

TELECOM ORIENTATION – TELCO 101



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Radio Network Planning & Optimization Expert

WHY ?

- How to learn wireless communication ; from lectures or from where ?
- All courses for what, EM wave and field theory, signals and system, digital modulations ,data communication, computer networks and so on.
- To be familiar with basic wireless communications terms
- Be aware of big picture and put the pieces together(Hardware(FPGA,DSP,embedded systems),Software(C++,Python,SysyemC,VHDL,Verilog),wireless)
- Be prepared for job interview



AGENDA

- Where is our life ?
 - What is Basestations , and it's types, parts ?
 - Mobile Industry Ecosystem, Operators and 3rd part firms
 - Differentiators of Mobile Cellular Network Standards
 - Fundamentals of Wireless
 - Mobile Cellular Network Standards & Generations
 1G,2G(GSM),3G(UMTS-WCDMA),LTE,NR
 - RNO/RNP JOB DESCRIPTION
-
- What is antenna ?
 - How to convert ?
 - Fundamental Parameters of Types of Antennas
 - Radiation pattern,Return Loss,VSWR,bandwith.....
 - Huawei Antenna Datasheet Review
 - Antenna Tilt
 - HFSS Feco
-
- Fundamental Metrics(Rx Lev,Rx Qual,RSCP,RSRP,SINR,CINR,Ec/No,BER,BLER)
 - OSI vs TCP/IP
 - Shannon Theory
 - Basic Call Flow
 - Huawei TT Golden Set Parameters(Extra)

TELECO 101

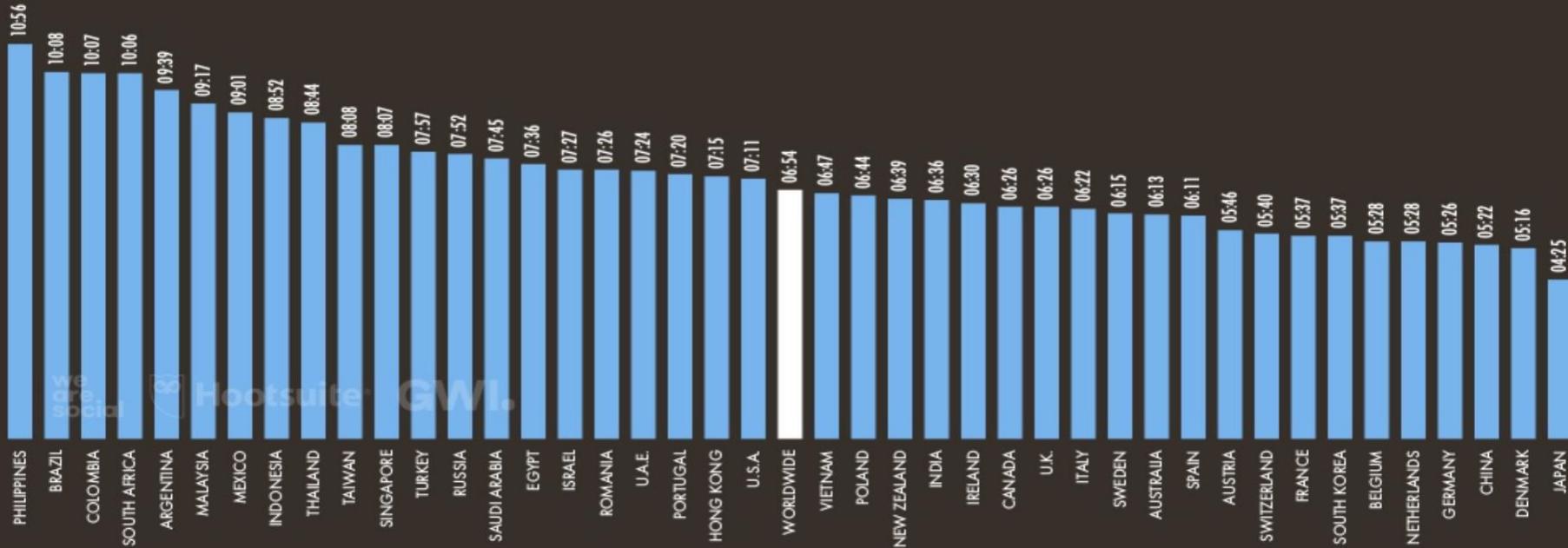
ANTENNAS

SIGNALS&
PARAMETERS

**JAN
2021**

DAILY TIME SPENT USING THE INTERNET

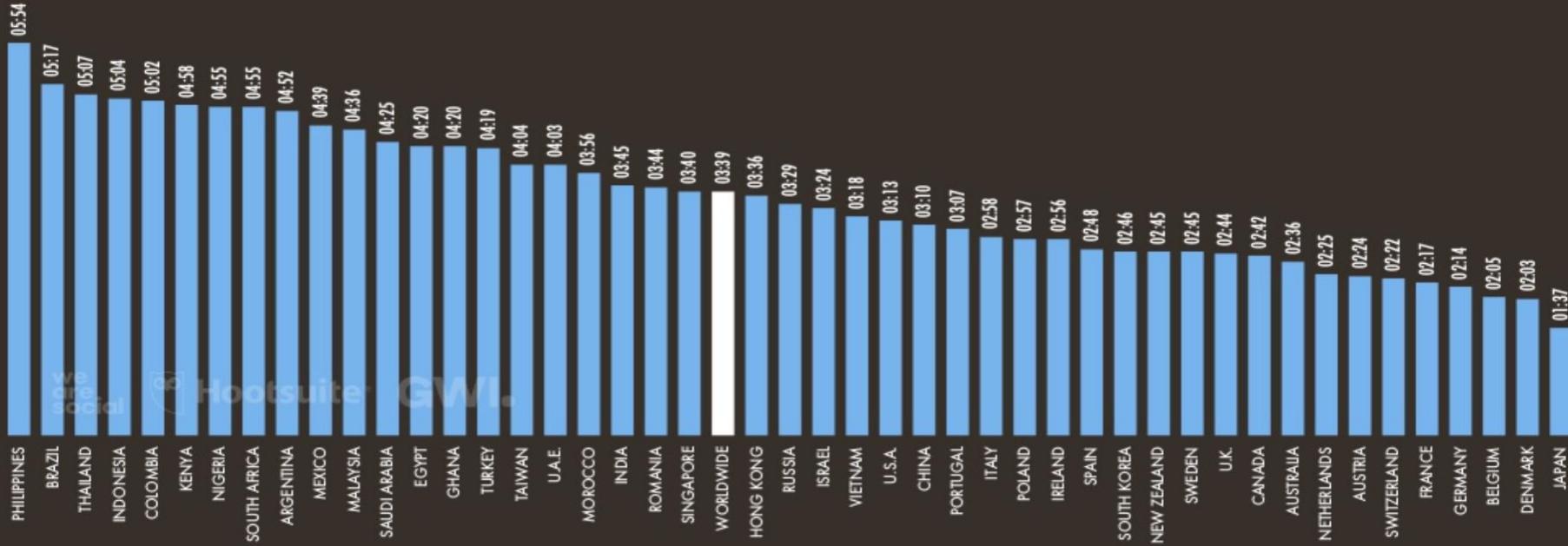
AVERAGE AMOUNT OF TIME (IN HOURS AND MINUTES) THAT INTERNET USERS AGED 16 TO 64 SPEND USING THE INTERNET EACH DAY ON ANY DEVICE



**JAN
2021**

DAILY TIME SPENT USING THE INTERNET VIA MOBILES

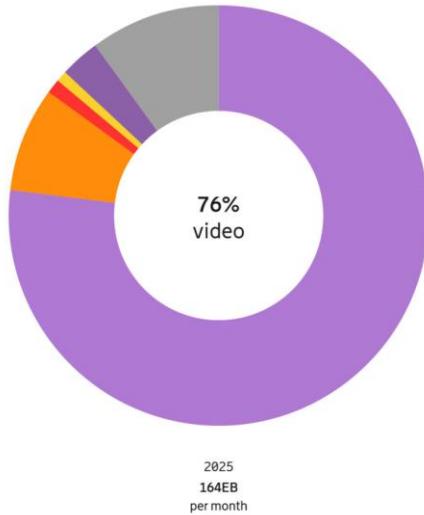
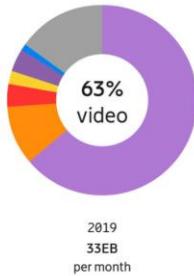
AVERAGE AMOUNT OF TIME PER DAY THAT INTERNET USERS AGED 16 TO 64 SPEND USING THE INTERNET VIA MOBILE PHONES



Market Shares



- Video
- Social networking
- Web browsing
- Audio
- Software download and update
- P2P file sharing
- Other segments

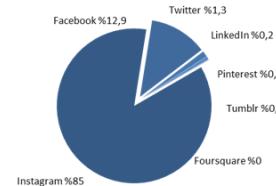


24%



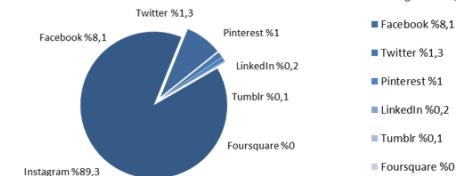
14%

MOBILE NETWORK
Social Media - Feb 2021



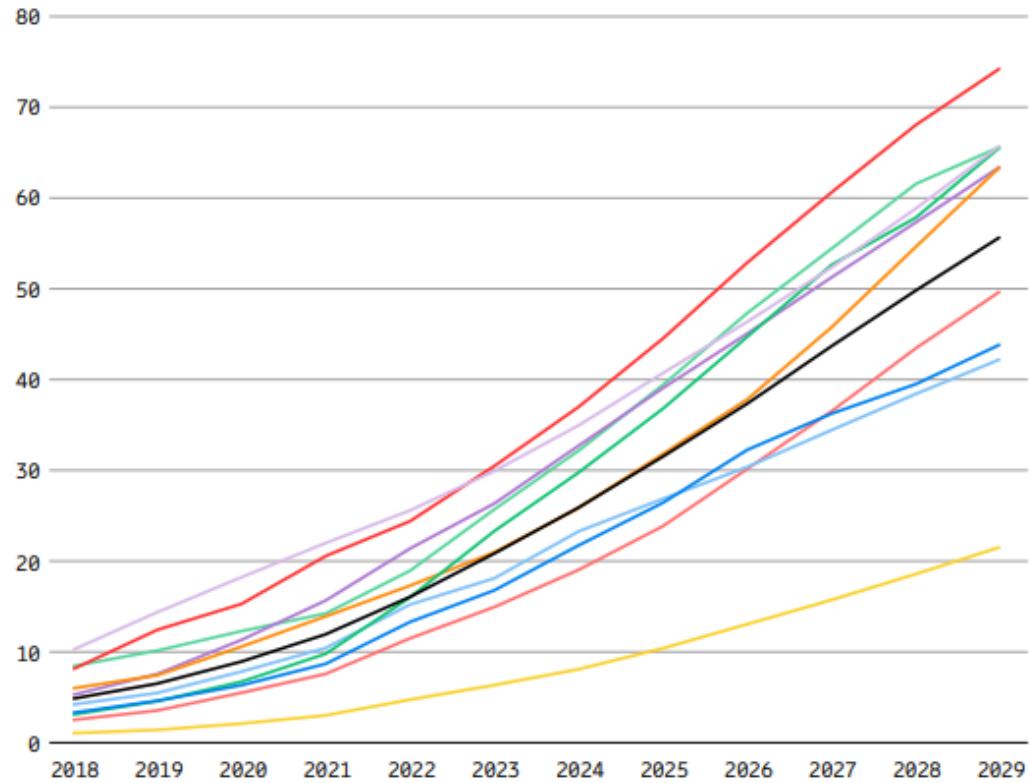
- Instagram %85
- Facebook %12,9
- Twitter %1,3
- Pinterest %0,6
- LinkedIn %0,2
- Tumblr %0,1
- Foursquare %0

FIXED NETWORK
Social Media -Feb 2021



- Instagram %89,3
- Facebook %8,1
- Twitter %1,3
- Pinterest %1
- LinkedIn %0,2
- Tumblr %0,1
- Foursquare %0

Figure 10: Mobile data traffic per smartphone (GB per month)

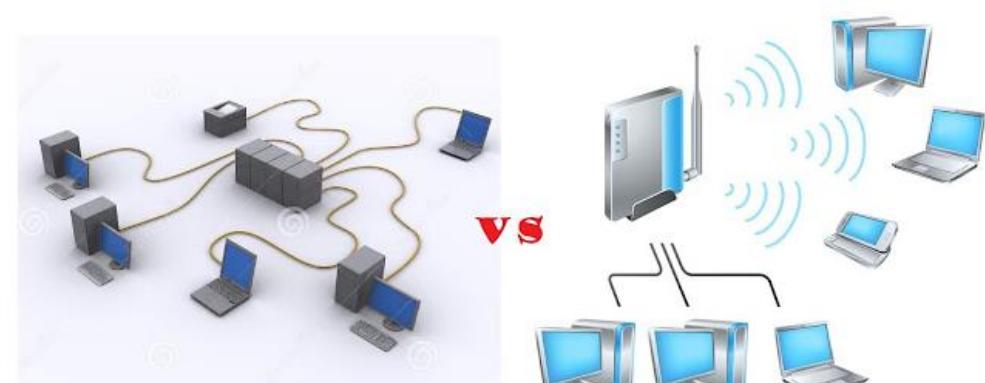


Regions	2023	2029	CAGR 2023–2029
India, Nepal, Bhutan	31	75	16%
GCC	30	66	14%
North America	26	66	17%
South East Asia and Oceania	24	66	19%
Western Europe	27	64	16%
North East Asia	21	64	20%
Global average	21	56	18%
Latin America	15	50	22%
Middle East and North Africa ¹	17	45	17%
Central and Eastern Europe	19	43	15%
Sub-Saharan Africa	6.7	23	22%

Wireless vs Wired Networks



- **Reduced cost:** Because wireless networks eliminate or reduce wiring expenses, they can cost less to operate than wired networks.
- **Convenience:** Access your network resources from any location within your wireless network's coverage area or from any Wi-Fi hotspot.
- **Mobility:** You're not tied to your desk, as you are with a wired connection. You and your employees can go online in conference room meetings, for example.
- **Expandability:** You can easily expand wireless networks with existing equipment, whereas a wired network might require additional wiring.



BaseStation Types



Roof Top



Inbuilding



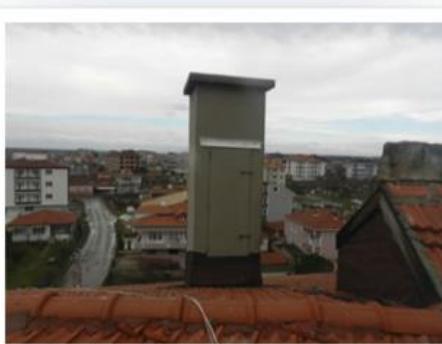
Lattice Tower



Monopole Tower



Tree Tower



Roof Top

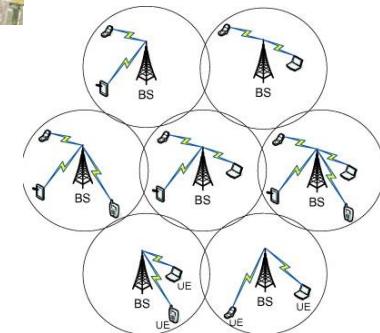
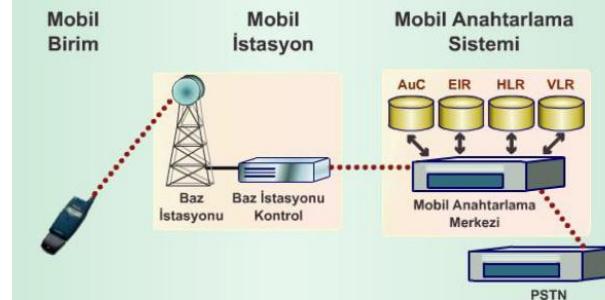


Totem Tower



Cells on Wheels

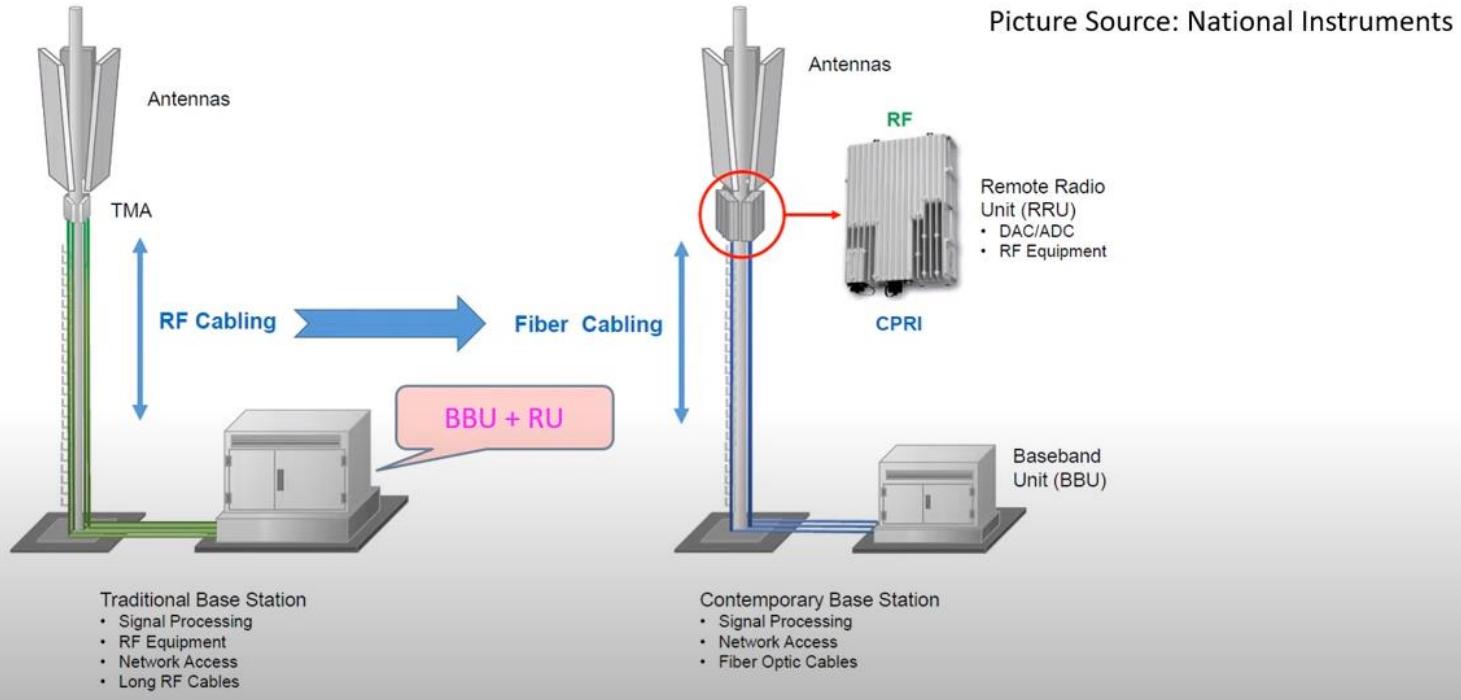
Cellular Network



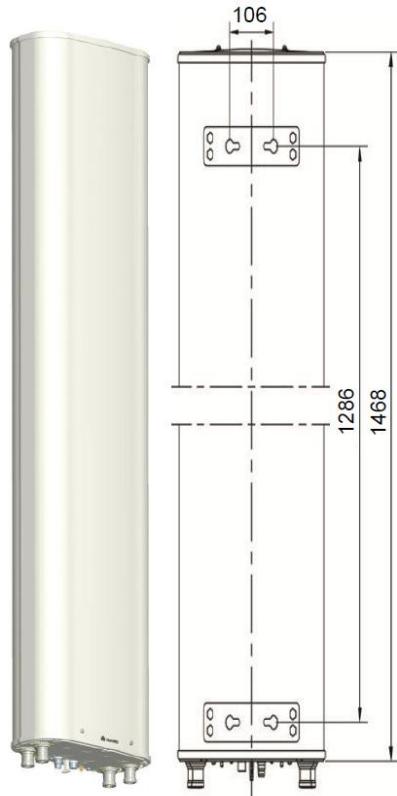
Part of BaseStations



Picture Source: National Instruments



Part of BaseStations

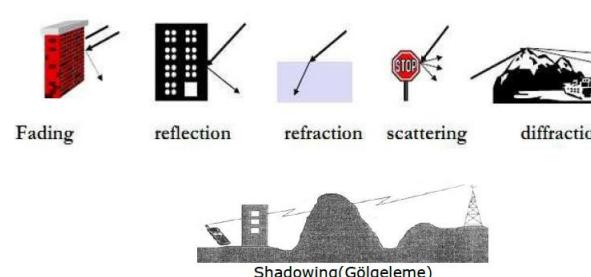
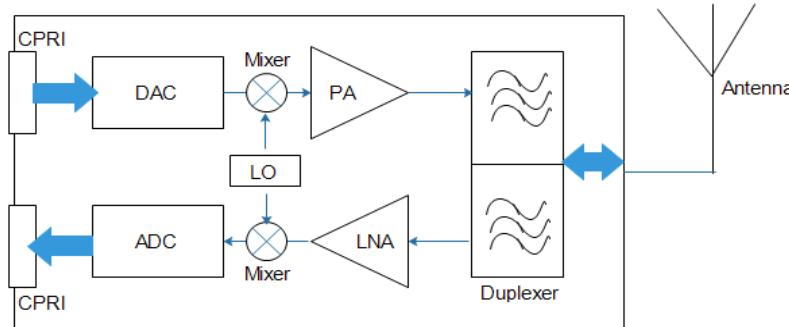


Part of BaseStations



RRU Functions:

- 1) Acts as a transceiver: transmit and receive the user signals to the base station and vice-versa.
- 2) Provides back to back support and connectivity between user equipment's like power, delay,etc.
- 3) Control and process the EM signals received from the Antenna via Jumper.
- 4) Provide interface between two physical link: Optical and EM(Electromagnetic).

