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3. Definitions

[Insert the following definitions:]

3.95 superframe: A structured data sequence of fixed duration used by the Advanced Air Interface specifications. A superframe is comprised of four frames.

3.96 subframe: A structured data sequence of fixed duration used by the Advanced Air Interface specifications. A superframe is comprised of four frames.

3.97 multi-carrier: More than 1 OFDMA carrier is used to exchange data between BS and MSs.

3.98 primary carrier: BS and the MS exchange traffic and full PHY/MAC control information defined in the Advanced Air Interface specification. Further, the primary carrier is used for control functions for proper MS operation, such as network entry. Each MS shall have only one carrier it considers to be its primary carrier in a cell.

3.99 secondary carrier: MS may use for traffic, only per BS's specific allocation commands and rules,typically received from the primary carrier. The secondary carrier may also include control signaling to support multicarrier operation.

3.100 fully configured carrier: A carrier for which all control channels including synchronization, broadcast, multicast and unicast control signaling are configured. Further, information and parameters regarding multi-carrier operation and the other carriers can also be included in the control channels.

3.101 partially configured carrier: A carrier with essential control channel configuration to support traffic exchanges during multi-carrier operation.s

4. Abbreviations and acronyms

[Insert the following abbreviations:]

SFH superframe header

[Insert the following clause:]

15. Advanced Air Interface

15.1 Introduction

15.2 Medium access control

15.2.1 Security

15.3 Physical layer

15.3.1 Introduction

The Advanced Air Interface is designed for NLOS operation in the licensed frequency bands below 6 GHz.

The Advanced Air Interface supports TDD and FDD duplex modes, including H-FDD MS operation. Unless otherwise specified, the frame structure attributes and baseband processing are common for all duplex modes.

The Advanced Air Interface uses OFDMA as the multiple access scheme in the downlink and uplink.

15.3.2 OFDMA symbol description, symbol parameters and transmitted signal

15.3.2.1 Time domain description

Inverse-Fourier-transforming creates the OFDMA waveform; this time duration is referred to as the useful symbol time T_b. A copy of the last T_g of the useful symbol period, termed CP, is used to collect multipath, while maintaining the orthogonality of the tones. Figure 387 illustrates this structure.

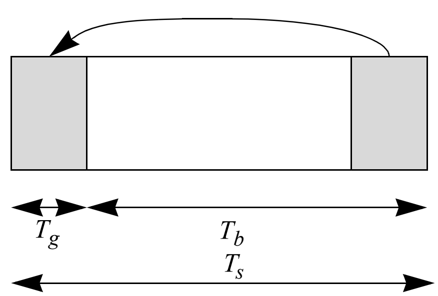

Figure 387—OFDMA symbol time structure

15.3.2.2 Frequency domain description

The frequency domain description includes the basic structure of an OFDMA symbol.

An OFDMA symbol is made up of subcarriers, the number of which determines the FFT size used. There are several subcarrier types:

— Data subcarriers: for data transmission

— Pilot subcarriers: for various estimation purposes

— Null carrier: no transmission at all, for guard bands and DC carrier

The purpose of the guard bands is to enable the signal to naturally decay and create the FFT “brick wall” shaping.

15.3.2.3 Primitive parameters

The following four primitive parameters characterize the OFDMA symbol:

— BW: The nominal channel bandwidth.

— N_{used}: Number of used subcarriers (which include the DC subcarrier).

— n: Sampling factor. This parameter, in conjunction with BW and N_{used} determines the subcarrier spacing and the useful symbol time. This value is set as follows: for channel bandwidths that are a multiple of 1.75 MHz, then $n = 8/7$; else, for channel bandwidths that are a multiple of 1.25 MHz, then $n = 28/25$.

— G: This is the ratio of CP time to “useful” time. The following values shall be supported: 1/8 and 1/16.

15.3.2.4 Derived parameters

The following parameters are defined in terms of the primitive parameters of 15.3.2.3:

— N_{FFT}: Smallest power of two greater than N_{used}

— Sampling frequency: $F_s = \text{floor}(n \cdot BW / 8000) \times 8000$

— Subcarrier spacing: $\Delta f = F_s / N_{FFT}$

— Useful symbol time: $T_b = 1 / \Delta f$

— CP time: $T_g = G \cdot T_b$

— OFDMA symbol time: $T_s = T_b + T_g$

— Sampling time: T_b / N_{FFT}

Values of the derived parameters and the primitive parameters above are specified in Table 647.

Table 647—OFDMA parameters

Nominal channel bandwidth, BW (MHz)	5	7	8.75	10	20
Sampling factor, n	28/25	8/7	8/7	28/25	28/25
Sampling frequency, F_s (MHz)	5.6	8	10	11.2	22.4
FFT size, N_{FFT}	512	1024	1024	1024	2048
Subcarrier spacing, Δf (kHz)	10.94	7.81	9.77	10.94	10.94
Useful symbol time, t_b	91.4	128	102.4	91.4	91.4

Table 647—OFDMA parameters

CP ratio, *G*, = 1/8	OFDMA symbol time, *Ts*, (μ s)	102.82	144	115.2	102.82	102.82
	Number of OFDMA symbols per 5ms frame	48	34	43	48	48
	Idle time (μ s)	62.86	104	46.40	62.86	62.86
CP ratio, *G*, = 1/16	OFDMA symbol time, *Ts*, (μ s)	97.143	[TBD]	[TBD]	97.143	97.143
	Number of OFDMA symbols per 5ms frame	51	[TBD]	[TBD]	51	51
	Idle time (μ s)	45.71	[TBD]	[TBD]	45.71	45.71
Number of guard sub-carriers	Left	40	80	80	80	160
	Right	39	79	79	79	159
Number of used sub-carriers		433	865	865	865	1729
Number of physical resource blocks		24	48	48	48	96

15.3.2.5 Transmitted signal

Equation (173) specifies the transmitted signal voltage to the antenna, as a function of time, during any OFDMA symbol.

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k = -(N_{used}-1)/2 \\ k \neq 0}}^{(N_{used}-1)/2} c_k \cdot e^{j2\pi k \Delta f (t - T_g)} \right\} \tag{173}$$

Where,

t is the time, elapsed since the beginning of the subject OFDMA symbol, with

C_k 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.

T_g is the guard time

T_s is the OFDMA symbol duration, including guard time

Δf is the subcarrier frequency spacing

15.3.2.6 Definition of basic terms on the transmission chain

The basic terms related with the transmission chain shall be defined as illustrated in Figure 388.

