Wireless Network (WLN) Standard

Part I: Medium Access Control and Physical Layer

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1 SCOPE

This document defines the physical layer (PHY) and the medium access control (MAC) sub layer of the Wireless Network (WLN). The WLN is a protocol for short range wireless communication developed primarily for use in military training simulators. The WLN uses carrier sense multiple access with collision avoidance and supports peer-to-peer as well as broadcast transmissions.

The WLN supports a data rate of 25 kbit/s and is designed for two frequency bands; 868 - 870 MHz and 902 - 928 MHz. The 868 - 870 MHz frequency band is dedicated for short-range devices and is approved in most European countries. While the 902 - 928 MHz frequency band is used for example in the USA and Australia. The WLN is compliant with the standards for electromagnetic compatibility (EN 300 220 [1], FCC method 47CFR/part 15 [2]) and the spectrum management requirements for short range devices (ERC 70-03 [3]).

1.1 Document overview

This document defines the PHY layer and MAC sub layer of the WLN and is divided into the following sections:

– Section 2 contains identification of reference documents.
– Section 3 contains definitions used in this document.
– Section 4 is the introduction chapter.
– Section 5 describes the PHY layer specification.
– Section 6 describes the MAC sub layer specification.
– Section 7 describes message sequence charts illustrating MAC-PHY interaction.

1.2 Revision history

Edition	*Date*	*Summary*
A	2010-10-19	First draft
B-	2011-02-10	Changed footer formulation

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2 REFERENCED DOCUMENTS

Ref.	*Reg. No.*	*Name of document*	*Issue*
<1>		Draft ETSI EN 300 220-1 Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW; Part 1: Technical characteristics and test methods	
<2>		FCC method 47CFR/part 15	
<3>		ERC RECOMMENDATION 70-03; RELATING TO THE USE OF SHORT RANGE DEVICES (SRD); Recommendation adopted by the Frequency Management, Regulatory Affairs and Spectrum Engineering Working Groups	
<4>		*Radio Regulations*, International Telecommunication Union (ITU), Geneva.	
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3 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

3.1 Abbreviations

ASB	application specific beacon
BCS	block checksum
BER	bit error rate
BFSK	binary frequency shift keying
CCA	clear channel assessment
CSMA-CA	collision sense multiple access with collision avoidance
dBm	decibel relative to a milliwatt
DC	direct current
EIRP	effective isotropic radiated power
EOM	end of message
FEC	forward error correction
FSK	frequency shift keying
HD	hidden device
ISO	international organization for standardization
ITU	international telecommunication union
LSB	Least significant bit
LSO	Least significant octet
MAC	Medium access control
MCS	Message checksum
MFR	MAC footer
MHR	MAC header
MIB	MAC sub-layer information base
MMSP	MAC management service request
MPDU	MAC protocol data unit
MSAP	MAC service access point
MSB	most significant bit
MSO	most significant octet
OSI	open systems interconnection
PAN	personal area network
PD	public device
PFR	PHY footer
PHY	physical layer
PIB	physical layer information base
PMSP	PHY management service request
PPDU	PHY protocol data unit
PSAP	PHY service access point
RF	radio frequency
RSSI	received signal strength indication
RX	receive or receiver
SHR	synchronization header

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STM	start of message
TX	transmit or transmitter
UART	universal asynchronous receiver/transmitter
UPDU	upper layers protocol data unit
WLN	wireless network

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4 GENERAL DESCRIPTION

4.1 Introduction

The Wireless Network (WLN) is a simple, low cost personal area network (PAN), used for communication between military training simulators, user interfaces and sensors to enable gunnery and tactical training for armies and Special Forces. The main requirements are ease of installation, short range transmission, and long battery life, while maintaining a simple and flexible network protocol without any need for infrastructure.

Some of the characteristics of WLN are as follows:

- Asynchronous packet data network
- 16-bit address
- Over-the-air-data rate of 25 kbit/s
- Very low power consumption
- Received signal strength indication (RSSI)
- Carrier sense multiple access with collision detection (CSMA-CA) channel access
- Up to 19 channels in the 868 MHz frequency band and 259 channels in the 915 MHz frequency band

There are two different WLN device types: a public device (PD) and a hidden device (HD). A PD is characterized by the possibility of being contacted at any time while an HD lacks this ability. The PD can operate in three different modes serving as associator, associated or independent device, while the HD can only operate in an associated mode. A PD communicates with other PDs while an HD communicates strictly with a PD. An HD is intended for applications with high demand on low power consumption such as small arms simulators, sensors, etc.

4.2 Network overview

WLN is an asynchronous, bi-directional, short-range, packet data network that provides multi-access between the different devices that form the training system. WLN uses two frequency bands: 868 MHz and 915 MHz frequency bands. The 868 MHz frequency band (868 - 870 MHz) is dedicated for short-range devices and is approved in most European countries, while the 915 MHz band (902 - 928 MHz) is used, for example, in the USA and Australia. WLN is compliant with the standards for electromagnetic compatibility (EN 300 220 [1], FCC method 47CFR/part 15 [2]) and the spectrum management requirements for short range devices (ERC 70-03 [3]).

The system is designed for radio communication between network devices at a distance ranging typically from 2 m to 50 m. The actual range depends upon the application and the used transmitting power. On some defined frequencies, whenever transmitting power regulations permit, a long communication range of 5000 meters can be attained. However, a well-defined coverage area does not exist for wireless media because propagation characteristics are dynamic and uncertain. Small changes in position or direction may result in

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drastic differences in the signal strength. These effects occur whether a device is stationary or mobile.

Depending on the application requirements, a WLN may operate in two topologies: the star (star of star) topology or loose ad-hoc topology. Both topologies are shown in Figure 4.1.

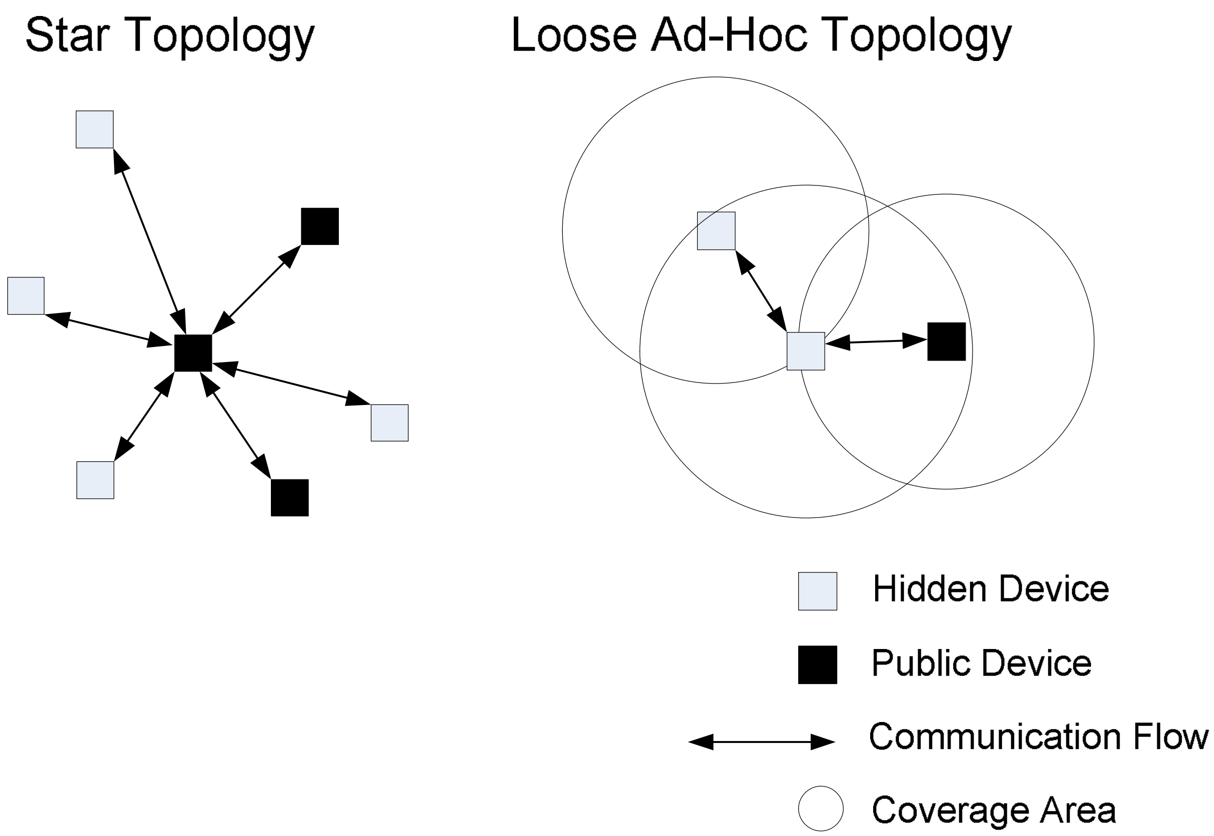

Figure 4.1. WLN topologies: star topology (left) and loose ad-hoc topology (right).

In the star topology, the communication is established between associated devices and a single central device. The associated devices can be both PD and HD and have some embedded application and are either the initiation point or the termination point for network communications. The central node is always a PD that has also a specific application coupled to it and it can be used to initiate, terminate, or route communication around the network.

The loose ad-hoc topology is a topology where no central device is designated and any device may communicate with any other device as long as they are in range of one another. No association is required and all devices are either the initiation point or the termination point for network communication.

4.3 Network architecture

The architecture of WLN is defined in terms of layers which are defined by the Open Systems Interconnection (OSI) seven-layer model developed by the International Organization for Standardization (ISO). Each layer is responsible for a part of the standard and offers services to the higher layers. This document describes the two lowest layers of the OSI model defining

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the WLN: the physical layer (PHY) and the medium access control sub layer (MAC). These two layers cooperate and offer the services needed by the upper layer (e.g. application layer) in order to build up a WLN PAN.

In WLN, PHY contains the radio frequency (RF) transceiver along with its low-level control mechanism which enables the transmission and reception of PHY protocol data units (PPDU) across the physical channel. The PHY is accessed by the MAC through a PHY service access point (PSAP) which enables the transmission and reception of MAC protocol data units (MPDU) and PHY management service requests (PMSP). The MAC provides access to the physical medium and it is accessed from upper layers by a MAC service access point (MSAP) which enables the transmission and reception of upper layers protocol data units (UPDU) and MAC management service requests (MMSP), see Figure 4.2. The MMSP and PMSP are messages used to manage different settings within the MAC sub layer and PHY layer, respectively. The UPDU, MPDU and PPDU are messages used to send data between WLN devices.

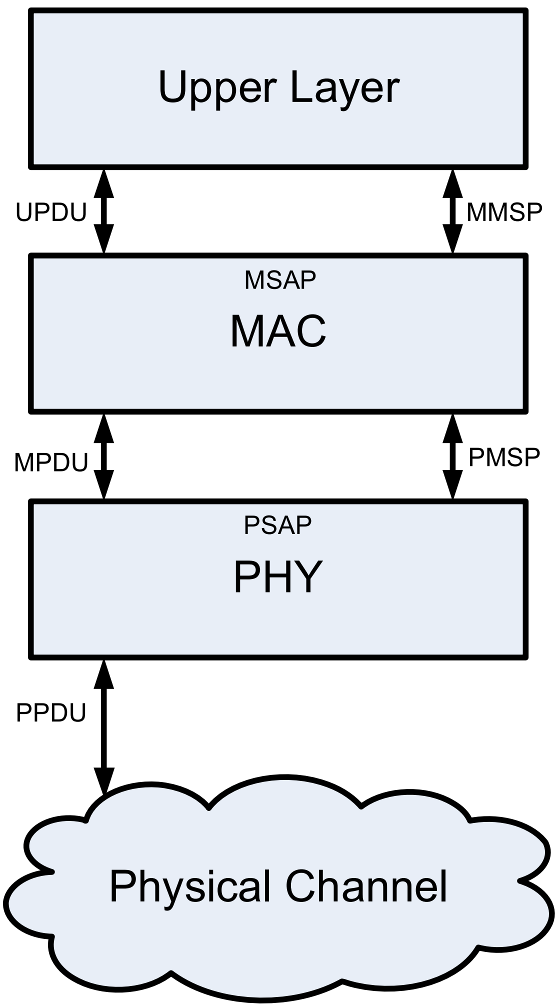

Figure 4.2. Network architecture of WLN.

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The PHY layer provides the following services:

- Activation and deactivation of the radio transceiver
- Received signal strength indication (RSSI)
- Channel selection within specified band: 868 - 870 MHz (e.g. Europe) or 902 - 928 MHz (e.g. North America)
- Forward error correction
- Clear channel assessment (CCA)
- Transmitting and receiving of PPDUs

The MAC sub layer provides the following services:

- Channel access
- Message filtering
- Error detection
- Device power management by duty cycling
- Application specific beacon management
- Application specific filtering
- Transmitting and receiving of MPDUs using the PHY layer

4.4 Functional overview

A brief overview of the general function of a WLN PAN is given in following sections and includes: the data transfer model, the representation and transmission order of data, the data frame structure, channel access mechanism, data verification, and power consumption considerations.

4.4.1 Data transfer model

There is a single type of data transfer transaction that is used for data transfer between network devices in a WLN PAN with star topology or peer-to-peer topology. When a given network device, network device 1, wishes to transfer data to another network device, network device 2, it simply transmits its data frame, using CSMA-CA, see Figure 4.3.

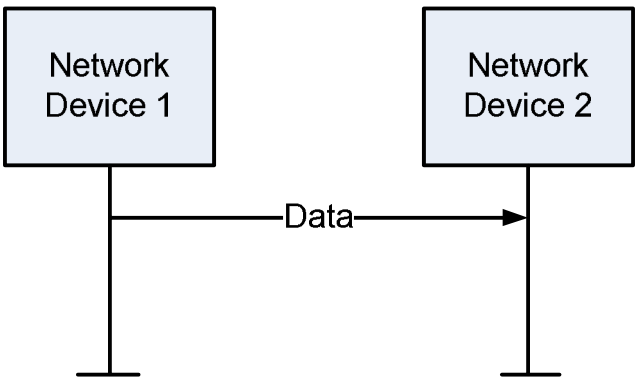

Figure 4.3. Data transfer model of WLN.

