SCTE CABLE-TEC EXPO 22
SEPTEMBER 19-22 • PHILADELPHIA, PA

2022 Fall Technical Forum
SCTE • CABLELABS • NCTA

Why, How, and Where to Converge your Fixed and Mobile Networks

Why it is Strategically Critical to Achieve the Right Level of Convergence, the Advantages and Benefits

A Technical Paper prepared for SCTE by

Robert Hallahan
Global Head of Cable Strategy
Nokia
13530 Dulles Technology Dr.
Herndon, VA 20171
+1 (703) 344-3834
Bob.hallahan@nokia.com

Table of Contents

Title **Page Number**

List of Figures

Title **Page Number**

1. Introduction

This white paper discusses the new drivers of fixed mobile network convergence, why it is important to achieve the right level of convergence, where, how, and when to converge, and the advantages and benefits of convergence.

2. Current State of Cable Fixed and Wireless Networks

One of the biggest challenges facing cable operators today as they converge service offerings across fixed and wireless networks is with the creation, deployment and management of services and customers as they roam between fixed and various types of wireless networks. Currently, with each network having its own operational support systems (OSS) stack, the job of managing services and customers experience in near real time is now exponentially more complicated and costly.

Cable operators are beginning to build and operate their own 5G networks in addition to the existing set of fixed and wireless networks they manage today and are planning to allow services to accessible agnostic to the network access. This is where network convergence becomes a real enabler of network agnostic service access.

Multi-system operators (MSO) have been successfully offering and managing services and applications over fixed and wireless networks for years, in the form of high-speed data internet, business voice, voice over internet protocol (VoIP), linear quadrature amplitude modulation (QAM) based video, over the top (OTT) streaming video, Internet of Things (IoT), smart home security, and automation services over hybrid fiber-coaxial (HFC) Data Over Cable Service Interface Specification (DOCSIS) cable, Wi-Fi, and 4G/5G via mobile virtual network operator (MVNO), and have not faced any real driver or benefit to converge their network; until recently.

3. Expansion of Cable into 5G Wireless Networks

Cable MSOs are currently rolling out new 5G networks and selling private wireless platforms, content, and applications accessible through fixed and wireless networks, all of which will require a new more effective network management and operational approach.

To fully exploit the advantage that cable MSOs will have with multi-network access options, they will need to pivot to an access network agnostic approach to selling, managing, and monetizing services and applications in their markets. Converging fixed and mobile networks for cable operators means identifying the strategic convergence points across networks to achieve a normalized level of control over services and customer experience.

Cable operators have been continually working and investing to streamline and optimize the massively complex multinetwork operational support systems (OSS) and business support systems (BSS) layers they rely on to create, offer, provision, monetize, secure, and assure services and are now facing a new complication as they pivot to deploy 5G and offer services in a network agnostic service model.

A perfect storm of network and IT challenges has developed as a result of the new competitive market pressures cable operators face from wireless mobile network operators (MNOs), Hyperscalers, and fiber operators, as well as virtual multi-channel video programming distributor (vMCVPD) streaming companies offering over the top players driving the need for more personalized measurement of customer experience and service assurance.

Cable MSOs are benefiting greatly from their bundling strategy including a low-cost wireless service as part of a stickiness play with their fixed line broadband services. Cable MSOs in the United States have achieved record new adds as existing and new fixed line subscribers sign up for the wireless bundled offering.

Adding their own 5G network to offload a majority of the MVNO data traffic will introduce new challenges to ensure that services are provisioned on multiple networks and subscribers are able to automatically hand off devices and data sessions between MVNO and Wi-Fi and their own 5G networks.

For example, with subscribers who all expect seamless mobility being automatically switched of handed off from network to network based on their location, access network availability, bandwidth, and/or speed required to support whatever application or session they are running, it will be challenging to track and measure the experience of each customer to assure the best possible experience and satisfaction.

Optimal convergence will need to be implemented between the existing MVNO wireless network and the new 5G data offload networks, as well as between these 5G networks and the cable operators extensive Wi-Fi networks, and ultimately between cable partner 5G networks to enable a 3- or 4-way dynamic handoff, all while maintaining management and control of subscribers, services, and experience.

