MR-464

Migrating Fixed Access to 5G Core

Issue: 1

ISSUE DATE: October 2019

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1 Introduction

The advent of 5G is seen by many operators as a once in a generation opportunity to converge their networks. Their motives for convergence are varied but include:

- Offer their customers a seamless, access-independent service experience
- Enable multi-access connectivity
- Streamlining the set of network functions required to operate their network
- Achieving common technology, on-boarding, training and services between fixed and mobile divisions
- Enabling common subscriber management
- Extending the reach of their core networks
- Extending the service offering of their fixed access

This is in addition to the new service capabilities enabled by the 5G Core (5GC). This is also discussed further in MD-427 (ref. 1).

However, the required network transformation is significant, demands substantial investment and needs to be performed “in service”.

Broadband Forum has been working in cooperation with 3GPP to define how fixed access to the 5G core will operate. The key concerns raised by operators and embodied in the work is that:

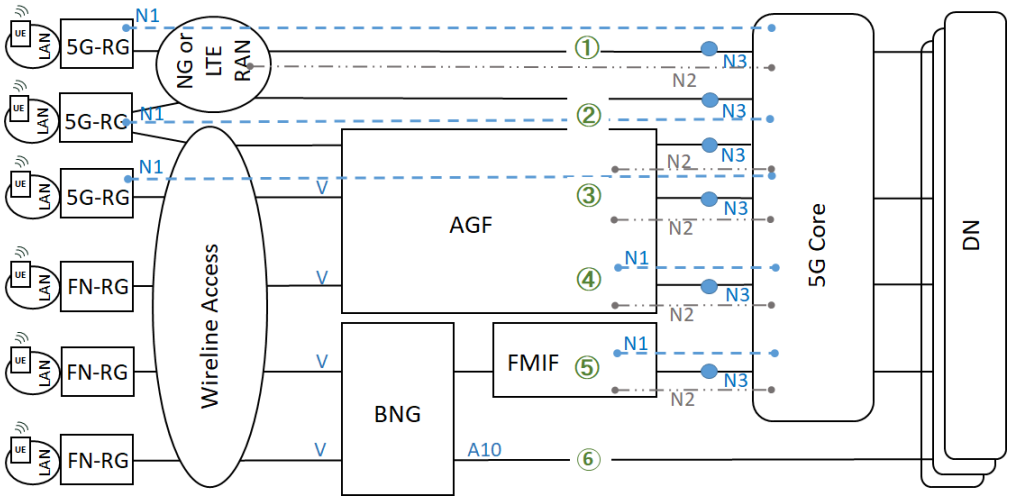
1. The fact that no two operators will have the same starting point in the journey to 5G,
2. The need to eliminate as many dependencies in the process as possible so that transformation steps can be implemented without requiring coordination.
3. The need for deployment flexibility in how 5G components are introduced into the network.

What follows is a high level guide to network architects/planners as to the value and applicability of the transformation toolkit.

2 5G FMC Deployment Scenarios

The BBF work on 5G Fixed Mobile Convergence enables several scenarios to support different network environments, starting points and priorities. The figure below represents the five scenarios, with different cases in terms of Residential Gateway (RG) type, access network and interfacing model with the 5G Core. As part of these scenarios, devices supporting 3GPP procedures (UE), connected to the RG via the WiFi in the LAN and/or over the NG-RAN, may also access the 5G core network. The architecture supports two classes of CPE type: fixed network RGs (FN-RGs) which are existing and deployed equipment that does not support 3GPP procedures, and 5G-RGs which have been enhanced to support the 5G control plane and communicate with the 5G-Core directly. 5G-RGs can have wireline only, wireless only (Fixed wireless access) or both types of WAN interface.

The architecture includes two classes of network function for adapting wireline access onto the 5G-Core, Access Gateway Function (AGF) and Fixed-Mobile Interworking Function (FMIF), both of which have been defined as functions to permit different deployment and implementation options; with or without a legacy Broadband Network Gateway (BNG).



