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| Chapter 7.1 restructuring |
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Abstract

This document proposes to restructure the text of subchapters 7.2, 7.3, and 7.4 to remove the subchapter structure by treating the different subchapters as use cases of access network setup. The proposed text realizes the proposals presented and discussed by document omniran-16-0079.

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# Functional Decomposition and Design

## Access network setup

### Introduction

An access network may require configuration before becoming operational. Initial configuration consists of the establishment of connections to associated SSs, ARs, and NMSs. Depending on the implementation of the network, the configuration may consist of adjustments to the radio interfaces, either to comply with regulatory requirements or to optimize radio resource usage.

The following subsections describe for IEEE 802 technologies:

* dynamic spectrum allocation and network setup for ASA bands
* dynamic allocation of operation channels in unlicensed spectrum
* access network setup and release

IEEE 802 technologies support dynamically established access networks either by making use of dynamic spectrum allocations for the radio interfaces or by dynamic establishment of network functions or virtual infrastructures.

An IEEE 802 access network infrastructure can be operated by an access network operator over ASA spectrum or unlicensed spectrum. When the access network is powered up, it may need to search for a radio frequency channel with less congestion or interference over one or more channels in ASA or unlicensed bands using the procedures defined in 7.1.2 and 7.1.3 respectively. Once the operating channel is found, the access network is initialized with the configuration parameters retrieved through the NMS of access network operator.

[7.1.3.1 Introduction]

Some of the IEEE 802 radio technologies for access networks are designed for operation in unlicensed bands. Special preparatory steps are required before turning on radio interfaces and operating access networks in unlicensed spectrum. The following chapters describe the necessary actions for initiating access network operation in unlicensed bands.

[7.1.2.1 Introduction]

The ASA (or LSA) is a mechanism that allows radio frequency spectrum licensed for international mobile telecommunications (IMT) to be used by more than one service entity.

According to FCC regulation, the Authorized Shared Access (ASA) spectrum is mainly allocated for primary users to provide radio services. Secondary users may occupy ASA spectrum to provide radio access services to their customers only when the primary users are not providing radio services.

In order to get the operational information of primary services in the ASA spectrum, the ANC in IEEE 802 NRM needs to communicate with CIS in order to execute ASA, and to get authorization before an AN or TE can turn on its radio transmission in authorized shared frequency.

### Roles and identifiers

#### [7.1.2.2.1] Terminal

An enabled TE operates in an authorized frequency channel, such as TV white space or 3.5GHz band, which is shared with primary services in the same authorized spectrum.

#### Node of Attachment

NA is defined in Section 6.5. NAs may consist of one or more radio interfaces for an access network operator in the basic network service model. Each NA in the basic deployment model has its own air interface identifier (like BSSID) and the same network identifier in the AN.

[7.1.3.2.1 Node of Attachment]

NA is defined in Section 6.2. It is the device accessing the spectrum for radio transmissions to the terminal and senses the existence of neighboring radio systems to enable shared access. Different NAs within an access network may have different capabilities regarding supported frequency bands and operation in unlicensed spectrum.

#### Access Network

AN is defined in Section 6.5. In the basic network deployment model, the AN consists of one or more NAs, one Access Network Control (ANC), and Backhaul network (BH).

[7.1.2.2.2 Access network]

An ASA-enabled Access Network contains one or more enabled nodes of attachment. In some specifications, the NA is also called the master device. An NA provides radio access connectivity to the TEs (called slave devices) in the authorized license frequency channel, which is shared with primary services in the authorized spectrum.

#### [7.1.3.2.2] Access Network Control

ANC is defined in Section 6.3. The ANC stores the collected spectrum usage information of each NA and eventually provides assistance to newly initiated NAs to speed up or optimize the channel selection procedure in the NA.

[7.1.2.2.3 Access network control]

The authorized shared access network control is a function in the ANC that is used to manage and control operations of ASA-enabled NAs, such as setup, provisioning, and teardown in the authorized spectrum shared with primary services. The ANC also controls operations of ASA-enabled TEs in the authorized shared spectrum through the reference point R8.