4. The Benefits and Value of Converging Fixed and Mobile Networks

For years the IT systems required to create, sell, manage, and operate services, whether voice, data, video, IoT, or applications, over separate fixed and wireless networks was best accomplished with separate silos or stacks of systems known as OSS (operational support systems) and BSS (business support systems), specifically designed around the nature and architecture of the network.

Services and applications are now expected to be agnostically accessible from any and all networks available to subscribers and the lines of distinction between fixed and wireless access are now blurred into a blended access capability. Historically, network access has been designed specifically around the requirements of the services and applications offered, sold, and managed by an MSO. In today's market, services and applications need to be decoupled from the network access, to enable network agnostic delivery of services through a multitude of access technologies, devices, and locations with mobility at the center.

The initial driver behind network convergence in 2022 and beyond will be the need to offload wireless data from the MVNO 4/5G MNO network onto the MSO's 5G network. This will require a specific convergence strategy mostly centered around the core network with specific core elements and interfaces coming together to enable seamless uninterrupted service and session handoffs between networks.

In addition to massive cost savings from offloading subscriber data, there will be new opportunities to deliver services, such as broadband with OTT (over the top) applications, and content to out of network footprint residential and business customers via FWA (fixed wireless access) while leveraging the existing fixed PON (passive optical network) and DOCSIS networks to carry the traffic to the cores.

With optimal convergence, operators will increase their ability to more cost effectively enhance customer onboarding to multiple networks, vastly improved assurance of service quality and customer experience, resulting in reduced churn, increased revenue, increased loyalty, and better retention.

5. Where and How to Converge to Achieve Maximum Benefit

Industry standards bodies and organizations are collaborating on research and analysis to define and recommend best practices and recommendation to achieve wireline and wireless convergence. The most prominent industry level convergence research is being conducted by a collaboration between the Broadband Forum (BBF) and the 3rd Generation Partnership Project (3GPP) organization through an active Wireless Wireline Convergence (WWC) work group which has already delivered a set of detailed technical recommendations for interfaces between fixed and mobile networks. The WWC work group is planning issue a new set of network convergence recommendation and specifications via 3GPP Release 16 by the end of 2022.

Cable MSOs are leveraging a range of new operational convergent fixed and wireless network models to go faster in the market to achieve business objectives, from fully outsourced and managed networks, to hybrid hosted open network as a service platforms aligned with existing architectures enabling end-to-end transformation with minimal risk and disruption. The critical success factor in deploying 5G networks and enabling a multi-network agnostic service architecture is in the execution of the optimal network convergence strategy.

There are several points of convergence which should be considered when evaluating the optimal fixed mobile strategy which can span from the access network, to the core, to the OSS/BSS, as well as from multiple dimensions of data and process flows for service, subscriber, and network operations.

As networks follow the evolution of IT with cloud and hyperscale deployments, virtualization, containerization, software as a service (SaaS), multi-tenant neutral hosting, and a range of new dynamic operational models, the opportunities to gain new efficiencies through convergence become more strategically critical to success in the market.

Like any complex technology transformation, it is usually best to converge in phases, starting with underlying foundational IT and data domains before taking surgical convergence steps in the RAN, nodes, head ends, and cores.

Cable MSOs can converge fixed and wireless networks at multiple points with in the network from the device, to the edge, and the Core.

At the device level, the new 5G phones may leverage DSDS (dual SIM dual standby) embedded subscriber identify module (eSIM) technology to allow the phone to connect to two different 5G networks to achieve offload, which will represent convergence at the deice level requiring network aware selection intelligence.

5G DSDS phone manufacturers are working to deliver intelligent network aware, device-based network switching capabilities and MSOs will have the opportunity to deploy master converged network service profiles which can enforce access and policies for devices on multiple network access types.

At the core network level convergence should be implemented between the following network types depending on which combination of networks an operator is running and offering cross network services.

