**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: | Technical Guidance Document for 802.15.8 | |
| Abstract | This is the draft baseline of 802.15.8 Technical Guidance Document | |
| Purpose | To provide the technical guidance including functional and technical requirements to the P802.15 Working Group. | |
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| Patent Policy | The contributor is familiar with the IEEE-SA Patent Policy and Procedures:  <http://standards.ieee.org/guides/bylaws/sect6-7.html#6> and  <http://standards.ieee.org/guides/opman/sect6.html#6.3>.  Further information is located at <http://standards.ieee.org/board/pat/pat-material.html> and  <http://standards.ieee.org/board/pat>. | |

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# Overview

The 802.15.8 specification shall be developed according to the P802.15.8 Peer Aware Communication (PAC) project authorization request (PAR), as approved on 30th March 2012 [1], and Five Criteria document [2].

# Definitions

## General definitions

## Specific definitions to this standard

# Abbreviations and acronyms

PD (PAC Device)

# General descriptions

This clause provides the basic framework of PDs and links. The framework serves as a prerequisite to supporting the functions of PDs and links and their interactions specified later in detail. It covers the following aspects — the architecture, components, services, the network topology used for medium access, the transmission range, the reference model used for functional partitioning, and the time base used for access scheduling, and the security paradigm used for message protection.

## Concepts and architecture

This subclause presents the concepts of IEEE 802.15.8 and how the architectural components are related to the overall procedure.

802.15.8 PAC shall support a fully distributed, decentralized, data scalable, and self organized system.

802.15.8 PAC shall support low data rate long distance.

Possibly aided by higher layers, PD shall support selective exchange of data with specific other PDs or groups of PDs

## Components

IEEE 802.15.8 consists of several components that operate corresponding to each other to provide Peer Aware Communications that supports peer aware discovery and communications to connected PDPDs.

[Example]

Discovering PD (DPD) means a PD which is doing discovery function and is not connected yet.

Connected PD (CPD) means a PD which is connected to another PD.

Service Group (SG) means a collection of PDs which are connected by the same service set.

## Topology

Several topologies are considered to support various service interactions within PDs.

One-to-one, one-to-many topology shall be supported.

802.15.8 PAC shall support PD participation in at least two independent one-to-many peer to peer communications with different peers at the same time.

802.15.8 PAC shall support a PD having simultaneous communication links for different applications.

Mesh topology may be supported.

## Services

802.15.8 PAC shall support a PD ability to:

* Discover other PDs in proximity and be discoverable by them
* Discover other PDs in proximity but not be discoverable by them
* Be discoverable by other PDs but not discover them
* Neither discover nor be discoverable

## Reference model

All PDs are internally partitioned into a physical (PHY) layer and a medium access control (MAC) sublayer of the data link layer, in accordance with the ISO/OSI-IEEE Std 802-2001 reference model. Direct communications between PDs are to transpire at the PHY layer and MAC sublayer as specified in this standard; Message security services are to occur at the MAC sublayer, and security key generations are to take place inside and/or outside the MAC sublayer.

Within a PD, the MAC provides its service to the higher layer through the MAC service access point (SAP) located immediately above the MAC sublayer, while the PHY provides its service to the MAC through the PHY SAP located between them. On transmission, the higher layer passes MAC service data units (MSDUs) to the MAC sublayer via the MAC SAP, and the MAC sublayer passes MAC frames (also known as MAC protocol data units or MPDUs) to the PHY layer via the PHY SAP. On reception, the PHY layer passes MAC frames to the MAC sublayer via the PHY SAP, and the MAC sublayer passes MSDUs to the higher layer via the MAC SAP. Both MAC SAP and PHY SAP are not exposed and their specifications are beyond the scope of this standard.



There may be a logical PD management entity (PDME) that exchanges network management information with the PHY and MAC as well as with other layers.

# General requirements

## Operating frequencies

All PDs shall operate in selected globally available unlicensed/licensed bands, below 11 GHz.

