Migration to 5G

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Migration to 5G

Introduction :

- Different configurations of 5G : SA and NSA
- SA : simple to manage , inter- generation HO between 4G-5G.
- NSA : leverage existing LTE deployments

5G network deployment options :

Standalone (SA) and non - standalone (NSA)

- Standalone uses only one Radio access technology. In this scenario, the 5G NR or the evolved LTE radio cells and the core network are operated alone.
- non - standalone is a simple solution for operators to manage and may be deployed as an independent network using inter-generation handover between 4G and 5G for service continuity.

Variations of SA defined by 3GPP :

- Option 1 : using EPC & LTE eNB access
- Option 2 : using 5GC & NR gNB access
- Option 5 : using 5GC & LTE ng-eNB access

Variations of NSA defined by 3GPP :

- Option 3 : using EPC & LTE eNB acting as master and NR en-gNB acting as secondary
- Option 4 : using 5GC & an NR gNB acting as master and LTE ng-eNB acting as secondary
- Option 7 : using 5GC & LTE ng-eNB acting as master and an NR gNB acting as secondary.

EPC & 5GC :

- EPC - evolution of packet core networks
- 5GC- “cloud-native” , inheriting many of the technical solutions used in cloud computing and with virtualisation at its core.
- 5GC offers superior network slicing and QoS features.
- 5GC offers separation of control plane & user plane.

5G network & migration paths

General observations & assumptions :

In this, it is assumed that the operator :

- Has deployed a full 4G system comprising an EPC and LTE access.
- Plans to migrate in mid- or long term to 5GS.

EPS to SA :

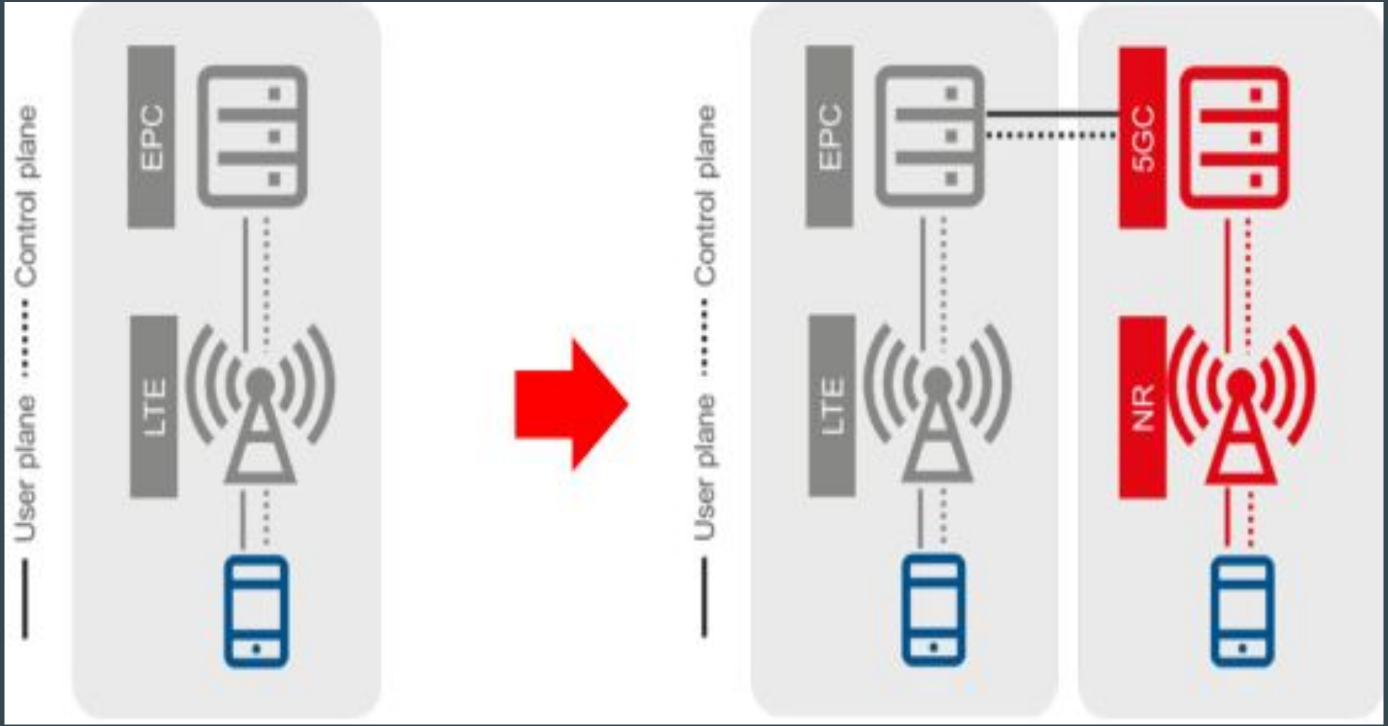
Feasibility of the path in meeting 5G use cases :

- It provides customized service especially to vertical industry in an efficient & effective way.
- New features including service based architecture, end- to -end network slicing and MEC can be enabled according to specific requirement of each service , providing superior user experience.

Deployment considerations :

- Option 2 provides an open , flexible and service based network architecture for 5G.
- For long term network architecture , it uses both the newly defined radio and core network.

Deployment considerations :



Impact on device and network :

- Option 2 provides an open , flexible and service based network architecture for 5G.
- For long term network architecture , it uses both the newly defined radio and core network.

