Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Draft IEEE 802.16m System Requirements: Section 9: Usage and Deployment Models**
Date Submitted	**2007-02-23**
Source(s)	Sassan Ahmadi (sassan.ahmadi@intel.com) Garold Fuks (garold.fuks@intel.com) Kamran Etemad (kamran.etemad@intel.com) Jose Puthenkulam (jose.p.puthenkulam@intel.com), Hassan Yaghoobi (hassan.yaghoobi@intel.com) Intel Corporation
Re:	Call for contributions regarding P802.16m project, 1/22/2007
Abstract	This document contains proposed system-level and service requirements for IEEE 802.16m standard.
Purpose	For discussion and approval by TGm
Notice	
Release	
Patent Policy and Procedures	

Contents

9.0Usage and Deployment Models

This section is informative and describes some example usage and deployment model scenarios for IEEE 802.16m systems. The scenarios described in the following sections include topologies and networks where 802.16m terminals and base stations are exclusively used, where a mix of 802.16m and 802.16e (migration from legacy to new systems), and a number of scenarios where fixed and mobile relay stations (used for coverage and throughput enhancements) are used.

9.1 Usage and Deployment Model Terminology

Some of the terms used are already specified in the IEEE Std 802.16 WirelessMAN-OFDMA physical layer, but are described here for assisting the reader as a quick overview

Segment – this term refers to the logical partition of the frequency range allocated to each base station. Each sector of the BS can be assigned a different segment number. The maximal possible number of segments is the number of sectors. It is also possible to assign the same segment number to all the sectors.

Preamble - the preamble in the IEEE 802.16 systems is designed to have 1/3 reuse pattern. This is defined in the standard by instructing that every segment will transmit every third carrier of the OFDM symbol. Thus preambles of different segments are orthogonal. Preambles of sectors with the same segment number will interfere to each other but since they come from different BSs, a different pseudo-random sequence that will be transmitted by each BS, will allow separating the BSs at the SS's receiver. The preamble sequence is uniquely determined as function of the IDCELL and the segment number.

Permutations – the different permutations are affected differently by the different deployments, thus some background about the permutations is given. The permutation base is given by the DL_PermBase field of the STC_DL_Zone information element (IE). In the FUSC permutation the physical tones allocated to a logical sub-channel are chosen pseudo-randomly with DL_PermBase serving as a seed. The PUSC is a combination of two permutations: the outer permutation and the inner permutation. The physical spectrum is divided into continuous pieces, called clusters. The outer permutation randomly assigns the clusters to major groups and the inner permutation randomly assigns the tones in each major group to the sub-channels. For both these permutations the DL_PermBase is used as the randomization seed. The first zone (where the map is transmitted) always transmitted with the PUSC permutation. In the first PUSC zone the IDCELL is used as the permutation seed for the inner permutation and 0 is the seed for the outer permutation (see [1] for a full description of the permutation seeds). This means that it is not possible to obtain a decrease in the number of hit tones, by allocating only part of the major groups to segments, since two segments with the same segment number will always fully hit each other tones (also notice that the map is allocated frequency first and partial loading is not possible for the map). This is also true for a PUSC zone with Use All SC indicator (this is also a field in the STC_DL_Zone IE) set to 0 (for this zone the outer permutation seed is also 0).

PUSC – in the PUSC permutation it is possible to assign to every segment a different part of the spectrum. An assignment where all the BS's spectrum is allocated to all the segments is called reuse 1 between the segments. The basic unit of allocation is the major group (MG) (in case of reuse 1 between the segments, all the MGs are allocated to all the segments). The standard allows allocating only part of the spectrum (for example 1/3) to every segment (the allocation is described in the FCH). In such a case the transmissions of the different segments of one BS will be orthogonal (not interfering to one another). Notice that according to the standard only the pilots belonging to the allocated MGs are transmitted by the segment.
FUSC - in FUSC permutation all the pilots are transmitted always, thus there is no way to reduce the interference on pilots.

