IEEE P802.22
Wireless RANs

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Abstract

This document is a revision of initialization and network association (7.14) for 802.22b systems and provies definitions related with the revision.

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**7. MAC Common Part sublayer**

**7.3 General superframe structure**

The IEEE 802.22 WRAN system includes two operational modes: a normal mode and a self-coexistence mode. In normal mode, one WRAN cell occupies one channel and operates on all the frames in a superframe; while in self-coexistence mode, multiple WRAN cells share the same channel and each coexisting WRAN cell operates on one or several different frames exclusively.

The IEEE 802.22 WRAN system includes two operational modes: a normal mode and a self-coexistence mode. In normal mode, one WRAN cell occupies one channel and operates on all the frames in a superframe; while in self-coexistence mode, multiple WRAN cells share the same channel and each coexisting WRAN cell operates on one or several different frames exclusively.

The IEEE 802.22b WRAN system includes two operational modes: a normal mode and a self-coexistence mode. In normal mode, one WRAN cell occupies one or more channels if multiple operating channels are available; while in self-coexistence mode, multiple WRAN cells share the same channel and each coexisting WRAN cell operates on one or several different frames exclusively.

When operating in normal mode, a WRAN cell shall transmit the Superframe Control header (SCH) at the beginning of the first frame of a superframe on the operating channel; when operating in self-coexistence mode, a WRAN cell shall transmit its SCH at the beginning of the first frame allocated to it in the superframe. The structure of the SCH for both normal mode and self-coexistence mode can be found in 7.5.1. A WRAN runs in normal mode by default and transits to self-coexistence mode when the WRAN can detect and decode an SCH or a CBP from an adjacent WRAN cell on its operating channel.

When operating in normal mode, an IEEE 802.22 WRAN cell shall transmit the Superframe Control header (SCH) at the beginning of the first frame of a superframe on the operating channel; when operating in self-coexistence mode, an IEEE 802.22 WRAN cell shall transmit its SCH at the beginning of the first frame allocated to it in the superframe. The structure of the SCH for both normal mode and self-coexistence mode can be found in 7.5.1. An IEEE 802.22 WRAN runs in normal mode by default and transits to self-coexistence mode when the WRAN can detect and decode an SCH or a CBP from an adjacent WRAN cell on its operating channel.

An IEEE 802.22b WRAN shall transmit the Frame Control Header (FCH) at the beginning of the first frame on the operating channel in both normal mode and self-coexistencce mode. An IEEE 802.22b WRAN runs in normal mode by default and transits to self-coexistence mode when the WRAN can detect and decode an FCH or a CBP from an adjacent WRAN cell on its operating channel.

**7.3.1 802.22 WRAN general superframe structure for normal mode**

**7.3.1.x 802.22b WRAN general frame structure for normal mode**

The frame structure depicted in Figure xx shall be constituted of the following:

\_ A PHY frame preamble, see Clause 9

\_ A Frame Control Header (FCH), see xxx

\_ The rest of the first frame including its frame header and data payload

At the beginning of every frame, the MR-BS shall transmit the frame preamble and the FCH on the operating channel using the modulation/coding specified in x.x.x and Table xxx respectively. In order to associate with an MR-BS, a CPE must receive the FCH to establish communication with the MR-BS. During each MAC frame, the MR-BS shall manage the upstream and downstream operations, which may include ordinary data communication, measurement activities, coexistence procedures, and so on.



**7.3.2 802.22 WRAN general superframe structure for self-coexistence mode**

**7.3.2.x 802.22b WRAN general frame structure for self-coexistence mode**

The 802.22b WRAN frame structure in self-coexistence mode is shown in Figure xx. The self-coexistence mode is for the scenario when multiple MR-BSs with overlapping coverage have to share the same channel. The frequency reuse factor cannot be maintained as one due to their mutual interference. In this case, these MR-BSs shall share the channel on a per frame basis. The negotiation process of frame allocation can be found in x.x.x.

