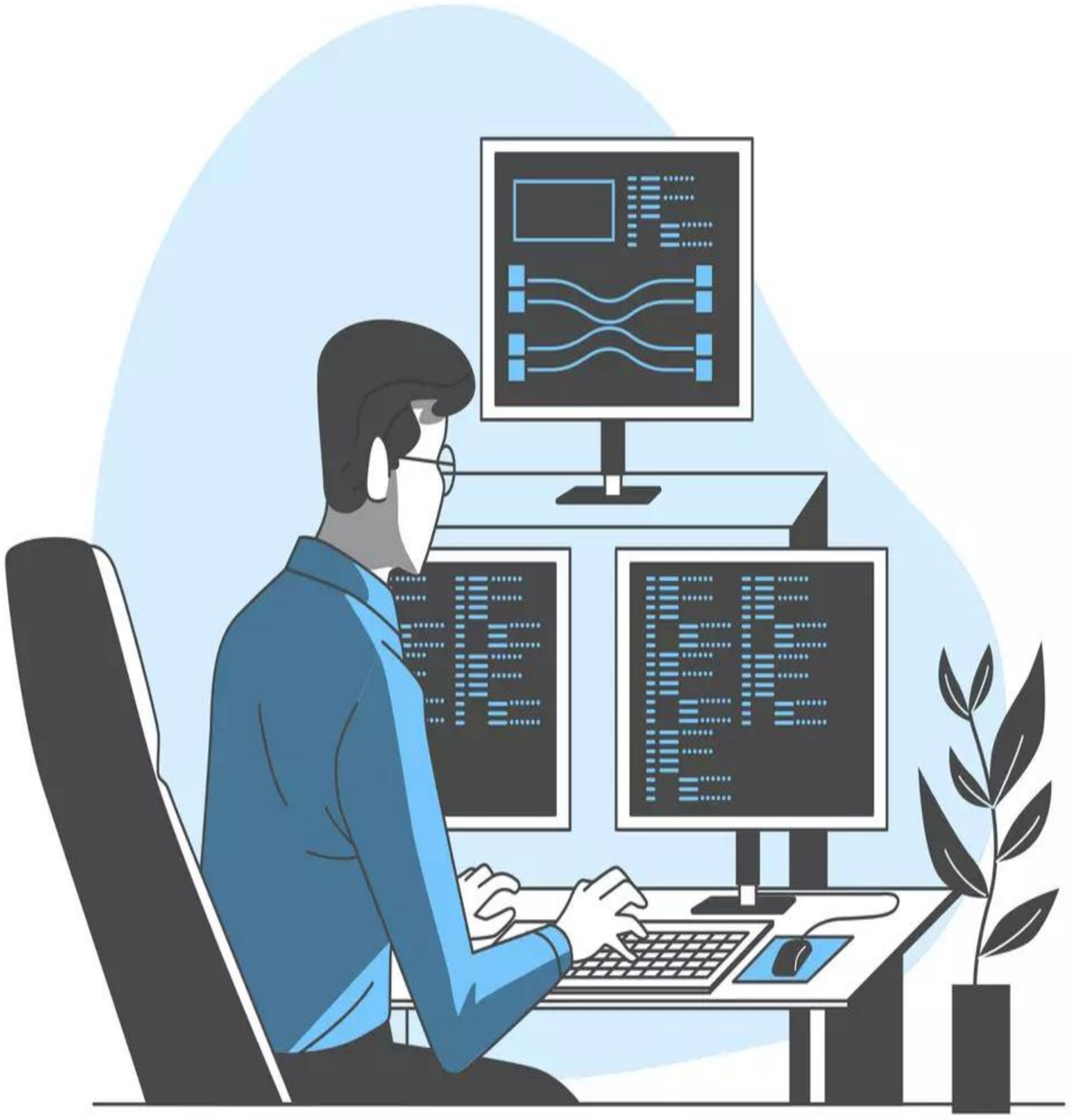

EVOLUTION OF MOBILE COMMUNICATION AND IOT

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MOBILE COMMUNICATION SYSTEM

➢ 1G

The 1G first generation mobile wireless communication system was introduced in 1980's.This 1G technology was a analog system which was based on a standard known as **Advance Mobile Phone Service (AMPS).** The AMPS system was frequency modulation radio system using frequency division multiple access (FDMA). The channel capacity of 1G is 30 KHz and frequency band was 800-900 MHz. The main service given is VOICE only.

➢ 2G

GSM technology was the first one to facilitate digital voice & data and international roaming and allowing customer to roam from place to another. GSM maintains end-to-end security by retaining the confidentiality of calls using Signaling and Data Confidentiality and Mobile station Authentication.

- Year – 1980 -1990
- Technology – Digital
- Speed – 14kbps to 64Kbps
- Frequency Band – 850 – 1900 MHZ (GSM) and 825 – 849 MHz (CDMA)

➢ 3G

The goal of 3G systems was to offer increased data rates. **International Telecommunication Union (ITU) has defined the demand for 3G in the International Mobile Telecommunication (IMT)-2000** standards to facilitate growth, greater voice and data capacity, support diverse applications, and high data transmission at low-cost. The data are sent through the technology called Packet Switching. Voice calls are interpreted through Circuit Switching.

