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INTERNATIONAL STANDARD

Industrial networks – Coexistence of wireless systems – Part 4: Coexistence management with central coordination of wireless applications

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INDUSTRIAL NETWORKS – COEXISTENCE OF WIRELESS SYSTEMS –

Part 4: Coexistence management with central coordination of wireless applications

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IEC 62657-4 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This second edition cancels and replaces the first edition published in 2022. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition.

a) The data item (parameter) to be exchanged between CCP and CMWCA and CMWD to ensure interoperability between CCP providers and device providers.
b) The sequence of services conducted between CCP and CMWCA and CMWD are now defined. When the CCP providers and the device providers implement similar process, clearly defined sequence and unified execution specifications ensure interoperability as expected.
c) The message formats of sequence diagram to be exchanged between CCP and CMWCA and CMWD are defined. By defining the message formats, the hierarchical structure of each data (parameter), and implementing the same message format by the CCP provider and the device provider, enables to exchange data correctly and ensure interoperability.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65C/1330/FDIS	65C/1338/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62657 series, published under the general title *Industrial networks – Coexistence of wireless systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

The IEC 62657 series provides background, foundations, process and examples to achieve wireless coexistence. With a coexistence management process according to IEC 62657-2, a predictable assuredness of coexistence can be achieved for a given spectrum while ensuring that application requirements continue to be met. The present document provides an automated coexistence management.

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INDUSTRIAL NETWORKS – COEXISTENCE OF WIRELESS SYSTEMS –

Part 4: Coexistence management with central coordination of wireless applications

1 Scope

This part of IEC 62657 specifies a concept and methods for central coordination (CC) of automation applications using wireless communications to extend the coexistence management according to IEC 62657-2. It establishes system elements, interfaces and relationships for a central coordination. Functions, data, and data exchange for assessing and maintaining the coexistence state are specified.

This document specifies the central coordination point (CCP) approach as one example of the usage of the formal description given in IEC 62657-3.

This document is applicable to develop, implement, or modify procedures or solutions.

This document provides requirements for automated coexistence management systems.

This document provides requirements for:

– determination of the coexistence state,
– automated coexistence management procedures,
– CC amendments for existing wireless communication solutions,
– CC functions that coordinate legacy and new wireless communication systems,
– CC sequences and message formats for data exchange.

This document is not restricted to a specific radio frequency range nor is it restricted to a specific wireless communication technology.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes the requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62657-2:2025, *Industrial networks – Coexistence of wireless systems – Part 2: Coexistence management*[1]

~~IEC 62443 (all parts), *Security for industrial automation and control systems*~~

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

[1] Under preparation. Stage at the time of publication: IEC/FDIS 62657-2:2024.

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IETF RFC 8259, Tim Bray, *The JavaScript Object Notation (JSON) Data Interchange Format*, available at RFC 8259 – The JavaScript Object Notation (JSON) Data Interchange Format (ietf.org) [viewed 2024-09-03]

3 Terms, definitions, abbreviated terms and conventions

3.1 General

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.2 Terms and definitions specific for this document

3.2.1
allocation
entry in the table of frequency allocations of a given frequency band for the purpose of its use by one or more radio communication services or the radio astronomy service under specified conditions

3.2.2
antenna
device designed to transmit or receive electromagnetic waves

3.2.3
coexistence distance
difference between the threshold value for the coexistence state and the actual value of the coexistence state function expressing the distance before reaching the coexistence state

3.2.4
coexistence margin
difference between the actual value of the coexistence state function and the threshold for the coexistence state expressing the reserve before leaving the coexistence state

3.2.5
database service
service officially operated under the rules of the local regulatory authority that provides a list of available channels and possibly the maximum EIRP allowable on these channels based on queries containing the geolocation of the wireless regional area network (WRAN) devices

3.2.6
geolocation
process of acquiring the location data of a device, determining its latitude and longitude

3.2.7
harmful interference
any emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunications service operating in accordance with the ITU and local regulations

3.2.8
incumbent radio system
wireless communication system that is not under the control of, and is not affected by, the coexistence manager

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~~**3.2.8**~~
~~**logical link**~~
~~application oriented communication relationship which enables the transmission of user data between one logical end point of the reference interface in a source device and one logical end point of the reference interface in a target device~~

3.2.9
master station
data station that has been designated by the control station to ensure data transfer to one or more slave stations

Note 1 to entry: At a given instant, there can be only one master station on a data link.

[SOURCE: IEC 60050-721:1991, 721-19-12]

3.2.10
service flow
QoS parameters for the PDUs that are exchanged on a connection, and provide a mechanism for upstream and downstream QoS management

3.2.11
service flow identifier
SFID
unique identifier for a service flow dealing with how higher layer packets/application sessions are mapped to their QoS requirements and scheduling constraints

3.2.12
slave station
data station that is selected by a master station to receive data

3.2.13
spectrum sensing system
SSS
combination of dedicated spectrum sensing nodes (SSN) and embedded spectrum sensing functions (SSF) integrated into the wireless devices for automation applications

3.3 Additional terms and definitions for the templates

3.3.1
array of frequency
collected values from sensing start frequency to sensing end frequency during the sensing process

3.3.2
array of power spectral density
collected values of power spectral density from sensing start frequency to sensing end frequency during the sensing process

3.3.3
CCP address
communication partner identification of the central coordination point for a service

3.3.4
coexistence assessment
process of evaluating wireless communication coexistence

3.3.5
communication link ID
identifier (ID) as part of the response of a service execution related to the communication link

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3.3.6
destination address
communication partner identification for a service

3.3.7
limits of performance parameter
value returned with the limit for a performance parameter

3.3.8
medium sensing report type
requested type of information related to the generation type of medium resource report

Note 1 to entry: The type is represented by a number with the following code: 1: Event driven; 2: Cyclic; 3: Requested.

3.3.9
parameter ID
identifier (ID) of a parameter that is specified by a standard or vendor and identifies the parameter whose value is returned

3.3.10
parameter value
value of the parameter to be returned

3.3.11
performance parameter type
requested type of information related to a communication link ID

Note 1 to entry: The type is represented by a number with the following code: 1: Transmission time; 2: Update time; 3: Response time; 4: Data throughput; 5: Communication availability.

3.3.12
radio regulation database ID
identifier (ID) of the radio regulation database

3.3.13
received signal strength indication
RSSI
value of the power present in a received radio signal

3.3.14
received signal strength indication mean
RSSI mean
mean value of the power present in a received radio signal

3.3.15
received signal strength indication standard deviation
RSSI standard deviation
standard deviation value of the power present in a received radio signal

3.3.16
report interval
interval time of cyclic reports

Note 1 to entry: This belongs to the cyclic "medium sensing report type".

3.3.17
sensing duration
parameter specifying the duration of a sensing process

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3.3.18
sensing end frequency
parameter specifying the stop frequency of sensing

3.3.19
sensing interval
parameter specifying the interval between sensing processes

3.3.20
sensing start frequency
parameter specifying the start frequency of sensing

3.3.21
service status
parameter that provides information on the result of service execution

Note 1 to entry: The service status can be either ABORTED or TIMEOUT.

3.3.22
SINR
signal to interference plus noise ratio
value of the power of a certain signal of interest divided by the sum of the interference power from all the other interfering signals and the power of some background noise

3.3.23
spectrum sensing entity ID
identifier (ID) of the spectrum sensing entity containing either SSN or SSF

3.3.24
status
parameter that specifies the behaviour of the wireless device concerning configuration by a code

Note 1 to entry: The status is represented by a number with the following code: 0: No address assigned; 1: Unconfigured; 2: Configured.

3.3.25
system address
communication partner identification of the system for a service

3.3.26
Timestamp
information concerning time of collected attribute data

3.3.27
wireless system ID
identifier (ID) as part of a service execution related to the concerned wireless system

~~**3.3.27**~~
~~**wireless type**~~
~~parameter that characterizes the model of a wireless system or a wireless device~~

~~Note 1 to entry: The parameter can contain either the wireless system or wireless device. If using the IEC CDD, then use the unique identifier.~~

3.3.28
wireless ID
identifier (ID) as part of a service execution related to the model of a wireless system or a wireless device

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3.4 Terms and definitions given in IEC 62657-2

For ease of understanding, the most important terms from IEC 62657-2 used within this document are listed but the definitions are not repeated in the list.

- antenna type,
- antenna gain,
- antenna radiation pattern
- automation application,
- bandwidth,
- centre frequency,
- coexistence (wireless communication coexistence),
- ~~coexistence assessment,~~
- coexistence planning,
- coexistence management,
- communication load,
- device,
- device type,
- duty cycle,
- dwell time,
- frequency band,
- frequency channel,
- logical link
- lower cut-off frequency,
- mechanisms for adaptivity,
- medium utilization factor
- message,
- number of consecutive lost messages,
- plant,
- power spectral density,
- radio channel,
- signal to interference and noise ratio,
- received signal strength indication,
- receiver sensitivity,
- transfer interval,
- wireless application,
- wireless communication,
- wireless communication application,
- wireless communication solution,
- wireless communication system,
- wireless device,
- wireless network,
- wireless system type,
- total radiated power,
- upper cut-off frequency.

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3.5 SRF specific definitions

3.5.1
SRF Wireless Platform
specification of hardware and software architecture for coexistence management

3.5.2
SRF Gateway
managed gateway used for SRF Wireless Platform

3.5.3
SRF Device
managed wireless device used for SRF Wireless Platform

3.5.4
SRF Sensor
sensing node used for SRF Wireless Platform to monitor the radio environment

3.5.5
SRF Wireless Set
group consisting of SRF Gateway and SRF Devices to communicate wirelessly between each other

3.5.6
Non-SRF Wireless Set
wireless devices that are not supporting the SRF Wireless Platform

3.6 Abbreviated terms

ACRM	application communication requirements management
AFH	adaptive frequency hopping
AL	application layer
AP	access point
ble	Bluetooth low energy
CC	central coordination
CCP	central coordination point
CDD	common data dictionary
CMWCA	CCP managed wireless communication application
CMWD	CCP managed wireless device
CONF	confirmation
CS	convergence sublayer
C-SAP	control service access point
DAA	detect and avoid
DAR	detect and reduce
DAS	detect and suppress
DoA	direction of arrival
EIRP	equivalent isotropic radiated power
HMI	human machine interface
ID	identifier
IETF	Internet engineering task force
IND	event notification

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IP	Internet protocol
ISM	industrial, scientific and medical
JSON	JavaScript object notation
LAN	local area network
MAC	medium access
MLME	medium access layer management entity
MRM	medium resource management
M-SAP	management service access point
PE	policy engine
PHY	physical layer
PLC	programmable logic controller
PLME	physical layer management entity
PSD	power spectral density
QoS	quality of service
REQ	request
RES	response to the request message
RF	radio frequency
RSSI	received signal strength indication
SAP	service access point
SDU	service data units
SFID	service flow identifier
SINR	signal to interference plus noise ratio
SSF	spectrum sensing function
SSN	spectrum sensing node
SSS	spectrum sensing system
~~TRP~~	~~Total radiated power~~
STA	station
WCA	wireless communication application
WCD	wireless communication device
WCS	wireless communication system
WCSDCC	wireless communication system and device configuration and control
WCSDS	wireless communication system and device subscription
WIA	wireless industrial automation
WSAN	wireless sensor actuator network

3.7 Conventions used for service descriptions

This document uses the descriptive conventions given in ISO/IEC 10731.

The service model and service primitives used are entirely abstract descriptions; they do not represent a specification for implementation.

Service primitives, used to represent service user/service provider interactions (see ISO/IEC 10731), convey parameters that indicate information available in the user/provider interaction.

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The parameters that apply to each group of primitives are set out in tables throughout the remainder of this document. Each table consists of ~~up to six~~ five columns, containing the name of the service parameter, and a column each for those primitives and parameter-transfer directions used by the service:

– the request primitive's input parameters;

~~– the request primitive's output parameters;~~

– the indication primitive's output parameters;

– the response primitive's input parameters, and

– the confirm primitive's output parameters.

One parameter (or part of it) is listed in each row of each table. ~~For local services, only request primitive with input and output parameters is used.~~ Under the appropriate service primitive columns, a code is used to specify the type of usage of the parameter on the primitive and parameter direction specified in the column:

M parameter is mandatory for the primitive.

