VoLTE/ViLTE interconnection.
Common issues and the way forward toward 5G

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- Draft Recommendation ITU-T Q.3953 "VoLTE/ViLTE interconnection testing for interworking and roaming scenarios"
- The way forward toward 5G

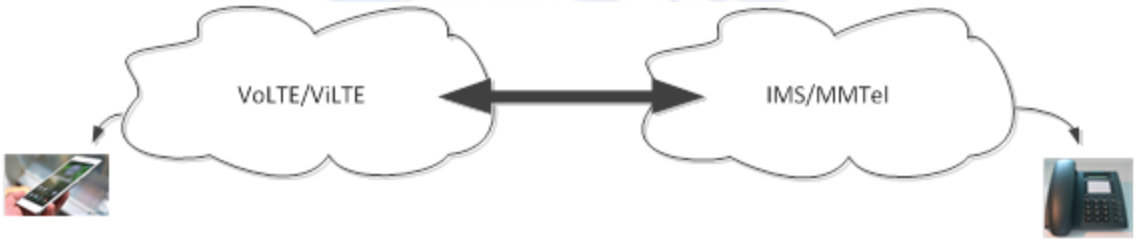
General info about IMS interconnection

- **The project VoLTE/ViLTE interconnection requirements and testing is a joint project between ITU-T SG11 and ETSI TC INT**
- **Published Recommendations and Standards**
  - **Recommendation ITU-T Q.3940: NGN/IMS interconnection tests between network operators at the IMS 'Ic' interface and NGN NNI/SIP-I**
  - **ETSI TS 101 585-1 IMS interconnection tests at the Ic Interface**
- **In development:**
  - **Draft Recommendation ITU-T Q.3640 "Framework of interconnection of VoLTE/ViLTE-based networks"**
  - **Draft Recommendation ITU-T Q.3953 "VoLTE/ViLTE interconnection testing for interworking and roaming scenarios"**

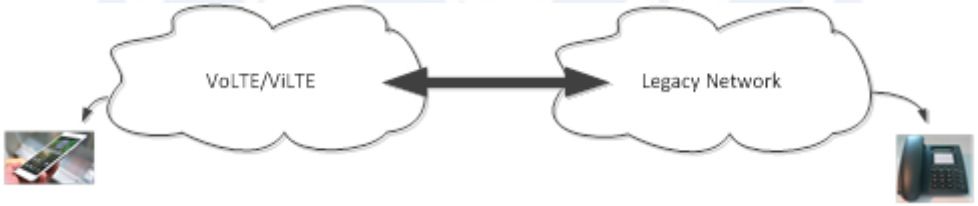
Draft Recommendation ITU-T Q.3640 "Framework of interconnection of VoLTE/ViLTE-based networks"

- **Key issues of interconnection**
  - **different options for signalling protocols used for Inter-IMS interconnection, which can support all existing services (basic call and supplementary services);**
  - **different options for roaming scenarios (there are no strict requirements for operators and no default option);**
  - **charging (e.g. roaming charges, calls using interconnection networks);**
  - **numbering/addressing (e.g. ENUM resolution, ITU-T E.164 → SIP-URI conversion);**
  - **floating delay (problem of providing legacy services and applications, e.g. Fax/Modem over IP);**
  - **Lawful interception**
  - **Data retention**
  - **Emergency services (e.g. emergency call 112)**

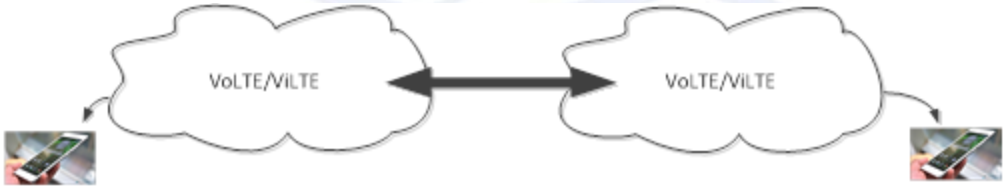
Q.3640
E2E scenarios in terms of interconnection and roaming



VoLTE – IMS/MMTel interconnection scenarios



VoLTE – Legacy network interconnection scenarios



VoLTE/ViLTE – VoLTE/ViLTE interconnection scenarios

Q.3640
E2E scenarios in terms of interconnection and roaming

- It the recommendation are listed 30 E2E scenarios (see example)

