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Re:	IEEE 802.16m-08/016r1 –Call for Contributions on Project 802.16m System Description Document (SDD); Preambles	
Abstract	The contribution presents DL preamble design for 802.16m system.	
Purpose	To be discussed and adopted by TGm for use in the IEEE 802.16m SDD	
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DL Preamble Design for 802.16m

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1 Instruction

This document will provide the DL preamble design consideration for 802.16m within the context of the SDD. Also, this document will be regarded as the basic assumption for the undergoing link level simulation of 16m cell search with the 16m preamble.

2 Design considerations of preamble

For 16m, the minimal functions of preamble should provide downlink time synchronization, downlink frequency synchronization, cell search, DL CQI measurement and channel estimation. And accordingly, the requirements for 16m preamble include enabling efficient receiver implementation (both hardware complexity and power consumption), auto-correlation and cross-correlation properties of the preamble sequences for detection and interference reduction in the multi cell environment or cell boundary, and lower L1 layer overhead.

As a result, design of 16m preamble should consider the following points:

- Bandwidth scalability

The 16m preamble bandwidth is fixed to a value which is common to the different operating bandwidths, the primary consideration is 5MHz(the minimum bandwidth of 16m system)，based on the following reason:

  - fast cell search for MS with different capabilities
  - fast cell search for BS with different operating bandwidths
  - fast cell search for BS aggregating multiple channels in more than one frequency band within the scope of a single MAC protocol instance
  - enable the new cell search design when 16e system is disabled, to reduce the dependence on the 16e preamble for 16m system

- Backward compatibility

For 16e and 16m mixed-operation scenario, the 16e preamble could be reused in the 16m system to reduce system overhead. The reused 16e preamble will only have a bandwidth of 5MHz or 10MHz.

Whether the reused 16e preamble will or will not be used when the backward supported legacy 16e is turned off, is FFS.

- Detection scheme

Hierarchical detection scheme is recommended to help MS initial access quickly.

3 Proposed solution

3.1 Transmission schemes

As shown in figure 1, the 16m preamble consists of primary preamble(P-Preamble) and secondary preamble(S- Preamble), the primary preamble bandwidth is 5MHz, P- Preamble and S- Preamble are multiplexed by TDM.

