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| Project | **IEEE 802.20 Working Group on Mobile Broadband Wireless Access**<br>**<http://grouper.ieee.org/groups/802/20/>** |
| Title | **IEEE C802.20-11/80**<br>**Multi-antenna Support for Air Interface Specifications in 802.20** |
| Date Submitted | **October 28, 2005** |
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| Re: | |
| Abstract | This partial proposal proposes the use of physical and MAC layer concepts and functionality within the 802.20 air interface in order to facilitate the use of multi-antenna systems (MAS) within a TDD 802.20 air interface. |
| Purpose | An 802.20 Partial Proposal |
| Notice |  |
| Release |  |
| Patent Policy |  |

# 1. Introduction & Scope

This partial proposal proposes the use of physical and MAC layer concepts and functionality within the 802.20 air interface in order to facilitate the use of multi-antenna systems (MAS) within an 802.20 air interface.

The proposal provides an integrated set of proposed elements for an air interface design wherein multi-antenna operation at the base station and subscriber terminal can be employed to maximal gain. Because the approach taken affects all layers of the air interface, the elements presented herein are intended to be carefully merged as a whole with other air interface proposals. We therefore welcome the opportunity to work with other proponents.

Furthermore, for clarity, normative language is used to describe the individual proposal items. This normative text should not be interpreted as the text to be incorporated into the air interface specification. Rather the text to be incorporated into the air interface specification is to be developed based on how this proposal is implemented in the context of the other specific characteristics of the air interface.

This proposal is a mutliantenna solution for TDD air interfaces. The elements described in this proposal can also serve solutions for FDD receive operation. FDD multi-antenna transmit operation would then be implemented through channel state feedback mechanisms or blind transmission techniques.

## 1.1. Overview of Multi-antenna System Operation

Multi-antenna systems utilize multiple antennas at the base station and optionally at the subscriber terminal.

At either the base station or subscriber terminal, baseband received signals from each of the spatially separate antenna elements are filtered by spatial/temporal filters with complex delay tap adjustments. These signals are combined to yield the array output. Figure 1 illustrates a simple example of such a receiver wherein an adaptive algorithm controls weight filters according to predefined objectives such as maximizing a particular user's SINR.

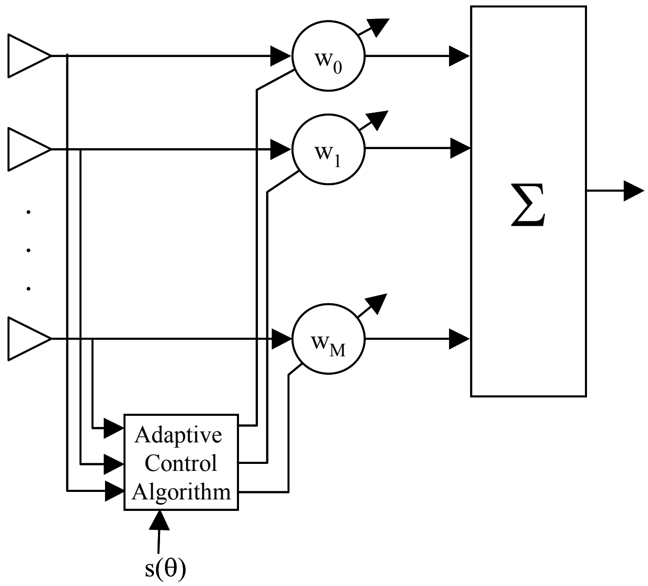


**Figure 1 Multi-antenna Spatial Processing**

Similarly on the transmit side signals to be transmitted are multiplied by filter banks with complex delay tap adjustments for each of the array elements. The weighting factors are chosen dynamically to ensure that the transmitted signals meet predefined criteria such as constructive combining at the location/user of interest while at the same time mitigating interference to other co-channel users in the same and other cells.

The processes of combining signals on the receive side or transmit side are called “receive spatial processing” and “transmit spatial processing” respectively. The benefits of multi-antenna spatial processing are well known and shown in Table 1.

Significant system gains can achieved with 4-12 antenna base stations. Consistent with the 802.20 SRD, in this partial proposal, multiple antennas at the subscriber terminal are considered optional. This enables significant system gains to be achieved while affording maximal flexibility in the cost and form factors of terminals.

In the case where multiple antennas at the subscriber terminal are available, the guidelines presented here-in (for example the availability of training data for channel state information) are equally applicable. This leads to further system levels gains using standard multiple input-multiple output (MIMO) techniques.

**Table 1System Level Benefits of Multi-antenna Processing**

| Gain | System-Level Significance |
|---|---|
| User Selective Uplink Gain<br>• Receive processing at base station | Increased Range, Improved Coverage, Increased Link Margin<br>• Coherent Combining gain<br>• Spatial Diversity gain<br>• Lower terminal transmit power<br>• |
| Uplink Interference Mitigation<br>• Receive processing at base station | Improved Signal Quality<br>• Robust to interference from multiple co-channel uplink interferers<br>• Higher spectral efficiency |
| Selective Downlink Gain<br>• Transmit strategy based on uplink information and feedback from terminal | Increased Range, Coverage, Link budget<br>• Coherent Combining gain<br>• Spatial Diversity gain<br>• Reduced base station PA sizing<br>• |
| Downlink Interference Mitigation<br>• Transmit strategy based on uplink information and feedback from terminal | Improved Signal Quality<br>• Interference immunity<br>• Higher Spectral Efficiency |

Obtaining accurate channel state information (CSI) is fundamental to the effective operation of multi-antenna systems. In the uplink direction, the base station can estimate CSI through properly designed uplink training sequences. Furthermore, for a suitably designed air interface, TDD channel reciprocity permits the base station to infer downlink CSI from the uplink. The principle of inferring downlink CSI from uplink training sequences is a core concept in this partial proposal.