U parameter is a user option and may or may not be provided depending on the dynamic usage of the ~~DLS~~ service user. When not provided, a default value for the parameter is assumed.

S only one parameter in a group of parameters using this code is required.

C parameter is conditional upon other parameters or upon the environment of the ~~DLS~~ service user.

CU parameter is a conditional user option, and may or may not be permitted depending upon other parameters or upon the environment of the ~~DLS~~ service user. When permitted, it may or may not be provided depending on the dynamic usage of the ~~DLS~~ service user. When permitted and not provided, a default value for the parameter is assumed.

(blank) parameter is never present.

In this document the service message formats are described using JSON notation according to IETF RFC 8259.

4 Area of consideration

4.1 Coexistence conceptual model

In Figure 1, the coexistence conceptual model, described in IEC 62657-2, is shown. In this example, three wireless communication applications – A, B and C are assumed. According to the definition of wireless coexistence, all three wireless communication applications shall fulfill their application communication requirements. One part of the wireless communication application (WCA) A is a selected wireless communication system (WCS) A. It uses the wireless ~~medium~~ resources for communication and can interfere with other WCS, e.g. WCS B. WCS B can be of the same wireless technology or of another one. Each WCS is characterized by a certain robustness against interference. Thus, not every interference leads to errors in communication or to application failures.

Coexistence management requires the investigation of the coexistence state throughout the entire life cycle of the system. This requires that measurements be taken to determine whether all wireless communications applications are fulfilling their application communications requirements.

An investigation of the application communication requirements and the characteristics of the wireless system (immunity and utilization) shall be reported in an inventory. The resulting coexistence planning shall be reported in a resource allocation plan. This shall be the basis for implementing the radio resources and their utilization.

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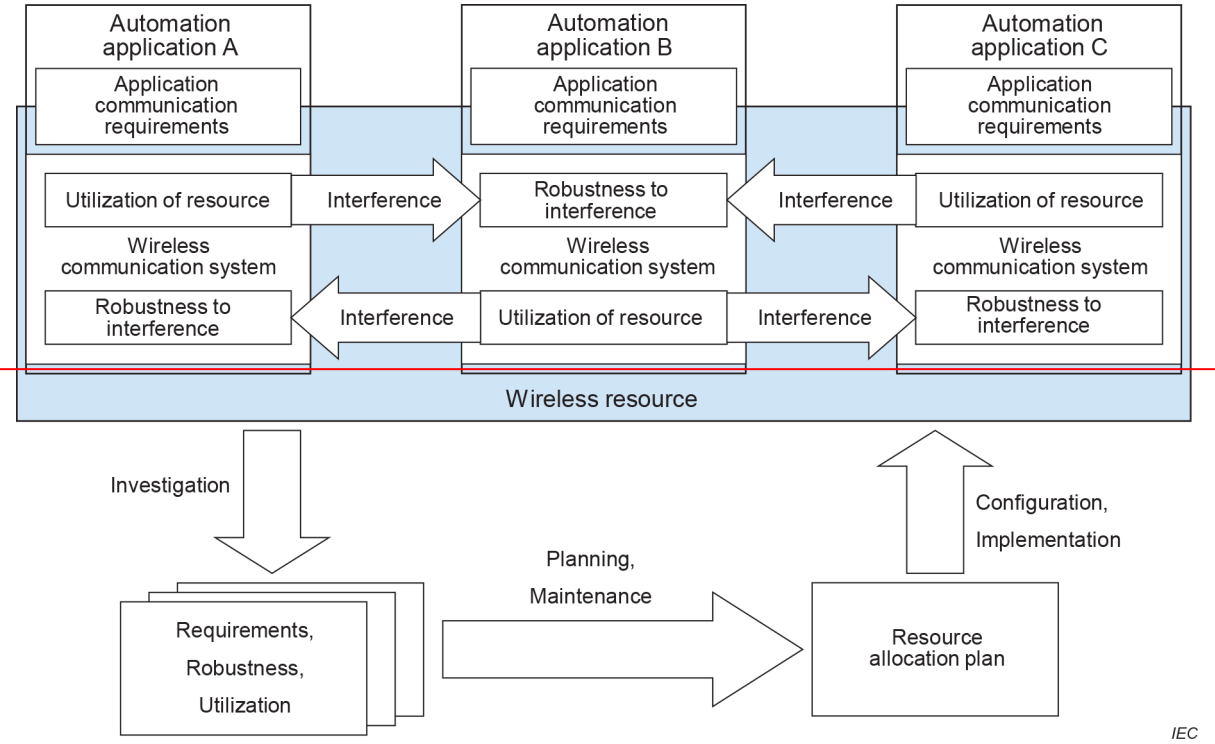

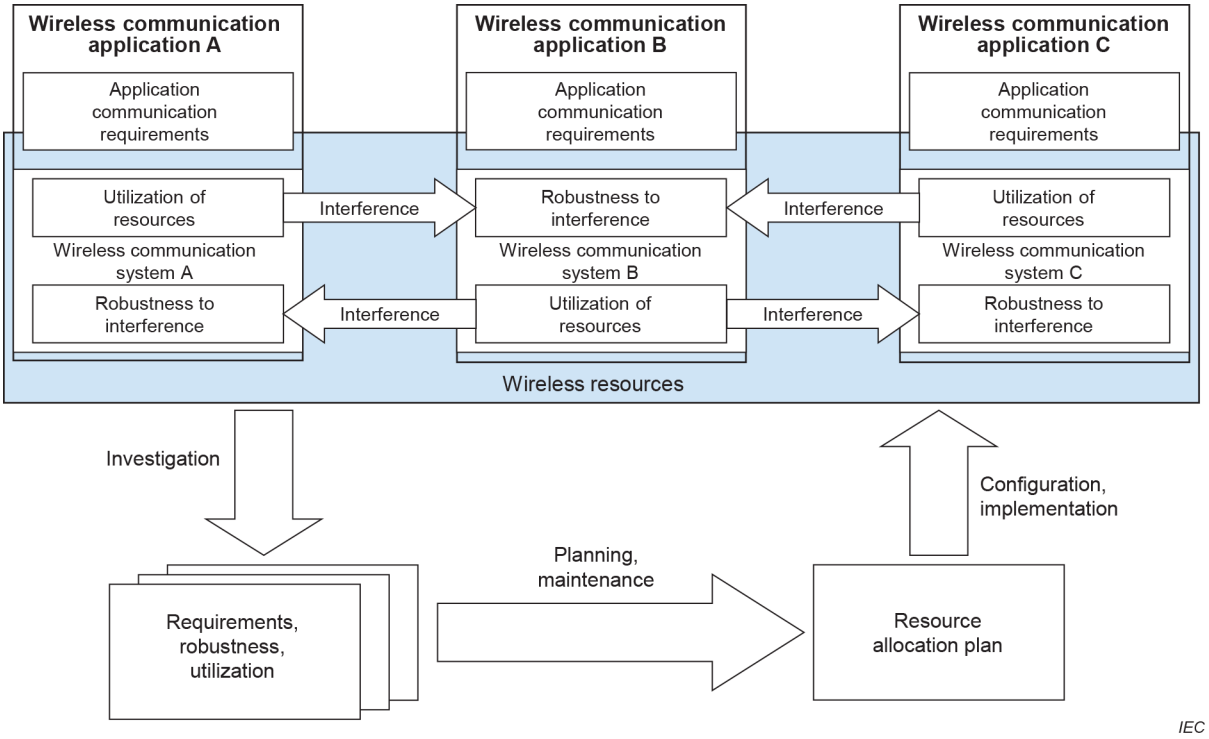

Figure 1 – Wireless coexistence conceptual model according to IEC 62657-2

4.2 Investigation of coexistence state

An essential task for coexistence management is to calculate and to evaluate the coexistence state. With respect to the definition of the term coexistence, in addition to spectrum parameters (e.g. frequency channel or power spectral density), application related characteristic parameters (e.g. transmission time) are also required to calculate the coexistence state.

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Figure 2 is intended to show where relevant parameters can be determined. The figure shows a scenario with two WCA (A and B) with one logical link per WCA. Messages of a distributed application are transferred via the source device, transmitter antenna, radio channel, receiver antenna, and target device to the target of the distributed application. Interferences can occur from the source antenna of one WCS to the antennas of the other WCS. These interferences are influenced by the radio channel characteristic between the relevant antennas. Table 1 lists the relevant radio channels of the scenario shown in Figure 2.

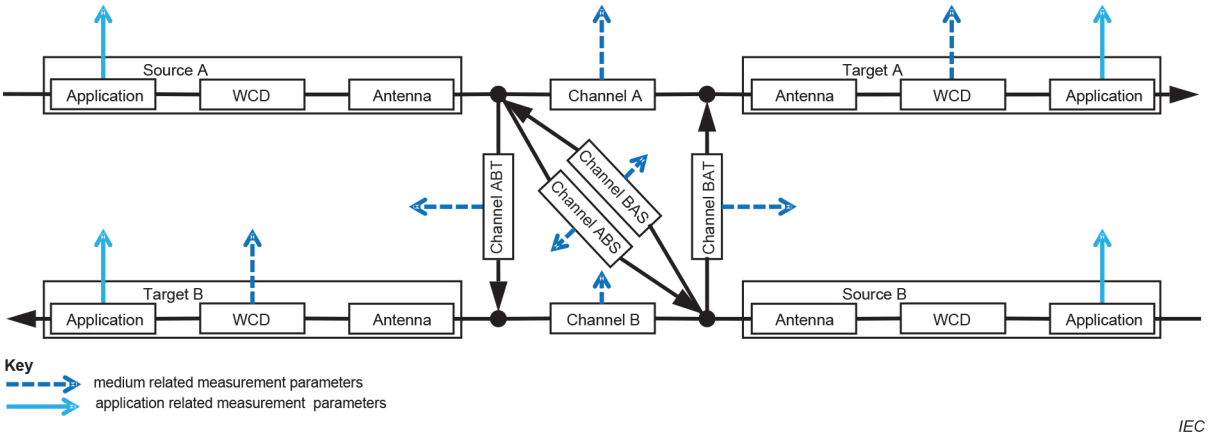

Figure 2 – Sources to determine parameters for coexistence state calculation

Table 1 – Explanations of radio channels

Radio channel	Explanation
Channel A	~~passive~~Active environmental influences for transmissions from source A to target A
Channel ABT	~~passive~~Active environmental influences for interferences from source A to target B
Channel ABS	~~passive~~Active environmental influences for interferences from source A to source B
Channel B	~~passive~~Active environmental influences for transmissions from source B to target B
Channel BAT	~~passive~~Active environmental influences for interferences from source B to target A
Channel BAS	~~passive~~Active environmental influences for interferences from source B to source A

Relevant parameters can be determined by:

– spectrum sensing function (e.g. frequency channel);
– source application (e.g. number of transferred messages);
– target wireless communication device (e.g. number of correct received messages);
– target application (e.g. transmission time).

Relevant parameters to determine and assess coexistence are specified in detail in Clause 6. In ECC Report 206, an approach is introduced to holistically assess the dependability of industrial communication. This approach is well-suited to derive a coexistence state function defined as follows.

$\sigma_i(t)$ is the normalized parameter of the characteristic parameter i, according to Clause 6, at time t. Index i with $i = 1...n$ specifies one of n types of characteristic parameters. Factors for normalizing depend on the type of the characteristic parameter and are specified in Clause 6. The parameter $\sigma(t)$ expresses the quality of a logical connection of a WCS at time t.

A weighting factor $u_i(t)$ is introduced with a possible range of 0 to 1. This factor allows to adapt a parameter of type i according to the requirements. While, for example, the transmission time

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is more relevant for applications with event driven communication, the update time is important to applications with periodic traffic. This can be expressed with $u_i(t)$. The time dependence of this factor considers emerging flexible concepts of industrial automation that could require adaptations of the relevance of different parameter types.

The coexistence state function shall consider all known $k = 1 \ldots p$ WCS. The priority of an application that uses WCS k is expressed with the weighting factor $w_k(t)$. Furthermore, the logical links $j = 1 \ldots m$ of a WCS should be taken into account. The importance of a logical link is expressed by the weighting factor $\upsilon_j(t)$.

