Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Improvements in System Performance due to simultaneous transmission of E-MBS and Unicast**
Date Submitted	**2008–05-05**
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Re:	802.16m-08/016r1: Call for SDD Comments and Contributions – Downlink MIMO Schemes
Abstract	We propose and analyze a novel broadcast/unicast superposition and interference cancellation approach in a MIMO system. The proposed approach superimposes the multi-stream broadcast signal over a multi-stream unicast signal and cancels the broadcast signal before unicast demodulation and decoding. Using this approach, the broadcast interference to unicast traffic from own cell and neighboring cells can be eliminated improving the overall system capacity and efficiency by making full system bandwidth available to both unicast and broadcast traffic.
Purpose	To discuss and adopt the superposition coding scheme for broadcast and unicast symbols into 802.16m SDD .
Notice	
Release	
Patent Policy	

Improvements in System Performance due to simultaneous transmission of E-MBS and Unicast

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Introduction

The 16m System Requirement Document [1] targets significant improvements to the spectral efficiency of unicast and broadcast traffic. In particular, the spectral efficiency target for unicast traffic in 16m for both average and cell edge user is 2 times the WirelessMAN-OFDMA reference system. For the enhanced multicast broadcast service (E-MBS), the requirements are 4bps/Hz and 2bps/Hz at 0.5km and 1.5km inter-site distances respectively.

As noted in [1], the performance requirements for E-MBS apply to a wide-area multi-cell multicast broadcast single frequency network (MBSFN). A single-frequency network (SFN) operation can be realized for broadcast traffic transmitted using OFDMA from multiple cells with timing errors within the cyclic prefix length. In the presence of SFN operation, the broadcast SINR can be very high particularly for smaller cells deployments.

In this contribution, we present a scheme that can provide significant performance improvements for the downlink spectral efficiency by carrying E-MBS and unicast traffic on the same resources.

Motivation for simultaneous transmission of Unicast/E-MBS symbols and interference cancellation

The proposed approach superimposes the E-MBS signal over the unicast traffic at the base station (BS) and cancels the E-MBS signal before unicast demodulation and decoding at the mobile station (MS). The resource for the E-MBS signal is derived from the excess unicast power available in interference limited scenarios. Thus, the unused power is transformed into useful capacity by superposition coding of unicast and E-MBS signals. The superposition at the BS and interference cancellation operation at the MS is illustrated in Figure 1 and Figure 2 respectively.

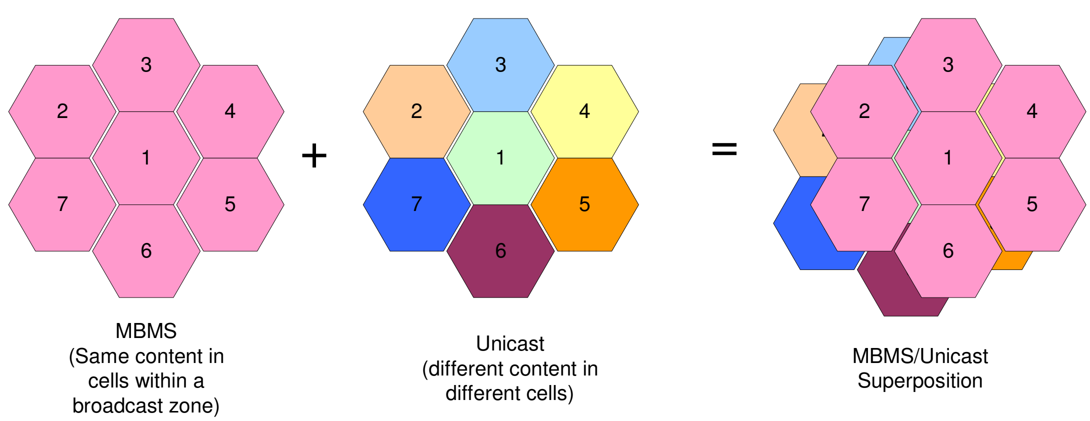

Figure 1: E-MBS/Unicast Superposition at BS

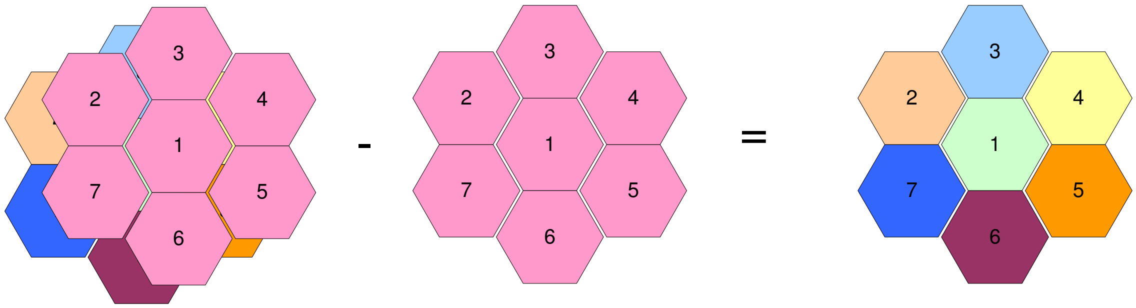

Figure 2: E-MBS/Unicast Interference Cancellation at MS

We first demonstrate that excess power is available at the base station carrying only unicast traffic and operating in interference limited situation. The Geometry or SINR for unicast traffic can simply be written as,

$$SINR_{unicast} = \frac{P}{fP + N_0},$$

where f represents the ratio between other-cell and own-cell signal. f in general, is larger for users at the cell edge. In an interference limited situation as is the case for most cellular micro-cell deployments, $fP >> N_0$. Therefore, increasing power P does not help in improving the unicast SINR.

However, in case of broadcast traffic using OFDM, the signals received from multiple synchronized base stations are combined in the air as long as the relative delays of the received signals are within the OFDM symbol cyclic prefix length. Therefore, there is no interference when the same broadcast content is transmitted system-wide apart from the background noise. The average SINR in an OFDM-based broadcast approach is then given as,

$$SINR_{broadcast} = \frac{KP}{N_0},$$

where K is the number of base stations from which broadcast content is received assuming equal received power from all K BSs. Note that the transmit power results in linear increase (within practical receiver limits) of broadcast SINR.

The broadcast and unicast Geometry or SINR for various values of base station transmit power are shown in Figure 3 for an interference limited situation with 2 Km cell-site to cell-site distance without assuming any additional path loss. It can be observed that increasing transmit power does not change the unicast SINR. However, increasing transmit power for broadcast traffic result in linear increase in broadcast SINR. The above discussion indicates that the overall system spectral efficiency can be improved if broadcast and unicast traffic are transmitted simultaneously and power is shared between the two traffic types [1]. The power allocated to the unicast traffic can be lowered without affecting the unicast SINR. The additional available power can then be allocated to broadcast traffic. The E-MBS/Unicast superposition and interference cancellation approach can be viewed in two different ways:

- The E-MBS signal is transmitted over the unicast resources without affecting unicast performance while allowing for additional "free" capacity for E-MBS as illustrated in Figure 4.

- As depicted in Figure 5, we can transmit additional unicast traffic in parallel with broadcast on resources reserved for broadcast. Significant unicast capacity advantage can be obtained with little or negligible reduction in E-MBS capacity.