The ANC may support the following functions for coexistence with primary servers or other services in the authorized shared spectrum. (Support is not limited to these functions.)

* Coexistence management enables an NA to coexist with primary wireless devices in the authorized shared spectrum.
* Coexistence discovery and information (local) server is used to store the information used for deter­mining coexistence of NAs operating in the authorized spectrum shared with primary wireless ser­vices.

#### [7.1.2.2.4] ASA Coordination and Information Service (ASA-CIS)

ASA Coordination and Information Service (ASA CIS) is a function in the CIS of the network reference model. It provides storage of the information used for the access services in the authorized spectrum shared with primary services. It could be implemented as a database server to provide information service for its clients. The information in CIS could include the following:

* authorized shared frequency band and channel information
* shared access spectrum geolocation information
* allowed maximum transmit power in the authorized shared access spectrum
* primary service provider and secondary service providers and their operating status
* potential neighboring services and their interference levels

ASA CIS could be accessed by the ANC through the reference point R10. The ANC may have a local copy in the local memory and is periodically synchronized with CIS.

### Use Cases

#### Access network infrastructure

In the basic network deployment model, an access network operator manages and operates the access network with the configuration parameters retrieved through the NMS of access network operator.

#### [7.1.3.3.1] Channel selection

Channel selection is part of NA radio configuration for tuning the receiver and transmitter to particular operating frequencies within unlicensed bands. Since unlicensed spectrum usually provides multiple channels, and radio devices can arbitrarily select one of these channels for operation, it may happen that several devices are operating in the same frequency channel in the same coverage area, such that interference among devices is inevitable. To reduce the interference with each other in the unmanaged environment, the NAs should select, during initial setup, the best operating channel with the least amount of interference.

When operating with a channel bandwidth of 20MHz, the 2.4GHz ISM band allows for three or four non-overlapping channels depending on the regulatory region. The 5GHz band for unlicensed operation provides more than 20 channels of 20MHz each. The channel selection procedure in the NA determines the channel with the least amount of interference of all available channels. The channel selection procedure in the NA may operate in a local manner, may communicate with the channel selection procedures in adjacent NAs, or may deploy a central entity in the access network control to speed up the selection process and generate more optimized results.

When the NA initiates its radio interface, the channel selection function of the NA should measure the channel occupancy or radio resource usage of all the channels in the unlicensed band. Based on those measurements, and potentially with further information and guidance from the neighbor NAs and the ANC, the NA selects the channel with the most appropriate properties and initiates the radio interface for that channel.

An NA may report the channel measurement results to the ANC. The ANC stores the collected spectrum usage information of each NA and eventually provides assistance to newly initiated NAs to speed up or to optimize the channel selection procedure in the NA.

#### [7.1.3.3.2] Channel reselection

The NA may switch during operation to another channel if it detects that the current operating channel is heavily overloaded or interfered. Switching the operating channel can be performed as a functional extension to the channel selection procedure and may cause a service interrupt.

As the ANC may store the operating channel information of each NA, it may provide assistance or coordination for reselecting a better operating channel in the coverage

Before switching to another channel, the NA may need to de-associate the devices under its service to trigger them to search for the service in another channel—potentially the channel to which the NA tunes in. The disassociation causes the terminal to enter the network discovery and selection procedure, which contains a scanning function for discovery of potential NAs in the coverage area.

#### Operation in Authorized Spectrum Access bands

Dynamic spectrum allocation and access network setup is a prerequisite for radio access network operation before providing services to terminals. The ASA-enabled NA shall initiate the dynamic spectrum allocation procedure to determine operating frequency.

##### [7.1.2.3.1[ Mutual authentication

Mutual authentication is used by ANC and CIS to provide strong security and protection before the AN provides authorized shared access.

##### [7.1.2.3.2] Dynamic spectrum allocation

Dynamic spectrum operation is controlled by ANC. ANC queries the CIS to get the channel usage information and determine the operating channel in the ASA spectrum for the radio system. If there is an available channel in the ASA spectrum, ANC would set up the NA to operate in that channel. Otherwise, if there is no available channel in the ASA spectrum, the ANC should not turn on the NA radio.