Other principles recommended by this partial proposal are as follows:

- As required in the 802.20 SRD, the air interface must neither preclude nor require the use of multiple antennas at the subscriber terminal.
- The air interface must enable robust multi-antenna processing in typical scattering environments at the base station and subscriber terminal.
- The air interface must enable robust multi-antenna processing for mobile users.
- The air interface must enable system operation without impractical restrictions on the geometry of either the base station antenna array or the subscriber station antenna structure.
- The air interface must provide physical- and MAC-layer support for Spatial Division Multiple Access (SDMA). For example, it must be possible to schedule

the same radio resource multiple times in the same sector. In cases of SDMA operation the base station will rely on the multi-antenna signal processing algorithms to separate co-channel users.

## 1.2. Implications of Multi-antenna Operation on Air Interface Design

As mentioned above, obtaining channel information during uplink transmissions to determine downlink transmission strategies is a core concept in this partial proposal. Of course, there may be channels, for example broadcast channels, where such information is not available. Therefore the air interface must differentiate between channels for which “directive” spatial processing and “non-directive” spatial processing is used.

“Directive” spatial processing will occur on channels in which reciprocal uplink channel information is readily available for downlink transmission, enabling “directive” downlink transmission to a user of interest. For example, downlink traffic channels can be readily organized to be directive by pairing them with reciprocal uplink training transmissions.

“Non-directive” spatial processing will occur on channels in which reciprocal uplink channel information is not readily available for downlink transmission. For example, downlink broadcast channels are likely to use “non-directive” spatial processing since recent uplink channel information is likely not to be available for the majority of users in the system. Similarly in a system with non-continuous uplink polling, paging channels are likely “non-directive”. Table 2 illustrates certain channel types, their function, and the type of spatial processing likely to be employed on those channels.

**Table 2 Examples of Directive and Non-directive Channels**

| Channel | Direction | Typical Function | Spatial Processing Type |
|---|---|---|---|
| Broadcast Channel | Downlink | Cell and System information | Non-directive |
| Paging Channel | Downlink | Paging to initiate downlink data. | Directive or Non-directive |
| Uplink Resource Request/Assignment | Bidirectional | Request to initiate uplink traffic transfer and subsequent resource assignment | Directive |
| Uplink Traffic Channel | Uplink | Traffic exchange on uplink | Directive |
| Downlink Traffic Channel | Downlink | Traffic exchange on downlink (coupled with uplink training) | Directive |

By designing the air interface to leverage multi-antenna systems, interference at the physical layer is considerably mitigated. As a result interference management in the network is straightforward enabling operation as shown in Figure 2:

- SDMA allows multiple traffic channels to share the same physical resource.
- Similarly, through spatial multiplexing users can be paged on the same physical resources as traffic channels without the need for dedicated paging resources or continual polling. See below for further discussion.
- Random access can occur on the same physical resources as traffic channels without the need for dedicated random access resources.

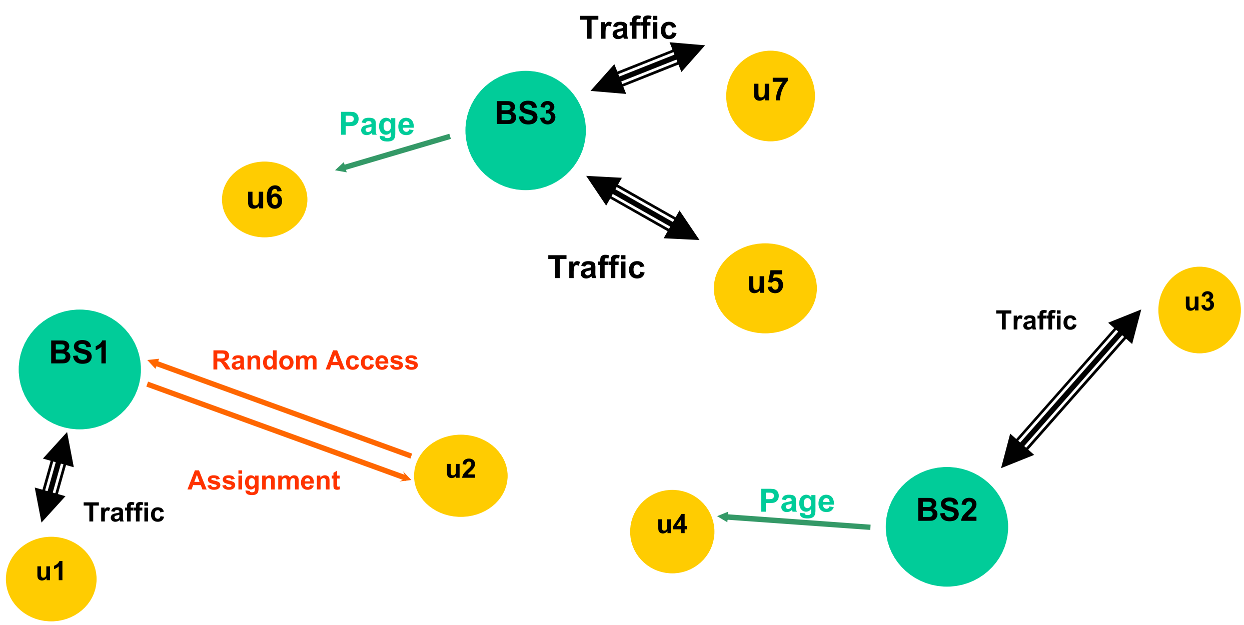


**Figure 2 Air Interface Operation Leveraging Multi-antenna Systems**

# 2. Physical Layer Requirements

## 2.1. Uplink Training data

Known “training” data is necessary in multi-antenna system in order to facilitate spatial signature estimation, spatial weight calculation and more sophisticated spatial/temporal processing.

