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5G Deployment Non-StandAlone

ADVANCE YOUR CAREER WITH 5G

Prerequisite for initial 5G NSA Option 3

Introduction

- 5G can be deployed in five different deployment options, where SA options consist of only one generation of radio access technology and NSA options consist of two generations of radio access technologies (4G LTE & 5G).
- The early deployments will be adopting either NSA option 3 or SA option 2 as the standardization of these two options have completed.

Introduction

- NSA option 3 is where RAN is composed of eNBs as the master node and gNBs as the secondary node.The RAN is connected to EPC.

- The NSA option 3, as it leverages existing 4G deployment, can be brought to market quickly with minor modification to the 4G network.

- This option also supports legacy 4G devices and the 5G devices only need to support NR protocols so device can be developed quickly.

Introduction

- On the other hand, NSA option 3 does not introduce does not introduce 5GC and therefore may not be optimised for new 5G use cases beyond mobile broadband.

- In addition, depending on how 5G devices are developed, the EPC may need to be retained longer than in the case of having EPS for 4G alone.

- SA option 2 is where radio access network consists of only gNB's and connects to 5GC , and the 5GC interworks with EPC.

Introduction

- SA option 2 has no impact on LTE radio and can fully support all 5G use cases by enabling network slicing via cloud native service-based architecture.

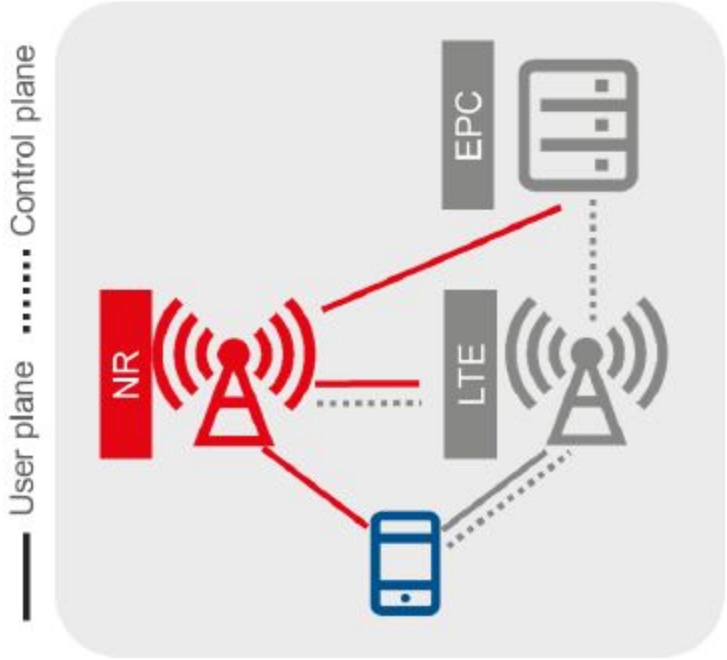
- On the other hand, this option requires both NR and 5GC, making time to market slower and deployment cost higher than that of NSA option 3.

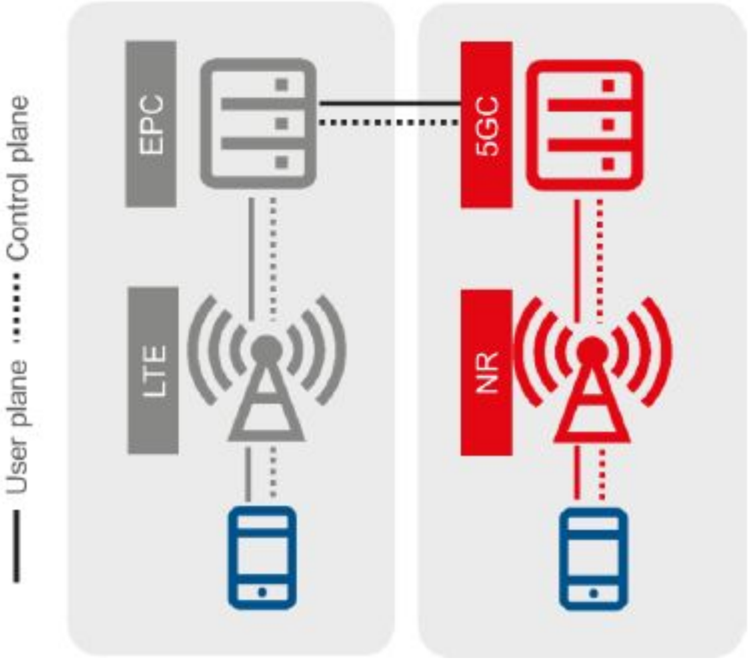
- Furthermore, the devices would need to support NR and core network protocols so it would take more time to develop devices.

