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Source(s)	Dale Branlund, Michael Webb BRN Phoenix Inc. 2500 Augustine Drive Santa Clara, CA, USA 95054	Voice: +1-408-572-9703 Fax: +1-408-351-4911 dbranlund@brnphoenix.com
	John Norin, Robert Popoli The DIRECTV Group, Inc. 2250 East Imperial Hwy El Segundo, CA 90245	Voice: +1-310-964-0717 Fax: +1-310-535-5422 john.norin@directv.com
	Kenneth L Stanwood NextWave Broadband 12670 High Bluff Drive San Diego, CA 92130	Voice: +1-858-480.3327 Fax: +1-858-480-3105 kstanwoood @cygnuscom.com
Re:	Call for Technical Comments and Contributions regarding IEEE Project P802.16j; See 802.16j-07/007r2	
Abstract	This contribution describes an optional AAS frame structure and access mechanism that can be used on MR-BS – Relay links to support high capacity MR base stations for out-of-band relay operation.	
Purpose	This document provides a proposal for an AAS Signaling Methodology for incorporation into the 802.16j amendment.	
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AAS Direct Signaling Methodologies to Support High Capacity MR-BS to RS Links

Dale Branlund, Mike Webb, BRN Phoenix Inc, Santa Clara, CA, USA;
John Norin, Robert Popoli, The DIRECTV Group, Inc., El Segundo, CA, USA
Kenneth Stanwood, Nextwave Broadband, San Diego, CA, USA

This document describes an optional AAS frame structure that can be used within the Relay Zone on MR-BS to Relay station links. The AAS "Relay Zone" is similar to the AAS Zone currently supported in 802.16e MS-to-BS links but with important modifications. These modifications add extended AAS training preambles to achieve higher capacity and spectral efficiency for MR-base stations in realistic propagation environments.

Introduction

The term AAS (adaptive antenna system) refers to an 802.16 system adaptively exploiting more than one antenna to improve the coverage and the system capacity[1]. Multi-user AAS[2] refers to the ability to support multiple user links simultaneously on the same sub-channel in the same timeslot through the use of AAS techniques coupled with active interference cancellation. Multi-user AAS is also known as "space division multiple access" or "multi-beam adaptive beamforming and null-steering".

Multi-user AAS extends cell coverage by improving the system link budget. Link budget gain is realized through the coherent combining of signals received or transmitted from multiple antenna elements, as well as by the increase in diversity provided by a multi-element antenna array. At the same time, multi-user AAS increases base station capacity by enabling the use of higher order modulation and reuse of spectral resources within the same cell.

This document defines an AAS "Relay Zone" frame structure with extended AAS training preambles and associated MAP IEs in order to achieve higher spectral efficiency for MR-base stations in realistic propagation environments. The frame structure and preambles enable the use of multi-user AAS on the MR-BS – RS link. In addition, modifications are proposed to increase capacity on the bandwidth request signaling channel so that bandwidth requests and grant allocations scale linearly with higher capacity.

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[1] IEEE Std. 802.16-2004 – Part 3 – Definitions.

[2] "Multi-user AAS" is also referred to as "multi-user beamforming" in this contribution.

This proposal is only applicable to the MR-BS to RS link. The proposed AAS processing is not mandatory in the Relay Zone. Just like 802.16e zones, multiple zones can exist in the MR-BS frame including the AAS Relay Zone mode described here.

Multi-user AAS is the preferred method for addressing requirement O9 (Multiple Antenna Support) of IEEE 802.16j-06/016r1 (Technical Requirements Guideline for Relay TG).

New Requirements Imposed by MR-BS to Relay Link

The MR architecture is particularly well suited to dense urban-core deployments where the highest user density will prevail. This high density coupled with high user activity will stress the MR base station capacity and its contention-based bandwidth request mechanism.

In addition, the relay architecture imposes new requirements on the capacity of the MR-BS. In cost effective architectures, the MR-BS must have the capacity to concentrate the traffic of multiple Relay Stations (RS) and to directly serve mobile stations (MS) within its own coverage footprint. Relay stations themselves aggregate mobile station traffic either through direct connection to mobile stations or via relay from other RS nodes in the network. Typical RS nodes may range from low capacity devices to moderately-sized base stations. Accordingly, 5 to 50 relay stations maybe serviced by a high capacity MR-BS in typical deployment scenarios.

Capacity & Spectral Efficiency Requirement of the MR-BS

The following example illustrates the capacity and spectral efficiency requirements imposed by the relay architecture. In this example, we assume the two hop architecture, whereby the MR-BS services 18 intermediately-sized RS nodes, as shown in Figure 1. A total of 18 high capacity links must be statistically multiplexed with MS nodes directly connected to the MR-BS.

In this example, the RS to MS cell radius is assumed to be 1 km. As a result, the radius of the MR-BS to RS link is approximately 3 to 3.5 km for exterior RS nodes, while the radius to an interior RS cell is approximately 1.7 km as shown in Figure 1. The MR-BS directly services MS traffic in the center cell. The additional range supported on the MR-BS – RS links is a direct result of two factors:

- Relay Stations are installed in a higher location than a typical MS
- Relay Links to the Base Station achieve higher system gain

