SNS COLLEGE OF TECHNOLOGY

Coimbatore – 35

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19ECT311 / Wireless Communication

III ECE/ VI SEMESTER

Unit III - **CELLULAR NETWORKS**

Topic 6: 5 G

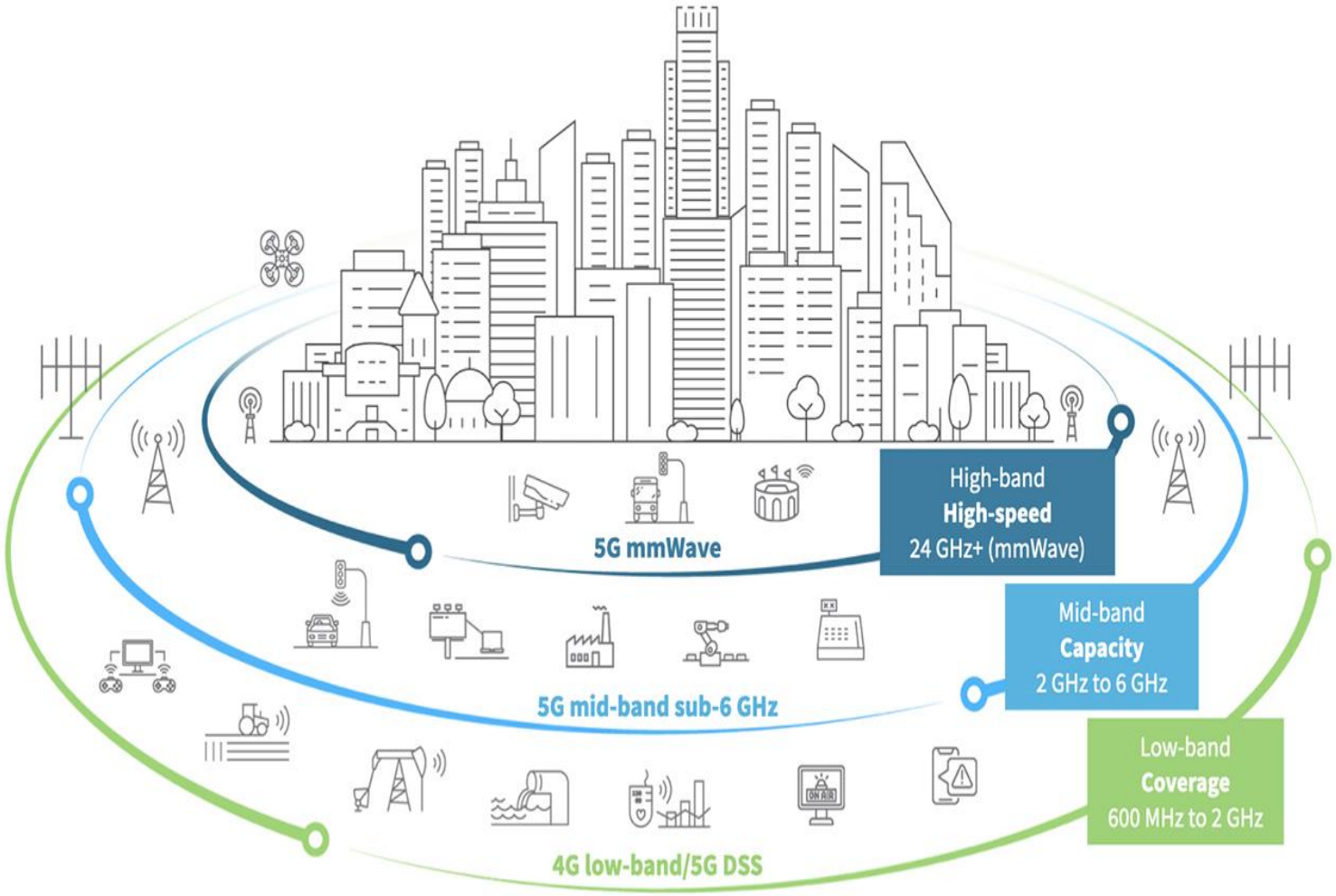
Why 5G?

