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Title	<b>IEEE 802.16m System Deployment Scenarios with Multi-carrier Support and Clarification on Multi-carrier Frame Structure</b>
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Re:	802.16m-08/033, "Call for Contributions and Comments on Project 802.16m System Description Document (SDD)," ◆ PHY: Multi-Carrier Operation
Abstract	This contribution investigates the possible scenario for IEEE 802.16m network deployment. Due to the restriction by backward compatibility when co-deployed with IEEE 802.16e network, the frequency channel bandwidth, center frequency and channel raster shall be the same as the parameters used in IEEE 802.16e based mobile WiMAX system.
Purpose	To facilitate the harmonization on multi-carrier operation for TGm
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# Multi-carrier Transmission Scheme and the Clarification on Multi-carrier Frame Structure for IEEE 802.16m

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## 1 Motivation

IEEE 802.16m is expected to be the technical specification to define PHY and MAC layer of WiMAX R2.0 system, which shall be backward compatible to IEEE 802.16e based WiMAX R1.0 and R1.5 systems. From service provider's perspective, the upgrade of radio access network is usually performed in evolutionary manner rather than in revolutionary manner. Therefore, IEEE 802.16m network will be expected to be co-deployed with IEEE 802.16e network over a period of time within the same or adjacent frequency bands.

This contribution will investigate the deployment scenarios should be considered by IEEE 802.16m and the reasonable transceiver architectures for both BS and MS to support multi-carrier transmission. Then some confusion between multi-carrier frame structure and the frame structure with wider bandwidth support in the latest SDD will be discussed and clarified.

## 2 Deployment Scenarios for IEEE 802.16m BSs with Multi-carrier Support

This section will discuss the possible scenarios should be considered when deploying the IEEE 802.16m radio access network. Two typical cases are discussed here. The first one is deploying the IEEE 802.16m BS over the specific area (e.g. hot spot area) where the IEEE 802.16e network has already performed full coverage. The legacy system operators usually prefer to upgrade their network step by step to balance their investment, customer request and overall network performances. The second one is to deploy the IEEE 802.16m network over the Greenfield spectrum without the problems from coexisting with legacy system.

### 2.1 Deploy the IEEE 802.16m Network coexist with IEEE 802.16e Network

There are many IEEE 802.16e based WiMAX networks being or going to be deployed in next one year. After few more years, the system operators may plan to further upgrade their WiMAX network to serve more users or to support more attractive services by higher data rate. Therefore, the operator may begin to launch the IEEE 802.16m based advanced WiMAX network over specific areas to satisfy demands on high data rate services from specific group of users. For the other areas where user doesn't have strong demand on higher data rate, the operator may keep using legacy 16e based WiMAX network to provide the coverage to satisfy the basic service requirements.

For example, users located around business center may have higher possibility to use some special services like video conferencing service and high speed data downloading. The operator may deploy the IEEE 802.16m BSs in such area first. For the rest area, users may only use normal services like telephone, LBS, MBS and web browsing. The operator can reuse the legacy 16e based WiMAX network to satisfy those services. After the 16m based user terminals are getting more and more popular, the operator can gradually upgrade the BSs with dual 16e/16m mode over the entire service area to take advantage on higher spectrum efficiency by 16m air interface. At the end, the operator upgrade all the BSs to support 16m mode and the highest spectrum efficiency can be achieved if the system only enable 16m air interface. An example is given in Figure 1 to explain the possible network evolution when upgrading the WiMAX network.

