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Title	**AAS enhancements for 1x Scalable PHY**	
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Re:	IEEE P802.16-REVd/D3-2003	
Abstract	This contribution introduces AAS enhancements for proposed 1x Scalable PHY as an optiona feature	
Purpose	Adopt into P802.16d/D4 draft.	
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1 Introduction

AAS can extend cell coverage by improving the system link budget. Link budget gain is achieved through beamforming. Beamforming coherently combines the RF wavefront received from multiple antennas in an adaptive combiner while increasing the order of the diversity combining mechanism. At the same time, AAS can increase base station capacity by enabling the use of higher order modulation through interference reduction and by enabling M-fold spectral reuse within the cell. To gain these benefits, the adaptive arrays must be trained using a known set of training symbols. Furthermore, robust signaling methods are needed to page subscriber stations when the adaptive arrays provided no beamforming gain. These training, paging, and initialization signals are collectively called AAS control signals in this document.

The current OFDMA standard is silent on the definition of these signals. To ensure compatibility across different base stations and SSs, the control signals must be defined. Accordingly, a compact set of AAS control signals, compatible with the 1x Scalable OFDMA PHY, is proposed in this submission. The use of these controls is only required for systems using the optional AAS mode. Non-AAS systems are not required to use these signals, and therefore bear no inefficiency.

2 Problem Definition

2.1 Broadcast Control Messages and Range

Coherent beamforming with a base station antenna array can effectively increase the transmission range of the uni-cast channels, since there exists an optimum beamforming solution to serve the intended SS, but it cannot directly increase the range of broadcast messages on broadcast channels – most crucially, broadcast MAP bursts do not enjoy the extended range. An SS who cannot receive the current DL-MAP is cut-off from receiving other downlink traffic intended for it even though enough link budget is available. The same problem occurs on the uplink – any SS that cannot receive the broadcast UL-MAP will not be able to transmit, even though the base station can use coherent combining gain to close the link.

The present OFDMA standard patches this problem in the AAS mode be redefining several of the broadcast messages, in particular the MAP messages, to be received as a series of private uni-cast messages. However, the large increase in overhead, the increase in latency and the inability to send uni-cast messages to portable or inactive SSs were not considered adequately.

2.2 Interference on Control Messages

AAS system that employ adaptive arrays for the purpose of increasing base station capacity do so by aggressive reuse of frequency – often by re-using frequencies within the cell several times. In such an RF environment, the control messages are buried by interference, not only from interference generated by adjacent cells, but by interference generated from multiple users within the same cell. Thus, it becomes imperative to protect control signaling that opens and closes data flows between various SS and the serving base station from this interference. This implies that control signaling be structured to enable interference mitigation using either in time, frequency, spatial and/or coding dimensions.

2.3 Proposed Solution

The proposed solution introduces low overhead control symbols and signaling that can be overlaid onto the 1x scalable PHY framing structure. This control signaling is specifically designed for the AAS mode and may be selectively removed in non-AAS modes. Specially, the control signaling is designed so that base stations that employ adaptive antenna arrays can use spatial or spatial/spectral filtering to isolate this critical signaling and maintain the link budget advantages described above. Reliance on extended uni-cast maps is reduced.

3 PHY Control Signaling Overview Solution

The following paragraphs provide an overview of the physical layer control signaling supporting the optional AAS mode. The signaling mechanisms described herein have been rationalized and integrated with the 1x scalable frame structure. The control signaling consists of special symbols modulating OFDMA carriers within the 1x scalable bin and sub-channel structure. The AAS symbol structure minimizes overhead thus maintaining high airlink efficiency. The handshaking mechanisms described below provide reliable, low latency airlink control in co-channel interference environments.

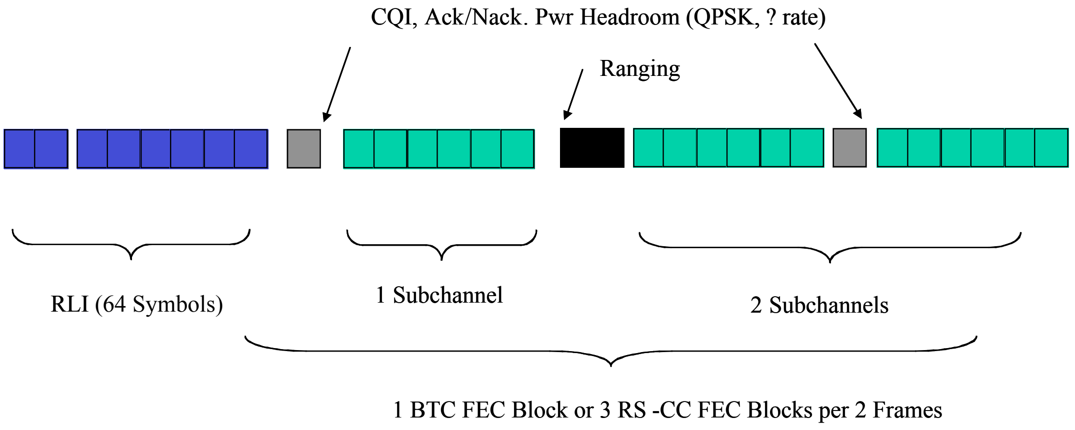
3.1 TDD Framing

In the informative text that follows, the target AAS system uses time division duplexing (TDD). The 1x scalable frame layout uses a frame time of 5 milliseconds and 48 OFDMA symbols per frame. The frame contains 84 bins x 48 symbols slots. For clarity throughout this document, a new term “partition” is used. A partition is defined as 1 bin by 48 symbol slots. It is assumed for illustration purposes that 33 symbols are allocated to the forward link and 15 symbols are allocated to the reverse link resulting in 2 to 1 asymmetry (provisioned) in the forward and reverse link rates. An AAS sub-channel is defined as six consecutive bins in time defined by a contiguous area of 1 bin x 6 symbol slots in length. Mandatory CC coding and optional BTC or CTC FEC is supported by this frame structure. Optional 2x spreading or SFC is used on the access channel for improved control channel reliability.