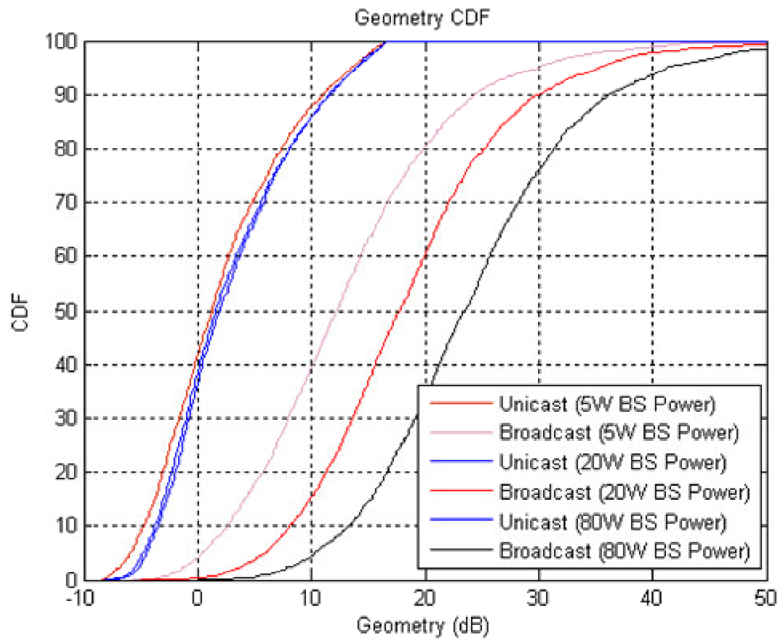

Figure 3: Unicast and Broadcast Geometry for various BS transmit powers

The broadcast superposition and interference cancellation approach allows to trade-off power allocation between unicast and broadcast traffic for certain performance and capacity targets. A similar power allocation strategy is also possible when broadcast and unicast traffic are frequency multiplexed using OFDM. However, in this case, the frequency resource needs to be shared between broadcast and unicast traffic as well. However, in the proposed approach full frequency resource is available to both broadcast and unicast.

It should be noted that MSs receiving only E-MBS traffic need not be aware of the underlying unicast traffic because E-MBS simply assumes unicast transmission as background interference. Also, unicast traffic can be transmitted in parallel with E-MBS on a E-MBS separate carrier if such an approach is employed. The scheme provides the flexibility to schedule only interference cancellation capable MSs to receive such superimposed traffic. The MSs that are incapable of interference cancellation can be scheduled on resources orthogonal to those used for E-MBS traffic.

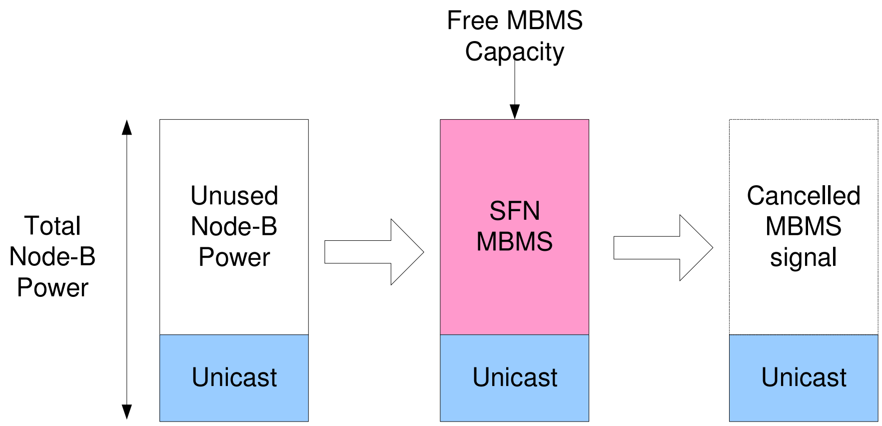

Figure 4: The E-MBS signal transmitted over the unicast resources without affecting unicast performance while allowing for additional "free" capacity for E-MBS

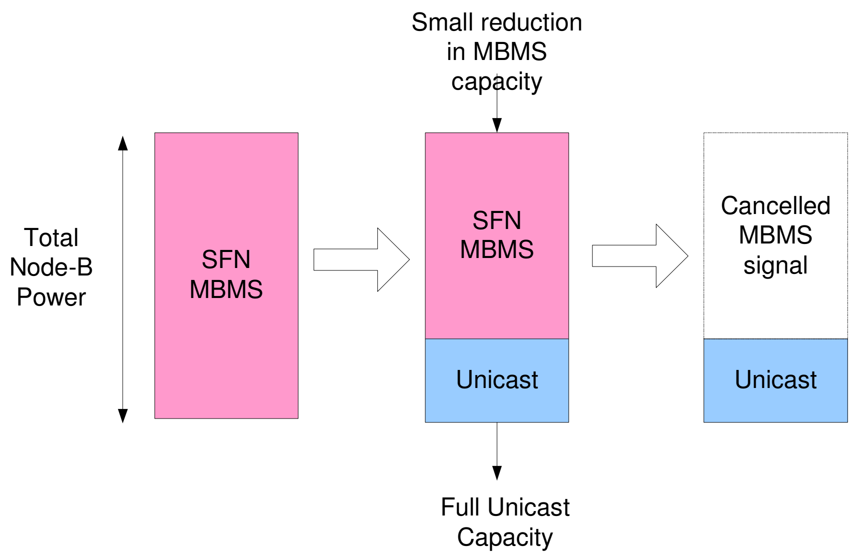

Figure 5: Additional unicast traffic transmitted in parallel with E-MBS providing significant unicast capacity advantage with little or negligible reduction in E-MBS capacity

Methodology for Unicast/E-MBS superposition

Superposition Transmission from the BS

The E-MBS signal is linearly superimposed on the unicast signal in the frequency-domain before IFFT at the BS as shown in Figure 6. The total transmit power at the BS is shared between the broadcast and the unicast traffic by appropriately selecting the gain factors g_b and g_u for E-MBS and unicast signals respectively. The broadcast and unicast streams may be scrambled by a stream specific scrambling code. The signal is then mapped to OFDM subcarriers at the input of IFFT. It should be noted that both E-MBS and unicast traffic use the same set of subcarriers thereby requiring no additional orthogonal resources. The power ratio g_b/g_u for superposition can be semi-statically configured to depend on available power and the desired data rate.

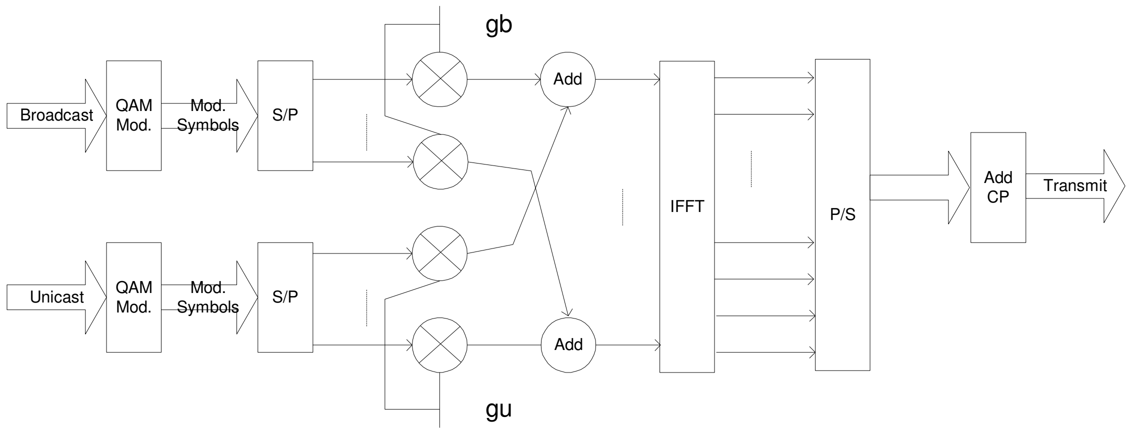

Figure 6: An example of E-MBS/Unicast superposition

Interference Cancellation at the MS

The receiver operation for a MS receiving superimposed E-MBS and Unicast traffic is shown in Figure 7. An FFT operation is performed on the received signal after discarding the cyclic prefix (CP). The frequency domain samples of the signal are then buffered for further processing. The broadcast data is first demodulated and decoded using channel estimates via E-MBS reference signals. The broadcast reference signals are transmitted using the same time-frequency positions and the same scrambling code from all the BSs in a broadcast zone. This provides for an overall composite channel estimate for the signal received from multiple base stations transmitting the same content in the broadcast zone. The successfully decoded broadcast data block signal is then reconstructed using the broadcast channel estimates. The reconstructed broadcast signal is cancelled from the overall received signal. The reconstruction of the broadcast signal using the overall composite channel estimate assures that all the broadcast interference including broadcast interference from neighboring cells to the unicast traffic is cancelled. This results in a clean unicast signal that is free from any broadcast interference. This clean unicast signal is then further processed for unicast traffic demodulation and decoding.

