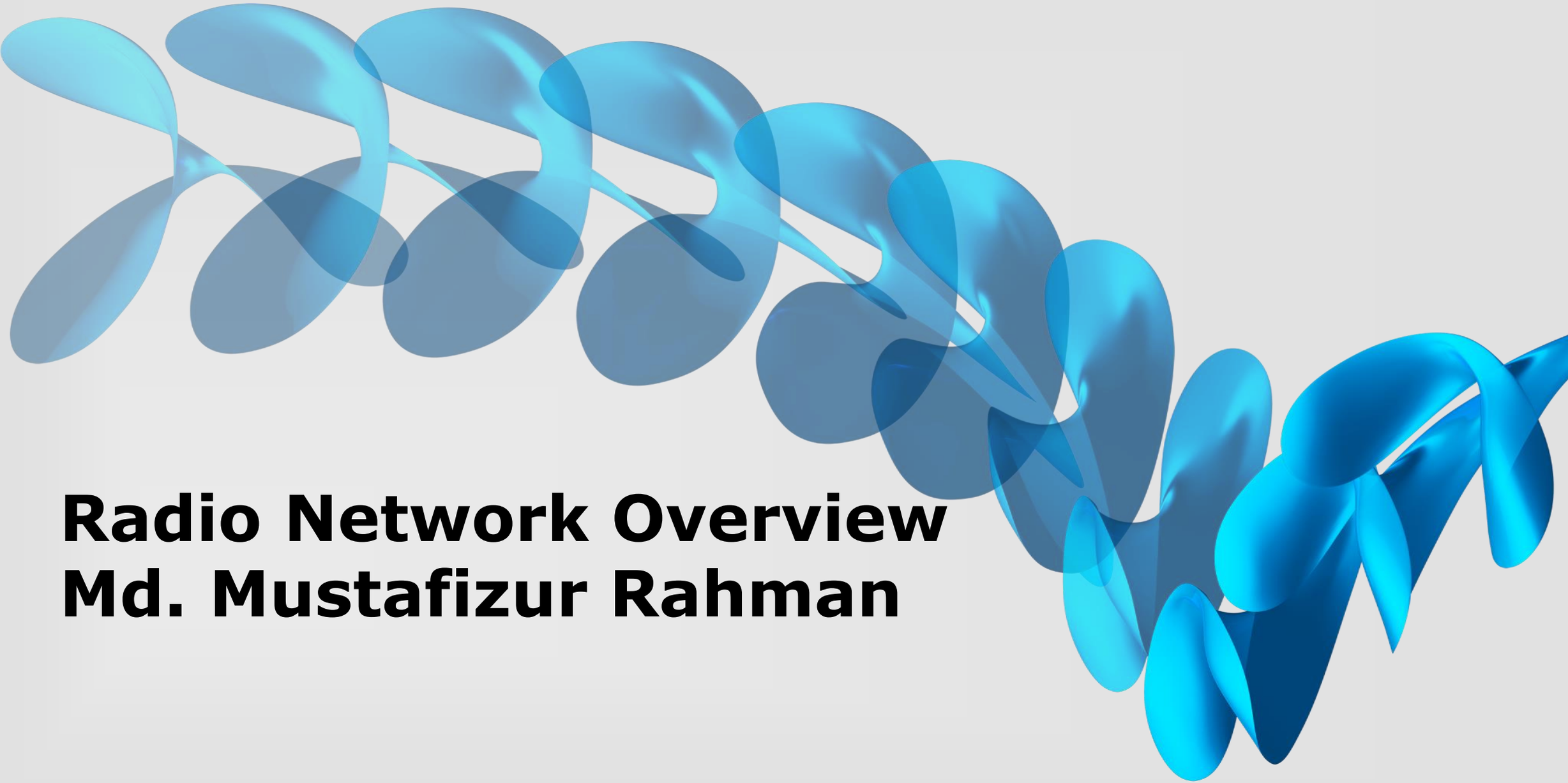
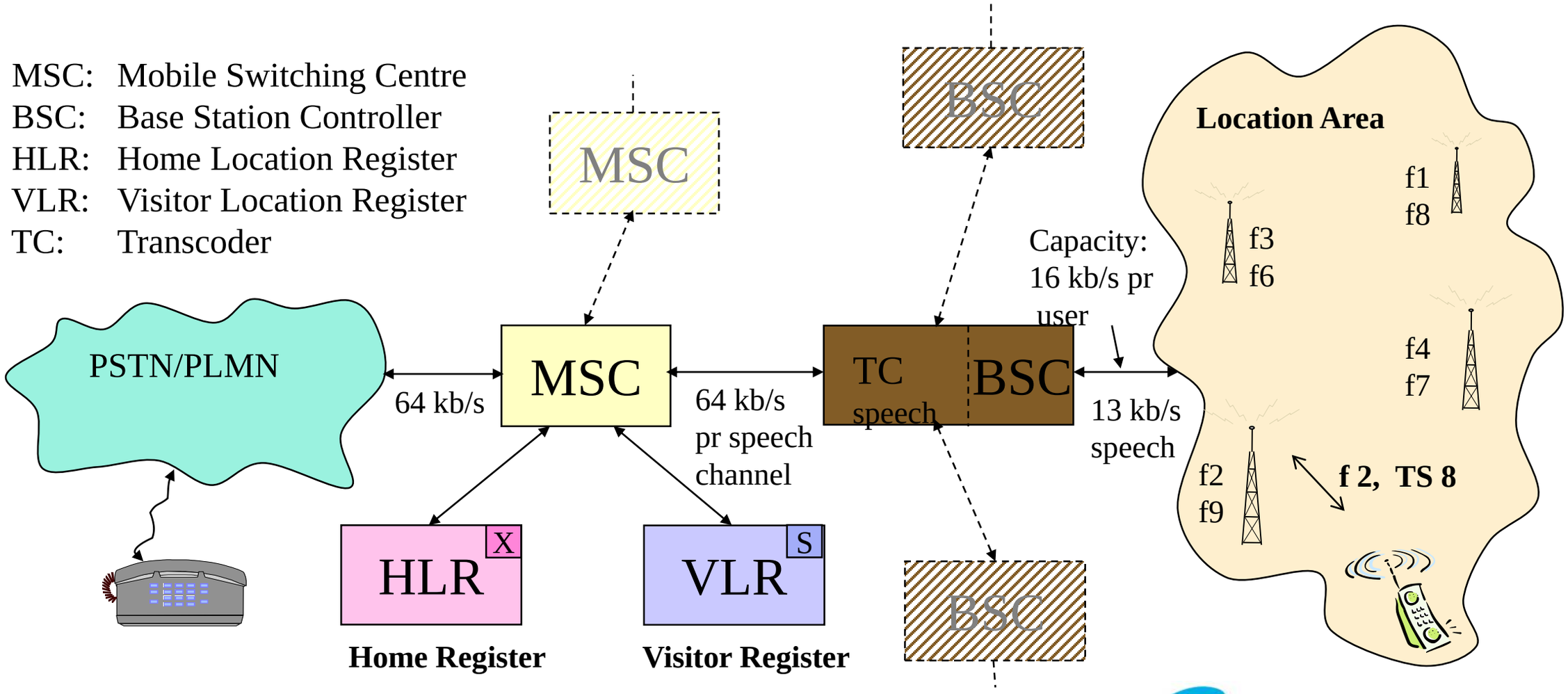


Radio Network Overview

Md. Mustafizur Rahman

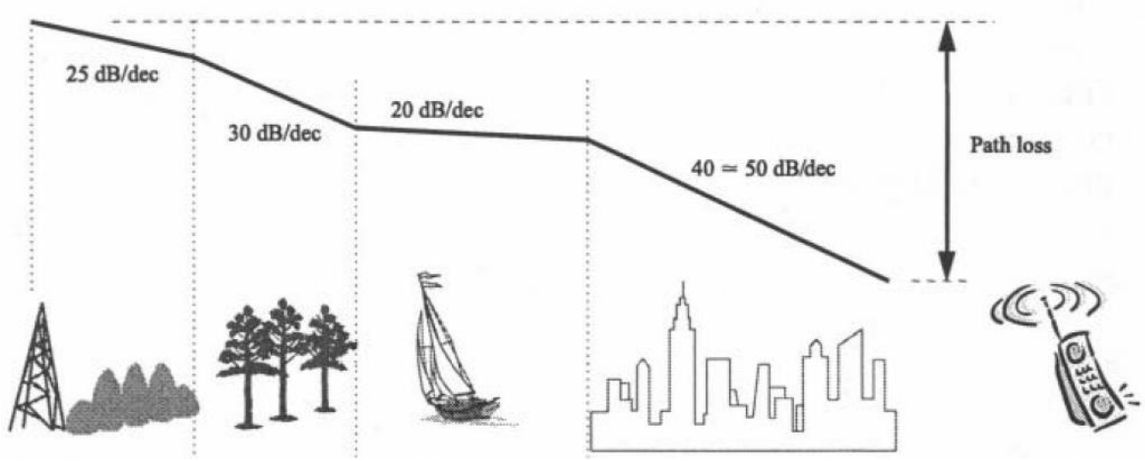
GSM System at a Glance:

MSC: Mobile Switching Centre
BSC: Base Station Controller
HLR: Home Location Register
VLR: Visitor Location Register
TC: Transcoder

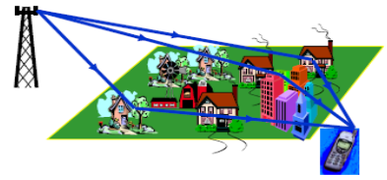


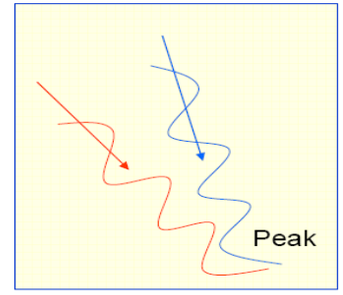
Radio singnal and its behaviour (Radio signal propagation)

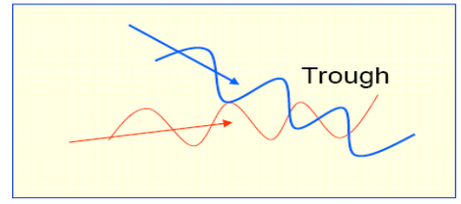
Path loss

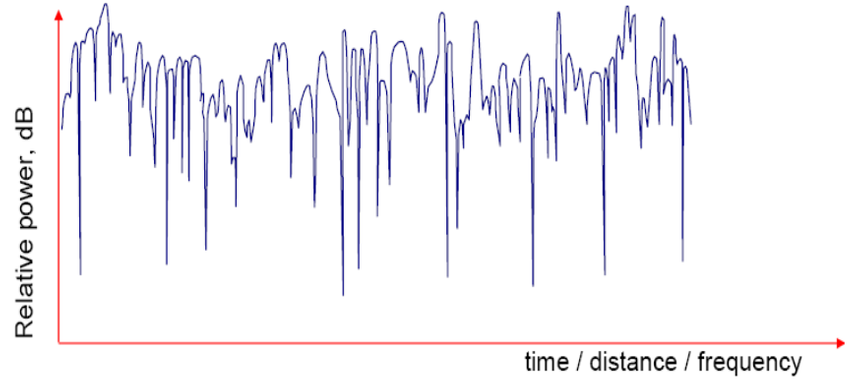


Multipath fading









Signal Fading

- Multi path/Raleigh and
- Log normal/shadow fading

Penetration loss

- Building loss: 15-25dBm
- In car: 5-10dBm

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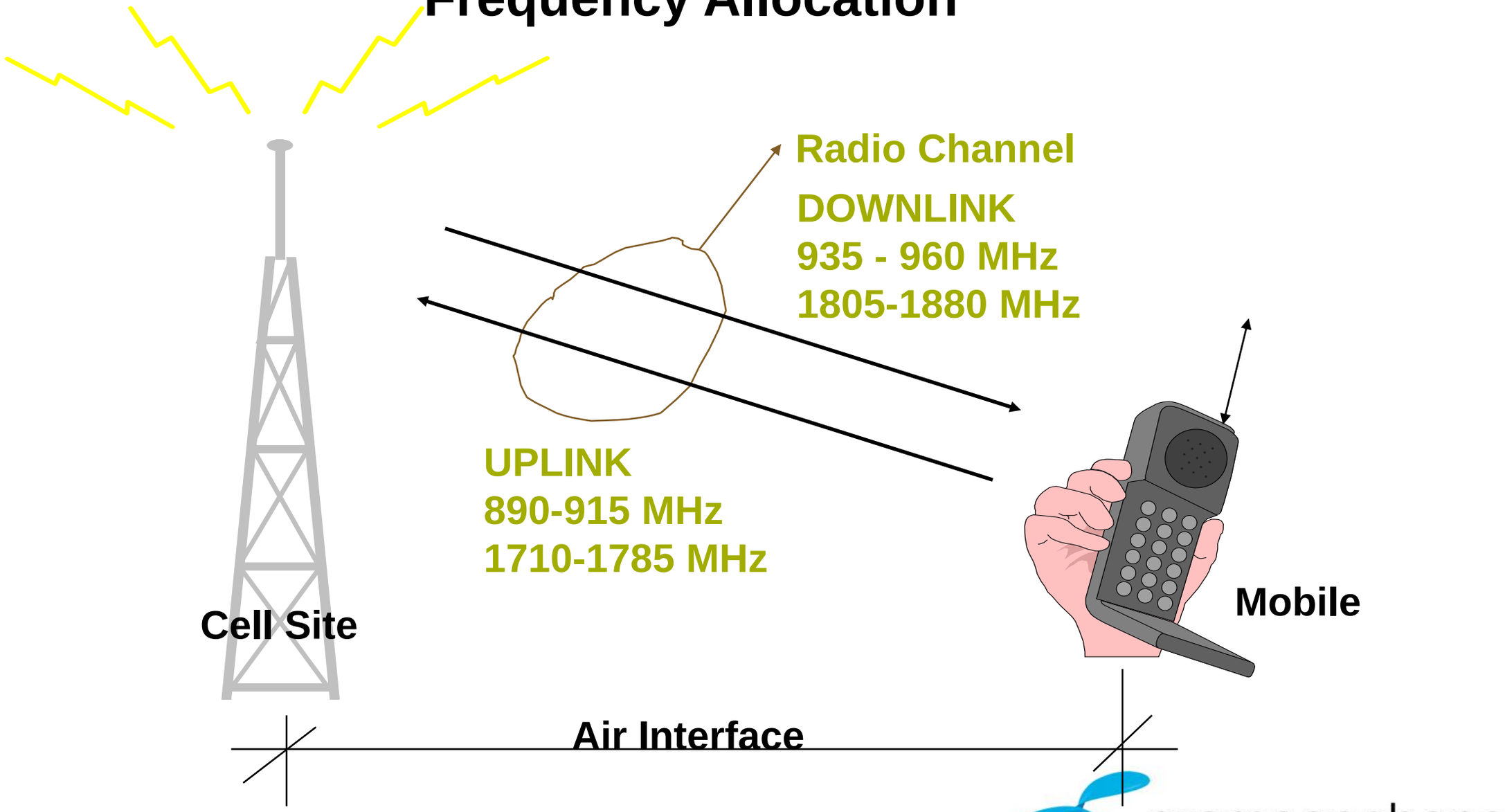
AIR INTERFACE
Frequency Allocation



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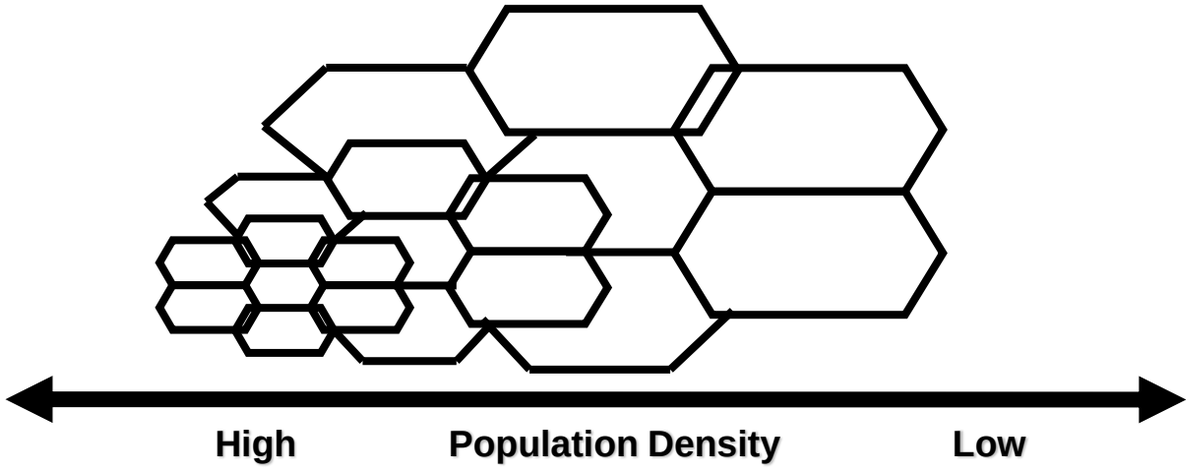
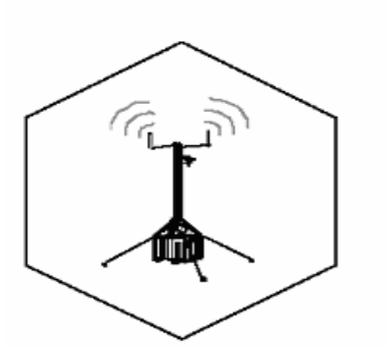
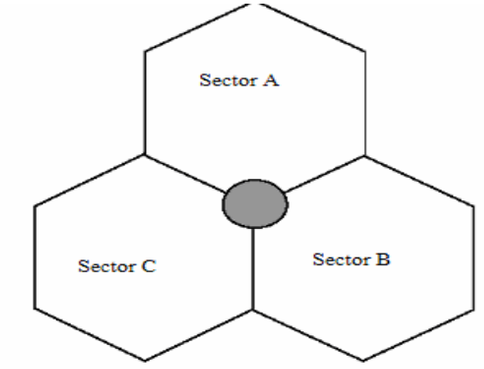
Cellular Concept



GSM: Site/Cell/Sector

- *Cell*
  - A cell may be defined as an area of radio coverage for a BTS (Base Transceiver Station) system. It is the smallest building block in a mobile network.
  - Typically, cells are represented graphically by hexagons. There are two types of cell:
- *Omni directional cell*
  - An Omni-directional cell (or Omni cell) is served by a BTS with an antenna which transmits equally in all directions (360 degrees).
- *Sector cell*
  - A sector cell is the area of coverage from an antenna, which transmits, in a given direction only.
  - One BTS can serve as two-sectored sites and more commonly, three-sectored sites.





