed clouds**, the operations and governance—as well as updates—continue to remain under the purview of the primary public cloud provider.
- Ex: **Intelligent Transport**





How Does Distributed Cloud Computing Work?

- In distributed cloud computing, all the computing power of a ***cloud provider is distributed*** *wherever a customer needs it:* on-premises in data centers or **Private** clouds or off-premises in **Public** cloud data centers.
- Distributed cloud computing extends the provider's centralized cloud with geographically distributed micro-clouds. The **provider controls** all distributed infrastructure centrally, including **Operations, Updates, Governance, Security,** and **Reliability**. Everything is accessible as a single cloud and managed from a single control plane.
- Distributed cloud computing offers, **extra features** as well. Users can request that certain data remain within specific regions or that they meet a specific latency or throughput target. These features are included in ***Service Level Agreements*** **(SLA)** between **the User** and the **Cloud Provider.**

What are the benefits of distributed cloud?

There are many benefits of a distributed cloud architecture. Gartner points to these as noteworthy:

- **Increased compliance.** Distributed by nature, workloads, and data can be located where they must be to meet regulatory demands.
- **Increased uptime.** Since cloud services can reside on local subnets, they can be isolated – even untethered from the main cloud – when needed to ensure they are isolated from a crashed system to provide redundancy.
- **Scalability:** Adding VMs or nodes as needed enables not only rapid scalability but also improves the overall availability of the cloud system as a whole.
- **Flexibility:** Distributed clouds simplify the installation, deployment, and debugging of new services.
- **Faster processing.** Distributed systems can be faster by leveraging compute of multiple systems for a given task. Also, the distributed cloud enables more responsive communications for specific regions.
- **Performance.** Unlike centralized computer network clusters, the distributed cloud can provide higher performance and better cost performance.

Disadvantages of Distributed Cloud Computing

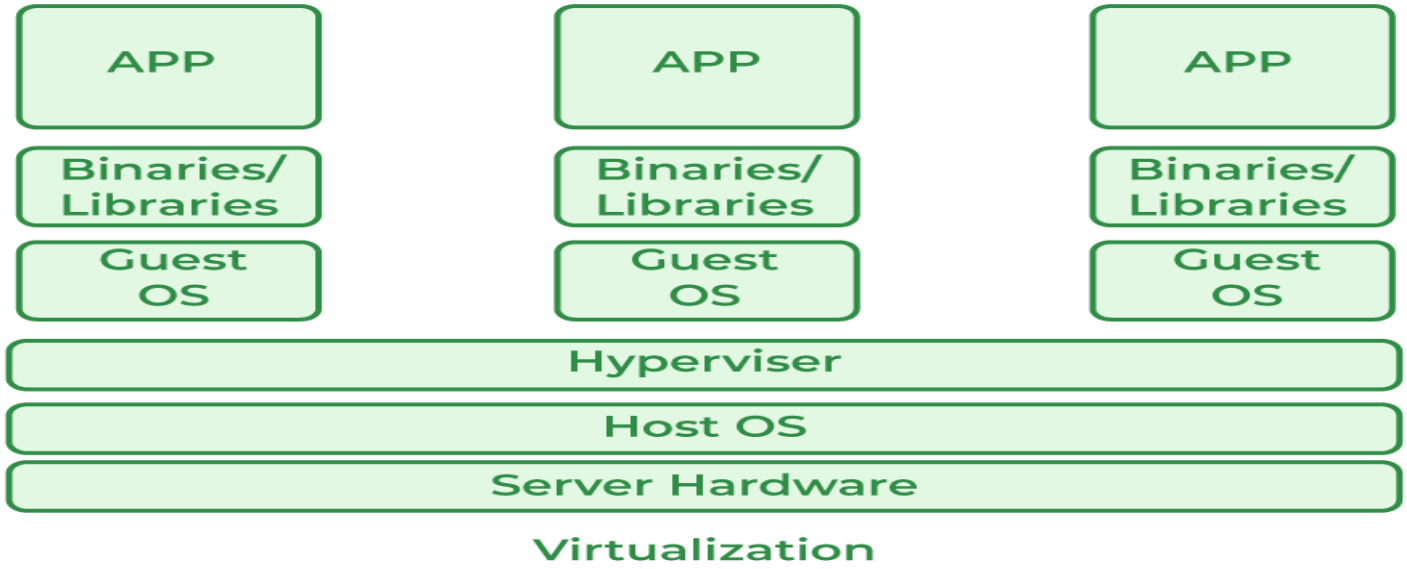
It is important to keep in mind certain disadvantages, though, including security and bandwidth issues.