However, the data frame is preceded by a preamble period of variable lengths in order to establish synchronization between network devices. This is further discussed in section 5.3.1.

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4.4.2 Representation and transmission order of data

Whenever an octet (8 bits) represents a numeric quantity, the left most bit in the diagram shall represent the high order or most significant bit (MSB). That is, the bit labeled 7 is the MSB. For example, Figure 4.4 represents the decimal value 234.

Bit No	7	6	5	4	3	2	1	0
Bit Value	1	1	1	0	1	0	1	0

Figure 4.4: Significance of bits.

Similarly, whenever a multi-octet field represents a numeric quantity, the left most bit of the whole field shall be the MSB. When a multi-octet quantity is transmitted, the most significant octet (MSO) is transmitted first while the least significant octet (LSO) is transmitted last, see Figure 4.5. The framework for all data on the radio channel follows the standard for asynchronous serial communication using 1 start bit, 1 stop bit and 8 data bits (no parity). Least significant bit (LSB), i.e. bit labeled 0, is the data bit that is transmitted first, preceded by the start bit. The start and stop bits are used to enable the possibility of using a standard UART for handling of the bit stream on lowest level.

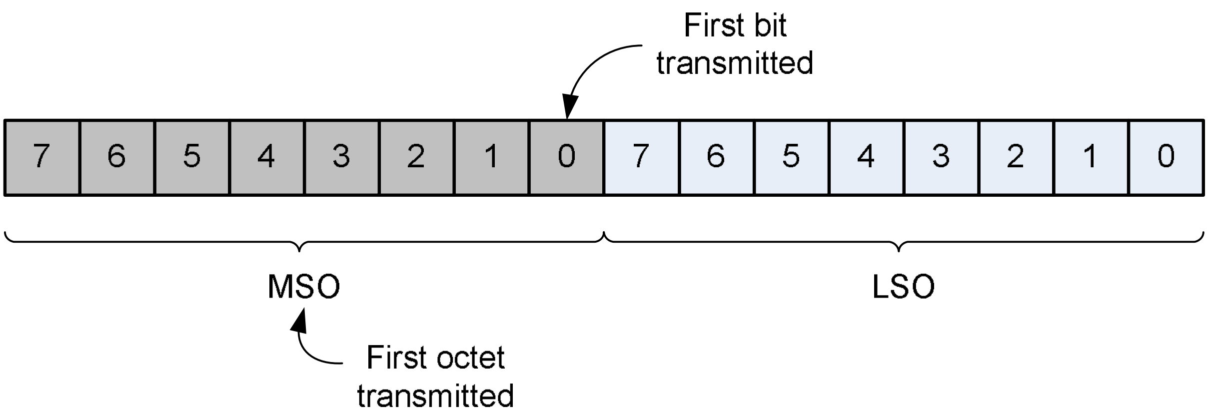

Figure 4.5: Order of octets

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4.4.3 Frame structure

The frame structures have been designed to keep the complexity to a minimum in order to reduce cost and power consumption. Each protocol layer adds to the structure with layer-specific headers and footers. This document defines two frame structures: An application specific beacon (ASB) frame and a data frame.

4.4.3.1 Application specific beacon (ASB) frame

Figure 4.6 shows the structure of the ASB frame, which originates from the MAC sub layer.

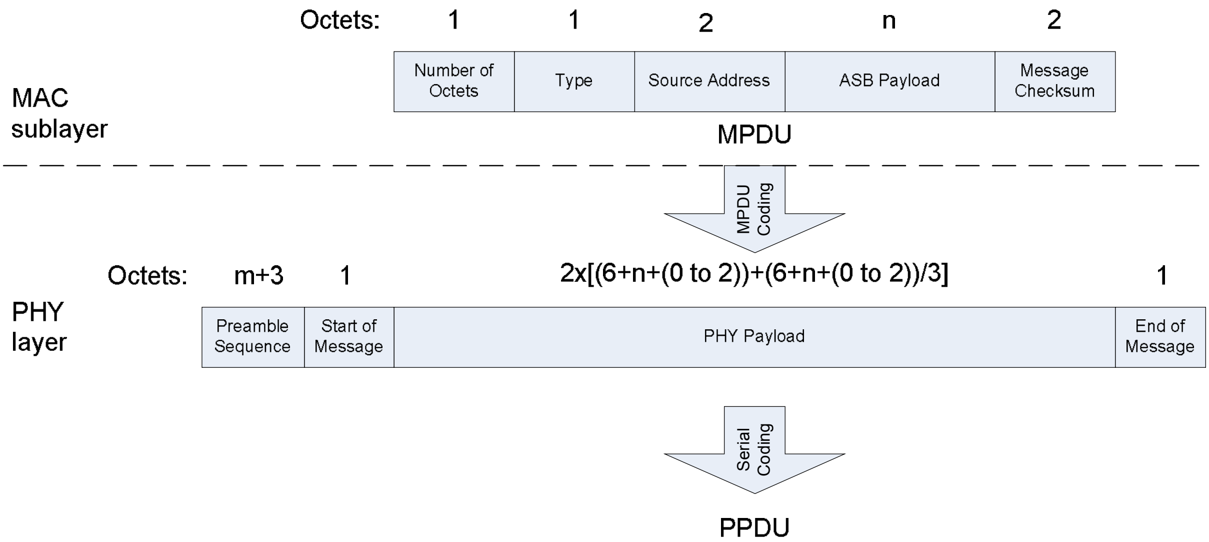

Figure 4.6. The structure of an application specific beacon (ASB) frame.

The ASB payload, with a maximum length of 66 octets ($n \leq 66$), is passed to the MAC sub layer from upper layers and stored within the MAC. The ASB payload is prefixed by header and appended by footer, thus creating a MAC protocol data unit (MPDU). The header contains the length of MPDU in octets, the type field and the addressing field of the source node. The footer contains a 16-bit message checksum (MCS) field.
The MPDU is passed to the PHY where a first step of block coding is applied thus creating the PHY payload. The block coding scheme is described in section 5.3.3.1. A header and footer are then added in a second step and finally a serial coding scheme is applied. The result frame is referred to as a PHY protocol data unit (PPDU). The header of the PPDU contains the preamble sequence with a maximum length of 250 octets ($m \leq 247$), and the start of message fields, while the footer contains an end of message field. The serial coding scheme is described in section 5.3.5.

4.4.3.2 Data frame

Figure 7 shows the structure of the data frame, which originates from the upper layers.

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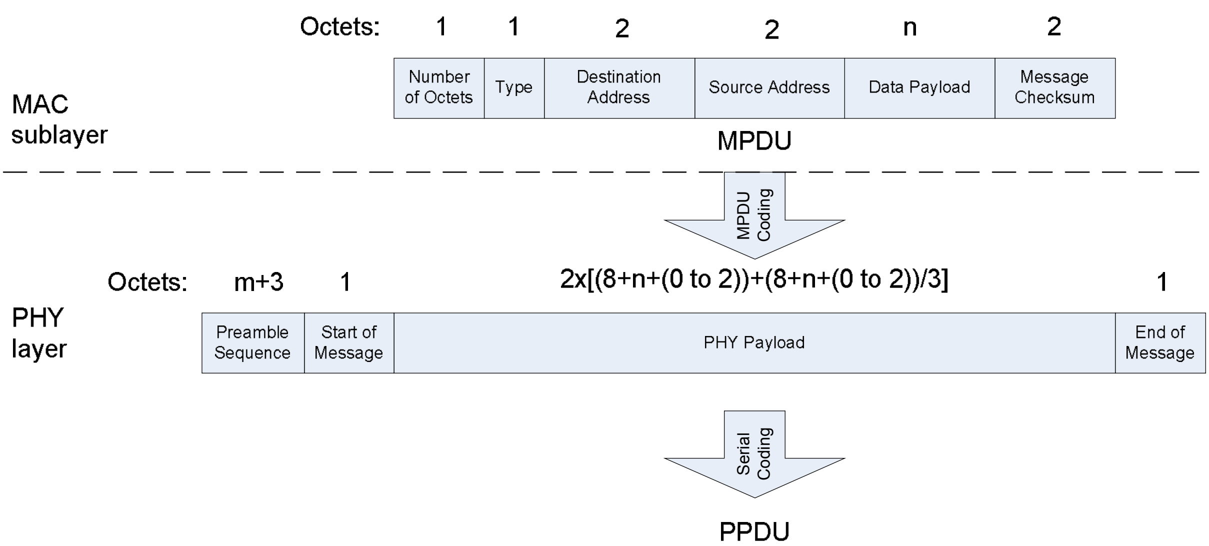

Figure 7. The structure of a data frame.

The data payload has a maximum length of 66 octets ($n \leq 66$) and is passed to the MAC sub layer where header and footer are added and the result frame is referred to as a MAC protocol data unit (MPDU). The header of the MPDU contains the length of the MPDU in octets, the type field, the addressing field of the destination node and the addressing field of the source node. The footer contains a 16-bit MCS.

The MPDU is passed to the PHY where a first step of block coding is applied thus creating the PHY payload. The block coding scheme is described in section 5.3.3.1. A header and footer are then added in a second step and finally a serial coding scheme is applied. The result frame is referred to as a PHY protocol data unit. The header of the PPDU contains the preamble sequence with a maximum length of 250 octets ($m \leq 247$), and the start of message fields, while the footer contains an end of message field. The serial coding scheme is described in section 5.3.5.

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4.4.4 Channel access mechanism

The WLN PAN devices use CSMA-CA channel access mechanism, as described in section 6.1.1. The method of accessing the radio channel is that a given device, wishing to transmit ASB or data frames, listens to the channel for a defined backoff period of time. If the channel is found to be idle, following the back off period, the device transmits its data. If the channel is found to be busy the device waits for a random period of time before accessing the channel again. The random period of time reduces the collision risk. This risk is further reduced by controlling the coverage area through adjustment of the transmitting power. Theoretically, the network allows 65533 individual devices, due to the used 16-bit addressing field. However, the WLN PAN will be able to operate normally, without excessive collisions, when at most 50 devices are communicating within the same coverage range.

4.4.5 Data verification

In order to detect bit errors within received frames, a message checksum mechanism, as described in section 6.1.3, is used within the MAC sub layer. Furthermore, additional error detection is added within the PHY layer when applying the block coding scheme to MPDUs, as described in section 5.3.6.

4.4.6 Power consumption considerations

The majority of applications that uses WLN are battery powered, i.e. battery replacement or recharging in relatively short intervals is impractical. Therefore, the WLN protocol was developed to include several low power strategies: duty cycling and message filtering.

4.4.6.1 Duty cycling

The duty cycling is a method to reduce power consumption by letting the WLN device to enter sleep state periodically for a given period of time. However, in order to synchronize transmission between the devices, the sending device has to transmit a preamble sequence that is, at least, as long as the sleep period. The protocol allows two different sleeping periods with a possibility to disable the duty cycling. This mechanism allows the application designer to decide on the balance between battery consumption and message latency. Devices with larger batteries or abundant power supply have the option of listening to the RF channel continuously.

4.4.6.1.1 Operating states

A WLN device can operate in 4 operating states: sleep, idle, receive, and transmit, see Figure 8. The sleep state is the state with the lowest power consumption where no activity can occur. The idle state is when the device is listening to the RF channel and the channel is free. A duty cycle is defined as the periodic switching between sleep and idle state. The receive state and transmit state are the states when receiving and transmitting data, respectively.

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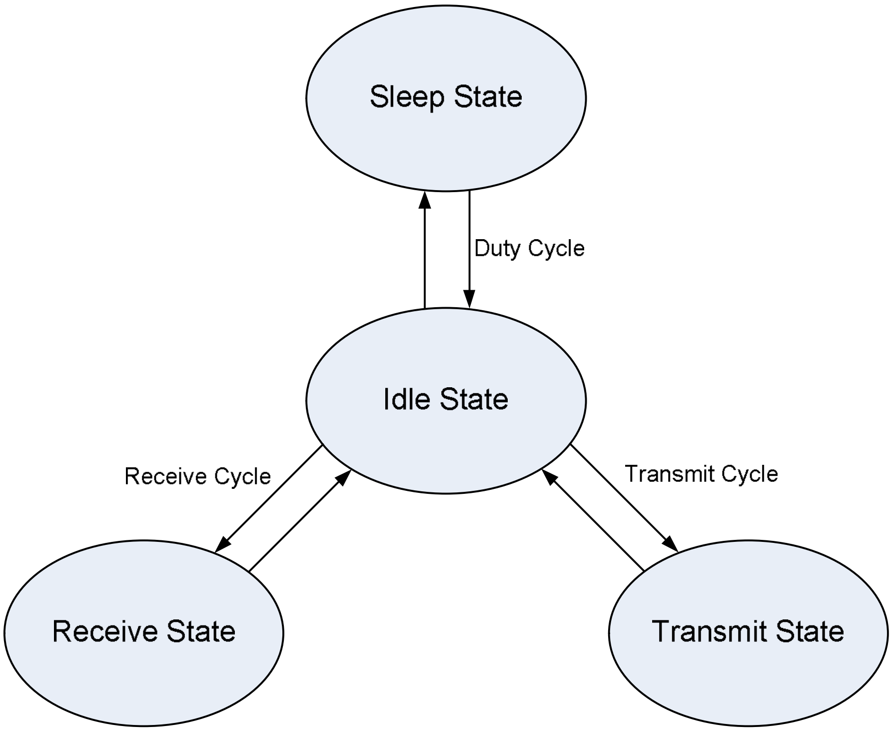

Figure 8. The different operating states of a WLN device.