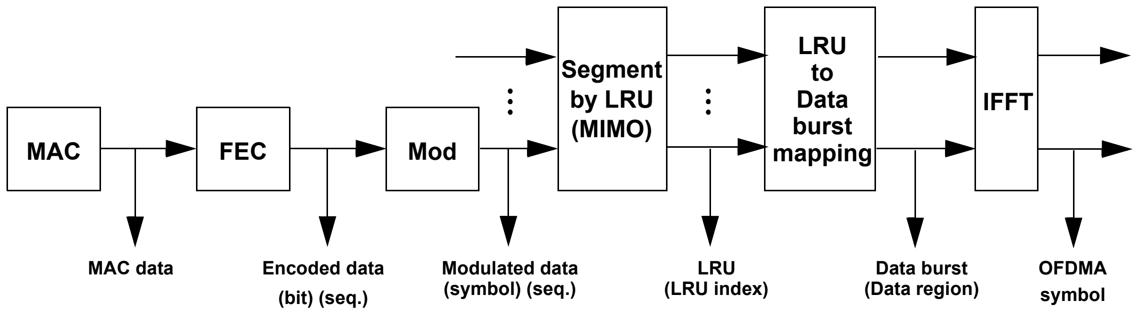

Figure 388—Definition of basic terms on the transmission chain

15.3.3 Frame structure

15.3.3.1 Basic frame structure

The advanced air interface basic frame structure is illustrated in Figure 389. Each 20 ms superframe is divided into four equally-sized 5 ms radio frames. When using the same OFDMA parameters as in Table 647 with the channel bandwidth of 5 MHz, 10 MHz, or 20 MHz, each 5 ms radio frame further consists of eight subframes. A subframe shall be assigned for either DL or UL transmission. There are two types of subframes depending on the size of cyclic prefix:

1) the type-1 subframe which consists of six OFDMA symbols, and
2) the type-2 subframe that consists of seven OFDMA symbols. In both subframe types, some of symbols may be idle symbols.

The basic frame structure is applied to FDD and TDD duplexing schemes, including H-FDD MS operation. The default number of switching points in each radio frame in TDD systems shall be two, where a switching point is defined as a change of directionality, i.e., from DL to UL or from UL to DL. Depending on the application, additional number of switching points (up to 4) may be considered.

When H-FDD MSs are included in an FDD system, the frame structure from the point of view of the H-FDD MS is similar to the TDD frame structure; however, the DL and UL transmissions occur in two separate frequency bands. The transmission gaps between DL and UL (and vice versa) are required to allow switching the TX and RX circuitry.

Every superframe shall contain a superframe header (SFH). The SFH shall be located in the first DL subframe of the superframe, and shall include broadcast channels.

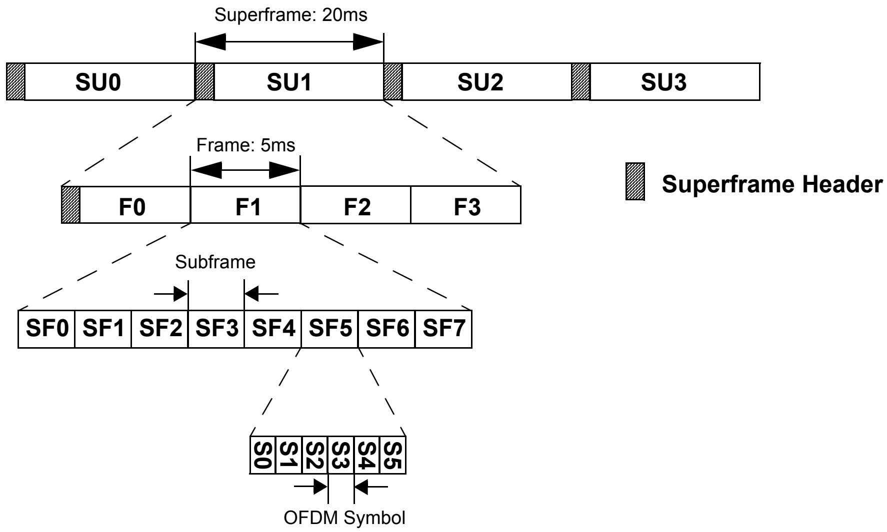

Figure 389—Basic frame structure for 5, 10 and 20 MHz channel bandwidths

15.3.3.2 Frame structure for CP = 1/8 T_b

15.3.3.2.1 FDD frame structure

A BS supporting FDD mode shall be able to simultaneously support half duplex and full duplex MSs operating on the same RF carrier. The MS supporting FDD mode shall use either H-FDD or FDD.

The FDD frame shall be constructed on the basis of the basic frame structure defined in 15.3.3.1. In each frame, all subframes are available for both DL and UL transmissions. The DL and UL transmissions are separated in the frequency domain.

FDD MS is able to receive data burst in any DL subframe while accessing UL subframe at the same time. For H-FDD MS, only one of transmission and reception is allowed in each subframe.

The idle time specified in Table 1 shall be placed at the end of each FDD frame as shown in Figure 4.

Figure 390 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 5, 10, and 20 MHz with G = 1/8.

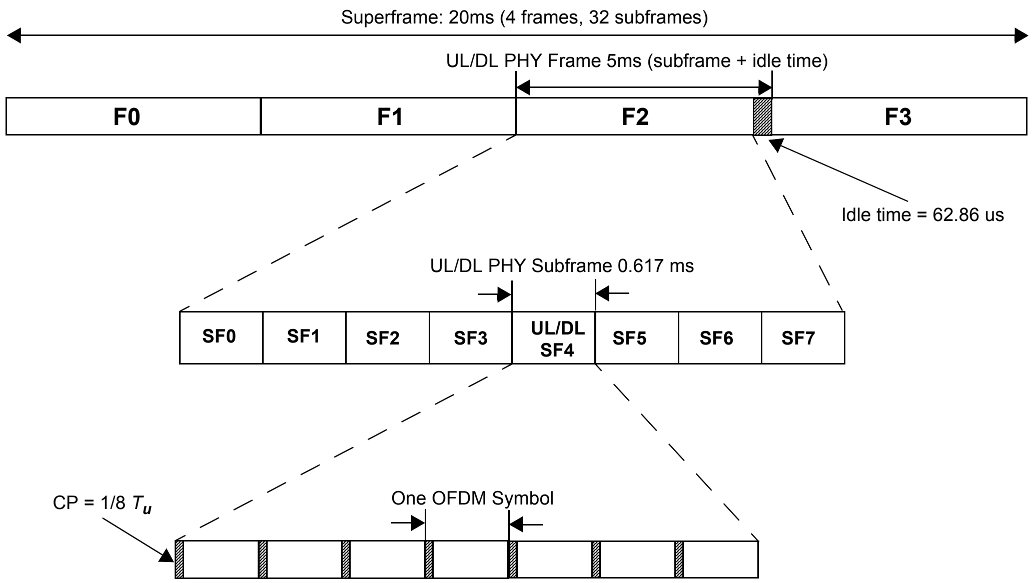

Figure 390—Frame structure with type-1 subframe in FDD duplex mode for 5, 10 and 20 MHz channel bandwidths (CP = 1/8 Tb)

15.3.3.2.1.1 H-FDD frame structure

15.3.3.2.2 TDD frame structure

The TDD frame shall be constructed on the basis of the basic frame structure defined in 15.3.3.1.

In a TDD frame with DL to UL ratio of D:U, the 1st contiguous D subframes and the remaining U subframes are assigned for DL and UL, respectively, where D + U = 8 for 5, 10 and 20 MHz channel bandwidths. The ratio of D:U for 5, 10 and 20 MHz channel bandwidths shall be selected from one of the following values: [TBD].

In each frame, the TTG and RTG shall be inserted between the DL and UL and at the end of each frame, respectively.

