**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title |  | |
| Date Submitted | July 7th, 2013 | |
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| Re: | Discussion | |
| Abstract | This is the proposed text for 802.15.8 PAC Framework Document. | |
| Purpose | This document provides the framework from which the draft PAC specification will be developed. The document provides an outline of each the functional blocks that will be a part of the final specification. The document is intended to reflect the working consensus of the group on the broad outline for the draft specification. As such it is expected to begin with minimal detail reflecting agreement on specific techniques and highlighting areas on which agreement is still required. It may also begin with an incomplete feature list with additional features added as they are justified. The document will evolve over time until it includes sufficient detail on all the functional blocks and their inter-dependencies so that work can begin on the draft specification itself. | |
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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), document number 15-12-0063r2 and Five Criteria (5c), document number 15-12-0064r1, which were approved by the IEEE-SA in March of 2012.

# Definitions

Device ID: Unique PAC device address e.g. MAC address

Service type ID: Service category for PAC discovery [Appendix A]

Service group: The set of PDs which became peering each other

Discovering PD: PD which transmits the request signal to discover other PD(s)

Discovered PD: PD which transmits the response signal to discovering PD

# Abbreviations and acronyms

PD PAC Device

PDU Protocol Data Unit

SDU Service Date Unit

# General descriptions

This clause provides the basic framework of PDs. The framework serves as a guideline in developing the functionalities of PDs and their interactions specified in detail in the subsequent clauses.

## Concepts and architecture

IEEE 802.15.8 shall support a fully distributed, decentralized, and self-organized system composed of PDs.

Some of these devices may be able to connect on an opportunistic basis to infrastructure, which is out of scope for IEEE 802.15.8.

IEEE 802.15.8 shall support one-to-one and one-to-many communications.

IEEE 802.15.8 shall support scalable data rate to accommodate many applications such as listed in the Application Matrix (document number 15-12-0684-00-0008).

Possibly aided by higher layers, a PD shall support data transfers between itself and identified PDs or groups.

IEEE 802.15.8 shall support both one-way and two-way communications.

## Topology

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

One-to-one and one-to-many topologies shall be supported.

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

IEEE 802.15.8 shall support a PD having simultaneous communication sessions for same or different applications.

Mesh topology may be supported.



Figure 1. An example of concurrent communication

## Overview of PAC procedures

PAC has three procedures: discovery procedure, peering procedure, and communication procedure.

* Discovery procedure
  + When a PD turns on, it starts from discovery phase (active scanning)
  + During communication, discovery phase is allocated when it wants to find others.
  + In discovery phase, a PD can discover other PDs over all channels by moving the each channel in each discovery slot.
* Peering procedure
  + After discovery, the PD goes to the channel in the discovered PDs.
  + They make hopping slot timing same and exchange the peering information.
* Communication procedure
  + After peering, the PD starts communication with the same hopping slot timing with connected PDs.

More details are in section 5. PAC operations.

## 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 operations 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.

MAC and PHY SAPs also pass control information between the layers.



Figure 2. Reference model

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.

# PAC Frame formats



Figure 3. PAC Frame formats

## PPDU structure

PPDU consists of preamble, physical header, and PSDU. Preamble is sequence(s) for timing offset, frequency offset and channel estimation, etc. Physical header is physical information such as bandwidth, PPDU length, etc.

## MPDU structure

MPDU consists of MAC header, frame body, and FCS. MAC header comprises data frame type, device IDs, service type IDs, MCS, MPDU length, etc. Frame body is data information. FCS contains an IEEE 32-bit CRC.

# MAC layer

## ~~MPDU structure~~

## Multiple access

~~e.g. Contention-based access, Contention-free access~~

The fundamental access method of the IEEE802.15.8 PAC is CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance).