5.1. MVNO Convergence with Cable MNO 5G Cores:

By stitching together key core network elements between the MVNO core network and the cable MNO 5G core, MSOs can gain greater control over devices accessing services under multi network agnostic scenarios. MSOs with MVNO arrangements will need to consider a phased approach to convergence

using a light, thick, or hybrid MVNO-MNO architecture depending on the level of exposure and control the MVNO partner provides to the cable operator. Wireless companies providing MVNO services to cable MSOs are considering dedicated packet core instances for their cable customers to gain more access and control over their subscribers' services. This dedicated packet core approach is also being referred to as network as a service (NaaS) giving cable MSOs "more knobs to turn" to manage their MVNO wireless operations, customer experience, and business more effectively.

MSOs can leverage an innovative hybrid convergence architecture between cable MVNO core network and the cable 5G core elements to maintain session data flow between networks at the user plane level. This MVNO to cable MNO core convergence will enable continuous session control and assurance resulting in a seamless uninterrupted service for the subscriber as their device hands off between networks.

5.2. Convergence of Fixed Network Broadband and Cable MNO 5G and Wi-Fi:

One of the main points of convergence is where devices access the networks. A key network function which enables fixed and wireless convergence is the access gateway function (AGF), which controls network access for fixed networks to the 5G core, and is critical to the success of any network convergence initiative. The AGF enables converged authentication to the 5G core by the authentication server function (AUSF).

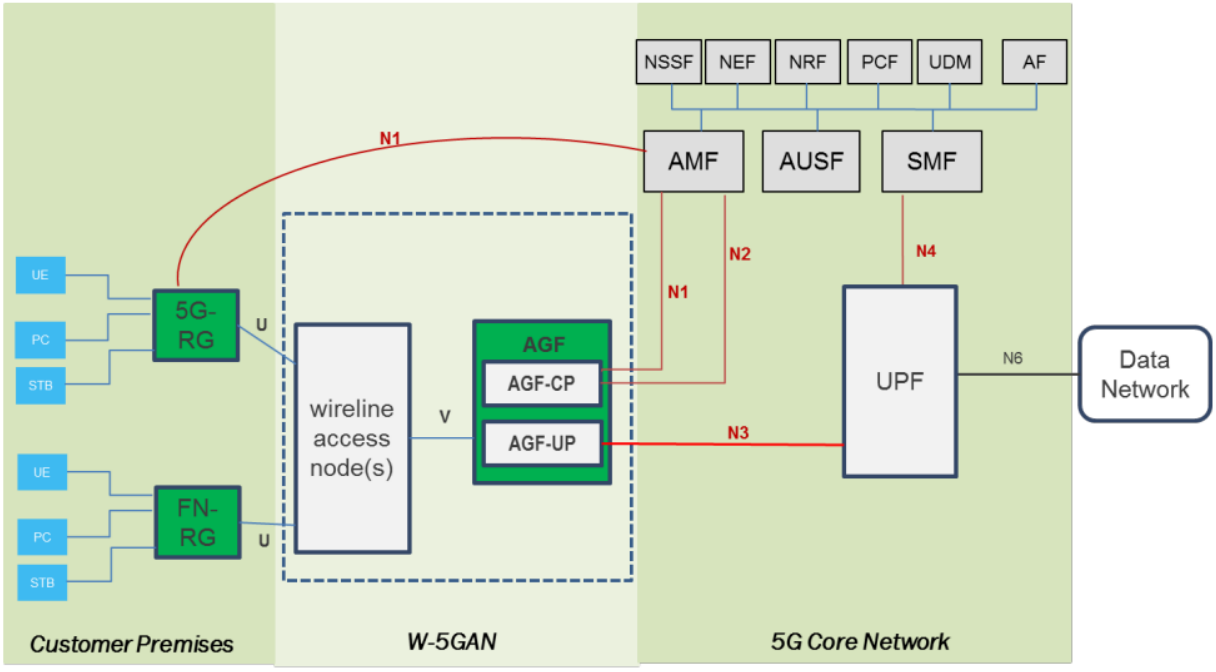


Figure 1 - FN-RG and 5G-RG Connected to the 5G Core Using the Access Gateway Function (AGF)

The AGF typically sits on the V interface, between the aggregation network of fixed access nodes and the 5G core network, controlling access from fixed network and 5G residential gateways (RGs) being served by a standard 3GPP user plane function (UPF) within the converged or common 5G core (5GC). Another important AGF convergence feature is the ability to define and enforce a set of standardized service level

agreements (SLA) which can be applied and enforced over different access networks leveraging a common or converged policy control function (PCF).