Figure 391 illustrates an example TDD frame structure with D:U = 5:3, which is applicable to the nominal channel bandwidths of 5, 10, and 20 MHz with G = 1/8.

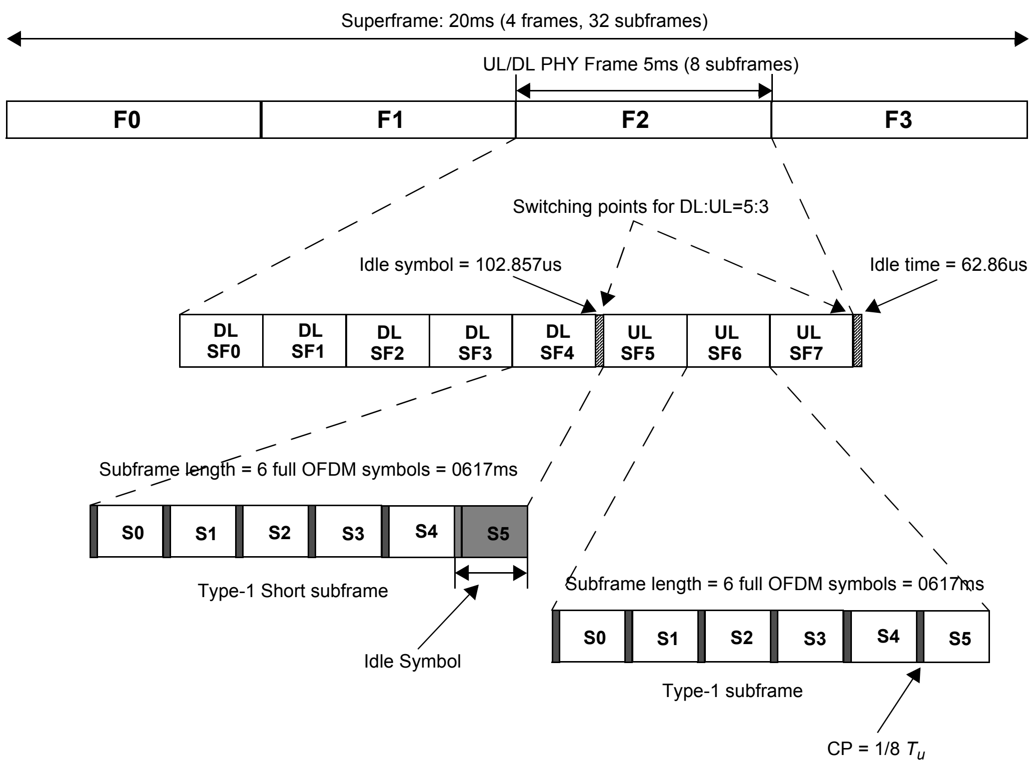

Figure 391—Frame structure with Type-1 subframe in TDD duplex mode for 5, 10 and 20 MHz channel bandwidths (CP=1/8 T_b)

15.3.3.3 Frame structure for CP = 1/16 T_b

The frame structure for a CP length of 1/16 T_b shall consist of type-1 and type-2 subframes.

For channel bandwidths of 5, 10, and 20 MHz, a frame shall have five type-1 subframes and three type-2 subframes.

In the TDD frame, the first and last subframes within each frame shall be type-2 subframes. The last OFDMA symbol in a type-2 subframe preceding a DL to UL switching point shall be an idle symbol, which is used to accommodate the gap required to switch from DL to UL.

In the FDD frame, the first, fifth, and last subframes within each frame shall be type-2 subframes.

392 illustrates an example of TDD and FDD frame structure with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 97.143 μs and a CP length of 1/16 T_b, the length of type-1 and type-2 subframes are 0.583 ms and 0.680 ms, respectively.

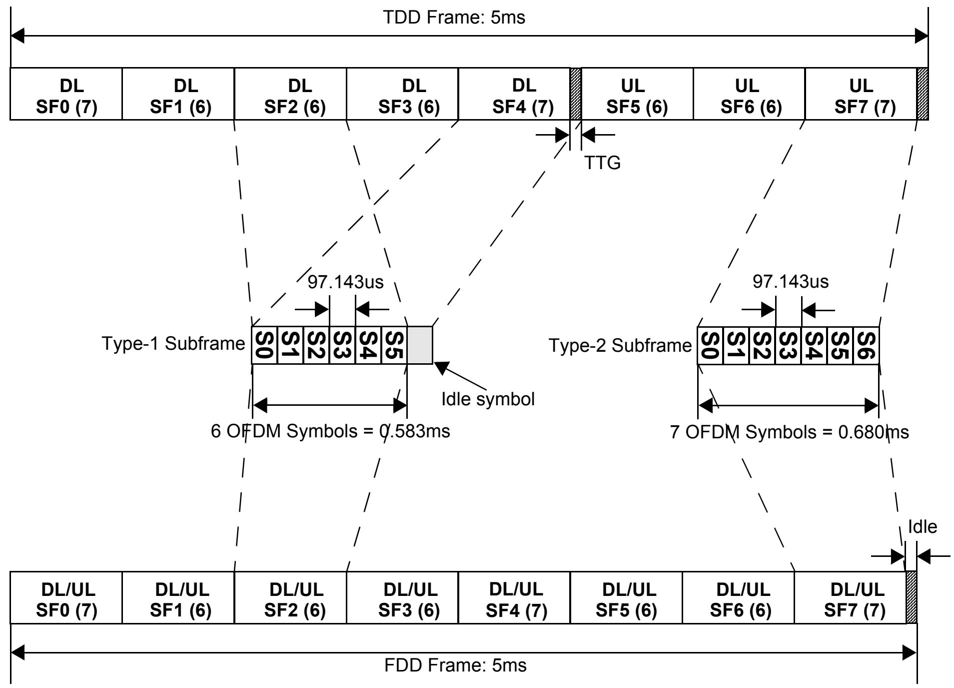

Figure 392—TDD and FDD frame structure with a CP of 1/16 T_b (DL to UL ratio of 5:3)

15.3.3.4 Frame structure supporting the WirelessMA-OFDMA frames

15.3.3.4.1 TDD frame structure

The basic frame structure shall be configured as follows to support the WirelessMAN-OFDMA MSs:

The WirelessMAN-OFDMA and the Advanced Air Interface frames shall be offset by a fixed number of subframes, TOFFSET = 1, 2, … , K, as shown in Figures 7 and 8. The FRAME_OFFSET is an offset between the start of the WirelessMAN-OFDMA frame and the start of the Advanced Air Interface frame, defined in units of subframes. The maximum value of parameter K is equal to the number of DL subframes minus one, since the Advanced Air Interface frame shall contain at least one DL subframe. In the case where Advanced Air Interface BSs coexist with WirelessMAN-OFDMA BSs, two switching points shall be selected in each TDD radio frame.

In the DL, a subset of DL subframes is dedicated to the WirelessMAN-OFDMA operation to enable one or more WirelessMAN-OFDMA DL time zones. The subset includes the 1st WirelessMAN-OFDMA DL time zone to support the transmission of the preamble, FCH and MAP, which are defined in 8.4.