1. **Proposal:** For a given set of uplink data resources there shall exist a corresponding set of uplink training resources. This correspondence shall be one-to-one and shall be known across all base stations and terminals in the network. Different uplink data resource sets and corresponding training sets shall all be mutually exclusive and shall

not overlap. A subscriber terminal shall transmit on the given uplink data resource if and only if it transmits on some portion corresponding uplink training resource.[1]

Discussion: This training data will facilitate spatial/temporal channel estimation for all in-cell and out-of-cell cochannel users. This channel estimation can then be used with **uplink** data signals received from the antenna array in order to synthesize signals received from the user of interest while substantially nulling strong interferers. This is shown schematically in Figure 3.

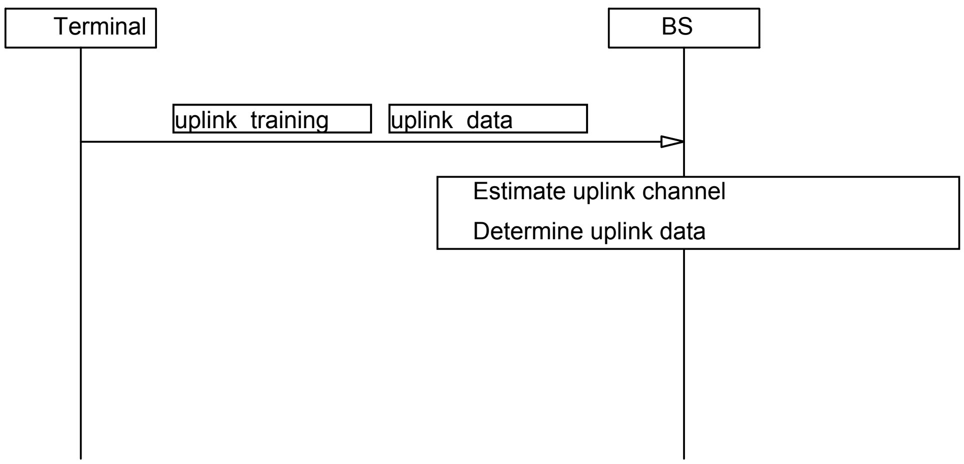


**Figure 3 Uplink training is used for uplink channel estimation and uplink spatial processing**

This requirement also establishes a strict correspondence between uplink training resources and uplink data resources for all cochannel users in the network on the uplink. The interference environment on uplink training resource is then duplicated on the uplink data resource.

Figure 4 illustrates how this scheme could work in an OFDM resource tile:

- User 1 and User 2 are both using **uplink** resource block 1.
- User 1 and User 2 are therefore both required to transmit **uplink** training on the corresponding training resources.
- User 1 is using **uplink** resource block 2.
- User 1 is then required to transmit **uplink** training on the corresponding training resources for block 2.
- User 2 is NOT using **uplink** resource block 2.
- User 2 must NOT transmit **uplink** training on the corresponding training resources for block 2.

[1] For clarity normative language is used to describe the individual proposal items. This normative text should not be interpreted as the text that would be incorporated into the air interface specification. Rather the text that would be incorporated into the air interface specification would be developed based on how this proposal is implemented in the context of the other, specific characteristics of the air interface.

