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TECHNICAL REPORT

**Digital Enhanced Cordless Telecommunications (DECT);
Study on Interworking of DECT with 3GPP networks**

Reference

DTR/DECT-00342

Keywords

DECT-2020, interworking, non 3GPP access

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Digital Enhanced Cordless Telecommunications (DECT).

Modal verbs terminology

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Introduction

With the introduction of DECT-2020 NR [i.6] as a new ETSI standard the integration of this new technology with other wireless systems becomes of interest.

The aim of the present document is to provide a starting point of using the DECT-2020 NR [i.6] as a non-3GPP radio access technology. With 3GPP Release 15 and onwards, the 5GS provides means of utilizing other access networks besides the 3GPP included one. DECT-2020 as a promising technology for ad-hoc wireless networks working as access and relaying networks could increase the radio coverage for 3GPP networks in areas where the 3GPP technology is not best suitable. Due to the scope of the DECT-2020 standard being application agnostic it can be easily utilized as a radio access technology for all the higher layer procedures within a 3GPP network.

1 Scope

The present document is a study on how to establish an interworking framework and functions of DECT with 3GPP networks. The present document analyses existing possibilities in 3GPP and DECT technical specifications and derives possible approaches, system architectures and functions to enable trusted and non-trusted interworking.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 123 501: "5G; System architecture for the 5G System (5GS) (3GPP TS 23.501)".

[i.2] ETSI TS 123 502: "5G; Procedures for the 5G System (5GS) (3GPP TS 23.502)".

[i.3] ETSI TS 133 501: "5G; Security architecture and procedures for 5G System (3GPP TS 33.501)".

[i.4] GSMA Whitepaper: "eSIM Whitepaper - The what and how of Remote SIM Provisioning".

[i.5] IETF RFC 3748 (2004): "Extensible Authentication Protocol (EAP)", B. Aboba, L. Blunk, J. Vollbrecht, J. Carlson und H. Levkowetz.

[i.6] ETSI TS 103 636 (all parts): "DECT-2020 New Radio (NR)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations apply:

3GPP 3rd Generation Partnership Project
5G 5th Generation Mobile Network
5GC 5G Core

5GS	5G System
AAA	Authentication, Authorization and Accounting
AKA	Authentication and Key Agreement
AKA'	AKA Prime
AMF	Access and Mobility Management Function
AS	Access Stratum
CP	Control Plane
CUPS	Control and User Plane Separation
DECT	Digital Enhanced Cordless Telecommunications
EAP	Extensible Authentication Protocol
eNB/gNB	3GPP Radio Access Point (gNodeB)
eSIM	embedded Subscriber Identity Module
FT	Fixed Termination point
IC	Integrated Circuit
IMS	Internet Protocol Multimedia Subsystem
IP	Internet Protocol
IPsec SA	IPsec Security Association
iSIM	integrated Subscriber Identity Module
L2	Layer 2
N3IWF	Non-3GPP InterWorking Function
NAI	Network Access Identifier
NAS	Non-Access Stratum
NAT	Network Address Translation
NR	New Radio
NWt	Reference point between the UE and TNGF
NWu	Reference point between the UE and N3IWF
PDU	Protocol Data Unit
PLMN	Public Land Mobile Network
PT	Portable Termination point
QoS	Quality of Service
RAN	Radio Access Network
RD	Radio Device
SA	Standalone
SIM	Subscriber Identity Module
SNPN	Standalone Non-Public Network
TLS	Transport Layer Security
TNAN	Trusted Non-3GPP Access Network
TNAP	Trusted Non-3GPP Access Point
TNGF	Trusted Non-3GPP Gateway Function
UE	User Equipment
UP	User Plane
USIM	Universal Subscriber Identity Module
WAN	Wide Area Network
WLAN	Wireless Local Area Network
Y1	Reference Point between UE and non 3GPP access

4 Overview

4.1 Target

The present document looks at the possible interworking solutions between 3GPP Release 16 systems and DECT-2020 as defined in ETSI TS 103 636 [i.6].

The 3GPP system defines a mobile network with end-user devices, base stations and core network. It enables communication between mobile end-user devices to external data networks through fixed infrastructure composed of base stations and core network. 3GPP Release 16 defines different modes of operation and follows Control and User Plane Separation (CUPS) principle. Thus, enabling interworking with other networks in the control plane as well as on the data plane.

DECT-2020 NR defines a network composed of radio devices. Each radio device can act in the role of Fixed Termination point (FT) and Portable Termination point (PT). These roles do not define the deployment, rather a logical role the devices announce to the network. Based on these roles, different network topologies can be realized.

Interworking both networks can be achieved on different levels. A DECT-2020 FT can act as a gateway between the DECT-2020 and 3GPP network based on the data plane connection and routing. A DECT-2020 PT can also be a UE in the 3GPP network and thus be seen as a mobile end-device in both networks.

Enabling interworking of both networks to support communication over network boundaries and thus accessing services requested by the user is the goal of the present document. Two modes of interworking can be derived: interworking via data plane only and interworking via data + control plane. While the first mode has the characteristics of a connection-based interworking, the second mode aims towards an integrated unified network (see Figure 1).

