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## IEEE P802.11 Wireless LANs

### Draft technical report on interworking between 3GPP 5G network & WLAN

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### Abstract

This contribution is a draft technical report on WLAN interworking to 3GPP 5G network. It describes the interworking reference model and interworking types supported by 3GPP 5G network and WLAN, and defines the necessary functionalities and specific procedures that enable WLAN access networks to interwork with 3GPP 5G network. This technical report on interworking between 3GPP 5G network and WLAN will provide a reference and guideline for stakeholders with interest in standardization and system development.

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## Revision History

- Rev.0 January 2020, Draft technical report on interworking between 3GPP 5G network and WLAN is presented by Hyun Seo Oh.
- Rev.1 April 2020, Draft technical report on interworking between 3GPP 5G network and WLAN is updated by Hyun Seo Oh.
- Rev.2 June 3, 2020, Harry Hwang added comments on 3.1 WLAN interworking type and N1 signaling forwarding.
- Rev.3 June 23, 2020, Joseph Levy added editorial comments and updated to clarify the technical report. 3 types of TSN bridges are described.
- Rev. 4 July 14, 2020, comments were made on the technical report by Binita Gupta and Necati Canpolat. Revision on the tightly coupled and loosely coupled interworking and the terminal types (UE and STA) was made.
- Rev. 5 July 28, 2020, rev. 4 of the document was reviewed on the AANI SC teleconference, all changes were discussed. This document accepts the changes and provides some minor editorial changes (spelling/grammar) to align the draft with the 802.11 editorial style (US English – based on the latest edition of Merriam-Webster’s New Collegiate Dictionary), note additional edits may be necessary. The document was also converted to PDF format, with line numbers, to support comment collection.

## 1. Definition, acronyms and abbreviations

### 1.1 Definitions

- ANC** Access network control function of WLAN access network, which refers to IEEE 802 network reference model [18].
- NWu** Reference point between the UE and N3IWF for establishing secure tunnel(s) between the UE and N3IWF so that control-plane and user-plane exchanged between the UE and the 5G Core Network is transferred securely over untrusted non-3GPP access, which refers to 3GPP TS 23.502 [9]. This is in the domain of WLAN access network.
- STA** WLAN STA consists of TEC (terminal control) and TEI (terminal data path interface), which refers to IEEE 802 network reference model [18].
- N1** Reference point between the UE and the AMF in 5G core network [8].
- N2** Reference point between the (R)AN and the AMF in 5G core network [8].
- N3** Reference point between the (R)AN and the UPF in 5G core network [8].
- N4** Reference point between the SMF and the UPF in 5G core network [8].
- N7** Reference point between the SMF and the PCF in 5G core network [8].
- N11** Reference point between the AMF and the SMF in 5G core network [8].
- N15** Reference point between the PCF and the AMF in the case of non-roaming scenario, PCF in the visited network and AMF in the case of roaming scenario in 5G core network [8].
- Y1** Reference point for PHY/MAC layer function between STA and the untrusted non-3GPP access network (e.g. WLAN). This depends on the non-3GPP access technology. This is in the domain of WLAN access network.
- Y2** Reference point for PHY/MAC layer function between the untrusted non-3GPP access network (e.g. WLAN) and the N3IWF for the transport of NWu traffic which refers 3GPP TS 23.502. This is in the domain of WLAN access network.
- Y3** Reference point for control and management interface between STA and the untrusted non-3GPP access network (e.g. WLAN). This depends on the non-3GPP access technology. This is in the domain of WLAN access network.
- Y4** Reference point for control and management interface between the untrusted non-3GPP access network (e.g. WLAN) and the N3IWF for the transport of NWu traffic which refers 3GPP TS 23.502. This is in the domain of WLAN access network.

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2	<b>1.2 Acronyms and abbreviations</b>
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4	<b>3GPP</b> 3 <sup>rd</sup> Generation Partnership Project
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6	<b>5G</b> 5 <sup>th</sup> Generation
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8	<b>5G-AN</b> 5 <sup>th</sup> Generation Access Network
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10	<b>AIFS</b> Arbitrary Inter-Frame Spacing
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12	<b>AN</b> Access Network
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14	<b>ANC</b> Access Network Control
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16	<b>AMF</b> Access and Mobility Management Function
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18	<b>ATSSS</b> Access Traffic Steering Switching and Splitting
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20	<b>CN</b> Core Network
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22	<b>HCCA</b> Hybrid Controlled Channel Access
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24	<b>EAP-5G</b> Extended Authentication Protocol-5 <sup>th</sup> Generation
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26	<b>EDCA</b> Enhanced Distributed Channel Access
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28	<b>GBR</b> Guaranteed Bit Rate
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30	<b>GRE</b> Generic Routing Encapsulation
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32	<b>IKEv2</b> Initial Key Exchange Protocol Version 2
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34	<b>IP</b> Internet Protocol
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36	<b>IPsec</b> Internet Protocol Security
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38	<b>MAC</b> Media Access Control
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40	<b>NAS</b> Non-Access Stratum
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42	<b>N3IWF</b> Non-3GPP Inter Working Function
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44	<b>PCF</b> Policy Control Function
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46	<b>PDU</b> Packet Data Unit
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48	<b>PER</b> Packet Error Rate
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50	<b>PHY</b> Physical Layer
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52	<b>RAN</b> Radio Access Network
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54	<b>RAT</b> Radio Access Technology

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2	<b>QoS</b>	Quality of Service
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4	<b>SMF</b>	Session Management Function
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6	<b>STA</b>	Station
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8	<b>TEC</b>	Terminal Control
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10	<b>TEI</b>	Terminal Interface
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12	<b>TSN</b>	Time Sensitive Network
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14	<b>UE</b>	User Equipment
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16	<b>UPF</b>	User Plane Function
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18	<b>V2X</b>	Vehicle to Anything
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20	<b>WLAN</b>	Wireless Local Area Network

## 2. Introduction

This clause introduces objective and scope of the technical report on WLAN interworking to 3GPP 5G core network. WLAN interworking types can be divided into tightly coupled or loosely coupled model, and functional reference model to interwork with 3GPP 5G network is described in Clause 3.