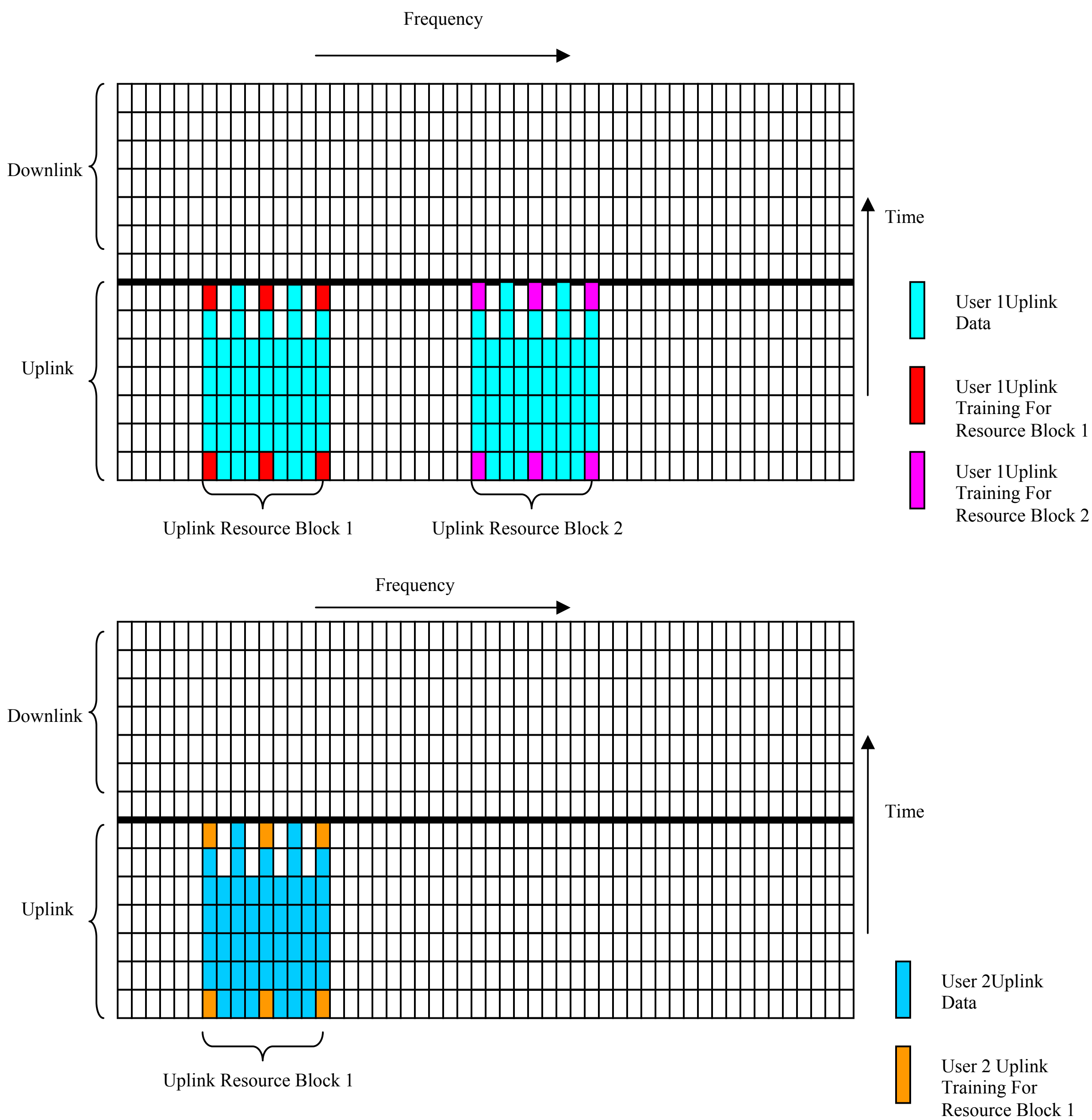


**Figure 4 Uplink Training Resources Corresponding To Uplink Data Resources**

2. **Proposal:** For a given set of downlink data resources (excluding broadcast data and possibly excluding downlink pages), there shall exist a corresponding set of uplink training resources. This correspondence shall be one-to-one and shall be known across all base stations and terminals in the network. Different downlink data resource sets and corresponding uplink training resource sets shall all be mutually exclusive and shall not overlap. A subscriber terminal shall transmit on the given downlink data resource if and only if it has transmitted on a portion of the corresponding uplink training resource.

Discussion: This uplink training enables the inference of downlink channel state information for spatial processing on the base station **downlink**. This is shown schematically in Figure 5.

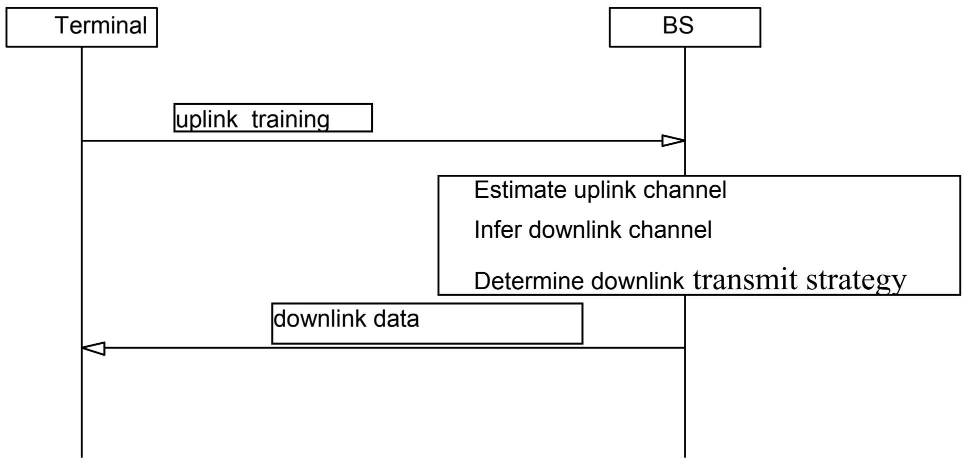


**Figure 5 Uplink Training Used in Downlink Spatial Processing**

Two important exceptions to this requirement are base station broadcasts, possibly downlink pages, or other downlink resources where the air interface resources required to provide timely training could be prohibitive. These are discussed in subsequent sections below.

This requirement also ensures that the group of cochannel users present in the training data is identical to the group of users on the corresponding traffic resource.

For example, on a given downlink resource, subscriber terminals with downlink data have transmitted on known uplink training resources. Thus the base station can easily infer downlink channel estimates for cochannel users that the base station could potentially interfere with. This requirement is fundamental to achieving tight interference management and high spectral efficiency on the downlink.

Figure 6 illustrates how this scheme could work in an OFDM resource tile:

- User 1 and User 2 are both using **downlink** resource block 1.
- User 1 and User 2 are therefore both required to transmit **uplink** training on the corresponding training resources.
- User 1 is using **downlink** resource block 2.
- User 1 is then required to transmit **uplink** training on the corresponding training resources for block 2.
- User 2 is NOT using **downlink** resource block 2.
- User 2 must NOT transmit **uplink** training on the corresponding training resources for block 2.

