5G

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Outline

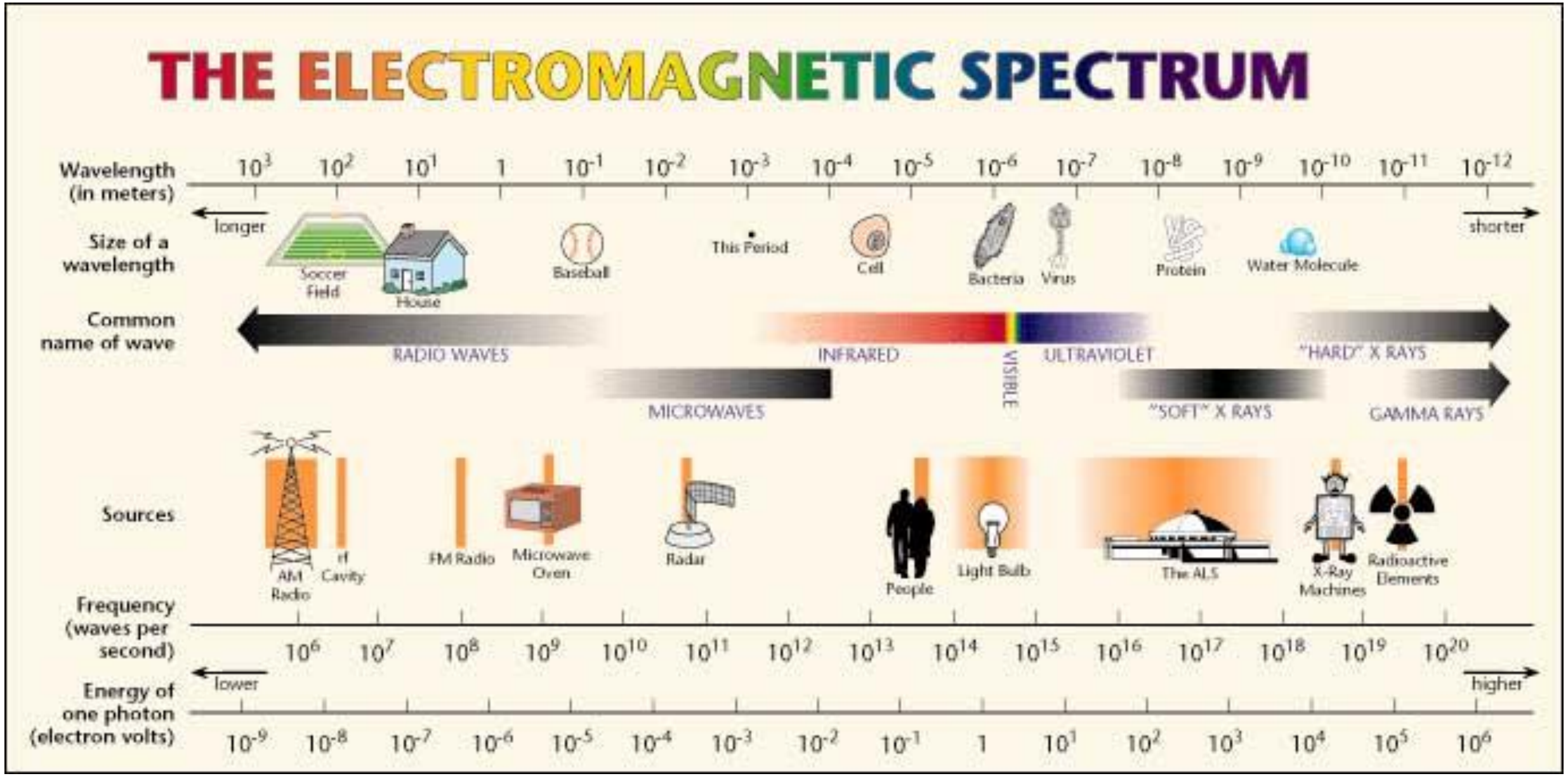
- Basics of Communication
- Evolution of Mobile Communication
- 5G Characteristics
- 5G Standard
- 5G Applications

Communication Technologies

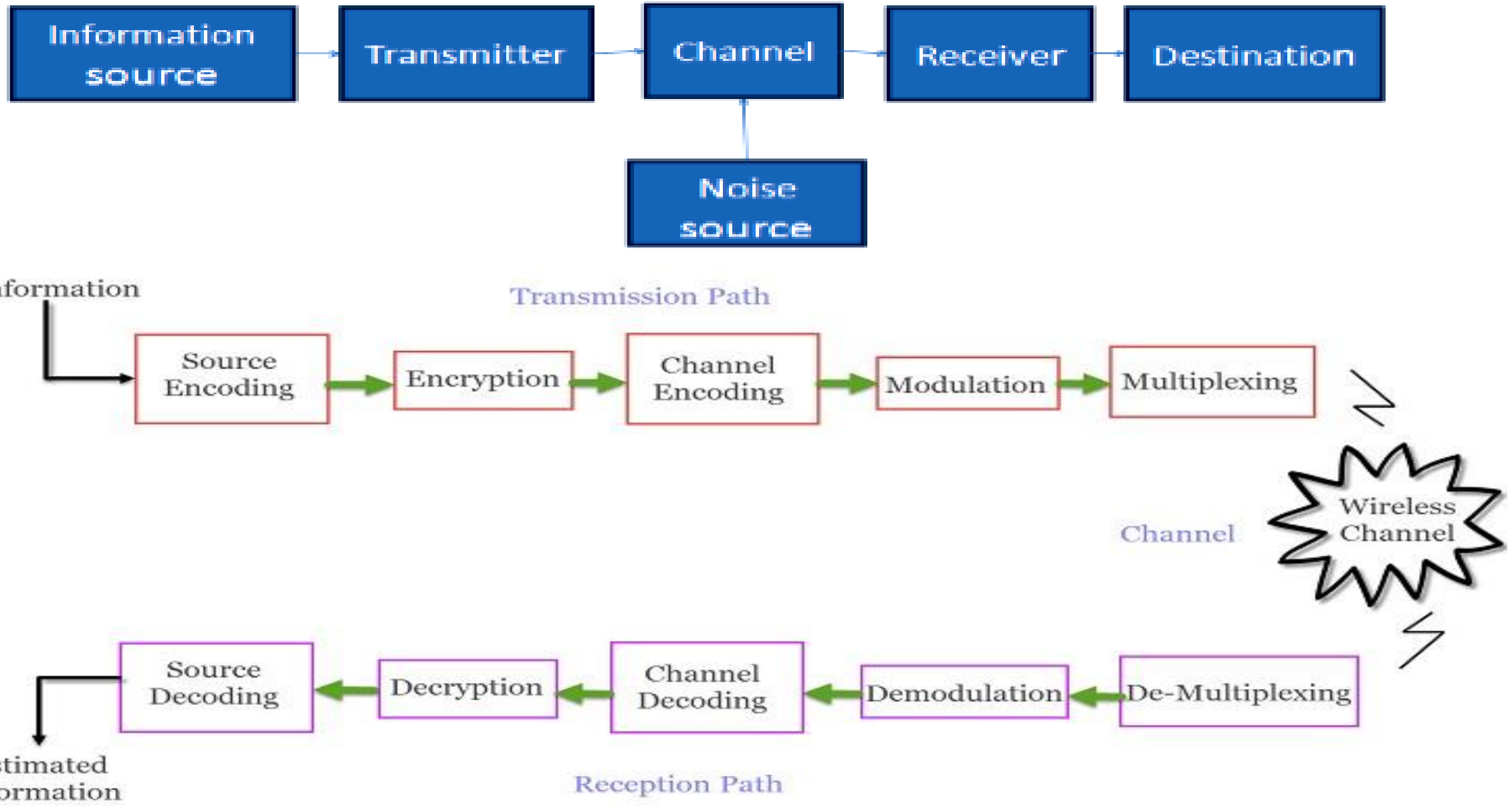
- Long range
  - Wired,
    - Ethernet, optical fiber
  - Wireless
    - Satellite (VSAT), Cellular, *Sub GHz*
- Short Range or Last mile Connectivity
  - NFC, RFID, Bluetooth, Wi-Fi, BLE, Zig Bee

Types of Wireless Communication

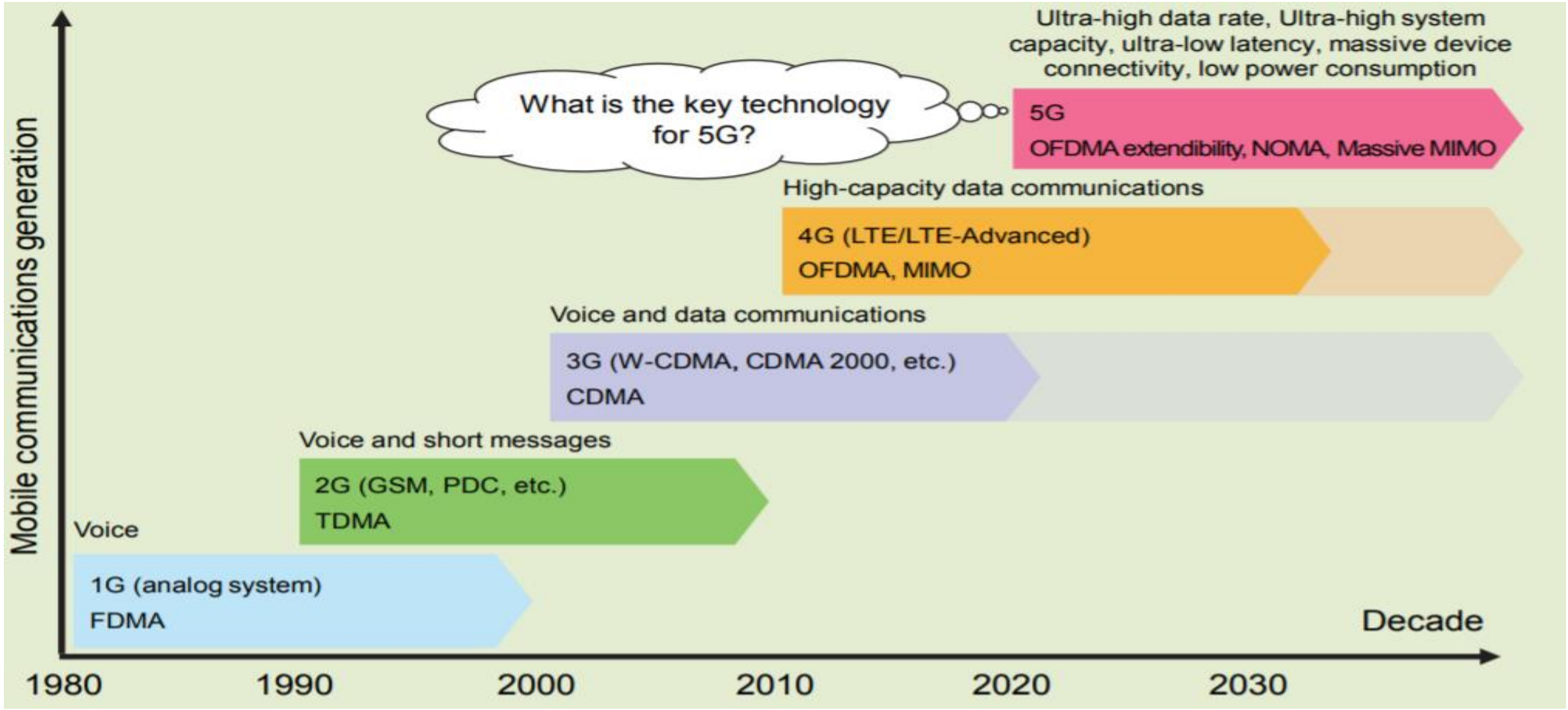
- Satellite Communication
- Infrared Communication
- RFID
- Broadcast Radio
- Microwave Communication
- Wi-Fi , Gi-Fi, Li-FI
- Mobile Communication Systems (GSM/CDMA)
- Bluetooth and BLE
- Near Field Communication (NFC) etc.


