RAN Convergence Paper

by WBA and NGMN Alliance

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Founded in 2003, the mission of the Wireless Broadband Alliance (WBA) is to resolve business issues and enable collaborative opportunities for service providers, enterprises and cities, enabling them to enhance the customer experience on Wi-Fi and significant adjacent technologies. Building on our heritage of NGH and carrier Wi-Fi, the WBA will continue to drive and support the adoption of Next Generation Wi-Fi services across the entire public Wi-Fi ecosystem, having a focus on four major programmes: Carrier Wi-Fi Services, Next Generation Wireless & 5G, IoT, and Connected Cities. Today, membership includes major fixed operators such as BT, Comcast and Charter Communication; seven of the top 10 mobile operator groups (by revenue) and leading technology companies such as Cisco, Microsoft, Huawei Technologies, Google and Intel. WBA member operators collectively serve more than 2 billion subscribers and operate more than 30 million hotspots globally.

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The NGMN Alliance (https://ngmn.org/home.html) was founded by leading international network operators in 2006. Its objective is to ensure that the functionality and performance of next generation mobile network infrastructure, service platforms and devices will meet the requirements of operators and, ultimately, will satisfy end user demand and expectations.

The NGMN Alliance will drive and guide the development of all future mobile broadband technology enhancements with a focus on 5G. The targets of these activities are supported by the strong and well-established partnership of worldwide leading operators, vendors, universities, and successful co-operations with other industry organisations

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Introduction

Wi-Fi and cellular ecosystems have traditionally followed their own development paths. The latest versions of each technology have greatly enhanced capability compared with early offerings, with Wi-Fi 6 and 3GPP's 5G, encompassing New Radio (NR) and LTE from Release 15 onwards, as well as the 3GPP 5G Core. However, as society increasingly depends on fast reliable data connectivity, the authors believe an important capability for the industry is the convergence at a network level between 3GPP's 5G and Wi-Fi, so that the unique and complementary capabilities of both RANs can be leveraged to provide seamless network services. Bearing in mind that a significant amount of data traffic from smartphones uses a Wi-Fi access, this will lead to a better user experience and create new business opportunities for both Wi-Fi and cellular providers.

As we move into the 5G era with new emerging 5G usage including eMBB such as AR/VR, massive machine type communication (mMTC) and URLLC use cases such as autonomous driving and industrial automation, connectivity becomes even more important, together with delivery of a harmonised set of 5G services (i.e. services from the 5G core), whether the access includes Wi-Fi, cellular or both. New set of 5G use cases and verticals may require combined resources from both 3GPP and Wi-Fi networks in providing cost effective solutions that meet diverse sets of requirements on throughput, latency, connection density, coverage, availability and reliability.

Operators will be deploying new 5G networks and new capabilities across their cellular networks. Users can use either 3GPP Radio or Wi-Fi or both in accessing the 5G services. In this new ecosystem, it makes sense to ensure continued operator control and management of the Wi-Fi access and for operators to have continued visibility and control of devices connected over Wi-Fi. The Wi-Fi only deployments can also benefit from the convergence with the 5G core network being used to provide a standard way to manage these Wi-Fi based networks.

This short paper from NGMN and WBA highlights some of the requirements and key challenges that need to be addressed to realize service and network convergence over 3GPP Access and Wi-Fi.

Enterprise and Public Wi-Fi Convergence with 5G

Enterprise deployments today predominantly use Wi-Fi technology to provide wireless connectivity. Services on cellular networks, and in particular those that the 5G Core enables, may require a new look at the use of an access-neutral mechanism for the following reasons:

- Indoor venues (e.g. Enterprise indoor venues) may experience gaps in coverage, which adversely impact user satisfaction and also result in cellular operators losing contact with their subscribers in these venues.
- Outdoor public Wi-Fi deployments are becoming more common as cities and other actors look to provide their own connectivity capability.
- The latest Wi-Fi standard Wi-Fi 6 includes substantial improvements, such as QoS mechanisms.
- The enterprise workforce is becoming more mobile, creating the need for seamless location-independent connectivity and enabling secure IT management for mobile devices on the basis of a unique identity.

- Current solutions may not include full support for policy settings and network manageability between Wi-Fi and 5G networks.
- There is potential to use a common management system to manage 5G networks and enterprise Wi-Fi deployments across one or more sites, creating a multi-site enterprise environment.
- There is a potential for improving the ability to leverage the access capabilities (e.g. coverage, capacity) by combining cellular and Wi-Fi connections (e.g. via dual connectivity, mutual anchoring and seamless session mobility capabilities).

Today, the cellular operations do not generally have control over and/or access to enterprise or public Wi-Fi, despite the market interest in balancing traffic load across cellular and Wi-Fi. The convergence of 5G and Wi-Fi can bring great benefits to cellular operators, Enterprise Wi-Fi and Public Wi-Fi solution providers, giving access to 5G and enterprise services from both Wi-Fi and 5G access networks.

To enable a diverse set of deployment scenarios and business opportunities for Wi-Fi providers and cellular operators, a tighter integration of Wi-Fi access in the 5G networks is needed. The integration should address key challenges such as mentioned above and include support for dual radio devices as well as Wi-Fi only devices.