Thus, a coexistence state function $\chi(t)$ according to Formula (1) can be defined.

$$\chi(t) = \frac{1}{\sum w_k(t)} \sum_{k=1}^{p} w_k(t) \times \left(\frac{1}{\sum \upsilon_j(t)} \sum_{j=1}^{m} \upsilon_j(t) \times \left(\frac{1}{\sum u_i(t)} \sum_{i=1}^{n} u_i(t) \times \sigma_i(t) \right)_j \right)_k \tag{1}$$

Assuming a threshold χ_{Thr} that specifies the state in which the application communication requirements of all wireless communication applications are fulfilled, the coexistence state can be specified as shown in Formula (2).

$$s\left(\chi(t) \geq \chi_{\text{Thr}}\right) = 1 \tag{2}$$

The complementary state of non-coexistence is defined according to Formula (3).

$$s\left(\chi(t) < \chi_{\text{Thr}}\right) = 0 \tag{3}$$

The difference of actual value $\chi(t)$ and threshold χ_{Thr} is called coexistence margin (see Formula (4)). The difference of threshold χ_{Thr} and actual value $\chi(t)$ is called coexistence distance (see Formula (5)).

$$\chi_{\text{M}}(t) = \chi(t) - \chi_{\text{Thr}} \tag{4}$$

$$\chi_{\text{D}}(t) = \chi_{\text{Thr}} - \chi(t) \tag{5}$$

A coexistence state function with its main values is shown as an example in Figure 3.

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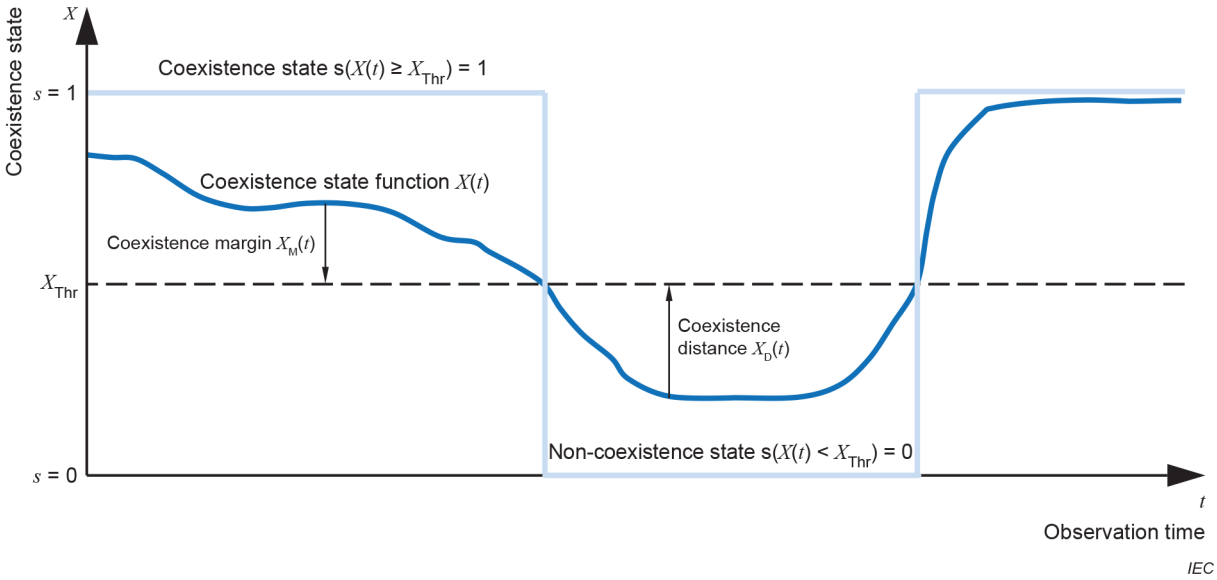

Figure 3 – Coexistence state function

The coexistence state function can be used to assess the level of coexistence and to derive measures to maintain coexistence. The characteristic parameters $\sigma_i(t)$ referred to WCS k and to logical link j offer the possibility to identify weak points within the area of consideration. Based on that algorithm, the central coordination approach is able to derive specific resource allocations.

4.3 Implementing radio resources and their utilization

In Figure 4, active environmental influences and targets to control coexistence are depicted. The scenario is the same as in Figure 3. In addition to the mutual interference of both systems, external interferences that cannot be influenced are indicated by dotted arrows. The mutual interference is attenuated by the radio channels ABT, BAS, BAT and ABS (see also Table 1).

Relevant parameters can be controlled by:

– source application (e.g. transfer interval);
– source wireless communication device (e.g. frequency channel);
– antenna type (e.g. beam forming);
– target wireless communication device (e.g. buffer management).

Changing the values of the above-mentioned parameters affects not only the coexistence (fulfilment of the requirements of all applications) but also directly the fulfilment of the requirements of the controlled application. An extension of the transfer interval, for example, can be helpful for other applications, but critical for the controlled application. Controlling the parameters accordingly should therefore be considered.

Relevant parameters to control coexistence are specified in detail in Clause 7. To comply with this document, the WCD shall implement parameters and services that allow the control of coexistence.

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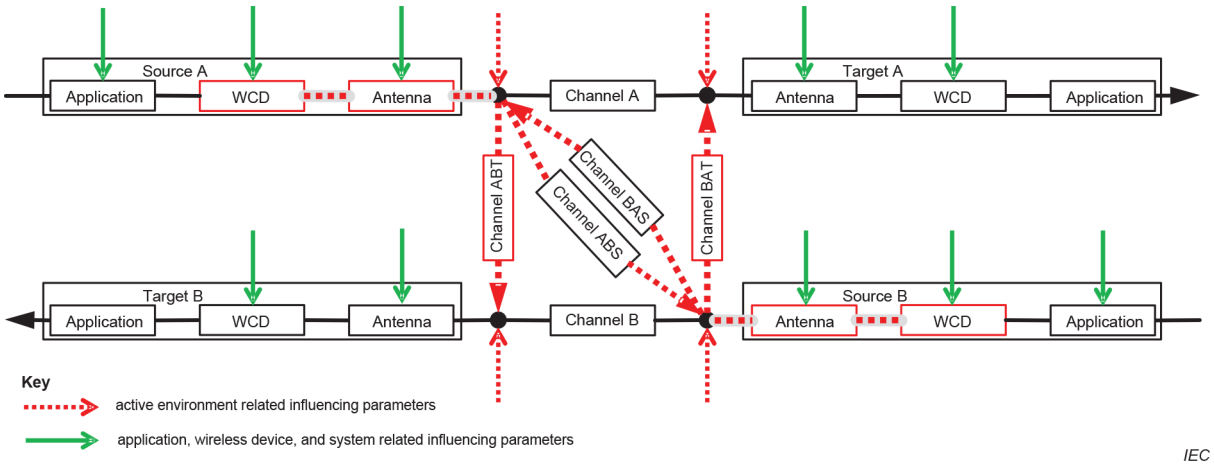

Figure 4 – Parameters describing active influences and control parameters used to manage coexistence

4.4 Coexistence management equipment

In compliance with the area of operation (industrial automation), coexistence management equipment shall be treated throughout the entire life cycle as automation equipment. This applies to the device description (for example field device integration according to the IEC 62769 series, the information exchange and management as well as questions of how much security, intrinsic safety, functional safety, high availability, etc. is needed). For example, a spectrum sensing function will be a vulnerability point in an automated coexistence management system by jamming radio waves. It is recommended to apply the IEC 62443 series for cyber security concerns like denial of service (wireless jamming). In an operational space, there are typically multiple control systems with separate wireless communication systems due to the separation of functionalities and concerns. The automated coexistence management system interacts with the devices of the wireless systems and the control system to receive information and to configure them.

5 Wireless coexistence management system architecture

5.1 General

This document deals with the basic idea of automated coexistence management of wireless communication systems for automation applications with central coordination (CC) of several wireless communication systems within industrial plants. This automated coexistence management with centralized coordination is an example implementation of the class CoexistenceManagementSystem described in IEC 62657-3:2022, 5.2. The wireless communication systems can use the same communication technology, called homogenous wireless communication infrastructure or different communication technologies, called heterogeneous wireless communication infrastructure. The aim is to further improve the efficient use of the radio resource. The main idea is to

– deal with wireless devices that can be controlled and take into account devices that cannot be controlled;

– consider available per device mitigation techniques in a central coordination approach;

– stop transmitting radio energy or to activate the per device mitigation technique if central coordination fails;

– ensure the compliance of wireless devices with local regulations by having a central coordination controlling and managing the use of the spectrum in the boundaries declared for the devices.

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In general, the functional architecture for central coordination of wireless communication systems for automation applications shall fulfill the following basic requirements:

– provide coordination mechanisms to achieve and maintain coexistence between different wireless communication solutions in the same frequency range;
– avoid harmful interferences. Provide mechanisms for automatic spectrum access and utilization, with the aim of:
  - recognition of free and occupied spectrum;
  - detection and classification of wireless communication solutions including incumbent radio systems;
  - establishment of communication channels;
  - registration of wireless communication systems in the location(s) of interest in the plant;
  - inventorying wireless automation applications with the associated wireless communication system;
  - release or rejection of newly registered wireless communication systems for automation applications;
  - gathering the requirements for the use of wireless communication based on the agreed decisions of the internal procedure;
– providing mechanisms for continuous monitoring of
  - the frequency spectrum condition, and
  - the coexistence state.

The available medium resources can be organized by assigning resource blocks to different wireless systems and/or devices by the CC. The resource blocks represent a combination of resources from the time, frequency and space domains and the coding.

The CC shall include communication with wireless systems or with wireless devices by means of one or more communication channels and protocols. Therefore, the CC shall fulfill the following requirements:

– support of different radio technologies;
– support of interface for coordination.

The coexistence management for intra-system coexistence can substitute manual coexistence management as defined by IEC 62657-2.

The CC is used to schedule resources to the different wireless communication solutions. This can include CC of single devices and CC of wireless systems. In the latter case, the wireless systems will then use the CC information to configure and control its own wireless network.

If the wireless communication applications are not controlled by CC and operate independently using the medium access control mechanisms of the wireless communication systems, then there is no coordination between them, and they rely on their own techniques for network formation, network discovery, service discovery and interference management, including the protection of incumbent radio systems.

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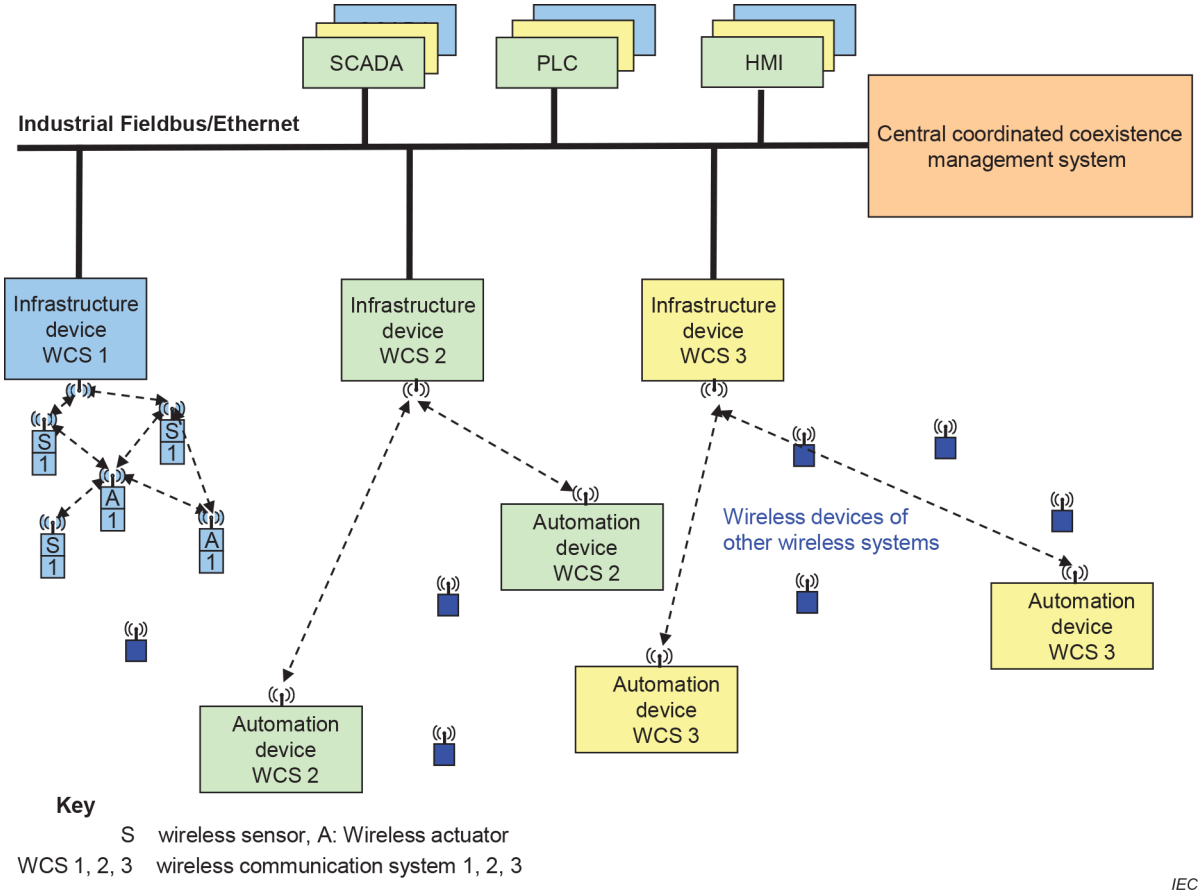

