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Information technology — Telecommunications and information exchange between systems — MAC/PHY standard for ad hoc wireless network to support QoS in an industrial work environment

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Norme MAC/PHY pour un réseau ad hoc sans fil qui supporte QoS dans un environnement de travail industriel

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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Information technology — Telecommunications and information exchange between systems — MAC/PHY standard for ad hoc wireless network to support QoS in an industrial work environment

1 Scope

This International Standard defines a protocol for the physical layer (PHY) and the data link layer in order to construct a reliable and high-speed data transmission network between devices on industrial sites such as factories and plants. This network specification provides a standardized protocol to provide a framework for various industrial devices to establish a simple, low-cost, energy-efficient, and high-speed network between them. In order to fulfil the service requirements of the factories and large plants, this network specification is designed to enable devices to establish a network by themselves without the help of any infrastructure and to reliably exchange various kinds of data, including real-time audio and video data, between them. In addition to high transmission rates, Quality of Service (QoS) for multimedia data - such as video - is also provided.

The devices mentioned in this International Standard refer to equipment that can be used on industrial sites such as factories and automated assembly lines. Devices include PLC (Programmable Logic Controller), and CNC (Computerized Numerical Controller) and manufacturing robots. However, beyond such conventional devices, devices mentioned in this document include personal IT devices that workers may carry and use while working, including cellular phones, personal industrial digital assistants (PDA), and laptop PCs.

2 Terms and definitions, and abbreviated terms

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

2.1 Terms and definitions

2.1.1
access control
control process to prevent unauthorized use of resources or bandwidth

2.1.2
ad hoc network
network that is spontaneously formed usually without system installation

NOTE Such networks are mainly characterized by time and space limitations.

2.1.3
association
service used to connect authorized devices in the network

2.1.4
authentication
device verification process allowing devices within the network to connect to one another

2.1.5
coverage area
territory over which two devices can achieve acceptable quality and performance while exchanging data

2.1.6
dissociation
service used in an established network

2.1.7
frame
format of bits in a data exchange

2.1.8
K
prefix indicating multiplication by 1024

2.1.9
Kμs
unit of 1024 μs

2.1.10
k
prefix indicating multiplication by 1000

2.1.11
logical channel
data link channel sitting distinctly above the physical layer

2.1.12
master
station that manages the network by periodically transmitting a beacon packet

2.1.13
MAC management protocol data unit
MMPDU
data unit exchanged between two media access control apparatuses in order to implement the media access control management protocol

2.1.14
MAC protocol data unit
MPDU
data unit exchanged between two media access control apparatuses by means of utilizing the physical layer services

2.1.15
MAC service data unit
MSDU
data unit transmitted between media access control service access points

2.1.16
mobile device
device that utilizes communication networks while in motion

2.1.17
packet
structure of bits sent in one data transmission

2.1.18
portable device
station that is normally portable but must be in a fixed location in order to link to the communication network

2.1.19
slave
station in the network other than the master

2.1.20
station
device that can operate according to this International Standard

2.2 Abbreviated terms

ARQ	automatic repeat request
ARQN	automatic repeat request N
ASN.1	abstract syntax notation 1
BER	bit error rate
CAP	contention access period
CCA	clear channel assessment
CDMA	code division multiple access
CODEC	coder/decoder
CRC	cyclic redundancy check
CTS	clear to send
DA	destination address
DBPSK	differential binary phase shift keying
DCE	data communication equipment
DLL	data link layer
DOQPSK	differential offset quadrature phase shift keying
DQPSK	differential quadrature phase shift keying
FCS	frame check sequence
FEC	forward error correction
FER	frame error rate
HCS	header check sequence
IETF	internet engineering task force
IDU	interface data unit
IP	internet protocol
ISM	industrial scientific medicine
IWN	industrial wireless network
LAN	local area network
LFSR	linear feedback shift register
LLC	logical link control
LM	link manager

LME	layer management entity
LMP	link manager protocol
LSB	least significant bit
MAC	medium access control
Master	network coordinator
MC-CDMA	multi-code CDMA
MCDU	MAC command data unit
MCPDU	MAC command protocol data unit
MDF	management-defined field
MIB	management information base
MLME	MAC layer management entity
MPDU	MAC protocol data unit
MSB	most significant bit
MSC	message sequence chart
MSDU	MAC service data unit
MTU	maximum transmission unit
NID	network ID
PAN	personal area network
PAR	project authorization request
PDU	protocol data unit
PER	packet error ratio
PHY	physical layer
PIB	PAN information base
PLME	physical layer management entity
PN	pseudo noise
PPDU	PHY protocol data unit
PPM	parts per million
PRNG	pseudo random number generator
PSDU	PHY service data unit
QAM	quadrature amplitude modulation

QoS	quality of service
QPSK	quadrature phase shift keying
OQPSK	offset quadrature phase shift keying
RF	radio frequency
RFC	request for comments
RSSI	received signal strength indication
RTS	request to send
RTX	response timeout expired
RX	receive or receiver
SAP	service access point
SDP	service discovery protocol
SDU	service data unit
SEQN	sequential numbering scheme
SME	station management entity
SQ	signal quality
SRC	short retry count
SRES	signed response
SS	station service
TA	transmitter address
TCM	trellis coded modulation
TDD	time division duplex
TDMA	time division multiple access
TX	transmit or transmitter
TXE	transmit enable
WAN	wide area network
WLAN	wireless local area network
WM	wireless medium

3 Overview

This section defines the general attributes of the industrial wireless network and describes the attributes of the physical layer and data link layer. The physical layer is built upon a binary CDMA, and the data link layer is composed of the media access control (MAC) layer.