##### [7.1.2.3.3] AN initialization

AN initialization brings up an AN operating in a specified channel in the authorized shared access spectrum. When the AN is operating in an authorized shared channel with the primary user, it has to notify the CIS.

##### [7.1.2.3.4] AN shutdown

During operation in the authorized shared access spectrum, the ANC should continue monitoring or be notified of the status of shared access spectrum in CIS. If it detects information that the primary user of the ASA spectrum would like to operate in the channel that is being used by the NA, the ANC should disable services in the ASA channel and turn off the NA radio.

### Functional Requirements

#### Basic access network setup

The access network needs to establish the connections with the subscription services and the access routers using the configuration parameters provided by the NMS for the configuration of access networks including NA backhaul network.

#### Access network configuration

AN configuration is the provisioning of the AN with:

* Air Interface Identifier
* Service Network Identifier
* Service Identity or Session Identifier
* Security information
* Radio parameters
* Service parameters, such as QoS information

AN configuration is under the control of ANC. After the AN is powered up, the ANC communicates with the NMS of the access network to get the configuration information, and then provisions the AN.

#### [7.1.3.4.1] Operation on various channels

Unlicensed bands usually consist of multiple channels. The NA should be able to operate on any of the channels of the band for which the radio interface is designed.

The NA may be equipped with a radio interface allowing operation in multiple unlicensed bands. In this case, the channel selection procedure should be able to operate across all the supported bands and select the least occupied channel of all the supported bands.

#### [7.1.3.4.2] Multi-mode support

The NA should support all the different radio modes specified for compliance of its radio interface to allow for adaptation of operational parameters to the radio environment in the chosen channel. Such adaptation allows for more efficient use of the shared spectrum and benefits the performance of the whole system.

#### [7.1.2.4.1] Support for multiple access technologies

The dynamic spectrum allocation and access network setup procedure SHOULD be able to support different access network technologies.

#### [7.1.2.4.2] Support for multiple access networks

The dynamic spectrum allocation and access network setup procedure SHOULD be able to support an access network operating on the same or different channel of ASA spectrum from the neighboring ANs.

### Access network setup specific attributes

#### ???

###  Access network setup specific basic functions

####  [7.1.2.6] Basic functions for dynamic spectrum allocation and access network setup proce­dure for ASA bands

Dynamic spectrum allocation and access network setup and configuration describes the procedure for operating one or multiple NAs in an authorized spectrum environment shared with primary wireless devices. The procedure includes the following steps:

* CIS discovery and mutual authentication
* Querying for authorized shared spectrum information
* Configuration of the radio access network for operation in the authorized shared access spectrum

##### 7.1.2.6.1 ASA-CIS discovery and mutual authentication

CIS discovery and mutual authentication is the process through which an AN finds and authenticates the CIS used to store authorized shared spectrum usage information for a given area, before querying the CIS to get the information about authorized shared spectrum usage.

The ANC may be preconfigured with the IP address or URL of the CIS server.

When ANC is powered up, it may load the default shared spectrum list, and it shall automatically communicate with CIS using preconfigured CIS information. If ANC can not communicate with CIS server, radio operation in the shared spectrum is not allowed for the NAs.

The communication between ANC and CIS should follow the protocols specified by the R10 reference point.

Once ANC receives the response from CIS, it shall start the mutual authentication with the CIS to make sure that the CIS being communicated with is the correct one.

##### 7.1.2.6.2 Querying for authorized shared spectrum information

Querying for authorized shared spectrum information is the process by which information is acquired from CIS about authorized shared spectrum usage.

Before operating in authorized shared spectrum, the ANC needs to query the CIS to get information about authorized shared spectrum usage, using the protocols specified by the R10 reference point. Once it has received the usage status of authorized shared spectrum, the ANC can determine whether the AN can operate in a particular channel.

During operation in authorized shared spectrum, the ANC needs to constantly query the CIS to get usage status updates about the authorized shared spectrum.