Figure 5 – Example instance of class CoexistenceSystem in accordance with IEC 62657-3

Figure 5 shows an example representation of the class model CoexistenceSystem from IEC 62657-3:2022, 5.2. The class DistributedAutomationSystem is represented by local automation functions implemented in Supervisory Control and Data Acquisition (SCADA), Programmable logic controller (PLC), Human Machine Interface (HMI), Sensor (S), Actuator (A), and the application component of the automation devices. The wireless communication components of the Wireless Communication Systems WCS 1 to WCS 3 are instances of the class WirelessCommunicationSystem. The wireless devices of other wireless systems are instances of the class ActiveEnvironmentalInfluence. The central coordinated coexistence management system is an instantiation of the class CoexistenceManagementSystem. In the following, the example representation of Figure 5 is used to describe the system elements, the architecture, the functions and the interfaces of a CCP system in more detail.

The central coordinated coexistence management system has three entities, as shown in Figure 6:

– central coordination point (CCP);
– spectrum sensing system (SSS), which is a combination of spectrum sensing nodes (SSN) and spectrum sensing functions (SSF), see 5.2.4;
– database services with information and configuration database and regulation database.

Each entity is defined by its functional roles and interaction with other entities.

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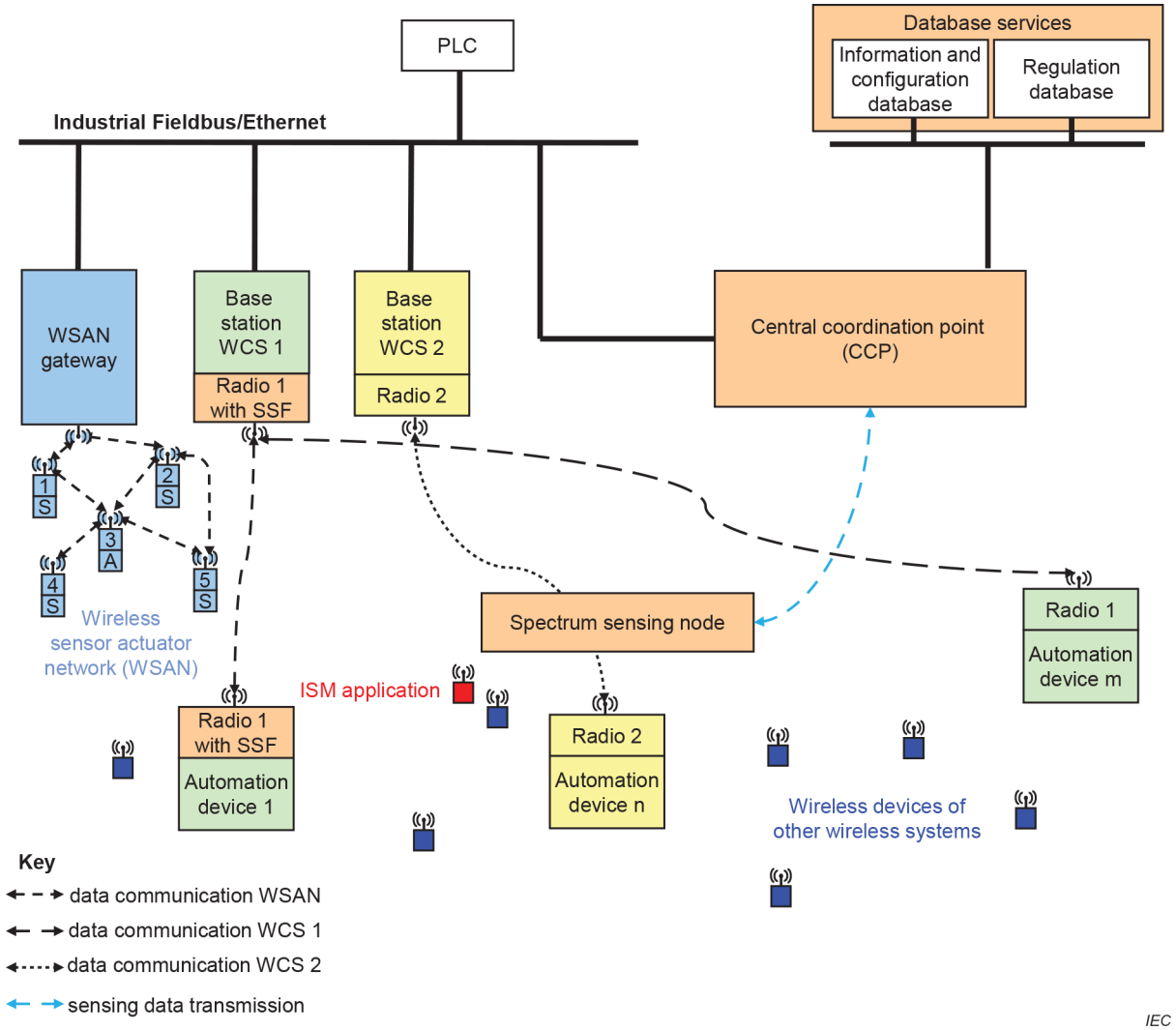

Figure 6 – Elements of central coordinated coexistence management system

Figure 6 shows three independent wireless communication systems that are subject to central coordination. A wireless sensor actor network (WSAN), a wireless communication system 1 (Radio 1) and a wireless communication system 2 (Radio 2). Furthermore, there are wireless devices of other wireless communication systems that are not under control of the CC (incumbent radio systems) and an ISM application that ~~may~~ can interfere with the wireless ~~communication~~ applications of interest. A line-based industrial communication system is used as a backbone to connect the wireless communication systems and the CCP.

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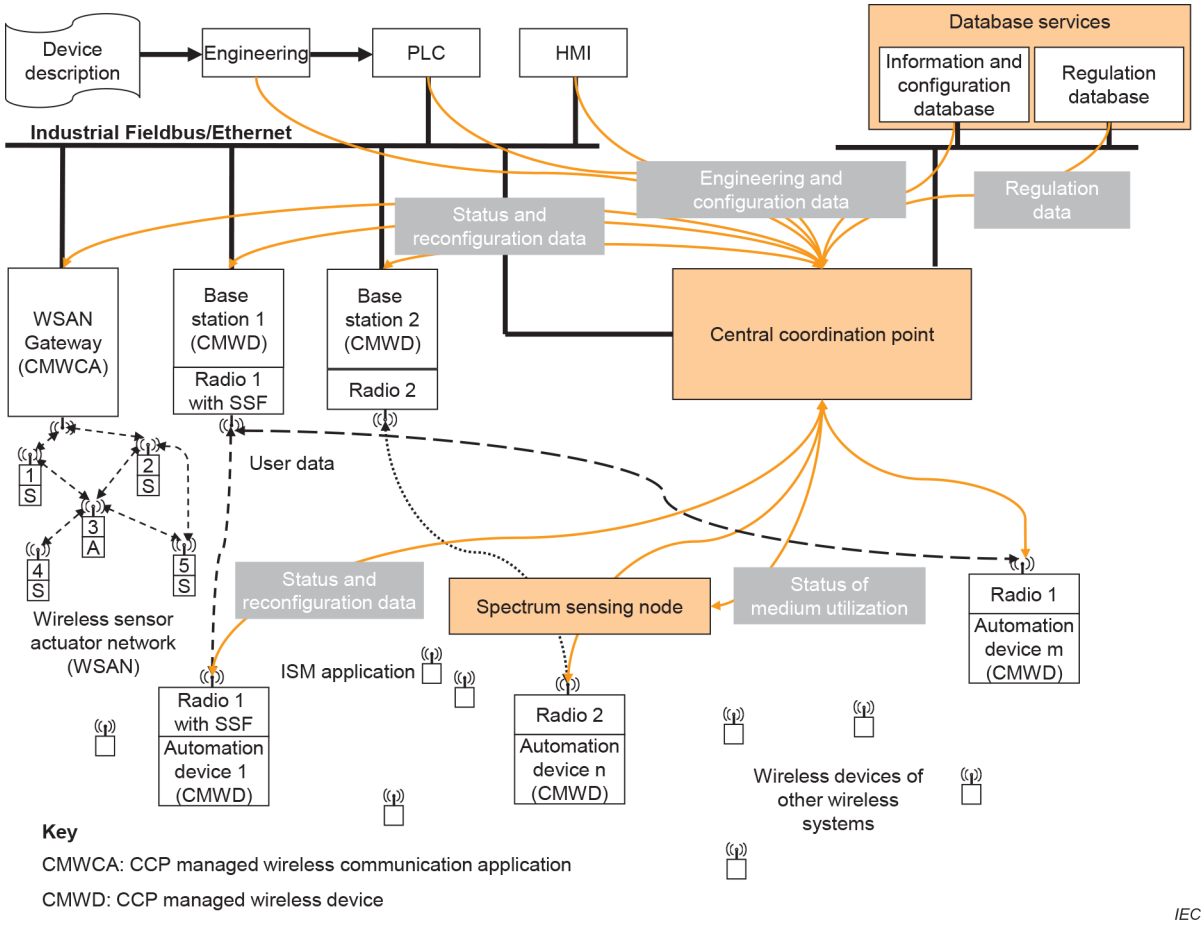

Figure 7 – Data exchange in central coordinated coexistence management system

Figure 7 shows the data exchange between the elements in a central coordinated coexistence management system. The central coordination point (CCP) is the key element of the coexistence management system. The CCP makes coexistence management decisions based on engineering baseline data, information from databases and current measurements of application behaviour and spectrum. Current measured values of application behaviour and spectrum can be collected for wireless systems via their central device, for example a base station, or directly from wireless devices. In the first case, there is only one connection between the CCP and the central component, as with WSAN in Figure 7. Then the application using the WSAN is a CCP managed wireless communication application (CMWCA). In the other case, there are connections from the CCP to the wireless devices, as with the wireless communication system 1 and wireless communication system 2. These are then called CCP managed wireless devices (CMWD). The exchange of coexistence data can take place directly between CCP and CMWD or via the central device of the WCS. Current measured values of spectrum are also provided by the spectrum sensing node (SSN).

The CCP manages the available resources spectrum, time and space and assigns the resources to the CMWCA and/or CMWD with respect to the requirements of the automation application. The central device of CMWCA receives the resource information and acts as master station and manages the registered and connected slave station of CMWCA. Therefore, the CMWCA uses available spectrum resources with additional knowledge about spectrum usage by its neighbour CMWCA and about incumbent radio systems.

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5.2 System elements

5.2.1 Wireless systems and wireless devices for automation applications

5.2.1.1 Wireless device with per device mechanisms for adaptivity and medium access control

Wireless devices with per device mechanisms for adaptivity and medium access control mechanism shall provide the needed mechanisms for adaptivity and medium access control mechanism for the assigned frequency band, such as dynamic frequency selection and frequency agility mechanisms. Manual coexistence management according to IEC 62657-2 can be used for intra-system coexistence but cannot replace mandatory mechanisms to fulfill regulatory requirements (for example protect incumbent radio system). IEC 62657-2 should be established to improve the efficient use of the medium in an industrial environment if the device cannot participate in the CCP concept.