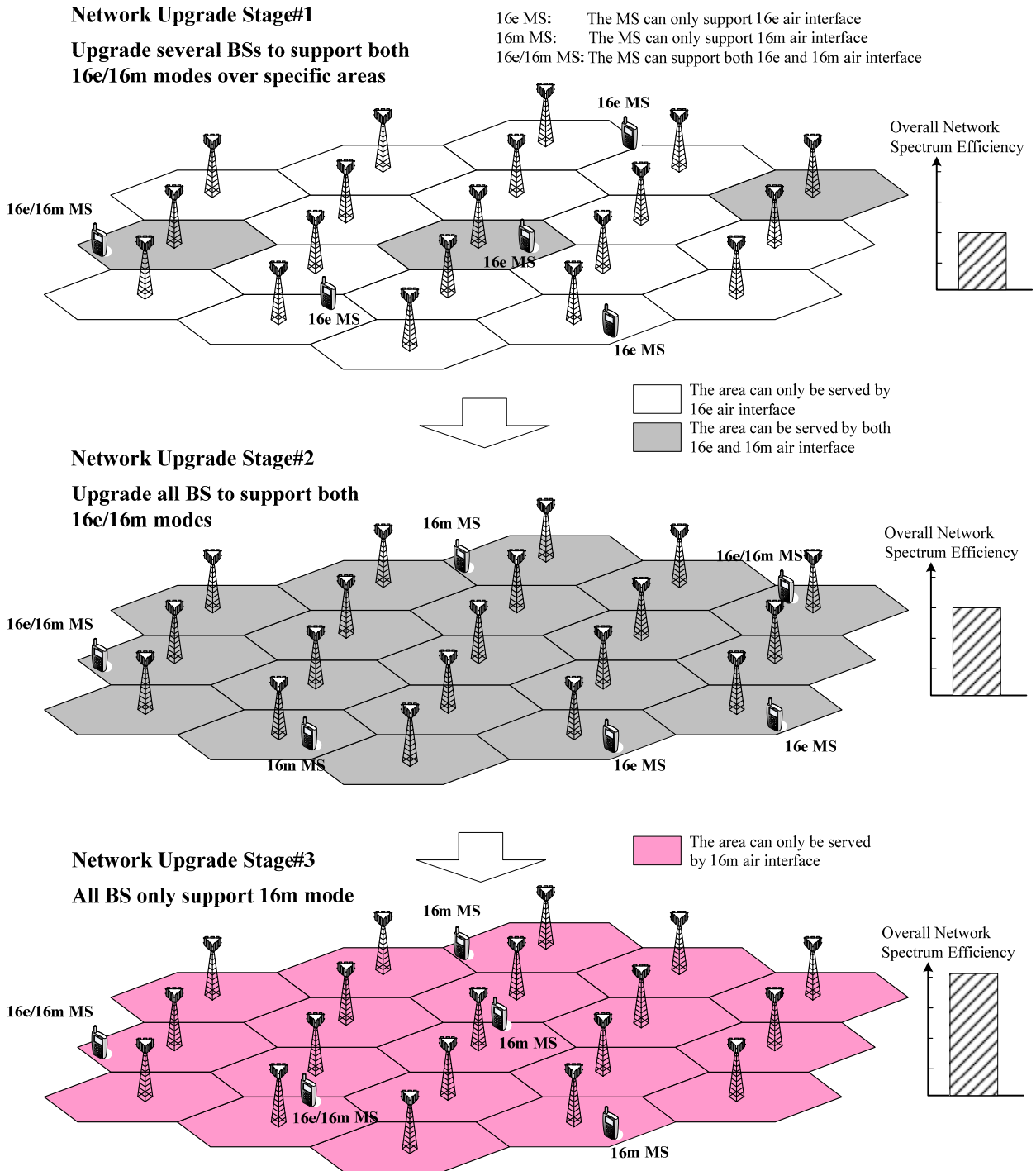


Figure 1 An example on WiMAX network evolution

### 2.1.1 Possible Spectrum Availability

When the IEEE 802.16e based WiMAX network is co-deployed with IEEE 802.16m based network, the available spectrum for the system operator may exist several possibilities:

- (1) Operator reuse the spectrum for legacy system to deploy IEEE 802.16m system

