5G and Wi-Fi RAN Convergence

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Abstract

- This contribution is submitted as a companion document to the Liaison statement from WBA (Wireless Broadband Alliance) to IEEE 802.11 WG (Working Group)

WIRELESS BROADBAND ALLIANCE
DRIVING NEXT WIRELESS EXPERIENCE

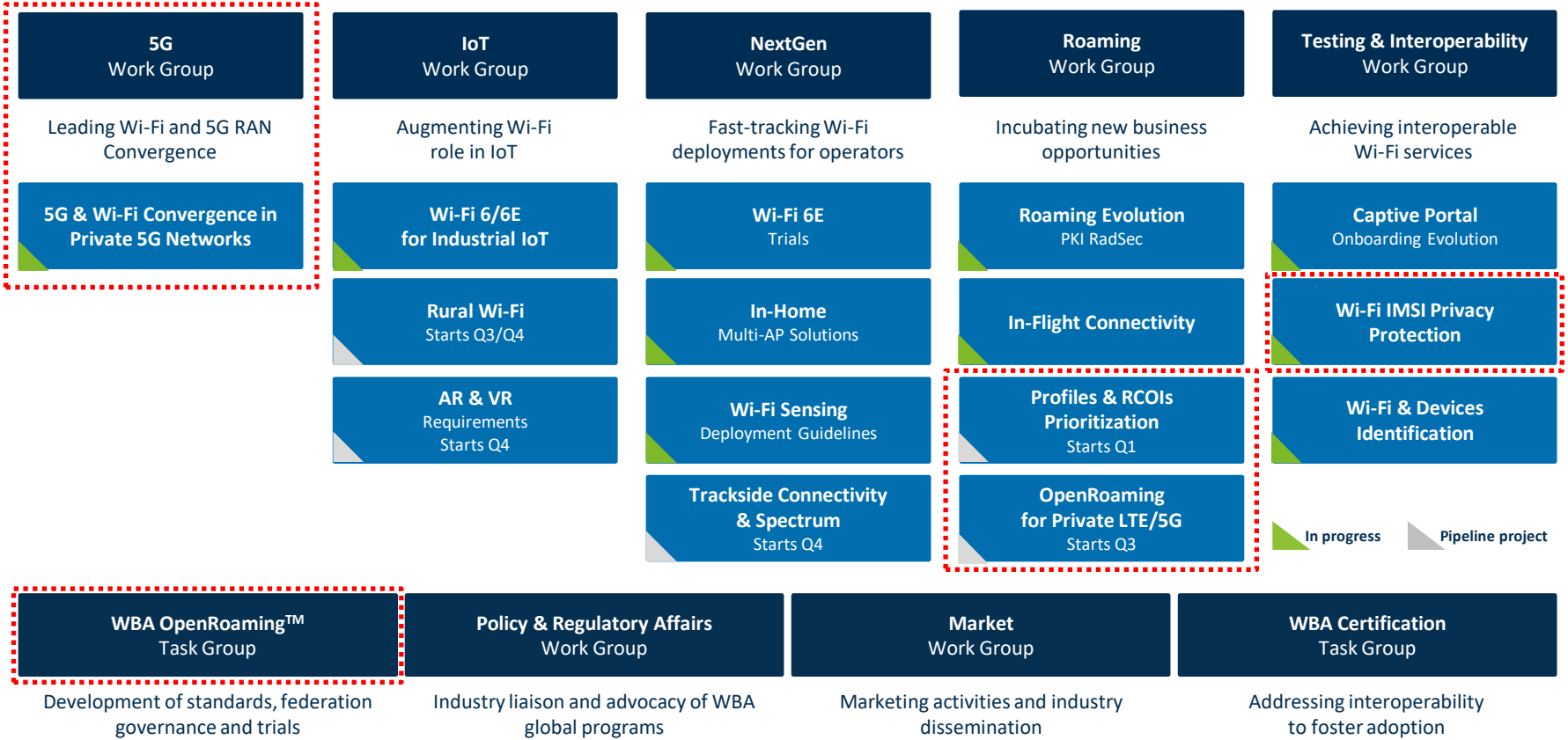
WBA & 5G WORK GROUP

Overview to IEEE

PMO – March 2021

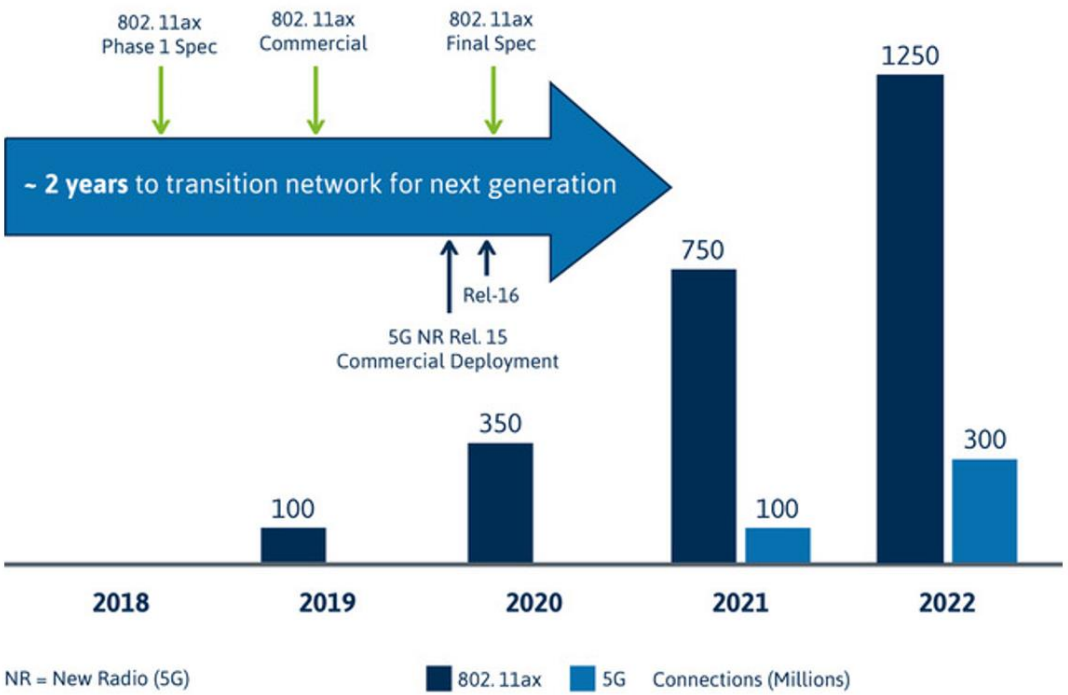
WBA Roadmap 2021

WBA WORK GROUPS & PROJECTS



Role of Wi-Fi in 5G Roadmap

Uptake of Wi-Fi 6 and 5G NR based on the number of connections …

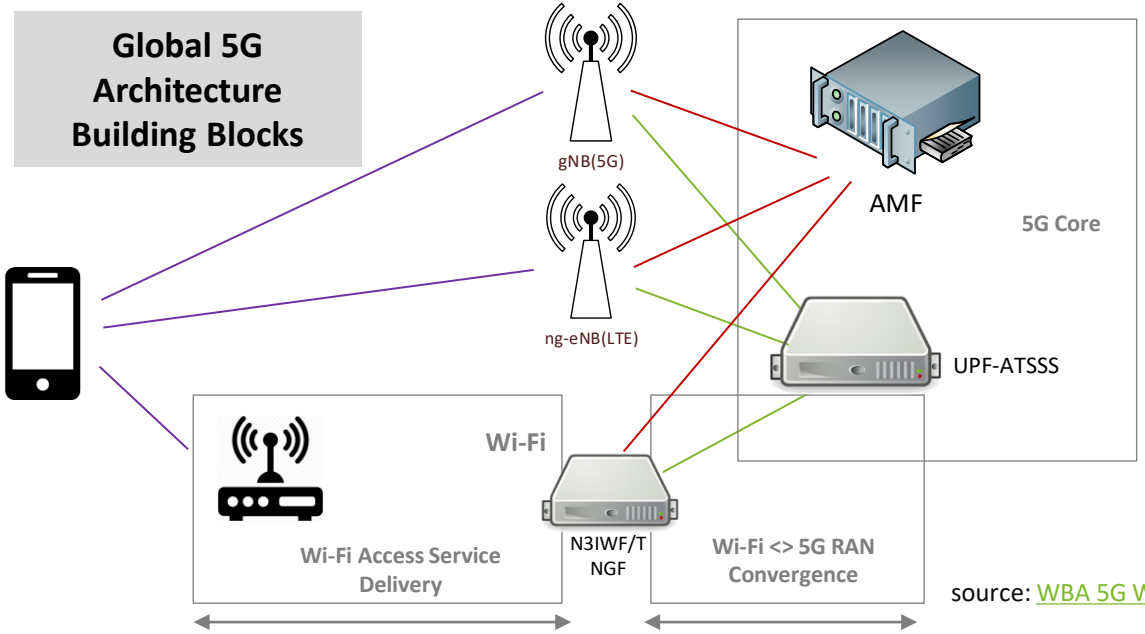


Source: GSMA, EISG, IHS Markit

Business rationale

- Accelerate Time to Market for 5G with Wi-Fi 6 & 6E
- Free, Global and Widely Available Spectrum
- Improves Return of Investment (ROI) for 5G
- Lower Cost/Bit & Complement other 5G Tech
- Enhanced Carrier Grade & Cellular Integration

