Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** <http://grouper.ieee.org/groups/802/20/>
Title	**Channel Bandwidth, Frequency Block Assignment and Spectral Efficiency Definitions**
Date Submitted	**2004-01-12**
Source(s)	**Dan Gal** 67 Whippany Road, Whippany, NJ 07981 Voice: 973-428-7734 Fax: 973-386-4555 Email: dgal@lucent.com
Re:	MBWA Call for Contributions: **Session # 6** – January 12-16, 2003
Abstract	This contribution provides a detailed discussion of the concepts listed in the Title and propose text changes to sections 4.1.2 and 4.1.3 of the IEEE 802.20 System Requirements document v10.
Purpose	Remove the ambiguity in the current text concerning the meaning of the terms “channel BW” versus “Block Assignment” and reflect the issue of in-channel guard-band in the spectrum-efficiency calculation method.
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1 Introduction

This contribution proposes an alternative text for sections 4.1.2 and 4.1.3 of the IEEE 802.20 System Requirements Document (SRD v10).
The purpose of this contribution is to reinstate the **channel bandwidth** requirement as the fundamental characteristic upon which every proposed radio technology must be based and to require that technology proposals define their RF specifications and performance statements for a specified channel bandwidth, consistent with the definitions provided in this document.

2 Discussion

2.1 Background

In the September 2003 session of the IEEE 802.20 working group, held in Singapore, a controversial proposal was incorporated into the SRD and significantly changed the previous version of section 4.1.3.

Two problems were identified in this proposal:
(1) Removal of the **channel bandwidth requirements** (established by the **IEEE 802.20 PAR**) leaves the evaluation process with no common ground for comparing the performance of the contending technology proposals.

(2) Without a clear definition of **channel bandwidth**, the **spectral efficiency calculation method** may vary from one proposal to another and be difficult to assess.

The main purpose of this proposal is to show that in the absence of **channel bandwidth** requirements in the SRD, it would be difficult to **evaluate** and **compare** the performance of the contending technologies.

It is also recommended to include in the radio **channel bandwidth** some extra buffer spectrum (herein referred to as "*in-channel guard bands*"). This concept is illustrated in figures 2 and 3 (shown as orange bands).

2.2 Tutorial

Terminology

The term "*channel bandwidth*" is defined in conjunction with the terms "*occupied bandwidth*" and "*necessary bandwidth*" that are defined by the (US) federal standard **FS-1037C** as follows:

> **occupied bandwidth:** The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are

each equal to a specified percentage *B* /2 of the total mean power of a given emission. Unless otherwise specified by the CCIR for the appropriate class of emission, the value of ***B* /2** should be taken as **0.5%.**
Note 1: The percentage of the total power outside the occupied bandwidth is represented by *B*.
Note 2: In some cases, *e.g.*, multichannel frequency-division multiplexing systems, use of the 0.5% limits may lead to certain difficulties in the practical application of the definition of occupied and necessary bandwidth; in such cases, a different percentage may prove useful."

necessary bandwidth: For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the **rate** and with the **quality** required under specified conditions.

The term **channel bandwidth** refers to a fundamental **radio characteristic** for which the essential performance characteristics are specified.

The term **channel spacing** is a **deployment variable** which is associated with a specific **spectrum block assignment.**

In common RF engineering practice and in standards development, a given radio technology's **spectral efficiency** is defined for its specified **channel bandwidth**.

In actual **deployment**, though, the specified spectral efficiency may be smaller than the specified when the **channel-spacing** is greater than the radio channel-bandwidth.

Illustrations

The concepts defined above are clarified in the following illustrations.

Figure 1 shows how a given block assignment, in a regulatory environment that permits changing the channel spacing, accommodates two different technologies, **A** and **B.** Note the different channel spacing and block-edge guard-bands. Typically, the channel spacing is chosen such that it is greater or equal to the corresponding radio technology's channel-bandwidth.

Figure 2 illustrates the concepts of *occupied-bandwidth*, *channel-bandwidth* and *channel-spacing*. In case 1, the channel spacing is equal to the radio's channel bandwidth and the occupied bandwidth. Case 2 is similar to case 1 except that the channel bandwidth includes in-channel guard bands.

Case 3 is shown in figure 3. Here, the radio's channel-bandwidth is smaller than the channel spacing, effectively getting an increased the channel to channel guard bands and providing a greater adjacent-channel protection. The actual **spectral efficiency,** in this case, is **smaller** than the specified.