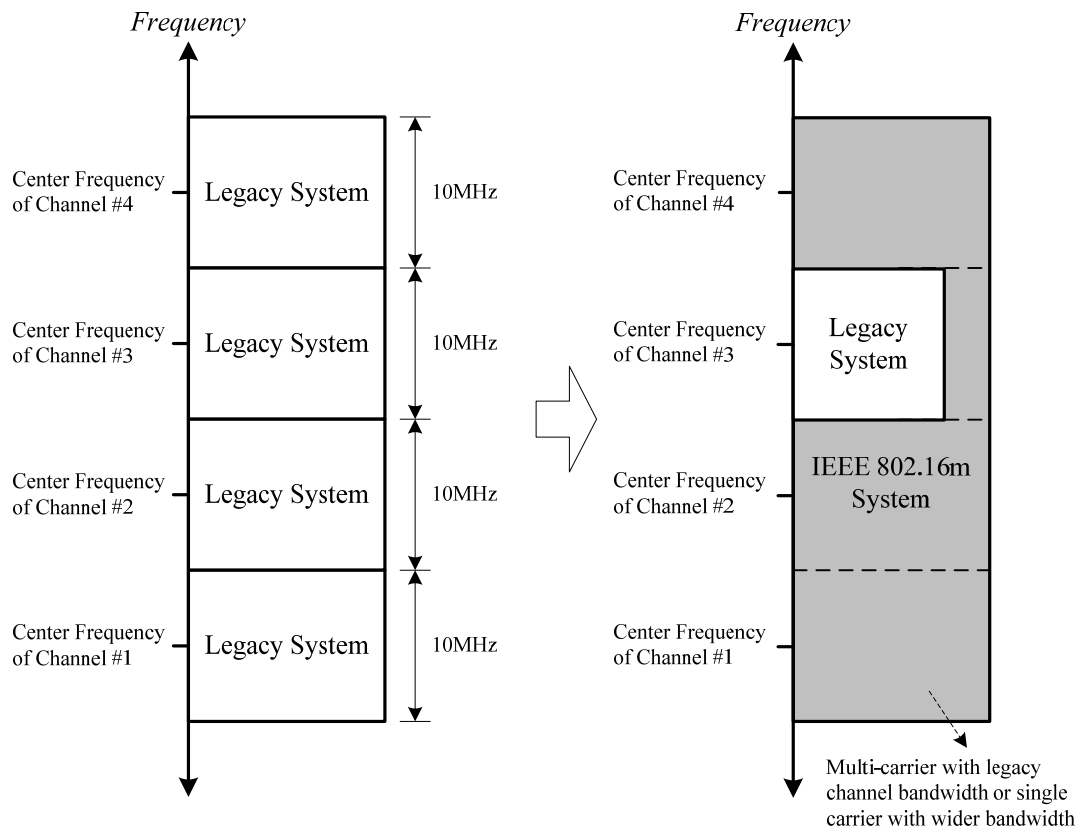


Figure 2 An example to reuse the spectrum for legacy system for deploying the IEEE 802.16m system

For this scenario, the channel raster, bandwidth of each frequency channel and the center frequency of each frequency channel for IEEE 802.16m based advanced WiMAX system shall be the same as current definition for IEEE 802.16e based mobile WiMAX system.

(2) Operator owns additional spectrum to deploy 16m

For this scenario, the channel raster, bandwidth of each frequency channel and the center frequency of each frequency channel of IEEE 802.16m system can be different than the current definition for legacy system. But it is still recommended to reuse the current parameters in legacy system due to the scenario in (1). This can substantially simplify the system design and network planning, so as to speed up the progress for product development and certification.

If the additional spectrum is not enough to support the heavy traffic in IEEE 802.16m network and the operator want to reuse part of the legacy system spectrum, the situation will be exactly the same as (1). Therefore, it is better to reuse the current parameters on channel bandwidth, channel raster and center frequency of each channel for IEEE 802.16m for consistency.

## 2.2 Greenfield deployment for IEEE 802.16m network

If the system operator can deploy the IEEE 802.16m system in a new spectrum without any co-deployment concern with legacy WiMAX system, the channel raster, bandwidth of each frequency channel and the center frequency of each frequency channel can be different than the legacy system. The situation for this case will be very similar with the situation in 2.1(2). It is still recommended to reuse the parameters used by legacy system because of the existence of case 2.1(1), so that the system

can have consistent configuration.

### 3 Recommended Multi-carrier Transmission Scheme to Support Scalable Bandwidth

According to the possible deployment scenarios discussed in previous section, the multi-carrier frame structure with backward compatibility with the legacy system is proposed in Figure 3 (a).