THE ELECTROMAGNETIC SPECTRUM
Wavelength (in meters)
10^{3} 10^{2} 10^{1} 1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
longer
shorter
Size of a wavelength
Soccer Field
House
Baseball
This Period
Cell
Bacteria
Virus
Protein
Water Molecule
Common name of wave
RADIO WAVES
INFRARED
VISIBLE
ULTRAVIOLET
"HARD" X RAYS
MICROWAVES
"SOFT" X RAYS
GAMMA RAYS
Sources
AM Radio
rf Cavity
FM Radio
Microwave Oven
Radar
People
Light Bulb
The ALS
X-Ray Machines
Radioactive Elements
Frequency (waves per second)
10^{6} 10^{7} 10^{8} 10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18} 10^{19} 10^{20}
lower
higher
Energy of one photon (electron volts)
10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}

Wireless Communication



Evolution of 1G to 5G



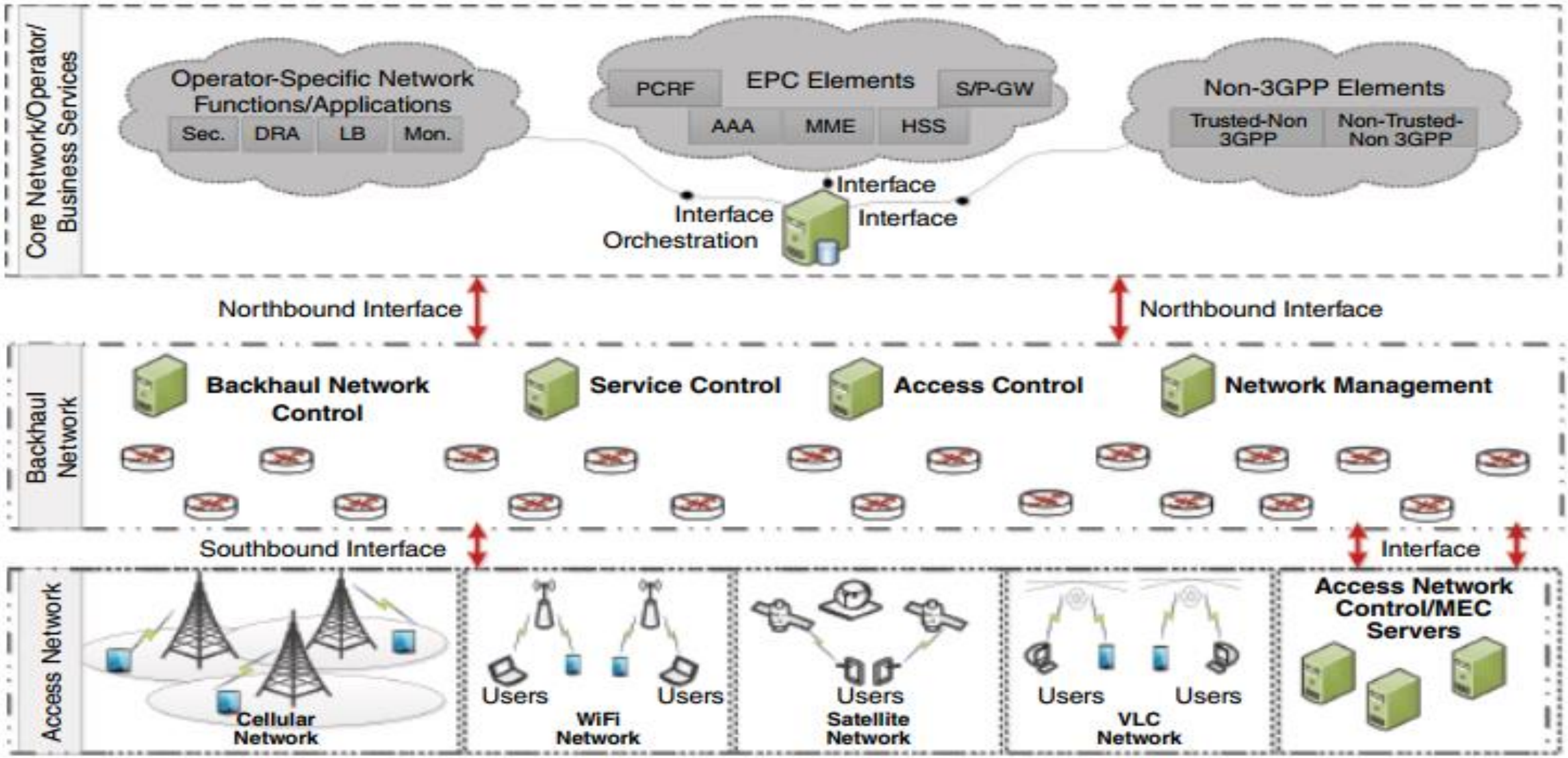
COMPARISION OF GENERATIONS

Generation→ Features↓	1G	2G	3G	4G	5G
Deployment	1970 – 1980	1990 - 2001	2001-2010	2011	2015-20 onwards
Data Rates	2kbps	14.4-64kbps	2Mbps	200 Mbps to 1 Gbps	1Gbps and higher
Technology	Analog Cellular Technology	Digital Cellular Technology: Digital narrow band circuit data Packet data	Digital Broadband Packet data: CDMA 2000 EVDO UMTS EDGE	Digital Broadband Packet data: WiMax LTE Wi-Fi	wwww Unified IP seamless combination of broadband LAN PAN MAN WLAN
Service	Analog voice service No data service	Digital voice with higher clarity SMS, MMS Higher capacity packetized data	Enhanced audio video streaming video conferencing support Web browsing at higher speeds IPTV support	Enhanced audio, video streaming IP telephony HD mobile TV	Dynamic Information access, Wearable devices with AI Capabilities
Multiplexing Switching	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Standards	MTS AMTS IMTS	2G:GSM 2.5:GPRS 2.75:EDGE	IMT-2000 3.5G-HSDPA 3.75G:HSUPA	Single unified standard LTE, WiMAX	Single unified standard
WEB Standard		www	www(IPv4)	www (IPv4)	wwww (IPv6)
Handoff	Horizontal only	Horizontal only	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical
Shortfalls	Low capacity, Unreliable handoff, Poor voice links, Less secure	Digital signals were reliant on location & proximity, required strong digital signals to help mobile phones	Need to accommodate higher network capacity	Being deployed	Yet to be implemented

5G Features

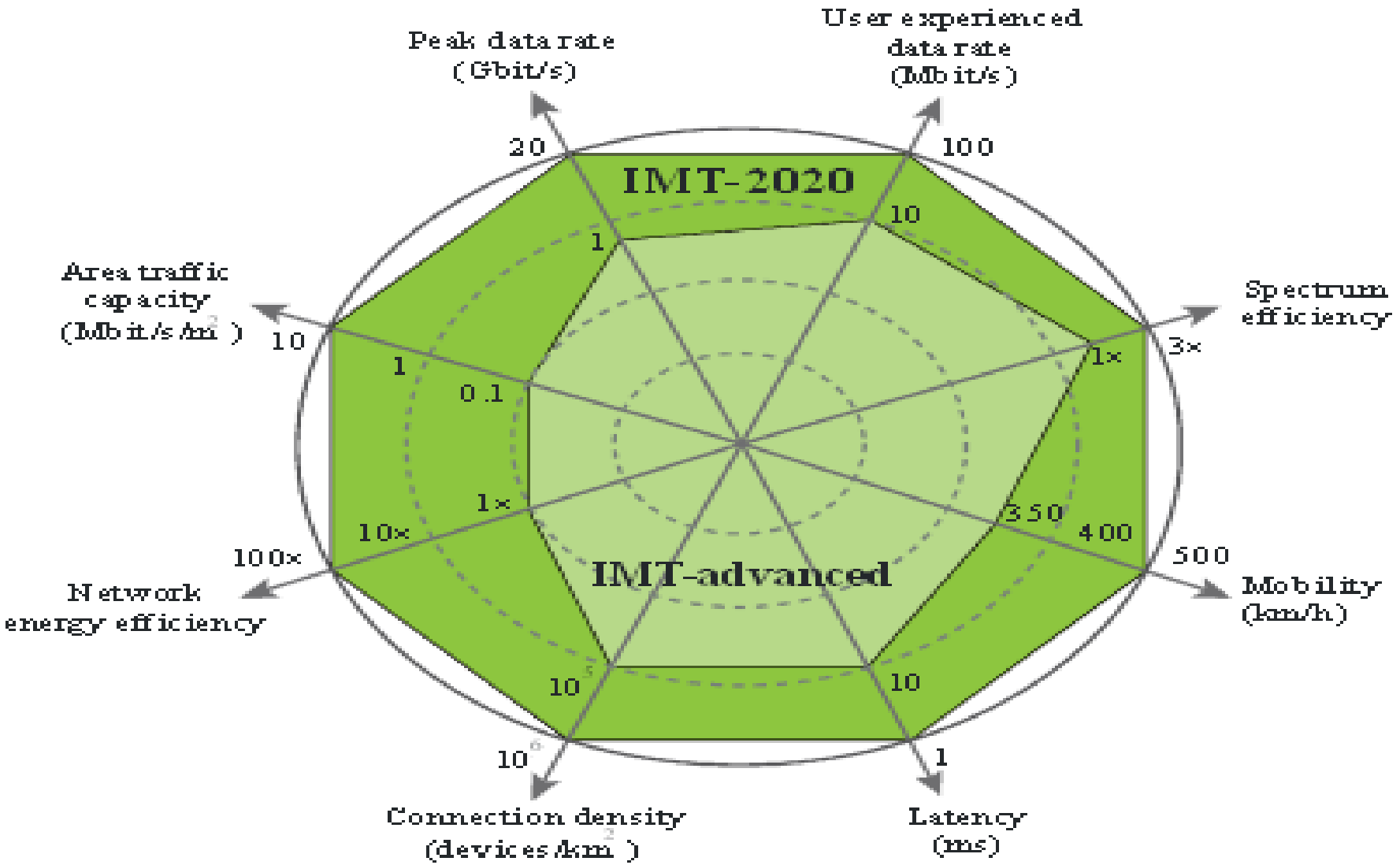
- Ultra Reliable Low latency Communication (URLLC)
- Peak data rate with Extended Mobile Broad Band (eMBB)
- Higher reliability and multi-level communication
- Better connectivity (eMBB) and high mobility (eMBB/URLLC) irrespective of the geographic region
- High capacity to allow more devices connectivity concurrently and instantaneously with Massive Machine to Machine Type Communication (MMTC)
- Larger number and density of supporting devices (MMTC)
- Larger data volume per unit area (i.e. high system spectral efficiency) (eMBB)
- Lower battery consumption (eMBB)
- Lower cost of infrastructural development

5G Architecture

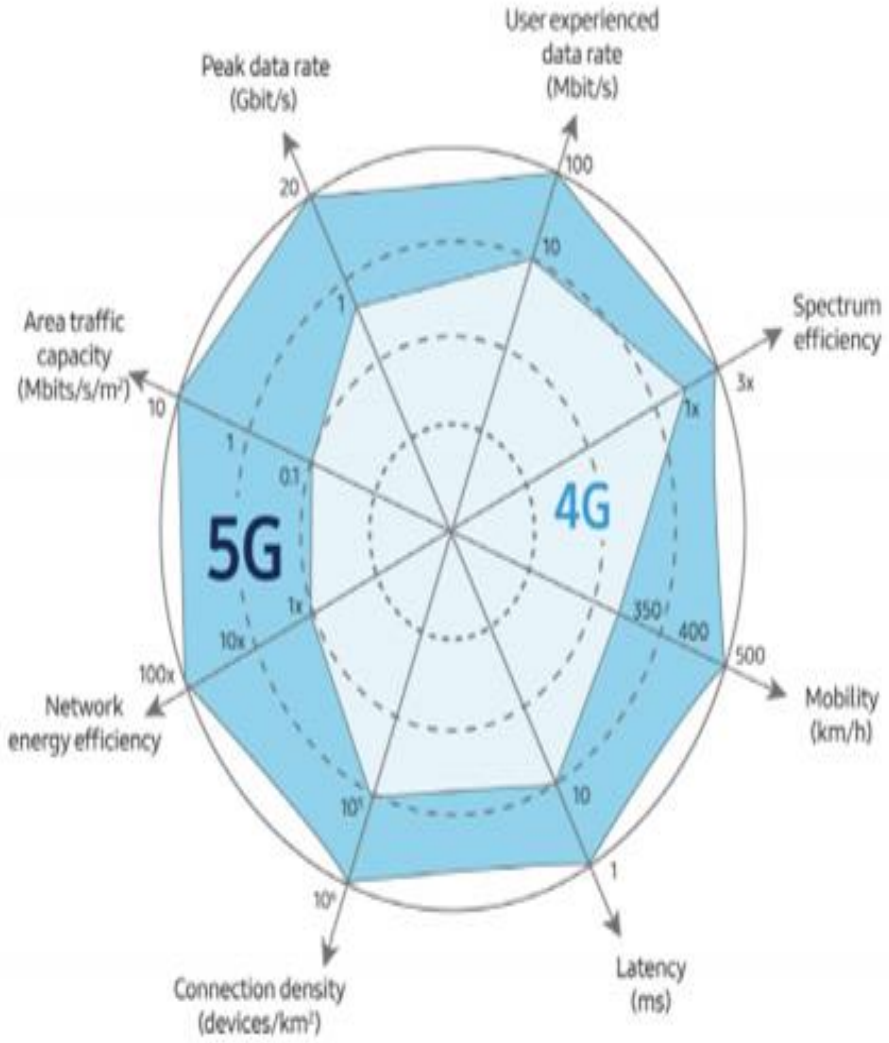


5G QoS Parameters	Corresponding 5G Key technologies	Respective Entities
High Data Rate	mmWave, Beamforming, Multi-RAT	High Frequency Bands
Ultra-Low Latency	mmWave, Advanced Networking, Latency Reduction Techniques, Mobile Edge/Fog Computing, D2D	Throughout the network
Connection Density	mmWave, Multi-RAT, Massive MIMO, Multiple Access, Advanced networking, Cellular IoT, D2D, M2M, Small Cell	gNodeB, Access Points
Reliability and High Availability	Cloud-RAN, SDN, NFV, MANO, Cloud Computing	Channel Bandwidth, Air interface
Flexibility and Programmability	Cloud-RAN, SDN, NFV, Network Slicing, MANO	Radio Access Network
Energy and Cost Efficiency	Cloud-RAN, SDN, NFV, Network Slicing, MANO	Radio Access Network

