Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Multi-user MIMO using non-orthogonal superposition in downlink**
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Re:	SDD Session 56 Cleanup; in response to the TGm Call for Contributions and Comments 802.16m-08/033 for Session 57
Abstract	SDD text proposal for MU-MIMO using non-orthogonal superposition in DL
Purpose	Consider for inclusion into the SDD
Notice	
Release	
Patent Policy	

Multi-User MIMO Using Non-orthogonal Superposition in Downlink

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Motivation

From the two-user rate region it can be seen that significant throughput gains can be achieved with non-orthogonal superposition (point B) compared to single-user operation (points A_1 and A_2) or TDMA, FDMA (straight line connecting points A_1 and A_2).

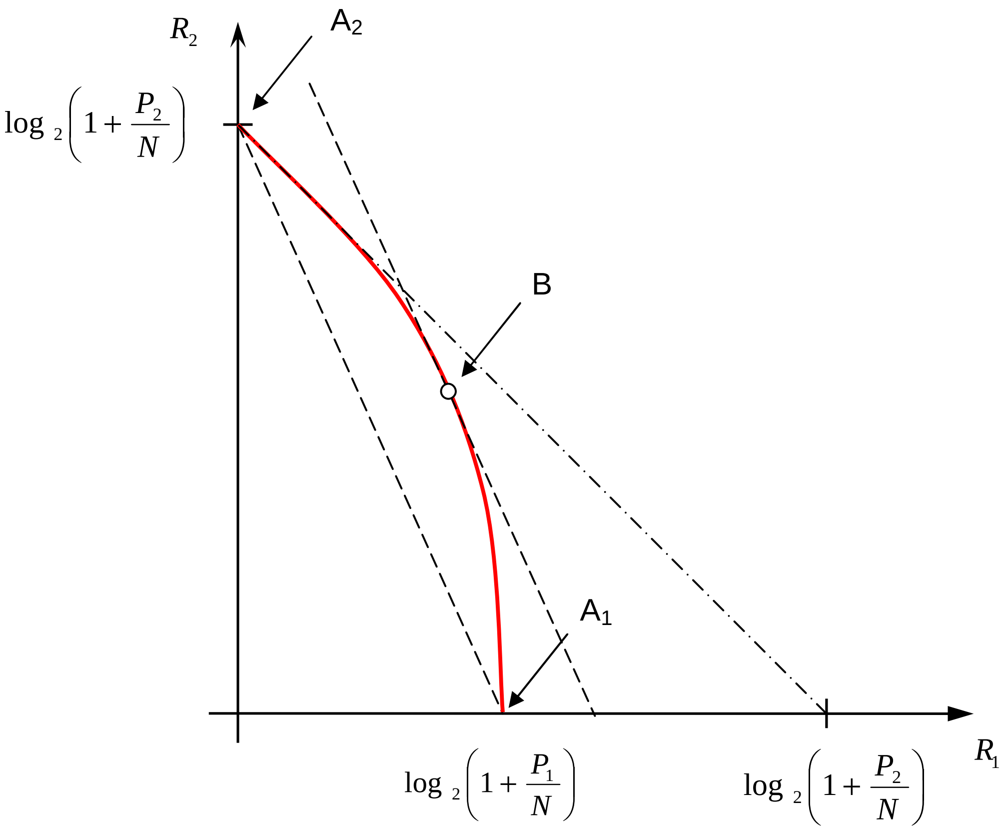

Figure 1: Two-user achievable rate region for superposition in downlink

Principles of Non-Orthogonal Superposition

- Signals for different users are not orthogonal; neither in time or frequency nor in the space or code domain
- Transmit signal on a time-frequency allocation is a weighted sum of the signals for different users
- Signals can be separated by multi-user detection, especially sucessive interference cancellation
- Typically the signals for different users have significantly different power levels
- No instantaneous channel state information CSI required at transmitter
- Can be used with single or multiple antennas

If the base station transmits a superposition (sum) of two uncorrelated signals that are neither orthogonal in time or frequency nor in space and arrive at a receiver with power P_1 and P_2, each signal is interference to the other signal. If the signals are Gaussian distributed, both signals can be detected by single-user detectio, if the assigned data rates are below the capacities

$$\log_2\left(1+\frac{P_1}{P_2+N}\right) \quad \text{and} \quad \log_2\left(1+\frac{P_1}{P_2+N}\right),$$

where N is the noise power. When successive interference cancellation is used and signal 1 is detected first, the rate has again to be smaller than

$$\log_2\left(1+\frac{P_1}{P_2+N}\right),$$

but the rate of the second signal can be up to

$$\log_2\left(1+\frac{P_2}{N}\right),$$

because the first signal, which has already been decoded, can be subtracted from the sum signal before detecting the second signal.

This means that different “superposition layers” can be separated and decoded, although they are neither orthogonal in time or frequency, nor in space. The different superposition layers can be decoded by different users at different locations. Depending on the relative noise level, only the upper layer or both layers can be decoded.

