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Information technology — Telecommunications and information exchange between systems — PHY/MAC specifications for short-range wireless low-rate applications in the ISM band —

Technologies de l'information — Téléinformatique — Spécifications PHY/MAC pour applications à bas débit sans fil à courte portée dans la bande ISM —

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Foreword

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Information technology — Telecommunications and information exchange between systems — PHY/MAC specifications for short-range wireless low-rate applications in the ISM band

1 Scope

This International Standard specifies the PHY characteristics and MAC procedures used for short-range, low-data-rate, wireless communications with very low latency and point-to-multipoint connection capability.

2 Normative references

The following referenced documents are indispensable for the application 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.

None.

3 Terms and definitions

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

3.1
pico-net
small operational range for wireless transmissions within about 10 meters in radius from the user or his/her device

3.2
group
total of devices interoperable within a pico-net, with their usage of the same group code separating them from other devices in different groups

3.3
master
device transmitting the reference synchronisation signal within a group

3.4
slave
device that is not a master

3.5
scan
process performed by slaves to search for the synchronising signal from the master

3.6
middleframe
basic unit of frame operation, consisting of one control frame and one or more payload frames

NOTE Sixteen middleframes constitute a superframe.

3.7
superframe
bigger frame consisting of sixteen middleframes

NOTE The superframe is the overall operational unit of pico-net MAC operations.

3.8
scan code
7-bit seed to generate one of the 127 gold codes which has a value between 1 and 127

3.9
open code
code used for broadcasting

3.10
closed code
code used exclusively for a specific communication group or purpose

3.11
group code
code to discriminate among communication groups

NOTE Either an open or a closed code may be applied.

3.12
security code
code applied to message data to enhance security or privacy of the communication

NOTE Either an open or a closed code may be applied.

4 Abbreviated terms

BF	beacon frame
DME	device management entity
FBF	fast beacon frame
FSK	frequency shift keying
GFSK	Gaussian frequency shift keying
ISM	industrial, scientific, and medical
MAC	medium access control
MACF	MCF acknowledge control frame
MCF	master control frame
MLME	MAC sublayer management entity
MLME-SAP	MAC sublayer management entity-service access point
MPDU	MAC protocol data unit
MSDU	MAC service data unit
PD-SAP	PHY data service access point

PDU protocol data unit

PF payload frame

PHY physical layer

PLME physical layer management entity

PLME-SAP physical layer management entity - service access point

PPDU physical layer protocol data unit

PSDU physical layer service data unit

RACF RCF acknowledge control frame

RCF request control frame

RF radio frequency

RSSI received signal strength indication

SAP service access point

SDU service data unit

5 Overview

There may be many applications in the ISM band. Such applications that require a short-range wireless communication channel can be listed as follows in the order of data rates; video, audio, voice, control, sensor, and so on. A different platform for a different application may be an ineffective way in light of cost, time-to-market, compatibility, etc. It would be beneficial to have a single platform which is capable of accommodating all these applications with the least overhead.

This International Standard is intended to provide a unified yet efficient and versatile platform for low-power, low-data-rate, short-range wireless communication applications. It is possible to accommodate diverse services of different nature in a single platform.

For mobile applications, low power consumption is one of the most important factors. To save power, data rate should be traded-off. This International Standard aims for the applications of 1 Mbps or less. To minimise implementation effort, it assumes the use of off-the-shelf RF components for the ISM band.

The International Standard makes use of frequency hopping, time-division multiple access, and time/frequency hybrid diversity. Frequency hopping is adopted to render immunity to the channel variations and to provide independent simultaneous communication channels. Time-division multiple access provides one with the control of interference of strong adjacent signals which otherwise should be avoided using an elaborate manipulation. The diversity technology is the means to maintain quality-of-service in the ISM band where channel fading is of serious concern.

Each device in the pico-net formed by this International Standard is either a master or a slave. In the pico-net, there exists only one single master which transmits a beacon signal to which all the other devices (slaves) are synchronised. The beacon signal contains the time synchronisation information and the frequency hopping pattern table. The frequency hopping pattern table contains the 16 best frequencies which are selected by sounding algorithms (see 7.4.5).