Partial loading – in addition to the possibility of allocating only part of the spectrum to a segment it is possible for the BS scheduler to utilize only 1/L of the available sub-channels. For example it may allocate always the first half of the sub-channels (in logical space). This situation is called partial loading. Partial loading can help reduce the interference level on the data subcarriers, but it can not reduce the interference level on the pilots.

Frequency planning – this is the process of assigning frequencies to the different cells and sectors. The frequency reuse factor is the rate at which the same frequency can be used in the network. If two neighboring cells would use the same RF frequency, it would cause co-channel interference. Frequency reuse factor allows lowering the level of interference between adjacent cells. In the CDMA systems the RF frequency reuse factor is 1 and every cell utilizes a larger bandwidth. The reduction of interference in those systems is obtained through a use of different code sequences.
In the 802.16e reference system the frequency planning is extended to designing the reuse pattern of the RF frequency and the reuse between the different segments. The situation is even more complicated since the reuse pattern between the segments can be different between the different zones (for example by using the Use All SC indicator).

Single frequency networks (SFN) – deployment of a reuse one system has several advantages and is highly desirable by the system operators. Reuse 1 system does not require RF frequency planning. All the modem processes involving search for base stations (such as scanning and handoff (HO)) becomes easier and take less time. SFN system allows employing macro diversity (for example for users that are in the soft handoff region). Macro diversity is a method to increase the diversity by transmitting the same signal from two BSs (as opposed to micro diversity techniques, such as MIMO).

9.2 Scenario I (IEEE 802.16m Systems Only- Single Frequency, Reuse 1)

The physical deployment of the cells and sectors is depicted in Figure 9.1-1. Each sector is denoted in the figure by two numbers. First is the RF frequency reuse indicator and the second is the segment reuse indicator. This deployment is combined with full use of sub-carriers (meaning that in the FCH all the major groups are assigned to all the segments such that both in the first PUSC zone and in other PUSC zones there will be full collision of sub-carriers from all the sectors, assuming 100% loading of sub-carriers – see the figure for the reuse pattern between the segments).

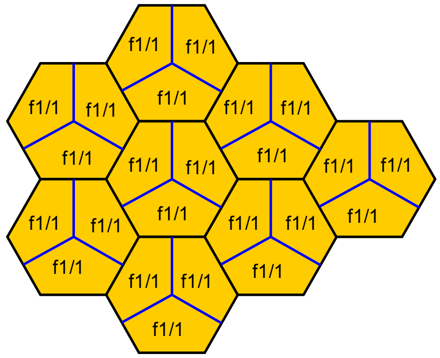

Figure 9.1-1: Frequency reuse pattern on data sub-carriers for Scenario I.

As far as the preamble (cell search) is concerned, there are two possibilities for preamble deployment in this case. In the first case all the sectors are assigned the same segment number, creating a full collision between all the sectors. In the second case every sector is assigned a different segment number, creating an orthogonal frequency allocation between the preambles of different sectors (see Figure 9.1-2).

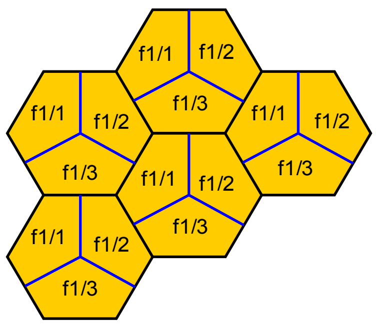

Figure 9.1-2 : Frequency reuse pattern on preamble sub-carriers for Scenario I with different segment numbers

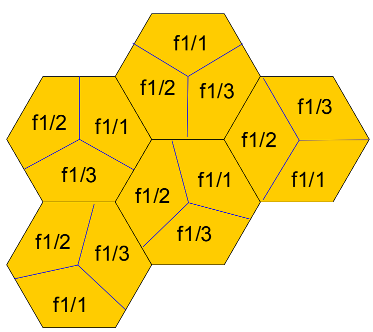

Figure 9.1-3: Frequency reuse pattern on preamble sub-carriers for Scenario I with different segment numbers in case of spatially unplanned antennas.