Clause 4 describes the interworking function and specific procedures regarding radio channel sharing, registration and authentication, IP tunneling, ATSSS and QoS function, and Clause 5 describes technical gap analysis and technical recommendations. Finally, conclusions are summarized in Clause 6.

### 2.1 Objective

This technical report on interworking between 3GPP 5G network and WLAN provides a reference and guideline for stakeholders with interest in standardization and system development of WLAN (IEEE Std. 802.11).

### 2.2 Scope

This report covers an interworking reference model, necessary functionalities and specific procedures that allow WLAN access networks to interwork with 3GPP 5G network. Two types of interworking reference models are considered: a tightly coupled model and loosely coupled model.

The interworking reference model consists of terminal part (an UE and a STA), access networks (3GPP and WLAN), 3GPP 5G core network and data network as shown in Figure 1. Two access networks are connected to server via 3GPP 5G core network. 3GPP access network and 5G core network are defined in 3GPP specification and WLAN access network considered is defined in the IEEE 802 network reference model of IEEE 802.1CF-2019 [18].

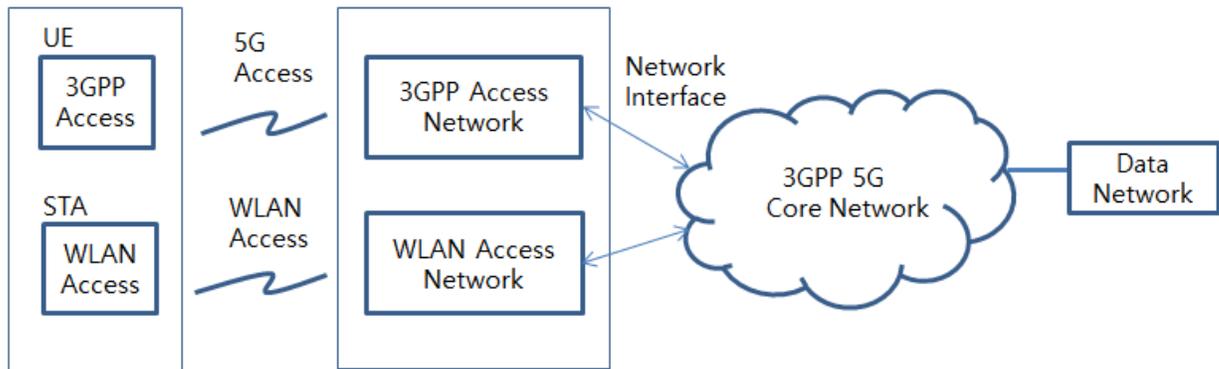


Figure 1. Overview of WLAN interworking with 3GPP 5G core network

3. WLAN interworking reference model

3.1 WLAN interworking types

We introduce two types of WLAN interworking: tightly coupled interworking and loosely coupled interworking. The tightly coupled interworking type assumes that functional entities of terminal and the two access networks are combined together and connect to 3GPP core network. Allowing a co-located 3GPP Access Network and WLAN Access Network to operate in a coordinated manner provides wireless services via the 3GPP 5G Core Network. This interworking model allows for the optimization of overall system performance by integrating the access of the two access networks from architecture design perspective, enabling improved overall network access to services.

The loosely coupled interworking type assumes that 3GPP and WLAN access networks are not co-located and two access networks operate independently. In this interworking model, there are two types of terminals: UE or STA. The terminal UE type can support both 3GPP access and WLAN access to interwork with 5G core network and STA type can support WLAN access only to interwork with 5G core network. This type of interworking can provide the same service functions as a tightly coupled interworking type, though the optimization of access to the two access networks will not be coordinated.

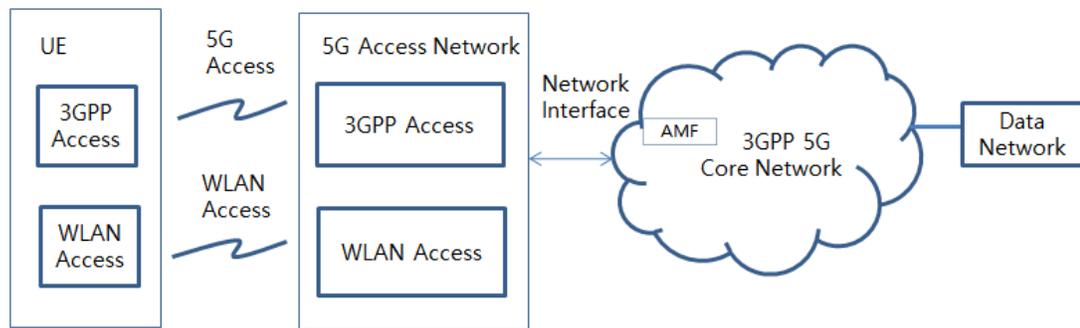


Figure 2. Tightly coupled interworking reference model between 5G core network and WLAN

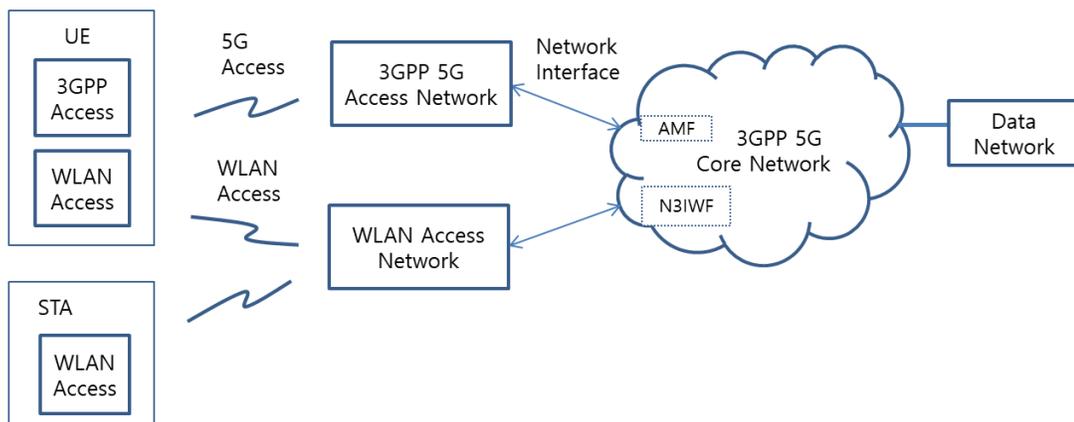


Figure 3. Loosely coupled interworking reference model between 5G core network and WLAN

3GPP LTE-based (4G) cellular system has specified both RAN level interworking and CN level interworking [2-4]. The RAN level interworking belongs to tightly coupled interworking model and the CN level interworking belongs to loosely coupled interworking model. However, 3GPP 5G system has allowed WLAN access as a non-3GPP Radio Access Technologies (RAT) that can be directly connected to 5G Core

1 Network (CN) via the N3IWF (Non-3GPP Interworking Function) or the TNGF (Trusted Non-3GPP  
 2 Gateway Function) depending on whether the WLAN is trusted or untrusted [8]. Therefore, the CN level  
 3 interworking model in the 5G system is different from the LTE system.