- Speed: 384KBPS to 2MBPS
- Frequency: about 8 to 2.5GHz
- Bandwidth – 5 to 20 MHz

➢ 4G

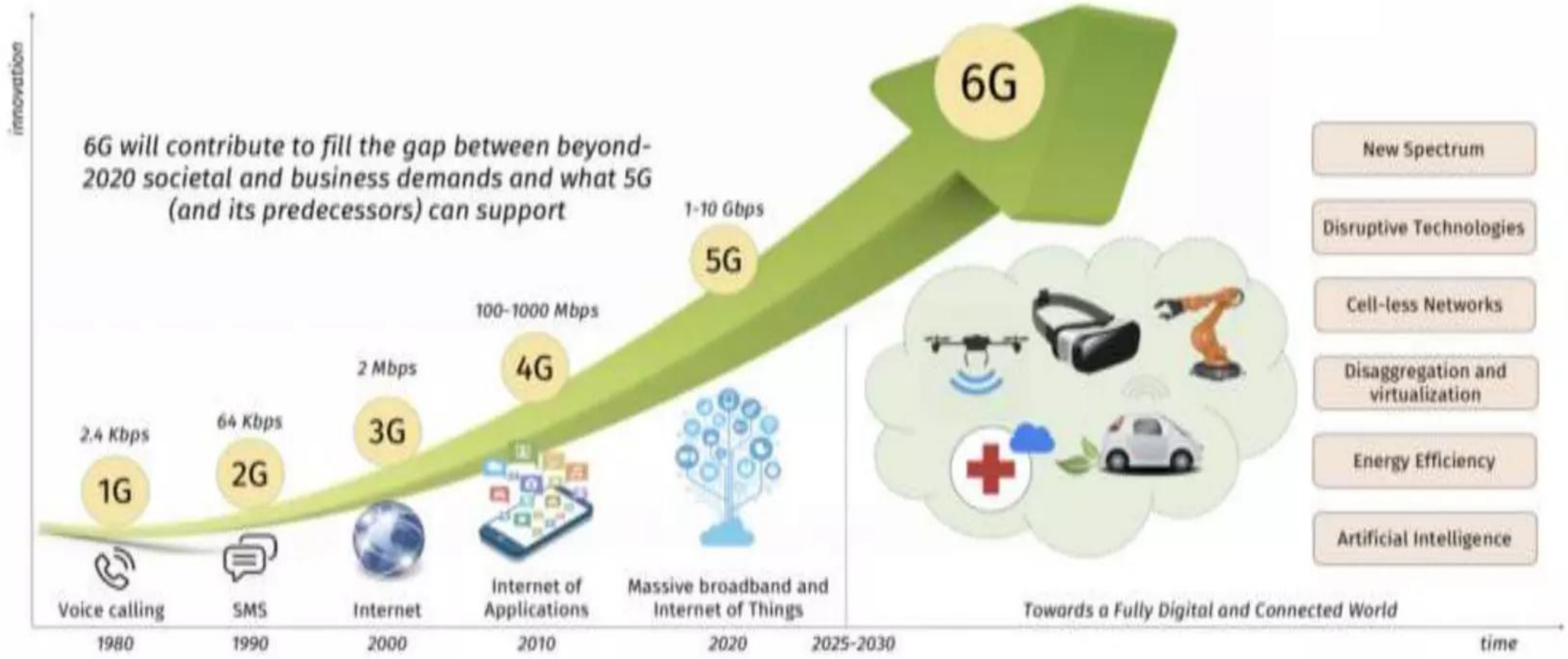
The fourth Generation mobile system is all IP based network system. The main goal of 4G technology is to provide high speed, high quality, high capacity, security and low cost services for voice and data services, multimedia and internet over IP.

- Speed 100Mbps while moving and 1Gbps
- New frequency bands, wider channel frequency bandwidth
- Multiplexing/Access Technologies – OFDM, MC-CDMA, LAS-CDMA and Network-LMDS
- Bandwidth – 5–20 MHz, optionally up to 40 MHz

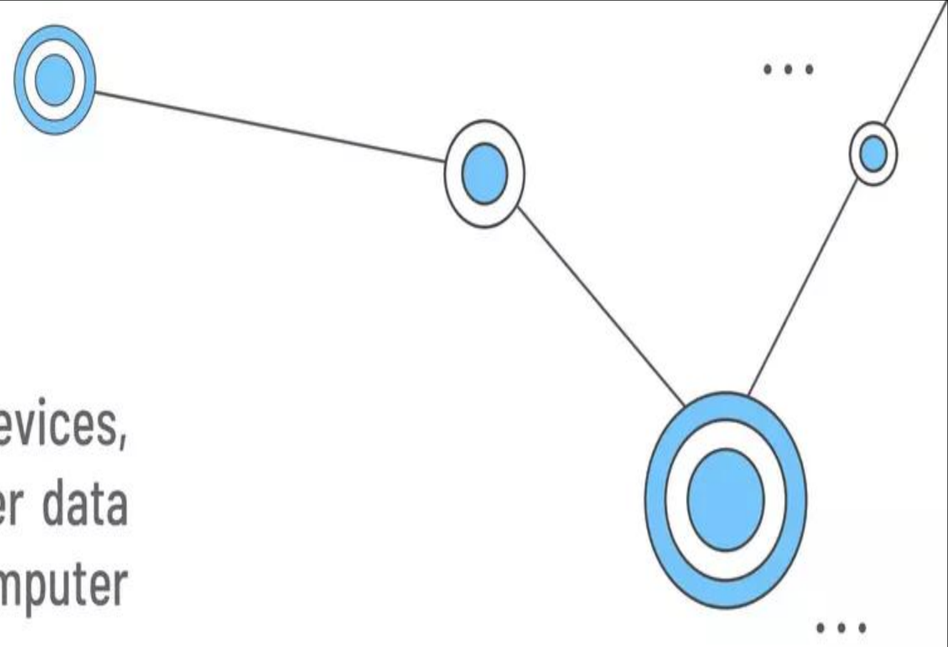
➢ 5G

It will make Unified global standard. The Physical and Data Link layer defines the 5G wireless technology indicating it as an Open Wireless Architecture (OWA). The 5G technology also maintain virtual multi-wireless network.

