ETSI TR 103 494 V1.1.1 (2018-01)

Broadband Radio Access Networks (BRAN); Study of central coordination of WAS/RLANs operating in the 5 GHz frequency band

Reference

DTR/BRAN-60022

Keywords

broadband, control, protocol

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Broadband Radio Access Networks (BRAN).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

Developing technologies for 5G Broadband Systems is one of the objectives of the European Commission. The EC H2020 project COHERENT [i.14], "Coordinated Control and Spectrum Management for 5G Heterogeneous Radio Access Networks" has addressed topics related to the application of the basic principles of wired Software - Defined Networks (SDN) to wireless networks.

The present document includes the main outcome of the project and the results of additional studies.

The present document does not address any regulatory issues and does not address mandatory requirements such as those related to article 3.2 of Directive 2014/53/EU [i.13].

Some results incorporated in the present document received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 671639.

1 Scope

The present document contains studies of the architectures and the protocols supporting the central coordination of WAS including RLANs (WAS/RLAN) operating in the 5 GHz bandIt also includes information provided by a radio node/network of radio nodes and the procedures for the coordination of the operation of these nodes.

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] Alexandros Kostopoulos, George Agapiou, Deng Junquan, Dorin Panaitopol, Fang-Chun Kuo (Editor-in-Chief), Kostas Katsalis, Navid Nikaein, Mariana Goldhamer, Tao Chen, Rebecca Steinert, Roberto Riggio: "System Architecture and Abstractions for Mobile Networks", EU H2020 5G-PPP COHERENT Project Deliverable D2.2, July 2016.

NOTE: Available online at http://www.ict-coherent.eu/.

[i.2] Nguyen et al.: "SDN and virtualisation-based LTE mobile network architectures: A comprehensive survey", Wireless Personal Communications, vol. 86, no. 3, pp. 1401-1438, 2016.

[i.3] F. Ahmed et al.: "Distributed Graph Coloring for Self-Organization in LTE Networks", Journal of Electrical and Computer Engineering, 2010.

[i.4] P. Cardieri: "Modeling interference in wireless ad hoc networks", IEEE Communication Surveys & Tutorials, vol. 12, no. 4, p. 551-572, 2010.

[i.5] Ericsson Technical White paper: "5G systems - enabling industry and society transformation", 2015.

[i.6] 5G White Paper, white paper, NGMN Alliance, 2015.

[i.7] Antti Anttonen (Editor-in-Chief), Tao Chen, Tapio Suihko, Aarne Mämmelä, Sundar Daniel Peethala, Nidal Zarifeh, Furqan Ahmed, Junquan Deng, Ragnar Frej-Hollanti, Sergio Lembo, Olav Tirkkonen, Antonio Cipriano, Dorin Panaitopol, Per Kreguer, Akhila Rao, Rebecca Steinert, Chia-Yu Chang, Roberto Riggio, Shah Nawaz Khan, Mariana Goldhamer, Pawel Kryszkiewicz, Fang-Chun Kuo, George Agapiou, Dimitri Marandin, Yi Yu: "First report on physical and MAC layer modelling and abstraction", EU H2020 5G-PPP COHERENT Project Deliverable D3.1, June 2016.

NOTE: Available online at http://www.ict-coherent.eu/.

[i.8] IEEE 802.11™-2012: "IEEE standard for Information Technology, Local and metropolitan area networks, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[i.9] 3GPP TS 36.213 (V14.0.0) (2016-09): "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 14)".

[i.10] ETSI TS 136 331 (V14.3.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (3GPP TS 36.331 version 14.3.0 Release 14)".

[i.11] ETSI TS 136 214 (V14.2.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements (3GPP TS 36.214 version 14.2.0 Release 14)".

[i.12] 3GPP TS 36.423 (V14.0.0) (2016-09): "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 application protocol (X2AP) (Release 14)".

[i.13] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC Text with EEA relevance.

[i.14] ICT-COHERENT.

NOTE: Available at http://www.ict-coherent.eu/.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

arc: in digraph, an ordered pair of vertices is called a directed edge or an **arc**

Central Controller and Coordinator (C3): C3 is a logically centralized entity in charge of network-wide control and coordination among entities in WAS/RLAN based on Centralized Network View (CNV)

NOTE: C3 could be implemented with physical control instances sharing network information with each other.

channel assignment: process which determines one or more frequency blocks (channels) for radio nodes

NOTE: Coexistence decision can be made when determining the channel(s) for radio nodes.