1. Fixed Wireless Access (5G-RG) – The 5G-RG is connected over the NG-RAN or LTE-RAN. EPC-5GC interworking is used if the RAN is LTE based.
2. Multi-access (5G-RG) - The 5G-RG is connected over both the wireline access network (direct mode) and the NG or LTE RANs. The 5G-RG may be connected over one of the accesses at once (active-standby) or may use both accesses in "steering" (flow based load spreading) or "splitting" (per packet based load spreading).
3. Integration in Direct Mode (5G-RG)– The RG is connected over the wireline access network. An Access Gateway Function (AGF) mediates between the wireline access network (aggregated at layer 2) and the 5G core network, based on N2 and N3 interfaces. The 5G-RG is able to register directly with the 5G core network based on N1 interface. For this reason, the AGF is said to integrate the session in “direct mode”.
4. Integration in Adaptive Mode (FN-RG) – Similar to (2), the RG is connected over the wireline access network and the AGF mediates layer 2 traffic with the 5G core network based on N2 and N3 interfaces. However, FN-RG does not support N1, so the AGF acts as end point of N1 on behalf of the FN-RG. The AGF is said to integrate the session in “adaptive mode”.
5. Interworking (FN-RG) – The session is managed by a BNG . Services that are based on 5G core network are passed to the 5G core via a Fixed Mobile Interworking Function (FMIF). The FMIF supports N2 and N3 interfaces to the 5G core network. Since the FN-RG does not support N1, the FMIF acts as end point of N1 on behalf of the FN-RG.
6. Coexistence (FN-RG) - This is not a converged session model, as these sessions are not part of the 5G core network. However, coexistence is required to allow services that are not supported by the 5G core network to be available in a converged service provider network. Coexisting subscriber sessions are managed by the BNG or specialized platforms for voice or IPTV. When the wireline access network is shared between converged sessions (models (2), (3), (4)) and coexisting sessions, the AGF / FMIF may need to be aware of the coexisting sessions, in order to offer an accurate traffic management in the wireline access network.

Embodied in the work of Broadband Forum is a triad of core concepts that address these concerns head-on. These are coexistence, interworking and migration.

3 Coexistence

Coexistence is the requirement to support adapting fixed broadband traffic to the 5GC on platforms deployed behind access nodes (coexistence at Layer 2) or Broadband Network Gateways (coexistence at Layer 3) such that the access network could be shared by multiple

actors. This did not preclude integrating this functionality into access nodes, but there are several motivations for the coexistence options:

1. It could reuse Layer 2 wholesale arrangements in use today
2. It would play into regulatory environments where fair access to the subscribers was required. An example would be local loop unbundling (LLU)
3. The addressable market would be maximized if a fork lift of the access network was not required.
4. Services delivered side by side with Internet and corporate access such as access node delivered linear IPTV could be left in place during the transition to 5G, or re-engineered for 5GC according to operator's business imperative and investment timetable.

There are a few consequences to the co-existence requirement.

The AGF may be deployed as a platform connected to the FN-RGs and 5G-RGs transiting an existing and unmodified Layer 2 aggregation network. This adds specific requirements to the protocol design:

1. Part of the signaling protocol exchange needed to be recognized by access nodes such that they would insert additional metadata in the exchange for consumption by the network. This included the line ID for the specific subscriber, and could include details of the DSL line physical characteristics (the objective was to automate leveraging existing practice as much as possible and avoid requiring additional datafill in operational systems).
2. An AGF deployed connected to the aggregation network would not have direct visibility of DSL or PON failures. Hence additional procedures would be required such that an AGF would have knowledge of the availability of connectivity to the CPE.
3. Many access nodes implement enhanced QoS, security features, and other proprietary "value-adds" that operators depend upon. The design of the User Plane encapsulation for 5G needs to be recognized by deployed equipment such that these dependencies in service design were not disrupted.

This does not preclude vendors integrating AGF functionality into DSLAMs and OLTs. Broadband Forum's work on Control User Plane Separation (CUPS) for FMC will facilitate this class of implementation as access equipment only needs to implement the user plane functionality. Coexistence simply means 5G FMC can be retrofitted to existing deployments.