On the system level, throughput gains up to about 50% can be achieved by sharing radio resources among users with different channel characteristics. Typically, resources that are assigned to a user with high path loss using a low modulation scheme can be shared with a second user with lower path loss.

Practical Implementation

- Superimposed signals can be coded/modulated using conventional modulation and coding schemes
- Simple e.g. two-user SIC receiver in the MS is sufficient for detection and separation of the superimposed signals

Simulation Results

According to the following figures, the performance loss due to compensation errors in the interference cancellation receiver can be kept small.

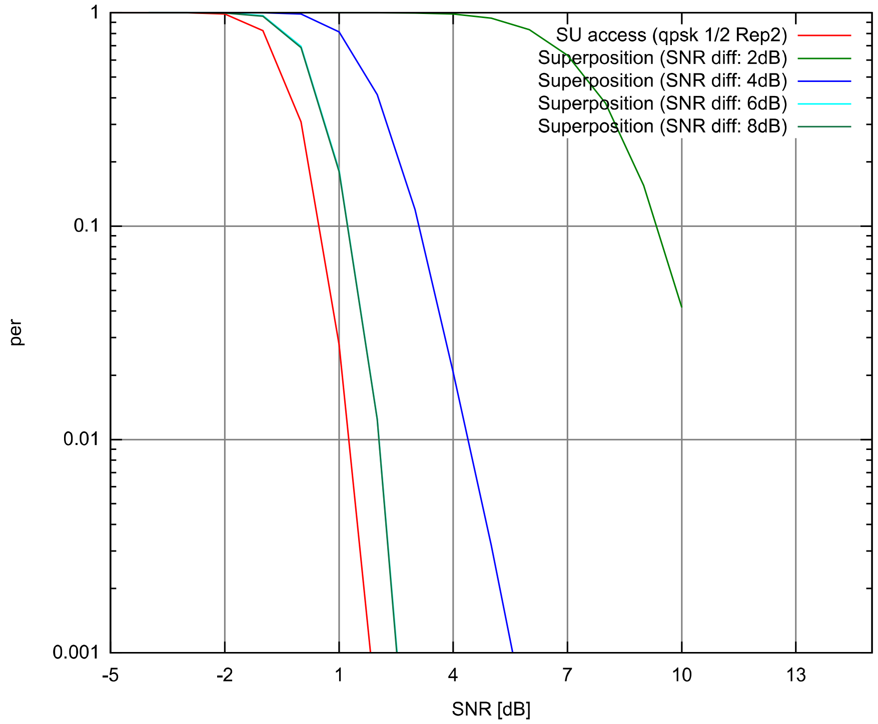

Figure 2: Packet error rate (per) vs. SNR with and without superposition in an AWGN channel

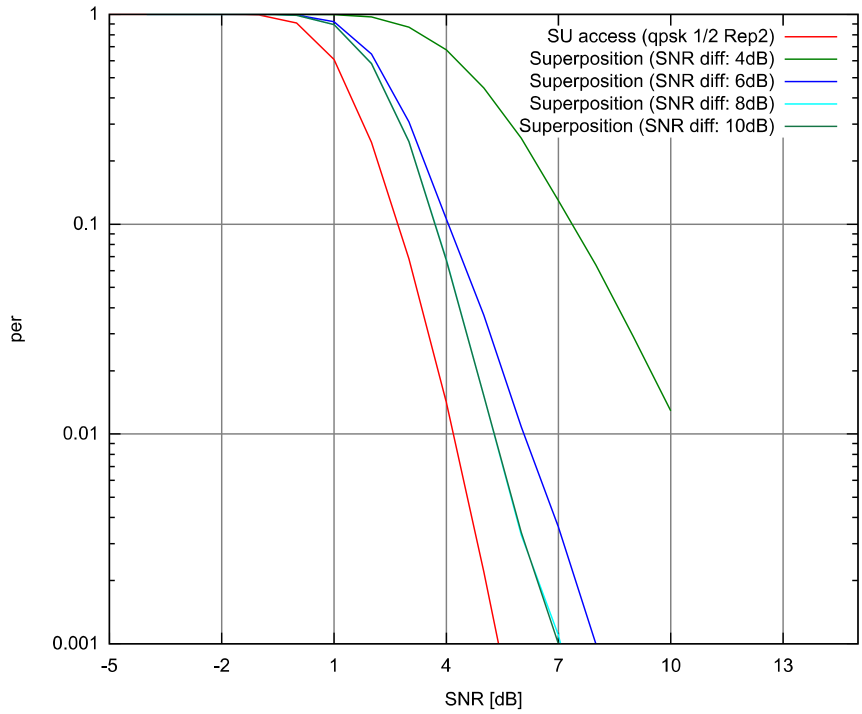

Figure 3: Packet error rate (per) vs. SNR with and without superposition in a frequency selective channel (Ped B 3 km/h)

Proposed SDD Text for Section 11.8.2.2.1

Add at the end of line 11 on page 73:
"Non-orthogonal superposition, which is a special kind of non-unitary precoding, is supported."