- Speed – 1 to 10 Gbps.
- Bandwidth – 1,000x bandwidth per unit area.
- Frequency – 3 to 300 GHz
- Multiplexing/Access Technologies – Sparse Code Multiple Access,(SCMA) ,BDMA(Beam-division-multiple access), Non-orthogonal multiple access (NOMA)



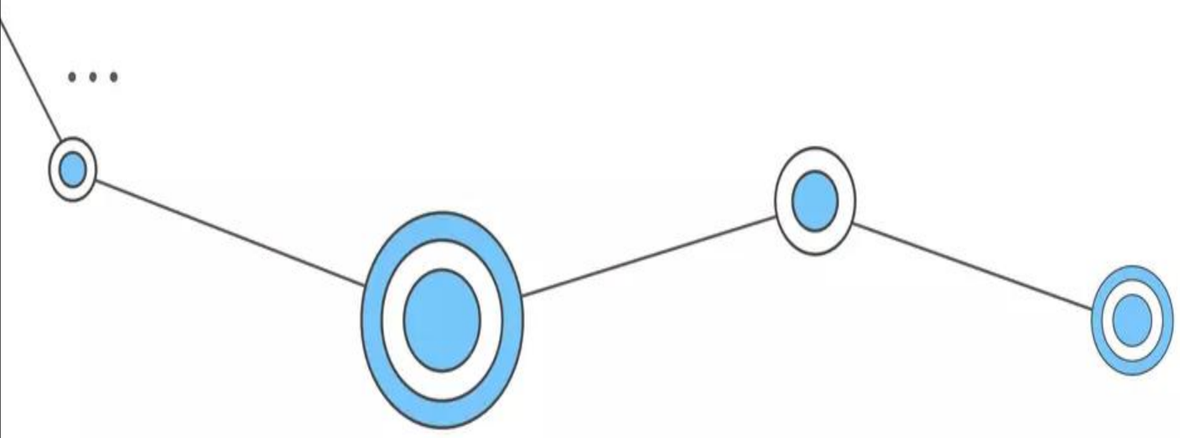
What is IoT?



The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, which can sense, accumulate and transfer data over the internet without requiring human-to-human or human-to-computer interaction.

What makes living things alive? They can sense and communicate with each other, can't they? Now imagine if inanimate objects could sense and interact with each other without any human intervention. Sounds amazing doesn't it?

This is pretty much the underlying concept of Internet of Things.



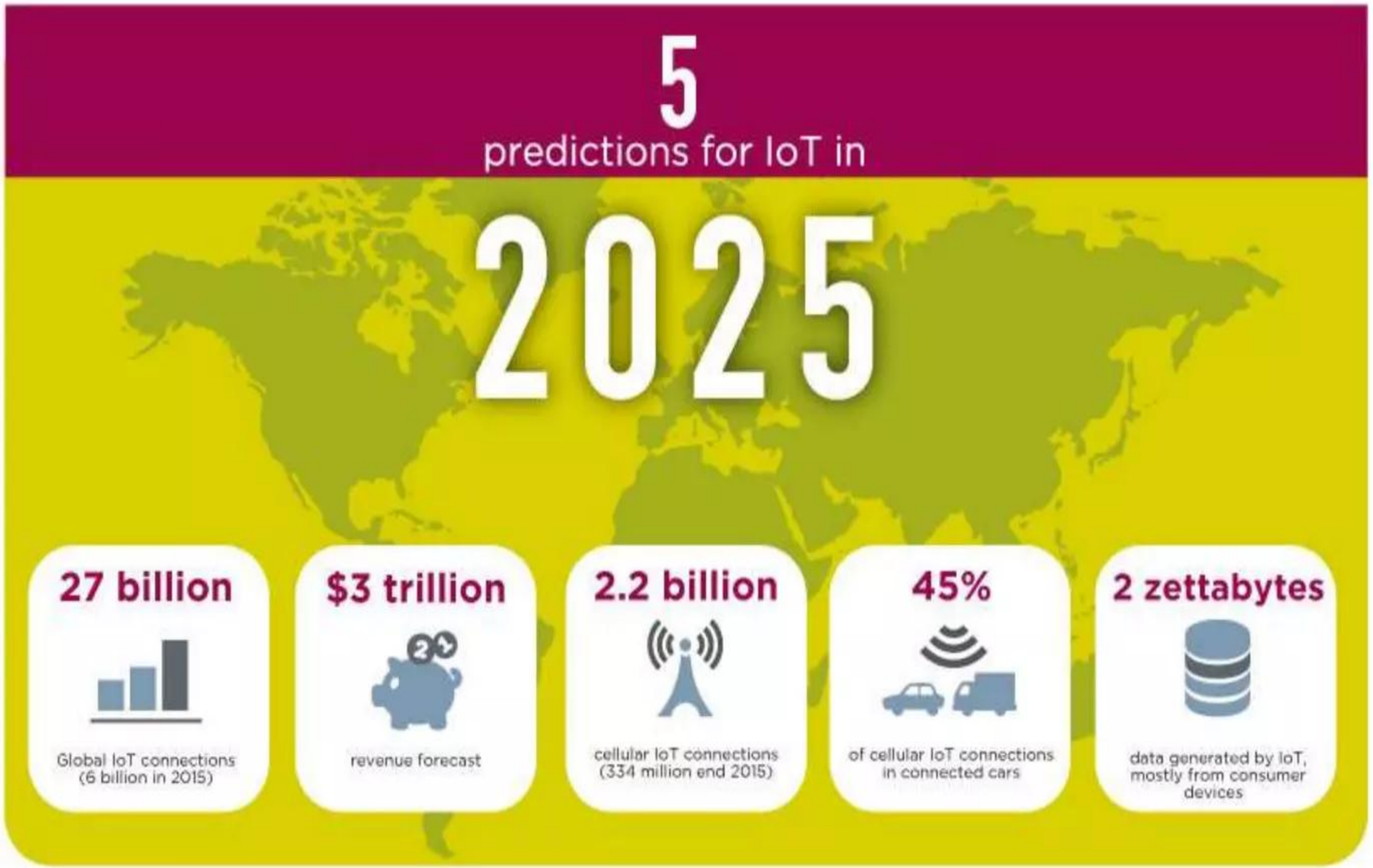
- The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet all collecting and sharing data.

- Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate real-time data without involving a human being.

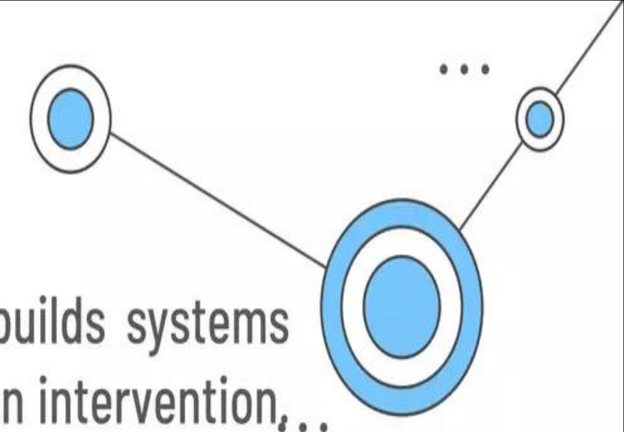
HOW BIG IS THE INTERNET OF THINGS?

- Tech analyst company IDC predicts that in total there will be **41.6 billion** connected IoT devices by **2025, or "things."** It also suggests industrial and automotive equipment represent the largest opportunity of connected "things.

- Another tech analyst, Gartner, predicts that the enterprise and automotive sectors will account for 5.8 billion devices this year



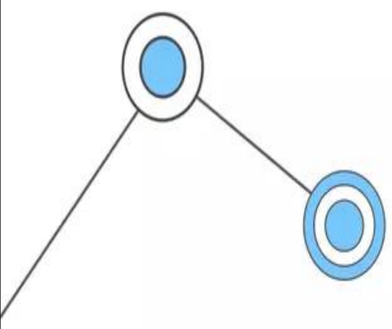
ARCHITECTURE OF IOT



IoT is not just Internet-connected consumer devices. In fact, IoT is the technology that builds systems capable of autonomously sensing and responding to stimuli from the real world without human intervention,..
We therefore need to develop a process flow for a definite framework over which an IoT solution is built. The IoT Architecture generally comprises of these 4 stages:

Stage-1 (Sensors/Actuators)

A thing in the context of "Internet of Things" should be equipped with sensors, actuators thus giving the ability to emit, accept, and process signals.



Stage 2 (Data Acquisition Systems)

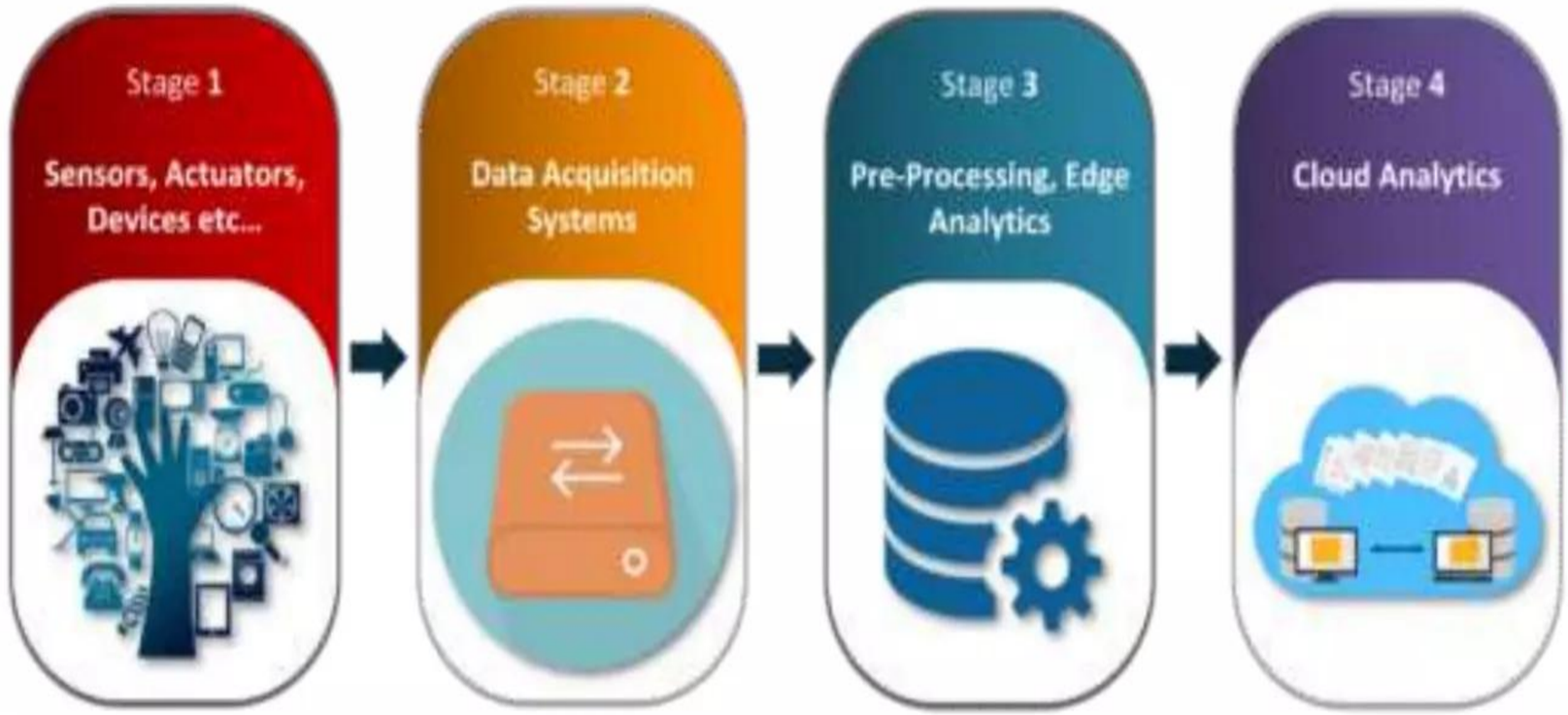
The data from the sensors starts in analogue form, which needs to be aggregated and converted into digital streams for further processing. Data acquisition systems perform these data aggregation and conversion functions.