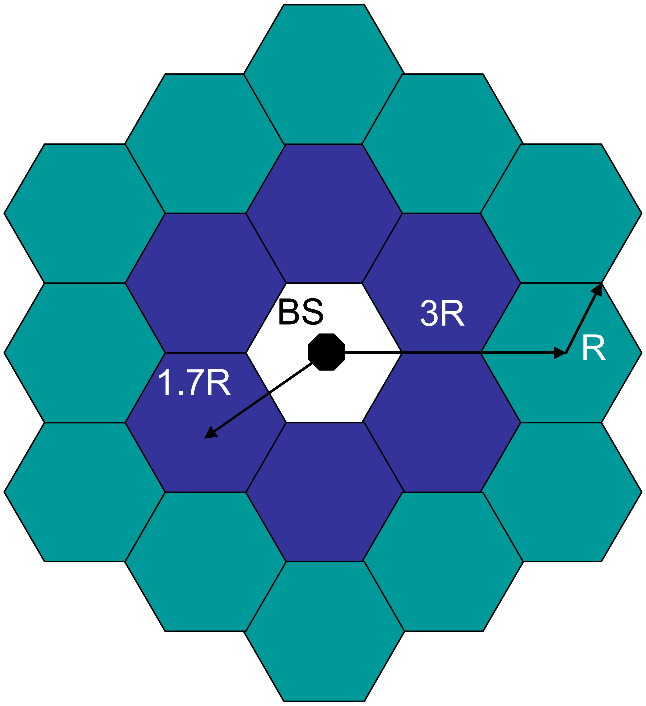


Figure 1. Mobile Multihop Basestation and Relay Station Architecture

In this example, it is assumed that each RS node has a downlink spectral efficiency of 1 bps/Hz and operates in 10 MHz of spectrum. A separate 10 MHz channel is dedicated to the MR-BS to RS link to simplify the following analysis, although other configurations are possible. Table 1 tabulates the required capacity and spectral efficiency of the MR- BS under this set of assumptions. As shown, the required spectral efficiency is 9 bps per Hz using a 50% traffic loading assumption at each RS. Although the peak load factor at any RS may be significantly higher than 50%, the loading factor is averaged over all RS nodes with the MR-BR coverage footprint for this analysis.

Table 1 MR-BS Capacity and Spectral Efficiency Requirements

Parameter	**Value**	**Comments**
BS-RS Link Bandwidth (MHz)	10	RF Channel BW
RS-MS Bandwidth (MHz)	10	RF Channel BW
RS Spectral Efficiency (bps/Hz)	1	For the DL, K=1 reuse
RS Peak Capacity (Mbps)	10	At full capacity

Number of RS Cells	12	2nd Tier of cells
Number of Interior RS Cells	6	1st Tier of cells
Total RS Cells	18	
Total Peak Capacity (Mbps)	180	Total, at full peak capacity
Average MS Utilization (%)	50	Averaged over cell
Total Average Capacity (Mbps)	90	Total average capacity
BS Spectral Efficiency, bps/Hz	9.0	To service RS nodes only

The MR-BS to RS Propagation Environment

The propagation environment for the MR-BS to RS link will be predominately NLOS in many urban core deployments. But because the RS nodes tend to be elevated above street level and have high transmitter power, the cell radius of the MR-BS to RS link will be 2 to 5 times greater than the cell radius of the RS to MS link under a broad set of conditions. While the maximum cell radius of the RS to MS link may range from 0.5 to 1.0 km, the range of the MR-BS to RS link may range from 3 to 5 km. Accordingly, the multipath delay spread of these links will be higher (typically, 0.2 to 1 microseconds rms). Appropriate propagation models for these links are indicated by SUI 3 and SUI 4 [1]. The SUI 3 and SUI 4 have similar delay spread to the suburban and urban macro-cellular models derived for “beyond” 3GPP as described in [5].

The Erceg B path loss model is appropriate for well-elevated RS nodes, while Erceg A or Walfish-Ikegami may be indicated for RS nodes closer to street level in dense urban cores [2]. Erceg B has less diffraction loss when compared to Erceg A, hence the difference between well-elevated RS and street level RS nodes.

Higher multipath delay spread lowers the coherent bandwidth of the link [3]. This stresses wide bandwidth training strategies used in closed-loop AAS and MIMO feedback schemes as will be demonstrated through simulation below. As an approximation, delay spread will not materially degrade AAS performance provided that the training bandwidth is limited to 1/10th of the channel’s coherence bandwidth.

Proposed Improvements to the AAS Relay Zone

The current IEEE 802.16-2005 standard supports advanced multi-antenna technologies such as MIMO and AAS in order to increase cell capacity and to enhance cell radius. It is generally accepted that a base station can achieve spectral efficiencies of up to 3 bps per Hz in a realistic propagation environment using the advanced antenna methods currently in the standard. However, AAS methods will generally achieve higher spectral efficiency than MIMO methods in the reduced multipath environment that is likely to apply to a large number of BS to RS links. Accordingly, this proposal focuses on improving the spectral efficiency of the AAS Relay Zone via multi-user AAS methods.

The driving requirements for the AAS Relay Zone are:

- Spectral efficiencies higher than supported by current AAS or MIMO methods through the support of high performance multi-user beamforming and interference cancellation
- Longer uplink preambles to support training of larger BS antenna arrays in realistic propagation environments
- A bandwidth request mechanism that can scale with an M-fold increase in the number of users afforded by multi-user beamforming
- A mechanism to communicate MAP information to the edge-of-cell RS nodes, which improves upon the current AAS Diversity Zone method

The proposed solution:

- Provides an AAS UL preamble that has adequate time-frequency support for adequately training antenna arrays up to 16 antennas.
- Increases the spectral efficiency of the MR-BS to 9 bps/Hz via multi-user AAS processing.
- Adds a bandwidth request and ranging channel that supports an M-fold increase in processing capacity by separating user requests on different spatial channels where M is proportional to the number of number of antennas.
- Reliably communicates MAP information to edge of cell AAS-RS nodes so that frame duration, subframe length, start time, DCD, and UCD information can be received.

A detail discussion of the solutions follows:

UL Link Preamble

This proposal increases the maximum number of AAS training preamble symbols to 8 and provides a maximum of 64 subcarriers per subchannel for training. This is adequate to adapt an array of up to 16 antenna elements with low misadjustment error within one frame. The preamble sequence length is set by a parameter in the AAS_Relay_Zone_UL_IE and is specified over the AMC subchannel permutation using either a 2 x 3 or 1 x 6 bin structure.