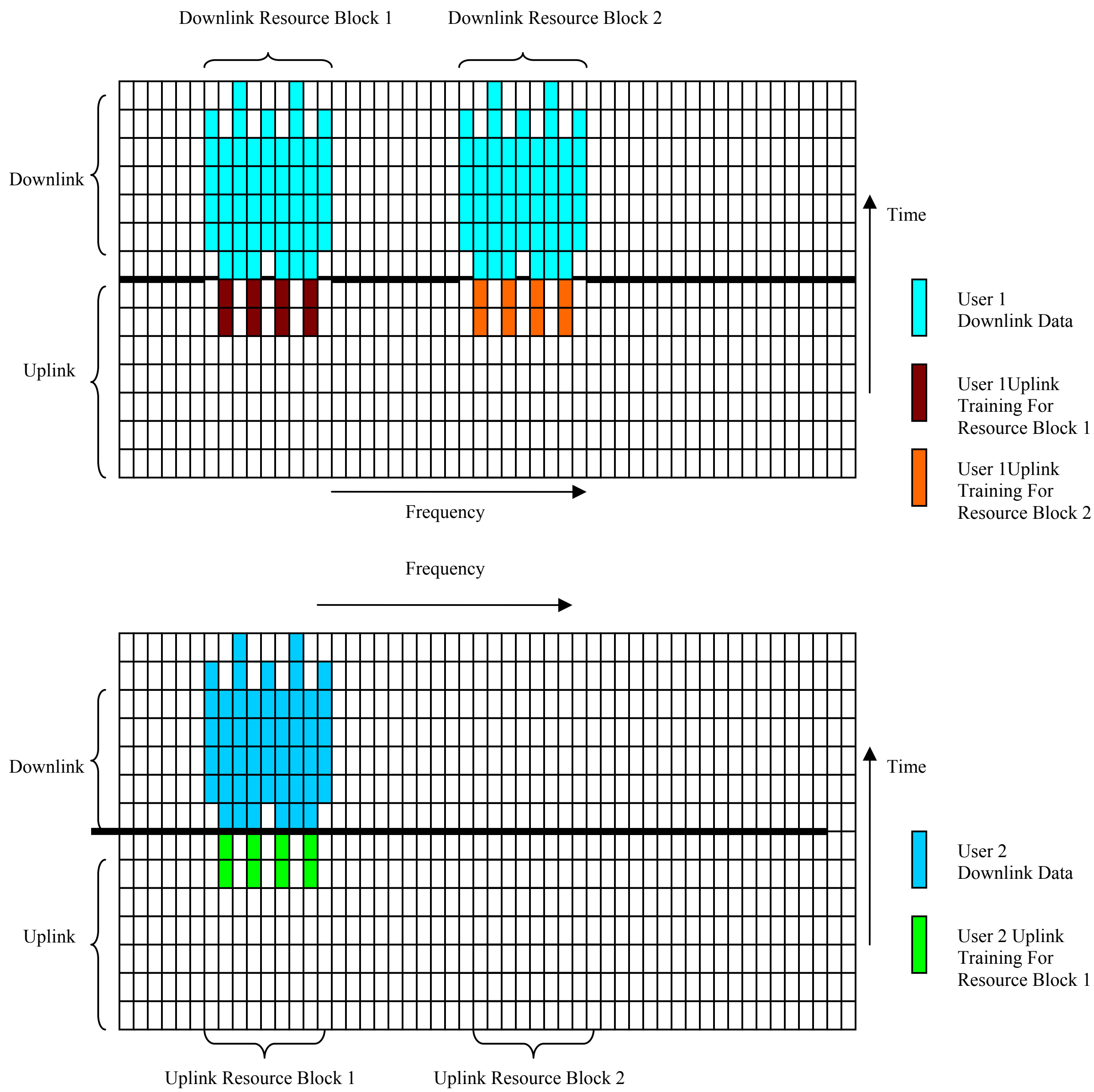


**Figure 6 Uplink Training Resources Corresponding To Downlink Data Resources**

The following requirements address the need for uplink training data to arrive in time and frequency so as to be maximally useful in channel estimation.

3. **Proposal:** Uplink spatial training shall be in close temporal proximity to the uplink or downlink transmission to which it corresponds.

Discussion: The temporal proximity is determined by the coherence time of the channel under consideration.

4. **Proposal:** The uplink training data shall be in close spectral proximity to the data to which it corresponds.

5. **Proposal:** The number of independent uplink training symbols shall be enough to maximize nulling ability without using excessive resources for the training.

Discussion:

Figure 7 shows simulation results showing how the number of training symbols impacts nulling performance using a simple MMSE receiver.

Two signals, one from a user of interest and one from an interferer, are assumed to impinge on the array each at an SNR per antenna of 10db-10*log10(M) where M is the number of antennas ie. SNR = 10db. Noise samples for each symbol are taken as independent AWGN.

The null depth is defined as the interferer power after application of unit normalized MMSE weights divided by the incoherent sum of the interference power across the array. i.e. Null depth = |(W*A2)|^2 /(|A2|^2 * |W|^2) where W is the MMSE weights (taken to be a 1xM complex vector) at the output of the spatial processor and A2 is the spatial signature (taken to be a Mx1 complex vector).

As seen in the figure (and as can be shown analytically) a general rule of thumb (for an MMSE receiver) with 8-12 antennas and moderately high SNR > 3dB (for both the user of interest and the interferer), the achievable null depths are approximately SNRi + 10log10(Ntraining) where SNRi is the interferer's SNR while Ntraining is the number of symbols used as reference for the user of interest. (This equation fails to holds in certain limits and should be taken as a rule of thumb only. For example, with infinite training the equation fails to hold.)