6 **3.2 WLAN interworking functional model in 5G system**

8 In the 5G system, WLAN interworking function model consists of UE/STA terminal, 3GPP/WLAN access  
 9 network and 3GPP core network as shown in Figure 4.

11 WLAN STA functions are divided into terminal interface (TEI) and terminal control (TEC). And WLAN  
 12 access network functions are divided into WLAN access data path and access network control (ANC)  
 13 according to the WLAN network reference model of IEEE 802.11CF-2019 [18]. 3GPP functions are divided  
 14 into UE and 3GPP access network, 5G core network and their signaling interfaces are described according  
 15 to 3GPP specification [8-9].

17 For WLAN interworking to 3GPP core network, 3GPP NWu interface signaling shall be processed in  
 18 WLAN domain and N1 signaling is transparently forwarded in WLAN domain. The N1 interface provides  
 19 the signaling procedures between UE and 3GPP core network supporting Authentication and Mobility  
 20 Function (AMF). The NWu interface provides the signaling procedures between UE and N3IWF of 3GPP  
 21 core network to support a secured IP channel.

23 In WLAN domain, Y1 and Y2 interfaces support the data flow via the PHY and MAC layers of STA and  
 24 WLAN access network. In addition to the Y1 and Y2 interfaces, we propose Y3 and Y4 interfaces which  
 25 are control and management interfaces to provide QoS management. In Figure 4, the red colored Y1/Y2  
 26 (already introduced in 3GPP) and new Y3/Y4 interfaces are in the domain of WLAN, and they are provided  
 27 in STA and WLAN access network. The other reference interfaces are defined in the 3GPP core network  
 28 specifications [10-12].

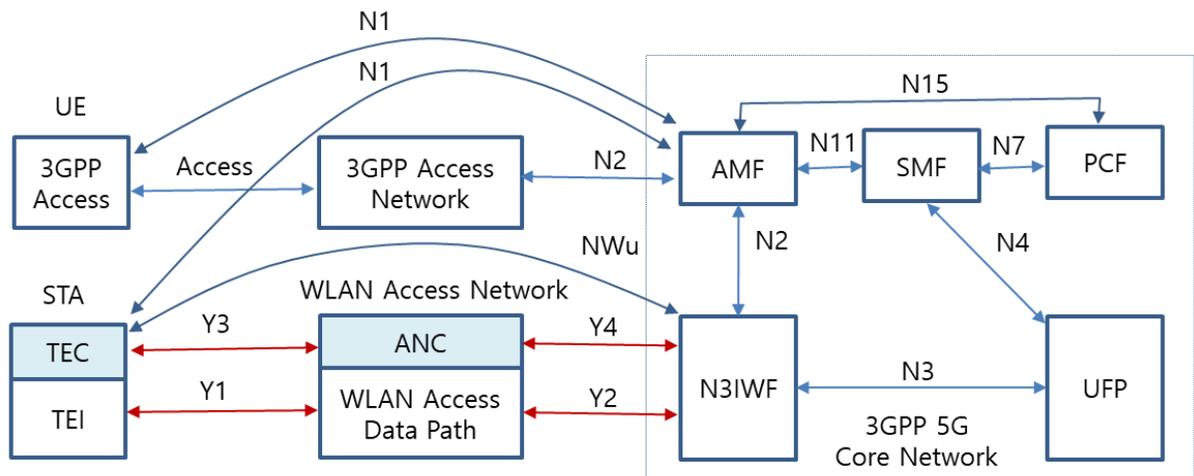


Figure 4. WLAN interworking reference model with 5G core network

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## 4. Interworking function and procedures

The radio channel access and communication procedures have to be specified to enable WLAN interworking with 5G core network. In this clause, except subclause 4.4, the terminal device is assumed to be the STA type to figure out the new functionalities to interwork with 5G core network in WLAN domain. A radio channel sharing method is described in 4.1. Initial registration and authentication procedures between STA and AMF of 5G core network are described in 4.2. Example IP secure transport and data exchange procedures between the STA of the terminal device and UPF of 5G core network are described in 4.3.

To support ATSSS function and QoS management, STA and WLAN access network require interface additions or modification on the MAC layer. These functions are described in 4.4 and 4.5.

### 4.1 WLAN radio channel sharing method

TEI of STA monitors the usage of WLAN access network (monitoring if the radio channel is busy or idle). If the radio channel is idle, the STA may attempt to send control or traffic data through the WLAN radio channel. If the radio channel is busy, the STA will not send control or traffic data through the WLAN radio channel, it will wait until the radio channel is idle.

### 4.2 Registration and authentication and its message procedures

STA shall initially support registration and authentication to establish a connection between STA and N3IWF. NWu for registration and authorization involves IP protocol, IKEv2 and EAP-5G protocol, and secured signaling tunnel over N1 (a.k.a. signaling radio bearer) is required to exchange NAS signals.