Some of the known challenges of using interference cancellation at the MS like higher error rate operation due to Hybrid ARQ and error propagation do not directly apply to broadcast signal cancellation as described above. The primary reason for this resilience is attributed to the availability of the E-MBS information at all users in the system with very high reliability i.e. the target block error rate on the broadcast traffic is 0.1-1%. It should be noted that broadcast generally does not use hybrid ARQ and therefore operate at very low FER target. Therefore, the broadcast signal can be effectively reconstructed and cancelled given that good channel estimates are available. Since a single broadcast stream is cancelled, the complexity of the proposed approach is also moderate. Thus, canceling an E-MBS signal offers attractive features from the complexity and robustness point of view.

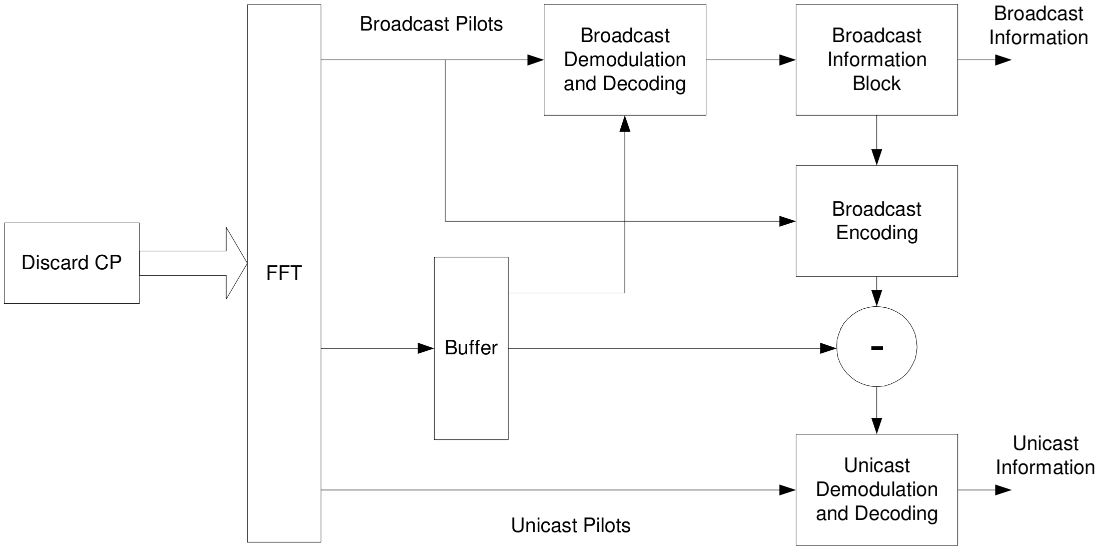

Figure 7: Unicast MS operation for E-MBS/Unicast Interference cancellation

Spectral Efficiency

The capacity for E-MBS with E-MBS/unicast superposition and interference cancellation can be written as,

$$C_{E-MBS} = \log_2\left(1 + \frac{\sum_i P_{Bi}}{\sum_i P_{Ui} + N_0}\right) \quad [b/s/Hz]$$

where i is the number of cells in the system. Broadcast performance is determined by the cell edge users where $\sum_i P_{Ui} >> N_0$, therefore, the broadcast capacity can be approximated as:

$$C_{E-MBS} = \log_2\left(1 + \frac{\sum_i P_{Bi}}{\sum_i P_{Ui}}\right) \approx \log_2\left(1 + \frac{P_B}{P_U}\right) \quad [b/s/Hz]$$

Note that a broadcast to unicast power ratio (P_B/P_U) is selected for a desired broadcast SINR, data rate target and should take into account system parameters like cell morphology, distance between base stations etc., In its simplest form, the broadcast to unicast power ratio is statically configured for each sector in a cell.

The capacity for unicast with broadcast/unicast superposition can be written as,

$$C_{unicast} = \log_2\left(1 + \frac{P_U}{I_B + fP_U + N_0}\right) \quad [b/s/Hz]$$

where I_B is the residual interference due to imperfect interference cancellation. It can be noted that unicast capacity is unaffected if a perfect interference cancellation is achieved i.e. $I_B = 0$. Moreover, the unicast traffic uses Hybrid ARQ and therefore may not be so sensitive to residual interference from broadcast. The important question is then to ask if we are getting broadcast for free. The assumption we made is that additional power is available at the base station that can be converted to useful capacity for SFN-based E-MBS. This additional power was not helping unicast traffic in an interference limited scenario.

Control and Signaling Complexity

In the proposed broadcast superposition and interference cancellation approach, the unicast decoding only happens after decoding the broadcast information. This may represent a significant computing burden on the mobile station processing and battery life if it continuously needs to perform interference cancellation on the broadcast traffic. However, we know that in packet based communications a user receives traffic for short periods of time with large inactivity periods in between. During inactivity periods, mobile only needs to listen to control information such as paging messages and scheduling grants transmitted from the network. Therefore, a system design that minimizes the computation effort for the mobile stations requires that the control information is transmitted on orthogonal OFDM subcarriers as shown in Figure 8. In this way, a mobile who is listening to just the control information does not need to perform interference cancellation of the broadcast traffic. When a traffic transmission happens for a mobile, it is indicated via the scheduling grant. Therefore, a mobile needs to perform interference cancellation of the broadcast signal only when it is receiving unicast traffic transmission. It is also possible to schedule only interference cancellation capable MSs in superposition with E-MBS. The MSs that are not capable of interference cancellation can be scheduled on orthogonal resources to those used for E-MBS. In general, the control and signaling information uses around 20-30% of the system bandwidth leaving remaining 70-80% of the bandwidth for traffic. Therefore, even by using orthogonal subcarriers for control and signaling, the broadcast traffic can be superimposed on a large fraction of the traffic bandwidth.

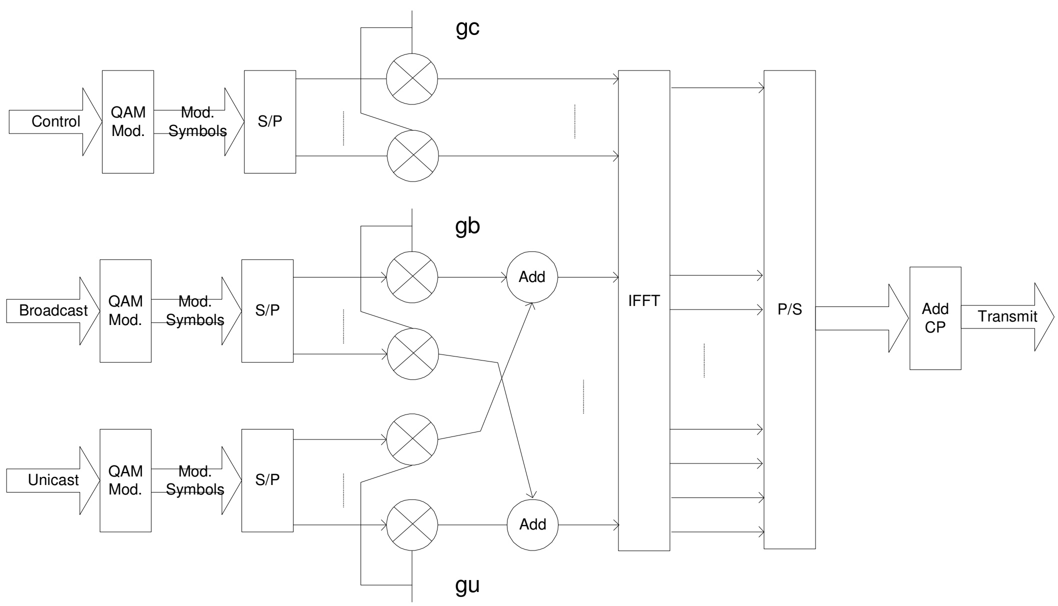

Figure 8: Control information transmission over orthogonal subcarriers

In general, the control and signaling channels do not use Hybrid ARQ and therefore needs to be transmitted with very high reliability on the first transmission attempt. Allocation of orthogonal resources to signaling and control assures high reliability for the critical system control information. The power allocated to control channels can also be adjusted dynamically by controlling the control channel gain factor, g_c as shown in Figure 8.

