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| Updated Text for Dynamic Spectrum Allocation and AN Setup Procedure in IEEE 802.1CF |
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Abstract

This document is to update the proposal of omniran-14-0078-00 about the dynamic spectrum allocation and the access network setup procedure in Recommended Practice specification of IEEE 802.1CF based on the latest omniRAN Network Reference Model. The procedure of dynamic spectrum allocation and access network set up could be used in IEEE 802 based technologies like WLAN over un-licensed spectrum or authorized shared access frequency band (TV white space). It could be used for co-existence of IEEE 802 based technologies with LTE operating on unlicensed band (LTE-U) as well.

IEEE 802 Dynamic Spectrum Allocation and Access Network Setup Procedure

1. **Introduction and Scope**
2. **Abbreviations, Acronyms, Definitions, and Conventions**

AN: Access Network

ANC: Access Network controller

ASA: Authorized Shared Access

CIS: Coordination and Information Service

CN: Core Network

CNC: Core Network Controller

CNI: Core Network Interface

LSA: Licensed Shared Access.

NA: Node of Attachment

SA: Shared Access

SS: Subscription Service

TE: Terminal

TEC: Terminal Controller

TEI: Terminal Interface

1. **References**

[1] IEEE 802.19.1 D3.06 Draft Standard for TV White Space Coexistence Methods

[2] IEEE 802.19

[3] IETF draft-ietf-paws-protocol-12 Protocol to Access White-Space (PAWS) Databases

[4] IEEE 802.1 omniran-15-0003-01-CF00-nrm-ambiguities

1. Network Reference Model
	1. IEEE 802 Network Reference Model

FIG 1. IEEE 802 based network reference model

FIG.1 shows basic Network Reference Model (NRM), which contains logic entities and interfaces for IEEE802 based technologies. Each logic entity is defined according to its functional roles in NRM and contains interface to other logic entities.

IEEE 802 based NRM consists of four main logic network entities:

* **Terminal (TE)**, which includes
	+ Terminal Interface (TEI): providing radio link connection to the access network
	+ Terminal Controller (TEC): controlling the TEI operating on radio frequency channel to provide air link connection.
* **Access Network (AN)**, which includes
	+ Node of Attachment (NA)
	+ Backhaul (BH)
	+ Access Network Controller (ANC)
* **Coordination and Information Service (CIS)**
	+ CIS is a database used to store the information of authorized shared access.
* **Core Network (CN)** operated by operator(s) to provide internet connection and other data service for the end users. CN consists of
	+ Core Network Interface (CNI): provides the data path connectivity of TE to reach the CN and Internet.
	+ Core Network Controller (CNC): controls the operation of CNI for data path establishment, teardown, or relocation. CNC also interfaces to Subscription Service (SS) to get subscriber’s information for the user authentication, authorization and data path establishment.
	+ Subscription Service (SS): stores the information of subscribers and provides the authentication and authorization of subscribers.

A reference point is a logic interface between two logic entities which contains a set of communication protocols used for the information exchange between two logic entities. The IEEE 802 access network reference model contains a couple of reference points.