Data bursts for the WirelessMAN-OFDMA MSs shall not be transmitted in the DL subframes for operation of the Advanced Air Interface. Those DL subframes shall be indicated as a DL time zone by transmitting an STC_DL_ZONE_IE() with the Dedicated Pilots field set to 1, as defined in Table 328, in the DL-MAP messages.

In the UL, the two configurations are applicable:

1) FDM mode: A group of subcarriers (subchannels), spanning the entire UL transmission, is dedicated to the WirelessMAN-OFDMA operation. The remaining subcarriers, denoted the Advanced Air Interface UL subchannels group and forming the Advanced Air Interface UL subframes, are dedicated to the Advanced Air Interface operation. Figure 393 illustrates an example frame configuration for supporting the WirelessMAN-OFDMA operation when FDM mode is used.

   Data bursts from the WirelessMAN-OFDMA MSs shall not be transmitted in the UL subchannels group for operation of the Advanced Air Interface. The UL subchannels group for operation of the WirelessMAN-OFDMA shall be indicated by the UL allocated subchannels bitmap TLV or the UL AMC Allocated physical bands bitmap TLV, defined in Table TBD, in the UCD message.

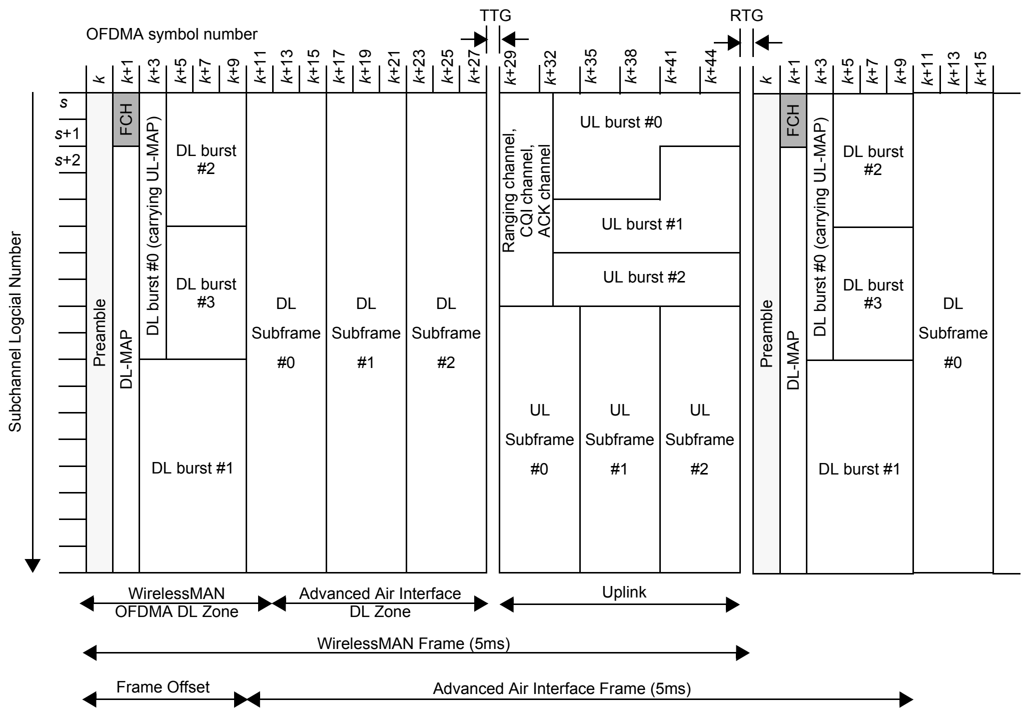

Figure 393—TDD frame configuration for supporting the WirelessMAN-OFDMA operation with UL FDM

2) TDM mode: A subset of UL subframes is dedicated to the WirelessMAN-OFDMA operation to enable one or more WirelessMAN-OFDMA UL time zones. The subset includes the 1st WirelessMAN-OFDMA UL time zone to support the transmission of the ranging channel, CQI channel and ACK channel, which are defined in 8.4. Figure 394 illustrates an example frame configuration for supporting the WirelessMAN-OFDMA operation when TDM mode is used.

Data bursts from the WirelessMAN-OFDMA MSs shall not be transmitted in the UL subframes for operation of the Advanced Air Interface. Those UL subframes shall be indicated as a UL time zone by transmitting an UL_ZONE_IE(), defined in Table TBD, in the UL-MAP message.

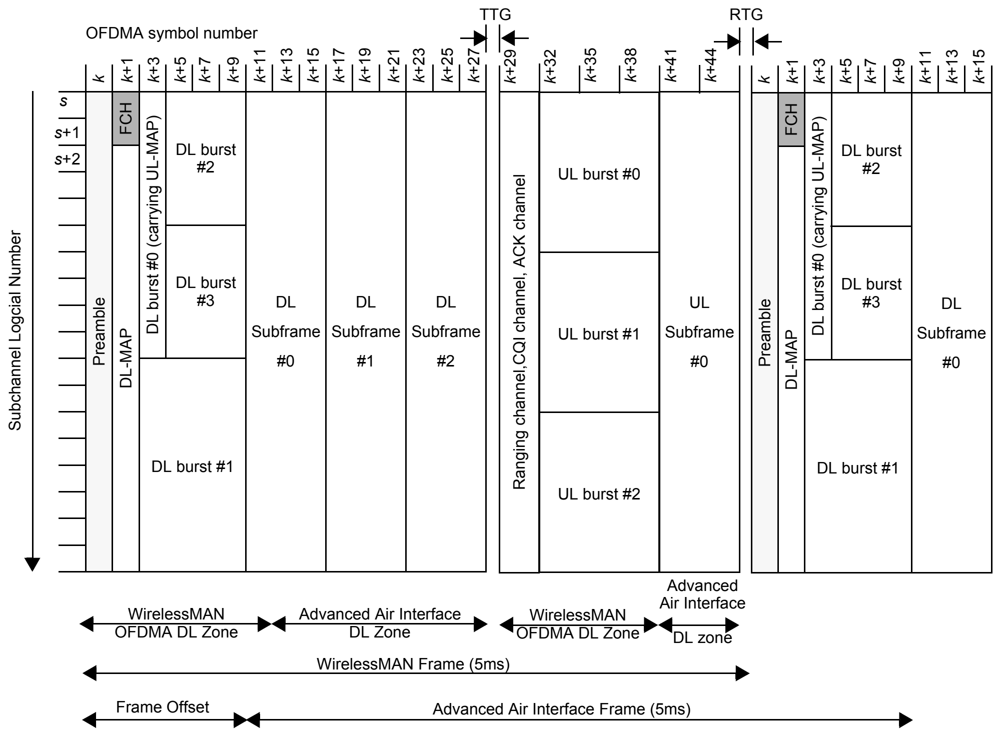

Figure 394—TDD frame configuration for supporting the WirelessMAN-OFDMA operation with UL TDM

15.3.3.4.2 FDD frame structure

15.3.3.5 Frame structure supporting wider bandwidth

The same frame structure (15.3.3.1, 15.3.3.2, 15.3.3.3) is used for each carrier in multicarrier mode operation. Each carrier may have its own superframe header. Some carriers may have only part of superframe header. Figure 395 illustrates the example of the frame structure to support multi-carrier operation. For FDD UL, the preamble and superframe header is replaced with traffic OFDMA symbols.