- **Security.** Distributed clouds can be tricky to secure with resources scattered worldwide. They can also be co-located with other servers and storage.
- **Data backup.** Distributed cloud computing may require rethinking backup and recovery strategies to ensure data stays in the right place.
- **Bandwidth.** In a widely distributed cloud environment, each location may use a different connectivity model. Moving more computing to the edge can therefore stress broadband connections and require them to upgrade or adapt.

S.No.	CLOUD COMPUTING	DISTRIBUTED COMPUTING
01.	Cloud computing refers to providing on demand IT resources/services like server, storage, database, networking, analytics, software etc. over internet.	Distributed computing refers to solve a problem over distributed autonomous computers and they communicate between them over a network.
02.	In simple cloud computing can be said as a computing technique that delivers hosted services over the internet to its users/customers.	In simple distributed computing can be said as a computing technique which allows to multiple computers to communicate and work to solve a single problem.
03.	It is classified into 4 different types such as Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud.	It is classified into 3 different types such as Distributed Computing Systems, Distributed Information Systems and Distributed Pervasive Systems.
04.	There are many benefits of cloud computing like cost effective, elasticity and reliable, economies of Scale, access to the global market etc.	There are many benefits of distributed computing like flexibility, reliability, improved performance etc.
05.	Cloud computing provides services such as hardware, software, networking resources through internet.	Distributed computing helps to achieve computational tasks more faster than using a single computer as it takes a lot of time.
06.	The goal of cloud computing is to provide on demand computing services over internet on pay per use model.	The goal of distributed computing is to distribute a single task among multiple computers and to solve it quickly by maintaining coordination between them.
07.	Some characteristics of cloud computing are providing shared pool of configurable computing resources, on-demand service, pay per use, provisioned by the Service Providers etc.	Some characteristics of distributed computing are distributing a single task among computers to progress the work at same time, Remote Procedure calls and Remote Method Invocation for distributed computations.
08.	Some disadvantage of cloud computing includes less control especially in the case of public clouds, restrictions on available services may be faced and cloud security.	Some disadvantage of distributed computing includes chances of failure of nodes, slow network may create problem in communication.

Virtualization

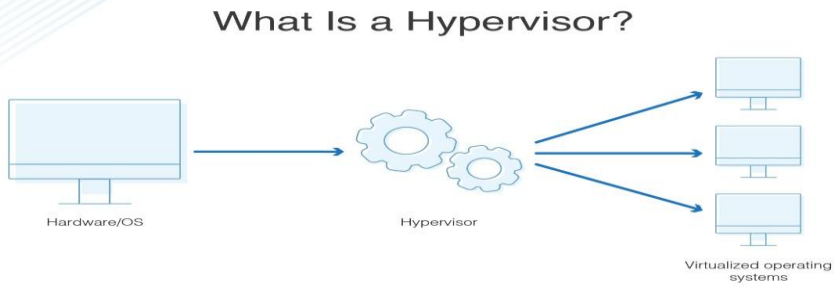
- **Virtualization** is technology, that you can use ***to create virtual*** representations of Servers, Storage, Networks, and Other Physical Machines.
- Virtual software mimics/simulator the functions of **physical Hardware to run multiple virtual machines** *simultaneously on a single physical machine*.
- Virtualization technologies provide a virtual environment for not only *executing applications* but also for **storage, memory, and networking.**



•**Host Machine:** The machine on which the virtual machine is going to be built is known as Host Machine.

•**Guest Machine:** The virtual machine is referred to as a Guest Machine.