Stage 3 (Edge Analytics)

Once IoT data has been digitized and aggregated, it may require further processing before it enters the data center, this is where Edge Analytics comes in.

Stage 4 (Cloud Analytics)

Data that needs more in-depth processing gets forwarded to physical data centers or cloud-based systems.

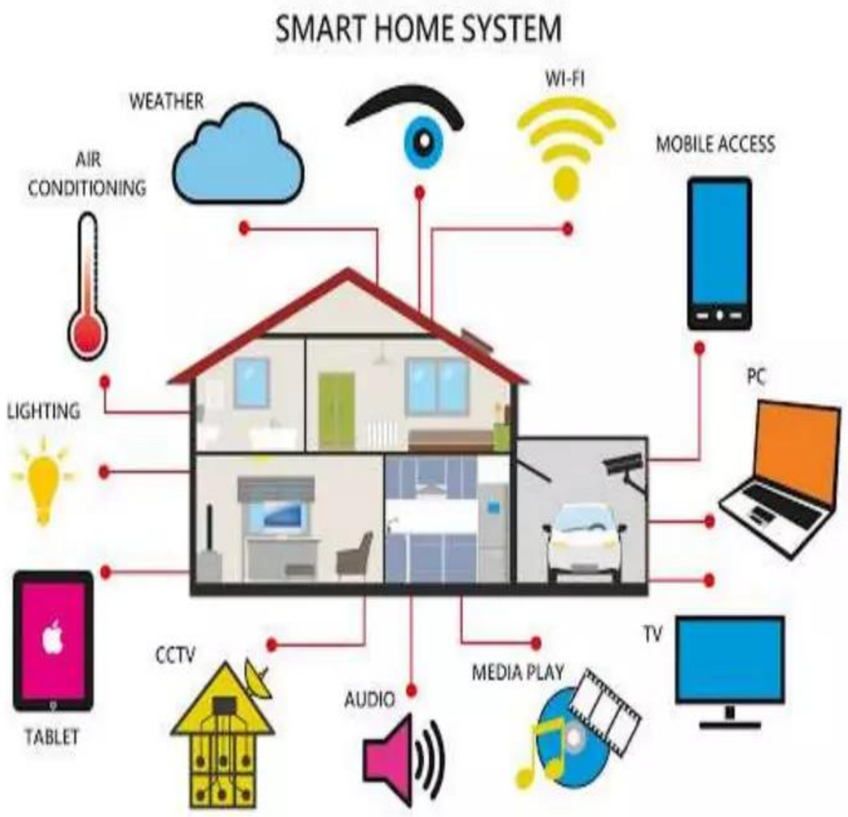


APPLICATIONS OF IOT

IoT applications are expected to equip billions of everyday objects with connectivity and intelligence. It is already being deployed extensively, in various domains, namely

