



## 5G Fixed-Mobile Convergence

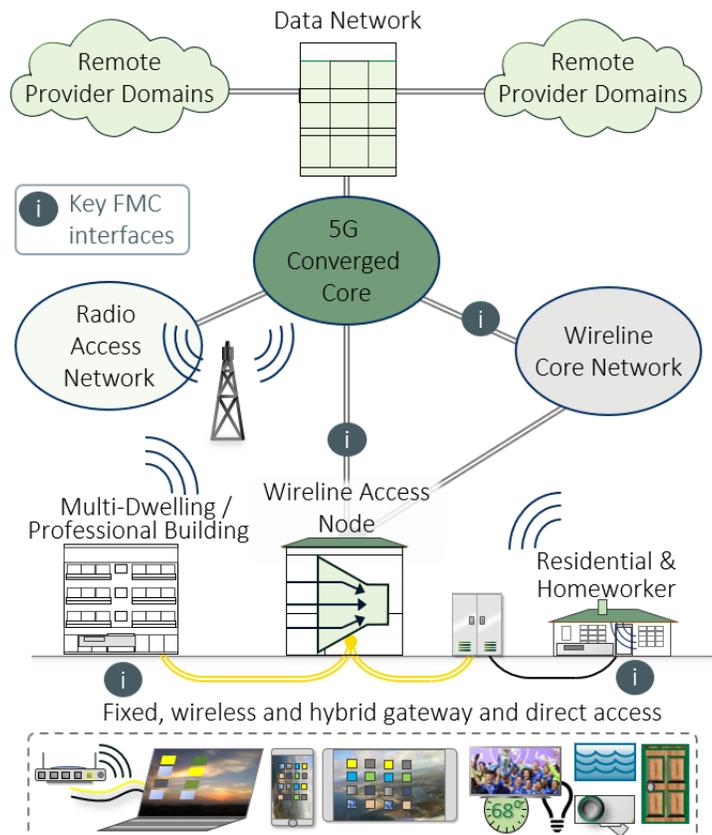
### 1 Enabling the 5G Connection for Broadband

The purpose of the Broadband Forum's 5G Fixed-Mobile Convergence (FMC) project is to provide the definitions and recommendations to enable 5G for Broadband networks – an area critical to the success of 5G - so that its market potential be fully realized.

To do this, the Forum is conducting an in-depth investigation of requirements in this area. This paper introduces the work of the Forum's 5G Project Stream relating to the FMC work in progress.

This work is intended as a contribution to the 5G industry to support the objectives that

- Customers have both a seamless service experience and multi-access connectivity
- Service providers and equipment manufacturers can integrate fixed and mobile networking at the edge of the network served by a common core that simplifies the user experience and promotes new services
- Key emerging initiatives in the broadband ecosystem – connected home, Virtualization/Cloud and ultrafast Access - are properly integrated



This paper also includes the Forum's perspective on the 5G, the Forum's role, the use cases and overview of the BBF Fixed-Mobile 5G projects, business drivers and impact. The paper's purpose is to both raise awareness of the projects and encourage active participation in the work to ensure all use cases and requirements are addressed.

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## 2 Project Overview

The investigation of FMC requirements focuses on the intersections between the fixed network and 5G mobile networks that will be an important component in the success of 5G deployment. These are the interfaces between the 5G Core, the wireline and wireless access networks, hybrid access nodes, and gateways. Other Forum projects cover 5G network slicing and 5G transport networks.

The work addresses deployment scenarios whereby the converged 5G Core network is used to deliver functions traditionally offered by the wireline core network. These scenarios include:

- Integration: access via a 5G-ready Residential Gateway directly to the 5G Core with full operational integration with particular care taken to allow operation using unmodified deployed equipment
- Interworking: customer access to 5G Core components

The developed architecture is intended to support coexistence - i.e. support a side-by-side deployment of 5G and legacy services on a common access network.