•**Hypervisor:** A hypervisor is a software that you can use to run **multiple virtual machines on a single physical machine**. ***Every virtual machine has its own operating system and applications***. The hypervisor allocates the underlying physical computing resources such as CPU and memory to individual virtual machines as required. A hypervisor is sometimes also called a **Virtual Machine Manager(VMM).**



Benefits of Virtualization

- More flexible and efficient allocation of resources.
- Enhance development productivity.
- It lowers the cost of IT infrastructure.
- Remote access and rapid scalability.
- High availability and disaster recovery.
- Pay peruse of the IT infrastructure on demand.
- Enables running multiple operating systems.

Drawback of Virtualization

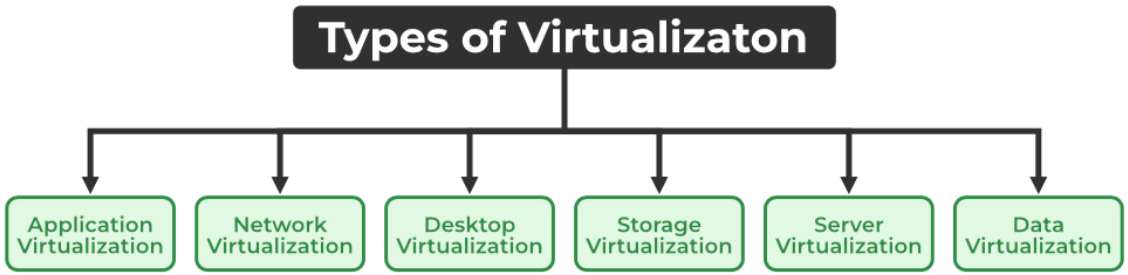
- **High Initial Investment:** Clouds have a very high initial investment, but it is also true that it will help in reducing the cost of companies.
- **Learning New Infrastructure:** As the companies shifted from Servers to Cloud, it requires highly skilled staff who have skills to work with the cloud easily, and for this, you have to hire new staff or provide training to current staff.
- **Risk of Data:** Hosting data on third-party resources can lead to putting the data at risk, it has the chance of getting attacked by any hacker or cracker very easily.

Characteristics of Virtualization

- **Increased Security:** The ability to control the execution of a guest program in a completely transparent manner opens new possibilities for delivering a secure, controlled execution environment. All the operations of the guest programs are generally performed against the virtual machine, which then translates and applies them to the host programs.
- **Managed Execution:** In particular, sharing, aggregation, emulation, and isolation are the most relevant features.
- **Sharing:** Virtualization allows the creation of a separate computing environment within the same host.
- **Aggregation:** It is possible to share physical resources among several guests, but virtualization also allows aggregation, which is the opposite process.

Types of Virtualization

1. Application Virtualization
2. Network Virtualization
3. Desktop Virtualization
4. Storage Virtualization
5. Server Virtualization
6. Data virtualization



1. Application Virtualization: Application virtualization helps a user to have remote access to an application from a server. The server stores all personal information and other characteristics of the application but can still run on a local workstation through the internet. An example of this would be a user who needs to run two different versions of the same software. Technologies that use application virtualization are hosted applications and packaged applications.

2. Network Virtualization: The ability to run multiple virtual networks with each having a separate control and data plan. It co-exists together on top of one physical network. It can be managed by individual parties that are potentially confidential to each other. Network virtualization provides a facility to create and provision virtual networks, logical switches, routers, firewalls, load balancers, Virtual Private Networks (VPN), and workload security within days or even weeks.

3. Desktop Virtualization: Desktop virtualization allows the users' OS to be remotely stored on a server in the data center. It allows the user to access their desktop virtually, from any location by a different machine. Users who want specific operating systems other than Windows Server will need to have a virtual desktop. The main benefits of desktop virtualization are user mobility, portability, and easy management of software installation, updates, and patches.

4. Storage Virtualization: Storage virtualization is an array of servers that are managed by a virtual storage system. The servers aren't aware of exactly where their data is stored and instead function more like worker bees in a hive. It makes managing storage from multiple sources be managed and utilized as a single repository. storage virtualization software maintains smooth operations, consistent performance, and a continuous suite of advanced functions despite changes, breaks down, and differences in the underlying equipment.