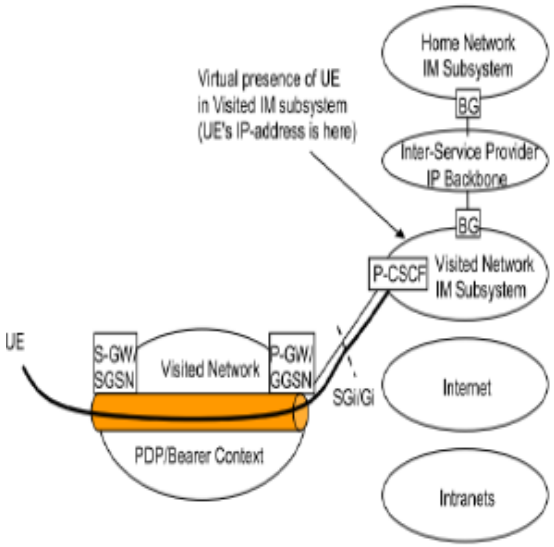
No.	Scenario	Description	Roaming options
VoLTE – IMS interworking scenarios			
1	Scenario 1	The user UE1 (a) is in the IMS network A , UE2 (a) in HPMN (a)	
2	Scenario 1A	The user UE 1 (a) is in the IMS network A , UE2 (a) in HPMN (a) with CSFB (circuit switched fallback) Note: occurs only in the case if VoPS is not supported in the HMPMN's LTE N/W	
3	Scenario 1B	The user UE1 (a) is in the IMS network A , UE2 (a) in HPMN (a) is moving from 4G to 3G coverage with SRVCC	
4	Scenario 1C	The user UE1 (a) is in the IMS network A , UE2 (a) roamed in VPMN (b)	- Local Breakout VPMN Routing architecture (LBO-VR) - LBO Home Routing architecture (LBO-HR) - S8HR VoLTE Roaming architecture
5	Scenario 1D	The user UE1 (a) is in the IMS network A , UE2 (a) roamed in VPMN (b) moving from 4G to 3G coverage with SRVCC	- Local Breakout VPMN Routing architecture (LBO-VR) - LBO Home Routing architecture (LBO-HR) - S8HR VoLTE Roaming architecture

Q.3640
VoLTE Considerations

- EPC Consideration
- EPC Configuration Requirements
- Device and U/ISIM consideration
  - Multi-Mode and Multi-band Terminal
  - General Requirements for VoLTE Terminal
  - RAN Features
  - IMS function on control plane
  - IMS function on media plane
  - Services Requirements

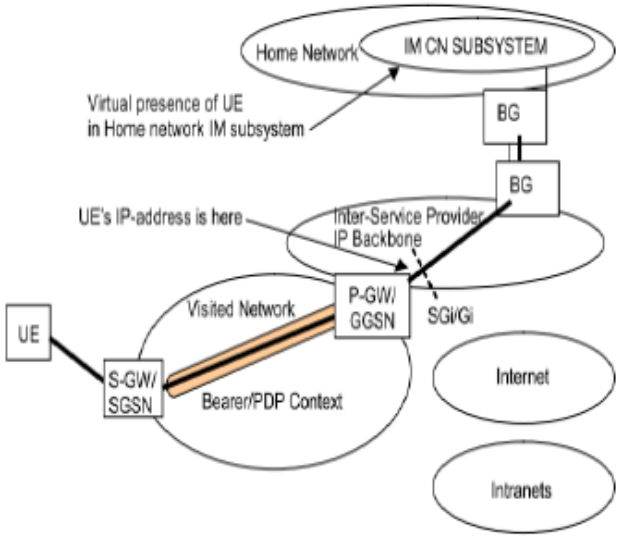
3 Types of IMS roaming architectures

Case1, PCSCF is located in VPLMN



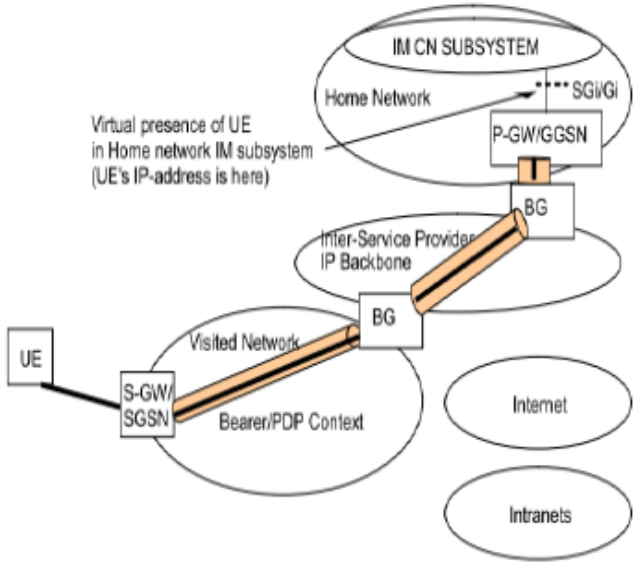
Target IMS roaming solution, IMS is required in both VPLMN and HPLMN

Case2: PCSCF is located in HPLMN, EPC local breakout (Sgi/Gi interface)