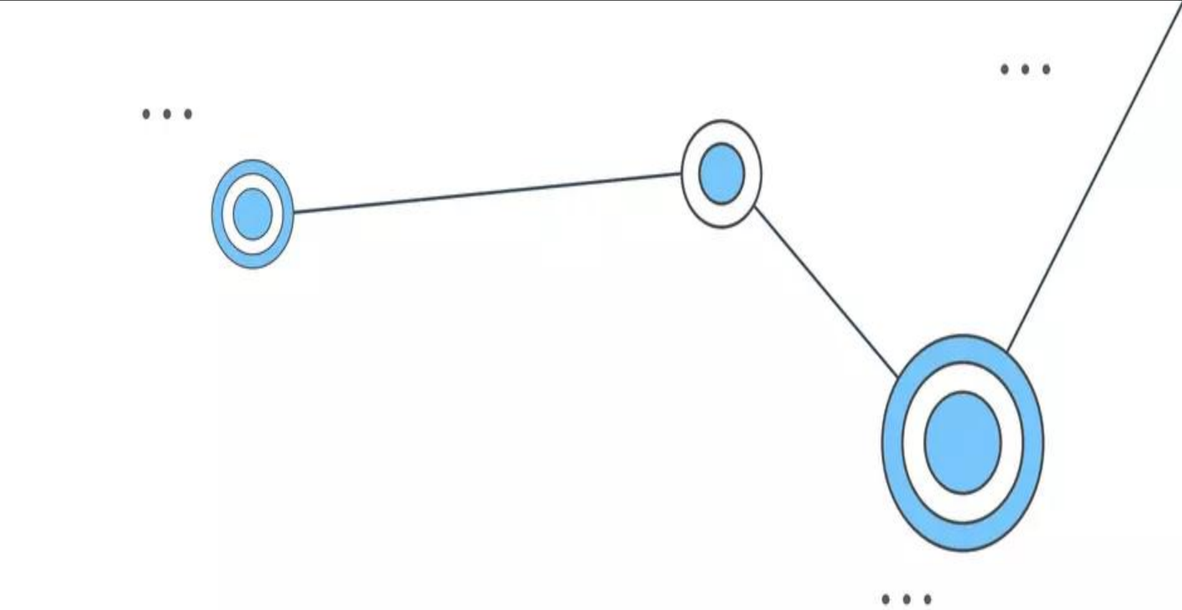
- **Wearables:** Wearable technology is a hallmark of IoT applications and probably is one of the earliest industries to have deployed the IoT at its service.

- **Smart Home Applications**

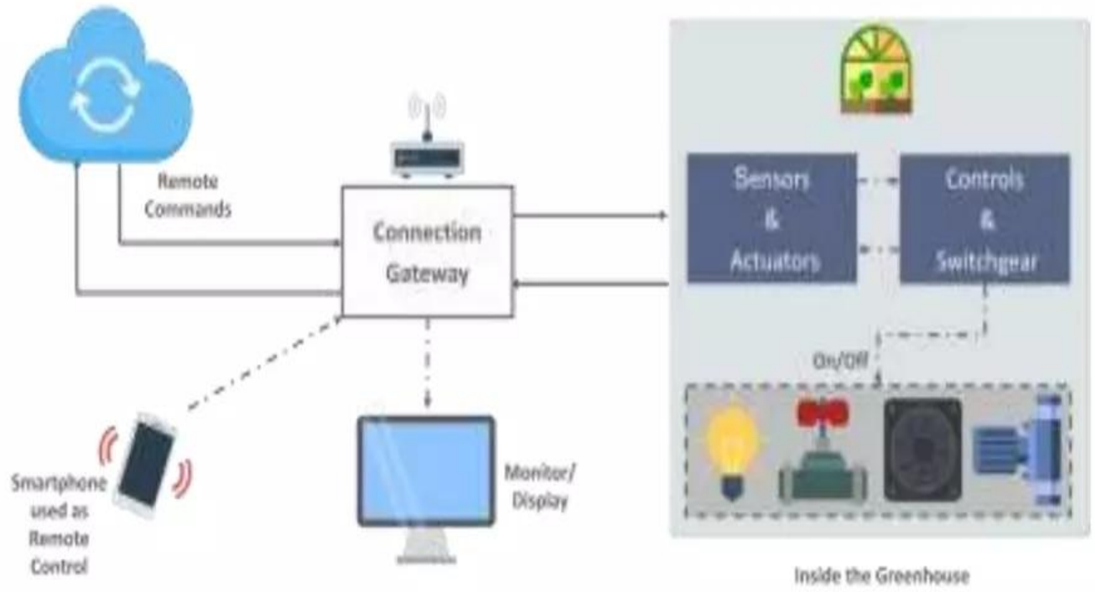


- **Health Care :** IoT applications can turn reactive medical-based systems into proactive wellness-based systems.

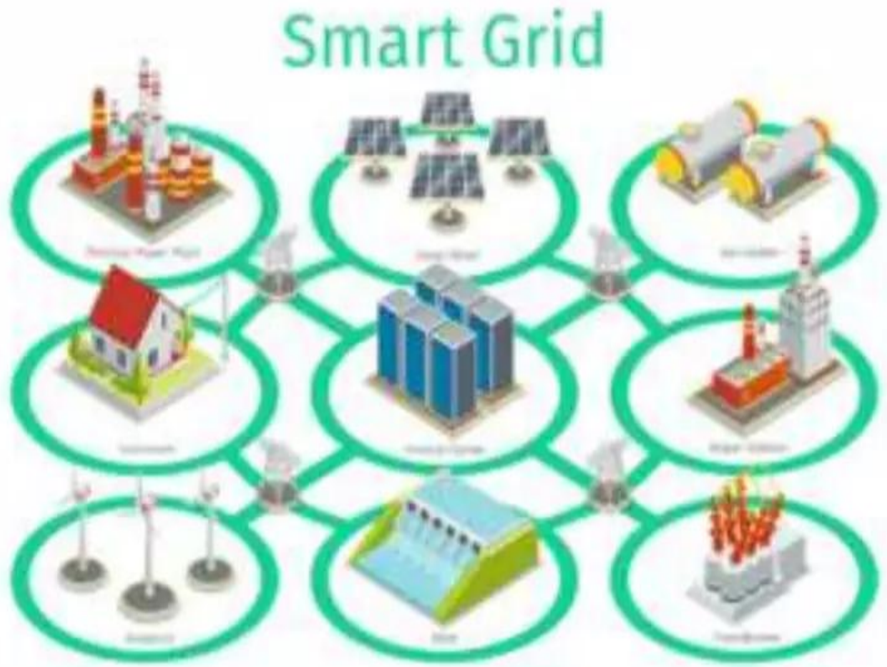
- **Smart Cities:** IoT solutions in the area of Smart City solve traffic congestion problems, reduce noise and pollution and help make cities safer.



