MAVENIR

Realizing the gains of versatile Wi-Fi

Delivering VoWiFi solutions with advanced technologies for improved connectivity and performance.

WHITE PAPER / SEP 2023

MAVcore™

The ubiquity of Wi-Fi networks is delivering significant benefits for both end users and Communication Service Providers (CSPs).

End users have a lot to gain from Wi-Fi connectivity thanks to its low cost and reliability, while CSPs benefit indirectly from the resulting offload of consumer traffic from cellular networks. To maximize these advantages, CSPs are now offering Voice Over Wi-Fi (VoWiFi) services to mobile users over 4G and 5G – delivering connectivity solutions and quality of service that can best meet the end customers' needs.

The global demand for VoWiFi capabilities is rapidly increasing because of their potential to improve voice call quality in low-signal areas and provide better indoor coverage. Consumer behavior is changing, with more people using Wi-Fi on mobile devices and giving up landlines. Optimizing voice call services is now emerging as a key customer retention tool for CSPs worldwide. As more smartphones that can support Wi-Fi calling enter the market, the percentage of calls made using VoWiFi is set for sustained growth, as the industry works to satisfy the consumer appetite for always-on connectivity.

In this white paper, you will discover how to:

Deploy seamless Voice Over Wi-Fi with evolved Packet Data Gateway (ePDG) technology.

Enable VoWiFi for local/internal 4G enterprise networks.

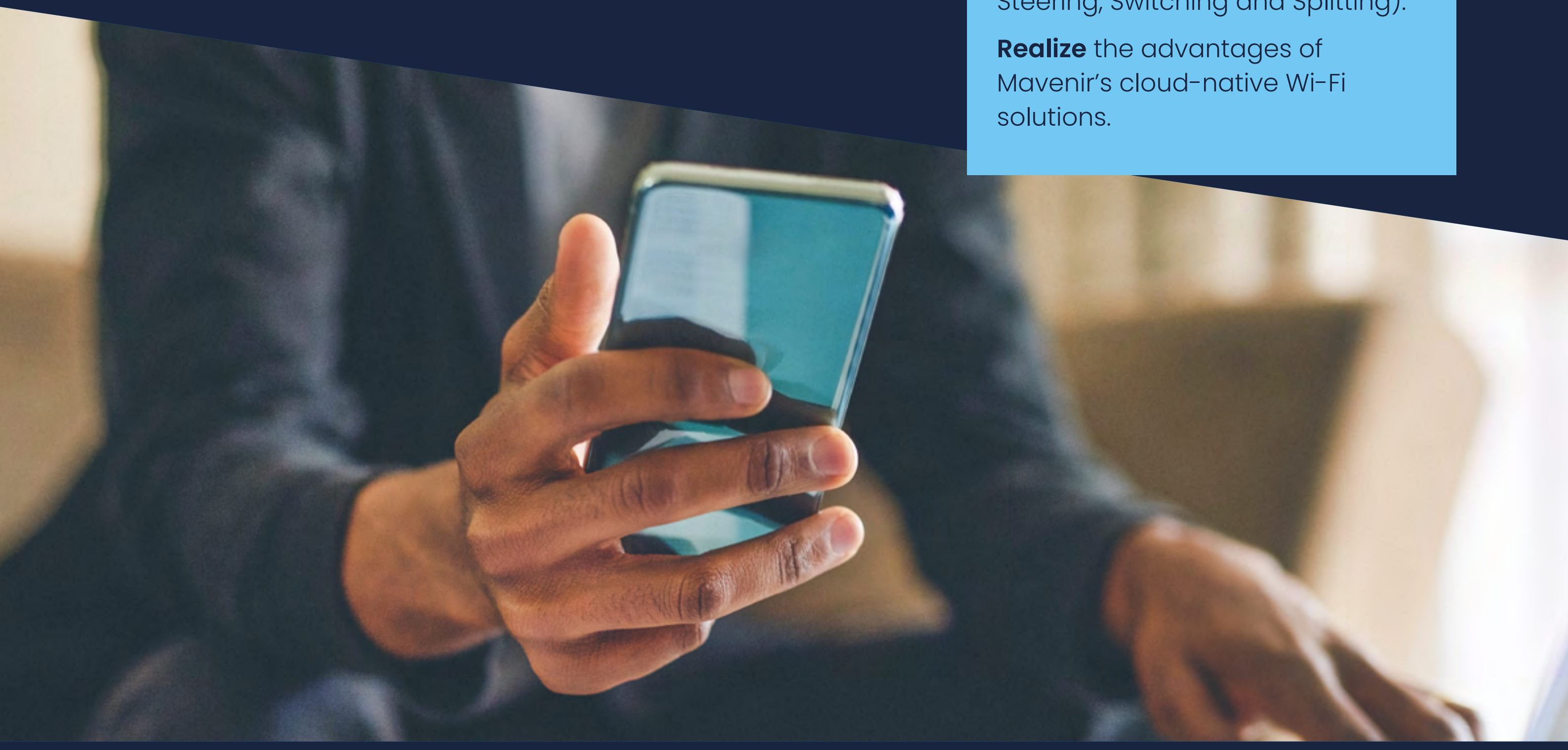
Ensure seamless VoWiFi continuity during 5G transition.

Implement VoWiFi services in 5G networks.

Leverage VoWiFi for local and/or internal 5G enterprise networks.

Gain from Wi-Fi Offload with non 3GPP Interworking Function (N3IWF) for ATSSS (Access Traffic Steering, Switching and Splitting).

Realize the advantages of Mavenir's cloud-native Wi-Fi solutions.



