Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** **<http://grouper.ieee.org/groups/802/20/>**
Title	**Partial proposal on channel multiplexing**
Date Submitted	**2007-03-05 (March 5, 2007)**
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Re:	IEEE 802.20 Call for Proposals
Abstract	This document proposes a flexible channel multiplexing scheme for the Mobile Broadband Wireless Access Systems.
Purpose	For consideration and adoption as a feature supported by 802.20 standard
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I. Introduction

A scheme is proposed to multiplex users who may achieve better performance through transmissions in distributed subcarrier channels, with those who may perform better in selected subbands.

Similar types of user multiplexing scheme have been proposed by other working group members previously [1], [2]. Comments that address similar issues have also been submitted by various WG members through Letter Ballots 1 and 2. In addition, this concept has already been adopted by the Ultra Mobile Broadband standard developed in 3GPP2 [3].

A more detail design will be described in this contribution to support both types of user channels.

II. Background

In the mobile broadband wireless access (MBWA) channel, frequency selective fading in the wideband channel is typical. Some user channels may have flat fading instead of frequency selective fading. In other words, the signal that is transmitted to these users will experience similar attenuation, in spite of the part of the frequency band used for the transmission.

Examples of channel quality (C/I) variations can be found as shown in Figure 1 and Figure 2 . It can be observed that the C/I of the signal received by a mobile user from the serving base station vary with time and frequency. The channel quality (C/I) is the ratio of desired signal power to the interference power.

Therefore, the system throughput and user throughput or link reliability can be maximized by scheduling user transmissions in a certain part of the spectrum that experiences the least fading effect for that particular user. This can be accomplished through channel quality (C/I) feedback provided by the user, in the FDD system. In the TDD system, some knowledge of the user channel characteristics may be available even without channel quality feedback.

On the other hand, frequency subband scheduling may not work in certain circumstances, for example, the channel quality feedback is not useful when the user is moving at a high mobility. This is another reason to schedule transmissions over distributed subcarriers to maximize frequency diversity gain. In other words, scheduling of the user transmission in a specific portion of the spectrum based on the unreliable channel quality feedback may result in a lost of data, as it is probable that the scheduled subband is in a deep fade.

As shown in the figure, both types of user channels, i.e., frequency selective and non-frequency selective, could exist in the same cell site, or sector of a cell. The MBWA system can be more efficient when users with these opposing channel characteristics are supported.

The current 802.20 standard draft [4], which has been adopted by the WG prior to the dissolution of the letter balloting group by the IEEE-SASB, is not capable of supporting both types of user channelization within the same cell site simultaneously.

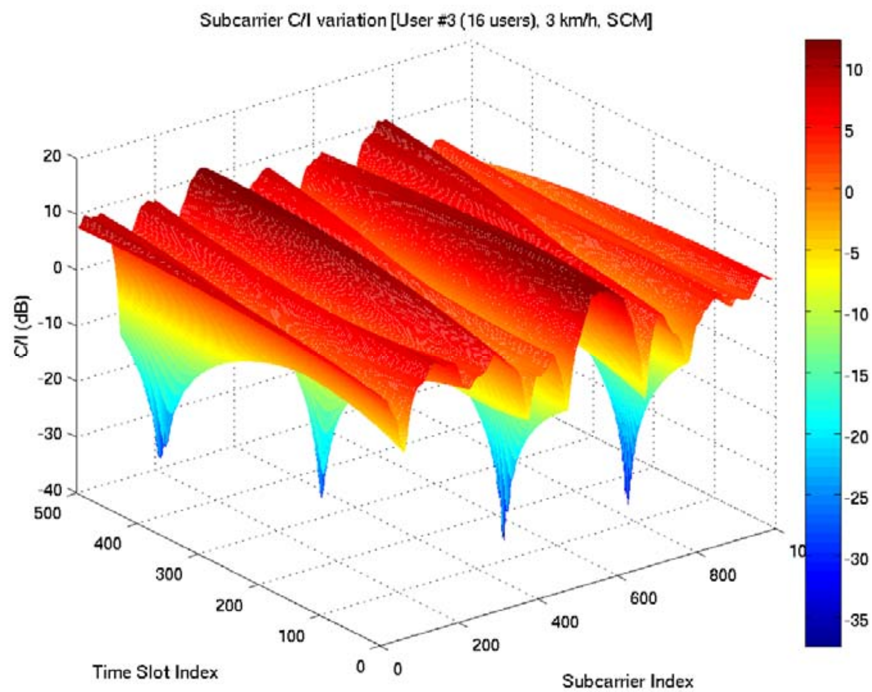

Figure 1 Subcarrier C/I variation across the entire bandwidth in time and frequency dimensions for a typical user with at 3 km/h mobile speed (Spatial channel models)