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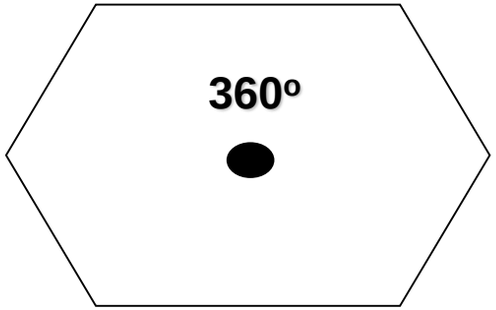
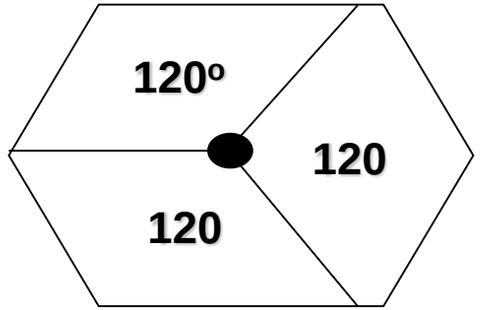
Cellular Concept :Sectorization

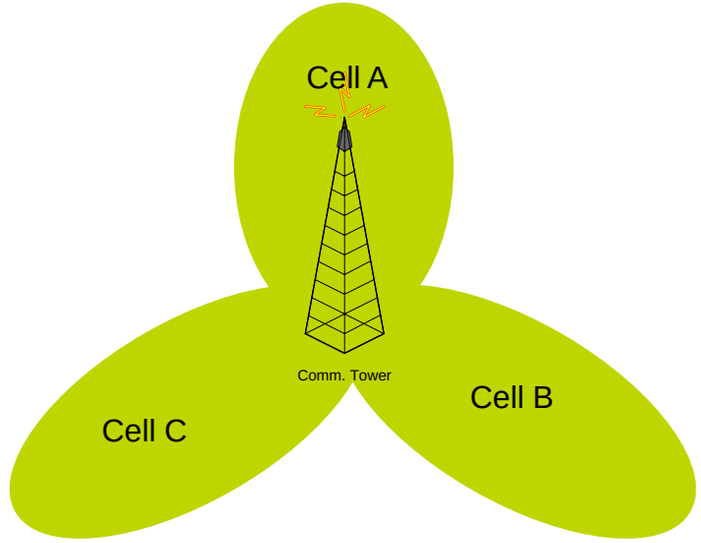
- Directional Antenna is used to divide the channels of the cell into specific areas
- GP is using 3 sectored cellular system



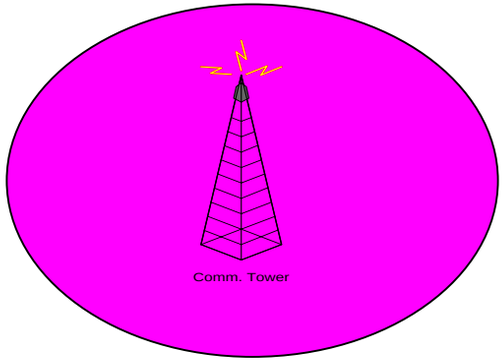
Omni directional cell



3-sectored cell

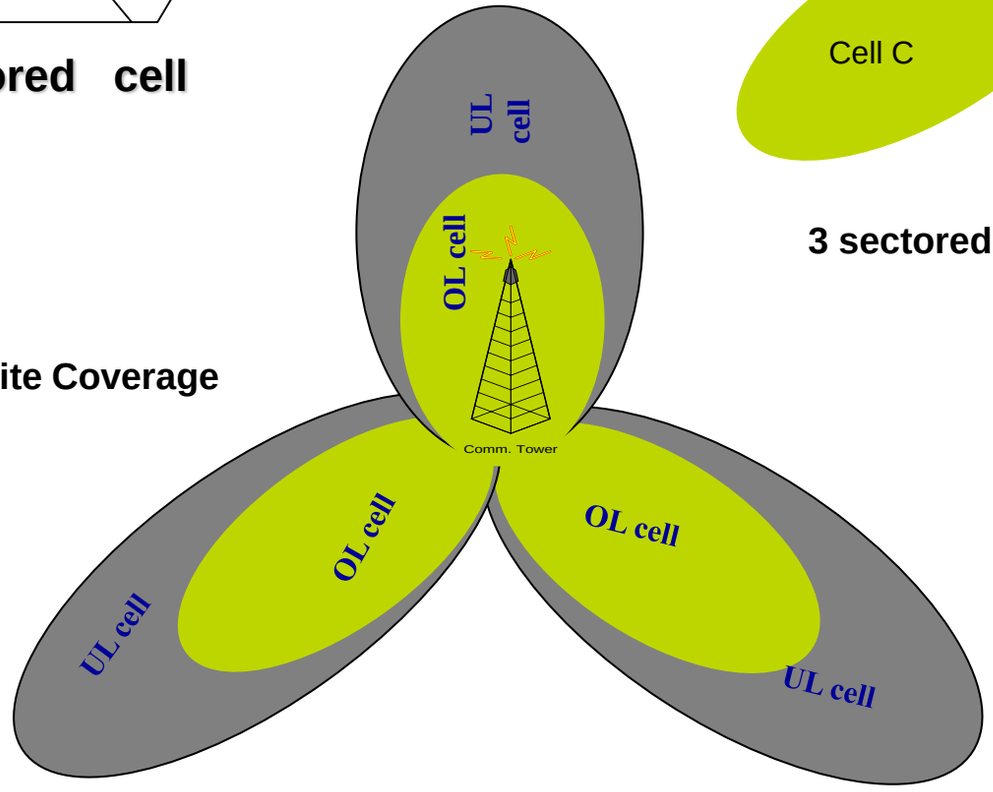


3 sectored site Coverage



Omni cell site Coverage

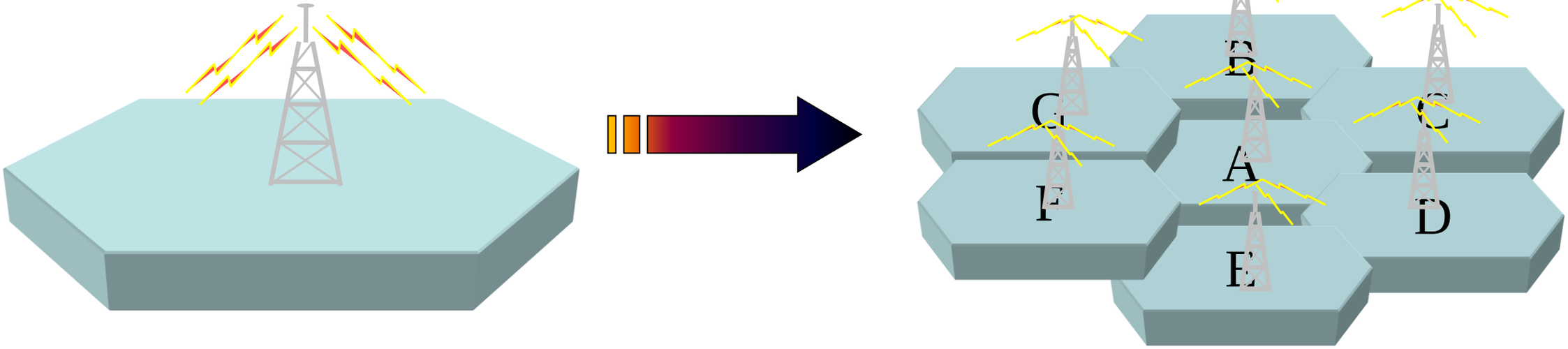
UL/OL cell site Coverage



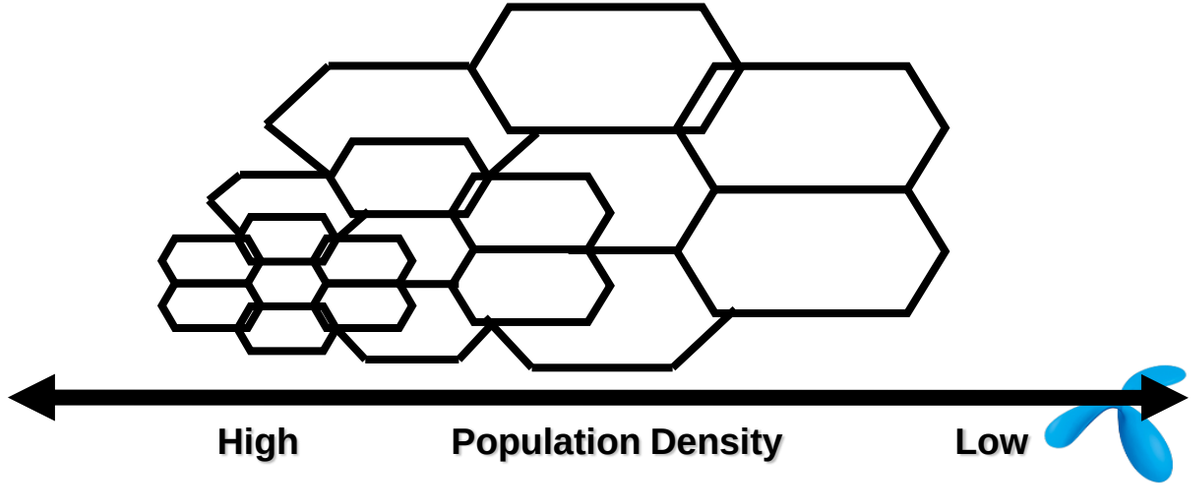
Cellular Concept: GSM Technology

- The cellular concept solved the problem of **limited spectrum** by replacing a single, high power transmitter (large cell) with many low power transmitters (small cells). Each providing coverage to only a small portion of the service area.

- The fundamental idea behind the cellular concept is frequency reuse



- Reuse pattern depends on the population density



Coverage Capacity and Quality

The main Responsibility of a Radio planner is to ensure

A. Coverage

- An area is under coverage if radio signal is sufficient enough to make successful call.
  - **Outdoor Coverage**
  - **In car Coverage**
  - **Indoor Coverage**

B. Capacity

- How many users can be served by the network maintaining a target Quality of Service (QoS)

C. Quality of Service (QoS)

- Accessibility of network
- Speech quality and call drop.

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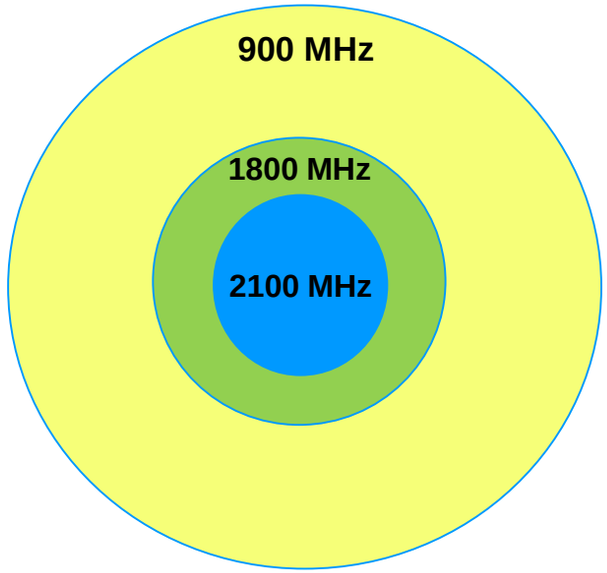
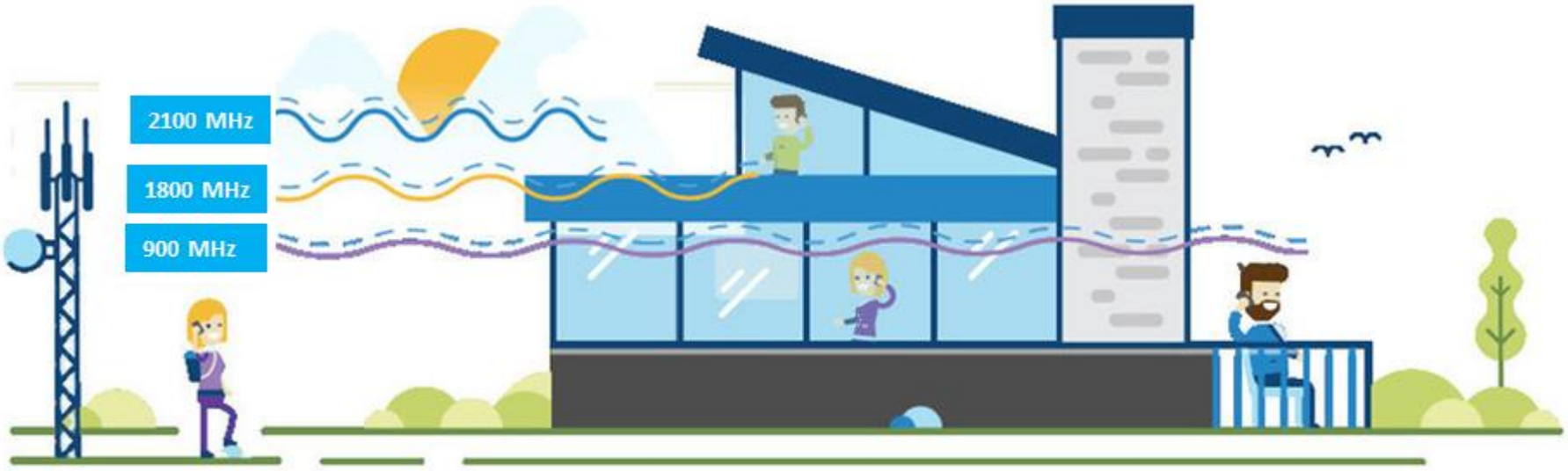
COVERAGE AREA AND FREQUENCY BANDS