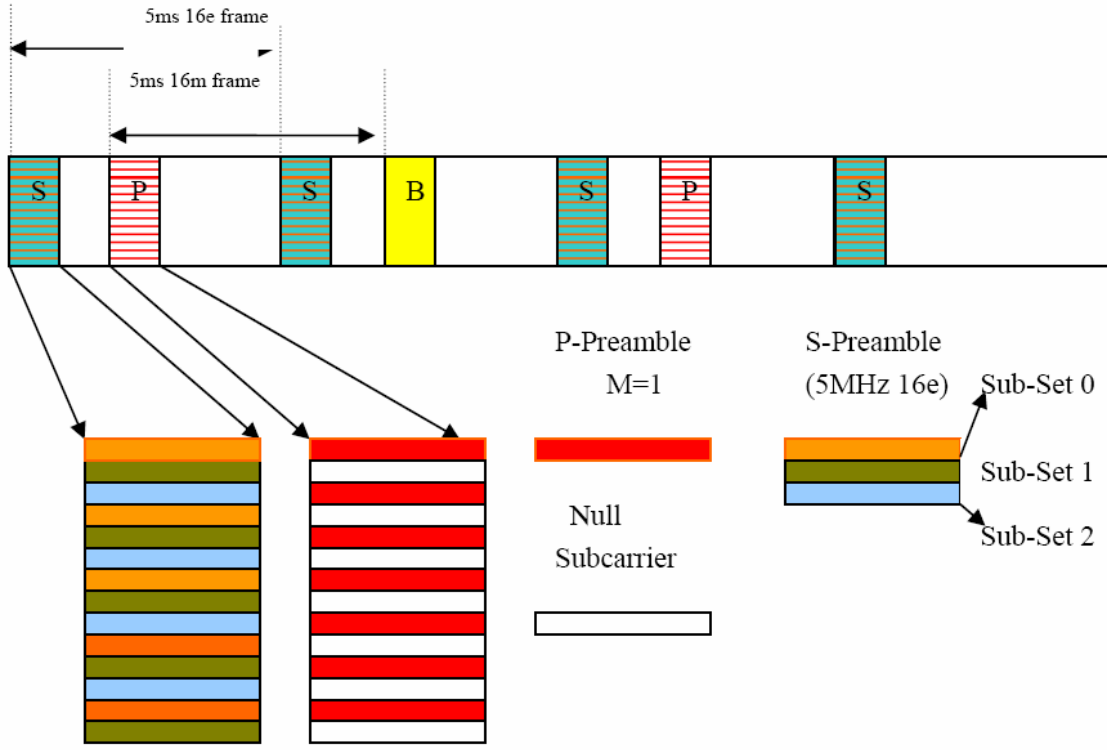

Figure 1. 16m system co-exist with 5MHz 16e system

The structure of the P-Preamble is every 2 sub-carriers mapping in the frequency domain. In this mapping scheme, 2 periodic waveforms appear within the duration of one OFDM symbol. Thus, in the first step, the P-Preamble symbol timing is detected by taking the auto-correlation of 2 periodic waveforms of the P- Preamble in the time domain without the information of the P- Preamble waveform.

The sequence of the P-Preamble is used to distinguish the 3 different types of S- Preamble (refer to Table 1):

- the reused 5MHz 16e preamble as S- Preamble when M=1 ,
- the reused 10 MHz 16e preamble as S- Preamble when M=2,
- the new designed 5MHz 16m S- Preamble when M=3.

Table 1

P-Preamble sequence Index	**S-Preamble sequence**	**S-Preamble sub-carrier mapping in the frequency domain**
M=1	5MHz 16e Preamble sequence	Sector1, with sub-carrier off set=0
M=1	5MHz 16e Preamble sequence	Sector2, with sub-carrier off set =1
M=1	5MHz 16e Preamble sequence	Sector3, with sub-carrier off set =2
M=2	10MHz 16e Preamble sequence	Sector1, with sub-carrier off set=0
M=2	10MHz 16e Preamble sequence	Sector2, with sub-carrier off set=1
M=2	10MHz 16e Preamble sequence	Sector3, with sub-carrier off set=2
M=3	5MHz 16m new sequence	FFS

The S-Preamble carries the cell ID, S-Preamble sequence belongs to different sectors is carried on different sub-carrier set, each sub-carrier set with every 3 sub-carriers mapping in the frequency domain.

In time domain, the offset of S-preamble symbol location with respect to the P-preamble location is n (>=1) symbols or sub-frames, the offset is fixed. In the 16m only case(M=3), two possible offset option can be used, a)n=1 OFDM symbol and b)n=8 sub-frames. For option a), coherent detection of S-Preamble with P-preamble as reference is possible, but for option b), flexibility in the design of other physic channel may be provided since placing less SCH +BCH symbols in the subframe reduces the design constrain to other physic channel. So in figure 3,option b) is shown.