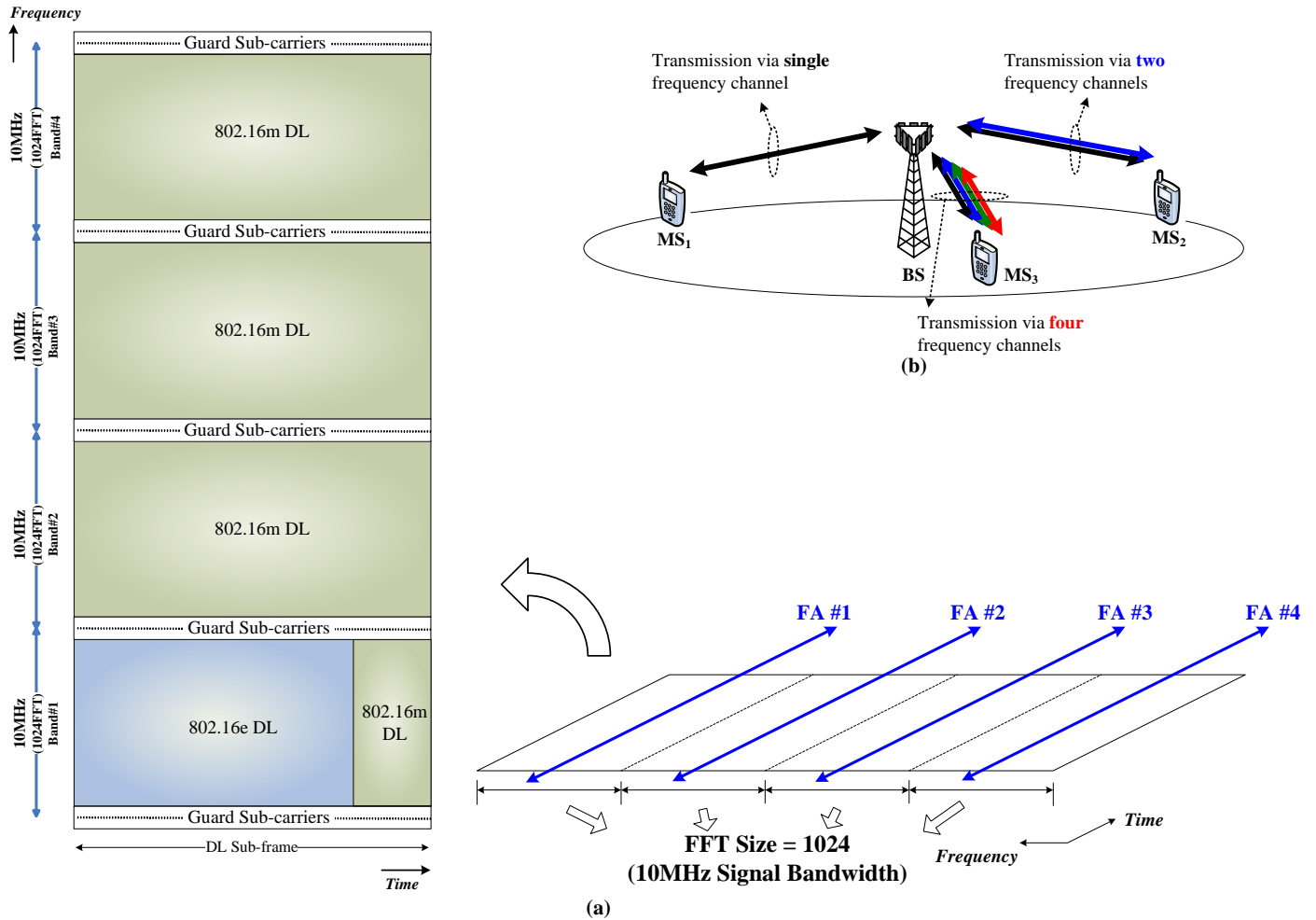


Figure 3 (a) Recommended multi-carrier frame structure with backward compatibility over the legacy system and (b) the flexibility for MS to support scalable bandwidth by equipping different number of carriers

In Figure 3(a), the multi-carrier frame structure with backward compatibility over the legacy system is proposed. Because the bandwidth of each frequency channel is 10MHz, it is recommended that the bandwidth of each frequency channel shall also be 10MHz. From standard perspective, it is recommended that the 10MHz channel bandwidth shall be mandatory for IEEE 802.16m, while the other bandwidth of 5MHz, 20MHz and 40MHz are optional. This can not only guarantee the backward compatibility for the legacy system, but also reduce the effort on hardware redesign and speed up the progress of implementation and certification.

Note that the 10MHz channel bandwidth may not necessary be implemented by 1024 FFT hardware, there are many possible and vendor specific solutions. For example, BS can use a 4096 FFT to implement  $4 \times 10\text{MHz}$  frequency channels [1] to simultaneously serve multiple MSs (single-carrier MS) in different

10MHz frequency channels or serve the MS (multi-carrier MS) by multiple frequency channels.

This architecture will be very helpful for IEEE 802.16m to support the scalable bandwidth (e.g. 10MHz~40MHz in Figure 3; note that different channel bandwidths may also be applied for the carriers without the coexistence requirement with legacy system) and allow the MS has the flexibility to support different level of hardware complexity. Because for most of the users,  $2 \times 10\text{MHz}$  frequency channels can already perform enough peak transmission rate and average throughput to satisfy most of the mobile services in the near future. For those special applications like high quality video conferencing or mobile wireless router,  $4 \times 10\text{MHz}$  frequency channel or single 40MHz channel for MS may be required. Therefore, it is highly desired to have 10MHz frequency channel bandwidth as the mandatory for IEEE 802.16m.

## 4 Clarification on Multi-carrier Frame Structure in P802.16m SDD

In the latest version of P802.16m System Description Document (SDD) [2], the definitions and the frame structures for multi-carrier and wider band are very confusing. The current understanding is that the “multi-carrier” means multiple RF carriers and the “wider bandwidth” means the bandwidth to the transmitted radio signal is wider than the bandwidth in legacy system.

However, it is very possible that the BS use single RF carrier with wider channel bandwidth (e.g. 40MHz) to serve the MS equipped with multiple RF carriers and narrower bandwidth channels (e.g. 10MHz), which is shown in Figure 4. It is because the BSs have to serve multiple MSs over different carriers simultaneously, having a single wide-band transceiver will be vary flexible for BS to coordinate this kind of the point-to-multi-point (PMP) data transmission.

On the other hand, the traffic demands by each MS and its affordable hardware complexity are usually much lower than BS. Therefore, it’s not reasonable for most MSs to equip the wide-band transceiver. Having single or multiple narrow band transceivers with the same channel bandwidth as legacy system (i.e. 10MHz) in MS terminal is much desired to balance the MS traffic demand, hardware complexity and backward compatibility. Therefore, the transceiver architecture and the transmission scheme in Figure 4 will be highly desired to support scalable bandwidth and multi-carrier operations.

Since the MS always need to have multiple RF devices to support MIMO operation, using multiple RF devices along with multiple baseband PHY can have some benefits on system control. For example, BS may serve MS by two carriers to support high data traffic in DL (e.g.  $2 \times 2$  MIMO over 2 carriers), but MS may only have much lower UL traffic and only need single carrier transmission. Therefore, MS can utilize the RF devices originally used for another carrier for higher order MIMO transmission for single carrier UL transmission (e.g.  $4 \times 4$  MIMO over 1 carriers) [3].