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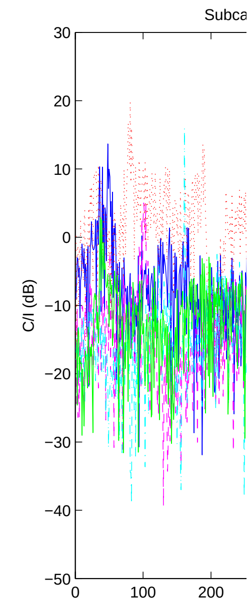

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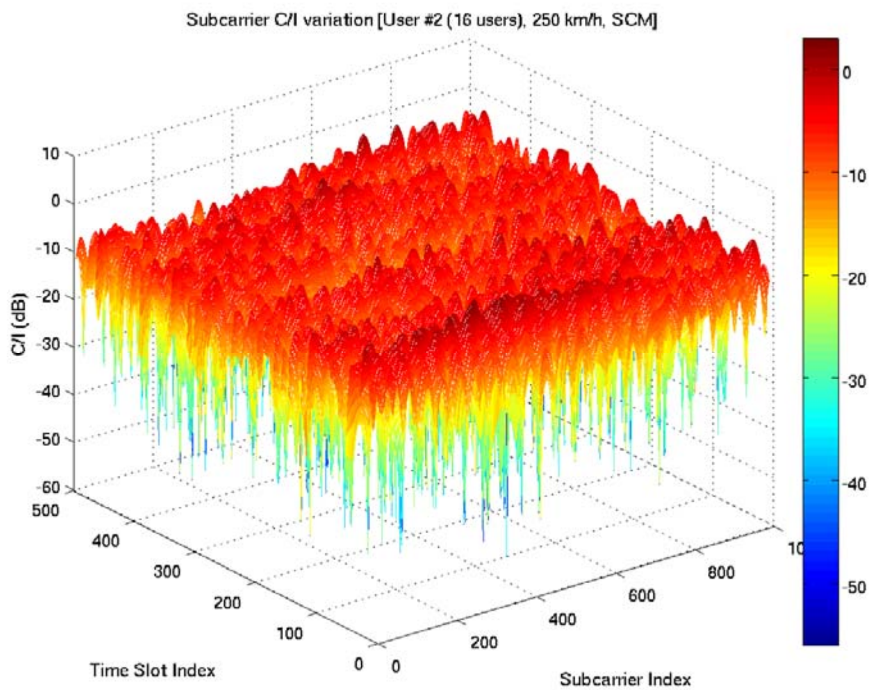

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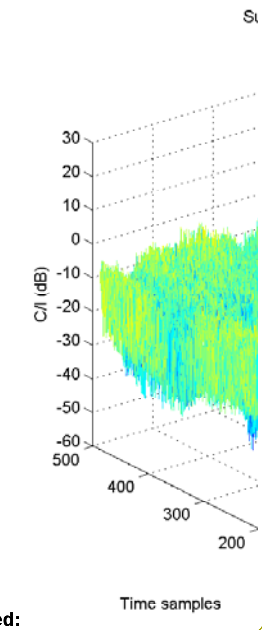

Figure 2 Subcarrier C/I variations in time and frequency dimensions for a typical User with 250 km/h mobility (SCM)

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III. Description of proposed design

A partitioning of the time-frequency resources into two types of channels, namely, the band-scheduling (BRCH) and distributed (DRCH) channel, can be found as shown in Figure 4.

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A. Channels composed of distributed subcarriers (DRCH)

Primary pilots with staggering between adjacent pilot tones are shown in the diagram. In the proposed scheme, DRCH is allocated starting from the subcarriers immediately below the one on which pilot tones are allocated. The advantage is to allow a better channel estimation for the DRCH. It will also simplify the signaling requirement, thus reduce signaling overhead.