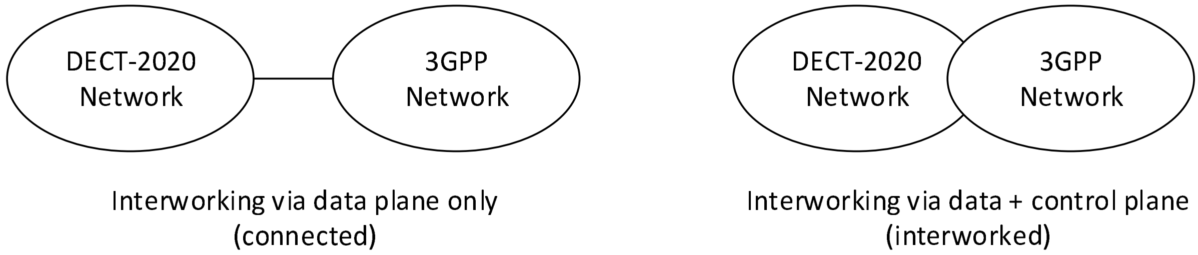

Figure 1: Modes of interworking

4.2 Use-cases and Requirements

Use-case 1: Wide Area Network connectivity

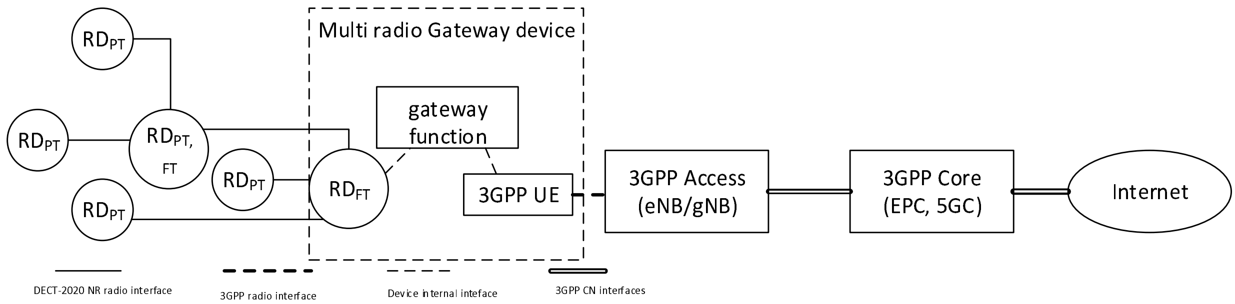

Figure 2: Use-case 1 WAN connectivity

The use-case describes the easiest and lowest version of interworking between DECT and 3GPP networks. Central element is a gateway with two radios, one DECT radio and one 3GPP radio. The standard compliant 3GPP UE connects via 3GPP Access technology to the 3GPP network and uses 3GPP authentication procedures. Identification and configuration in the 3GPP domain are up to 3GPP standards. After successful connection, the 3GPP connection acts as backhaul for the DECT-2020 network and thus providing WAN connectivity.

The DECT network, hence all the RD devices, uses DECT-2020 standard to connect. The DECT radio in the gateway is configured in the DECT-2020 FT role and provides a WAN connection to the DECT network domain. All DECT network authentication is handled in the DECT network without any co-ordination from 3GPP.

The gateway function can be implemented by switching layer 3 (IP) data streams. This can be done by simple routing information as well as Network Address Translation (NAT) schemes. Alternatively, the gateway has a translation function where non-IP data received/sent from/to DECT-2020 NR network is translated to/from IP datagrams sent/received from 3GPP UE interface. The gateway functionality is out of scope of current DECT-2020 NR specifications [i.6].

Requirements:

- Gateway device with two radios including commercial of the shelf 3GPP UE and DECT RD.

- DECT RD in gateway device is configured in FT role to provide WAN connectivity.
- Processing for IP routing or translation function to encode/decode non-IP datagrams to/from IP datagrams.
- Optional NAT capabilities.

Use-case 2: Integrated Multi-Standard Device

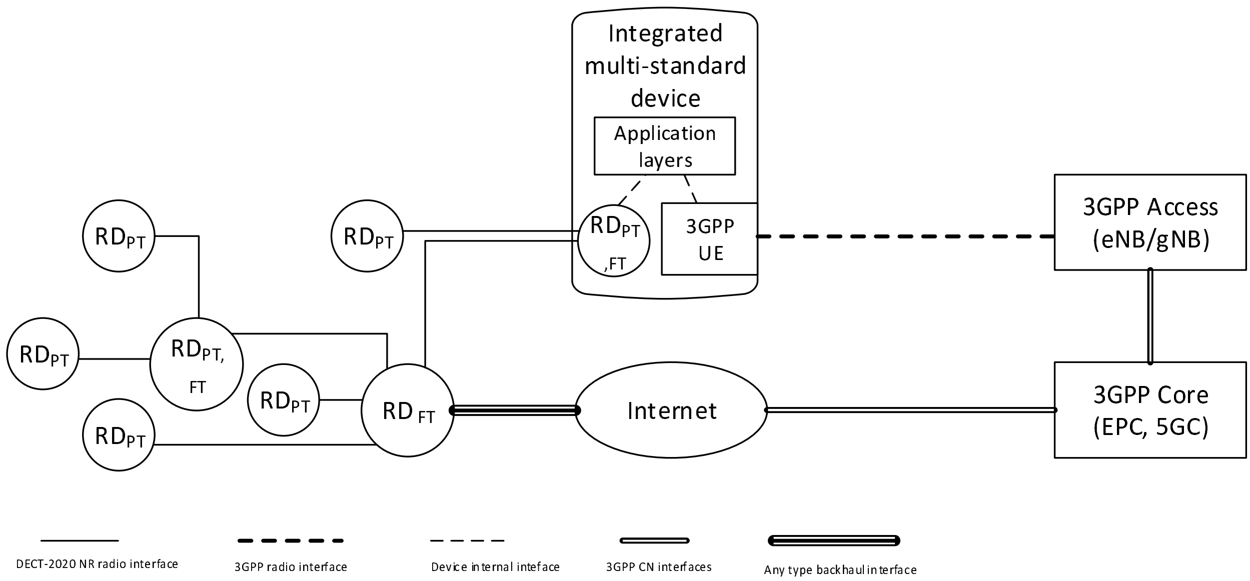

Figure 3: Use-case 2 Integrated Multi-Standard device

The use-case focuses on a mobile end-user device which is capable to connect to two networks. Either simultaneously or on-demand. The decision on which radio interface to use or prioritize for certain application is expected to be done by the application layer. The integrated multi-standard device is similar to the one in use-case 1 with two radios, one for 3GPP access and one radio for the DECT-2020 network, however, it is not announcing that it has connectivity to external networks, thus not acting as a possible gateway to the internet for the DECT-2020 network. The DECT-2020 radio can announce itself as both in FT and PT role, i.e. it is capable of routing other devices data in DECT-2020 network, or only the PT role. As shown in Figure 3, the internet access for the DECT-2020 network is managed by another RD with FT role with separate backhaul interface to internet.

The use-case increases the internet service availability for the user by enabling the device to connect to two different networks. For example, the 3GPP network can provide coverage and thus internet access in outdoor scenarios while the DECT-2020 network can provide coverage in indoor scenarios, especially in challenging environments. Alternatively, DECT-2020 connectivity can be used to access local services available only where DECT-2020 network is present or connect directly with other RDs in DECT-2020 networks.

Requirements:

- Gateway device with two radios including commercial of the shelf 3GPP UE and DECT RD.
- DECT RD in gateway device is configured in both FT and PT or PT role only to act as mobile in both networks.
- IP capabilities for internet access.