At present, the global VoWiFi market is predicted to achieve double-digit CAGR over the next few years[1], generating estimated revenues of $22.8012 billion by 2025[2] and the global market for Voice over Wireless LAN (VoWLAN) is projected to reach US$89.2 billion by 2030[3]. Converging factors are acting as powerful enablers of growth, including consistent technology advances, surging numbers of Voice over Long-Term Evolution (VoLTE) subscribers, the adoption of IMS, swelling demand from emerging economies, supportive government initiatives (including a worldwide push for increased availability of public Wi-Fi hotspots), favorable regulatory policies, plus an overall boost in R&D investment levels. Over the next decade, the requirement to integrate advanced technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) will act as further spurs for fast-paced growth. Wi-Fi calling can also reduce the need for deployed network infrastructure in dense and urban areas – making it an attractive and cost-effective strategy for complementing macro coverage and boosting operator revenue growth, particularly in emerging markets.

This whitepaper explores how CSPs can successfully optimize their network investments by extending wireless coverage and voice service reach using available private and public Wi-Fi networks.

Mavenir's Converged Packet Core solution can be easily deployed in mobile operators' networks to provide 4G EPC and 5G Core, which also unlocks VoWiFi use cases – creating a seamless, unified and enhanced network experience for users.

1. TechSci Research report, "Global Voice over Wi-Fi Market By Technology, By Voice Client, By Device Type, By End User, By Region, Forecast & Opportunities, 2026".
2. From 2.93 billion in 2020, the global Voice Over Wi-Fi (VoWiFi) market size is expected to reach $22.2billion by 2025, registering a CAGR of 24.5% during the envisioned period (2020-2025).
3. The global market for Voice over Wireless LAN (VoWLAN) estimated at US$35.2 Billion in the year 2022, is projected to reach a revised size of US$89.2 Billion by 2030, growing at a CAGR of 12.3% over the analysis period 2022-2030.

Contents

1. Introduction

Today, Wi-Fi technology is widely used for internet connectivity and internal communication in consumer spaces, including throughout homes and businesses. Increasingly, it is also being leveraged by CSPs to extend their voice services in a secure and reliable way – dramatically boosting connectivity choice and quality for mobile users. By deploying VoWiFi solutions that harness the capabilities of evolved Packet Data Gateway (ePDG) or N3IWF, CSPs can measurably improve their coverage and reduce the traffic load on their cellular networks – resulting in enhanced voice call quality for mobile customers.

Deploying VoWiFi can also help CSPs to offer extended coverage for other core services, such as messaging and emergency calls, while also ensuring high levels of privacy and security for mobile users. The use cases for VoWiFi in the context of CSPs are rich and varied, offering a uniquely flexible solution to meet the needs of different network environments.

Accessing Wi-Fi to make phone calls and send text messages provides an ideal solution in places where cellular service is weak. This offers a convenient option for users who experience issues with cellular coverage but have good access to Wi-Fi. In these scenarios, CSPs can leverage the latest Wi-Fi technologies to provide Voice over Wi-Fi services to their customers for seamless cellular voice calls.

Figure 1 and Figure 2 depict the current widely adopted use cases of Wi-Fi, where it is typically used for internet access or local traffic within an enterprise or campus.

CSPs can integrate their core network infrastructure with Wi-Fi networks to enable seamless connectivity between cellular and Wi-Fi networks for voice calls. This integration allows subscribers to maintain call continuity and enjoy consistent service availability and quality, regardless of which network they are connected to.

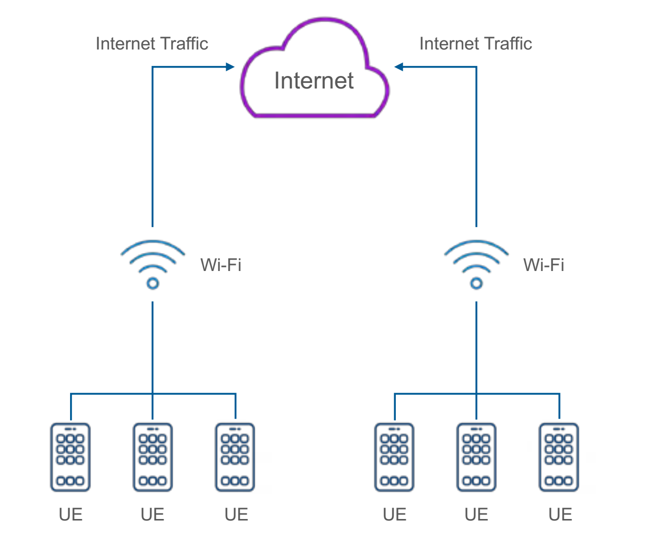


Figure 1 : Wi-Fi for data/internet traffic

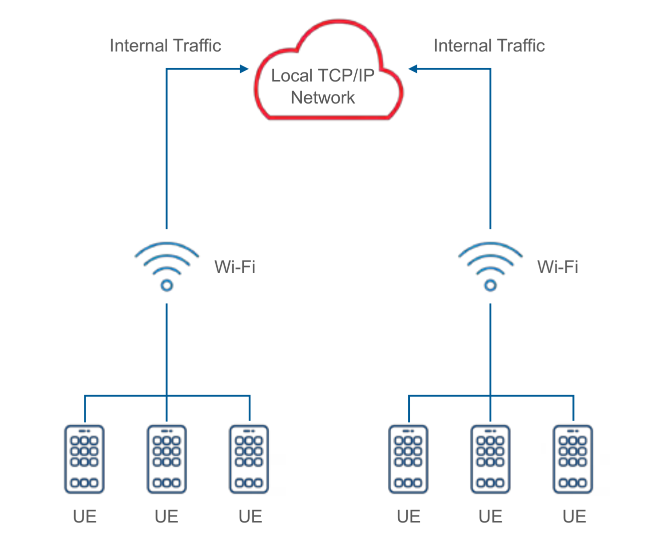


Figure 2 : Wi-Fi for local or internal access

2. Deploying Seamless Voice Over Wi-Fi With ePDG Technology

A CSP can enable VoWiFi services for its subscribers connected to a Wi-Fi network. For subscribers, this affords the ability to make and receive voice calls using their mobile devices over a Wi-Fi connection, instead of relying solely on traditional cellular networks.