Impact on device and network :

- Since SA operator provides services that are delivered over standalone 5GS, interworking between 5GS and EPS for service continuity for those services may be required.
- Single registration solution with or without AMF-MME interface.
- The UE supports complete set of functionalities for control plane & user plane and for all interfaces to the network.

Impact on voice including service continuity :

- Depends on whether the operator supports voice services over IMS and whether it provides national coverage.
- If the operator provides VoLTE with national coverage, then the operator can either provide IMS voice service over 5G network (5GS) or utilize existing VoLTE service.

EPS to NSA Option #3

EPS to NSA :

- It covers migration from EPS (option 1) to NSA (option 3) with the E-UTRA extended to allow compatible devices to use dual connectivity to combine LTE and NR radio access.

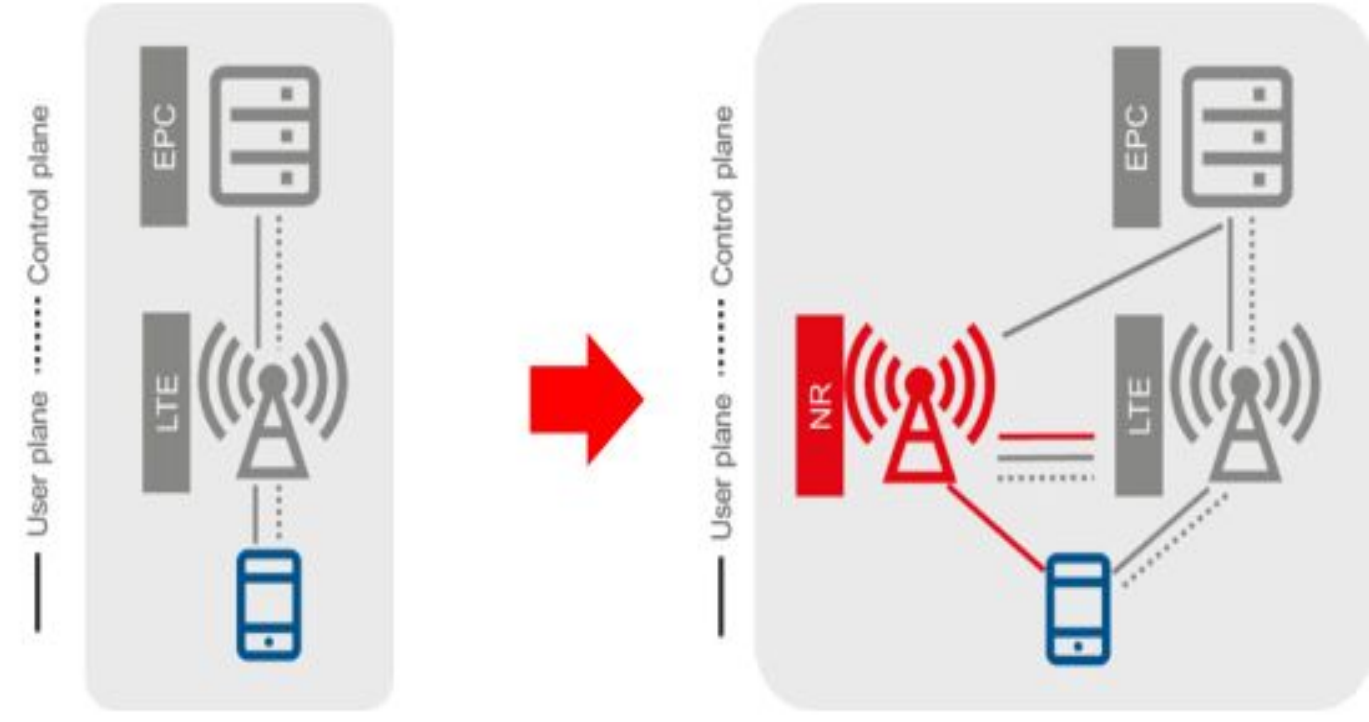
Feasibility of the path in meeting 5G use cases :

- It only requires the development of specifications of NR as NSA access as part of E-UTRAN connected to EPC.
- 3GPP completed the specifications of option 3 with the corresponding ASN.1
- The capability of deploying NR while anchoring the communication to the EPC network offers the opportunity of making optimal use of spectrum above 6 Ghz.

Deployment considerations of option 3:

- Depending on EPC features defined by 3GPP in rel-15, the EPC features may represent a possible bottleneck.
- Data throughput per 5G connected subscriber is expected to increase via NR and LTE in dual connectivity.

Description of EPS to NSA option 3 :



Impact on device and network :

- Option 3 requires deployment of NSA NR en-gNB in E-UTRAN and new features on LTE eNB to support EN-DC procedures , hence has impact on e-UTRAN.
- It also has an impact on UE, but limited impact on EPC and HSS depending on operator's choice , and no impact on IMS.
- From the point of view of the device , the attractiveness of this solution is that it only requires the additional support of specifications of NR as non-standalone access as part of E-UTRAN connected to EPC.

Impact on IMS voice including service continuity :

- Depending on whether the operator supports voice services over IMS and whether it provides national coverage or not, the feasibility of voice service continuity in this migration step will differ.
- If the operator provides VoLTE with national coverage, then there is no negative impact associated with migrating from EPS to NSA. the operator can utilize existing VoLTE service.