#### 4.2.1 Registration and authentication function

Registration and authentication between STA and N3IWF shall have specific functional requirements to interwork with 3GPP 5G core network

- IP communication protocol
- IKEv2 authorization protocol
- EAP-5G protocol



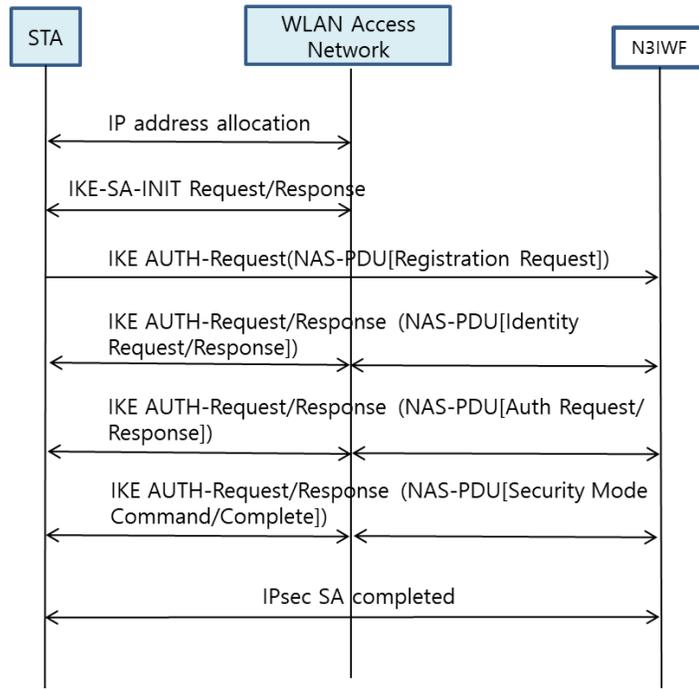


Figure 7. NWu interface

• **N1 interface**

N1 interface is secured IP communication protocol between STA of WLAN access network and AMF of 3GPP 5G core network to provide NAS signaling

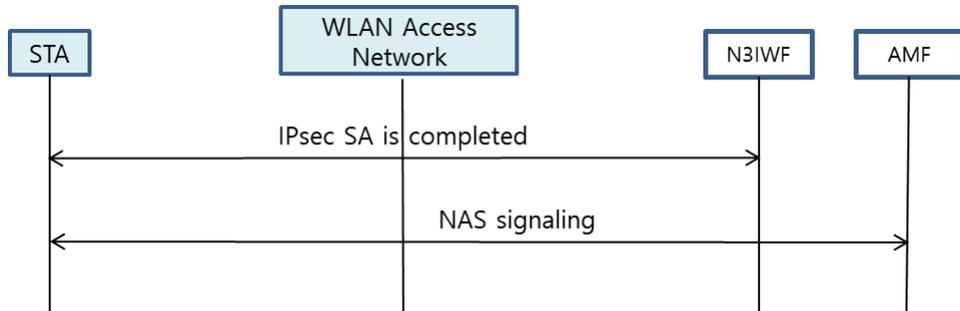


Figure 8. N1 interface

**4.3 IP Tunneling function and its message procedures**

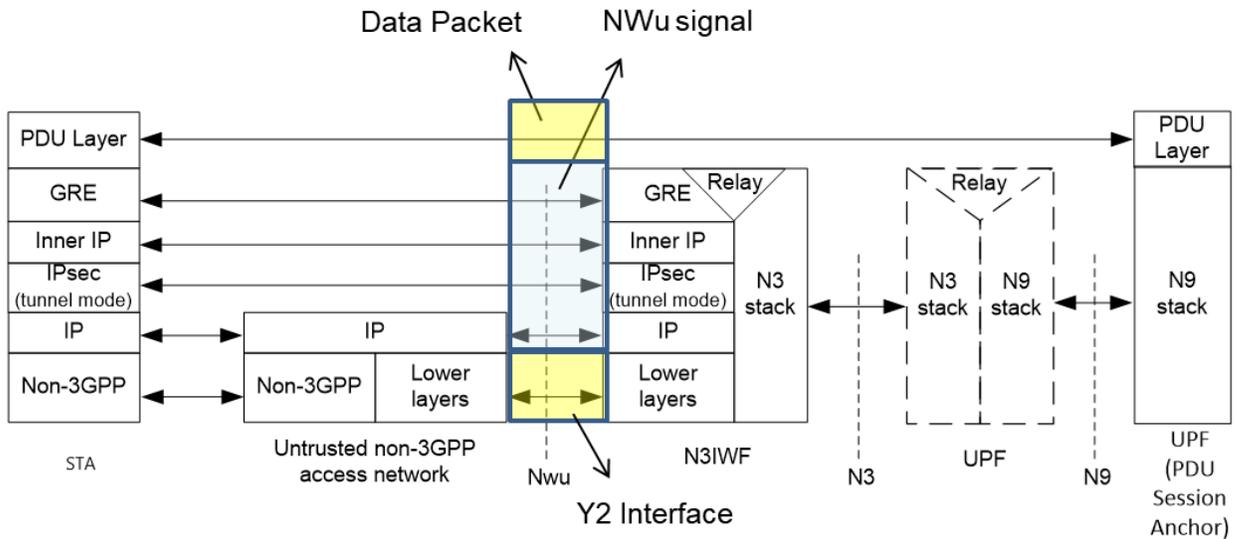
STA shall initially support secured IP transport between terminal unit and UPF, and traffic data is exchanged over the established IP channel.

**4.3.1 IP Tunneling Function**

STA and N3IWF shall have specific functional requirements to interwork with 3GPP 5G core network.

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- IP communication protocol
- IPsec communication protocol
- GRE communication protocol



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Figure 9. Data plane between STA and N3IWF (3GPP TS 23.501)

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#### 4.3.2 Message procedures

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- IPsec tunneling procedures shall be processed via WLAN access network
- PDU session establishment shall be processed via WLAN access network.

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#### 4.4 ATSSS function support

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Traffic data shall be transmitted over WLAN access channel and/or 3GPP access channel by using ATSSS function. In this subclause, the terminal UE type is assumed to support ATSSS function in the loosely coupled interworking model.