3.1 Characteristics

This International Standard is designed for the construction and management of an optimal network for industrial use applications.

3.1.1 Ad hoc network

This International Standard is based upon an ad hoc network that can be established even without a network infrastructure. A network is made up of two kinds of devices - a master and a slave, which is differentiated according to their functions. All stations can function as a master or a slave and one of them is selected as a master based on the device layout and its capabilities. An independent network structure is feasible without requiring infrastructure.

3.1.2 Quality of service

The number of devices participating in an industrial wireless network changes vastly over time due to the channel conditions and industrial mobile device operation characteristics of a wireless environment. The bandwidth allocated to each device and the transmission delay time also have a significant effect, making it difficult to support real-time multimedia traffic services that require a certain quality of service.

This document requires one station in the network to be the master, which allocates and controls resources and thereby manages the connection quality of each network traffic.

3.1.3 Binary CDMA technology

This International Standard uses Binary-CDMA technology so that it has strong noise resistance, inherent advantage of CDMA, and has another good capability of changing bandwidth finely,

and thereby has the advantages of noise resistance and finely tuned and flexible resource allocation.

First, Binary-CDMA possesses superior noise resistance that is characteristic of CDMA technology, and this is an outstanding attribute in a wireless network environment which, unlike a wireline network, has a high noise factor. In addition, the nature of Binary CDMA makes it possible to adjust the bandwidth by changing the number of codes used, thereby allowing flexible and finely-tuned resource allocation.

3.2 Components of network

The components of a network can be roughly depicted as shown in Figure 1. The primary component is the station. The first station trying to connect or establish a network becomes the master of the network and helps other stations to associate with it by periodically transmitting beacons. It also takes responsibilities such as quality of service and power management. The network is made up of two or more stations operating on the same wireless frequency channel in an industrial activity area.

3.2.1 Station

The station is the primary component of the network and is classified as either master or slave depending on its role. The master assumes full management, and no more than one can exist in a particular network. The master controls slaves by broadcasting beacons. Slaves send or receive data as directed by the master. To acquire time slots for data transfer, slaves make resource allocation requests to the master during the contention period.

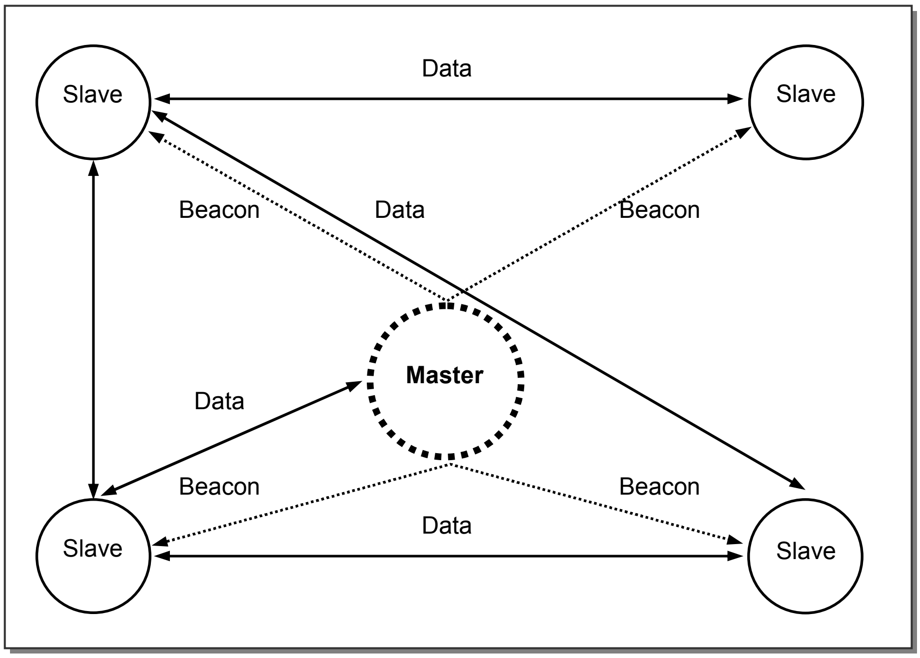

Figure 1 - Network

3.2.2 Resources

Stations in the network should acquire time slots from master to perform their aimed job – exchanging data. After a station acquired rights to use some time slots from master, it can transmit packets exclusively during assigned time slots. In this sense, this International Standard depicts time slots as resources, which stations in the network share and compete for. Time slots are supervised by the master and are distributed according to requests from slaves at the discretion of the master.

3.3 Functional overview

The media access control layer provides the following services:

- Network synchronization

- Data transmission

- Power management

- Change of the master

Data transmission and reception between stations are possible under different standards of quality of service.

3.3.1 Network synchronization

The network is established once the master transmits the beacon packet. The beacon packet contains the status information of the network, and all slaves in the network use this information to sync with the network. The superframe is roughly composed of three parts as shown in Figure 2, and each period has a variable length. (The allocation period must be a multiple of the timeslot length.)