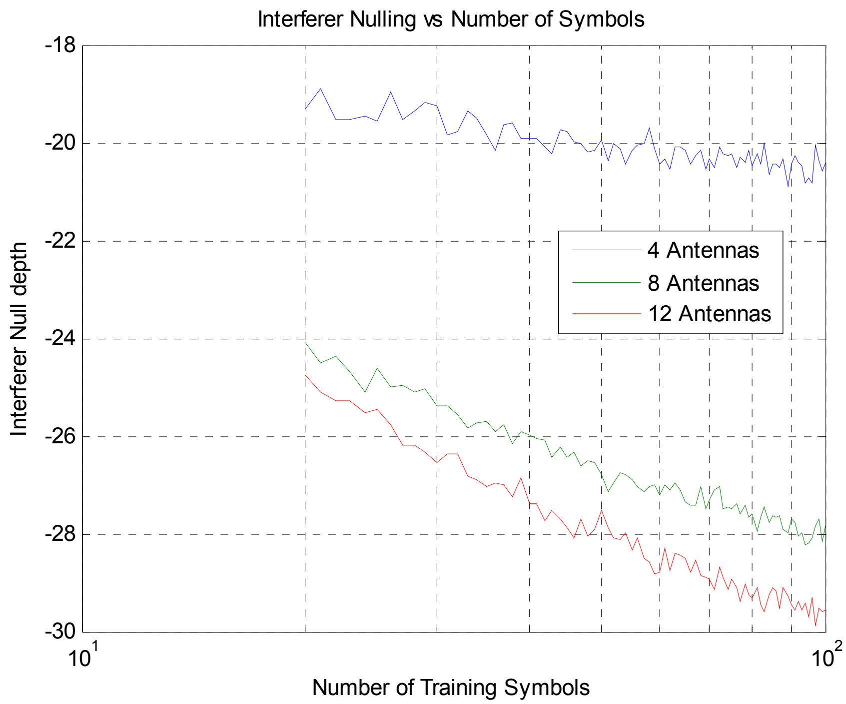


**Figure 7 Interferer Null Depth vs Number of Training Symbols. Simulations are performed using a simple MMSE receiver with one user of interest and one interferer each at 10dB SNR. Spatial signatures are taken randomly on complex M dimensional space (where M is the number of BS receive antennas) subject to the constraint of 10db SNR. Null depths shown are averages over 1000 trials for a given number of training symbols.**

Finally an important implication of this requirement in an OFDMA system is that training data and therefore corresponding traffic resources should be in close spectral proximity to one another rather than as isolated subcarriers. This allows channel estimation to be performed on a local block basis, improving the resulting spatial processing.

6. **Proposal:** The uplink training data shall have low cross correlation across different users and different base stations for typical timing and frequency offsets.

Discussion: This requirement is important for the training data to be useful in spatial discrimination of multiple users.

7. **Proposal:** The uplink training data should allow a mode with the same training data at each of multiple antennas at the same user terminal. The uplink training data should allow a mode with low cross correlation training across different antennas at the same user terminal.

Discussion: This latter case is important for the training data to be useful in spatial discrimination of a multitude of antennas at the subscriber terminal.

8. **Proposal:** The uplink training data shall allow robust channel estimation in the presence of frequency selective fading.

Discussion: This requirement ensures the fidelity of training in cases where fading is not flat across the band of interest.

## 2.2. Downlink Training data

In a very similar manner to the above discussion downlink training data is required for downlink channel estimation, data synthesis, and corresponding uplink transmission.

9. **Proposal:** For given downlink reception at the subscriber, training shall be provided on the downlink in order to facilitate downlink reception.

Discussion: This training data will facilitate temporal equalization and if applicable (e.g. for multi-antenna terminals) spatial processing on the subscriber receive.

10. **Proposal:** For given uplink data transmission at the subscriber, training data shall be provided on the downlink in order to facilitate uplink transmission

Discussion: If applicable (e.g. for multi-antenna terminals) this training data will facilitate spatial processing on the subscriber transmit.

11. **Proposal:** Downlink training shall be in close temporal proximity to the data to which it corresponds.

Discussion: The temporal proximity is determined by the coherence time of the channel under consideration. This requirement addresses the need to ensure that downlink training data arrives in time so as to be maximally useful in channel estimation

12. **Proposal:** The downlink training data shall be in close spectral proximity to the data to which it corresponds.

Discussion: This requirement addresses the need to ensure that downlink training data arrives in frequency so as to be maximally useful in channel estimation. The spectral proximity is determined by spectral coherence of signatures.

13. **Proposal:** The downlink training data shall have low cross correlation across different users and different base stations for typical timing and frequency offsets.

Discussion: This requirement is important for the training data to be useful in discrimination of multiple users.

14. **Proposal:** The downlink training data training data shall allow robust channel estimation in the presence of frequency selective fading.

## 2.3. Non-spatial Channel Estimation Mechanisms

15. **Proposal:** Non-spatial channel estimation mechanisms required for demodulation of data in the air interface shall be provided for both directive and non-directive channels where applicable.

Discussion: This requirement is especially important in OFDM systems where pilot tones are required for data demodulation. In the case of a traffic channel, for example, it is important for such pilot tones to be transmitted using the same antenna weightings as used for the traffic channel to which they correspond.

## 2.4. Broadcast channels

Broadcast information sent by a base station to all or a plurality of subscriber terminals requires special handling in multi-antenna systems.

As discussed above broadcast channels must use "non-directive" spatial processing. Broadcast channels will therefore in the typical case be received at much lower SNR compared to directive channels.

From an air interface standpoint this means that the broadcast channel structure design must take into consideration a higher coding rate on the broadcast channel, the need to avoid sending more than the essential amount of information on the broadcast channel, and the ability to exploit temporal and spatial diversity techniques to maximize the probability of reception.

16. **Proposal:** The broadcast channel shall achieve a balanced link when compared to channels that can inherently benefit from the directivity afforded by multi-antenna spatial processing. An example of the latter is typically the traffic channel.

17. **Proposal:** The broadcast channel shall allow configurable coding rates with coding more robust than other directive channels.

18. **Proposal:** The air interface shall broadcast limited amount of information so as to restrict use of spectral resources and allow use of robust coding.