In self-coexistence mode, the MR-BS and CPEs in a WRAN cell shall only transmit during the active frames allocated to that WRAN cell. They can only transmit during other frames when a self-coexistence window (SCW) has been scheduled. During the frames not allocated to the present cell, the MR-BS and CPEs may monitor the channel for any transmission from neighboring WRAN cells to improve self-coexistence.

**7.4 IEEE 802.22 general frame structure**

**7.4.x IEEE 802.22b general frame structure**

The top-down time division duplex (TDD) frame structure employed in the MAC is illustrated in Figure xx.

As illustrated in Figure xx, a frame is comprised of two parts: a downstream (DS) subframe and an upstream (US) subframe. A portion of the US subframe may be allocated as a window to facilitate self- coexistence. This SCW may be scheduled by the base station at the end of the US subframe when necessary to allow transmission of opportunistic coexistence beacon protocol bursts. The SCW includes the necessary time buffers to absorb the difference in propagation delay between close-by and distant base stations and CPEs operating on the same channel. The boundary between the DS and US subframes shall be adaptive to adjust to the downstream and upstream relative capacity.

An IEEE 802.22b general frame structure has two different modes for relaying: centralized scheduling mode and distributed scheduling mode.

**7.4.x.x IEEE 802.22b general frame structure on centralized scheduling mode**



Each of the downstream and upstream subframes for a centralized scheduling mode may be separated of two parts: downstream and relay downstream subframes, and upstream and relay upstream subframes. Downstream and upstream subframes are used for transmission between MR-BS and CPEs (R-CPEs and S-CPEs), while relay downstream and upstream subframes are used for transmission between R-CPE and S-CPEs.

For a centralized scheduling mode, the downstream and upstream subframes and the relay downstream and upstream subframes are managed by an MR-BS.



 At the beginning of every frame, the MR-BS shall transmit the frame preamble and the FCH on the operating channel using the modulation/coding specified in x.x.x and Table xxx respectively. In order to associate with an MR-BS, a CPE must receive the FCH to establish communication with the MR-BS. During each MAC frame, the MR-BS shall manage the upstream and downstream operations as well as the relay upstream and downstream operations, which may include ordinary data communication, measurement activities, coexistence procedures, and so on. During the relay downstream subframe, the R-CPE transmits the MAC frames, which are transferred from the MR-BS during the downstream subframe, to the S-CPE on the scheduled slots determined by the MR-BS.

The upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic. It may also include contention intervals scheduled for the following:

 CPE association (initial ranging)

 CPE link synchronization, power control and geolocation (periodic ranging)

 Bandwidth request

 Urgent coexistence situation (UCS) notification

 Quiet period resource adjustment

The relay upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic from being relayed by the R-CPE. It may also include contention intervals scheduled for the following:

 CPE association (relay initial ranging x.x.x)

 CPE power control and geolocation (relay periodic ranging x.x.x)

 Relay bandwidth request (x.x.x)

 Relay urgent coexistence situation (UCS) notification

 Quiet period resource adjustment

The PHY PDUs depicted in Figure 12 may be transmitted across several subchannels as shown in Figure 13, which depicts how a frame may be transmitted (in time and frequency) by the PHY layer.

Figure 13 shows an example of the two-dimensional (time/frequency) structure of the MAC frame that shall consist of an integer number of fixed size OFDM slots. Each slot shall consist of one OFDM symbol by one subchannel (i.e., 1 OFDM slot = 1 symbol × 1 subchannel). To help understand Figure 13, the MAC packets are assumed to be structured in a linear TDM manner (see Figure 12) while the PHY packets are arranged in a two-dimensional time/frequency domain (symbol in the horizontal direction, logical subchannels in the vertical direction). For the FCH, the DS/US-MAP, Relay DS/US MAP if appeared, the DCD, the UCD, the Realy DCD/UCD if appeared as well as for the downstream payload and the relay downstream payload if appeared, the MAC information is first laid vertically by subchannels then stepped horizontally in the time direction. This vertical layering allows early scheduling of DS bursts assigned to distant CPEs to compensate for propagation delays and to avoid potential interference at the CPE in the case of overlapping WRAN cells with different DS/US capacity split.