Data local breakout, but IMS home routed, IMS is no needed in VPLMN

Case3: PCSCF and P-GW/GGSN are both located in HPLMN



Data and IMS are both home routed, IMS is no needed in VPLMN

Comparison of VoLTE Roaming Architectures

Item	Option 1 LBO-VR (Target IMS roaming solution, IMS is required in both VPLMN and HPLMN)	Option 2, LBO-HR (Data local breakout, but IMS home routed, IMS is not needed in VPLMN)	Option 3 S8HR Data and IMS are both home routed, IMS is not needed in VPLMN
HPLMN with VoLTE implementation	Required	Required	Required
VPLMN with VoLTE implementation	Required	Not required	Not required
IMS service over GRX	Not required	Required	Required
Charging depending on Evolved Packet Core (EPC)	Optional (Charge on IMS service layer)	Required	Required
Policy and charging control mode	HPLMN hPCRF can controlthe VPLMN vPCRF via S9 Interface (S9 interface is optional)	HPLMN hPCRF controls VPLMN vPCRF via S9 Interface or via roaming agreement and support of common QCIs	HPLMN hPCRF controls HPLMN PGW, 2/3G and 4G (e.g Web browsing) data roaming via S8
Single Radio Voice Call Continuity (SRVCC) support capability	Fully Supported	Supported	Partially supported
VoLTE local emergency call	Supported	Supported	Not supported
VoLTE local LI	Supported	Supported	Not supported (LI will be possible at the S-GW (under development in Rel. 14 of 3GPP).
LBO with Optimal Media Routeing (OMR)	Supported	Not supported	Not supported

Services for e2e VoLTE/ViLTE interconnection scenarios

#	Service	ITU-T Recommendation	Relevant standard developed by other SDO	Status
1.	Basic call (voice and video sessions)	Q.3403 v.1	ETSI TS 124.229	M
Supplementary services				
1.	TIP/TIR	Q.3617 v.1	ETSI TS 124.608	O
1.	OIP/OIR	Q.3618 v.1	ETSI TS 124.607	M
1.	HOLD	Q.3619 v.1	ETSI TS 124.610	O
1.	CDIV	Q.3620 v.1	ETSI TS 124.604	O
1.	CONF	Q.3621 v.1	ETSI TS 124.605	O
1.	CW	Q.3622 v.1	ETSI TS 124.615	O
1.	ECT	Q.3623 v.1	ETSI TS 124.629	O
1.	MCID	Q.3624 v.1	ETSI TS 124.616	O
1.	CC	Q.3625 v.1	ETSI TS 124.642	O
1.	MWI	Q.3626 v.1	ETSI TS 124.606	O
1.	CUG	Q.3627 v.1	ETSI TS 124.654	M
1.	ACR-CB	Q.3628 v.1	ETSI TS 124.611	O

Protocol implementation statement (PICS)

Example of the PICS

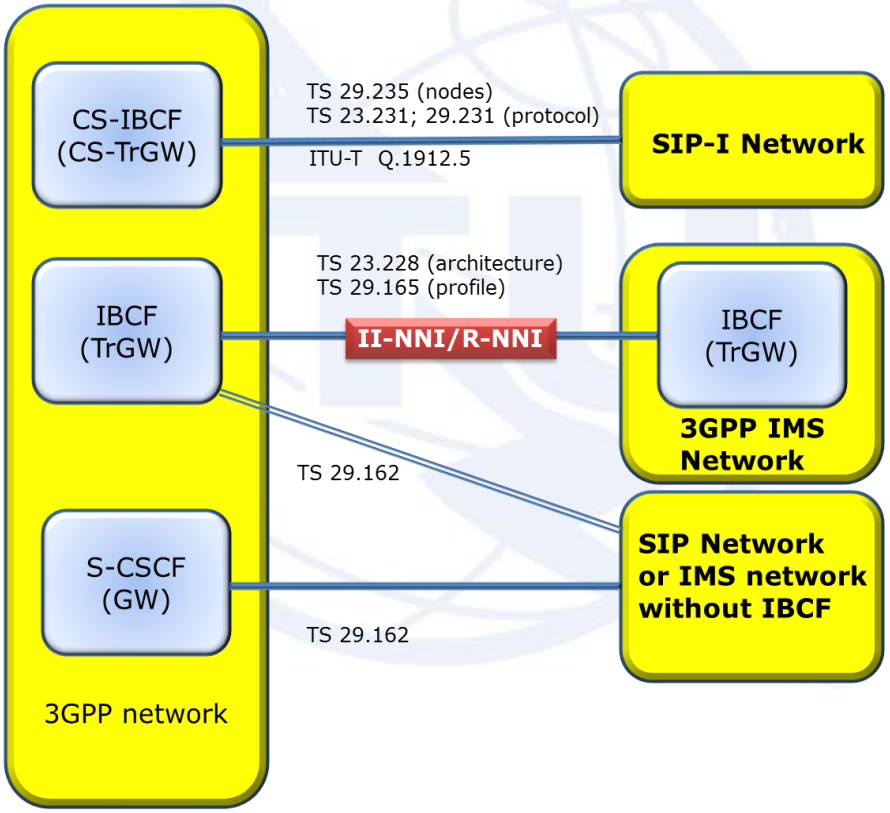
SELECTION EXPRESSION:	Support Network A	Support Network B
Network capabilities		
SE 1: The originating network (Network A) sends the P-Charging-Vector header?		
SE 2: The originating network (Network A) sends a subset of parameters in the P-Charging-Vector header?		
SE 3: The P-Early-Media header is supported?		
SE 4: Overlap procedure using multiple INVITE method is supported?		
SE 5: Overlap sending using in-dialog method is supported?		
SE 6: Network A supports the PSTN XML schema?		
SE 7: The resource reservation procedure is supported?		
SE 8: Does the network perform the "Fall back" procedure (PSTN or MGCF)?		
SE 9: The network is untrusted?		
SE 10: Originating network does not have a number portability data base, the number portability look up is done in the interconnected network?		
SE 11: The network supports the REFER method?		
SE 12: The Network supports the 3 party call control procedure (REFER interworking)?		
SE 13: The Number Portability is supported?		
SE 14: Carrier Selection is performed?		
SE 15: The Network is a Long distance carrier?		
SE 16: SIP Support of Charging is supported?		
SE 17: The interworking ISUP - SIP I is performed in the network?		
Supplementary services		