5. Server Virtualization: This is a kind of virtualization in which the masking of server resources takes place. Here, the central server (physical server) is divided into multiple different virtual servers by changing the identity number, and processors. So, each system can operate its operating systems in an isolated manner. Where each sub-server knows the identity of the central server. It causes an increase in performance and reduces the operating cost by the deployment of main server resources into a sub-server resource. It's beneficial in virtual migration, reducing energy consumption, reducing infrastructural costs, etc.

6. Data Virtualization: This is the kind of virtualization in which the data is collected from various sources and managed at a single place without knowing more about the technical information like how data is collected, stored & formatted then arranged that data logically so that its virtual view can be accessed by its interested people and stakeholders, and users through the various cloud services remotely. Many big giant companies are providing their services like Oracle, IBM, At scale, Cdata, etc.

Building Cloud Computing Environments

Computing environments refer to the technology infrastructure and software platforms that are used to develop, test, deploy, and run software applications.

There are several Types of Computing Environments, including:

1. **Mainframe**: A large and powerful computer system used for critical applications and large-scale data processing.
2. **Client-Server:** A computing environment in which client devices access resources and services from a central server.
3. **Cloud Computing:** A computing environment in which resources and services are provided over the Internet and accessed through a web browser or client software.
4. **Mobile Computing:** A computing environment in which users access information and applications using handheld devices such as smartphones and tablets.
5. **Grid Computing:** A computing environment in which resources and services are shared across multiple computers to perform large-scale computations.
6. **Embedded Systems:** A computing environment in which software is integrated into devices and products, often with limited processing power and memory.

Advantages of different computing environments:

1. Mainframe: High reliability, security, and scalability, making it suitable for mission-critical applications.
2. Client-Server: Easy to deploy, manage and maintain, and provides a centralized point of control.
3. Cloud Computing: Cost-effective and scalable, with easy access to a wide range of resources and services.
4. Mobile Computing: Allows users to access information and applications from anywhere, at any time.
5. Grid Computing: Provides a way to harness the power of multiple computers for large-scale computations.
6. Embedded Systems: Enable the integration of software into devices and products, making them smarter and more functional.

Disadvantages of different computing environments:

1. Mainframe: High cost and complexity, with a significant learning curve for developers.
2. Client-Server: Dependence on network connectivity, and potential security risks from centralized data storage.
3. Cloud Computing: Dependence on network connectivity, and potential security and privacy concerns.
4. Mobile Computing: Limited processing power and memory compared to other computing environments, and potential security risks.
5. Grid Computing: Complexity in setting up and managing the grid infrastructure.
6. Embedded Systems: Limited processing power and memory, and the need for specialized skills for software development

What is a Cloud-based Application?

- An online application that saves data, permits remote access and administration, and runs at least some of its code on a distant server is an example of a "cloud-based application." Remember that the web browser on a desktop computer or mobile device serves as the standard user interface for cloud apps.
- An API makes reaching the data kept on the remote computer easier. (API). The primary process is not impacted by a user's device, which only acts as an entry device in the cloud program.

Types of Cloud Applications in Development

Cloud-Based Web Applications

Web apps allow users to access computer programs from any computer or mobile device with an internet link because they are saved and run in the cloud. Users might have to sign up for an account and check in on their devices before accessing the application. Examples include social networking sites like Facebook and LinkedIn and online storage and sharing services for documents like Dropbox Paper and Google Docs.

Customer Relationship Management(CRM)

This application makes arranging clients, prospects, and other relationships possible. Email marketing, lead management tools, and contact lists are the most useful features. The information you get from these will help you enhance customer insights and business management.

Enterprise Resource Planning(ERP)

Enterprise resource planning, or ERP, is the software businesses use to monitor everything from customer support to financial reporting and inventory administration. Such software frequently includes tools for managing customers, goods, workers, and money.

