Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Proposed Text for Mitigation Techniques Section of Part 3 of the Coexistence Recommended Practice – Working Document Version 1.3**
Date Submitted	**2002-07-11**
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Re:	Call for contribution on the amendment to the Coexistence Recommended Practice document under development in 802.16.2. Specifically, this contribution proposes text for Part 3 of the Recommended Practices document.
Abstract	The proposed text briefly covers the role of the adaptive beamforming antennas in a wireless system and describes the interference mitigating effects of such antennas on the coexistence of BWA systems in co-channel and adjacent-channel cases.
Purpose	The purpose of this contribution is to propose text for TG2 to adopt to be included in the 2-11 GHz amendment to the Recommended Practice document.
Notice	
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Proposed text for Mitigation Techniques Section of Part 3 of the Coexistence Recommended Practice – Working Document Version 1.3

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Introduction

Mitigation Techniques section of Part 3 of the draft version 1.3 of the Coexistence Recommended Practice is meant to include mitigation techniques used to combat interference. It was originally suggested that the material from Part 1 be used as a starting point. Due to the inclusion of Adaptive Antennas (AA) in the 802.16a draft standard and the importance of AA technology in any future BWA system, this submission proposes that a subsection on AA be added to this section. It also proposes supporting text for this new section.

Proposed Text

Adaptive Antennas

Adaptive Antennas (AA) have been successfully implemented in commercial and military systems for many years. AA increase the coverage and capacity of wireless networks and enhance their performance through spatial processing, beamforming, coherent combining of the arrived signals, exploiting uncorrelated fading among multiple antennas, and interference suppression and mitigation. Using a variety of signal-processing algorithms, an AA system effectively senses channel conditions and works to “locate” and adaptively “track” all the relevant signals and interferers present in order to dynamically minimize interference and maximize reception of the signals of interest. With adaptive arrays, it is possible to discriminate users from interferers, even at low SINR, and provide reliable gain and interference mitigation.

In FDD systems, downlink beamforming techniques such as Direction of Arrival (DoA)-based approaches use the uplink signals to construct an estimate of the downlink channel response by assuming some degree of correlation between the uplink and downlink channels. In contrast, channel reciprocity in TDD acts as an inherent feedback mechanism and allows the adaptive antennas to perform at their best for both uplink and downlink channels. There are many public domain and proprietary beamforming algorithms that are each optimized for a particular wireless channel or technology. Depending on the details of the air interface and the service definition, so-called “spatial channels” can be robustly created via spatial processing whereby each conventional temporal channel (e.g. frequency and timeslot or code combination) may be reused within the cell, achieving re-use factors less than one. Figure 1 shows how the adaptive algorithms behave with respect to interferers and the desired signal.

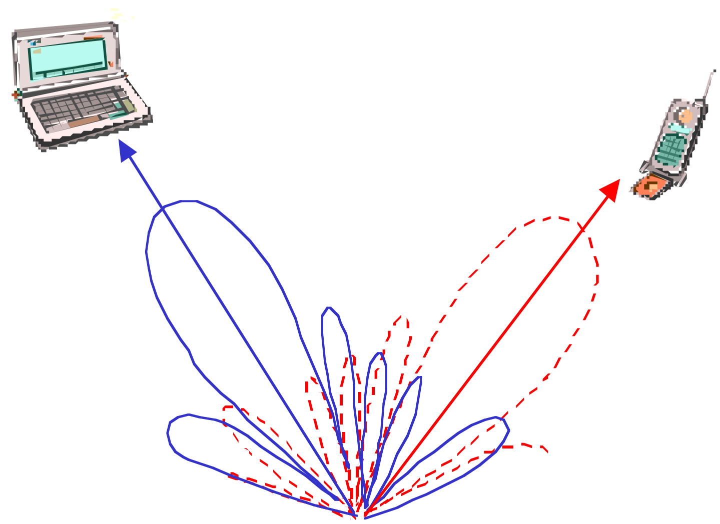

FIGURE 1

Beam forming and interference cancellation

For detailed information about AA, please refer to [1-11].

The direct effect of AA on coexistence, however, is due to the fact that the RF energy radiated by transmitters is focused in specific areas of the cell and is not radiated in all directions. Moreover, beamforming with the goal of maximizing the link margin for any given user inside the cell coverage area at any given time makes the AA beams' azimuth and elevation vary from time to time. Given the differences in height and surrounding environment of the base and subscriber station antennas, chances for main-beam coupling as depicted in figure 2, are greatly reduced. These factors suggest that, in simulating the coexistence, the adaptive antenna pattern and gain need to be considered as random variables both in E- and H-plane. This characteristic plays a major role in determining the likelihood of interference in coexistence scenarios. While an absolute worst case may look prohibitive, the statistical factor introduced by the use of AA determines the percentage of time that the worst case happens. If this percentage is satisfactorily small, the coexistence rules may be relaxed, thus helping the economics of the wireless deployment.