Control Plane Function: function which controls the operation of the system through appropriate messages

Control Vertex: vertex in a (di)graph which represents a C3 instance

digraph: graph which consists of a set of vertices connected by edges, where the edges have a direction associated with them

directed path: digraph, a directed path is a sequence of arcs which connect a sequence of vertices, with the restriction that all arcs in the path are directed in the same direction

dissimilar WAS/RLANs: dissimilar WAS/RLANs are WAS/RLANs that use different RATs without the same/common wireless network coexistence technologies

graph: set of vertices connected by edges

head: arc (v_i,v_j) is considered to be directed from vertex v_i to vertex v_j, v_j is called the **head** of the arc

hierarchical control: control architecture based on a central controller which coordinates the operation of other controllers

network slice instance: run-time instantiation of a Network Slice

network slice or service slice: network slice/service slice is a logical network that comprises a set of network functions and the corresponding resources required to provide **End-to-End** support for specific network services, network applications and radio configurations of WAS/RLAN

NOTE: The network services may be specific to some particular use cases or business applications. A network slice can span all domains of the network: software programs running on cloud nodes, specific configurations of the transport network, a dedicated radio access configuration, as well as settings of the WAS/RLAN devices. Different network slices contain different network applications and configuration settings.

Network View (**NV**)**:** database containing information specific to the network operation

NOTE: A Local NV includes parameters available at a local radio entity while a Central NV includes parameters available at a central controller/coordinator which are provided or resulting from the LNV.

Northbound interface (NBi): API transferring information and controls between a program running additional control application and a Controller

path: in a graph is a finite or infinite sequence of edges which connect a sequence of vertices which, by most definitions, are all distinct from one another

programmable control: function of the controller platform transferring the information from the SBi to the NBi and enabling a programmer to write control applications on top of the controller

Radio Access Network: radio access network (RAN) is part of a public land mobile telecommunication system controlled by an Operator

Radio Local Area Network (RLAN): intended to cover smaller geographic areas like homes, offices and to a certain extent buildings being adjacent to each other

NOTE: Radio LANs are also known as Wireless LANs (WLANs).

Radio Transceiver (RT): logical entity that provides radio access with full WAS/RLAN node functions

NOTE: RT can be realized by either of the combinations of R-TP, vRP and/or RTC. A set of RTs forms a radio access network (RAN/WAS) which is coordinated and controlled by C3. Some implementation examples of RTs include LTE eNBs in cellular networks or WiFi APs in the WLANs. An RT could be composed by one vRP (virtual device) and one or more R-TPs (physical devices). For example, in the Cloud-RAN (C-RAN) architecture the R-TP coincides with the RRH, while the vRP coincides with the BBU Pool. However, several other functional splits can be considered.

Radio Transmission Point (R-TP): physical entity implementing full or partial WAS/RLAN node functions while the rest of functions are offloaded to and handled by the vRP

NOTE: An R-TP may include control plane functions.

Real-Time Controller (RTC): logical entity in charge of local or region-wide control, targeting at low latency control operations such as, for example, MAC scheduling. RTC maintains the Local Network View (LNV)

NOTE: RTC can run on one RT or on a virtualized platform.

residency duration: represents the total time for a moving node to reside within the service area of a certain C3

service plane: collection of network applications and configurations of WAS/RLAN systems designed to deliver services that satisfy the needs of system users

similar WAS/RLANs: WAS/RLANs that use the same RAT or different RATs with the same/common wireless network coexistence technologies

Southbound interface (SBi): API transferring information and controls between network entities and a Controller

spectrum: within the present document the word "spectrum" indicates a combination of time-frequency resources

tail: arc (v_i,v_j) is considered to be directed from vertex v_i to vertex v_j, v_i is called the **tail** of the arc

Transport Node (TN): logical entity that is located between RTs and the core network (CN)

NOTE: A set of TNs forms a backhaul/fronthaul network whose data plane can be configured by C3. A network switch is one of the implementation examples of TN.