### 2.1 Expectations for 5G

With the digital society poised to enter the 5G era, we know that consumers and business users will expect a perfect, seamless connectivity experience across all their devices - anytime, anywhere - regardless of the underlying network. With the proliferation of new connected devices, services, and access types, seamless connectivity implies a context-driven, connected experience, combined with the highest fixed broadband quality.

### 2.2 Broadband Forum Experience

This latest work is built on more than a decade of expertise and experience in providing contributions in both Fixed-Mobile Convergence and mobile transport over several mobile generations. This is the foundation for the Forum developing work that is critical to the quality of the seamless experience referenced above.

### 2.3 5G Fixed-Mobile Convergence Project Scope and Outcome

By considering the interfaces between the 5G Core, wireline and wireless access networks, new hybrid access nodes and gateways, this project will:

- Review the current 5G system architecture and ascertain the changes necessary to enable wireline access to the 5G Core
- Cooperate with 3GPP to ensure the necessary changes are embodied in its Release 16 and further, standardization work
- Leverage the resulting 3GPP specifications to provide a specification of a 5G Access Gateway Function that adapts wireline access onto the 5G Core, and then consider and specify several architectural deployment options as well as the underlying infrastructure sharing aspects
- Devise strategies and develop specifications to address a desire by a number of operators for interworking of existing fixed customers and deployed equipment into a 5G Core
- Develop specifications for Customer Premises Equipment, e.g., 5G-Residential Gateway, designed to integrate to the 5G Core

The work is being developed by many participating members of the Broadband Forum. Currently, this work is in the form of members-only documents that are one of several sources for a number of deliverables such as feedback and recommendations to 3GPP. The roadmap of this work is aligned with the timeline for 3GPP Release 16. There will also be recommendations for further work from BBF on different tracks, such as the 5G Residential Gateway and interface specifications, etc.



wireline convergence (as recommended by the joint 3GPP-BBF 2017 Workshop) and to facilitate 3GPP work in this area as swiftly as possible.

The work in progress at the time of this writing includes the examination of the following:

- Support for the requisite service models in different deployment scenarios
- Registration and Connection Management procedures
- Transport and encapsulation in the wireline access of Control Plane and User Plane traffic exchanged with the 5G Core
- Regulatory Requirements
- Harmonization of Operation and Management
- Customer Authentication and Line Identifier
- Resource Management in the Access
- Session Management
- Addressing for IPv4 and IPv6
- Home LAN support
- IPTV and Multicast support
- Network Slice Selection
- QoS and Policy Management

This project specifies a 5G Access Gateway Function that adapts fixed access onto the 5G Core and extends the 5G Core control plane to the home network, and a 5G Residential Gateway that leverages that control plane to enable new services. In addition, the demand to provide for a more incremental transition will result in the specification of a network-based interworking function, the Fixed Mobile Interworking Function (FMIF) that adapts existing premises equipment onto the 5G Core. At the same time the BBF will consider and specify several architectural deployment options as well as the underlying infrastructure sharing aspects.

The work relates closely to other BBF work since the 5G and fixed networking brings the promise of service protection and integration in the home and office.

### **3.4 End-to-End Network Slicing (SD-406)**

This project investigates the concept of network slicing with respect to the BBF architecture. Network slicing is considered as a fundamental enabler to migrate “one architecture fits all” to the logical “network per service”. Network slicing will enable value creation for vertical segments that lack physical network infrastructure by offering network and cloud resources. In particular, this project has the following objectives:

- Address business needs for network slicing
- Identify and analyze potentially relevant slice types to be supported in the BBF Multi-Service Broadband Network
- Study existing work on network slicing of other industry bodies
- Identify specifications to address any potential gaps to support the identified network slice type VNFs, i.e., CloudCO, etc.