Recommendation ITU-T Q.3940: NGN/IMS interconnection tests between network operators at the IMS 'Ic' interface and NGN NNI/SIP-I

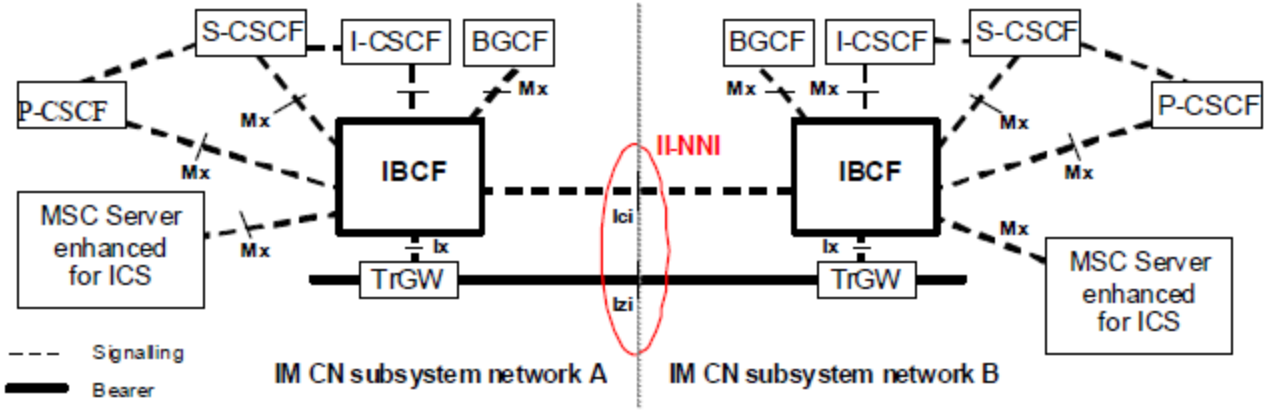
ITU-T Q.3940,
NGN/IMS interconnection tests between network operators at the IMS 'Ic' interface and NGN NNI/SIP-I

- **The Recommendation Q.3940 defines interconnection tests between national and international network operators, at the IMS interconnection (Ic) interface and NGN network-to-network interface (NNI)/SIP-I.**
- **Such tests have been developed to verify the overall compatibility of the session initiation protocol (SIP), the integrated services digital network (ISDN) and the non-ISDN (public switched telephone network (PSTN) over the national or international NGNs, with regard to the use of end devices in the relevant networks (recommended by the network operator).**

Recommendation ITU-T Q.3940
Control Plane Interfaces



Recommendation ITU-T Q.3940
Control / User Plane Interfaces



Recommendation ITU-T Q.3940
End devices used in the relevant network

	Network A	Network B
	0	0
SIP-VoIP		
POTS		
ISDN		
GSM		
VoUMTS		
VoLTE		
PSTN		

Highlight color	Explanation	Refernce
	The user equipment is a SIP hardphone or a SIP soft client on a PC in the fixed network The user equipment is a 4G mobile device in an LTE network The user equipment is a 3G mobile device in an UMTS network	TS 124 229
	The user equipment is an integrated end device in the fixed network - access via a legacy analogue device	TS 183 043
	The user equipment is an integrated end device in the fixed network - access via a legacy ISDN device	TS 183 036
	The user equipment is a 2G mobile device in an GSM network. SS7 / SIP interworking applies The user equipment is located in a fixed SS7 network (analogue or ISDN)	ITU-T Q.761 - Q764 TS129 163 ITU-T Q.1912.5

Draft Recommendation ITU-T Q.3953 "VoLTE/ViLTE interconnection testing for interworking and roaming scenarios"

Draft Recommendation ITU-T Q.3953

General info

- **The draft Q.3953 is based on the ITU-T Q.3940**
- **The Recommendation Q.3940 has been extended with the requirements defined in ITU-T Q.3640 "Framework of interconnection of VoLTE/ViLTE-based networks"**
  - **E2E scenarios in terms of interconnection and roaming**
  - **IMS Roaming and Interconnection Guidelines**