3GPP 5G Standards Expectations over IMT-2020 of ITU-R

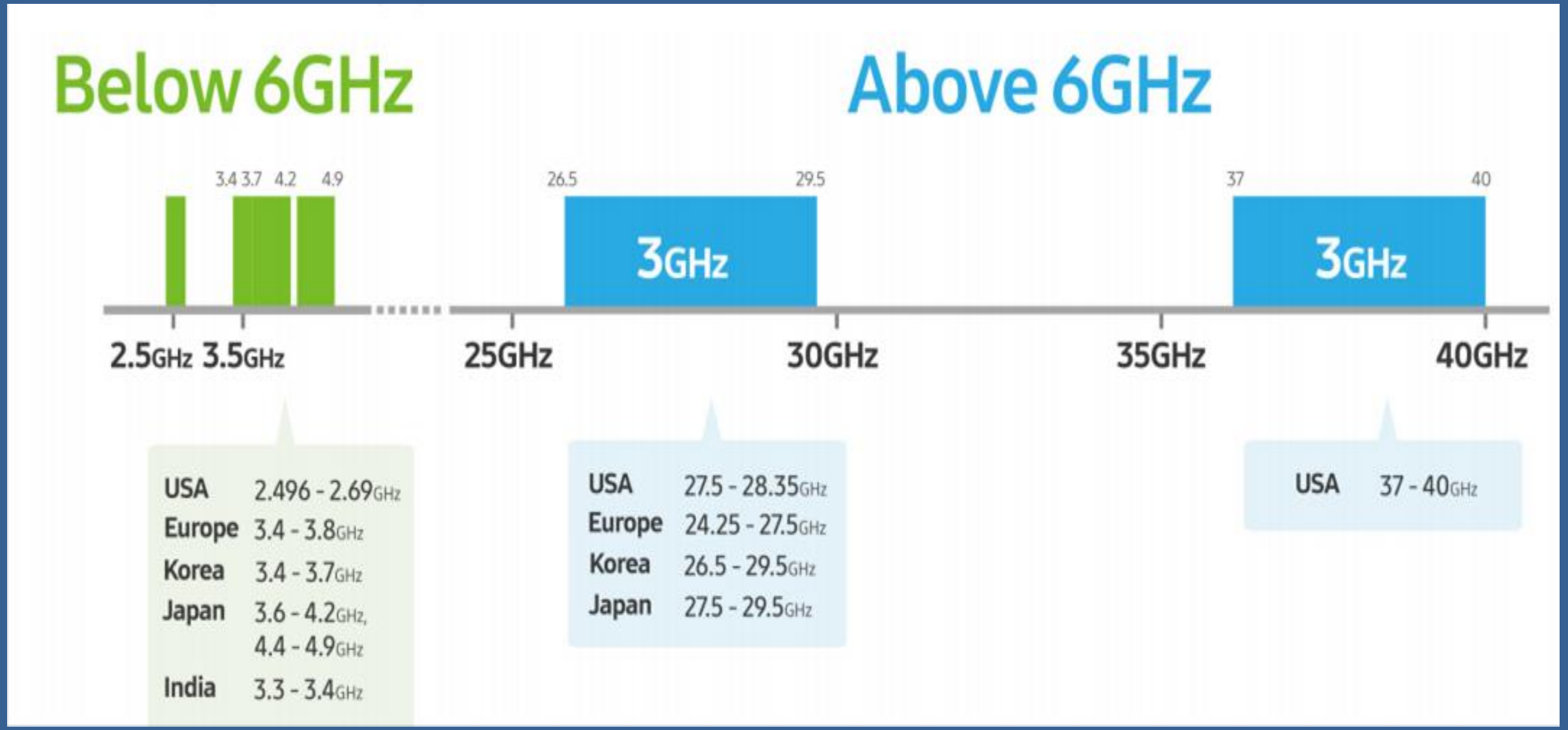


Comparison between 4G & 5G



Item	4G	5G
Peak data rate	1Gbps	20Gbps
User experienced data rate	10Mbps	100Mbps
Spectrum efficiency	-	x 3
Area traffic capacity	0.1Mbps/m²	10Mbps/m²
Latency	10ms	1ms
Connection density	100,000/km²	1,000,000/km²
Network energy efficiency	-	x 100
Mobility	350km/h	500km/h

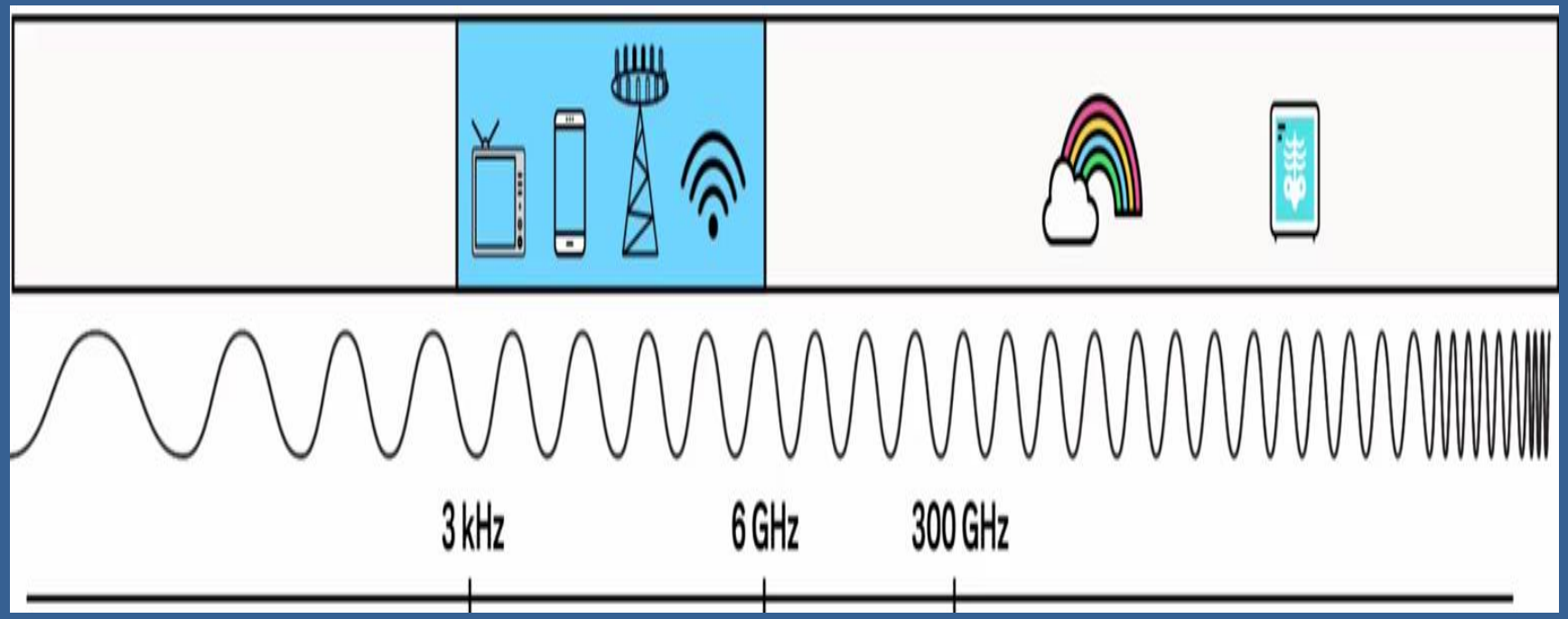
5G Frequency Bands



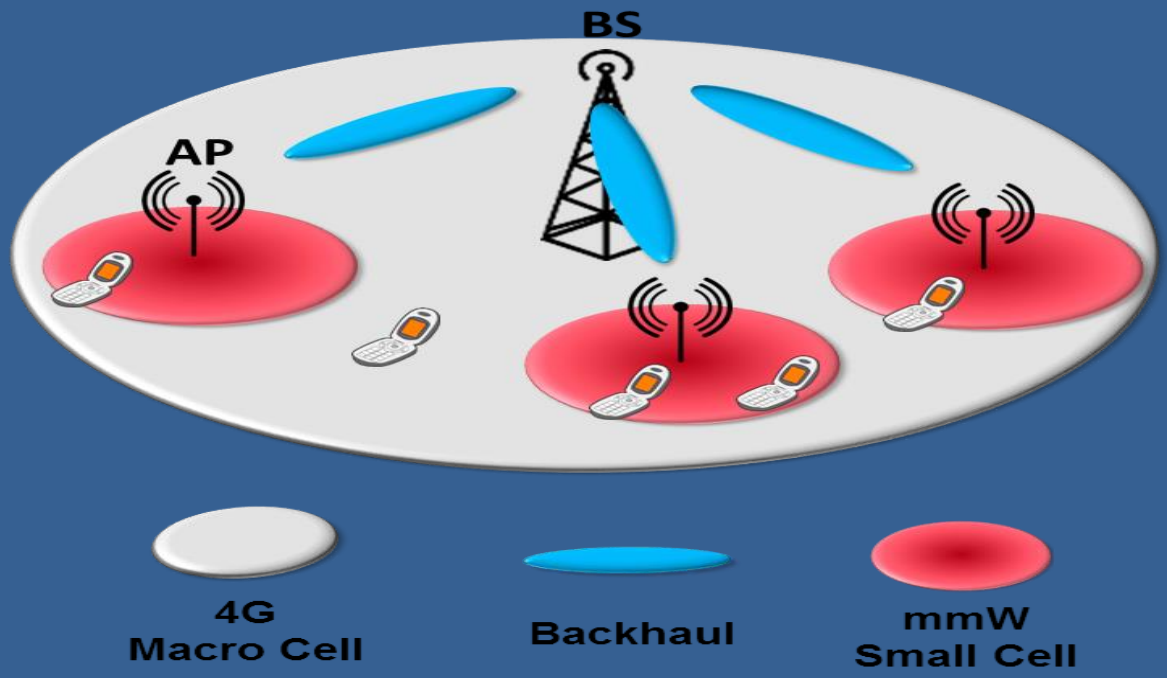
New Foundation Technologies for 5G

Millimetre waves

- Millimetre waves are broadcast at frequencies between 30 and 300 GHz, compared to the bands below 6 GHz that were used for mobile devices in the past.
- Wavelength vary from 1 to 10 mm.
- Allows for higher data rates up to 10 Gbps.
- Cannot travel well through buildings, other obstacles had tend to get absorbed by plants and rains.



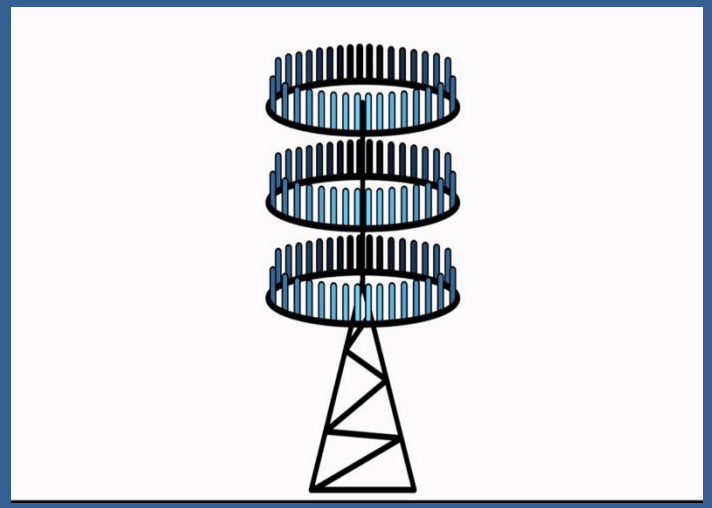
Small Cells Networks

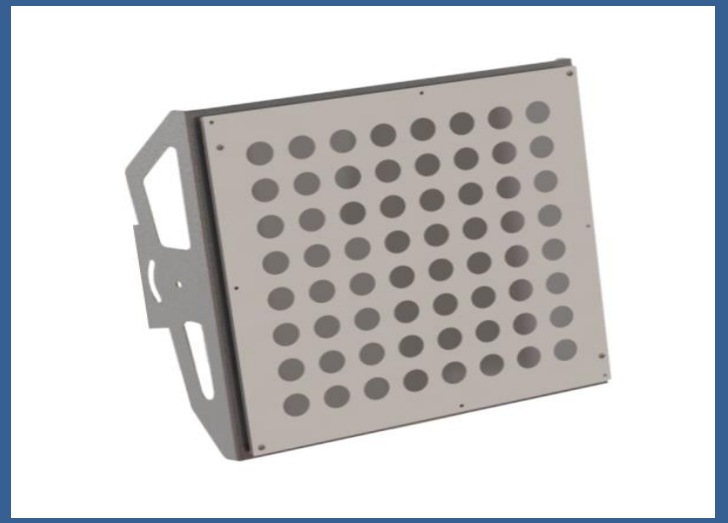


Cell Type	Output Power	Cell Radius	Locations
Macrocell	10-50W	1-10km	Indoor
Microcell	1-10W	250m-1km	Indoor/Outdoor
Picocell	0.25-1W	100m-300m	Indoor/Outdoor
Femtocell	0.001-0.25W	10m-50m	Outdoor

Massive MIMO(Multiple Input Multiple Output)

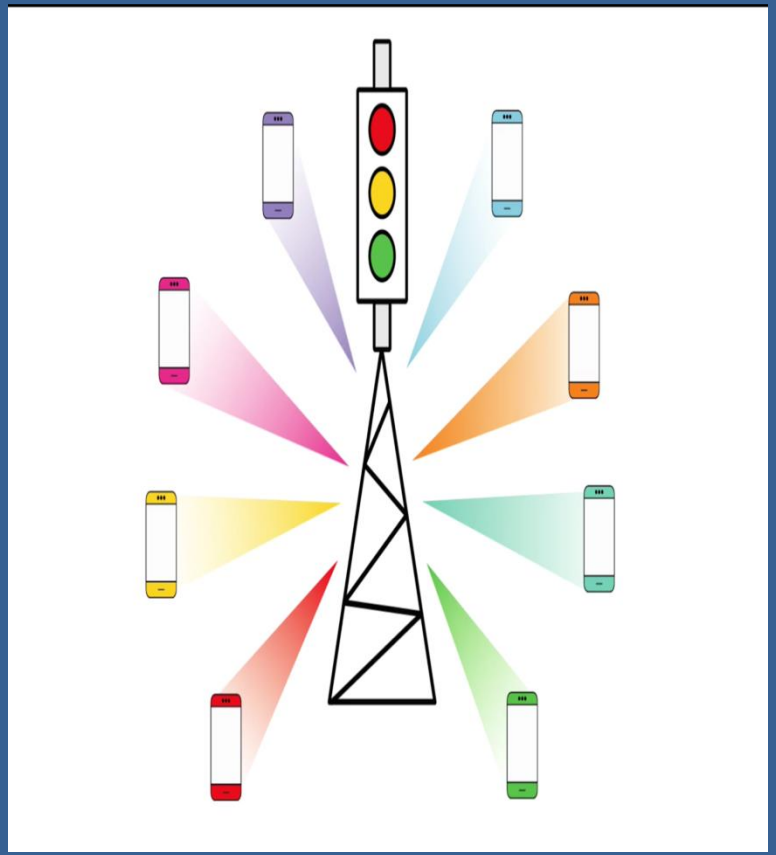
- Support s about a hundred ports
- Increasing the capacity of mobile networks by a factor of 22 or greater.
- Use two or more transmitters and receivers to send and receive more data at once.
- Massive MIMO takes this concept to a new level by featuring dozens of antennas on a single array.
- But this can cause a severe interference. This takes us to the next technology.