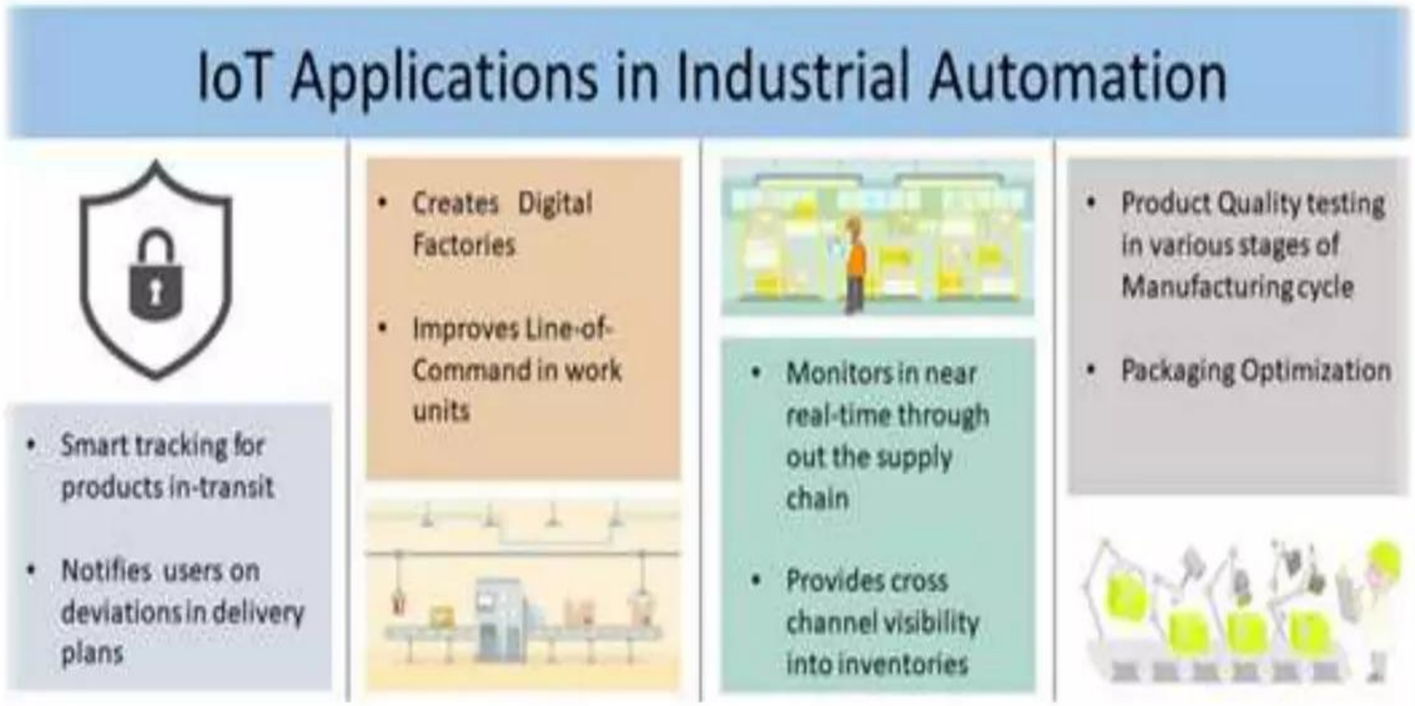
- **Agriculture:** There are numerous possibilities in this field. One of them is the Smart Greenhouse.



- **Smart Energy Management with IoT**



- **Industrial Automation**



- **Smart Car**

PROBLEMS AND SECURITY CHALLENGES FOR THE FUTURE OF THE INTERNET OF THINGS (IOT)

Network Latency: Latency is the slow delivery of applications and data over a network. . Many IoT devices will require real-time application processing and fail-safe transfer of data. latency can result in data loss during transference

Outdated hardware and software: Since the IoT devices are being used increasingly, the manufacturers of these devices are focusing on building new ones and not paying enough attention to security.

Malware and ransomware: The rapid rise in the development of IoT products will make cyberattack permutations unpredictable. Cybercriminals have become advanced today – and they lock out the consumers from using their own device.

Difficult to find if a device is affected: The thing with IoT devices is that most of the users don't get to know if their device is hacked.

Data protection and security challenges: All this data is transferred or transmitted over the internet, which can lead to data leak. Not all the devices through which data is being transmitted or received are secure. Once the data gets leaked, hackers can sell it to other companies that violate the rights for data privacy and security.

Home security: Today, more and more homes and offices are getting smart with IoT connectivity. But not everyone is aware of the best practices that should be taken care of for IoT security. Even if the IP addresses get exposed Attackers or interested parties can use this information for evil purposes. This leaves smart homes at potential risk.

Security of autonomous vehicles: Just like homes, the self-driving vehicles or the ones that make use of IoT services, are also at risk. Smart vehicles can be hijacked by skilled hackers from remote locations.

6G MOBILE COMMUNICATION SYSTEM

- 6G is the successor to 5G cellular technology, 6G networks will be able to use higher frequencies than 5G networks and provide substantially higher capacity and much lower latency. One of the goals of the 6G Internet will be to support one micro-second latency communications, representing 1,000 times faster -- or 1/1000th the latency -- than one millisecond throughput.