5.2.1.2 CCP managed wireless communication application and wireless device

The CCP managed wireless communication application (CMWCA) and/or the CCP managed wireless devices (CMWD) are supervised, managed and controlled by the CCP. The CCP managed wireless communication application combines all related functions in one wireless device~~, which are necessary in order to ensure its role as master~~. ~~Station for the wireless communication application and slave station for CCP. The CCP managed wireless devices function as slave station for CCP only and can take over the role as end device or infrastructure device in a wireless communication system, as depicted in Figure 7.~~ That is, the control functions (for example base station or access point functions) for the wireless communication system and the client functions for the CCP. The CCP managed wireless devices include the client functions for the CCP and the functions of a wireless communication module (WCM) or an infrastructure device in a wireless communication system, as depicted in Figure 8.

The CCP controlled wireless communication application and wireless device shall not transmit wireless data messages by itself. If the communication between CCP and CCP managed wireless device is established and the CCP enables the transmission, then the CCP managed wireless device can transmit wireless data messages with or without mechanisms for adaptivity and/or medium access control mechanism. If the communication between CCP and the CCP managed wireless device fails, the wireless transmission shall stop if, for example, the regulatory required mitigation is not in the device, or the device does not have access to the antenna. A heart-beat signal or similar mechanisms shall enable monitoring of the communication between CCP and CCP managed wireless communication application and wireless device.

CCP managed wireless devices can have implemented spectrum sensing functions. These can be integrated into the overall spectrum sensing system (see 5.2.4).

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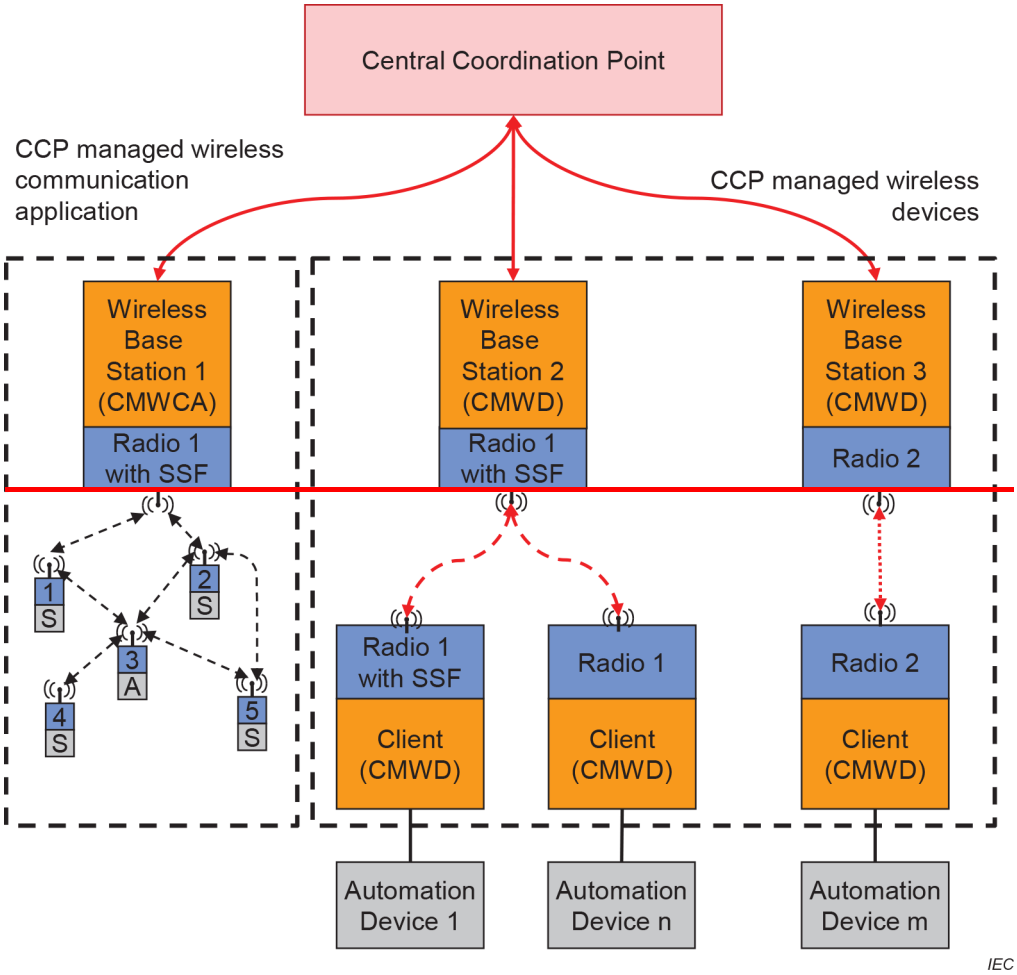

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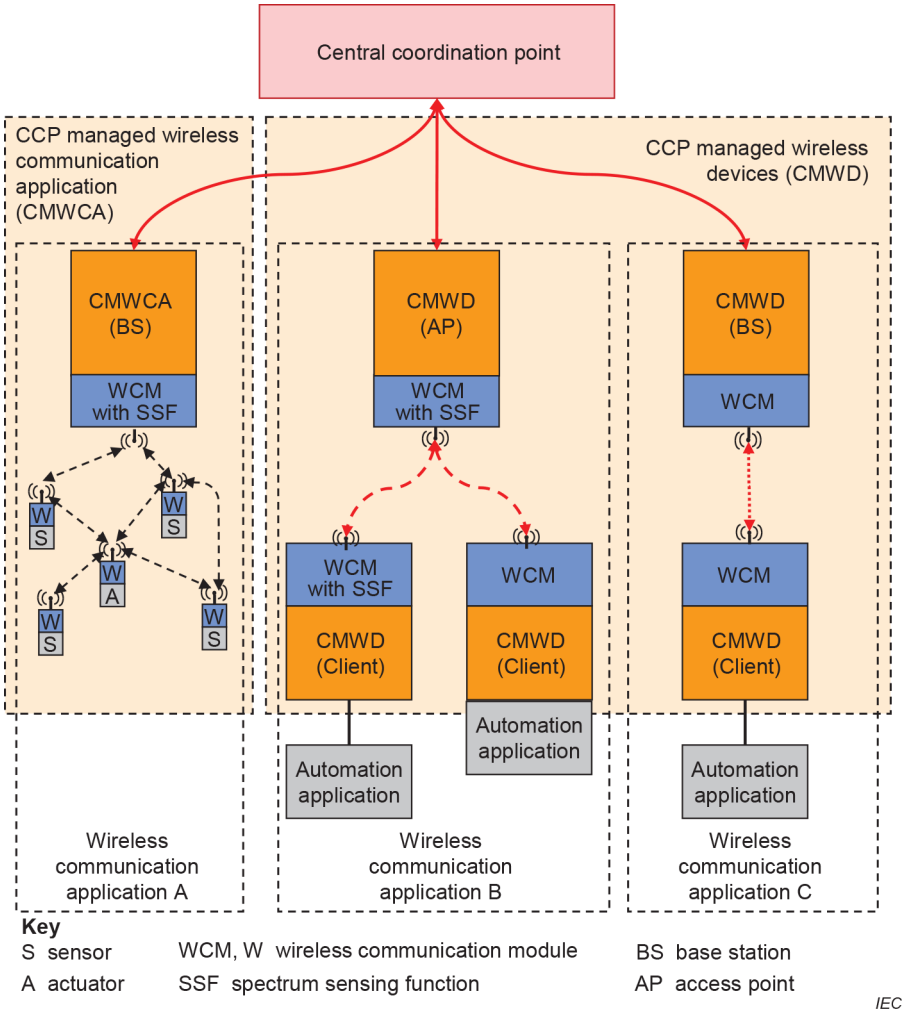

Figure 8 – CCP managed wireless devices and CCP managed wireless systems

Wireless devices of CMWCA that do not perform active spectrum sensing to save power have limited sensing capability and are therefore subject to dynamic interference. In that context, the spectrum sensing system can perform specific sensing measurements to support a wireless system consisting of such low-power wireless devices with limited sensing capability.

5.2.1.3 CCP managed wireless device with per device mechanisms for adaptivity and medium access control mechanism

Wireless devices with per device adaptivity and medium access control mechanisms which are also CCP controlled shall fulfill the requirements of 5.2.1.1.

If the communication between CCP and a CMWCA or a CMWD is established and the CCP enables the transmission, the wireless device or wireless system can transmit without adaptivity and medium access control mechanisms. If the communication between CCP and a CMWCA or a CMWD fails, the transmission shall be in line with adaptivity and medium access control mechanisms.

5.2.2 Central coordination point

5.2.2.1 General

The central coordination point (CCP) is a centralized coordination device or system for management of heterogeneous wireless infrastructures for spatially distributed automation applications. As shown in Figure 9, the CCP consists of an access to backplane(s) and an access to the RF channel, a spectrum engine, a resource engine and a policy engine.

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The tasks for the CCP are:

- management (control and coordination) of a heterogeneous wireless communication infrastructure for spatially distributed automation applications;
- establishment of automatic coexistence management within a heterogeneous wireless communication infrastructure for automation applications;
- consideration of the automation application requirements;
- detection and protection of wireless communication applications;
- consideration and fulfilment of regional regulatory requirements for wireless communication systems and wireless devices with support of geolocation.

The CCP shall:

- establish a wired or wireless communication to the information and configuration data base containing geolocation and medium usage information from wireless communication applications and incumbent radio systems;
- detect incumbent radio systems and select the appropriate mitigation technique to protect these systems;
- use application related characteristic parameters according to IEC 62657-2:2025, 6.6 to determine the coexistence state described in 4.2;
- obtain the requirements of the automation applications (see IEC 62657-2) and assign resources accordingly to the CMWCA and CMD;
- establish a wired or wireless connection to the CMWCA and CMD;
- establish a wired or wireless connection to the regulation database.
- reconfigure CCP managed wireless communication applications and wireless devices using influencing parameters defined in IEC 62657-2:2025, Clause 7.

If more than one CCP is in use in a certain configuration, then wired or wireless communication shall be established directly or indirectly between the CCPs. All requirements of a single CCP shall apply.

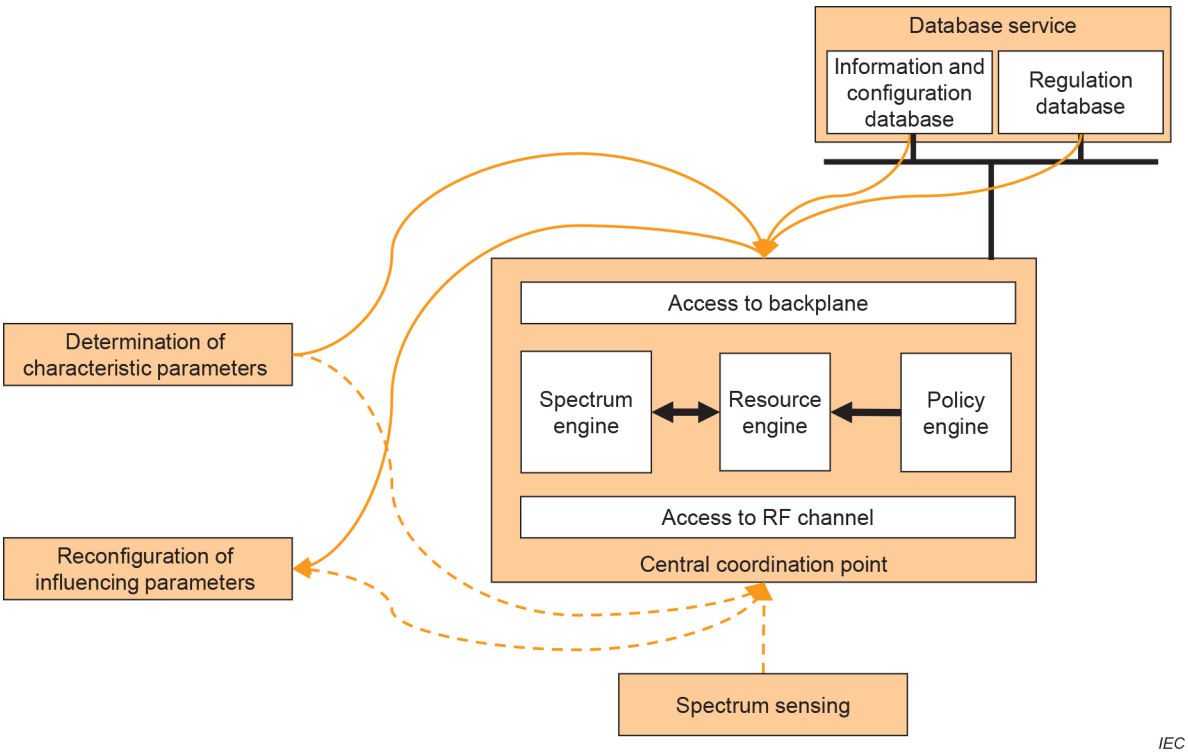

Figure 9 – Overview of CCP

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5.2.2.2 Spectrum engine

The spectrum engine (SE) is a management and control function and an entity of the CCP. The SE centralizes all medium usage decisions for various wireless communication applications, taking into account medium availability information and location-specific medium utilization.