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Coverage

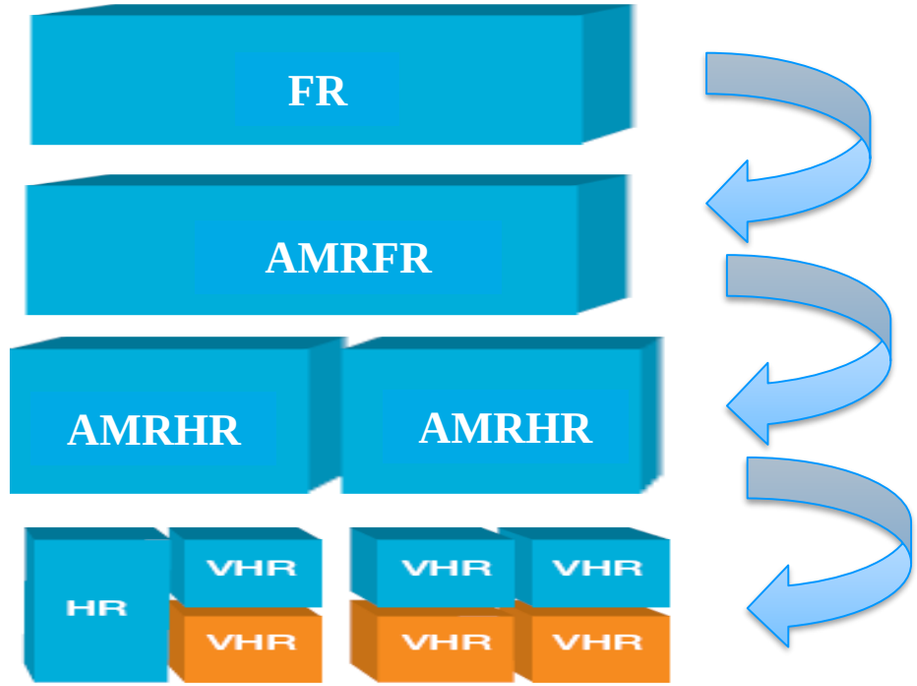
Coverage is a fluctuating parameter depends on lot of factors which changes from area to area and position of user. Coverage can be classified as-

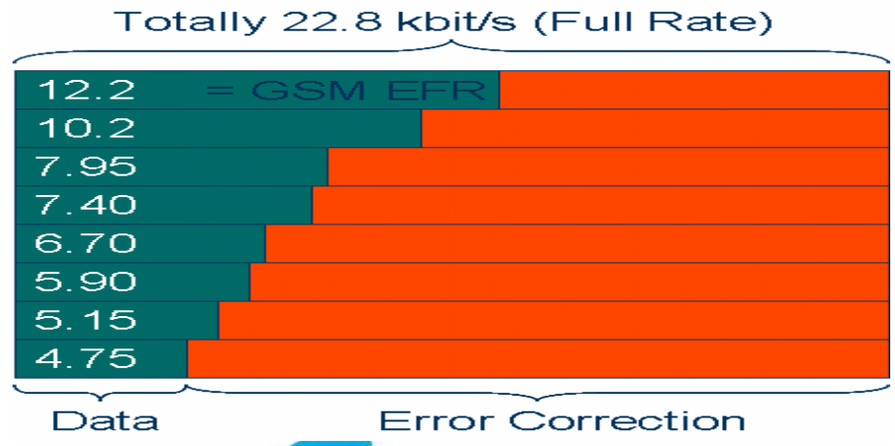
- **Indoor Coverage**
  - Indoor coverage is defined as sufficient coverage for making a successful call inside building from ground floor level.
  - Very important in Urban and Dense urban Area for Home and office.
- **Incar Coverage**
  - Incar coverage is defined as sufficient coverage to make a successful call inside a car.
  - Very important in Urban, Suburban and Highways
- **Outdoor Coverage**
  - Outdoor coverage is defined as sufficient coverage to make a successful call in open air.
  - Important for everywhere
- **Probability of Coverage(area):**

Capacity

Capacity of a network can be defined as follows…

- Busy hour traffic handling ability
- Calling minutes handling ability [BH traffic vs Avg traffic]
- No. of Subscriber [BH mErl per Sub]
- Unit of Traffic capacity is usually expressed as Erlang
- Capacity of the network may vary based on offered QoS
- Subscriber behavior
- Build ahead capacity (% of buffer capacity)





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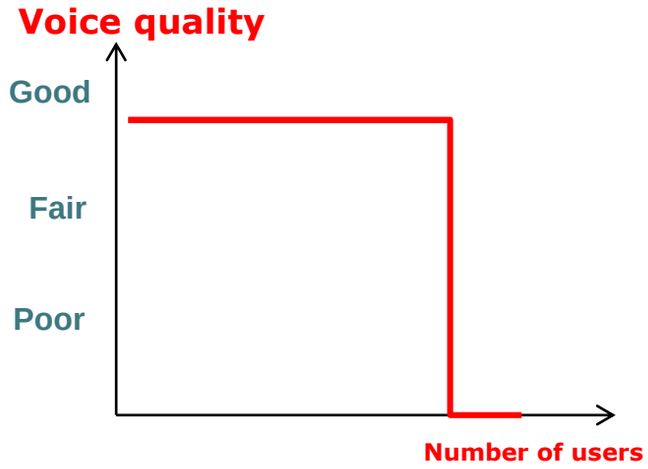
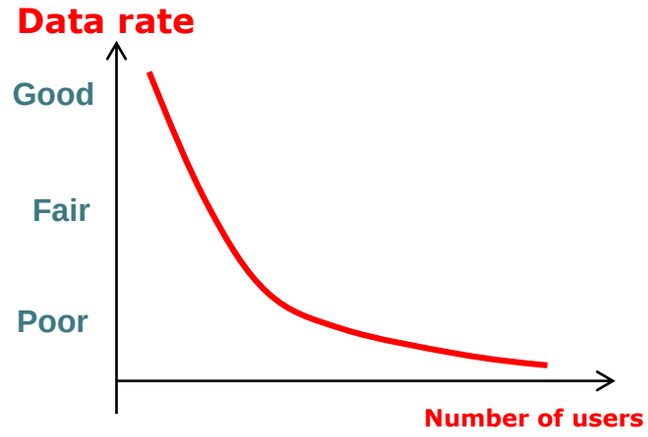
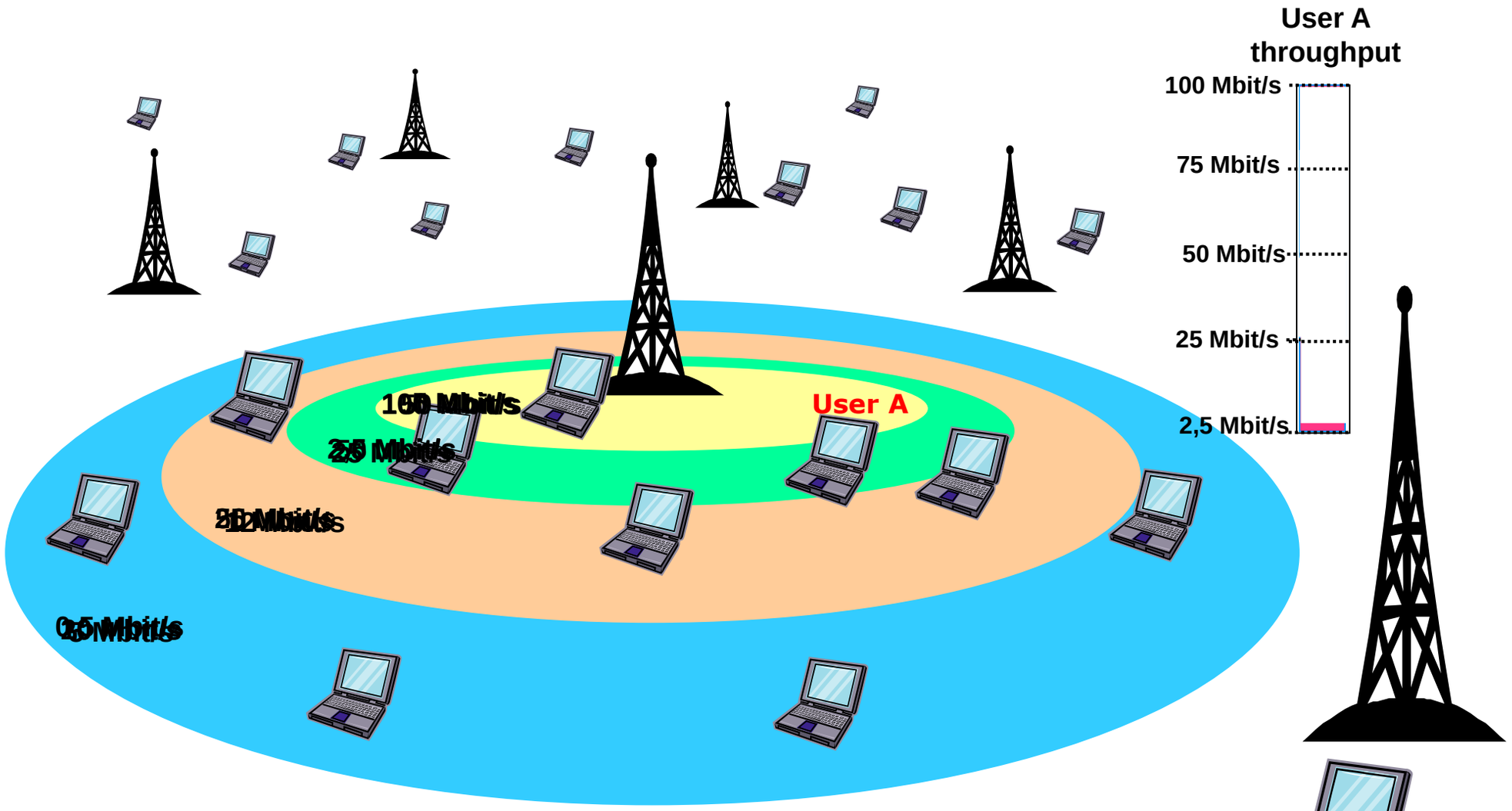
CAPACITY : VOICE AND DATA





At equal conditions, MBB user experience depends on number of active users per cell. But voice experience is independent of other users

QUALITY : USER EXPERIENCE BASED ON DISTACNE



Download data rates depend on distance to base station, density of LTE sites and number of simultaneous users and their service types

C. Quality of Service [QoS]

1. Accessibility E2E (%)

- ***Success rate of attempted calls reaching to called party***
- The attempted calls have to be successful on SDCCH (signaling channel), TCH (traffic channel), BSC-MSC routes, MSC-TSC routes to achieve the overall accessibility
- (Success of Signaling x Success of traffic x Success of core network)^2=(0.98 x 0.97 x 1)^2 = 90%

2. Retain ability (%)

- ***Percentage of on-going calls that are retained by our network until disconnected intentionally by the subscribers***. It is commonly expressed by Drop Call Rate (DCR)…
- Drop call rate [DCR]
  - It is a measure of retainability. Lower drop rates signify better QoS
  - DCR= $\frac{No.\ of\ Drop}{No.\ of\ Attempt} \times 100\%$
- Minute per Drop [MPD]
  - It is also a measure of retainability. Higher MPD signifies better QoS but it requires higher investment.
  - MPD= $\frac{Total\ Calling\ Minutes}{Total\ No.\ of\ Drop}$

C. Quality of Service [QoS] contd…

3. Speech quality: MOS [Mean opinion score]

- ***It is a measure of integrity of service***. It is measured by subjective or objective test.
- **Subjective method:** A listener panel to assess speech quality. Speech quality is expressed as a *mean opinion score (MOS)*, which is the average speech quality perceived by the members of the panel. Speech quality is marked by 1-5 scale. 1 means worst and 5 means best.
- **Objective method** replace the listener panel by an algorithm to compute a MOS value from a speech sample.
- **Toll Grade Quality:** MOS above 3.5 is termed as Toll grade speech quality.
- Targeted Speech quality threshold in UMTS(3G) is 3.2

ITU P 862.1	MOS:	
	min.	max.
Excellent	>= 3.5	4.5
Good	>= 2.7	< 3.5
Fair	>= 2.1	< 2.7
Poor	>= 1.5	< 2.1
Bad		< 1.5

Radio Cabinet

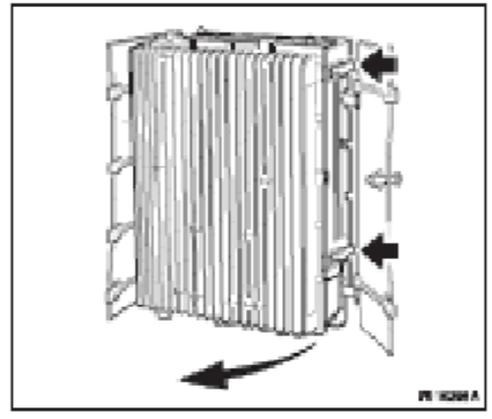
Combination of RBS 2216 w/ 24 TRX

Combination of RBS 2216 w/ BBS

TG sync cable

RBS2216

RBS 2111



RBS 2308

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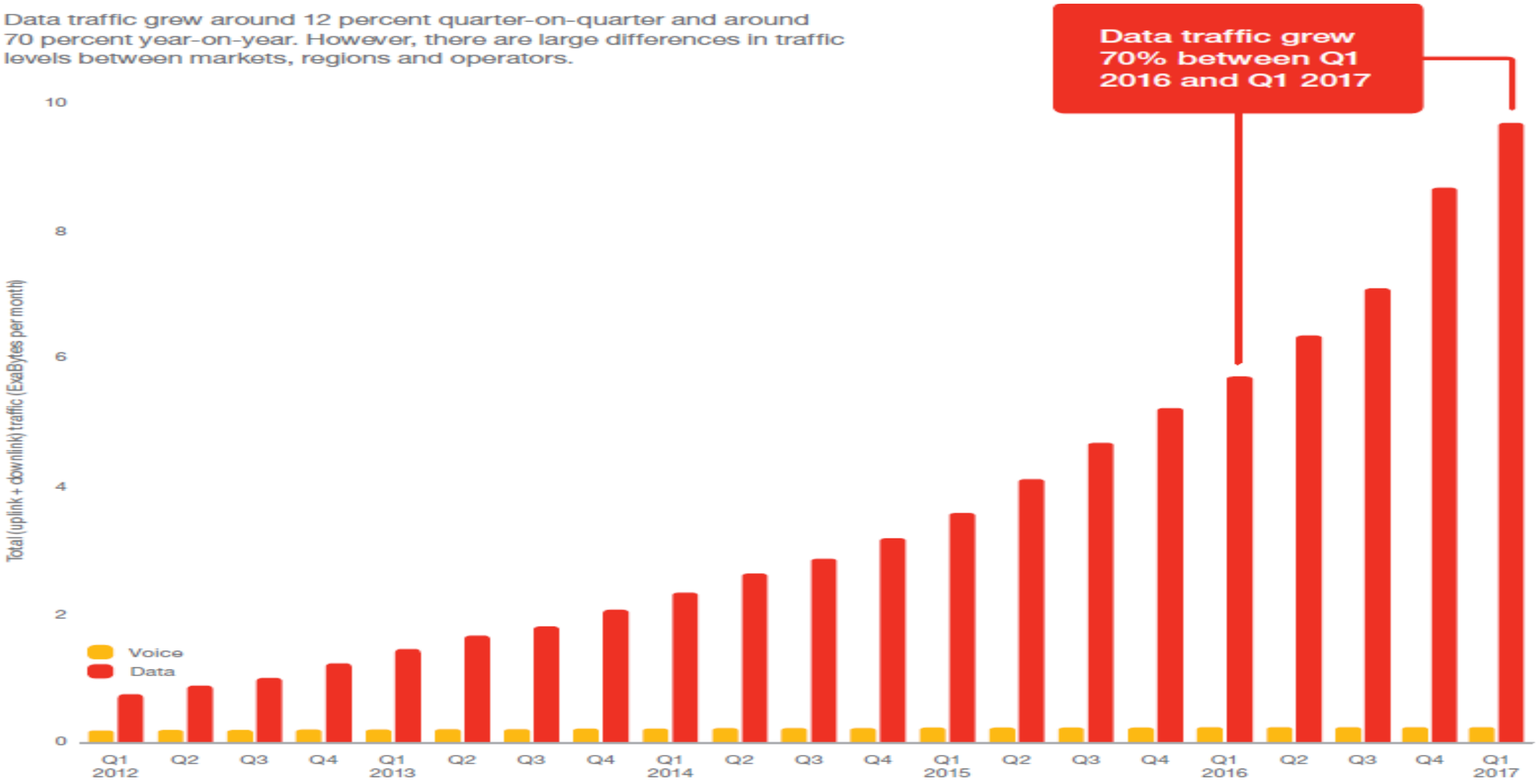
MOBILE TRAFFIC Q1 2017

