6LowPAN

- 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks)
- a low power wireless mesh network where every node has its own IPv6 address
- This allows the node to connect directly with the Internet using open standards
- reated with the intention of applying the Internet Protocol (IP) even to the smallest devices

Advantages of 6LoWPAN

- Uses Open IP Standards
  - It works great with open IP standard including TCP, UDP, HTTP, COAP, MATT and web-sockets.
- Offers End-To-End IP Addressable Nodes
  - It offers end-to-end IP addressable nodes. There's no need for a gateway, only a router which can connect the 6LoWPAN network to IP.
- Offers Self-Healing, Robust and Scalable Mesh Routing
  - It supports self-healing, robust and scalable mesh routing.
  - Offers one-to-many & many-to-one routing.
  - The 6LoWPAN mesh routers can route data to others nodes in the network.
- Leaf Nodes Can Sleep For a Long Duration of Time
  - In a 6LowPAN network, leaf nodes can sleep for a long duration of time.
- Offers Thorough Support For The PHY Layer
  - It also offers thorough support for the PHY layer which gives freedom of frequency band & physical layer, which can be used across multiple communication platforms like Ethernet, WI-Fi, 802.15.4 or Sub-1GHz ISM with interoperability at the IP level.
- It is a Standard: RFC6282

6LoWPAN basics

- The 6LoWPAN technology utilises IEEE 802.15.4 to provide the lower layers for this low power wireless network system.
- In order to send packet data, IPv6 over 6LowPAN, it is necessary to have a method of converting the packet data into a format that can be handled by the IEEE 802.15.4 lower layer system.
- IPv6 requires the maximum transmission unit (MTU) to be at least 1280 bytes in length. This is considerably longer than the IEEE802.15.4's standard packet size of 127 octets which was set to keep transmissions short and thereby reduce power consumption.
- To overcome the address resolution issue, IPv6 nodes are given 128 bit addresses in a hierarchical manner.

6LoWPAN application

- General Automation
  - There are enormous opportunities for 6LoWPAN to be used in many different areas of automation.
- Home automation
  - There is a large market for home automation.
  - By connecting using IPv6, it is possible to gain distinct advantages over other IoT systems.
- Smart Grid

- Smart grids enable smart meters and other devices to build a micro mesh network and they are able to send the data back to the grid operator's monitoring and billing system using the IPv6 backbone.
- Industrial monitoring
  - Automated factories and industrial plants provide a great opportunity for 6LoWPAN and using automation, can enable major savings to be made.
  - The ability of 6LoWPAN to connect to the cloud opens up many different areas for data monitoring and analysis.

LPWAN

- low-power WAN (LPWAN), a wireless wide area network technology specialized for connecting devices
- LPWAN technologies are designed for
  - machine-to-machine networking environments
  - lower power requirements
  - longer range
  - lower costs than traditional mobile networks.
- the networks are able to support more devices over a larger coverage area than traditional consumer mobile technologies.

Licensed LPWAN

- Licensed LPWANs run on public cellular networks which use the licensed radio spectrum and support the GSM and 3GPP standards.
- Types of licensed LPWAN

  - Narrowband IoT (NB-IoT)

    - developed to enable a wide range of new IoT devices and services.
    - NB-IoT significantly improves
      - the power consumption of user devices,
      - system capacity and spectrum efficiency,
    - uses existing infrastructure of LTE and GSM network providers to facilitate low bandwidth communications for IoT devices.

  - LTE-M

    - Part of Release 13 of the 3GPP standard
    - LTE-M aims to
      - lower power consumption
      - reduce device complexity and cost
      - provide deeper coverage to reach challenging locations
    - This standard will improve upon NB-IoT in terms of bandwidth.
    - It also boasts the highest security of LPWAN technologies.

Unlicensed LPWAN

- Unlicensed LPWAN use radio spectrum that is unlicensed and can be used by anyone

- Types of unlicensed LPWAN
    - LoRaWAN
        - intended for wireless battery operated things in a regional, national or global network.
        - targets key requirements of IoT such as secure bidirectional communication, mobility and localization services.
        - provides seamless interoperability among smart things without the need of complex local installations
    - Sigfox
        - A narrowband (or ultra-narrowband) technology
        - suited best for the lowest bandwidth applications with extremely tight energy budgets
        - it is an entirely separate network for IoT devices

Overview of 5G technologies

- 5G is the 5th generation mobile network.
- designed to connect virtually everyone and everything together including machines, objects, and devices.
- Features:
    - deliver higher multi-Gbps peak data speeds
    - ultra low latency
    - more reliability
    - massive network capacity
    - increased availability
    - uniform user experience to more users
    - higher performance
    - improved efficiency

Invention of 5G

- several companies within the mobile ecosystem that are contributing to bringing 5G to life.
- Qualcomm has played a major role in inventing the many foundational technologies
- 3rd Generation Partnership Project (3GPP) - organization that defines the global specifications for 3G UMTS (including HSPA), 4G LTE, and 5G technologies

Underlying technologies

- 5G is based on OFDM (Orthogonal frequency-division multiplexing)
- 5G uses 5G NR air interface alongside OFDM principles.
    - A new Air Interface for LTE
    - improve the performance, flexibility, scalability and efficiency of current mobile networks
- 5G also uses wider bandwidth technologies such as sub-6 GHz and mmWave.
    - mmWave refers to higher frequency radio bands ranging from 24GHz to 40GHz
    - Sub-6GHz refers to mid and low-frequency bands under 6GHz.
    - Low-frequency bands are under 1GHz, while mid-bands range from 3.4GHz to 6GHz

Generations

- First generation - 1G

- 1980s: 1G delivered analog voice.
- Second generation - 2G
    - Early 1990s: 2G introduced digital voice (e.g. CDMA- Code Division Multiple Access).
- Third generation - 3G
    - Early 2000s: 3G brought mobile data (e.g. CDMA2000).
- Fourth generation - 4G LTE
    - 2010s: 4G LTE ushered in the era of mobile broadband.

Reasons that 5G will be better than 4G

- 5G is significantly faster than 4G
    - 5G can be significantly faster than 4G, delivering up to 20 Gigabits-per-second (Gbps) peak data rates and 100+ Megabits-per-second (Mbps) average data rates.
- 5G has more capacity than 4G
    - 5G is designed to support a 100x increase in traffic capacity and network efficiency.1
- 5G has significantly lower latency than 4G
    - 5G has significantly lower latency to deliver more instantaneous, real-time access: a 10x decrease in end-to-end latency down to 1ms
- 5G is a unified platform that is more capable than 4G
    - 5G can also natively support all spectrum types (licensed, shared, unlicensed) and bands (low, mid, high), a wide range of deployment models (from traditional macro-cells to hotspots), and new ways to interconnect (such as device-to-device and multi-hop mesh).
- 5G uses spectrum better than 4G
    - 5G is also designed to get the most out of every bit of spectrum across a wide array of available spectrum regulatory paradigms and bands—from low bands below 1 GHz, to mid bands from 1 GHz to 6 GHz, to high bands known as millimeter wave (mmWave).