4.4.6.2 Message Filtering

The message filtering is a service offered by the MAC sub layer to the upper layer where certain types of messages as well as messages with low RSSI values are not passed forward. This reduces the processing time of the application and lets the application processing unit to be in sleep state, thus reducing the power consumption.

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4.5 Concept of primitives

Each protocol which communicates in a layered architecture (e.g. based on the OSI Reference Model) communicates in a peer-to-peer manner with its remote protocol entity. Communication between adjacent protocol layers (i.e. within the same device) is managed by calling functions, called primitives, between the layers. There are various types of actions that may be performed by primitives. Examples of primitives include: read, write, data, etc. Each primitive specifies the action to be performed or advises the result of a previously requested action. A primitive may also carry the parameters needed to perform its functions. One parameter could for example be the packet to be sent/received to/from the layer above/below. There are four types of each primitive used for communicating data, see Figure 9. The four basic types are:

- Request: A primitive sent by layer N+1 to layer N to request a service. It invokes the service and passes any required parameters.
- Indication: A primitive returned to layer N+l from layer N to advise of activation of a requested service or of an action initiated by the layer N service.
- Response: A primitive provided by layer N+1 to layer N in reply to an indication primitive. It may acknowledge or complete an action previously invoked by an indication primitive.
- Confirm: A primitive returned to the requesting layer N+l by layer N to acknowledge or complete an action previously invoked by a request primitive.

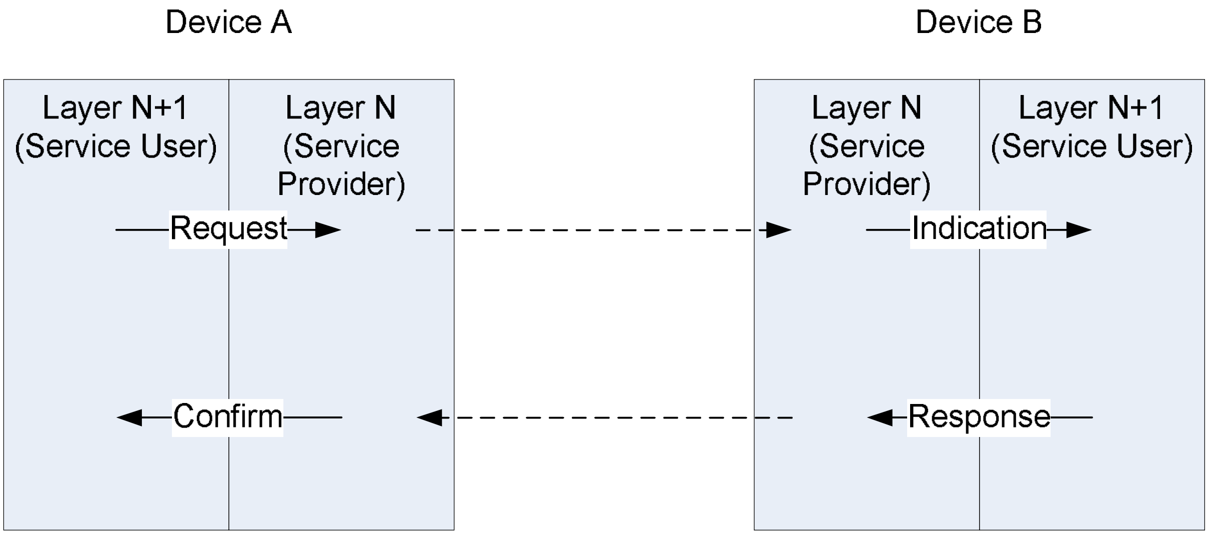

Figure 9. The different types of primitives.

In order to send data, the sender invokes a DATA.request specifying the packet to be sent at the service access point of the layer below. When the packet is successfully sent, a DATA.confirm is issued by the lower layer at the sender in order to acknowledge the DATA.request. At the receiver, a DATA.indication primitive is passed up to the corresponding higher layer, presenting the received packet. A DATA.response is then issued by the higher layer to acknowledge the DATA.indication.

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5 PHY SPECIFICATION

5.1 General requirements and definitions

The PHY is responsible for the following tasks:

- Activation and deactivation of the radio transceiver
- Received signal strength indication (RSSI)
- Channel selection within specified band: 868-870 MHz (e.g. Europe) or 902-928 MHz (e.g. North America)
- Forward error correction
- Clear channel assessment (CCA)
- Transmitting and receiving of PPDUs

5.1.1 Operating frequency range

A WLN device can operate in two frequency bands: 868 MHz (868-870 MHz) and 915 MHz (902-928 MHz). The frequency setting within the PHY should be able to be reconfigured in order to switch channel used for transmission.

5.1.2 FSK modulation

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. WLN uses the binary FSK (BFSK) which implies using a pair of discrete frequencies to transmit binary (0s and 1s) information.

5.1.2.1 Implementation considerations

The transmission frequencies used within the BFSK modulation are: the carrier frequency ±35 kHz. The type of emission designation is 90K0F1D according to the ITU scheme [4]. A logic "1" is represented by adding 35 kHz to the carrier frequency while a logic "0" is represented by subtracting 35 kHz from the carrier frequency. The PPDUs to be transmitted are coded in a way that symmetry is achieved and the baseband signal has no DC-offset. This is achieved by Manchester encoding of the MPDUs described in the block coding scheme, see 5.3.3.1. However the preamble, start of message and end of message fields remain uncoded. The symbols defining these fields are chosen so that they consist of equal numbers of 0s and 1s.

5.1.2.2 Data rate

The bit rate of the radio channel raw data is 25 kbit/s. The effective transmission bit rate within a message is approximately 8 kbit/s.

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5.1.3 Channel assignments

The available frequency bands are divided into 278 channels (19 channels in the 868 MHz band and 259 channels in the 915 MHz band) at specific frequencies. The carrier frequencies, F_c, of each of the channels are defined as follows:
F_c=868.1 + 0.1k in MHz, for k=0,1, …, 18 (868MHz band)
F_c=902.1 + 0.1(k-19) in MHz, for k=19, 20, …, 277 (915MHz band)

5.2 General radio specifications

To ensure correct balance in the network, it's important that every WLN device is designed to have almost the same sensitivity and power output. The WLN standard is designed to respect fundamental recommendations given by ERC 70-03.

5.2.1 Transmit power

The transmit power used in the standard WLN is adjustable. WLN supports a variable power level. The nominal transmitted effective isotropic radiated power (EIRP) is 250 µW (-6 dBm) while the lowest transmitted EIRP is defined as 50 nW (-45 dBm) or lower. The tolerance of the transmitted EIRP is ±2 dBm. The maximal transmitted power is indicated by *pMaxTransmitPower*, see Table 5.3.

5.2.2 Receiver sensitivity

The receiver sensitivity is better than -87 dBm (typically -90 dBm) at 3% BER, measured at antenna connector.

5.2.3 TX-to-RX and RX-to-TX turnaround time

The Tx-to-Rx turn around time is defined as the time for a WLN device to switch from transmitting (TX) to listening (RX) and vice versa from RX to TX. This time interval represents the time when the WLN device does neither transmit nor listen. Both the TX-to-RX and the RX-to-TX turnaround time are less than 2.0 ms.

5.2.4 Received signal strength indicator (RSSI)

The received signal strength indicator provides a voltage that is proportional to the RF input level. The relative change of the RSSI value is approx. 1.5 per dBm with a fast response time (1 µs per -20 dBm to off step). The tolerance of the relative change is ±1. The RSSI for a received PPDU is calculated as the average of the measured voltage within the reception time of the PPDU. An RSSI value of 110 corresponds to an EIRP of -60 dBm.

5.2.5 Clear channel assessment (CCA)

The CCA is performed within the PHY and is based on detecting an ongoing message transmission on the channel. The CCA reports busy channel upon the detection of a signal compliant to the WLN standard within the time period of *pCCATimePeriod*, see Table 5.3.

5.3 PPDU format

The PPDU packet structure is presented so that the leftmost field as written in this standard shall be transmitted or received first. All multiple octet fields, payload excluded, shall be transmitted or received most significant octet first and each octet shall be transmitted or

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received least significant bit (LSB) first. The same transmission order should apply to data fields transferred between the PHY and MAC sub layer.
Each PPDU packet consists of the following basic components:

- A synchronization header (SHR) consisting of variable length of preamble octets and a start of message (STM) character and, which allows a receiving device to synchronize and lock onto the bit stream
- A variable length payload, which carries the coded MAC sub layer frame
- A PHY footer (PFR), containing an end of message (EOM) character, which allows the PHY layer to detect the end of a packet and transfer the data payload to the MAC layer

The PPDU packet structure shall be formatted as illustrated in Figure 5.1.

Octets:	Variable	1	Variable	1
	Preamble	STM	PHY payload	EOM
	SHR			PFR

Figure 5.1. PPDU format.

5.3.1 Preamble field

Preamble is used to alert receiving devices that a message is about to be transmitted. WLN-devices can be in various duty cycle modes and the preamble must be long enough to wake up the receiver devices. A preamble octet is defined by the following bit pattern, see Figure 5.2.

Bit No	7	6	5	4	3	2	1	0
Value	1	1	1	1	0	0	0	0

Figure 5.2. Definition of the preamble octet.

Three lengths of preamble can be selected:

- No preamble (1 ms, a string of 3 octets)
- Short preamble (15 ms, a string of 38 octets)
- Long preamble (100 ms, a string of 250 octets)

No preamble is selected when a high throughput and low latency are essential. Short preamble is the normal mode of operation and should be used by default unless other specified. Long preamble is used to wake up devices that are only periodically active due to power consumption restraints.

5.3.2 Start of message (STM) field

The STM is a field indicating the end of the preamble field and the start of the PHY payload field. The octet chosen to define the STM is shown in Figure 5.3.

Bit No	7	6	5	4	3	2	1	0
Value	1	1	0	0	1	1	0	0

Figure 5.3. Definition of the STM octet.

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5.3.2.1 Synchronization /Re-synchronization

Synchronization is accomplished when a STM octet is detected preceded by a preamble octet. Since the strongest/closest WLN-device often is the most interesting, each device has to be able to handle a situation where a new message is transmitted before the previous is finished. If a WLN-device detects a preamble symbol followed by an STM symbol inside a radio message, the ongoing reception shall be terminated and the device shall start receiving the new.

5.3.3 PHY payload field

The PHY payload field has a variable length and carries the data of the PHY packet. The PHY payload is obtained by taking the MPDU delivered by the MAC layer and applying a block coding scheme as described as follows.

5.3.3.1 Block coding scheme

The block coding scheme consists of two steps: a check summing step and a Manchester encoding step:

- Check summing step: this step starts by dividing the MPDU in 3 bytes blocks. The last block will if necessary be filled with dummy octets in order to fill the block. A dummy octet is defined as shown in Figure 5.4. After each block an 8-bit block checksum (BCS) is added and used in the PHY layer of the receiver device for error correction, as described in section 5.3.6, resulting in 4-bytes blocks. The BCS is calculated by taking the sum of the 3 bytes within a given block.

Bit No	7	6	5	4	3	2	1	0
Value	0	0	0	0	0	0	0	0

Figure 5.4. Definition of the dummy octet.

- Manchester encoding step: The resulting bit stream, from the check summing step, containing all 4-bytes blocks is then encoded according to Manchester code. This step is applied in order to achieve a symmetric bit stream with no DC offset, which is required for common radio transceivers. The Manchester code guarantees that each data bit has at least one transition and occupies the same time. A 0-bit is expressed by a low-to-high transition, i.e. 01, a 1-bit by high-to-low transition, i.e. 10. For example a binary data sequence “1011” is encoded into “10011010”. The 4 bytes blocks are therefore transformed into 8-bytes blocks.

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Figure 5.5 illustrates the different steps in the block codding scheme.

3 octets block of MPDU

Octet 1	Octet 2	Octet 3

Block checksum added

Octet 1	Octet 2	Octet 3	BCS

Manchester encoding is performed (doubles the number of octets)

Octet 1 (MSO)	Octet 1 (LSO)	Octet 2 (MSO)	Octet 2 (LSO)	Octet 3 (MSO)	Octet 3 (LSO)	BCS (MSO)	BCS (LSO)

Figure 5.5. Block coding scheme.

5.3.3.2 Block decoding scheme

In order to extract the MPDU in the PHY layer of the receiver device, first a Manchester decoding step on the 8-bytes blocks is applied. Then the BCSs and the added dummy octets are eliminated after that the erroneous octets are identified when performing the forward error correction, as described in section 5.3.6. The resulting bit stream is then forwarded to the MAC layer.

5.3.4 End of message (EOM) field

The EOM is a field indicating the end of the PHY payload field and the end of the PPDU. The octet chosen to define the EOM is shown in Figure 5.6.

Bit No	7	6	5	4	3	2	1	0
Value	0	0	1	1	0	0	1	1

Figure 5.6. Definition of the EOM octet.

5.3.5 Serial coding scheme

The serial coding scheme is a bit stuffing procedure where a start bit and a stop bit are inserted at the beginning and end of each and every octet within the bit stream, respectively, see Figure 5.7.

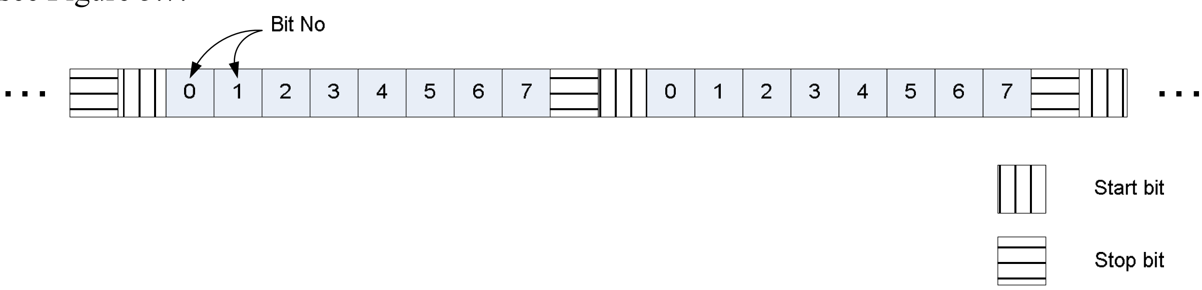

Figure 5.7. A bit stream with the serial coding scheme applied to it.