Selection of the bin structure and sequence length is dictated by the performance objectives of maximizing the post beamforming SINR while minimizing the preamble overhead. Performance loss is in part determined by the “difficulty” of the propagation environment and use case. RF channels with high frequency dispersion or high time dispersion are more difficult channels.

As a demonstration of this principle, Figure 2 provides Monte Carlo simulation of the downlink signal-to-interference and noise ratio (SINR) using a 16 element array and 12 RS nodes. All 12 RS nodes communicate simultaneously with the MR-BS on 12 co-channel RF links. In this case, the SUI-3 model channel model is used with the prescribed moderate gain antennas at the RS.

To adapt each link, each RS uses a unique preamble containing 64 subcarriers to train the array. In the simulation, 1500 data subcarriers are used to determine the post-beamforming SINR. The SINR is used as the measure of performance as the bandwidth of the training is varied in this simulation. Over the Monte Carlo trials, the 90th percentile of the SINR is plotted in Figure 2. The preamble subcarriers were distributed in a contiguous frequency-symbol region according to the bandwidth parameter specified on the x-axis. The subcarriers were distributed across frequency from 10 kHz to 3500 kHz. In the former case, the frequency-symbol region is 1 subcarrier x 64 symbols. In the latter case (mode B), the frequency-symbol region is 64 subcarrier x 1 symbol evenly distributed across 3500 kHz.

Mode C in Figure 2 shows that training over a 1 x 6 AMC bin (100k) produces good results by using 8 preamble symbols (1 pilot + 8 preamble subcarriers x 8 symbol times). By changing the preamble frequency support to the 2 x 3 AMC subchannel (200 kHz), the SINR falls 1.5 dB. However, the training overhead is reduced since only 4 preamble symbol times (16 subcarriers x 4 symbol times) are required. Note that broadband training strategies covering regions greater that 200 kHz results in a substantial loss of SINR, and while apparently attractive from an efficiency standpoint, fail to perform adequately. The worse case is shown in Figure 2, Mode B where the preamble is spread across the entire bandwidth. The SINR loss is 14 dB compared to the better preamble training strategy indicated by Mode C. Clearly, the frequency dispersion of the channel does not permit broadband training. Moreover, relatively narrowband preamble training is preferred, particularly as the delay spread of the channel increases.

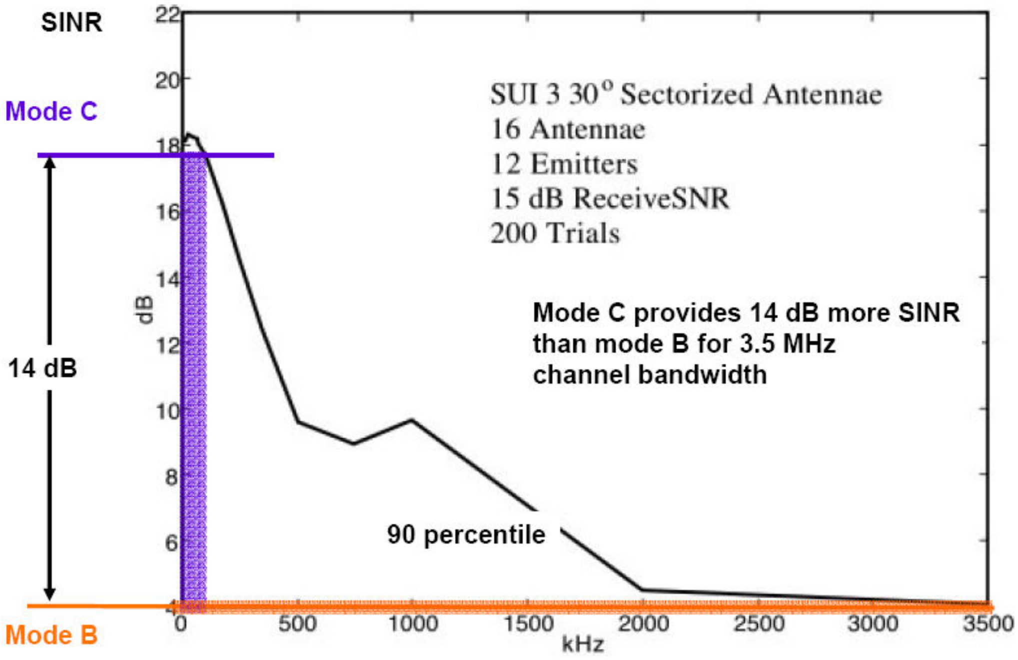


Figure 2. DL Output SINR vs. Preamble Bandwidth

Capacity

The uplink preambles are designed to support multiple co-channel users enabling multi-user beamforming. Construction of the UL preambles are based on Hadamard codewords modulating a QPSK constellation. The modulation has favorable cross correlation properties with other Hadamard codewords and this ensures accurate vector channel estimation in a multi-user MR-BS scenario. To test the effectiveness of the approach, a simulation of 19 MR-BS and 190 RS nodes was performed using the SUI-3 channel model. The model was extended as reported in [4] to include realistic angle spread and multipath delay using the ray-tracing geometrical elliptical model (GEM). This ensures that each multipath has a unique spatial signature, time delay, and complex reflection coefficient. The model is calibrated to produce the same K-factor and rms delay spread as indicated by the corresponding parameters in the SUI models. The GEM creates Doppler by moving the reflectors, by moving the RS nodes or by moving both each symbol period.

Since each multipath has a unique spatial signature and time delay, the effects of frequency dispersion (related to the coherence bandwidth and delay spread) and time dispersion (related to relative motion and Doppler) are accurately modeled.

