

Performance Evaluation of MIMO Schemes based on IEEE 802.16m Technology

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Abstract— The performance evaluation of the MIMO transmission schemes based on the IEEE 802.16m technology by the system level simulation is conducted in this paper. IEEE 802.16m technology supports various MIMO transmission schemes. We perform the evaluation of the system by applying various MIMO transmission schemes and compare the results. The evaluation results for each channel can be indicator to select the appropriate transmission method in terms of sector spectral efficiency or user throughput. The system level simulation is based on the ITU-R evaluation guidelines and IEEE 802.16m evaluation methodology.

Keywords— IEEE802.16m, MIMO, System level simulation, Performance evaluation

I. INTRODUCTION

The IEEE 802.16m is a candidate technology of the IMT-Advanced proposed by IEEE. One of the main features of the IEEE 802.16m technology compared to existing systems is to support various MIMO transmission methods in order to achieve higher data rates. In the IEEE 802.16m, a BS has maximum 8 antennas and a MS has maximum 4 antennas. The MIMO encoding methods such as the SFBC and CDR for diversity gain and the SM for increasing the capacity are supported. Also, many different types of the precoding or beamforming can be applied for increasing the channel capacity, because the IEEE 802.16m supports the CL-MIMO as well as the OL-MIMO. Additionally, the diversity gain and throughput enhancement can be obtained through the MU-MIMO scheme compared to the SU-MIMO. Data bursts can be transmitted by resources which different types of permutations are applied, i.e. DLRU, NLRU and SLRU. The frequency diversity gain or scheduling gain can be acquired by depending on permutation types.

In this work, we'll conduct the performance evaluation for different types of MIMO transmission schemes in terms of cell average spectral efficiency, cell edge spectral efficiency and user average throughput. By using the evaluation results, we can make a decision what scheme is efficient and can increase the throughput.

II. SYSTEM SIMULATION

The simulation procedure and evaluation criteria comply with the IMT-Advanced evaluation guidelines[1] and IEEE

802.16m evaluation methodology[2] for the performance evaluation. The system configuration is based on the IEEE 802.16m standard[3].

A. Channel Model

In this paper, we consider one indoor channel, i.e. InH with a rectangular cell layout and three outdoor channels, i.e. UMi, UMa and RMa with a wrap-around hexagonal cell layout based on the WINNER Channel Model[4] for the test environments.

B. Simulation Setup

The main parameters for the system simulation are listed in the Table1.

TABLE 1. SYSTEM LEVEL SIMULATION PARAMETERS

Items	Configuration
Simulation Plane	Indoor: Rectangular cell layout with 2 BS, Outdoor: Wrap-around hexagonal cell layout with 19 BS
Frequency Reuse	Full frequency reuse
Traffic Type	Full buffer model
CP Ratio	1/16
Duplex	FDD
Bandwidth	Indoor: 20MHz, Outdoor: 10MHz
Frame Configuration	51symbols, DL:UL=8:8
Link-to-System Mapping	MIESM-RBIR
HARQ	CC upto 4 retransmissions, Minimum delay: 3subframes
Channel Estimation Error	Using MSE on midamble, sounding and receiving burst
MIMO Receiver Type	MMSE-IRC
Antenna Configuration	BS 4 x MS 2, 0.5 wavelength element spacing
Sub-channelization	12(6) partitions of resource over 96(48) LRUs in case of 20(10)MHz
DL Correlation Matrix Feedback	Quantized feedback in every SF
CQI/PMI/Rank Feedback Period	Every frame
UL Sounding Period	Every frame

Channel Coding	CTC
Number of Active Users	10 users / sector
Scheduling	PF scheme and frequency selective scheduling in case of localized resource allocation
UL Power Control	OLPC

The MIESM-RBIR approach was used for the link-to-system mapping. For prediction of a BLER, the link performance table (330 BLER curves) and interpolation were used.

Scheduling is conducted in a frame. Entire frame resources are divided into the same size and PF algorithm is applied for resource allocation. Also, quasi-optimum algorithm is applied for user multiplexing on MU-MIMO transmission. BS and MS measure the channel quality for MIMO rank adaptation, AMC and adaptive precoding by using midamble and sounding symbol. The CC is applied for HARQ operation and control overhead size is decreased through the long TTI scheduling.