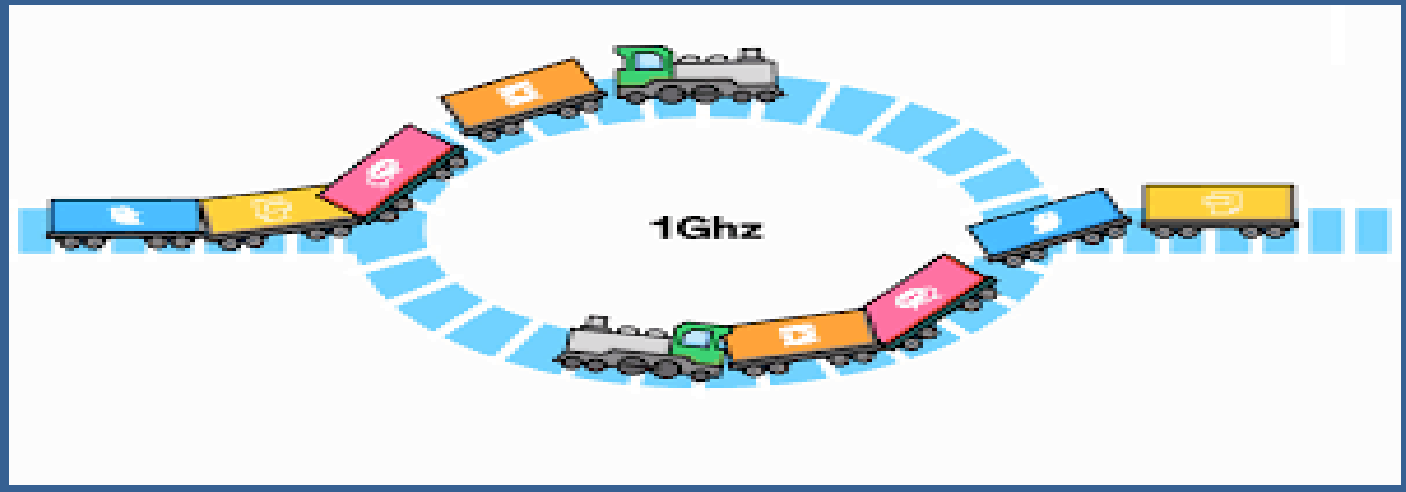
Beam Forming

- It’s like a traffic signalling system for cellular signals
- Instead of broad casting in every direction it would allow the base station to focus stream of data to specific user.
- This precision prevents interference.
- Beam forming can help massive MIMO arrays make more efficient use of the spectrum around them.
- By choreographing the packets’ movements and arrival time, beam forming allows many users and antennas on a massive MIMO array to exchange much more information at once.



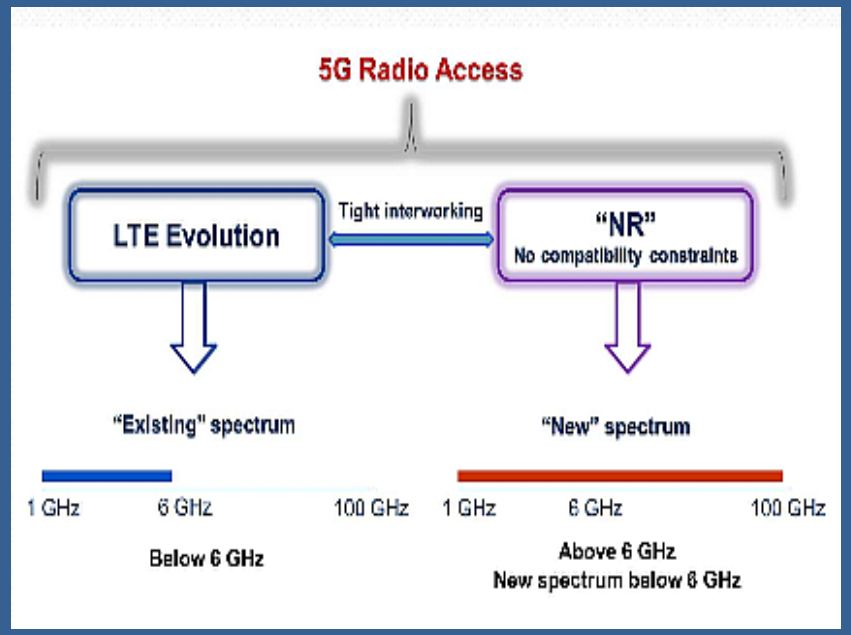
Full Duplex

- With 5G, a transceiver will be able to transmit and receive data at the same time, on the same frequency. This technology is known as full duplex.
- To achieve full duplex in personal devices, a circuit must be designed which can route incoming and outgoing signals so they don’t collide while an antenna is transmitting and receiving data at the same time.
- Assembling silicon transistors that act like high-speed switches can halt the backward roll of these waves (a principle known as reciprocity)enabling transmission and reception of the signals on the same frequency at once.
- Full duplex is kind of a signalling system that can momentarily reroute two signals so that they get past each other.

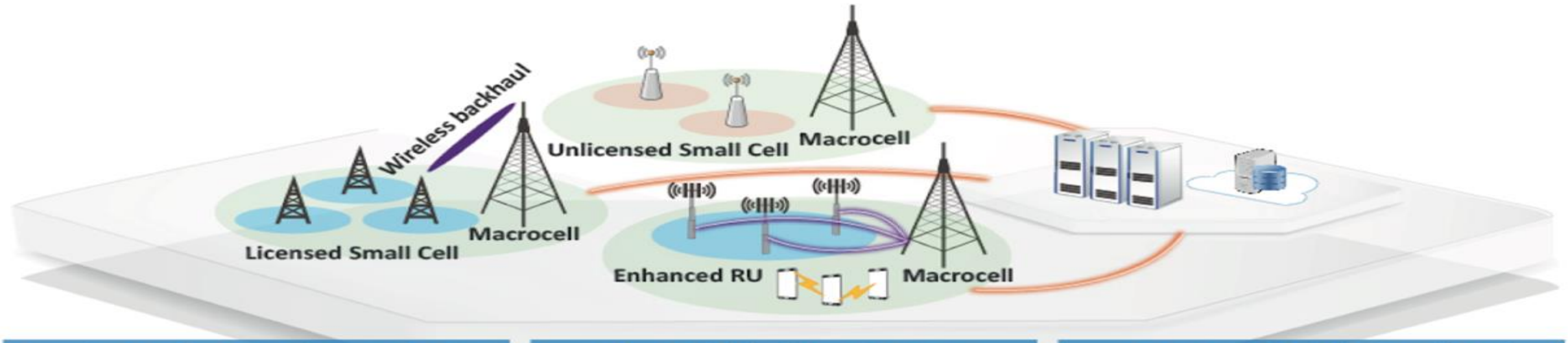


5G New Radio

- 5G uses new air interface technology- 5G NR.
- Air interface is the radio frequency portion of the circuit between the mobile device and the active base station.
- 5G NR is designed to significantly improve the performance, flexibility, scalability and efficiency of the current mobile network.



5G Deployment Scenarios



Massive Machine-type Communications

U-health / Wearables

Smart Home / Smart City

Ultra Reliable & Low Latency

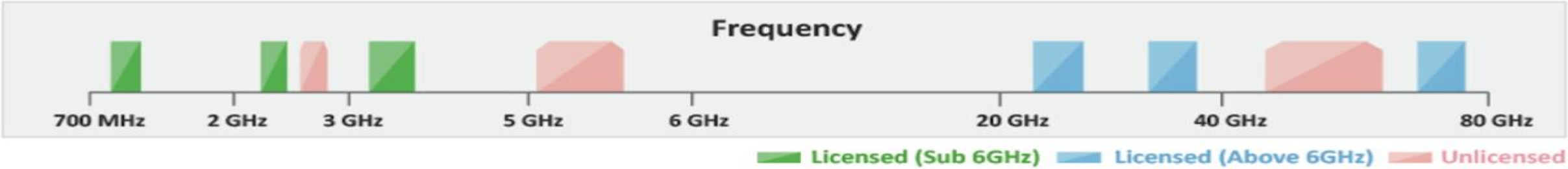
Smart Vehicle

Industrial Automation

Enhanced Mobile Broadband

Mobile Cloud Computing

UHD Streaming



5G Network Transformation

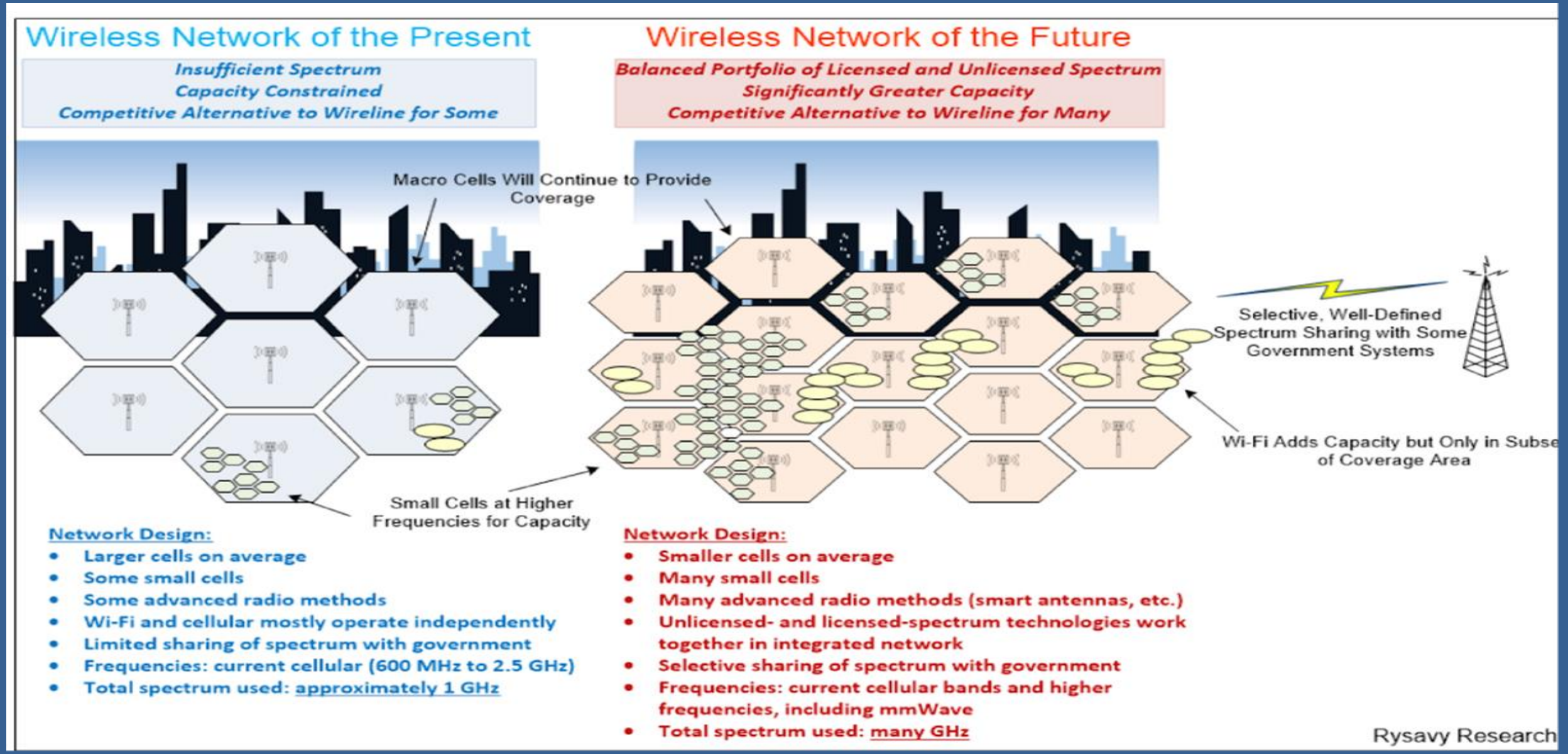


Table for different cells

Cell Type	Output Power	Cell Radius	Locations
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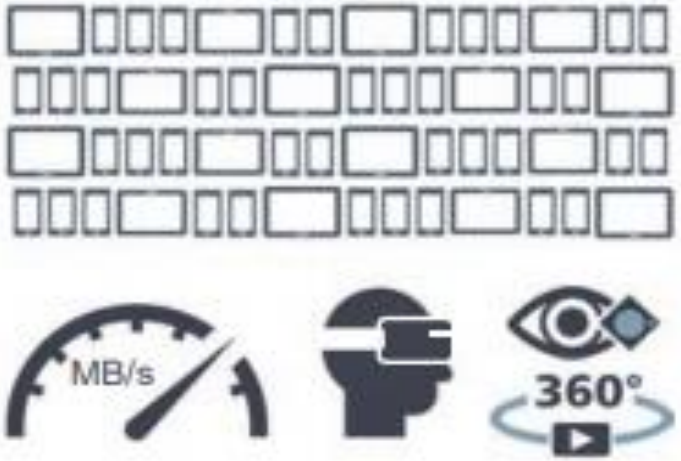
Standardizing bodies

The International Telecommunication Union (ITU) sets the main visions and goals while 3GPP develops the standards.