Wi-Fi & 5G RAN Convergence Trials



Driving requirements and early trials including coexistence mechanisms

source: WBA 5G Work Group

WBA Role:

- Use of an access-neutral mechanism
- End-to-end service delivery over Wi-Fi
- Verticals test plans and trials
- Network Manageability and Policy Control
- Enablement of Wi-Fi Only Devices

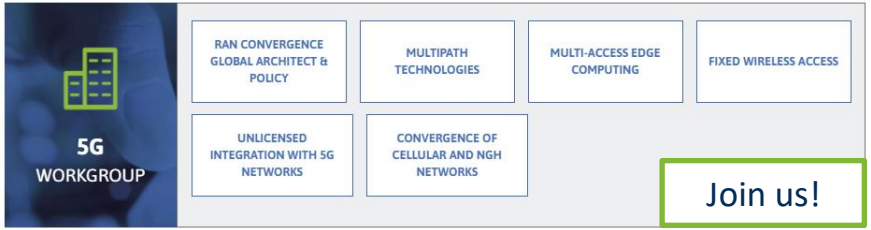
WBA Role:

- Traffic Routing across Multiple Accesses
- EAP authentication framework
- WLAN Gateway Function (N3IWF/TNGF)
- ATSSS for traffic routing
- End-to-end QoS across 5G and Wi-Fi

Kicking-off trials on Q2 2021

Call to Action

WBA Value Proposition



https://wballiance.com/resource

THANK YOU

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Engage on projects via WBA extranet | PMO contact: pmo@wballiance.com

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5G WORKGROUP OVERVIEW
IEEE 802.11

8 March 2021

5G Workgroup – Story So Far

5G Work Group 2017 <> 2021 Deliveries

WBA storyline since 2017 work inception:

1. 5G Networks – The Role of Wi-Fi and Unlicensed Technologies
2. Network Slicing for 5G – Wi-Fi Capabilities
3. Unlicensed Integration with 5G Networks
4. WBA & NGMN RAN Convergence paper
5. NEW - 5G and Wi-Fi RAN Convergence

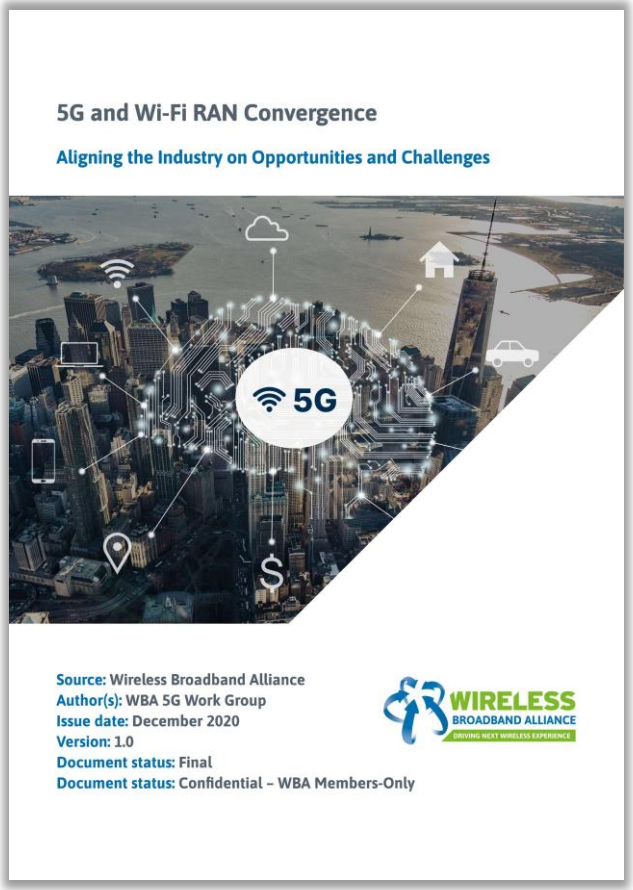
Next Steps:

Next project –

5G and Wi-Fi Convergence in Private 5G Networks

5G Workgroup – Story Today – 5G & Wi-Fi RAN Convergence

5G Work Group 2020 Deliverable



Next:

Whitepaper

Sections

Overview

5G and Wi-Fi RAN Convergence: Section Description

Three Main Parts:

Part I (Chapter 2):

- 3GPP state-of-the-art of integrating WLAN with the 3GPP 5G system Release 15 and 16.
- WLAN integration architecture, related features, functions, policies and associated procedures.

Part II (Chapter 3):

- Identifies key challenges and gaps in current 3GPP-defined solutions to support interworking between WLAN and 3GPP 5G system
- Suggests high-level solutions to address some of the identified gap items.

Part III (Chapter 4 & 5):

- Provides recommendations and next steps for the industry and the relevant standard bodies to address the key challenges and gaps related to the 5G and Wi-Fi convergence.

5G and Wi-Fi RAN Convergence: Summary and Recommendations

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Key Messages Covered:

- 5G and Wi-Fi Convergence Architecture
- ATSSS Multi-Access Steering Functionality
- End-to-end QoS Support
- Policy Interworking and Enhancements across 5G and Wi-Fi
- Support for Wi-Fi only devices

5G and Wi-Fi RAN Convergence - Presenter

Our presenter, and paper Editor, will cover the technical areas as follows:

Whitepaper Editor: Binita Gupta (Intel)
Integration Architecture, Wi-Fi Only Devices, 3GPP ATSSS Multi-Access Functionality, Policy Interworking and End-to-end QoS

5G Work Group Co-Chairs

Co-Chair: Florin Baboescu (Broadcom)

Co-Chair: Mark Grayson (Cisco)

WIRELESS BROADBAND ALLIANCE

DRIVING NEXT WIRELESS EXPERIENCE

IEEE 802.11 Plenary, WNG SC Session

March 8th, 2021

5G and Wi-Fi RAN Convergence

Integration Architecture, Wi-Fi Only Devices, ATSSS Multi-Access Functionality, Policy interworking, End-to-end QoS

Binita Gupta, *Systems Architect*

Intel Corporation

5G and Wi-Fi Convergence Opportunities

Business Drivers

- Ubiquitous Wi-Fi devices
- Significant Wi-Fi Advancements
- Lower TCO
- Higher Network Capacity
- Improved Reliability
- Seamless Mobility

Applications and Verticals

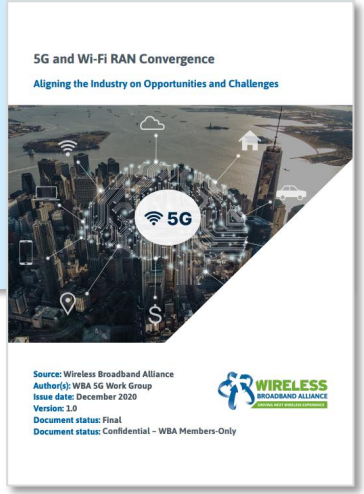
Enterprise/Retail

Healthcare

Smart Cities

Industry 4.0

AR/VR



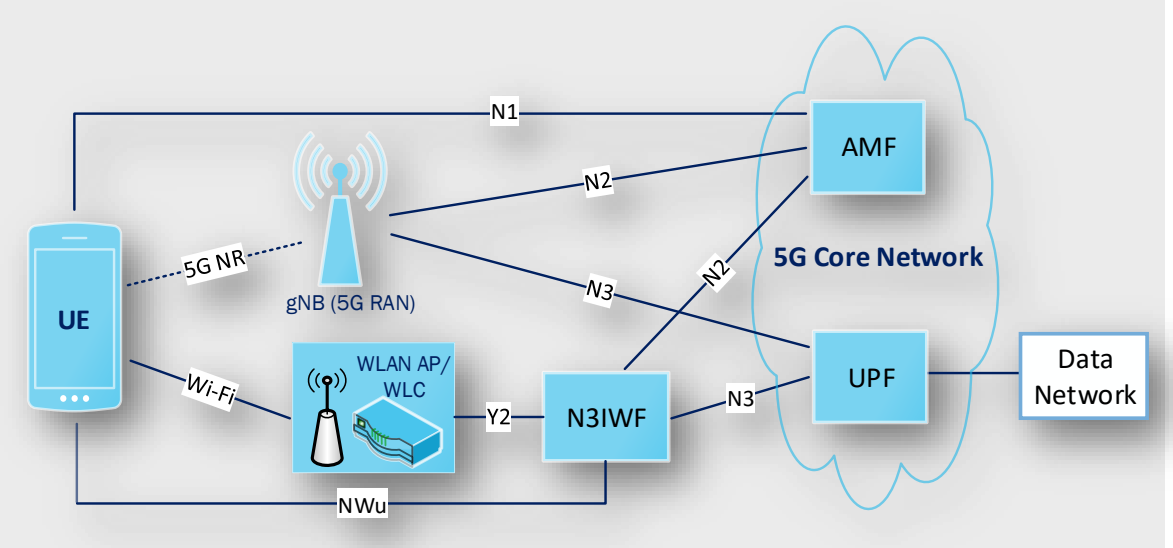
WBA's 5G and Wi-Fi RAN Convergence paper aims to educate the industry on convergence solutions and highlights associated challenges for the industry to address