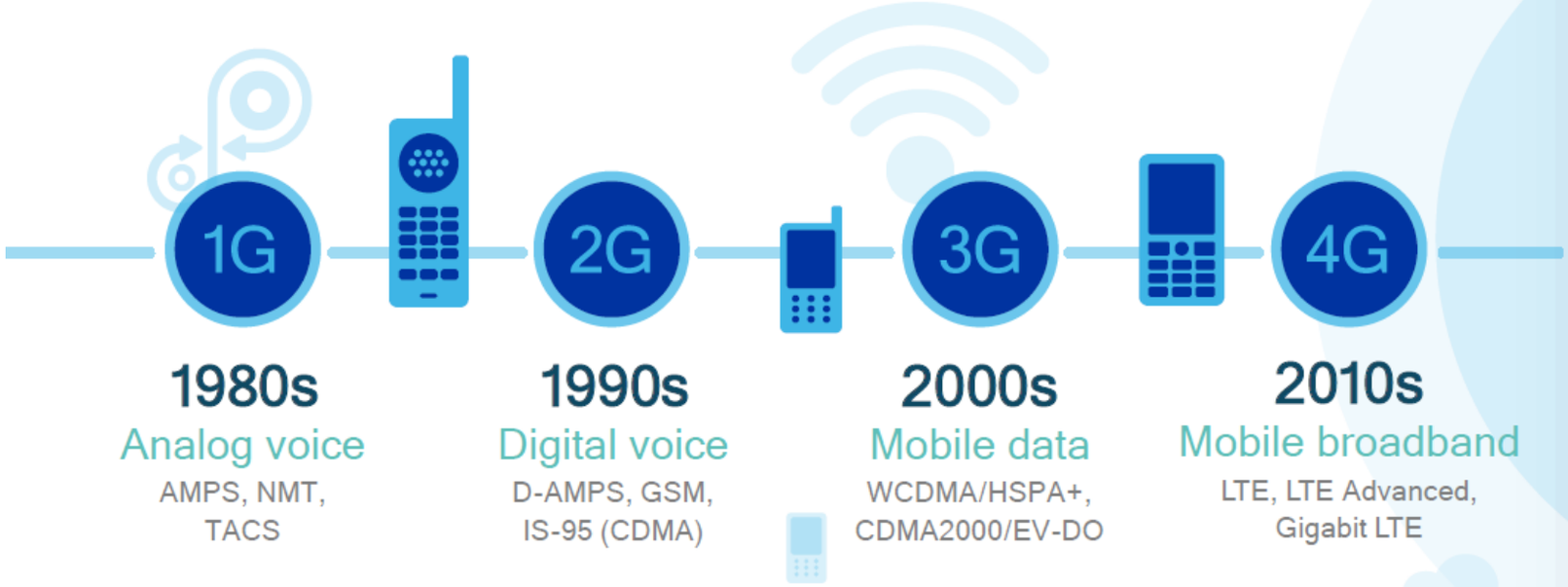
Data traffic grew around 12 percent quarter-on-quarter and around 70 percent year-on-year. However, there are large differences in traffic levels between markets, regions and operators.

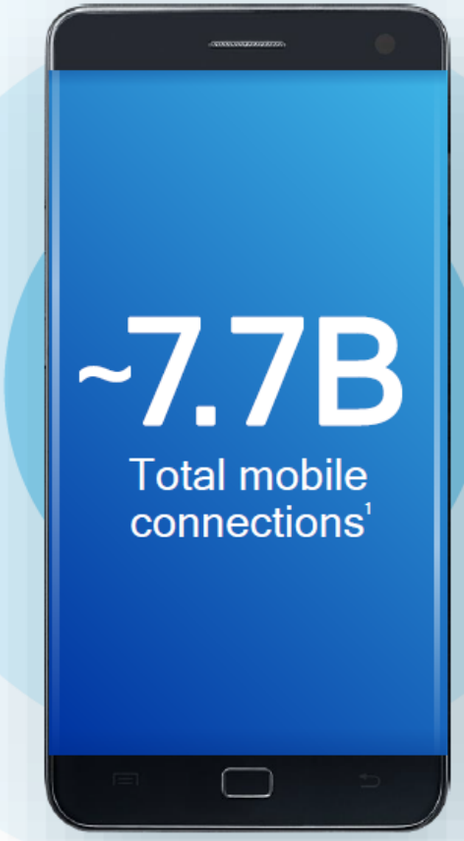


Source: Ericsson traffic measurements (Q1 2017)

[1] Traffic does not include DVB-H, Wi-Fi, or Mobile WiMAX. VoIP is included in data traffic

Mobile is the largest technology platform in human history





[1] Source: GSMA Intelligence, July 2017

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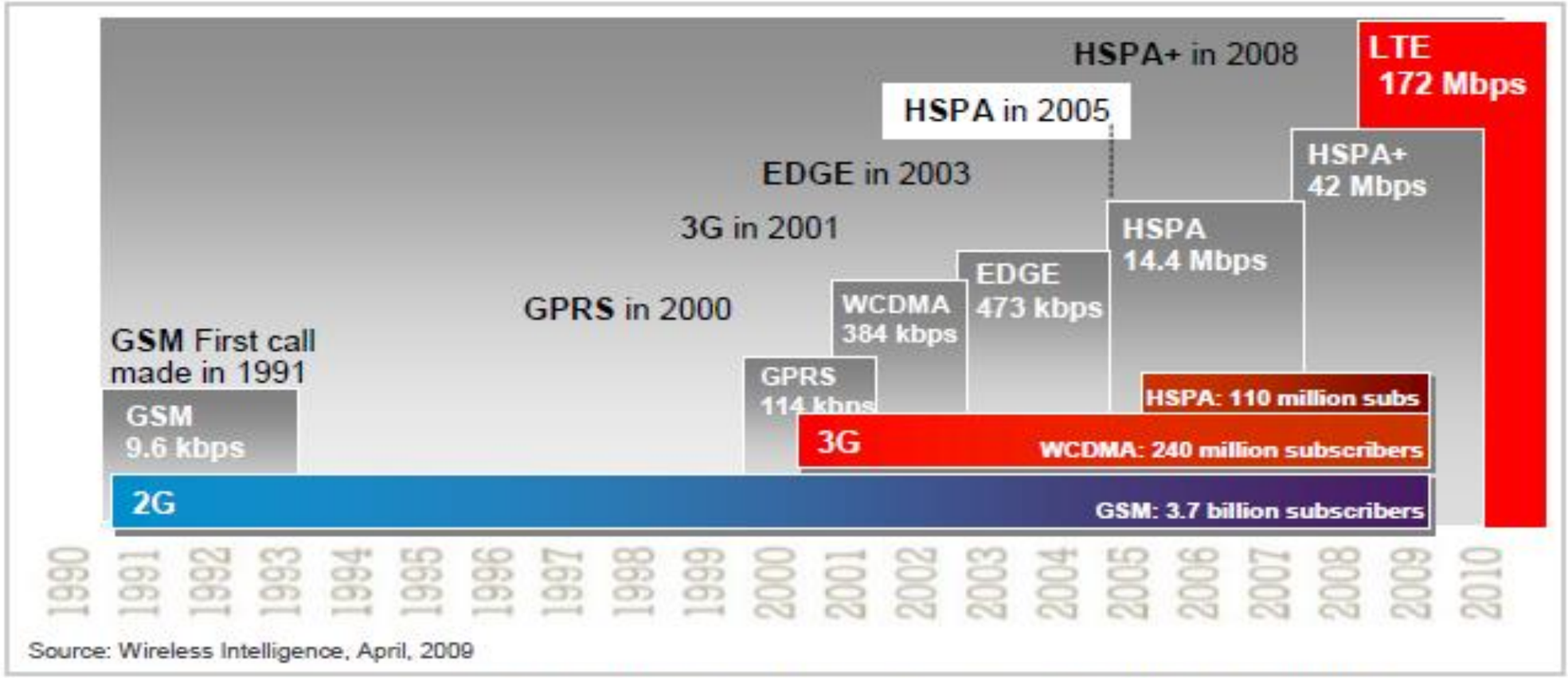
Evolution of Data Service

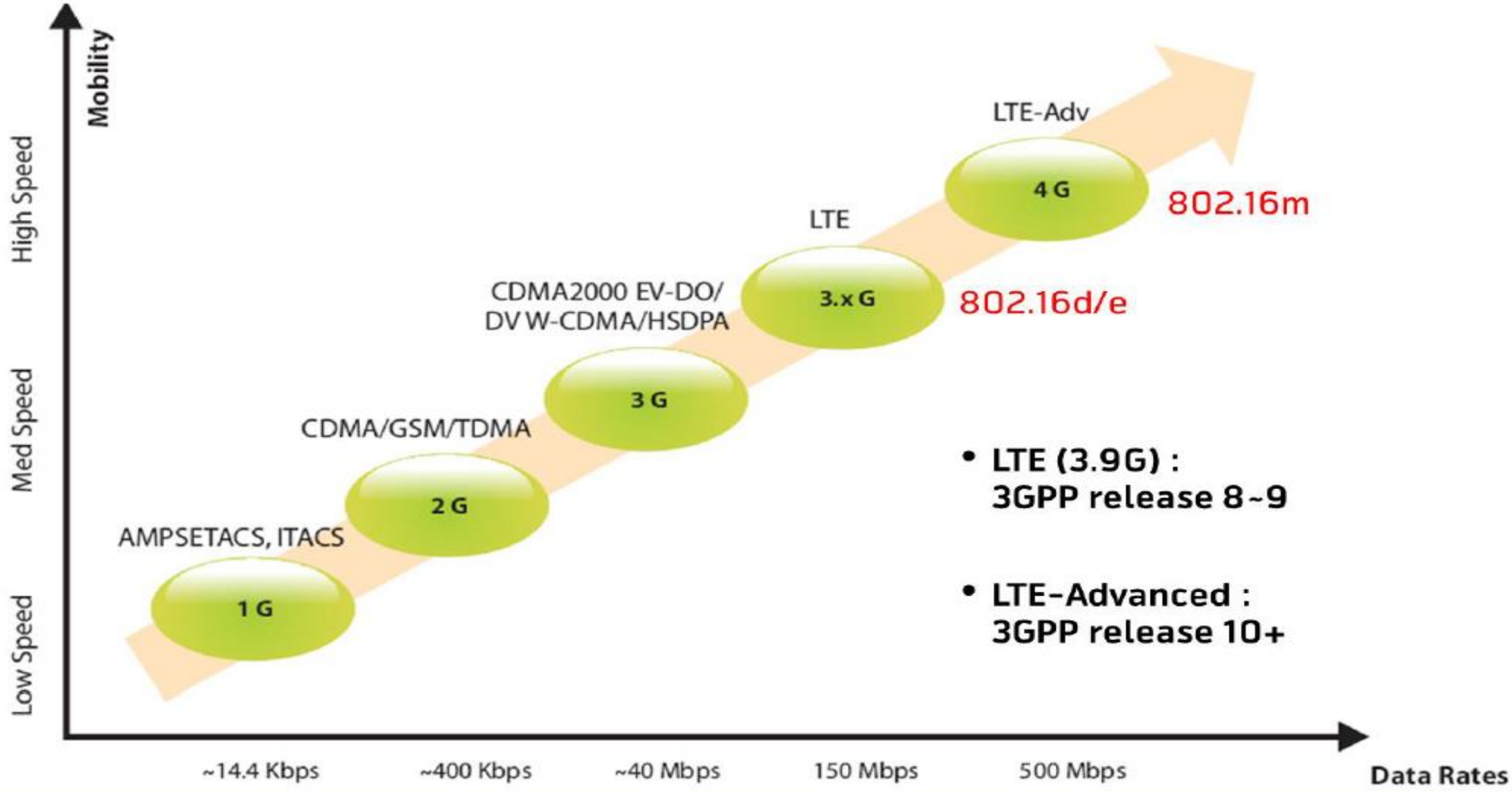
GSM technology holds nearly two decades of proven developme nt, proving a reliable future for investment decisions



Source: Wireless Intelligence, April, 2009

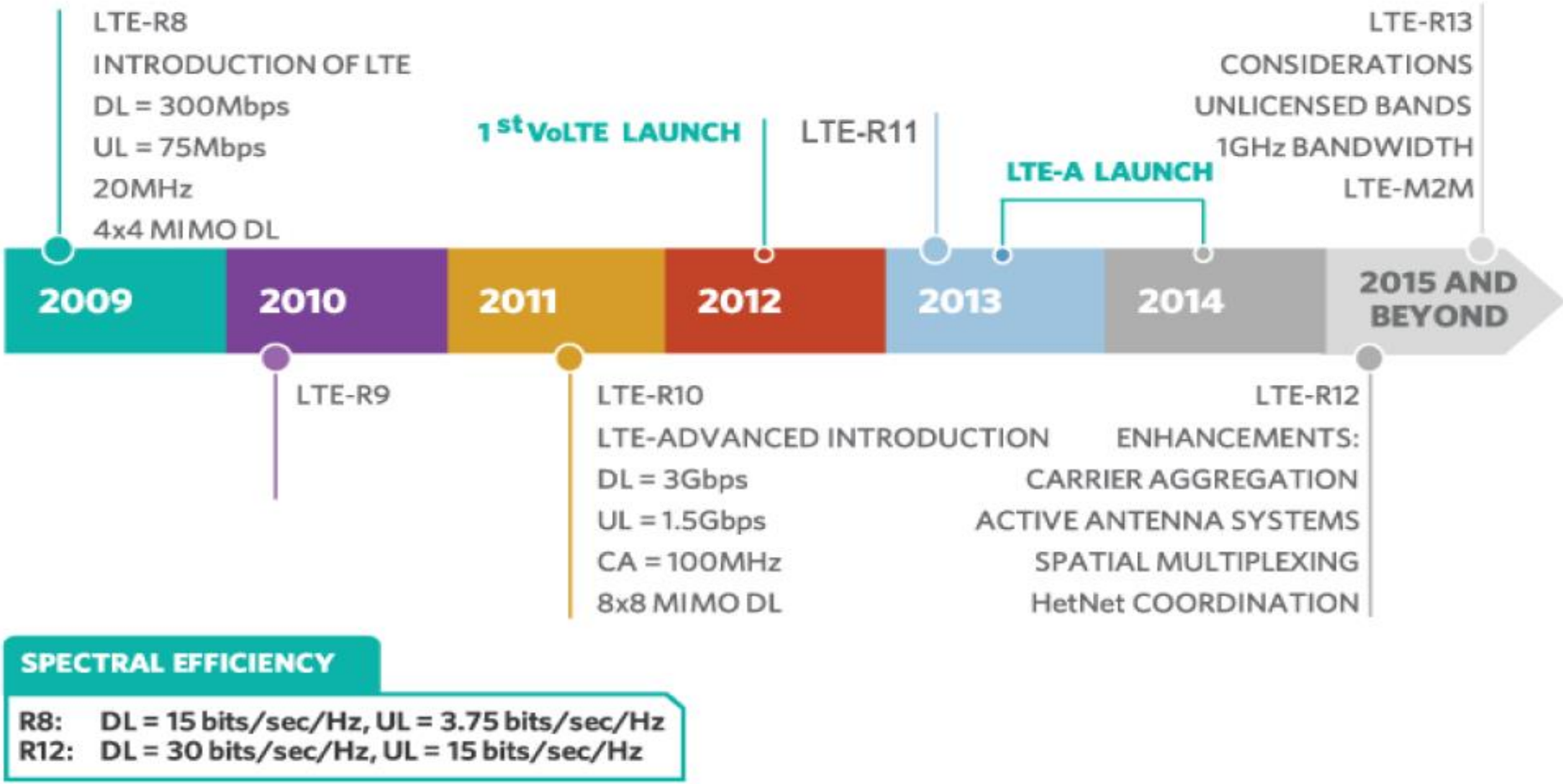
HSPA+ peak theoretical data rate reaches up to 42 Mbps when using single carrier with QAM 64 and 2x2MIMO
LTE peak theoretical data rates reaches up to 172Mbps when using 20MHz channel and 2x2 MIMO