A Broadcast Information Block is independently coded along with a CRC and is transmitted within a subframe as shown in Figure 9. By using the same subframe for both broadcast and unicast, practically no additional delay is introduced for the unicast traffic as shown in Figure 9. The Unicast decoding starts immediately after decoding of the broadcast information block. It can be noted that use of outer coding such as Reed-Solomon code is still possible for broadcast if needed. It can be noted that some loss of time-diversity for broadcast may occur relative to the case where the broadcast information block may be transmitted over multiple subframes. However, in the broadcast superposition and interference cancellation approach, broadcast traffic benefits from full frequency diversity because the broadcast signal is transmitted over almost the whole system bandwidth making it less dependent upon time diversity.

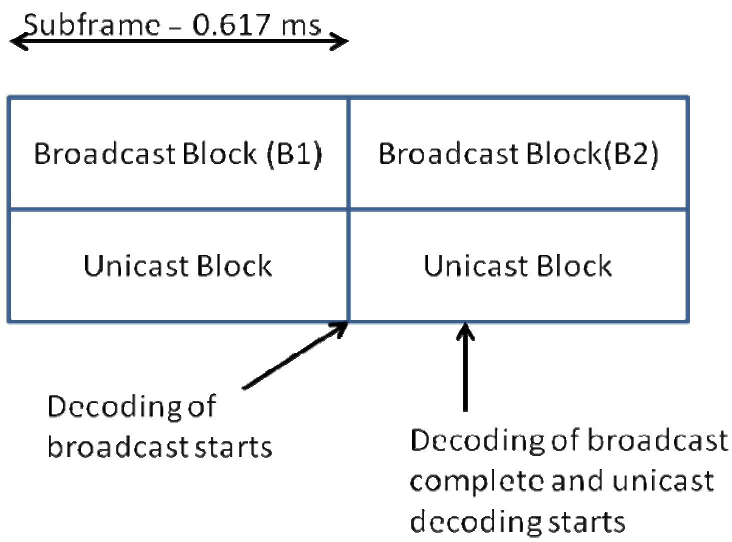

Figure 9: Broadcast and unicast Block decoding

Pilot Design

The broadcast E-MBS data see a composite channel at the MS which is different compared to the unicast traffic. Therefore, broadcast pilots for E-MBS demodulation are defined in addition to the unicast common/dedicated pilots in order to aid successful demodulation. These broadcast pilots are transmitted across sectors using the same time-frequency resources to enable sensing of the composite channel. In contrast, the unicast pilots use different time-frequency resources and power boosting to avoid collision across sectors.

MIMO with Unicast/E-MBS Superposition

The Unicast/E-MBS superposition principle can be easily extended to the MIMO case. Two possible scenarios are shown in Figure 10 and Figure 11. The scenario shown in Figure 10 uses a single-stream transmission for the E-MBS traffic while two-stream MIMO transmission is considered for the unicast traffic. In the second scenario shown in Figure 11, we employ 2-streams transmission for both E-MBS and the unicast traffic.

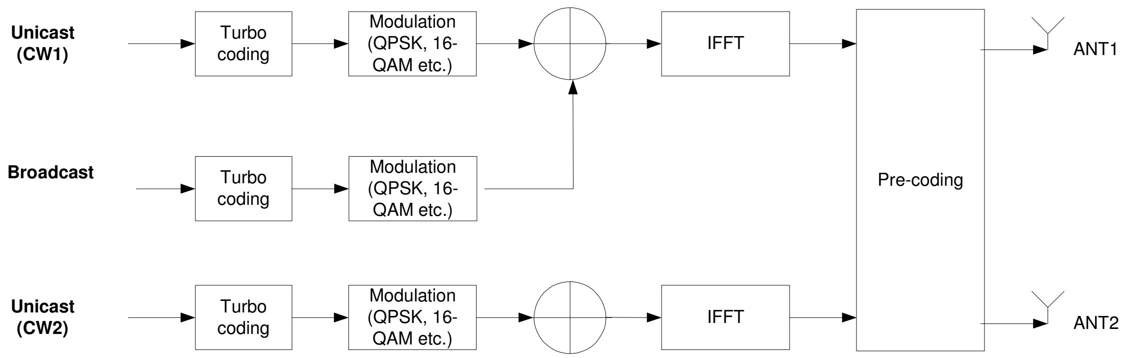

Figure 10: Two-streams for Unicast and a single stream for E-MBS

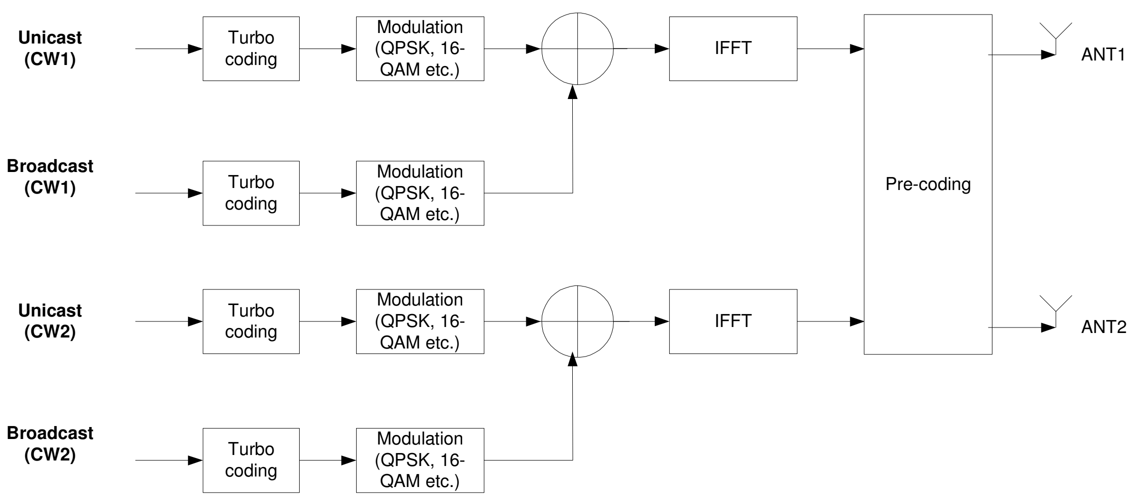

Figure 11: Two-streams for both Unicast and E-MBS

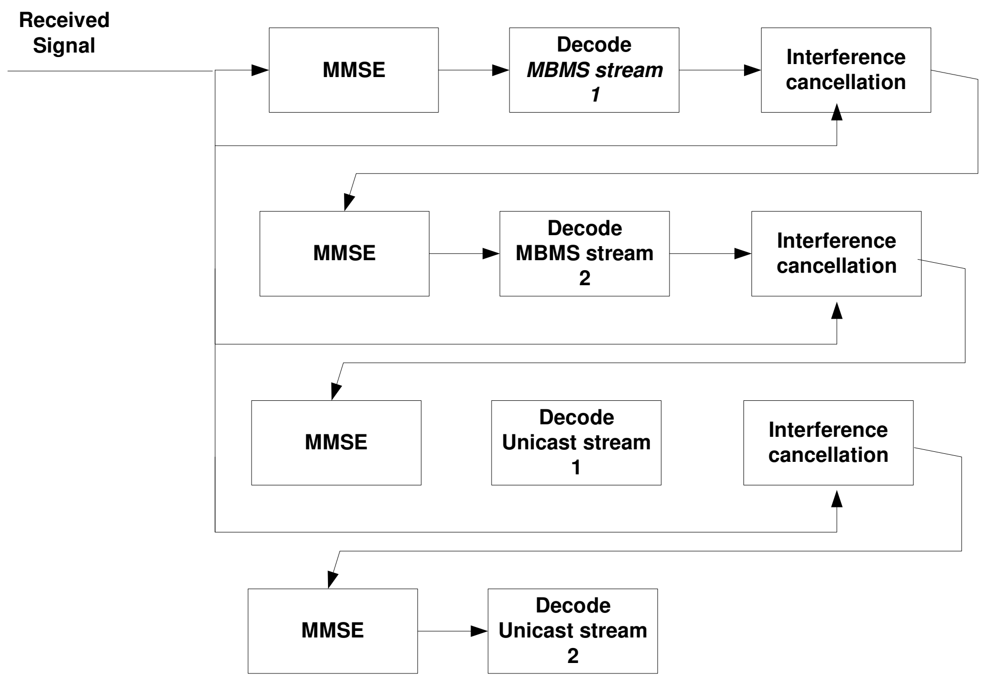

Figure 12: Joint MMSE-SIC MIMO Receiver operation in Unicast/E-MBS Superposition and Interference Cancellation Approach

Receiver Operation for MIMO

The joint MMSE-SIC MIMO receiver operation for the case of two-stream transmission for both unicast and E-MBS is shown in Figure 12. It should be noted that a total of three interference cancellation operations are required in this case. In case of single-stream E-MBS transmission and 2-stream unicast transmission, two cancellation operations are performed. In case of single-stream transmission for both unicast and E-MBS, a single interference cancellation operation is performed. Therefore, it is expected that with the proposed scheme, some additional processing would be required to decode both E-MBS and unicast traffic. However, buffering required for cancellation will about the same as in a MIMO PARC interference cancellation approach even when multiple interference cancellation operations are performed.