5G and Wi-Fi Integration Architecture (1/2)

3GPP Releases 15/16 define architecture for WLAN integration and support UEs connecting to 5G core over WLAN access, without requiring primary connectivity over cellular access

Untrusted WLAN integration:

- Loose coupling over generic IP (Y2) between untrusted WLAN access and N3IWF
- IPsec tunnel between UE and N3IWF (NWu) – applies encryption for secure transport of signaling & data
- Wi-Fi Only UEs need to be 5G capable (support 5G NAS)



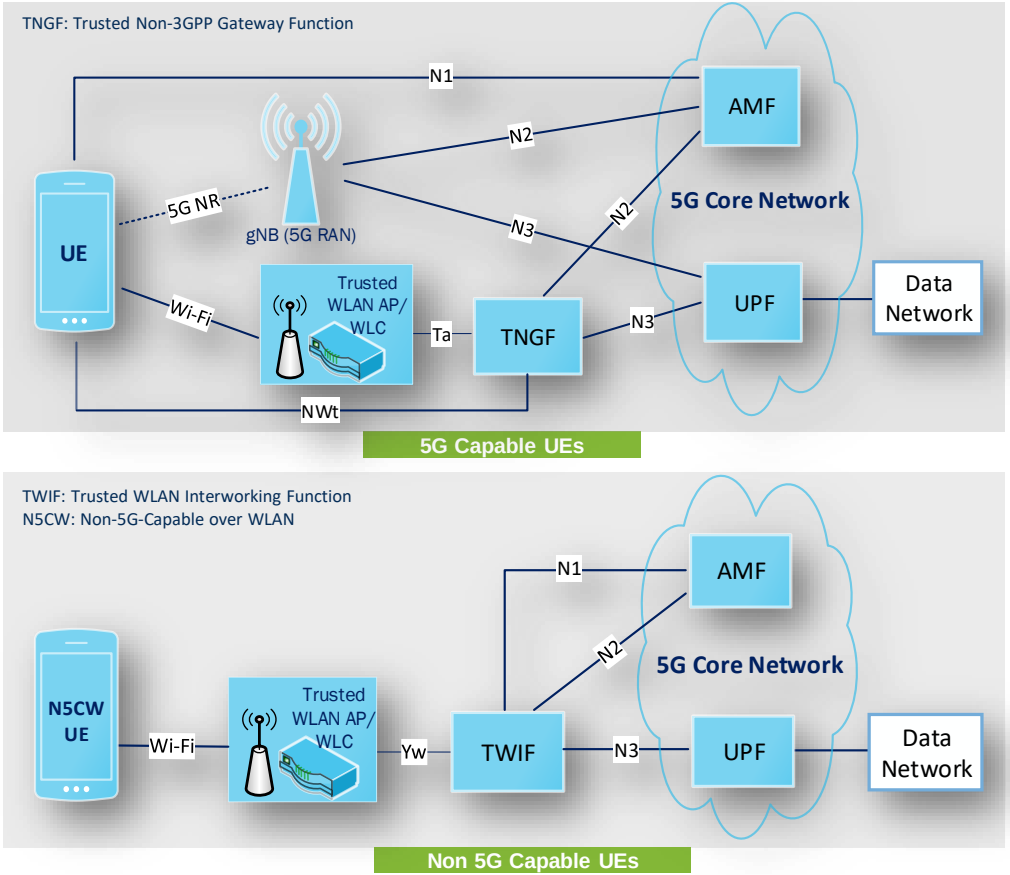
N3IWF: Non-3GPP Interworking Function
AMF: Access and Mobility Management Function
UPF: User Plane Function
NAS: Non-Access Stratum

source: WBA 5G Work Group

5G and Wi-Fi Integration Architecture (2/2)

Trusted WLAN integration:

- Tight coupling between trusted WLAN access and gateway functions TNGF & TWIF
- WLAN layer-2 authentication gets tied to a key derived from UE 5G core authentication
- IPsec tunnel between UE and TNGF with NULL encryption applied (NWt), avoiding double encryption
- Non 5G Capable UEs supported via TWIF
- AAA-based interfaces Ta and Yw between WLAN access and gateway functions



source: WBA 5G Work Group

Trusted WLAN Access Selection (1/2)

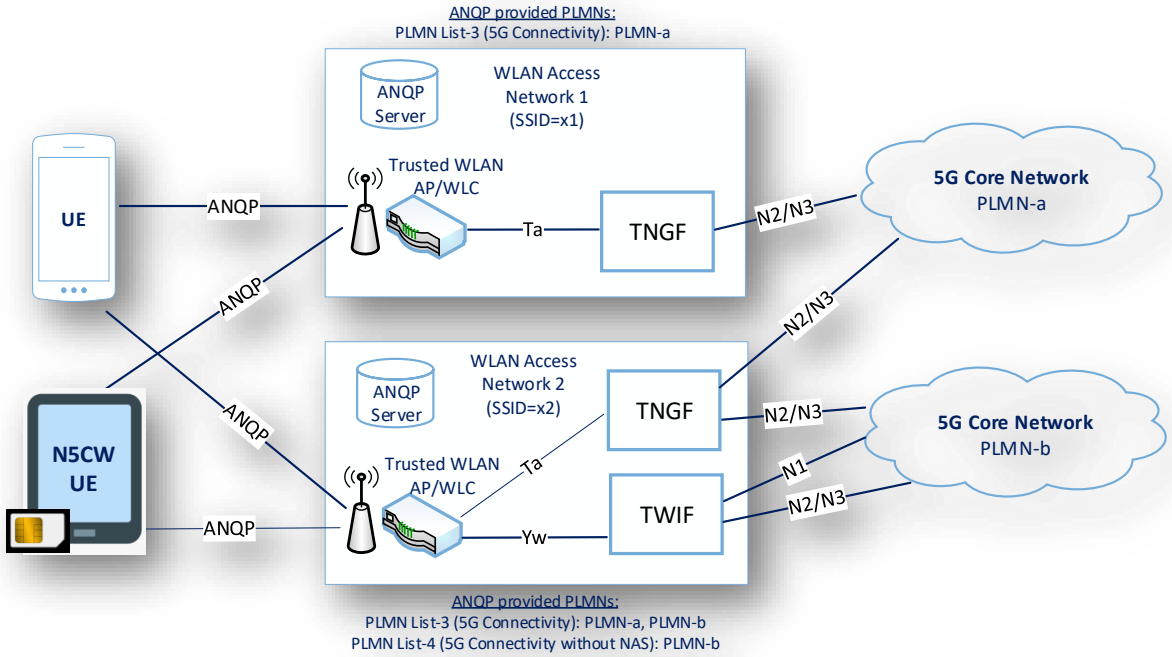
Trusted WLAN access discovery using 802.11 ANQP

- Using ANQP a WLAN access can provide the list of PLMNs with which trusted 5G connectivity is supported
- PLMN List-3: list of PLMNs with trusted 5G connectivity through TNGF
- PLMN List-4: list of PLMNs with trusted 5G connectivity through TWIF

UE follows steps below:

- Using ANQP, UE queries PLMNs with which trusted 5G connectivity is supported
- UE selects a PLMN to connect from the list of available PLMNs (per 3GPP procedure)
- UE selects a WLAN access providing trusted 5G connectivity to selected PLMN