- With the promises of high data speed, ultralow latency, and billions of connections, 5G technology for mobile networks is gaining attention worldwide.
- Faster data transmission speed, up to multi-Gigabit/s speeds.
- Greater capacity, fueling a massive amount of IoT devices per square kilometer.
- Lower latency, down to single-digit milliseconds, which is critically important in applications such as connected vehicles in ITS applications and autonomous vehicles, where near instantaneous response is necessary.

5G Design considerations

- The design considerations for a 5G network architecture that supports highly demanding applications is complex.
- The range of applications requires data to travel distances, large data volumes, or some combination.
- So 5G architecture must support low, mid and high-band spectrum – from licensed, shared and private sources – to deliver the full 5G vision.
- For this reason, 5G is architected to run on radio frequencies ranging from sub 1 GHz to extremely high frequencies, called “millimeter wave” (or mmWave).
- The lower the frequency, the farther the signal can travel. The higher the frequency, the more data it can carry.

5G Frequency allocation



5G Frequency allocation

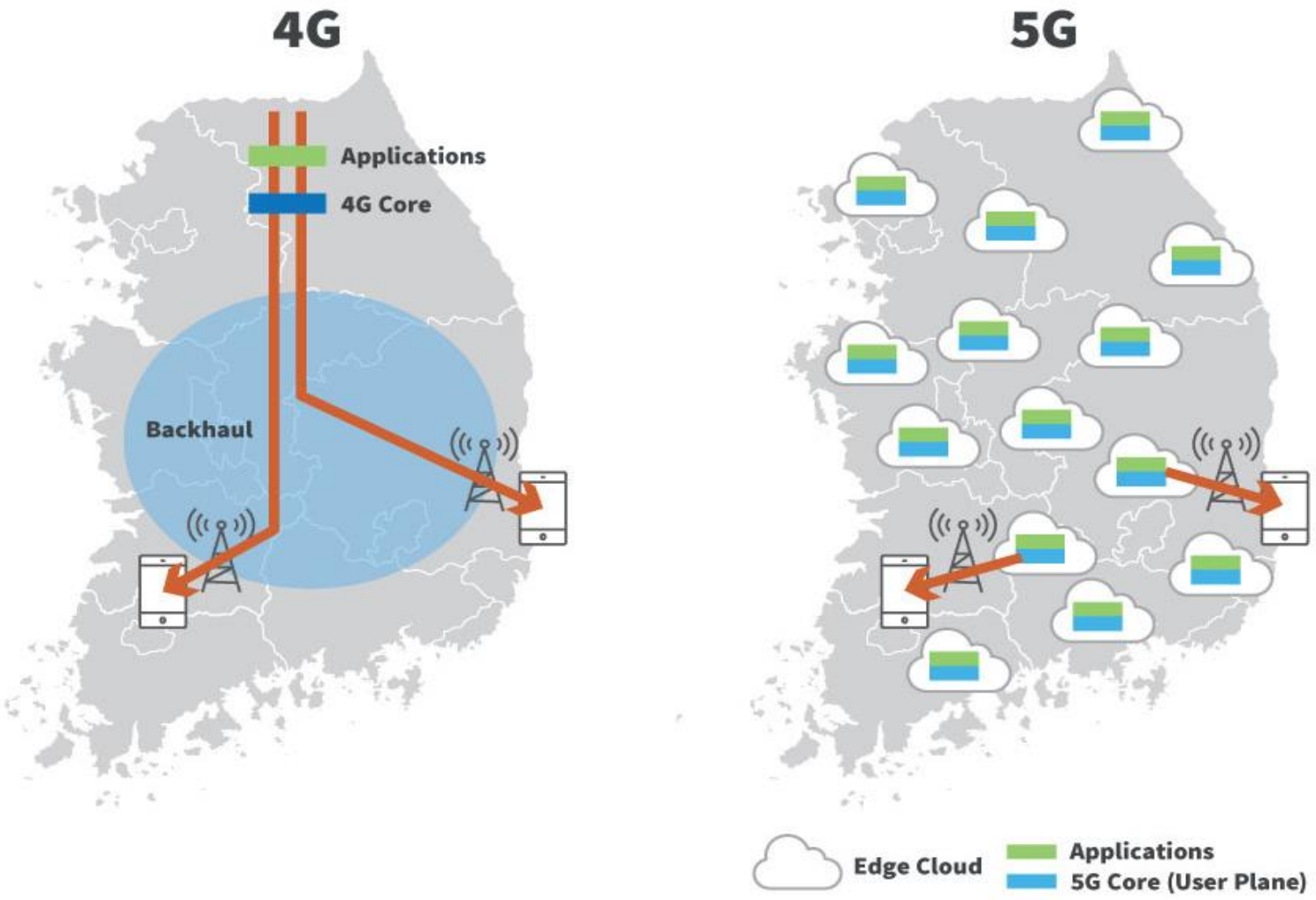
- There are three frequency bands at the core of 5G networks:
  - 5G high-band (mmWave) delivers the highest frequencies of 5G. These range from 24 GHz to approximately 100 GHz.
    - Because high frequencies cannot easily move through obstacles, high-band 5G is short range by nature.
    - Moreover, mmWave coverage is limited and requires more cellular infrastructure.
  - 5G mid-band operates in the 2-6 GHz range and provides a capacity layer for urban and suburban areas.
    This frequency band has peak rates in the hundreds of Mbps.
  - 5G low-band operates below 2 GHz and provides a broad coverage. This band uses spectrum that is available and in use today for 4G LTE, essentially providing an LTE 5g architecture for 5G devices that are ready now.
    - Performance of low-band 5G is therefore similar to 4G LTE, and supports use for 5G devices on the market today.