NSA option #3 to NSA option #7 & SA option #5

NSA option#3 to #7 & SA option #5 :

Feasibility of the path in meeting 5G use cases :

- In case, where the network was not able to leverage the advantages of 5GC in NSA option#3.
- In this path, 5GC is deployed so that the full advantage of 5G end-to-end network capabilities can be delivered to the users.

Deployment considerations :

- Since the 5GC is now used, this path requires that devices support the new protocol stack to access this core network.
- LTE RAN also needs upgrade to connect to 5GC and more LTE base stations may need to be upgraded to interwork with NR.
- It requires tight interworking between LTE & NR.

Impact on device & network :

- Option #7/5 upgrade from option #3 requires deployment of 5GC & upgrade of LTE eNB to support 5G session , mobility, QoS management and MR-DC procedures and 5GC N2/3 RAN core interfaces along with the upgrade of NR gNB to support 5GC N3 RAN- core user plane interface.

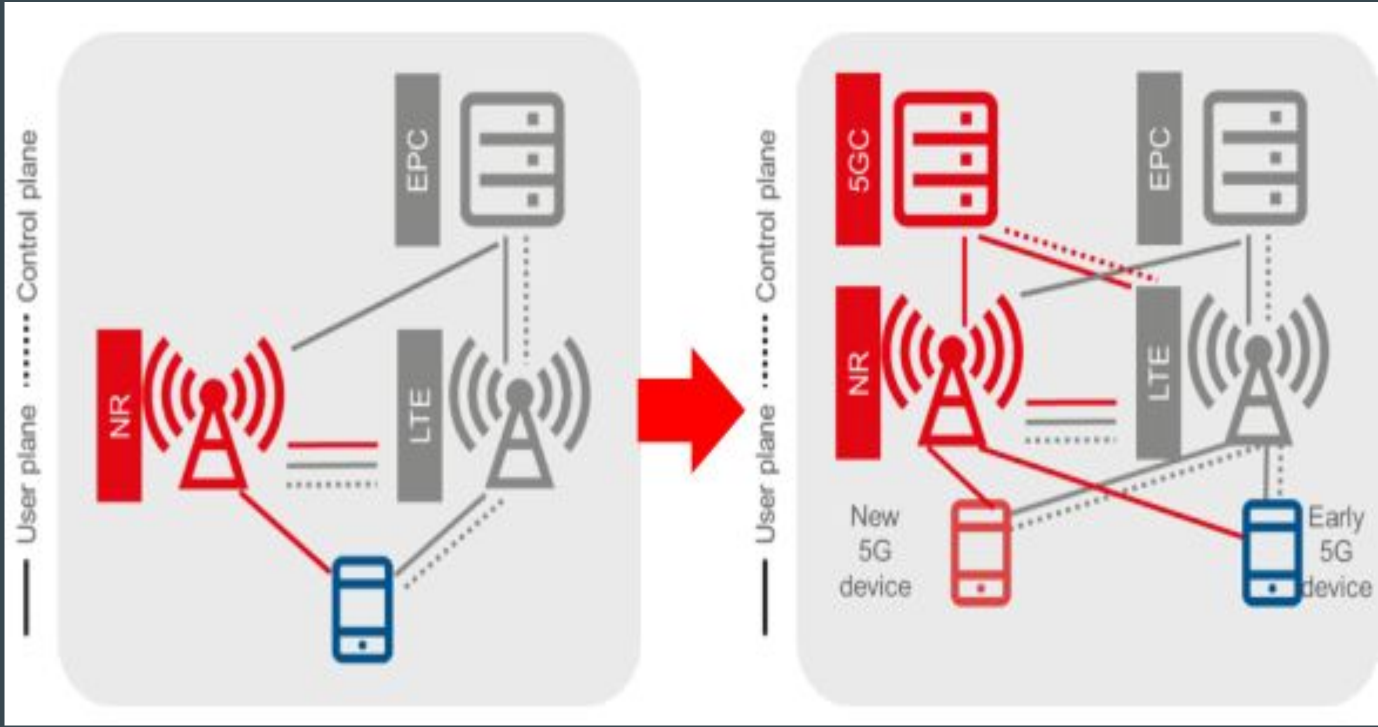
Impact on IMS voice including service continuity :

- If the operator provides VoLTE with national coverage, then there is no significant impact to service continuity as a result of migrating from NSA option #3 to NSA option #7 and SA option #5.
- The operator can either provide IMS voice service over 5GC or utilize existing VoLTE service.

Impact on IMS voice including service continuity :

- If the operator provides VoLTE with partial coverage and CS voice complements VoLTE to support national coverage, then the operator needs to utilize existing VoLTE service and ensure that continuity between LTE & CS access is implemented.(e.g SRVCC & CSFB).
- If the operator doesn't provide VoLTE and provide CS voice with national coverage only, then this migration step would involve investment.

Impact on IMS voice including service continuity :



NSA Option #3 to NSA option #3 and SA option #2

Description :

- It covers the migration from having only NSA option #3 to adding SA option #2 with inter-RAT mobility mechanisms used to move devices between 5G NSA plus NR under EPC coverage and 5G NR under 5GC coverage.

Feasibility of the path in meeting 5G use cases :

- In this path, 5GC is deployed so that the full advantage of 5G end-to-end network capabilities can be delivered to the users.
- This path enables operators to address all use cases on clean slate 5GS architecture.
- Operator need to consider migration of initial use cases served by EPC to 5GC if all cases are to be supported by 5GC.