Example Scenario 1: Gateway functions deployed as part of WLAN Access Network

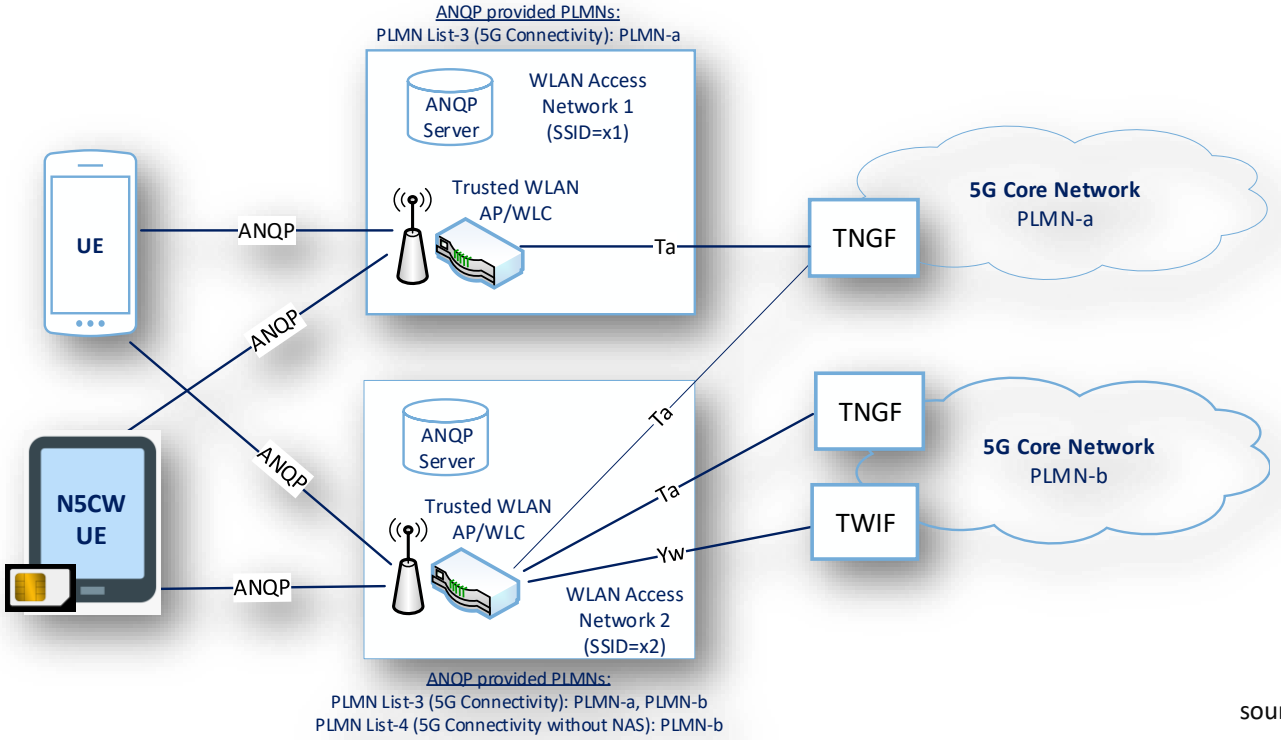


ANQP: Access Network Query Protocol

source: WBA 5G Work Group

Trusted WLAN Access Selection (2/2)

Example Scenario 2: Gateway functions deployed as part of the 5G Core



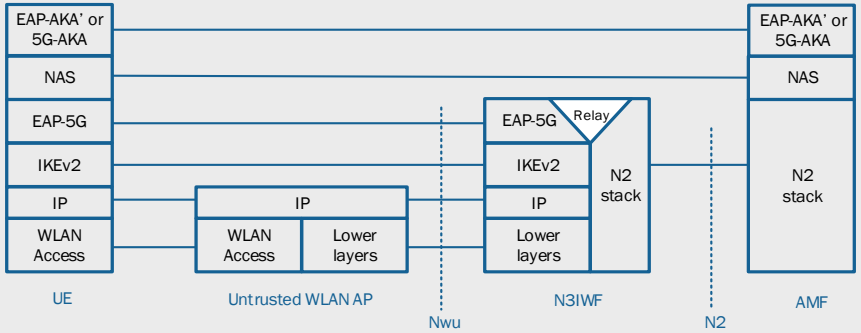
source: WBA 5G Work Group

WLAN Access Integration – Control Plane

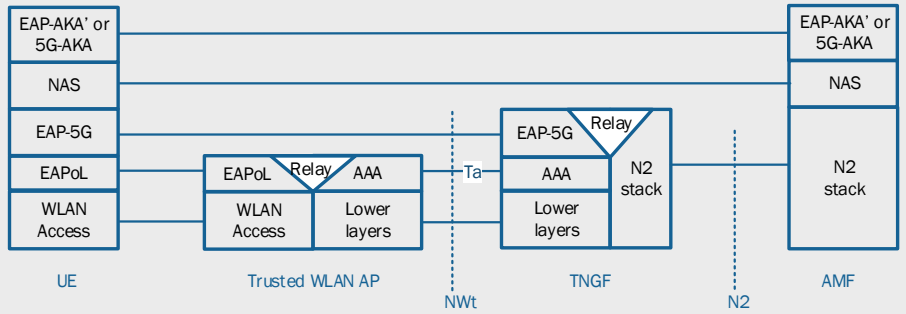
Signaling IPsec SA for control plane:

- Signaling IPsec SA created between UE and N3IWF/TNGF
- Vendor specific EAP-5G method defined for encapsulating 5G NAS messages
- For trusted WLAN, a key from TNGF/TWIF used as PMK for the 802.11 4-way handshake for WLAN security

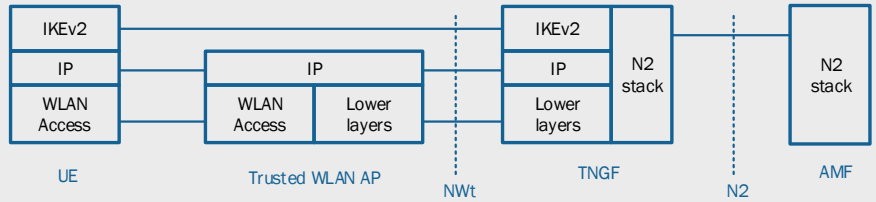
Control plane for Signaling IPsec SA for Untrusted WLAN



Control plane for Signaling IPsec SA for Trusted WLAN



Control plane over Trusted WLAN before UE is assigned IP address



Control plane over Trusted WLAN after UE is assigned IP address

IKEv2: Internet Key Exchange Version 2
SA: Security Association

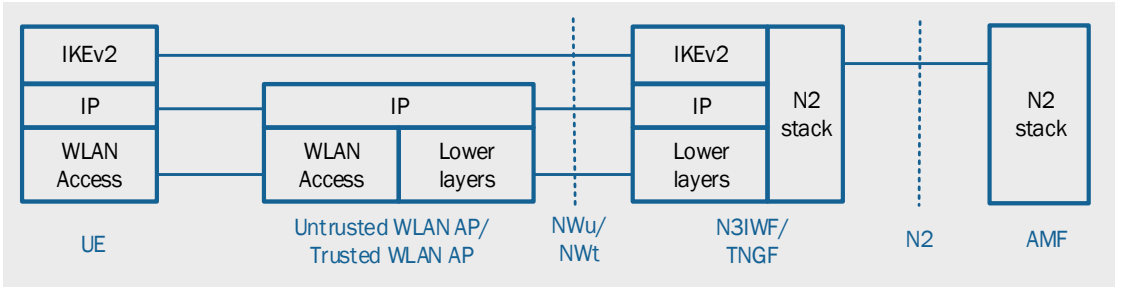
source: WBA 5G Work Group

WLAN Access Integration – User Plane

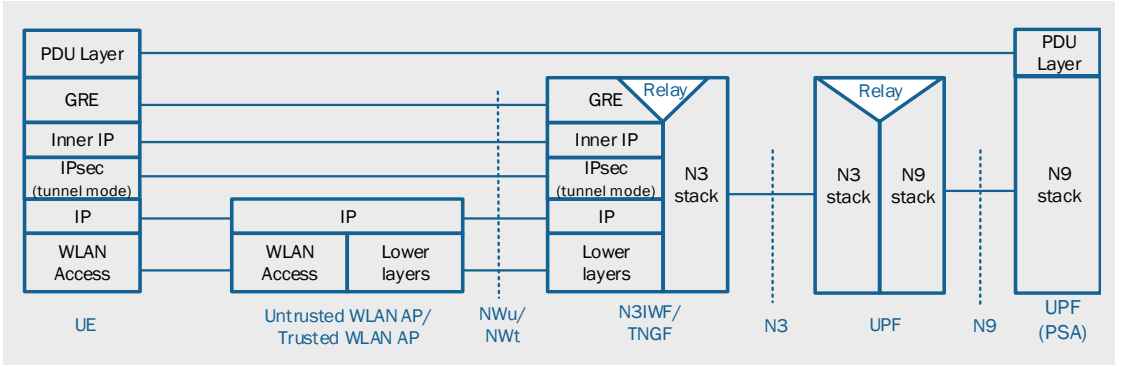
IPsec child SAs for user plane:

- PDU session establishment over WLAN access is based on procedure defined over 3GPP access
- Multi-access PDU session to carry user data over both 3GPP and WLAN access
- One or more IPsec child SAs created between N3IWF/TNGF and UE to carry user data over WLAN
- N3IWF/TNGF determine how to map 5G QoS flow(s) to IPsec child SAs
- User data packets get encapsulated in GRE packets