Introduction

- Finally, as the standalone 5G system would need to interwork with EPS to ensure service continuity depending on coverage, the interworking between EPC and 5GC may be necessary.

High level architecture of NSA option 3x & SA option 2





Spectrum

Introduction

- Availability of a suitable amount of spectrum is the most important prerequisite to launch 5G.

- While globally harmonised bands will be allocated formally at WRC-19 , several countries and regions have already identified candidate bands and in some cases already allocated them.

- When 5G deployment is driven by providing eMBB, the S and C bands , communication bands extending from 2 GHz to 4GHz and 4GHz to 8 GHz respectively, accommodate the 3.4 GHz to 4.2 GHz frequency range which seems to be the most suitable option.

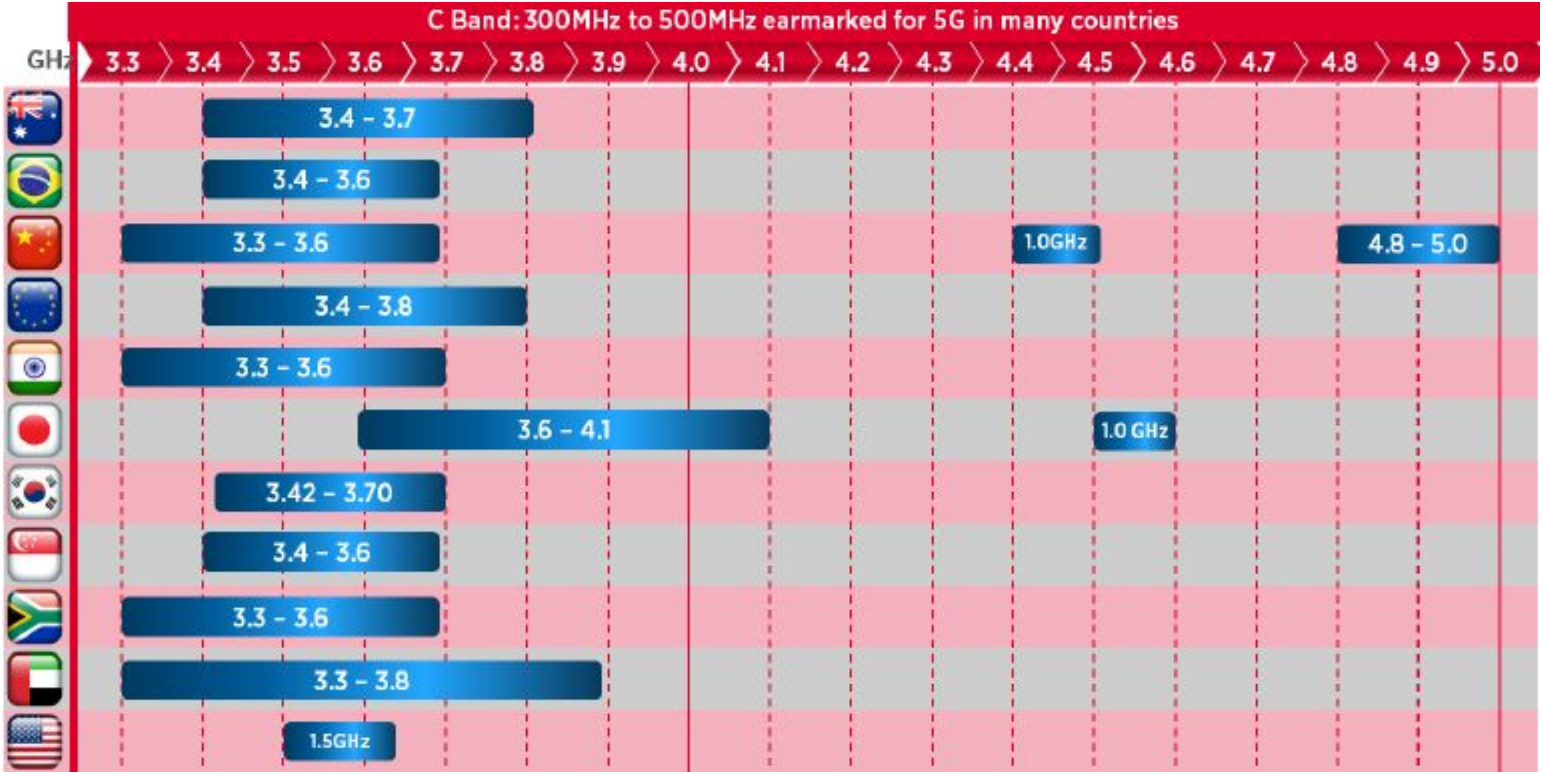
Introduction

- These bands have been identified in many countries as primary bands for 5G , global harmonisation seems feasible in the lower part of such bands thus unlocking economies of scale in devices.

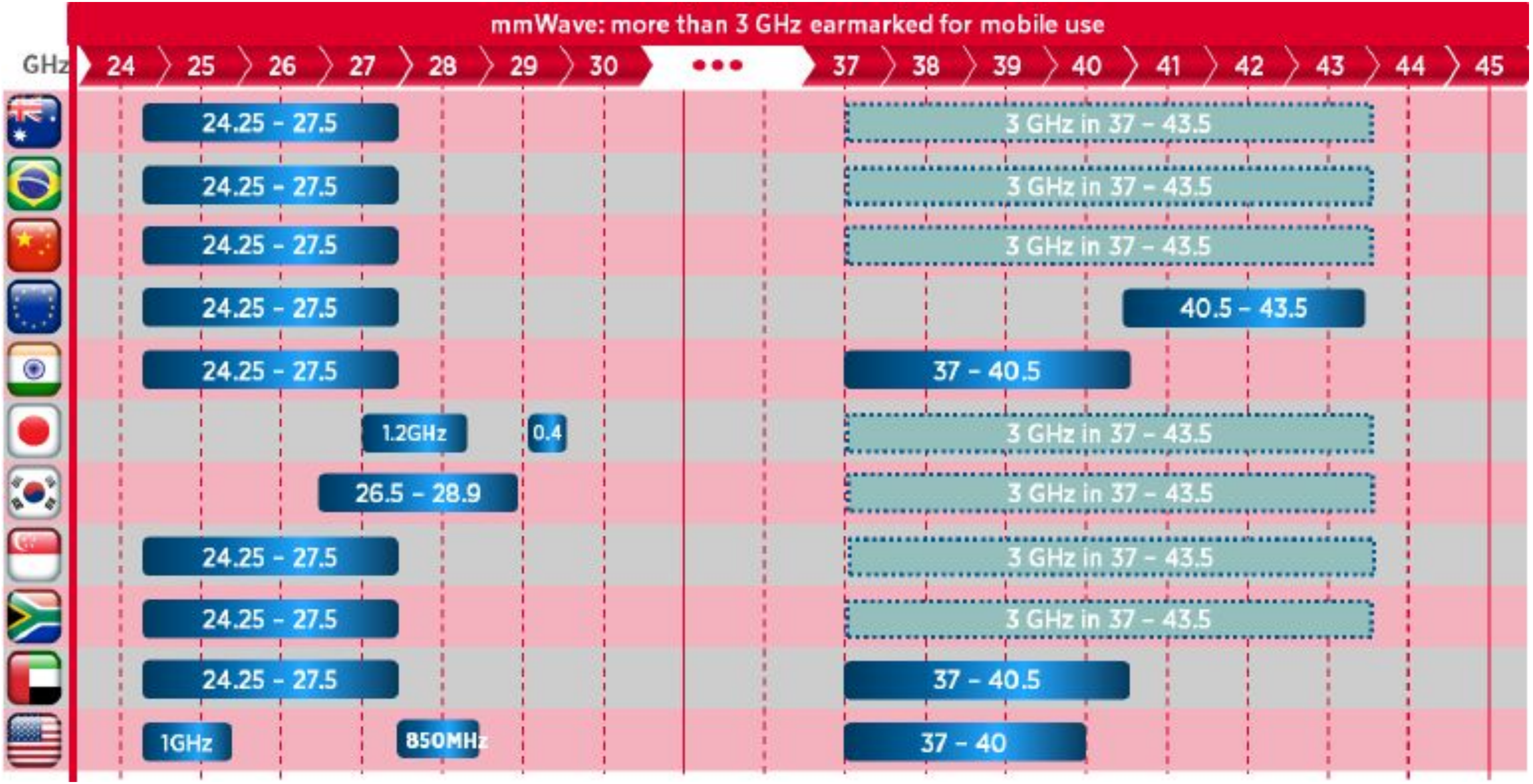
- Another band that has been gaining popularity for use in 5G is called millimeter wave band that includes spectrum spanning from 24 GHz to 29.5 GHz as well as spectrum in the 37 GHz to 43.5 GHz.