1. **R1**: represents the radio access interface between Terminal (TE) and Access network (AN) (i.e. the NA of AN) related to IEEE802 technologies over the authorized shared spectrum or unlicensed spectrum.
2. **R2**: represents the interface between TE and Subscription Service (SS) entity in the Core Networks through the radio access connection. This logic interface contains protocols above transport layer across different network entities and is used to exchange information for authentication, authorization and accounting.
3. **R3**: represents the interface of AN to one or multiple Core Networks (CNs) through backhaul network such as Software Defined Network (SDN). R3 interface contains two independent planes: data plane and control plane:
* R3d: represents the data plan interface which consists of a set of data transmission protocols that are used for packet data communication such as user data traffic encapsulation, sequencing, encryption, tunneling, forwarding amongst the CN and NA.
* R3c: represents the control plane interface between ANC and CNC which consists of a set of control plane protocols used for implementing the control functions of individual service including user traffic connection setup, switching and teardown.
* R3s: represents the subscription plane interface between Access Network Controller (ANC) and the Subscription Service (SS). It consists of a set of protocols for ANC to acquire the information of subscribers from the subscription service database.
1. **R6c**: represents the internal interface between NA and ANC, which is used to provision and control the NA’s operation in the unlicensed spectrum or in the authorized shared spectrum by the ANC. R6c contains a set of protocols to control NA setup, initialization and teardown in the authorized shared access spectrum.
2. **R7c**: represents the internal interface between ANC and BH within the access network. R7c contains a set of protocol set to provision and control the BH’s forwarding functions.
3. **R8c**: represents the interface between ANC and TEC. It consists of a set of protocols for communication between ANC and TEC which is used for ANC to control the TE’s operation.
4. **R9c**: represents the external interface between ANC and CIS which is used for the ANC to query the Authorized Shared Access information on particular location and receive the instruction from the CIS. In some implementation, R9c could be an external interface between CNC and CIS.
	1. Network Reference Model for Operating on Unlicensed Band

FIG 2. IEEE 802 based network reference model in unlicensed band

The network reference model for operation on un-licensed band is similar to the basic network reference model without CIS entity and associated reference point R9c.

* 1. Reference Points and Specifications Mapping

The mapping of reference points with other specifications is shown in Table 1.

Table 1. Mapping of Reference Point to Interfaces of other Specifications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reference Point** | **802.11** | **802.16** | **802.19.1** | **IETF** |
| R1 | IEEE802.11 | IEEE802.16 |  |  |
| R2 |  |  |  |  |
| R3c |  |  |  |  |
| R3d |  |  |  |  |
| R3s |  |  |  | RADIUS |
| R4 |  |  |  |  |
| R5 |  |  |  |  |
| R6c |  |  | Interface A | CAPWAP |
| R7c |  |  |  |  |
| R8c | ANQP, IEEE802.11IEEE802.1x |  |  |  |
| R9c |  |  | Interface C | PAWS |

* 1. Network Entities Operating on ASA Band

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

According to FCC regulation, the Authorized Shared Access (ASA) spectrum is mainly allocated for the primary users to provide radio services. Only when the primary users are not providing radio services, the secondary users may allow occupying the ASA spectrum and provide radio access services to their customers.

In order to get the operation information of primary service over the ASA spectrum, the ANC in IEEE802 NRM needs to communicate with (ASA) CIS first, and to get authorization before AN (and/or TE) can turn on its radio transmission on authorized shared frequency.

* + 1. ASA Terminal (TE)

IEEE 802 radio access network contains one or more terminals (TE), which provides radio connection for the end user to access the service in Core Network. An ASA TE is operating in the authorized frequency channel(s) such as TV white space, which is shared with primary services over the same authorized spectrum.

* + 1. ASA Access Network (AN)

IEEE 802 ASA Access Network contains one or more ASA Nodes of Attachment (NA). In some specification, the NA also called the Master Device. An NA provides radio access connectivity to the IEEE 802 ASA TEs (or called Slave Devices) in the authorized license frequency channel(s), which is shared with primary services over this authorized spectrum. An ASA NA could be controlled and managed by single network control entity (ANC), and also represents the entity to interface to the backhaul and to perform the data forwarding function between TE and BH.

* + 1. ASA Access Network Controller (ANC)

The authorized shared access network controller (ANC) is a logic entity in the IEEE 802 ASA AN, which is used to manage and control operations of NAs, such as setup, provisioning, and/or tear-down over the authorized spectrum shared with primary services. The ANC also control operations of TEs over the authorized shared spectrum through the reference point R8c.

The ANC may support following but not limited to functions for co-existence with primary servers and/or other services over the authorized shared spectrum.