An AGF working with a PCF in a converged 5G core can take a quality of service (QoS) request and map dedicated resources to support a specific protocol data unit (PDU) session linked to the AGF's user plane level QoS. The separation of control plane from user plane in 5G cores, also known as control user plane separation (CUPS), enables a common control of the management of sessions and services over user planes distributed to the optimal network location to minimize latency.

Additionally, a new interworking function will be required to support the interworking of broadband services between the wireline access networks and 3GPP 5G networks and to enable fixed network gateways can use services that are based on 3GPP 5G core network.

5.3. Convergence of Cable MNO 5G and Wi-Fi:

Additional network convergence opportunities will be between the Wi-Fi networks and the MVNO and MNO 5G networks, where sessions can be sustained and managed. The MSO's Wi-Fi networks would be considered trusted non-3GPP networks for convergence with the 5G core where, for trusted access, the device and subscriber can be authenticated using the SIM. 5G convergence of trusted Wi-Fi networks leverage access traffic steering switching and splitting (ATSSS) technology to maintain simultaneous connectivity to 5G and Wi-Fi providing maximum resiliency. ATSSS enables bandwidth aggregation of data traffic and allows PDU sessions to be handed off between 5G and Wi-Fi networks seamlessly.

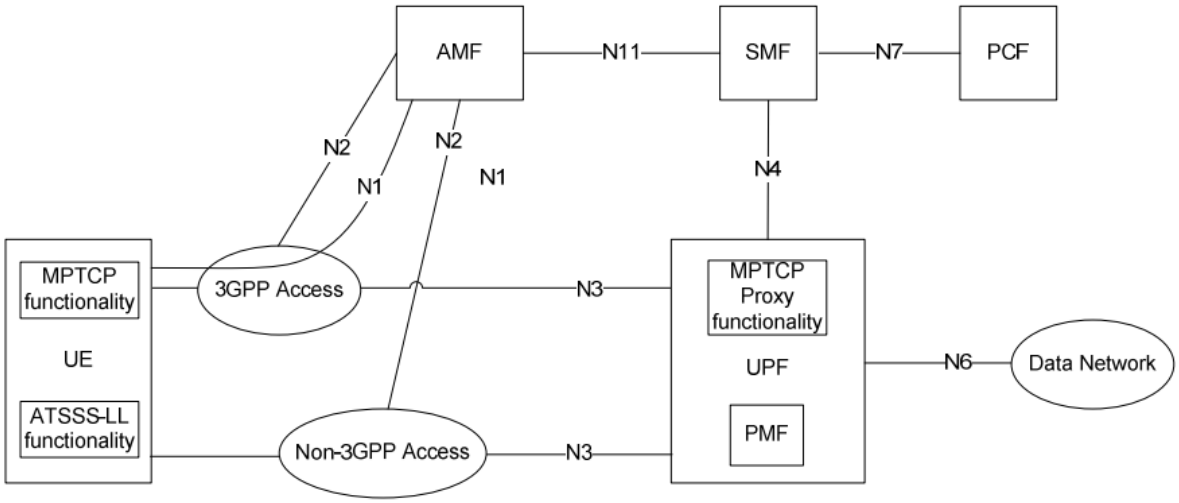


Figure 2 - Non-roaming and Roaming with Local Breakout architecture for ATSSS support

5.4. Convergence of Fixed and Wireless Network Voice Services:

On the voice side of the services, convergence should be pursued at the IMS level to bringing together wireline and wireless voice services across all access networks, which will enable centralized management and control of voice services access thru and spanning fixed and wireless networks.

5.5. 5G Adaptive Core Convergence:

Wireline and wireless packet and voice core networks have evolved in separate ecosystems, restricting support for network-agnostic service delivery or multi-network connectivity. With the advent of network function virtualization (NFV), these separate core platforms are being virtualized into cloud native platforms and with the increasing commonality in the functionality and scale of wireless and wireline solutions, a new universal adaptive core solution is now feasible

New services will require complete "connectivity agnosticism" with subscriber expectation of seemingly infinite service quality and ubiquitous connectivity. This capability will need to be enabled by convergence and massive scale in access, coupled to an evolved converged core, or new universal adaptive core control function that provides seamless service control and resilient continuity for all devices and associated flows.