The start bit is a 1-bit while the stop bit is a 0-bit.

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5.3.6 PHY forward error correction (FEC)

By using the BCS and the symmetric bit stream requirement, at least 1 and at most 8 bit errors can be identified and corrected within the same octet in a given block. This equals a bit error rate (BER) of minimum 1.2% (1/80) and maximum 10% (8/80). The FEC algorithm is divided in two parts: detect and correct.

The detect part, see Figure 5.8, is where the erroneous octets are found by identifying Manchester code violations. The position of the detected errors are saved in a data array referred to as *PHYFCS*, see Figure 5.8, which is then forwarded to the correct part of the PHY FEC algorithm. If the error occurs in the BCS, it will be ignored and no further control of the block is done. A final check of the complete message will be done within the MAC sub layer using the MCS.

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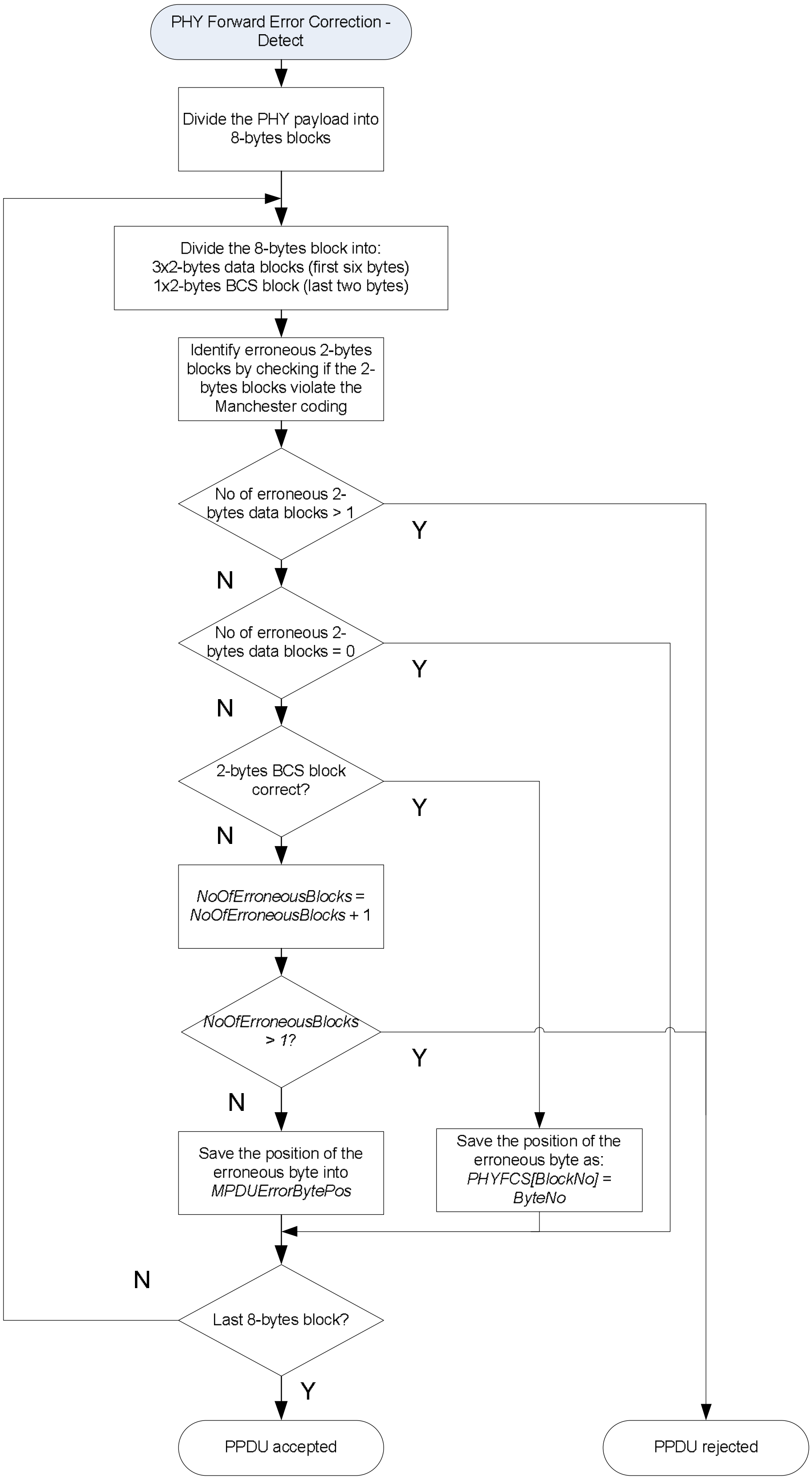

Figure 5.8. The detect part of the PHY FEC algorithm.

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Once the PPDU is accepted, the erroneous octet within a block is corrected by using the BCS after that Manchester decoding is applied, see Figure 5.9. This is only possible if and only if one of the data octets is incorrect.

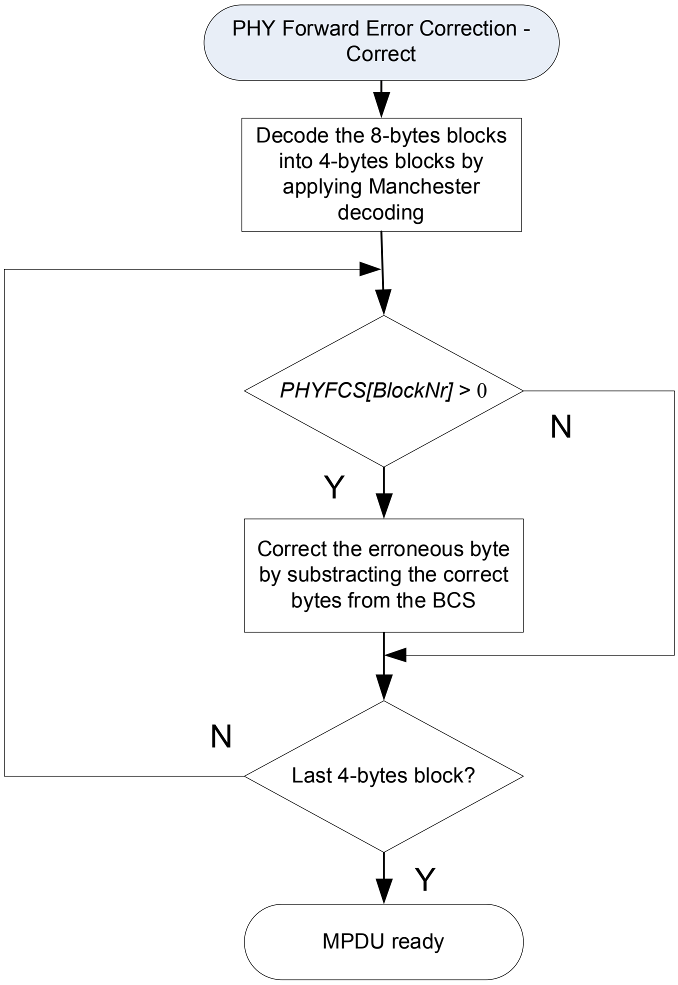

Figure 5.9. The correct part of the PHY FEC algorithm.

5.4 PHY service specification

The PHY provides data services to the MAC sub layer and the physical radio channel, via the RF firmware and RF hardware. The PHY conceptually includes a PHY service access point entity (PSAP). This entity provides the layer interface through which layer management and data service functions may be invoked. The PHY provides two services, accessed through PSAP: the PHY data service, and the PHY management service.

5.4.1 PHY data service

The PSAP supports the transport of MPDU between peer MAC sub layers. Table 5.1 lists the primitives that supports data transport within the PSAP. These primitives are discussed in the sections referenced in Table 5.1.

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Table 5.1. PHY data service primitives

PSAP data primitive	Request	Confirm	Indication	Response
PSAP-DATA	5.4.1.1	5.4.1.2	5.4.1.3	-

Table 5.2 specifies the parameters for the PSAP-DATA primitive.

Table 5.2. Parameters of the PHY data service primitives

Name	Type	Valid range	Description
MPDULength	Integer	-	The number of octets contained in the MPDU to be transmitted or received by the PHY layer
MPDU	Array	-	The set of octets forming the MPDU to be transmitted or received by the PHY layer
ReceiveResult	Enumeration	SUCCESS, ERROR_OCCURED	This indicates whether an error has been detected in the MPDU or not
MPDUErrorBytePos	Integer		The position of the erroneous byte
TransmitResult	Enumeration	SUCCESS, RECEIVE TRANSMIT, SLEEP	The result of the request to transmit a MPDU
TransmitPower	Signed Integer	-128 - +127	Provides the power level in dBm to be used when transmitting
RSSI	Integer	0-255	Provides the signal strength indication of the received PPDU

5.4.1.1 PSAP-DATA.request

The PSAP-DATA.request primitive requests the transfer of a MPDU from the MAC sub layer to the local PHY layer. The semantics of the PSAP-DATA.request primitive is as follows:

```
PSAP-DATA.request        (
                         MPDULength,
                         MPDU
                         TransmitPower
                         )
```

5.4.1.1.1 When generated

The PSAP-DATA.request primitive is generated by a local MAC sub layer and issued to its PHY layer to request the transmission of a MPDU.

5.4.1.1.2 Effect on receipt

The PHY layer builds up and transfers the PPDU containing the supplied MPDU from the MAC sub layer.

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5.4.1.2 PSAP-DATA.confirm

The PSAP-DATA.confirm primitive acknowledges the end of the transmission of a MPDU from the local PHY layer. The semantics of the PSAP-DATA.confirm primitive is as follows:

```
PSAP-DATA.confirm        (
                         TransmitResult
                         )
```

5.4.1.2.1 When generated

The PSAP-DATA.confirm primitive is generated by the PHY layer and issued to its MAC sub layer in response to a PSAP-DATA.request primitive. The PSAP-DATA.confirm primitive will return a result of either SUCCESS, indicating that the request to transmit was successful, or an error code of RECEIVE, TRANSMIT or SLEEP.

If the PSAP-DATA.request primitive is received while the transceiver is disabled (sleep state), the PHY entity will discard the MPDU and issue the PSAP-DATA.confirm primitive with a result SLEEP. If the PSAP-DATA.request primitive is received while the transmitter is already busy transmitting (transmit state), the PHY layer will discard the MPDU and issue the PSAP-DATA.confirm primitive with a status of TRANSMIT. If the PSAP-DATA.request primitive is received while the receiver is already busy receiving (receive state), the PHY layer will discard the MPDU and issue the PSAP-DATA.confirm primitive with a status of RECEIVE.

5.4.1.2.2 Effect on receipt

The MAC sub layer is notified of the requested transmission.

5.4.1.3 PSAP-DATA.indication

The PSAP-DATA.indication primitive delivers the received MPDU from the PHY layer to the MAC sub layer. The semantics of the PSAP-DATA.indication primitive is as follows:

```
PSAP-DATA.indication     (
                         MPDULength,
                         MPDU,
                         ReceiveResult,
                         MPDUErrorBytePos,
                         RSSI
                         )
```

5.4.1.3.1 When generated

The PSAP-DATA.indication primitive is generated by the PHY layer and issued to its MAC sub layer to deliver a received MPDU.

5.4.1.3.2 Effect on receipt

The MAC sub layer is furnished with a MPDU received by the PHY layer. If ReceiveResult shows SUCCESS then no attention is paid for MPDUErrorBytePos otherwise the forward

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error correction within MAC sub layer is furnished with the MPDUErrorBytePos in order to correct the erroneous octet.

5.4.2 PHY management service

The PHY management service enables the MAC sub layer to control the PHY layer by transporting PHY management service primitives (PMSP) through the PSAP. The PSAP is also responsible for maintaining a database of managed objects pertaining to the PHY. This database is referred to as the PHY information base (PIB). The PIB attributes are listed in Table 5.3.

Table 5.3. Definition of the different PIB attributes

Attribute	**Identifier**	**Type**	**Range**	**Description**
pCurrentChannel	0x00	Integer	0-277	The RF channel to use for all following transmissions and receptions (see section 4.1.3)
pMinChannel(+)	0x01	Integer	0-277	Indicates the lowest channel supported by the RF hardware
pMaxChannel(+)	0x02	Integer	0-277	Indicates the highest channel supported by the RF hardware
pMaxTransmitPower(+)	0x03	Signed Integer	0	Maximal transmit power level in dBm
pPreambleMode	0x04	Integer	NO_PREAMBLE, SHORT_PREAMBLE, LONG_PREAMBLE	The length of the added preamble field (see section 5.3.1)
pCCATimePeriod(+)	0x05	Integer	2	The length of the CCA time period specified in octets
pCCAState(+)	0x06	Enumeration	CHANNEL_BUSY, CHANNEL_CLEAR	Indicates the RF channel activity
pTrxState(*)	0x07	Enumeration	TRANSMIT, RECEIVE, IDLE, SLEEP	Specifies the state of the transceiver. Only IDLE and SLEEP state can be set by MAC sub layer. TRANSMIT and RECEIVE can be set only by the PHY layer itself.

Attributes marked with a plus (+) are read-only attributes, attributes marked with an asterisk (*) have specific values that are accepted.

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Table 5.4 lists the PMSP that support PHY management within the PSAP. These PMSPs are discussed in the sections referenced in Table 5.4.

Table 5.4. PHY management service primitives.

PMSP	Request	Confirm	Indication	Response
PSAP-MGMT-SET	5.4.2.1	5.4.2.2	-	-
PSAP-MGMT-GET	5.4.2.3	5.4.2.4	-	-

Table 5.5 specifies the parameters for the PSAP-MGMT-SET and PSAP-MGMT-GET primitives.

