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| Template Functional Design and Decomposition |
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Abstract

This document provides the text of access network setup procedure over for the unlicensed bands and shared access networks in Recommended Practice specification of IEEE 802.1CF.

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# Functional Decomposition and Design

## Access Network Setup

### Introduction and overview

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.

This

### Dynamic spectrum allocation and access network setup for ASA bands

#### Introduction

#### Roles and Identifiers

#### Use Cases

#### Functional Requirements

#### Detailed procedures

#### Mapping to IEEE 802 Technologies

### Dynamic spectrum allocation for unlicensed bands

#### 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.

#### Roles and Identifiers

##### Node of Attachment

NA is defined in section 6.5. 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. It may assist the NAs in their selection of spectrum bands and of operational modes to optimize the use of shared spectrum.

#### Use Cases

##### Channel Selection

Channel selection is part of radio configuration of NA for tuning in the receiver and transmitter to particular operating frequencies within unlicensed bands. As 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 same coverage area, such that the interference among devices is inevitable. In order to reduce the interference to each other in the unmanaged environment, the NAs should select during the 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 controller 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 the measurements and potentially further information and guidance from the neighbor NAs and the ANC the NA selects the channel with the most appropriate 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.

##### Channel Re-selection

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 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 re-selecting a better operating channel in the coverage area.

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 comprises a scanning function for discovery of potential NAs in the coverage area.

#### Functional Requirements

##### Operation on various channels

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

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.

##### 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.

#### Detailed Procedure

##### Discovery Procedure

>>>>more text required here<<<<

#### Mapping to IEEE 802 Technologies

##### Overview

##### IEEE 802.3 specifics

##### IEEE 802.11 specifics

##### IEEE 802.16 specifics

##### IEEE 802.22 specifics

### Dynamic access network instantiation

#### Introduction

A single IEEE 802 access network infrastructure can be shared among multiple operators by creation of virtual access networks for each of the operators. Effectively some or all functions in the access network can be established by multiple instances on the same hardware, e.g. Virtual LANs in bridges or virtual Access Points on IEEE 802.11 hardware.

#### Roles and Identifiers

##### Node of Attachment

NA is defined in section 6.5. NAs may consist of a single radio interface allowing the instantiation of multiple virtual NAs on the same device. While some of the attributes may be common to all the initiated NAs, each of the initiated NA represents an own identity with its own interface identifiers and own network identifiers.

##### Access Network

AN is defined in section 6.5. In a virtualized environment with the possibility for virtualized NAs, the whole AN can be modeled as a logical entity. The model allows to create multiple instances of AN on a single hardware infrastructure, each of the AN instances with its own identifiers, its own ANC and its own interfaces towards subscription services and access routers.

#### Use Cases

##### Access network infrastructure sharing

In high dense deployment scenarios, like shopping malls, airports, stations or office buildings, often multiple ANs are installed to serve the various needs for public, corporate and offloading usage. Coverage areas of these particular ANs are widely overlapping which creates challenges due to interference and congestion in the shared radio resource. To make the operational challenges manageable and to reduce installation and operation cost, service providers might consider sharing the access networks, which means that a single infrastructure creates multiple virtual ANs for each of the service provider, with dedicated connections to the service provider’s subscription service and access router. The virtualized AN approach is different to a roaming scenario by each service provider having full access to their portion of the access network infrastructure. Before operating such a virtualized AN, the AN has to be instantiated by configuration of the virtual NAs and related backhaul connectivity

#### Functional Requirements

##### Creation of multiple networking entities

The access network infrastructure requires an orchestrator with the possibility to create multiple instances of the ANC, the NAs and the backhaul and bind them together to a virtual AN with a virtual ANC instance, that allows the control and operation of the instantiated entities like have dedicated hardware for each of it. The orchestrator has not only to create the virtual networking instances but also to establish the connections between the networking functions to establish a virtual AN. In addition the orchestrator has to set up the connectivity between the virtual AN and its subscription services and access routers.

##### Virtual AN Configuration

AN configuration is the provisioning of the AN with:

* Network Identity
* Service Identity or Session Identity
* Security information
* Radio parameters.
* Service parameters, such as QoS information

AN configuration is performed through an orchestrator within the ANC. Configuration parameters for the virtual ANs should be queried from the service providers operating the subscription service and the access router.

In the case of multiple instances of AN on an infrastructure shared by multiple service providers, each service provider may provide its own configuration parameters. The virtualized ANs on a shared infrastructure might provide the same radio coverage out of each of the virtualized ANs.