Establishment of User Plane IPsec child SA



User plane for transport of data over WLAN Access



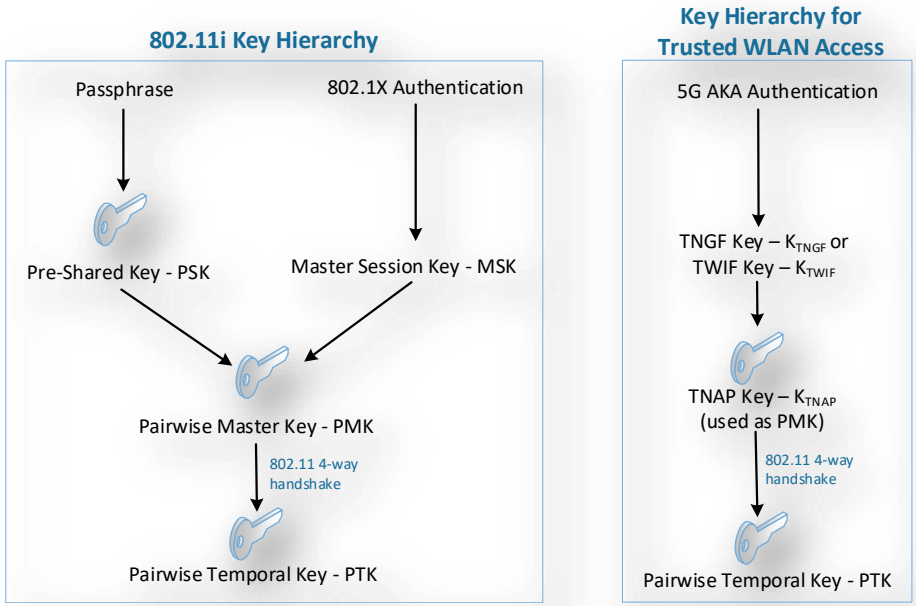
GRE: Generic Routing Encapsulation

source: WBA 5G Work Group

Key Hierarchy for Trusted WLAN Access

- Further study needed to examine any impact of the 5G Trusted WLAN Access key hierarchy on the 802.11r Fast BSS Transition key hierarchy

Comparing Trusted WLAN Access key hierarchy with 802.11i key hierarchy



TNAP: Trusted Non-3GPP Access Point

source: WBA 5G Work Group

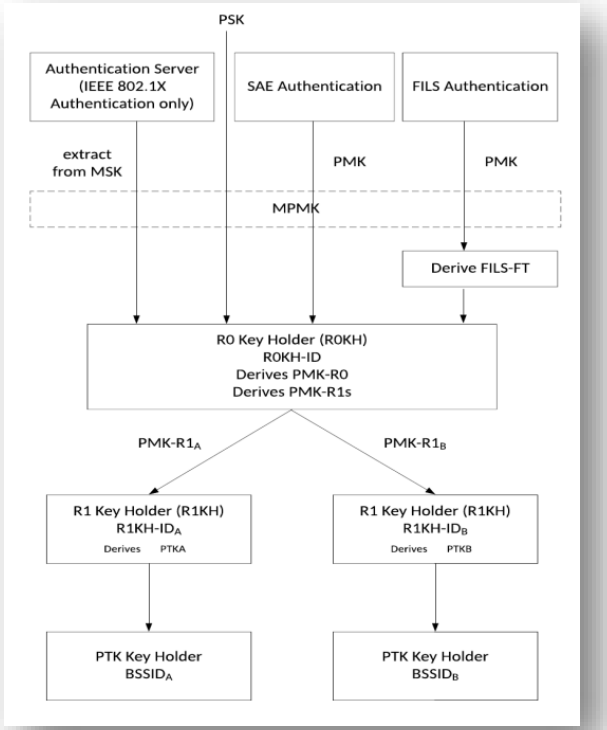


Figure 12-32, IEEE P802.11-REVmd D5.0

Enhancements to Support Trusted WLAN Integration

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Trusted WLAN Access Selection

Discover using ANQP the list of PLMNs with which trusted 5G connectivity is supported by WLAN access and select a PLMN to connect.

Support for EAP-5G

WLAN AP and STA need to support filtering EAP-5G protocol messages and pass to gateway functions and 3GPP access, respectively.

Support using TNAP key as PMK

WLAN AP and STA need to support using the TNAP key generated from the TNGF or TWIF Key as the PMK for 802.11 4-way handshake.**

Support for Ta and Yw Interfaces

WLAN AP/WLC need to support Ta and Yw AAA-based interfaces to integrate with TNGF and gateway functions.*

Generate 3GPP specific NAI

WLAN STA needs to provide 3GPP specific NAI to trigger connectivity via TNGF/TWIF.

"<any_non_null_string>@nai.5gc.mnc<MNC>.mcc<MCC>.3gppnetwork.org"

NAI: Network Address Identifier

WLAN/3GPP UE side integration

Need UE side integration between WLAN STA and 3GPP to pass discovered trusted WLAN networks, TNAP key and EAP-5G messages.

*Standardization of Ta and Yw interfaces can provide improved integration of WLAN access with 5G System

**Need further study on any impact to 802.11r key hierarchy

source: WBA 5G Work Group

Support for Wi-Fi Only Devices

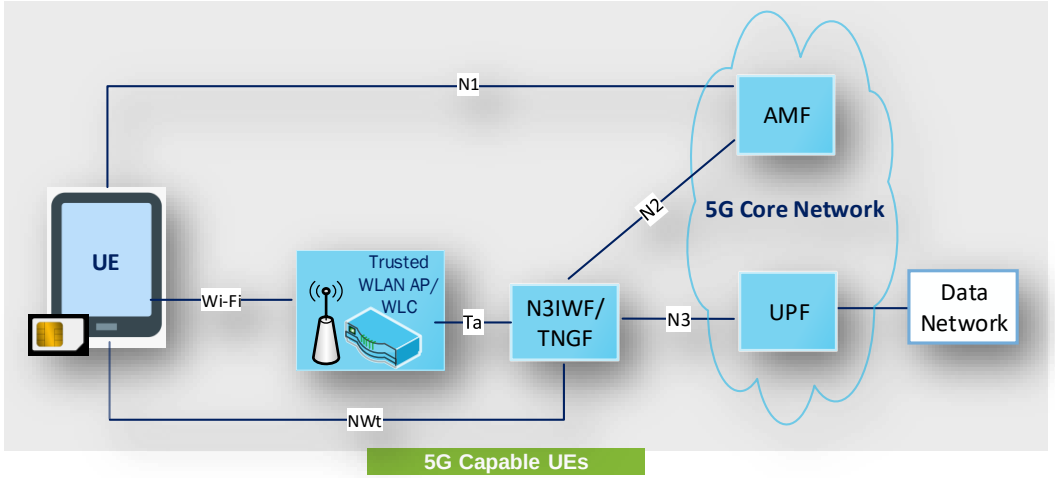
Wi-Fi Only devices with USIM capability:

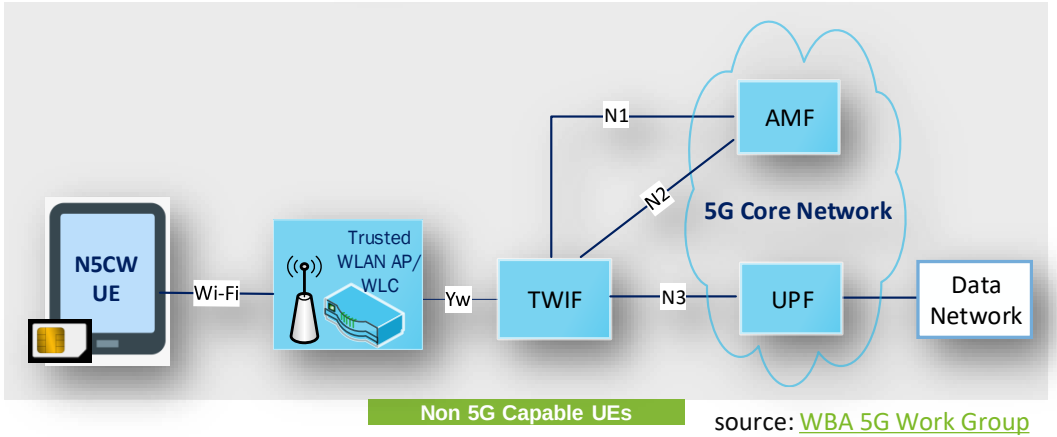
- Such devices supported by the 5G Core
- Authenticated using SIM-credential based auth. methods EAP-AKA' or 5G-AKA
- Both 5G Capable and Non-5G-Capable Wi-Fi Only UEs with SIM are supported