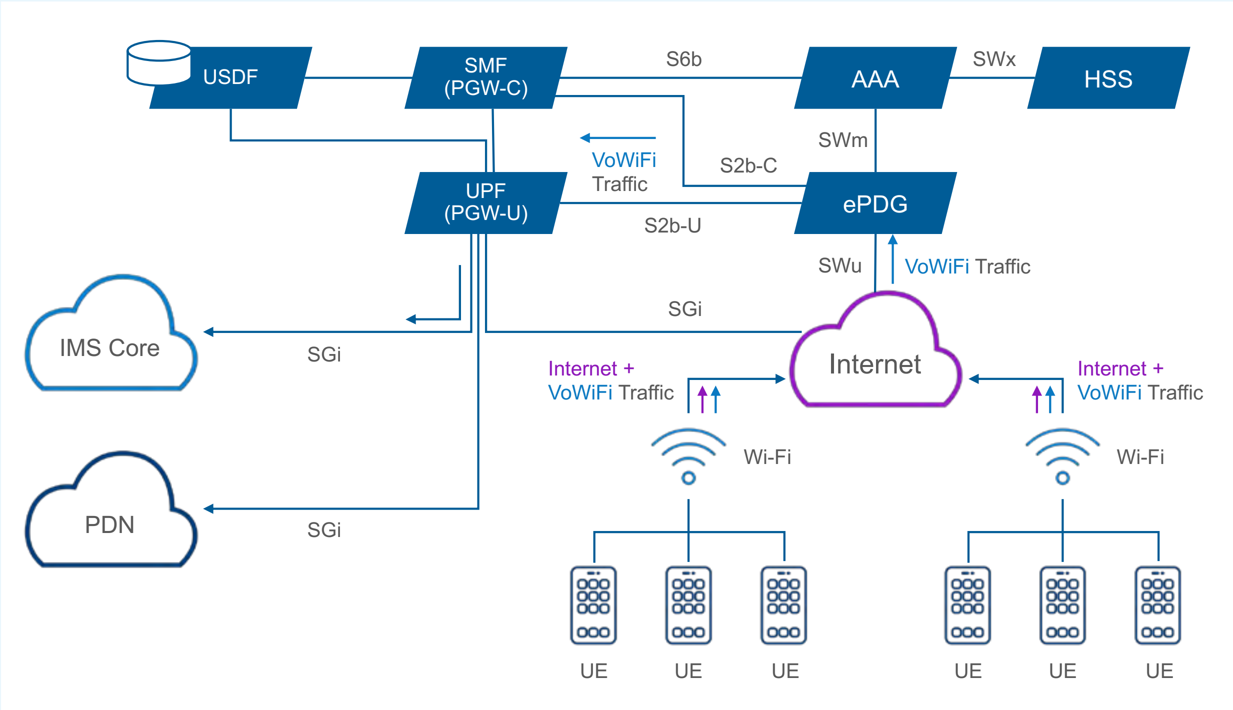


Figure 3 : VoWiFi with ePDG technology

Figure 3 shows inside the 3GPP cellular network architecture, illustrating how the ePDG is the interface between the operator's EPC network and the Wi-Fi users through the internet. ePDG is responsible for securely connecting Wi-Fi users to the operators' EPC network.

ePDG technology is particularly useful in areas where cellular coverage is weak or non-existent. Based on the CSP's offering, VoWiFi can enable users to make international or long-distance calls using the same mobile number while avoiding potentially high cellular calling rates.

VoWiFi technology can handle SMS and MMS traffic, allowing users to send and receive messages while connected to a Wi-Fi network (provided that the UE/Client and IMS Core include the necessary capability). Moreover, users with a capable UE/client in such networks will also be able to send SMS and MMS messages from flights that provide Wi-Fi connectivity.

In the scenario shown, only VoWiFi traffic is routed through ePDG node, while all other internet traffic is terminated before reaching the ePDG. This approach ensures that the ePDG node only handles VoWiFi traffic, thereby reducing the load on the cellular network and improving overall service quality.

Using VoWiFi with ePDG in mobile networks enables seamless handover between cellular and Wi-Fi networks. Users can move between different types of networks without dropping their voice calls, which can help to improve the overall quality of service.

VoWiFi with ePDG in a mobile network is a highly useful technology that offers multiple benefits for mobile users, including improved call quality, lower call charge rates, and the ability to send and receive messages while connected to a Wi-Fi network. Integrating this technology means CSPs can seamlessly provide their customers with high-quality and reliable communication services.

Both VoWiFi and VoLTE utilize the IP Multimedia Subsystem (IMS) core network, which is responsible for managing the signaling and routing of voice and multimedia traffic.