The multiple carriers involved in multicarrier operation may be in a contiguous or non-contiguous spectrum. When carriers are in the same spectrum and adjacent and when the separation of center frequency between two adjacent carriers is multiples of subcarrier spacing, no guard subcarriers are necessary between adjacent carriers.

Each MS is controlled through a RF carrier which is the primary carrier. When multi-carrier feature is supported, the system may define and utilize additional RF carriers to improve the user experience and QoS or provide services through additional RF carriers configured or optimized for specific services. These additional RF carriers are the secondary carriers. The detailed description of the multi-carrier operation can be found in (ref TBD).

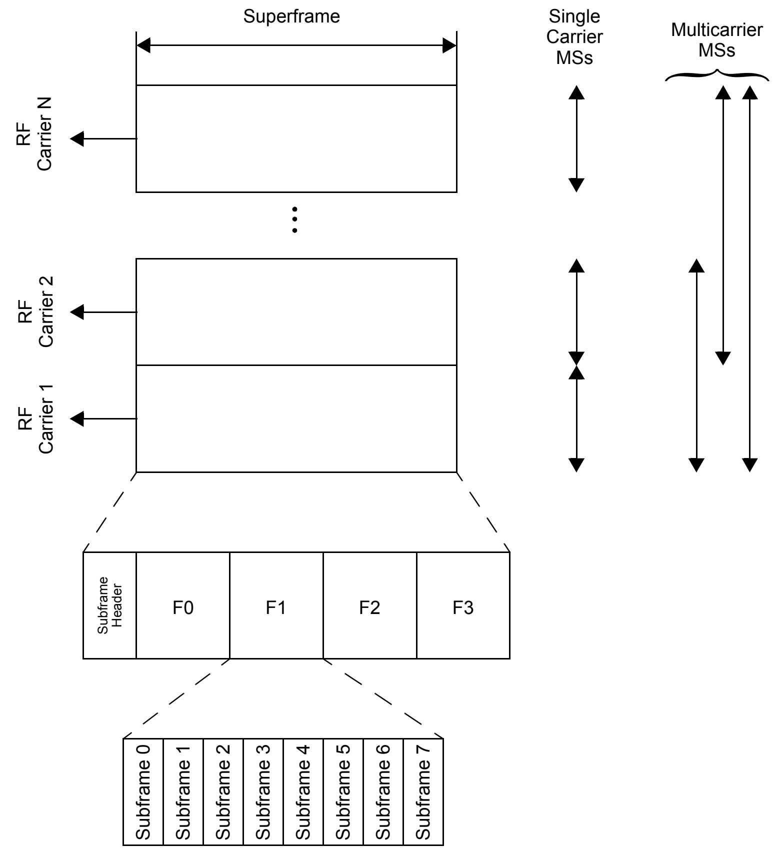

Figure 395—Example of the frame structure to support multi-carrier operation

15.3.3.5.1 Frame structure supporting multicarrier operation in WirelessMAN-OFDMA support mode

In the multicarrier mode supporting WirelessMAN-OFDMA, each carrier can have either a basic frame structure (15.3.3.1) or a basic frame structure configured to support the WirelessMAN-OFDMA (15.3.3.3). 396 illustrates an example of the frame structure in the multicarrier mode supporting WirelessMAN-OFDMA. In the carrier to support WirelessMAN-OFDMA, uplink can be also configured in TDM as defined 15.3.3.3.

The multicarrier operation (ref. TBD) is only performed between subframes where the Advanced Air Interface frame is defined. No multicarrier operation is defined between the Advanced Air Interface frames and WirelessMAN-OFDMA frames.

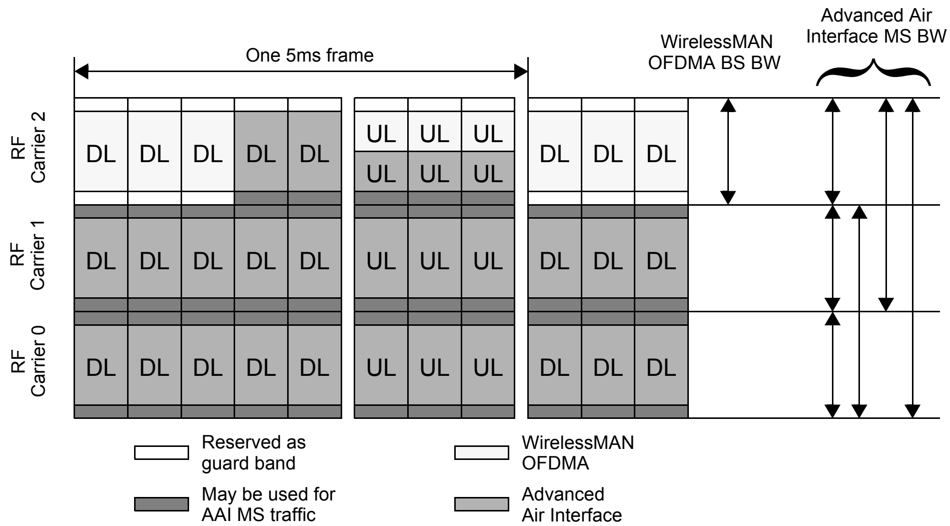

Figure 396—Example of the frame structure to support multi-carrier operation in WirelessMAN-OFDMA support mode

15.3.3.6 Relay support in frame structure

15.3.4 Reserved

15.3.5 Downlink physical structure

Each downlink subframe is divided into 4 (TBD) or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR) or multicast and broadcast services (MBS). Figure 397 illustrates the downlink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations.

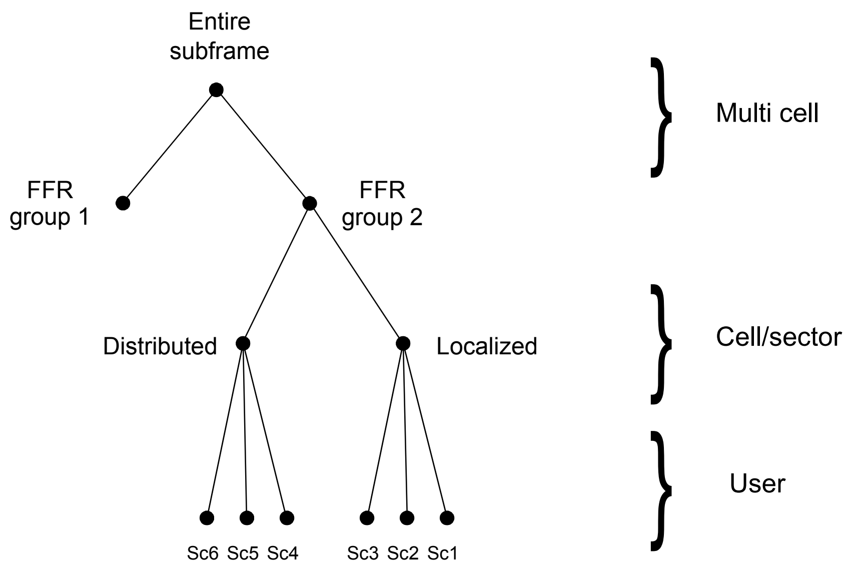

Figure 397—Example of downlink physical structure

15.3.5.1 Physical and logical resource unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 subcarriers and N_{sym} is 6 OFDMA symbols for type-1 subframes, and N_{sym} is 7 OFDM symbols for type-2 sub frames. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. A LRU is $P_{sc} \cdot N_{sym}$ subcarriers for type-1 subframes and type-2 subframes. The LRU includes the pilots in (ref. TBD) that are used in a PRU. The effective number of subcarriers in an LRU depends on the number of allocated pilots.