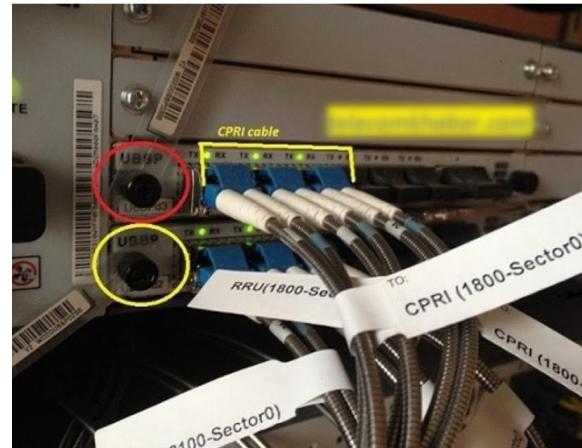
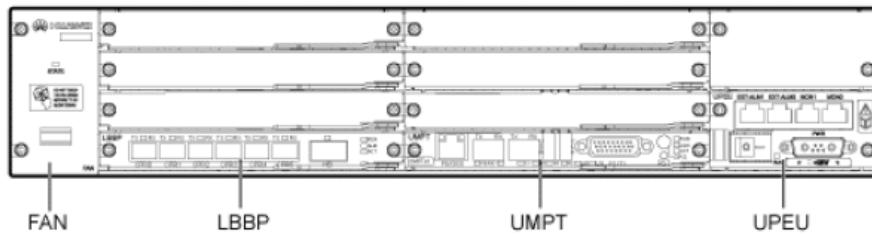


Engel Tipi	Zayıflama
Algı Duvar	3dB
Tuğla Duvar	4dB
Metal Çerçeveli Cam Duvar	6dB
Cam Çerçeve	3dB
Metal Kapı	6dB

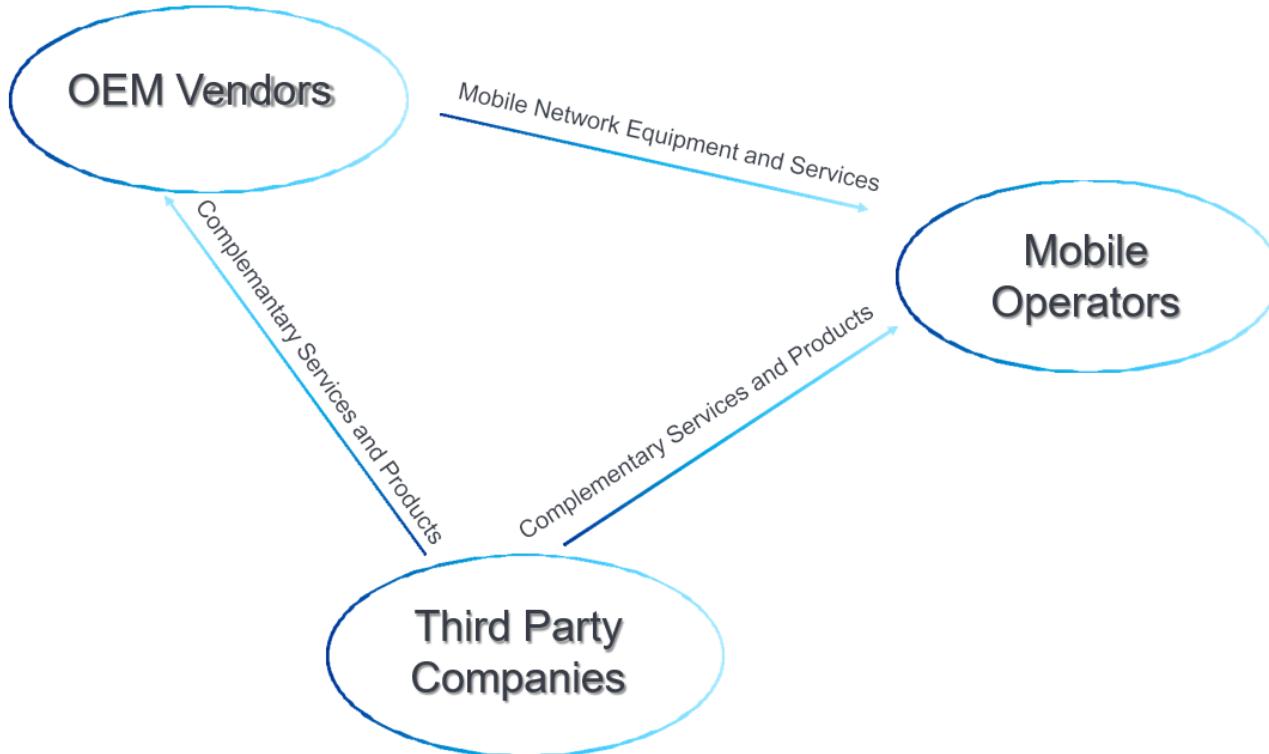
Part of BaseStations



1. Base band unit (BBU) processes the signal of original frequency before it is modulated.
2. Provides clock ports for clock synchronization, alarm monitoring ports for environment monitoring, and a Universal Serial Bus (USB) port for commissioning using a USB flash drive.



Ecosystem



Values 3rd party companies offers to its customers

$$\text{Profit} = \text{Revenue} - \text{Expense}$$



Revenue



Expense

- Increasing Traffic
- Reducing Churn
- Increasing Capacity
- Reducing Opex
- Reducing (Deferring) Capex

Mobile Cellular Network Standards & Generations



Generation Organization Standard

0G radio telephones (1946)	MTS · IMTS · Altai · OLT · MTA - MTB - MTC - MTD · AMTS · Autotel (PALM) · ARP · B-Netz · AMR	
1G (1979)	AMPS family	AMPS · N-AMPS · TACS · ETACS
	Other	NMT · C-450 · Hicap · Mobitex · DataTAC
2G (1991)	GSM/3GPP family	GSM · CSD - HSCSD
	3GPP2 family	cdmaOne (IS-95)
	AMPS family	D-AMPS (IS-54 and IS-136)
	Other	CDPD · iDEN · PDC · PHS
2G transitional (2.5G, 2.75G)	GSM/3GPP family	GPRS · EDGE · EGPRS - Evolved EDGE
	3GPP2 family	CDMA2000 1X (TIA/EIA/IS-2000) · CDMA2000 1X Advanced
	Other	WiDEN · DECT
3G (2001)	3GPP family	UMTS · UTRA-FDD / W-CDMA (FOMA) · UTRA-TDD LCR / TD-SCDMA · UTRA-TDD HCR / TD-CDMA
	3GPP2 family	CDMA2000 1xEV-DO Release 0 (TIA/IS-856)
3G transitional (3.5G, 3.75G, 3.9G)	3GPP family	HSPA (HSDPA · HSUPA) · HSPA+ (DC-HSDPA) · LTE · E-UTRA
	3GPP2 family	CDMA2000 1xEV-DO Revision A (TIA/EIA/IS-856-A) · EV-DO Revision B (TIA/EIA/IS-856-B) · EV-DO Revision C
	IEEE family	Mobile WiMAX (IEEE 802.16e) · Flash-OFDM · iBurst (IEEE 802.20) · WiBro
	ETSI family	HiperMAN
4G (2009) IMT Advanced (2013)	3GPP family	LTE Advanced · E-UTRA · LTE Advanced Pro · 4.5G Pro/pre-5G/4.9G
	IEEE family	WiMAX (IEEE 802.16m) (WiMax 2.1 (LTE-TDD / TD-LTE) · WiBro)
5G (2019) IMT-2020 (under development)	3GPP family	NR · NR-IoT · LTE-M · NB-IoT
	Other	DECT-5G

Evolution of Mobile Phones

1983 – 2020



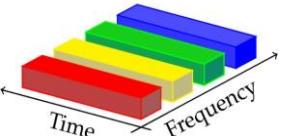
- Multiple access technologies
- Modulation techniques
- Carrier bandwidths
- Switching techniques
- Duplexing methods
- Features

Multiple Access Schemes

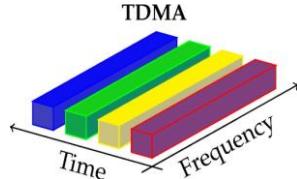


TURKCELL

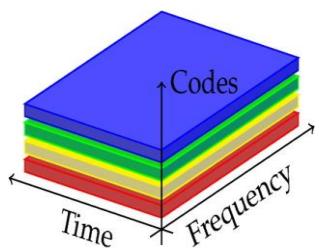
FDMA



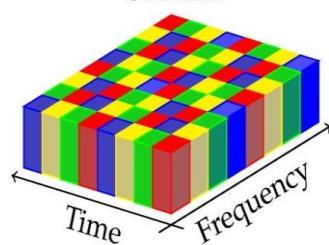
TDMA



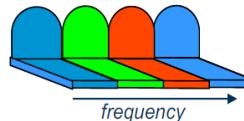
CDMA



OFDMA



Frequency Division Multiple Access

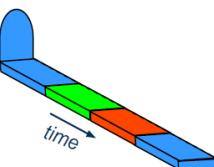


Each User has a unique frequency
(1 voice channel per user)

All users transmit at the same time

AMPS, NMT, TACS

Time Division Multiple Access



Each User has a unique time slot
Each Data Channel has a unique position within the time slot

Several users share the same frequency

IS-136, GSM, PDC

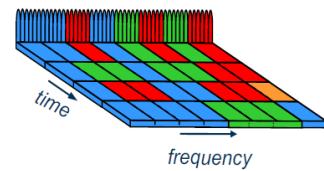
Spread Spectrum Multiple Access



Each Transmitter has a unique Scrambling Code
Each Data Channel has a unique Channelization code

Many users share the same frequency and time
IS-95, cdma2000, WCDMA

Code Division Multiple Access



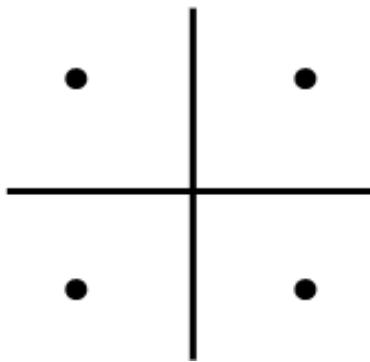
Each User and each channel has a unique Time and Frequency Resource

Many users are separated in frequency and/or time

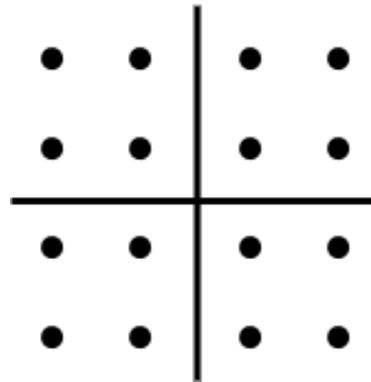
LTE, WiMax
(WLAN 802.11a,g, DAB radio)

Modulation Techniques

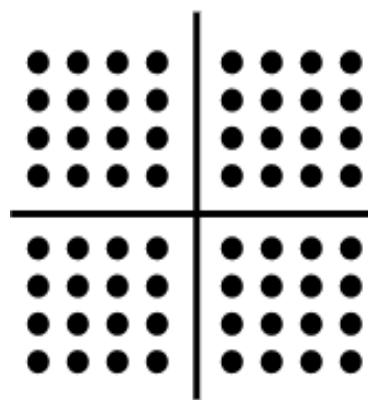
QPSK
2 bits/symbol



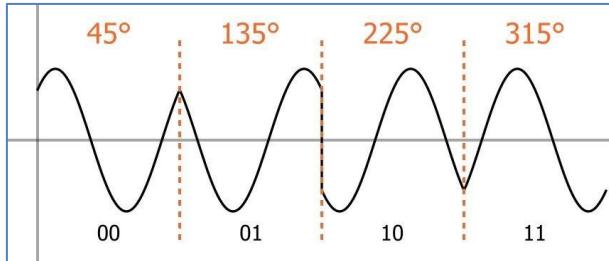
16QAM
4 bits/symbol



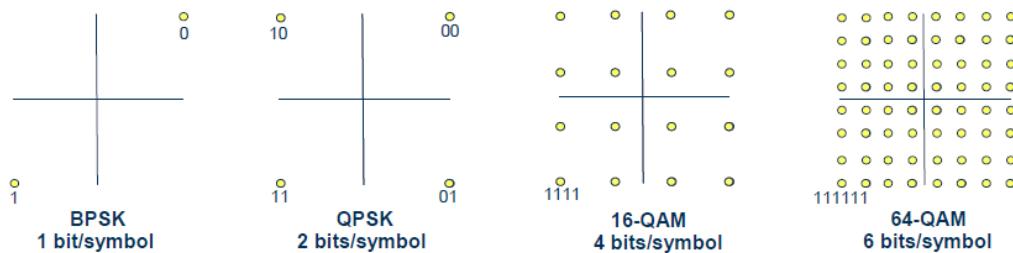
64QAM
6 bits/symbol



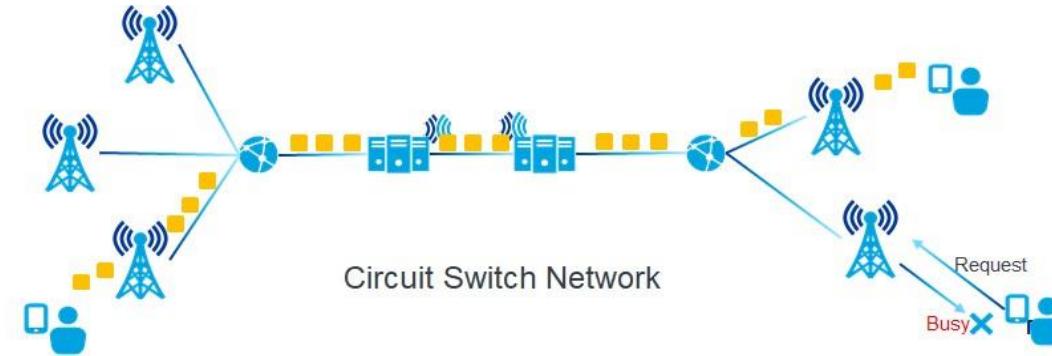
Modulation Techniques



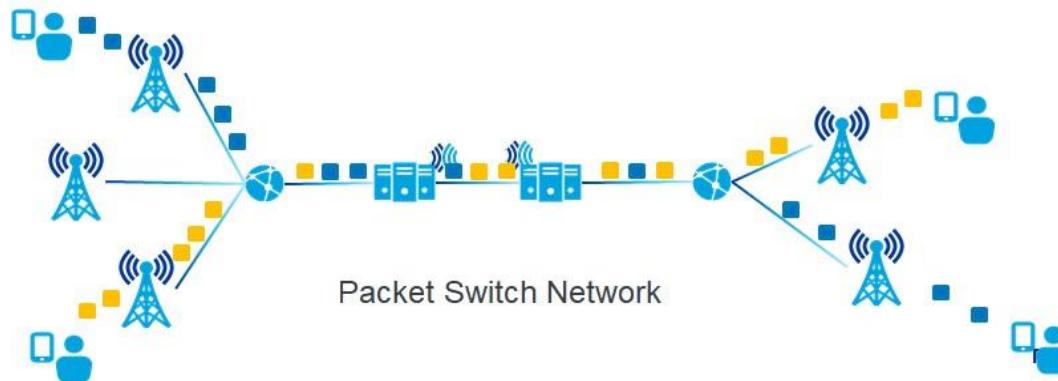
- The sub-carriers are modulated with a certain modulation scheme
 - maps the data bits into a carrier phase and amplitude (symbols)
- E-UTRAN user data channels supports QPSK, 16QAM and 64QAM
- 16QAM allows for twice the peak data rate compared to QPSK
- 64QAM allows for three times the data rate compared to QPSK
- Higher order modulation more sensitive to interference
 - Useful mainly in good radio channel conditions
(high C/I, Little or no dispersion, Low speed)
e.g. Close to cell site & Micro/Indoor cells
- BPSK is used for some signaling (PHICH)



Switching Techniques



Circuit Switch Network



Packet Switch Network

Duplexing Methods

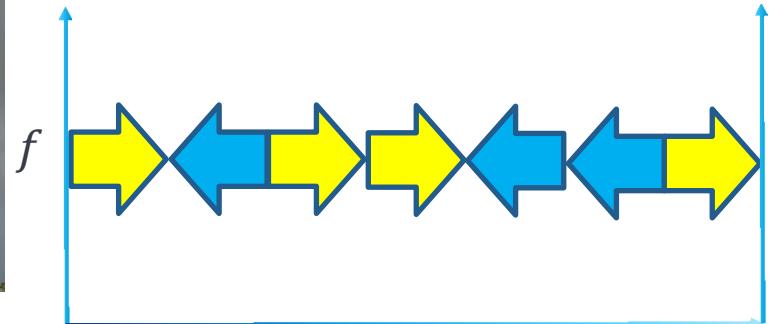
Frequency



FDD (Frequency Division Duplex)

DL

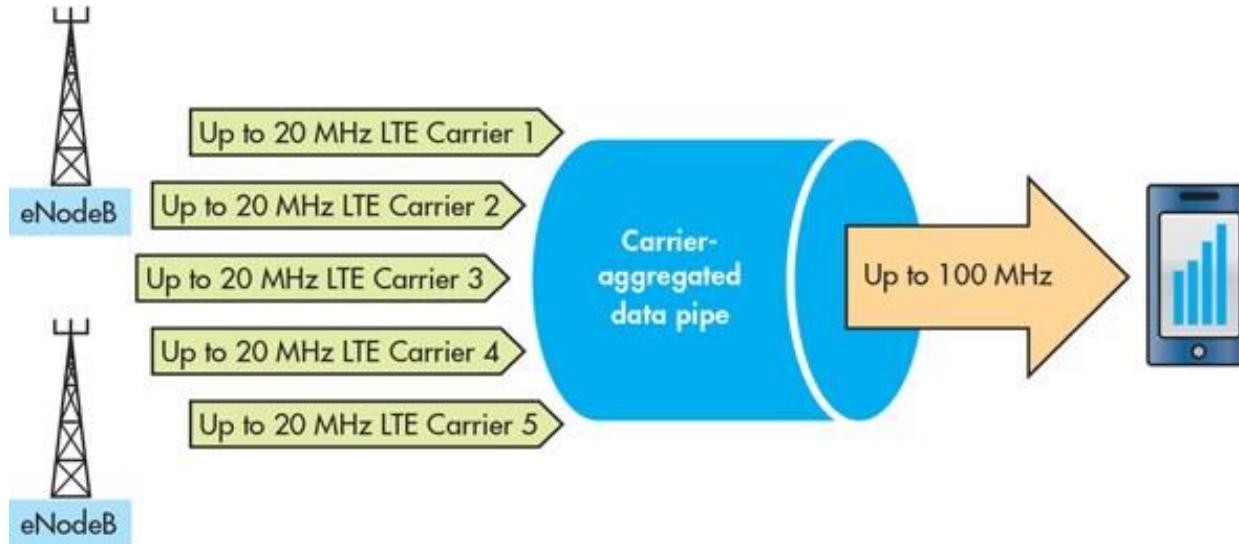
Frequency



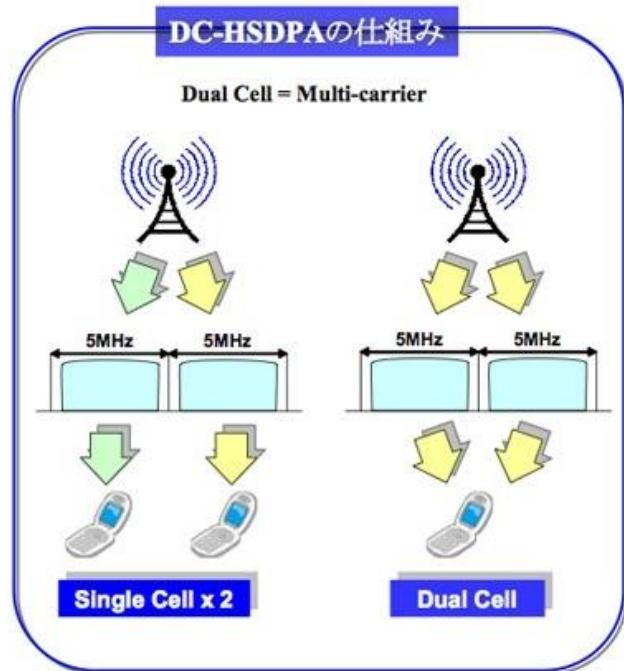
TDD (Time Division Duplex)

UL

Features - Carrier Aggregation (Multi-carrier)



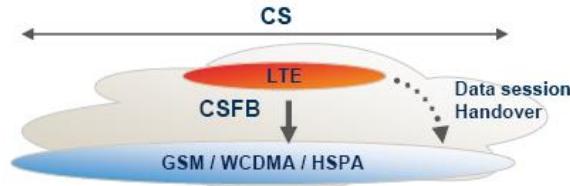
Features – Dual Cell (UMTS)



