IEEE P802.22
Wireless RANs

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| Proposed Text of PHY technical items related to Sections 9.7, 9.8 and 9.9 of the Std.802.22-2011 |
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Abstract

This document contains the proposed text of PHY technical items related to Section 9.7, 9.8 and 9.9 of the current 802.22 standard.

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**Summary of this document**

In this document, based on the proposed (1K FFT-based) PHY, detailed texts regarding “OFDM slot concatenation” , “data modulation” , and “CDMA bursts” are proposed. These items correspond to Section 9.7.2.1.3, 9.8.1 and 9.9.3.1, respectively as shown below. (Some marks have been modified from Doc.IEEE 22-13-0031-02-000b)

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In this document, texts are described with revision marks based on the current IEEE802.22 standard.

**9.X.7.2.1.3 OFDM slot concatenation**

The encoding block size shall depend on the number of OFDMslots allocated and the modulation specified for the current transmission. Concatenation of a number of OFDM slots shall be performed in order to allow for transmission of larger blocks of coding where it is possible, with the limitation of not exceeding the largest block size for the corresponding modulation and coding. Table 9.X.7.2.1.3-1 specifies the concatenation index for different modulations and coding.

For any modulation and coding, the following parameters are defined:

— *j* : index dependent on the modulation level and FEC rate

— *n* : number of allocated OFDM slots

— *k* : floor (*n* / *j*)

— *m* : *n* mod *j*

Table 9.X.7.2.1.3-2 shows the rules used for OFDM slot concatenation.

**Table 9.X.7.2.1.3-1—** **Concatenation index for different modulations and coding**

|  |  |
| --- | --- |
| **Modulation and Rate** | ***j*** |
| QPSK 1/2 | 6 |
| QPSK 2/3 | 4 |
| QPSK 3/4 | 4 |
| QPSK 5/6 | 3 |
| 16-QAM 1/2 | 3 |
| 16-QAM 2/3 | 2 |
| 16-QAM 3/4 | 2 |
| 16-QAM 5/6 | 1 |
| 64-QAM 1/2 | 2 |
| 64-QAM 2/3 | 1 |
| 64-QAM 3/4 | 1 |
| 64-QAM 5/6 | 1 |

**Table 9.X.7.2.1.3-2— OFDM slot concatenation rule**

|  |  |
| --- | --- |
| **Number of slots** | **Slots concatenated** |
| $$n\leq j$$ | 1 block of *n* slots |
| $$n>j$$ | If (*n* mod *j* = 0)*k* blocks of *j* slotselse$ (k-1)$ blocks of *j* slots1 block of ceil(($m+j)/2)$slots1 block of floor(($m+j)/2)$slots |

Table 9.X.7.2.1.3-3 defines the basic sizes of the useful data payloads (in bytes) to be encoded in relation with the selected modulation type, encoding rate, and concatenation rule.

**Table 9.X.7.2.1.3-3—Useful data payload for an FEC Block**

|  |  |  |  |
| --- | --- | --- | --- |
|  | QPSK | 16-QAM | 64-QAM |
| Encoding rate | 1/2 | 2/3 | 3/4 | 5/6 | 1/2 | 2/3 | 3/4 | 5/6 | 1/2 | 2/3 | 3/4 | 5/6 |
| Data Payload (byte) | 6 |  |  |  |  |  |  |  |  |  |  |  |
|  | 8 |  |  |  |  |  |  |  |  |  |  |
|  |  | 9 |  |  |  |  |  |  |  |  |  |
|  |  |  | 10 |  |  |  | 20 |  |  |  |  |
| 12 |  |  |  | 12 |  |  |  |  |  |  |  |
|  | 16 |  |  |  | 16 |  |  |  |  |  |  |
| 18 |  | 18 |  |  |  | 18 |  | 18 |  |  |  |
|  |  |  | 20 |  |  |  |  |  |  |  |  |
| 24 | 24 |  |  | 24 |  |  |  |  | 24 |  |  |
|  |  | 27 |  |  |  |  |  |  |  | 27 |  |
| 30 |  |  |  |  |  |  |  |  |  |  | 30 |
|  | 32 |  |  |  | 32 |  |  |  |  |  |  |
| 36 |  | 36 |  | 36 |  | 36 |  | 36 |  |  |  |

**9.X.8.1 Data modulation**

(only Table 227 is modified as follows)