1. Scheduling in the frequency dimension

The number of DRCH in each resource block or frame is a variable, depending on the number of users that are determined to be benefited from DRCH. The following rule is used when DRCH is assigned:

a) First DRCH (DRCH0) in the frame is allocated to the set of subcarriers immediately below those that carry the primary pilot tone;
b) Second DRCH (DRCH1) is allocated to the set of subcarriers that carry the staggered pilot tone;
c) Additional DRCH is allocated to the set of subcarriers immediately following DRCH0 or DRCH1, alternatively.

Define:
N_primary_pilot = Index of the primary pilot subcarrier
Pilot_SC_spacing = Spacing between primary pilot subcarriers

Index of the first subcarrier allocated to DRCHn
= N_primary_pilot + n, n even;
= N_primary_pilot + Pilot_SC_spacing/2 + n, n odd

This design enables the maximum frequency diversity gain to be achieved as the transmission spreads over subcarriers that span the entire system bandwidth. The signaling is also simplified as the scheduler will need only to specify the DRCH index ‘n’. The subcarrier locations can be identified easily based on the above definition.

2. Scheduling in the time dimension

With the number of subcarriers allocated to each DRCH user fixed, the time slot allocation is allowed to vary so as to be more effective in supporting the transmission of data blocks of various sizes.

This channel structure will also be especially suitable for transmission of traffic types that consists of smaller packet size, or traffic types that require relatively constant data rate. In other words, it can be used to support traffic types that need to be transmitted periodically with similar data packet size.

B. <u>Channels composed of contiguous subcarriers (BRCH)</u>

For users who have exceptional channel quality at specific portions of the spectrum, a set of contiguous subcarriers may be allocated. This could optimize the user throughput and the overall system throughput.

1. Tile structure

The structure of the allocation is in the form of a tile as it spans the space of frequency and time contiguously. Structure of the tile is depicted in Figure 3 below. Pilot tones are located at two diagonally opposite corners of the tile. Thus there are two possible orientations of the pilots. Two optional pilot tones can be included at the mid-point of the longer boundaries of the tile, if necessary. The orientation of the pilots is selected depending on its location in the time-frequency space of the system as shown in Figure 4.

Specifically, the pilot orientation is selected such that channel estimation can be performed using a combination of the tile pilot, the primary and staggered pilot tones in its vicinity.

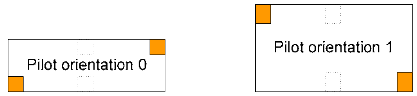

Figure 3 BRCH Tile structure and pilot orientations

To support multiple transmit antenna systems, an additional pilot tone per additional antenna can be included in adjacent to the primary and staggered pilot tones in the time dimension. Orientations of the pilots in the adjacent tiles can be arranged so as to facilitate a particular MIMO scheme.

2. Scheduling in the frequency dimension

   As described in Subsection A, the number of DRCH changes depending on the channel conditions of users in the same cell site, or sector of a cell. Thus the number of contiguous subcarriers available for a tile varies depending on the number of DRCH allocated. This dependency can be expressed as follows.

   For BRCH m, number of frequency subcarriers
   = Pilot_SC_spacing/2 – n mod 2, m even; n: number of DRCH assigned
   = Pilot_SC_spacing/2 – (n-1) mod 2, m odd

   Besides the default case as described above, other number of subcarriers can also be supported for the BRCH.

3. Scheduling in the time dimension

   In contrast to the case of DRCH, the time dimension in a tile is fixed to one half of the spacing between primary pilot tones in the time dimension. In other words, it is the time symbol spacing between the primary and its adjacent staggered pilot tones, as illustrated in Figure 4.

   Flexibility in the tile allocation size is achievable through the variable width in the frequency dimension as described above.