Table 5.5. Parameters of the PHY management service primitives.

Name	Type	Valid range	Description
PIBAttribute	Integer	Any PIB attribute identifier as defined in Table 5.3	The identifier of the PIB attribute
PIBValue	Variable	As defined in Table 5.3	The value of the PIB attribute
ResultCode	Enumeration	SUCCESS, INVALID_PIB_ATTR, INVALID_PIB_VALUE, READ_ONLY_PIB_ATTR	The result of the request to read or write an PIB attribute

5.4.2.1 PSAP-MGMT-SET.request

The PSAP-MGMT-SET.request primitive attempts to set the indicated PIB attribute to a given value. The semantics of the PSAP-MGMT-SET.request primitive is as follows:

```
PSAP-MGMT-SET.request          (
                               PIBAttribute,
                               PIBValue
                               )
```

5.4.2.1.1 When generated

The PSAP-MGMT-SET.request primitive is generated by a local MAC sub layer and issued to its PHY layer to set the indicated PIB attribute.

5.4.2.1.2 Effect on receipt

The PHY layer attempts to set the indicated PIB attribute in the database. If the PIB attribute implies a specific action, then an action is performed to fulfill the request. The PHY layer responds via the PSAP with PSAP-MGMT-SET.confirm that notify the MAC sub layer with the result.

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5.4.2.2 PSAP-MGMT-SET.confirm

The PSAP-MGMT-SET.confirm primitive reports the result of the attempt to set the PIB attribute to a given value. The semantics of the PSAP-MGMT-SET.confirm primitive is as follows:

```
PSAP-MGMT-SET.confirm          (
                               PIBAttribute,
                               PIBValue,
                               ResultCode
                               )
```

5.4.2.2.1 When generated

The PSAP-MGMT-SET.confirm primitive is generated by a PHY layer and issued to its local MAC sub layer in response to PSAP-MGMT-SET.request.

5.4.2.2.2 Effect on receipt

If the result is SUCCESS then no action is required otherwise an appropriate error handling procedure is issued by the MAC sub layer.

5.4.2.3 PSAP-MGMT-GET.request

The PSAP-MGMT-GET.request primitive attempts to read the indicated PIB attribute stored within the PHY layer. The semantics of the PSAP-MGMT-GET.request primitive is as follows:

```
PSAP-MGMT-GET.request          (
                               PIBAttribute
                               )
```

5.4.2.3.1 When generated

The PSAP-MGMT-GET.request primitive is generated by a local MAC sub layer and issued to its PHY layer to read the indicated PIB attribute.

5.4.2.3.2 Effect on receipt

The PHY layer attempts to read the indicated PIB attribute in the database and responds via the PSAP with PSAP-MGMT-GET.confirm that notify the MAC sub layer with the result.

5.4.2.4 PSAP-MGMT-GET.confirm

The PSAP-MGMT-GET.confirm primitive reports the result of the attempt to read the PIB attribute. The semantics of the PSAP-MGMT-GET.confirm primitive is as follows:

```
PSAP-MGMT-GET.confirm          (
                               PIBAttribute,
                               PIBValue,
                               ResultCode
                               )
```

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5.4.2.4.1 When generated

The PSAP-MGMT-GET.confirm primitive is generated by a PHY layer and issued to its local MAC sub layer in response to PSAP-MGMT-GET.request.

5.4.2.4.2 Effect on receipt

If the result is SUCCESS then no action is required otherwise an appropriate error handling procedure is issued by the MAC sub layer.

5.4.3 PHY enumeration description

Table 5.7 shows the description of the PHY enumeration values used in the PHY service specification

Table 5.7. List of of the PHY enumeration values.

Enumeration	Value	Description
SUCCESS	0x00	Transmit or SET/GET operation have been successful
RECEIVE	0x01	The transceiver is asked to transmit or to change state while receiving
TRANSMIT	0x02	The transceiver is asked to transmit or to change state while transmitting
IDLE	0x03	Indicates idle transceiver state. The idle state is when the receiver is activated and the RF channel and the channel is free (no ongoing transmission).
SLEEP	0x04	The transceiver is asked to transmit or to enable transmitter or receiver part while sleeping
CHANNEL_BUSY	0x05	CCA detected busy channel
CHANNEL_CLEAR	0x06	CCA detected clear channel
INVALID_PIB_ATTR	0x07	A SET/GET operation is issued with PIB attribute that is not supported
INVALID_PIB_VALUE	0x08	A SET operation is issued with an attribute value that is out of range
READ_ONLY_PIB_ATTR	0x09	A SET operation is issued with a PIB attribute that is read-only
ERROR_OCCURED	0x0a	FEC in PHY has detected an erroneous octet in received MPDU

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6 MAC SPECIFICATION

6.1 MAC functional description

The MAC sub layer is responsible for the following tasks:

- Channel access
- Message filtering
- Error detection
- Device power management by duty cycling
- Application specific beacon management
- Application specific filtering
- Transmitting and receiving of MPDUs using the PHY layer

6.1.1 Channel access

When several WLN devices are within range it might happen that two or more devices try to transmit at the same time resulting in air collision. To avoid this, the CSMA-CA algorithm applies for accessing the radio channel before any transmission, see Figure 6.1:

1. If no valid WLN data is being received/transmitted on the channel, i.e. the channel is clear, the message can be sent immediately thus ending the transmit cycle. Otherwise continue to point 2.
2. A timer is set to a random time ranging from 1.0 ms to 20.0 ms.
3. When the timer has run out, a check is made whether the channel is busy or clear using the CCA mechanism within the PHY layer.
4. If the channel is found to be clear, the message can be sent thus ending the transmit cycle.
5. If the channel is found to be busy, return to point 2 and set the timer again.

If the algorithm above has not allowed the message to be sent within 250 ms, the message will be transmitted anyway ignoring the channel status. This is done due to the fact that the transmission will probably be received by the WLN devices closest to the sender even if other transmissions are being done at the same time.

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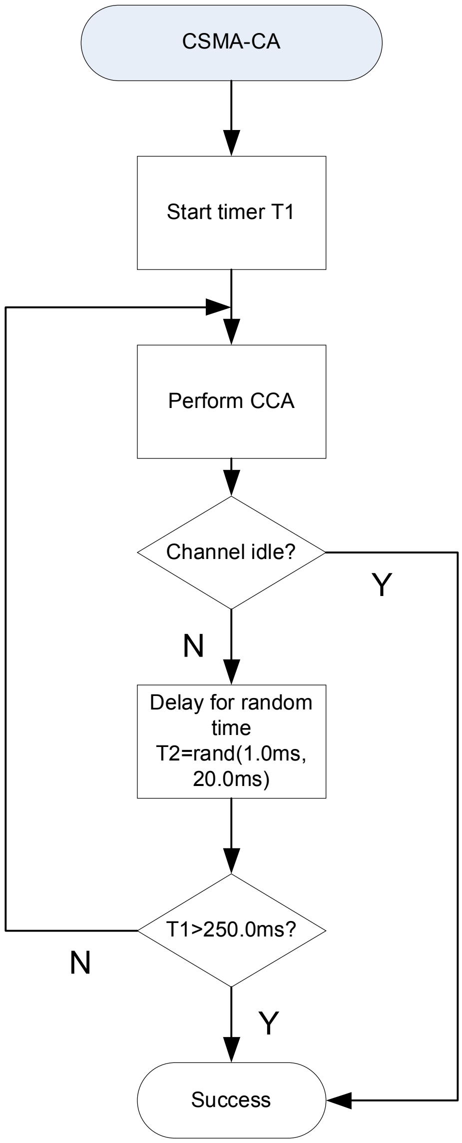

Figure 6.1. The CSMA-CA algorithm.

6.1.2 Message filtering

Three types of message filtering are available within the MAC sub layer: RSSI filter, identity filter, MPDU type filter.

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6.1.2.1 RSSI filter

The RSSI filter is an adjustable threshold filter that discriminates all received messages that show an RSSI that is below the threshold. This filter is practical when there is a need to limit communication area of a given device.

6.1.2.2 Identity filter

The identity filter is a selective filter that discriminates all messages that are neither addressed to the received device nor broadcast messages.

6.1.2.3 MPDU type filter

The MPDU type filter offers the application a possibility to subscribe for reception of selected types of MPDUs. The MAC sub layer discards the messages that are not of interest thus reducing the processing workload within the application layer. However, if a message of interest is received, the message is forwarded to the upper layer.

6.1.3 MAC Forward Error Correction

The MAC sub layer includes a FEC mechanism based on a 16 bit message checksum (MCS). The 16 bit MCS is calculated by simple addition of all octets within the MPDU excluding the MCS field. When a MPDU is received and the ReceiveResult does not show SUCCESS and the MPDUErrorBytePos is not pointing on the received MCS field then the correct octets are subtracted from the MCS in order to correct the erroneous octet within the received MPDU, see Figure 6.2.

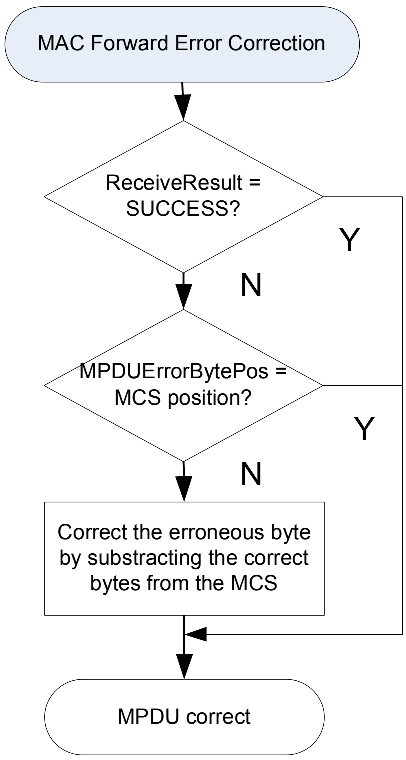

Figure 6.2. MAC forward error correction algorithm.

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6.1.4 Addressing

Each device has a dedicated 16-bit address or identity, referred to as WLN identity. Two WLN identity values are treated differently: 0x0000 and 0xffff. The 0x0000 is not allowed and should not be used while 0xffff is used as a broadcast address where the message is sent to all devices within reach.

6.1.5 Duty cycling

The duty cycling is a well defined time schedule that toggles the transceiver between idle mode and sleep mode. The resulting schedule consists of sequence of toggle periods, where toggle period consists of an idle period followed by a sleep period, see Figure 6.3.

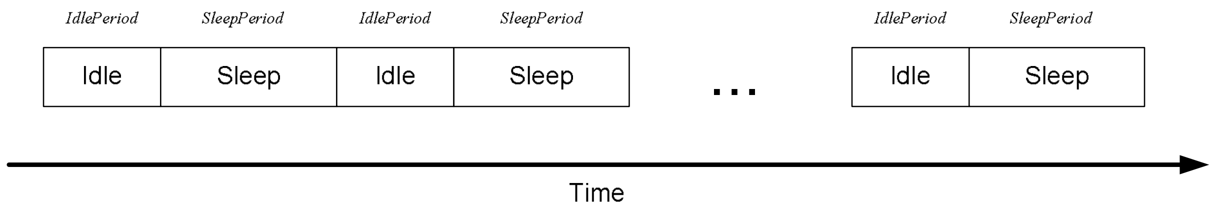

Figure 6.3. Duty cycling schedule.

This enables low power consumption within WLN devices at the cost of higher latency. WLN devices are battery powered and low power consumption is a high priority to enable longer operational time. The duration of the idle period, *IdlePeriod*, ranges from 0 to 3 octets, while the duration of the sleep period, *SleepPeriod*, ranges from 0 to 250 octets to allow different duty cycle schedules. There are five different duty cycle schedules that can be chosen by the higher layer: power down, low power, normal RX and hot RX. These different cycles are shown in Table 6.1 together with their respective time periods given in number of transmitted octets and in milliseconds calculated with a data transfer rate of 25 kbit/s.

Table 6.1. Definition of the different duty cycling schedules.

Duty Cycle	**Idle Period**	**Sleep Period**
Power down duty cycle	0 octets (0 ms)	> 0 octets (>0 ms)
Low power duty cycle	3 octets (1 ms)	250 octets (100 ms)
Normal RX duty cycle	3 octets (1 ms)	38 octets (15 ms)
Hot RX duty cycle	3 octets (1 ms)	0 octets (0 ms)

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6.2 MPDU format

An overview of the format of the MAC frames (MPDU) with descriptions of common fields is given and followed by sections for each frame type. The MPDU packet structure is presented so that the leftmost field as written in this standard shall be transmitted or received first. All multiple octet fields, payload excluded, shall be transmitted or received most significant octet first and each octet shall be transmitted or received least significant bit (LSB) first. The final section contains a list of enumeration that may appear in application specific beacon frames and data frames.

6.2.1 General MAC frame format

A MPDU frame consists of a fixed-length MAC Header (MHR), a variable-length MAC payload and fixed-length MAC Footer (MFR), see Figure 6.4.

Octets:	1	1	0/2	2	Variable	2
	Number of Octets	Type	Destination Address	Source Address	MAC payload	Message Checksum
	MHR					MFR

Figure 6.4. General MAC frame format.

The MHR comprises length of frame, type of frame and address related information. The addressing fields may not be included in all frames. The MAC payload contains information specific to the frame type and has a length that ranges from zero to *mMaxAllowedMACPayload*. The MFR contains the message checksum (MCS).

The MPDU frames are described as a sequence of fields in a specific order. All frame formats in the sections below are depicted in the order in which they are passed to the PHY, from left to right, where the leftmost octet is sent first in time.

6.2.1.1 Number of octets field

The number of octets filed specifies the total number of octets contained in the MPDU. It is a value that ranges from 6 octets to *mMaxAllowedMACPayload* + (6 or 8 octets) and depends on the type of the MPDU.