Use-case 3: DECT as non-3GPP access RAN

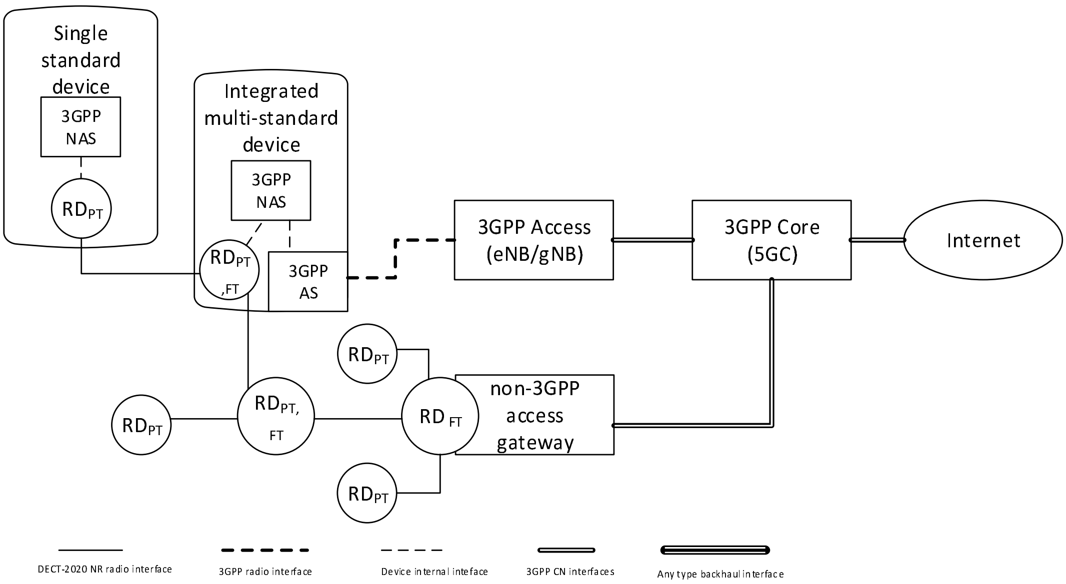

Figure 4: Use-case 3 DECT as non-3GPP access RAN

Use-case 3 integrates data plane and control plane, such that the DECT-2020 network will be interconnected to the 3GPP core directly. There are two modes, depending on if the non-3GPP access is trusted or untrusted by the 3GPP core. In both cases, a gateway or interworking function closely located at the 3GPP core will be the communication endpoint. Therefore, a DECT-2020 NR gateway implements DECT-2020 radio interface and either trusted or untrusted interface option to connect to 3GPP core.

The use-case enables symbiosis of both technologies to one network. A mobile end-user device may have two radios, one for each technology, the integration level is higher as in use-case 1 or use-case 2. Since the UE is known to the 3GPP core also via the non-3GPP access control plane, it can access 3GPP services (such as IMS), while connected over the DECT-2020 network and thus via the non-3GPP access. In addition, a seamless handover could be realized if the control plane of the 3GPP core can manage the DECT-2020 radio within the mobile. Alternatively, a device may only implement DECT-2020 radio interface functionality but support 3GPP Non-Access Stratum (NAS) functionality for authentication and session management functionalities to access 3GPP services.

Requirements:

- Gateway DECT-2020 FT implementing non-3GPP access scheme of 3GPP.
- Connection to 3GPP core.
- Integrated mobile end-user device with two radios including commercial of the shelf 3GPP UE and DECT RD or DECT RD with 3GPP NAS functionality.

This architecture is presented with more details in clauses 5 and 6.

5 Existing Interworking Procedures in 3GPP 5G Domain

5.1 Overview

The 5GS supports three modes of non-3GPP access:

- untrusted;
- trusted;

- wireline.

For the scope of the present document, the focus is on the untrusted and trusted interworking functionalities.

The untrusted non-3GPP access is realized via the N3IWF (see Figure 5), the trusted non-3GPP access via the TNGF (see Figure 6). Both functions interface with the 5G Core Network CP und UP functions via the N2 and N3 interfaces, respectively.

5.2 System Architecture

Based on ETSI TS 123 501 [i.1] the following system architectures support non-3GPP access. In Figure 5 the system architecture for an untrusted non-3GPP access is shown, in Figure 6 the trusted non-3GPP access is shown respectively.

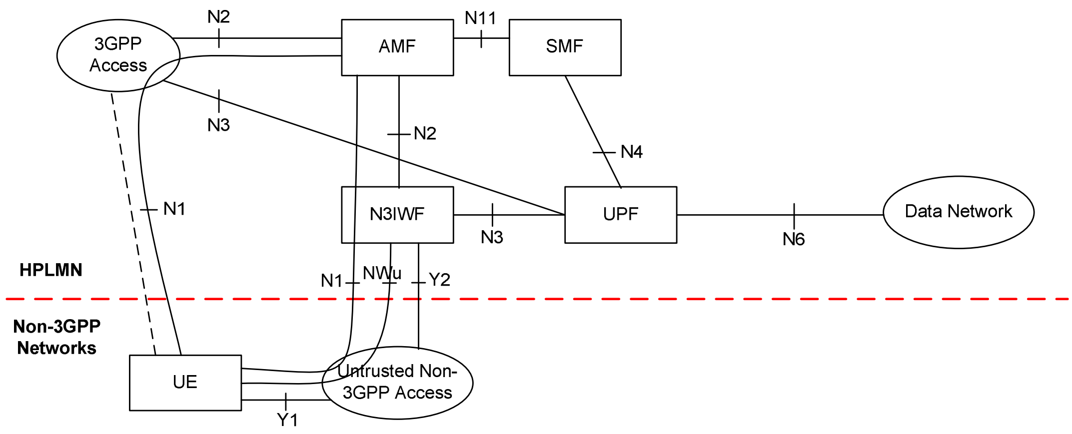

Figure 5: Non-roaming architecture for 5G Core Network with untrusted non-3GPP access