Virtual Radio Processing (vRP): logical entity comprising a computing platform allowing for centralized processing of full or partial RAN node functions (including the user plane and the control plane) offloaded from one R-TP or multiple R-TPs

NOTE: A vRP includes control plane functions.

weight: one value or a set of values, assigned as a label to a vertex or edge (arc) of a graph (digraph)

weighted graph: graph whose vertices or edges have been assigned weights; more specifically, a vertex-weighted graph has weights on its vertices and an edge-weighted graph has weights on its edges

weighted digraph: digraph whose vertices or arcs have been assigned with weights

Wireless Access System (WAS): defined as end-user radio connections to public or private networks. In the present document WAS and RAN are interchangeably used

NOTE: Both RAN and WAS can include RLANs

3.2 Symbols

For the purposes of the present document, the following symbols apply:

(*)	ordered sequence
{*}	unordered sequence
$\in$	is a member of
$\cup$	union
$\cap$	intersection
\	the difference of two sets
α	pathloss exponent
$a=(v_i,v_j)$	the arc a that connects an ordered pair of vertices v_i and v_j
A(G)	the arc set of a digraph G
CH_i	the i-th channel
CI_i	the i-th C3 instance
d_{ij}	the distance between the i-th and the j-th node
$D(p_1, p_2)$	the distance between two points p_1 and p_2
$e=v_iv_j$	an edge e that connects vertices v_i and v_j
E(G)	the edge set of a graph G
$\mathcal{F}$	failed spectrum usage event
G=(V,E)	a graph G that consists of a pair of vertex set V and edge set E
$I_{(tail, head)}$	interference level from tail vertex to head vertex
$I_{(vi,vj)}$	interference from vertex v_i to vertex v_j
L_i	a selection priority level of C3 instance CI_i determined by the amount of estimated available spectrum for the moving node from CI_i
L_{iPk}	distance from the i-th node to the reference point P_k
$N_{\mathcal{F}}$	number of failed spectrum usage event
$N_{\mathcal{S}}$	number of successful spectrum usage event
$N_{\mathcal{U}}$	number of spectrum usage event
$P(v_s,v_e)=(v_s,v_i,v_j,v_e)$	a path from start vertex v_s to end vertex v_e, which consists of a sequence of vertices v_s,v_i,v_j,v_e and the edges between adjacent vertices along the sequence
P_k	index of the reference point
P_{max}	transmit power of each node
$\mathcal{S}$	successful spectrum usage event
$SINR_{th}$	signal to interference plus noise ratio threshold
T_i^a	an estimated arrival time for a certain moving node to enter the serving area of C3 instance CI
T_i^r	an estimated residency duration for a certain moving node within serving area of C3 instance CI_i
T_i^{th}	a threshold of time duration for successful spectrum usage on channel CH_i

$T_{WinStart}$	a start time of estimation window
$T_{WinStop}$	a stop time of estimation window
u	spectrum usage event
v	the vertex v
V(G)	the vertex set of a graph G
W_{ij}	weight of the arch between the i-th and the j-th node

3.3 Abbreviations

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

3GPP	Third Generation Partnership Project
5G	5th Generation Mobile Networks
AC	Access Category
ANDSF	Access Network Discovery and Selection Function
AP	Access Point
AP	Access Point
API	Application Programming Interface
APSD	Automatic Power Save Delivery
AWGN	Additive White Gaussian Noise
BBU	Baseband Unit
BS	Base Station
BSS	Basic Service Set

NOTE: As used in [i.8].

C3	Central Controller and Coordinator
CDF	Cumulative Distribution Function
CM	Coordination Manager
CN	Core Network
CNV	Centralized Network View
COE	Coordination Enabler
CQI	Channel Quality Indicator
C-RAN	Cloud Radio Access Network
CSI	Channel State Information
CW	Contention Window
DL	Downlink
DSCP	Differentiated Services Coding Point
eNB	Evolved Node B
eNodeB	Evolved Node B
EU	European Union
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GPS	Global Positioning System
HO	Hand-Over
IE	Information Element
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IP	Internet Protocol
LAA	Licensed-Assisted Access
LAN	Local Area Network
LBT	Listen Before Talk
LNV	Local Network View
LTE	Long-Term Evolution
MAC	Media Access Control
MCS	Modulation and Coding Schemes
MIB	Management Information Base
MLME	MAC subLayer Management Entity
NaaS	Network as a Service
NBi	Northbound Interface
NGMN	Next Generation Mobile Networks Alliance
NR	New Radio (3GPP name for 5G technology)