## 4 Business Impact, Development and Deployment Considerations

### 4.1 Impact of the Work

The manner in which fixed, mobile and Wi-Fi connected 5G devices will be used in the home, business and public locations depends on many technical, operational and financial factors. However the seamless provisioning of network connectivity in these locations will determine if user and provider expectations will be met. This is a critical part of the network and to expand on the paper's opening remarks:

The intended outcome for customers:

- Seamless service experience
- Multi-access connectivity

The intended outcome for service providers and equipment manufacturers:

- To enable the integration of fixed and mobile networking at the edge of the network and customer premises to allow customers to be served by a common core across all accesses, simplifying the user experience and promoting new services

The intended outcome for service providers:

- To enable harmonization of fixed and wireless services to simplify provider offerings
- To open up the possibility of always-available services based on converged connectivity
- To promote the opportunity of supporting various use cases efficiently via network slicing
- To open up new opportunities for multi-tenant, multi-dwelling service providers

### 4.2 Development and Deployment Considerations

5G design requirements and technology enablers drive both mobile and fixed developments.

The 5G system will support:

- Simultaneous connection via different accesses, including the capability to access the services provided by the 5G network using non-3GPP access
- Mobility between 3GPP and non-3GPP networks with optional session continuity
- Capability for the user equipment, based on network control, to discover and select the appropriate access
- A common authentication framework

These capabilities will provide both customers and operators with significant benefits:

- The extension of the mobile service into hard-to-serve areas
- Consistent application of customer policies across all accesses
- New business opportunities enabled by extending the 5G Core control plane and network slicing into the premises
- Operational streamlining, common customer management, and a common service platform

5G-Fixed-Mobile Convergence is one of the areas of high priority to be addressed, given that:

- Seamless service experience is key for users and drives the need for full FMC
- 5G services are to be deployed across several access technologies, including wireless and wireline
- On-demand network services, e.g., different levels of mobility, may be required according to the application needs

Multiple simultaneous attachments will be very common for certain devices and applications

## 5 5G and Fixed-Mobile Convergence

### 5.1 5G Vision

5G is an end-to-end system that involves all aspects of the network, with an architecture that achieves a high level of convergence while leveraging today's access mechanisms (and their evolution); this includes wireline, wireless, and cellular access. This is the vision for network-based Fixed-Mobile Convergence.

### 5.2 Industry Perspectives

The Next Generation Mobile Network Alliance (NGMN) envisages 5G operating in a heterogeneous environment characterized by multiple types of access, multi-layer networks, and a wide variety of device types and user interactions, supporting a much greater diversity of use cases (consumer, public, industrial) than previous technology generations. There is a need for 5G to provide a seamless and consistent customer experience across time and space, i.e., an experience that is the same regardless of the access type and end-device.

This implies that many new scenarios beyond the obvious ones such as the seamless use of compute, entertainment, IoT, and portable devices in the home and office. In the age of a networked society, there is an expectation that intense network and compute resources will be available everywhere.

A cornerstone of FMC is to have one view of the customer irrespective of their access to the network. Since the intelligence lies mainly in the network, the architecture needs to be able to support devices from a wide range of manufacturers. The FMC approach has the potential to significantly improve customer experience by providing the most appropriate connectivity regardless of location. There are market imperatives for service providers to find new network-enabled ways to deliver an enhanced, seamless connectivity experience.

Network operators also have a pressing need to improve network efficiency. This can be done by better utilization of their existing fixed and mobile assets, providing integrated connectivity-based offerings, as well as simplifying and automating network provisioning and operation. FMC improves infrastructure efficiency using a common, access-independent core, and can benefit from the flexibility of virtualized network functions.

Today's fixed and mobile network systems have different architectures, access mechanisms, and network functions. The selection of an access network (e.g. cellular or Wi-Fi) is typically device-controlled. FMC will allow the pooling of access assets, and dynamic traffic steering could contribute to reduced access network costs, as well as converged connectivity service propositions. This can be achieved by sending traffic over the wireline, wireless, or cellular access network as appropriate, or even multiple access networks simultaneously.

Furthermore, depending on the type of service, there will be a need to bring more compute intelligence and performance nearer to consumers so that delivery of these services is viable. The 5G Core has the architectural flexibility to allow resources to be deployed where most effective.