For a PD to transmit, it shall sense the medium to determine if another station is transmitting. If the medium is not determined to be busy, the transmission may proceed. The CSMA/CA distributed algorithm mandates that a gap of a minimum specified duration exists between contiguous frame sequences. A transmitting PD shall verify that the medium is idle for this required duration before attempting to transmit. If the medium is determined to be busy, the PD shall defer until the end of the current transmission. After deferral, or prior to attempting to transmit again immediately after a successful transmission, the PD shall select a random backoff interval and shall decrement the backoff interval counter while the medium is idle. A transmission is successful when an ACK frame is received from the STA addressed of the transmitted frame.

## PAC structure and procedure

PAC structure consists of discovery phase, peering phase, and communication phase as figure 1. PDs perform discovery procedure, peering procedure and communication procedure in discovery phase, peering phase, and communication phase, respectively.



Figure 4. PAC structure

### Discovery operation

#### Discovery phase

It is phase for discovering PD to discover other neighbour PD(s). The phase size is unit(s) of hopping slot. Discovery phase consists of multiple discovery slots. Discovering PD may be in different channel in each slot.

 

Figure 5. Discovery phase structure

#### Discovery procedure

Discovering PD sets up discovery phase when it wants to discover others. Discovered PD may not be in discovery phase.

Discovery procedure is as below:

1. Discovering PD transmits ‘discovery request message’ and waits ‘discovery response message’ in first discovery slot.
2. Discovered PD(s) receiving the message transmit(s) ‘discovery response message’ within the discovery slot.
3. Discovering PD transmits ACK message right after the response message. (it’s omitted in figure 2)
4. Repeat 1~3 in the next discovery slot.

Discovery phase is pre-announced to already communicated PDs.

When discovering PD discovers multiple PDs over several channels, the discovering PD performs peering in multiple peering phases without re-discovery. Discovered PDs wait peering message until peering timer is expired. Peering timer sets to zero from when discovered PD receives ACK message.

### Peering operation

#### Peering phase

It is phase for discovering PD to fit slot sync and make peering with discovered PDs. The phase size is flexible because slot sync may be changed.

 

Figure 6. PAC peering frame structure

#### Peering procedure

Discovering PD sets up peering phase when it discover a or more PDs.

Peering procedure is as below:

* 1. Wait for timing1
     + Discovering PD moves to the channel of discovered PD. When the remaining duration of the hopping slot of discovered PD is less than time of 3 messages exchange, discovering PD waits and do peering in the next hopping slot.
  2. Slot-sync & peering
     + Discovering PD transmits ‘Peering request message’ with device ID of discovered PD, which is ‘I want to do peering to you and follow your slot timing’.
     + Discovered PD receives the message and check its device ID, and transmits ‘Peering response message’, which is ‘OK’ and peering information.
     + Discovering PD transmits ‘Peering confirmation’ message, which is peering information.
  3. Wait for timing2
     + Discovering PD waits the newly revised slot timing before communication phase is started.

### Communication operation

#### Communication phase

It is phase for PD to communicate with peered PDs. The phase size is units of hopping slot. The operating channel of each hopping slot is changed by hopping pattern.



Figure 7. PAC communication frame structure

#### Communication procedure

After peering procedure, peered PDs have the same hopping slot timing. The PDs has own hopping pattern and when they meet in the hopping slot with the same channel, they may communicate each other.

The PDs in communication phase also may listen the discovery request message from other PDs in discovery phase.

#### Hopping Pattern in 2.4 GHz band

In 2.4 GHz band, there are 6 possible patterns in Table 1 for PAC device. Each pattern has its Pattern ID. If a PD use hopping pattern ID 2, it operates in channel 1 at slot 1, channel 3 at slot 2, and channel 2 at slot 3. At slot 1, it can communicate with a PD which use pattern ID 1 at channel 1. In a similar way, the PD which use pattern ID 2 can communicate with PDs which use pattern ID 1, 4, 5. That ID set is Communication Possible Pattern (CP-Pattern) in Table 1.