Property Management Software(PMS)

PMS, or property management system, is the acronym. It's a piece of software made to save property managers' time by handling repetitive tasks. This involves requesting replacement estimates and gathering funding. A database can also create financial measures and keep track of possessions.

Solutions for Cloud-based Application Development

The cloud has made classic on-premises programming tools more adaptable, scalable, and affordable. Because of this, more and more people are turning to cloud-based platforms to create their applications. Some of the most common kinds of cloud-based application development solutions are as follows –

Platform as a Service (PaaS)

These tools and resources allow for the comprehensive development, distribution, and administration of cloud-based applications. To streamline the app-creation process, many companies now give coders access to a "platform as a service."

Infrastructure as a Service (IaaS)

Developers now have a consolidated platform from which to create, distribute, and manage their applications thanks to Infrastructure as a Service. Services like networking, storage, and virtual computers are just some of what IaaS providers can provide for their clients.

Software as a Service (SaaS)

Users may acquire cloud-based programs using this kind of service from a distance. Most SaaS providers provide access to a library of programs that can be accessed from any location with an internet link. CRM (client relationship management) and project management are two examples of these programs' possible uses.

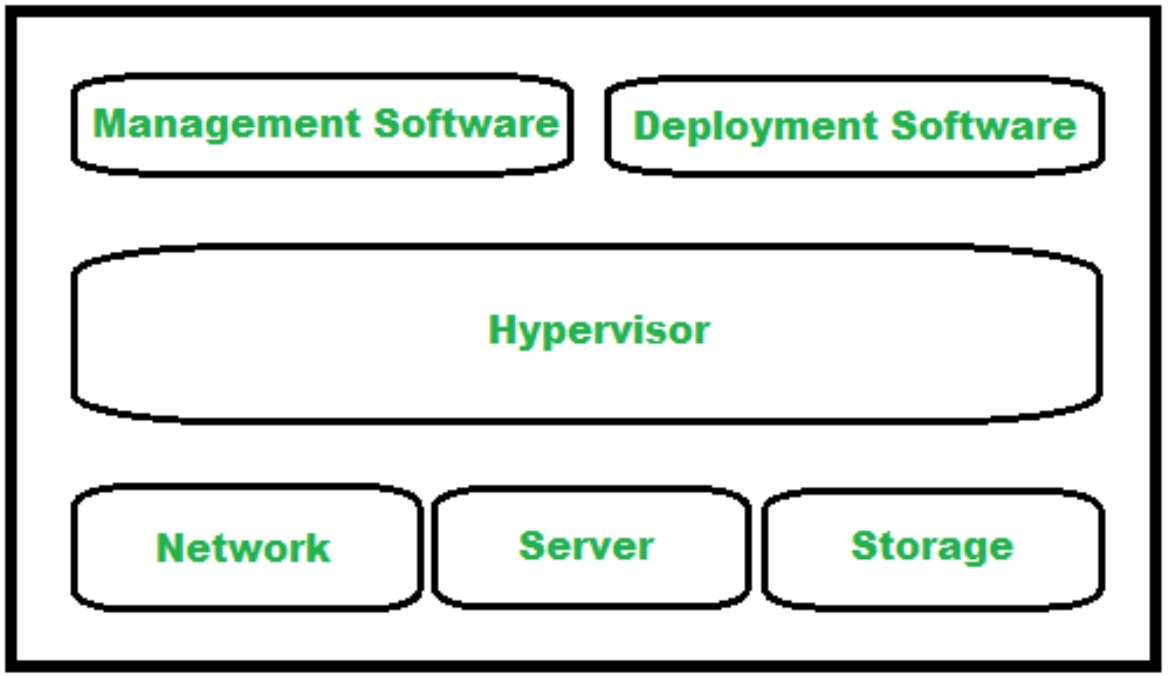
Mobile Backend as a Service (MBaaS)

Using these choices, authors enter into a comprehensive framework designed with mobile applications in mind. An MBaaS should assist its customers with user identification, data storage, SMS notifications, and data analysis.