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- 3GPP supports ATSSS between 3GPP and non-3GPP access networks
- ATSSS can enable traffic selection, switching and splitting between 5G-AN and WLAN

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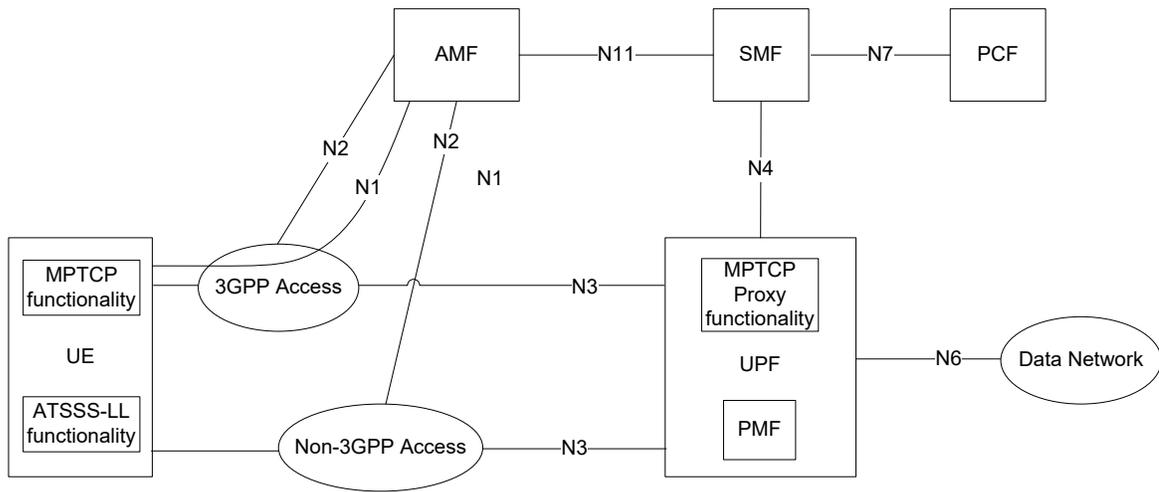


Figure 10. Architecture reference model for ATSSS support (3GPP TS 23.501)

Figure 10 shows the reference architecture for supporting ATSSS which handles either Guaranteed Bit Rate flow (GBR) QoS flow or Non-GBR QoS flow traffic. The 3GPP QoS flow is access agnostic, when the traffic is distributed between 5G access network and WLAN access network, the same QoS should be supported as long as the WLAN access network can support the same QoS treatment as 5G access network. QoS flows on GBR traffic and Non-GBR traffic are specified in 3GPP TS 23.501 and QoS flows are defined as follows:

- GBR QoS Flow: A QoS Flow using the GBR resource type or the Delay-critical GBR resource type and requiring guaranteed flow bit rate.
- Non-GBR QoS Flow: A QoS Flow using the Non-GBR resource type and not requiring guaranteed flow bit rate.

Table 1 shows the characteristics of GBR and delay critical GBR QoS flows from 3GPP. Therefore, it is required to consider how to support GBR flows in WLAN. The key point is how to provide GBR support in two directions, e.g. STA to AP and AP to STA. The following table is applicable to two directions.

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Table 1. QoS characteristics (3GPP TS 23.501)

Resource Type	Default Priority Level	Packet Delay Budget	Packet Error Rate	Default Maximum Data Burst Volume	Default Averaging Window	Example Services
GBR	20	100 ms	$10^{-2}$	N/A	2000 ms	Conversational Voice
	40	150 ms	$10^{-3}$	N/A	2000 ms	Conversational Video (Live Streaming)
	30	50 ms	$10^{-3}$	N/A	2000 ms	Real Time Gaming, V2X messages Electricity distribution – medium voltage, Process automation - monitoring
	50	300 ms	$10^{-6}$	N/A	2000 ms	Non-Conversational Video (Buffered Streaming)
	7	75 ms	$10^{-2}$	N/A	2000 ms	Mission Critical user plane Push To Talk voice (e.g., MCPTT)
	20	100 ms	$10^{-2}$	N/A	2000 ms	Non-Mission-Critical user plane Push To Talk voice
	15	100 ms	$10^{-3}$	N/A	2000 ms	Mission Critical Video user plane
	56	150 ms	$10^{-6}$	N/A	2000 ms	"Live" Uplink Streaming (e.g. TS 26.238 [y])
	56	300 ms	$10^{-4}$	N/A	2000 ms	"Live" Uplink Streaming (e.g. TS 26.238 [y])
	56	300 ms	$10^{-8}$	N/A	2000 ms	"Live" Uplink Streaming (e.g. TS 26.238 [y])
	56	500 ms	$10^{-8}$	N/A	2000 ms	"Live" Uplink Streaming (e.g. TS 26.238 [y])
Delay Critical GBR	19	10 ms	$10^{-4}$	255 bytes	2000 ms	Discrete Automation (see TS 22.261 [x])
	22	10 ms	$10^{-4}$	1354 bytes	2000 ms	Discrete Automation (see TS 22.261 [x])
	24	30 ms	$10^{-5}$	1354 bytes	2000 ms	Intelligent transport systems (see TS 22.261 [x])
	21	5 ms	$10^{-5}$	255 bytes	2000 ms	Electricity Distribution- high voltage (see TS 22.261 [x])

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#### 4.5 QoS function and its message procedures

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3GPP resource types and QoS related parameters shall be shared with WLAN using Y3 and Y4 interfaces and WLAN will support QoS function and related message procedures. QoS management functions need to cover QoS mapping, scheduling algorithm and MAC interface and TEC of STA and ANC of WLAN access network will deal with them.

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PHY and MAC specification are important factor to meet the required QoS value. The current technologies to provide QoS management is EDCA and HCCA, which are distributed based access scheme. IEEE 802.11e provides 4 kinds of access categories, which are background, best effort, video, video and voice. According to access categories, contention window size and arbitration inter-frame space (AIFS) is variable to meet the required quality of service.

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3GPP specification provides GBR, Non-GBR and delay critical GBR. Delay critical GBR needs lower latency (less than 30msec) and higher packet error rate (PER) (less than  $10^{-4}$ ). And 3GPP have more

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1 characterized QoS management to support packet delay, PER, default maximum data burst volume and  
2 default average window for the service types.

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4 Although EDCA and HCCA of WLAN technology can support some kinds of GBR QoS service as well as  
5 non-GBR service, they can't fully guarantee all kinds of GBR QoS service. Thus, they have limitations to  
6 meet the QoS requirements of low latency and high reliability for GBR and delay critical GBR types.

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## 5. Gap analysis and Recommendations

### 5.1 Gap Analysis

In the technical gap analysis, the terminal STA type is assumed to figure out new functionalities and communication protocol to interwork with 5G core network in WLAN domain. The new functionalities and communication protocols can be assigned and implemented in STA and WLAN access network.