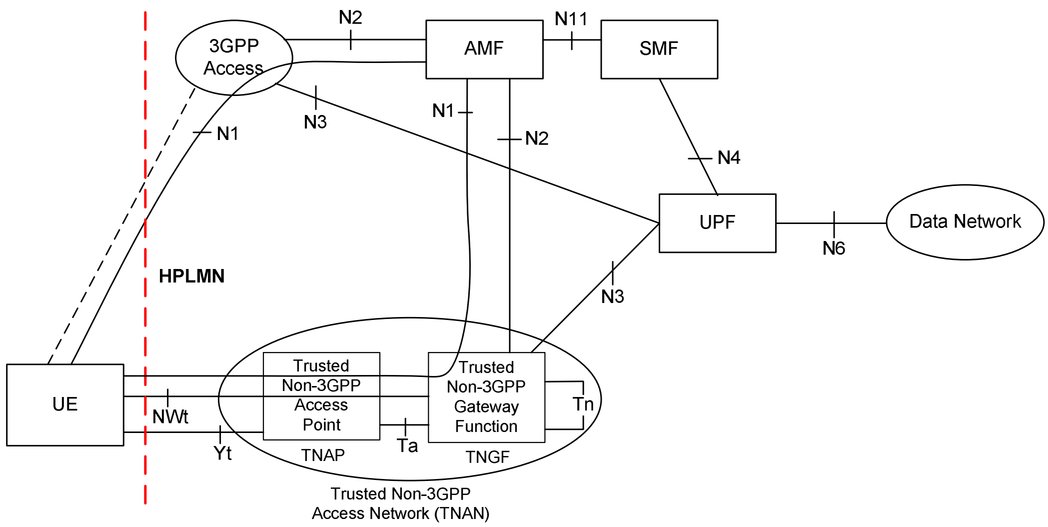

Figure 6: Non-roaming architecture for 5G Core Network with trusted non-3GPP access

5.3 Availabilities Functionalities

5.3.1 Untrusted non-3GPP Access

The untrusted non-3GPP access reference point Y1 defines the access technology (e.g. DECT, WLAN) and is not specified by 3GPP. The NWu reference point between UE and N3IWF establishes a secure connection to the 5G Core Network exchanging UP and CP functions.

To connect via untrusted non-3GPP access the UE establishes a connection with the untrusted non-3GPP access network and obtains a local IP address. Through that, in can select an N3IWF via IP and establish the necessary IPSec tunnel to the N3IWF.

All NAS messages between UE and 5GC are encrypted via established IPSec tunnel and thus the UE can establish a PDU Session with the AMF. After success, the UE gets an IP address from the 5GC.

The signal flow is shown in Figure 7. For more details refer to clause 4.12 in ETSI TS 123 502 [i.2].

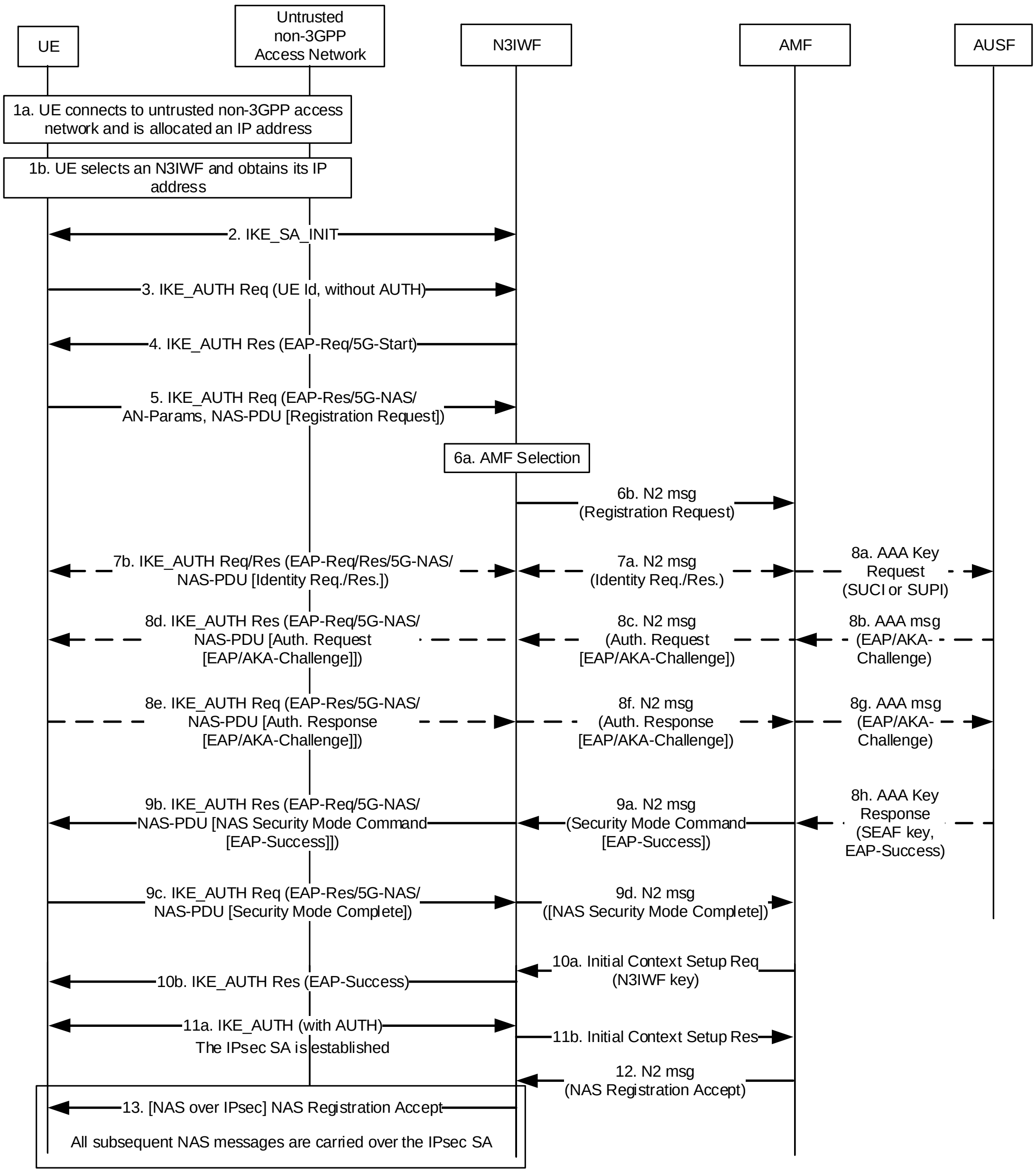

Figure 7: Registration via untrusted non-3GPP access

5.3.2 Trusted non-3GPP Access

For trusted non-3GPP access the UE connects via Yt and NWt to a TNAN. The registration procedure is similar to the untrusted non-3GPP access. The link between UE and TNAN needs to support EAP encapsulation and can be any data link on L2. After EAP-5G connection is established the TNAN sends an IP configuration to UE. Based on the local IP address between UE and TNAN, the UE can set up a secure NWt connection with 5GC.

The signal flow is shown in Figure 8. For more details on the trusted non-3GPP access procedure refer to clause 4.12a in ETSI TS 123 502 [i.2].