Cloud Computing Infrastructure

- **Why Cloud Computing Infrastructure :**
- Cloud computing refers to providing on demand services to the customer anywhere and anytime irrespective of everything where the cloud infrastructure represents the one who activates the complete cloud computing system.
- Cloud infrastructure has more capabilities of providing the same services as the physical infrastructure to the customers. It is available for private cloud, public cloud, and hybrid cloud systems with low cost, greater flexibility and scalability.

Components of cloud infrastructure



1. Hypervisor :

Hypervisor is a firmware or a low level program which is a key to enable virtualization. It is used to divide and allocate cloud resources between several customers. As it monitors and manages cloud services/resources that's why hypervisor is called as VMM (Virtual Machine Monitor) or (Virtual Machine Manager).

2. Management Software :

Management software helps in maintaining and configuring the infrastructure. Cloud management software monitors and optimizes resources, data, applications and services.

3. Deployment Software :

Deployment software helps in deploying and integrating the application on the cloud. So, typically it helps in building a virtual computing environment.

4. Network :

It is one of the key component of cloud infrastructure which is responsible for connecting cloud services over the internet. For the transmission of data and resources externally and internally network is must required.

5. Server :

Server which represents the computing portion of the cloud infrastructure is responsible for managing and delivering cloud services for various services and partners, maintaining security etc.

6. Storage :

Storage represents the storage facility which is provided to different organizations for storing and managing data. It provides a facility of extracting another resource if one of the resource fails as it keeps many copies of storage.

What is cloud system developer?

- A professional Cloud Developer is one who builds computer applications and software.
- Cloud professionals can use the same software and tools to build these, just like the other IT developers. However, the resources that are used by these professionals are taken from a cloud-based platform.

Cloud Computing Platforms and Technologies

- Cloud computing applications develops by leveraging *platforms and frameworks.*
- Various types of services are provided from the bare metal infrastructure to customize-able applications serving specific purposes.

- **Amazon Web Services (AWS)**
- **Google AppEngine**
- **Microsoft Azure**
- **Hadoop**

- **Amazon Web Services (AWS)**

  AWS provides different wide-ranging clouds IaaS services, which ranges from virtual compute, storage, and networking to complete computing stacks. AWS is well known for its storage and compute on demand services, named as Elastic Compute Cloud (EC2) and Simple Storage Service (S3).

- **Google AppEngine –**

  Google AppEngine is a scalable runtime environment frequently dedicated to executing web applications. These utilize benefits of the large computing infrastructure of Google to dynamically scale as per the demand. AppEngine offers both a secure execution environment and a collection of which simplifies the development if scalable and high-performance Web applications.

- **Microsoft Azure** –

Microsoft Azure is a Cloud operating system and a platform in which user can develop the applications in the cloud. Generally, a scalable runtime environment for web applications and distributed applications is provided. Application in Azure are organized around the fact of roles, which identify a distribution unit for applications and express the application's logic. Azure provides a set of additional services that complement application execution such as support for storage, networking, caching, content delivery, and others.

- **Hadoop** –

  Apache Hadoop is an open source framework that is appropriate for processing large data sets on commodity hardware. Hadoop is an implementation of MapReduce, an application programming model which is developed by Google. This model provides two fundamental operations for data processing: map and reduce. This cloud infrastructure supports many business processes of the corporates.

Web resources

- https://docs.microsoft.com/en-us/learn/browse/?term=iot
- https://www.sanfoundry.com/iot-questions-answers-arduino/
- https://www.tutorialspoint.com/InternetofThings

MOOC resources

- https://online.stanford.edu/programs/internet-things-graduate-certificate
- https://www.iot-inc.com/#Training
- **https://www.cloudcredential.org/certifications/internet-of-things/iotf/#:~:text=Internet%20of%20Things%20Foundation%20Certification,early%20adoption%20and%20monetization%20models.**

Certification courses

- **Internet of Things Foundation Certification (IoTF)**
- Internet of Things: Multimedia Technologies, UCSan Diego
- Internet of Things and the Cloud Certification by Alison

Thank YOU

https://www.studocu.com/in/document/maharshi-dayanand-university/computer-science/assignment-1-internet-of-things-notes/30382718

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