Since VoWiFi technology leverages the same IMS core network already used by VoLTE, CSPs can exploit their existing infrastructure to offer VoWiFi services to customers. This approach minimizes the need for additional hardware and software investments – reducing the cost and complexity of deploying VoWiFi services.

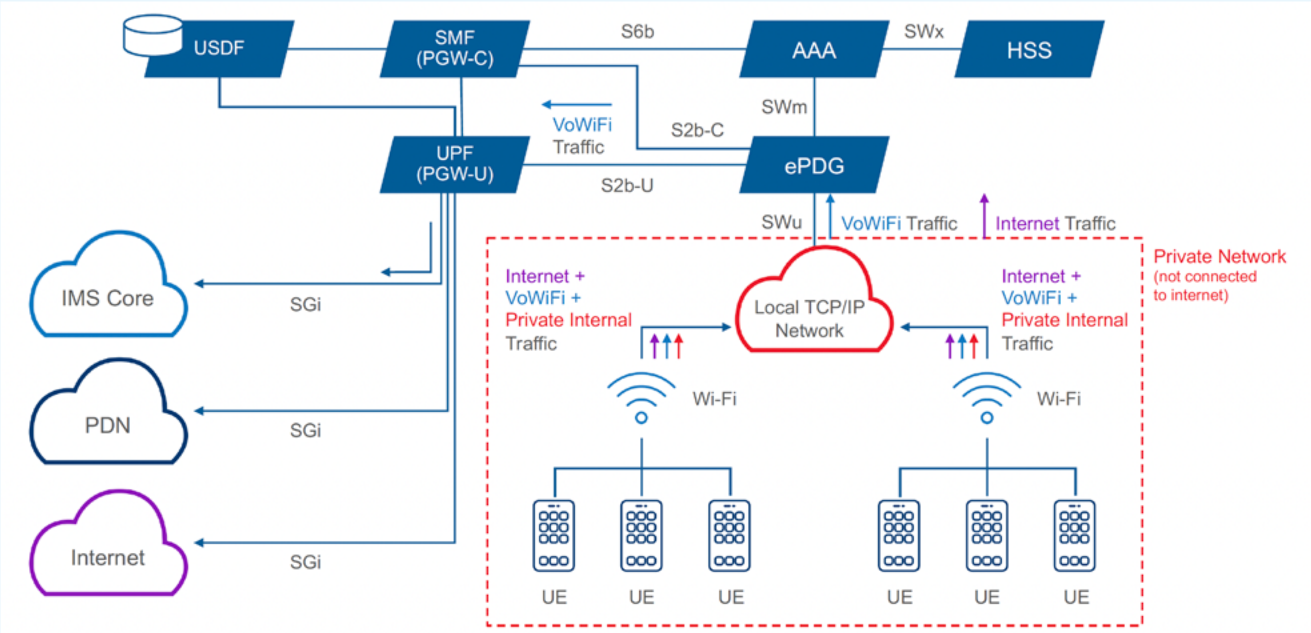


Figure 4 : Voice over Wi-Fi (VoWiFi) with ePDG for a local/internal network

3. Enabling Internet Access (Along With VoWiFi) For Local/ Internal Enterprise Networks

The ePDG deployed in a CSP network also enables internet access (along with VoWiFi) for local/internal Wi-Fi networks that are not directly connected to internet but can establish connectivity to a CSP network through some alternate methods. In such instances, the ePDG serves to direct both VoWiFi traffic and internet traffic. Only authorized users are permitted access to the internet through a secure client that ensures local data is protected. The user's local network traffic (i.e., activity within the organization's internal network) and their internet traffic (i.e., activity on external websites) are kept separate from each other, meaning that the user's internet browsing doesn't interfere with the organization's internal network, and vice versa. Such internal networks can use special or custom UE/client configuration to control VoWiFi, Internet and local traffic and robustly enforce policies.

FOR CSPs, THIS APPROACH OFFERS SEVERAL ADVANTAGES:

- Allows seamless voice and data communication without relying on an internet connection.
- Particularly useful in environments where internet connectivity is unreliable or unavailable. By routing all traffic through the ePDG, the local network can ensure high-quality voice and data communication, improving user experience and productivity. *Figure 4: Voice over Wi-Fi (VoWiFi) with ePDG for a local/internal network*
- When the Wi-Fi network is insecure or lacks security measures, this approach ensures security by routing all the internet traffic through the ePDG, which establishes an IPSec secured tunnel between the ePDG and the User Equipment(UE)

It is important to note here that ePDG sizing must account for processing the internet traffic along with the VoWiFi traffic. This is because routing all internet traffic through the ePDG can increase the load on the ePDG, which can lead to issues such as latency or dropped calls. Therefore, it's essential to ensure that the ePDG is adequately sized to handle both types of traffic, while also providing adequate bandwidth and processing power to deliver a reliable and high-quality communication experience.

4. Ensuring Seamless VoWiFi Continuity During 5G Transition

So far, we have explored the significance and advantages of VoWiFi technology, and the need for an evolved Packet Data Gateway (ePDG) to facilitate deployment in Evolved Packet Core (EPC) networks for 4G mobile communications. Given this context, different scenarios emerge when CSPs transition to 5G packet core networks.