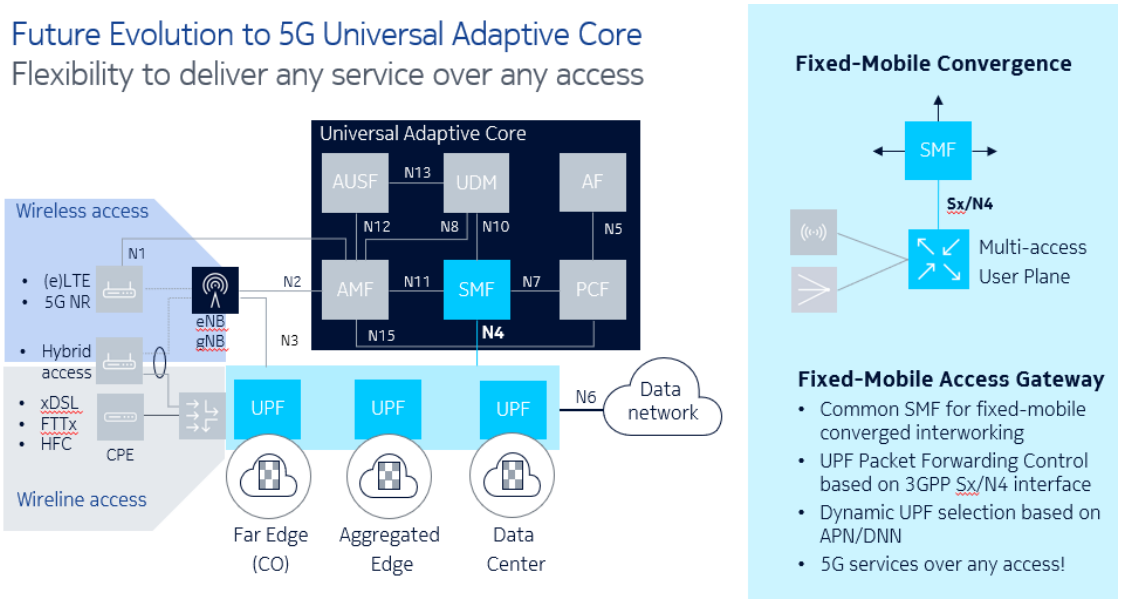
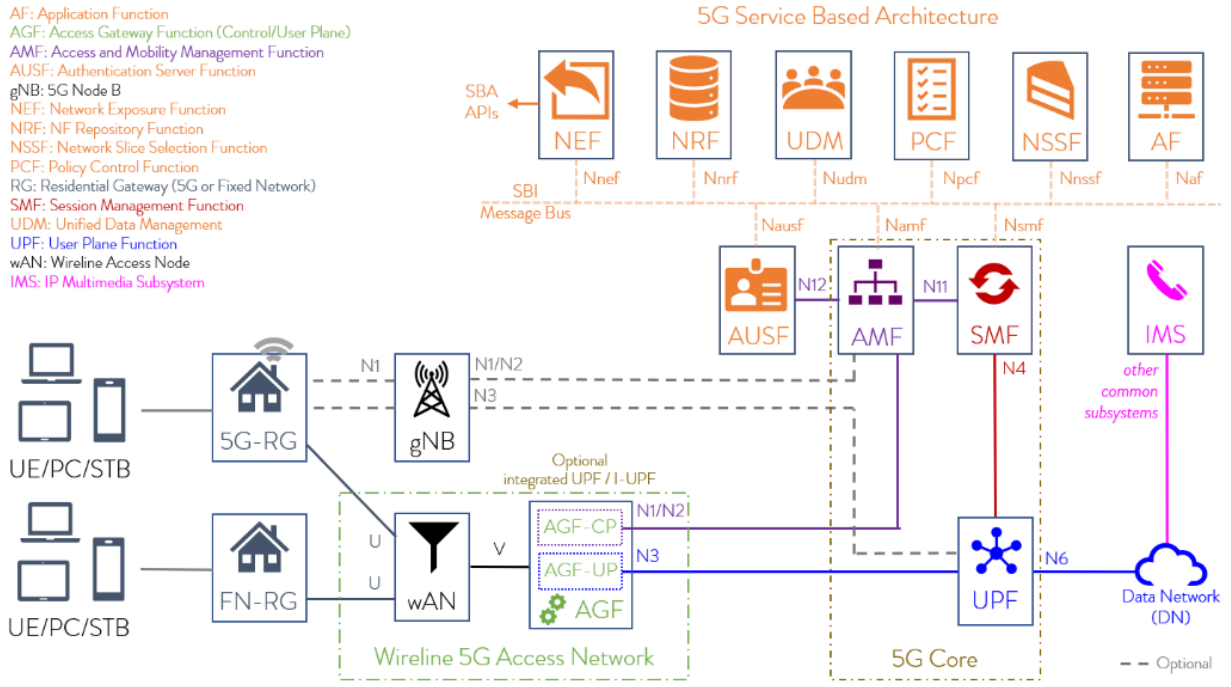