Features – VoLTE-CSFB-SRVCC



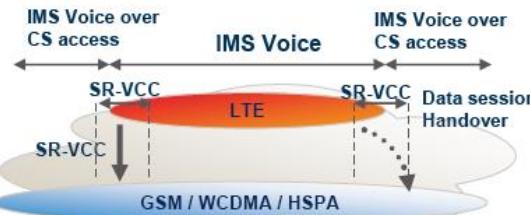
CSFB



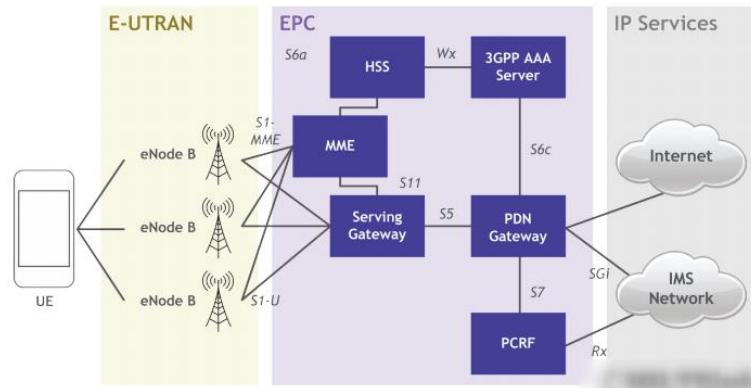
CSFB : Circuit Switch Fall Back

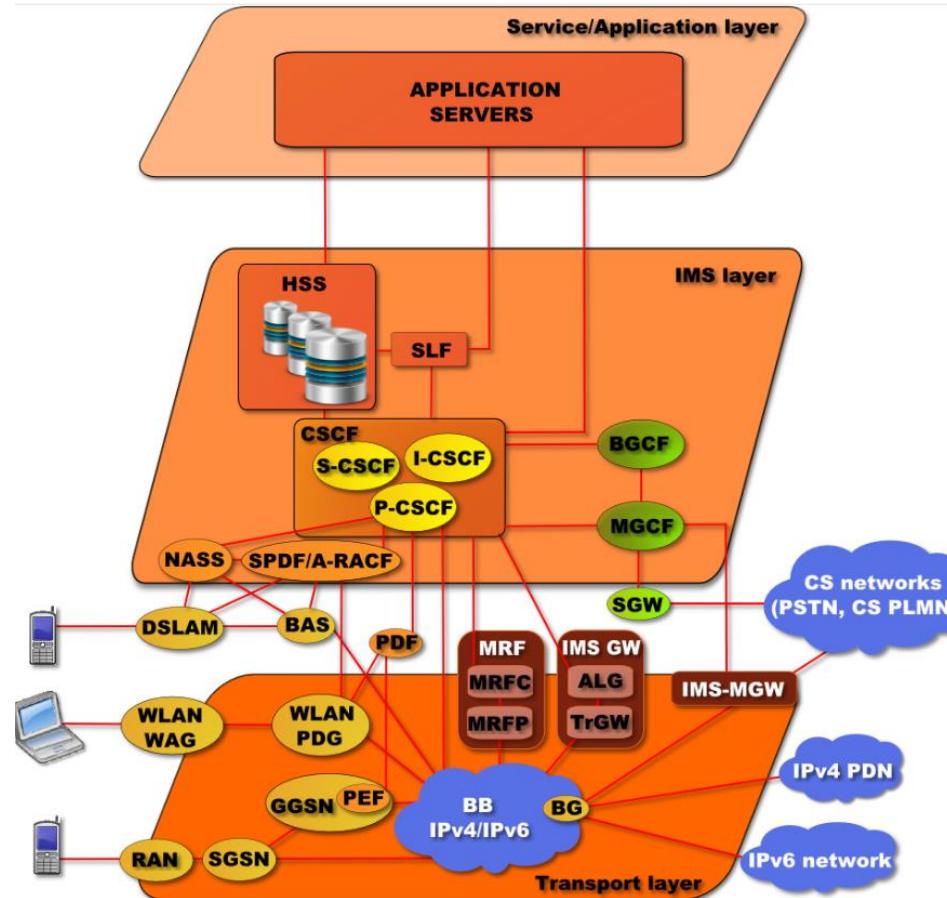
VoLTE : Voice Over LTE

SRVCC : Single Radio Voice Call Continuity



IMS Voice





VoLTE Building blocks

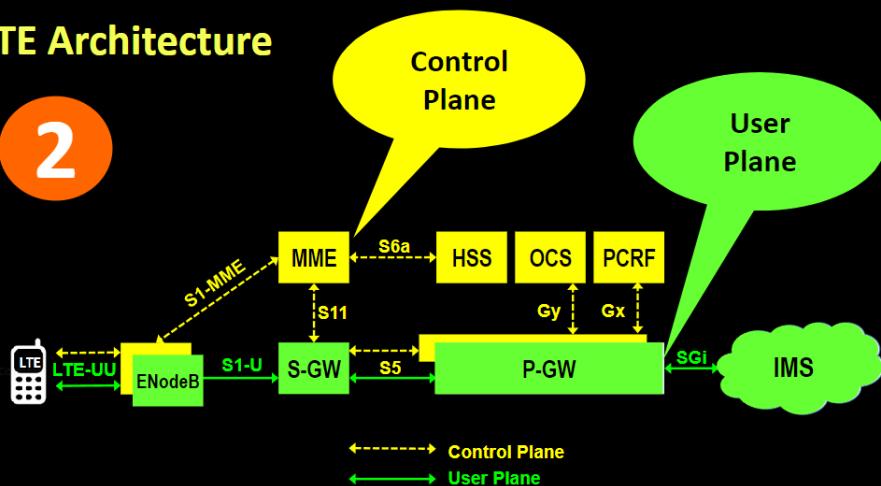


Universal Integrated Circuit (UICC)
✓ IMPI
✓ IMPU

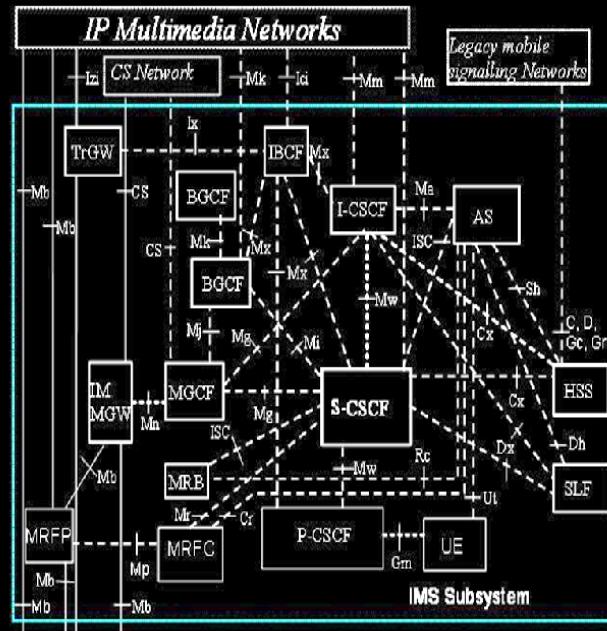


LTE Architecture

2



IMS VoLTE Architecture & Specs



3



IMS SPECS

3GPP 23.228

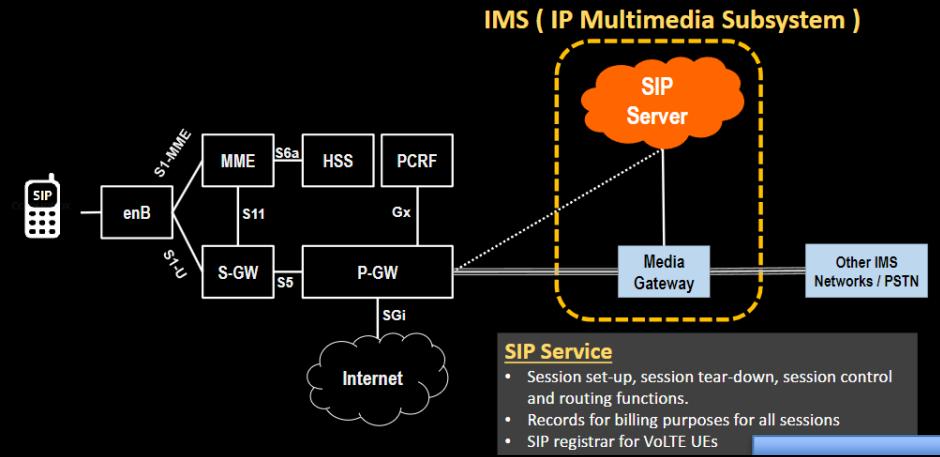


- GSMA FCM.01
- GSMA IR.92

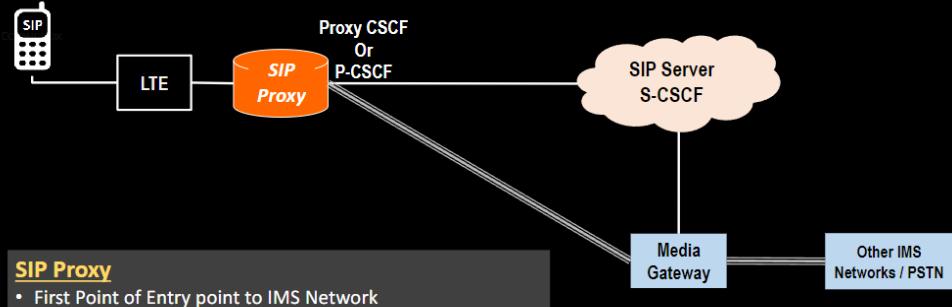
Here is IMS ..



SIP Server



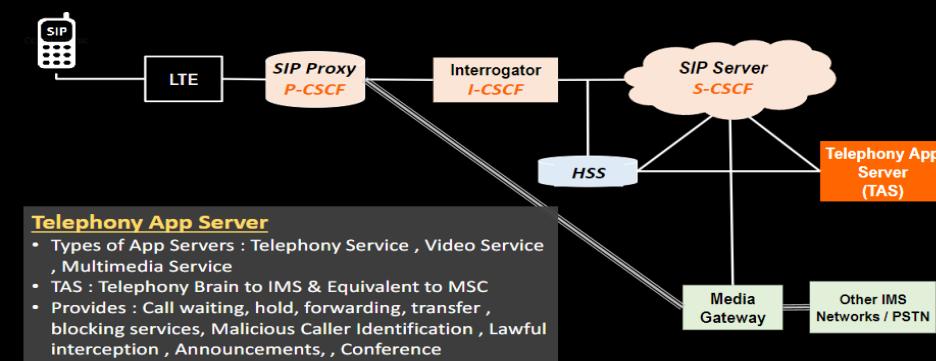
The Proxy



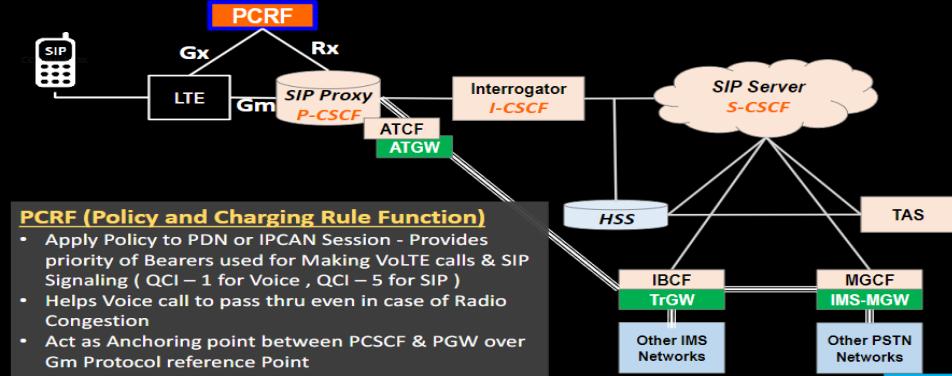
SIP Proxy

- First Point of Entry point to IMS Network
- Typically Belongs to VPLMN
- Function : Integrity of SIP Messages , Ensures the security , Authenticates & identity of the UE
- Find out Home SIP Server & Routes Traffic to same

The Telephony App Server (TAS)



PCRF (Policy and Charging Rule Function)



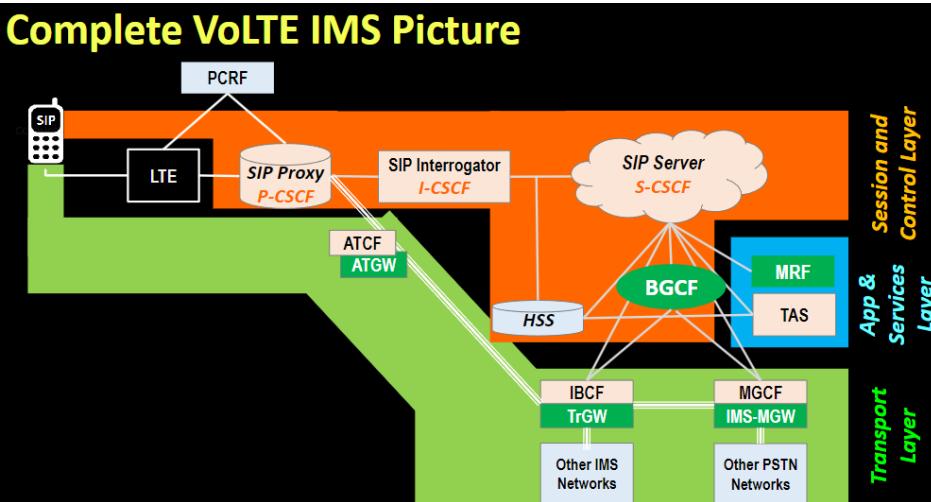
PCRF (Policy and Charging Rule Function)

- Apply Policy to PDN or IPCAN Session - Provides priority of Bearers used for Making VoLTE calls & SIP Signaling (QCI – 1 for Voice , QCI – 5 for SIP)
- Helps Voice call to pass thru even in case of Radio Congestion
- Act as Anchoring point between PCSCF & PGW over Gm Protocol reference Point

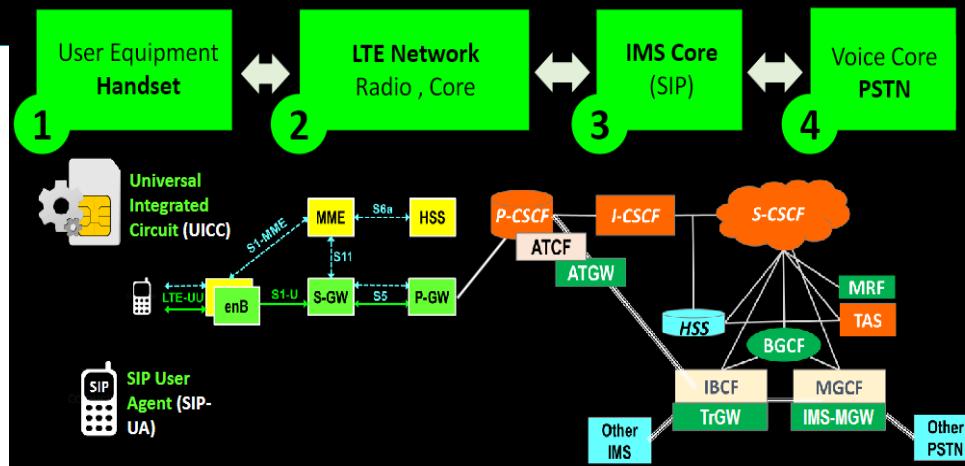
Here is IMS ..



Complete VoLTE IMS Picture



The Big Picture ..



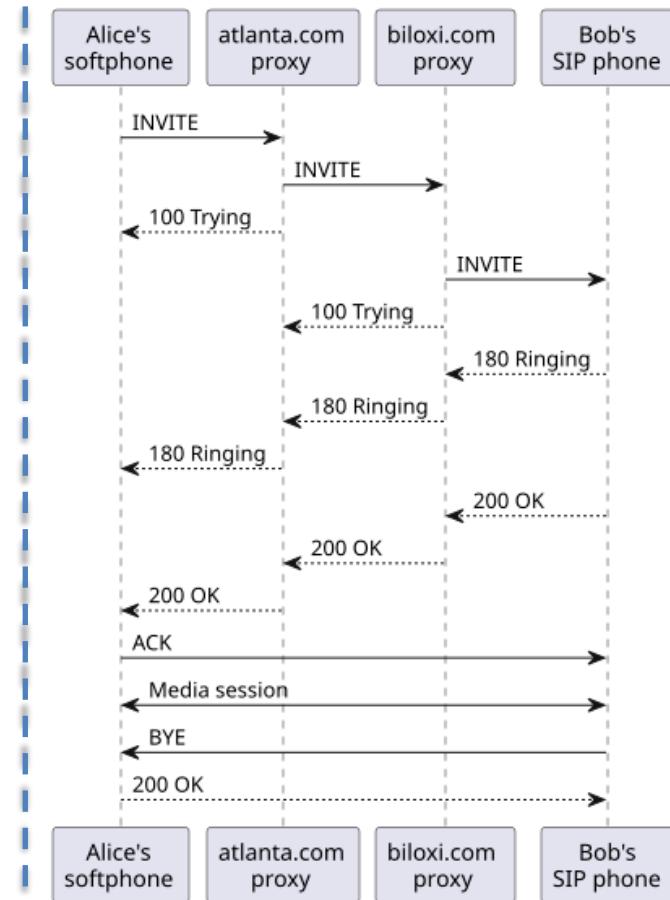
VoLTE – SIP -IMS



Session Initiation Protocol

Communication protocol	
Abbreviation	SIP
Purpose	Internet telephony
Introduction	March 1999; 25 years ago
OSI layer	Application layer (Layer 7)
Port(s)	5060, 5061
RFC(s)	2543, 3261

No.	Source	Destination	Protocol	Length	Info
5	10.133.2	10.133.202.47	SIP	974	Request: REGISTER sip:test.3gpp.com
6	10.133.2	10.133.202.46	SIP	817	Status: 200 OK (1 bindings)
7	10.133.2	10.133.202.47	SIP	713	Request: SUBSCRIBE sip:+11234567890@test.3gpp.com
8	10.133.2	10.133.202.46	SIP	431	Status: 200 OK
9	10.133.2	10.133.202.46	SIP/XML	858	Request: NOTIFY sip:+11234567890@test.3gpp.com
10	10.133.2	10.133.202.47	SIP	480	Status: 200 OK
21	10.133.2	10.133.202.47	SIP/SDP	72	Request: INVITE sip:0123456789@test.3gpp.com;user=pho
22	10.133.2	10.133.202.46	SIP	337	Status: 100 Trying
23	10.133.2	10.133.202.46	SIP	557	Status: 180 Ringing
24	10.133.2	10.133.202.47	SIP	715	Request: PRACK sip:0123456789@10.133.202.47:63903;tra
25	10.133.2	10.133.202.46	SIP	529	Status: 200 OK
26	10.133.2	10.133.202.46	SIP/SDP	1090	Status: 200 OK , with session description
27	10.133.2	10.133.202.47	SIP	577	Request: ACK sip:0123456789@10.133.202.47:63903;trans
					<<< Voice Traffic (RTP) >>>
2478	10.133.2	10.133.202.47	SIP	785	Request: BYE sip:0123456789@10.133.202.47:63903;trans
2481	10.133.2	10.133.202.46	SIP	473	Status: 200 OK



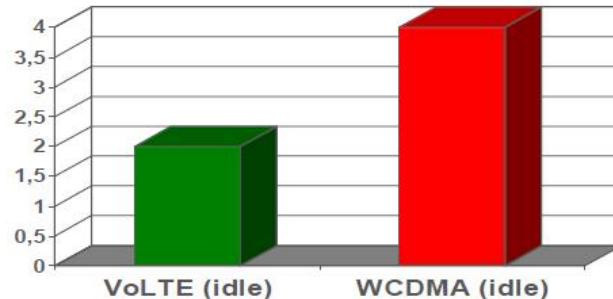
Features – VoLTE-CSFB-SRVCC



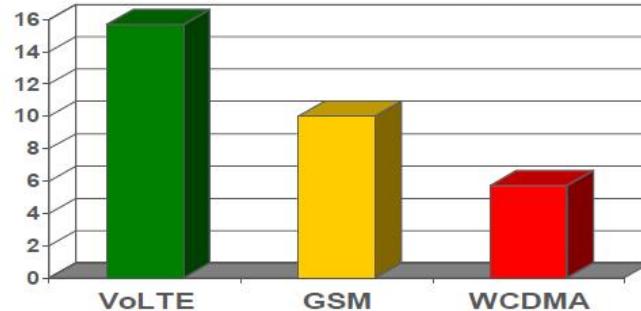
Efficient Radio Resource Usage



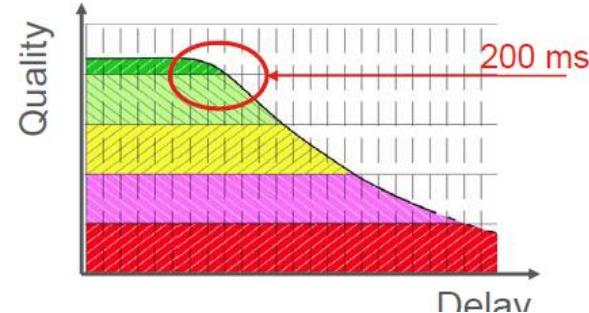
Fast Call Set-up (UE-to-UE [s])