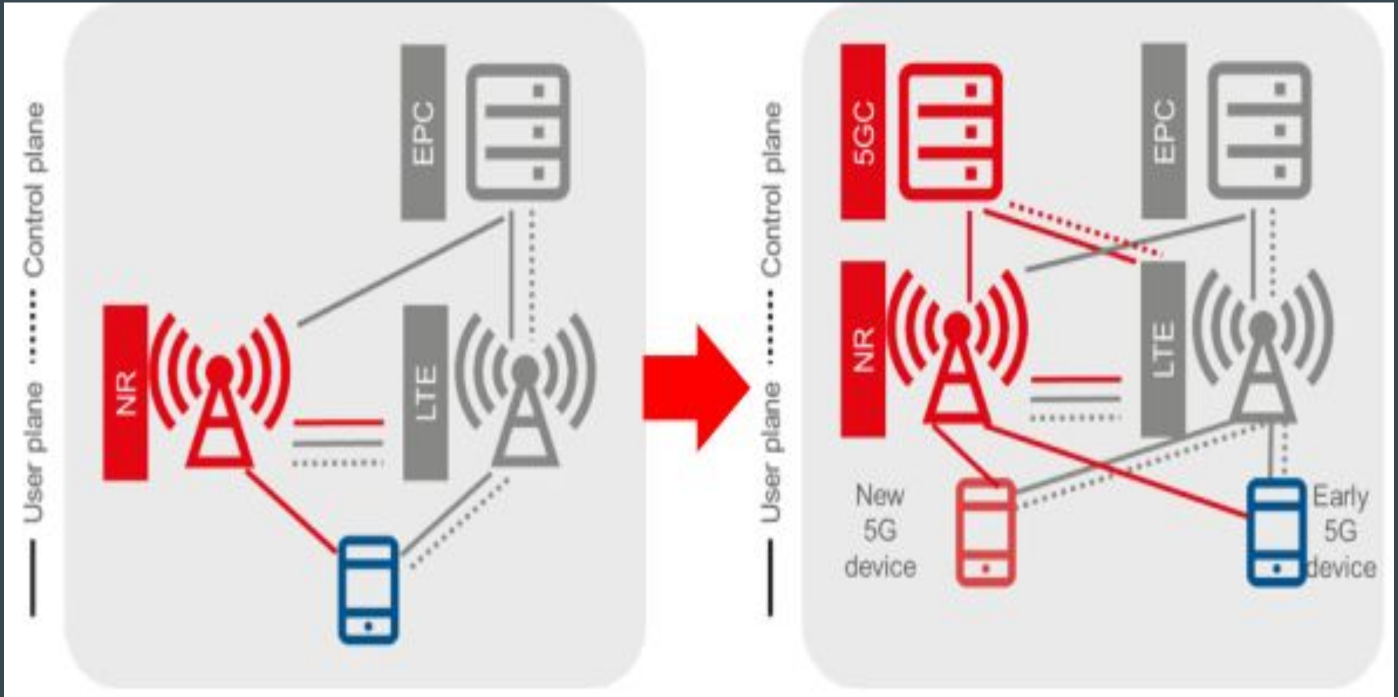
Deployment considerations :

- There is no tight interworking at radio level between 4G & 5G , this path works best when NR has been deployed to support wide area coverage.
- Early 5G devices supporting only NSA option #3 , and capable of communicating only with EPC , will be able to use their 5G radio capabilities in the target scenario provided the gNB is able to support both option #2 & 3 simultaneously.

Impact on device & network :

- Option #2 requires deployment of 5GC and update of NR gNB to support both NSA and SA option in parallel.
- Option #2 has impact on E-UTRAN connected to EPC to support inter-RAT mobility , IMS to support 5GS QoS management and also on UE.

NSA option #3 to 3 & SA option #2 :