##### Multiple Service Provider support

An virtualized AN may be interconnected dynamically to one or more subscription services and to one or more access routers. Therefore the AN SHOULD be able to provide a sharing mechanism amongst different subscription services and access routers.

* The virtualized ANs SHOULD be capable to discover and join multiple subscription services and multiple access routers, to which connectivity exists.
* The virtualized ANs SHOULD be capable to share with more than one subscription service and access router.
* The virtualized ANs SHOULD maintain different access network identifier associated with the various subscription services and access routers.
* The virtualized ANs SHOULD provide fair radio resource sharing among terminals belonging to different ANs.
* The virtualized ANs SHOULD be capable to be configured and controlled via the ANC by the service provider.
* The virtualized backhaul SHOULD be able to forward the user packets to the service providers’ access routers, to which the user are subscribed to.

#### Detailed Procedure

##### Discovery Procedure



The Service Provider should send Discovery Request Message to the AN Orchestrator. The message may be distributed to a list of AN orchestrators either by multicast addressing or by replicating the message and sending it per unicast to each of the AN Orchestrators.

The message should include the following information:

* Service Provider Identity
* Subscription Service Interface ID and Identity
* Access Router Interface ID and Identity
* Timestamp
* List of attributes to specify the requirements for the virtual AN

When the AN Orchestrator receives the Discovery Request, it should send a Discovery Response Message to the Service Provider with the following information:

* AN Orchestrator Identity
* Timestamp of related request message
* List of NAs in the requested service area with geographic location, coverage area and base radio parameters
* Backhaul capabilities to the Service Provider’s subscription service and access router
* Operational possibilities and limitations of a virtual AN created based on Service Providers requirements
* Cost information

##### CreateAN Procedure

According to the Discovery Response Messages from different AN Orchestrators, the Service Provider can choose one or multiple AN Orchestrators initiate the CreateAN procedure.



The CreateAN Request Message should include the following information:

* Service Provider Identity
* Subscription Service Interface ID and Identity
* Access Router Interface ID and Identity
* Timestamp
* List of NAs for the requested service area with desired base radio parameters
* Backhaul parameters to the Service Provider’s subscription service and access router
* Operational capabilities of the virtual AN

The AN Orchestrator receiving the CreateAN Request should determine whether to accept the CreateAN Request according the requirements in the message and other information such as access network infrastructure load, etc.

The AN Orchestrator should return a CreateAN Response message to the Service Provider to inform about the result of the evaluation and eventually about the newly instantiated AN. The CreateAN Response message should include the following information:

* AN Orchestrator Identity
* Timestamp of related Request message
* Result code and reason

and if successful:

* AN Identifier
* Subscription Service Interface ID and Identity
* Access Router Interface ID and Identity
* List of NAs for the requested service area with desired base radio parameters
* Backhaul parameters to the Service Provider’s subscription service and access router
* Operational capabilities of the virtual AN

##### DisposeAN Procedure

When a Service Provider wants to disband a virtualized AN, it requests the AN Orchestrator to dispose the virtual AN.



The DisposeAN Request message provides the following information:

* Service Provider Identity
* AN Orchestrator Identity
* Subscription Service Interface ID and Identity
* Access Router Interface ID and Identity
* Timestamp
* AN Identifier

When receiving a DisposeAN Request message the AN Orchestrator evaluates the message and verifies that the request matches completely with an instance of a virtualized AN. Only when complete match is determined the AN Orchestrator will dispose the reference AN and respond with a success to the Service Provider. Otherwise the DisposeAN Response contains Result=FAIL and a reason code. The DisposeAN Response message should include the following information:

* AN Orchestrator Identity
* Service Provider Identity
* Timestamp of related Request message
* Result code and reason

##### AN Configuration Update Procedure

After successful instantiation of a virtual AN, the operation of the AN can commence following the functional behavior and messaging described in the following chapters.



During operation of the virtual AN the Service Provider can request modifications to the set-up of the virtual AN. Only when the modifications do not collide with the operation of other virtual ANs of the same access network infrastructure, the AN Orchestrator will change the configuration parameters of the AN according to the wishes of the Service Provider.

Otherwise the AN Orchestrator will respond with an alternative proposal to best match the required modifications.

#### Mapping to IEEE 802 Technologies

##### Overview

##### IEEE 802.3 specifics

##### IEEE 802.11 specifics

##### IEEE 802.16 specifics

##### IEEE 802.22 specifics