**Table 9.X.8.1 — Number of coded bits per OFDM slot (*N*CBPS) and corresponding number of**

**data bits for different modulation constellation and coding rate combinations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Constellation type** | **Coding rate** | ***N*CBPS** | **corresponding number of data bits** |
| QPSK | 1/2 | 96 | 48 |
| QPSK | 2/3 | 96 | 64 |
| QPSK | 3/4 | 96 | 72 |
| QPSK | 5/6 | 96 | 80 |
| 16-QAM | 1/2 | 192 | 96 |
| 16-QAM | 2/3 | 192 | 128 |
| 16-QAM | 3/4 | 192 | 144 |
| 16-QAM | 5/6 | 192 | 160 |
| 64-QAM | 1/2 | 288 | 144 |
| 64-QAM | 2/3 | 288 | 192 |
| 64-QAM | 3/4 | 288 | 216 |
| 64-QAM | 5/6 | 288 | 240 |

**9.X.9.3 Opportunistic upstream bursts**

A ranging channel is composed of one or two groups of six adjacent subchannels, using the symbol structure defined in 9.X.6.3.1, where the groups are defined starting from the first subchannel. Subchannels are considered adjacent if they have successive logical subchannel numbers. The indices of the subchannels that compose the ranging channel are specified in the US-MAP message. BS shall allocate ranging, bandwidth (BW) request or UCS notification allocation within 6 or 12 subchannels.

**9.X.9.3.1 CDMA bursts**

The number of subchannels for the ranging channel and the number of symbols for each transmission (CDMA initial ranging, CDMA periodic ranging, CDMA BW request and CDMA UCS notification) are specified in the US-MAP\_IE Table 35.

CPEs are allowed to collide on the ranging channel. To still provide reliable transmission, each CPE randomly chooses one ranging code from the subgroup of specified binary codes that is defined in 9.X.9.3.1.1. These codes are then BPSK modulated onto the subcarriers in the ranging channel. The length of these binary codes is the same as the number of subcarriers in the ranging channel.

**9.X.9.3.1.1 CDMA codes**

The binary codes shall be the pseudo-noise codes produced by the PRBS generator described in Figure 9.X.9.3.1.1-1, which illustrates the following polynomial generator: 1+ *x*1 + *x*4+ *x*7+ *x*15. The PRBS generator shall be initialized by the seed b15...b1 = 0,0,1,0,1,0,1,1,s0,s1,s2,s3,s4,s5,s6 where s6 is the LSB of the PRBS seed, and s6:s0=US\_PermBase, where s6 is the MSB of the US\_PermBase.

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**Figure 9.X.9.3.1.1-1— PRBS generator for ranging code generation**

The binary ranging codes shall be subsequences of the pseudo-noise sequence appearing at its output *Ci*. The length of each ranging code is 144 bits. These bits are used to modulate the subcarriers in a group of six adjacent subchannels. The bits are mapped to the subcarriers in increasing frequency order of the logical subcarriers, such that the lowest indexed bit modulates the subcarrier with the lowest subcarrier index and the highest indexed bit modulates the subcarrier with the highest index. The index of the lowest numbered subchannel in the six shall be an integer multiple of six.

For example, the first 144 bit obtained by clocking the PN generator as specified and by setting US\_PermBase = 0, the first code shall be 00110000010001... The next ranging code is produced by taking the output of the 145th to 288th clock of the PRBS generator, etc.

The number of available codes is 256, numbered 0...255. Each BS uses a subset of these codes, where the subgroup is defined by a number *S*, 0<*S*<255. The group of codes shall be between *S* and (*S*+*O*+*N*+*M*+*L*) mod 256

* The first *N* codes produced are for initial ranging. Clock the PRBS generator 144 × (*S* mod 256) times to 144 × ((*S* + *N*) mod 256) – 1 times.
* The next *M* codes produced are for periodic ranging. Clock the PRBS generator 144 × ((*N* + *S*) mod 256) times to 144 × (*(N* + *M* + *S*) mod 256) – 1 times.
* The next *L* codes produced are for BW request. Clock the PRBS generator 144 × ((*N* + *M* + *S*) mod 256) times to 144 × ((*N* + *M* + *L* + *S*) mod 256) – 1 times.
* The next *O* codes produced are for UCS notification. Clock the PRBS generator 144 × ((*N* + *M* + *L* + *S*) mod 256) times to 144 × ((*N* + *M* + *L* + *O* + *S*) mod 256) – 1 times.

The BS shall separate colliding codes and extract timing (ranging) and power information by using a correlation function. The time (ranging) and power measurements shall be used by the system to compensate for the various BS-CPE-BS propagation distances. In the process of CPE code detection, the BS will also get the Channel Impulse Response (CIR) for the transmission link from the specific CPE. The precise timing offset shall be estimated by terrestrial ranging (see 10.5.2).