Each MR-BS in the simulation uses 16 antennas where 4 antennas are distributed in 4 sectors aligned to the rectangular street grid of an urban core. Each base station connects to 10 co-channel full-bandwidth RS nodes simultaneously in this simulation. The cell-to-cell reuse factor corresponds to K=1. The simulation uses 1 x 6 AMC subchannels with 64 preamble training subcarriers. The location of each RS node is randomly selected from a uniform distribution on each Monte Carlo trial and the RS nodes are located 6 meters above street level. An RS location plot of a typical Monte Carlo run is shown in Figure 3 for reference.

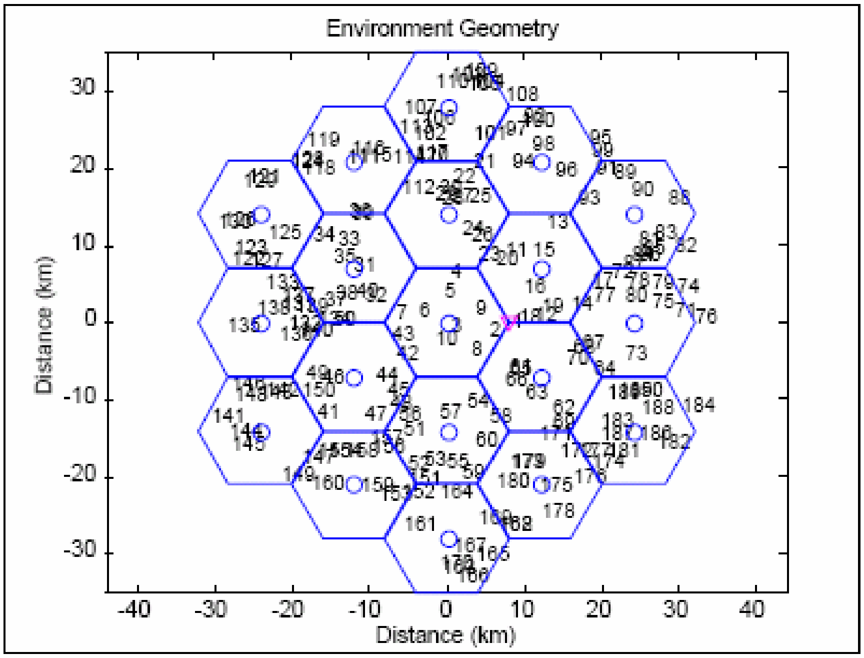


Figure 3. Capacity Test: 19 MR-BS and 190 Co-Channel RS Nodes

Figure 4 shows the cumulative distribution of the output SINR on the uplink for the simulation parameters given above. Note that the multi-user AAS SINR of 17-20 dB supports most CC and CTC 64QAM constellations at the 2/3 and 3/4 code rates. For reference, a second curve is plotted for the same antenna array titled “sectored antennas”. In this case the simulation employed sectored antennas at the base station that are pointed at each desired user. The beamforming was based on estimates of the antenna steering vector with power control but without directing nulls at interference. Thus, the antennas are electronically combined, albeit without interference cancellation, to achieve the best SINR.