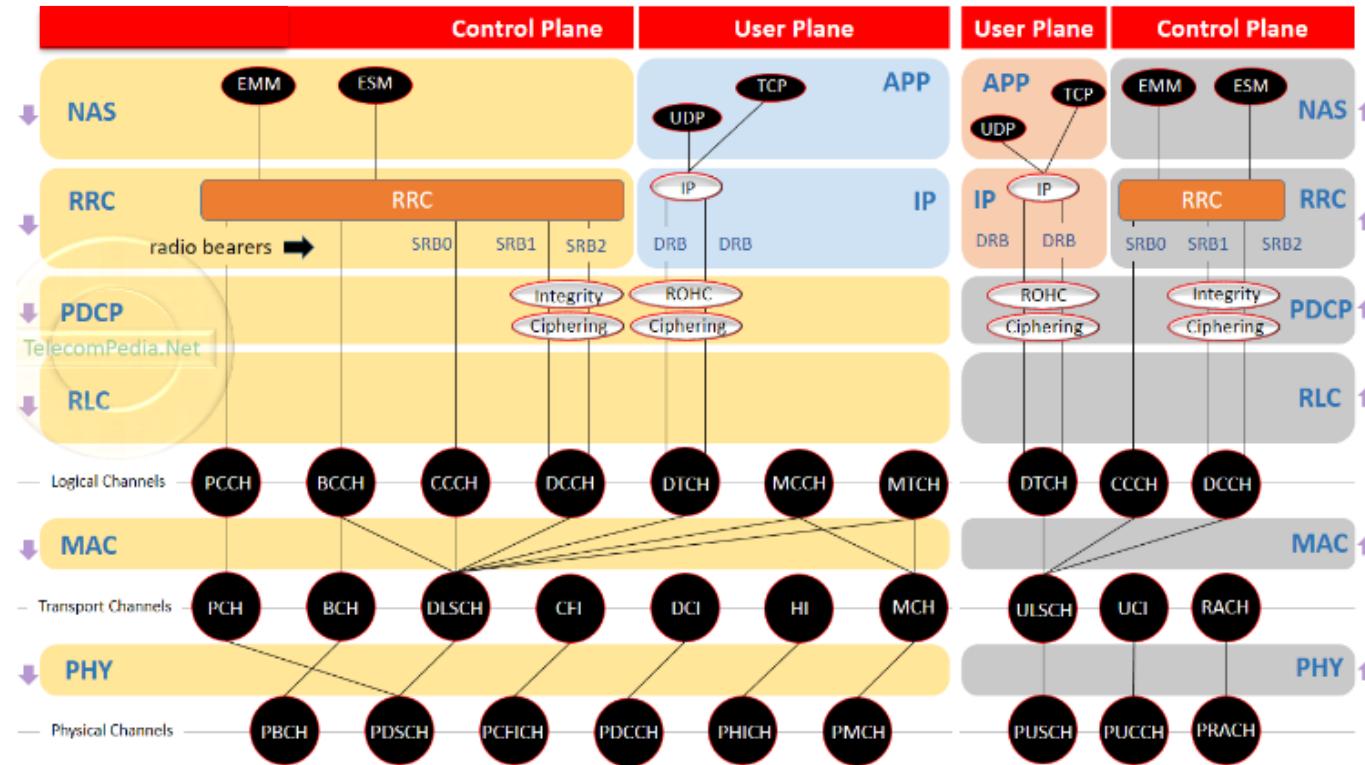
Great Talk Time [h]



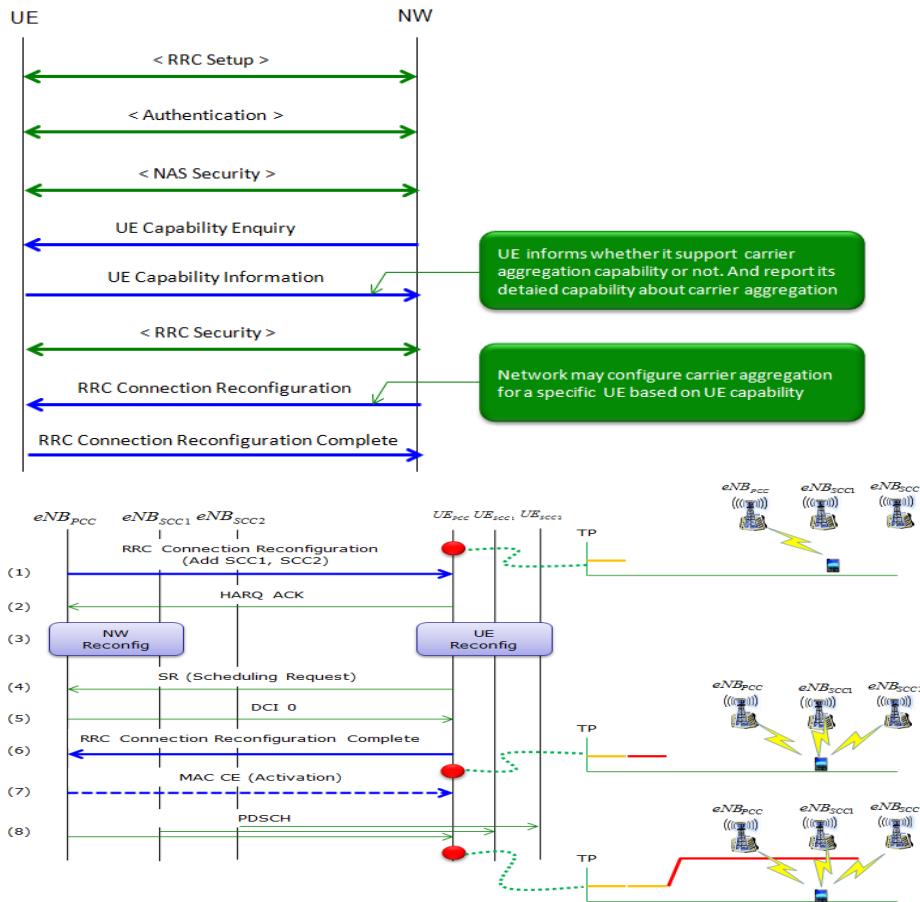
Quality on par or better than CS



RRC – Protocol Stack



RRC – Protocol Stack



```

RRCConnectionReconfiguration-v1020-IEs ::= SEQUENCE {
    scellToReleaseList-r10           SCellToReleaseList-r10          OPTIONAL, -- Need ON
    scellToAddModList-r10           SCellToAddModList-r10          OPTIONAL, -- Need OP
    nonCriticalExtension           SEQUENCE {}                         OPTIONAL, -- Need OP
}

SCellToAddModList-r10 ::= SEQUENCE (SIZE (1..maxScell-r10)) OF SCellToAddMod-r10
SCellToAddMod-r10 ::= SEQUENCE {
    sCellIndex-r10                SCellIndex-r10          OPTIONAL, -- Cond SCellAdd
    cellIdentification-r10         SEQUENCE {
        physCellId-r10           PhysCellId,
        dl-CarrierFreq-r10       ARFCN-ValueEUTRA
    }
    radioResourceConfigCommonScell-r10 RadioResourceConfigCommonScell-r10 OPTIONAL, -- Cond SCellAdd
    radioResourceConfigDedicatedScell-r10 RadioResourceConfigDedicatedScell-r10 OPTIONAL, -- Cond SCellAdd2
    ...
}

PhysicalConfigDedicatedScell-r10 ::= SEQUENCE {
    -- DL configuration as well as configuration applicable for DL and UL
    nonUL-Configuration-r10        SEQUENCE {
        antennaInfo-r10          AntennaInfoDedicated-r10 OPTIONAL, -- Need ON
        crossCarrierSchedulingConfig-r10 CrossCarrierSchedulingConfig-r10 OPTIONAL, --
    }
    Need ON
        cs1-RS-Config-r10          CSI-RS-Config-r10          OPTIONAL, -- Need ON
        pdsch-ConfigDedicated-r10  PDSCH-ConfigDedicated-r10 OPTIONAL, -- Need ON
        ...
    } -- UL configuration
    ul-Configuration-r10          SEQUENCE {
        antennaInfoUL-r10         AntennaInfoUL-r10          OPTIONAL, -- Need ON
        pushch-ConfigDedicatedScell-r10 Pushch-ConfigDedicatedScell-r10 OPTIONAL, --
    }
    Need ON
        uplinkPowerControlDedicatedScell-r10 UplinkPowerControlDedicatedScell-r10 OPTIONAL, --
    Need ON
        cqi-ReportConfigScell-r10   CQI-ReportConfigScell-r10 OPTIONAL, -- Need ON
        soundingRS-UL-ConfigDedicated-r10 SoundingRS-UL-ConfigDedicated-r10 OPTIONAL, -- Need ON
        ON
            soundingRS-UL-ConfigDedicated-v1020 SoundingRS-UL-ConfigDedicated-v1020 OPTIONAL, -- Need ON
            soundingRS-UL-ConfigDedicatedAperiodic-r10 SoundingRS-UL-ConfigDedicatedAperiodic-r10 OPTIONAL, -- Need ON
            soundingRS-UL-ConfigDedicatedAperiodic-r10 SoundingRS-UL-ConfigDedicatedAperiodic-r10 OPTIONAL, -- Cond COMMONUL
    }
}

AntennaInfoDedicated-r10 ::= SEQUENCE {
    transmissionMode-r10          ENUMERATED {
        tml, tm2, tm3, tm4, tm5, tm6, tm7, tm8-v920,
        tm9-v1020, spare7, spare6, spare5, spare4,
        spare3, spare2, spare1},
    codebookSubsetRestriction-r10  BIT STRING
    ue-TransmitAntennaSelection CHOICE {
        release,
        setup,
        NULL,
        ENUMERATED {closedLoop, openLoop}
    }
}

```

Features - SON (Self Organizing Network) - 1

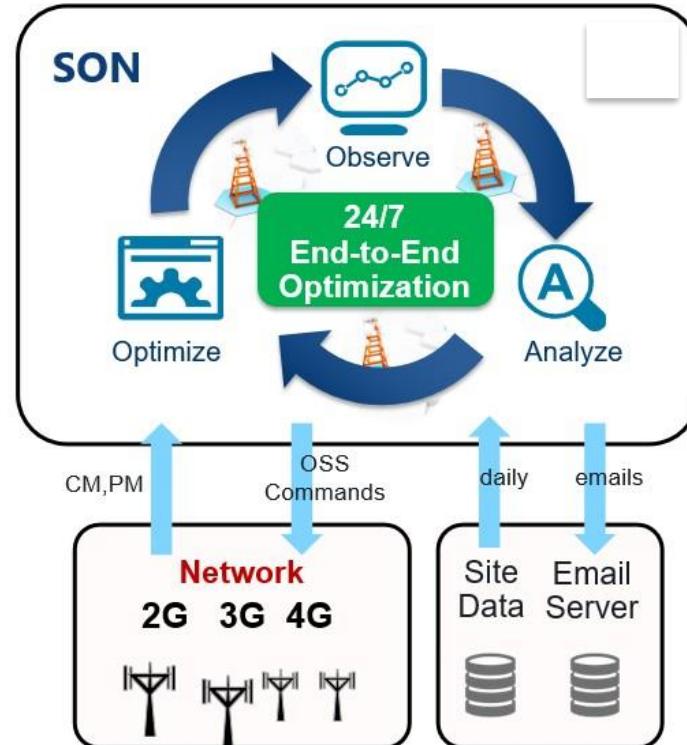


SON Use Cases

Self-Configuration

Self-Optimization

Self-Healing



Benefits

Stable Service Quality

Defect-Free Network

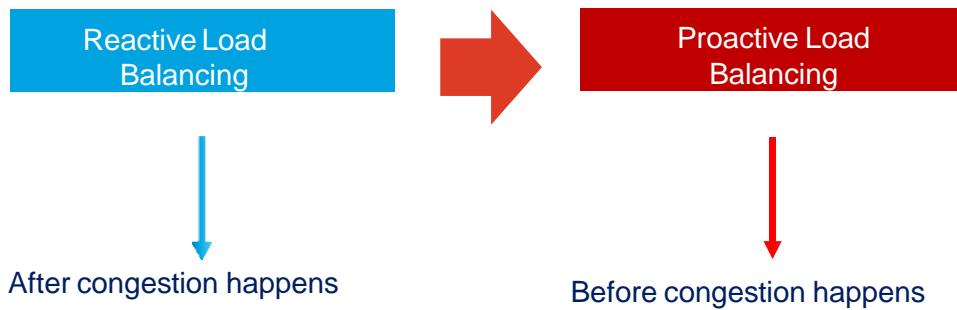
Infrastructure Efficiency

Operational Scalability

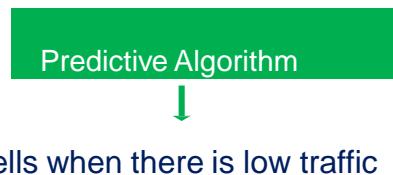
Features - SON (Self Organizing Network) - 2



- Traffic Load Balancing



- Energy Saving



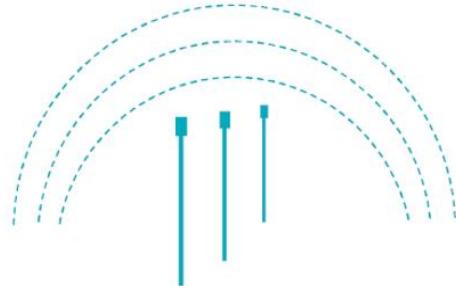
Why Evolution?



- The need for more **capacity** due to increasing number of mobile devices
- The need for more **bandwidth** due to more diverse data services and applications (faster internet, AR/VR...)
- The need for more **efficient usage of network resources (bandwidth, hardware resources, power)**
due to increasing cost of deployment
- The need for lower **latency** due to delay intolerant services and applications (online gaming, autonomous cars..)



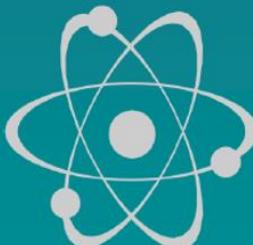
Coverage



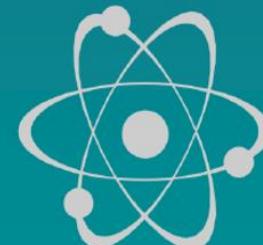
Spectrum



Capacity



**Wireless fundamentals are
the foundation to mobile**



Coverage is delivering a reliable signal to your mobile device despite harsh wireless environments, while on-the-go



Key Fundamentals

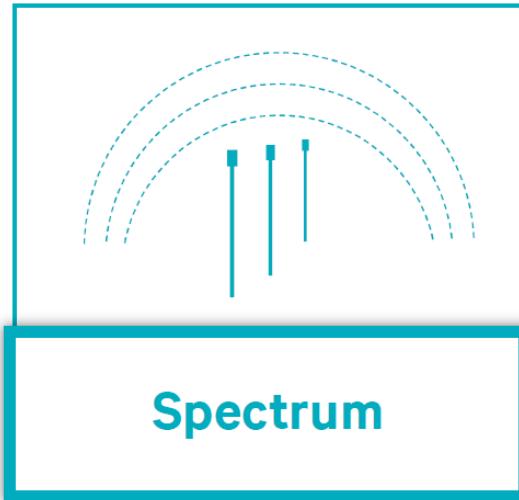
- Radio Signal
- Modulation
- Signal-to-Noise Ratio
- Range
- Mobile Cell
- Mobile Network
- Seamless Handoff
- Mobility

Analogy



Radio signals are like a ripple in the water

Mobile must deliver fast data rates despite finite spectrum, the lifeblood of mobile connectivity



Key Fundamentals

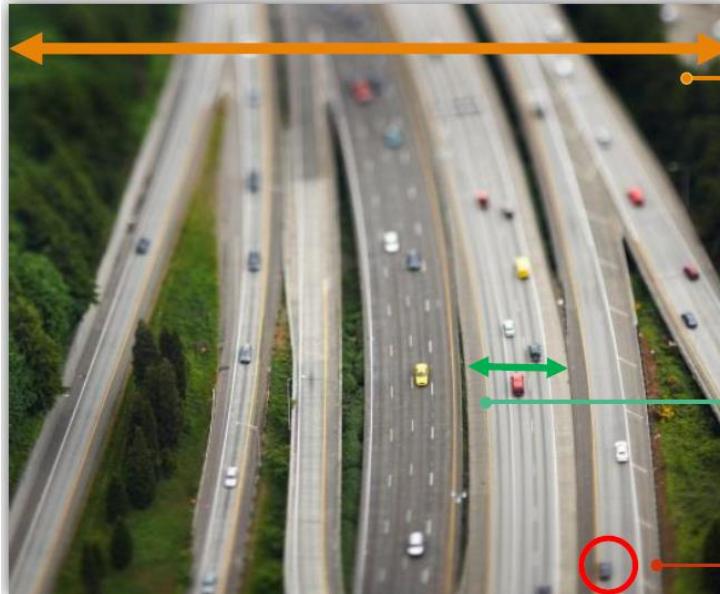
-
- Radio Frequency Spectrum
 - Radio Channel
 - Peak Data Rate
 - Licensed Spectrum
 - Unlicensed Spectrum
 - Time Division Duplex (TDD)
 - Frequency Division Duplex (FDD)

Analogy



Radio channels are like highways built on finite land

Spectrum is like land – a finite resource;
Radio channels are like highways built on this land



Radio Frequency Spectrum (land):

Frequency range for different types of wireless communication



Radio Channel (highway):

Spectrum for specific communication link



105.3 FM Radio Channel

Data (vehicles):

Bits of information carried on Radio channel

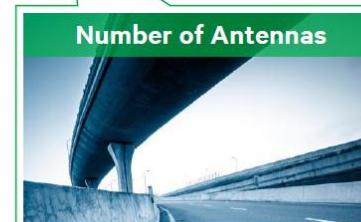
A radio channel has a peak data rate

$$\text{Peak Data Rate} \approx W \cdot n \cdot M - \text{overhead}^*$$

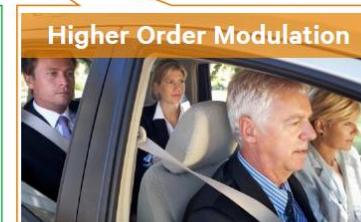
Theoretical max data rate in ideal conditions measured in bits per second (bps)



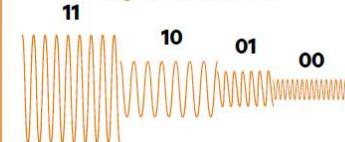
The width of the radio channel (highway) built on spectrum (land)

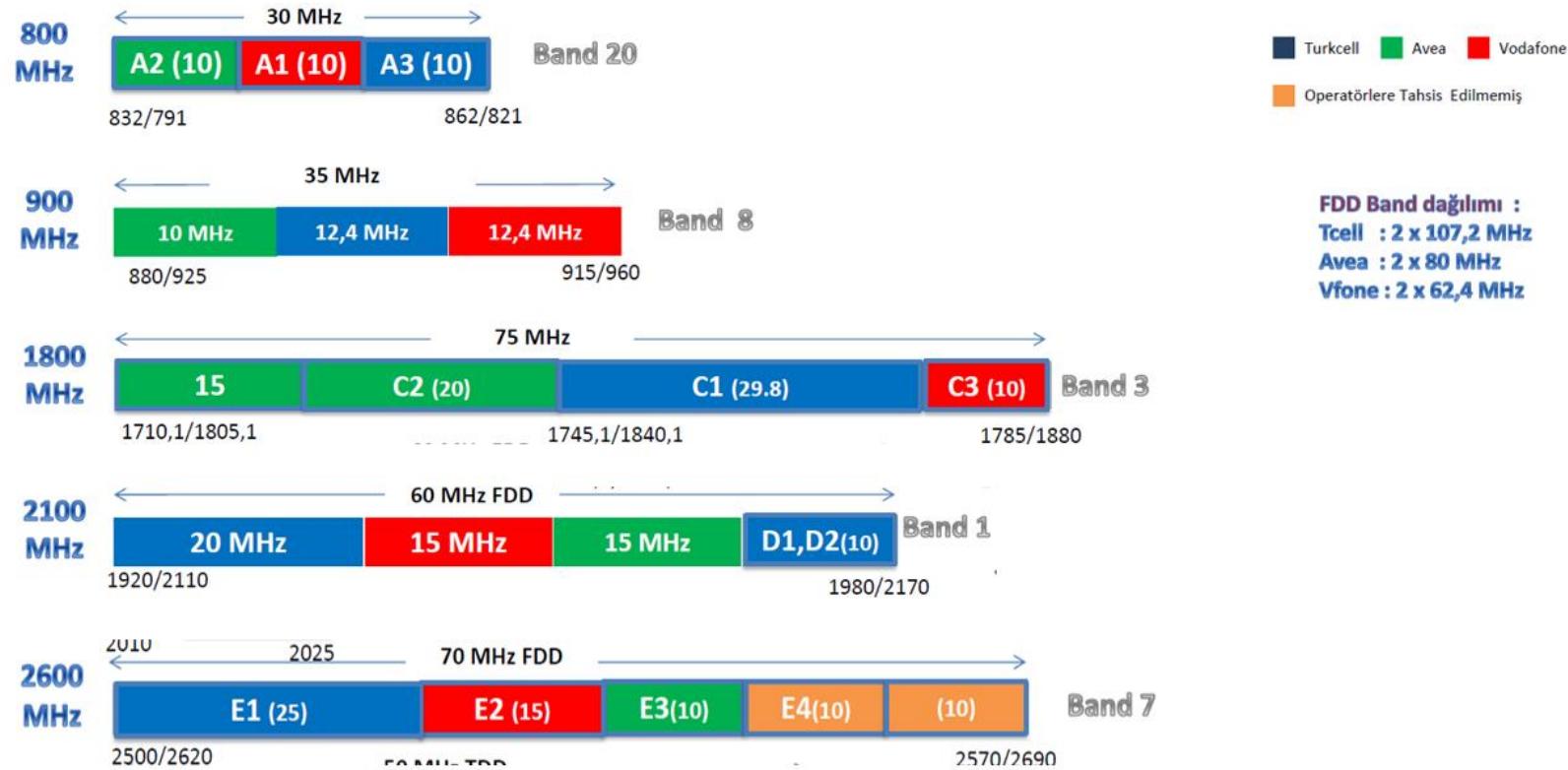


The number of spatially separated paths (highway overpasses)



The number of bits (passengers) transmitted per signal (vehicle)





Mobile must deliver fast data rates despite finite spectrum, the lifeblood of mobile connectivity



Capacity

Key Fundamentals

- Capacity
- Multiple Access
- Shannon's Law
- Spectrum Aggregation
- 1000x Mobile Data Challenge
- Small Cells

Analogy

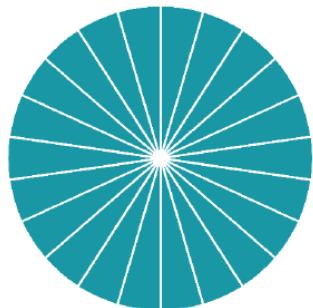


Radio channel has a finite capacity like a pipe

A radio channel has a finite capacity

Capacity

Theoretical max amount of data traffic that can be reliably transmitted over a noisy radio channel at a given time