There are 4 target bands;

* Unlicensed Sub 1 GHz band
* Unlicensed 2.4 GHz, 5 GHz ISM band
* Unlicensed 6 ~ 10 GHz UWB band
* Licensed bands

## Operating bandwidths

## Duplex

IEEE 802.15.8 may support the following types of duplex.

Time Division Duplex (TDD)

Frequency Division Duplex (FDD) (note: if one wants to support licensed band)

## Multiple access

The multiple access schemes shall be designed as follows: Contention-free access scheme, contention-based, or other access scheme may be considered for control and data transmission.

802.15.8 PAC shall support prioritized channel access.

Functional requirements

This cause contains system level functional requirements targeting peak spectral efficiency, latency, synchronization time, discovery capacity, scheduling, QoS, interference management, power management, system complexity, security. The functional requirements described in this document shall be met with a system comprised solely of IEEE 802.15.8 compliant PDs.

## Synchronization

## Discovery (PD discovery or Peer discovery)

The system shall provide discovery in [TBD] ms.

There are following requirements for discovery.

* Autonomous(should be edited) and continuous discovery(TBD)
* Energy-efficient discovery
* Support high PD density
* Efficient spectrum utilization
* Discovery without peering(association) (from PAR)

802.15.8 PAC shall support data discovery latency to xxx ms

Possibly aided by higher layers, 802.15.8 PAC shall support selective discovery and discoverability by specific other PDs or groups of PDs.

## Peering (Link establishment, or association)

IEEE 802.15.8 shall support a peering function to establish a link or multiple links between PDs or among PDs, respectively.

802.15.8 PAC shall support a quick peering between PDs that have already discovered each other.

## Scheduling

The system shall provide the fully distributed scheduling mechanism.

## QoS

IEEE 802.15.8 shall support prioritized services, various QoS classes, enabling an optimal matching of service, application and protocol requirements (including higher layer signalling) to resources and radio characteristics.

## Interference management

IEEE 802.15.8 shall provide the functionality to mitigate interference.

## Multicast

IEEE 802.15.8 shall support a multicast transmission.

## Broadcast

IEEE 802.15.8 shall support a broadcast transmission.

## Multi-hop support

IEEE 802.15.8 shall provide at least 2-hop relaying function.

## Relative positioning

IEEE 802.15.8 shall support relative positioning for proximate PD.

## Power management

IEEE 802.15.8 shall support a power management functionality to reduce power consumption in PDs for all services and applications.

802.15.8 PAC discovery shall minimize impact on battery consumption without affecting user experience.

## Security

IEEE 802.15.8 should include a security function which provides the necessary means to achieve:

* protection of the integrity of the system (e.g., stability and availability)
* protection and confidentiality of user-generated traffic and user-related data (e.g. location privacy, user identity)

The impact of security procedures on the performance of other system procedures, such as discovery and pairing procedures shall be minimized.

Possibly aided by higher layers, 802.15.8 PAC shall support the authenticity and privacy of the identity of a PD.

Possibly aided by higher layers, 802.15.8 PAC shall support the privacy and confidentiality of communication.

## Scalability

IEEE 802.15.8 shall support scalability according to the number of PDs or data rates.

802.15.8 PAC discovery and communications shall take place in mass deployment of PDs.

## Coexistence

IEEE 802.15.8 shall coexist with other specifications or systems (radio interface technology)at the same frequency band.

802.15.8 PAC system shall support the coexistence of PDs used for different applications as well as non-PDs in the same spectrum.

## Requirements for high layer and infrastructure interaction

802.15.8 PAC shall be able to interact with higher layers to access suitable infrastructure, if it exists, e.g. to facilitate the set up and maintenance of communication.

802.15.8 PAC shall support the report to higher layers with updated discovery and association info.

802.15.8 PAC shall perform measurements at the request of and report results to higher layers. These measurements include received signal strength and interference levels.