3.2 Reverse Link Signals

A reverse link partition in the TDD frame is shown in Figure 1 for one of 84 partitions. The reverse link in this example provides 15 symbol slots and is organized as two AAS sub-channels. One of the 2 AAS sub-channels contains one AAS reverse link control signals transmitted once every multi-frame. A multi-frame is 1, 2, or 4 frames. Non-AAS systems do not send this AAS control signal.

There are two physical layer control signals for the reverse link. The first is a reverse link initialization (RLI) signal, which allows a SS to send an AAS training signal to the base for a given sub-channel. The RLI provides the time-bandwidth product necessary to adapt up to 12 antennas at the base station. The RLI signal occurs at the beginning of the reverse link frame as shown in Figure 1 and is sent alternately every frame, every other frame or every fourth frame as provisioned by the “multi-frame parameter”. Map and traffic data are sent after the RLI in the first sub-channel and in subsequent sub-channels thereafter also shown in Figure 1. The RLI occupies a maximum of 8 bins by 8 tones (9 tones with pilot) per bin providing 64 QPSK symbols for base station training.



15 Symbols/Frame, 2 Frames Shown

Figure 1 Reverse Link AAS Frame Structure Showing RLI Signaling

The second control signal is the reverse link access (RLA) signal. The SS uses the RLA to inform the base that it has information to send on the uplink. The reverse link access partition is identical to the traffic partition shown in Figure 1. SSs use the RLA signal mechanism for sending supervisory messages such as bandwidth requests and signaling for initial ranging. The base in turn, with coordination through its scheduling mechanism, sets up traffic sub-channels using forward link control signaling, either an FLI or FLA as described below.

At least one access partition is allocated in the TDD frame for network entry and ranging, bandwidth request, and auxiliary SICH communications. The access partition, shown in Figure 2, occupies the first bin location in the frame structure. A second partition that occupies the last bin location may be paired with

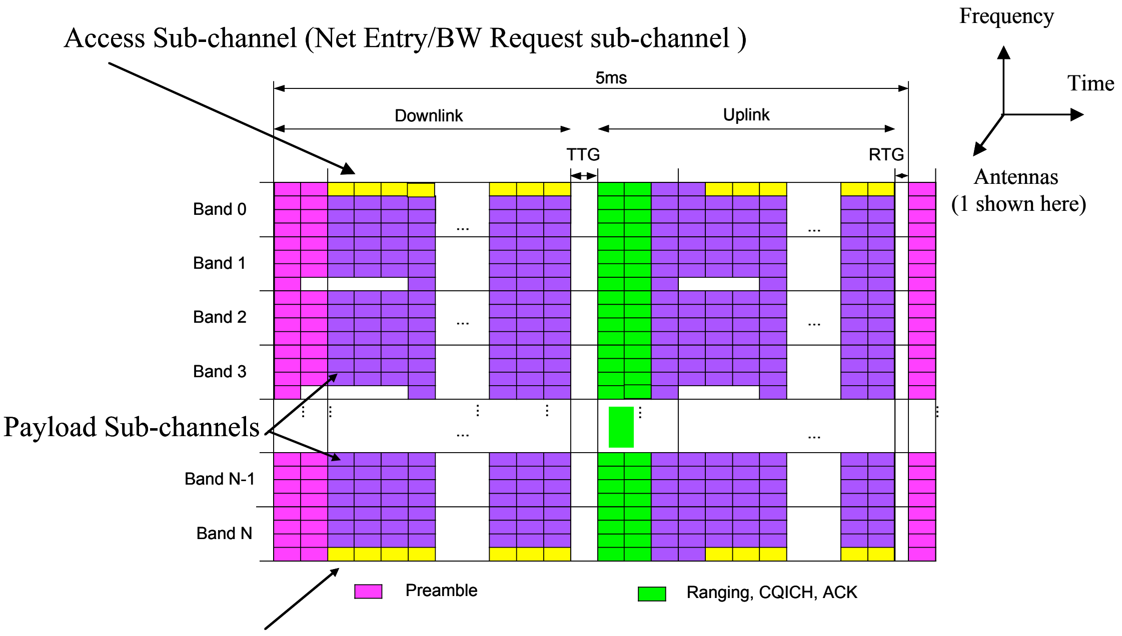


Figure 2 1x Scalable Frame Layout

the first to improve reliability and SINR through diversity combining methods. Either simple 2x spreading or space-frequency coding (SFC) maybe used as the diversity combining method. The partitions are spaced at the extremes of the RF channel to maximize the spectral diversity and may be power boosted.

3.3 Access Sub-Channels

At least one access partition is required for each 5 MHz channel. In addition, sectorized base stations provision at least one access partition per sector. For the case where the RF band has been divided into sub-bands, at least one access partition is provisioned per sub-band.

The access partition is contention based. If collisions occur, SSs use a random back-off algorithm to randomize retry timing. By using the coding methods described latter in this document, AAS base stations are able to spatially separate subscriber stations thus minimizing contention, and linearly increasing the number of logical access partitions in proportion to the number of spatially processed antennas.

3.4 Forward Link Signals

The forward link partition is shown in Figure 3 for one of 84 bins. The forward link partition in this example provides 33 or 32 symbol slots and is organized as five

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