Shared amongst multiple users

$$\approx W \cdot n \cdot \log_2(1 + SNR)$$

More Spectrum



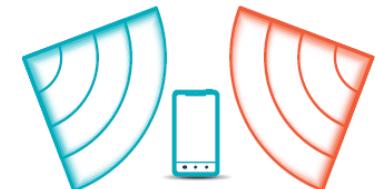
Increasing the size of the radio channel (bandwidth)

Number of Antennas



Adding antennas to create spatially separated paths

Mitigate Interference



Improving the quality of the radio signal (SNR)

1G (First Generation) Standards



- Services : **Voice only**
- **Analog voice**
- Modulation Type : **FM** (Frequency Modulation) and **PM** (Phase Modulation)
- Multiple Access Technology : **FDMA** (Frequency Division Multiple Access)
- Carrier Bandwidth : **10 to 30 khz**
- **FDD** (Frequency Division Duplex)
- Standards : AMPS, N-AMPS, TACS, ETACS, C450, NMT, Mobitex, DataTAC

2G (Second Generation) 3GPP Standards



GSM (2G)

(Global System for Mobile Communication)

- TDMA
- Time Slot
- FDD
- GMSK
- 200 kHz BW
- **CS**

GPRS (2.5G)

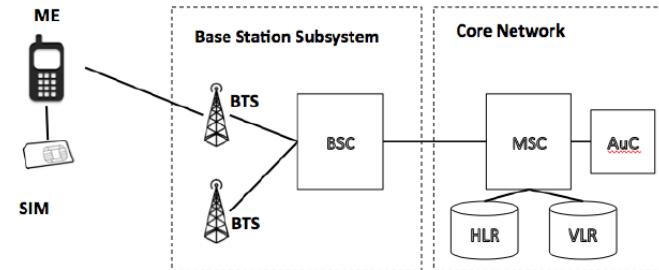
(Global Packet Radio Services)

- **PS**

EDGE (2.75G)

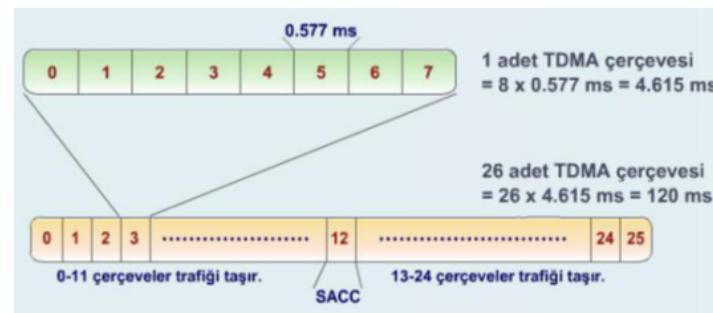
(Enhanced Data rates for GSM Evolution)

- **8-PSK (DL)**



- Services : CS Voice, SMS
- **Digital voice**

- Data rate up to **160 kbps DL**



- Data rate up to **474 kbps DL**

3G (Third Generation) 3GPP Standards



UMTS (3G)

(Universal Mobile Telecommunication System)

- WCDMA
- Channelization Code
- QPSK (DL), BPSK (UL)
- 5 MHz BW
- **CS/PS**
- **FDD/TDD**

HSPA (3.5G)

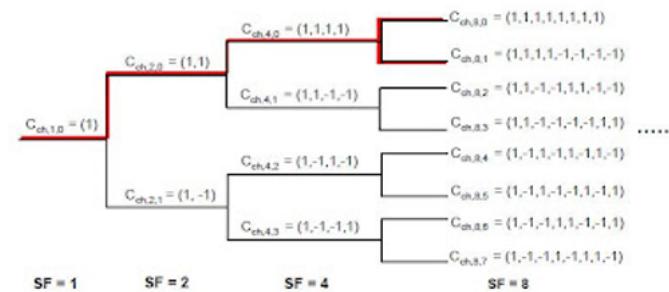
(High Speed Packet Access)

- **PS**
- **FDD**
- **16-QAM (DL)**

HSPA+ (3.75G)

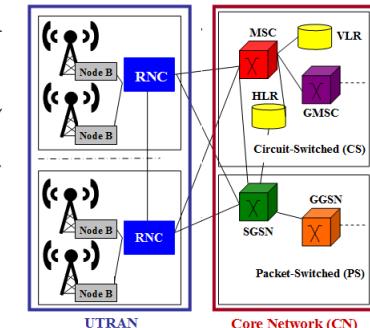
(Evolved High Speed Packet Access)

- **64-QAM (DL), 16-QAM (UL)**
- **MIMO (2x2 DL and UL)**
- **Multi-carrier**



- Data rate up to **384 kbps DL** for FDD & **2 Mbps DL** for TDD & **64 kbps UL** and down to **120 ms** latency

- Data rate up to **14.4 Mbps DL** & **5.76 Mbps UL** and down to **80 ms** latency
- Data rate up to **86.4 Mbps DL** & **11.52 Mbps UL** and down to **60 ms** latency



4G (Fourth Generation) 3GPP Standards



LTE (3.9G)

(Long Term Evolution)

- OFDMA (DL), SC-FDMA (UL)
- PS
- Resource Element
- FDD/TDD
- QPSK, 16-QAM, 64-QAM (both DL & UL)
- 1.4 - 3 - 5 - 10 - 15 - 20 MHz BW
- VoLTE (Voice over LTE)
- CSFB (CS Fallback)
- SON (Self Organizing Networks)
- **MIMO (4x4 DL and 2x2 UL)**

LTE Advanced (4G)

(Long Term Evolution Advanced)

- **256-QAM (DL)**
- **MIMO (8x8 DL and 4x4 UL)**
- **Carrier aggregation (5 x 20 MHz)**

LTE Advanced Pro (4.5G or 4.9G)

(Long Term Evolution Advanced Pro)

- **Massive MIMO (> 8 antennas in DL and UL)**
- **Beamforming**
- **Carrier aggregation (32 x 20 MHz)**

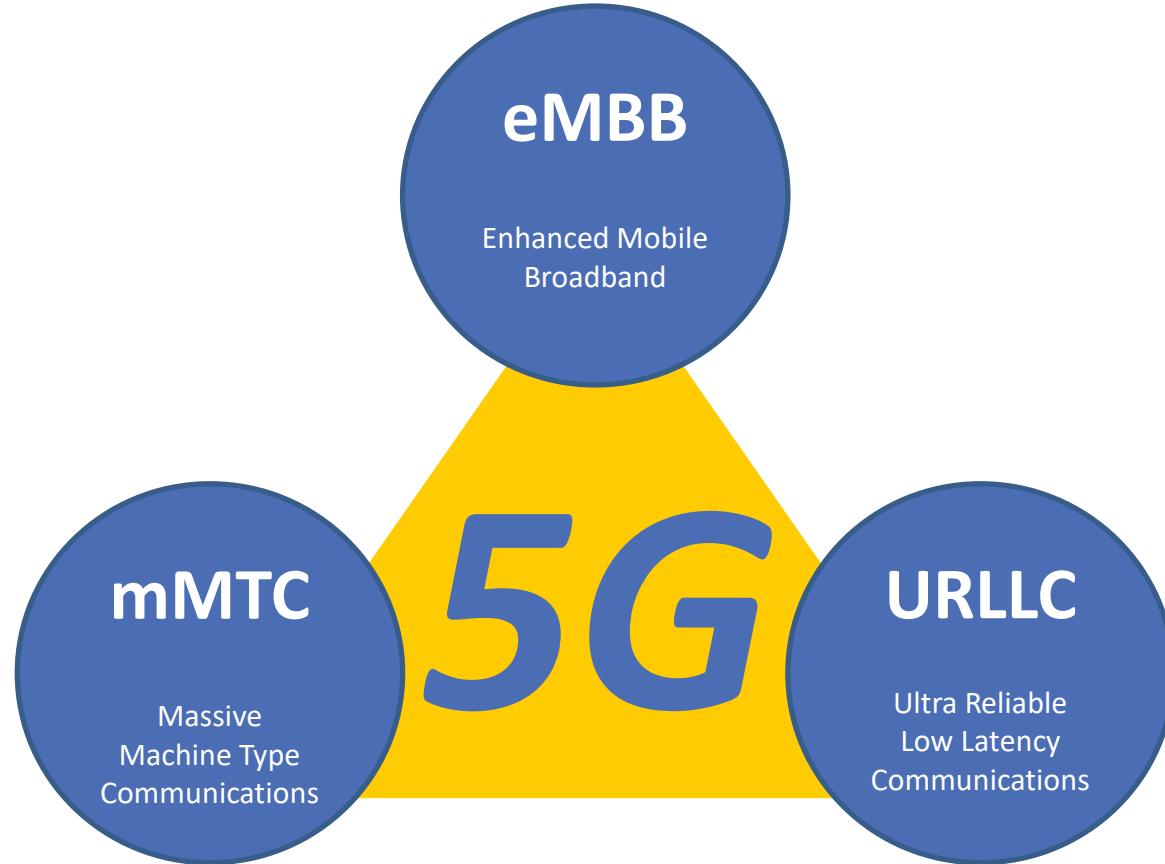
- Data rate up to **300 Mbps DL** &
75 Mbps for UL and down to **40 ms** latency
- Data rate up to **1 Gbps DL** &
0.5 Gbps for UL and down to **10 ms** latency
- Data rate up to **3 Gbps DL** &
1.5 Gbps for UL and down to **2 ms** latency

NR (5G)

(New radio)

- OFDMA (DL), SC-FDMA & OFDMA (UL)
- PS
- Resource Element
- FDD/TDD
- QPSK, 16-QAM, 64-QAM, 256-QAM (both DL & UL), π/2-BPSK (UL)
- 5 - 10 - 15 - 20 - 25 - 30 - 40 - 50 - 60 - 70 - 80 - 90 - 100 - 200 - 400 MHz BW
- VoNR (Voice over NR)
- EPS Fallback
- SON (Self Organizing Networks)
- **Massive MIMO (> 8 antennas in DL and UL)**
- **Beamforming**
- **Carrier aggregation (16x400 MHz)**

- Data rate up to **20 Gbps DL & 10 Gbps for UL** and down to less than **1 ms** latency



eMBB

>10 Gbps Peak Data Rates

100 Mbps whenever needed

10.000 x more traffic

mMTC

10-100 x more devices

Long device battery life

Improved link budget

URLLC

High Reliability

Low Packet Error Loss Rate

Low Latency <1ms Radio Latency

Enhanced Mobile broadband eMBB



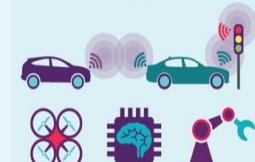
Improved consumer experience
More connected devices
Faster connection speeds
Virtual and Augmented Reality

Massive Machine type communications mMTC



e-health
Transport & logistics
Environmental monitoring
Smart energy networks
Smart agriculture, smart retail

Ultra-reliable and low latency communications uRLLC

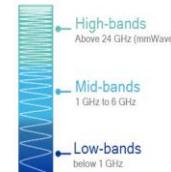


Vehicle-to-everything communication
Drone delivery
Autonomous monitoring
Smart manufacturing



Diverse services

Scalability to address an extreme variation of requirements



Diverse spectrum

Getting the most out of a wide array of spectrum bands/types



Diverse deployments

From macro to indoor hotspots, with support for diverse topologies

NR - Services



Immersive entertainment and experiences



Safer, more autonomous transportation



Reliable access to remote healthcare



Improved public safety and security



Smarter agriculture



More efficient use of energy/utilities



More autonomous manufacturing

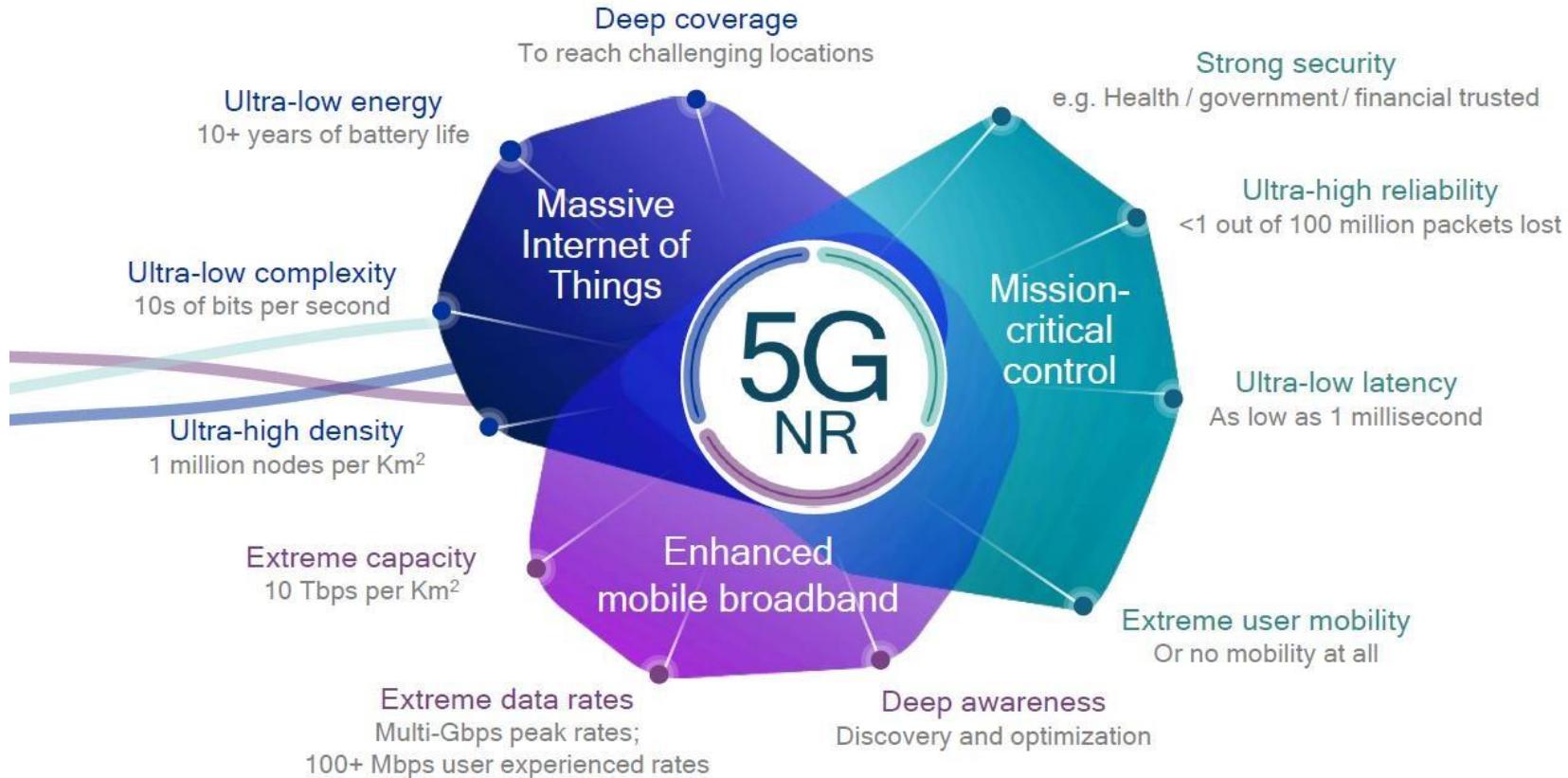


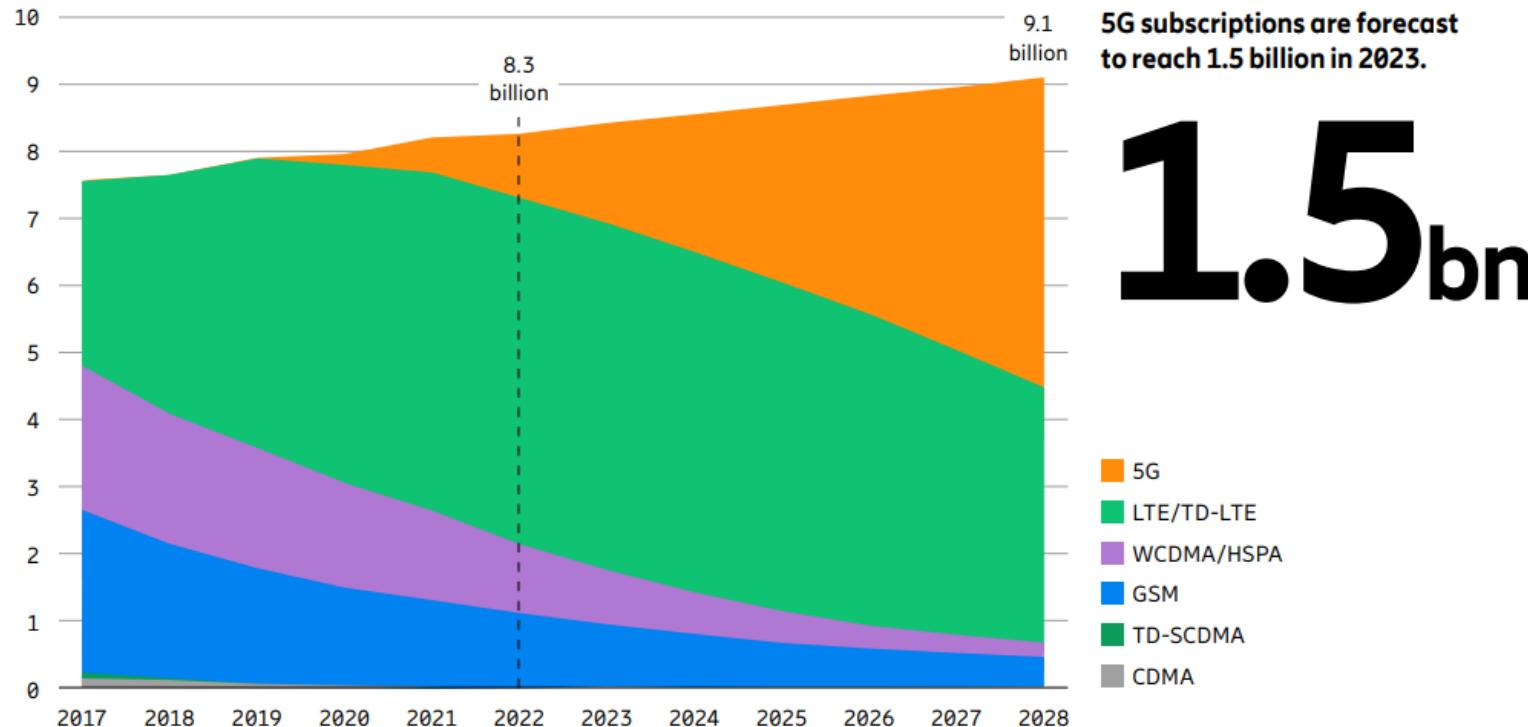
Sustainable cities and infrastructure



Digitized logistics and retail

NR - Services



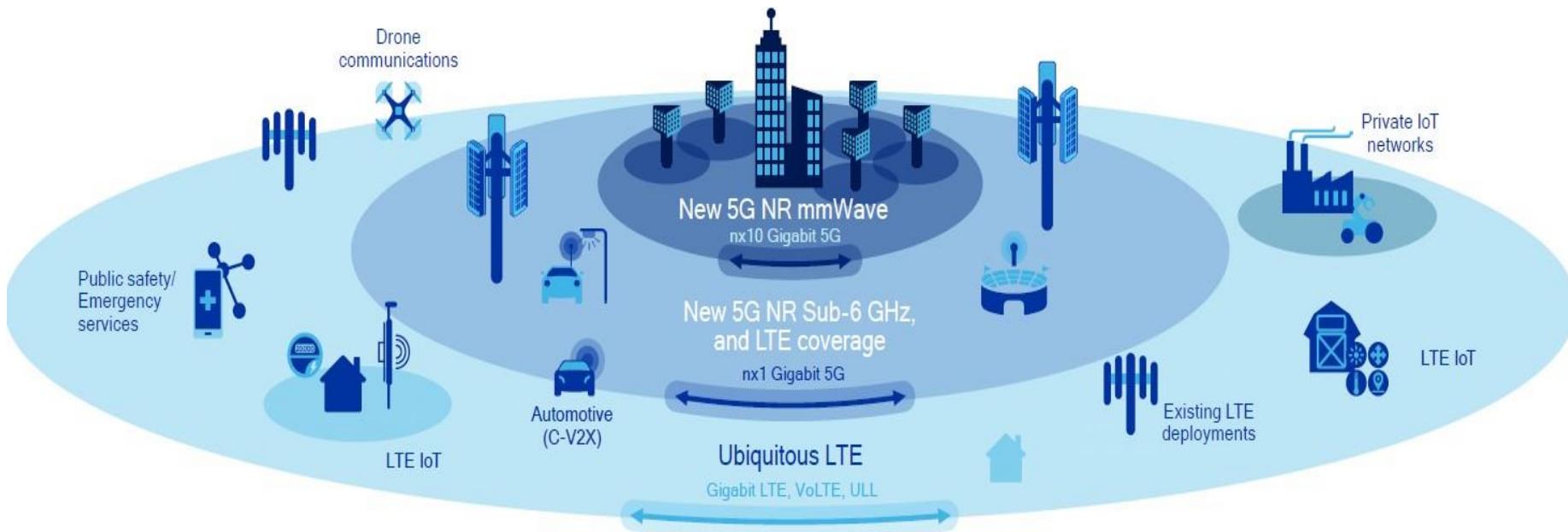


Evolution

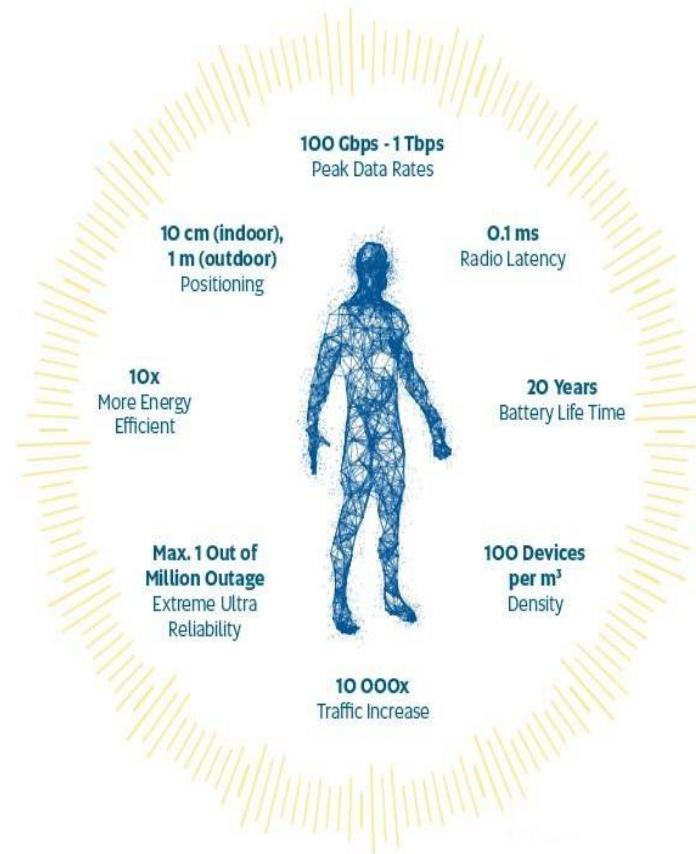


- CS (Circuit Switch) → PS (Packet Switch)
- Narrowband → Broadband
- Lower Order Modulation → Higher Order Modulation
- Fixed modulation → Adaptive modulation
- Fixed carrier bandwidth → Flexible carrier bandwidth
- Single carrier → Multi carrier
- Lower spectral efficiency → Higher spectral efficiency (*in bits per Hz)
- Lower frequencies → Higher frequencies
- Large cells → Small cells
- Homogeneous network → Heterogeneous network
- Less subscriber capacity → More subscriber capacity
- Lower data rate → Higher data rate
- Higher latency → Lower latency
- Bare-metal → Virtualized
- Only voice → Various services (Voice, SMS, http, ftp, video streaming...)