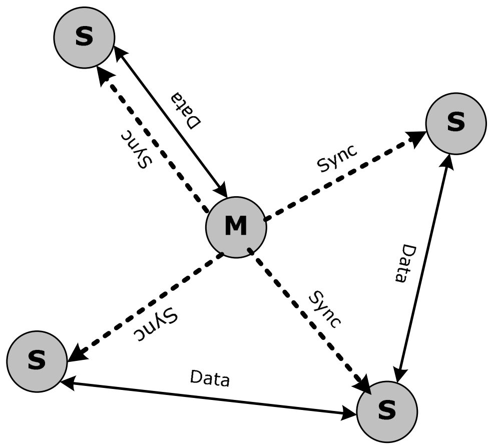

Figure 1 — A group communication example

At start-up, the master checks the frequency channels and selects the best 16 channels out of 80 to form a table of sixteen orthogonal frequency hopping patterns (see 8.4.2). Each frequency hopping pattern corresponds to a channel. The master assigns a communication channel (or channels) using the MCF (Master Control Frame) to be described below (see 7.4). Within each communication channel which is specified by a unique frequency-hopping pattern, the devices communicate with each other using time-division multiple access without any other intervention of the master.

The pico-net may have up to sixteen independent simultaneous communication channels. Within each communication channel, point-to-multipoint communication (broadcasting) is possible not to mention one-to-one communications. Moreover, each device may switch to another communication channel other than the current one if permitted by the master. Figure 1 shows an example of group communication in the pico-net. The master (M) transmits a beacon signal and is communicating with only one slave (S). The other slaves are communicating with another via other channels independently of the master.

Data are encased into the well-tailored standard units of a frame, a middleframe, and a superframe (see 8.3). Figure 2 shows the relationship between these units. These data formats are synchronised to the master beacon signal. To accommodate different applications in a single framework, this International Standard fixes the length of protocol frames to 16 ms which gives a permissible level of latency in most applications. A middleframe consists of frames. Sixteen middleframes constitute a superframe.

A frame is categorised into one of the seven kinds depending on its use: (1) a beacon frame (BF), (2) a fast beacon frame (FBF), (3) a request control frame (RCF), (4) a master control frame (MCF), (5) an RCF acknowledge control frame (RACF), (6) an MCF acknowledge control frame (MACF), and (7) a payload frame (PF). All the frames except the payload frame (PF) are control frames. All the frames have an identical format consisting of Lock Time, Preamble, Header, Message, and EoF Delimiter (see 8.2). Header is used to identify the kind of the frame. The message field is used to convey information and data necessary for communications (see 7.1-7.7).