- The very fast attenuation of the radio signal at these frequencies has cast doubts on the potential of using this spectrum to provide wide area coverage especially in UL direction where MIMO and beamforming may not be effective as in DL.

Spectrum in the S & C bands for 5G



Spectrum Allocation in mmWave



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Amount of Spectrum needed

- It should be observed that the ITU IMT - 2020 requirements, especially with regards to maximum throughput are based on the assumption of using 100 MHz channels.

- From an analysis of the results of recent spectrum auctions in the 3.5 GHz spectrum, it was observed that only in few cases operators will have that amount of spectrum available.

- Spectrum allocation of at least 100 MHz is vital for use cases.

4G Radio Network Updates

No. of sites needed

- The possibility of utilising advanced antenna techniques such as MIMO and beamforming , simulations have shown the feasibility of matching the DL coverage provided by LTE 1800 MHz with 5G radio base stations operating at 3.5 GHz , the same cell grid can therefore be reused for the initial rollout.

- In the uplink direction MIMO and beamforming are impractical due to limited real estate in the device, therefore if the uplink was to use the same frequencies as downlink, the size of the cell would " shrink" to the maximum range in the UL.

No. of sites needed

- To overcome this problem it has been proposed to utilise lower band spectrum such as the 1800 Mhz spectrum for the uplink data.

- In the first step, this is done using option EN-DC , where the uplink data is transmitted on the FDD-band using LTE.

- To optimize the coverage further, both NR uplink data is transmitted on the FDD band using LTE.

No. of sites needed

- To optimize the coverage further , both NR uplink control and user data channels can be transmitted on the FDD band.

- This can be done using either NR-NR Carrier Aggregation (CA) or Supplementary uplink (SUL).

- Both these techniques allow the uplink transmission to be switched between the FDD band and the 3.5 GHz band.

LTE upgrade to support EN-DC (option 3)

- For a successful deployment of EN-DC the 4G network needs to support dual connectivity between E-UTRAN (LTE) and NR.

- This enhancement allows a device to consume radio resources provided by both 4G and 5G.

- Typically the 4G radio will be used to carry control signalling while NR and/or LTE will be used for user data.

- Three variants of the NSA solution have been defined each producing a different impact on the LTE network.

LTE upgrade to support EN-DC (option 3)

- Option 3 uses the MN (Master Node) terminated MCG (Master Cell Group) bearer for signalling.

- There are a few variants for data bearer configuration within option 3.

- The industry main-stream is to use an SN-terminated split bearer.

- This variant has low impact on EPC and enables data to route directly to the NR gNB to avoid excessive use plane load on the existing LTE eNB, which was designed for 4G LTE traffic load and not additional NR traffic load.

Considerations in aligning maintenance of LTE sites

- When existing LTE network is upgraded to EN-DC (dual connectivity between master eNB and secondary gNB) , the maintenance of the LTE network may also be affected.

- Operators should be mindful of disruption in service for traditional 4G subscribers as well as 5G subscribers when maintaining LTE sites.

- In many commercial deployments, LTE networks will be overlaid on multiple bands and therefore will not significantly impact customer experience during downtime of a particular eNB.

4G Radio Network Updates

Supporting dynamic spectrum sharing

- DSS is a technology in which there is a deployment of both 5G NR and 4G LTE in the same frequency band and based on the user demand it dynamically allocates spectrum resources between two technologies.

- With DSS, utilization of spectrum resources can be maximized.

- As users of 5G NR increase, more spectrum resource can be allocated to 5G, leading to smooth transition.

Supporting dynamic spectrum sharing

- Deploying DSS only requires software upgrade, so cost will be less.

4G Core Network Updates

Option 3/3a/3x Networking Comparison

- NSA EPC networking architecture includes option 3, option 3a and option 3x.