##### 7.1.2.6.3 Operating in authorized shared spectrum

Operating in authorized shared spectrum involves enabling the radio transmission of AN and informing the surrounding TEs about the operating channel, transmit power, and other radio parameters.

Once the AN is operating in the authorized shared spectrum, the ANC is responsible for controlling the radio transmission of NAs and TEs in the operating channels to meet the authorized shared access regulations in the given area.

### Detailed procedures

#### Access Network Setup Procedure

The access network setup procedure includes

* Discovery of supported subscription services and access routers
* Establishing the connections with the subscription services and access routers

The discovery procedure for supported subscription services and access routers is used by the powered up AN to find the configuration parameters for access network setup. Once the associated NMS is found and provides the configuration parameter, the ANC sets up the access network with the configuration information retrieved from the NMS of the AN using either unlicensed spectrum or ASA spectrum.

Figure 18 shows an example of procedure of access network setup. When the access network is powered up, the ANC on behalf of NAs sends a Discovery Request message to the NMS which is a part of the access network. After receiving the Discovery Request message, the NMS sends the Discovery Response message with the access network information for the ANC to provision the access network.

NA

NMS

2. Discovery Request

ANC

3. Discovery Response

4. Join Request

5. Join Response

1. Access network power-up

Figure 19—An example of access network setup procedure

The Discovery Request message may contain the following information:

* ANC/NA Identifiers
* List of required configuration parameters
* Time stamp of this message
* Discovery type through which the AN retrieves the IP addresses of the connected subscription ser­vices and access routers, such as manual configuration, DNS server, etc.
* The capability information of physical NAs attached to the AN

The Discovery Response message should include the following information:

* Required configuration parameters
* ANC Identifier
* Time stamp
* Access Router Interface ID and IP addresses which help NAs to choose a proper port for the follow­ing communication
* Subscription Service Interface ID
* Radio configuration information for the required area
* Connection parameters to the subscription services and access router such as ports and addresses of the network and the load information of each port.
* Access network capabilities (e.g., max NA number, max user number), security information, etc.

The Join Request message should include the following information:

* ANC or NA Identifier
* The Access Network Identifier
* Time stamp of this message
* ANC or NAs location information. This helps the NMS to determine whether to accept the join request
* Access network capabilities, encryption information, etc.

The Join Response message should include the following:

* Access network Identifier
* ANC or NA Identifier
* Time stamp of this message
* Result code indicating whether the Join Request is admitted or not. If not, it lists the reason of the rejection.

#### Access Network Release Procedure

There are two ways to release the access network: access network is released by itself, or it is released by the access network operator through the NMS.

NA

NMS

ANC

2. Release Confirm

1. Release Indication

(a)

NA

NMS

ANC

2. Release Response

1. Release Request

(b)

Figure 20—an example of access network release procedure

Figure 19 shows an example of access network release procedure. The access network could be released by the ANC (Figure 19a), or by the access network through NMS (Figure 19b). In some particular cases, such as at certain abnormal conditions, the access network may have to initiate access network release under the control of ANC (Figure 19a). In such case, the ANC will notify the access network operator through the NMS that the access network will be shut down. Either the access network operator responds to the notification or the access network will release itself.

The Release Indication message may contain the following information:

* ANC/NA Identifier
* Access Network identifier
* Time stamp of this message
* Reason code for release

The Release Confirm message should include the following:

* Access Network Identifier
* ANC/NA Identifier
* Time stamp of this message
* Result code

In normal case, the access network release should be controlled by the access network operator through the NMS. When the access network operator needs to release the access network for maintenance, power saving, or major software/hardware upgrade, it may initiate the access network release through the NMS (Figure13b). When the ANC receives the Release Request message from the NMS, it will verify the command and start the access network release according to the requirements. The ANC will send the Release Response to the NMS about the result of access network release.