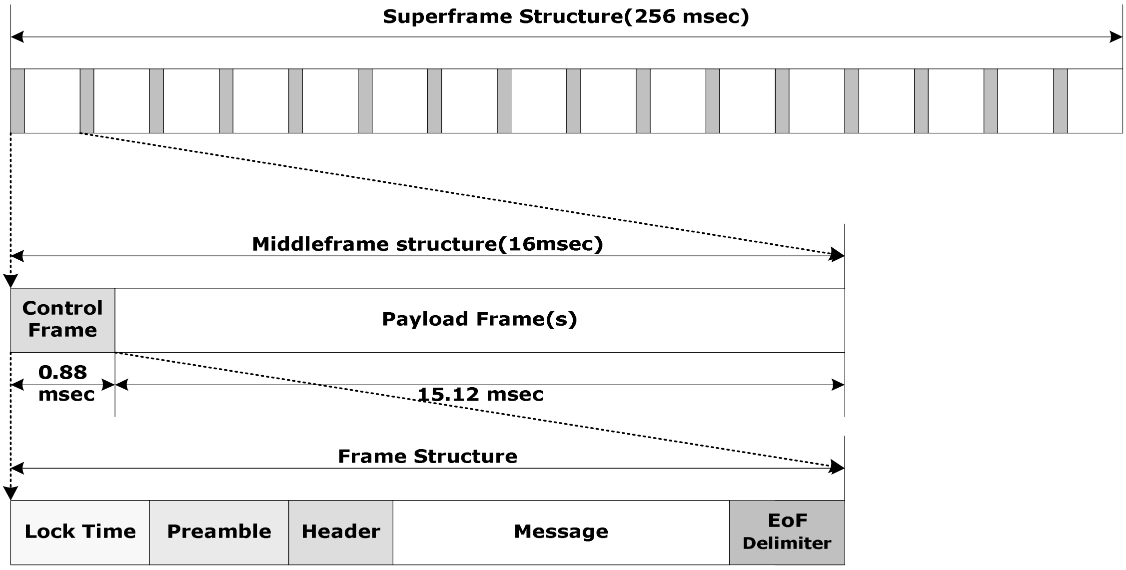

Figure 2 — Data formats: a frame, a middleframe, and a superframe

A middleframe consists of one control frame and one or more payload frames (PF's). The middleframe starts with a control frame whose length is fixed to 0,88 ms. The length of the middleframe is fixed to 16 ms. The length of the payload frames varies depending on applications. The maximum number of payload frames within a middleframe is eighteen. Carrier frequencies hop in harmony with the middleframes.

A superframe consists of sixteen middleframes and is of 256 ms. Superframes have two modes: a normal mode and a fast synchronisation mode (see 8.3.2). A fast synchronisation mode is used for robust synchronisation. In a fast synchronisation mode, a frame called 'fast beacon frame (FBF)' is used instead of 'beacon frame (BF)'. Two modes may be interchangeably adopted by the unit of a superframe.

For security reasons, the preamble in the frame uses Gold codes for group identification. The message field data are also encrypted with security codes (see 9.3.2).

The MAC/PHY services and primitives will be defined and described in Section 6.

This International Standard uses the 2,4 GHz band and offers two classes of power transmission levels. Class one is up to 100 mW and class two is up to 10 mW. As a modulation scheme, the International Standard uses (G)FSK (see 9).

6 Interlayer service specification

This clause defines the interface between the MAC and PHY layers, and between the MAC layer and the upper layer.

6.1 Overview

Both MAC and PHY layers conceptually have management entities, called the MLME (MAC Layer Management Entity) and the PLME (PHY Layer Management Entity), respectively. These entities provide a service interfaces for the layer management functions.

The PHY provides data and management services through two SAPs (Service Access Points). The PHY data services are provided through the PD-SAP (PHY Data SAP), and PHY management services are provided through the PLME-SAP. The DME-PLME_SAP is equivalent to MLME-PLME-SAP except that it operates through DME rather than MLME.

The MAC provides data and management services through two SAPs (Service Access Points). The MAC data services are provided through the MAC-SAP, and MAC management services are provided through the MLME-SAP.

In order to provide correct MAC operation, each device must possess a DME (Device Management Entity). The DME is a layer-independent entity and act under the direction of a higher-level management application. Figure below depicts the relationships between the various management entities.