# Performance requirements

## Transmission range

IEEE 802.15.8 shall provide sufficient one-hop transmission range to meet nominal service requirements. Transmission range may be extended by multi-hop.

|  |  |
| --- | --- |
| shorter than 200 m | Best performance |
| 200 to 500 m | Graceful degradation |
| longer than 500 m | Best effort |

## Peak spectral efficiency

The system shall support the peak spectral efficiency up to [TBD] bps/Hz with single antenna in a PD.

## Areal spectral efficiency

The areal spectral efficiency means that the summation of link spectral efficiency in the certain dimension. The system shall maximize the areal spectral efficiency without sacrificing other requirements.

*Example: The areal spectral efficiency in 1 km2 dimension is at least x [bps/Hz] when the number of links is y.*

*(PD distribution model should be considered.)*

## Dara rate

802.15.8 PAC shall support data rate up to typically 10 Mbps.

## Error rate

### Bit error rate (PHY)

### Packet error rate

The system shall provide the packet error rate smaller than or equal to [TBD] without retransmission.

### Frame error rate (MAC)

## Latency

The system shall support the data latency requirement of the different QoS of class.

802.15.8 PAC shall support low data latency (to 5-15ms per hop) communication (Note: requirement needed)

### Discovery latency

### Data latency

## Fairness

The system shall meet fairness constraints..

Example: Max-min fairness, proportional fairness, 5%-tile user throughput, 5%-tile user latency

## Mobility

IEEE 802.15.8 shall support PDs with various mobility scenarios.

|  |  |
| --- | --- |
| Walking speed (up to 3km/h) | Best performance |
| Running speed (up to 10 km/h) | Graceful degradation |
| Vehicular (up to 60 km/h) | Best effort |

802.15.8 PAC shall be optimized for pedestrian speeds 0-10 km/h

802.15.8 PAC shall support (relative / absolute) mobility of up to 100 km/h.

## System overhead

Overhead, including overhead for control signalling as well as overhead related to data communications shall be reduced as far as feasible without compromising overall performance and ensuring proper support of systems features.

## Complexity

Complexity should be minimal to enable mass commercial adoption for a variety of cost sensitive products.

# Regulations

## Overview

## Sub 1 GHz band

### US

#### 902 ~ 928 MHz

### EU

#### 863 ~ 870 MHz

### China

### Japan

#### 950.8 ~ 957.6 MHz

### Korea

#### 917 ~ 923.5 MHz

## 2.4 GHz ISM band

### US

#### 2400 ~ 2483.5 MHz

### EU

### China

### Japan

#### 2400 ~ 2483.5 MHz

#### 2471 ~ 2497 MHz

### Korea

#### 2400 ~ 2483.5 MHz

A set of regulatory requirements for device using Direct Sequence Spread Spectrum (DSSS), Chirp Spread Spectrum (CSS), or Orthogonal Frequency Division Multiplexing (OFDM) in 2400 ~ 2483.5 MHz band is listed as follows:

**Maximum transmit power:**

|  |  |  |
| --- | --- | --- |
| Bandwidth | Maximum transmit power | Maximum antenna gain |
| 0.5 MHz ~ 26 MHz | 10mW/MHz | 6 dBi |
| 26 MHz ~ 40 MHz | 5mW/MHz |
| 40 MHz ~ 60 MHz | 0.1mW/MHz |

**Maximum frequency tolerance:**

Maximum frequency tolerance is ±50 \* 10-6.

**Spurious emission limit:**

Out-of-band spurious emission limit is -30dBm with 100kHz resolution bandwidth measurement.

## 5 GHz ISM band

### US

#### 5.15 ~ 5.35 GHz

#### 5.47 ~ 5.725 GHz

#### 5.725 ~ 5.825 GHz

### EU

### China

### Japan

### Korea

#### 5.15 ~ 5.25 GHz

A set of regulatory requirements for device operating in 5.15 ~ 5.25 GHz band is listed as follows:

**Maximum transmit power:**

|  |  |  |
| --- | --- | --- |
| Bandwidth | Maximum transmit power | Maximum antenna gain |
| 0.5 MHz ~ 40 MHz | 2.5mW/MHz | 6 dBi |

**Maximum frequency tolerance:**

Maximum frequency tolerance is ±20 \* 10-6.