In summary, the SE shall be responsible for:

– maintaining medium availability and medium utilization information;
– channel classification and selection;
– association control;
– channel set management;
– accessing the database service;
– scheduling spectrum sensing operation;
– making channel move decisions for one or more CCP managed wireless systems or wireless devices for the automation application;
– supporting coexistence of wireless communication applications;
– considering incumbent radio systems and other wireless applications;
– establishing a wired or wireless connection to all CCP managed wireless communication applications and devices;
– establishing a connection to the resource engine.

5.2.2.3 Resource engine

The resource engine (RE) is a management and control function and an entity of CCP. The RE centralizes all information about automation application, application communication requirements and general plant characteristics. This information shall be analysed and processed with respect to the use of the wireless medium by the wireless communication applications. Furthermore, the RE shall consider the radio regulation restrictions.

The resource engine (RE) within the CCP shall be responsible for:

– collection, analysing and processing of engineering and automation application data;
– providing coexistence control parameters to the SE with respect to the radio regulation restrictions and limitations;
– maintaining the requirements of the automation application;
– maintaining and monitoring QoS information of the communication links.

5.2.2.4 Policy engine

The policy engine (PE) is a management function and an entity of CCP. The PE centralizes all location-dependent radio regulation restrictions and limitations about the used frequency ranges. The PE shall be responsible for:

– maintaining regulatory requirements, restrictions and limits regarding the geographical location, as well as the range of frequencies used by the wireless systems and wireless devices for automation applications;
– establishing a wired or wireless communication to the regulation database containing geolocation limit of radio spectrum regulation.

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It is impossible to get a general approval of administrations for the CC concept in general. To get an assuredness that vendors can start to invest in products compliant with this document, it is important to know that a vendor that put products on the market and put the product into service is responsible to comply with local and regional policies. There exist two principles on the worldwide markets:

– the process of self-declaration of conformity;

– type approval.

NOTE 1 In Europe, as a harmonized standard for this type of product does not exist, the process is to ask a notified body for its expert opinion.

NOTE 2 The responsibility for the product remains by the vendor.

The product description shall provide the needed information to describe the system:

– CCP;

– CCP managed wireless communication applications and devices,

with their CCP-service-interfaces to operate using a communication interface. The communication interface could be based for example on IEEE Std 802.11. The CCP-service-interfaces shall be according to this document.

Table 2 – Level of effectiveness of wireless automation

Scenario	Achievement of coexistence	Spectrum efficiency
Without coexistence management	Hardly	—
With coexistence management	Most likely	Not efficient
With CCP based coexistence management	Most likely	Efficient
With CCP based coexistence management and only controlled traffic	For sure	Efficient

As shown in Table 2, the CCP increases the achievement of the coexistence of wireless communication applications compared to not using a CCP concept. That means the policy engine shall contain all relevant restrictions to fulfil the regional and local requirements of regulations, policies and others.

5.2.3 Coordination database

5.2.3.1 Information and configuration database

The information and configuration database (ICD) stores information about automation application communication requirements, CCP managed wireless applications and CCP managed devices, wireless systems and wireless devices with per-device adaptivity and medium access control mechanisms, location-specific information, and radio-specific information. The ICD shall provide this information to the CCP. The radio-specific information shall include information on available radio frequencies and associated maximum EIRP values, implemented adaptivity mechanisms, and medium access control mechanisms used by the systems wireless and wireless devices under consideration. This enables the protection of incumbent radio systems. The information is derived from documentation of the wireless systems and wireless devices.

5.2.3.2 Regulation database

The regulation database (RD) contains regulation information about the used frequency band(s). The RD shall include information on radio regulation limits and information on incumbent radio systems and other wireless applications, as well as which frequency bands or parts of them can be used during operation.

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Furthermore, the RD contains information on how wireless communication systems will respond when an incumbent radio system is detected. The CCP's policy uses the RD to configure wireless systems and wireless devices according to regulatory requirements. The incumbent radio systems are defined by:

– frequency band;
– incumbent type:
  - defense (radiolocation);
  - fixed service;
  - transportation;
– incumbent operation characteristic:
  - static;
  - dynamic by time;
  - dynamic by geography;
  - dynamic by time and geography.

Due to incumbent radio systems, a number of disadvantages can arise for wireless communication systems and thus for wireless communication applications (WCA), for example:

– reduced frequency band;
– reduced coverage;
– decreased capacity;
– decelerated access to spectrum.

5.2.4 Spectrum sensing system

The spectrum sensing system (SSS) is a combination of dedicated spectrum sensing nodes (SSN) and embedded spectrum sensing functions (SSF) integrated into the wireless devices for automation applications. The SSS shall continuously provide medium utilization information to the CCP. The SSS observes the relevant frequency bands in and around the environment of the local industrial premises to determine the occurrence of wireless applications including incumbent radio systems. This process is called sensing and takes into account parameters of the radio channel, of the known wireless applications, of the automation application, and of the environment. Furthermore, the determined spectrum values can provide information about the location of a transmitting wireless device.

Spectrum sensing is generally a passive process and shall not interfere with wireless applications. The sensed signals shall be detected from the SSS and the parameters shall be transferred to the SE function in CCP. ~~The parameters indicate frequency range, energy level, and occupation time and so identify the radio pattern of the transmitter. Based on this information, the SE can characterize, catalog and classify incumbent radio systems, wireless communication systems and devices, ISM applications and other wireless applications.~~ The parameters indicate frequency range, energy level and occupation time. To assess the energy level, for example the received signal strength indication (RSSI) or the signal to interference plus noise ratio (SINR) are used as parameters. Based on this information, the SE can identify the radio pattern of the transmitter and can so characterize, catalog and classify incumbent radio systems, wireless communication systems and devices, ISM applications and other wireless applications.

The spectrum sensing nodes (SSN) independently implement specific procedures for sensing the radio frequency environment inside and outside the local automation environment. The SSN shall permanently sense the radio frequency environment and report to the CCP so that it can refresh the status of the medium resources.

The spectrum sensing function (SSF) is present at the CMWCA and CMWD. The SSF in CMWCA independently implement specific procedures for sensing the radio frequency

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environment at initialization of the master station and before the registration of a slave station with the master station and during operation.

The SSF in a CMWD shall contain essential features to allow proper operation when the device is not under the control of the WCS master station, for example, during initialization or during a channel change. When a CMWD is idle, the SSF shall conduct out-of-band sensing and report to the master station so that it can refresh the status of the channels in the backup/candidate channel list. At any other time, the SSFs in the CMWD are under the control of the CCP. When the master station is not transmitting, the SFF is active to conduct out-of-band sensing. The SSF can then also carry out sensing to clear channels.

CMWD may be subject to limitations in terms of processing capacity, memory resources or power requirements (battery powered). In these cases, the following measures can be applied:

– The SSF is not started immediately after registration of the CMWD but on command of the CCP.
– The SSF senses only the frequency range that the wireless device can use operationally.
– The SSF can be suspended to conserve battery power.

These spectrum sensing limitations can be compensated by using information from the SSN and/or by selectively activating SSFs and performing sophisticated data analysis.

5.3 Protocol reference architecture

5.3.1 General

The protocol reference model (PRM) of CCP managed wireless automation applications and wireless devices, shown in Figure 10, is divided in three parts. The conventional wireless device stack transfers the user data. It is called user plane or data plane. The CCP stack management provides the CCP management and control services of the device according to Clause 8. The CCP interface contains the management/control plane functionality, creating a new coordination plane to support the central coordination capabilities.

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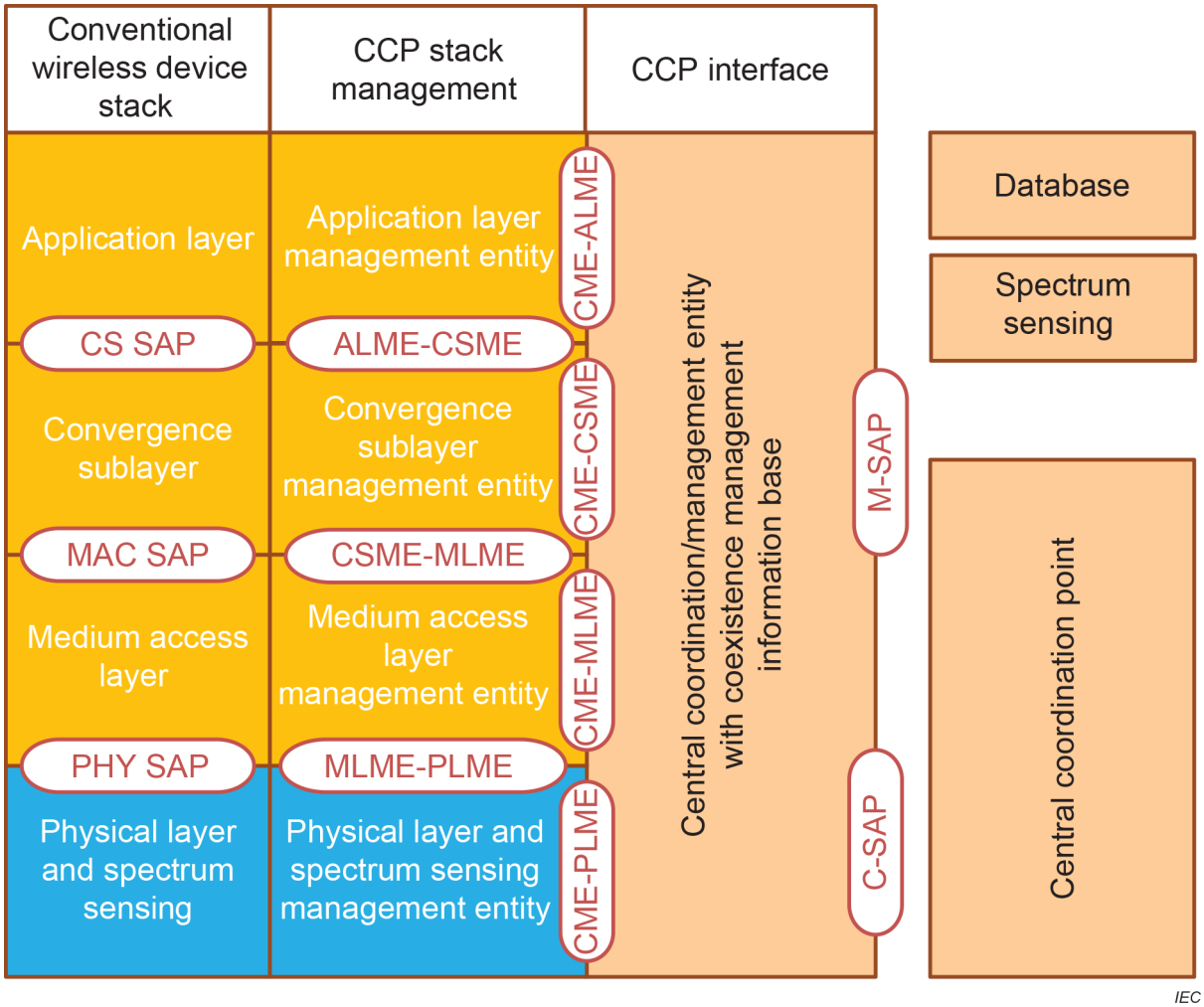

Figure 10 – Protocol reference model of CCP managed wireless device

5.3.2 Data plane

The data plane consists of the physical layer (PHY), the medium access control (MAC) layer, the convergence sublayer (CS) and application layer (AL). Service access points (SAPs) are added in between these layers to allow modularization of the system. An SAP is provided with a well-defined interface or a set of primitives to exchange information, by virtue of which these different components can talk to each other.