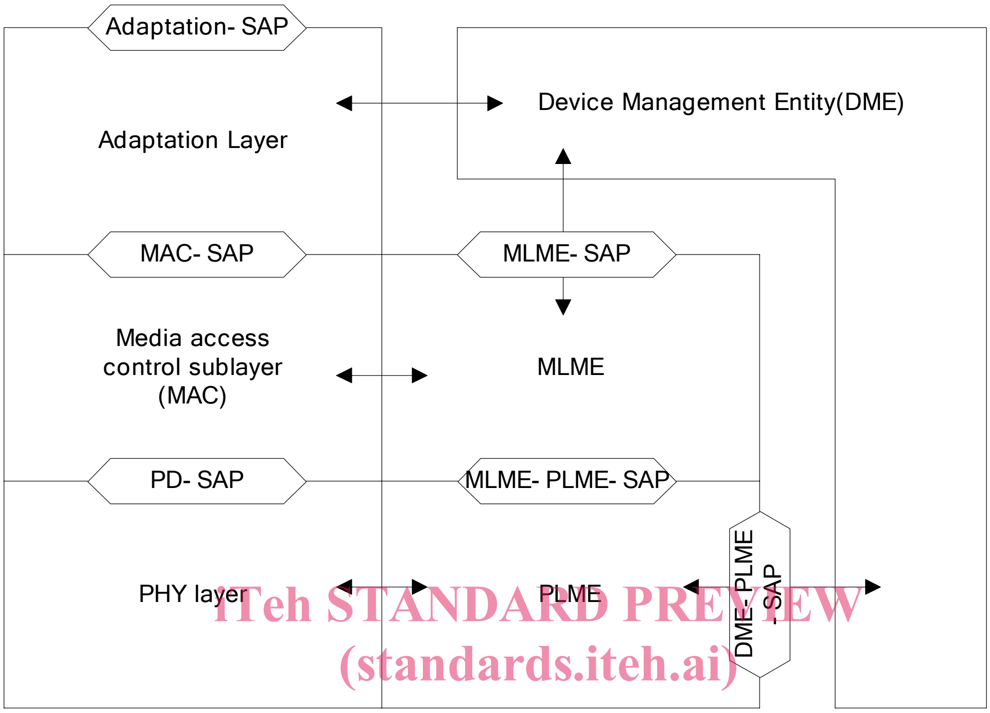

Figure 3 — The protocol model used in this International Standard

6.2 General format of management primitives

Each sublayer's specific management information is organised into the relevant Management Information Base (MIB). Corresponding to the MIB of the PAN, the LAN/MAN contains the MIB that operates according to the Simple Network Management Protocol (SNMP). However, since management within network is restricted to an individual network (i.e. one network does not interfere in the management of another) the MIB is used to define the specifications of each sublayer.

MLME and PLME are assumed to have a MIB for each sublayer, and the management primitives of the MIB are exchanged by means of management SAPs. The manager can "GET" or "SET" the value of the MIB attribute via the primitives. The "SET" request primitive can also trigger certain actions within the relevant layer.

A "GET" or "SET" primitive may be expressed in the form of a request accompanying a confirm primitive. Such primitives have the prefix MLME or PLME depending on whether the point of exchange is the MAC SAP or the PHY SAP. DME utilizes the services provided by MLME through the MLME SAP.

In Table 1, "XX" stands for "MLME" or "PLME", and the parameters of the primitives are defined in Table 2.

Table 1 — General management primitive overview

Name	Request	Confirm
XX-GET	6.2.1	6.2.2
XX-SET	6.2.3	6.2.4

Table 2 — MLME/PLME general management primitive parameters

Name	Type	Valid range	Description
MIBattribute	Octet string	Any MIB attribute	MIB attribute name
MIBvalue	Variable		MIB value
ResultCode	Enumeration	SUCCESS, INVALID_MIB_ATTRIBUTE, READ_ONLY_MIB_ATTRIBUTE, WRITE_ONLY_MIB_ATTRIBUTE	Result of MLME or PLME request

6.2.1 MLME-GET.request and PLME-GET.request

This primitive requests information about the relevant MAC MIB or PHY MIB. The semantics of these primitives are as follows.

XX-GET.request (
MIBattribute
)

The primitive parameters are defined in Table 2.

6.2.1.1 When generated

DME and MLME (in the case of a PLME-GET.request) create these primitives to retrieve information from the MAC or PHY MIB.

6.2.1.2 Effect of receipt

The relevant management entity fetches the requested MIB attribute from the database and returns the value as the result of XX-GET.confirm.

6.2.2 MLME-GET.confirm and PLME-GET.confirm

This primitive returns the result of an information request to the relevant MAC MIB or PHY MIB. The semantics of these primitives are as follows.

XX-GET.confirm (
Status,
MIBattribute,
MIBattributevalue
)

The primitive parameters are defined in Table 2.

6.2.2.1 When generated

DME or MLME (in the case of a PLME-GET.confirm) creates these primitives in response to an XX-GET.request.