The MAC data elements from Figure 12, starting from the FCH and including the first broadcast burst, shall be entered into the second OFDM symbol, as shown in Figure 13, in the increasing order of logical subchannels until all logical subchannels are occupied. Then, the subsequent data elements, if they have not all been mapped, shall be placed in the same order on the following OFDM symbols. The balance of the last OFDM symbols shall be padded with zeros. The modulation and coding schemes for the padding zeros are defined by the DIUC for the last DS burst in the DS-MAP. Note that the DS-MAP indicates the length of the contiguous DS MAC elements, not their absolute position in the DS subframe.

If the relay downstream subframe is appeared in the downstream subframe, the relay downstream subframe shall be appeared followed by the downstream subframe in the MAC frame. The MAC data bursts in the relay downstream subframe may be entered into the first subchannel in the increasing order of logical subchannels until all logical subchannels are occupied. Then, the subsequent data elements if they have not all been mapped, shall be placed in the same order on the following OFDM symbols. The balance of the last OFDM symbols shall be padded with zeroz. The modulation and coding schemes for the padding zeros are defined by the DIUC for the last DS burst in the Relay DS-MAP. Relay DS-MAP indicates the length of the contiguous Relay DS MAC elements in the relay downstream subframe.

The MAC data elements that are contained in upstream bursts shall be mapped to the US subframe in a different order as shown in Figure 13. They are first mapped horizontally, OFDM symbol by OFDM symbol, in the same logical subchannel. Once a logical subchannel has been filled to the end of the upstream subframe, the balance of the MAC data elements shall be mapped to the next logical subchannel, in an increasing subchannel order. This process continues until all of the subchannels and symbols allocated to the burst are filled. If the quantity of MAC data elements is insufficient to fill an upstream burst so that an integer number of OFDMA slots is occupied once encoded, zero padding shall be inserted at the end.

Alternatively, the horizontal laying of the MAC data elements may fill one subchannel with at least 7 OFDM symbols at a time and continue on the following subchannels. However, when all logical subchannels have been filled, the next MAC data elements shall be placed in the first available logical subchannel in the following burst. The width of the last vertical burst will be between 7 and 13 symbols depending on the total number of symbols in the upstream subframe.

The long upstream packet structure, where a logical subchannel is completely filled before moving to the next subchannel, is used to maximize the allowed power per subcarrier for a given CPE EIRP limit, i.e., this horizontal laying reduces the EIRP required by the CPE for its upstream burst by minimizing the number of subchannels needed. In the upstream, the shorter burst alternative shown in Figure 13 is used to reduce latency by allowing advance of the US burst in the US subframe to give the base station time to react before the start of the next frame, at the cost of reduced transmit power and efficiency (e.g., video game near real-time versus transmission efficiency).

If the relay upstream subframe is appeared in the upstream subframe, the relay upstream subframe may be appeared followed by the upstream subframe in the MAC frame. The MAC data elements that are contained in relay upstream bursts shall be mapped to the relay US subframe in the same order of US subframe mapping.

The format of the FCH MAC burst is described in 7.5.2. The FCH is modulated using the data mode selected (e.g., Mode 4 or 5, see Table 202). Binary convolutional coding (BCC, 9.7.2.1) shall also be applied to the FCH burst. The FCH specifies the burst profile and the length of either the DS-MAP, the Relay DS-MAP, if transmitted, the US-MAP, or the Relay US-MAP. If neither, the DS-MAP, the Relay DS-MAP, the US-MAP, nor the Relay US-MAP is transmitted, the value shall be set to zero. The DS-MAP message, if transmitted, shall be the first MAC PDU in the burst following the FCH. A US-MAP message, if transmitted, shall immediately follow either the DS-MAP message, if transmitted, or the FCH. The Relay DS-MAP message, if transmitted, shall be immediately follow either the DS-MAP message or the FCH. The Relay US-MAP message, if transmitted shall be immediately follow either the Relay DS-MAP message, if transmitted, or the Relay US-MAP message. The Relay DS-MAP shall not be appeared without the being DS-MAP and the Relay US-MAP shall not be appeared without being the US-MAP. If DCD UCD, Realy DCD and Relay UCD messages are transmitted in the frame, they shall immediately follow the DS-MAP, US-MAP, Relay DS-MAP and Relay US-MAP messages. The symbols containing these broadcast MAC control messages shall be modulated using data mode 5 as described in Table 202 with the mandatory BCC mode (see 9.7.2.1).