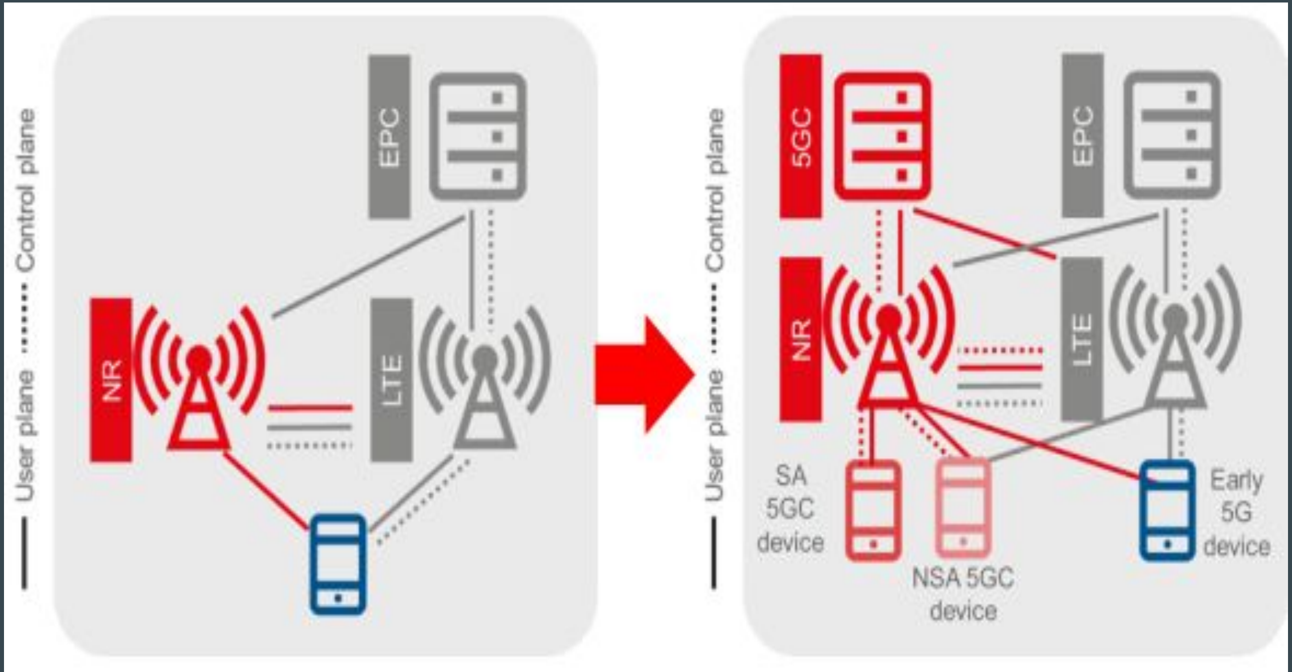


Impact on IMS voice including service continuity:

- If the operator provides VoLTE with national coverage, then there is no significant impact associated with migration from NSA option #3 to SA option #2.
- The operator can either provide IMS voice service over 5G network (5GS) or utilize existing VoLTE service.
- If VoLTE service is utilized, then it is necessary to continue to support EPC for subscribers using voice services.

NSA option #3 to NSA option #4 & SA option #2

NSA option #3 to #4 & SA option #2 :



Feasibility of the path in meeting 5G use cases :

- The 5G core network is used to replace the EPC in serving 5G use cases.
- This path enables operators to address all use cases on clean slate 5GS architecture.
- The operator may need to consider migration of initial use cases served by EPC to 5GC if all use cases are supported by 5GC.

Feasibility of the path in meeting 5G use cases :

- The 5G core network is used to replace the EPC in serving 5G use cases.
- This path enables operators to address all use cases on clean slate 5GS architecture.
- The operator may need to consider migration of initial use cases served by EPC to 5GC if all use cases are supported by 5GC.

Deployment considerations :

- Early 5G devices supporting only NSA option #3 and only able to connect to EPC will imply that operators will keep maintaining the EPC for long term.
- LTE RAN needs upgrade to connect to 5GC and more LTE base stations may need to be upgraded to interwork with NR.
- This path allows operators to continue to selectively deploy NR only when needed.

Impact on device and network :

- It requires deployment of 5GC and upgrade of NR gNB to support 5GS session, mobility, QoS management.
- N2 interface is the interface between the 5G RAN and AMF.
- N3 interface is the interface between 5G RAN and UPF.

Impact on IMS voice including service continuity :

- If the operator provides VoLTE with national coverage, then there is no significant impact associated with migrating from NSA option #3 to option #4.
- The operator can either provide IMS voice service over 5G network or utilize existing VoLTE service.
- If VoLTE service is utilized , the EPC is necessary for subscribers when voice service is used.

Analysis of 5G migration options

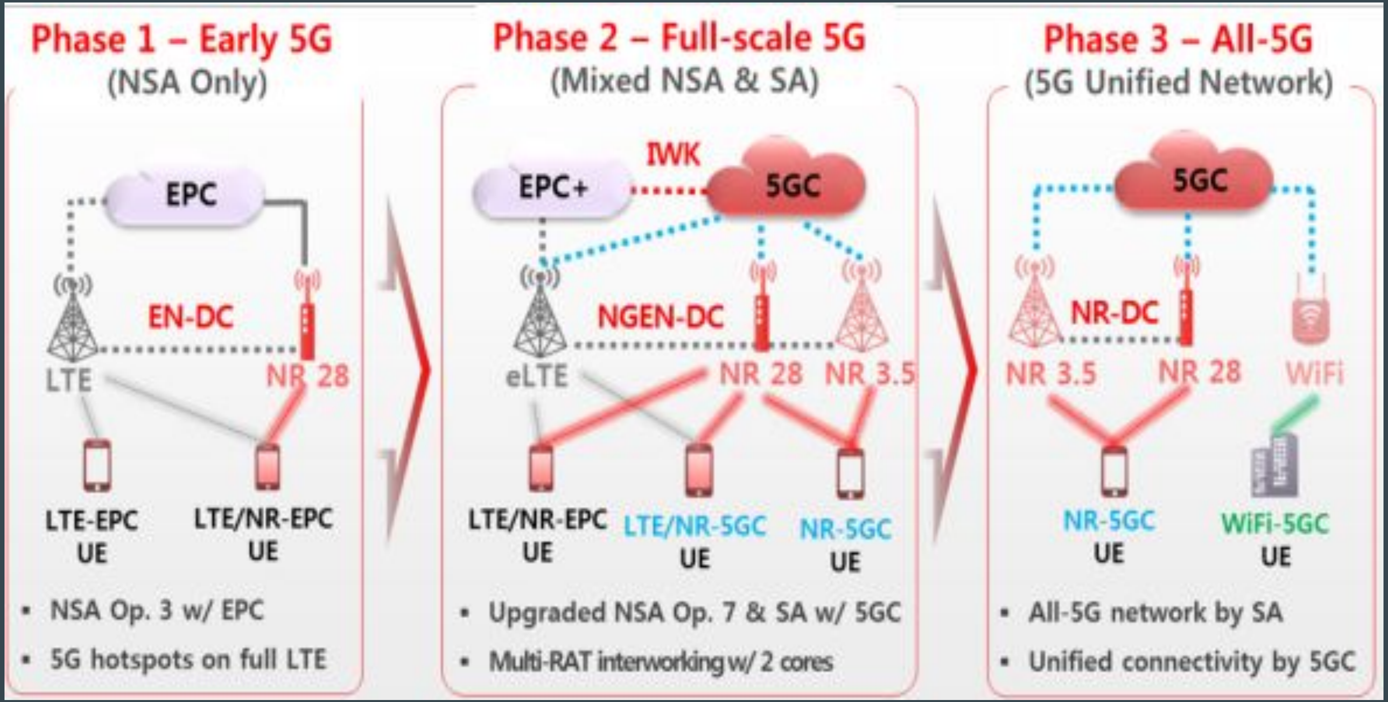
Major technical issues of NSA & SA :