Evolution of Radio Access Technologies



- **LTE (3.9G) : 3GPP release 8~9**
- **LTE-Advanced : 3GPP release 10+**

Evolution within LTE



5G

5G will address the insatiable demand for mobile broadband

30x growth in mobile data traffic from 2014 to 2020

>75% of traffic from multi-media streaming in 2020

~8B

Gigabytes

Daily global mobile data traffic in 2020

Source: Nokia Bell Labs Consulting Report, 2016

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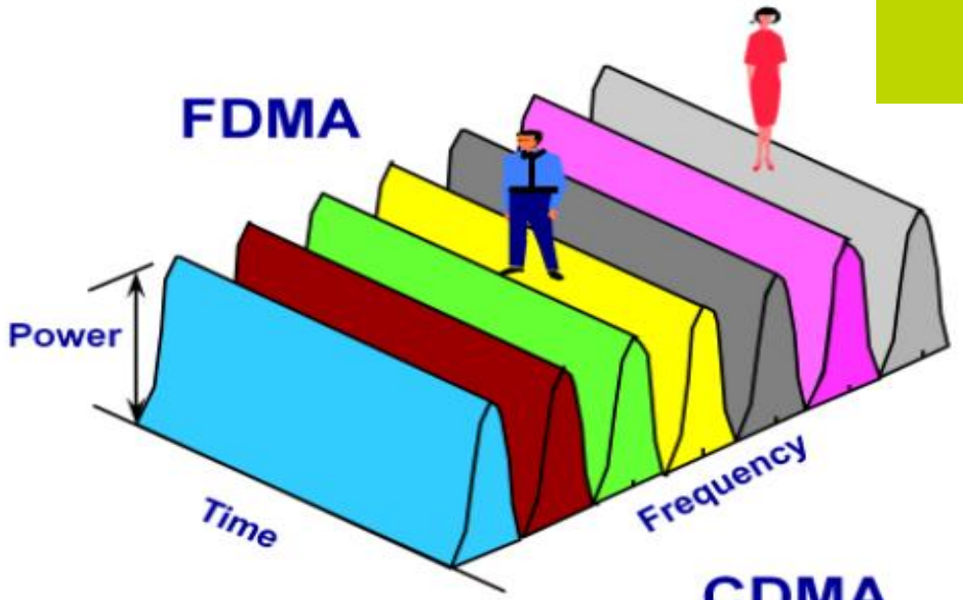
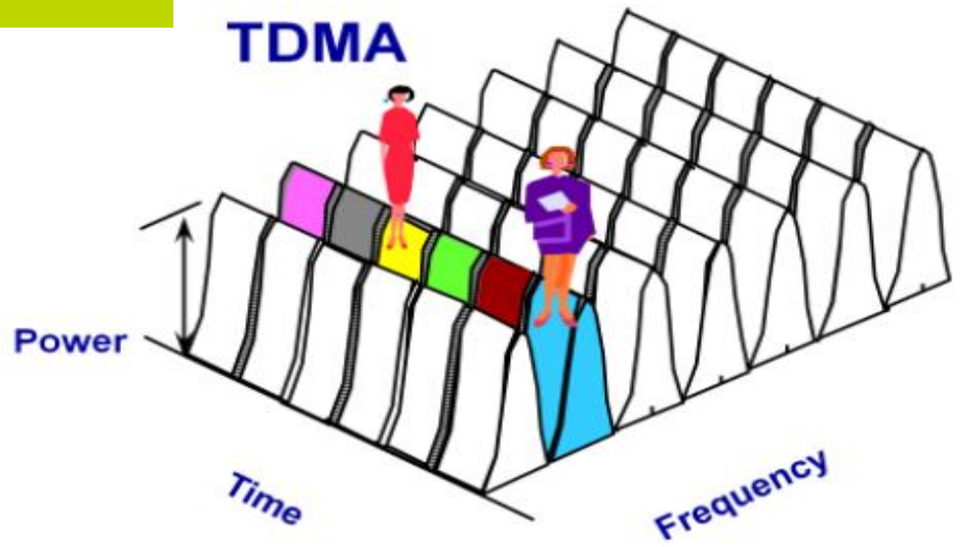
Access Techniques

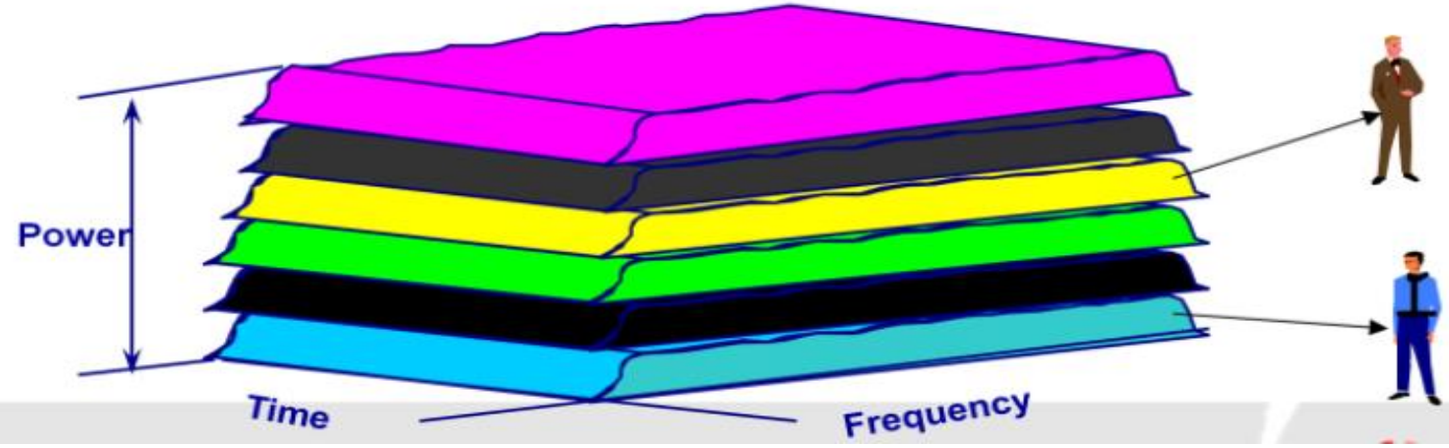
2G



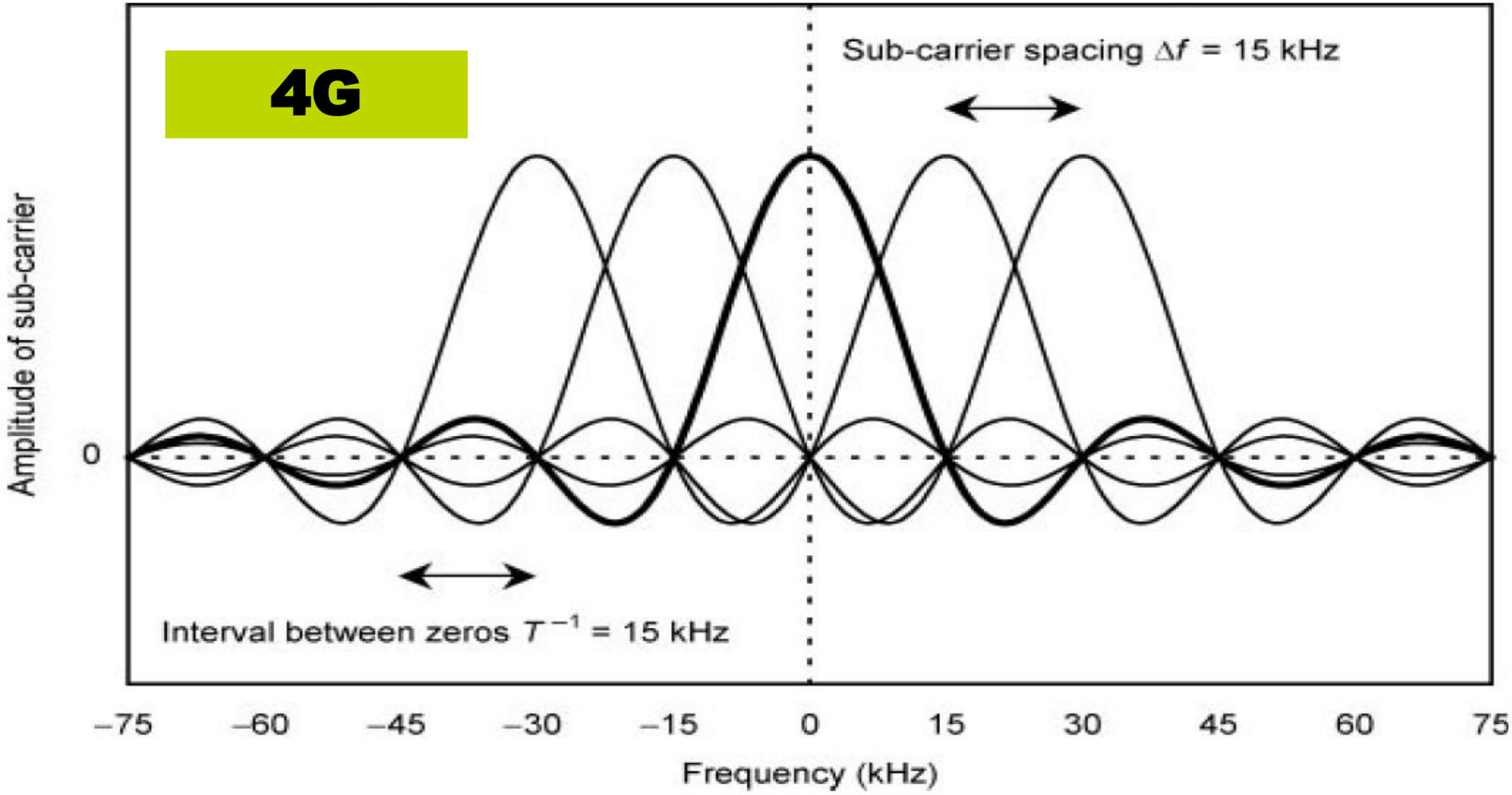


CDMA

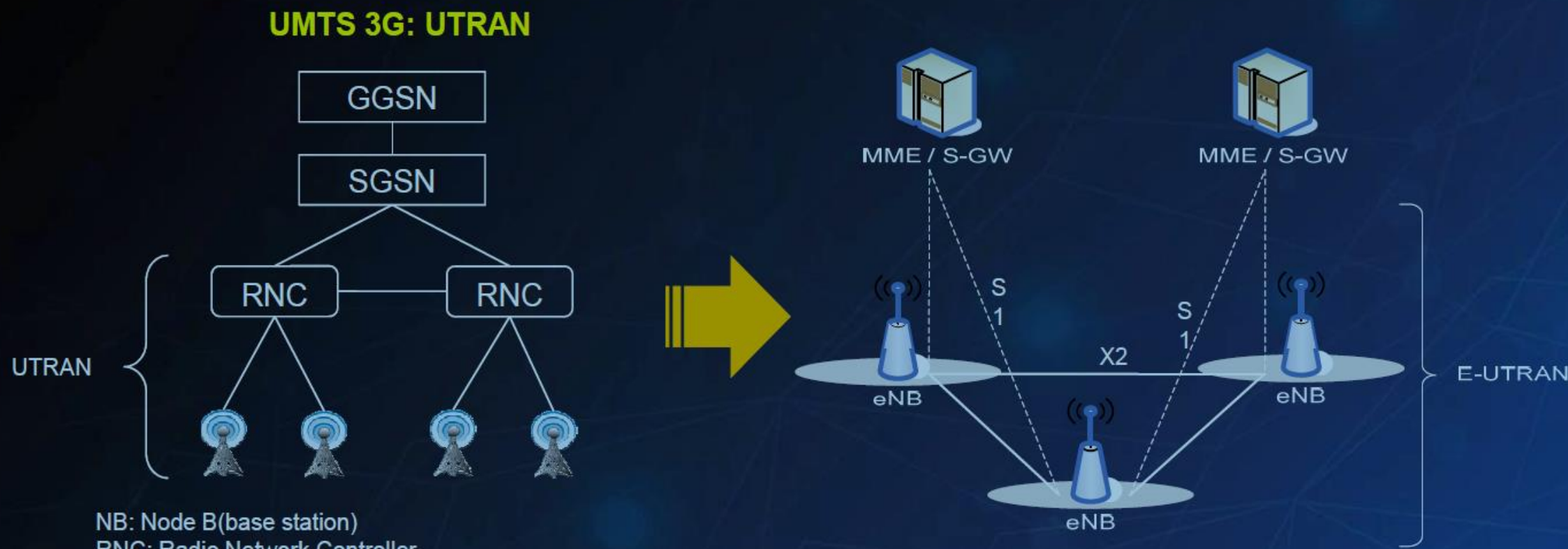
3G



Access Techniques OFDMA



Comparison of UTRAN & E-UTRAN Network



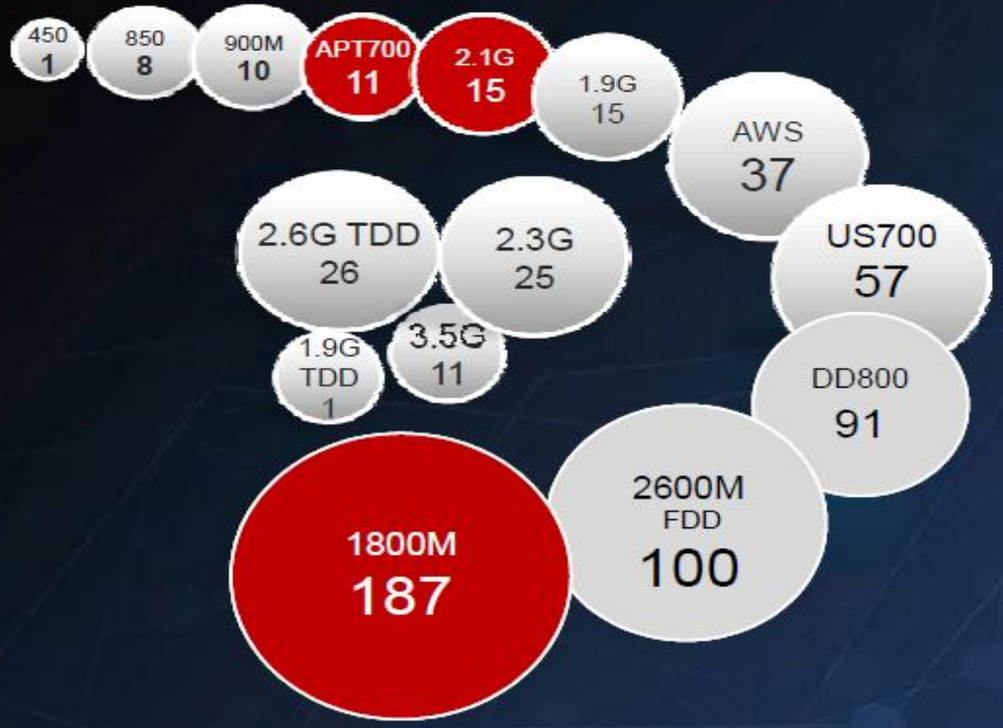
NB: Node B(base station)
RNC: Radio Network Controller
SGSN: Serving GPRS Support Node
GGSN: Gateway GPRS Support Node

The main difference between UMTS and LTE: **the removing of RNC network element and the introduction of X2 interface**, which make the network more simple and flat, leading lower networking cost, higher networking flexibility and low latency

Worldwide LTE Network

1800M is the Mainstreaming Band for LTE

LTE Commercial Networks Per Band



3253 LTE Commercial Devices Per band

Band	Qty.
1800	1543
2600FDD	1381
700	756
APT700	139
AWS	727
DD800	812
1900	194
2100	1185
850	684
900	668
2600TDD	1375
2300TDD	869
3500TDD	32

Source: GSA Evolution to LTE report (July 2015)

ERICSSON MOBILITY REPORT

As Ericsson's newly appointed CSO, I am proud to take over as publisher of the Ericsson Mobility Report. Over the last five years, we have published insights and data points that clearly illustrate the tremendous evolution of mobile technology.

Recently, the industry has taken major steps to progress network evolution, including the approval of the Non-Standalone 5G New Radio (NR) that will enable early 5G deployments. By 2022, we anticipate that there will be more than half a billion 5G subscriptions, with a population coverage of 15 percent.