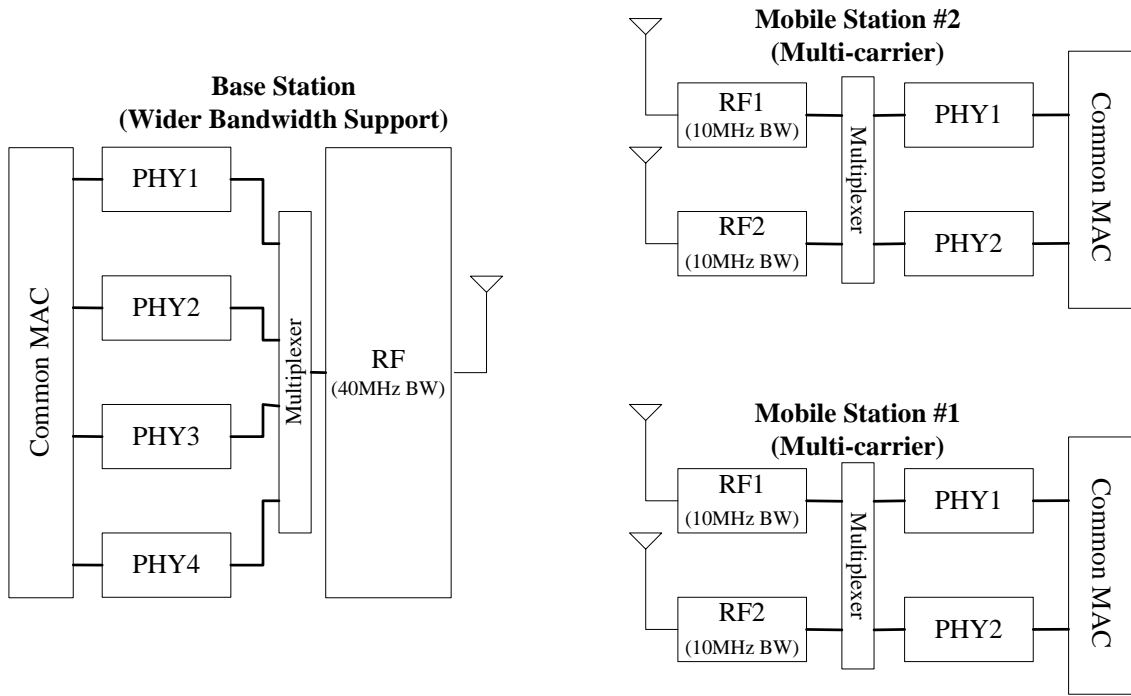


Figure 4(a) The transceiver architecture of the BS with wider bandwidth and the multi-carrier MSs

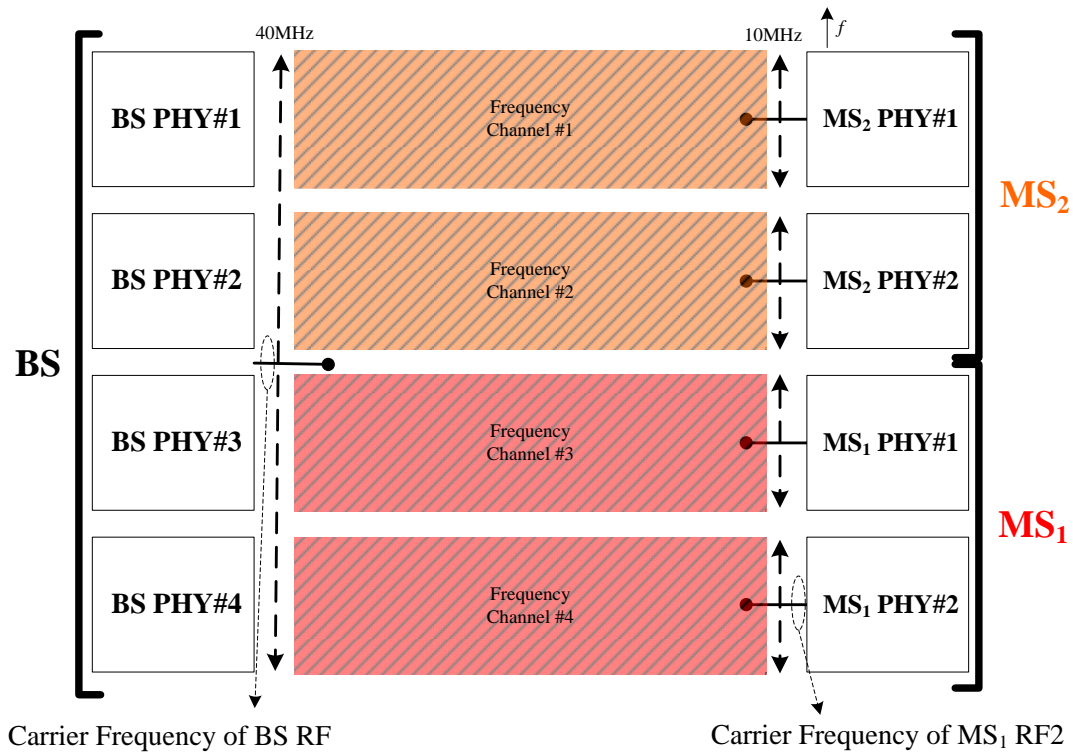
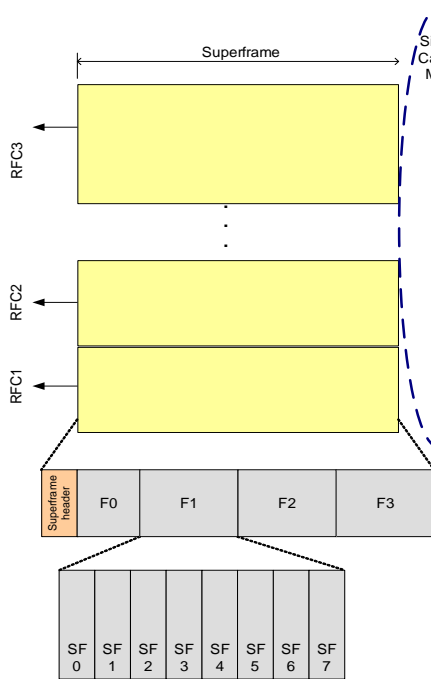