Another factor that should be taken into account is the spatial planning. Even though a reuse 1 deployment with full use of sub-carriers that is described in this section does not require frequency planning, it could be impacted by the antenna's orientation of different sectors. In case of frequency deployment shown in Figure 9.1-1, the number of interfering sectors for every tone is not influenced by the BS's orientation, but the interference power per tone could be influenced by it. This effect is much more significant for the interference levels for the preamble (see Figure 9.1-3 for illustration of spatially unplanned preamble deployment).

Use of partial loading (for example using only first 1/3 of the sub-channels) can help reduce interference in the second PUSC zone for this deployment. Randomization of the actual transmitted carriers due to outer permutation will cause a reduction in mean interference power by a factor of L (which is the loading factor). This is true with and without the spatial planning. Notice that this reduction is not possible in the first PUSC zone since the outer permutation seed in this case is 0 for all the base stations thus every MG get the same physical clusters in all the BSs. Since the map is allocated in a frequency first manner, it is almost impossible to obtain partial loading in the first PUSC zone.

Note that the pilots always interfere in any zone, since in this deployment all the major groups are assigned to all the segments.

9.3 Scenario II (IEEE 802.16m Systems Only- Multiple Frequencies)

In this deployment, every sector is transmitting using a different RF frequency, utilizing the full allocation bandwidth. This scenario could be suitable for example in situations where the operator does not have a contiguous spectrum but has several chunks of spectrum (in this case it also possible to deploy a system with reuse factor 3 between the BSs, which would allow utilization of the segmentation mechanism through FCH). In this deployment transfer of a user between two sectors of the same BS would require a change of RF frequency.

This deployment is combined with full use of sub-carriers. (Notice that though in the FCH all the major groups are assigned to all the segments, there is no collision of sub-carriers between the sectors due to different RF frequencies). The physical deployment of the cells and sectors is given in Figure 9.2-4.

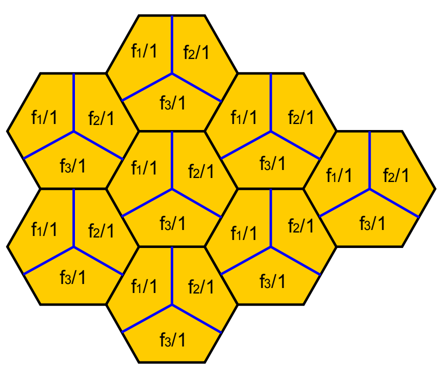

Figure 9.2-4: Frequency reuse pattern on data sub-carriers for Scenario II.

There are three possibilities for preamble deployment in this scenario. In the first case, all the sectors are assigned the same segment number, creating a full collision between all the sectors with the same RF frequency (It must be noticed that this case is equivalent to 1/3 reuse factor in case of single frequency deployment). In the second scenario, segment numbers are distributed randomly. In the third case, a different segment number is assigned to every BS. In latter case, there will be no interference between the three sectors of the same BS due to the different RF frequencies used and the reuse factor between the BSs will also be 1/3 due to the segment planning. This means that no two neighboring BSs will interfere with each other in the preamble.

For this deployment spatial planning could influence the performance of the algorithms based on preamble, pilots and data (see Figure 9.1-2 and Figure 9.1-3).

The expected interference levels in Scenario I and Scenario II deployments are different, but the effect of partial loading on the interference level in this deployment is identical to the one in Scenario I.

9.4 Scenario III (IEEE 802.16m Systems Only- Single Frequency, Reuse 3)

The third deployment of the cells and sectors is given in Figure 9.3-5. This deployment is combined with partial use of sub-carriers (meaning that in the FCH only 1/3 of the major groups are assigned to every segment – to say that in the first PUSC zone and in PUSC zone with Use_all_SC = 0 there will be no collision of sub-carriers between the sectors). This deployment is equivalent to Scenario II deployment with different BW allocated to every BS.