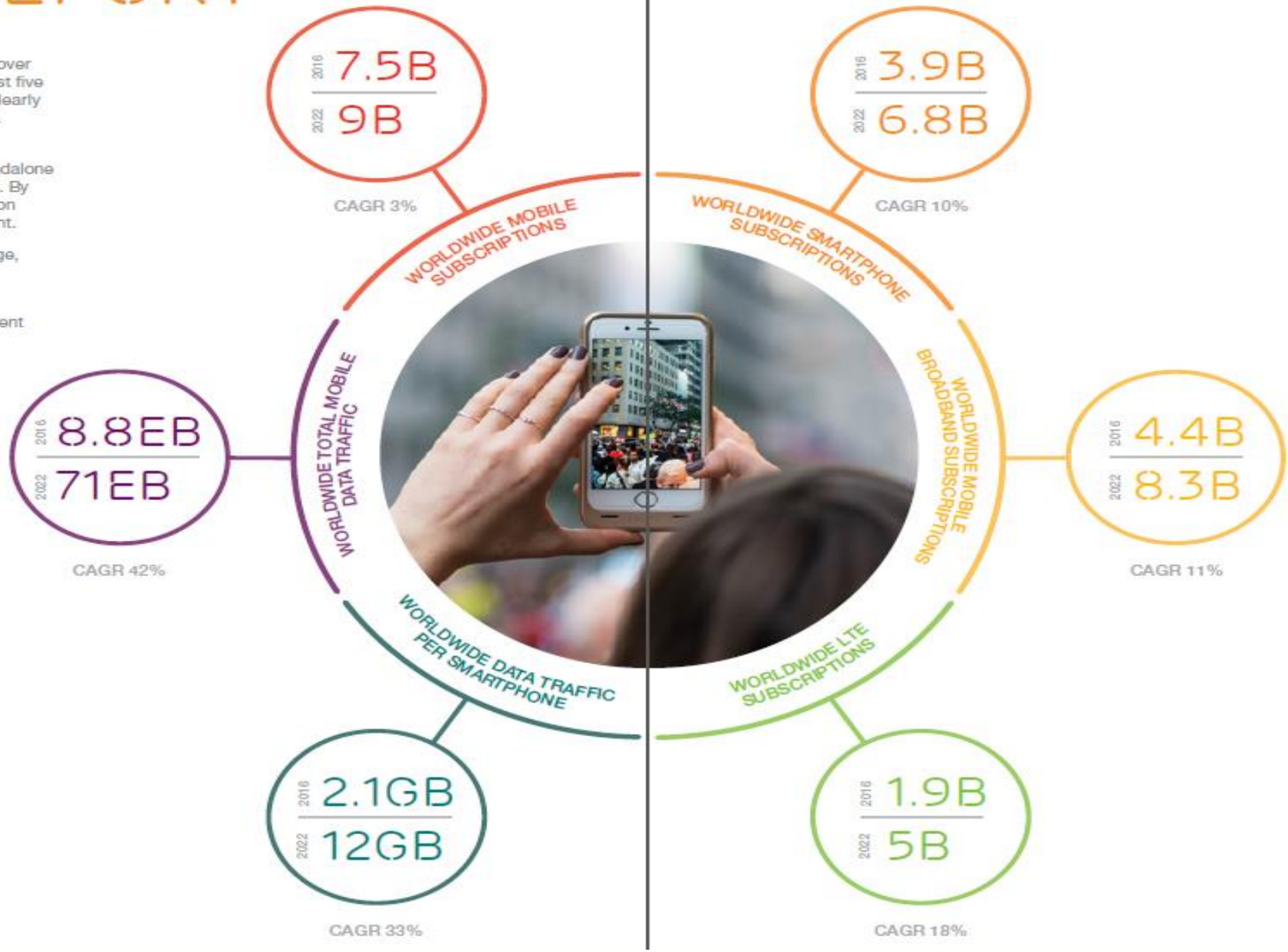
Mobile broadband continues to grow strongly. On average, more than 1 million new mobile broadband subscribers will be added every day up to the end of 2022.

The total traffic in mobile networks increased by 70 percent between the end of Q1 2016 and the end of Q1 2017. Part of this increase was due to one Indian operator's introductory LTE offer that included free data traffic.

In this edition, we have included four feature articles, exploring various aspects of the mobile industry. The findings presented range from how leveraging existing mobile infrastructure is the most cost-effective way to connect the 50 percent of the global population that still doesn't have internet access, to how attributes of 5G will make public transport using autonomous vehicles safer.

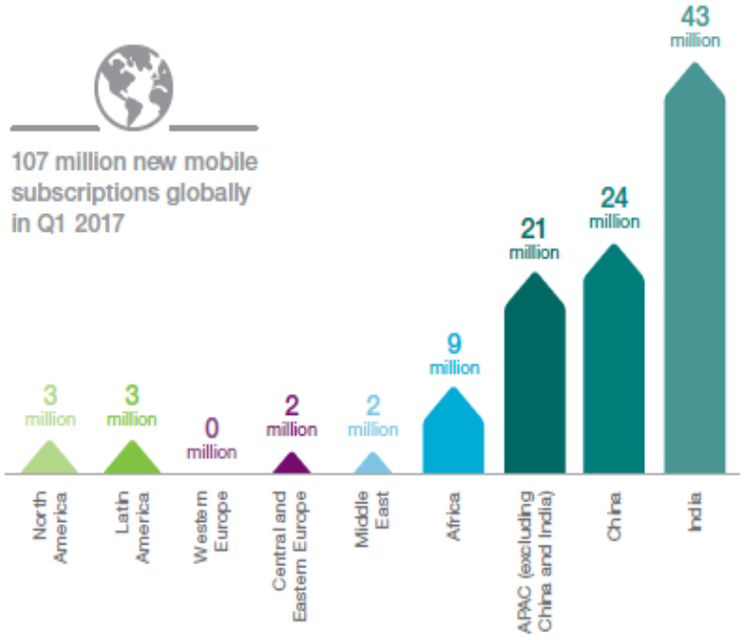
I hope you find this report engaging and valuable. All our content is available at **www.ericsson.com/mobility-report**

PUBLISHER
Niklas Heuveldop,
Chief Strategy Officer
and Senior Vice President
Technology and Emerging Business



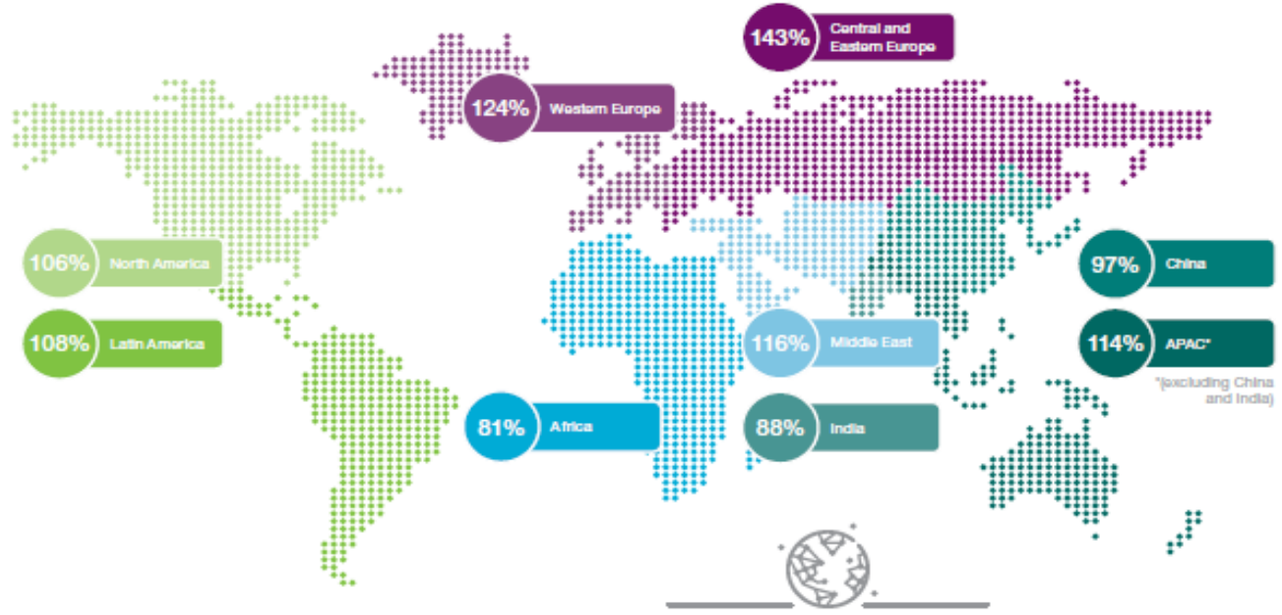
New mobile subscriptions Q1 2017

107 million new mobile subscriptions globally in Q1 2017



Top 5 countries by net additions Q1 2017

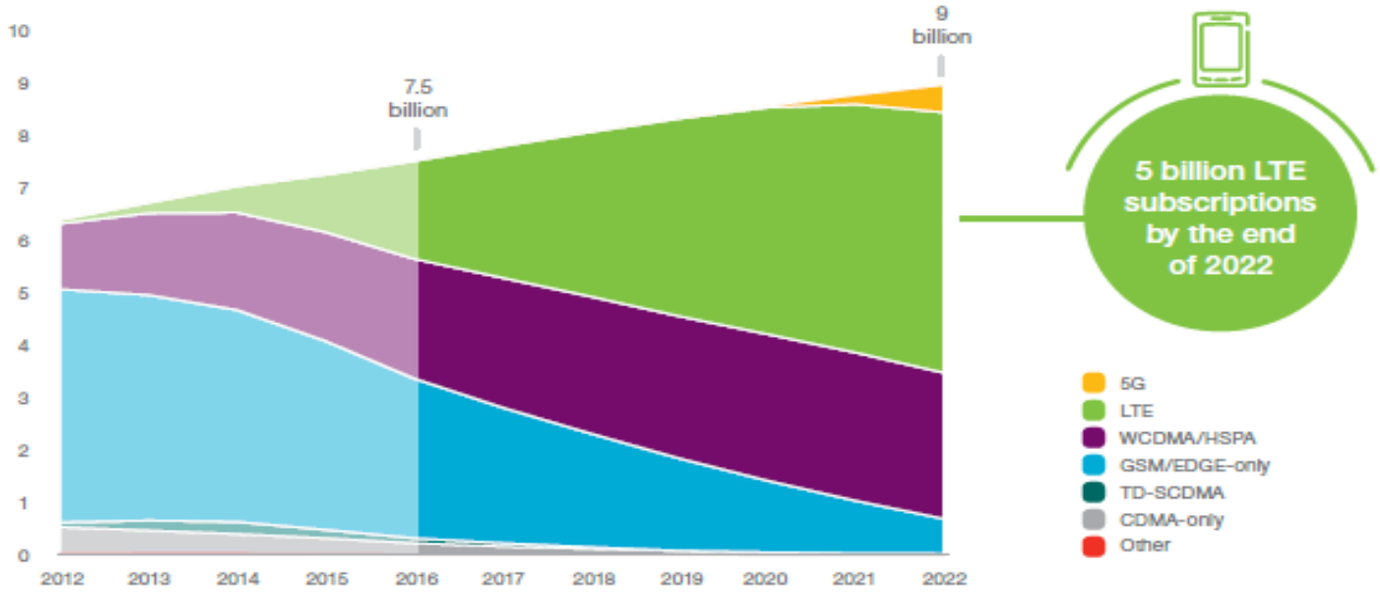
1	India	+43 million
2	China	+24 million
3	Indonesia	+10 million
4	Pakistan	+5 million
5	Nigeria	+3 million



Subscription penetration (percent of population)

102% global subscription penetration in Q1 2017

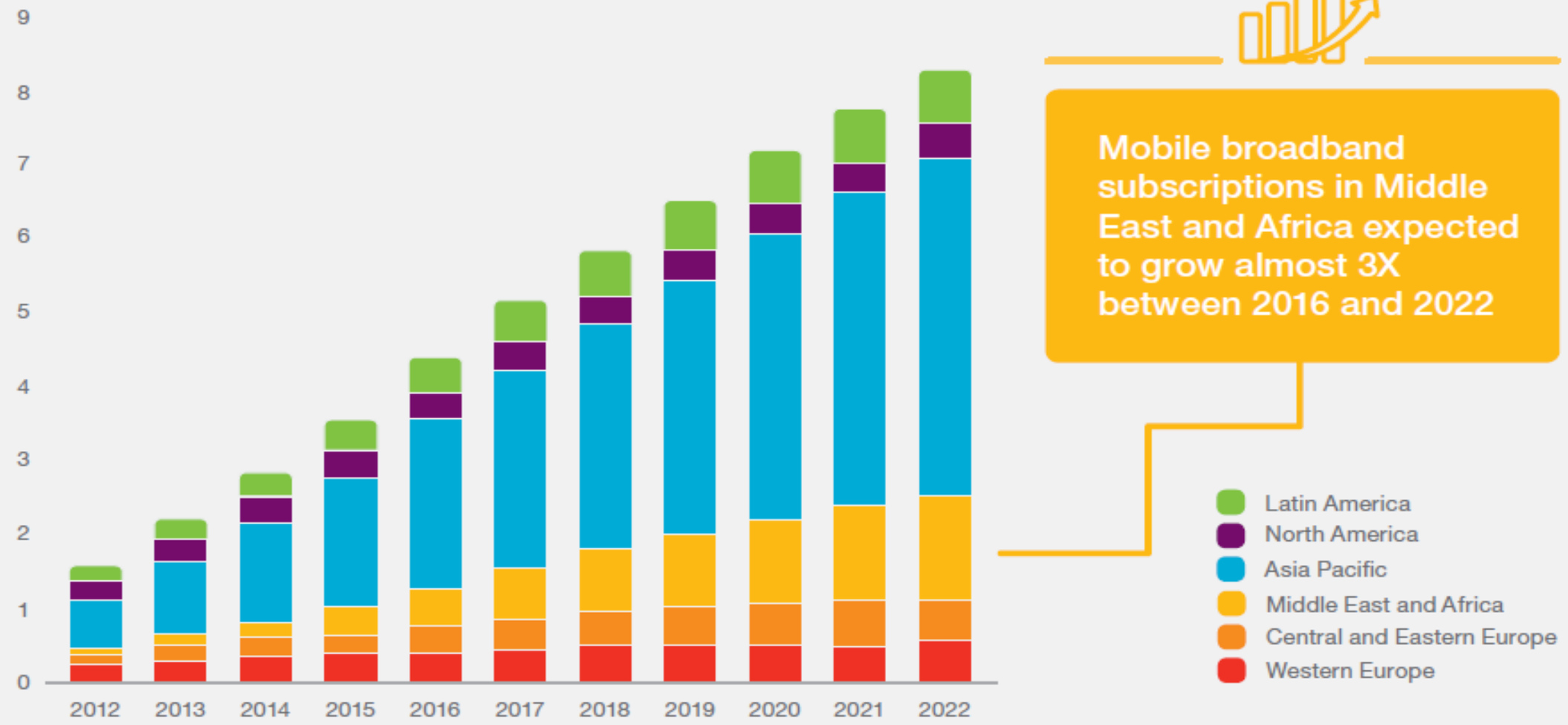
Mobile subscriptions by technology (billion)



[1] Non-Standalone 5G NR will utilize the existing LTE radio and Evolved Packet Core network as an anchor for mobility management and coverage, while adding a new 5G radio access carrier to enable certain 5G use cases starting in 2019