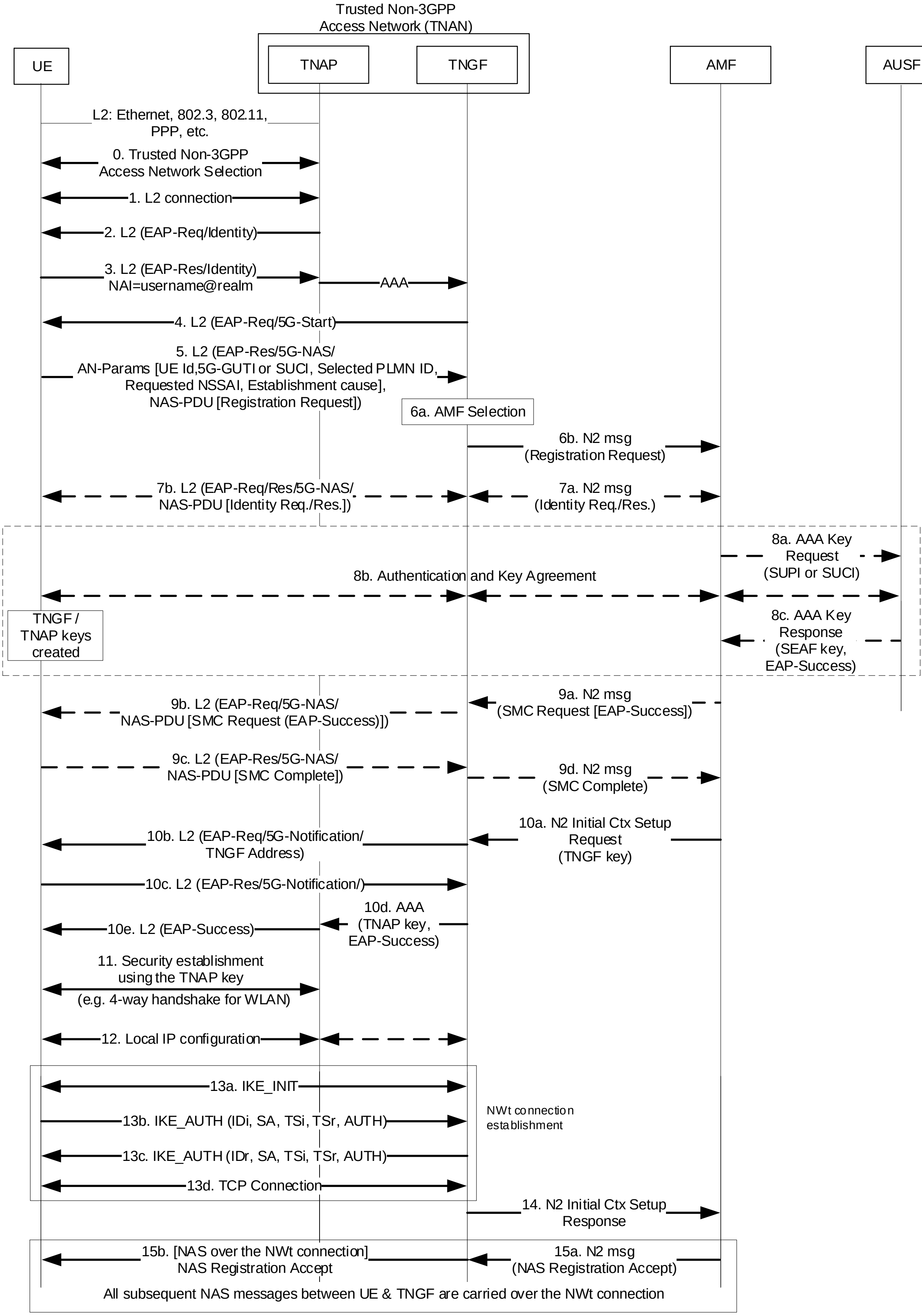

Figure 8: Registration via trusted non-3GPP access

6 Approach for Interworking of DECT Domain with 3GPP domain

6.1 Overview

The use-cases 1 and 2 in clause 4.2 define the interworking between DECT and 3GPP domain on the user plane. This is achieved by IP layer interconnect of both technologies. This is easy to accomplish and does not need any further investigation. The two interworking options of the 3GPP domain in use-case 3 are investigated in this clause in more detail since it includes the control plane. In fact, the control plane interworking functionalities are the prerequisite for any non-3GPP access to enable user plane interworking. Additional focus is set on the authentication procedures defined in the non-3GPP access procedures.