Three Key 5G Uses Cases

Enhanced Mobile Broadband

eMBB



- Improved user experience
- High device connectivity
- High mobile data rates
- Mobile virtual and augmented reality applications

Massive Machine Type Communications

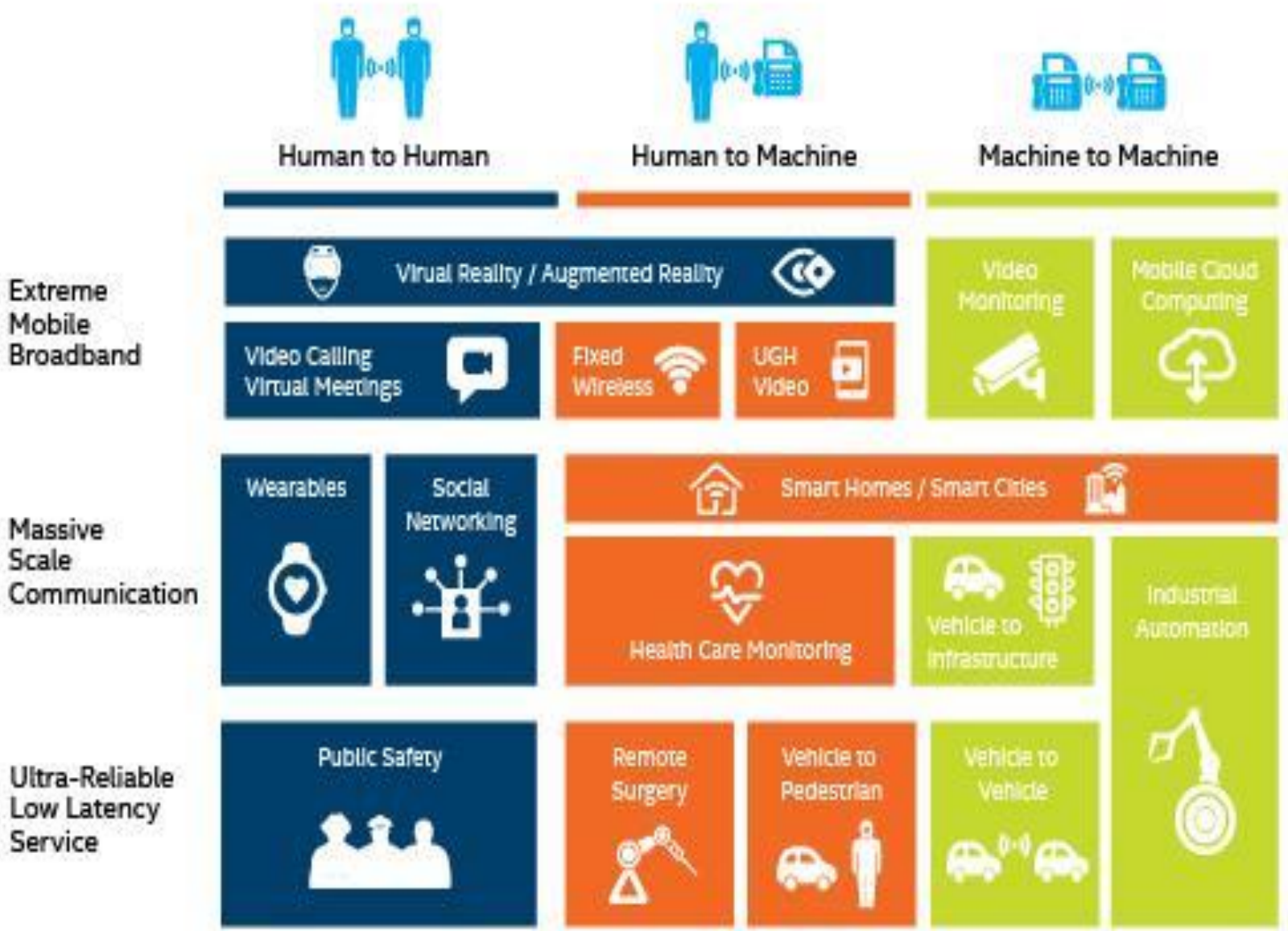
mMTC

- eHealth applications
- Industry 4.0 applications
- Intelligent logistics
- Environmental monitoring
- Smart grids
- Smart farming

Ultra-Reliable and Low-Latency Communications

URLLC

- Car-to-X communication
- Control of parcel drones
- Vital data monitoring
- Smart manufacturing


Human to Human
Human to Machine
Machine to Machine
Extreme Mobile Broadband
Virual Reality / Augmented Reality
Video Calling Virtual Meetings
Fixed Wireless
UGH Video
Video Monitoring
Mobile Cloud Computing
Massive Scale Communication
Wearables
Social Networking
Smart Homes / Smart Cities
Health Care Monitoring
Vehicle to Infrastructure
Industrial Automation
Ultra-Reliable Low Latency Service
Public Safety
Remote Surgery
Vehicle to Pedestrian
Vehicle to Vehicle

5G Standard

- 5G Technical Specification Standard by 3GPP (Rel.17, June 2021) - Overview

  (https://www.3gpp.org)

Paradigms demanding Standard's Specification: Technological and Sectoral Convergence, Preserving Heterogeneity, Interoperability, Plug and Play, Pay per Use, High speed mobility and connectivity, Ubiquity, Flexible Migration, Security by Design, Intelligent Data Analytics, Timely and Precision based User Specific on-demand services, Virtualized Management Services, Just in time learning etc.

Scope

- The 5G Technical Specification document of 3GPPP defines the Stage 2 system architecture for the 5G System. The 5G System provides data connectivity and services.
- This specification covers both roaming and non-roaming scenarios in all aspects, including interworking between 5GS and Evolved Packet System (EPS), mobility within 5GS, QoS, policy control and charging, authentication and in general 5G System wide features e.g. SMS, Location Services, Emergency Services.

3GPP TS23.501 v17.1.1 (2021-2026)

(3rd Generation Partnership Project Technical Specification of 5G System)

- 3GPP is an International Consortium having HO at Valbonne, France
- 5G System Standard, Latest Release 17, Stage-2, published in May 2021
- It is a freely available, copyright document with 8 chapters in 520 pages.
- Chapter 1 to 3 : Scope, References, Definitions and Abbreviations (Pgs.1-32)
- Chapter-4: Architecture Model and Concepts (Pgs.32-74)
- Chapter-5: High Level Features (Pgs.76-387)
- Chapter-6: Network Functions (Pgs.387-435)
- Chapter-7: Network Function Services and Descriptions (Pgs.435-451)
- Chapter-8: Control and User Plane Protocol Stacks (Pgs.451-462)
- Annexures (Pgs.462-520)

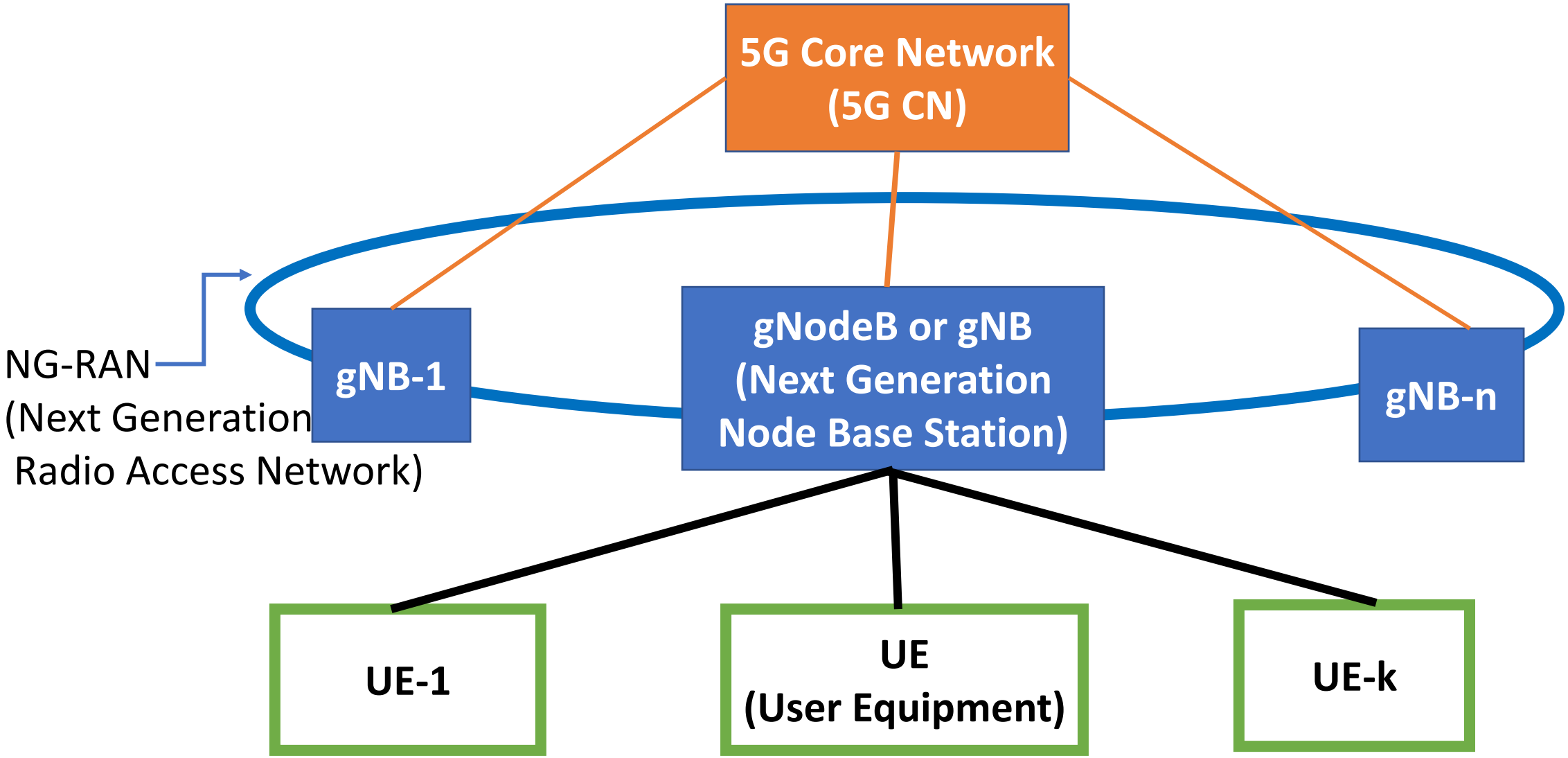
5G System Architecture

- It is defined to support data connectivity and services enabling deployments to use techniques such as e.g. Network Function Virtualization and Software Defined Networking.
- It shall leverage service-based interactions between Control Plane (CP) Network Functions where identified.
- Some key principles and concept are to:
  - Separate the User Plane (UP) functions from the Control Plane (CP) functions, allowing independent scalability, evolution and flexible deployments e.g. centralized location or distributed (remote) location.
  - Modularize the function design, e.g. to enable flexible and efficient network slicing.
  - Wherever applicable, define procedures (i.e. the set of interactions between network functions) as services, so that their re-use is possible.