Figure 4(b) Wider bandwidth BS communicates with multi-carrier MSs over different frequency channels

However, the confusion comes from which frame structure is applicable for the case in Figure 4?

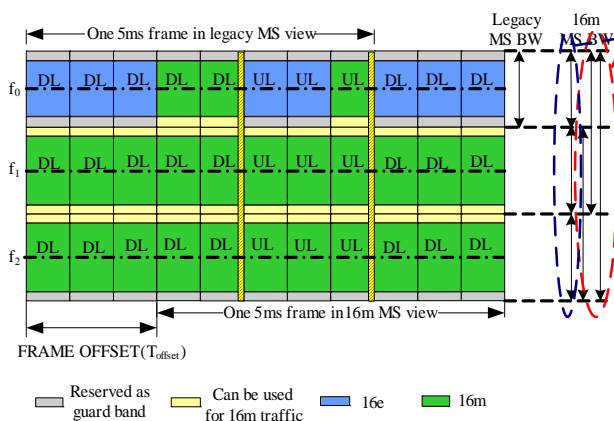
Consider the case depicted in Figure 4, it's very confusing that whether the multi-carrier frame structure or the frame structure with wider bandwidth support should be applied? Figure 5 put the current figures in SDD for comparison to show how people may confuse on the definitions on "multi-carrier" and "wider bandwidth".



The drawing for multi-carrier MS in Fig.18 is the same as the drawing for 16m MS with wider BW support.

This will definitely confuse people the definitions on "multi-carrier" and "wider bandwidth"

Figure 18 Example of the proposed frame structure to support multi-carrier operation



The drawing for single carrier MS in Fig. 18 is also the same as the 16m MS with wider BW support in Fig. 22.

This will confuse people what is the definition of "wider bandwidth"

Figure 22 Illustration of frame structure supporting legacy frames with a wider channel

Figure 5 Confusion on the definition on multi-carrier MS and wider bandwidth MS due to the confusing drawing in current SDD



In addition to the confusion on multi-carrier MS and the MS with wider bandwidth support, the frame structures will also confuse people what is the meaning of the wider bandwidth support. Because both Figure 18 and Figure 22 in SDD specifies multiple frequency channels, and both of them actually looks like multi-carrier frame structure. A simple method to resolve the confusion is adding the lines to indicating the 16m BS bandwidth in the frame structure with wider bandwidth support. This can help people understand the definition of wider bandwidth defined in IEEE 802.16m.

In order to resolve the confusions in current SDD without largely revise the current SDD text, the slightly modified frame structures is proposed in Figure 6 for clarification.