A small number of preamble symbols per superframe is desirable in order to reduce the overhead. However, time diversity employing multiple preamble symbols is very effective in achieving fast cell search by improving the detection probability of the preamble symbols particularly in a high mobility environment. Multiple preamble symbols per superframe can also reduce the minimum required correlation detection period for preamble timing detection .Therefore, we propose multiple preamble symbols mapping in a 20-msec superframe (typically two or four preamble symbols for 16m only case) as shown in Fig. 3. The optimum number of preamble per radio superframe is to be specified from the cell search time performance.
In the above design, a basic-BCH(P-BCH) is assumed to provide additional cell specific information such as the system bandwidth, the number of transmission antennas, CP length of each sub-frame and ratio of 16m/16e within the frame,etc, and it is part of the superframe header. The location of P-BCH is fixed in the superframe. Figure1, 2 and 3 give examples of P-BCH locations for 16m system co-exist with 5MHz 16e system, 10MHz 16e system and 16m only system respectively.
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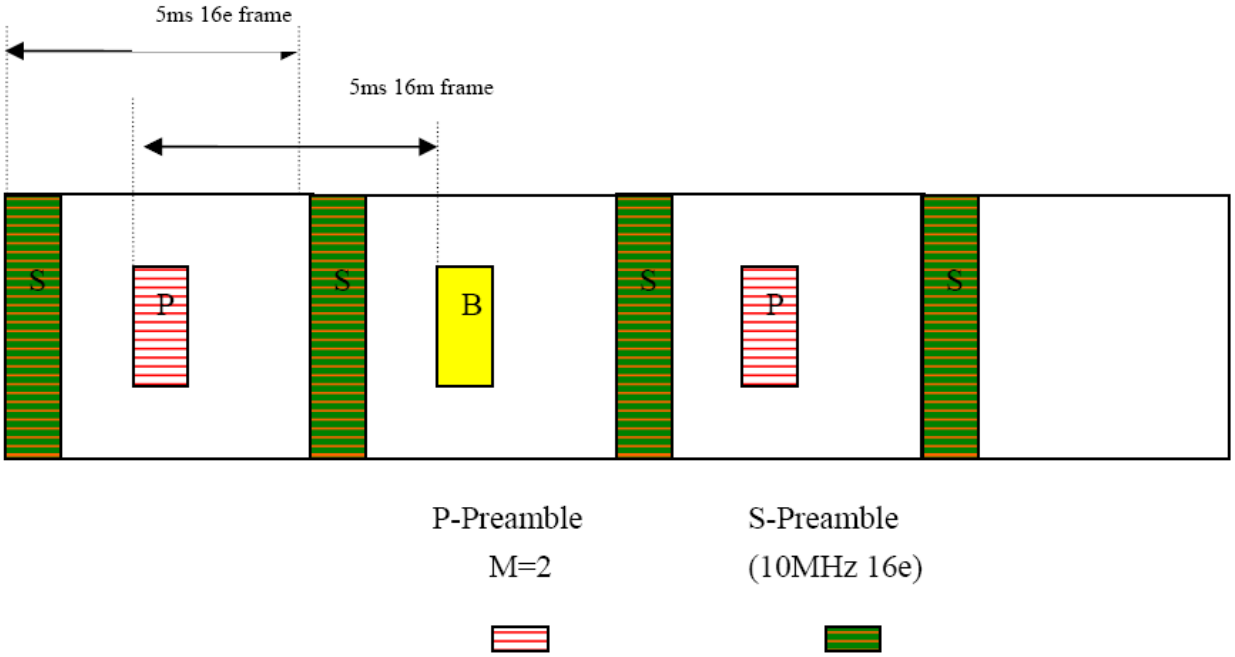

Figure 2. 16m system co-exist with 10MHz 16e system

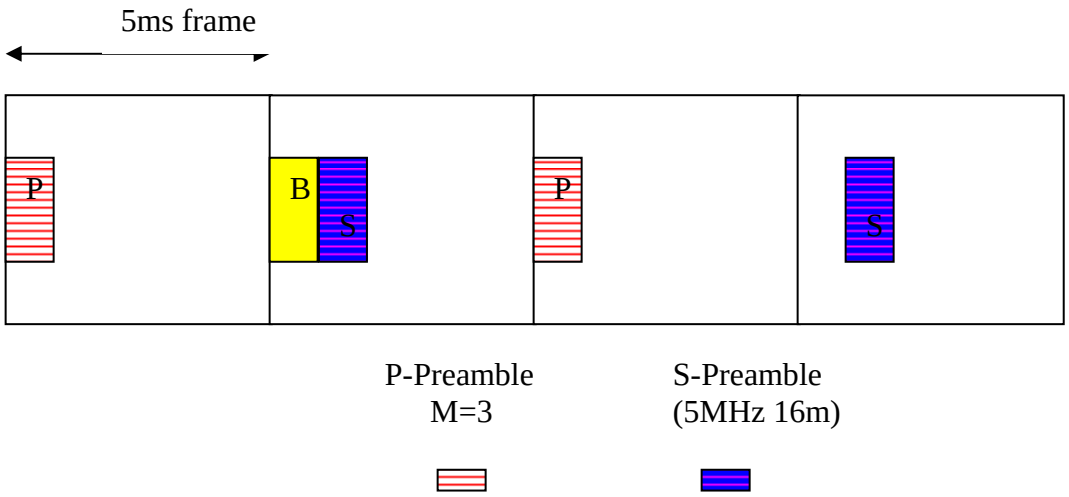

Figure 3. 16m only system

3.2 Cell search procedure

It is proposed to adapt the following cell search procedure:

- The MS searches P-Preamble and gets frequency, sub-frame and OFDM symbol synchronization by auto-correlation based detection of P-Preamble in time domain;
- The MS get the sequence index M and fine symbol synchronization by P-Preamble correlation in the frequency domain;
- The MS seeks the sector ID from the S- Preamble sub-carrier offset;
- The MS seeks the Cell ID with the S- Preamble sequence detection.