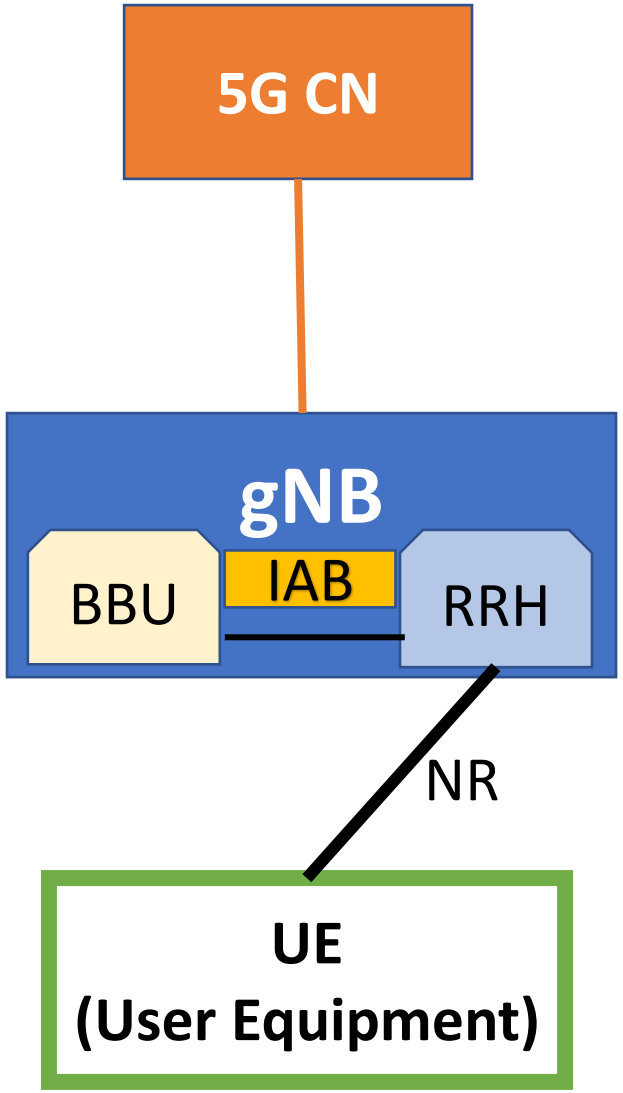
5G System Entities

- 5G Core Network (5G CN)
- Next Generation Radio Access Network (NG-RAN)
- 5G User Equipment (UE)
- Service Communication Proxy (SCP)
- Security Edge Protection Proxy (SEPP)

5G System Architecture



gNodeB (gNB) Interfaces in 5G System



BBU : Base Band Unit

- It supports L1/L2 + L3

RRH : Remote Radio Head

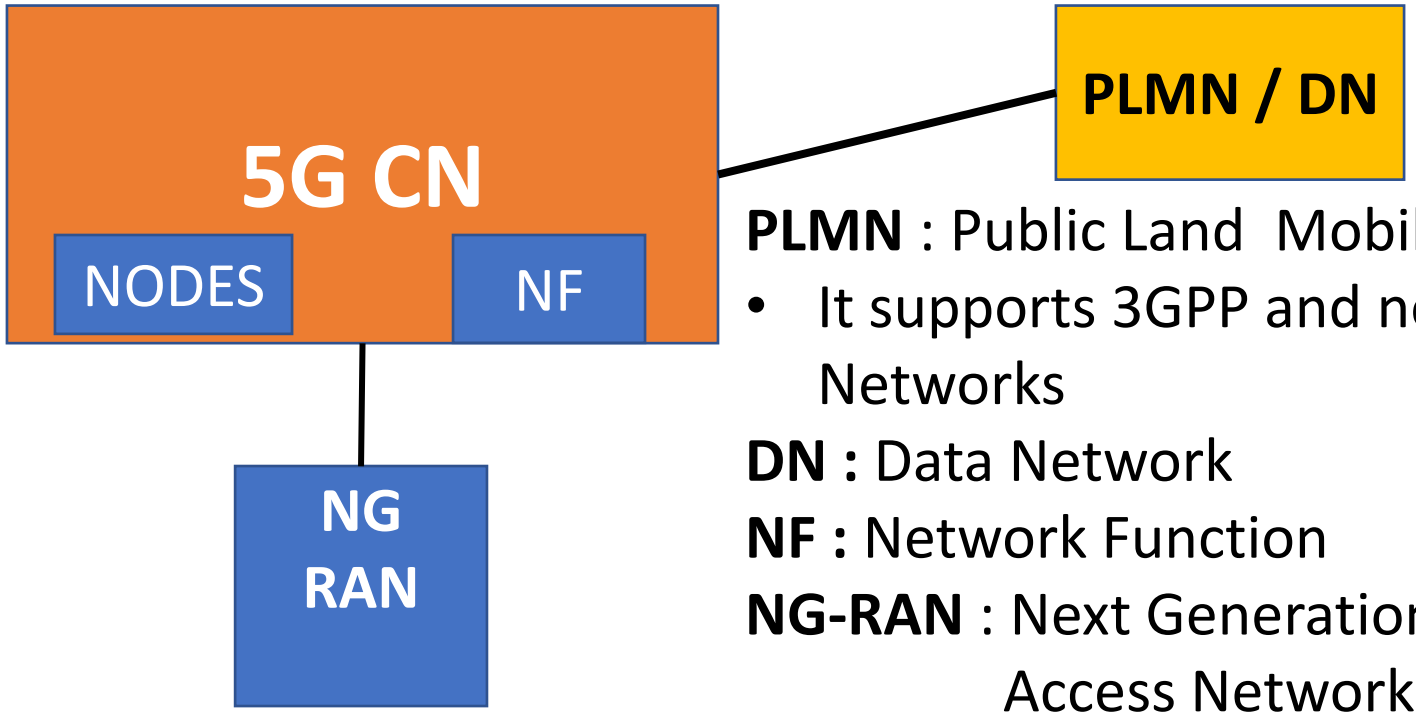
- It has Radio Frequency (RF) Unit and Antennas
- It supports 4/8/16/32/64 Antennas

IAB : Integrated Access and Backhaul

NR : New Radio

- It supports UL: Uplink, DL: Downlink

5G Core Network (5G CN) Architecture



PLMN : Public Land Mobile Network

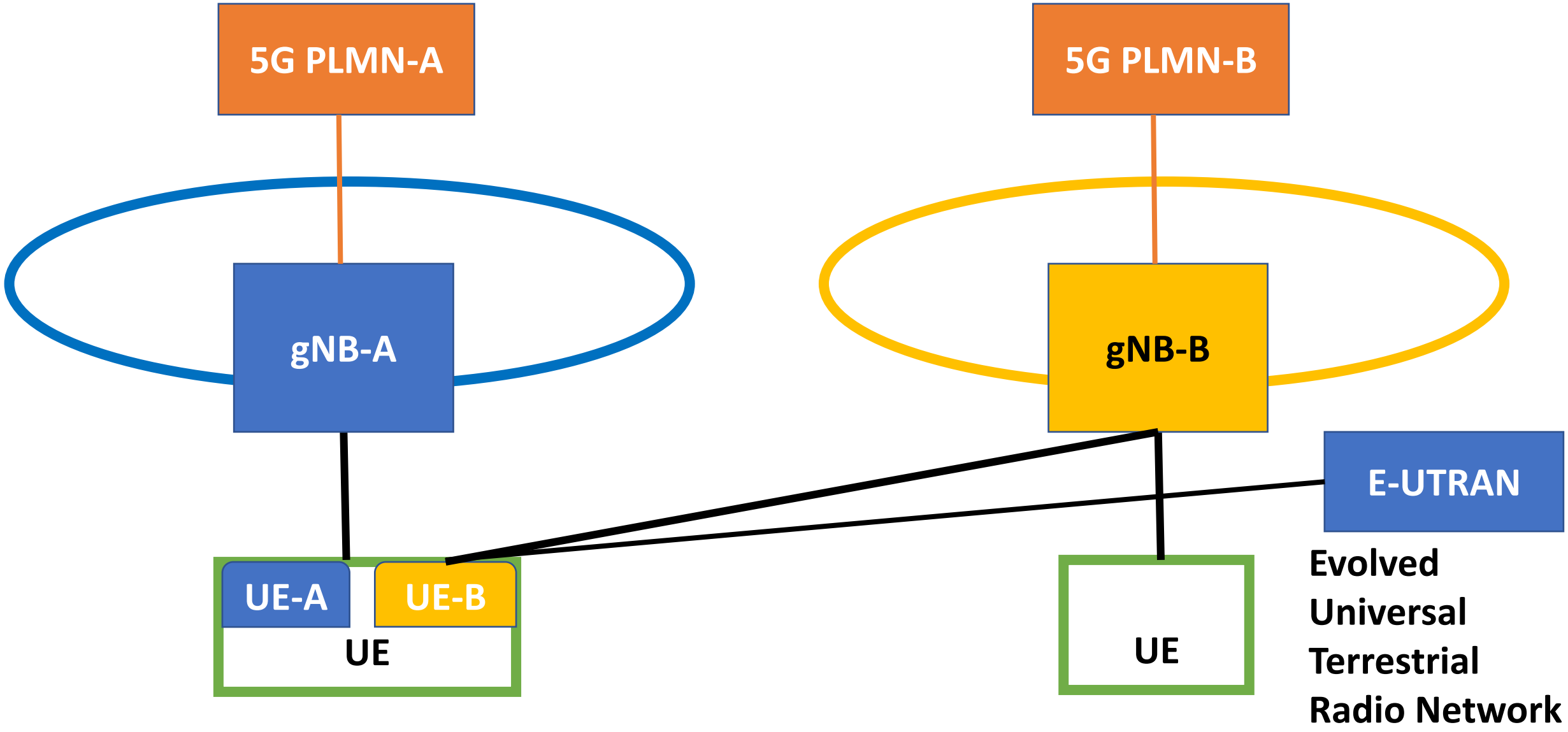
- It supports 3GPP and non-3GPP Networks