E2E scenarios examples in terms of interconnection and roaming

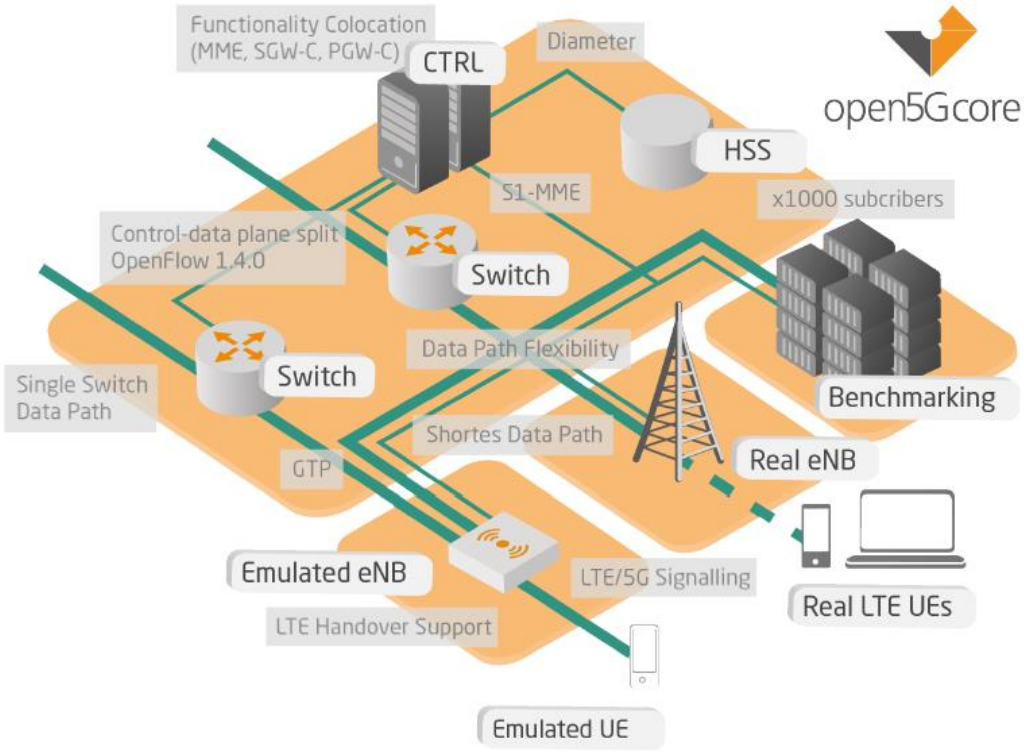
No.	Scenario	Description	Roaming options	Calling options
VoLTE – IMS interworking scenarios				
1	Scenario 1	The user UE1 (a) is in the IMS network A , UE2 (a) in HPMN (a)		The test shall be performed in both directions
2	Scenario 1A	The user UE 1 (a) is in the IMS network A , UE2 (a) in HPMN (a) with CSFB (circuit switched fallback) . Note: occurs only in the case if VoPS is not supported in the HMPMN's LTE N/W		The test shall be performed in both directions
3	Scenario 1B	The user UE1 (a) is in the IMS network A , UE2 (a) in HPMN (a) is moving from 4G to 3G coverage with SRVCC		The test shall be performed in both directions
4	Scenario 1C	The user UE1 (a) is in the IMS network A , UE2 (a) roamed in VPMN (b)	- Local Breakout VPMN Routing architecture (LBO-VR) - LBO Home Routing architecture (LBO-HR) - S8HR VoLTE Roaming architecture	The test shall be performed in both directions
5	Scenario 1D	The user UE1 (a) is in the IMS network A , UE2 (a) roamed in VPMN (b) moving from 4G to 3G coverage with SRVCC	- Local Breakout VPMN Routing architecture (LBO-VR) - LBO Home Routing architecture (LBO-HR) - S8HR VoLTE Roaming architecture	The test shall be performed in both directions

QoS User Plane Tests

- **The latest generation of interconnection tests includes QoS user plane tests**
- **For VoLTE interconnect and roaming with QoE and QoS Tests are following KPI mandatory:**
  - **call set-up time (Post Dialling Delay)**
  - **Listening speech quality**
  - **End-to-end audio delay,**
  - **End-to-end audio delay variation**
  - **Early media**

The way forward toward 5G

Cooperation ETSI TC INT / Fraunhofer FOKUS Project on Open5Gcore testing (Q10/11, Q11/11 ToR)