6.2 System Architecture

6.2.1 Untrusted non-3GPP access

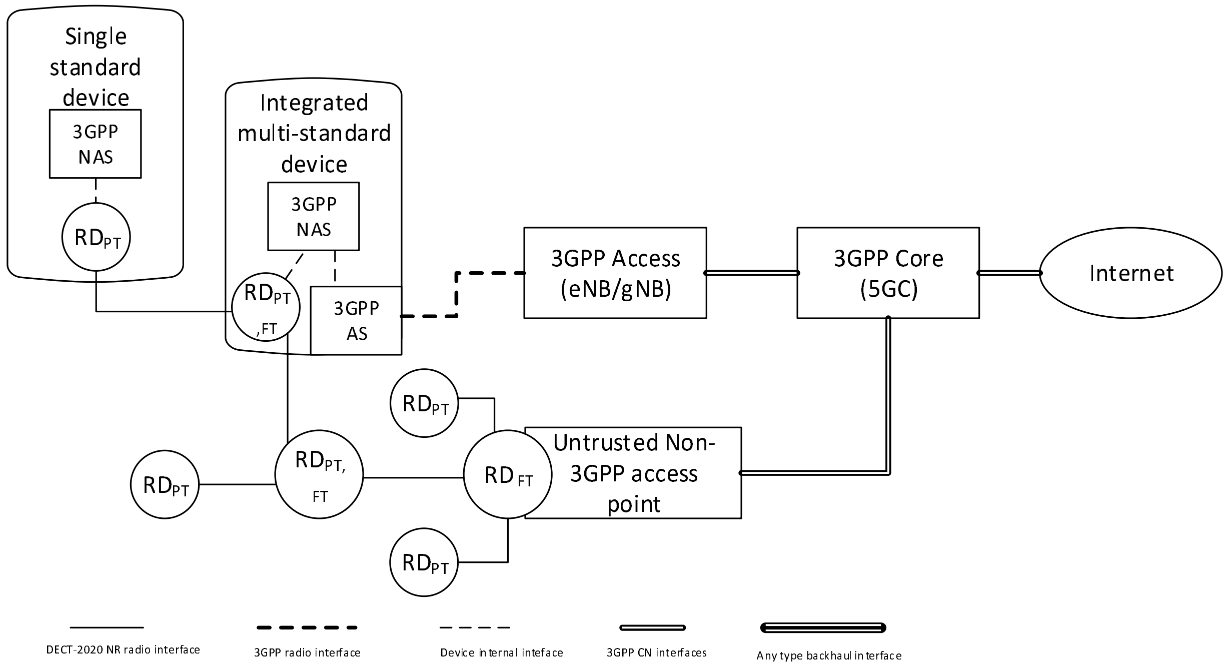

Figure 9: System architecture for untrusted non-3GPP access

The system architecture to interwork the DECT-2020 system with the 3GPP system via untrusted non-3GPP access is shown in Figure 9. The DECT-2020 network consists of multiple Radio Devices (RDs). One device is operating in DECT-2020 PT mode. This device also includes a standard 3GPP UE connected via 3GPP access to the 3GPP core. The DECT-2020 PT part is connected to a DECT-2020 FT part which provides the untrusted non-3GPP access. Additionally, DECT-2020 networks consist of a device that supports only DECT-2020 NR radio interface but also 3GPP NAS functionality. As it can been seen in the following clause, in addition to 3GPP NAS layer, a few additional protocol layers are needed between NAS and or PDU layer and DECT-2020 NR.

A RD FT having untrusted non-3GPP access point functionality operates as an access point for DECT-2020 network toward the 3GPP core via the N3IWF.

6.2.2 Trusted non-3GPP access

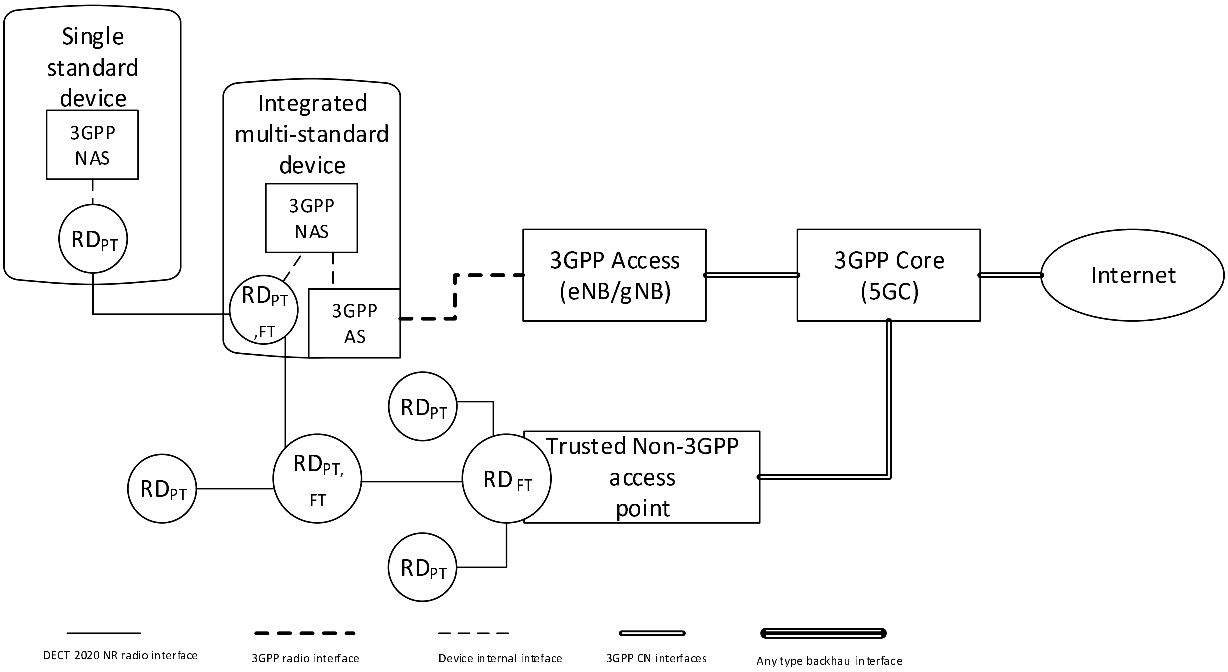

Figure 10: System architecture for trusted non-3GPP access

The system architecture to interwork the DECT-2020 system with the 3GPP system via trusted non-3GPP access is shown in Figure 10. As in clause 6.2.1 the DECT-2020 system is similar, but the DECT-2020 FT is acting as a TNAP, creating together with a TNGF a TNAN. (see clause 5.2). In the trusted non-3GPP access case, every DECT-2020 device associated is controlled by the 5GC.

6.3 Procedures and Functionalities

6.3.1 Untrusted non-3GPP access

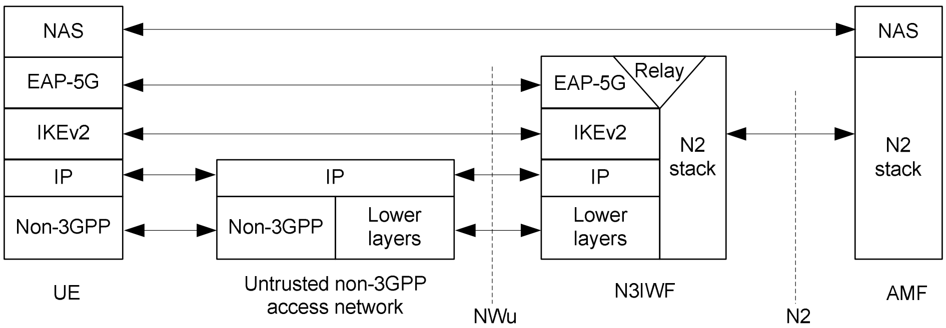

Figure 11: Control plane before the signalling IPsec SA is established between UE and N3IWF

In Figure 11 the control plane signalling for authentication in the untrusted non-3GPP access case is shown in ETSI TS 123 501 [i.1]. The authentication between the UE and AMF needs to be routed on top of the IP layer of the untrusted non-3GPP access network. Here the UE is creating a tunnel to the N3IWF on top of the untrusted non-3GPP access network, to access the AMF for authentication. While Figure 11 shows the stack before the signalling IPsec SA is established, Figure 12 shows the stack after the IPsec SA is established.