Link Performance

Simulation Assumptions

The link parameters are provided in Table 1. We consider up to 2x2 MIMO for both E-MBS and unicast. We used an MMSE-SIC Receiver shown in Figure 12. The MIMO Pre-coding consists of a fixed Fourier-based pre-coding matrix. Furthermore, we assume localized transmissions consisting of eight consecutive resource blocks. The Hybrid ARQ for unicast is based on simple Chase combining. The MCS for unicast is selected based on effective SINR and AWGN curve look-up. The MCS for E-MBS is fixed as QPSK 2/3 coding rate which provides a spectral efficiency of 1.33 b/s/Hz for the single-stream transmission and 2.66 b/s/Hz for the two-stream MIMO transmission case. It should be noted that it may be possible to support a higher data rate using, for example using 16-QAM modulation, for E-MBS in Unicast/E-MBS superposition scheme under the assumption of 10dB power ratio (P_b/P_u) between E-MBS and unicast traffic.

Table 1: Link Simulation Assumptions

Parameter	Value
DL Modulation	QPSK, 16-QAM,
Coding for data channel	Turbo, ½, 2/3, 4/5
Non-ideal receiver functions	Ideal and noisy channel estimates
Subframe duration	0.5ms
Transmission BW	10MHz
Usable subcarriers	600
CP Length	Short
Number of OFDM symbols per subframe	5 (data) + 2 (pilot)
RB size	25 tones, 1 sub-frame
Block size	FEC block fills up 8 resource blocks.
Turbo-Decoding	Max-Log, 8 iteration
HARQ	Symbol-level Chase Combing/ Maxi Re-trans. =3
Target PER	1 %
MCS selection	Dynamic based on CQI feedback
Carrier Frequency	2 GHz
Channel model	SCM for Unicast Composite channel consisting of a set of 3-SCM channels for E-MBS
Antenna Configuration	10 wavelength spacing
MS speed	3km/h
Precoding	Unitary
CQI delay	10 TTI (3km/hr)
Broadcast to unicast power ratio (Pb/Pu)	10dB
Receiver	Jointly MMSE and SIC

Link Performance Results

In all the link results, we provide link spectral efficiency [bps/Hz] as a function of unicast SNR. We also assumed a 10dB power ratio (*Pb/Pu*) between E-MBS and unicast traffic. The SINR seen for the E-MBS in the link simulations can be written as:

$$SINR_{E-MBS} = \frac{\left(\frac{P_b}{P_u}\right) \cdot SNR_{unicast}}{SNR_{unicast} + 1}$$

It should be noted that this is a conservative SINR estimate for the E-MBS traffic. For example, when unicast SNR is 0.0dB, the SINR for E-MBS is only 7dB assuming 10dB power ratio (*Pb/Pu*) between E-MBS and unicast traffic. However, we know that in a system level, with 10dB power ratio (*Pb/Pu*) between E-MBS and unicast traffic, the E-MBS SINR will be close to 10dB (=*Pb/Pu*).

The link performance results showing spectral efficiency for E-MBS and unicast as a function of unicast SNR are provided in Figure 13 through Figure 15. The MCS for E-MBS is fixed as QPSK 2/3 coding rate which provides a spectral efficiency of 1.33 b/s/Hz for the single-stream transmission and 2.66 b/s/Hz for the two-stream MIMO transmission case. It should be pointed out that with *Pb/Pu* power ratio of 10dB assumed in the simulations; the maximum SINR for E-MBS is limited to 10dB. It can be noted that unicast performance is unaffected when E-MBS signal is superimposed over unicast and cancelled before unicast decoding.

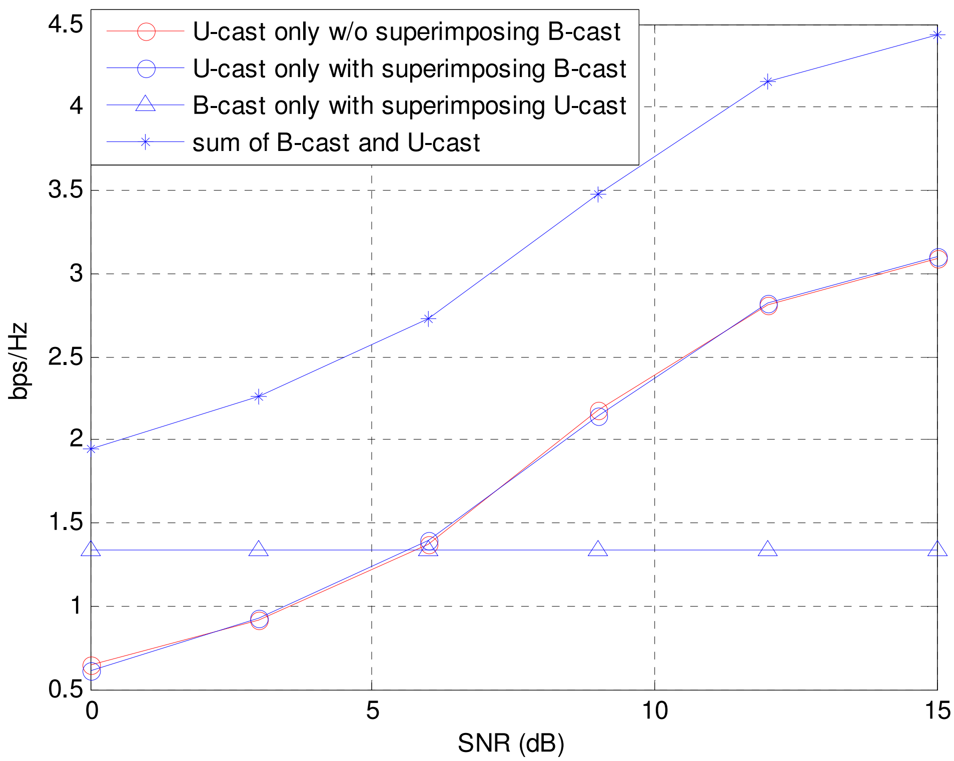

Figure 13: Link Performance with single stream superposition of both unicast and E-MBS as shown in Figure 6