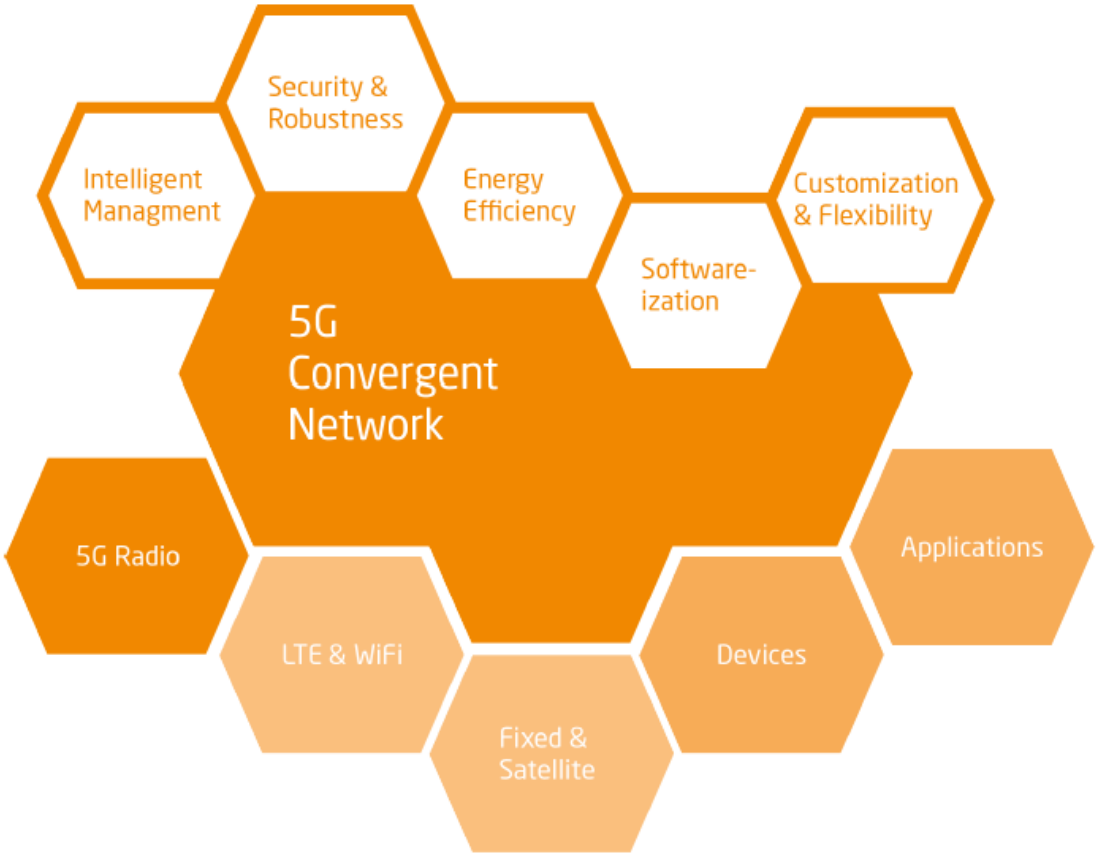


REF: A whitepaper of the Fraunhofer FOKUS Open5Gcore Project (www.Open5GCore.net)

Fraunhofer FOKUS Open5GCore

Fraunhofer FOKUS Open5GCore toolkit represents a pre-standard software implementation, of a comprehensive mobile environment beyond the 3GPP Evolved Packet Core architecture. The components of Open5GCore represent the R&D prototypes including the features with the highest industry relevance from the Fraunhofer FOKUS research activities.
Open5GCore follows the main research directions previously considered for the evolution of the 5G environment. The features are suitable for laboratory deployments and testing and not designed as products.

High Level View of 5G Ecosystem 5G Research Directions



REF: A whitepaper of the Fraunhofer FOKUS Open5Gcore Project (www.Open5GCore.net)

5G Research Directions of the Fraunhofer FOKUS

- New 5G RAN requires new Network
- Wireless System Convergence: LTE-A and WiFi
- Total convergence: fixed and satellite
- Customization and Flexibility
  - With the common acceptance of cloud technology/network functions virtualisation (NFV) as a means to provide computing and storing resources on demand and to flexibly scale these resources whenever required
- Software-ization
  - Software-ization is one of the most powerful concepts proposing the complete implementation of the core network, and partially of the radio, functions as software which runs on top of common hardware platforms for development and maintenance efficiency reasons.

REF: A whitepaper of the Fraunhofer FOKUS Open5Gcore Project (www.Open5GCore.net)

5G Research Directions of Fraunhofer FOKUS

- Complexity Management

  The 5G environment is foreseen to become even more complex, beyond human administration capabilities due to the integration of a new 5G access network, a high diversification of the radio-access within the same technology, convergence with other wireless access technologies and backhaul, massive parallelization, separate administration on top of a single shared physical infrastructure and the localization and distribution of applications.
- Security and Robustness
- The 5G Devices and Application
  - Devices are foreseen to span from small sensors, with challenged power consumption,and stringent delay concerns, up to high capacity real-time communicating devices. Based on these characteristics different connectivity models can be adopted and identified by the network, depending on the momentary conditions, such as device multi-access capabilities, radio access networks available in the vicinity, availability of the services in the proximity

REF: A whitepaper of the Fraunhofer FOKUS Open5Gcore Project (www.Open5GCore.net)