5G Networks and Devices

- 5G networks will have to accommodate diverse types of traffic, spectrum, and devices.
- Hierarchical nodes of various characteristics and capacities
- The 5G network will support multiple radio access technologies (RATs), such as 3G/4G/5G, WiFi, and WiGig
- Multiple modes ranging from ultradense small cells, device-to-device (D2D) communications,
- New sub-networks oriented toward wearable devices
- The user experience and quality will need to be maintained as users move along various networks and get connected to the various types of node

5G Networks and Devices

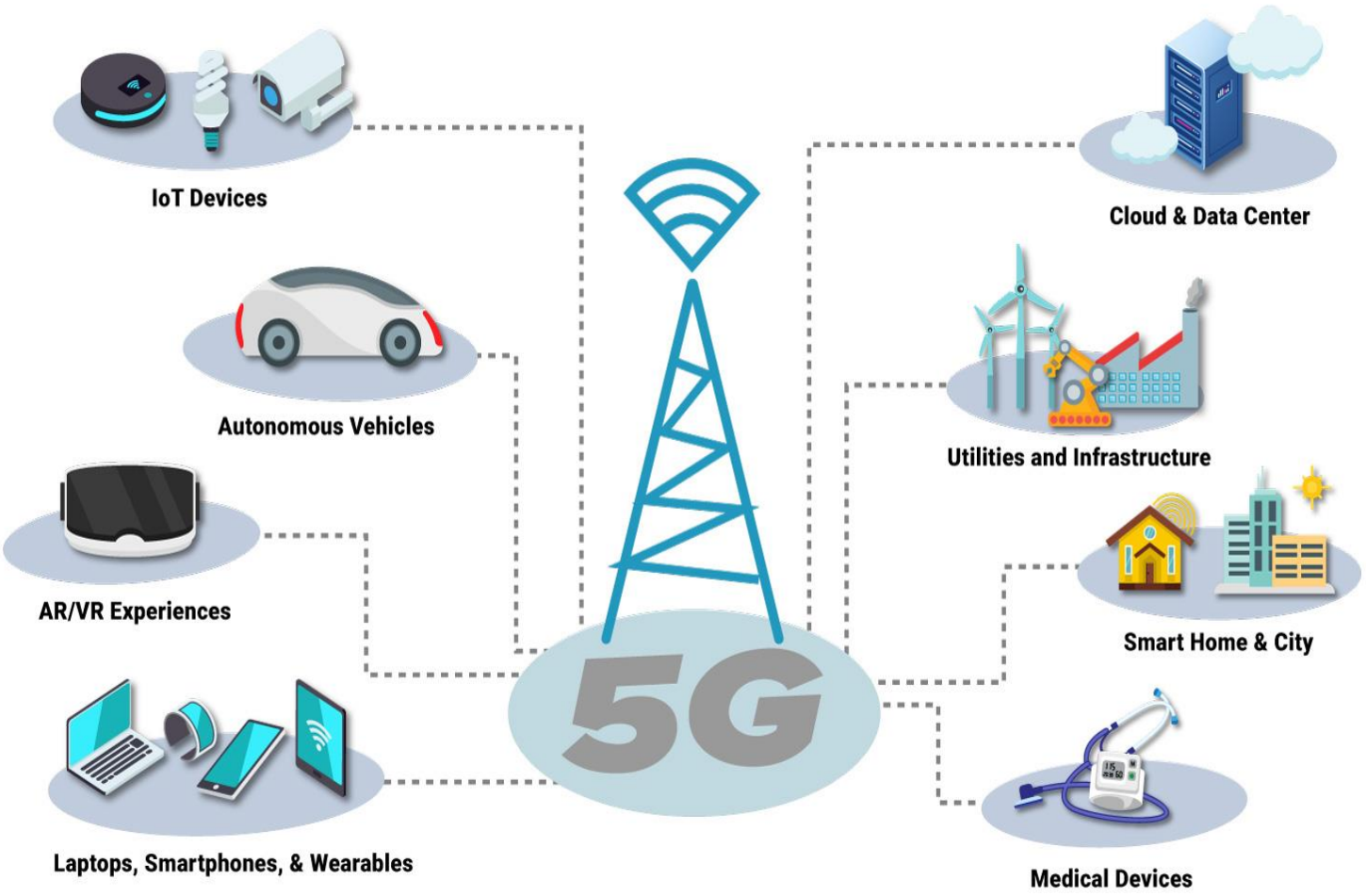
- 5G networks will likely use a multi-layer network architecture
  - Macro layer provides coverage to users moving at high speeds or for secure control channels
  - Lower layer comprising network nodes with smaller capabilities
- Provides high data rates and connectivity to other RATS (WiFi or new mmWave RATs).
- 5G device may have simultaneous active connections to more than one network node, with the same or different RATs, each connection serving a specific purpose
- one connection to a given node for data and a second connection to another node for control.
- In addition, the use of remote radio heads connected to central processing nodes with the aid of ultra-high-speed backhaul is expected to be extended to more areas.
- Fast and high-capacity backhaul will enable tighter coordination between network nodes in a larger area.
- All of these changes will require a high level of integration of different nodes in the network and of technologies located even within the same node.


4G
Applications
4G Core
Backhaul
5G
Edge Cloud
Applications
5G Core (User Plane)

5G Networks and Devices

- Devices will be capable of operating in multiple spectrum bands, ranging
- from RF to mmWave, while being compatible with existing technologies such as 3G and 4G.
- The need to support several RATs with multiple RFT chains will impose tremendous challenges for 5G device chipset and front end module suppliers, as well as system and platform integrators.
- Another key feature of 5G devices will be their advanced interference suppression capabilities.
- The dense deployment of network nodes and increasing sources of interference will require that the devices deployed autonomously detect, characterize, and suppress interference from any source: intra cell, inter cell, or D2D.