|  |  |  |
| --- | --- | --- |
| Pattern ID | Hopping Pattern | Communication Possible Pattern  (CP-Pattern) |
| 1 | (1, 2, 3) | 2 (in Ch.1 at Slot 1)  3 (in Ch.3 at Slot 3)  6 (in Ch.2 at Slot 2) |
| 2 | (1, 3, 2) | 1 (in Ch.1 at Slot 1)  4 (in Ch.3 at Slot 2)  5 (in Ch.2 at Slot 3) |
| 3 | (2, 1, 3) | 1 (in Ch.3 at Slot 3)  4 (in Ch.2 at Slot 1)  5 (in Ch.1 at Slot 2) |
| 4 | (2, 3, 1) | 2 (in Ch.3 at Slot 2)  3 (in Ch.1 at Slot 1)  6 (in Ch.2 at Slot 3) |
| 5 | (3, 1, 2) | 2 (in Ch.2 at Slot 3)  3 (in Ch.1 at Slot 2)  6 (in Ch.3 at Slot 1) |
| 6 | (3, 2, 1) | 1 (in Ch.2 at Slot 2)  4 (in Ch.1 at Slot 3)  5 (in Ch.3 at Slot 1) |

Table 1. Hopping Pattern of communication phase in 2.4 GHz band

#### Hopping Pattern decision rule

A PD shall following rule for decision of its hopping pattern.

If a PD doesn't have peered link:

1. Discover hopping pattern ID of target PD and PDs which are peered with target PD.
2. Subtract pattern IDs used by PDs which are peered with target PD from CP-Pattern of target PD.
3. If there are remaining IDs, choose a pattern ID from them.
4. If there are not reaming IDs, choose a pattern ID from CP-Pattern of target PD.

If a PD has peered link(s):

1. Discover hopping pattern ID of target PD.
2. If the CP-Pattern of target PD include own using pattern ID, use the pattern ID as it is.
3. If the CP-Pattern of target PD doesn't include own using pattern ID, change the pattern ID to the identical ID of target PD.

Example:

* Case 1: No peered link. Pattern ID of target PD = 3, Pattern ID of PD which is peered with target PD = 1
  + CP-Pattern of target PD is 1, 4, 5 and subtract 1. And then we have 4, 5. And choose a pattern ID from 4 and 5.
* Case 2: Pattern ID of target PD = 3, Pattern IDs of PD which are peered with target PD = 1, 4, 5
  + CP-Pattern of target PD is 1, 4, 5 and subtract 1, 4, 5. And then we have nothing. And choose a pattern ID from 1, 4 and 5.
* Case 3: Having peered link. Pattern ID of target PD = 3, Using pattern ID = 1
  + CP-Pattern of target PD is 1, 4, 5 and include 1. Use pattern ID 1 as it is.
* Case 4: Having peered link. Pattern ID of target PD = 3, Using pattern ID = 2
  + CP-Pattern of target PD is 1, 4, 5 and doesn't include 2. Use pattern ID 2.

## ~~Synchronization procedure~~

## ~~Discovery procedure~~

## ~~Peering procedure~~

## Scheduling

## QoS

## Interference management

## Transmit power control

## Multicast

## Broadcast

## Multi-hop operation

## Relative positioning

## Power management

## Security

## Coexistence

PAC shall coexistence systems such as IEEE802 using unlicensed bands in section 7.1.1.

## Higher layer interaction

# Physical layer

## Channelization

### Operating frequency bands

PAC uses unlicensed bands with multiple channels. E.g. PAC can use all or partial channels among 3 channels in 2.4GHz and 8 channels in 5GHz (UNII-1, UNII-3) when bandwidth is 20MHz per channel.

## Duplex schemes

PAC is TDD system.

## Multiplex schemes

~~(e.g. CDMA, OFDMA)~~

PAC multiplexing scheme is OFDM.

## ~~Frame structure~~

### ~~Discovery frame structure~~

### ~~Data frame structure~~

## Modulation and coding scheme (MCS)

### Data rates

## Multiple antennas

## Appendix A

Table A. List of Service types

|  |  |
| --- | --- |
| **Value** | **Meaning** |
| 0 | All Service Types |
| 1 | real-time streaming |
| 2 | display |
| 3 | talking (VoIP) |
| 4 | two-way gaming |
| 5 – 254 | Reserved |
| 255 | Vendor Specific |