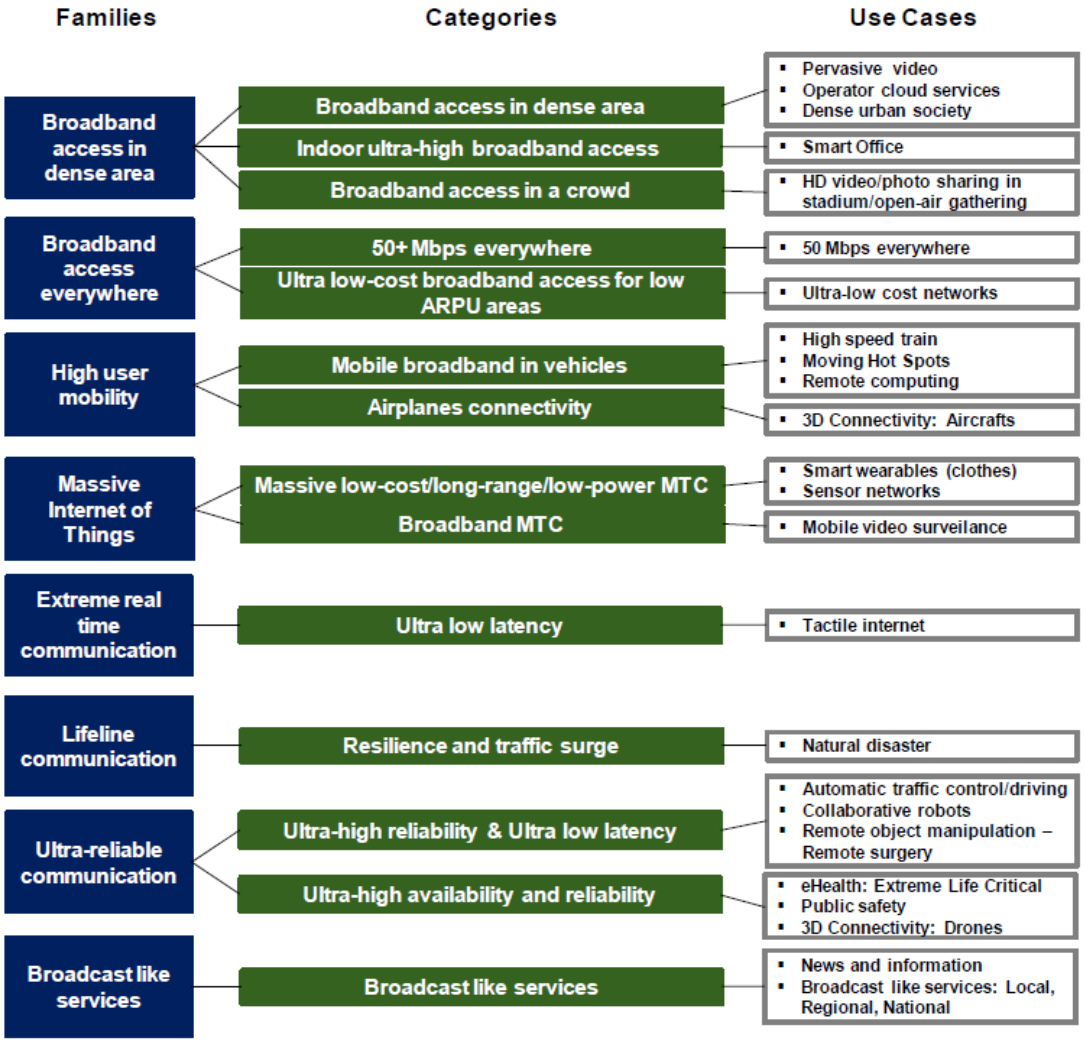
Timeline for 5G in ITU-R (WP5D) and 3GPP

Detailed timeline for 5G in 3GPP between 2016 and 2017

Report No.	Title	Completion
TSG-RAN		
TR 38.900	Study on channel model for frequency spectrum above 6 GHz	2016.06
TR 38.912	Study on New Radio (NR) Access Technology	2017.03
TR 38.801	Study on New Radio Access Technology; Radio Access Architecture and Interfaces	
TR 38.802	Study on New Radio Access Technology; Physical Layer Aspects	
TR 38.803	Study on New Radio Access Technology; RF and co-existence aspects	
TR 38.804	Study on New Radio Access Technology; Radio Interface Protocol Aspects	
TR 38.805	Study on New Radio Access Technology; 60 GHz Unlicensed Spectrum	
TR 38.913	Study on Scenarios and Requirements for Next Generation Access Technologies	2016.09
TSG-SA		
TR 22.891	Study on New Services and Markets Technology Enablers	2016.03
TR 22.861	FS_SMARTER - Massive Internet of Things	2016.06
TR 22.862	FS_SMARTER - Critical Communications	
TR 22.863	FS_SMARTER - Enhanced Mobile Broadband	
TR 22.864	FS_SMARTER - Network Operation	
TR 23.799	Study on Architecture for Next Generation System	2016.12
TR 33.899	Study on the security aspects of the next generation system	2017.03

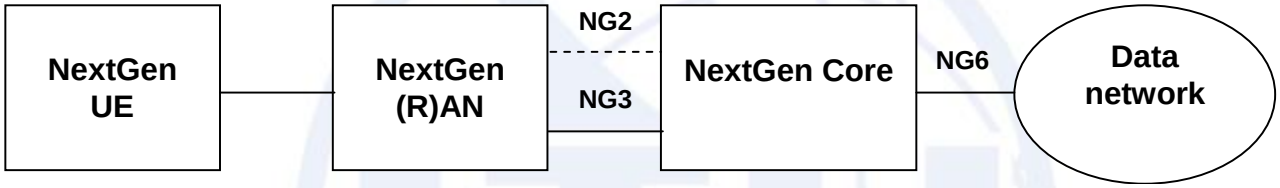
Some potential architecture configuration options are shown in RP-161266 (ftp://ftp.3gpp.org/TSG_RAN/TSG_RAN/TSGR_72/Docs/RP-161266.zip for information and will be analyzed further during the study)

Technologie Evolution - 5G Use cases



REF: NGMN 5G White Paper, Feb. 2015

Initial High level architecture view for NextGen System (REF: TS 23.799)



NG2: Reference point for the control plane between NextGen (R)AN and NextGen Core.