We used the MMSE-IRC receiver for the MIMO detection and mode change was performed among SFBC, SM rank-1 and SM rank-2 depending on the link performance in case of the non-adaptive precoding.

The NI value is broadcasted periodically from a BS to MS and the IoT is maintained below the level 10dB through the OLPC.

C. Simulation Process

The simulation process is shown in Figure 1.

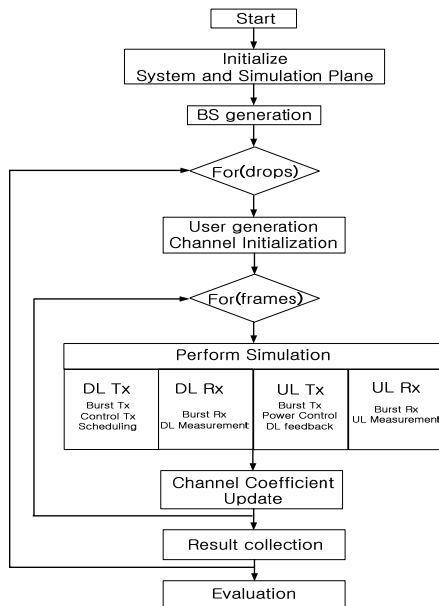


Figure 1. Simulation process

First of all, simulation parameters and simulation plane are initialized. we need to understand the 'drop' concept. A drop is a simulation entity where the random properties of channel remain constant except for the fast fading caused by the

changing phase of the rays. The simulation of frames is performed certain times in a drop. Main simulation routine is consist of 4 blocks, i.e. DL transmit side, DL receive side, UL transmit side and UL receive side. After simulation is performed in a frame, channel coefficient is updated and after all drops and frames are done, the results are collected and evaluated.

III.MIMO TRANSMISSION SCHEME

IEEE 802.16m technology supports various MIMO transmission methods, so we consider significant schemes of below.

- SU_OL_DRU: Single-user open-loop MIMO, diversity allocation with DLRU, precoding by using base codebook subset.
- SU_CL_LC: Single-user closed-loop MIMO, localized allocation with SLRU, precoding by using wideband PMI.
- SU_CL_BF: Single-user closed-loop MIMO, diversity allocation with NLRU, wideband longterm beamforming by using correlation matrix.
- MU_CL_LC: Multi-user closed-loop MIMO, localized allocation with SLRU, precoding by using transformed codebook.
- MU_CL_BF: Multi-user closed-loop MIMO, diversity allocation with NLRU, wideband longterm beamforming by using correlation matrix.

Wideband or subband CQI, wideband or subband rank, wideband or subband PMI and wideband channel correlation matrix is required for CL MIMO transmission and scheduling. Such information is measured by using midamble and sounding symbol in DL and UL, respectively. Also, the information is quantized and transmitted by the control and feedback channels. Especially, analog feedback may be applied for TDD case.

IV.PERFORMANCE EVALUATION RESULT

After completion of the simulation, control overheads should be excluded from the cell throughput. The types of the DL control overheads are the SFH, preamble, midamble, NUS-A-MAP, DL A-MAP and UL A-MAP. The types of the UL control overheads are the FBCH, sounding, ranging and BRCH. The pilot overhead was considered in the simulation process.

If χ_i is a correctly received bits by i -th user, i -th user throughput is given by

$$\frac{\chi_i}{T} \quad (1)$$

where T is the time over which the data bits are received. Also, sector average spectral efficiency, η is represented by

$$\eta = \frac{\sum_{i=1}^N \chi_i}{T \cdot \omega \cdot M} \quad (2)$$

where ω , N and M are simulation bandwidth, number of

users in cell and number of cells, respectively. The cell edge user spectral efficiency is the value corresponding to 5% point of the CDF of the normalized user throughput.

Figure 2-3. represent the DL sector average and edge spectral efficiency and Figure 4-5. represent the UL sector average and edge spectral efficiency. Also, Figure 6-7 represents the DL and UL user average throughput.