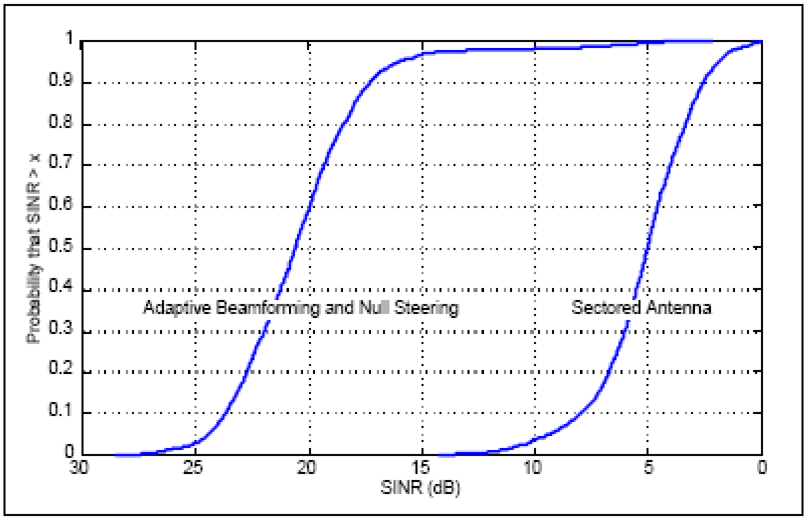


Figure 4. Capacity Test: Output SINR for Multi-user AAS and Sectorized Antennas

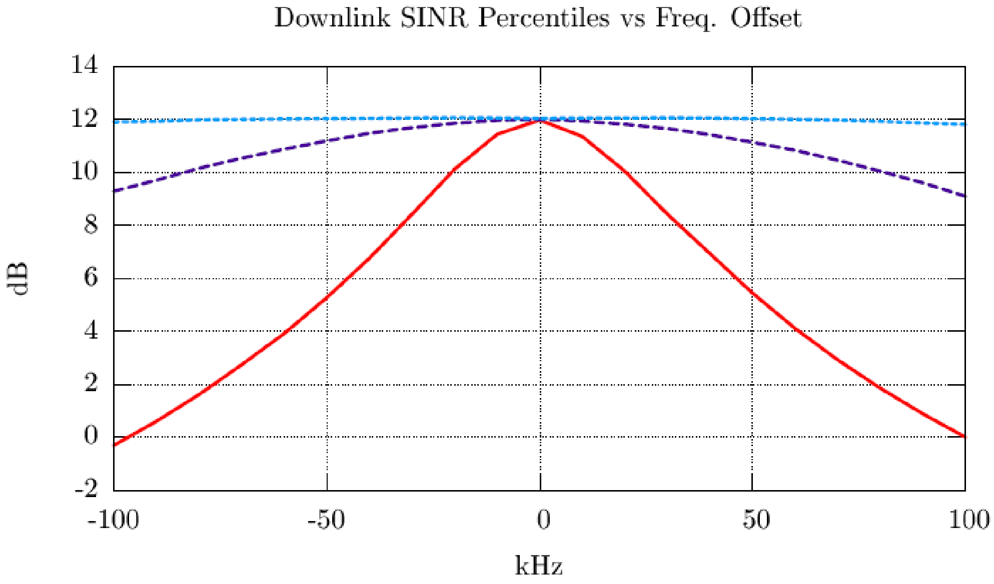
Figure 4 shows the quantitative difference between the two approaches and the benefits of multi-user AAS in a fully cellularized MR-BS deployment where the frequency reuse factor is 1/10. The Adaptive Beamforming and Null Steering method achieves an SINR of 17 dB for 95% of the RS link. This SINR supports the CTC 64QAM rate 3/4 modulation providing 4.5 information bits per subcarrier. The Sectored Antenna with beam-steering achieves 2.5 dB for 95% of the RS links. This supports the CTC QPSK rate ½ modulation providing 1 information bit per subcarrier.

Moderate to Severe Multipath Simulation

To characterize the effect that multipath and channel dispersion has on SINR, the multipath in the network illustrated in Figure 3 was varied. Three additional cases are reported here. In the first case (Case #1), severe multipath is simulated. In Case #2 and in Case #3, multipath is generated according the power coefficients and delay profile provided in the SCM model [5]. Beamforming weights were derived using the channel model corresponding to the center subcarrier in each AMC bin. Then, the SINR is plotted for other subcarriers displaced from the center subcarrier. For the most severe multipath case, the drop off in performance as measured by SINR is severe, particularly as the frequency displacement become larger than one AMC bin.

Severe Rayleigh Channel Case

Case #1 is a worst case scenario, with severe multipath unlikely to occur in most MR-BS deployments. We allow a large 2 μsec. excess delay coupled with 3 spatially distinct multipath components equal in power to the main path. The uplink degradation stays within 1.5 dB, but the downlink sees about 7 dB and 12 dB degradation over the subcarriers in one AMC bin and two AMC bins respectively (red line is the 10th percentile, dotted blue is the 90th percentile). Nevertheless even in this case more than half of the users see less than 1 dB of performance loss over one AMC bin (dashed blue line) as shown in the figure below.



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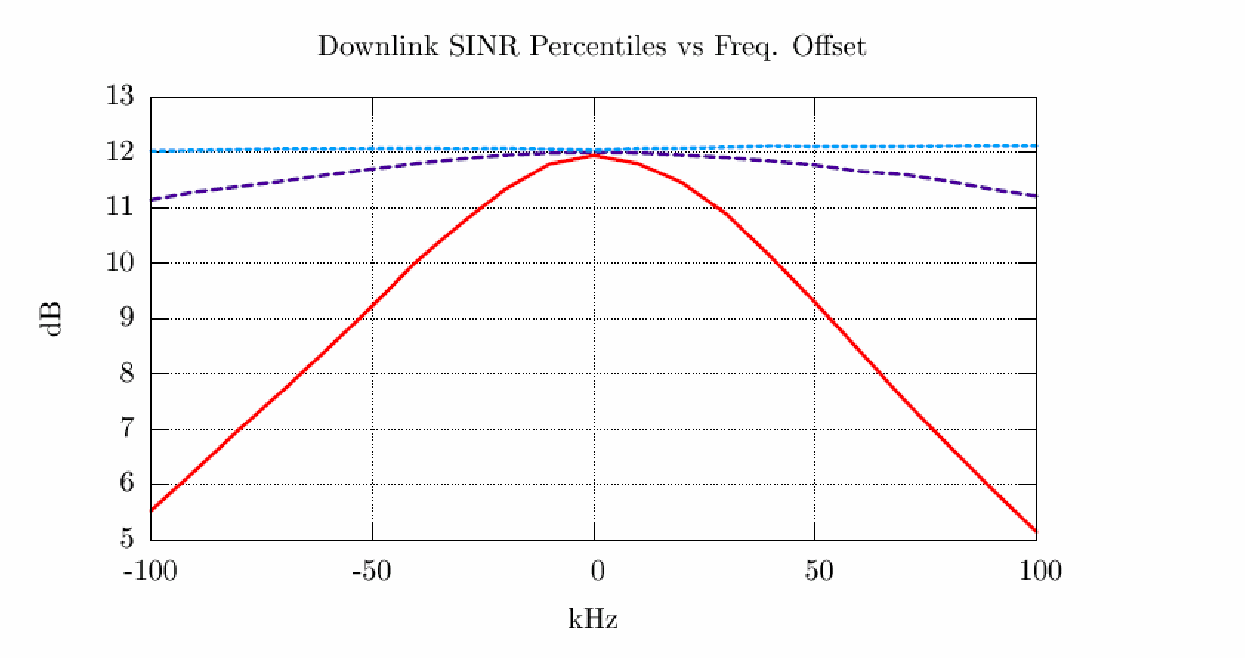
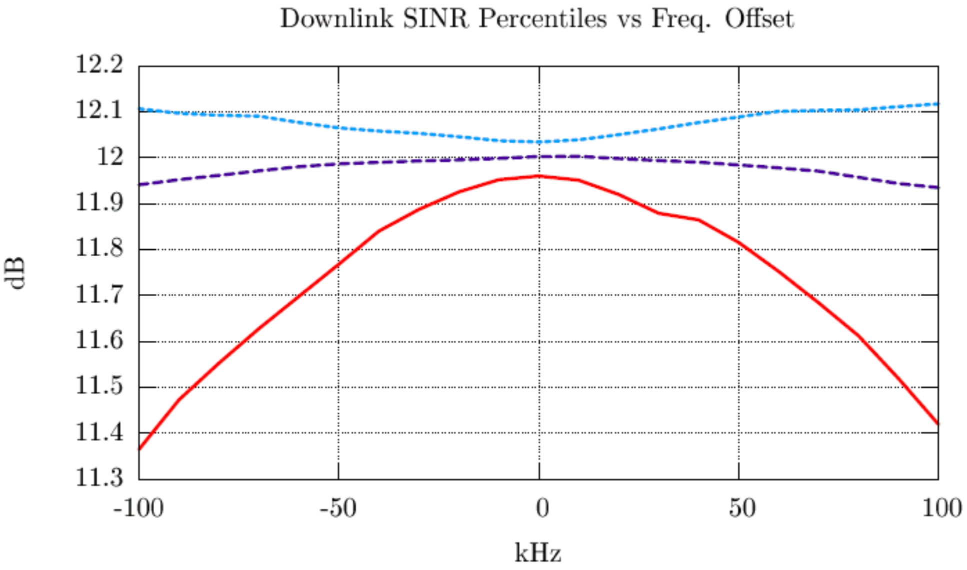
Urban Macro Cell