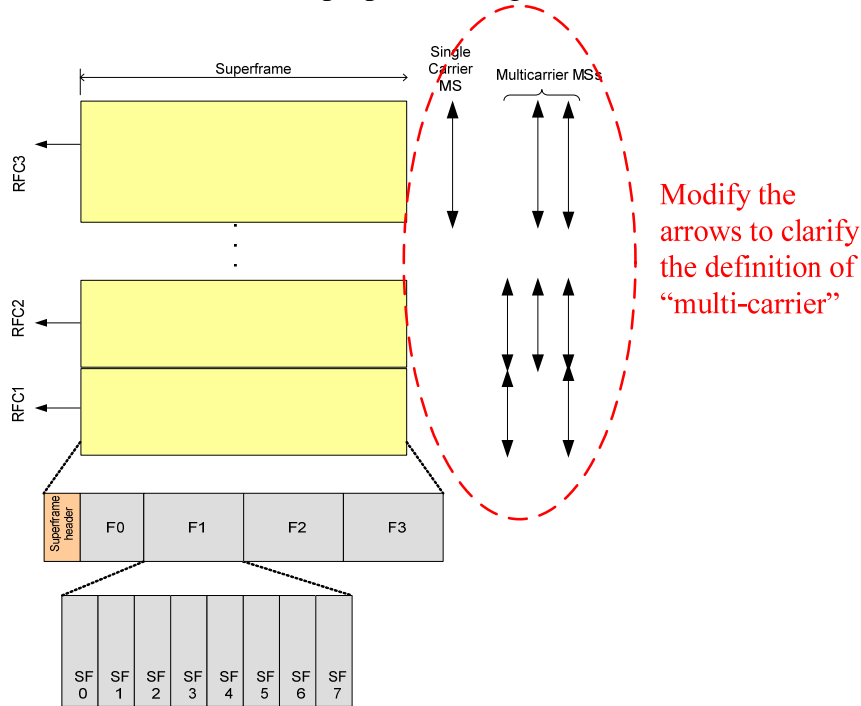


Figure 18 Example of the proposed frame structure to support multi-carrier operation

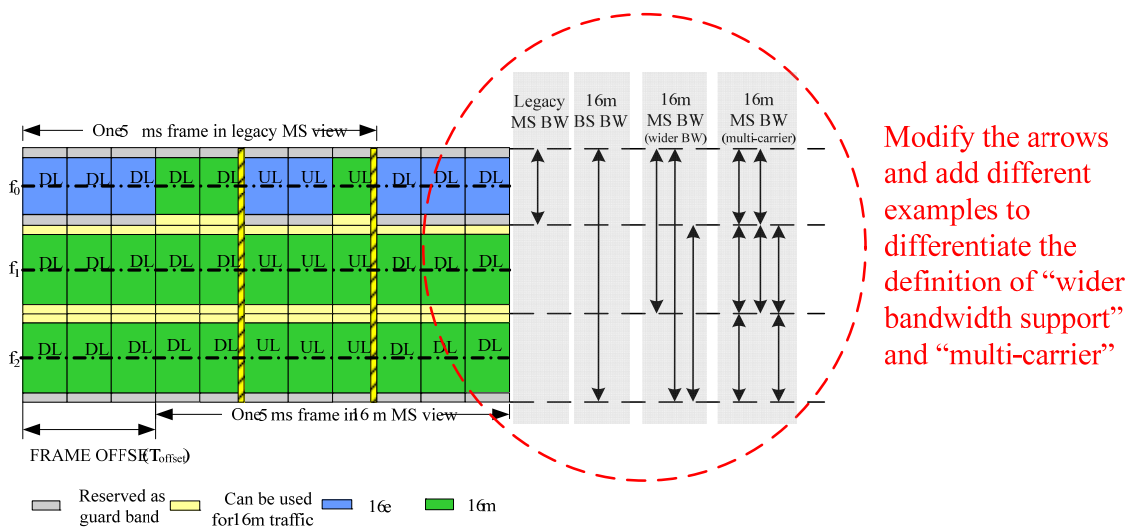


Figure 22 Illustration of frame structure supporting legacy frames with a wider channel

Figure 6 Proposed modifications to clarify the definitions on multi-carrier and wider bandwidth support

# 5 Text Proposal

-----Start of the Text-----

[Use the following figure to replace the Figure 18 in 802.16m-08/003r4]

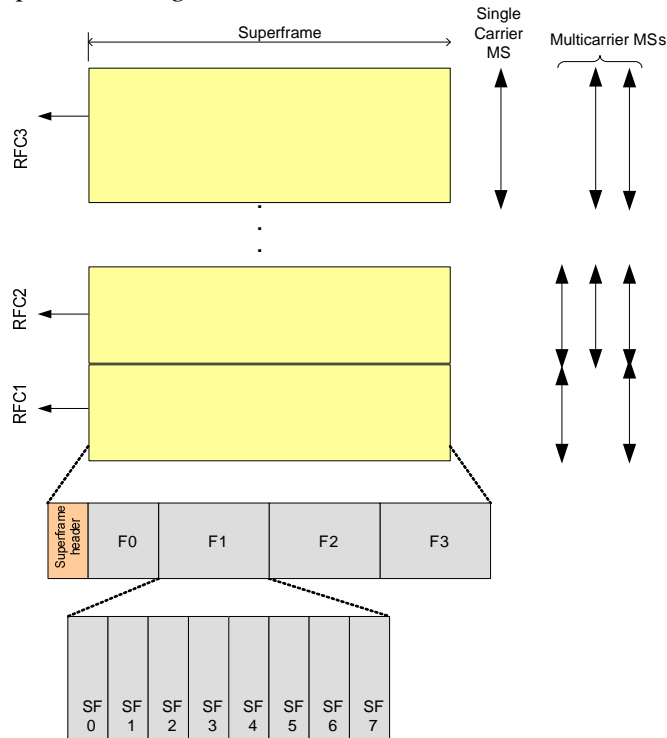


Figure 18 Example of the frame structure to support multi-carrier operation

[Add the following figure after line#19, page#35 in 802.16m-08/003r4]