- Spectrum
- Core network
- RAN

Rationale behind migration options :

- System/device availability
- Deployment
- Migration
- services

5G network migration plan :



Deployment phases :

- Phase 1 : early 5G
- Phase 2 : full - scale 5G
- Phase 3 : all - 5G

5G mobile network deployment scenarios

Deployment scenarios :

There are two possible scenarios for nationwide deployment :

- Scenario #1
- Scenario #2

5G Deployment & migration issues :

- Migration timeframe from NSA to SA
- Whether to upgrade to option 7 after the initial deployment of option 3 or not.
- Partial reframing of lTE to NR band can be considered at the mature 5G stage.
- Support of legacy 5G devices
- Unified control of wi-fi apps through 5G network.

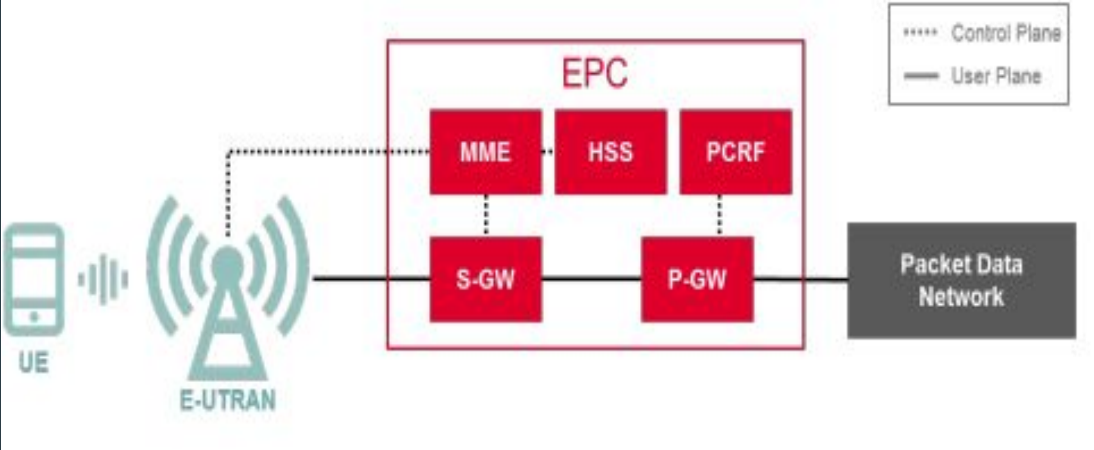
5G core network considerations

5G core network solutions

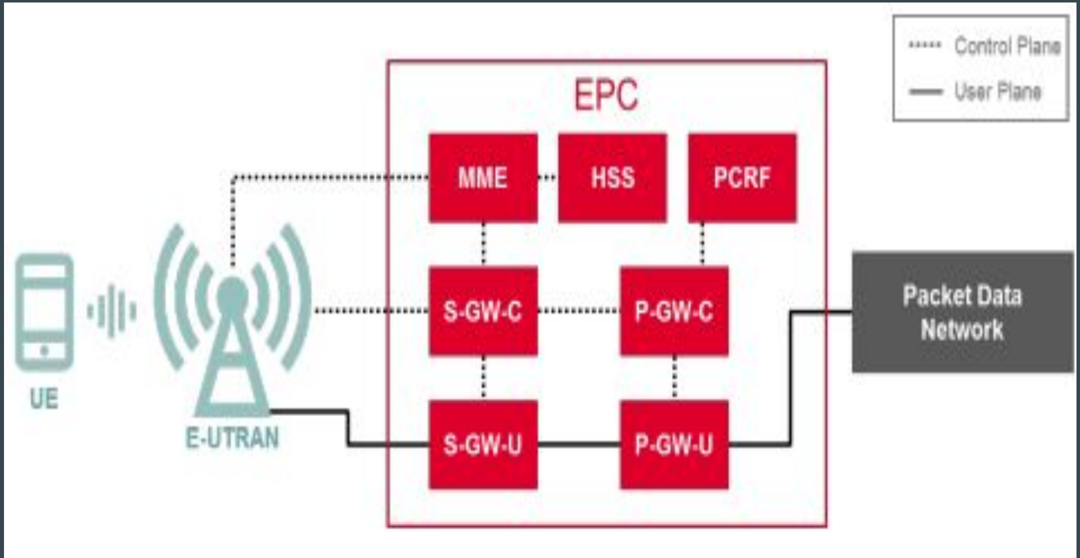
Evolved packet core (EPC) :

- It is the core network element of 4G.
- EPC handles EMM & ESM procedures.
- CUPS is a new feature introduced in rel-14 of 3GPP.
- CUPS supports flexible/scalable user plane deployment without expanding or upgrading the control plane.