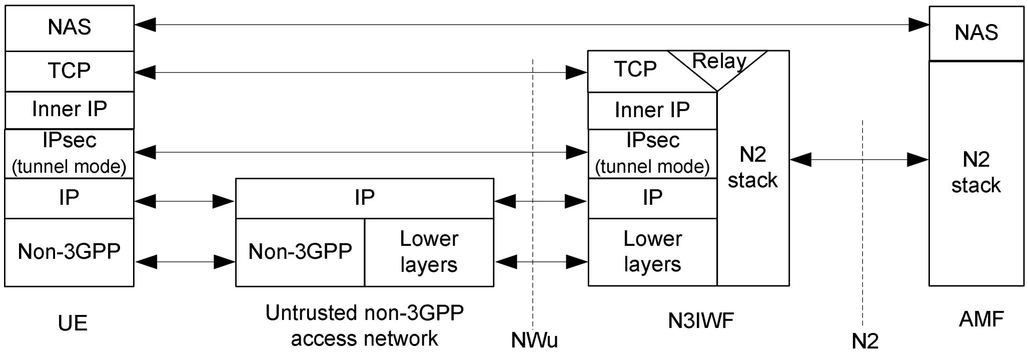

Figure 12: Control plane after the signalling IPsec SA is established between UE and N3IWF

After establishing the IPsec tunnel and successful authentication, the control plane connection is established and can be used to initiate a user plane PDU session to access services of the 5G network as shown in Figure 13. The respective user plane stack is shown in Figure 14.

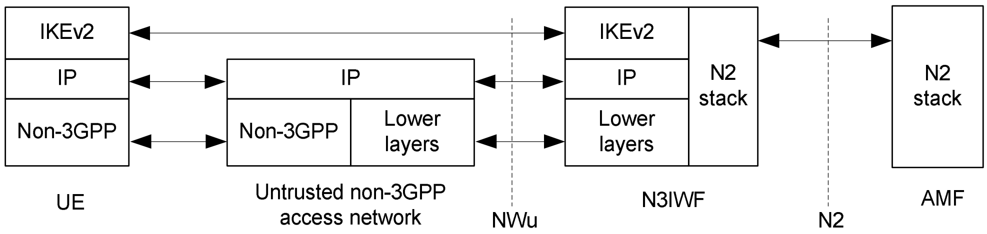

Figure 13: Control plane for establishment of user plane via N3IWF

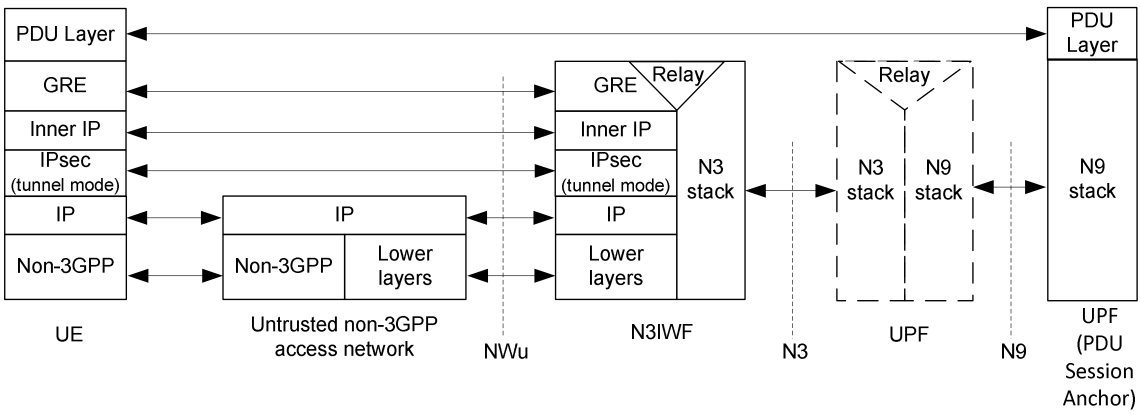

Figure 14: User plane via N3IWF

6.3.2 Trusted non-3GPP access

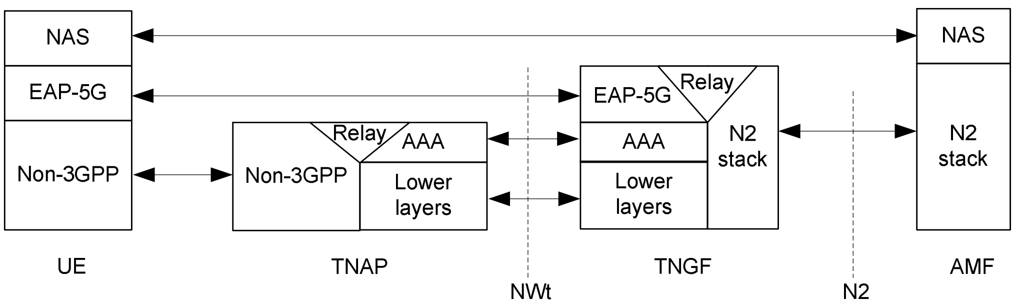

Figure 15: Control plane before the NWt connection is established between UE and TNGF

Figure 15 shows the control plane stack before NWt connection is established via trusted non-3GPP access. Upon registration request from the UE via NAI, the TNAP sends an AAA-request to the TNGF, which acts as an AAA-proxy. The connection between the UE and the TNAN (TNAP+TNGF) can be any L2 protocol. An EAP-5G procedure can be executed for authentication. See clause 5.3.2 for detailed procedure.

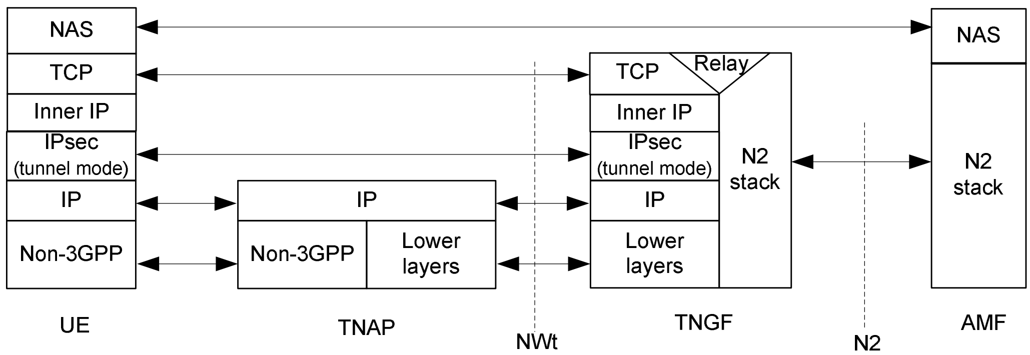

Figure 16: Control plane after the NWt connection is established between UE and TNGF

After successful authentication, the control plane stack is shown in Figure 16. The TNAN has associated an IP address to the UE. The UE also created an IPsec tunnel to the TNGF to receive an inner IP address. All following control messages are carried over this NWt connection. The UE can now initiate a PDU session.