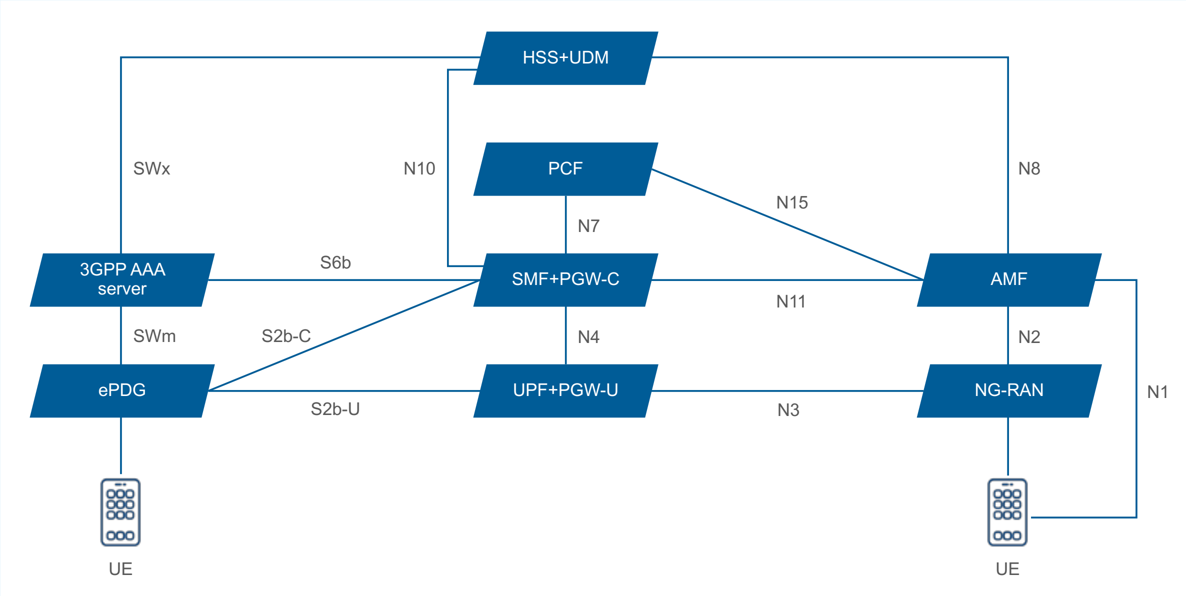


Figure 5 : Architecture for interworking of ePDG between EPC and 5GS

The diagram above is sourced from the 3GPP 23.501 section 4.3.4, which outlines the architecture for interworking between ePDG/EPC and 5GS for UEs capable of supporting both 4G and 5G. This use case indicates that ePDG nodes are adequate for handovers between VoWiFi and VoNR, as long as UEs are dual mode (that is, capable of supporting both 4G and 5G), and the network itself supports both 4G and 5G. In other words, the deployment of 5G N3IWF nodes becomes necessary for mobile networks only when UEs become purely 5G (i.e., stop supporting 4G) and/or the network itself supports only 5G. For a 5G SA mobile network (with no EPS interworking), N3IWF nodes are needed to enable and support non-3GPP access and VoWiFi services.

THE TABLE BELOW SUMMARIZES THE NECESSITY AND APPLICABILITY OF ePDG AND N3IWF NODES:

UE Capability \ Network	4G Network + Wi-Fi	4G + 5G Network + Wi-Fi	5G Network + Wi-Fi
4G UE	Use ePDG	Use ePDG	Not compatible
4G + 5G UE	Use ePDG	Use ePDG or N3IWF	Use N3IWF
5G UE	Not compatible	Use N3IWF	Use N3IWF

A key benefit of using VoWiFi with N3IWF in mobile networks is that it provides much greater flexibility for CSPs. CSPs can deploy 5G N3IWF nodes to support VoWiFi on 5G networks, while still supporting existing 4G and 5G networks with ePDG. This means that CSPs can continue to offer VoWiFi services to users, regardless of the type of network or device they are using.

5. Implementing VoWiFi Services In 5G Networks

The advent of 3GPP improved and streamlined non-3GPP access architecture by introducing the N3IWF node so that it leverages the same interfaces and authentication mechanism as 3GPP access architecture.