3.3 P-Preamble sequence and 16m new S-Preamble sequence consideration

The desired sequence properties are:

- Enabling efficient receiver implementation (both hardware complexity and power consumption)
- Good auto-correlation and cross-correlation properties even with large frequency offset
- Constant amplitude both in time and frequency (this requirement can be relaxed)
  - Peak to average ratio consideration

The sequence design is under consideration.

3.4 Overhead of preamble design

For 16m only system shown in Figure 3, we can see that the proposed preamble have an overhead the same as that of a 5 MHz 16e system, so its overhead is bigger than that of a 5MHz 16e system and less than that of a 20MHz 16e system for mixed operation case.

3.5 Conclusion

The consideration of 16m preamble design is provided in this contribution, the key points are listed below:

1) Synchronization scheme: Hierarchical, the 16m preamble consists of primary preamble(P-Preamble) and secondary preamble(S- Preamble), P- Preamble and S- Preamble are multiplexed by TDM;
2) P-preamble function and design:
   - Time and Frequency Synchronization;
   - Different sequence to distinguish different system deployment scenario:16e/16m mixed operation and 16m only;
3) S-Preamble function and design:
   - Cell Id detection;
   - Legacy 16e preamble sequence of 5/10MHz reused as S-preamble in 16e/16m mixed operation mode, and new 16m sequence of 5MHz in 16m only mode;
4) Legacy 16e Preamble use by 16m terminals in mixed mode deployment:yes;
5) BW for 16m preamble:5MHz for P-Preamble and also for new S-Preamble;
6) # of 16m preamble symbols: 1 symbol for P-Preamble every 10ms. Also 1 symbol every 10ms for new S-Preamble. 16e based S-Preamble every 5ms;
7) Period of Preamble transmission: 10ms for P-Preamble and S-Preamble is 5ms when re-using legacy preamble;
8) Subcarrier Mapping of Preamble: for P-preamble, every other subcarrier is null (time domain repetition period = T/2).
9) Total Preamble symbol resources required per 16m Superframe (20ms) for 16m only mode: 4 (ie. 2 symbols for P-preamble, 2 symbol for New S-Preamble)
10) A basic-BCH(P-BCH) is assumed to provide additional cell specific information such as the system bandwidth, the number of transmission antennas, CP length of each sub-frame and ratio of 16m/16e within the frame,etc, and it is part of the superframe header.

4 Proposed Text for SDD

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11.x preamble

11.x.1 Preamble structure

- ✓ The 16m preamble consists of primary preamble(P- Preamble) and secondary preamble(S- Preamble);
- ✓ The primary preamble bandwidth is 5MHz;
- ✓ P- Preamble and S- Preamble are multiplexed by TDM;
- ✓ The structure of the p-preamble: every 2 sub-carrier mapping in the frequency domain. In this mapping scheme, 2 periodic waveforms appear within the duration of one OFDM symbol. Thus, in the first step, the P- Preamble symbol timing is detected by taking the auto-correlation of 2 periodic waveforms of the P- Preamble in the time domain without the information of the P- Preamble waveform;
- ✓ The sequence of the p-preamble is used to distinguish the M=3 different S- Preamble type:a)the reused 5MHz 16e preamble when M=1 ,b)the reused 10 MHz 16e preamble when M=2,c)the new 5MHz 16m S- Preamble when M=3.
- ✓ The S-Preamble carries the cell ID, S-Preamble sequence belongs to different sectors is carried on different sub-carrier set with every 3 sub-carriers mapping in the frequency domain,

Table xx

P-Preamble sequence	**S-Preamle sequence**	**S-Preamle sub-carrier mapping in the frequency domain**