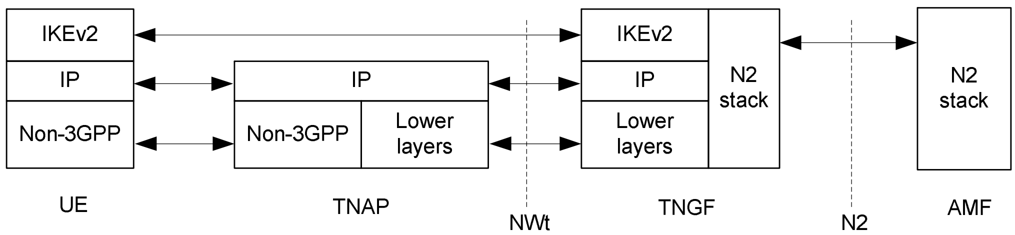

Figure 17: Control plane for establishment of user plane via TNGF

In Figure 17 the control plane stack for establishing a user plane PDU session. The UE initiates additional IPsec SA per PDU session. During the establishment procedure for the PDU session, the IPsec child SA can carry QoS information, thus the TNGF has to react and inform the trusted non-3GPP access technology on how to implement the per flow QoS information.

The user plane stack is shown in Figure 18.

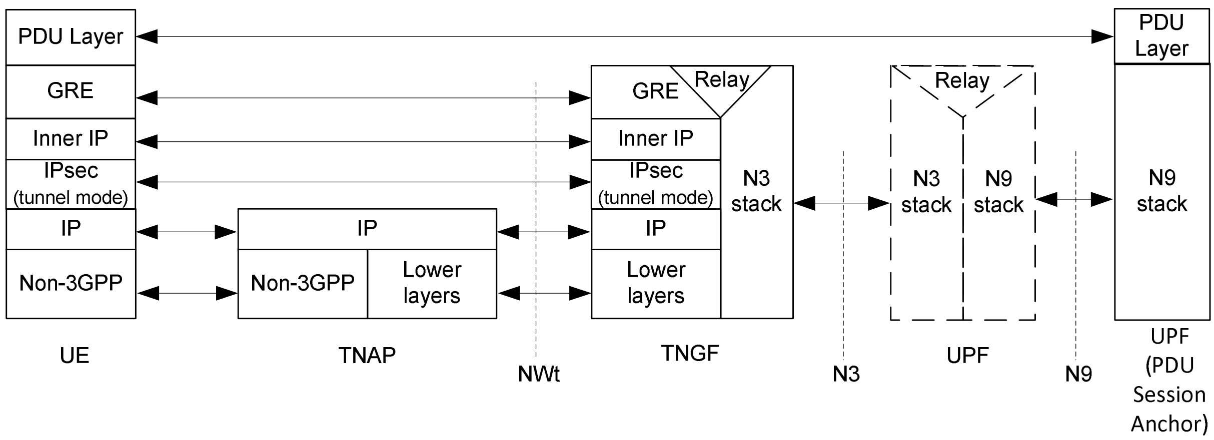

Figure 18: User plane via TNAN

6.3.3 Authentication Procedure

The untrusted non-3GPP access and trusted non-3GPP access are quite similar in architecture. One of the main aspects is the authentication of the UE at the AMF within the 5GC. The authentication procedures are based on EAP-5G. This clause discusses some detailed aspects of 3GPP based authentication via non-3GPP RANs. In the case of SNPN with non-3GPP access (DECT) this has some implications.

If the UE is a DECT RD (without any 5G NR modem), which connects via non-3GPP access network, another method of storing this information is advised.

The authentication procedures EAP-AKA' [i.5] requires an USIM, which can be integrated directly into the device. Either as a dedicated IC (eSIM) or as integrated circuits within the modem, the so-called iSIM. This solution is able to store the necessary secret information for authentication in a standard compliant way. This can be done directly during manufacturing. In addition, the provisioning of the USIM can be done via a backend solution without any user interaction. For details, refer to [i.4].

Public Land Mobile Networks (PLMNs)

Usually, a 3GPP UE has an USIM card, provided by the operator of the 3GPP network. The USIM has identification information based on the origin network and carries secret information for secure authentication. If the operator of the PLMN deploys a DECT-2020 based non-3GPP radio access network, the stored information on the USIM certainly contains the necessary information. The AMF within the 5G-Core network of the PLMN operator will authenticate the UE regardless of the RAN connection. 5G RAN, untrusted non-3GPP or trusted 3GPP can be used with the same credentials provided by the operator of the PLMN. In this scenario it is most likely that the UE has both connection methods (5G and DECT) and a physical SIM or eSIM capabilities.

Standalone Non-Public Networks (SNPNs)

If the connecting network is an SNPN, thus the operator of the network and the user of the UE(s) are most likely the same person, a non USIM based authentication method can be used. In addition, it is likely that the UE(s) will not support 5G NR and only have DECT-2020 radio capabilities.

The 5G system provides authentication via EAP-TLS. There is no USIM needed, and the authentication secret (here certificate) can be deployed directly on the UE, see ETSI TS 133 501 [i.3]. This allows for highly integrated devices. The SNPN operator is expected to enable their AMF for this mode of authentication and deploy the certificates in the core as well as on the UE. The UE may be provisioned via the 5GC through an TNAN for EAP-TLS automatically. The TLS certificate maybe deployed directly on the device during on-boarding by the operator.

7 Conclusion

The present document introduces three use-cases for interworking DECT-2020 NR networks with 3GPP networks. The level of interworking is increasing with each use-case. First a DECT-2020 NR network is using a 3GPP network as a way to connect to the internet. In use-case 3 the DECT is acting as an additional radio access network besides 3GPP 5G NR connected to the same 3GPP core network. This creates a non-3GPP access and the present document investigates the needed authentication procedures in detail.

The scope of interworking DECT-2020 NR with 3GPP presented in the present document offers a variety of choices one can use depending on the envisioned deployment scenario. Both technology standards have the necessary capabilities to support interworking on different layers and thus allow users to choose the best suitable option for their needs.

History

Document history		
V1.1.1	March 2023	Publication