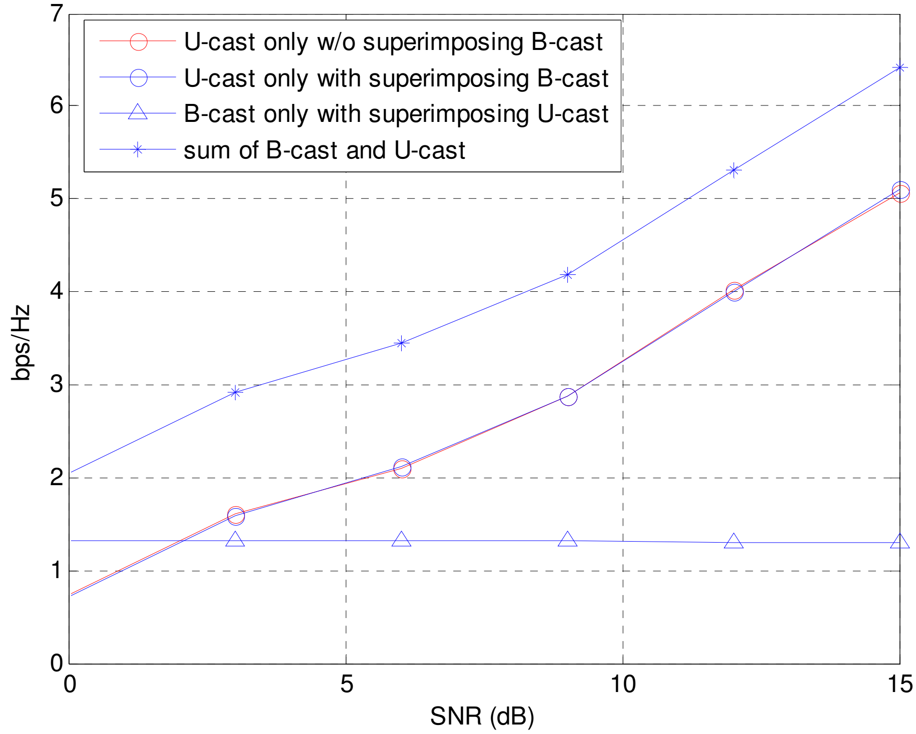

Figure 14: Link Performance with two stream unicast and one stream E-MBS as shown in Figure 10

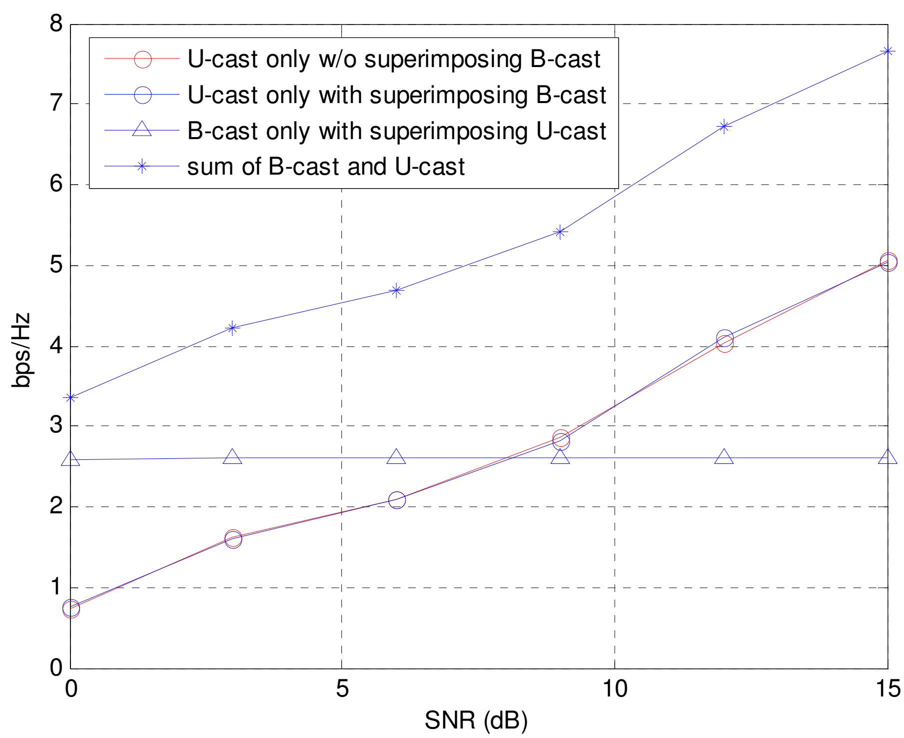

Figure 15 Link Performance with two streams for both unicast and E-MBS as shown in Figure 11

Link Performance with Channel Estimation Error

In this section, we provide link performance with channel estimation error. Since the reference signal structure for multi-cell E-MBS is yet to be finalized in 802.16m SDD, we provide some initial assessment of channel estimation error impact by assuming noisy channel estimates with estimation error of -15dB. It should be noted that since E-MBS to unicast power ratio of 10dB is assumed in the simulations, the channel estimates for E-MBS are assumed to be 10dB better than the unicast channel estimates. Moreover, as the unicast SNR is increased, the channel estimates also become more accurate. This is to model the case where users closer to the cell at higher Geometry have generally better channel estimates than the users at the cell edge. The channel estimation error affects both E-MBS and unicast demodulation and decoding performance. Also, the channel estimates affect the interference cancellation of the E-MBS signal because the E-MBS signal is reconstructed based on the noisy channel estimates. Both of these effects are captured in the link simulations.
The link performance with channel estimation error is shown in Figure 16, Figure 17 and Figure 18 respectively. It can be noted that there is slight degradation in unicast performance due to imperfect cancellation of the E-MBS signal resulting from the noisy channel estimates.

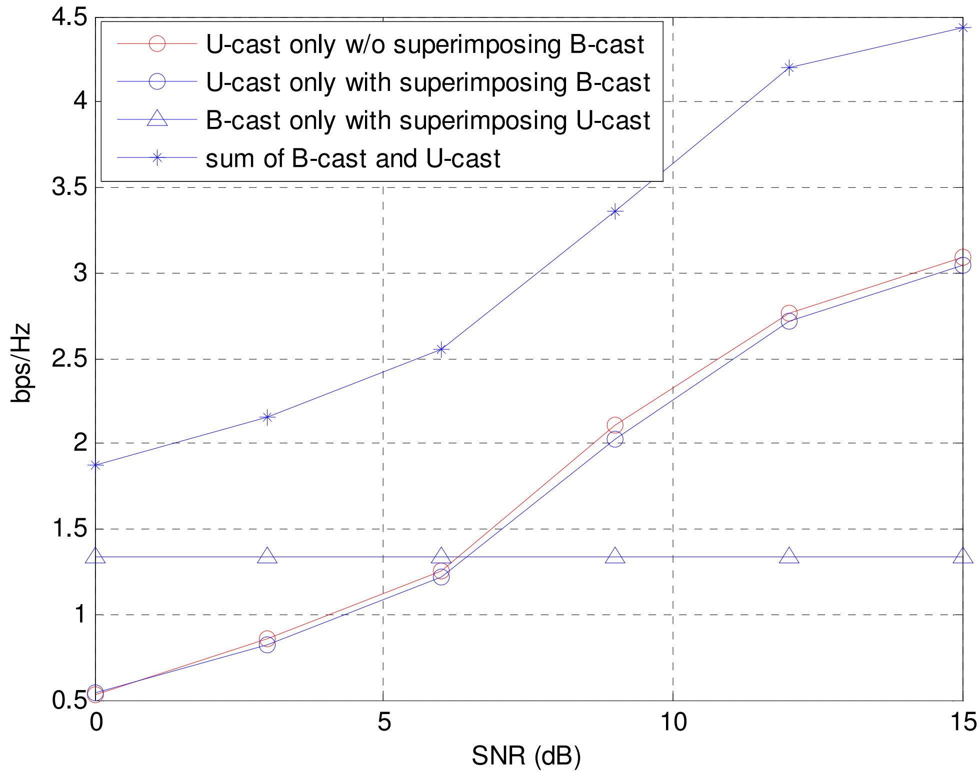

Figure 16: Link Performance with channel estimation error for a single stream superposition of both unicast and E-MBS as shown in Figure 6