We also show the more challenging urban macro cell model from [5], which has path losses of 2.2204, 1.7184, 5.1896, 9.0516, and 12.5013 dB, and an excess path delay of 0.84 μsec. This reveals a worst case downlink degradation of 2.5 dB and 6.5 dB at the one AMC bin edge and two ACM bin edge respectively.



Suburban Macro Cell

To put this in perspective we compare the previous result with the suburban macro cell model proposed in [5]. This model has path losses of 2.6682, 6.2147, 10.4132, 16.4735, 22.1898 dB over the 5 multipath rays. More importantly the excess path delay is set to a maximum of 0.231 μsec.s. In this case, frequency dispersion effects are well contained across either one or two AMC bins.



Bandwidth Request and Periodic Ranging

Figure 4 indicates that substantial spectral efficiency gains are possible with multi-user AAS processing using the extended Hadamard preambles for training. In this case, ten spatial planes of traffic processing are supported with an SINR supporting 64QAM. However, this capacity can only be realized if traffic can be efficiently multiplexed onto multiple spatial planes via the bandwidth request and scheduling processes. In this case, the contention-based CDMA access mechanism may be overloaded, or conversely, so many CDMA slots are needed for access that the transport efficiency of the zone is severely impaired. The latter case is particularly costly since lost slots must be multiplied by the Co-Channel Reuse Multiple (CCRM) to determine the payload loss in the AAS zone. In this example, the Co-Channel Reuse Multiple is 10-fold.

The solution to this problem is to effectively multiply the BW request/grant throughput, by the co-channel reuse multiple. This proposal achieves this goal by using multi-user AAS processing, frequency repetitions and new preambles in an AAS Relay Zone. A new physical channel called the “AAS Relay Zone Access Channel” is proposed using the AMC subchannel permutation in the AAS Relay Zone. This channel effectively multiplies the number of access opportunities by the CCRM while using only a small number of AMC slots. In this case, the beamforming processing separates the access operations into multiple spatial planes via MMSE channel estimation techniques. Both spatial degrees of freedom and the frequency repetitions can be used to optimize the solution.

As an added benefit, the AAS Relay Zone Access Channel has extended system gain as a result of beamforming gain, frequency repetitions and reduced interference. In addition, this access channel can be used for ranging tasks including periodic and handover ranging.

Summary of Proposed Solution

The Relay Zone is comprised of one or more zones as specified in the R-MAP. These sub-zones can support relay nodes that implement optional processing such as MIMO and AAS. The scope of this proposal defines the framing structure within one of these sub-zones herein called the AAS Relay Zone. The AAS Relay Zone includes standard allocations for data transport, an allocation for an AAS Relay Zone Access Channel and defines extended preambles for use in this access channel. The proposed changes are signaled in the AAS_Relay_Zone DL_IE and AAS_Relay_Zone_UL_IE. These information elements (IEs) are contained within the DL R-MAP and UL R-MAP as shown in Figure 5.

Investigation of Alternatives

Two alternate methods were investigated to set up PHY signaling, permutations, and map allocations. These are the Sounding zone/Sounding command method (8.4.6.2.7.1) and the AAS Zone Method (8.4.4.6 and 8.4.4.7)). The AAS Zone Method was selected for the following reasons

1) The AAS zone method provides allocations within the zone for bandwidth request and ranging. The Sounding zone method would need an additional allocation with command IE to accomplish the same thing. Thus, the AAS zone method is more efficient
2) The complex sounding zone command is sent as a map element and is often not decodable by AAS end-of-cell user. The AAS Zone method solves this problem as described by below.
3) The Sounding zone method provides cyclic shifted preambles and decimation preambles of somewhat limited separability. The frequency support of these preambles is too wide for accurate vector channel estimation where the coherence bandwidth of the channel is low, nor is the length (number of symbols) of the preambles high enough to train larger antenna arrays.

Proposal

Insert this section as 8.4.4.7.2.3 and renumber figures

8.4.4.7.2.3 Optional AAS Relay Zone Frame Structure

For reference, the MR-BS to RS frame construction for non-transparent relay is illustrated in Figure xxx of Section 8.4.4.7.2.1 showing the Relay Zone for the downlink and the Relay Zone for the uplink. The AAS Relay Zone is a zone within the Relay Zone of the referenced figure.