**Maximum bandwidth:**

Maximum bandwidth is 40 MHz

**Spurious emission limit:**

Out-of-band spurious emission limit is -27dBm.

#### 5.25 ~ 5.35 GHz, 5.47 ~ 5.65 GHz

A set of regulatory requirements for device operating in 5.25 ~ 5.35 GHz band or 5.47 ~ 5.65 GHz is listed as follows:

**Maximum transmit power:**

|  |  |  |
| --- | --- | --- |
| Bandwidth | Maximum transmit power | Maximum antenna gain |
| 0.5 MHz ~ 20 MHz | 10mW/MHz | 7 dBi |
| 20 MHz ~ 40 MHz | 5mW/MHz |

**Maximum frequency tolerance:**

Maximum frequency tolerance is ±20 \* 10-6.

**Maximum bandwidth:**

Maximum bandwidth is 40 MHz

**Spurious emission limit:**

Out-of-band spurious emission limit is -27dBm.

**Transmitter power control (TPC):**

A device which has average transmit power over 25mW/MHz should be capable of degrading transmit power under 12.5 mW/MHz

**Dynamic frequency selection (DFS):**

|  |  |
| --- | --- |
| Interference detection threshold | * Transmit power < 10mW/MHz: -62dBm * 10mW/MHz ≤ Transmit power ≤ 50mW/MHz: -64dBm |
| Channel availability check time | Over 60 seconds |
| Channel move time | Under 10 seconds |
| Non occupancy period | Over 30 minutes |

#### 5.725 ~ 5.825 GHz

A set of regulatory requirements for device using Direct Sequence Spread Spectrum (DSSS), Chirp Spread Spectrum (CSS), or Orthogonal Frequency Division Multiplexing (OFDM) in 5.725 ~ 5.825 GHz band is listed as follows:

**Maximum transmit power:**

|  |  |  |
| --- | --- | --- |
| Bandwidth | Tx. power | Max. antenna gain |
| 0.5 MHz ~ 26 MHz | 10mW/MHz | 6 dBi |
| 26 MHz ~ 40 MHz | 5mW/MHz |

**Maximum frequency tolerance:**

Maximum frequency tolerance is ±50 \* 10-6.

**Spurious emission limit:**

Out-of-band spurious emission limit is -30dBm with 100kHz resolution bandwidth measurement.

## 6 ~ 11 GHz UWB

### US

#### 5.925 ~ 7.25 GHz

### EU

### China

### Japan

### Korea

#### 3.1 ~ 4.8 GHz, 7.2 ~ 10.2 GHz

A set of regulatory requirements for device operating in 3.1 ~ 4.8 GHz UWB band or 7.2 ~ 10.2 GHz UWB band is listed as follows:

**Maximum transmit power:**

|  |  |  |
| --- | --- | --- |
| Bandwidth | Average power | Peak power |
| > 450 MHz | -41.3 dBm/MHz | 0 dBm/50MHz |

**Minimum bandwidth:**

Minimum bandwidth is 450 MHz

**Spurious emission limit:**

|  |  |
| --- | --- |
| Frequency band | Average power |
| ~ 1.6 GHz | ≤ -90 dBm/MHz |
| 1.6 GHz ~ 2.7 GHz | ≤ -85 dBm/MHz |
| 2.7 GHz ~ 3.1 GHz | ≤ -70 dBm/MHz |
| 3.1 GHz ~ 4.8 MHz | ≤ -51.3 dBm/MHz |
| 4.8 GHz ~ 7.2 GHz | ≤ -70 dBm/MHz |
| 7.2 GHz ~ 10.2 GHz | ≤ -51.3 dBm/MHz |
| 10.2 GHz ~ | ≤ -70 dBm/MHz |

# Evaluation methodology

## Channel models

### Large scale fading

#### Outdoor path loss

#### Indoor path loss

### Small scale fading

## Simulation scenarios and parameters

# References