- In option 3 networking mode, all plink/downlink data flows to and from the LTE part of the LTE/NR base station i.e to and from the eNB.

- Traffic is split between 4G and 5G at eNB.

Option 3/3a/3x Networking Comparison

- In the option 3a, traffic is split between 4G and 5G at EPC (S-GW) .
- In this option, both LTE eNB and the 5G gNB can directly talk to the EPS core network.
- In this, a single data bearer cannot share the load over LTE and NR.

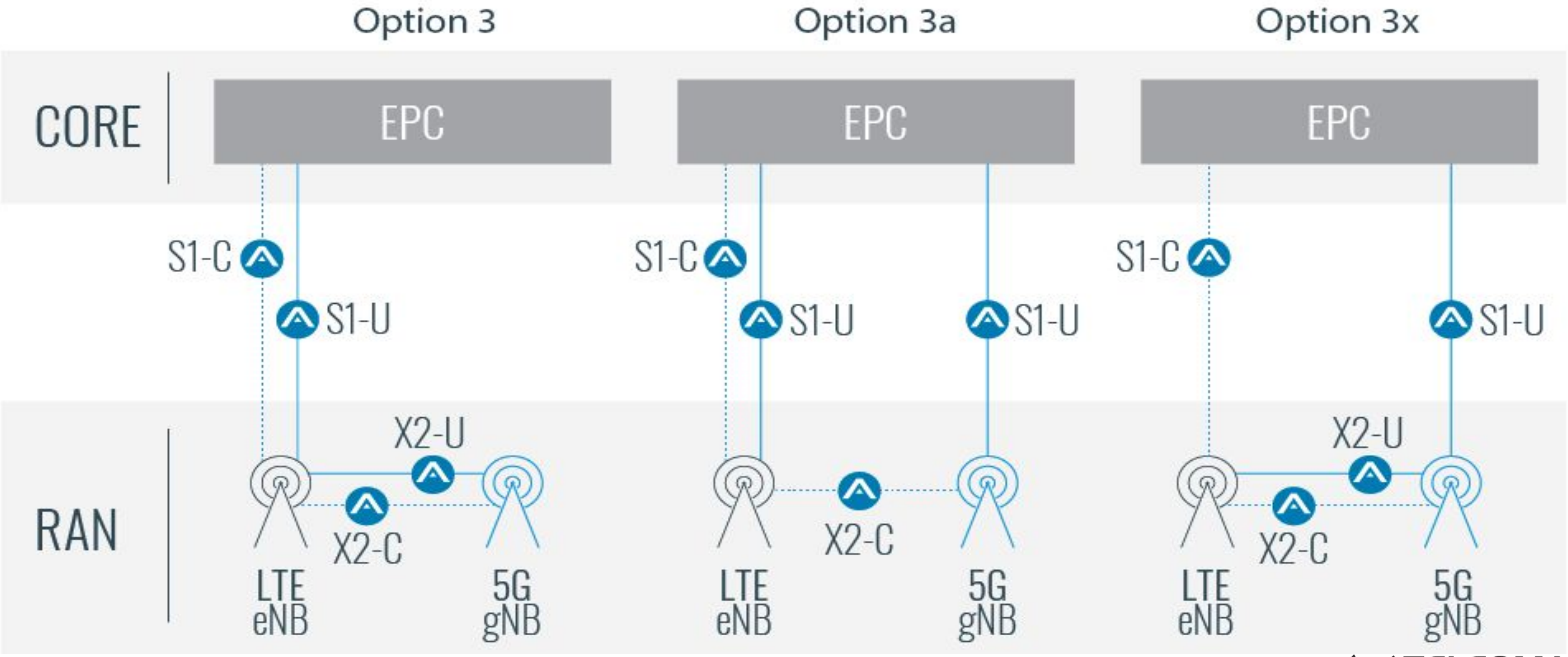
Option 3/3a/3x Networking Comparison

- In the option 3x, user data traffic will flow directly to the 5G gNB part of the base station.

- There is a little LTE user plane traffic in the X2 interface.

- It became the mainstream choice for NSA networking.

Option 3/3a/3x Networking Comparison



5G Deployment

5G Deployment

- 5G network application area includes : eMBB, URLLC and mMTC.

- Deployment considerations mainly focus on network planning, Massive MIMO selection, optimization of the coverage , synchronization configurations of time slot , deployment strategies and various steps in network deployment.