Figure 3 - 5G Universal Adaptive Core



The Access Gateway Function (AGF) with a 5G wireline wireless convergence (5G-WWC) infrastructure

Figure 4 - Classic Fixed Mobile Network Convergence Architecture

6. Why Converged Networks Requires a New Approach

Achieving the right convergence of fixed and mobile networks will mean rethinking the way you currently collect, aggregate, and normalize service and experience data from different access networks.

The initial foundational network convergence goal should be around a vendor agnostic normalization of network, subscriber, and service data into a common ingestion layer, architected to curate and funnel data into models which are tuned for each of the operational domains such as fault, configuration, performance management, service assurance, security, device management, analytics, and insights.

Data is the oil of the new network and with an exponentially increasing number of services, devices, and applications, especially in the IoT space, it will be more critical than ever to have the right tools to collect the right data at the right time from the network and devices to measure and manage the business, ensuring profitability and success.

Subscriber data convergence is critical to achieve a more fully converged fixed and wireless network architecture. Wireless mobile networks use a standard defined shared data layer (SDL) from the 3GPP referred to as TR 22.985 V9.0.0, referred to as the unified data repository (UDR), which enables the sharing and consistency of subscriber data across multiple network elements, simplifying the creation of

new services while facilitating the creation and deployment of new services through a common set of user data.

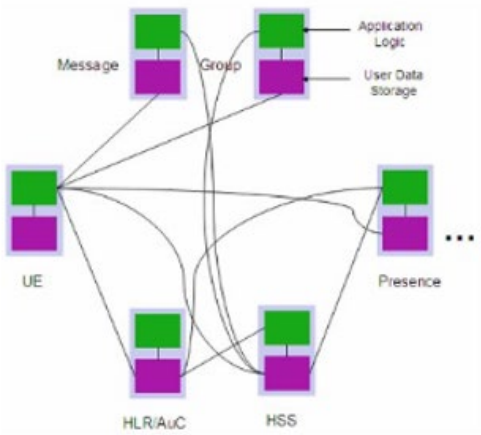


Figure 5 - Separate silos of user data without UDR

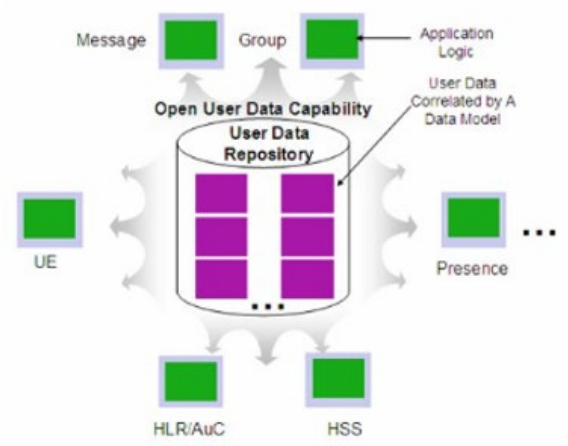


Figure 6 - Using UDR simplifies and optimizes user data management

In the fixed network the equivalent function is referred to as the shared data layer (SDL) which can support both 3GPP standards-based data models for wireless, as well as subscriber data management for fixed legacy networks. The SDL will ultimately enable convergence of subscriber and network data across a fully converged fixed and wireless network.