6.2.1.2 Type field

The type field is set to specify the type of frame that is being sent. Table 6.2 lists the valid frame type values, descriptions, and the sub clauses that describe the format and use of each of the individual frame types.

Table 6.2. Definition of the different MPDU types.

Type value	Description
0	Application specific beacon type 0
1	Application specific beacon type 1
2	Application specific beacon type 2
3	Data frame
4-255	Reserved

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6.2.1.3 Message checksum field

The MCS is a 16-bit checksum that is calculated by adding all octets within the MPDU, excluding the MCS field. The MCS is then used, if needed, by the MAC FEC algorithm, see section 6.1.3.

6.2.2 Format of application specific beacon frame

The ASB frame is formatted according to Figure 6.5.

Octets:	1	1	2	Variable	2
	Number of Octets	Type	Source Address	ASB payload	Message Checksum
	MHR			MAC payload	MFR

Figure 6.5. Format of ASB frame.

The source address, i.e. WLN identity of sending device, is included within the ASB frame. The WLN identity is defined in section 6.1.4.

6.2.3 Format of data frame

The data frame is formatted according to Figure 6.6.

Octets:	1	1	2	2	Variable	2
	Number of Octets	Type	Destination Address	Source Address	Data payload	Message Checksum
	MHR				UPDU	MFR

Figure 6.6. Format of data frame.

Both the source address and the destination address are included within the data frame. The WLN identity is defined in section 6.1.4.

6.3 MAC service specification

The MAC sub layer provides data and management services to the upper layers through the MAC service access point (MSAP). These services are described in this section in terms of MSAP primitives exchanged between the upper layer and the MAC sub layer.

6.3.1 MAC data service

The MSAP supports the transport of upper layer protocol data unit (UPDU) between WLN devices. Table 6.3 lists the primitives supported by the MSAP together with their respective section number.

Table 6.3. MAC data service primitives.

MSAP primitive	**Request**	**Confirm**	**Indication**
MSAP-DATA	6.3.1.1	6.3.1.2	6.1.3.3

Table 6.4 specifies the parameters for the MSAP-DATA primitive.

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Table 6.4. Parameters of the MAC data service primitives.

Name	Type	Valid range	Description
UPDULength	Integer	-	The number of octets contained in the UPDU to be transmitted or received by the MAC sub layer
UPDU	Array	-	The set of octets forming the UPDU to be transmitted or received by the MAC sub layer
TransmitPower	Signed Integer	-128 - +127	Indicates the power level to be used when transmitting
TransmitResult	Enumeration	SUCCESS, INVALID_ADDRESS, TRANSMIT_CUE_FULL, FRAME_TOO_LONG, POWER_TOO_HIGH	The result of the request to transmit an UPDU
ChannelAccess	Enumeration	CSMA_CA, FORCED_TX	Indicates the channel access method to be used before transmission
RSSI	Integer	0-255	Provides the signal strength indication of the received MPDU

6.3.1.1 MSAP-DATA.request

The MSAP-DATA.request primitive requests the transfer of an UPDU using a data frame and is sent from a local upper layer to a local MAC layer. The semantics of the MSAP-DATA.request primitive is as follows:

```
MSAP-DATA.request          (
                           DestinationAddress,
                           UPDULength,
                           UPDU,
                           TransmitPower,
                           ChannelAccess
                           )
```

6.3.1.1.1 When generated

The MSAP-DATA.request primitive is generated by a local upper layer and issued to its MAC sub layer to request the transmission of an UPDU.

6.3.1.1.2 Effect on receipt

The MAC sub layer builds up and transfers the MPDU containing the supplied UPDU using the CSMA-CA algorithm.

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6.3.1.2 MSAP-DATA.confirm

The MSAP-DATA.confirm primitive acknowledges the end of the transmission of an UPDU from the local MAC sub layer. The semantics of the MSAP-DATA.confirm primitive is as follows:

```
MSAP-DATA.confirm          (
                           TransmitResult
                           )
```

6.3.1.2.1 When generated

The MSAP-DATA.confirm primitive is generated by the MAC sub layer and issued to its upper layer in response to a MSAP-DATA.request primitive. The MSAP-DATA.confirm primitive will return a result of either SUCCESS, indicating that the request to transmit was successful, or an error code of INVALID_ADDRESS, TRANSMIT_CUE_OVERFLOW, FRAME_TOO_LONG, and POWER_TOO_HIGH.

If the MSAP-DATA.request primitive is received with an address that is zero, the MAC sub layer will discard the UPDU and issue the MSAP-DATA.confirm primitive with a result INVALID_ADDRESS. If the MSAP-DATA.request primitive is received while the transmitting cue is full, the MAC sub layer will discard the UPDU and issue the MSAP-DATA.confirm primitive with a status of TRANSMIT_CUE_OVERFLOW. If the MSAP-DATA.request primitive is received with UPDU that is too long, the MAC sub layer will discard the UPDU and issue the MSAP-DATA.confirm primitive with a status of FRAME_TOO_LONG. If the MSAP-DATA.request primitive is received with a TransmitPower > *pMaxTransmitPower*, the MAC sub layer will discard the UPDU and issue the MSAP-DATA.confirm primitive with a status of POWER_TOO_HIGH.

6.3.1.2.2 Effect on receipt

The upper layer is notified of the requested transmission.

6.3.1.3 MSAP-DATA.indication

The MSAP-DATA.indication primitive delivers the received UPDU from the MAC sub layer to the upper layer. The semantics of the MSAP-DATA.indication primitive is as follows:

```
MSAP-DATA.indication       (
                           SourceAddress,
                           DestinationAddress,
                           UPDULength,
                           UPDU,
                           RSSI
                           )
```

6.3.1.3.1 When generated

The MSAP-DATA.indication primitive is generated by the MAC sub layer and issued to its upper layer to deliver a received UPDU.

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6.3.1.3.2 Effect on receipt

The upper layer is furnished with an UPDU received by the MAC sub layer.

6.3.2 MAC management service

The MSAP allows the transport of MAC management service commands (MMSP) from the upper layer to the MAC sub layer. Table 6.5 summarizes the primitives supported by the MSAP together with their respective section number.

Table 6.5. MAC management service primitives.

Name	**Request**	**Confirm**	**Indication**
MSAP-MGMT-ASB-START	6.3.2.1.1	6.3.2.1.2	-
MSAP-MGMT-ASB-STOP	6.3.2.1.3	6.3.2.1.4	-
MSAP-MGMT-ASB	-	-	6.3.2.1.5
MSAP-MGMT-CHANGE-CHANNEL	6.3.2.2.1	6.3.2.2.2	-
MSAP-MGMT-RSSI-FILTER	6.3.2.3.1	6.3.2.3.2	-
MSAP-MGMT-IDENTITY-FILTER	6.3.2.3.3	6.3.2.3.4	-
MSAP-MGMT-MPDU-TYPE-FILTER	6.3.2.3.5	6.3.2.3.6	-
MSAP-MGMT-DUTY-CYCLE	6.3.2.4.1	6.3.2.4.2	-
MSAP-MGMT-GET	6.3.2.5.1	6.3.2.5.2	-
MSAP-MGMT-SET	6.3.2.5.3	6.3.2.5.4	-

6.3.2.1 Application specific beacon primitives

The MSAP ASB primitives define how to enable beacons. Table 6.6 specifies the parameters for the MSAP-MGMT-ASB-START, MSAP-MGMT-ASB-STOP, and MSAP-MGMT-ASB primitives.

Table 6.6. Parameters used in the ASB primitives.

Name	**Type**	**Valid range**	**Description**
ASBType	Enumeration	ASB_TYPE_0, ASB_TYPE_1, ASB_TYPE_2	Specifies the requested ASB type
ASBPayloadLength	Integer	0-*mMaxAllowedMACPayload*	Specified the length of the ASB payload
ASBPayload	Field		The data that will be transmitted
FirstTX	Enumeration	SEND_IMMEDIATELY, SEND_SCHEDULED	Indicates whether the first transmission should occur immediately or wait until next scheduled ASB transmission.
RepetitionInterval	Integer	500 – 25000 ms (100ms resolution)	Indicates the frequency of transmission of ASB
TransmitPower	Signed	-128 - +127	Indicates the power

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	Integer		level when transmitting ASB
ChannelAccess	Enumeration	CSMA_CA, FORCED_TX	Indicates the channel access method to be used before transmission
ResultCode	Enumeration	SUCCESS, INVALID_ASB_TYPE, INVALID_FIRST_TX, INVALID_REPETITION_INTER VAL, INVALID_TRANSMIT_POWER FRAME_TOO_LONG POWER_TOO_HIGH	Indicates the result of an ASB-start request

6.3.2.1.1 MSAP-MGMT-ASB-START.request

The MSAP-MGMT-ASB-START.request primitive requests the transfer of an ASB using an ASB frame from a local upper layer to a local MAC layer. The semantics of the MSAP-MGMT-ASB-START.request primitive is as follows:

```
MSAP-MGMT-ASB-START.request     (
                                ASBType,
                                ASBPayloadLength,
                                ASBPayload,
                                FirstTX,
                                RepetitionInterval,
                                TransmitPower
                                )
```

6.3.2.1.1.1 When generated

The MSAP-MGMT-ASB-START.request primitive is generated by a local upper layer and issued to its MAC sub layer to request the transmission of an ASB.

6.3.2.1.1.2 Effect on receipt

The MAC sub layer saves the request parameters and transfers repetitively according to furnished parameters the MPDU containing the supplied ASB payload using the CSMA-CA algorithm.

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6.3.2.1.2 MSAP-MGMT-ASB-START.confirm

The MSAP-MGMT-ASB-START.confirm primitive acknowledges the reception of an ASB request from the local MAC sub layer. The semantics of the MSAP-MGMT-ASB-START.confirm primitive is as follows:

MSAP-MGMT-ASB-START.confirm (
ResultCode
)

6.3.2.1.2.1 When generated

The MSAP-MGMT-ASB-START.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT-ASB-START.request. This primitive returns a result code of either SUCCESS indicating that the request to initiate an ASB is successful, or an error code of INVALID_ASB_TYPE, INVALID_FIRST_TX, INVALID_REPETITION_INTERVAL, POWER_TOO_HIGH or FRAME_TOO_LONG.

6.3.2.1.2.2 Effect on receipt

On receipt of the MSAP-MGMT-ASB-START.confirm, the upper layer is notified with the result of it MSAP-MGMT-ASB-START.request.

6.3.2.1.3 MSAP-MGMT-ASB-STOP.request

The MSAP-MGMT-ASB-STOP.request primitive requests the stop of transfer of an ASB from a local MAC sub layer. The semantics of the MSAP-MGMT-ASB-STOP.request primitive is as follows:

MSAP-MGMT-ASB-STOP.request (
ASBType
)

6.3.2.1.3.1 When generated

The MSAP-MGMT-ASB-STOP.request primitive is generated by a local upper layer and issued to its MAC sub layer to stop ASB transmission that was started by MSAP-MGMT-ASB-START.request.

6.3.2.1.3.2 Effect on receipt

The MAC sub layer immediately initiates ending the transmission of ASB of the given type.

6.3.2.1.4 MSAP-MGMT-ASB-STOP.confirm

The MSAP-MGMT-ASB-STOP.confirm primitive acknowledges that the transmission of ASB has been stopped. The semantics of the MSAP-MGMT-ASB-STOP.confirm primitive is as follows:

MSAP-MGMT-ASB-STOP.confirm (
ASBType
ResultCode
)

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6.3.2.1.4.1 When generated

The MSAP-MGMT-ASB-STOP.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT-ASB-STOP.request. This primitive returns a result code of either SUCCESS indicating that the request to stop transmission of ASB is successful, or an error code of INVALID_ASB_TYPE.

6.3.2.1.4.2 Effect on receipt

On receipt of the MSAP-MGMT-ASB-STOP.confirm, the upper layer is notified with the result of its MSAP-MGMT-ASB-STOP.request.

6.3.2.1.5 MSAP-MGMT-ASB.indication

The MSAP-MGMT-ASB.indication primitive delivers the received ASB payload from the MAC sub layer to the upper layer. The semantics of the MSAP-MGMT-ASB.indication primitive is as follows:

```
MSAP-MGMT-ASB.indication          (
                                  SourceAddress,
                                  ASBType,
                                  ASBPayload,
                                  RSSI
                                  )
```

6.3.2.1.5.1 When generated

The MSAP-MGMT-ASB.indication primitive is generated by the MAC sub layer and issued to its upper layer to deliver a received ASB.

6.3.2.1.5.2 Effect on receipt

The upper layer is furnished with an ASB received by the MAC sub layer.

6.3.2.2 Channel management primitives

The MSAP channel management primitives define how to change radio channel. Table 6.7 specifies the parameters for the MSAP-MGMT-CHANNEL-CHANGE primitives.

Table 6.7. Parameters used in the channel management primitives.

Name	Type	Valid range	Description
ChannelNumber	Integer	0-277	Specifies the requested channel number
ResultCode	Enumeration	SUCCESS, CHANNEL_NOT_SUPPORTED	Indicates the result of channel change request

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6.3.2.2.1 MSAP-MGMT-CHANNEL-CHANGE.request

The MSAP-MGMT-CHANNEL-CHANGE.request primitive requests the change of channel on which transmission is being done. The semantics of the MSAP-MGMT-CHANNEL-CHANGE.request primitive is as follows:

```
MSAP-MGMT-CHANNEL-CHANGE.request      (
                                      ChannelNumber
                                      )
```

6.3.2.2.1.1 When generated

The MSAP-MGMT- CHANNEL-CHANGE.request primitive is generated by a local upper layer and issued to its MAC sub layer to select a new channel for transmission.

6.3.2.2.1.2 Effect on receipt

The MAC sub layer initiates the change within the PHY layer by issuing appropriate PSAP primitive.