OAM	Operations and Management
PDU	Protocol Data Unit
PHY	Physical Layer
QCI	QoS Class Identifier
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology
RLAN	Radio Local Area Network
RRH	Remote Radio Head
RS	Reference Signal
RSSI	Received Signal Strength Indicator
RT	Radio Transceiver
RTC	Real-Time Controller
R-TP	Radio Transmission Point
SAP	Service Access Point
SBi	Southbound Interface
SDN	Software Defined Network
SINR	Signal to Interference and Noise Ratio
SME	Station Management Entity
SNIR	Signal to Noise plus Interference Ratio
SNMP	Simple Network Management Protocol
SNV	Slice-Specific Network View
SSID	Service Set IDentifier
STA	Station
TN	Transport Node
TP	Transmission Point
TS	Technical Standard
UE	User Equipment
UL	Uplink
UP	User Plane
vRP	Virtual Radio Processing
WAS	Wireless Access System
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network
WNM	Wireless Network Management
WT	WLAN Termination

4 Use cases of central control/coordination of WAS/RLAN in 5 GHz bands

4.1 Use case 1: Coexistence management between coordinated and uncoordinated WAS/RLANs

Coordinated and un-coordinated WAS/RLANs are shown in Figure 4.1, where Operator A manages its network operation (i.e. coordinated WAS/RLAN) on 5 GHz band (e.g. LAA-LTE) while private WLAN access point operates nearby (i.e. uncoordinated WAS/RLAN).

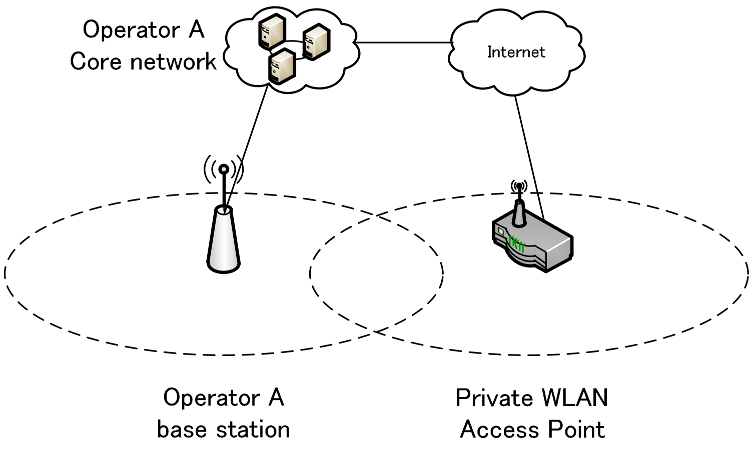

Figure 4.1: Coordinated and uncoordinated WAS/RLANs

4.2 Use case 2: Coexistence management between coordinated and uncoordinated WAS/RLANs managed by a single network operator

Similar/dissimilar WAS/RLANs managed by a single network operator are shown in Figure 4.2, where operator A network operates two LTE base stations and a 5G base station. Operator A network can also operate Wireless LAN access point by utilizing ANDSF.