NG3: Reference point for the user plane between NextGen (R)AN and NextGen Core.

NG1: Reference point for the control plane between NextGen UE and NextGen Core.

NG6: It is the reference point between the NextGen Core and the data network. Data network may be an operator external public or private data network or an intra-operator data network, e.g. for provision of IMS services. This reference point corresponds to SGi for 3GPP accesses.

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Network slicing
  - Network slicing enables the operator to create and optimized solutions for different market scenarios which demands diverse requirements, e.g. in the areas of functionality, performance and isolation (defined in TR 22.864).
- QoS framework
  - The QoS framework should enable the operator to provide QoS for the wide range of use cases is expected to be fulfilled by the NextGen architecture.

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Mobility management signalling for:
  - UE/User registration to the network;
  - Support of reachability to enable mobile terminated communication;
  - Detection of UEs no longer reachable;
  - Assignment of CP and UP network functions (as needed); and
  - Mobility Restrictions, e.g. forbidding mobility at certain locations.
- Session management
  - Support for session and service continuity and efficient user plane path
  - Network function granularity and interactions between them
  - Next Generation core and access - functional division and interface
  - Policy Framework

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Support for session and service continuity and efficient user plane path
  - In order to address the specific needs of different applications and services, the next generation system architecture for mobile networks should support different levels of data session continuity based on the Mobility on demand concept of the Mobility framework defined in Key Issue “Mobility management signalling” or service continuity.
- Network function granularity and interactions between them
  - It is expected that network systems will consist of multiple physical and/or virtual network functions that may be deployed in the operator's network, and be able to support diverse service requirements.

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Next Generation core and access - functional division and interface
  - analyze in detail the functionality for the Next Generation Core and for the interface between the access networks and the Next Generation Core to support the LTE radio access network, the new, expected 5G radio access network (depending on information available from RAN design and the SMARTER requirements), and for non-3GPP access networks, in order to identify the functional split between AN and Core Network, and to identify if a single AN-CN interface can be specified which can be used across many different access networks. In particular, the functionality should be decomposed between:
  - identify how the various functionality correlate to each other and identify interdependencies - i.e. impacting Next Generation Core, AN and UE.
  - identify how the functionality can be modularized for the definition of a modular Next Generation Core -ANs interface that minimizes access dependencies and applies to any access networks.
  - identify how to decouple the access network and the core network, and identify its effects and implications to the Next Generation Core. Such decoupling shall allow for parallel and independent design and evolution of access networks and core networks
  - identify how the UE interfaces with the Next Generation Core in a manner that minimizes access dependencies and that is applied independent of the access network via which the UE is accessing the Next Generation Core.

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- 3GPP architecture impacts to support network capability exposure and context information awareness
  - The next generation system is expected to accommodate various services and should support key service categories, i.e. massive IoT, critical communications, and enhanced mobile broadband, respectively

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Charging
  - Mobile System Architecture cannot be considered complete without having appropriate charging support. While the charging requirements in Next Generation System are expected to be similar in nature to LTE/EPC, depending upon the Next Gen System Architecture how, where and when charging data gets collected and communicated can be different. This key Issue will look into the architectural aspects of collection of charging data.
- Security framework
  - The authentication function is responsible for the authentication of the identity (e.g. user identity) that is presented to the network, when a UE requests to receive service(s) from the next generation network.

Key issue of the 5 G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Broadcast/Multicast Capabilities
  - all communication involving 5G capabilities specified by RAN;
  - Group handling (e.g. geographic scope of groups) ;
  - Group communication (e.g. setup performance, services to the group member, group member requests of the system, priority and pre-emption of group communication, services provided during an ongoing group communication, and user perception of group communication);
  - Functionality and performance needed to satisfy current and emerging 3GPP broadcast/multicast service requirements and application architecture requirements (e.g. MCPTT, MCVideo, MCData, CriC, and massive MTC);
  - Functionality and performance needed to satisfy current mandated PWS

Key issue of the 5G Architecture with regards to the signalling control plane (REF: TS 23.799)

- Support for Off-Network Communication
  - off-network group communication is needed to support current and emerging critical communications, including the individual- and group-based mission-critical voice, data, and video communications needed by public safety
- NextGen core support for IMS
- Interworking and Migration
  - Interworking and migration scenarios within an operator
  - Interworking scenarios on roaming

Thank you!

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