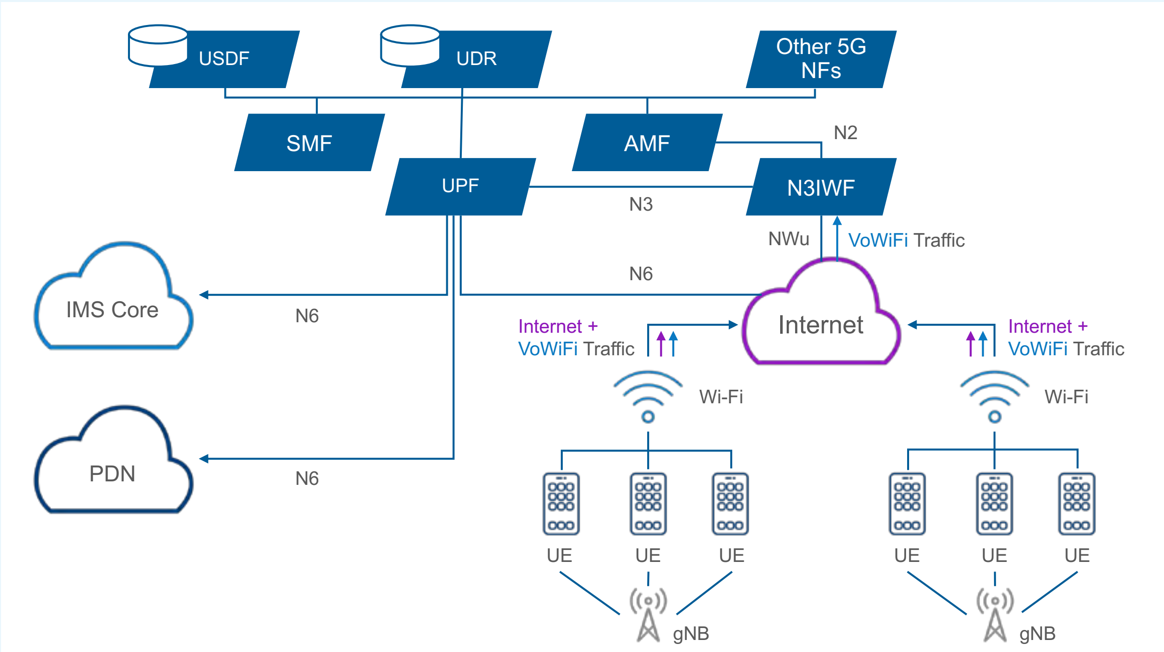


Figure 6 : Voice over Wi-Fi (with N3IWF) in mobile network

An N3IWF has both N2 and N3 interfaces with Access and Mobility Function (AMF) and User Plane Function (UPF) respectively, which is the same as a 5G New Radio (NR) – a gNB. So, N3IWF effectively functions more like a gNB than an ePDG.

3GPP designed N3IWF specifically for 5G. It can be considered as equivalent of a gNB for 3GPP access, since it operates on the same interfaces without requiring new authentication or interfaces, aligning perfectly with the 5G core architecture.

In 5G networks, VoWiFi can be provided using the N3IWF Network Function (NF). This allows for seamless interworking between the 5G core network and Wi-Fi. In this use case, only VoWiFi traffic is routed through the N3IWF node, while all other traffic is terminated before it reaches the N3IWF node. This helps to reduce the load on the cellular network, which results in improved overall network performance and a better user experience.

In the case of a newly deployed 5G network that is only 5G and/or the UE/client is only 5G enabled, CSPs will need to set up 5G N3IWF nodes to support VoWiFi services. This scenario involves utilizing the N3IWF node to provide VoWiFi over mobile networks.

6. Enabling VoWiFi For Local/ Internal Enterprise Networks

The N3IWF deployed in the CSP network also enables internet access (along with VoWiFi) for local/internal Wi-Fi networks that are not directly connected to internet but can establish connectivity to the CSP network through some alternate methods. In this scenario, all traffic – including VoWiFi and internet traffic – must go through the 5G N3IWF node, which acts as the gateway between the local network and the public network.

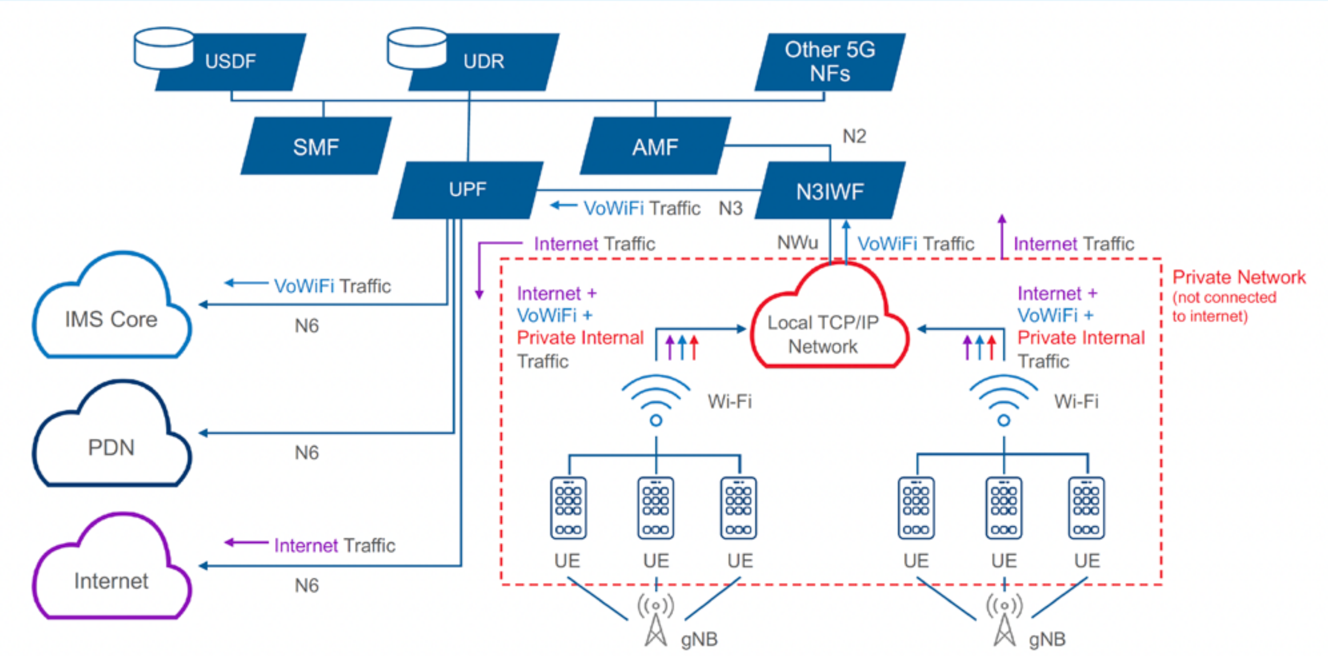


Figure 7 : Voice over Wi-Fi (with N3IWF) in local network

The use of N3IWF in a local network set-up enables enterprises to leverage their existing Wi-Fi infrastructure to provide voice services, and also to provide a secure communication channel, since all the traffic stays within the local network (preventing it from being intercepted or tampered with by unauthorized parties). Finally, by routing all the traffic through the N3IWF node, the local network can provide a consistent user experience, ensuring high quality voice and integrity of data services.