Another important aspect is support of the vast number of IoT devices that are expected in the near future. The majority of IoT devices are low-bandwidth and will have some form of short-range, low-power radio technology such as Bluetooth, ZigBee, or Z-Wave; others will use Wi-Fi. A new generation of devices with advanced capabilities will also emerge and operators must find ways of ensuring efficient delivery of services to vast number of new devices in the converged network architecture.

The diversity of network requirements drives the need for logical networks with different properties. This renews the pressure on more intelligent home networking, including Wi-Fi, and better integration with fixed and mobile networks.

## 6 The Need for an Open Approach and the BBF's Role



Examining what's needed to economically deliver on its expectations, it becomes clear that by drawing upon its expertise and experience Broadband Forum can make a significant contribution to assist the realization of 5G.

Not only is the BBF working on key wireless-wireline convergence projects, but it is also constantly enhancing connected home networking, such as with the new User Services Platform; high speed access technologies enabling distributed networking, including the CloudCO work; and virtualized Open Broadband projects, such as the Broadband Access Abstraction initiative.

The key role of the Forum and other similar bodies is to encourage a standardized approach so that fully interoperable, large-scale deployment can occur economically. A range of new FMC standards is required, which involves several organizations that need to find efficient ways of working together to avoid duplication of effort and incompatible systems. The converged network functions should, wherever possible, be based on the common 5G functions that can be configured to suit the application and customer needs, regardless of the access.

BBF is committed to developing technical specifications addressing the Fixed Broadband system evolution related to 5G, while considering migration and operational integration. This is being done in close cooperation with 3GPP and other select global organizations.

The Broadband Forum is aligned with NGMN's vision and expectation level set regarding a converged 5G Core network that leverages the flexibility of virtualized and programmable network functions. The work is also supportive and contributing to the work of 3GPP.

### 6.1 Timing of this Paper

Publishing this paper while the work is in progress rather than at its completion has three purposes:

- To raise the awareness of the importance of the work in the realization of 5G where the integration of existing and new networks and devices will be in play more than anywhere else
- To raise awareness of the scope and progress of Broadband Forum work in order to support those organizations developing dependent and complementary work
- To encourage as many interested parties as possible to actively participate in this and future Broadband Forum 5G related projects so that all the requirements are properly handled

At the conclusion, updates to this introductory work are anticipated along with the detailed technical recommendations in the form of published technical work and further white papers.

## 7 Summary

The work of defining the integration of fixed and mobile network is critical for the success of 5G both in the Transport Network – which has been evolving over several years – and most urgently in the Broadband Access, customer premises and at interfaces between the Fixed and Mobile Networks. Alongside the emergence of 5G, the commitment for households to have access to Ultrafast Broadband networks has never been stronger.

The use of multi-network devices (currently 4G, Wi-Fi and wireline) is increasing and the proper integration of Fixed, Mobile and Wi-Fi networks will dictate customer acceptance and thereby the financial success for all stakeholders. The Broadband Forum work introduced in this paper has the potential to make a very positive impact on the market in this area and the active participation or carefully following the work in progress by all industry stakeholders is strongly encouraged.

In summary: the BBF 5G Convergence work is well-supported and operator-driven

- It's based on use cases summarized as
  - 5G-enabled portables and residential gateways multi-connected through Wireless and Wireline, Fixed Wireless, and Hybrid Access
  - Common infrastructure (Transport and Cloud)
  - Common processes on any access (credentials, policies, accounting, etc.)
- With the goal of enabling converged wireless-wireline networks and projects focused on:
  - Converged Core Network Functions and Interfaces
  - End-to-End Network Slicing (cross-domain)

We hope that this paper has been a useful introduction and has raised awareness of its importance. We strongly encourage involvement in the work by participating in the Broadband Forum and these 5G projects in particular as members of the Broadband Forum.

- For membership: <https://www.broadband-forum.org/membership>.
- Public web site: and <https://www.broadband-forum.org/5g>.
- Latest project progress <https://wiki.broadband-forum.org/display/BBF/5G+Project+Stream> (members)

## 8 Terminology

### 8.1 References

The following references are of relevance to this paper. At the time of publication, the editions indicated were valid. All references are subject to revision; readers of this paper are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at [www.broadband-forum.org](http://www.broadband-forum.org).