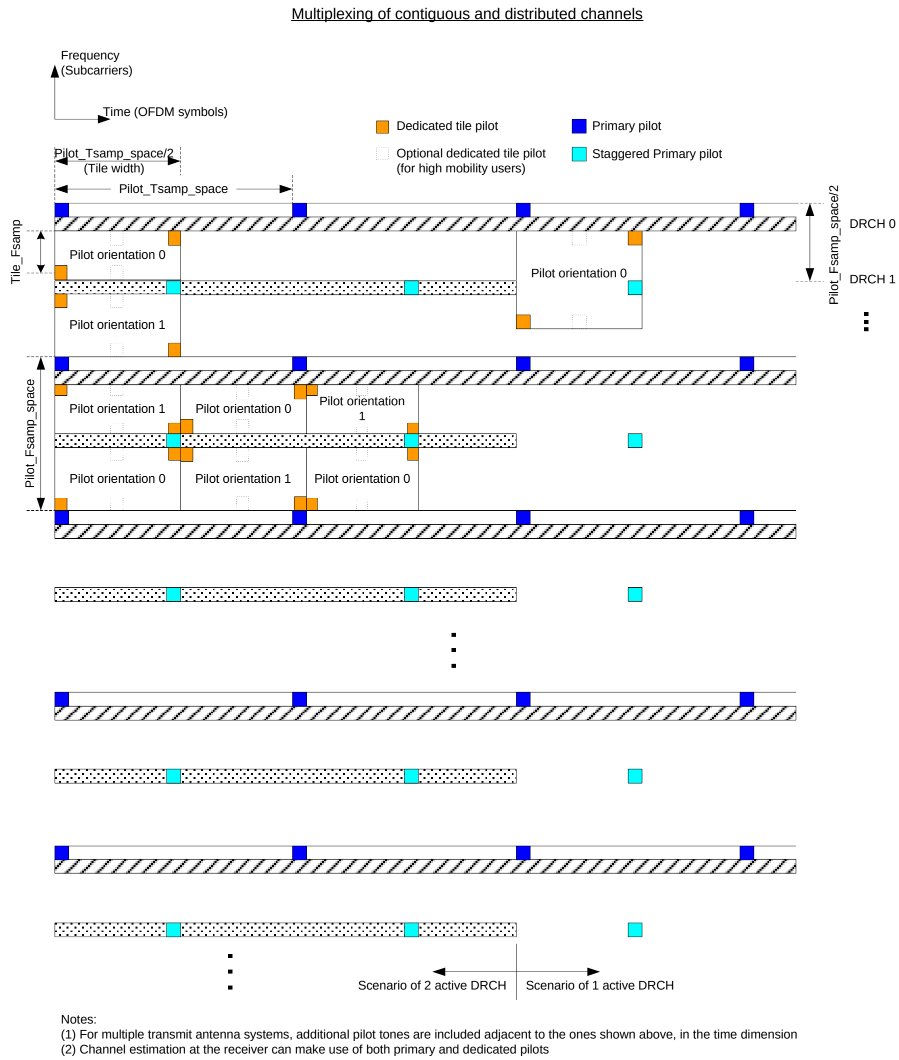

Figure 4 **Multiplexing of DRCH and BRCH users in the same time slot**

C. Forward Link Control Channel

In association with the channel multiplexing scheme as described above, it is proposed to transmit the forward link control channel in the distributive manner, on the same subcarrier as occupied by the primary pilot tones.

One FL control channel is transmitted on the same set of subcarriers that carry the Primary pilot tones. A second FL control channel, if necessary, can be transmitted on the same set of subcarriers that carry the staggered pilot tones.

Thus the use of distributed control channel can take advantage of frequency diversity gain. This can maximize the probability for more users to receive the control channel information.

D. Channel quality measurement (C/I) feedback

The C/I feedback overhead can be reduced by requiring the access terminals (AT) to feedback the mean and standard deviation of the pilot C/I measurement, taken across all pilot subcarriers (SC) in the frequency dimension, i.e., for measurements taken within the similar time frame.

In addition, the best N pilot subcarrier (SC) measurements, together with the indices of the pilot SC should be fed back to the access network. The value of N is a parameter that is configured at the access network (AN). It can be broadcasted as part of the SystemInfo through the primary broadcast control channel, pBCH0. Alternatively, N may also be included as part of the information transmitted in the forward link shared control channel.

The AT shall feedback a "maximum" of N pilot SC measurements, including the pilot SC indices, that are larger than the computed mean across all the pilot SC, in the C/I report, as the 'Delta' above mean, e.g., let (C/I)x = Measurement of pilot SC x,

$$Delta\_{x} = (C/I)_{x} - (C/I)_{mean}$$

E. Support of frequency hopping

Both hopping and non-hopping modes can be supported by this channel structure. If hopping is desirable, the entire structure as shown in Figure 4 will be mapped to different physical subcarriers at different time frames or time slots as desirable.