15.3.5.1.1 Distributed resource unit

The distributed resource unit (DRU) contains a group of subcarriers which are spread across the distributed resource allocations within a frequency partition. The size of the DRU equals the size of PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DRU is equal to a pair of subcarriers, called tone-pair, as defined in (ref. TBD).

15.3.5.1.2 Contiguous resource unit

The localized resource unit, also known as contiguous resource unit (CRU) contains a group of subcarriers which are contiguous across the localized resource allocations. The size of the CRU equals the size of the PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

15.3.5.2 Multi-cell resource mapping

15.3.5.2.1 Subband partitioning

The physical PRUs are first subdivided into subbands and minibands where a subband comprises N_1 adjacent PRUs and a miniband comprises N_2 adjacent PRUs, where N_1=4 [or 8 for the 2048 FFT] & N_2=1 [or 2 for the 2048 FFT]. Subbands are suitable for frequency selective allocations as they provide a contiguous allocation of PRUs in frequency. Minibands are suitable for frequency diverse allocation and are permuted in frequency.

The number of subbands reserved is denoted by K_{SB}. The number of PRUs allocated to subbands is denoted by L_{SB}, where $L_{SB} = N_1 \cdot K_{SB}$. A 5-bit (TBD) field called Subband Allocation Count (SAC) field determines the value of K_{SB}. The SAC is transmitted in the BCH. The remainder of the PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB}. The number of PRUs allocated to minibands is denoted by L_{MB}, where $L_{MB} = N_2 \cdot K_{MB}$. The total number of PRUs is denoted as N_{PRU} where $N_{PRU} = L_{SB} + L_{MB}$.

PRUs are partitioned and reordered into two groups subband PRUs and miniband PRUs, denoted $\mathrm{PRU}_{\mathrm{SB}}$ and $\mathrm{PRU}_{\mathrm{MB}}$, respectively. The set of $\mathrm{PRU}_{\mathrm{SB}}$ is numbered from 0 to (L_{SB} – 1). The set of $\mathrm{PRU}_{\mathrm{MB}}$ are numbered from 0 to (L_{MB} – 1). Equation (174) defines the mapping of PRUs to $\mathrm{PRU}_{\mathrm{SB}}$s. (ref. TBD) defines the mapping of PRUs to $\mathrm{PRU}_{\mathrm{MB}}$s. Figure 398 illustrates the PRU to $\mathrm{PRU}_{\mathrm{SB}}$ and $\mathrm{PRU}_{\mathrm{MB}}$ mapping for a 5 MHz bandwidth with SAC equal to 3.

$$PRU_{SB}[j] = PRU[i]; j = 0, 1, \ldots, L_{SB} - 1 \tag{174}$$

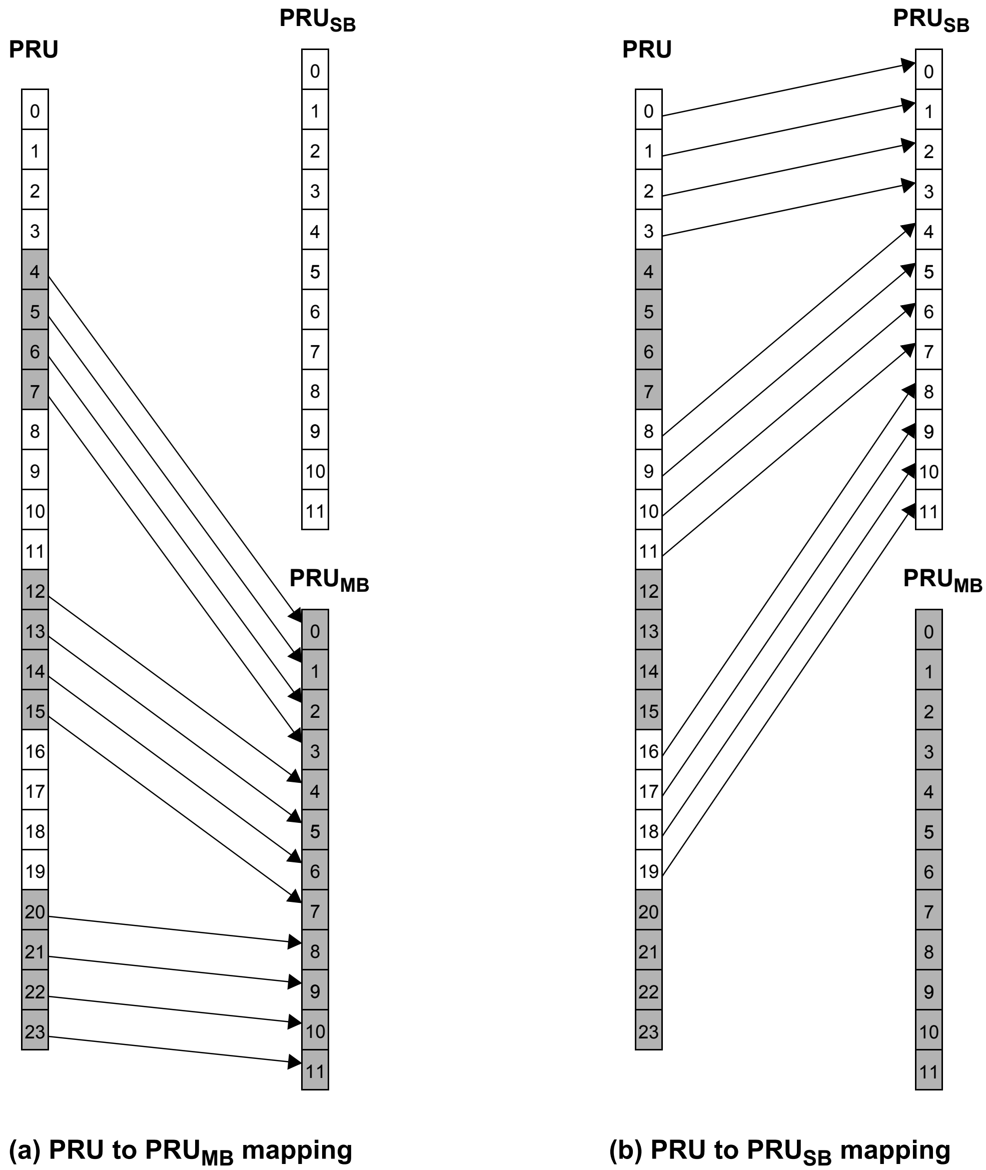

Figure 398—PRU to PRU$_{SB}$ and PRU$_{MB}$ mapping for BW=5 MHz, SAC=3

15.3.5.2.2 Miniband permutation

The miniband permutation maps the PRU$_{MB}$s to Permuted PRU$_{MB}$s (PPRU$_{MB}$s) to insure frequency diverse PRUs are allocated to each frequency partition. Equation (175) provides a mapping from PRU$_{MB}$ to PPRU$_{MB}$s:

$$PPRU_{MB}[j] = PRU_{MB}[i]; j = 0, 1, \ldots, L_{MB} - 1 \qquad (175)$$

Figure 399 depicts the mapping from PRUs to PRU_{SB} and PRU_{MB}.