**9.X.9.3.1.2 Initial-ranging transmission**

The initial ranging transmission shall be used by all CPEs to synchronize to the system when attempting to associate. The initial ranging transmission will be used for detecting and adjusting the timing offset and adjusting the transmission EIRP level. The initial-ranging transmission is performed using two or four consecutive symbols starting, as indicated in the US-MAP for the CPE, on the first symbol after the TTG.

These symbols shall be generated according to Equation (9.X.9.3.1.2-1) , except that $0\leq t\leq 2T\_{s}$. A time-domain illustration used for the initial-ranging transmission is shown in Figure 9.X.9.3.1.2-1.

$$s\left(t\right)=Re\left\{e^{j2πf\_{c} t}\sum\_{k=-\frac{N\_{used}-1}{2},k\ne 0}^{\frac{N\_{used}-1}{2}}c\_{k} ∙e^{j2πk∆f(t-T\_{g})}\right\}$$

 (Eq.9.X.9.3.1.2-1)

 where

* *t* is the time, elapsed since the beginning of the subject OFDMA symbol
* *ck*is a complex number; the data to be transmitted on the subcarrier whose frequency offset index is *k*, during the subject OFDMA symbol. It specifies a point in a QAM constellation
* *Tg* is the guard time
* *Ts* is the OFDMA symbol duration, including guard time
* *f* is the subcarrier frequency spacing



**Figure 9.X.9.3.1.2-1 —Initial-ranging transmission**

The BS can allocate two consecutive initial ranging slots; onto those slots, the CPE shall transmit the two consecutive initial ranging codes (starting code shall always be a multiple of 2), as illustrated in Figure 9.X.9.3.1.2-2.



**Figure 9.X.9.3.1.2-2 —Initial-ranging transmission, using two consective initial ranging codes**

**9.X.9.3.1.3 CDMA periodic-ranging, BW-request, and UCS notification transmission**

Periodic-ranging transmissions shall be sent periodically by CPEs identified by the BS for system periodic ranging. Bandwidth-request transmissions shall be for requesting upstream allocations from the BS. UCS notification transmissions shall be used for reporting detection of an incumbent. These transmissions shall be sent only by CPEs that have already associated with the base station. To perform periodic-ranging, bandwidth-request or UCS notification transmission, the CPE can send a transmission in one of the following manners.

1. Modulate one ranging code on the ranging subchannel for a period of one OFDM symbol. Ranging subchannels shall be dynamically allocated by the MAC layer at the BS and indicated by the number of subchannels in the US-MAP\_IE. A time domain illustration of the periodic-ranging, bandwidth-request or UCS notification transmission is shown in Figure 9.X.9.3.1.3-1.



**Figure 9.X.9.3.1.2-1 —Periodic-ranging/Bandwidth-request/UCS notification transmission using one code**

1. Modulating three consecutive ranging codes (starting code shall always be a multiple of three) on the ranging subchannel for a period of three OFDMA symbols (one code per symbol). Ranging subchannels are dynamically allocated by the MAC and indicated in the US-MAP. A time-domain illustration of the periodic ranging, BW-request, or UCS notification transmission is shown in Figure 9.X.9.3.1.3-2.



**Figure 9.X.9.3.1.3-2 — Periodic-ranging/Bandwidth-request/UCS notification transmission using three consecutive codes**

**9.X.9.3.1.4 Ranging, BW request, and UCS notification opportunity windows**

For CDMA ranging, BW-request and UCS notification transmission, the ranging opportunity size is the number of symbols required to transmit the appropriate ranging/BW-request/UCS notification code (1, 2, 3, or 4 symbols), and is denoted *N*1. *N*2 denotes the number of subchannels required to transmit a ranging code. In each allocation of ranging/BW-request/UCS notification, the opportunity size (*N*1) is fixed and conveyed by the corresponding US-MAP IE that defines the allocation.

The ranging allocation is subdivided into slots of *N*1 OFDMA symbols by *N*2 subchannels, in a time first order, i.e., the first opportunity begins on the first symbol of the first subchannel of the ranging allocation, the next opportunities appear in ascending order in the same subchannel, until the end of the ranging/BW-request/UCS notification (or until there are less than *N*1 symbols in the current subchannel), and then the number of subchannel is incremented by *N*2. The ranging allocation is not required to be a whole multiple of *N*1 symbols, so a gap may be formed (that can be used to mitigate interference between ranging and data transmissions). Each CDMA code shall be transmitted at the beginning of the corresponding slot. See Figure 9.X.9.3.1.4-1.



**Figure 9.X.9.3.1.4-1 — Example of Ranging/BW request/UCS notification opportunities windows**