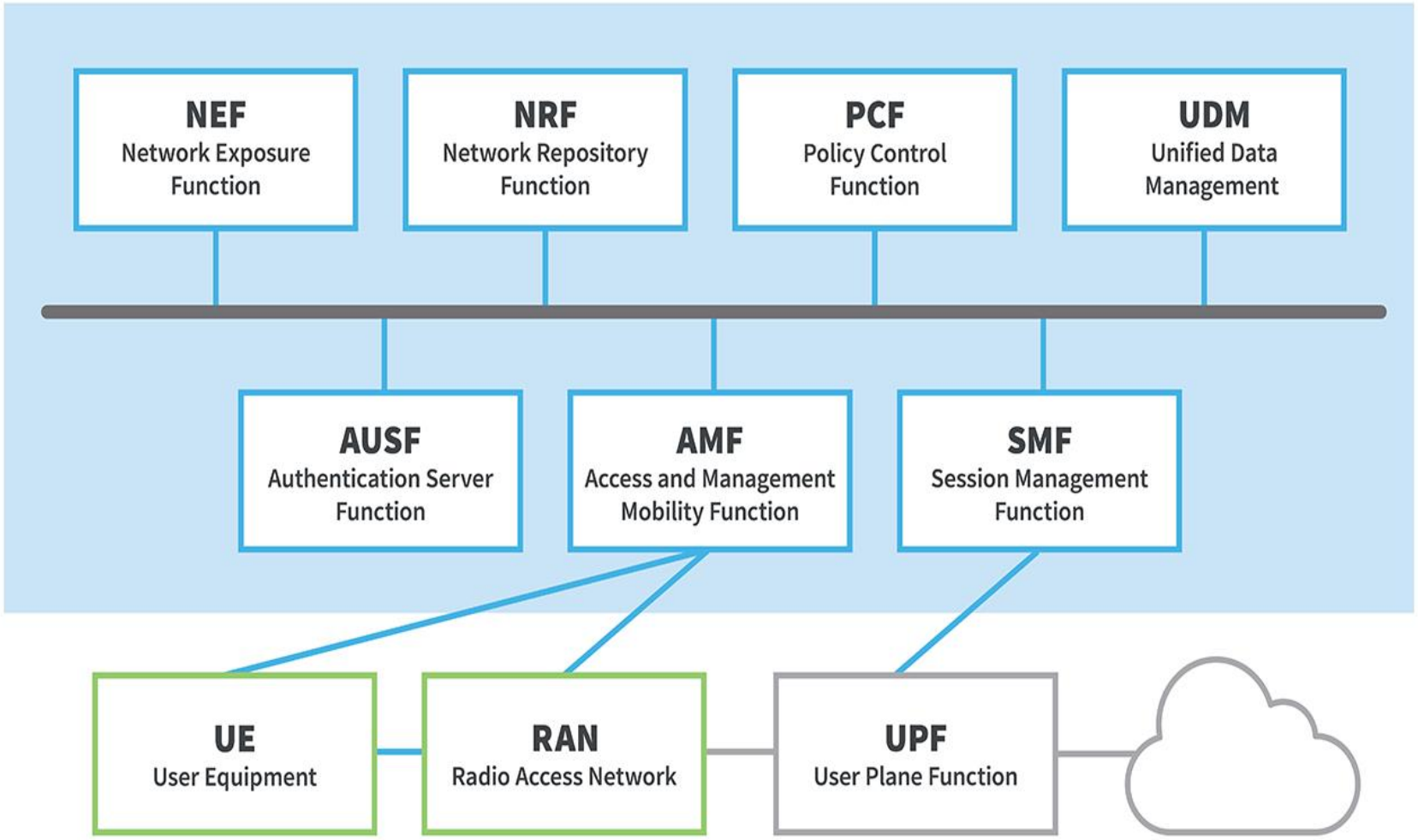
5G Connections & Devices



ACTIVITY

Activity: Draw a logo which may describe your character or things you like.