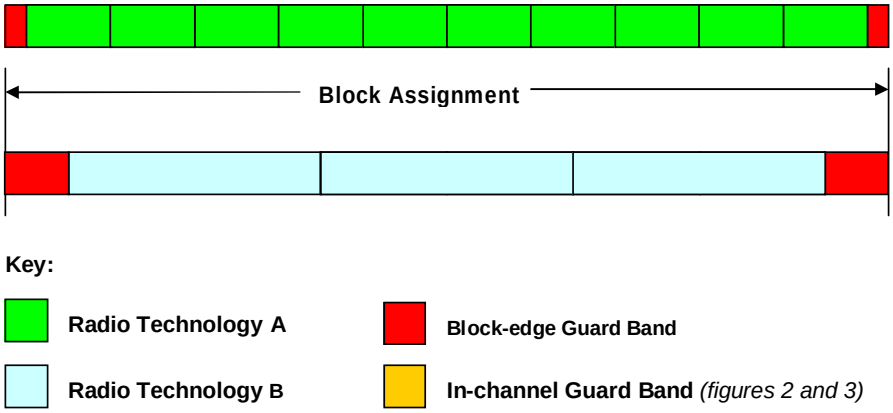


Figure 1: Two Radio Technologies, Same Block Assignment, Different Channel-Bandwidth, Channel Spacing and Block-edge Guard-bands

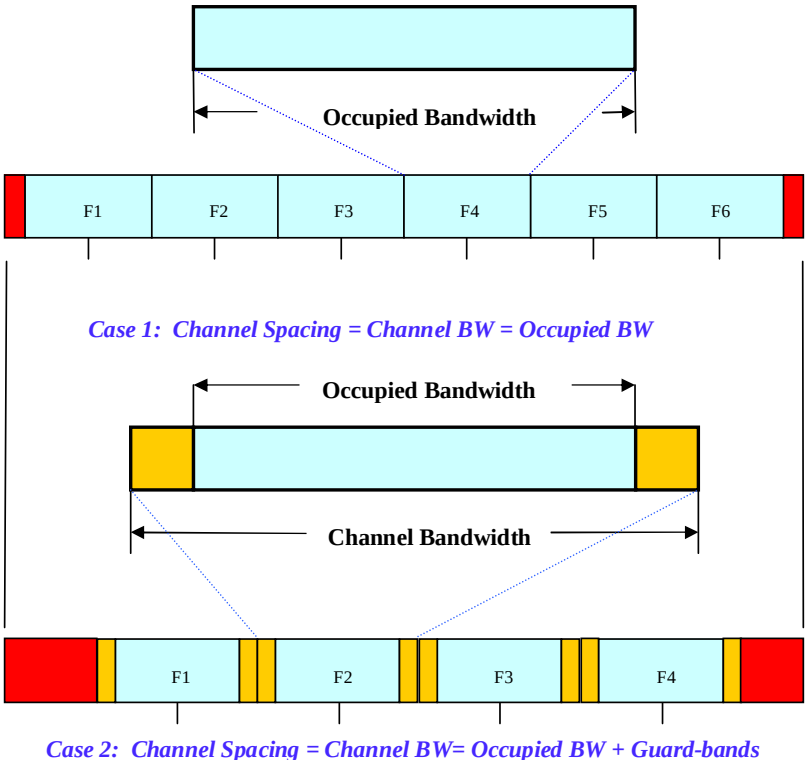
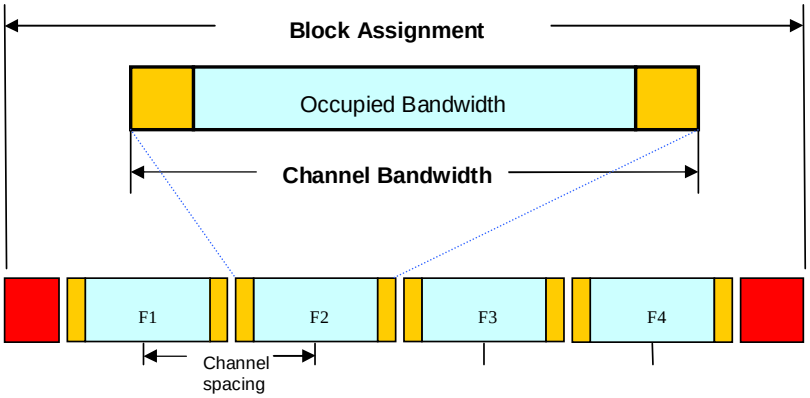


Figure 2: Occupied-Bandwidth vs. Channel-Bandwidth vs. Channel-Spacing



Case 3: Channel Spacing > Channel BW

Figure 3: An Example of Block Assignment with Channel-Spacing Greater Than Channel-BW

2.3 Recommendations

- All **RF performance characteristics** of the 802.20 radio transmitter and receiver should be specified for a given stated **channel bandwidth.**
- The 802.20 radio **channel bandwidth** should be greater than its **occupied bandwidth** and include some **in-channel guard bands** required to insure the RF performance specifications in the intended deployment environment.
- The 802.20 standard should support 1.25 MHz and 5 MHz channel bandwidths. Additional, wider channel bandwidths may be proposed.
- **Block-edge guard-bands** which are necessary to minimize interference with other services (deployed in adjacent bands/channels) may also be required in actual deployments of 802.20 systems. These guard bands should be defined in the 802.20 standard in conjunction with specific regional regulatory requirements.