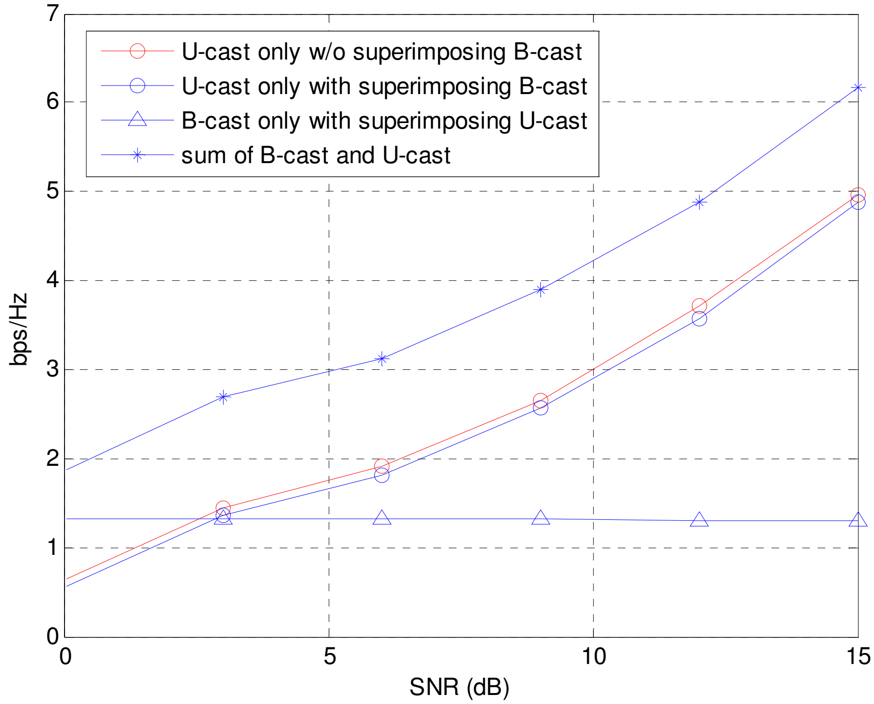

Figure 17: Link Performance with channel estimation error for 2-stream unicast and 1 stream E-MBS as shown in Figure 10

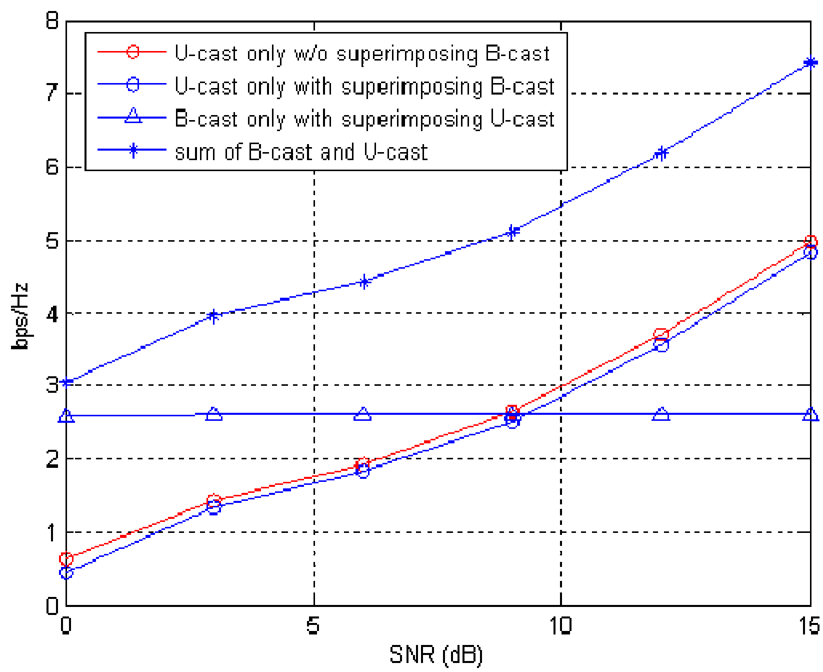

Figure 18: Link Performance with channel estimation error two streams for both unicast and E-MBS as shown in Figure 11

System Simulation Results

Simulation Assumptions

We simulated the following two cases.

1. A Baseline case of 1 BS transmit antenna and each MS having 2 receive antennas

2. A PARC type Unicast scheme where the BS has 2 transmit antennas and each MS having 2 receive antennas with full MCS selection and rank adaptation on the unicast traffic.

The detailed system parameters are provided in Table 2 below.

Table 2: System Simulation Assumptions

Parameter	Value
Unicast DL Modulation	QPSK, 16-QAM, 64 QAM
Coding for Unicast	Turbo, 1/3, ½, 2/3, ¾, 4/5
Broadcast MCS	1x2: 16-QAM with rate 1/2 code rate 2x2: QPSK with 2/3 code rate
Receiver functions	Ideal channel estimation, Ideal SIC
Subframe duration	0.5ms
Transmission BW	10MHz
Usable subcarriers	600
MIMO Receiver	2x2 PARC (MMSE+SIC)
Number of OFDM symbols per subframe	5 (data) + 2 (pilot)
RB size	25 tones, 1 sub-frame
Base Line	1x2
Broadcast to Unicast Power Ratio	10dB
Number of MS's per sector	10
Unicast HARQ	Symbol-level Chase Combing/ Max. RTX. =6
Target PER	10 %
Carrier Frequency	2 GHz
Channel model	SCM
Antenna Configuration	10 wavelength spacing
MS speed	3km/h
Precoding	Unitary
CQI delay	3 TTI (3km/hr)
Control Channel Overhead	29%

System Simulation Results

The simulation results are summarized in Table 3. The results are for spectral efficiency of sector throughput in bps/Hz. Note that the addition (superposition) of the E-MBS signal on top of the unicast signal does not have any significant impact on the unicast spectral efficiency. Therefore, we can say that we effectively get the E-

MBS spectral efficiency for "free". In Figure 19 and Figure 20 we show that the cell edge user throughput and fairness is not impacted by the broadcast superposition. It should be noted that when E-MBS to unicast power ratio of 10dB is used and E-MBS signal is cancelled before unicast decoding, this just appears like additional 10dB lower transmit power (or 10dB path loss) for the unicast traffic. In interference-limited situations, this additional path loss has no impact on unicast performance. Note however, that with Unicast/E-MBS superposition, the E-MBS signal needs to be decoded and cancelled first before any unicast can be decoded. Therefore, it is very important that the broadcast FER is very low. We show the FER for different MCS selections on the broadcast channel in Figure 21. In Table 3 we show that this is indeed the case for both the schemes considered where the broadcast FER is less than 1% for QAM16 with ½ coding for 1x2 scheme and QPSK with 2/3 coding for 2x2 scheme.

Table 3: System Throughput (THP) Results in bps/Hz for Case 1

	Unicast THP	**Broadcast THP**	**Total**	**5% User THP**
Base Line w/o E-MBS Superposition	1.90	0	1.90	0.0667
Base Line with E-MBS Superposition	1.89	2	3.89	0.0677
PARC w/o E-MBS Superposition	2.17	0	2.17	0.0708
PARC with E-MBS Superposition	2.16	2.66	4.82	0.0690