1. Co-existence management: it is responsible to control enabling NA to co-exist with primary wireless device in the authorized shared spectrum.
2. Co-existence discovery and information (local) server is used to store the co-existence information used for determining co-existence of NAs operating in the authorized spectrum shared with primary wireless services.
	* + 1. R6c for ASA

The ASA ANC communicates with one or more IEEE 802 based NAs through the reference point (R6c) for NA’s authentication, authorization and provisioning. In IEEE 802.19.1, the ANC communicates with IEEE 802 ASA NAs through the element called Co-existence Enabler (CE) that represents one or more IEEE 802 based NAs in the co-existence system.

* + - 1. R7c for ASA

The ASA ANC uses the reference point (R7c) to communicate with BH entities to provision the forwarding functions of BH.

* + - 1. R8c for ASA

The ASA ANC uses R8c to communicate with TEC to control the operation of TE.

* + - 1. R9c for ASA

R9c provides the interface to CIS. In one implementation, the ANC communicates with the shared access coordination and information service (CIS) through the reference point R9c to get the shared operation information and determine whether the NA could be turned on to share with the primary services over the shared spectrum in the same goe-location.

In some implementation, the CIS is connected through the CN. In such implementation, if the ANC needs to get the ASA information, it has to go through the CNC to query and receive the dedicated information about ASA.

* + 1. ASA Coordination and Information Service (CIS)

CIS (or called Listing Database in some specification) is a logic entity in the IEEE 802 based authorized shared access network reference model to provide storage of the information used for the access services over 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

1. authorized shared frequency band and channels information
2. shared access spectrum geo-location information
3. allowed maximum transmit power in the authorized shared access spectrum
4. primary service provider and secondary service providers and their operating status
5. potential neighboring services and their interference levels

CIS could be accessed through the reference point R9c directly or indirectly over CN. The authorized shared access information may have a local copy in the local memory and is periodically synchronized with CIS.

CIS is only used for shared access with primary services in the authorized spectrum.

1. **Roles and Identifiers**
	1. Terminal
	2. Access Network
		1. Access Network Controller
		2. Node of Attachment
		3. Backhaul Network
	3. Core Network
		1. Subscription Service
		2. Core Networking Control
		3. Core Network Interface
	4. Coordination and Information Service
		1. CIS
2. **Use Cases**

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

* 1. Mutual authentication

The mutual authentication is used for ANC and CIS to mutual authenticate each other to provide strong security and protection before AN provides the authorized shared access.

* 1. Dynamic spectrum allocation

The dynamic spectrum operation is controlled by ANC. ANC queries the CIS to get the channel usage information, and determine the operating channel for WLAN in the ASA spectrum. If there is an available channel in ASA spectrum, ANC would setup NA operating on that channel. Otherwise, if there is no available channel in ASA spectrum, the ANC should not turn on the radio of NA.

* 1. AN Initialization

AN initialization is to bring up AN operating on the given channel in the authorized share access spectrum. When the AN is operating on the authorized shared channel with primary user, it has to notify the CIS.

* 1. AN Shut-down

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

1. **Functional Requirements**

The following requirements apply to dynamic spectrum allocation and access network setup procedure.

* 1. Support for multiple access technologies

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

* 1. Support for multiple access networks

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

1. **Dynamic Spectrum Allocation and AN Setup Functions**

The dynamic spectrum allocation and access network setup/configuration is to provide the procedure of operating one or multiple NAs in the authorized spectrum environment shared with primary wireless devices. The procedure includes following steps

* CIS discovery and mutual authentication
* Query the authorized shared spectrum information
* Configuration of radio access network to operate on the authorized shared access spectrum.

* 1. CIS discovery and mutual authentication

CIS discovery and mutual authentication is the process of AN to find and authenticate the CIS which is used to store the authorized shared spectrum usage information at given area, before querying the CIS to get the information about authorized shared spectrum usage.

The ANC may be pre-configured with IP address, or URL of CIS server. When ANC is powered up, it shall automatically communicate with CIS using pre-configured CIS information. If ANC could not be able to communicate with CIS server, it needs to report the failure in MMI.

The communication between ANC and CIS shall follow the protocols specified by R9c 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 right one.