While deploying N3IWF in local networks, careful consideration of the N3IWF node sizing is again imperative, as it must account for processing the internet traffic along with the VoWiFi traffic. This can impact the network performance, making it critical for CSPs to properly size the N3IWF node to ensure a smooth and seamless user experience.

7. Efficient Wi-Fi Offload For Advanced Traffic Steering And Seamless Switching

Access Traffic Steering, Switching, and Splitting (ATSSS) is an advanced technology designed to help CSPs optimize network performance and improve the user experience. This innovative solution allows operators to seamlessly steer, switch, and split traffic between multiple access networks, such as Wi-Fi, and 5G, to maximize network efficiency and ensure optimal quality of service. By intelligently utilizing the available network resources, ATSSS enables operators to effectively manage network congestion, minimize latency, and provide a seamless user experience across various network environments. Furthermore, the implementation of ATSSS can significantly reduce operating costs, optimizing network resource allocation, and minimizing the need for additional infrastructure investments. As a result, these improvements can directly translate into revenue growth – making the ATSSS feature a natural pathway for CSPs to monetize 5G.

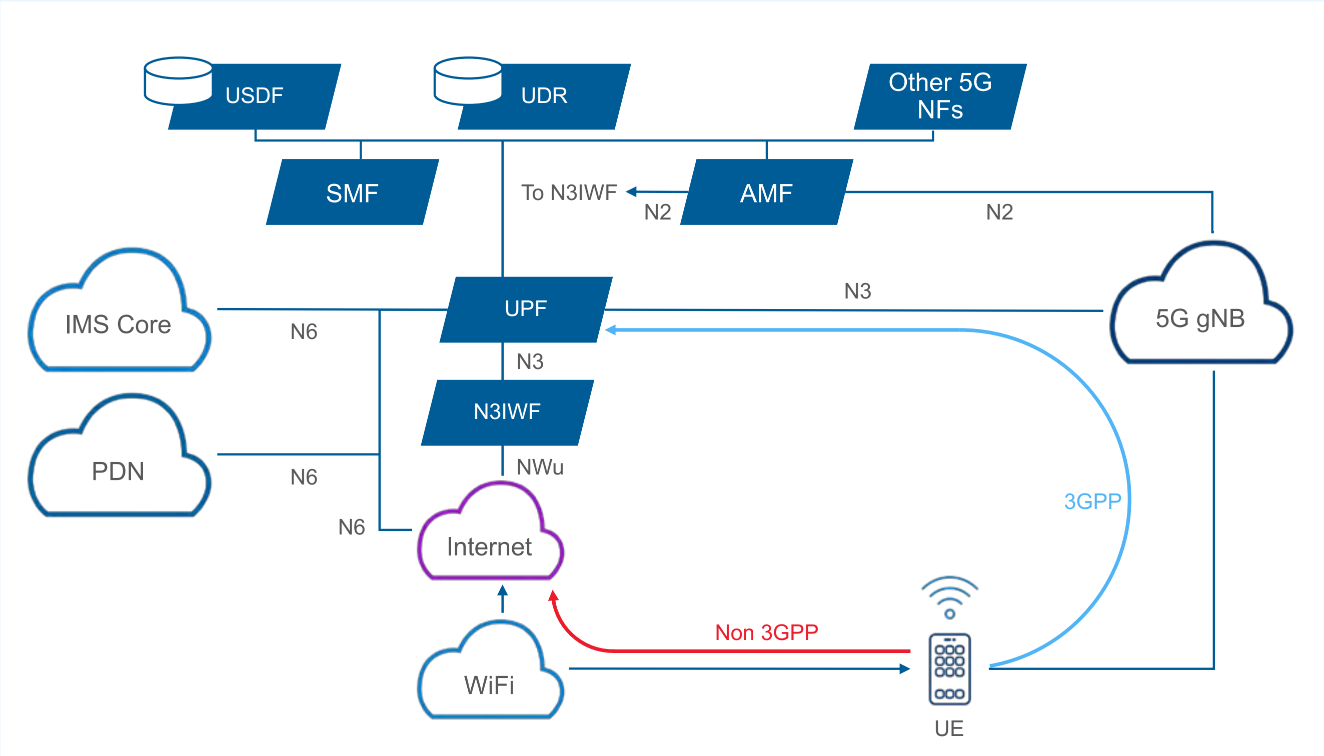


Figure 8 : Wi-Fi offload for ATSSS

The ATSSS feature enables Multiple-Access PDU Sessions (MA-PDU). This means a PDU Session may have user-plane resources on two access networks. This assumes both 3GPP access (in this case: 5G) and non-3GPP access (in this case: Wi-Fi) are allowed for the PDU Session. The User Equipment (UE) and User Plane Function (UPF) exchange information about signal strength, latency, and other metrics to facilitate the decision of selecting 5G versus Wi-Fi access, to switch between them while in the middle of a session, or even to load-share between 5G and Wi-Fi access networks.

THIS RESULTS IN 3 ATSSS MODES:

1. **Steering** – choosing the best available network between 5G and Wi-Fi based on speed, cost, and latency.
2. **Switching** – moving seamlessly between 5G and Wi-Fi networks.
3. **Splitting** – splitting the traffic over 5G and Wi-Fi (split can be set by defined policies).

ATSSS uses the Multipath TCP (MPTCP) technology, that allows IP data traffic to flow simultaneously over Wi-Fi and 5G networks. While this decision-making is done by the UE and UPF, it is supported and enabled by other 5G network functions, such as the AMF, SMF, and Policy Control Function (PCF).