In the case that hopping is not desirable, planning between adjacent sectors can be done to avoid the same pilot subcarriers to be used in adjacent sectors.

F. Reduction of intercell interference

When frequency reuse factor of one is desirable, intercell interference can be minimized through the use of power control with this structure. For example, the DRCH can be transmitted at maximum power typically, while the BRCH may be transmitted at lower power, as the channel quality is normally better than the DRCH. With DRCH located at potentially different frequency subcarriers between adjacent sectors, the intercell interference can be minimized.

The following protocol can be used for transmission in BRCH with HARQ operations:

1. Initial transmission at a lower power, Po;

2. With each HARQ re-transmission, the transmit power can be increased by a fixed step, ΔP:

$$P_{max} = Po + N_{max}*\Delta P$$

where Nmax: maximum number of HARQ re-transmissions.

IV. Comparison with the current 802.20 standard draft (V2.1)

A. Channel structure

The current 802.20 standard draft supports either symbol hopping or block hopping mode in the forward link, and block hopping mode only in the reverse link. The symbol hopping mode is similar to the distributed subcarrier channel structure (DRCH), while the block hopping mode is similar to the contiguous subcarrier channel structure (BRCH). It does not support the two modes in the same time slot, time frame nor superframe.

The proposal described above provides a mechanism for multiplexing of both modes in the same symbol time.

B. Tile and pilot structure

In the current 802.20 standard draft, there are 3 formats for the tiles which differ in the location of the pilot tones. The dimensions of the tiles are fixed to 16 subcarriers by 8 symbols, which is the duration of one PHY frame. The number of dedicated pilot tones per tile is either 18 or 24, independent of the primary pilot locations. The pilot overhead is significant especially when transmission is only in SISO mode.

In this proposal, the basic tile size is relatively small, with a minimum of 2 pilot tones located at diagonally opposite corners of the tile, and 2 optional, additional pilot tones. This structure enables channel estimation using a combination of common, primary (and staggered) pilots and dedicated pilots on the tile.

To support MIMO schemes, the tiles can be aggregated into a bigger tile, i.e., by assigning 2 or 4 tiles which are adjacent to each other in time and frequency dimensions. The pilot orientation can be selected such that the one of the pilot tones in one tile is located next to another in the adjacent tile.

V. Required changes to the standard draft

- Include additional tile formats for the forward link, Section 9.3.2.6.2.3.4 F-DPICH Format 3; modify Table 70, Section 7.4.6.3.1.2
- Include additional tile formats to the RL, Section 9.4.1.6.1.1.3; modify Table 70, Section 7.4.6.3.1.2
- Include an additional field (1 bit) in the link assignment block to indicate which type of channel structure is assigned

- Assignment message include channel index; with information about the number of assigned DRCH, in the case of BRCH assignment
- In the case of new tile format, include one bit for the pilot orientation, and an additional bit to indicate if the optional pilot tones are used

VI. Conclusion

This proposal provides the support for an MBWA system that can optimize the user and system throughput performance by using channel knowledge. When the channel knowledge is not available for some user channels, the system can be benefited from frequency diversity gain.

This will be an improvement over the design as described in the current version of the standard draft, as the latter does not have the capability to support both DRCH and BRCH users simultaneously in the same frame and time slot (OFDM symbol).

Furthermore, a new tile structure which is flexible in size with lower pilot overhead has been proposed. The flexible tile size is beneficial especially for bursty traffic that may consist of small data packets, as the granularity of resource assignment is increased.

On the other hand, as the technology supports non-MIMO users, the extra pilot tones in the fixed tile design in the current 802.20 standard draft become unnecessary overhead for those users. Therefore, the proposed tile structure will increase the efficiency of the system.

References

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[3] 3GPP2 C30-20060731-040R2, "Joint proposal for 3GPP2 physical layer for FDD spectra" by China Unicom, Huawei, KDDI, LGE, Lucent, Motorola, Nortel, Qualcomm, RITT, Samsung, and ZTE, July 31, 2006.
[4] ‘Draft Standard for Local and Metropolitan Area Networks - Standard Air Interface for Mobile Broadband Wireless Access Systems Supporting Vehicular Mobility - Physical and Media Access Control Layer Specification’, IEEE P802.20/D2.1, May 2006.