Index		
M=1	5MHz 16e Preamle sequence	Sector1, with sub-carrier off set=0
M=1	5MHz 16e Preamle sequence	Sector2, with sub-carrier off set =1
M=1	5MHz 16e Preamle sequence	Sector3, with sub-carrier off set =2
M=2	10MHz 16e Preamle sequence	Sector1, with sub-carrier off set=0
M=2	10MHz 16e Preamle sequence	Sector2, with sub-carrier off set=1
M=2	10MHz 16e Preamle sequence	Sector3, with sub-carrier off set=2
M=3	5MHz 16m new sequence	FFS

11.x.2 Preamble structure in time frequency domain:

11.x.2.1. P-Preamble structure in time domain with fixed CP

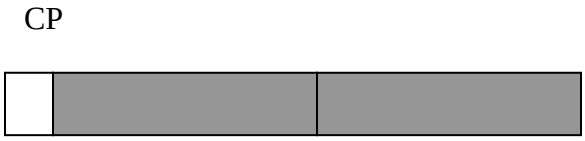

Fig.xx P-Preamble structure in time domain

11.x.2.2. S-Preamble symbol offset with respect to the location of P-Preamble is n (>=1) symbols/sub-frames

11.x.2.2.1 16m system co-exist with 5MHz 16e system

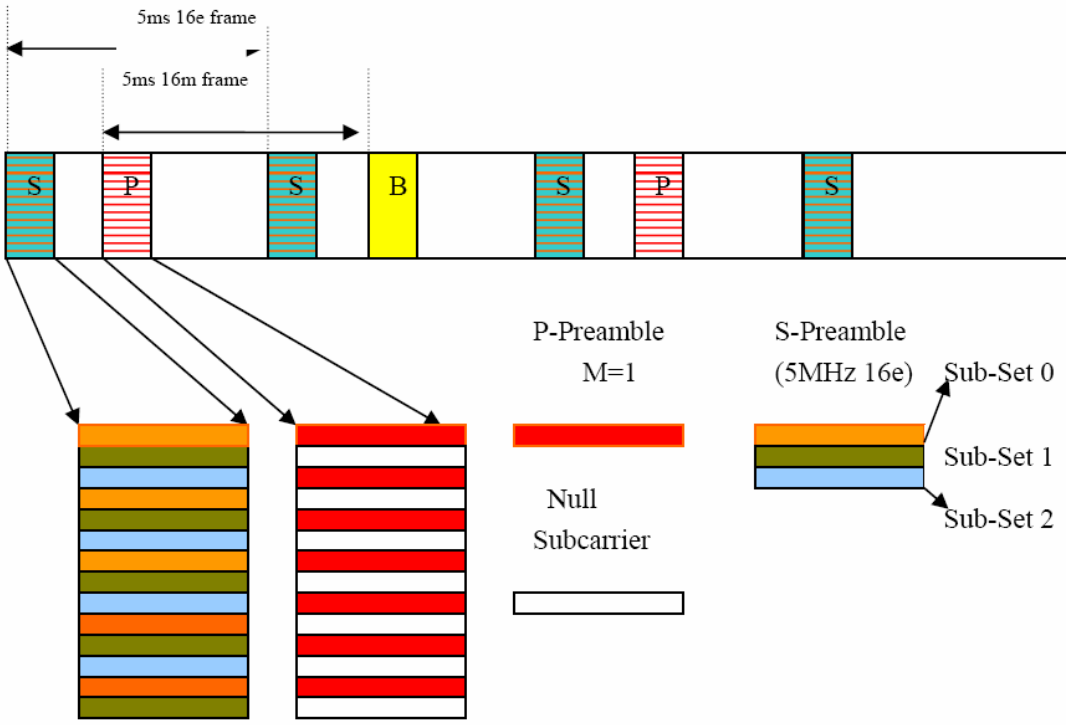

Fig.xx Preamble structure for16m system co-exist with 5MHz 16e system

11.x.2.2.2 16m system co-exist with 10MHz 16e system

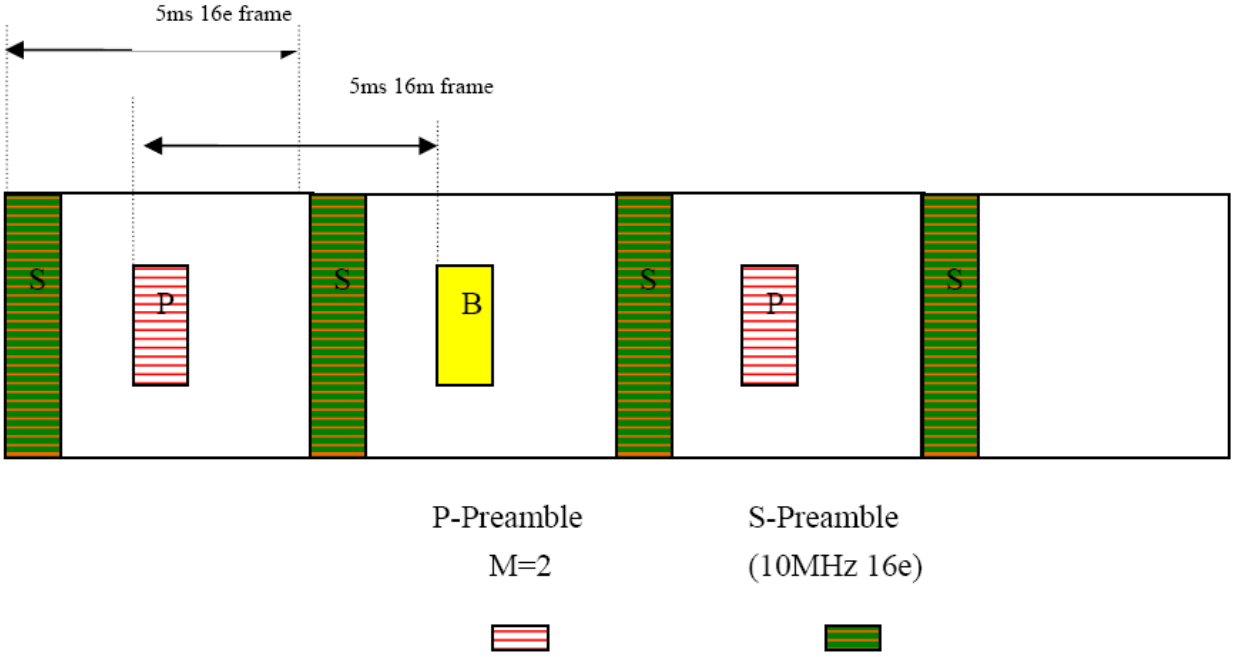

Fig.xx Preamble structure for16m system co-exist with 10MHz 16e system

11.x.2.2.3. 16m only system

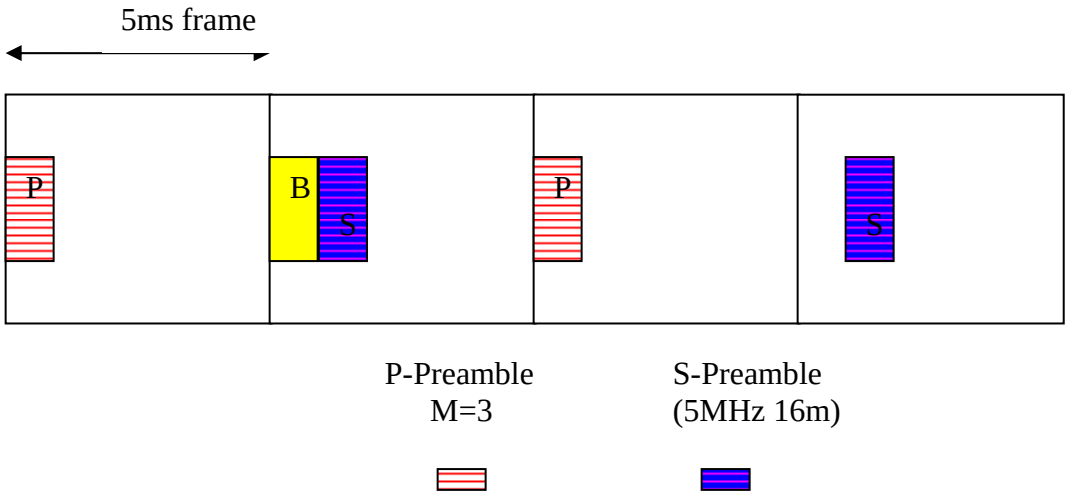

Fig.xx Preamble structure for16m only system

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5 References

[1] 80216m-07_002r4,