EPC architecture - non-roaming :



EPC architecture with CUPS - non-roaming :



5G core network considerations

5GC or 5G Core

5G core :

- With NFV technologies, the mobile network functions can be virtualized and hosted in a cloud environment.
- AF, AMF, AUSF, NEF, NRF, NSSF, PCF, SMF, SMSF, UDM and UPF.

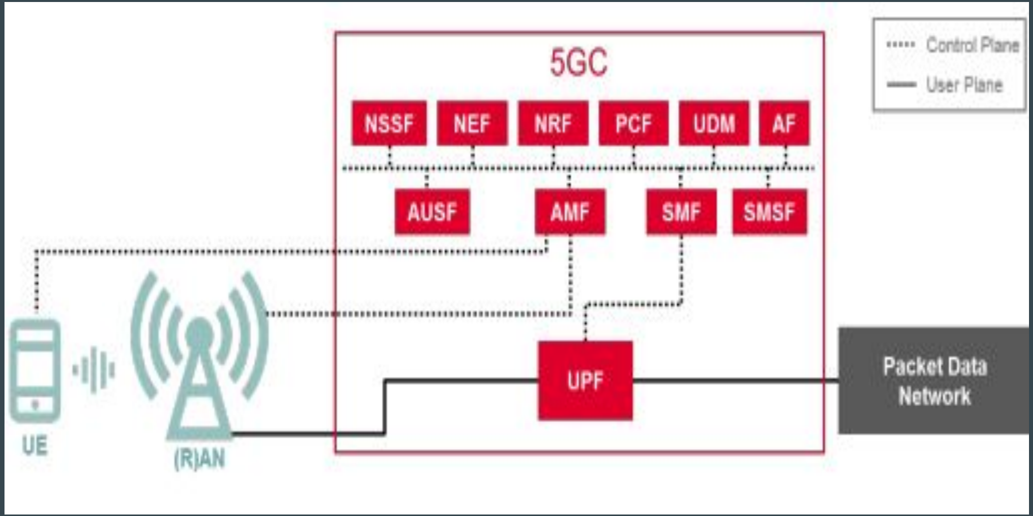
5G core :

- 5GC proposes the SBA architecture which provides efficiency and flexibility for the network.
- SBA is an architectural for building system based on fine-grained , interaction of loosely coupled and autonomous components called services.
- This architectural model is chosen to take full advantage of the latest virtualization and software technologies.

5G core :

- NRF (network repository functions) allows every network function to discover the services offered by other network functions.
- A service is an atomized capability in a 5G network , with the characteristics of high-cohesion, loose coupling and independent management from other services.

SBA of 5G core - non-roaming :



SBA benefits to 5G :

- The network is highly efficient on rolling out new network features , allowing network operators to quickly deploy new business & services.
- The network is extensible.
- The network will be modular and support re-usability.
- The network is easily open.

Detailed considerations on 5G deployment options

Standalone considerations :

- In SA deployment, only single RAT is used to connect UE to the relevant core network.
- Depending on the deployment option considered, the following radio access network elements are considered :
- eNB : option #1
- gNB : option #2
- Ng - eNB : option #5

Non-standalone considerations :

- In NSA deployment, MR-DC is employed.
- One schedular is located in the master node and other in the secondary node.
- The MN and SN are interconnected and at least MN is connected to the core network.

Impact on voice including service continuity

voice/video communications service :

- IMS voice and video call will be supported in all 5G deployment options.
- There are differences regarding which core network and which RAT is being used for media and SIP signalling in each of the deployment options.

Solution 1 :

IMS voice & video call via 5GC, media and SIP signalling using :

- In option 2 : NR via 5GC
- In option 4 : NR and/or LTE via 5GC using MCG, SCG and/or split bearer (controlled by NG-RAN)
- In option 5 : LTE via 5GC
- In option 7 : LTE and/or NR via 5GC using MCG, SCG and /or split bearer (controlled by NG-RAN)

Solution 1 :

- RAT fallback from NR connected to 5GC in option 2/4 to E-UTRA connected to 5GC in option 5/7.
- EPS fallback from 5GS in option 2/4/5/7 to option 1 or 3.

Solution 2 :

IMS voice or video call via EPC media and SIP signalling :

- In option 3 : LTE and/or NR via EPC using MCG, SCG and/or split bearer (controlled by E-UTRAN).

For networks that have not deployed IMS voice and video and have continued to use CSFB solution.

Solution 3 :

CS voice via MSC

- In option 3 : CSFB to 2G/3G CS - devices currently attached to EPC may use this solution to initiate or terminate a voice or video call .

From an IMS voice or video call, the session continuity during mobility is ensured.

Recommendations for voice/video communications service in 5G

Recommendations :

- EVS codec is recommended as default voice codec.
- HEVC codec is recommended as default video codec for IMS voice and video call on NR capable terminal for better QoS/QoE.

Recommendations :

- When evolving to 5G based on EPC, IMS voice and video call most applicable.

Massive MIMO technology

Overview :

- Massive MIMO benefits the network in terms of both capacity and coverage.
- A 20 Mhz channel of spectrum can transmit more data quicker using 64 different antenna paths than it would with 4 antenna paths.
- Applying massive MIMO to larger spectrum channels found in the 3.5 Ghz band will bring even greater capacity improvements to that band.