In the upstream direction, if a CPE does not have any data to transmit in its US allocation, it shall transmit an US PHY burst containing a generic MAC header (see 7.6.1.1) with its basic FID, together with a Bandwidth Request subheader (see 7.6.1.2.1). This would allow the BS to reclaim this CPE’s allocation in the following frames and use the resource for some other purpose.

In the upstream direction, if a CPE does not have any data to transmit in its relay US allocation, it shall transmit an US PHY burst containing a generic MAC header (see 7.6.1.1) with its basic FID, together with a Bandwidth Request subheader (see 7.6.1.2.1). This would allow the MR-BS to reclaim this CPE’s allocation in the following frames and use the resource for some other purpose.

The MR-BS may schedule up to eight types of contention windows (see 7.13): the Initial Ranging window is used for initializing the association; the periodic ranging window is used for regularly adjusting the timing and power at the CPE; the BW request window is for CPEs to request upstream bandwidth allocation from the BS; the UCS notification window is used by CPEs to report an urgent coexistence situation with incumbents; the relay initial ranging window is used for initializing the association by relaying; the relay periodic ranging window is used for regularly adjusting the timing and power at the CPE for relaying; the relay BW request window is for CPEs to request relay upstream bandwidth allocation from the MR-BS; the UCS notification window is used for CPEs to report an urgent coexistence situation with incumbents; while the SCW is employed by CBP packets for signaling information to adjacent and overlapping WRAN cells for the purpose of self-coexistence, signal the device identification for resolving interference situations with incumbents when requested by local regulation, and for carrying out terrestrial geolocation between CPEs of the same WRAN cell. However, CBP burst transmissions for terrestrial geolocation purpose shall have lower priority than any other coexistence transmission on the CBP burst

**.4.x.x IEEE 802.22b general frame structure on distributed scheduling mode**



Each of the downstream and upstream subframes for a distributed scheduling mode may be separated of two parts: downstream and local downstream subframes and upstream and local upstream subframes. Downstream and upstream subframes are used for transmission between MR-BS and CPEs, while relay downstream and upstream subframes are used for transmission between R-CPE and S-CPEs.

For a distributed scheduling mode, the local downstream and upstream subframes are controlled by an R-CPE, which is capable of configurating and maintaining a local cell within an 802.22b WRAN cell.



At the beginning of every frame, the MR-BS shall transmit the frame preamble and the FCH on the operating channel using the modulation/coding specified in 9.4.1.2 and Table 202 respectively. In order to associate with an MR-BS, a CPE must receive the FCH to establish communication with the MR-BS. During each MAC frame, the MR-BS shall manage the upstream and downstream operations, which may include ordinary data communication, measurement activities, coexistence procedures, and so on.

For local cell operations within an 802.22b WRAN, the MR-BS may provide a local downstream subframe for an R-CPE, which is capable of managing a local cell. During a local downsteam subframe, the R-CPE (distributed scheduling R-CPE) shall transmit the local frame preamble and the local FCH (L-FCH) on the operating channel using the modulation/coding specified in 9.4.1.2 and Table 202 respectively. In order to associated with the distributed scheduling R-CPE, a CPE must receive the L-FCH to establish communication with the distributed scheduling R-CPE. During the local downstream and upstream subframes, the distributed scheduling R-CPE shall manage the upstream and downstream operations within its cell, which may include ordinary data communication, measurement activities, coexistence procedures, and so on.

The upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic to the MR-BS. It may also include contention intervals scheduled for the following:

 CPE association (initial ranging)

 CPE link synchronization, power control and geolocation (periodic ranging)

 Bandwidth request

 Urgent coexistence situation (UCS) notification

 Quiet period resource adjustment

The local upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic to the R-CPE. It may also include contention intervals scheduled for the following:

 CPE local association (local initial ranging)

 CPE local link synchronization, power control and geolocation (local periodic ranging)

 Local bandwidth request

 Local urgent coexistence situation (UCS) notification

 Quiet period resource adjustment

The PHY PDUs depicted in Figure 12 may be transmitted across several subchannels as shown in Figure 13, which depicts how a frame may be transmitted (in time and frequency) by the PHY layer.

Figure 13 shows an example of the two-dimensional (time/frequency) structure of the MAC frame that shall consist of an integer number of fixed size OFDM slots. Each slot shall consist of one OFDM symbol by one subchannel (i.e., 1 OFDM slot = 1 symbol × 1 subchannel). To help understand Figure 13, the MAC packets are assumed to be structured in a linear TDM manner (see Figure 12) while the PHY packets are arranged in a two-dimensional time/frequency domain (symbol in the horizontal direction, logical subchannels in the vertical direction). For the FCH, the DS/US-MAP, the DCD, and UCD, as well as for the downstream payload, the MAC information is first laid vertically by subchannels then stepped horizontally in the time direction. For the L-FCH, the L-MAP, the L-DCD /UCD on the distributed scheduling mode, the MAC information is first laid vertically by subchannels then stepped horizontally in the time direction. This vertical layering allows early scheduling of DS bursts assigned to distant CPEs to compensate for propagation delays and to avoid potential interference at the CPE in the case of overlapping WRAN cells with different DS/US capacity split.

The MAC data elements from Figure 12, starting from the FCH and including the first broadcast burst, shall be entered into the second OFDM symbol, as shown in Figure 13, in the increasing order of logical subchannels until all logical subchannels are occupied. Then, the subsequent data elements, if they have not all been mapped, shall be placed in the same order on the following OFDM symbols. The balance of the last OFDM symbols shall be padded with zeros. The modulation and coding schemes for the padding zeros are defined by the DIUC for the last DS burst in the DS-MAP. Note that the DS-MAP indicates the length of the contiguous DS MAC elements, not their absolute position in the DS subframe.

If the local downstream subframe is appeared in the downstream subframe, the local downstream subframe shall be appeared followed by the downstream subframe in the MAC frame. The MAC data bursts in the local downstream subframe shall be entered into the first subchannel in the increasing order of logical subchannels until all logical subchannels are occupied. Then, the subsequent data elements if they have not all been mapped, shall be placed in the same order on the following OFDM symbols. The balance of the last OFDM symbols shall be padded with zeroz. The modulation and coding schemes for the padding zeros are defined by the DIUC for the last DS burst in the Local DS-MAP. Local DS-MAP indicates the length of the contiguous DS MAC elements in the local downstream subframe.

The MAC data elements that are contained in upstream bursts shall be mapped to the US subframe in a different order as shown in Figure 13. They are first mapped horizontally, OFDM symbol by OFDM symbol, in the same logical subchannel. Once a logical subchannel has been filled to the end of the upstream subframe, the balance of the MAC data elements shall be mapped to the next logical subchannel, in an increasing subchannel order. This process continues until all of the subchannels and symbols allocated to the burst are filled. If the quantity of MAC data elements is insufficient to fill an upstream burst so that an integer number of OFDMA slots is occupied once encoded, zero padding shall be inserted at the end.

Alternatively, the horizontal laying of the MAC data elements may fill one subchannel with at least 7 OFDM symbols at a time and continue on the following subchannels. However, when all logical subchannels have been filled, the next MAC data elements shall be placed in the first available logical subchannel in the following burst. The width of the last vertical burst will be between 7 and 13 symbols depending on the total number of symbols in the upstream subframe.