WLAN interworking to 3GPP core network can have merits in terms of access and mobility, QoS managed ATSSS of packet data service. However, new functional entities and signaling procedures are required for WLAN to support these capabilities. In this section, we identify and analyze gaps in the current WLAN specification which must be addressed to allow full interwork with 3GPP core network.

New functional entities to support interwork with 3GPP core network that are not currently in the WLAN specification are: a radio sharing function, registration and authentication, NAS message transport, IP tunneling, Packet session control, and QoS managed ATSSS.

A radio sharing function with Y1 interfaces can be implemented by WLAN channel scanning and association procedure. Registration and authentication should have IP communication protocol, IKEv2 and EAP-5G communication protocol using NWu interfaces. NAS messages with NWu interfaces should have IPsec and GRE communication protocol referred from 3GPP specification.

IP tunneling and packet session control with NWu interfaces should refer to IPsec and GRE protocol specified by 3GPP core network. ATSSS function with Y1 and Y2 interfaces is packet data transmission specified by WLAN 802.11 specification. QoS management with Y3 and Y4 interfaces should define QoS identification and profiling.

Table 2. New functional entities and communication protocols to interwork with 3GPP core network

New functional entities	Communication protocols	Interfaces
Radio sharing function	Channel scanning and association	Y1
Registration & authentication	IP protocol, IKEv2 and EAP-5G protocol	NWu
IP tunneling	IPsec and GRE protocol	NWu
Packet session control	Session control protocol	NWu
ATSSS	Packet data transmission	Y1, Y2, NWu
QoS management	QoS identification and profile	Y3 and Y4

In the view of higher layer control and protocol to interwork with 3GPP 5G core network, IKEv2, EAP-5G, IPsec and GRE protocol are referred to IETF specification and modified for interworking. And these protocols can be implemented in TEC of the STA and ANC of WLAN access network.

NAS signaling to AMF and packet session control to SMF are referred to 3GPP specification and can be implemented in TEC and ANC of WAN access network. And WLAN QoS management is referred to IEEE 802.11e and should be adapted to support fine granularity of QoS levels.

Table 3. New signaling to interwork with 3GPP core network

Communication protocols	Related WLAN function	Related WLAN Specification
IKEv2	TEC, ANC	IETF Internet Key Exchange Protocol
EAP-5G	TEC, ANC	IETF EAP protocol
IPsec	TEC, ANC	IETF IPsec protocol
NAS	TEC, ANC	3GPP Protocol

GRE	TEC, ANC	IETF ESP protocol
Session control	TEC, ANC	3GPP protocol
QoS identification and profile	TEC, ANC	IEEE 802.11e

In QoS management, the current IEEE 802.11-2016 covers four classes: background, best effort, audio and video. And QoS is managed according to service class, contention window and AIFS value. Thus, WLAN currently can support some kinds of GBR as well as non-GBR service and has to consider QoS identification and profile to fully support GBR service. 3GPP system specifies QoS profile and characteristics in QoS level as follows:

- Service priority level
- Packet latency
- Packet error rate
- Guaranteed data rate
- Averaging window

TEC of STA and ANC of WAN access network should process QoS management according to QoS profile provided by 3GPP 5G core network.

Table 4. Service categories to interwork with 3GPP core network

Service Categories	Related WLAN function	Related WLAN Specification
Non-GBR	4 service classes; Background, Best effort, audio and video	IEEE 802.11e
GBR	To be defined in fine granularity of service classes and QoS management	Shall specify QoS mapping and scheduling. And IEEE 802.1 TSN is for deterministic Ethernet network.

The SMF assigns QoS profile to AN in WLAN domain with QoS Flow Identification (QFI), which defines the QoS parameters for a QoS flow in the PDU session. And the QoS flow is mapped to AN resources for the assigned QFI.

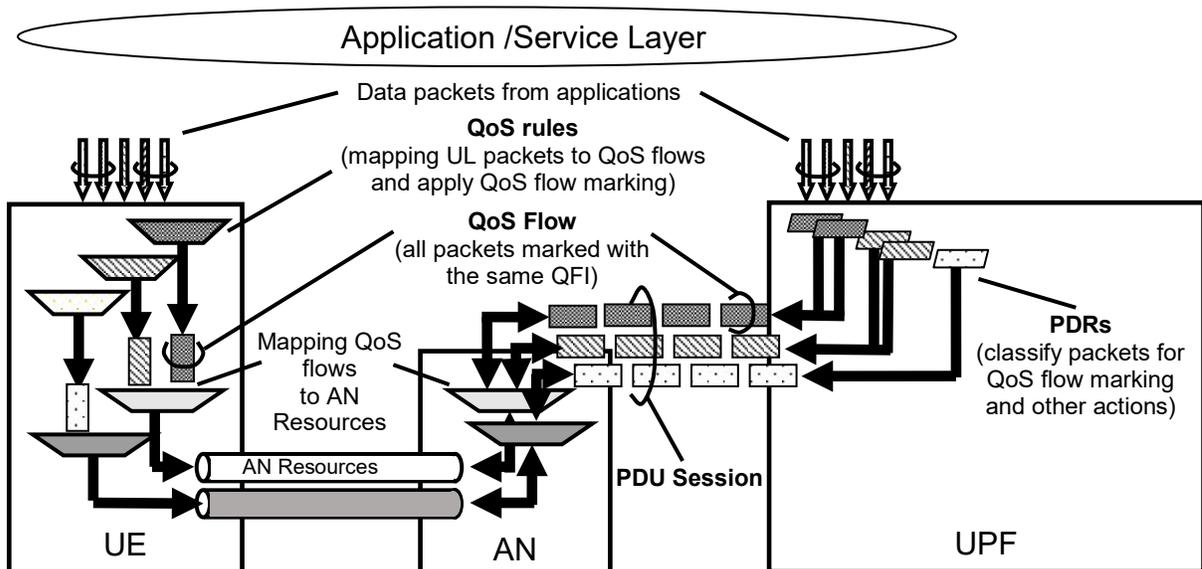


Figure 11. QoS flows and mapping to AN resources in user plane (3GPP TS 23.501)