5G capable Wi-Fi only UEs need to support 5G control plane and user plane functions

- EAP-5G, IKEv2, IPsec/ESP and 5G NAS protocols for 5G control plane functions
- GRE and IPsec/ESP protocols for 5G user plane transport

Most Wi-Fi only devices do not include USIM – need support for non-SIM devices





source: WBA 5G Work Group

Support for Wi-Fi Only Devices w/o USIM

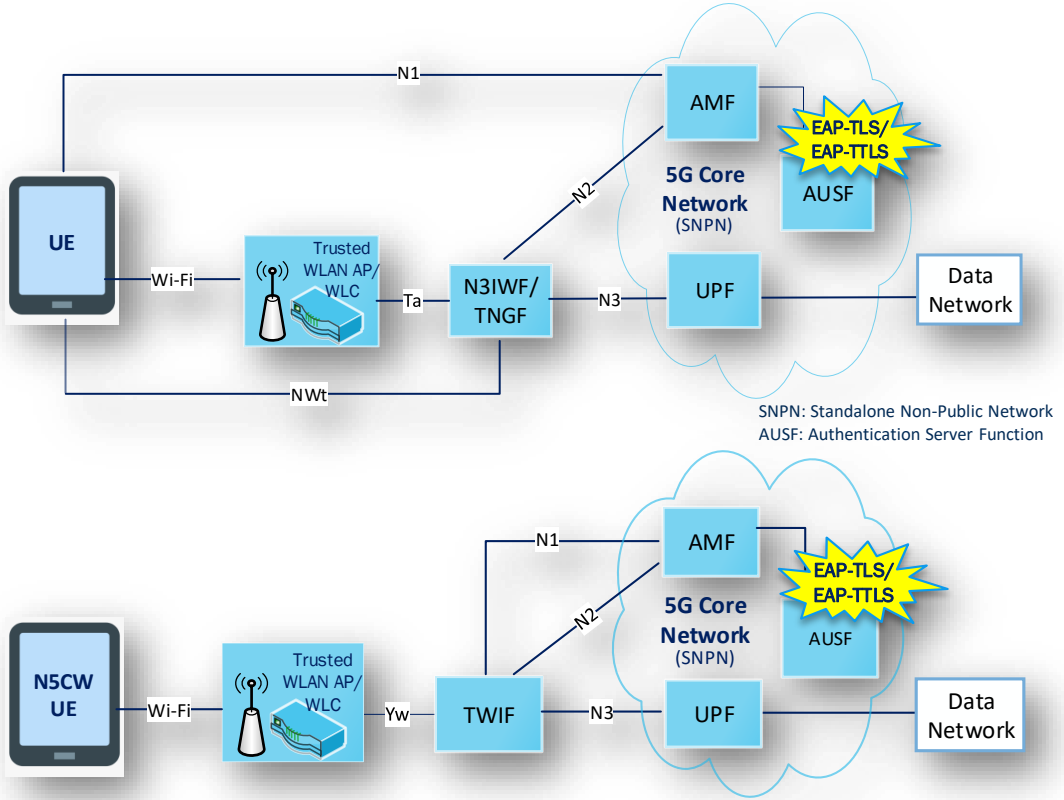
Requires support for EAP-TLS/EAP-TTLS

- Support for non-IMSI based identity and certificate based auth methods EAP-TLS/EAP-TTLS
- Current 3GPP specs define EAP-TLS/EAP-TTLS for private networks (NPN) over 3GPP access only

3GPP support for NPN over WLAN access

- 3GPP specs need to define access to NPN over WLAN access via N3IWF/TNGF/TWIF
- Define EAP-TLS/EAP-TTLS procedure for NPN over WLAN access

Up to operators to support EAP-TLS/EAP-TTLS support over PLMNs for Wi-Fi only devices



Enabling Wi-Fi only devices w/o USIM can expand reach of 5G services and applications to many more devices across enterprises and verticals

source: WBA 5G Work Group

Access Traffic Steering, Switching and Splitting (1/2)

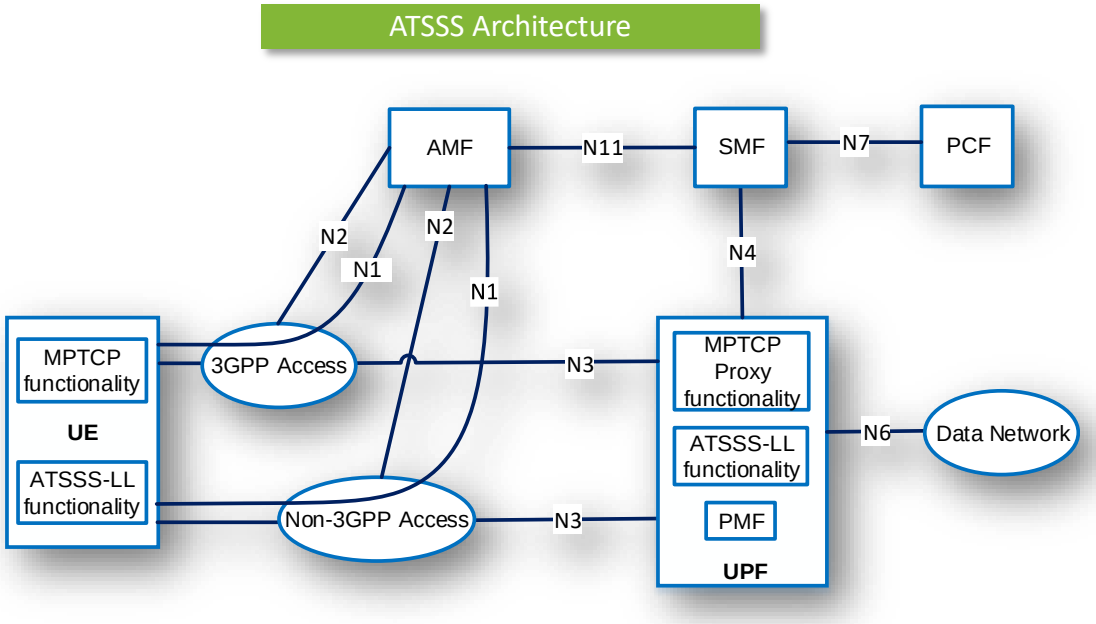
ATSSS feature provides support for Multi-Access PDU (MA PDU) session

- Enables PDU data delivery over 3GPP and WLAN access simultaneously
- When UE registered over both access, user plane resources established over both

Support for two steering functionalities

- **MPTCP functionality** for TCP traffic, with MPTCP converter proxy in UPF
- **ATSSS-LL functionality** for all traffic types including TCP, UDP, ethernet traffic
- UE/UPF may support one or more steering functionality. ATSSS-LL is mandatory for ethernet PDU session

Performance Measurement Function (PMF) supported for ATSSS-LL



ATSSS: Access Traffic Steering, Switching and Splitting

source: WBA 5G Work Group

Access Traffic Steering, Switching and Splitting (2/2)

ATSSS Rules

Steering Mode – traffic distribution policy over 3GPP and non-3GPP access

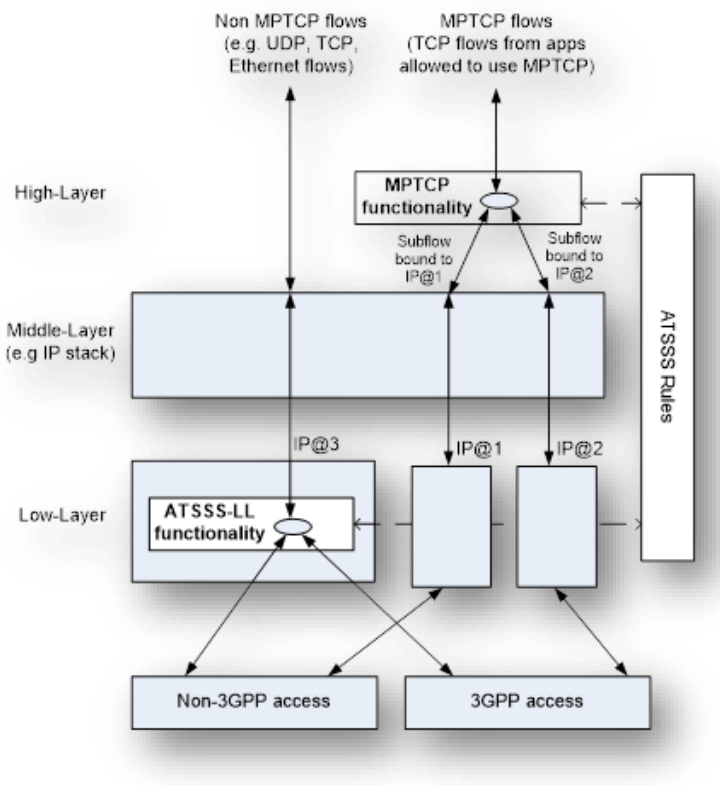
- **Active Standby:** Steer traffic on the Active access, when the Active access becomes unavailable switch to Standby access
- **Smallest Delay:** Steer traffic to the access with smallest RTT delay
- **Load Balancing:** Split traffic across both access based on percentage specified
- **Priority Based:** Steer traffic to high-priority access, until that access gets congested. Then steer traffic also to the low-priority access