Overview :

- The enhanced coverage is possible.
- Massive MIMO enhances the already attractive properties of 3,5 Ghz making it suitable for 5G initial deployments.

5G spectrum & deployment

Steps :

1. Current LTE operator status
2. Add NR @ mid band (3.4 - 3.8 Ghz)
3. Add NR @ low band (700/1800 Mhz)
4. Add NR @ high band (26 Ghz)
5. Critical IOT

3.4 - 3.8 GHz spectrum :

- C-band is the primary band in EU with earlier availability.
- Early C-band terminal availability v/s other bands

Non stand-alone :

- Early NR introduction
- Extended DL coverage
- Increased bandwidth
- Minimal network impact & voice support

NR @ low band :

- NR coverage through low band
- Better performance of NR vs LTE
- Extended DL coverage

NR-LTE spectrum sharing :

- Pre - refarming
- NR at lowest TCO

Mm wave 26 Ghz :

- 26 Ghz is the pioneer band in EU.

Stand alone :

- 5G full architecture

Global spectrum picture

Global spectrum :

- To deploy 5G in new mid-bands (3.5 - 6 GHz) and existing legacy mid - bands (1800-2600 MHz).
- Utilizing legacy spectrum in combination with new bands enables operators to serve a wider variety of use cases more efficiently.

Spectrum allocation over time :

- High bands : 24 GHz - 40 GHz
- Mid bands : 3.5 GHz - 6 GHz
- Mid bands : 1 - 2.6 GHz
- Low bands : sub 1 GHz

Spectrum :

- Each spectrum band has different physical properties, which means that there is a trade off between capacity, coverage and latency, as well as reliability and spectral efficiency.
- New mid band spectrum allocated in 3.5 GHz spectrum bands.

Two phase approach

Two phase approach :

- It will use the 3GPP standardized options for LTE-NR interworking connected to an upgraded EPC, 5G EPC.
- NSA 5G option 3 providing connectivity for combined LTE and NR systems.
- It is important in this that existing network is not disrupted.

Two phase approach :

- It will use the 3GPP standardized options for LTE-NR interworking connected to an upgraded EPC, 5G EPC.
- NSA 5G option 3 providing connectivity for combined LTE and NR systems.
- It is important in this that existing network is not disrupted.

Two phase approach :

- SA 5G operation creates an independent 5G overlay with both control plane and user plane are carried over 5G NR access.
- New 5GC is required to support 5G SA.
- Phase 2 : it is based on new architecture and support it in both RAN and CN

5G Deployment cases

Case 1 :

NSA 5G with 4G and 5G in similar mid/low bands :

- Both 4G and NSA 5G radios are deployed in similar mid/low band frequencies.
- All radios can be physically co-located and connected to the existing core network.

Case 1 :

- Most operators deploying 5G in a way that has already an EPC network supporting 4G.
- If the 5G RAN carries significantly more traffic, operators may need to add additional baseband capacity to provide the additional processing power needed.

Case 2 :

NSA 5G with 4G in low/mid bands and 5G in high bands

- 4G is deployed in low frequencies, while NSA 5G is deployed in high frequencies. 5G cell coverage areas will be smaller than 4G, especially for UL.
- It may be possible to co-locate most 4G and 5G radios , some new sites will be needed outside the existing site grid to achieve contiguous coverage.

Case 3 :

SA 5G in low, mid or high bands

- In this, SA 5G is deployed in a combination of low, mid and possibly high bands.
- SA 5G deployments are likely to be used in private or enterprise networks, and industrial IOT in self contained factory or campus environment.

Key challenges in rolling out 5G

Challenges in rolling out 5G :

- Small cell deployment challenges
- Fiber backhaul
- Spectrum
- Other factors

Small cell deployment challenges :

Constraints to deploying small cells include :

- Local permitting & planning processes.
- Lengthy engagement & procurement exercises
- High fees & charges to access street furniture
- Human exposure to RF EMF
- Access and code powers

Fiber backhaul :

- Deploying fiber backhaul networks for small cells to support high data rates and low latency.
- A portfolio of wireless technologies including mmwave and satellite should be considered in addition to this.

Spectrum :

- Uniform allocation of spectrum has many advantages , as it minimizes radio interference across borders , facilitates international roaming and reduces the cost of equipment.
- Developed countries consider 700 MHz, 3.4 GHz and 24 GHz bands for initial deployment of 5G to satisfy coverage and capacity requirements.

Other factors :

- Device availability
- Coordination of industry verticals
- Net neutrality

Streamlining small cell deployments

Streamlining small cell deployments :

- The bills restrict the fees that local governments may charge and some go further to ensure no exclusive arrangements are made with wireless providers.
- Granting providers non-discriminatory access to public property.
- Allowing local governments to charge permit fees that are fair and reasonable.

factors :

- Policy intervention - fiber & spectrum
- Infrastructure sharing
- Transition to fiber
- Addressing local planning challenges

Spectrum harmonisation :

- The focus on early 5G applications has been on the bands above 24 GHz and below 6 GHz.
- Use of mmwave bands to maximize the opportunity for global spectrum harmonisation.

Spectrum licensing :

- The licensed spectrum allows mobile operators to plan and invest in mobile infrastructure with certainty and should include conditions to ensure that the allocated spectrum is effectively used, particularly in rural areas.
- Unlicensed spectrum is more appropriate in high frequency bands such as mmwave band which has poorer propagation characteristics.

Thanks ...

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