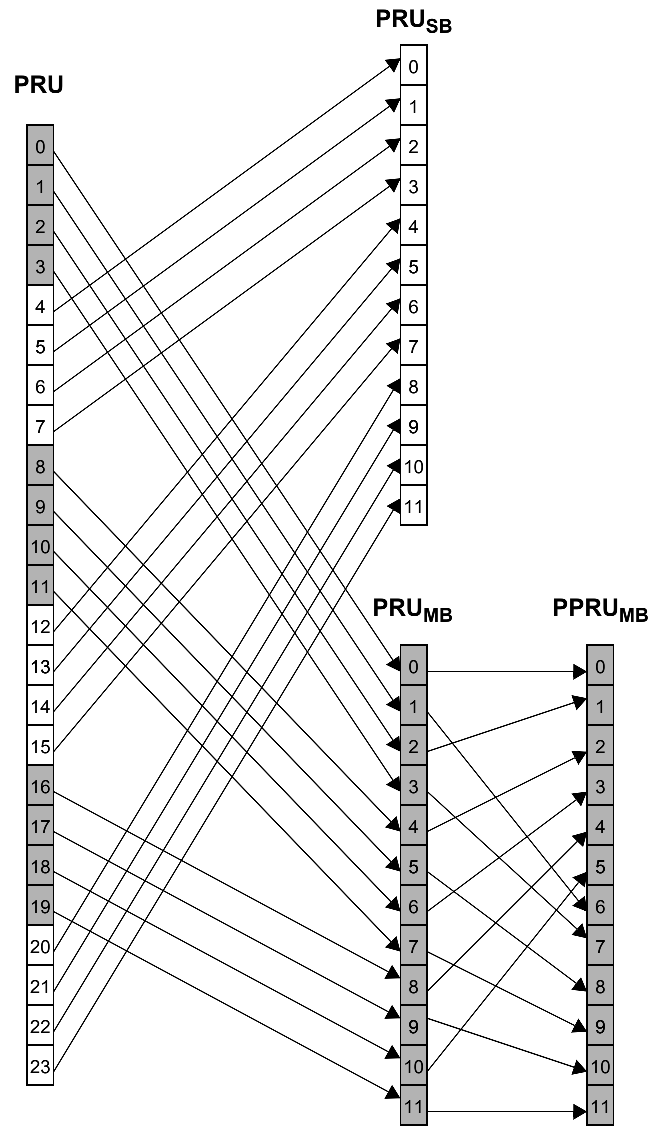

Figure 399—Mapping from PRUs to PRU_{SB} and $PPRU_{MB}$ for BW=5 MHz, SAC=3

15.3.5.2.3 Frequency partitioning

The PRU_{SB} and PRU_{MB} are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4 (TBD). The frequency partition configuration is transmitted in the BCH in a 12-bit called the Frequency Partition Configuration (FPC).

The FPC consists of a Frequency Partition Count (FPCT), Frequency Partition Size (FPS) and Frequency Partition Subband Count (FPSC). The first two bits carry the FPCT that defines the number of frequency partitions (1 to 4). The following 6 bits carry the FPS that defines the number of PRUs allocated to FP_i, i>0 in the number of minibands (N_2). The remaining 4 bits carry FPSC that define the number of subbands allocated to FP_i, i>0.

The number of subbands in i-th frequency partition are denoted by $K_{SB,FPi}$. The number of minibands is denoted by $K_{MB,FPi}$, which are determined by FPS and FPSC fields. The number of subband PRUs in each frequency partition is denoted by $L_{SB,FPi}$, which is given by $L_{SB,FPi} = N_1 \cdot K_{SB,FPi}$. The number of miniband PRUs in each frequency partition is denoted by $L_{MB,FPi}$, which is given by $L_{MB,FPi} = N_2 \cdot K_{MB,FPi}$.

$$K_{SB,\,FP_i} = \begin{cases} SAC - (FPCT - 1) \cdot FPSC & i = 0 \\ FPSC & i > 0 \end{cases} \tag{176}$$

$$K_{MB,\,FP_i} = \begin{cases} K_{MB} - (FPCT - 1) \cdot \left(FPS - \dfrac{FPSC \cdot N_1}{N_2}\right) & i = 0 \\ FPS - \dfrac{FPSC \cdot N_1}{N_2} & i > 0 \end{cases} \tag{177}$$

The mapping of subband PRUs and miniband PRUs to the primary FFR permutation is given by Equation (178):

$$PRU_{FP_i}(j) = \begin{cases} PRU_{SB}(k_1) & \text{for } 0 \le j < L_{SB,\,FP_i} \\ PPRU_{MB}(k_2) & \text{for } L_{SB,\,FP_i} \le j < (L_{SB,\,FP_i} + L_{MB,\,FP_i}) \end{cases} \tag{178}$$

where

$$k_1 = \sum_{m=0}^{i-1} L_{SB,\,FP_m} + j$$

and

$$k_2 = \sum_{m=0}^{i-1} L_{MB,\,FP_m} + j - L_{SB,\,FP_i} .$$

Figure 400 depicts the frequency partitioning BW=5 MHz, SAC=3, FPCT=2, FPS=12, and FPSC=1.