The service-specific CS shall provide transformation or mapping of external network data that is received through the CS SAP from AL, into MAC service data units (SDUs). This transformation or mapping shall include classifying external network SDUs and associating them to the proper MAC service flow identifier. Multiple CS specifications are provided for interfacing with various protocols.

The MAC shall provide the functionality of system access, connection establishment and connection maintenance. The data that the MAC layer receives from the various CSs through the MAC SAP shall be assigned to particular MAC connections. Quality of Service (QoS) is applied to the transmission and scheduling of data over the PHY. Data, PHY control, and monitoring statistics (spectrum sensing, RSSI, etc.) shall be transferred between the MAC and the PHY via the PHY SAP.

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The parameter for coexistence assessment shall be determined from the message transfer in the data plane. The PHY, MAC, CS and AL shall provide the determined parameters to the central coordination/management entity with coexistence management information base, where these parameters are available for the CCP.

5.3.3 Management and control plane

5.3.3.1 General

The management and control plane shall consist of physical layer and spectrum sensing management entity (PLME), medium access layer management entity (MLME), convergence sublayer management entity (CLME), application layer management entity (ALME) and the central coordination entity (CCE) with a coexistence management information base (CMIB). Service primitives are used to communicate with the CMIB database and some of its primitives ~~may~~ can be used to manage the wireless system and wireless device entities. The CMIB primitives shall be used for system configuration, monitoring statistics, notifications, triggers and session management, medium resources management, communication with the database, the spectrum sensing system and the CCP. The CMIB data ~~may~~ can be obtained either from the wireless system, pre-defined within the system, or obtained from other devices after an exchange of information using the communication medium. The CCP has a key role in the overall architecture. It is the central coordinator for all CMWCA and CMWD, where all information about the availability of the spectrum is collected, resulting from the database and the spectrum sensing system. Based on this combined information, local regulations and predefined CCP policies, the CCP shall provide the needed configuration information to the MAC, which shall remotely configure all registered CMWCA and CMWD.

5.3.3.2 Management plane

The CCP shall reside in the management plane of the wireless communication application. The management SAP (M-SAP) may include, but is not limited to, primitives related to the following:

– general plant characterization;
– application communication requirements;
– communication system and device management;
– monitoring statistics;
– notifications/triggers;
– sensing management.

5.3.3.3 Control plane

The control plane shall be comprised of the spectrum sensing system (SSS) function and central coordination point (CCP) function. The SSS shall implement spectrum sensing algorithms and the RE shall provide the information to determine the location of the CMWCA and CMWD.

The CCP shall maintain medium availability information, manage channel lists, manage quiet periods, scheduling and implement coexistence mechanisms. The CCP shall also take requests from the MAC and PHY. For example, the MAC shall inform the CCP if an interference situation has been detected during normal operation in the channel. The CCP shall then take appropriate actions to resolve the issue such as moving to another channel. For this purpose, the CCP first requests sufficient idle time from the wireless communication application to perform an in-band sensing. It shall update the list of backup and candidate channels in a prioritized order. The CCP then ensures that the wireless communication application has sufficient idle time to select a sufficient number of backup channels. If an incumbent is found during in-band sensing, the MAC uses the corresponding service to inform the CCP to perform the switching operation.

C-SAP shall be used by the CCP to initiate channel move, to configure the spectrum sensing function at the wireless devices (backup or candidate channel list, specific channels to be sensed, etc.) as well as to gather information from the wireless devices (local sensing information, etc.).

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The C-SAP may include, but is not limited to primitives related to the following:

– subscriber and session management;
– medium resource report;
– sensing result.

5.4 System of wireless communication applications

5.4.1 CCP concept for sharing with incumbent radio systems

The CCP concept is intended to reduce the effort required to implement the necessary mitigation techniques for the used spectrum in each device. Another advantage of this approach is that the CCP can detect incumbent radio systems at the edges of the plant with a higher receiver sensitivity than the wireless devices can. While the location of a wireless device in a building depends on the automation application, SSNs can be placed in positions with optimal receiving performance.

If the available frequency band not used by incumbent radio systems is identified by the CCP, then the CCP shall calculate the most efficient spectrum assignments that can be assigned to the CCP managed wireless communication applications and CCP managed wireless devices based on their automation application requirements on communication needs.

Wireless communication applications in a factory environment may operate exclusively over one or more network access technologies and many of these applications may be capable of operating simultaneously in a factory environment.

An example of a CCP controlled WCA and incumbent services/applications within the 5,8 GHz WIA band is provided in Annex A.

Another example of a CCP controlled WCA is provided in Annex D.

5.4.2 Protection of incumbent radio systems

CCP controlled WCA employ centralized coordination with centralized or distributed spectrum sensing to identify free and occupied frequency ranges. The spectrum sensing node (SSN) may have multiple radio interfaces or a universal radio interface for monitoring a number of channels or frequency ranges simultaneously. It determines the operation of incumbent services on certain channels or frequencies. If available, SSF of the devices of the CMWCA can be used to obtain a more accurate status of the utilization of the medium, especially with respect to the spatial distribution.

To protect incumbent services and applications, an automated non-collaborative metrics-based coexistence management shall be used, as WCA and incumbent services/applications are not capable of exchanging information. Since they are fully independent, WCA ~~will have to~~ shall rely only on incumbent service/application detection and estimation. In other words, each potentially interfered WCA classifies the behaviour of the interfering incumbent services or applications and adapts its own behaviour to the new conditions.

5.4.3 CCP concept for intra-system coexistence

The intra-system coexistence, as achieved by the CCP concept, fulfils the viewpoint of an automatic adaptive coexistence management mechanism.

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The CCP shall organize the spectrum access for multiple WCA within the frequency band. Currently many coexistence issues and mitigation techniques exist, because there is no coordination between WCA. Therefore, WCA should use new intra-system coexistence schemes in order to optimize radio resource usage. These coexistence schemes can be enabled by a CCP. The CCP can provide assistance for wireless coexistence via the transmission of context information such as quality of service, priority of service, etc. and measurement results. The CCP also can enable control for multiple WCA.

The CCP organizes the simultaneous operation of multiple WCA and wireless devices in industrial environments. Therefore, the CCP, CCP controlled WCA and CCP controlled wireless devices shall provide a control channel for information collection from WCA and wireless devices to the CCP as well as to carry control or assistance information from the CCP to the WCA and wireless devices. In order to provide control or assistance services, the CCP performs decision making via a control channel. In order to provide information collection services, the CCP shall provide information on available WCA and wireless devices via a control channel. The control channel can use

– line-bound connections between CCP and CCP controlled WCA;
– wireless connections between CCP and CCP controlled WCA or CCP controlled wireless devices;
– wireless connections between CCP controlled WCA and CCP controlled wireless devices;
– wireless connections between CCP controlled WCA;
– wireless connections between CCP controlled wireless devices.

The CCP shall provide multi radio technology capability and a line-bound network access.

WCA in an industrial environment may operate exclusively over a single radio technology, but wireless devices within these networks may be capable of operating on multiple different radio technologies simultaneously. Therefore, multiple WCA control shall use the ability of specific wireless devices to communicate on more than one WCA in order to provide advanced services to WCA on which that device is not active. A device with multi-radio access capability can be used to provide assistance to WCA in an effort to coordinate transmissions across WCA and to improve the performance within a WCA. Intra-network wireless devices can exist that are capable to communicate with WCA 1 and also capable to communicate with WCA 2. This wireless device can be seen as marked in green in Figure 11. WCA with single radio access capability need assistance from CCP. The CCP manages the medium utilization of WCA by coordinating their transmissions.

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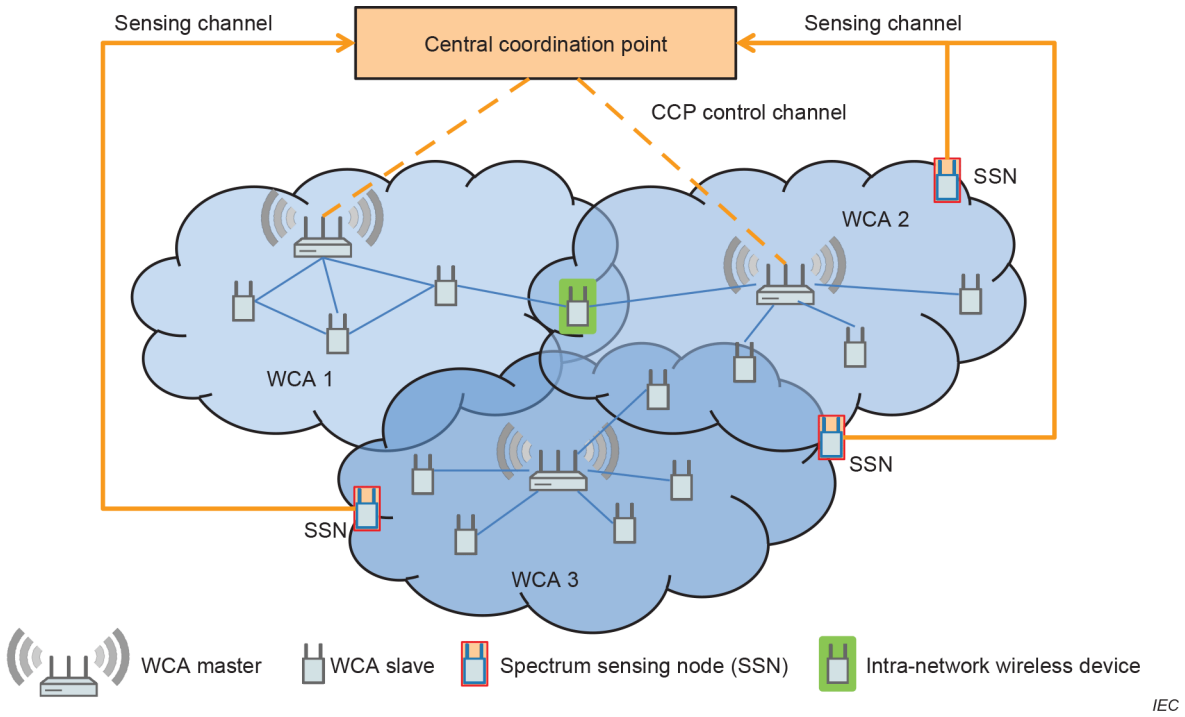

Figure 11 – CCP for intra-system coexistence

Conceptually, multi-radio access technology assistance or line-bound technology assistance helps to cooperate with coexistence issues not only by minimizing harmful interference, but also by expanding the services available to wireless devices and to include services from devices outside the local network. The services offered by every device are added to the CCP, but in order to access this CCP, a common control channel capable of WCA-agnostic communication is required.

WCA 1 (see Figure 11) or wireless devices belonging to WCA 1 can be requested to sense the operating channel of WCA 2 and report the results to a CCP. This could be useful for networks consisting of low-powered devices with limited sensing capability.

The CCP collects location information and operating characteristics of different WCA including the operating channel of the low complexity WCA. The CCP then instructs SSN or wireless devices to perform periodic sensing on the operating channel of the low complexity WCA with specific sensing algorithms applicable to detect low complexity WCA with low medium utilization. If harmful interference is detected, the CCP informs the low complexity WCA and instructs it to move to another operation channel provided no incumbent service is operating on that channel.

Optionally, the CCP can also instruct the SSN to monitor one or more alternative channels for the WCA. Once high interference is detected, the CCP can instruct the WCA to change the acting channels to a validated alternative channel. Hence, the service discontinuity, which occurs as a result of the harmful interference, is reduced at the WCA.

5.5 Interfaces

5.5.1 CCP

The CCP is interfaced to the AL, CS, MAC and PHY layer entities of the CCP managed wireless communication applications and devices through the two SAPs M-SAP and C-SAP. The M-SAP is used for less time sensitive management plane primitives and the C-SAP is used for more time-sensitive control plane primitives.

The CCP is interfaced to the SSN through the M-SAP and C-SAP. The M-SAP is used for the management plane primitives and the C-SAP is used for more control plane primitives.

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The CCP is interfaced to the database via the M-SAP, which used the management plane primitives.

The CCP is interfaced to the automation application via the M-SAP, which used the management plane primitives.