DN : Data Network

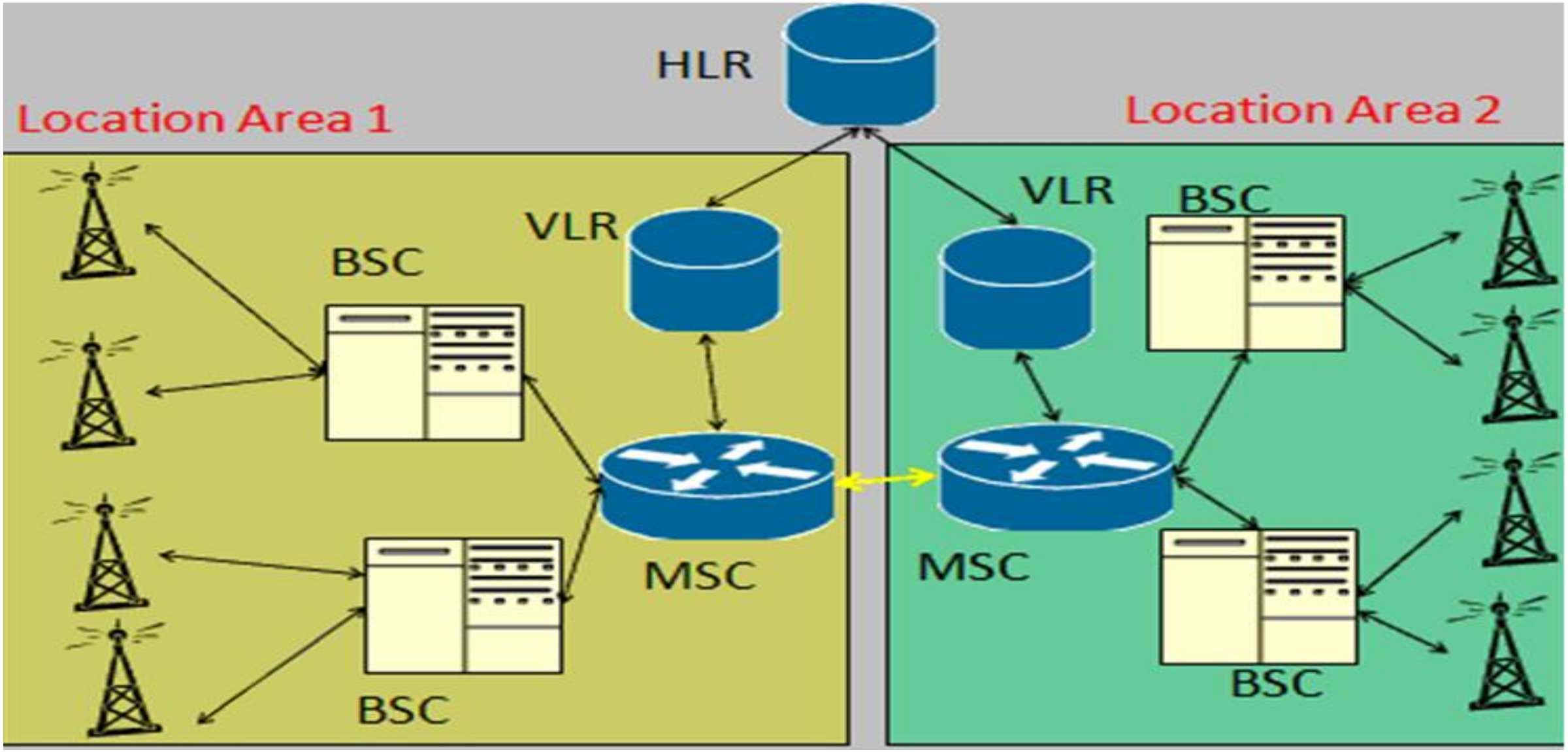
NF : Network Function

NG-RAN : Next Generation Radio Access Network

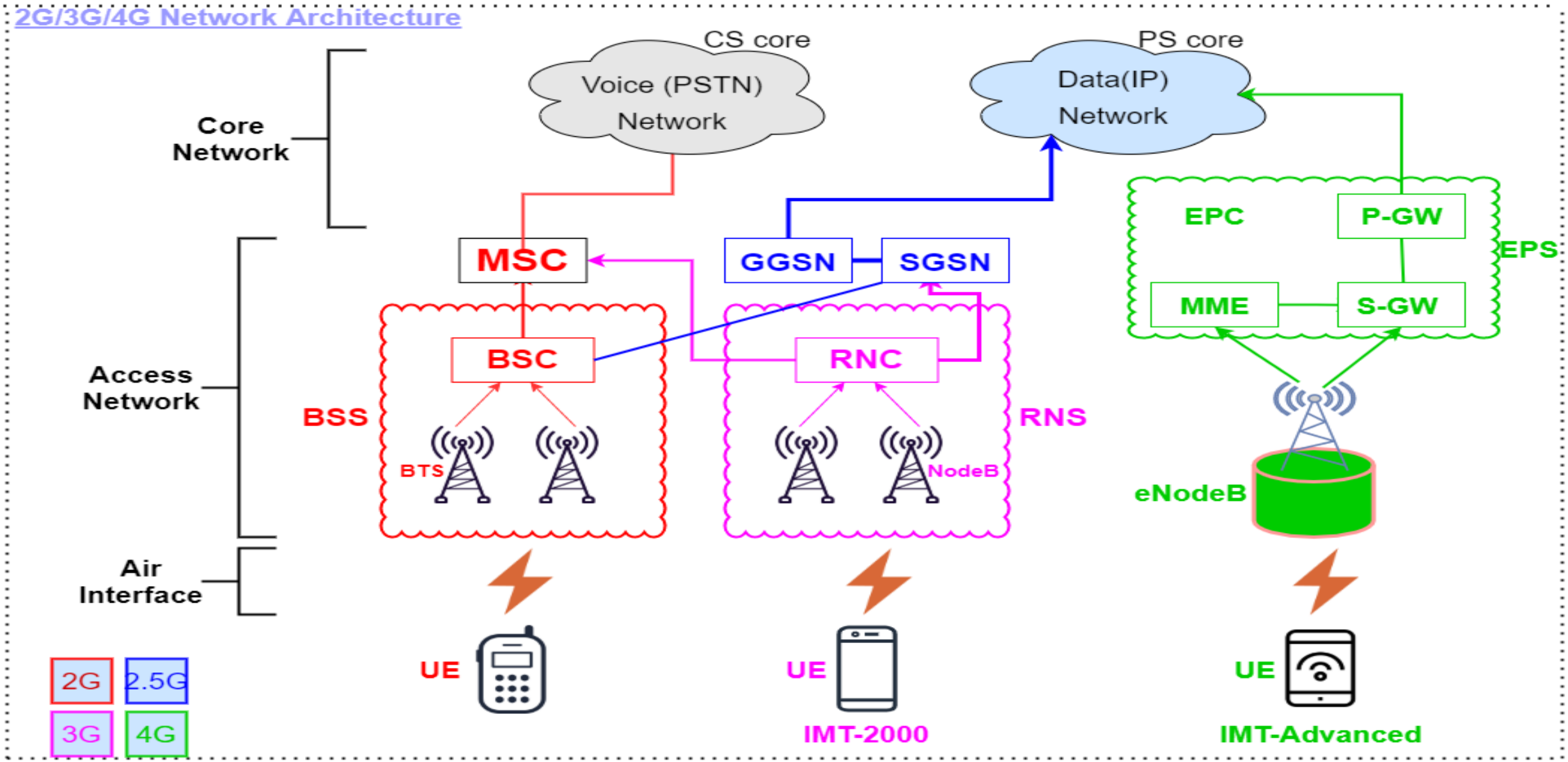
Multi-operator 5G Network



2G/3G Mobile Network Architecture



Non-3GPP Networks



5G Core – Service Based Architecture

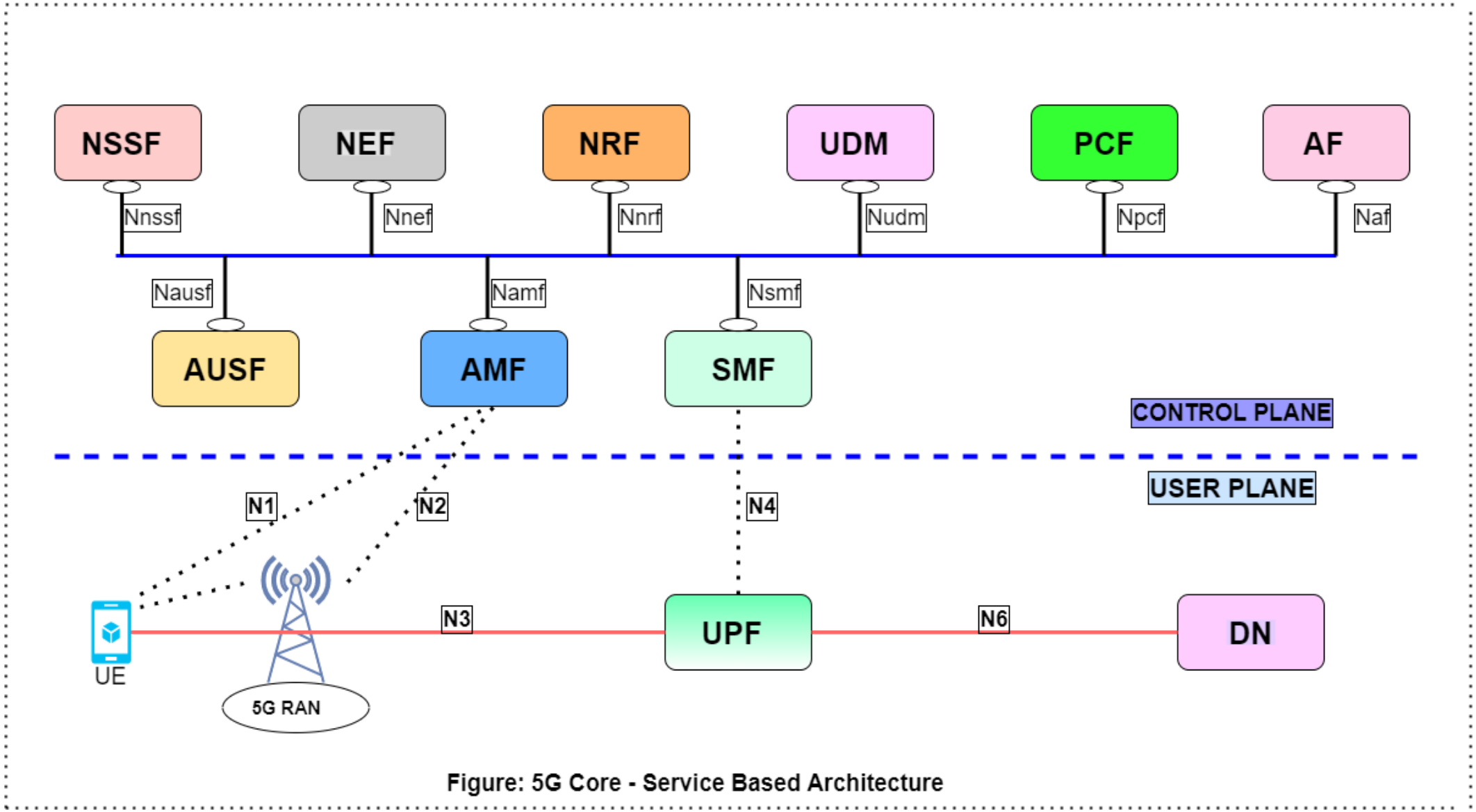


Figure: 5G Core - Service Based Architecture

Reference Point (RP) List-6 of 5G System Architecture

- N80: Reference point between AMF and NSACF.
- N81: Reference point between SMF and NSACF.
- N82: Reference point between NSACF and NEF.
- The reference points to support SMS over NAS are listed in clause 4.4.2.2.
- The reference points to support Location Services are listed in TS 23.273 [87].
- The reference points to support SBA in IMS (N5, N70 and N71) are described in TS 23.228 [15].
- The reference points to support AKMA (N61, N62 and N63) are described in TS 33.535 [124].
- The reference points to support ProSe (N64, N65, N66, Nxx and Npd) are described in TS 23.304 [128].
- The reference points to support 5G multicast-broadcast services are described in TS 23.247 [129].
- The reference points to Support Uncrewed Aerial Systems (UAS) connectivity, identification and tracking are described in TS 23.256 [136].

Use cases for Banks

Existing Banking Scenarios

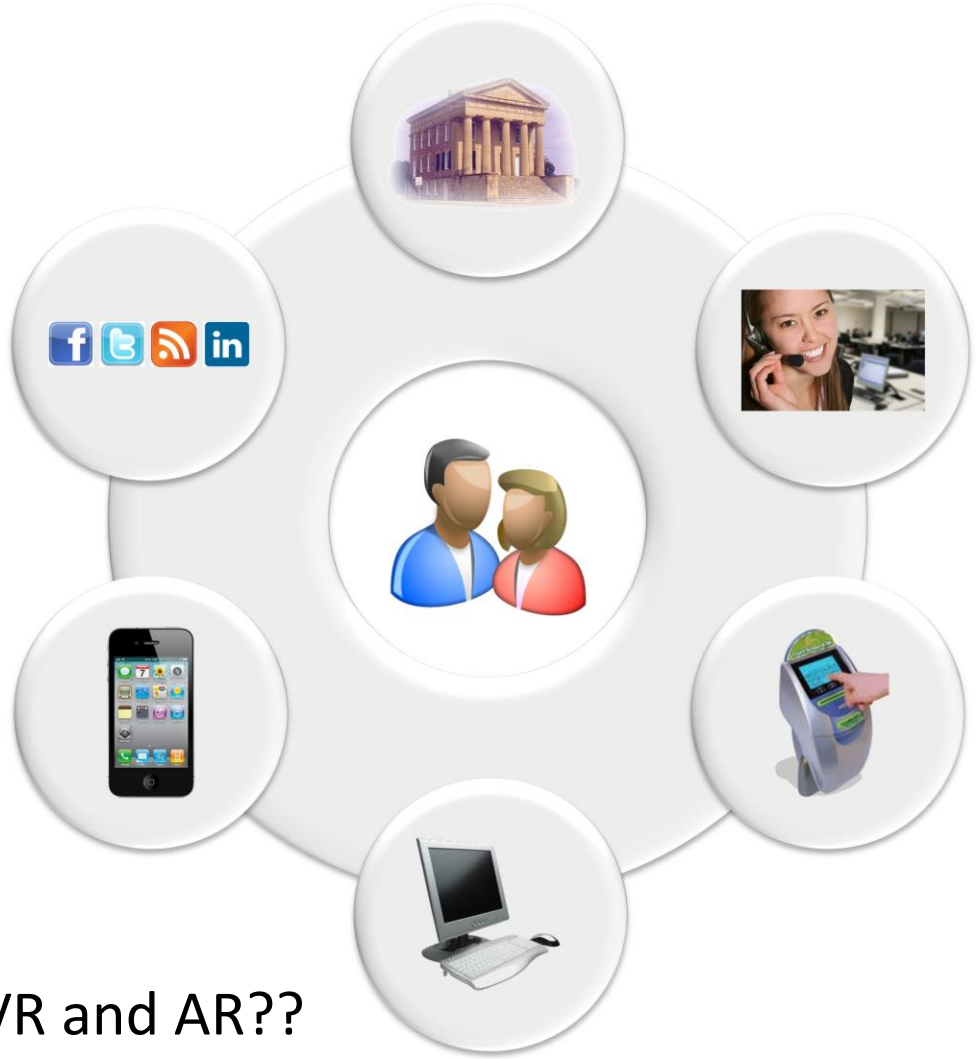
- Revisit need of Near DCs
- Better control on Fraud detection
- ATM Monitoring and Surveillance
- Biometric based authentication
- Deeper coverage for rural banking
- Enhanced experience in Omni-channel

Futuristic Banking Scenarios

- Smart Branch – Multi-User services, Live broadcasting, Location based alert services
- Home Banking
- AR and VR based Banking
- IoT usage for claim settlement
- Artificial Intelligence and Robo Advisors
- Faster Payments and Mobile Trading

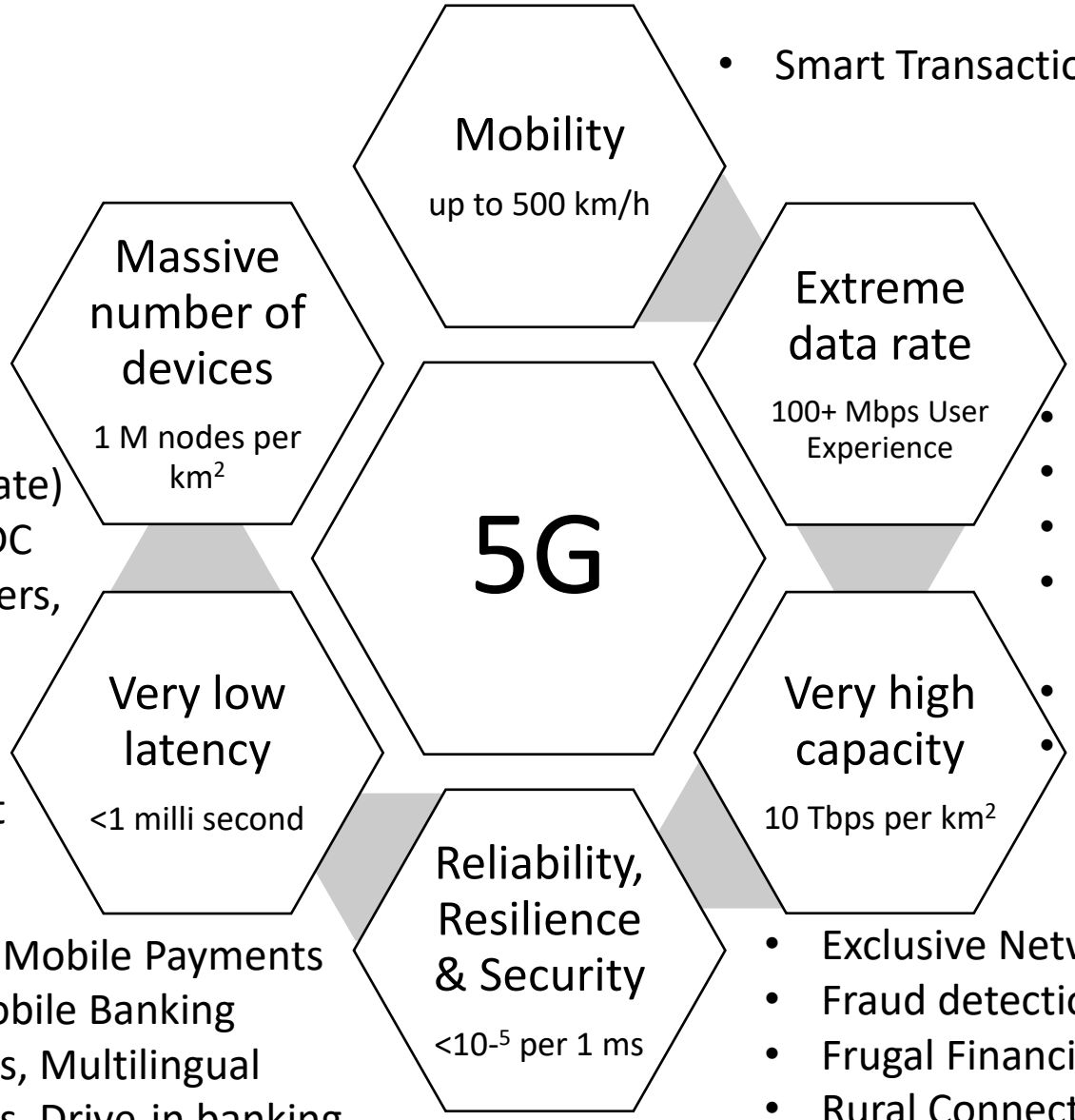
Banking Services

- Retail/Consumer Banking
- Corporate Banking
- Payments & Channels
- Lending includes Cards
- Wealth Management
- Banking relations and Development
- Corporate Functions



Video, IoT, VR and AR??