Co-channel – Adjacent Area

If one or both operators in adjacent areas use adaptive beamforming antennas at their base stations, the cross-border interference can be greatly reduced due to null-steering capabilities of such antennas. It should be noted that an M-element array is capable of suppressing up to M-1 interferers as long as they can be spatially separated from the wanted users. The main source of serious interference in co-channel adjacent area situations, however, is main beam coupling when wanted and interfering signals cannot be spatially separated. As an example, the SS-to-BS interference due to main-beam coupling is depicted in figure 2. This phenomenon, which happens irrespective of the types of antennas used, could create more severe interference power when the victim BS is using AA. This is due to the typically higher gain of the AA beams compared to a conventional wide-sectored antenna. An M-element array could produce an additional $10\log_{10}(M)$ dB of gain towards the intended users through spatial processing that may affect the co-channel stations of the other system. However, due to the statistical factor introduced by the AA, the likelihood of this scenario occurring is greatly reduced compared to the case with conventional antennas. Simulation results confirm this. In the case of uplink beamforming at the base station (AA being the victim), spatial signatures used in the process are uniquely attributed to the propagation environment surrounding the intended user and could be significantly different from that of an interfering station miles away in the adjacent service area, thus being affected by less or no additional gain from the interferer.

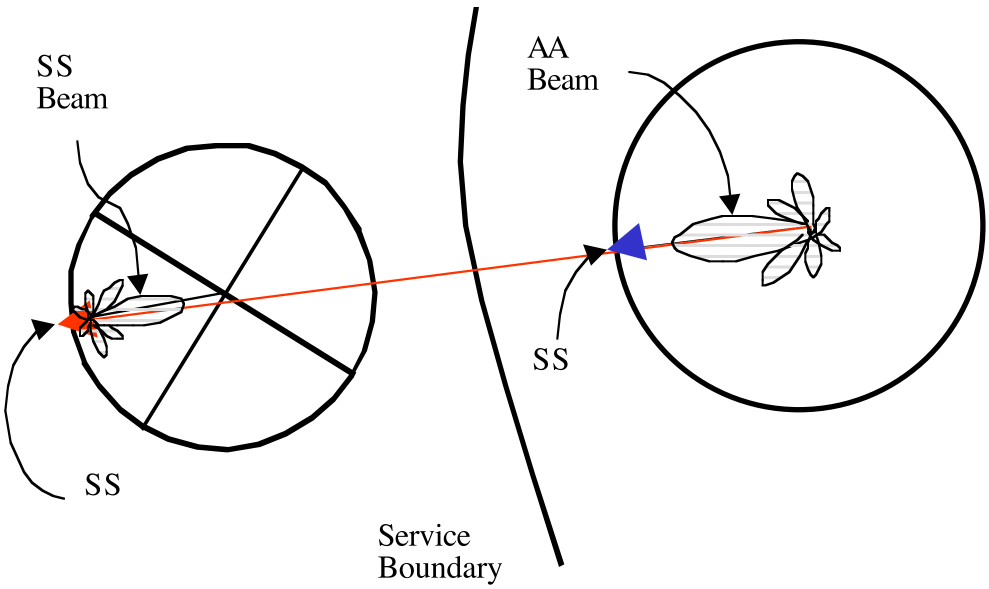

FIGURE 2

Main beam coupling

Same Area – Adjacent Channel

The introduction of a statistical factor in the creation and reception of interference power also helps coexistence in the same area – adjacent channel case. In this case, the uplink of the AA may be affected more than the co-channel, adjacent area case due to the fact that in same area the intended user and the interferers could be much closer to each other, thus producing spatial signatures with higher degree of correlation. On the other hand, the additional array gain of the AA is reduced because of the loss of baseband coherency in its out-of-band operation. Therefore, although in this case the distances between interferers and victims are smaller, the reduction in the main beam gain of the AA further reduces the interference power into AA from other antennas operating in adjacent bands and vice versa. All simulations point to the fact that the BS-to-BS direct antenna coupling is the most problematic case for coexistence. With the use of AA, the loss of coherency in out-of-band operations reduces the gain towards the interferers/victims, thus lowering the amount of interference power.

Suggested Reading

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