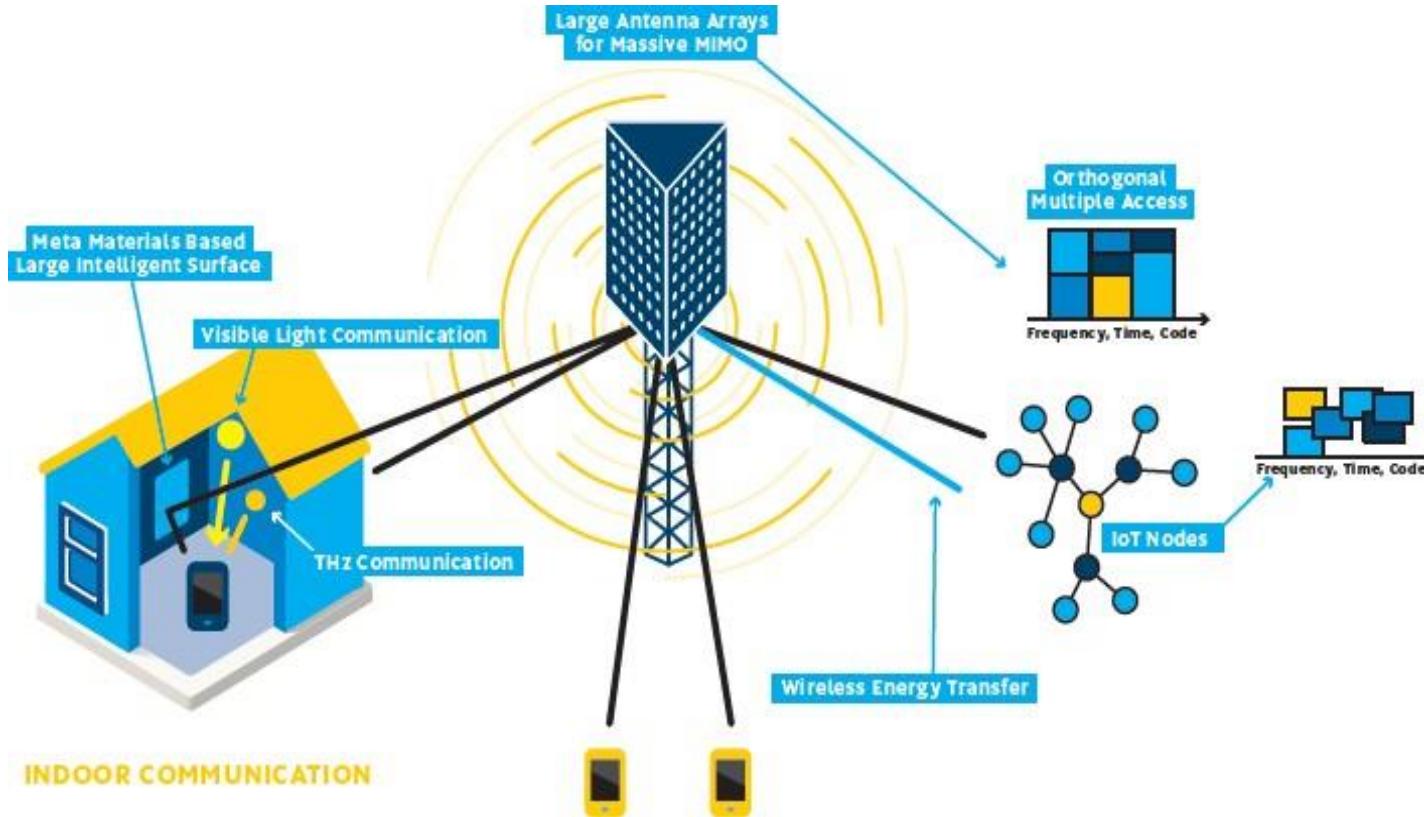
NR Deployment



6G – What it brings us



6G – Challenges



Where evolution takes us



Transforming our world

through intelligent
connected platforms

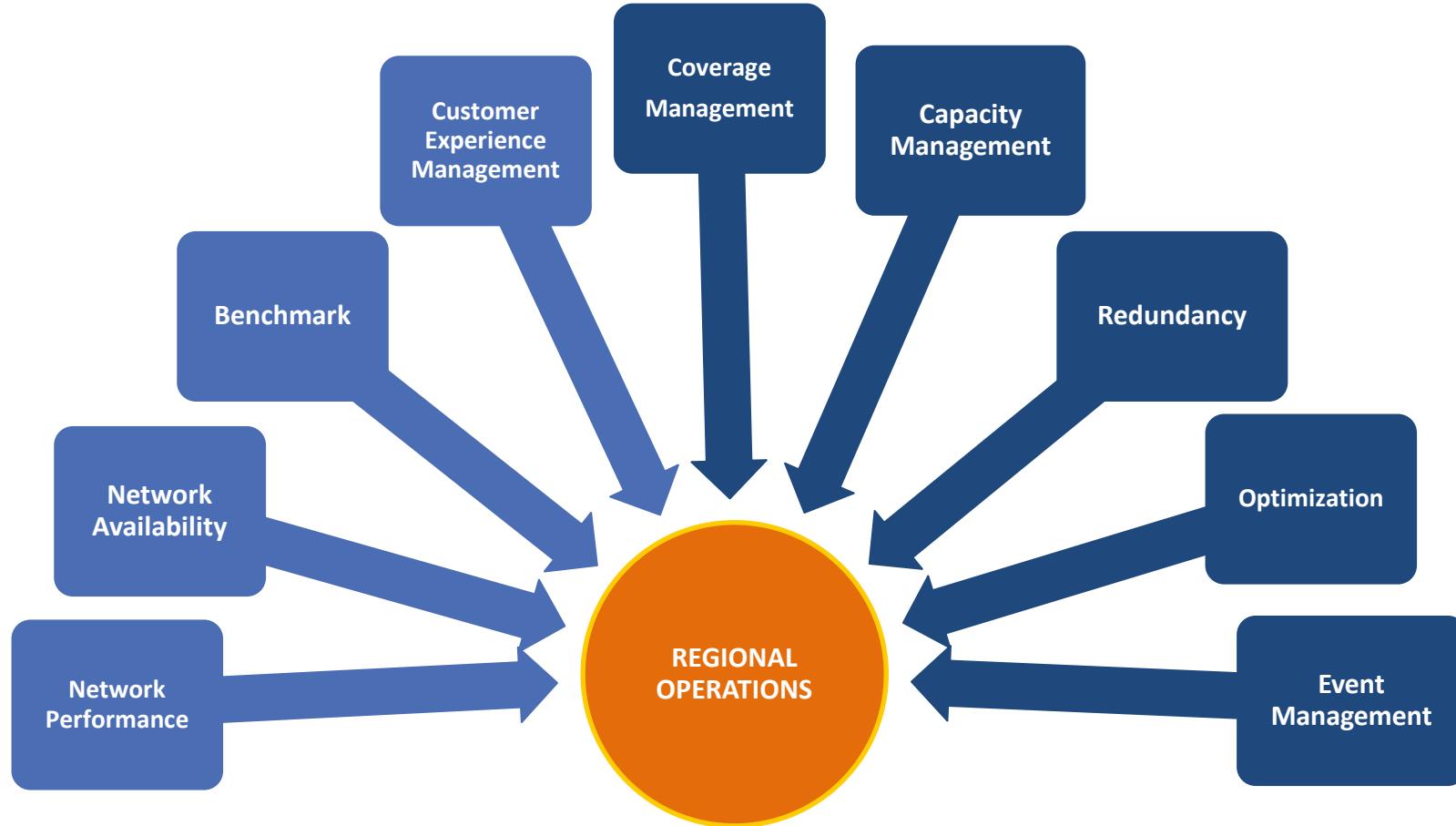


Last 30 years
Interconnecting people



Next 30 years
Interconnecting their worlds

What We Do



What We Do



ERICSSON NETWORK MANAGER



Atoll MultiRAT



cSMARTNET



iBwave Design



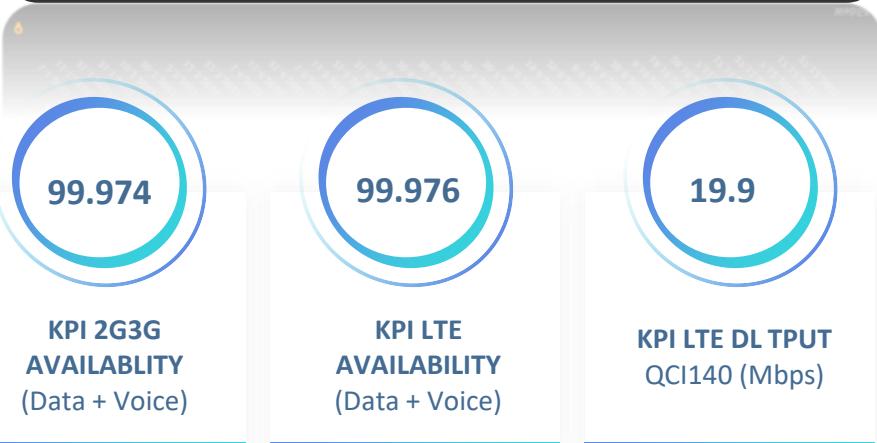
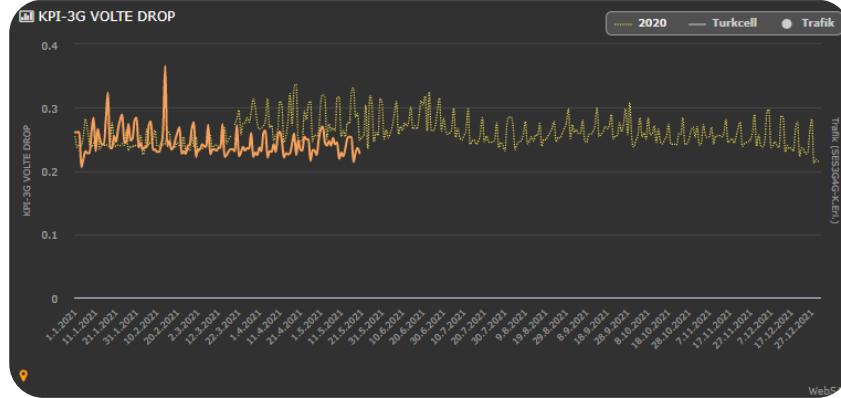
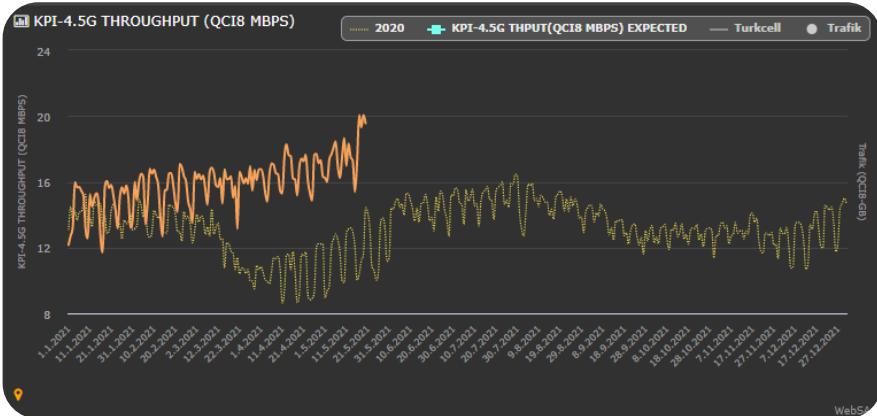
WEBSQA



INSPECTOR



What We Do



KPI LTE AVAILABILITY (Data + Voice)



KPI LTE DL TPUT QCI140 (Mbps)



KPI 3G VOLTE ACC %

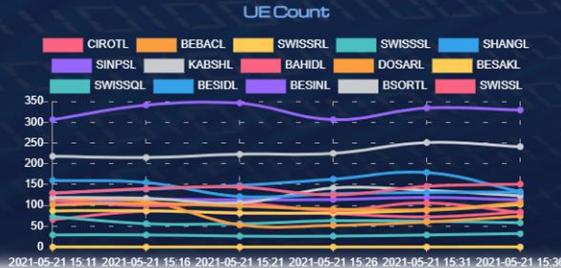


KPI 3G VOLTE DROP %

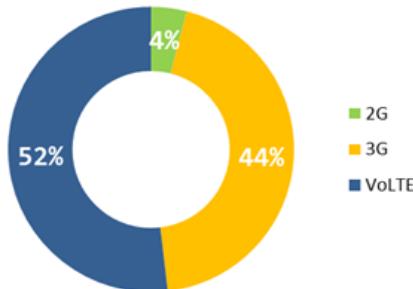
What We Do



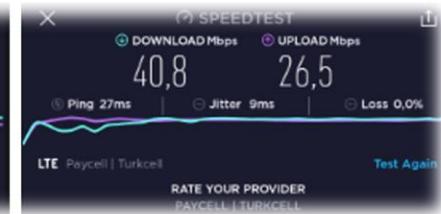
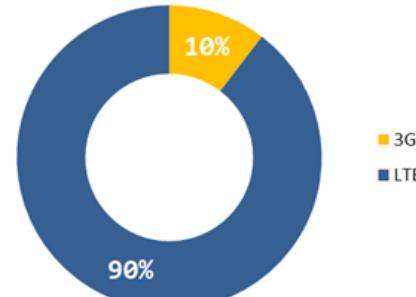
Statistics



Ses Trafik Dağılımı



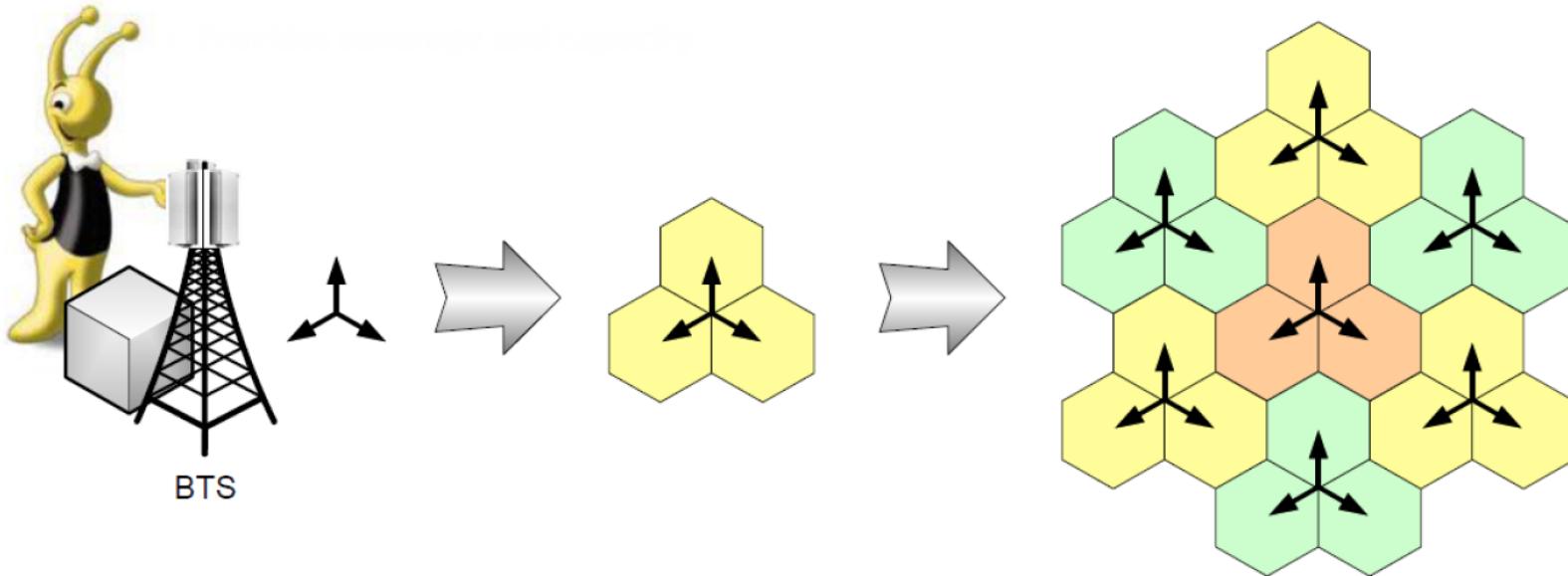
Data Trafik Dağılımı



Planlama Faaliyetleri



Nominal Plan



NS Yatırım Planı



NS – SR Kiralama Çalışmaları (Hayaller)



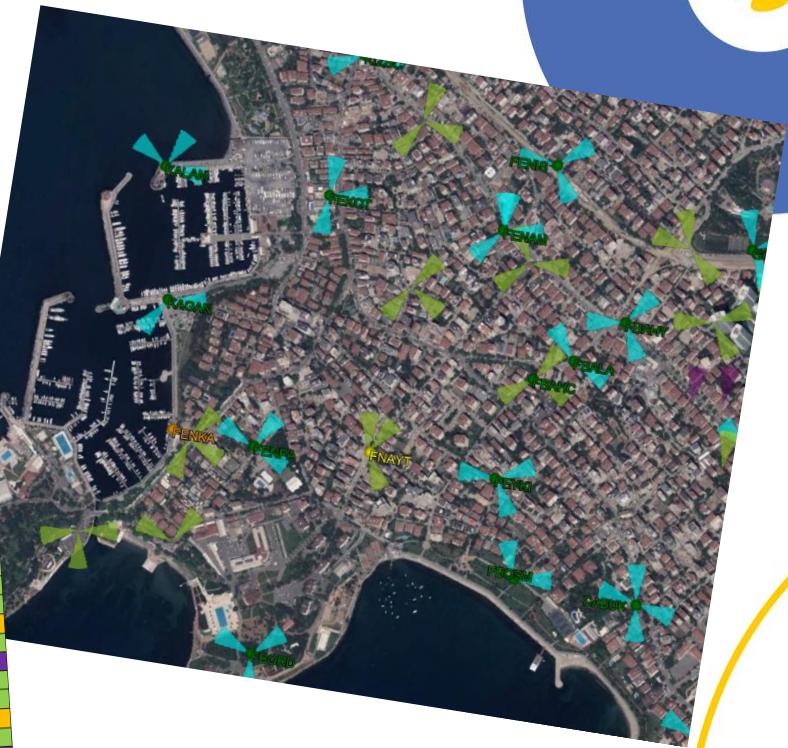
NS – SR Kiralama Çalışmaları (Gerçekler)