The ATSSS feature requires the Internet and VoWiFi traffic to go through the N3IWF, which would need careful network planning and management to ensure that the N3IWF is appropriately sized and capable of handling the expected traffic load.

By dynamically steering traffic to the best available network, the ATSSS feature improves user experience, reduces latency, and increases throughput.

8. Realizing The Advantages Of Mavenir's Cloud-Native Wi-Fi Solutions

LOW-TOUCH MIGRATION PATH TO MODERN NETWORKS

By deploying containerized and cloud-native ePDG and N3IWF on a Kubernetes-based cloud architecture, operators can leverage a scalable and flexible platform that efficiently manages and orchestrates multiple network functions – including 4G, 5G, and Wi-Fi – on a unified platform. This approach simplifies network operations, reduces costs, and provides the ability to deliver new services and applications, enabling operators to take advantage of a low-cost migration path towards a converged packet core architecture. This architecture allows for the efficient management of containerized components across different computing environments, providing a unified and agile network infrastructure.

EFFORTLESS INTEGRATION OF ePDG & N3IWF IN MAVENIR'S CONVERGED PACKET CORE

Mavenir's solution offers support for a converged packet core that combines the SMF and UPF. This architecture enables seamless integration of both the ePDG and N3IWF functions to the same converged core, eliminating the need for separate packet cores. Moreover, the SMF supports the Serving Gateway Control Plane (SAEGW-C) and the UPF supports the User Plane Function (SAEGW-U), thereby allowing the ePDG to utilize the same SMF and UPF as the N3IWF.

STREAMLINED NETWORK CONVERGENCE WITH ATSSS

Access Traffic Steering, Switching, and Splitting (ATSSS), as well as advanced 3GPP-defined features of Wi-Fi, play a crucial role in expanding Wi-Fi convergence and enabling the integration of Wi-Fi and 5G mobility into a common core network. These capabilities enable the seamless steering and switching of traffic between Wi-Fi and cellular networks, ensuring a more cohesive and consistent network experience for end-users. Utilizing these functionalities, CSPs can enhance network reliability and performance, ultimately leading to improved quality of service and user experience.

CLOUD-NATIVE CONVERGED PACKET CORE

Mavenir's Converged Packet Core – deployed to support Wi-Fi use cases – is built from the ground up using stringent cloud-native principles. It is 100% microservices-based, 100% containerized, deploys CI/CD pipeline, delivers network automation, and offers a service-mesh architecture. It enables a highly scalable, flexible, and programmable network. The same architecture can be deployed in a range of different network environments – from large Tier 1 networks serving millions of consumers to small private and edge networks serving specific industry verticals.

9. Conclusion

Wi-Fi's continuous innovation path – from OFMDA, MU-MIMO and 1024-QAM to 6GHz spectrum – is succeeding in increasing reach, capacity and speed. These advances are set to be boosted further with the new Wi-Fi 7 standards, including 320 MHz channels, 4096-QAM, High Band Simultaneous Multi-Link, and Flexible Channel Utilization. As demand for Wi-Fi continues to grow, the integration of new technologies will play a crucial role in addressing the ever-increasing expectations of users for seamless, high-speed, and reliable connectivity. As a result, CSPs have a unique opportunity to capitalize on the vast potential of their existing Wi-Fi infrastructure.

Mavenir, a leading provider of telecommunications network software, is well-positioned to help CSPs effectively monetize their invested Wi-Fi footprint.

By integrating our industry-leading VoWiFi solutions, operators can leverage existing Wi-Fi infrastructure to deliver enhanced voice and messaging services, optimize network capacity, and reduce operational costs. Our comprehensive suite of VoWiFi solutions is designed to ensure seamless interoperability with current network deployments – simplifying the transition process and maximizing return on investment.

About Mavenir

Mavenir is building the future of networks and pioneering advanced technology, focusing on the vision of a single, software-based automated network that runs on any cloud. As the industry's only end-to-end, cloud-native network software provider, Mavenir is transforming the way the world connects, accelerating software network transformation for 300 Communications Service Providers in over 120 countries, which serve more than 50% of the world's subscribers.

www.mavenir.com

10. Appendix

Acronyms

3GPP	3rd Generation Partnership Project
5G	5th Generation
AAA	Authentication, Authorization and Accounting
AMF	Access and Mobility Management Function
AR/VR	Augmented Reality/Virtual Reality
ATSSS	Access Traffic Steering, Switching & Splitting
CSP	Communications Service Provider
EPC	Evolved Packet Core
ePDG	Evolved Packet Gateway
gNB	gNodeB
GSMA	Global System for Mobile Communications Association
HSS	Home Subscriber Server
IMS	IP Multimedia Subsystems
LTE	Long Term Evolution
MAPS	Multiple-Access PDU Sessions
MMS	Multimedia Messaging Service
N3IWF	Non-3GPP Interworking Function
NF	Network Function
NR	New Radio
PGW	Packet Network Data Gateway
PDN	Packet Data Network
PDU	Packet Data Unit
RAN	Radio Access Network
SAEGW-C	Serving Gateway Control Plane
SBA	Service Based Architecture
SMF	Session Management Function
SMS	Short Messaging Service
UDM	Unified Data Management
UDSF	Unstructured Data Storage Function
UE	User Equipment
UPF	User Plane Function
VoLTE	Voice Over LTE
VoWiFi	Voice Over Wi-Fi
Wi-Fi	Wireless Fidelity

For further information or enquiries, please contact

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