The CCP provides a user interface for management, control and engineering.

5.5.2 CCP managed wireless communication application and wireless device

The CCP managed wireless communication applications and wireless devices shall include a control-SAP (C-SAP) and management-SAP (M-SAP) that provide CCP access to the control plane and management plane functions.

The CMWD shall provide an interface to the automation application.

5.5.3 Database

The coordination database shall provide an M-SAP that provides CCP access to the database content.

The database provides a user interface for management, control and engineering.

5.5.4 Spectrum sensing system

The SSN and SSF shall provide a C-SAP that provides CCP access to the spectrum sensing results.

6 Parameter for coexistence assessment

Characteristic parameters are used to describe and assess the behaviour of the media access mechanism and the performance of the complete communication of a wireless solution. In this Clause 6, the characteristic parameters are specified to assess wireless communication systems and especially media access mechanisms with respect to industrial automation applications. The parameters can be distinguished in the description of the time and error behaviour and in measures concerning all kinds of spectrum efficiency.

The assessment of coexistence shall be done by using the parameters listed in Table 3.

Table 3 – List of parameters for coexistence assessment

Parameter name	Symbol	Unit	Data type
Data throughput	T_D	bit/s	REAL_MEASURE_TYPE
Communication availability			
Message loss ratio	MLR	%	REAL_MEASURE_TYPE
Number of consecutive lost messages	N_{SML}	.	INT_TYPE
Transmission time	t_{TT}	s	REAL_MEASURE_TYPE
Update time	t_{UT}	s	REAL_MEASURE_TYPE
Response time	t_{RT}	s	REAL_MEASURE_TYPE

The specifications of the parameters are provided in IEC 62657-2.

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7 Parameter for coexistence control

7.1 General

The values of the characteristic parameters are influenced by several parameters. That is why it is important to control and manage parameters and their values. The first set of influencing parameters is related to the application. This includes, for instance, the communication load. Another set of influencing parameters is related to the radio devices, e.g. the frequency band or transmission power. In 7.2 and 7.3, the relevant influencing parameters for the management and control of media utilization and coexistence are listed and declared.

This document describes general parameters for coexistence management. Depending on the specific radio technology, special resource allocation parameters could be available, for example, routing parameters of a mesh network. Other special parameters are available due to the evolution of radio technologies, for example parameters for frequency-time resource block assignments or for beamforming of smart antenna types.

NOTE The tools supporting the CCP can also be based on the catalogue data definitions and specifications given in the IEC 61360 series and the data base, called common data dictionary (~~CCD~~ IEC CDD), filled with the classes and properties of the IEC 62657 series. Annex B provides an overview of the processes by which the content of the IEC CDD can be filled and used in an application. Annex C provides templates as a possible basis to fill the IEC CDD with the parameters used in the services of this document.

7.2 Application parameter

The CCP can control the application parameters for coexistence control in Table 4. Especially in the context of smart manufacturing, there is the possibility to efficiently use communication resources according to the flexible changing requirements of the application.

Table 4 – List of application parameters for coexistence control

Parameter name	Symbol	Unit	Data type	Description
Communication load	A_{CL}	bit/s	REAL_MEASURE_TYPE	Communication load per communication link
Initiation of data transmission	A_{IDT}	-	ENUM_STRING_TYPE	Type of initiations of data transmission for each automation device for communication link
Length of user data per ~~transmission~~ transfer interval	A_{LUD}	octet	INT_TYPE	Length of user data for each automation device for communication link
Transfer interval	A_{TI}	s	LEVEL(MAX) of REAL_MEASURE_TYPE	Transfer interval for each automation device for communication link

The specifications of the parameters are provided in IEC 62657-2.

7.3 Radio parameter

The CCP can control the radio parameters for coexistence control in Table 5.

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Table 5 – List of radio parameters for coexistence control

Parameter name	Symbol	Unit	Data type	Description
Frequency band				
Lower cut-off frequency	f_{BL}	Hz	REAL_MEASURE_TYPE	Lower cut-off frequency of frequency band
Upper cut-off frequency	f_{BU}	Hz	REAL_MEASURE_TYPE	Upper cut-off frequency of frequency band
Frequency channel				
Centre frequency	f_C	Hz	REAL_MEASURE_TYPE	Centre frequency of frequency channel
Bandwidth	BW	Hz	REAL_MEASURE_TYPE	Bandwidth of frequency channel
Lower cut-off frequency	f_{CL}	Hz	REAL_MEASURE_TYPE	Lower cut-off frequency of frequency channel
Upper cut-off frequency	f_{CU}	Hz	REAL_MEASURE_TYPE	Upper cut-off frequency of frequency channel
Type of radio channel identification	Ch		ENUM_STRING_TYPE	Radio channel number or identification of frequency channel
Power spectral density	PSD	dBm/Hz	REAL_MEASURE_TYPE	PSD of frequency channel
Number of frequency hopping channels	N_{HC}	-	INT_TYPE	Number of frequency channels for frequency hopping
Dwell time	t_{dwell}	s	LEVEL(MAX) REAL_MEASURE_TYPE	Time period of frequency hopping
Operational frequency channel				
Type of frequency channel identification			ENUM_STRING_TYPE	Centre frequency of frequency channels for operation
Blocked frequency list				
Type of frequency channel identification			ENUM_STRING_TYPE	Centre frequency of blocked frequency channels
Transmit power				
Equivalent isotropic radiated power	EIRP	W	REAL_MEASURE_TYPE	EIRP of radio device
Equivalent radiated power	ERP	W	REAL_MEASURE_TYPE	ERP of radio device
Transmitter output power	P_{out}	W	REAL_MEASURE_TYPE	Transmit output power of radio device
Channel occupancy time				
Duty cycle	DC	%	LEVEL(MAX)REAL_MESURE_TYPE	Duty cycle per communication link
Transmitter sequence	t_{seq}	s	LEVEL(MAX)REAL_MESURE_TYPE	Transmitter sequence per wireless device
Maximum number of retransmissions	N_{RT}	-	LEVEL(MAX)INT_MESURE_TYPE	Maximum number of retransmissions per wireless device
Mechanisms for adaptivity			ENUM_STRING_TYPE	Mechanisms for adaptivity per wireless system
CCP	-	-	Char	A central systems element controls the medium utilization.
DAA	-	-	Char	If the channel is occupied, change the channel (for example AFH~~)~~).
DAR	-	-	Char	If the channel is occupied, reduce the output power.
DAS	-	-	Char	If the channel is occupied, don't transmit (for example listen before talk). The Clear Channel Assessment might be an equivalent term but is a precondition.

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The specifications of the parameters are provided in IEC 62657-2.

8 Management and control services

8.1 General

The primitive name defined on the SAP consists of three fields – SAP, Function, and Operation:

a) SAP
   - C-SAP: Control plane SAP;
   - M-SAP: Management plane SAP;

b) Function
   - Application communication requirements management;
   - Wireless communication system and device subscription;
   - Wireless communication system and device configuration and control;
   - Medium resource management;
   - Database access;

c) Operation
   - REQ – Request;
   - RES – Response to the REQ message;
   - CONF – Confirmation;
   - IND – Event notification.

The CCP, CCP managed wireless communication applications (CMWCA) and CCP managed wireless devices (CMWD), the SSN and the database can send these primitives depending on the functional behaviour defined for M-SAP and C-SAP.

– A service primitive of type REQ is used whenever a response to the primitive is solicited. If there is an REQ message, it is generally mapped to a REQ on C-SAP/M-SAP.
– A service primitive of type RSP is used in response to a REQ primitive. Moreover, if there is an RSP message, it is generally mapped to an RSP on C-SAP/M-SAP.
– A service primitive of type IND is used at C-SAP or M-SAP for event notification if a response to this primitive is not solicited, and if the primitive is not sent in response to an REQ primitive.

The specific usage of these operation types for the respective control and management functions is specified in 8.2 to 8.6.

8.2 Application communication requirements management services

8.2.1 Supported services

This Subclause 8.2 contains the definition of services that are unique to this application communication requirements management (ACRM) service. The services defined for this ACRM are:

– GetGeneralPlantCharacteristic, see 8.2.2;
– SetGeneralPlantCharacteristic, see 8.2.3;
– GetApplicationCommunicationRequirements, see 8.2.4;
– GetApplicationCommunicationStatus, see 8.2.5;
– SetApplicationCommunicationReport, see 8.2.6 and
– NotificationApplicationCommunicationstatus, see 8.2.7.

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8.2.2 GetGeneralPlantCharacteristic

8.2.2.1 Service overview

GetGeneralPlantCharacteristic service is a confirmed service and uses the M-SAP. The CCP sends the GetGeneralPlantCharacteristic service request attempts to the database. The primitive flow of GetGeneralPlantCharacteristic service is depicted in Figure 12. Legacy engineering and database implementation should be supplemented by a software module for this service.

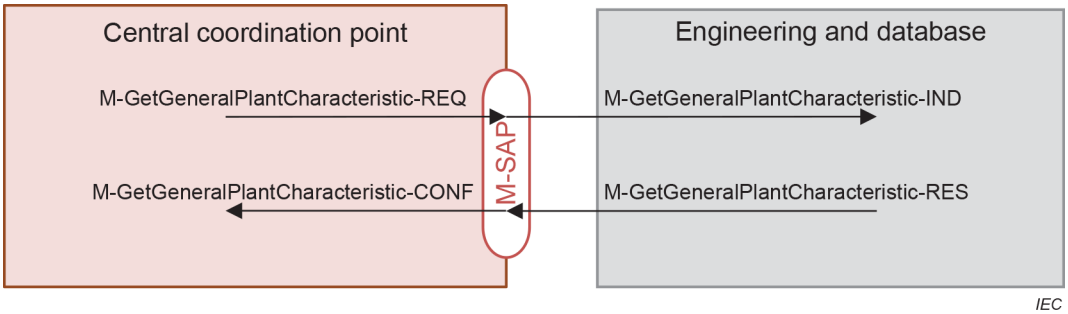

Figure 12 – Primitive flow of GetGeneralPlantCharacteristic

8.2.2.2 Service primitives

The service parameters for GetGeneralPlantCharacteristic service are shown in Table 6.

Table 6 – GetGeneralPlantCharacteristic service parameters

Parameter name	Request	Indication	Response	Confirm
Argument				
Destination address	M	M(=)		
Result (+)			S	S(=)
CCP address			M	M(=)
Attribute data			M	M(=)
Regional radio regulations			M	M(=)
Future expansion plan			M	M(=)
Area of operation			M	M(=)
Object movement			M	M(=)
Geographical dimension of the plant			M	M(=)
Natural environmental condition			M	M(=)
Intervisibility			U	U(=)
Frequency band			M	M(=)
Wireless communication solution density			M	M(=)
Interference type			M	M(=)
Limitation from neighbours of the plant			M	M(=)
Result (-)			S	S(=)
Service status			M	M(=)

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Argument

The argument contains the parameters of the service request.

Destination address

This parameter specifies the destination address to which the service request is to be sent.

Result (+)

This selection type parameter indicates that the service request succeeded.

CCP address

This parameter specifies the address of the requested CCP. It is present in the response primitive.

Attribute data

This parameter returns a stream of information containing all the attributes.

– regional radio regulations;
– future expansion plan;
– area of operation;
– object movement;
– geographical dimension of the plant;
– natural environmental condition;
– intervisibility;
– frequency band;
– wireless communication solution density;
– interference type;
– limitation from neighbours of the plant.

Result (-)

This selection type parameter indicates that the service request failed.

Service status

This parameter provides information on the result of service execution. It shall be one of ABORTED or TIMEOUT.

8.2.2.3 Service procedure

The GetGeneralPlantCharacteristic request shall send a message to the database, which contains the general plant characteristic from the engineering. When the message arrives at the target device (database), this shall result in a GetGeneralPlantCharacteristic indication at the database. The database, in turn, shall forward the message to the appropriate target object. When the object responds, the database shall forward the response via the GetGeneralPlantCharacteristic response primitive. When the response arrives at the CCP which originated the request, a GetGeneralPlantCharacteristic confirmation shall be returned to the application object which sent the request. The application delivers the requested attributes for plant characterization.

8.2.2.4 Service sequence

The service sequence of GetGeneralPlantCharacteristic service is shown in Figure 13. Alt in the figure means a conditional branch on the service sequence.

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