The long upstream packet structure, where a logical subchannel is completely filled before moving to the next subchannel, is used to maximize the allowed power per subcarrier for a given CPE EIRP limit, i.e., this horizontal laying reduces the EIRP required by the CPE for its upstream burst by minimizing the number of subchannels needed. In the upstream, the shorter burst alternative shown in Figure 13 is used to reduce latency by allowing advance of the US burst in the US subframe to give the base station time to react before the start of the next frame, at the cost of reduced transmit power and efficiency (e.g., video game near real-time versus transmission efficiency).

If the local upstream subframe is appeared in the upstream subframe, the local upstream subframe shall be appeared followed by the upstream subframe in the MAC frame. The MAC data elements that are contained in local upstream bursts shall be mapped to the local US subframe in the same order of US subframe mapping.

Alternatively, the horizontal laying of the MAC data elements may fill one subchannel with at least 7 OFDM symbols at a time and continue on the following subchannels. However, when all logical subchannels have been filled, the next MAC data elements shall be placed in the first available logical subchannel in the following burst. The width of the last vertical burst will be between 7 and 13 symbols depending on the total number of symbols in the local upstream subframe.

The long upstream packet structure, where a logical subchannel is completely filled before moving to the next subchannel, is used to maximize the allowed power per subcarrier for a given CPE EIRP limit, i.e., this horizontal laying reduces the EIRP required by the CPE for its upstream burst by minimizing the number of subchannels needed. In the upstream, the shorter burst alternative shown in Figure 13 is used to reduce latency by allowing advance of the US burst in the US subframe to give the R-CPE time to react before the start of the next frame, at the cost of reduced transmit power and efficiency (e.g., video game near real-time versus transmission efficiency).

The format of the L-FCH MAC burst is described in 7.5.2. The L-FCH is modulated using the data mode selected (e.g., Mode 4 or 5, see Table 202). Binary convolutional coding (BCC, 9.7.2.1) shall also be applied to the L-FCH burst. The L-FCH specifies the burst profile and the length of either the L-DS-MAP, if transmitted, or the L-US-MAP. If neither, the L-DS-MAP nor the L-US-MAP is transmitted, the value shall be set to zero. The L-DS-MAP message, if transmitted, shall be the first MAC PDU in the burst following the L-FCH. A L-US-MAP message, if transmitted, shall immediately follow either the L-DS-MAP message, if transmitted, or the L-FCH. If L-DCD and L-UCD messages are transmitted in the frame, they shall immediately follow the L-DS-MAP and L-US-MAP messages. The symbols containing these broadcast MAC control messages shall be modulated using data mode 5 as described in Table 202 with the mandatory BCC mode (see 9.7.2.1).

In the upstream direction, if a CPE does not have any data to transmit in its local US allocation, it shall transmit an US PHY burst containing a generic MAC header (see 7.6.1.1) with its basic FID, together with a Bandwidth Request subheader (see 7.6.1.2.1). This would allow the MR-BS to reclaim this CPE’s allocation in the following frames and use the resource for some other purpose. (Centralized Scheduling Mode)

In the upstream direction, if a CPE does not have any data to transmit in its local US allocation, it shall transmit an US PHY burst containing a generic MAC header (see 7.6.1.1) with its basic FID, together with a Local Bandwidth Request subheader (see 7.6.1.2.1). This would allow the R-CPE to reclaim this CPE’s allocation in the following frames and use the resource for some other purpose. (Distributed Scheduling Mode)

The distributed scheduling R-CPE may schedule up to four types of contention windows (see 7.13): the local Initial Ranging window is used for initializing the association; the local periodic ranging window is used for regularly adjusting the timing and power at the CPE; the local BW request window is for CPEs to request local upstream bandwidth allocation from the dirstibuted scheduling R-CPE; the UCS notification window is used by CPEs to report an urgent coexistence situation with incumbents.