6.3.2.2.2 MSAP-MGMT-CHANNEL-CHANGE.confirm

The MSAP-MGMT-CHANNEL-CHANGE.confirm primitive acknowledges the change of the PHY transmission channel as a result of MSAP-MGMT- CHANNEL-CHANGE.request. The semantics of the MSAP-MGMT- CHANNEL-CHANGE.confirm primitive is as follows:

```
MSAP-MGMT- CHANNEL-CHANGE.confirm      (
                                       ResultCode
                                       )
```

6.3.2.2.2.1 When generated

The MSAP-MGMT- CHANNEL-CHANGE.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT- CHANNEL-CHANGE.request. This primitive returns a result code of either SUCCESS indicating that the request is successful. If the ChannelNumber < *pMinChannel* or ChannelNumber > *pMaxChannel* then the result code is CHANNEL_NOT_SUPPORTED.

6.3.2.2.2.2 Effect on receipt

On receipt of the MSAP-MGMT- CHANNEL-CHANGE.confirm, the upper layer is notified of the procedure of changing channel.

6.3.2.3 Primitives to manage filter services

The MSAP filter primitives define how to manage message filtering within MAC sub layer. Table 6.8 specifies the parameters for the MSAP-MGMT-RSSI-FILTER, MSAP-MGMT-IDENTITY-FILTER, and MSAP-MGMT-MPDU-TYPE-FILTER primitives.

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Table 6.8. Parameters used in the filter management services.

Name	Type	Valid range	Description
FilterState	Enumeration	ACTIVATED, DISABLED	Used to turn on and off any of the filters
RSSILimit	Integer	0-255	Indicates the limit used in the RSSI filter
MPDUType	Enumeration	ASB_TYPE_0, ASB_TYPE_1, ASB_TYPE_2, DATA_TYPE	Indicates the MPDU type that will be filtered out
ResultCode	Enumeration	SUCCESS, INVALID_FILTER_STATE, INVALID_MPDU_TYPE	Indicates the result of channel change request

6.3.2.3.1 MSAP-MGMT-RSSI-FILTER.request

The MSAP-MGMT-RSSI-FILTER.request primitive requests the start or stop of RSSI filter. The semantics of the MSAP-MGMT-RSSI-FILTER.request primitive is as follows:

```
MSAP-MGMT-RSSI-FILTER.request        (
                                     FilterState,
                                     RSSILimit
                                     )
```

6.3.2.3.1.1 When generated

The MSAP-MGMT-RSSI-FILTER.request primitive is generated by a local upper layer and issued to its MAC sub layer to enable or disable the RSSI filter.

6.3.2.3.1.2 Effect on receipt

The MAC sub layer enable or disable the RSSI filter depending on the FilterState.

6.3.2.3.2 MSAP-MGMT-RSSI-FILTER.confirm

The MSAP-MGMT-RSSI-FILTER.confirm primitive acknowledges the reception and execution of the MSAP-MGMT-RSSI-FILTER.request. The semantics of the MSAP-MGMT-RSSI-FILTER.confirm primitive is as follows:

```
MSAP-MGMT- RSSI-FILTER.confirm        (
                                      ResultCode
                                      )
```

6.3.2.3.2.1 When generated

The MSAP-MGMT-RSSI-FILTER.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT-RSSI-FILTER.request. This primitive returns either a result code of SUCCESS indicating that the request is successful or an error code of INVALID_FILTER_STATE.

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6.3.2.3.2.2 Effect on receipt

On receipt of the MSAP-MGMT-RSSI-FILTER.confirm, the upper layer is notified of the procedure of enabling or disabling the RSSI filter.

6.3.2.3.3 MSAP-MGMT-IDENTITY-FILTER.request

The MSAP-MGMT-IDENTITY-FILTER.request primitive requests the start or stop of identity filter. The semantics of the MSAP-MGMT-IDENTITY-FILTER.request primitive is as follows:

```
MSAP-MGMT-IDENTITY-FILTER.request        (
                                          FilterState
                                          )
```

6.3.2.3.3.1 When generated

The MSAP-MGMT-IDENTITY-FILTER.request primitive is generated by a local upper layer and issued to its MAC sub layer to enable or disable the identity filter.

6.3.2.3.3.2 Effect on receipt

The MAC sub layer enable or disable the identity filter depending on the FilterState.

6.3.2.3.4 MSAP-MGMT-IDENTITY-FILTER.confirm

The MSAP-MGMT-IDENTITY-FILTER.confirm primitive acknowledges the reception and execution of the MSAP-MGMT-IDENTITY-FILTER.request. The semantics of the MSAP-MGMT-IDENTITY-FILTER.confirm primitive is as follows:

```
MSAP-MGMT-IDENTITY-FILTER.confirm        (
                                          ResultCode
                                          )
```

6.3.2.3.4.1 When generated

The MSAP-MGMT-IDENTITY-FILTER.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT-IDENTITY-FILTER.request. This primitive returns either a result code of SUCCESS indicating that the request is successful or an error code of INVALID_FILTER_STATE.

6.3.2.3.4.2 Effect on receipt

On receipt of the MSAP-MGMT-IDENTITY-FILTER.confirm, the upper layer is notified of the procedure of enabling or disabling the identity filter.

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6.3.2.3.5 MSAP-MGMT-MPDU-TYPE-FILTER.request

The MSAP-MGMT-MPDU-TYPE-FILTER.request primitive requests the start or stop of the MPDU type filter. The semantics of the MSAP-MGMT-MPDU-TYPE-FILTER.request primitive is as follows:

```
MSAP-MGMT-MPDU-TYPE-FILTER.request      (
                                        FilterState,
                                        MPDUType
                                        )
```

6.3.2.3.5.1 When generated

The MSAP-MGMT-MPDU-TYPE-FILTER.request primitive is generated by a local upper layer and issued to its MAC sub layer to enable or disable the MPDU Type filter.

6.3.2.3.5.2 Effect on receipt

The MAC sub layer enable or disable the MPDU type filter depending on the FilterState and MPDUType variables.

6.3.2.3.6 MSAP-MGMT-MPDU-TYPE-FILTER.confirm

The MSAP-MGMT-MPDU-TYPE-FILTER.confirm primitive acknowledges the reception and execution of the MSAP-MGMT-MPDU-TYPE-FILTER.request. The semantics of the MSAP-MGMT-MPDU-TYPE-FILTER.confirm primitive is as follows:

```
MSAP-MGMT-MPDU-TYPE-FILTER.confirm      (
                                        ResultCode
                                        )
```

6.3.2.3.6.1 When generated

The MSAP-MGMT-MPDU-TYPE-FILTER.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT-MPDU-TYPE-FILTER.request. This primitive returns either a result code of SUCCESS indicating that the request is successful or an error code of INVALID_FILTER_STATE or INVALID_MPDU_TYPE.

6.3.2.3.6.2 Effect on receipt

On receipt of the MSAP-MGMT-MPDU-TYPE-FILTER.confirm, the upper layer is notified of the procedure of enabling or disabling the MPDU type filter.

6.3.2.4 Primitives to manage duty cycling services

The following primitives define how to manage duty cycling services within MAC sub layer of a WLN device. Table 6.9 specifies the parameters for the MSAP-MGMT-DUTY-CYCLE primitives.

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Table 6.9. Parameters used in the duty cycling management services.

Name	Type	Valid range	Description
DutyCycleSchedule	Enumeration	POWER_DOWN, LOW_POWER, NORMAL_RX, HOT_RX	Indicates the duty cycle to be used according to Table 6.1
PreambleMode	Enumeration	NO_PREAMBLE, SHORT_PREAMBLE, LONG_PREAMBLE	Indicates the length of the preamble measured in octets
ResultCode	Enumeration	SUCCESS, INVALID_DUTY_CYCLE_SCHEDULE, INVALID_PREAMBLE_MODE	Indicates the result of duty cycling request

6.3.2.4.1 MSAP-MGMT-DUTY-CYCLE.request

The MSAP-MGMT-DUTY-CYCLE.request primitive requests a given type of duty cycle schedules. The semantics of the MSAP-MGMT-DUTY-CYCLE.request primitive is as follows:

```
MSAP-MGMT-DUTY-CYCLE.request        (
                                    DutyCycleSchedule,
                                    PreambleMode
                                    )
```

6.3.2.4.1.1 When generated

The MSAP-MGMT-DUTY-CYCLE.request primitive is generated by a local upper layer and issued to its MAC sub layer to start a duty cycle schedule and to set the preamble mode.

6.3.2.4.1.2 Effect on receipt

The MAC sub layer starts duty cycling depending on the requested DutyCycleSchedule. The requested duty cycle can be one of the following LOW_POWER, NORMAL_RX, or HOT_RX, the MAC layer issues a PSAP-MGMT-SET.request to set the PIB attribute *pPreambleMode* to LONG_PREAMBLE, SHORT_PREAMBLE, or NO_PREAMBLE, respectively.

6.3.2.4.2 MSAP-MGMT-DUTY-CYCLE.confirm

The MSAP-MGMT-RSSI-FILTER.confirm primitive acknowledges the reception and execution of the MSAP-MGMT-DUTY-CYCLE.request. The semantics of the MSAP-MGMT-DUTY-CYCLE.confirm primitive is as follows:

```
MSAP-MGMT-DUTY-CYCLE.confirm        (
                                    ResultCode
                                    )
```

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6.3.2.4.2.1 When generated

The MSAP-MGMT-DUTY-CYCLE.confirm primitive is generated by a local MAC sub layer and issued to its upper layer in response to MSAP-MGMT-DUTY-CYCLE.request. This primitive returns either a result code of SUCCESS indicating that the request is successful or an error code of INVALID_DUTY_CYCLE_SCHEDULE.

6.3.2.4.2.2 Effect on receipt

On receipt of the MSAP-MGMT-DUTY-CYCLE.confirm, the upper layer is notified of the procedure of duty cycling request.

6.3.2.5 Generic primitives to manage MAC attributes

The management information specific to the MAC sub layer is represented as a MAC sub layer information base (MIB), i.e., the MIB is a database comprising attributes required to manage MAC sub layer of a WLN device. The MIB related management primitives are exchanged through the MSAP to allow the upper layer to either read the value of a MIB attribute (MSAP-MGMT-GET primitives), or to write the value of a MIB attribute (MSAP-MGMT-SET primitives).). The MIB attributes are listed in Table 6.10.

Table 6.10. Definition of the MIB attributes.

Attribute	**Identifier**	**Type**	**Range**	**Description**
mDeviceIdentity	0x00	Integer	0x0001-0xfffe	The WLN device identity.
mMaxAllowedMACPayload(+)	0x01	Integer	66	The maximum allowed length of the MAC payload

Attributes marked with a plus (+) are read-only attributes, attributes marked with an asterisk (*) have specific value that are accepted.

Table 6.11 specifies the parameters for the MSAP-MGMT-GET and MSAP-MGMT-SET primitives.

Table 6.11 Parameters of the generic management service primitives

Name	**Type**	**Valid range**	**Description**
MIBAttribute	Integer	Any MIB attribute identifier as defined in Table 6.10	The identifier of the MIB attribute
MIBValue	Variable	As defined in Table 6.10	The value of the MIB attribute
ResultCode	Enumeration	SUCCESS, INVALID_MIB_ATTR, INVALID_MIB_VALUE, READ_ONLY_MIB_ATTR	The result of the request to read or write an MIB attribute

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6.3.2.5.1 MSAP-MGMT-GET.request

The MSAP-MGMT-GET.request primitive attempts to read the indicated MIB attribute stored within the MAC sub layer. The semantics of the MSAP-MGMT-GET.request primitive is as follows:

```
MSAP-MGMT-GET.request          (
                               MIBAttribute
                               )
```

6.3.2.5.1.1 When generated

The MSAP-MGMT-GET.request primitive is generated by a local upper layer and issued to its MAC sub layer to read the indicated MIB attribute.

6.3.2.5.1.2 Effect on receipt

The MAC sub layer attempts to read the indicated MIB attribute in the database and responds via the MSAP with MSAP-MGMT-GET.confirm that notify the upper layer with the result.

6.3.2.5.2 MSAP-MGMT-GET.confirm

The MSAP-MGMT-GET.confirm primitive reports the result of the attempt to read the MIB attribute. The semantics of the MSAP-MGMT-GET.confirm primitive is as follows:

```
MSAP-MGMT-GET.confirm          (
                               MIBAttribute,
                               MIBValue,
                               ResultCode
                               )
```

6.3.2.5.2.1 When generated

The MSAP-MGMT-GET.confirm primitive is generated by a MAC sub layer and issued to its local upper layer in response to MSAP-MGMT-GET.request.

6.3.2.5.2.2 Effect on receipt

If the result is SUCCESS then no action is required otherwise an error handling is taken by the upper layer based on the error code.

6.3.2.5.3 MSAP-MGMT-SET.request

The MSAP-MGMT-SET.request primitive attempts to set the indicated MIB attribute to a given value. The semantics of the MSAP-MGMT-SET.request primitive is as follows:

```
MSAP-MGMT-SET.request          (
                               MIBAttribute,
                               MIBValue
                               )
```

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6.3.2.5.3.1 When generated

The MSAP-MGMT-SET.request primitive is generated by a local upper layer and issued to its MAC sub layer to set the indicated MIB attribute.

6.3.2.5.3.2 Effect on receipt

The MAC sub layer attempts to set the indicated MIB attribute in the database. If the MIB attribute implies a specific action, then an action is performed to fulfill the request. The MAC sub layer responds via the MSAP with MSAP-MGMT-SET.confirm that notify the upper layer with the result.

6.3.2.5.4 MSAP-MGMT-SET.confirm

The MSAP-MGMT-SET.confirm primitive reports the result of the attempt to set the MIB attribute to a given value. The semantics of the MSAP-MGMT-SET.confirm primitive is as follows:

```
MSAP-MGMT-SET.confirm          (
                               MIBAttribute,
                               MIBValue,
                               ResultCode
                               )
```

6.3.2.5.4.1 When generated

The MSAP-MGMT-SET.confirm primitive is generated by a MAC sub layer and issued to its local upper layer in response to MSAP-MGMT-SET.request.