Steering Functionality – MPTCP or ATSSS-LL functionality used to steer the matching traffic

Release 17 eATSSS:

- Adding support for new multi-access steering functionality using MPQUIC

ATSSS Steering Functionalities at the UE

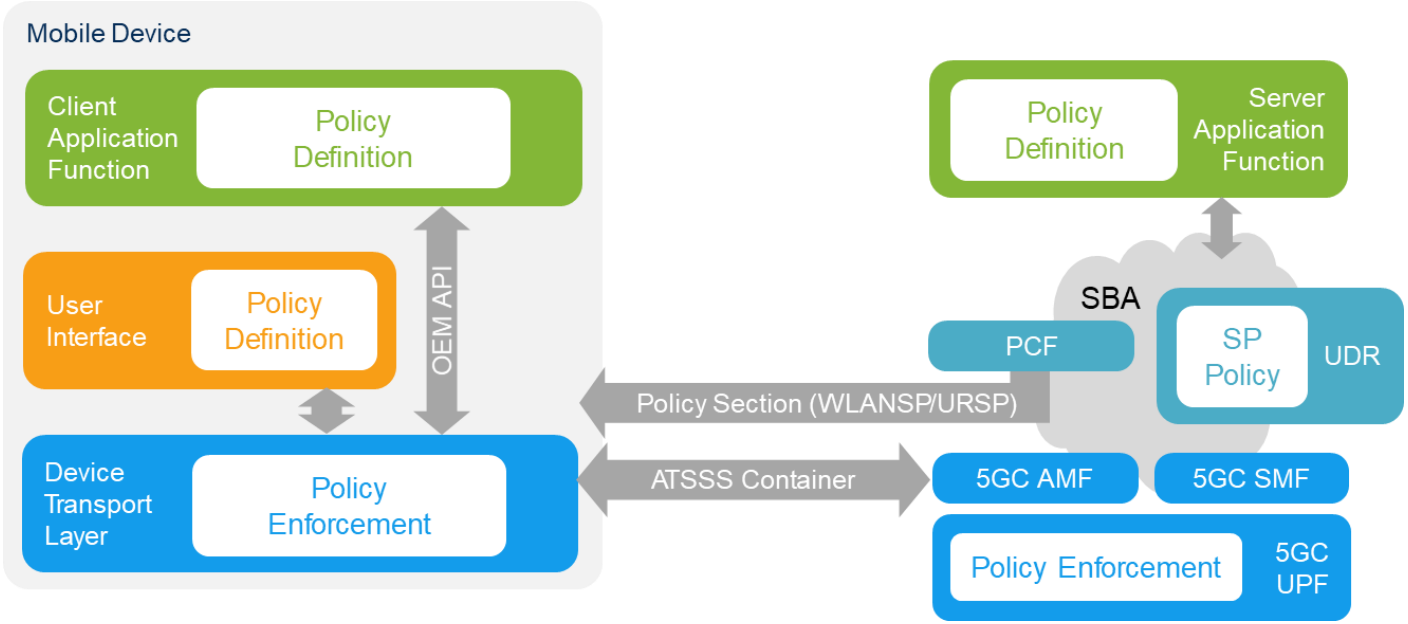


source: WBA 5G Work Group

Complex Coexistence of Policies

Blurring between Wi-Fi and 5G creates opportunities for Wi-Fi, but complicates policy decisions

- Access selection (ANDSP), Pre-establishment (URSP) and Multi-path policy (ATSSS)
- Large number of policy stakeholders (device OEM, app providers, end user, service provider and enterprise IT)



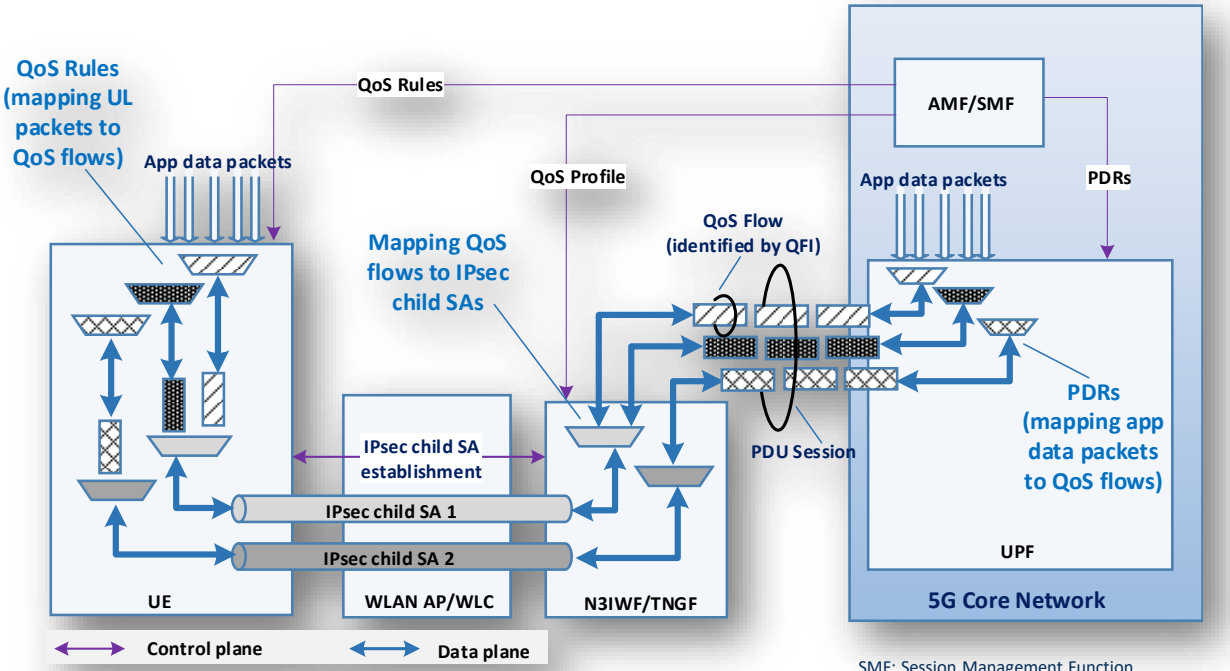
source: WBA 5G Work Group

End-to-end QoS over WLAN Access

5G QoS model over WLAN access:

- 3GPP 5G QoS model is also applied when traffic is carried over WLAN access
- QoS Flow (identified by QFI) is the finest granularity of QoS differentiation
- 5QI (5G QoS Identifier) value identifies QoS characteristics for a QoS flow
  - Standardized 5QI values defined for frequently used services
- 5G QoS flows get mapped to IPsec child SAs when carried over WLAN access

5G QoS Model Applied over WLAN Access



SMF: Session Management Function
QFI: QoS Flow Identifier
PDR: Packet Detection Rule

source: WBA 5G Work Group

QoS Differentiation over WLAN Access

- To support end-to-end QoS, need QoS differentiation for 5G flows over WLAN access per 5G QoS characteristics and parameters
- Two approaches to provide QoS management for 5G flows within WLAN access:

1) DSCP based QoS Mapping

- ❑ QoS differentiation done based on DSCP marking in the IP header for UL and DL data packets
- ❑ Applicable across all types of WLAN integration architecture (via N3IWF, TNGF and TWIF)

2) IPsec SA based QoS Management

- ❑ QoS differentiation done based on identifying and prioritizing IPsec child SAs carrying 5G flows
- ❑ WLAN STA initiates QoS Traffic Stream setup for IPsec child SAs using EDCA admission control
- ❑ Applicable for WLAN integration architecture via N3IWF and TNGF