5G Architecture

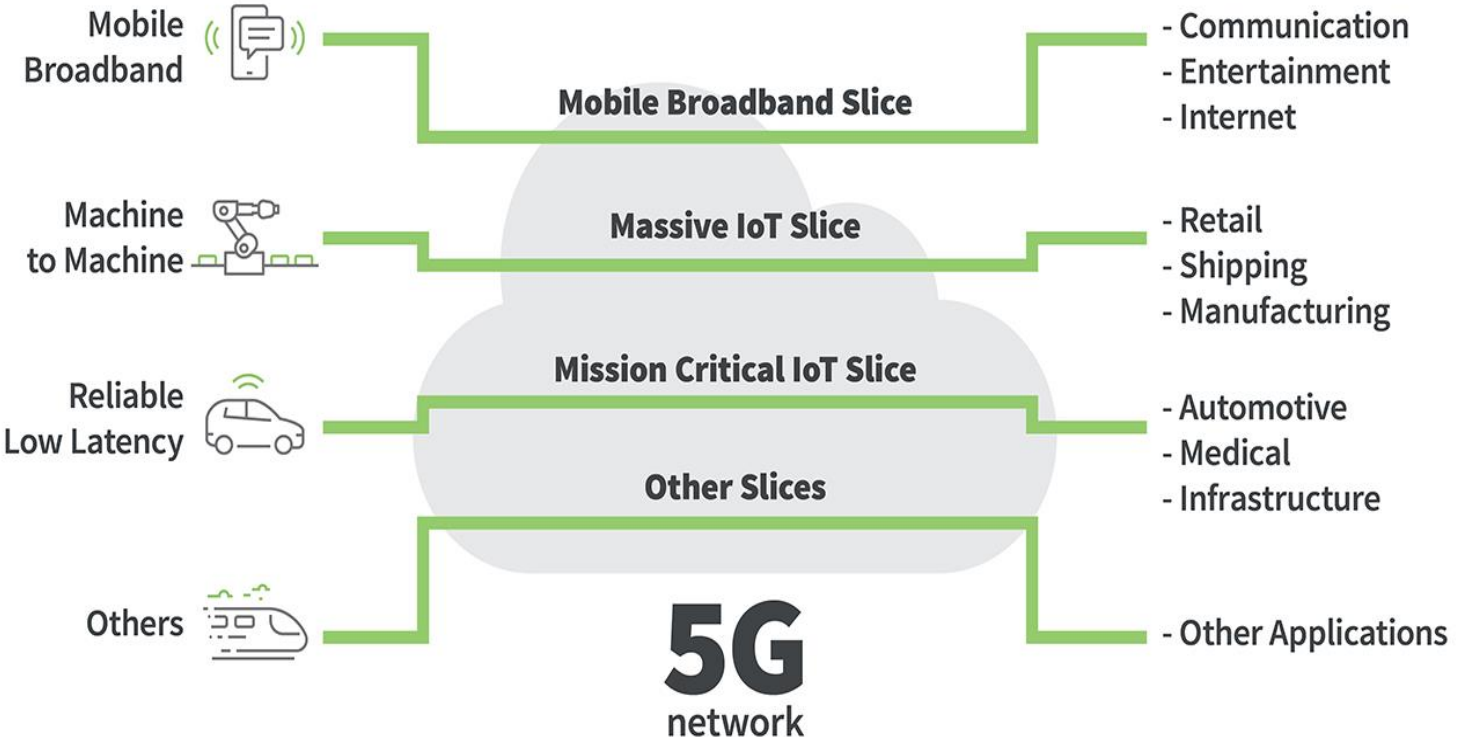


5G Architecture

•**User Equipment (UE)** like 5G smartphones or 5G cellular devices connect over the 5G New Radio Access Network to the 5G core and further to **Data Networks (DN)**, like the Internet.
•The **Access and Mobility Management Function (AMF)** acts as a single-entry point for the UE connection.
•Based on the service requested by the UE, the AMF selects the respective Session Management Function (SMF) for managing the user session.
•The **User Plane Function (UPF)** transports the IP data traffic (user plane) between the User Equipment (UE) and the external networks.
•The **Authentication Server Function (AUSF)** allows the AMF to authenticate the UE and access services of the 5G core.
•Other functions like the **Session Management Function (SMF)**, the **Policy Control Function (PCF)**, the **Application Function (AF)** and the **Unified Data Management (UDM)** function provide the policy control framework, applying policy decisions and accessing subscription information, to govern the network behavior.