5G Use Cases under development



- Smart Transactions

NB-IoT for FI

- ATM with BTS
- Micropayments
- IoT Gateway (UPI/SFMS alternate)
- IoT for ATM/Bank Branch/HO/DC
- Humanoid, Drones, Smart Lockers,
- Home TV Banking

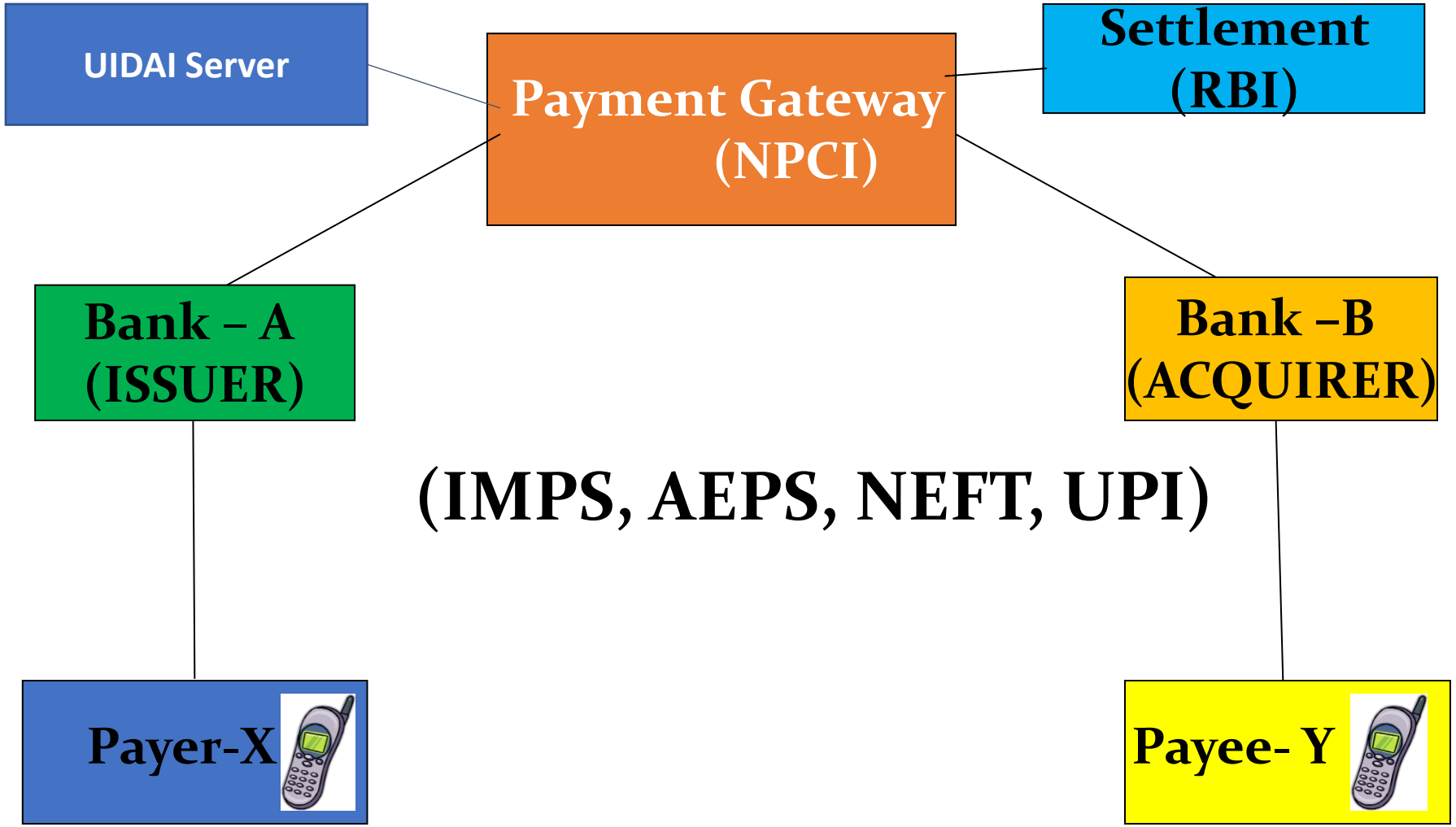
- Near DC
- Regional Language Support

- Video Analytics & KYC
- Futuristic ATM/Virtual Kiosk
- VR and AR Apps
- Alternate Authentication – Voice & other Biometrics
- AI/ML use cases
- Edge Analytics

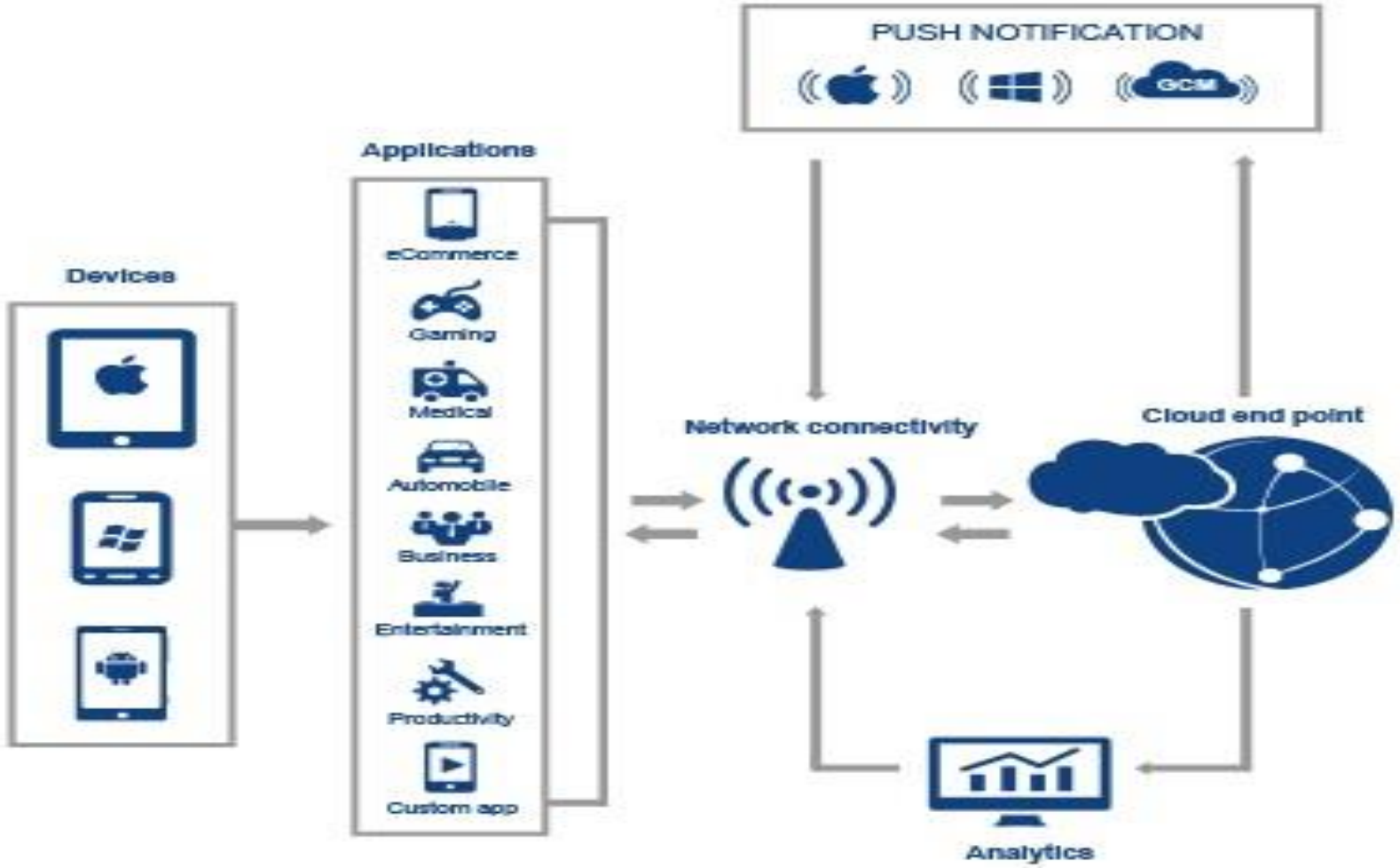
- Secure Mobile Payments and Mobile Banking Services, Multilingual Services, Drive-in banking, Security Testing

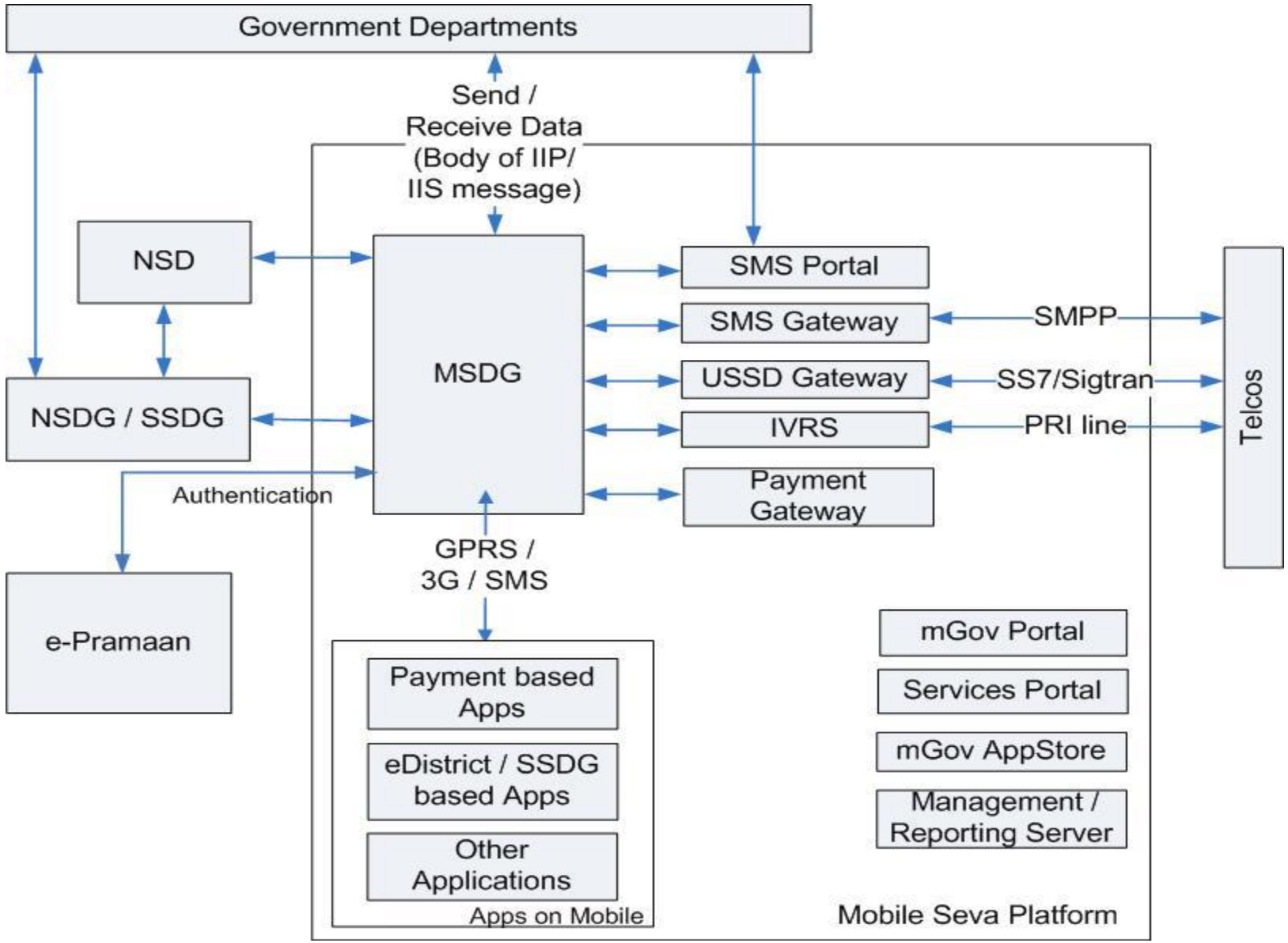
- Exclusive Network Slice for BFS
- Fraud detection
- Frugal Financial Inclusion
- Rural Connectivity
- Green Banking Services

Mobile Banking



Mobile Cloud Services




Government Departments
Send / Receive Data (Body of IIP/ IIS message)
NSD
NSDG / SSDG
MSDG
SMS Portal
SMS Gateway
USSD Gateway
IVRS
Payment Gateway
SMPP
SS7/Sigtran
PRI line
Telcos
Authentication
e-Pramaan
GPRS / 3G / SMS
Payment based Apps
eDistrict / SSDG based Apps
Other Applications
Apps on Mobile
mGov Portal
Services Portal
mGov AppStore
Management / Reporting Server
Mobile Seva Platform

THANK YOU