Figure 5 shows an expanded view of these same zones using the AAS Relay Zone frame structure with zone “A” part of DL relay zone and zone “B” part of the UL relay zone. Figure 5 is shown with the AAS Relay Zone Type =1. In this case, the AAS zone uses the AMC subchannel permutation and either the 2 bin x 3 symbol or 1 bin x 6 symbol construction. The AAS Relay Zone Access Channel is defined to be 1 or more subchannels starting at subchannel 0 for both the uplink and downlink. Subchannel 0 is paired with subchannel n-1-k where n is the total number of subchannels and k is the number of subchannels designated in the IE. Two repetitions of the AAS preamble and data are used in the subchannel pair to aid robust reception via signal processing methods (i.e. diversity combining).

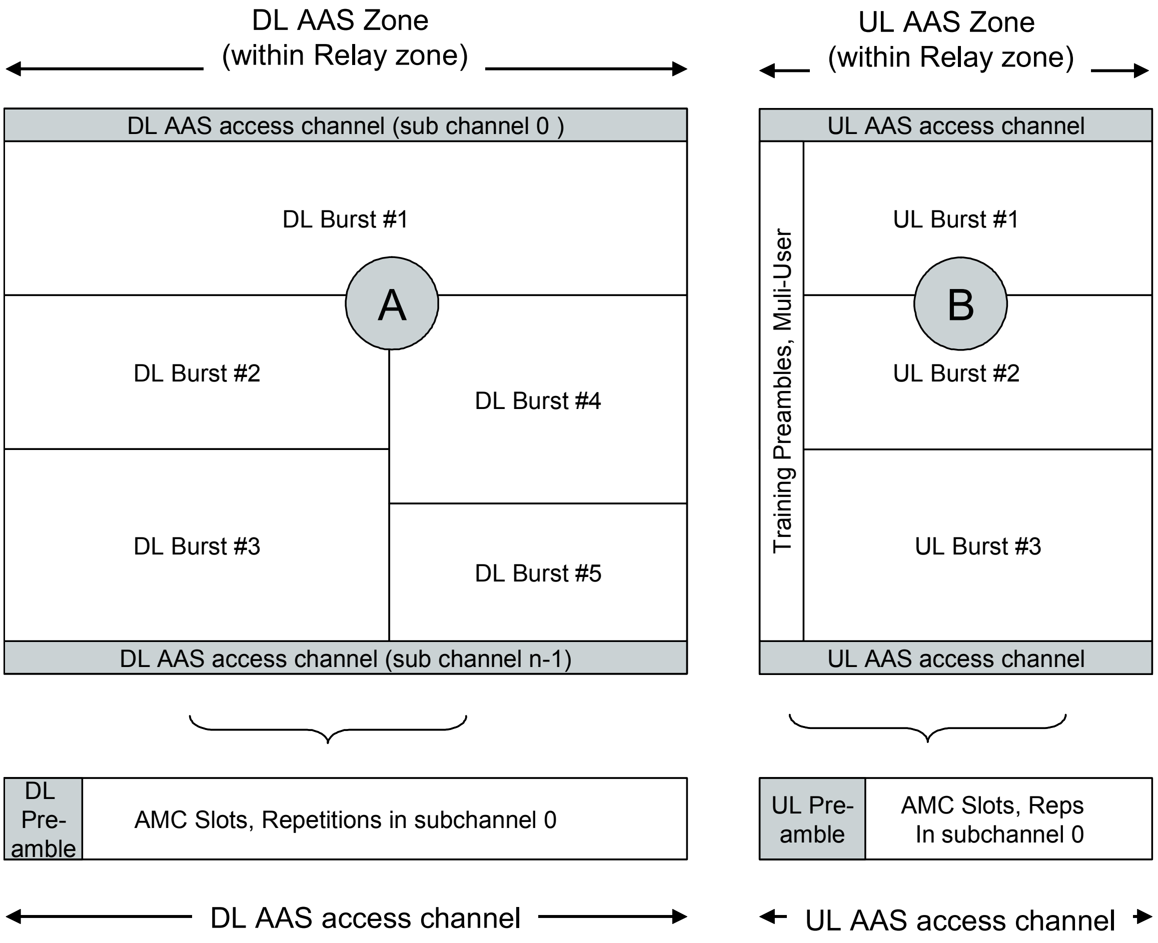


Figure 5. AAS Relay Zone Construction

Figure 5 shows that the AAS Relay Zone Access Channel begins with the AAS DL preamble. Edge-of-cell RS nodes that cannot decode the R-MAP can find the access channel by searching for this preamble.

The AAS network entry utilizing the AAS Relay Zone Access Channel involves the following procedure:

- The AAS-RS synchronizes frame timing and frequency to the MR-BS.

- Most AAS-RS receive and decode the broadcast R-DL-MAP and R-UL-MAP messages. These broadcast messages define the AAS Relay Zone (within the Relay Zone) via informational elements within the MAP.

- An AAS-RS at the cell edge that cannot decode the standard R-MAP messages will search for the AAS preamble in the AAS Relay Zone Access Channel. Since the location of the access subchannels are well known in the subchannel domain, only a 1-D search across the symbol time dimension is required. The edge-of-cell AAS-RS then receives the R-MAP containing the AAS_DL_IE and AAS_UL_IE. The AAS Relay Zone Access Channel provides the benefit of scatter-cast beamforming and selection diversity enabled by the frequency repetitions. The R-MAP starts immediately after the AAS zone start preamble. The R-MAPs are transmitted using the well-known rate 1/2 QPSK modulation with 2 repetitions.

- Most AAS-RS receive broadcast messages such as the DCD and UCD using standard allocations pointed to by standard MAP IEs while edge-of-cell RS nodes receive DCD and UCD messages in the AAS Relay Zone Access Channel via allocations pointed to by IEs contained in the R-MAP received in the access channel.

- Once the AAS-RS decodes the DCD and UCD, it performs initial ranging using the initial ranging preambles (drawn from the codeword set) defined below. The preamble length is specified in the AAS_UL_IE.