The Release Request message may contain the following information:

* Access Network identifier
* ANC
* NA Identifier
* Time stamp of this message

The Release Response message should include the following:

* ANC/NA Identifier
* Access Network Identifier
* Time stamp of this message
* Result code

#### [7.1.3.5.1] Discovery procedure

#### [7.1.2.7] Detailed procedures for operation in ASA bands

##### [7.1.2.7.1] AN setup

TE

NA

CIS

2. SA Registration Request

ANC

3. SA Registration Response

4. SA Information Request

5. SA Information Response

8. Configure IEEE 802 radio

Transmit Radio Signal

 1. Setup the control link and

Configure the backhaul connection

7. SA Use Response

6. SA Use Notification

Figure 16—An example of the procedure for IEEE 802 access network setup

1. When IP connection is established after boot-up, the NA should discover the URI of ANC through preconfigured information. NA may update its stored URI information to adapt the deployment change. The NA would then send an SA registration request message through the reference point R5 to the ANC to register with the ANC for shared access service operation over the authorized shared spectrum. The SA registration request is used to provide information about the NA to the ANC, including, for example, subscription and location information for ASA operation. The ANC may forward this SA registration request message to the CIS for authentication and authorization over the reference point R10 using an appropriate protocol.
2. The CIS authenticates the NA to determine operation on the shared spectrum. The CIS sends a response message to ANC about the authentication and authorization result. Then the ANC sends the SA registration response message to the NA upon receiving the response message from the CIS.
3. Once the registration for the shared access service succeeds, the NA can query the CIS, by sending an SA information request message to the ANC, to get shared spectrum usage information and sta­tus.
4. The ANC communicates with CIS over the reference point R10 to get shared spectrum usage infor­mation and status and sends it back to the NA.
5. Based on received shared spectrum information and status, the NA decides how to provide wireless services in the shared spectrum. If the NA will provide wireless access services in the shared spec­trum, it sends an SA usage notification message to the ANC for updating the shared spectrum usage status.
6. The ANC sends an acknowledgment message to the NA after it communicates the updated shared spectrum usage to CIS.
7. The NA can then turn on its radio transmission in the authorized shared spectrum to provide access services. The NA may provide radio configuration information used for the ASA spectrum to the TEs in the overhead message, in order to control the interference to the primary services.

##### [7.1.2.7.2] AN teardown

TE

NA

CIS

ANC

3. SA De-Registration Notification

7. Disable IEEE 802 radio

6. De-association

 1. Primary Service will be back to service

4. SA Use Notification

2. ANC queries (pushed by) CIS

5. SA Use Response

Figure 17—An example of the procedure for IEEE 802 network teardown

1. The primary service is back operating in the authorized shared spectrum and has notified CIS.
2. ANC gets the authorized shared spectrum usage status update information via either periodical query or registered notification service with CIS. If the ANC has registered a notification service with CIS, the CIS should receive the notification when the primary service status changes or when the period of time has expired for authorized use of shared spectrum.
3. When ANC receives the notification about authorized shared spectrum usage, it shall send the de-registration notification to the existing registered NAs operating in the authorized shared frequency channels, to force them to tear down existing services.
4. Once the NA receives the de-registration notification, it shall respond with a use notification to indi­cate it will shut down its radio service in the authorized shared frequency channels.
5. The ANC and CIS update the record in the database and notify the NA.
6. The NA then starts the procedure of de-association with TEs operating in the authorized shared fre­quency channels, or it immediate enters step 7).
7. NA disables its radio transmission.

##### [7.1.2.7.3] AN renewal



Figure 18—An example of the procedure for IEEE 802 network renewal

1. The NA is operating in the shared spectrum and sets up a timer to track the granted period of opera­tion.
2. When the shared spectrum use timer expires, the NA sends an SA registration message to the ANC, to renew the use of shared spectrum.
3. The ANC forwards the registration renewal message to CIS.
4. If no primary service will occupy the shared spectrum for the renewal period, the CIS will grant the renew request. Otherwise, it will reject the renewal request.
5. ANC forwards the CIS renewal response to the NA in the SA registration response message.
6. If the renewal request is granted, the NA will reset the timer for shared spectrum operation to the new granted period and continue operation in the shared spectrum.

### Mapping to IEEE 802 Technologies

#### Overview

#### IEEE 802.3 specifics

#### IEEE 802.11 specifics

#### IEEE 802.16 specifics

#### IEEE 802.22 specifics