LTE Co-Site

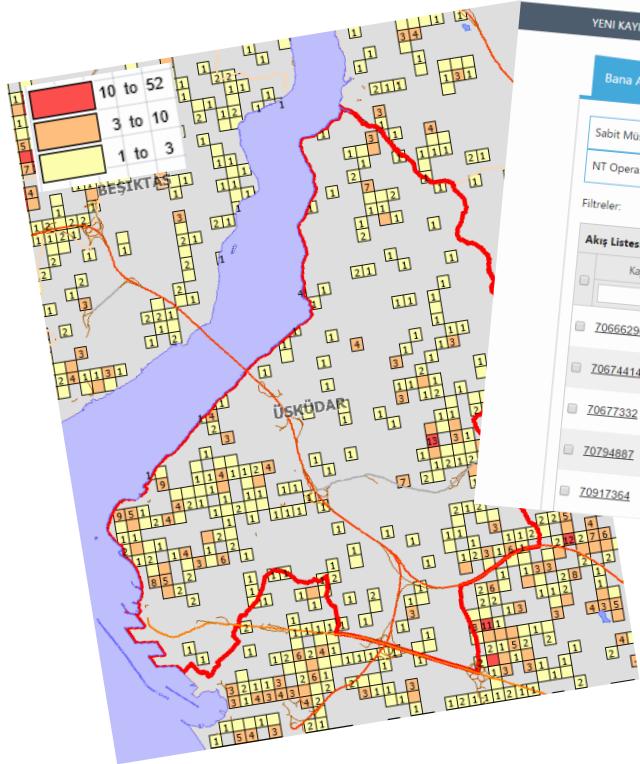


SITE ID	ANABÖLGE	ILCE	PLAN	LTE Kullanıcı Trafiği				Tüm Abonelerin Trafiği				LTE Oran	
				2G	3G	4G	2G	3G	4G	0.00%	40%		
09NEF	AVRUPA	Kagithane		0.01	26.94	0.00	0.01	68.04	0.00	0.00	0.00%	40%	
12SUB	GUNEY	Onikişubat		0.00	182.20	0.00	0.00	450.52	0.00	0.00	0.00%	40%	
15BIN	KUZEY	Canik		0.00	292.81	0.00	0.00	636.16	0.00	0.00	0.00%	46%	
19MYS	KUZEY	Elmesgut		0.00	34.66	0.00	1.01	245.21	0.00	0.00	0.00%	14%	
20ATB	AVRUPA	Zeytinburnu		0.07	34.31	0.00	0.70	471.47	0.00	0.00	0.00%	37%	
22CAD	AVRUPA	Sarıyer		0.00	57.54	0.00	1.64	440.09	0.00	0.00	0.00%	21%	
26NIS	BATI	Konyaaltı		0.28	59.48	0.00	1.33	296.77	0.00	0.00	0.00%	24%	
28EMPL	AVRUPA	Kagithane		0.44	91.74	0.00	0.75	201.84	189.00	0.00	0.00%	62%	
3KAFY	KUZEY	Çankaya		0.33	71.32	189.00	0.28	101.68	106.00	0.00	0.00%	57%	
3KAVS	ASYA	Beykoz		0.19	51.77	106.00	0.59	159.23	220.00	0.00	0.00%	65%	
3KBAH	ASYA	Beykoz		0.11	26.17	220.00	0.08	78.17	39.21	0.00	0.00%	71%	
3KBZ	ASYA	Beykoz		0.04	10.38	59.00	1.38	249.22	389.00	0.00	0.00%	86%	
3KCKE	ASYA	Beykoz		0.59	11.56	389.00	0.96	334.05	371.00	0.00	0.00%	41%	
3KCKM	ASYA	Beykoz		0.37	66.37	59.00	4.48	124.81	365.00	0.00	0.00%	76%	
3KCMS	ASYA	Beykoz		0.00	29.11	371.00	0.48	60.41	60.00	0.00	0.00%	54%	
3KCTC	ASYA												
3KHFM	ASYA												
County	#Site	#LTE Site	Havuz	Hedef	enB Installed	OSS Active	%LTE Cosite	%eNB Installed	%OSS Active				
ASYA EAST	966	583	84	74	36	29	60%	49%	39%	-	-	-	-
Adalar	18	18	0	0	0	0	100%	-	-	-	-	-	-
Beykoz	146	91	7	6	5	4	62%	83%	67%	-	-	-	-
Cekmeköy	63	46	8	7	3	3	73%	43%	43%	-	-	-	-
Cekmeköy	145	78	13	11	4	2	54%	36%	18%	-	-	-	-
Maltepe	137	76	12	12	3	3	55%	28%	25%	-	-	-	-
Pendik	171	104	15	14	7	6	61%	50%	43%	-	-	-	-
Sancaktepe	85	57	10	9	6	5	67%	67%	56%	-	-	-	-
Sultantaylı	61	40	7	6	3	2	66%	50%	33%	-	-	-	-
Sile	34	17	3	3	2	1	50%	67%	33%	-	-	-	-
Tuzla	106	56	9	6	3	3	53%	50%	50%	-	-	-	-
ASYA WEST	935	547	60	57	22	17	59%	39%	30%	-	-	-	-
Ataşehir	178	108	12	12	4	3	61%	33%	25%	-	-	-	-
Kadıköy	291	173	16	15	4	3	59%	27%	20%	-	-	-	-
Ümraniye	216	132	16	15	9	8	61%	60%	53%	-	-	-	-
Üsküdar	250	134	16	15	5	3	54%	33%	20%	-	-	-	-
BURSA	2405	930	278	240	94	62	39%	39%	28%	-	-	-	-
Balıkesir	376	124	37	30	10	8	33%	33%	27%	-	-	-	-
Bilecik	81	15	1	1	0	0	19%	0%	0%	-	-	-	-
Bursa	891	316	101	84	36	25	35%	43%	30%	-	-	-	-
Çanakkale	164	56	16	15	7	4	34%	47%	27%	-	-	-	-
Kocaeli	502	238	66	55	14	3	47%	25%	5%	-	-	-	-
Sakarya	285	133	45	43	24	21	47%	25%	8%	-	-	-	-
Yalova	106	48	12	12	3	1	45%	25%	29%	-	-	-	-
Grand Total	4306	2060	422	371	152	108	48%	41%	29%				



Müşteri Şikayetleri Analizi

TURKCELL | OneDesk



YENİ KAYIT ▾ KONFIGÜRASYON ▾ ICT CMDB Erişim

Kayıt No Ara...

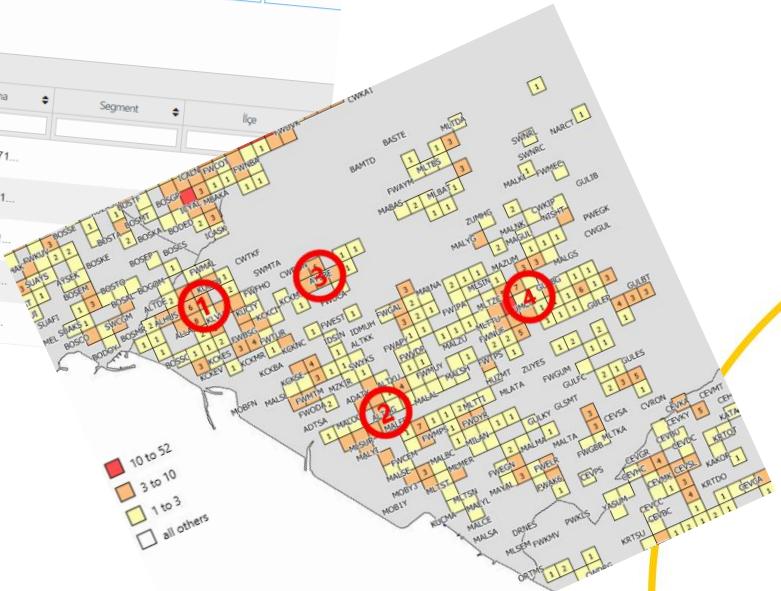
Bana Atananlar 23 Ekibime Atananlar 228 Takip Ettiklerim Uyarılar

Sabit Müşteri Şikayetleri - Ariza 0 Servis Tarife Kampanya 0 NT Mobil Arza 0 Turkcell Müşteri Şikayetleri 22 Bilgilendirme 0 Operasyonel A

NT Operasyonel Talepler 1 NT Operasyonel Değişiklikler 0

Filtreler:

Kayıt Numarası	Kategori	Abone Adı Soy.	Açıklama	Segment	İncele
70666296	Müşteri Kritik Veri Sorgulama		REQUEST-20171...		
70674414	Müşteri Kritik Veri Sorgulama		REQUEST-20171...		
70677332	Müşteri Kritik Veri Sorgulama		REQUEST-20171...		
Z0794887	Müşteri Kritik Veri Sorgulama		REQUEST-20171...		
70917364	Müşteri Kritik Veri Sorgulama		REQUEST-20180...		



Kapasite Yönetimi



Optimizasyon Faaliyetleri



Parametre &
feature
denemeleri

Projeler

KPI/CQI takip ve
iyileştirme faaliyetleri

Etkinlik Takip

Kapasite
Yönetimi

Benchmark &
Drive Test
Faaliyetleri





Parametre & Feature Faaliyetleri

LTE Coverage Improvement



Çalışmalar	Etki	Uygulama Boyutu	Durum
L800 40W Aktivasyonu	Kapsama	Rural sektörler	Sertifikalar bekleniyor (B problemi)
3G 'den LTE 'ye Hızlı Dönüş Çalışması	Time on LTE	ROMA	RwR Fast Dormancy switch denemesi
LTE Co-site'ı olmayan 3G sahalarında LTE 'ye Hızlı Dönüş Aktivasyonu	Time on LTE	Avrupa East / Asya West	Bakırköy'deki olumlu sonuçlardan dolayı alt bölgelerde açıldı, onlarda da sonuçlar olumlu. RO için 3G tarafında LTE Meas. Özelliği bekleniyor.
LTE Kapsama Artırma Çalışması	Kapsama	ROMA	2dB denemesi yapıldı, Time on LTE arttı, Tput düştü. Üst yönetim onay verdi, rollout yapıldı
Tilt Senkronizasyon Çalışması	Time on LTE	L800 Carrierlar	Default tilt değerlerinin düzenlenmesi. Time on LTE ve Tput iyileşmesi sağlandı
LTE->3G Eşik Değerlerinin Değişimi	Time on LTE	ROMA	Rollout yapıldı (Avrupa, Asya) IRAT oranı azaldı, LTE 'de kalma oranı arttı
LTE -> 3G Geçişlerinin Kalite bazlı Yapılması	Time on LTE	ROMA	ROLLOUT yapıldı, geçiş performansında %38 iyileşme sağlandı
LTE Extented Range Çalışmaları	Kapsama	Rural / Deniz Sektörleri	İhtiyaç durumunda yapılıyor
LTE Verimlilik Çalışmaları	Kapsama	ROMA	Haftalık raporlanıyor, aksiyonlar alınıyor

LTE Throughput İyileştirme Çalışmaları



Çalışmalar	Etki	Uygulama Boyutu	Durum
Inter-eNB Carrier Aggregation	Throughput	ROMA	FNI süreci devam ediyor. Senk alarmları geldiği için GPS takılarak denendi, monitoring süreci devam ediyor
Systemconstant 83 (ulGainOuterLoopAdjustmentInit)	Throughput	ROMA	Default = -100 , TC1 = -30 UL Tput iyileşti, Rollout yapıldı
Configurable Scell Priority	Throughput	ROMA	Şişli ve İzmit'te denendi. Toplam bant genişliği kullanımı %10 arttı, RO karan alındı. Asya/Avrupa sırasıyla uygulandı
800 - 1800 Inter Sector CA	Throughput	ROMA	Tüm Cellerde uygulandı, CA oranında artış sağladı
4x4 DL MIMO	Throughput	ROMA	Saha bazlı etki tam olarak görülemedi, cluster bazlı denendi. Rollout yapıldı
L800 -> L1800 Trafik Aktarımı	Throughput	ROMA	Trafiği olabildiğinde L1800' e aktararak Tput artışı sağlamak Tput artışı görüldü. Avrupa RO yapıldı, Asya yapılacak
Tilt Senkronizasyon Çalışması	Throughput	800 Carrier	Default tilt değerlerinin düzenlenmesi. %7 Tput artışı sağlandı
TM4 Support for Dual Antenna DL FDD (2x2)	Throughput	2x2 Carrierlar	Bağcılarlarda denendi, %14 Tput iyileşti. Rollout yapıldı
Systemconstant 100 (dlGinrOuterLoopAdjustmentInit)	Throughput	ROMA	Default = -100 , TC1 = 30 , TC2= 50 DL Tput iyileşmesi bekleniyor, olumlu sonuç görülmedi
Ericsson Lean Carrier	Throughput	ROMA	Tamamlandı, olumlu bir sonuç görülmeli. Gerekirse 2018'de tekrar bakılabilir, fayda bekentisi bulunmuyor
Carrier Aggregation Aware IFLB	Throughput	ROMA	Captive & FNI testleri tamamlandı, sonuçlar olumsuz
UE Throughput Aware IFLB	Throughput	ROMA	Captive & FNI testleri tamamlandı, sonuçlar olumsuz Gerekirse 2018'de yeni SW ile tekrar denenebilir
Measurement Gap Increasing	Throughput	Esenyurt, Sancaktepe Yıldırım	measGapPeriodTraffic -- 0 >> 1 Olumlu bir sonuç görülmeli, deneme bitirildi
CA Parameter Tuning	Throughput	Beşiktaş, Fatih	Configuration ve Activation Parametre Değişiklikleri Olumlu bir sonuç görülmeli, deneme bitirildi
Mobility Parameter Tuning between L1800 & L2600	Throughput	Belirlenecek	Trafiği olabildiğinde L2600' e aktarmak (Ericsson önerisi)



PROJELER

Şebeke Carrier Kullanımı



C5 - L2600 (5MHz)
C4 - L2600 (**20MHz**)
C3 - L1800 (**10MHz**)
C2 - L1800 (**20MHz**)
C1 – L0800 (**10MHz**)

C6 - L2100 (10MHz)
C5 - L2600 (5MHz)
C4 - L2600 (**20MHz**)
C3 - L1800 (**10MHz**)
C2 - L1800 (**20MHz**)
C1 – L0800 (**10MHz**)

C7 - L2100 (20MHz)
C6 - L2100 (**10MHz**)
C5 - L2600 (5MHz)
C4 - L2600 (**20MHz**)
C3 - L1800 (**10MHz**)
C2 - L1800 (**20MHz**)
C1 – L0800 (**10MHz**)

2020

2021

2022

U2100 (**6 Carrier**)

U900 (**1 Carrier**)

GSM

U2100 (**6 CC+4 CC**)

U900(**1 CC+2CC**)

GSM

U2100(**2 Carrier**)

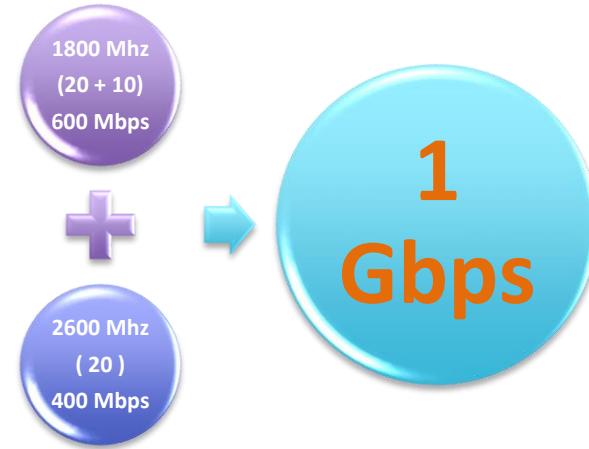
U900 (**2 Carrier**)

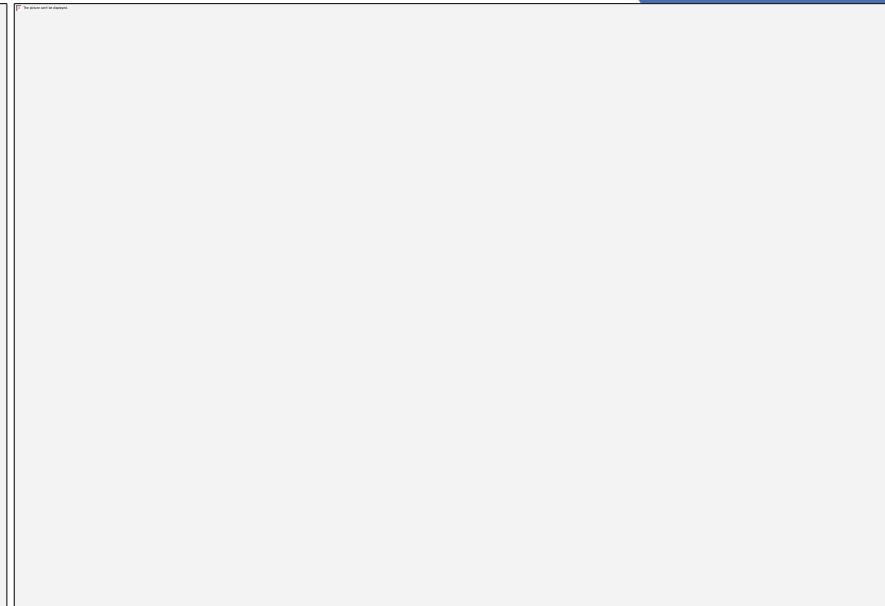
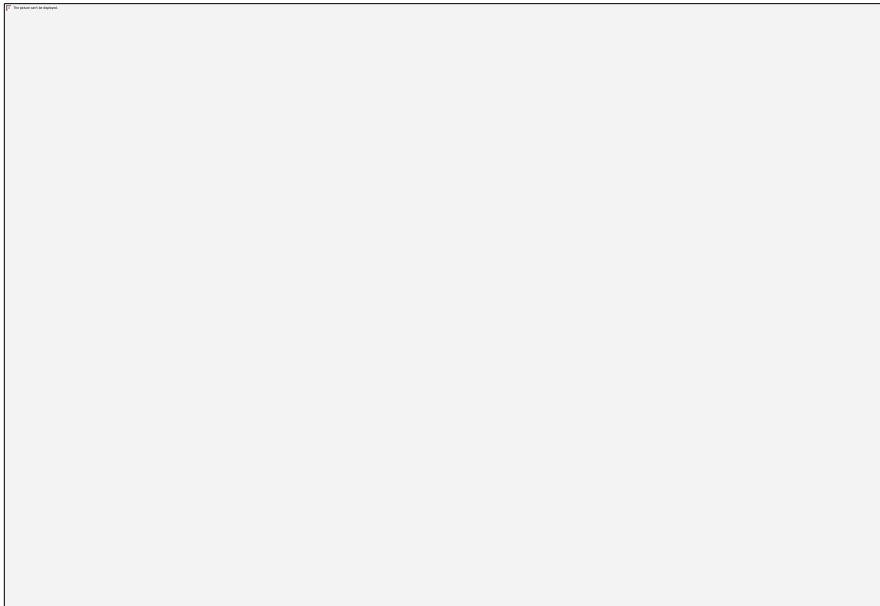
GSM(**2TRX**)



4x4 MIMO Denemesi

- Turkcell Şebekesi'nde **ilk defa** Turkcell Teknoloji Plaza Konferans Salonundaki "**Indoor Pasif Sistem**"'de **4x4 MIMO** kurulumu yapılarak aktif edilmiştir.
- **3 Carrier Aggregation** (C2+C3+C4) kullanılmaktadır. **1800Mhz (20+10Mhz)** ve **2600Mhz (20Mhz)** Carrier'lar kullanılmaktadır.
- **4x4 MIMO, DL 256 QAM ile 616 Mbps DL, 63Mbps UL** hızları gözlemlenmiştir (Teorik hız 1 Gbps)
- Mart ayında çıkacak **Samsung S9 Terminal** modelleri, 4x4'ü desteklemektedir.
- Core tarafında kullanıcı bazlı 600 Mbps hızı limitinin kaldırılması için
 - Geçici olarak test hatlarına özel tanımlama yapıldı.
 - İlgili kabinet Captive'deki SGW/PGW üzerinden çalıştırıldı.





ROMA geneli 1775 U900 saha

OnAir durumdadır

2018'de U900 Rollout hedefi 1000 sahadır. Aday sahalar

belirlenmiş ve süreçleri başlatılmıştır.