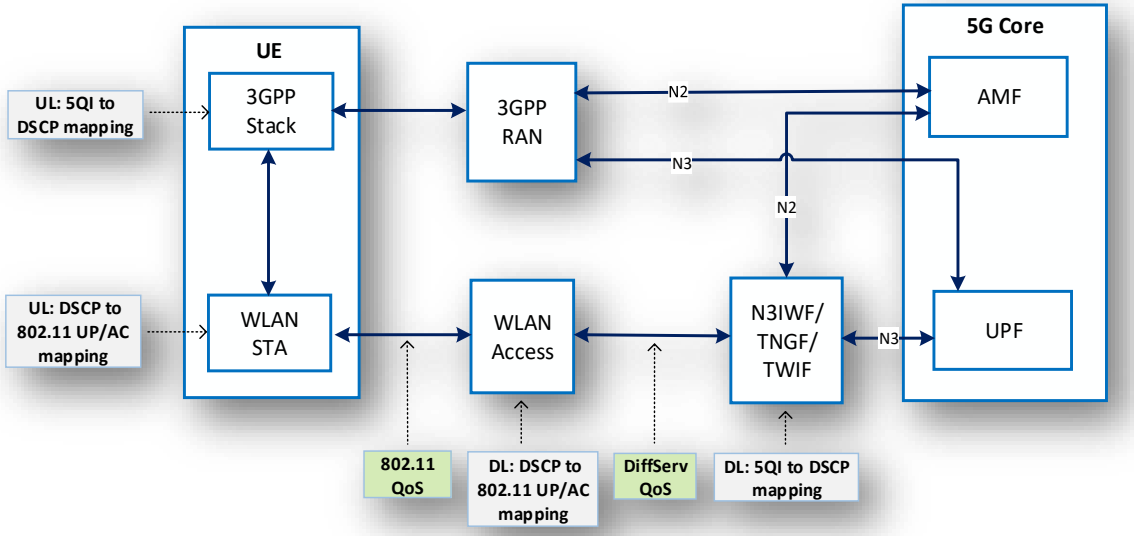
source: WBA 5G Work Group

DSCP based QoS Mapping

- 5QI to DSCP mapping done at the N3IWF/TNGF (for DL) and at the UE (for UL)
- DSCP markings get mapped to 802.11 UP/AC on WLAN AP (for DL) and STA (for UL)

Gaps and enhancements needed:

- ❑ Standardized 5QI values to DSCP mapping not defined
  - IETF **draft-henry-tsvwg-diffserv-to-qci-04** defines a mapping but it has expired
  - GSMA IR.34 defines mapping for LTE QCIs but not for 5G
- ❑ Support for tagging 5G data packets with appropriate DSCP for UL/DL
- ❑ Define mapping between updated set of DSCP values to 802.11 UP/AC



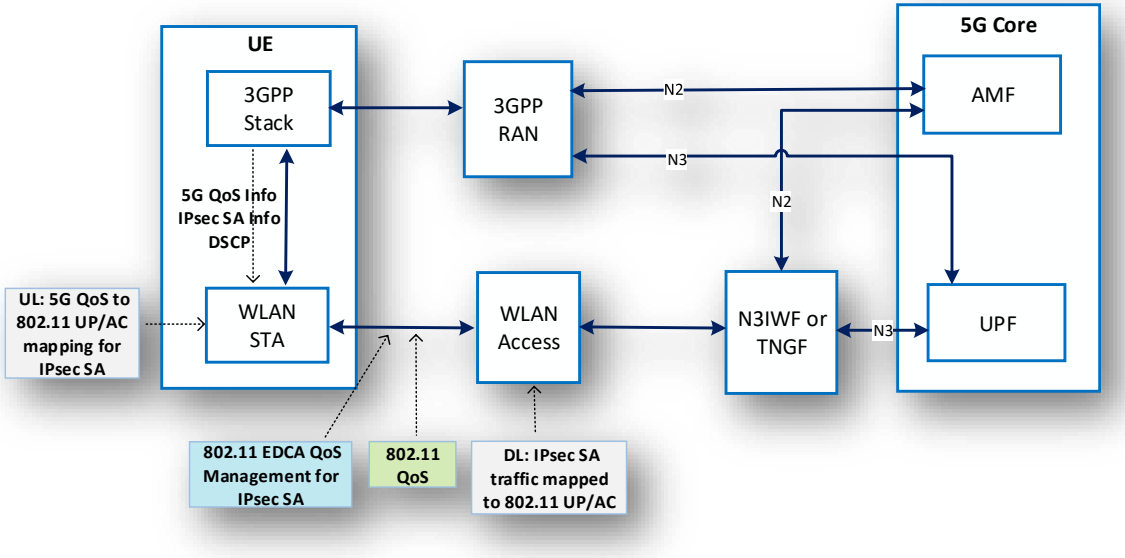
source: WBA 5G Work Group

IPsec SA based QoS Management

- 5G QoS parameters and IPsec SA info for child SAs sent to WLAN STA on the UE
- WLAN STA maps 5G QoS parameters to 802.11 TSPEC, UP/AC and creates TCLAS from IPsec SA info and initiates QoS Traffic Stream setup for IPsec child SAs using EDCA admission control
- **WFA OCE** project is addressing IPsec SA based QoS management within WLAN

Gaps and enhancements needed:

- ❑ UE integration to pass IPsec SA and 5G QoS info to WLAN STA
- ❑ Mapping of 5G QoS parameters to 802.11 TSPEC parameters for WLAN QoS Traffic Stream setup
- ❑ Determine 802.11 UP/AC based on 5G QoS parameters (or DSCP)
- ❑ TCLAS element to specify filtering for IPsec SA traffic



source: WBA 5G Work Group

Fine Grain QoS for 5G Flows

- IEEE 802.11ax has added several new capabilities such as TWT, scheduling, OFDMA and MU-MIMO
- IEEE 802.11be includes features like Multi-link operation, Multi-AP and TSN support
  - TSPEC enhancements being considered
- Further study needed on how 802.11ax resource scheduling can provide fine grain QoS for 5G flows based on 5G QoS characteristics (5QI) and parameters
- For 802.11be, QoS enhancements should consider how fine grain QoS (on throughput, latency, PER, data burst) can be provided for 5G flows based on mapping of 5G QoS characteristics and parameters to 802.11be enhanced TSPEC parameters

source: WBA 5G Work Group

Summary and Key Takeaways

WLAN access can be integrated in 5G System using untrusted or trusted integration model as defined by 3GPP Release 15/16

Some challenges and enhancements need to be addressed to enable full end-to-end system support for 5G and Wi-Fi convergence

Trusted WLAN access integration

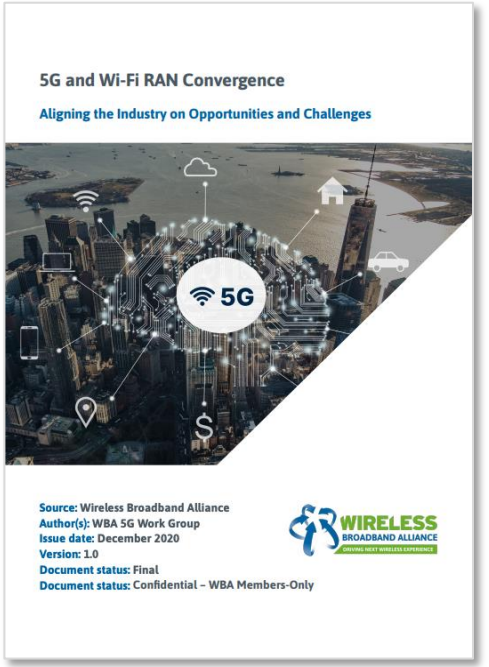
- ANQP based trusted WLAN access discovery, generation of 3GPP specific NAI, support Ta and Yw interfaces, EAP-5G messages filtering, and using TNAP key as the PMK
- Ta and Yw AAA-based interfaces not defined by the standard
- Examine any impact of 5G Trusted WLAN Access key hierarchy on the 802.11r key hierarchy

Support for Wi-Fi Only devices w/o USIM

- Requires supporting EAP-TLS/EAP-TTLS methods in private networks
- Add 3GPP support for WLAN access for NPN (Non-Public Network)
- 5G capable Wi-Fi only UEs need to support 3GPP control plane and user plane functions

Support for end-to-end QoS

- **DSCP based QoS:** Define 5QI to DSCP mapping and 3GPP specific DSCP values to 802.11 UP/AC mapping
- **IPsec SA based QoS:** UE side integration to pass IPsec SA and 5G QoS info, mapping of 5G QoS to 802.11 TSPEC parameters, support IPsec SA based QoS TS setup
- Further study on how **fine grain QoS** for 5G flows can be provided in 802.11ax and 802.11be



source: WBA 5G Work Group

Next Steps

Liaison Activity

Liaisons sent to other SDOs to align the industry and facilitate actions to address identified issues on 5G/Wi-Fi Convergence

- LS to 3GPP SA, WFA, IEEE 802.11, GSMA, IETF, ATIS and NGMN
- Follow-up collaboration with IEEE and WFA

Private 5G and Wi-Fi Convergence

New project for WBA 5G WG in 2021 - examine unique set of 5G and Wi-Fi convergence related challenges in private networks

- **Phase 1:** Technical whitepaper focusing on use cases, deployment scenarios, challenge analysis (including QoS/TSN support), potential solutions and deployment guidelines.
- **Phase 2:** Conduct Private 5G and Wi-Fi 6/6E convergence trials in key verticals.

Call-for-Action!

IEEE and WBA to work together to address challenges and fully define end-to-end support for 5G and Wi-Fi convergence

source: WBA 5G Work Group

Thank you!

Q & A

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