State of the art on 5G and Wi-Fi Interworking

3GPP has already developed specifications to ensure tight integration of 3GPP and non-3GPP radio technologies, such as Wi-Fi. In order to better serve customers and provide the full 5G experience the tight integration of non-3GPP technologies needs to be ensured also within the 5G Core Network. Solutions enabling some of these objectives have already been adopted by 3GPP and Wi-Fi 6, such as the EAP authentication framework similar to Wi-Fi, to accommodate different wireless service subscription-types (e.g. mobile, wireless or fixed broadband) and their native authentication methods.

3GPP Release 15 provides some support for interworking between 5G and Wi-Fi. In particular, 3GPP Release 15 provides support for untrusted non-3GPP access (such as Wi-Fi) to the 5G core via Non-3GPP Interworking Function (N3IWF), with secure transport of Control-Plane/User-Plane (CP/UP) messages over an IKEv2/IPSec tunnels between the terminal devices and the N3IWF.

3GPP Release 16 is continuing the work by enhancing capabilities for Wi-Fi integration, including trusted Wi-Fi support and access traffic steering, switching and splitting.

Key Challenges

Enablement of Wi-Fi Only Devices

It is important that Wi-Fi only devices be able to connect to the 5G core. Enabling Wi-Fi only devices requires support for alternative device identity types, based on Wi-Fi centric subscription and authentication types, and support for corresponding alternative authentication credentials in the 5G Core network. The 3GPP standard currently supports core identities and authentication based on 5G-AKA or EAP-AKA' authentication schemes, which require presence of SIM credentials. The current 3GPP standard also supports EAP-TLS and EAP-TTLS non-3GPP identification/authentication, although it limits the usage to private 5G networks only.

Further work may be needed to enable Wi-Fi only devices connect to 5G core. Wi-Fi only devices include those that support the 5G NAS protocol, as well as those that do not support the 5G NAS protocol.

Tight Integration between 5G and Wi-Fi

3GPP Releases 15 and 16 provide interworking between the 5G and Wi-Fi networks by enabling access to the 5G Core via untrusted and trusted non-3GPP access networks such as Wi-Fi. These efforts are focussed on defining architecture and messaging to provide secure transport for the 5G control plane and data plane over non-3GPP access via gateway functions (N3IWF or TGNF). Further study is needed to ensure a tight integration between 5G and Wi-Fi networks, to better utilize resources from both access networks to meet requirements for a wide array of current and future 5G use cases.

A tighter integration between 5G and Wi-Fi may be able to improve session mobility control through better metrics and triggering mechanisms, reduce signalling complexity by providing better anchoring points, as well as improved data path support through the use of both accesses when those are available.

Network Manageability and Policy Control

There is a demand from cellular operators to ensure that there is a standardised solution for cellular operations to have improved visibility and control in the configuration and management of Wi-Fi access networks, and for some Enterprise Wi-Fi Providers to have access to request core network resources. To realize new sets of business opportunities between cellular operators and Wi-Fi vendors, an interface is needed to enable certain level of network manageability and policy control between 5G core and Wi-Fi networks. For example, such an interface can be used to set Wi-Fi bandwidth dedicated for 5G service traffic, configurations and QoS settings for the Wi-Fi slice dedicated for 5G services and devices allowed to access the dedicated Wi-Fi slice. Such an interface can also enable enterprise Wi-Fi vendors to set policies in the 5G core for handling traffic, or request network slices, for certain enterprise users and/or applications.

Traffic Routing across Multiple Accesses

At the heart of cellular/Wi-Fi convergence is the ability of a client to route traffic over one or more accesses, making optimal use of the available connectivity. This might involve using more than one access network at the same time, or seamlessly switching traffic flows between the access networks as the network conditions vary. A Traffic routing solution over multiple accesses should ideally have all of the following characteristics:

- Fast reaction (sub-second) to changes in connection quality
- Support session continuity
- Support all IP protocols (not just TCP)
- Traffic routing should be under policy control
- Should not rely on radio access networks being physically co-located
- Should be efficient, in terms of network traffic, computation and battery power
- Should be standardised

3GPP Release 16 ATSSS work is addressing some of the above requirements for traffic routing over 3GPP and Wi-Fi access.

Economics of convergence

One possible issue that might partially explain the relatively low market adoption of cellular/Wi-Fi convergence solutions is cost. Industry figures suggest that the cost per bit of sending traffic through a cellular network is roughly an order of magnitude greater than that of traversing a fixed network. If converged Wi-Fi/3GPP solutions for 5G service delivery are to gain widespread adoption, not only must the technologies converge, but also the underlying costs must converge too. This is both a technical and commercial challenge that the industry will have to address to make convergence a success.

Next Steps

The WBA and NGMN are working on a full whitepaper, which will provide more detail on some of the challenges outlined in this short paper and will attempt to answer the question of why deployments integrating both Wi-Fi and cellular access with the cellular operator core have been so limited to date, and what we as a community can do differently with the launch of 5G to change this.

The whitepaper will also present and review potential solutions to these challenges and recommend a future strategy for Converged RAN deployment ensuring the best user experience making use of both Wi-Fi and Cellular access.

To find out more about this project, please contact:
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