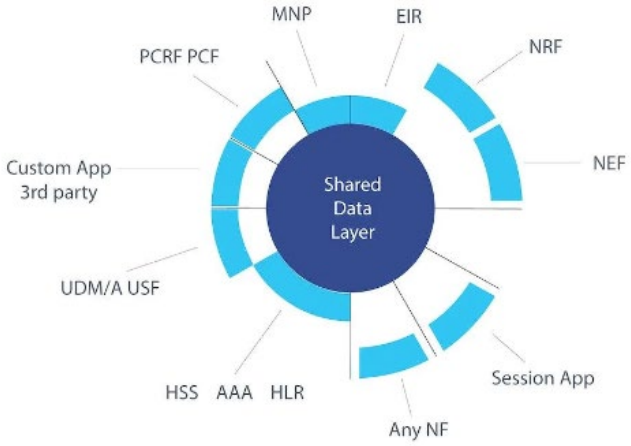


Figure 7 - Shared Data Layer Concept

The goal of this initial convergence is enabling fixed and wireless network operations to create and measure a universal set of KPIs (key performance indicators) reworked from different networks by collecting and aggregating a blended set of operational network data from Wi-Fi, 5G SA, MVNO, DOCSIS, PON, and other network technologies and ecosystem participants, including those supporting IoT, and eventually brought together under a single management umbrella.

This convergence of network and IT data at multiple layers from the OSS/BSS to the network spanning the device, to the RAN, to the backhaul, to the cores, will give cable operators more actionable insights into the situations that will affect the service experience of their customers. The right application of closed loop automation can self-heal and tune networks to ensure the highest level of service quality and reliability.

This architecture model and approach would result in a unified, coordinated, multi-access and multi-vendor converged network, which would improve business agility and interoperability across multiple networks, applications, and systems.

7. Conclusion

Cable operators will need to execute the right convergence strategy as they pivot to 5G wireless and a network access agnostic service model for residential and business markets.

Current fixed and mobile network domains remain isolated, however specific network convergence points need to be well understood and defined with clear value and benefits. Additionally converged fixed and wireless networks will drive the need to optimize how network data a pertaining to customers using your services across different networks is consumed and normalized in a single platform regardless of the countless dynamic handoffs which will occur between Wi-Fi, MVNO 4/5G, CBRS 5G core, and RAN owned or partnered.

Taking a multi-pronged network and data approach to fixed and wireless network convergence will empower cable operators with the agility to quickly go to market and monetize new fixed and wireless

network agnostic revenue generating services and feature offerings, while increasing, retaining, and monetizing customers.

Abbreviations

BSS	business support systems
CBRS	Citizens Broadband Radio Service
DOCSIS	Data Over Cable Service Interface Specifications
DSDS	dual SIM dual standby
eSIM	embedded subscriber identify module
FWA	fixed wireless access
IMS	IP multimedia subsystem
KPI	key performance indicator
KQI	key quality indicator
MNO	mobile network operator
MSO	multi-system operator
MVNO	mobile virtual network operator
OSS	operational support systems
OTT	over the top
PGW-U	packet gateway for user plane
PON	passive optical network
RAN	radio access network
RDOF	Rural Digital Opportunity Fund
SaaS	software as a service
SDL	shared data layer
SGW-U	serving gateway for user plane function
UDR	unified data repository
UPF	user plane function
vMCVPD	virtual multi-channel video programming distributor
3GPP	3rd Generation Partnership Project
5G SA	5G stand alone

Bibliography & References

Broadband Forum (Technical Report) TR-470 5G Wireless Wireline Convergence Architecture Issue: 2 Issue Date: March 2022

ETSI Technical Specification System architecture for the 5G System (5GS) (3GPP TS 23.501 version 16.6.0 Release 16)

3GPP TR 22.985: Service requirement for the User Data Convergence (UDC) (Release 9)

Nokia Website 5G Core Products 5G Adaptive Core architecture overview

Metaswitch website: The Access Gateway Function (AGF) with a 5G wireline wireless convergence (5G-WWC) infrastructure