Etkinlik Takibi



15 Temmuz Demokrasi Milli Beraberlik Günü



29 Ekim Cumhuriyet Bayramı



Spor Organizasyonları Takibi



Uludağ Ekonomi Zirvesi Capital Element

HAKKIMIZDA KONFERANSLAR STARS OF REGION - UEZ TV BİDİM KAİT SİTEİM ARŞİV

İŞ DÜNYASI ZİRVE'DE BULUŞUYOR GELECEĞİ KONUSUYOR 23-24 MART 2018

Uludağ Ekonomi Zirvesi

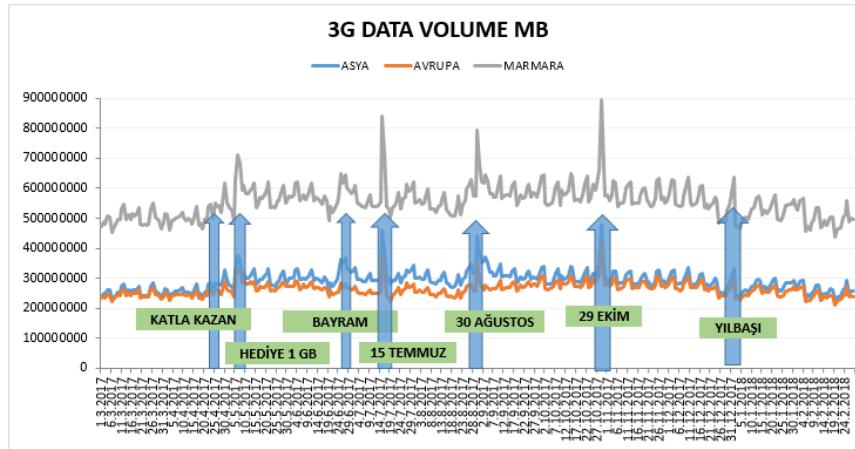
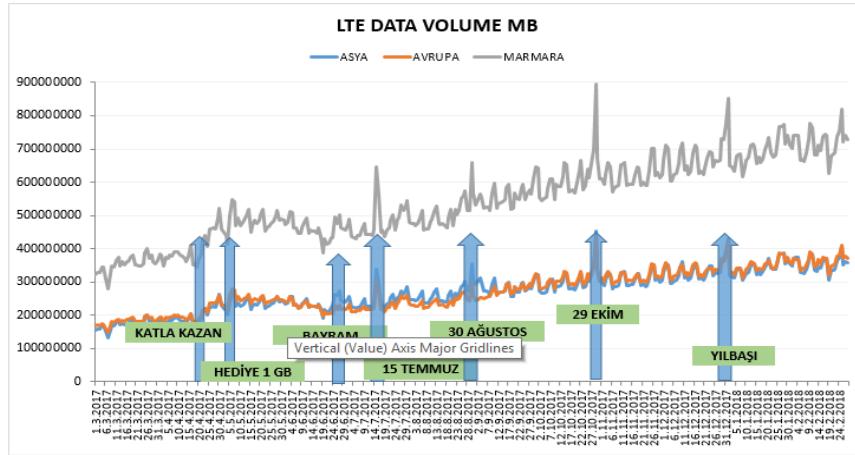


INFOday17

ETKİNLİK BİLGİLENDİRME	
Etkinlik Adı	Uludağ Ekonomi Zirvesi 2018
Tarih/Saat	23-24 Mart 2018
Yer	Uludağ Grand Yazıcı Otel
Beklenen Katılımcı	~500
Hazırlık çalışmaları	<ul style="list-style-type: none">5 sektör 3G (4CC)2 sektör LTE (800, 1800, 2600) konfigürasyonlu mobil istasyon kurulacaktır.Etkinlik aktif olarak takip edilecektir



KPI / CQI



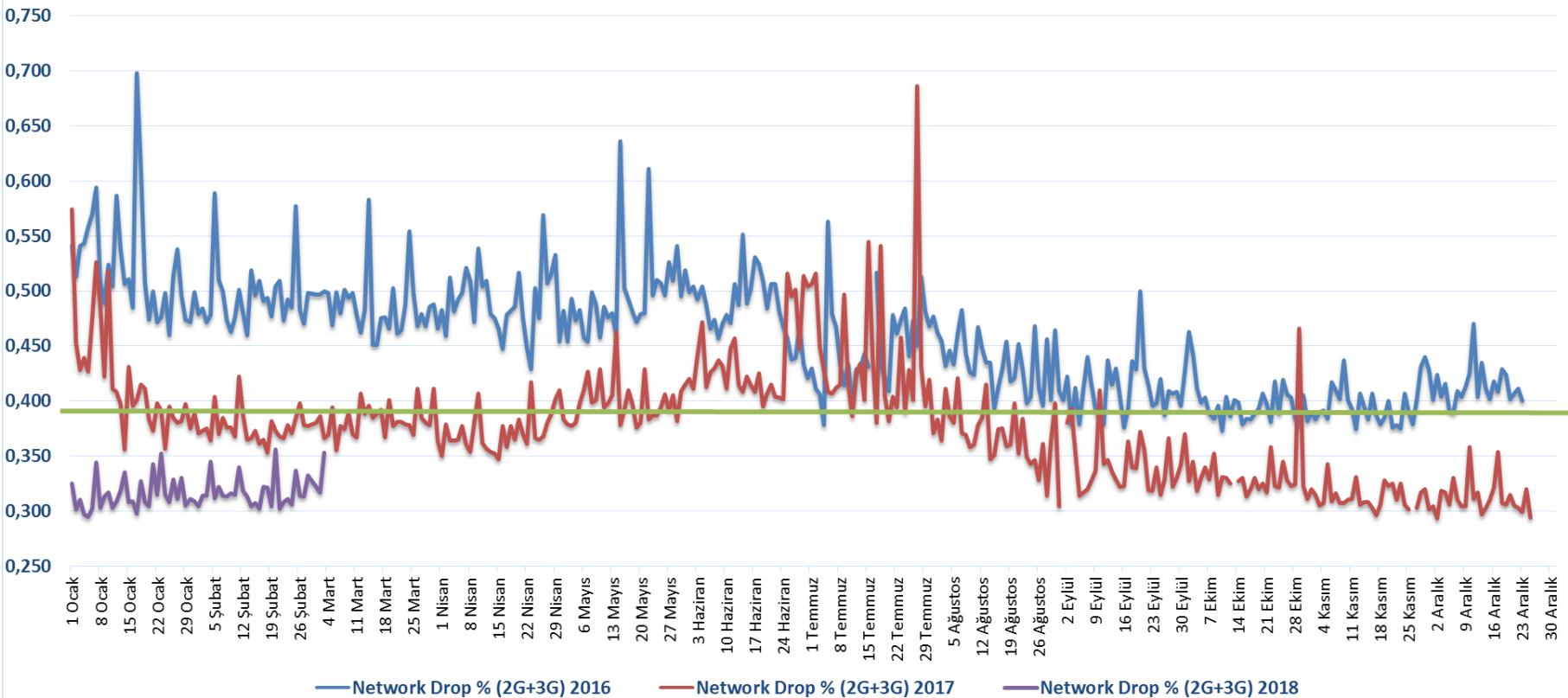
Problem No	Tarih	Açıklama
1	19.Nis	Katla Kazan
2	4.May	4 Mayıs DRA Problemi sonrası Hediye 1 GB
3	24.Haz	Bayram Etkisi
4	15.Tem	15 Temmuz Demokrasi Günü 1GB Hediye
5	30.Ağu	30 Ağustos Zafer Bayramı 1 Gb hediye
6	29.Eki	29 Ekim kampanyası 1GB hediye
7	21 Ara	LTE Coverage Improvement
8	1.Oca	Yılbaşı



Drop & Availability



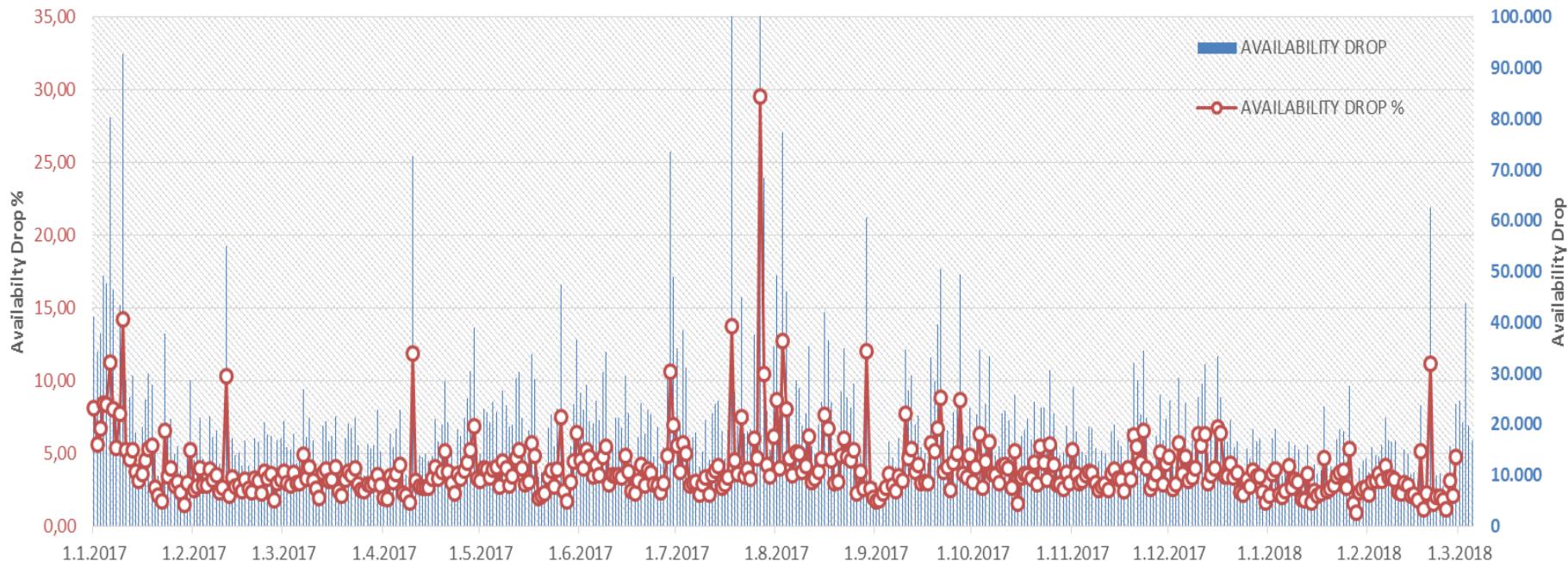
ROMA CQI DROP TRENDİ



Drop & Availability



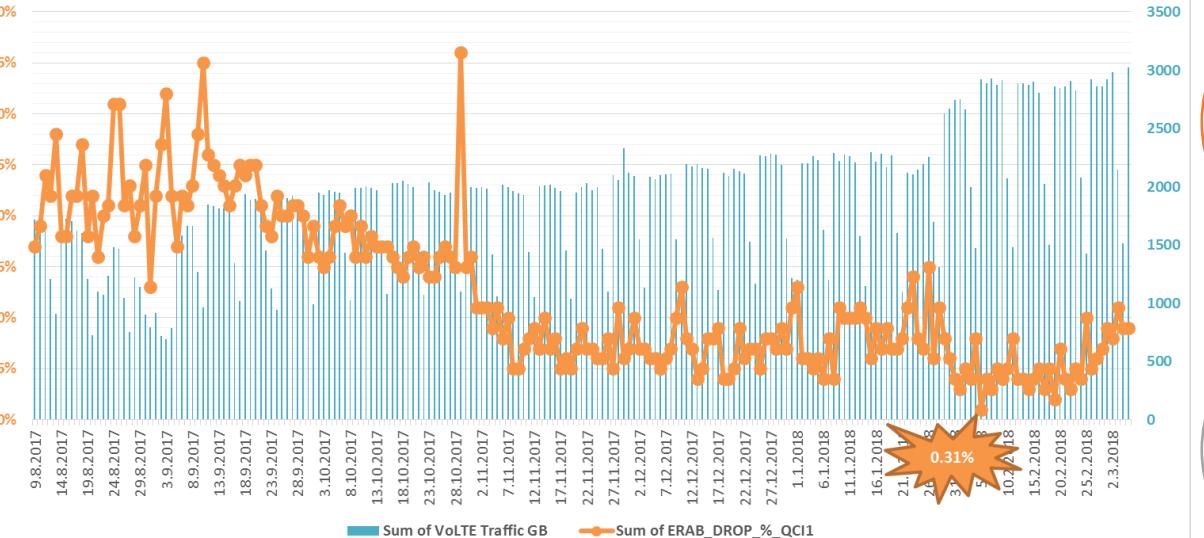
ROMA AVAILABILITY DROP TREND (KPI)



VoLTE KPI



VoLTE Drop vs Traffic GB



Apple tarafından yapılan bulk provisioning ile trafik miktarında %25 artış ve VoLTE droplarında bir miktar düşüş yaşanmıştır.

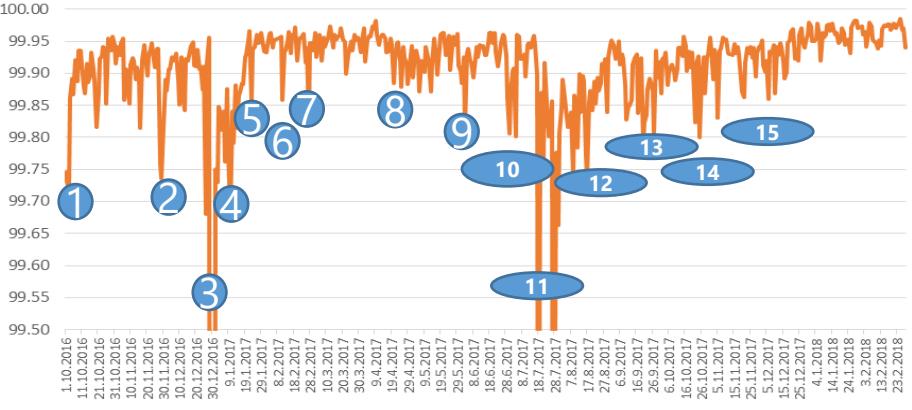
Inter-Freq Handover Trigger'ının RSRP → RSRQ değişimi için Pendik ve Bayrampaşa ilçelerinde denemeler yapılmaktadır.



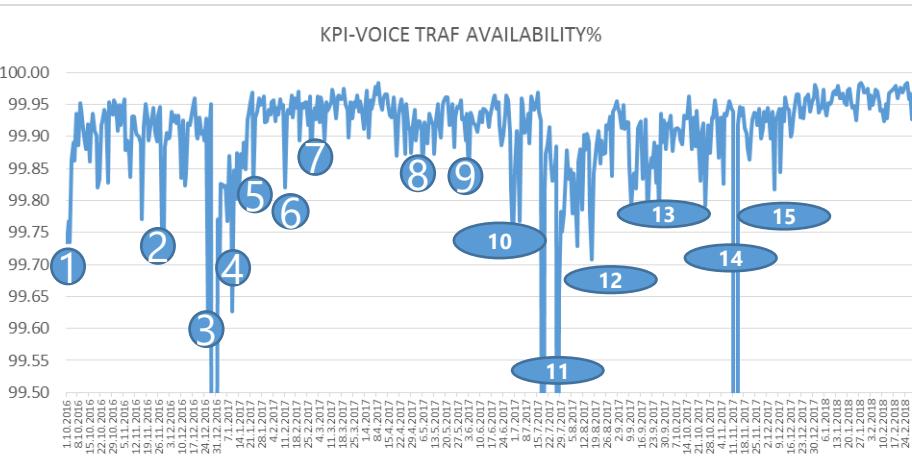
KPI Trend – Traffic Availability



KPI-DATA TRAFFIC AVAILABILITY%



KPI-VOICE TRAF AVAILABILITY%



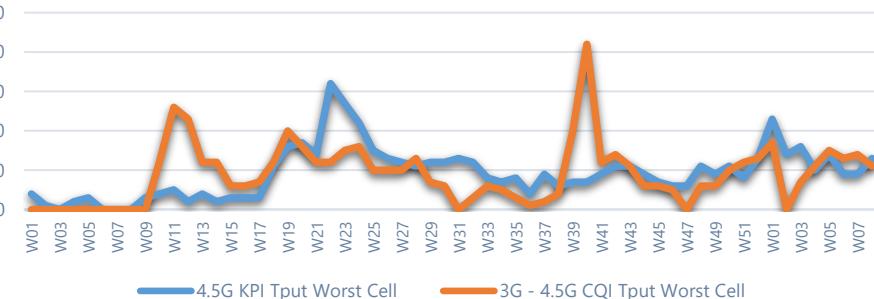
Problem No	Tarih	Açıklama
1	1-3 Ekim	Olumsuz Hava Şartları-Kesinti
2	28-29 Kasım	Olumsuz Hava Şartları-Kesinti
3	29-31 Aralık	Elektrik Kesintisi
4	7-10 Ocak	Olumsuz Hava Şartları-Kesinti
5	23.Oca	4 İlçe Elektrik Kesintisi
6	11.Şub	Marmara Genelini Etkileyen FTTX Kesintisi
7	27.Şub	NGN Switch hardware kart arıza
8	4 Mayıs	4 Mayıs DRA Problemi
9	3.Haz	Avrupa Bölge Fiber Kesinti-Sultangazi-Beyoğlu Kesintileri
10	30.Haz	Bayram etkisi
11	18-19-27 Tem	Olumsuz Hava Şartları-Kesinti
12	27.Ağu	Olumsuz Hava Şartları-Kesinti
13	10.Eyl	Tekirdağ Enerji ve Bahçeşehir Fiber Kesintisi
14	25-27 Ekim	Olumsuz Hava Şartları-Kesinti
15	6 Kasım	Enerji kesintileri (Güngören-Zeytinburnu)



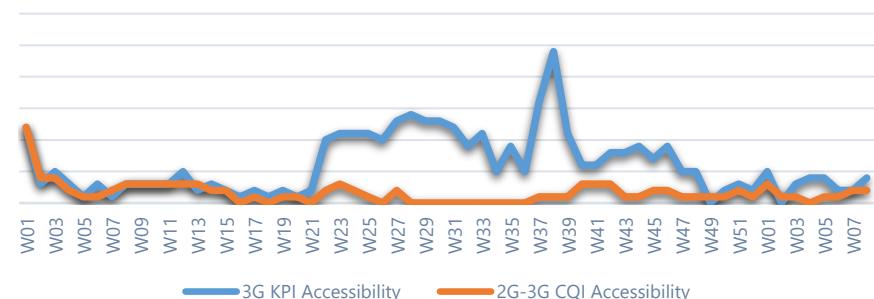
Worst Cell Trendi



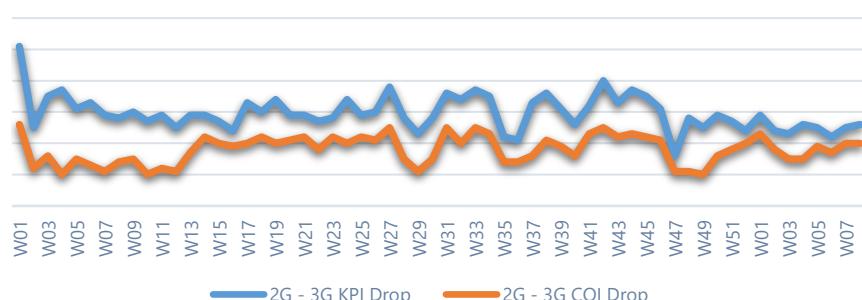
Tput Worst Cell Trend



Accessibility Worst Cell Trend



Drop Worst Cell Trend



Availability Worst Cell Trend



Benchmark



4.5G

81 il benchmark
coverage
csfb, volte
application
data



Customer Satisfaction

Network Capability

	KPI	weight
LTE Visibility	Time on LTE (%)	10
	LTE Return Rate (%)	10
CSFB	Call Setup Time (sec)	8
	Drop/Hour	24
VoLTE	CSFB MOS	8
	Call Setup Time (sec)	2
VolTE	Drop/Hour	2
	VolTE MOS	6
App.	Youtube Score (15)	15
	Facebook Score (5)	5
App.	Twitter Score (5)	5
	Instagram Score (5)	5
App.	Web Browsing Score (10)	5
	Dropbox Score (10)	15

	KPI	weight
Coverage	4.5G Coverage (%)	20
	Available BW (MHz)	20
Capacity	DL Throughput (Mbps)	20
	UL Throughput (Mbps)	60
Data	Latency (msec)	20

3G

81 il benchmark
coverage

voice

application

data



Customer Satisfaction

Network Capability

	KPI	weight
Voice	Time on 3G (app) (%)	10
	Call Setup Time (sec)	10
App.	Drop/Hour	10
	3G MOS	10
Data	Youtube Score	15
	Facebook Score	5
App.	Twitter Score	5
	Instagram Score	5
Data	Web Browsing Score	15
	Dropbox Score	50

	KPI	weight
Coverage	3G Coverage (%)	20
	Available BW (MHz)	20
Capacity	DL Throughput (Mbps)	20
	UL Throughput (Mbps)	20
Data	Latency (msec)	20
		60

ROMA- BM Sonuçlar



	Customer Satisfaction			Network Capability		
	Opt-1	Opt-2	Opt-3	Opt-1	Opt-2	Opt-3
BALIKESİR	80,0	70,0	73,0	83,0	68,0	76,0
BİLECİK	82,8	70,1	76,6	86,6	59,3	79,5
KOCAELİ	75,0	68,4	68,9	80,0	65,7	78,2
SAKARYA	78,5	75,8	70,5	79,0	65,0	70,7
BURSA	80,1	71,3	71,5	86,5	76,8	78,7
ÇANAKKALE	76,8	67,8	70,5	83,9	65,4	74,2
YALOVA	75,0	70,7	68,1	83,6	69,8	75,9
EDİRNE	78,6	64,7	68,3	86,3	73,2	85,8
KIRKLARELİ	75,8	65,1	68,7	84,2	65,9	83,1
TEKİRDAG	79,5	65,8	69,0	86,7	66,0	83,3

	Customer Satisfaction			Network Capability		
	Opt-1	Opt-2	Opt-3	Opt-1	Opt-2	Opt-3
BALIKESİR	84,0	76,0	74,0	85,0	58,0	55,0
BİLECİK	80,9	70,8	75,7	81,8	57,2	48,3
KOCAELİ	80,3	77,8	73,2	81,9	61,4	60,6
SAKARYA	82,5	80,0	75,5	81,2	63,4	58,8
BURSA	82,1	77,6	74,5	80,3	60,4	59,2
ÇANAKKALE	81,2	73,3	72,7	87,2	54,7	63,2
YALOVA	86,6	75,9	72,5	86,9	62,1	59,7
EDİRNE	85,6	67,8	77,6	87,6	52,2	64,8
KIRKLARELİ	84,6	68,8	75,6	81,5	51,8	59,6
TEKİRDAG	86,0	76,1	76,9	85,2	61,7	61,8

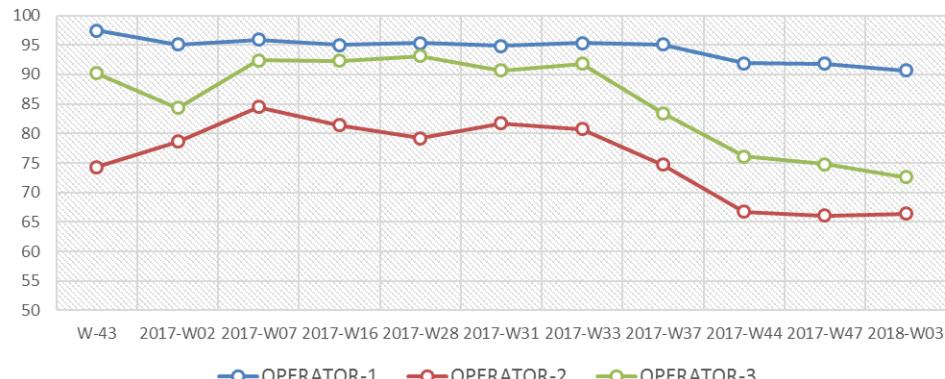


Customer Satisfaction ve Network Capability'de testi tamamlanan **tüm illerde lideriz**

Anayol LTE Test Sonuçları-Bölge Önerileri



4.5G NETWORK CAPABILITY TREND



4.5G CUSTOMER SATISFACTION TREND



Teşekkürler...