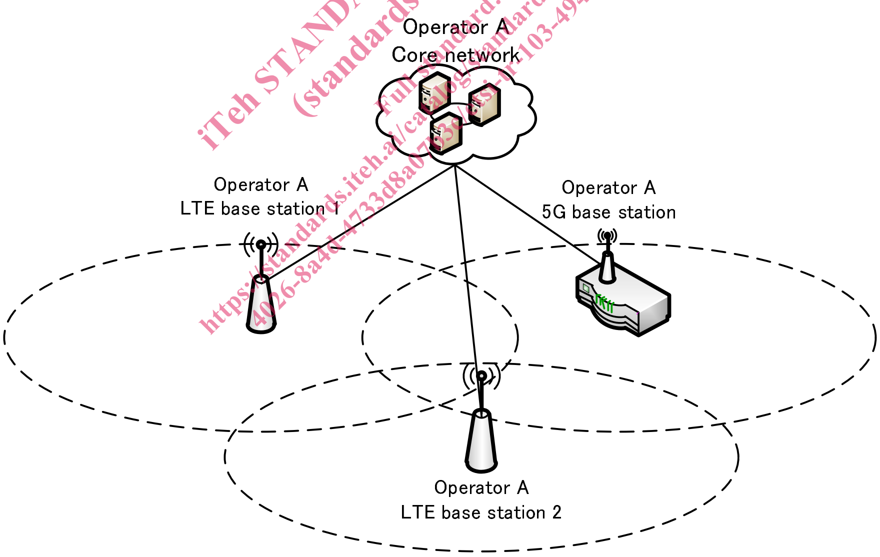

Figure 4.2: Similar/dissimilar WAS/RLANs managed by single network operator

4.3 Use case 3: Coexistence management between similar/dissimilar WAS/RLANs managed by multiple network operators

Similar/dissimilar WAS/RLANs managed by multiple network operators are shown in Figure 4.3, where operator A network operates two LTE base stations and a 5G base station while operator B operate a 5G base station, LTE base station and WLAN access point. The coexistence management between different network operators could enhance their network performance.

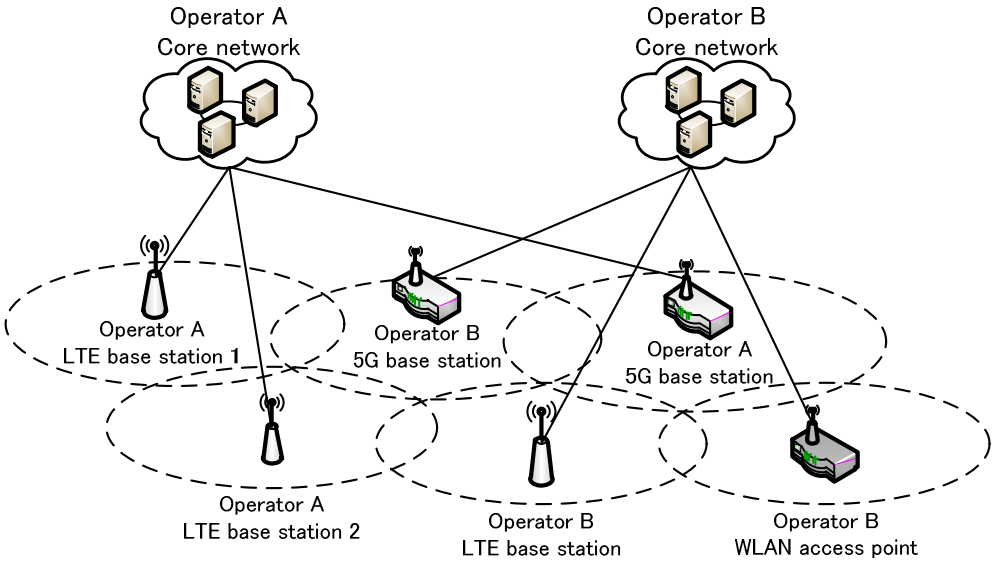

Figure 4.3: Similar/dissimilar WAS/RLANs managed by multiple network operators

5 Possible requirements

5.1 Requirements for application to WAS/RLAN in 5 GHz bands

According to the use cases as shown in clause 4, the following general requirements should be satisfied in the central control/coordination of WAS/RLAN in 5 GHz bands:

- Central control/coordination mechanism should support coexistence management between coordinated and uncoordinated WAS/RLANs.
- Central control/coordination mechanism should support coexistence management between similar/dissimilar WAS/RLANs.
- Central control/coordination mechanism should support coexistence coordination between different network operators operating WAS/RLANs in 5 GHz bands.

5.2 Other possible requirements

In order to achieve global optimization of the network operations of WAS/RLAN, the following requirements should be satisfied:

- Central control/coordination mechanism should support network management for high efficient resource utilization, which considers both radio spectrum and, when appropriate, core network resource per service slice.
- Central control/coordination should support the mechanism for low complexity spectrum reassignment, which considers spectrum transition capability within availability time period of the allocated spectrum.
- Central control/coordination should support moving radio nodes.
- Central control/coordination should support the service continuity of moving nodes, which includes serving C3 selection for moving nodes considering available spectrum and residency duration within the C3 along predicted trajectory of the moving node.
- Central control/coordination should support the quick identification of the spectrum in which a radio node can operate with high efficiency while considering the spectrum utilization pattern.