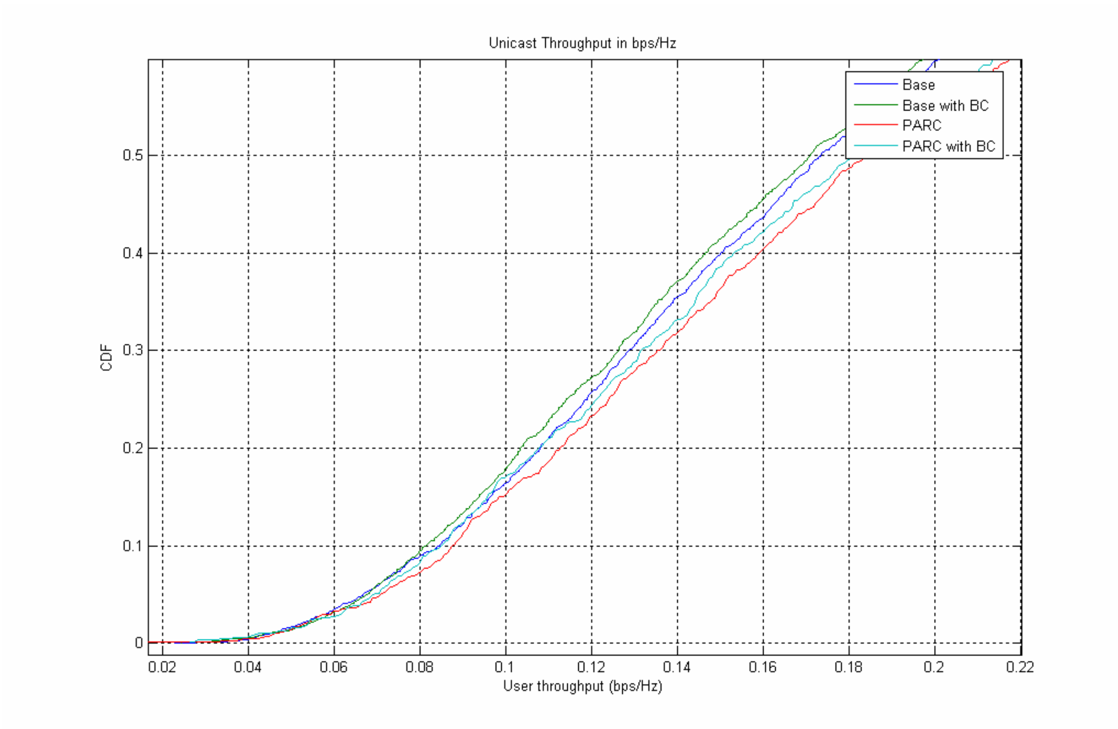

Figure 19: CDF of Unicast User Throughput

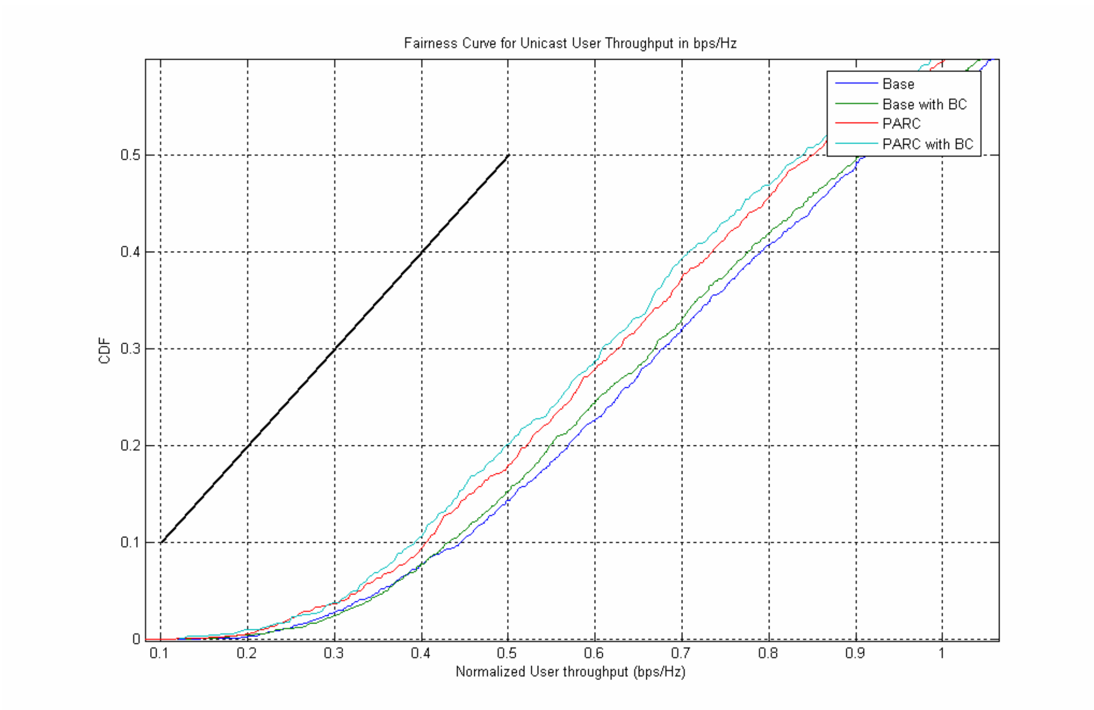

Figure 20: Fairness Curve for Unicast user throughput

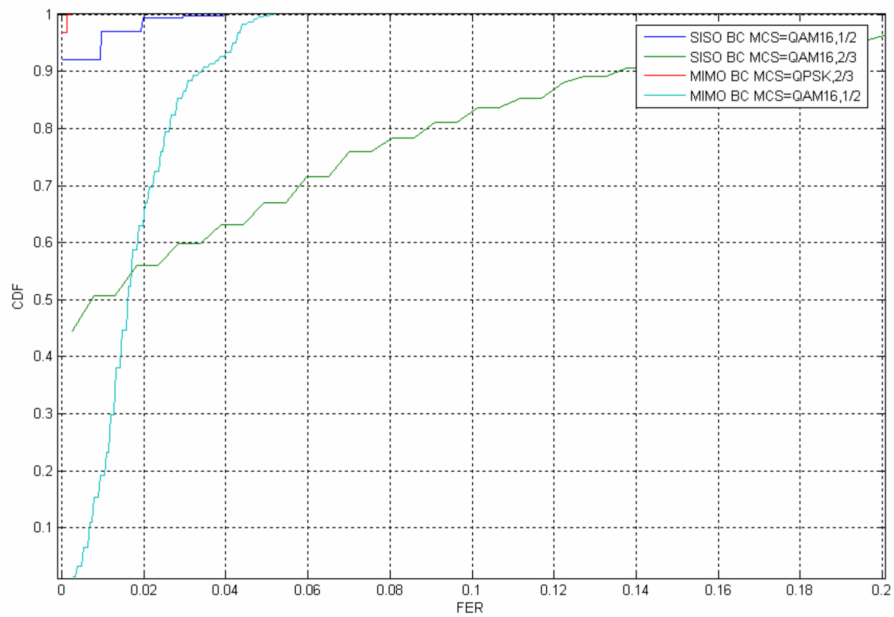

Figure 21: CDF of FER for the 1x2 and 2x2 Schemes, where the E-MBS MCS level is shown

Summary

We described an E-MBS/unicast traffic multiplexing and transmission approach based on superposition and interference cancellation concept. The proposed approach superimposes the broadcast signal over the unicast traffic and cancels the broadcast signal before unicast demodulation and decoding. Using this approach, the broadcast interference to unicast traffic from own cell and neighboring cells can be eliminated in an SFN environment improving the overall system capacity and efficiency.

We noted that E-MBS/Unicast superposition and interference cancellation approach can be viewed in two different ways:

- The E-MBS signal is transmitted over the unicast resources without affecting unicast performance while allowing for additional "free" capacity for E-MBS.
- Additional unicast traffic can be transmitted in parallel with E-MBS on resources reserved for E-MBS. The significant unicast capacity advantage can be obtained with little or negligible reduction in E-MBS capacity.

The scheme also allows to schedule only interference cancellation capable MSs in superposition with E-MBS. The MSs that are not capable of interference cancellation can be scheduled on orthogonal resources to those used for E-MBS. In terms of MS complexity, some additional processing would be required to decode both E-MBS and unicast traffic. However, the buffering required for interference cancellation would be about the same as in, for example, a MIMO PARC interference cancellation approach.

We presented link performance of the Unicast/E-MBS superposition and interference cancellation scheme for improving downlink spectral efficiency of the 802.16m system. The following observations can be made from the link simulations:

- Under the assumption of ideal channel estimates, unicast performance is unaffected when E-MBS signal is superimposed over unicast signal and cancelled before unicast decoding. This is true for both the single stream transmission for E-MBS and unicast and also multi-layer MIMO transmissions.

- Under noisy channel estimates, there is slight degradation in unicast performance due to imperfect cancellation of the E-MBS signal. However, significant overall performance improvements are observed in this case as well.

We also performed system simulations to determine the spectral efficiency improvement by Unicast/E-MBS superposition and interference cancellation. In particular, we noted that for simulation, 2b/s/Hz spectral efficiency for E-MBS in the 1x2 system can be achieved without impacting the performance of the unicast traffic.

Proposed Text for 16m SDD (802.16m-08/003r1)

Incorporate the following text in Chapter 15: Enhanced Multicast Broadcast Service of the SDD:

To improve system resource utilization and capacity, super-impose unicast traffic with E-MBS traffic for the MSs capable of interference cancellation. The available power can be dynamically allocated between unicast and E-MBS data to enable superposition. This superposition of unicast with E-MBS shall support both single codeword and multiple codeword MIMO transmissions. For the MSs that do not support interference cancellation, unicast and E-MBS traffic shall be scheduled on orthogonal resources.

References

[1] IEEE 802.16m-07/002r4, “IEEE 802.16m system requirements”

[2] F. Khan, “Broadcast Overlay on Unicast via Superposition Coding and Interference Cancellation,” *IEEE VTC-2006 Fall Conference*, Montreal, Canada, September 2006.