6.3.2.5.4.2 Effect on receipt

If the result is SUCCESS then no action is required otherwise an error handling is executed by the upper layer depending on the error code.

6.3.3 MAC enumeration description

Table 6.12 shows the description of the PHY enumeration values used in the PHY service specification

Table 6.12 A list of the different enumeration value used in the MAC sub layer.

Enumeration	Value	Description
SUCCESS	0x00	Transmit, CHANGE-CHANNEL, FILTER, DUTY-CYCLE, or SET/GET operation have been successful
INVALID_ADDRESS	0x01	The destination address is a forbidden WLN identity
TRANSMIT_CUE_FULL	0x02	The MAC is asked to transmit while having a full transmitting cue
FRAME_TOO_LONG	0x03	The MAC is asked to transmit a MAC payload that is longer than expected
POWER_TOO_HIGH	0x04	The MAC is asked to transmit with a power level that is higher than expected
CSMA_CA	0x05	The MAC is asked to transmit using CSMA-CA algorithm

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FORCED_TX	0x06	The MAC is asked to transmit without using the CSMA-CA
ASB_TYPE_0	0x07	The MAC is asked to start or stop transmitting ASB of type 0
ASB_TYPE_1	0x08	The MAC is asked to start or stop transmitting ASB of type 1
ASB_TYPE_2	0x09	The MAC is asked to start or stop transmitting ASB of type 2
SEND_IMMEDIALTELY	0x0a	The MAC is asked to transmit the first ASB as soon as the request is received
SEND_SCHEDULED	0x0b	The MAC is asked to transmit the first ASB as scheduled by the internal timer
INVALID_ASB_TYPE	0x0c	The MAC is asked to transmit an invalid type of ASB
INVALID_FIRST_TX	0x0d	The MAC is asked to transmit an invalid type of first transmission schedule
INVALID_REPETION_INTERVAL	0x0e	The MAC is asked to transmit an invalid type of repetition interval
CHANNEL_NOT_SUPPORTED	0x0f	The MAC is asked to change transmission channel to an invalid channel number
ACTIVATED	0x10	The MAC is asked to enable filter
DISABLED	0x11	The MAC asked to disable filter
DATA_TYPE	0x12	The MAC is asked to enable or disable filter of MPDU of data type
INVALID_FILTER_STATE	0x13	The MAC is asked to enable or disable filter of invalid type
INVALID_MPDU_TYPE	0x14	The MAC is asked to enable or disable filter of MPDU of invalid type
POWER_DOWN	0x15	The MAC is asked to power down the transceiver
LOW_POWER	0x16	The MAC is asked to start duty cycling according to low power schedule
NORMAL_RX	0x17	The MAC is asked to start duty cycling according to normal RX schedule
HOT_RX	0x18	The MAC is asked to start duty cycling according to hot RX schedule
INVALID_DUTY_CYCLE_SCHEDULE	0x1a	The MAC is asked to start duty cycling according to an invalid type of schedule
INVALID_PREAMBLE_MODE	0x1a	The MAC is asked to adjust the preamble mode according to an invalid mode
INVALID_MIB_ATTR	0x1b	A SET/GET operation is issued with MIB attribute that is not supported
INVALID_MIB_VALUE	0x1c	A SET operation is issued with an attribute value that is out of range
READ_ONLY_MIB_ATTR	0x1d	A SET operation is issued with a MIB attribute that is read-only

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7 MESSAGE SEQUENCE CHARTS ILLUSTRATING MAC-PHY INTERACTION

This section consists of several sequence charts that illustrates some of the main tasks within the WLN standard. The sequence charts illustrates the chronological order, rather than the exact timing, of the primitives required for each of the tasks.

The main tasks that are described in the following are:

- Setup channel, see Figure 7.1.
- Setup duty cycle, see Figure 7.2.
- Transmitting and receiving a single data packet, see Figure 7.3 and 7.4.

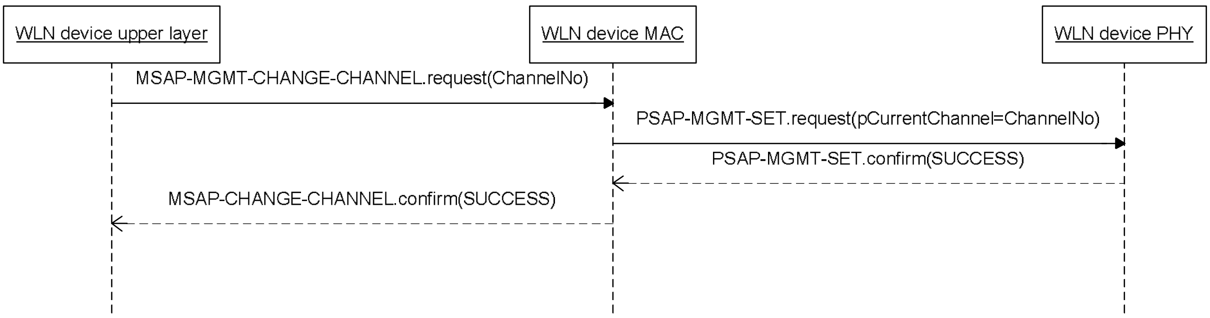

Figure 7.1. Sequence chart for setting up a channel.

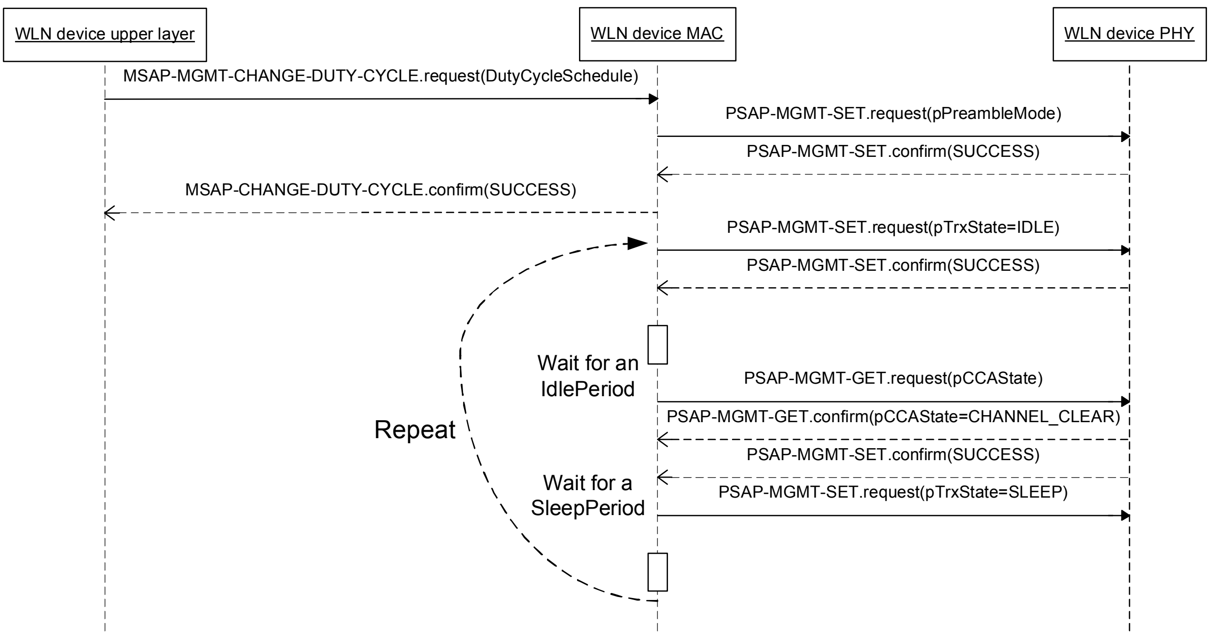

Figure 7.2. Sequence chart for setting duty cycle.

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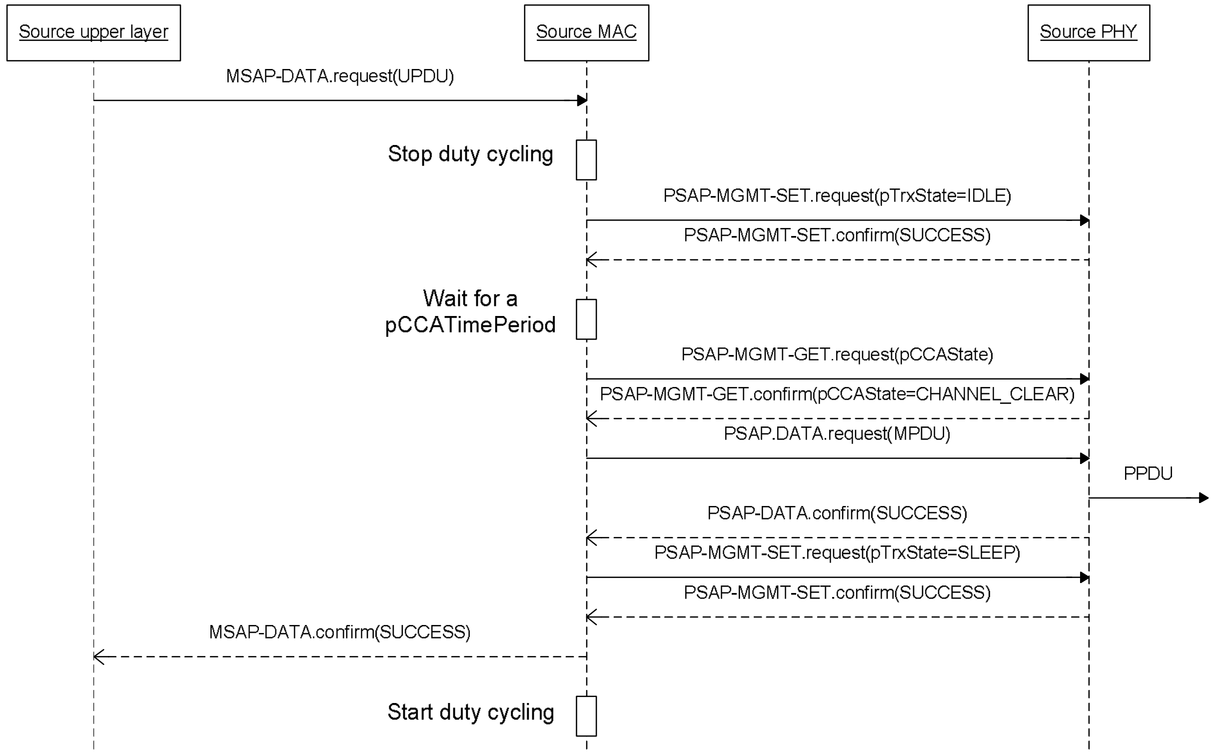

Figure 7.3. Sequence chart for data transmission – Source WLN device.

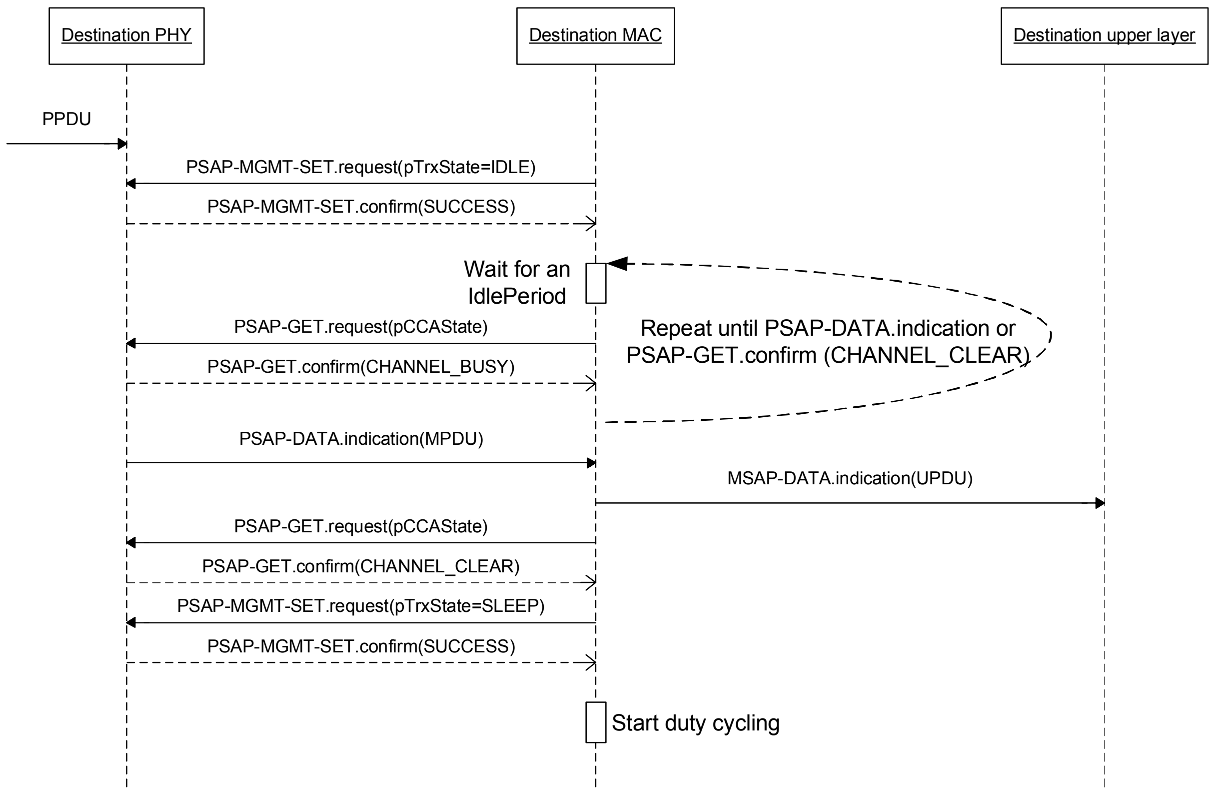

Figure 7.4. Sequence chart for data reception – Destination WLN device.

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