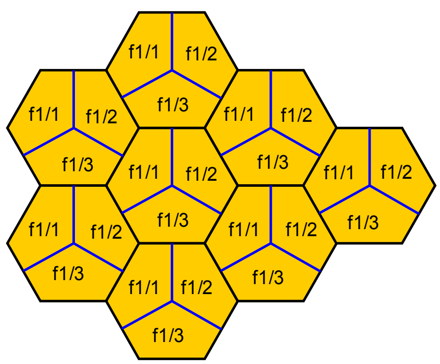

Figure 9.3-5: Frequency reuse pattern on data sub-carriers for Scenario III

There is only one possibility for preamble deployment in this case (the one described in Figure 9.1-2. For this deployment spatial planning could impact the performance of the algorithms based on preamble, pilots and data (see Figure 9.1-2 and Figure 9.1-3).

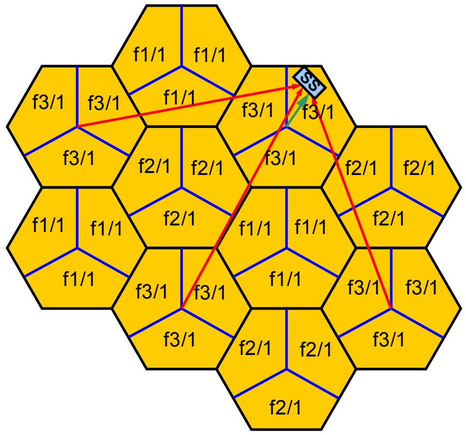

Figure 9.3-6: An example 3x3x1 deployment

As a convention, it is recommended adding two letters to the deployment description. One in the beginning to describe the spatial planning and the other at the end to separate reuse 3 of RF frequencies between the sectors and reuse 3 due to segmentation in the FCH.

To describe the spatial planning, additional indicator p/u can be used, for example the deployments in Figure 9.1-2 and Figure 9.1-3 can be described as p1x3x3s and u1x3x3s, respectively. Note that in practice frequency planning and spatial planning must be performed jointly and cannot be separated into two different tasks.

9.5 Scenario IV (Mixed Network - Single Frequency, Reuse 1)

This scenario exemplifies a transitional deployment phase where both IEEE 802.16m and IEEE 802.16e based terminals and base stations are operating on the same RF carrier. The different colors illustrate legacy and the new base stations. Similar to Scenario I, this deployment is combined with full use of sub-carriers (meaning that in the FCH all the major groups are assigned to all the segments such that both in the first PUSC zone and in other PUSC zones there will be full collision of sub-carriers from all the sectors, assuming 100% loading of sub-carriers – see the figure for the reuse pattern between the segments).

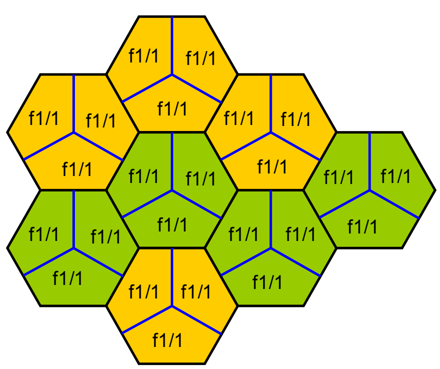

Figure 9.4-7: Frequency reuse pattern on data sub-carriers for Scenario IV.

As far as the preamble (cell search) is concerned, there are two possibilities for preamble deployment in this case. In the first case all the sectors are assigned the same segment number, creating a full collision between all the sectors. In the second case every sector is assigned a different segment number, creating an orthogonal frequency allocation between the preambles of different sectors (see Figure 9.4-8).

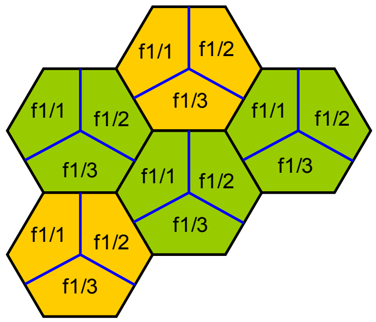

Figure 9.4-8 : Frequency reuse pattern on preamble sub-carriers for Scenario IV with different segment numbers

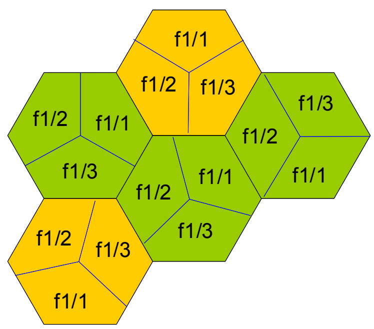

Figure 9.4-9: Frequency reuse pattern on preamble sub-carriers for Scenario IV with different segment numbers in case of spatially unplanned antennas.