Discussion: A simple technique for restricting broadcast information is to utilize unicast channels for configuration after the subscriber terminal synchronizes to the broadcast channel. Under such a scheme the subscriber terminal sends an uplink configuration request after synchronizing to the broadcast channel. Channel information obtained from this uplink request can then be used to send information to the terminal in a directive fashion.

19. **Proposal:** The broadcast channel structure shall allow the use of spatial/temporal diversity wherein the same information is sent throughout the cell with spatial and temporal diversity for more robust reception.

Discussion: One example of spatial/temporal diversity is to simply transmit broadcast bursts by using orthogonal weights across multiple broadcast time slots or across slightly delayed versions of the same transmitted symbols.

20. **Proposal:** The air interface shall not share radio resources for the broadcast channel with those for directive channels such as traffic or paging across a network of base stations.

Discussion: This requirement is important in controlling downlink interference during broadcast channel reception at terminal.

## 2.5. Paging

Paging information sent by a base station to a subscriber terminal requires special handling in multi-antenna systems.

In cases, where the base station is aware of the subscriber's spatial, the air interface should accommodate the use of this information to directively transmit paging channels to a particular user. Directive pages are encouraged whenever training data can be acquired without additional overhead. For example, in a system that allows continual uplink polling the paging structure would allow directive pages immediately following an uplink poll by a particular subscriber terminal.

When training data is not available this proposal recommends utilizing the inherent benefits of a multi-antenna approach. In such an approach, the base station is unaware of the subscriber's spatial signature, and the paging channel will be received at low SNR typically requiring extra compensation just as in the case of the broadcast channel.

21. **Proposal:** The air interface shall allow pages to be sent on bursts that may be shared with other traffic bursts.

Discussion: Since spatial multiplexing allows multiple bursts to be sent on the same physical resource, pages can be sent in an SDMA manner on resources shared by traffic channels. This can be accomplished even without prior knowledge of the user of interest's spatial signature.

For example, given user 1 in active traffic communication with a base station, user 2 can be paged by using transmit weights orthogonal to the spatial signature of user 1. This is shown schematically in Figure 8.

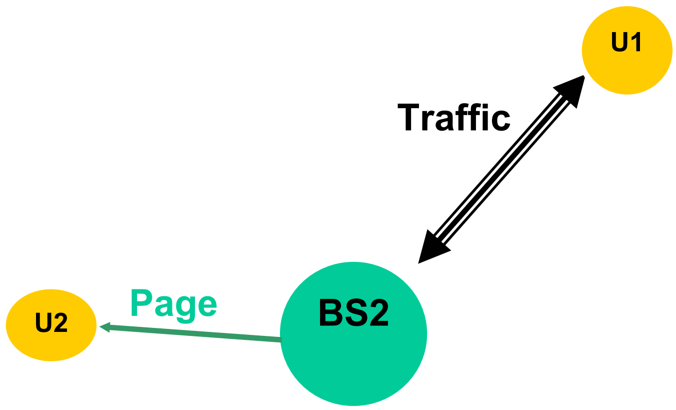


**Figure 8 Downlink page shared can be shared with downlink traffic via SDMA**

22. **Proposal:** The paging burst structure shall achieve a balanced link when compared to channels that can inherently benefit from the directivity afforded by multi-antenna spatial processing.

Discussion: As an example this can be accomplished per the requirements below by employing additional coding compared to directive channels and by employing spatial/temporal diversity techniques during the page.

23. **Proposal:** The air interface should restrict information bits in the paging burst so as to restrict use of spectral resources and allow use of robust coding.

24. **Proposal:** The paging burst structure shall allow the use of spatial/temporal/spectral diversity wherein the same information is sent across the array with spatial and temporal diversity for more robust reception.

## 2.6. Link quality reporting

25. **Proposal:** Link quality reporting for directive and non-directive channels shall be supported.

Discussion: Since received signal strengths can vary greatly between non-directive and directive channels it is necessary to report link quality on each independently.

## 2.7. Coding and interleaving

There are no specific requirements in this area.

# 3. MAC

## 3.1. Bandwidth allocation

26. **Proposal:** The air interface should avoid using broadcast information in order to coordinate bandwidth and resource allocation.

Discussion: This requirement can be met by allowing allocations to persist for short periods of time and by enabling an initial allocation to indicate where and when subsequent allocations may be used. Besides lowering latency this requirement minimizes information required to be transmitted on broadcast channels.

## 3.2. Resource Allocation

27. **Proposal:** The air interface shall utilize SDMA, shall utilize TDMA, and shall utilize FDMA or OFDM.

Discussion: This requirement ensures maximum flexibility in allocating resources in the spatial, frequency, and time dimensions. This is shown schematically in Figure 9.

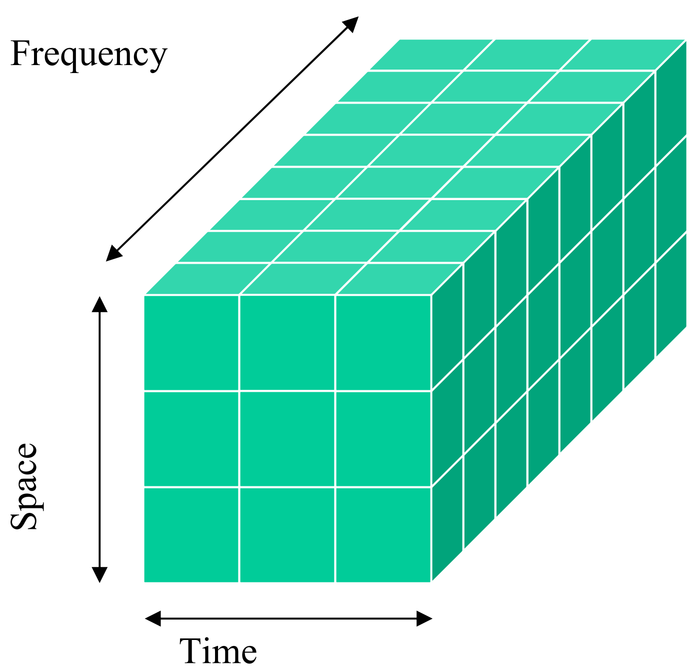


**Figure 9 Resource Indexing must include time, frequency, and space**

## 3.3. Uplink Random Access

28. **Proposal:** The air interface shall allow random access bursts to be shared on the same resources as uplink traffic bursts.