5G Network Slicing

5G network slicing enables service providers to build virtual end-to-end networks tailored to application requirements.



5G Requirements

- cooperative radio access architectures to enable greater energy efficiency and network
- performance
- small cell networks with in built caching
- multiple RAT integration, which is inevitable to provide a seamless user experience
- distributed resource allocation
- advances in device to device communications
- energy efficient network design
- multi antenna processing and interference co ordination techniques
- design for M2M communications

Capacity Requirements

- Due to the huge growth in total traffic, there will be more variations in traffic volume, depending on the times, locations, applications, and types of device involved.
- Data traffic growth between 2008 and 2013 was 45 fold.
- Combining this with the forecasts from 2014 to 2018, the growth between 2008 and 2018 will be almost 500 times.
- Assuming a similar growth rate is maintained in the future, mobile traffic in 2025 will easily be 1000 times the 2010 level.
- In recent years, many forecasters have projected mobile data traffic will grow
- 24 fold between 2010 and 2015, which corresponds to a compound annual growth rate of almost 1.9

User Data rate Requirements

- Considering the rapidly emerging trends towards richer content and cloud services, 5G should aim to provide higher data rate services along with a more uniform quality of user experience than LTE.
- Achieved through improvements in both the achievable data rates and fairness in user throughput
- The target is set here to a 10 fold improvement in peak data rate
- Targeting more than 10 Gbps and a 100 fold increase in user experienced throughput, delivering throughput rates of 1 Gbps to users everywhere.

Latency Requirements

- Augmented reality and time critical M2M communications, such as remote control and monitoring and V2X, will impose very stringent requirements on end-to-end latency
- Radio, core, and backhaul latencies
- There are two types of latencies:
  user plane latency and control plane latency
- The end-to-end latency can be generally reduced by reducing the latency related to:
  - .. processing delays of the equipment (UE/eNB processing)
  - .. TTI duration
  - .. HARQ delays(Hybrid Automatic repeat Request)

  .. transport and core network latency.
  - Control plane Latency - The LTE advanced requirement for control-plane latency is 100 ms. Control plane latency can be classified into idle to connected or dormant to active latency.

Massive Device Connectivity

- In 2020 and beyond, mobile operators wanting to expand their business will need to become a total service provider by offering a greater range of services and providing a mobile “smart life” to every user
- real-time interactive services, such as Google glasses, data storage and processing, and others.
- To support these future cloud services, it is important to provide connectivity to a larger numberof devices.
- This becomes a challenge in particular in areas with high user density

Energy Saving and Robustness against Emergencies

- In order to make 5G a sustainable system, its total energy consumption should not be much larger than that of current systems.
- Battery life is important for some specific M2M devices such as sensors and smart meters, where lifetimes of the order of 10 years may be required.
- 5G should be able to provide lifeline communications in case of natural disasters such as earthquakes, tsunamis, floods, and hurricanes.
- Several basic types of communication, such as voice and text messages, are needed instantaneously and simultaneously by the survivors
- Network robustness is important in order to avoid suspension of services because of network damage. In addition, low network and user terminal energy consumption is critical in emergency cases.