4 Interworking

Interworking was not originally identified as a priority for the work. It soon became clear that operators wanted to deploy 5GC FMC in a fashion decoupled from CPE replacement cycles. This resulted in two approaches to interworking. The first was that the AGF (originally intended as a pure 5G adaptation function) accreted FN-RG support. This was intended both to facilitate incremental CPE upgrade and to potentially reflect how some operator's organizational structures would subsume fixed access to the 5GC. The second was to formally define the FMIF as a function that would be deployed behind an unmodified BNG to provide an L3 interworking option in addition to the AGF based L2 interworking model. This model has the disadvantage of serializing functions in the user plane, but has been specifically requested by some operators.

5 CPE Migration

The decision was made to support FN-RGs and provide the capability to perform incremental deployment of 5G-RGs and the possibility to back out a CPE change. This capability, termed "migration", resulted in additional protocol design requirements. Primarily some of the 5G signaling exchange needed to be recognized by access nodes so that the meta data would be

inserted. This meant at some level it employed protocol elements in common with legacy FN-RGs, but the exchange could also be identified as either legacy session establishment or 5G registration by the AGF. Similarly a 5G-RG would be able to detect if it was connected to a BNG or an AGF and behave accordingly to provide service. In particular, if the 5G-RG detects it faces a BNG instead of an AGF, it reverts back to functioning as an FN-RG.

The design decision was made to address interworking by specifying a proxy UE signaling termination in the AGF acting on behalf of legacy RGs. This produced a legacy support model the minimized the impacts on the 5G core. When an FN-RG was known to be attached to a particular DSL or PON port the AGF would act on behalf of the FN-RG to set up the required service connectivity in response to subscription information in the 5GC User Data Management repository and then map the 5G connectivity to the legacy IP sessions. The one change made to the 5GC was to modify authentication to permit the line ID to act as a trusted identifier so that a rack of credentials co-located with the AGF or FMIF would not be required. The mode of operation and onboarding would not be perfectly aligned with credentials based 5G subscription management, but would leverage the architecture with a minimum of impact and simplify the configuration of subscription information at the start of deployment.

Ultimately the set of approaches to transition reflected the fact that different operators would have different starting points, and different business cycles from that of the mobile broadband business.

6 Service Migration

Some operators offer VLAN delineated services to the home with voice on one VLAN, video on another, internet access on a third. The coexistence model provides carriers with this class of operation to choose what services they migrate to 5GC and when. The option of simply treating some services as a cash cow with a “best before” date is also an option and they can be maintained in parallel with 5G migration.

7 TR-069/TR-369 CPE Management

The 5GC has been extended to support TR-069/369 for CPE management. This permits a significant suite of service capabilities to be easily ported to the converged core. Extensions to the TR-069/369 data models explicitly for 5G are included in this work.

8 The Transformation Narrative

With the toolkit described above, the road to 5G becomes roadblock free. An operator deploying 5G FMC performs a series of steps:

- Deploy the 5G core and services
- Populate UDM with line ID based identifiers for the subscribers to be transitioned and subscription information for the 5GC instantiation of their wireline service profile
- Deploy the preferred interworking solution. This can be any combination of FMIF, standalone AGF (either integrated into the access or connected via the access), or BNG integrated AGF.
- As 5G-RGs are rolled out, the 5G Core Unified Data Management and Authentication Server Function are updated to include the 5G-RG UICC credentials.
- Customers may self-install the upgraded CPE at their leisure, and back out the install if any issues arise.

9 Conclusion

The roads to 5G convergence are made easy by the architectural choices embodied in the Fixed Mobile Convergence work. These have been made specifically to address key challenges in the process identified by the operator community, and to enable a variety of deployment and transformation options. At the same time the impacts to the 5G-Core itself were minimized consistent with a true convergence approach.

The BBF is close to completing a set of specifications documenting functional requirements that embodies the toolkit and the associated concerns of operators seeking to transform their networks and facilitate a smooth migration to 5G.

10 References

1. MR-427: 5G Fixed-Mobile Convergence. July 2018.

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