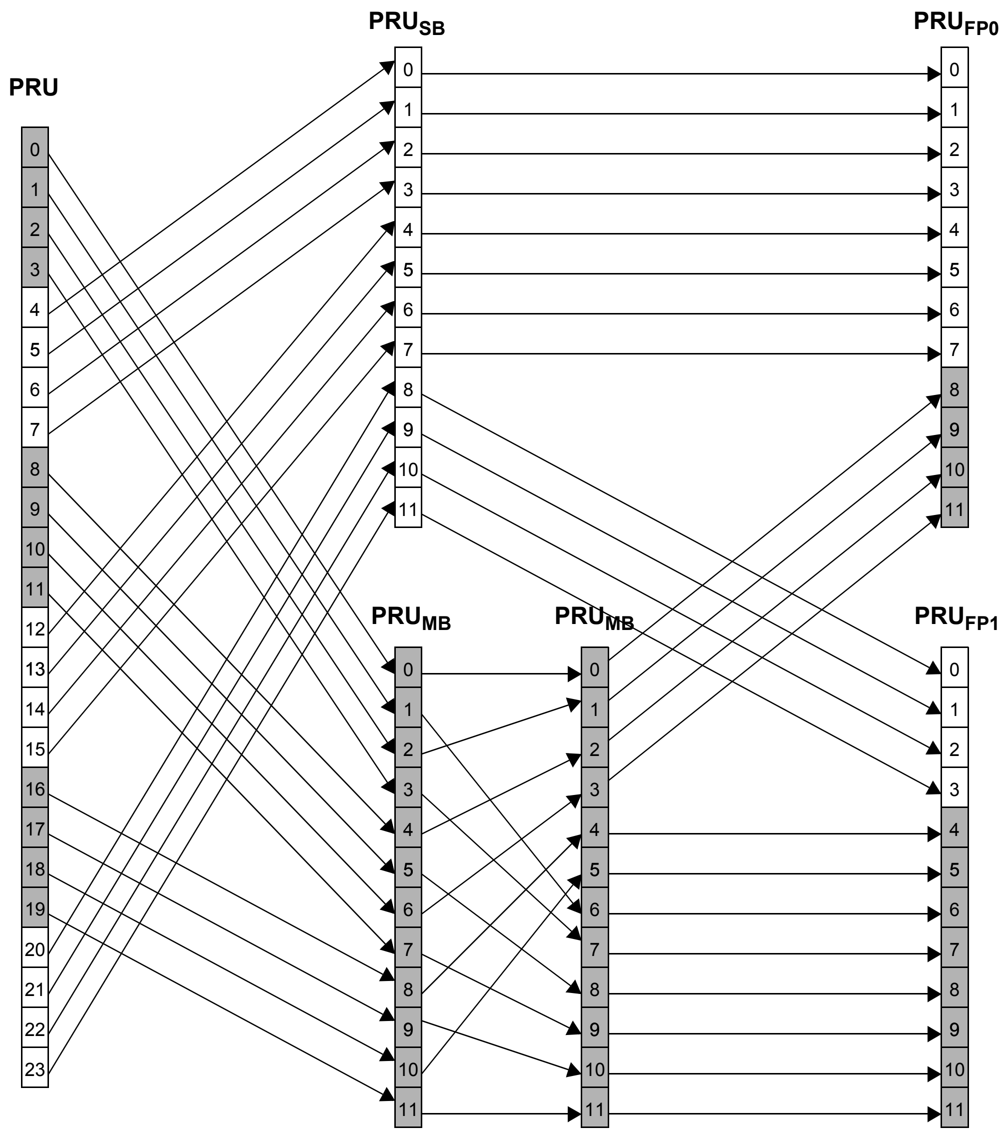

Figure 400—Frequency partitioning

15.3.5.3 Cell-specific resource mapping

PRU_{FPi}s will be mapped to LRUs. All further PRU and subcarrier permutation will be constrained to the PRUs

15.3.5.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. DRU allocation is signaled in two step process.

There are four possible pre-configured allocations signaled in two bits:

00 -- All PRU_{FPi}s are allocated to DRUs

01 -- All PRU_{FPi}s are allocated to CRUs

10 -- All subband PRUs are allocated to CRUs and all miniband PRUs are allocated to DRUs

11 -- The mapping is signaled explicitly

When explicit mapping is indicated, additional 4-bit (TBD) CRU allocation size (CAS) field is sent in the BCH for each allocated frequency partition. CASi indicated the number of allocated CRUs for partition FPi in a unit of subband size.

The number of CRUs in each frequency partition is denoted by $L_{CRU,FPi}$, where

$$L_{CRU,FP_i} = CAS_i \cdot N_1 \quad \text{for } 0 \le i < FPCT$$

The number of DRUs in each frequency partition is denoted by $L_{DRU,FPi}$, where $L_{DRU,FP_i} = FPS_i - CAS_i \cdot N_1$ for $0 \le i < FPCT$

The mapping of $PRUFP_i$:

$$CRU_{FP_i}[j] = PRU_{FP_i}[j] \qquad 0 \le i \le FPCT \;\; 0 \le j \le L_{CRU,FP_i}$$

$$DRU_{FP_i}[j] = PRU_{FP_i}[j + L_{CRU,FP_i}] \quad 0 \le i \le FPCT \;\; 0 \le j \le L_{DRU,FP_i}$$

15.3.5.3.2 Secondary permutation

The miniband CRUs may be permuted on a sector specific basis by a secondary permutation. Permutation of the secondary permutation will be signaled by a 1-bit secondary permutation field in the BCH.

The secondary permutation will be governed by Equation (179):

$$TBD \qquad (179)$$

15.3.5.3.3 Subcarrier permutation

The subcarrier permutation defined for the DL distributed resource allocations within a frequency partition spreads the subcarriers of the DRU across the whole distributed resource allocations. The granularity of the subcarrier permutation is equal to a pair of tones.

After mapping all pilots, the remainders of the used subcarriers are used to define the distributed LRU. To allocate the LRUs, the remaining subcarriers are paired into contiguous tone-pairs. Each LRU consists of a group of tone-pairs.

Let $L_{pair,l}$ denote the number of tone-pairs in *l-th* OFDMA symbol within a PRU, i.e., $L_{pair,l} = (P_{sc} - n_l)/2$, where n_l denotes the number of pilot tones in the *l*-th OFDMA symbol within a PRU. A permutation sequence *PermSeq( )* is defined by (TBD) to perform the DL subcarrier permutation as follows:

For each *l*-th OFDMA symbol in the subframe:

1) Allocate the n_l pilots within each PRU as described in section (TBD)
2) Renumber the remaining $L_{DRU, FPi} \cdot (P_{sc} - n_l)$ data subcarriers in order, from 0 to $L_{DRU, FPi}\,(P_{sc} - n_l)$ -1. Group these contiguous and logically renumbered subcarriers into $L_{DRU, FPi} \cdot L_{pair,l}$ pairs and renumber them from 0 to $L_{DRU, FPi} \cdot L_{pair,l}$-1. The renumbered tone pairs in the *l*-th OFDMA symbol are denoted by $RTP_{FPi,l}$.

3) Apply the subcarrier permutation formula Equation (180) to form the permuted tone-pairs 0 to $L_{DRU, FPi} \cdot L_{pair,l}$-1.

4) Map logically contiguous tone-pairs [i $\cdot$ $L_{pair,l}$, (i+1) $\cdot$ $L_{pair,l}$-1] into the i-th distributed LRUs, i=0,1,…, $L_{DRU, FPi}$ -1.

For the *s*-th distributed LRU of the *t*-th subframe, the subcarrier permutation formula is given by

$$pair(s, m, l, t) = L_{DRU, FPi} \cdot f(m, s) + g(PermSeq(), s, m, l, t) \qquad l = 0, 1, \ldots, N_{sym} \tag{180}$$

where *pair(s,m,l,t)* is the tone-pair index of the *m*-th tone-pair (0<=m< $L_{pair,l}$) in the *l*-th OFDMA symbol (0<=l<N_{sym}) in the *s*-th distributed LRU of the *t*-th subframe; *t* is the subframe index with respect to the frame, *s* is the distributed LRU index (0<=s < $L_{DRU, FP,i}$), *m* is the tone-pair index within the *l*-th OFDMA symbol. *PermSeq()* is the permutation sequence generated by a function or by a lookup table; *g(PermSeq(),s,m,l,t)* is a function (TBD) with value from the set [0, $L_{DRU, FP,i}$-1]; *f(m,s)* is a function (TBD) with value from the set [0, $L_{pair,l}$ -1]