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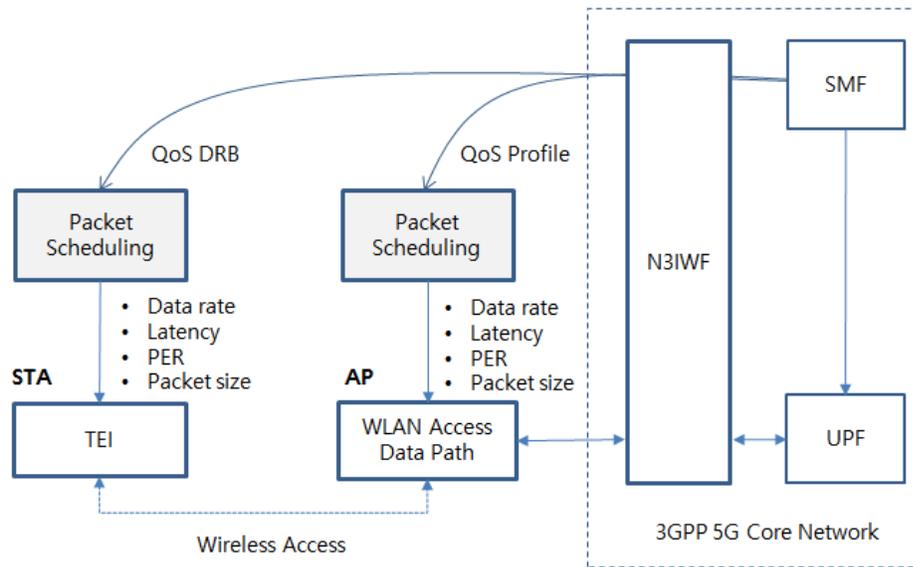
Table 5. Gap analysis of GBR service between 3GPP 5G network and WLAN

Resource Type	Services Examples	Packet Delay Budget	PER	Default Maximum Data Burst Volume	Gap Analysis of WLAN specification
GBR	Conversational Voice	100 ms	$10^{-2}$	N/A	<p>. 802.11ax MAC cannot support 3GPP GBR service requirements of deterministic packet latency, PER and data rate because EDCA is CSMA based MAC and supports only 4 service types of best effort, back ground, voice and video by controlling TXOP, AIFSN &amp; contention window size.</p> <p>. Enhanced MAC (802.11be) should consider QoS mapping, packet scheduling and related management procedures to support GBR. And PHY and MAC should be improved to control packet latency and reliability.</p> <p>. QoS flow identification and service priority shall be mapped to have fine granularity of service types and QoS parameters.</p>
	Conversational Video	150 ms	$10^{-3}$	N/A	
	Real Time Gaming, V2X messages	50 ms	$10^{-3}$	N/A	
	Non-Conversational Video	300 ms	$10^{-6}$	N/A	
	MCPTT	75 ms	$10^{-2}$	N/A	
	Non-MCPTT	100 ms	$10^{-2}$	N/A	
	MC-Video	100 ms	$10^{-3}$	N/A	
	"Live" Uplink Streaming	150 ms	$10^{-6}$	N/A	
	"Live" Uplink Streaming	300 ms	$10^{-4}$	N/A	
	"Live" Uplink Streaming	300 ms	$10^{-8}$	N/A	
	"Live" Uplink Streaming	500 ms	$10^{-8}$	N/A	
"Live" Uplink Streaming	500 ms	$10^{-4}$	N/A		
Delay Critical GBR	Discrete Automation	10 ms	$10^{-4}$	255 bytes	<p>. 802.11ax MAC cannot guarantee 3GPP delay critical GBR service requirements of latency, PER and guaranteed data rate.</p> <p>. Enhanced MAC (802.11be) should consider QoS mapping, packet scheduling and related management procedures to support GBR. And PHY and MAC should be improved to control packet latency and reliability.</p> <p>. 802.11bd NGV should consider ITS service requirement.</p>
	Discrete Automation	10 ms	$10^{-4}$	1354 bytes	
	Intelligent transport systems	30 ms	$10^{-5}$	1354 bytes	
	Electricity Distribution- high voltage	5 ms	$10^{-5}$	255 bytes	

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3GPP QoS flow in SMF defines QoS identification and its priority according to resource types and QoS information is transferred to AP and STA. At first, QoS mapping from 3GPP QoS to WLAN QoS is necessary. WLAN shall support fine granularity of QoS and priority because 5G QoS ID has 6bits and specifies QoS parameters involving GBR (Guaranteed Bit Rate), latency and PER. Secondly, packet scheduling in STA and AP shall control MAC operation to meet required QoS. AP QoS profile and STA DRB (Data Radio Bearers) contains service QoS identification and its parameters to define data rate, packet latency and PER value. Packet scheduler configures data rate, packet latency, PER and packet size for MSDU packet. And QoS mapping to WLAN domain needs to specify Y4 and N1 interface to send QoS profile and QoS DRB information, respectively. Alternatively, QoS DRB may be delivered from the AP to the STA over Y3 interface if QoS DRB through NAS signaling is not available.

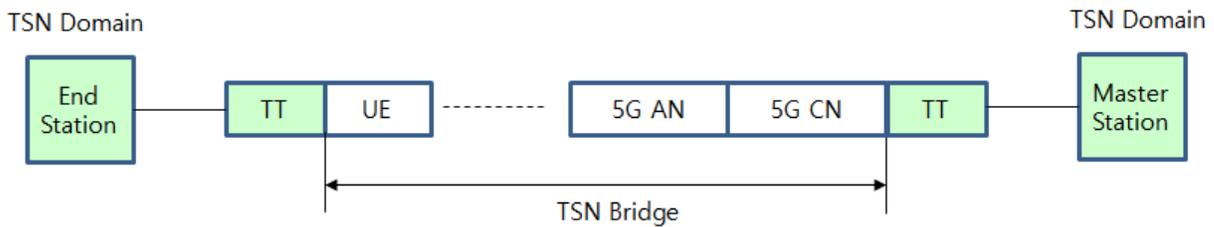
1 It is reported that transmission time scheduling guaranteed low packet latency and Hybrid ARQ supports  
 2 PER improvement. And data rate and bandwidth control shall support GBR.  
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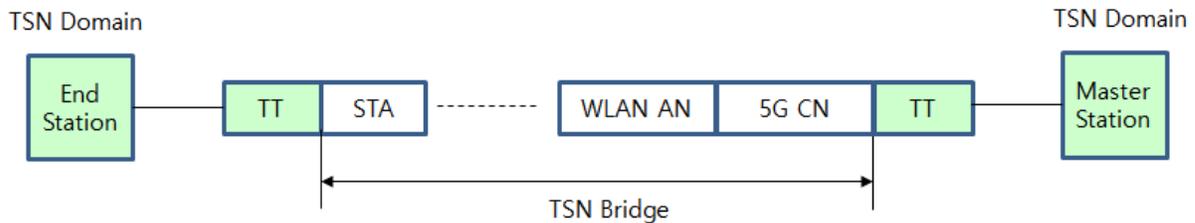
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 5 Figure 12. QoS mapping and scheduling example of WLAN  
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7 3GPP 5G System can be integrated with the external TSN as a TSN bridge. The TSN bridge includes TSN  
 8 Translator functionality for interoperation between TSN System and 5G System both for user plane and  
 9 control plane. 5G system TSN translator functionality consists of Device-side TSN translator (DS-TT) and  
 10 Network-side TSN translator (NW-TT). 5G system specific procedures in a 5G core network and RAN,  
 11 wireless communication links, etc. remain hidden from the TSN network [8]  
 12