- 5G network needs to meet all the requirements of eMBB service experience.

5G Deployment

- 3GPP has defined performance requirements for high data rates and traffic densities. For eMBB 50 mbps for downlink is the basic requirement.

- To meet all the service experienced requirements in 5G early deployment, 100 mbps DL and 5 mbps UL required.

Performance Requirements

Scenario	Experienced data rate (DL)	Experienced data rate (UL)	Area traffic capacity (DL)	Area traffic capacity (UL)	Overall user density
Urban	50 mbps	25 mbps	100 gbps/km2	50 gbps/km2	10000/km2
Rural	50 mbps	25 mbps	1 gbps/km2	500 mbps/km2	100/km2
Indoor hotspot	1 gbps	500 mbps	15 Tbps/km2	2 Tbps/km2	250 000/km2
Dense urban	300 mbps	50 mbps	750 gbps/km2	125 gbps/km2	25 000/km2
High speed vehicle	50 mbps	25 mbps	[100]gbps/km2	[50]gbps/km2	4 000/km2

Service Requirements

Service	Resolution	2D	3D
Smart phone / surveillance	720P 1080P 2K	~1.5 mbps ~4 mbps ~10 mbps	
4K/Basic VR/AR	4K	~25 mbps	~50 mbps
8K/Immersive VR/AR	8K	~50 mbps	~100 mbps

Massive MIMO Selection

Massive MIMO selection

- The technical solution for 5G network that can improve both coverage and capacity is a technique known as Massive MIMO.

- Deployment of Massive MIMO requires basic considerations that includes performance requirements, installation requirements and TCO savings.

- In the initial stage of 5G deployment, 5G and 4G co-site deployment is recommended to ensure continuous coverage, reduced infrastructure, planning and optimization costs.

Massive MIMO selection

- The deployment options for 5G includes 16 T, 32 T and 64 T options.

- In high rise scenarios, 2D beamforming will provide benefits compared to 1D beamforming.

- 64T or 32T may have performance advantages compared to 16 T.

Massive MIMO selection

- 5G network deployment needs to fully consider performance, cost and weight limitation etc.

- 64T/32T tends to perform better in dense urban high-rise scenarios and are more efficient.

- 32T/16T tend to be more cost efficient in urban and sub-urban scenarios.

Massive MIMO selection

- 2T2R/4T4R/8T8R solution should be considered as a basic configuration for 5G deployment, deploying 16T16R/32T32R/64T64R to meet all the capacity requirements in these sites that need capacity upgrades.

Coverage Enhancement

Coverage Enhancement

- 5G network has C-band which is the primary band , it has large bandwidth which makes it perfect for eMBB services.

- DL coverage is better than UL coverage on the C-band due to large tx power of the gNB and time slot allocations of NR.

- The application of different technologies like beam forming and cell specific reference signal - free reduces DL interference and increases the difference between C-band UL and DL coverage.

Coverage Enhancement

- 3GPP Rel-15 introduces two mechanisms to handle the limited UL coverage on the higher bands, which are NR CA (Carrier Aggregation) and SUL (Supplementary Uplink) .

- The use of these mechanisms effectively utilize idle sub-3 GHz band resources, improve the UL coverage of C-band and enable the provisioning of 5G services in a wider area.

- Various field tests shows that combining DL on C-band with UL on sub 3 GHz can improve both UL & DL experience by 6 times.

NSA & SA Strategy

NSA & SA Strategy

- 3GPP defines NSA and SA architectures.
- Option 3X for NSA and option 2 for SA has become an industry consensus.
- The NSA can quickly deploy 5G network to support eMBB services and can be software upgraded to SA in the future.
- A network that migrates from NSA to SA will typically support multiple options simultaneously , by selecting the most suitable configuration for each device.

5G Network Deployment Strategy in Initial Stage

Network Deployment Strategy

- The capacity of 5G network is larger which can greatly enhance the user experience.
- Operators need to consider 5G network deployment from high value scenarios, users and services to enhance brand and user experience.
- Operators will focus on core urban areas, hotspots and high value areas to rapidly deploy 5G networks and provide services with traffic and brand demand.

Network Deployment Strategy

- High value scenarios and area include CBD, universities, governments, hospitals, airports , subways, venues etc.

- High value users include three type users : high package, high traffic volume and high value terminal.