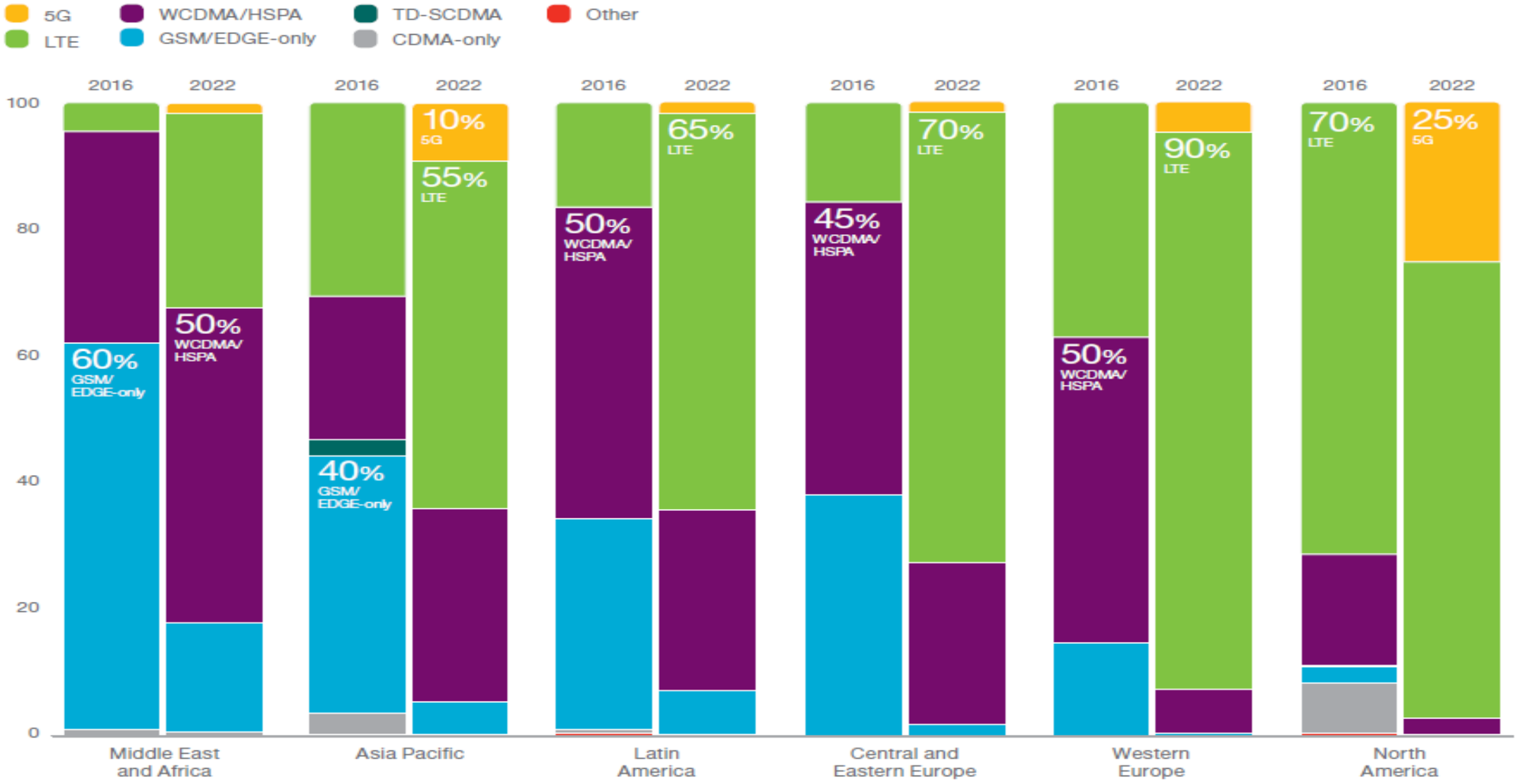
Figure note: IoT connections and Fixed Wireless Access (FWA) subscriptions are not included in the above graph

Mobile broadband subscriptions by region (billion)



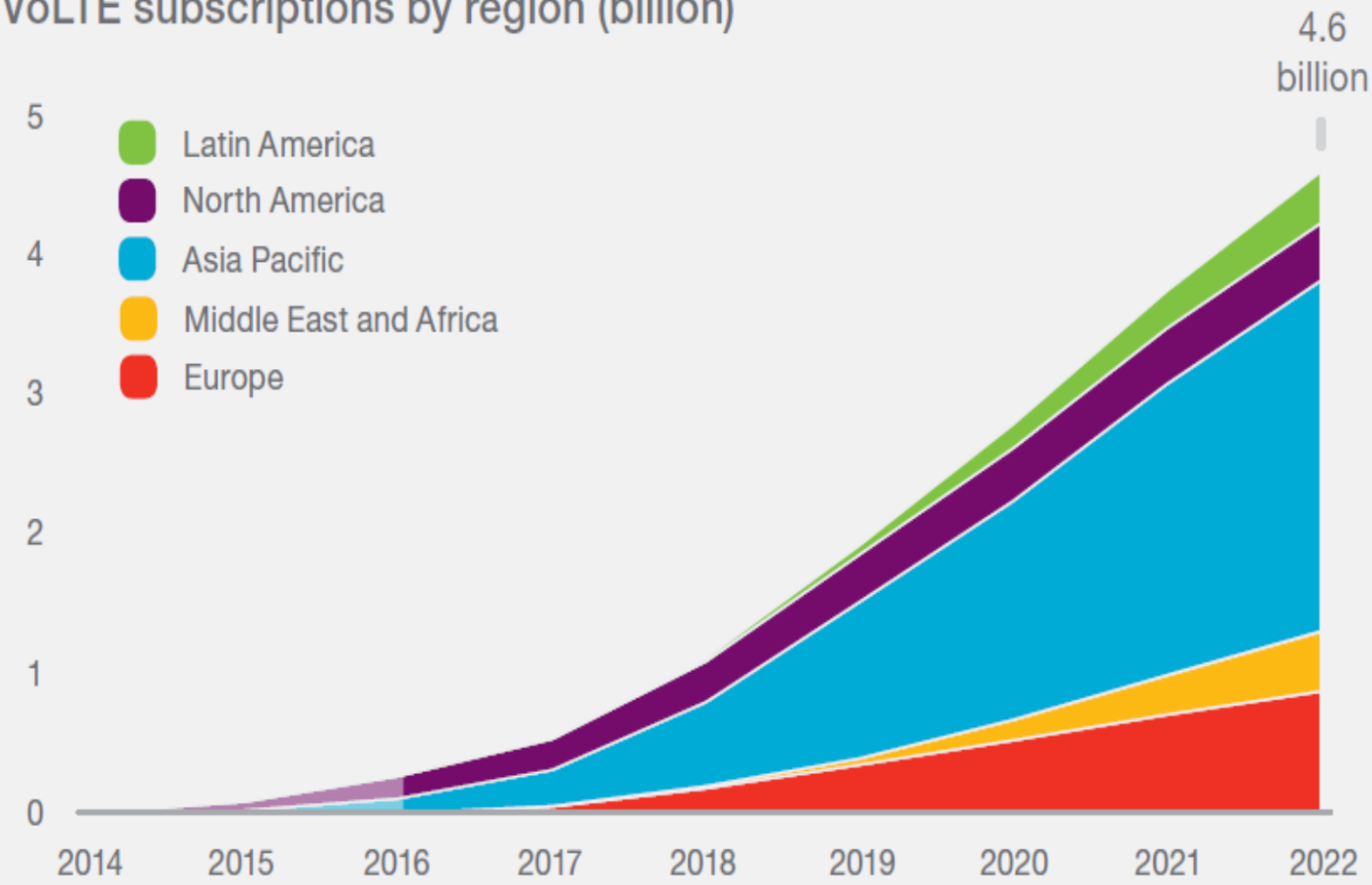
[1] Mobile broadband includes radio access technologies HSPA (3G), LTE (4G), 5G, CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX
Note: WCDMA without HSPA and GPRS/EDGE (2G) are not included

Mobile subscriptions by region and technology (percent)



25% of subscriptions in North America and 10% in Asia Pacific will be for 5G in 2022

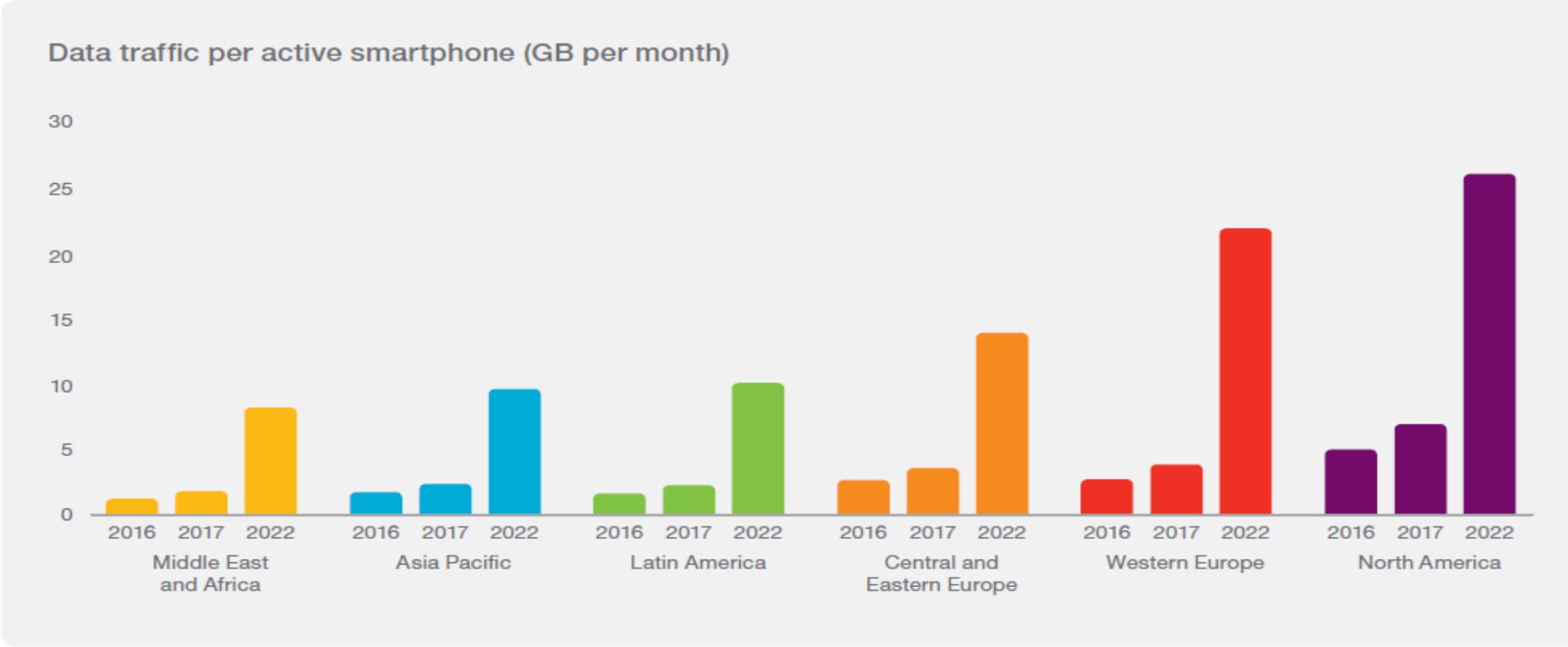
VoLTE subscriptions by region (billion)



VoLTE subscriptions expected to reach 4.6 billion in 2022

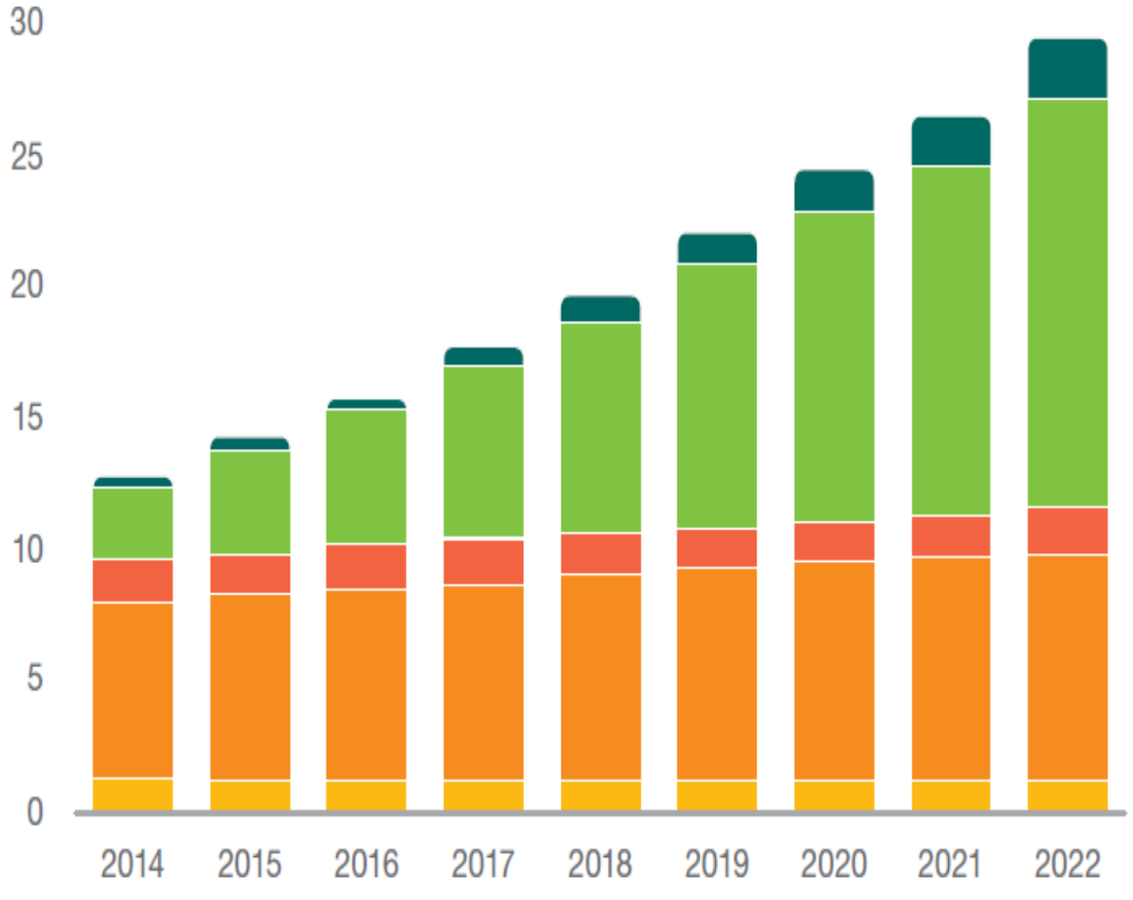
[1] A subscriber is counted as having a VoLTE subscription if making at least one VoLTE call per month
[2] GSA (April 2017)
[3] GSMA (March 2017)

MOBILE TRAFFIC OUTLOOK



INTERNET OF THINGS OUTLOOK

Connected devices (billions)



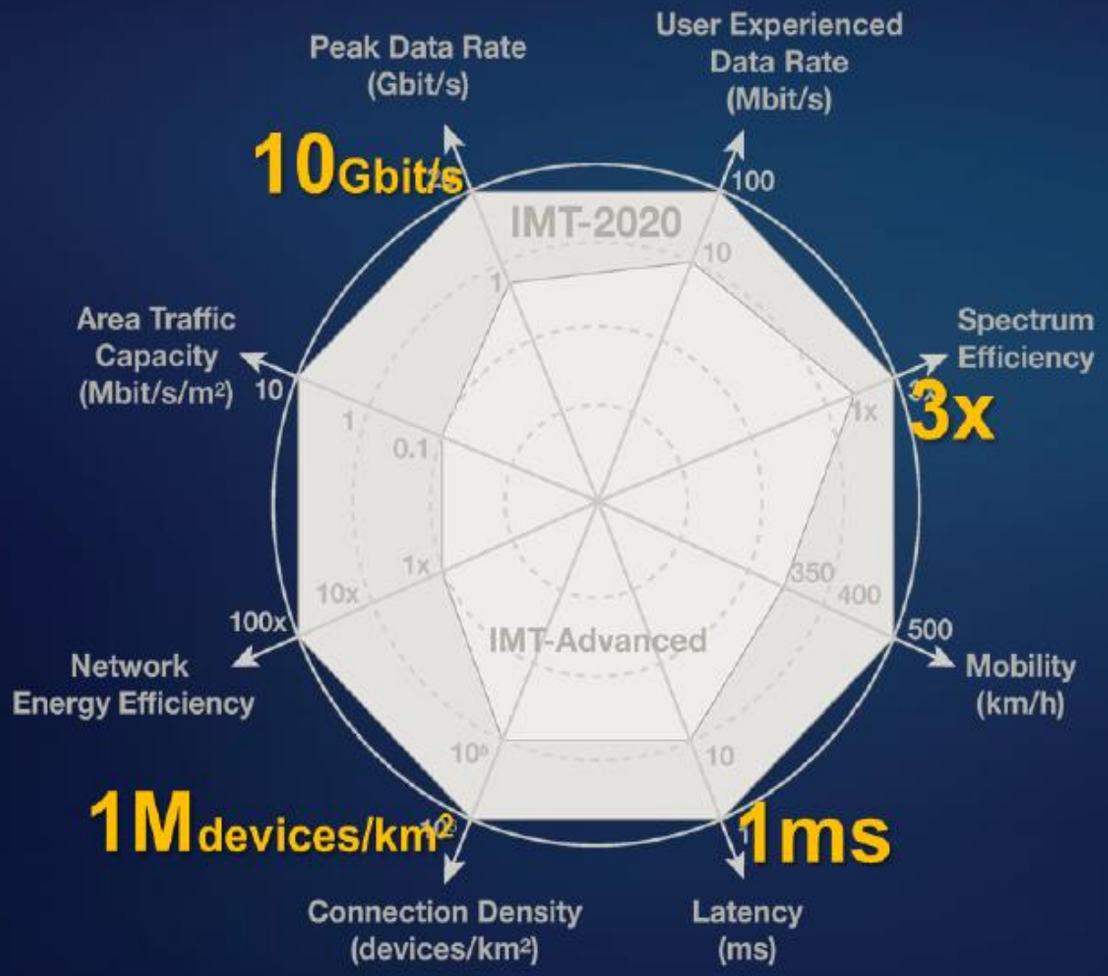
	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	15.5	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	