13 As for TSN applications such as smart factory and automation field, TSN bridges can be configured in three  
 14 different types. The first type is to use 5G system as a TSN bridge in Figure 13. 3GPP domain needs to  
 15 consider the timing synchronization and TSN translator (TT) function in UE and 5G CN. The second type  
 16 is to use WLAN and 5G CN interworking as a TSN bridge in Figure 14. The third type is to use WLAN  
 17 only as a TSN bridge in Figure 15.  
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 20 Figure 13. TSN Bridge using 5G AN and CN  
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 23 Figure 14. TSN Bridge using WLAN and 5G CN interworking  
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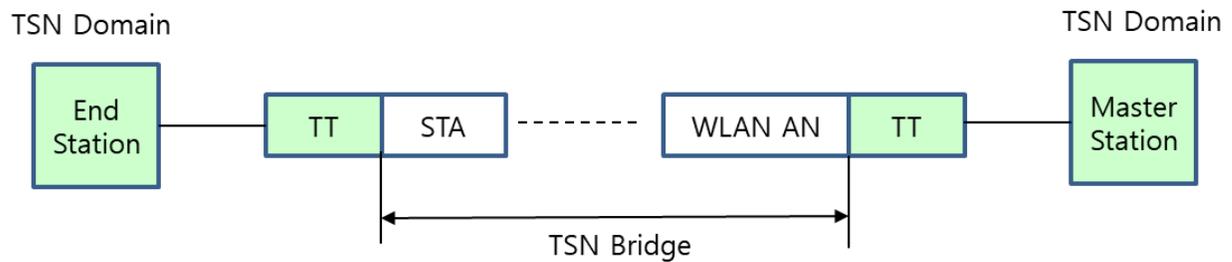


Figure 15. TSN Bridge using WLAN only

## 5.2 Technical Recommendations

WLAN supports high data rate to meet the performance of 5G network vision in the low mobility scenario and it is integrated as one of access networks for 3GPP 5G network. Therefore, 802.11 should consider adding new functional entities and signaling procedures to support interworking with the 3GPP 5G network. The following new functional entities should be added:

- Radio scanning and association
- Registration and authentication
- NAS signaling messages
- Packet session initiation/modification/termination
- Packet data QoS management

The key considerations on WLAN to interwork 5G core network as follows:

- Radio scanning and association process is well specified in WLAN 802.11 and is capable of supporting WLAN interworking with the 5G core network.
- IKEv2, EAP-5G and IPsec protocol for registration and authentication support should be added in the TEC of the STA and ANC of WLAN access network.
- NAS signaling to connect AMF should be added in the TEC of the STA and ANC of the WLAN access network.
- Packet session initiation/modification/termination to connect SMF should be added in TEC of the STA and ANC of WLAN access network.
- Packet data QoS management of WLAN shall specify QoS identification, profile and DRB to guarantee packet delay and PER for the required service types.
  - QoS mapping to WLAN is necessary to support more granularity of QoS ID and parameters
  - Packet scheduling in the STA and AP should meet data rate, latency and PER
  - Timing scheduling and the introduction of a Hybrid ARQ scheme are very important
  - 802.11ax cannot support 3GPP service QoS, and improved version (11be EHT, 11bd NGV) should consider MAC enhancement to support the service requirements.

The WLAN interworking model and terminal types will give impacts on interworking system design and implementation. For example, the terminal STA type should support both data and control functions to interwork with 5G core network. But the terminal UE will support all the control functions to interwork with 5G core network and WLAN access function of UE can be used for radio data forwarding.

For TSN applications, WLAN domain needs to consider the following requirements

- Timing synchronization
- TSN translation in WLAN STA and 5G CN

## 6. Conclusions

WLAN can support interworking with the 3GPP 5G network and is able to support high data rate to meet the performance of 5G network vision in the low mobility scenario. The new functional entities and signaling procedures were identified:

- Radio scanning and association
- Registration and authentication
- NAS signaling messages
- Packet session initiation/modification/termination
- Packet data QoS management

Through gap analysis, IEEE WLAN radio scanning and association process, IETF specification such as IKEv2, EAP-5Ga and IPsec can be used or adapted and implemented in TEC of the STA and ANC of WLAN access network. NAS signaling, ATSSS and QoS management can be implemented in TEC of the STA and ANC of WLAN access network and should follow the guidance of the 3GPP specifications.

In the loosely coupled interworking model, the new functional entities and signaling procedures can be assigned to UE or STA to interwork with 5G core network. The terminal UE can support the above control and signaling functions. However, the terminal STA type should support all the control and signaling functions to interwork 5G network.

As for QoS management, WLAN should specify QoS mapping and MAC scheduling including QoS identification and profile to guarantee QoS in terms of deterministic packet delay, low PER and data rate. The new interface Y3 and Y4 are defined to deliver QoS profile between 5G CN (N3IWF) and WLAN STA.

For TSN applications, WLAN domain needs to consider the timing synchronization with TSN domain and TSN translation in WLAN STA and 5G CN.

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