Discussion: This requirement ensures a large uplink resource set for random access leading to low latency access and eliminates the need to set aside a large resource pool that could otherwise be used for data transmission. Note that use of SDMA enables the ability to share uplink random access on data bursts otherwise used for traffic channels since such collisions are naturally resolved in the spatial domain. See Figure 10.

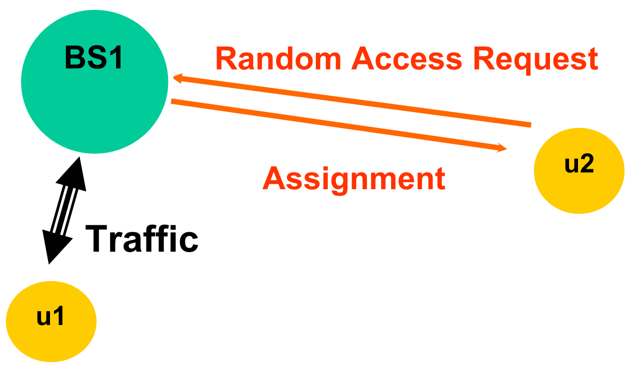


**Figure 10 Random access can be shared with traffic channels**

29. **Proposal:** The air interface should allow configurable resource sets eligible for random access.

Discussion: This requirement ensures that the random access resource set can be matched against criteria such as random access loading and the BS's effectiveness in spatial resolution.

# 4. Network

## 4.1. Synchronization

30. **Proposal:** Base stations and shall be synchronized. Terminals shall synschronize to their corresponding serving base station.

Discussion: This is a natural requirement in a wide area TDD system.

# 5. Annex 1: System Requirements Document Compliance Table

| # | Requirement | SRD Section # | Requirement Type | | Compliance Level | |
|---|---|---|---|---|---|---|
| | | | Shall | Should | Yes | Notes |
| 4 | non-line of sight outdoor to indoor scenarios and indoor coverage | 3.1 | ● | | | Note 1: Incorporation of this partial proposal into an air interface improves the ability of the air interface to meet this requirement. It is not possible to assess whether this requirement would be fully met in isolation of the specific air interface into which this proposal would be included. |
| 6 | Spectral efficiency – DL @ 3 km/hr: 2.0b/s/Hz/sector | 4.1.1 | ● | | | See note 1. |
| 7 | Spectral efficiency – DL @ 120km/hr: 1.5b/s/Hz/sector | 4.1.1 | ● | | | See note 1. |
| 8 | Spectral efficiency – UL @ 3km/hr: 1.0b/s/Hz/sector | 4.1.1 | ● | | | See note 1. |
| 9 | Spectral efficiency – UL @ 120km/hr: .75b/s/Hz/sector | 4.1.1 | ● | | | See note 1. |

| # | Requirement | SRD Section # | Requirement Type | | Compliance Level | |
|---|---|---|---|---|---|---|
| | | | Shall | Should | Yes | Notes |
| 11 | Duplexing Scheme | 4.1.3 | ● | | | *Can be implemented on TDD or FDD air interfaces. Specifics of implementation differ depending on the specific characteristics of the air interface.* |
| 14 | Aggregated data rate consistent with item 6 | 4.1.5 | ● | | | See note 1. |
| 15 | Aggregated data rate consistent with item 7 | 4.1.5 | ● | | | See note 1. |
| 16 | Aggregated data rate consistent with item 8 | 4.1.5 | ● | | | See note 1. |
| 17 | Aggregated data rate consistent with item 9 | 4.1.5 | ● | | | See note 1. |
| 18 | Peak User Data Rate (DL) of 4.5 Mbps in 1.5 MHz | 4.16 | ● | | | See note 1. |
| 19 | Peak User Data Rate (UL) of 2.25 Mbps in 1.25 MHz | 4.16 | ● | | | See note 1. |
| 20 | Peak User Data Rate (DL) of 18 Mbps in 5.0 MHz | 4.16 | ● | | | See note 1. |
| 21 | Peak User Data Rate (UL) of 9 Mbps in 5.0 MHz | 4.16 | ● | | | See note 1. |

| # | Requirement | SRD Section # | Requirement Type | | Compliance Level | |
|---|---|---|---|---|---|---|
| | | | Shall | Should | Yes | Notes |
| 25 | MAC/PHY features to support multi-antenna capabilities at the BS | 4.1.9 | ● | | ● | Specifics of the implementation of this partial proposal within the standard is dependent on the specific characteristics of the air interface. |
| 27 | Support coverage enhancing technologies | 4.1.11 | ● | | | Improves BS coverage and is compatible with the use of other coverage enhancing technologies |
| 50 | Not preclude proprietary scheduling algorithms, so long as the standard control messages, data formats, and system constraints are observed. | 4.6 | ● | | ● | |

Note 1: Incorporation of this partial proposal into an air interface improves the ability of the air interface to meet this requirement. It is not possible to assess whether this requirement would be fully met in isolation of the specific air interface into which this proposal would be included.