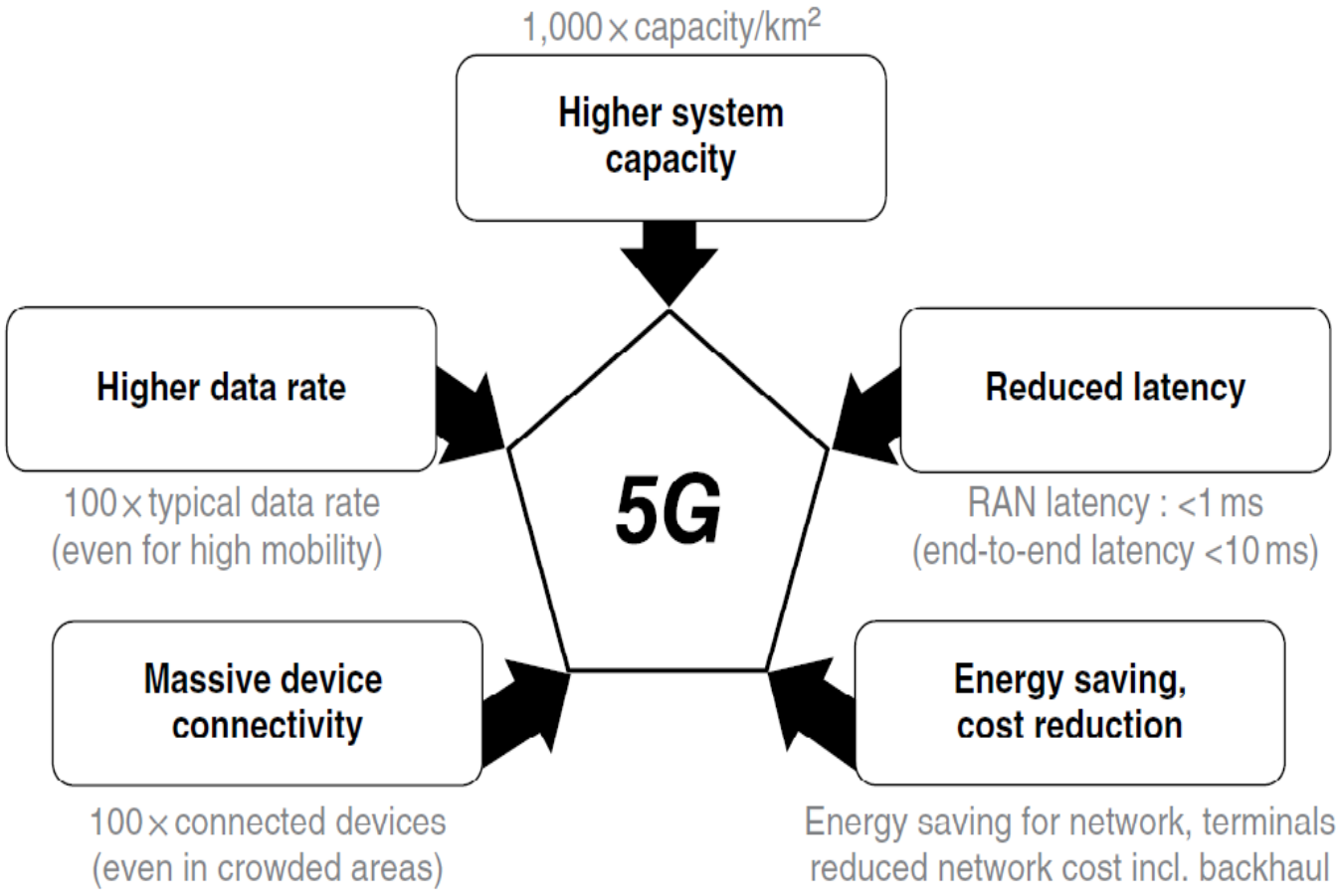


Figure 5G performance targets.

https://www.digi.com/blog/post/5g-network-architecture

Assessment

- **1. The rainbow pattern seen on a CD is an example of**
  1. Reflection
  2. Refraction
  3. Diffraction
  4. None of the above
- **2. Fresnel Reflection Coefficient is a factor of**
  1. Polarization of the wave
  2. Properties of the material at which reflection occurs
  3. Angle of incidence of wave

  a. 1) and 2) are correct

  b. All the three are correct

  c. 1) and 3) are correct

  d. 2) and 3) are correct.

- **3. Diffraction, at high frequencies, depends upon**
  1. Geometry of the object
  2. Polarization of the incident wave
  3. Amplitude of the incident wave
  4. Frequency of the incident wave

  a. 1) and 2) are correct

  b. 1), 2) and 3) are correct

  c. 2) and 3) are correct

  d. All are correct