Document	Title	Source
<a href="#">3GPP TR 22.261</a>	Service requirements for next generation new services and markets	3GPP
<a href="#">3GPP TS 23.501</a>	System architecture for the 5G System	3GPP
<a href="#">3GPP TS 23.502</a>	Procedures for the 5G System	3GPP
<a href="#">NGMN 5G WP</a>	NGMN 5G whitepaper V1	NGMN
<a href="#">TR-291</a>	Nodal Requirements for Interworking between next generation fixed and 3GPP wireless access	BBF
<a href="#">TR-300</a>	Policy convergence for next generation fixed and 3GPP wireless networks	BBF
<a href="#">SD-357*</a>	Combined 3GPP and BBF functions	BBF

SD-373*	5G requirements and enablers	BBF
SD-406*	End-to-End Network Slicing	BBF
SD-407*	5G Fixed-Mobile Convergence	BBF

\* These investigative documents, available only to Broadband Forum members, are works-in-progress that are under consideration towards published work.

## 8.2 Abbreviations, Terms and Definitions

The following terminology is used throughout this paper and in related work

Abbreviation	Term	Definition
5G-RG	5G Residential Gateway	A Residential Gateway acting as User Equipment with regard to the 5G Core. It holds a secure element and exchanges NAS signaling with the 5G Core.
AGF	Access Gateway Function	A function which added to a wireline AN, allows connectivity to the 5G Core.
AGF-CP	Access Gateway Function – Control Plane	The control plane of the AGF is in charge of the mediation between the AN control plane and N2'.
AGF-UP	Access Gateway Function – User Plane	The user plane of the AGF is in charge of the mediation between the AN user plane and N3'.
AN	Access Node	
CUPS	Control and User Plane Separation	
FMC	Fixed-Mobile Convergence	
FN-RG	Fixed Network-Residential Gateway	An RG not supporting direct connection with 5G Core Network Function e.g. it does not support 5G NAS. The FN-RG is an RG specified by TR-124i5.
FMIF	5G Fixed Mobile Interworking Function	A function which is added to a wireline AN, allows interworking with the 5G Core supporting the interconnection of user plane with UPF and control plane with 5G Core Network Functions. The 5G FMIF may also be split into FMIF Control Plane and FMIF User plane to support N1''/N2'' and N3'' in control plane and user plane, respectively.
HA	Hybrid Access	Access that utilize both wireline access network and wireless access networks. From the perspective of RG, 5G-RG or UE, this can either be exclusive or simultaneous access.
N1		Reference point between 5G-Residential Gateway and the AMF.
N2		Reference point between W-5GAN and the AMF. On the W-5GAN side, the termination point is the AGF-CP.
N3		Reference point between W-5GAN and the UPF. On the W-5GAN side, the termination point is the AGF-UP.
RG	Residential Gateway	
UE	User Equipment	
WA	Work Area	Broadband Forum Technical Committee working group

## 9 Acknowledgements

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5G Project Stream leaders	Manuel Paul, Deutsche Telekom AG Greg Dalle, Juniper Networks
Wireless-Wireline Work Area Director	David Allen, Ericsson

## 10 About the Broadband Forum

The Broadband Forum, a non-profit industry organization, is focused on engineering smarter and faster broadband networks. The Forum's flagship TR-069 CPE WAN Management Protocol has now exceeded 800 million installations worldwide.

The Broadband Forum's work defines best practices specifications and software for global networks, enables new revenue-generating service and content delivery, establishes technology migration strategies and service management for the connected home, Cloud, Access and 5G broadband ecosystem. More than 70 Technical committee projects in progress embrace all relevant emerging technologies.

The Forum's Open Broadband strategy brings together open source agility and standards-based architecture to enable large-scale markets. We develop test interoperability and certification specifications and programs to accelerate deployment. Visit [www.broadband-forum.org](http://www.broadband-forum.org). Twitter @Broadband\_Forum.

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