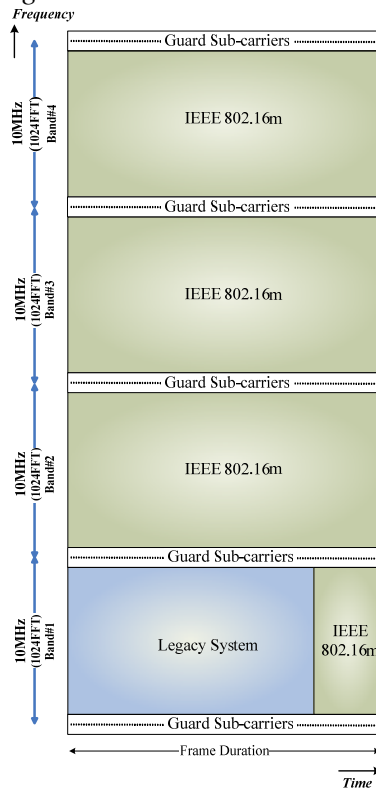


Figure x Example of the frame structure to support multi-carrier operation and backward compatibility

[Use the following figure to replace the Figure 22 in 802.16m-08/003r4]

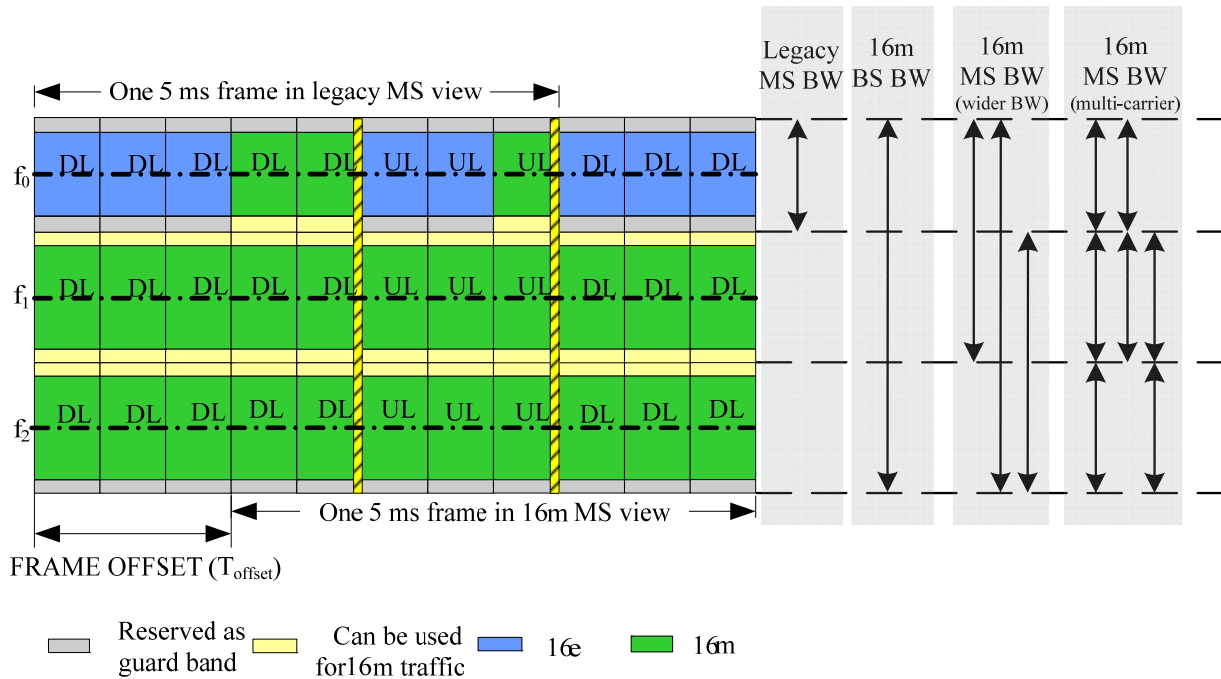


Figure 22 Illustration of frame structure supporting legacy frames with a wider channel

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## Reference

- [1] Hujin Yin et al, "Virtual Multi-Carrier Operation for IEEE 802.16m," S802.16m-08/364r1, May 2008.
- [2] Shkumbin Hamiti, "The Draft IEEE 802.16m System Description Document," IEEE 802.16m-08/003r4, July 2008.
- [3] I-Kang Fu et al, "Clarification on Possible Bandwidth Aggregation for Multi-carrier MS in IEEE 802.16m," IEEE C802.16m-08/562, July 2008.