- When initial ranging code is successfully detected, the base station is able to compute UL and DL beamforming solutions and thus, is able to send and receive unicast messaging with beamforming gain.

- The AAS-RS receives a unicast ranging response message through a private allocation in the AAS Access Zone with the broadcast CID. In addition, it receives a periodic ranging codeword. Subsequent ranging uses the periodic ranging codeword. The ranging protocol proceeds normally as described in Section 6.3.10.3 CDMA-Based Ranging.

- Subsequent allocations can be managed with private allocations sent to the RS nodes using multi-user beamforming.

8.4.4.7.2.3.1 Definition of Uplink Preambles (Codewords)

The uplink training preambles are based upon 64 QPSK subcarriers constructed from Hadamard sequences. The properties of these preambles are as follows:

- Provides a spatial training sequence for up to 16 antennas with the adequate time bandwidth product
- Provides unique RS identification at the base station. The preambles can be detected in co-channel interference with beamforming gain
- Provides an initial and periodic ranging capability for edge-of-cell RS
- Provides multi-user AAS bandwidth request capability with appropriate messaging.
- 8064 codewords are available
- High probability of detection, low false alarm rate consistent with modest cross-correlation properties between assigned codewords at various code delays
- The same codewords may be re-used multiple times at the base station if sectors or sub-bands are used
- Robust codeword reuse factor of 4 between base stations.
- The base station can separate multiple RS in the AAS Relay Zone using different codewords

Codeword construction

Each RS registered to a base is assigned a basic CID and a unique Hadamard access codeword (ACW) for bandwidth requests and for training. The base station binds the access code with the basic CID. Thus, within a given sub-band or sector, each RS has its own unique access and traffic code. There are a maximum of 8064 access codewords. The access codewords, $a = 2016t + c$, are divided into four equal sets; $0 \leq t \leq 3$, where t is the MR-BS reuse "color". Each set of 2016 codewords are divided into two types with each type allocated a certain number of access codes: up to 2000 are assigned to the RS nodes for bandwidth request, periodic ranging and traffic: $0 < c < 1999$, and there are 16 access codewords, c, for RS initial ranging: $2000 < c < 2015$.

ACW codewords are based on Hadamard basis functions. ACW are described by an access code, a, $0 \le a < 8064$. A ACW codeword, $\mathbf{p}_{i_1 i_0}$ modulating the 64 QPSK subcarriers has in-phase and quadrature components taken from the columns of a 64 by 64 Hadamard matrix,

$$\mathbf{p}_{i_1 i_0} = A\mathbf{F}_1\mathbf{h}_{i_1} + jA\mathbf{F}_1\mathbf{h}_{i_0}, \quad i_1 \neq i_0 ...if\, 0 \leq a \leq 4031$$

$$\mathbf{p}_{i_3 i_2} = A\mathbf{F}_2\mathbf{h}_{i_1} + jA\mathbf{F}_2\mathbf{h}_{i_0}, \quad i_3 \neq i_2 ....if\, 4032 \leq a \leq 8063$$

F1 is a 64 x 64 toggle matrix derived from the identity matrix with the following diagonal values toggled to -1: 4, 8, 9, 14, 15, 20, 24, 30, 35, 41, 46, 47, 50, 52, 56, 62.

F2 is a 64 x 64 toggle matrix derived from the identity matrix with the following diagonal values toggled to -1: 1, 2, 5, 6, 18, 21, 23, 26, 28, 32, 34, 38, 43, 48, 49, 54, 60.

The first 2-bit symbol of the Hadamard sequence modulates the first subcarrier in the first bin of the subchannel definition. Mapping proceeds in ascending order with all pilot subcarriers in the AMC subchannel skipped.

8.4.4.7.2.3.2 AAS Relay Zone Access Channel Downlink Preamble

The AAS downlink preamble marks the beginning of the DL AAS Relay Zone Access Channel. It length is specified in the AAS_DL_IE. Construction of the preamble follows 8.4.4.6.4.1

8.4.5.4.6 AAS Informational Elements

Modify Table 293 in section 8.4.5.4.6 with the following:

Table 293 AAS_Uplink_IE

Syntax	Size	Notes
AAS_UL_IE() {		
Extended UIUC	4 bits	AAS = 0x02
Length	4 bits	Length = 0x04
Permutation	2 bits	0b00 = PUSC permutation 0b01 = Optional PUSC permutation 0b10 = adjacent-subcarrier permutation 0b11 =*Reserved*
UL_PermBase	7 bits	
OFDMA symbol offset	8 bits	
AAS zone length	8 bits	Number of OFDMA symbols in AAS zone

Uplink_preamble_config	2 bits	0b00 - 0 symbols 0b01 - 1 symbols 0b10 - 2 symbols, 4 symbols if AAS Relay Zone Type=1 0b11 - 3 symbols, 8 symbols if AAS Relay Zone Type=1
Preamble type	1 bit	0 – Frequency shifted preamble is used in this UL AAS zone 1 – Time shifted preamble is used in this UL AAS zone 0 = Hadamard preamble, if AAS Relay Zone Type =1) 1 = Reserved
Number of AAS Relay Zone Access Channel subchannels	1 bit	0 = 1 subchannel pair 1 = 2 subchannel pairs
AAS Relay Zone Type	1 bit	0 = Diversity MAP Relay Zone 1 = Direct Signaling Relay Zone
Reserved	2 bits	Shall be set to zero
}		

References

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[3] *Microwave Mobile Communications*, Edited by William C. Jakes, Jr., John Wiley & Sons, 1974.

[4] P. Kelly, Amir Sarajedini, *“Evaluating FWA System Performance in NLOS Environment, Observations and Results”*2002 WCA TECHNOLOGY SYMPOSIUM”.

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