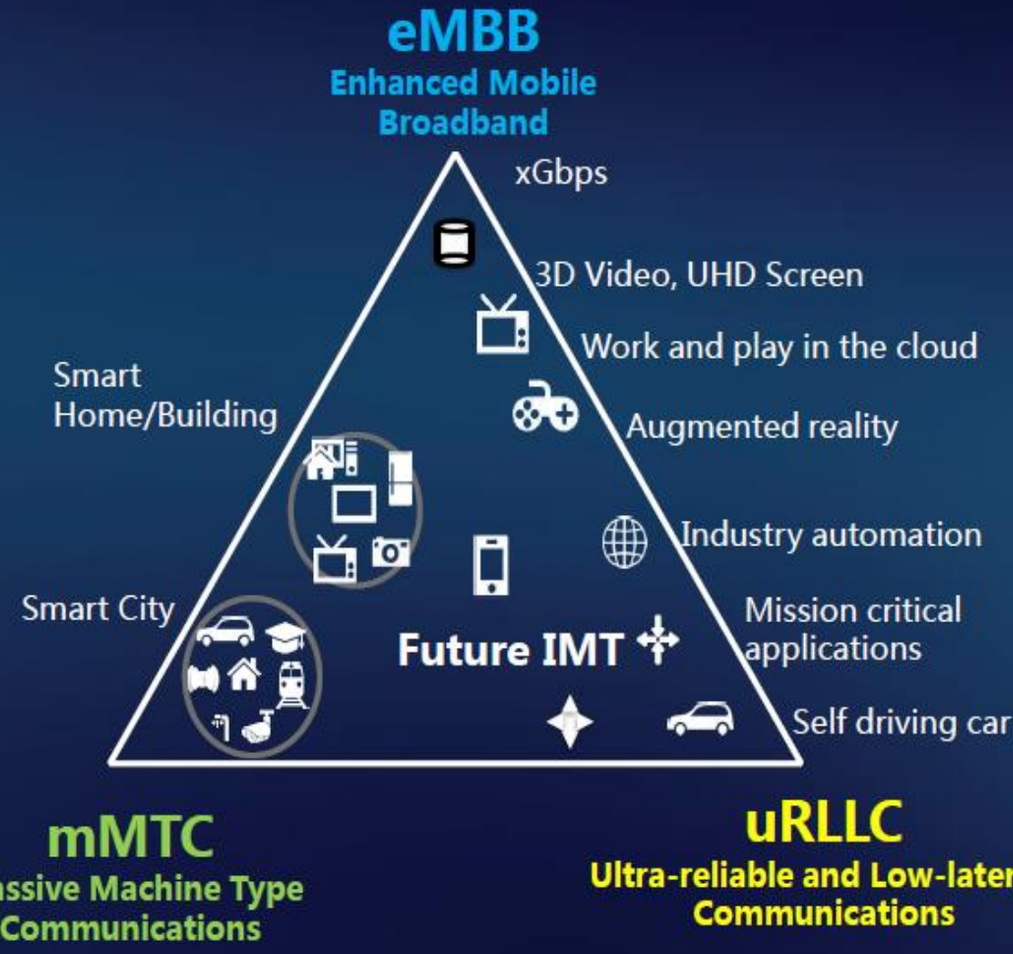

5G
USE CASES
BROADBAND AND MEDIA EVERYWHERE
SMART VEHICLES, TRANSPORT
CRITICAL SERVICES AND INFRASTRUCTURE CONTROL
CRITICAL CONTROL OF REMOTE DEVICES
HUMAN MACHINE INTERACTION
SENSOR NETWORKS

About 5G,

5G User Cases and Capability Requirement

ITU-R

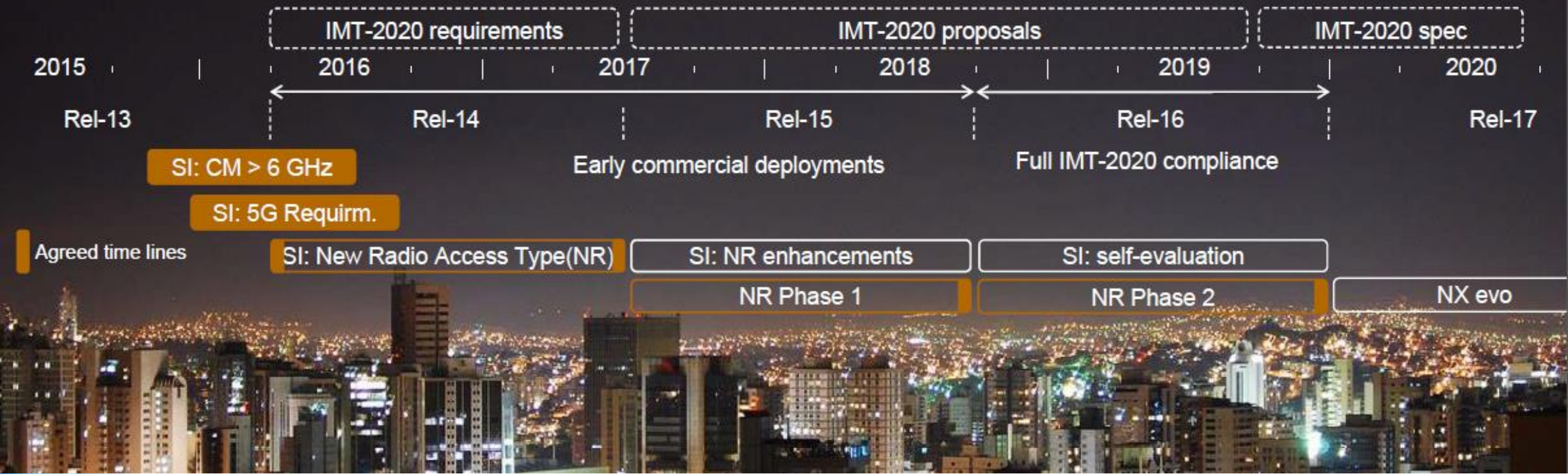




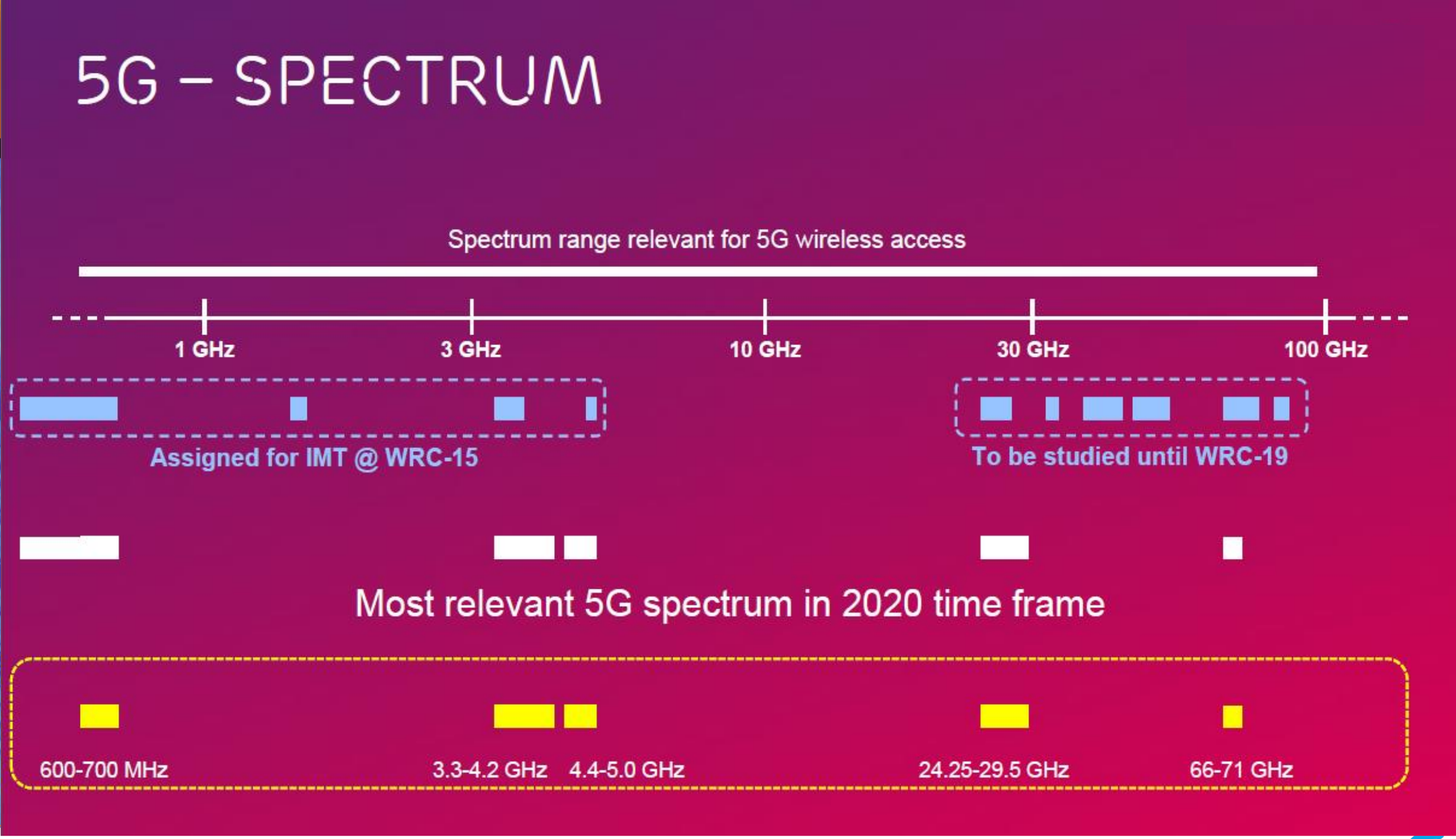
5G OVERALL PLAN

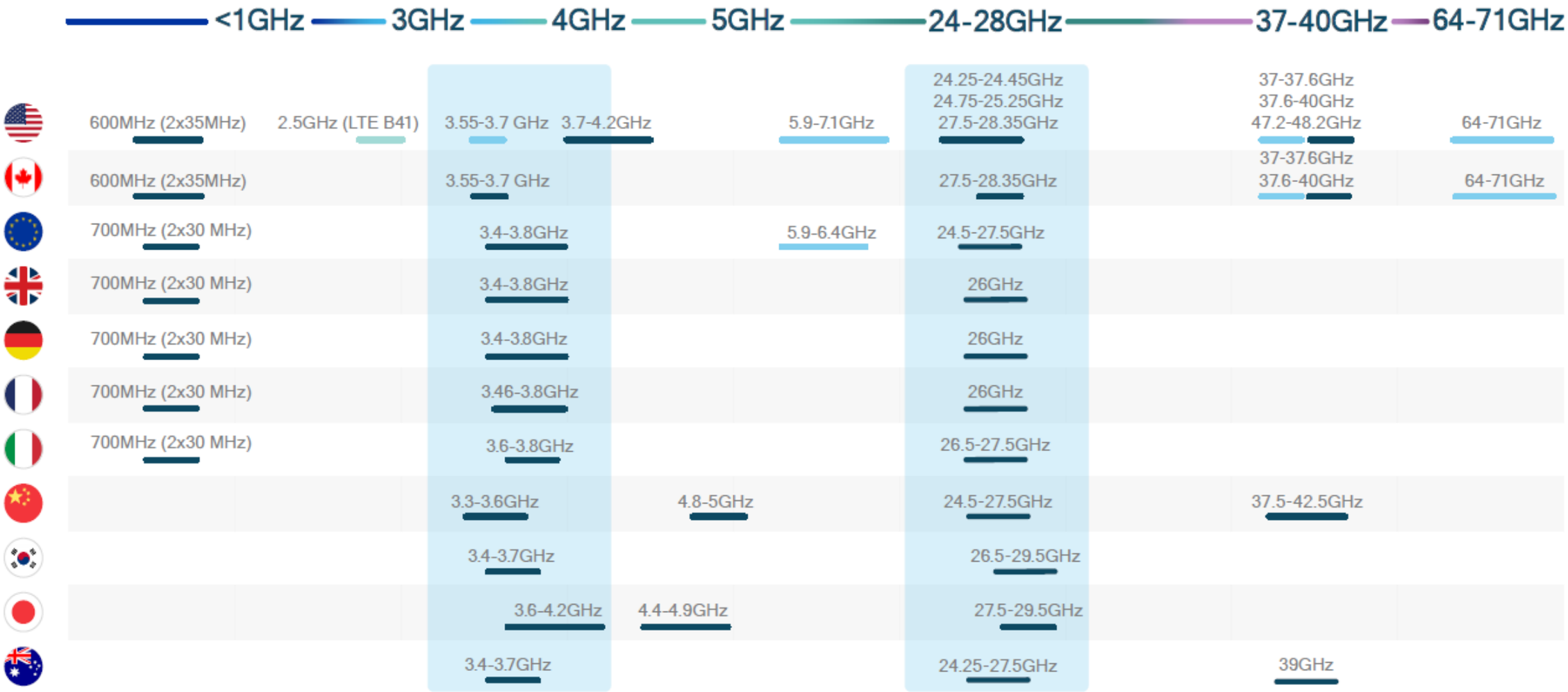
- 2 steps to 5G Standardisation
  - 3GPP Rel-15 ending H2 2018
  - 3GPP Rel-16 ending Dec 2019
- First step includes a subset of use cases & requirements
  - and should be forward compatible with use cases & requirements added in a later phase

- No consensus at this stage
  - Which use cases should be prioritized
  - Whether there should be prioritization of frequency ranges
  - Whether prioritization should already occur in the study phase



5G – SPECTRUM


Spectrum range relevant for 5G wireless access
1 GHz
3 GHz
10 GHz
30 GHz
100 GHz
Assigned for IMT @ WRC-15
To be studied until WRC-19
Most relevant 5G spectrum in 2020 time frame
600-700 MHz
3.3-4.2 GHz
4.4-5.0 GHz
24.25-29.5 GHz
66-71 GHz



Designed for diverse spectrum bands/types

Global snapshot of 5G spectrum bands allocated or targeted

New 5G band

- Licensed
- Unlicensed/shared
- Existing band

IOT/M2M COMMUNICATION
- EVOLVING WITH WIDE RANGE OF REQUIREMENTS

MASSIVE MTC / IOT

SMART BUILDING

LOGISTICS, TRACKING AND FLEET MANAGEMENT

SMART METER

SMART AGRICULTURE

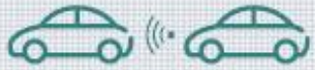
CAPILLARY NETWORKS

CELLULAR M2M TODAY

- ELECTRICITY METERS
- CONNECTED CARS
- POS TERMINALS
- ETC

CRITICAL MTC

REMOTE HEALTH CARE



TRAFFIC SAFETY & CONTROL

REMOTE MANUFACTURING, TRAINING, SURGERY

INDUSTRIAL APPLICATION & CONTROL

Massive IoT RAN

LOW COST, LOW ENERGY
SMALL DATA VOLUMES
MASSIVE NUMBERS

4G Evolution & 5G

ULTRA RELIABLE
VERY LOW LATENCY
VERY HIGH AVAILABILITY

Examples of use case evolution and supporting network technologies

	Current services	On the road to 5G	5G experiences
Enhanced mobile broadband	Browsing, social media, music, video	Fixed Wireless Access, interactive live concerts and sport events	4K/8K videos, mobile AR/VR gaming, immersive media
Automotive	Wi-Fi hotspots, on-demand GPS map data	Predictive vehicle maintenance, capturing real-time sensor data for different services	Autonomous vehicle control, cooperative collision avoidance, vulnerable road user discovery
Manufacturing	Connected goods, intra-inter enterprise communication	Process automation and flow management, remote supervision and control of machines and materials	Remote control of robots, augmented reality support in training, maintenance, construction, repair
Energy and utilities	Smart metering, dynamic and bidirectional grid	Distributed energy resource management, distribution automation	Control of edge-of-grid generation, virtual power plant, real-time load balancing
Healthcare	Remote patient monitoring, connected ambulance, electronic health records	Telesurgery, augmented reality aiding medical treatment	Precision medicine, remote robotic surgery
Network technologies	> Multi-standard network > Cat-M1/NB-IoT > Cloud optimized network functions > VNF orchestration	> Gigabit LTE > Massive MIMO > Network slicing > Dynamic service orchestration > Predictive analytics	> New Radio (NR) > Virtualized RAN > Federated network slicing > Distributed cloud > Real-time machine learning/AI

Thank You

grameenphone