- In 6G very fast internet speed access on air through wireless devices possibly upto 11Gbps.specialy designed nano antennas will be implemented at different geographical locations.

Features/Advantages of 6G Technology

- Ultra fast access of Internet.
- Data rates will be up to 10-11 Gbps.
- Home automation and other related applications.
- Smart Homes, Cities and Villages.
- May be used in the production of Energy from galactic world.
- Space technology, Defense applications will be modified with 6G networks.
- Home based ATM systems.
- Satellite to Satellite Communication for the development of mankind.
- Natural Calamities will be controlled with 6G networks.
- Sea to Space Communication.
- Mind to Mind Communication may be possible

COMPARISON BETWEEN 5G AND 6G

Characteristic	5G	6G
Operating frequency	3 - 300 GHz	upto 1 THz
Uplink data rate	10 Gbps	1 Tbps
Downlink data rate	20 Gbps	1 Tbps
Spectral efficiency	10 bps/Hz/m2	1000 bps/Hz/m2
Reliability	10^{-5}	10^{-9}
Maximum mobility	500 km/h	1000 km/hr
U-plane latency	0.5 msec	0.1 msec
C-plane latency	10 msec	1 msec
Processing delay	100 ns	10 ns
Traffic capacity	10 Mbps/m2	1 - 10 Gbps/m2
Time buffer	not real	time real-time
Satellite integration	No	Fully
AI integration	Partially	Fully
XR integration	Partially	Fully
Automation integration	Partially	Fully

EMERGING TECHNOLOGIES AND APPLICATIONS

Tera Hertz Communication in 6G:

- The THz band, ranging from 0.1 THz to 10 THz, will play a crucial role in 6G supplying more bandwidth, more capacity, ultra-high data rates and secure transmission.

- The THz band will support the development of minuscule cells in nanometer to micrometer dimensions supplying very high-speed communications within a coverage area of up to 10 m and supporting the Internet of Nano-things.
- 6G will be the first wireless communication system supporting Tbps for highspeed communication.

Cell-Free Communication

- Unmanned Aerial Vehicles (UAV) were proposed to be used in other generations in places where there is no infrastructure. However, this technology will be fully used in 6G allowing cell-free communication.
- When the user equipment (UE) moves from one cell coverage to another, the user's call should be transferred to the other cell. This handover might be unsuccessful and in some occurrences the user's call is terminated and the QoS will be reduced in the system.
- 6G will end the problem of cell coverage, as the UE will be connected to the whole network, not a specific cell.

Block chain technology

- The data in the blockchain technology are represented as distributed blocks connected to each other and cryptographically secured.
- Blockchain will be used in managing and organizing big data and in managing huge connectivity in 6G.
- Integrating the blockchain with AI and using Deep reinforcement learning will improve the QoS allowing smart-resources sharing, Implementing an advanced caching scheme and making the network more flexible.

Wireless Power Transfer

- Wireless energy transfer will be involved in 6G, providing suitable power to the batteries in devices such as; smartphones and sensors.
- The base stations in 6G will be used for transferring power as Wireless Information and Energy Transfer (WIET) uses the same fields and waves used in communication systems.
- WIET is an innovative technology that will allow the development of batteryless smart devices, charging wireless networks and saving the battery life-time of other devices.

Wireless Brain-Computer Interface

- Recently wearable devices are increasingly used, some of them are brain-computer interface (BCI) applications.
- BCI applications involve smart wearable headsets, smart embedded devices and smart body implants.
- Using BCI technologies, the brain will easily communicate with external discrete devices which will be responsible for analyzing brain signals and translating them.
- BCI also will involve affective computing technologies, in which devices will function differently depending on the user's mood.

CHALLENGES AND FUTURE RESEARCH DIRECTIONS

Tera Hertz Band

- The main challenge in the 6G wireless communication system is the THz band.
- For long-distance communications, the atmospheric absorption and propagation loss are very high. This is an important issue that needs to be addressed. Because of the broad bandwidth, new multipath channel models need to be developed to overcome the problem of frequency dispersion.
- The existing modulation and coding techniques are not sufficient for the THz band. Therefore, implementing new modulation and coding techniques is challenging research.
- So new transceivers should be designed to operate on the high frequency band supporting the very large bandwidth, high power, high sensitivity and low noise figure to overcome the atmospheric losses.

Device Capabilities

- Recently, companies are working on devices supporting 5G, these devices should be able to support 6G and all the different wireless communication generations.
- Billions of devices smartphones will be connected to the 6G network, therefore, efficient energy transferring methods should be considered especially wireless energy transfer methods and devices connected should be developed so that they can support different charging methods. These capabilities in the devices are costly and challenging.

Network Security

- 6G wireless communications network will connect not only smartphones but also smart devices used in automation, AI, XR, smart cities and satellites.

- The security approaches used in 5G will not be sufficient in 6G, and hence new security techniques with innovative cryptographic methods should be considered including the physical layer security techniques and integrated network security techniques with low cost, low complexity and very high security.

Transceiver and Antenna Designs

- 6G wireless communication technology supports high-frequency band in THz and supports spectrum and resources sharing.

- The transceivers should be able to support this technology having the antenna designed with the required size; nanometer to micrometer components satisfying the holographic beamforming requirements.

- Meta surface-based transceivers could be the solution to this issue to increase the throughput and the QoS. However, integrating meta surface with OFDM-MIMO is a great challenge.

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Thank You