- Besides eMBB services such as video and VR, operators must focus on industry incubation

Areas for initial 5G deployment

- Core urban
- Hotspot
- Value area

Transmission/Backhaul

- To meet all the requirements of 5G use cases i.e mobile data traffic growth, reduced latency, and scalability for densification of RAN networks, microcell deployments and cloud RAN - fronthaul implementation is considered as a key element.

- eCPRI and O-RAN interfaces are the main candidate for RRU and CU/DU connection for 5G scenario.

- eCPRI is the single interface which is required to be adopted for both 4G and 5G with defined requirements in terms of jitter & latency.

Transmission/Backhaul

- 5G networks are mainly based on TDD multiplexing where accurate phase synchronization is mandatory.
- The implementation of a GPS receiver on each radio system represents a solution but it has high deployment costs and security issues.
- IPSec deployment in 5G transport network will have to consider potential edge computing implementation.

Devices

Devices

- The device deployment needs to follow the related Network deployment option.

- A device that needs to work with a Network implementing NSA option, shall support all protocols requested by NSA implementation as well as all protocols requested by SA implementation.

- A device that needs to work with a Networking implementation SA option, shall support all protocols requested by SA implementation as well as all protocols requested by NSA implementation.

Devices

- The NSA option permits to the devices to avoid supporting 5G core network protocols at first stage.

- Sub 6 GHz band is not optimized for new 5G use cases except the mobile broadband.

Network Sharing

Network Sharing

- As network have been densified from previous generations to 4G, sharing of network infrastructure has become more popular.

- As 5G networks are more densified, so network sharing is becoming more popular.

- Network sharing comes in many forms : Passive Infrastructure sharing and Active infrastructure sharing

Network Sharing

- Passive infrastructure sharing is where non-electronic infrastructure at a cell site , such as power supply and management system, and physical elements such backhaul transport networks are shared.

- This form can be further classified into site sharing, where physical sites of base stations are shared, and shared backhaul , where transport networks from the radio controller to base stations are shared.

Network Sharing

- Active infrastructure sharing is sharing of electronic infrastructure of the network including RAN and CN.

- This is basically classified as : MORAN (Multi-operator Radio Access Network) : where radio access networks is shared and dedicated spectrum is used by each sharing operator, MOCN (Multi-operator core network) where RAN and spectrum are shared and core network sharing where servers and core network functionalities are shared.

Features supported by NSA Deployments (option 3)

Features

- NSA Network Architectures : option 3/3a/3x

- Connection management : System information broadcasting, Synchronization, Random Access Procedure, Radio access bearer management, interface management (S1-U/X2/Xn/F1)

- Mobility management : SN change procedure in NSA , Intra-MN handover without SN change in NSA, Intra-MN handover with SN Add/Release/change in NSA

Features

- Radio Resource management : Radio Admission control, Congestion control , load control.

- QoS management : MBR/AMBR , MBR for non-GBR services , legacy standard QCI

- User plane process : MAC PDU and functions, RLC PDU and functions , PDCP PDU and functions.

Features

- RAN Split and cloud RAN : eCPRI , Integrated management and control, NFV

- Radio part : basic physical layer support, SC-OFDM, sub-carrier spacing, PRACH with long/short sequences, long PUCCH/short PUCCH

Network transformation

Network Transformation

- 5G core networks will be designed with the assumption that the network will be fully virtualized and cloud native.

- 3GPP has standardized CUPS technology that decouples control and user plane of the 4G core network.

- Virtualized networks possess advantages in terms of cost , time to market and innovation.

Network Transformation

- In initial stages of virtualisation, single vendor approach may have advantages as it avoids complicated troubleshooting and cross layer fault detection.

- Such integration can also be realized lowering the TCO.

- An end-to-end design of the network can help achieve the telco-grade quality as industry standards for virtualized components are generally below telco-grade and hence end-to-end approach helps to overcome it.

Network Transformation

- The operator organisation needs to reflect the shift in operations and management paradigm associated with virtualized network.

- Roaming : 5G NSA option 3 will not introduce any changes in roaming architectures.

- Services (IMS-voice) : one of the important aspects of migration to 5G is the support of voice and related services.

Network Transformation

- Roaming with VoIMS : roaming support for VoIMS is an important feature and is essentially based on IMS roaming in a 4G or 5G environment.