* 1. Query the authorized shared spectrum information

Query of authorized shared spectrum information is the process to acquire the information about the authorized shared spectrum usage status stored in CIS.

Before operating on the authorized shared spectrum, ANC (or through CNC) needs to query the CIS to get the information about authorized shared spectrum usage status using the protocols specified by the R9c reference point. Once receiving the usage status of authorized shared spectrum, the ANC can determine whether the AN could be able to operate on a particular channel of the authorized shared spectrum.

During the operation on the authorized shared spectrum, the ANC needs to constantly get the usage status update about the authorized shared spectrum via querying the CIS.

* 1. Operating in authorized shared spectrum

Operating in the authorized shared spectrum is the process of enabling the radio transmission of AN and informing the surrounding TEs the operation channel, transmit power and other radio parameters.

Once the AN is operating on the authorized shared spectrum, the ANC is responsible to control the radio transmission of NAs and TEs over the operating channels to meet the authorized shared access regulation on the given area.

1. **Detailed Procedure**
	1. AN setup

FIG 3 An example of the procedure of IEEE 802 based access network setup.

1. The IEEE 802 based NA establishes the backhaul IP connection using the control plane protocols to communicate to the ANC. After the IP connection is established, the NA and ANC can exchange the information through the interface of backhaul.
2. Once IP connection is established, the NA should discover the URI of ANC through pre-configured information. NA may update its stored URI information to adapt the deployment change. The NA would send a SA registration request message through the reference point R6c to the ANC to register with the ANC for the shared access service operation over the authorized shared spectrum. The SA registration request is used to provide the ANC the information about NA such as subscription information 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 R9c using a protocol such as PAWS.
3. The CIS authenticates the NA to determine operation on the shared spectrum. The CIS sends the 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.
4. Once the registration for the shared access service succeeds, the NA can query the CIS via sending the SA information request message to ANC to get the status of the shared spectrum usage information and status.
5. The ANC communicates with CIS over the reference point R9c to get the shared spectrum information and usage status and sends back the NA.
6. Based on received shared spectrum information and status, the NA decides how to operate the wireless services over the shared spectrum. If NA would operate the wireless access services over the shared spectrum, it sends the SA usage notification message to the ANC for updating the shared spectrum usage status.
7. The ANC sends an acknowledgement message to the NA after it communicates and updates the shared spectrum usage in CIS.
8. The NA can now turn on its radio transmission on the authorized shared spectrum to provide access services. 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.
	1. AN Teardown

FIG 4 An example of the procedure of IEEE 802 based access network tear-down.

1. The primary service would be back over the authorized shared spectrum and notifies with CIS.
2. ANC gets the authorized shared spectrum usage status update information either via periodical query or registered notification service with CIS.
3. When ANC receives the notification about authorized shared spectrum usage notification, it shall send the re-registration notification to the existing registered NAs operating on 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 Use Notification to indicate to shut-down the radio service over the authorized shared frequency channels.
5. The ANC and CIS updates the record in the data base and notify the NA.
6. NA may start the procedure of de-association with TEs operating on the authorized shared frequency channels, or immediate enter step 7).
7. NA disables its radio transmission
	1. Network Protocol Stacks

FIG 5. IEEE 802 based authorized shared access protocol stacks

FIG 5 shows an example of protocol stacks of control plane for control of authorized shared access network.

1. The reference point R9c defines a set of protocols (such as IETF-PAWS) over the IP/UDP layer for ANC to communicate with CIS.
2. The reference point R6c between ANC and NA defines a set of protocols for ANC to configure and control NAs according to information received over R9c, such as the protocols refereed as Interface A in IEEE 802.19.1. The extended protocol such as CAPWAP might be used for ANC to configure and control the operation of NAs as well.
3. The reference point R8c contains protocols (such as IEEE 802.11 ANQP) on the top of IEEE 802 data link layer used by NA to broadcast the ASA radio configuration information to TEs. The NA could also use the reference point R8c to control the transmissions from TEs