Another factor that should be taken into account is the spatial planning. Even though a reuse 1 deployment with full use of sub-carriers that is described in this section does not require frequency planning, it could be impacted by the antenna's orientation of different sectors. In case of frequency deployment shown in Figure 9.4-7, the number of interfering sectors for every tone is not influenced by the BS's orientation, but the interference power per tone could be influenced by it. This effect is much more significant for the interference levels for the preamble. See Figure 9.4-8 for illustration of spatially unplanned preamble deployment).

Use of partial loading (for example using only first 1/3 of the sub-channels) can help reduce interference in the second PUSC zone for this deployment. Randomization of the actual transmitted carriers due to outer permutation will cause a reduction in mean interference power by a factor of *L* (which is the loading factor). This is true with and without the spatial planning. Notice that this reduction is not possible in the first PUSC zone since the outer permutation seed in this case is 0 for all the base stations thus every MG get the same physical clusters in all the BSs. Since the map is allocated in a frequency first manner, it is almost impossible to obtain partial loading in the first PUSC zone. It must be noted that the pilots always interfere in any zone, since in this deployment all the major groups are assigned to all the segments.

9.6 Scenario V (IEEE 802.16m with Multi-hop Relay Networks)

This scenario (shown in Figure 9.5-10) is an example of IEEE 802.16m deployments (network topologies) that include fixed and/or mobile relays for coverage extensions and filling coverage holes and throughput improvement. The air-interface between the mobile stations and the relay stations are specified by IEEE 802.16m standard (some deployment scenarios may include IEEE 802.16e based air-interface). The performance evaluation of the proposals containing fixed or mobile relay stations shall follow the evaluation methodology defined by IEEE 802.16j Relay Task Group for mobile multi-hop relay networks [6].

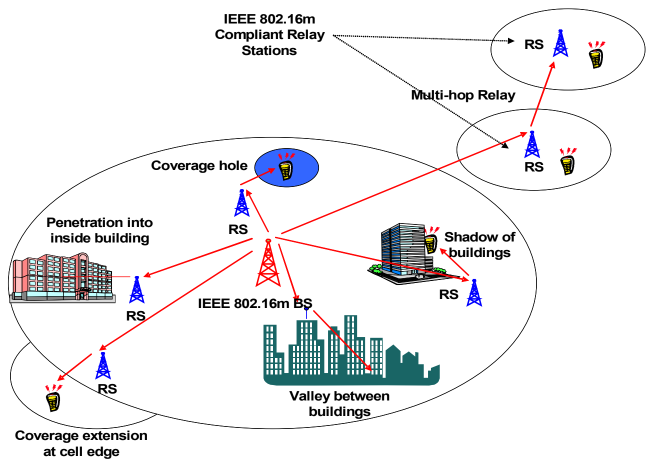

Figure 9.5-10: IEEE 802.16m with multi-hop relay networks (the RS can be fixed or mobile depending on the usage and deployment specifics).

9.7 Scenario VI (Provision for PAN/LAN/WAN Collocation / Coexistence)

As a provision for proper operation of various wireless access technologies on multi-radio terminals, the IEEE 802.16m should provide (measurement / report / radio resource allocation) methods to mitigate interference from other wireless radios on the same (collocated) device given minimum adjacent channel isolation. As a result, IEEE 802.16m radio will not suffer from interference from other wireless devices, or cause destructive interference to other wireless devices. Currently, Wi-Fi and Bluetooth radios are likely to coexist/collocate with an IEEE 802.16m radio.