3 Proposed Text for the SRD Sections 4.1.2, 4.1.3

Reference: IEEE 802.20 SRD v10

[section] 4.1.2 System Spectral Efficiency (bps/Hz/sector) (open)

[Sustained spectral efficiency is computed in a loaded multi-cellular network setting. It is defined as the ratio of the expected aggregate throughput (taking out all PHY/MAC overhead) to all users in an interior cell divided by the system bandwidth. The sustained spectral efficiency calculation shall assume that users are distributed uniformly throughout the network and shall include a specification of the minimum expected data rate/user.]

[Downlink > 2 bps/Hz/sector**]**
[Uplink >1 bps/Hz/sector**]**

- *editors note: Below is the text that was developed at the November Plenary meeting.*

- *The system spectral efficiency (def.1) of the 802.20 air interface shall be quoted for the case of a three sector baseline configuration[1]. It shall be computed in a loaded multi-cellular network setting, which shall be simulated based on the methodology established by the 802.20 evaluation criteria group. It shall consider among other factors a minimum expected data rate/user and/or other fairness criteria, and percentage of throughput due to duplicated information flow. The values shall be quoted on a b/s/Hz/sector basis. The system spectral efficiency of the 802.20 air interface shall be greater than X b/s/Hz/sector.*

Definitions:

(def. 1) ***System Spectral Efficiency (SSE)*** is defined as the ratio of the ***aggregate throughput*** (def. 2), (in bits/sec), to all users in the system, divided by the ***network-wide bandwidth*** (def. 3), (in Hz), and divided further by the total number of sectors of the system.

(def. 2) ***Aggregate throughput*** is defined as the total throughput to all users in the system (user payload only).

(def. 3) ***Network-wide bandwidth*:** The network-wide bandwidth is the sum of all channel-bandwidths of the unique carriers deployed in the network.

[1] *Since the base configuration is only required for the purpose of comparing system spectral efficiency, proposals may submit deployment models over and beyond the base configuration.*

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Comment: *As of 11/12/03*
The open items are:
−Single value vs multiple for uplink and downlink
−X bits/sec/Hz [note 1 b/s/Hz –or- downlink > 2 b/s/Hz/(cell or sector?) @ 3km/hr ;uplink > 1 b/s/Hz/(cell or sector?) @ 3 km/hr].
−Actual values of spectral efficiency at higher speeds
TDD/FDD

[Section] 4.1.3 Support for Different Block Assignments (open)

"*channel bandwidth*" is defined in conjunction with the terms "*occupied bandwidth*" and "*necessary bandwidth*" that are defined by the (US) federal standard **FS-1037C** as follows:

> **occupied bandwidth:** The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage *B* /2 of the total mean power of a given emission. Unless otherwise specified by the CCIR for the appropriate class of emission, the value of ***B* /2** should be taken as **0.5%.**
> *Note 1:* The percentage of the total power outside the occupied bandwidth is represented by *B*.
> *Note 2:* In some cases, *e.g.*, multichannel frequency-division multiplexing systems, use of the 0.5% limits may lead to certain difficulties in the practical application of the definition of occupied and necessary bandwidth; in such cases, a different percentage may prove useful."
>
> **necessary bandwidth:** For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the **rate** and with the **quality** required under specified conditions.

The 802.20 radio channel-bandwidth(s) shall include in-channel guard-bands and should support deployment in the following block assignment sizes:

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Note: Additional block assignment sizes may be defined in the 802.20 standard:

FDD Assignments	2 x 1.25 MHz 2 x 5 MHz 2 x 10 MHz 2 x 20 MHz
TDD Assignments	2.5 MHz 5 MHz 10 MHz 20 MHz 40 MHz

The individual 802.20 technology proposals may optimize their MAC and PHY designs for specific bandwidth and Duplexing schemes.

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Note: This section is not intended to specify a particular channel bandwidth. Proposals do not need to fit into all block assignments.

Comment: Editors note: Text added at the November Plenary. It is intended to clarify the intent in this section.. The subject of what channel BW to use is a totally separate issue and/or section.