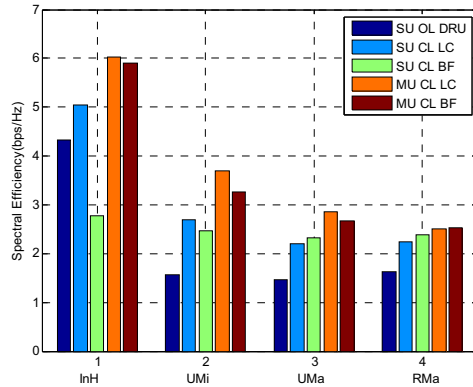


Figure 2. Average spectral efficiency in DL FDD case

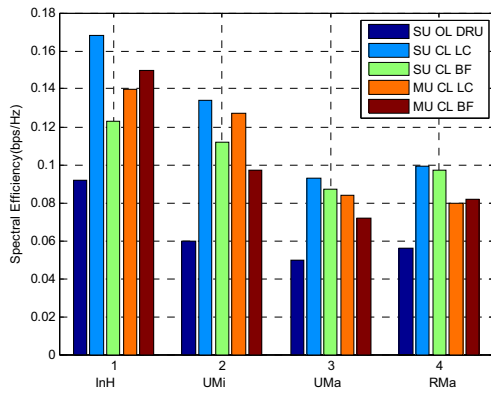


Figure 3. Edge spectral efficiency in DL FDD case

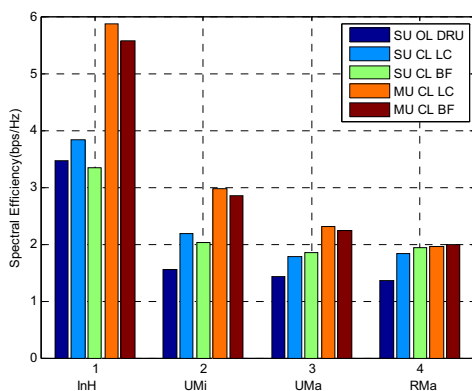


Figure 4. Average spectral efficiency in UL FDD case

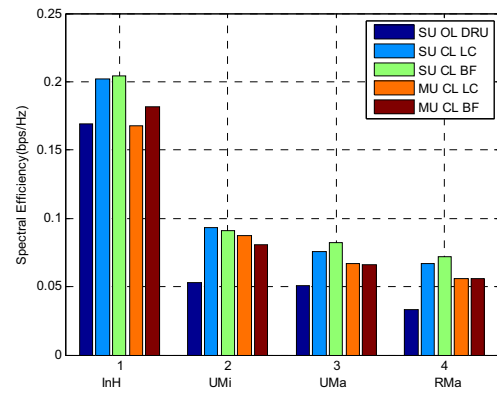


Figure 5. Edge spectral efficiency in UL FDD case

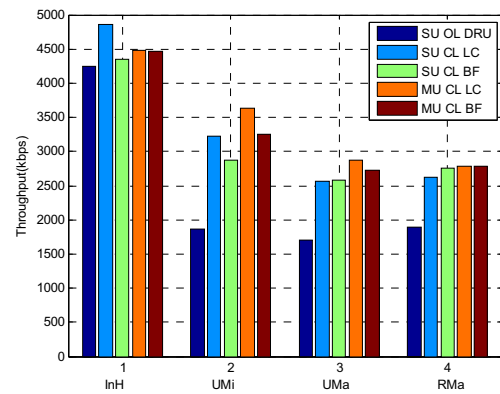


Figure 6. Average user throughput in DL FDD case

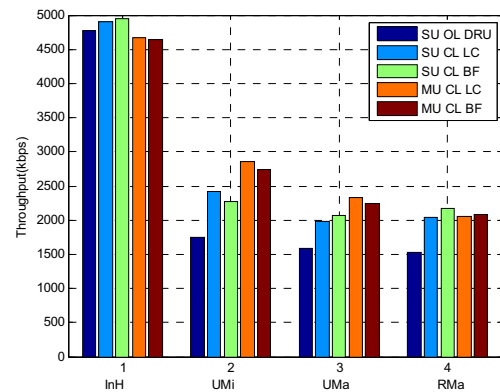


Figure 7. Average user throughput in UL FDD case

Figure 8-11. and Figure 12-15. are the CDF result of DL and UL user average throughput for each channel.

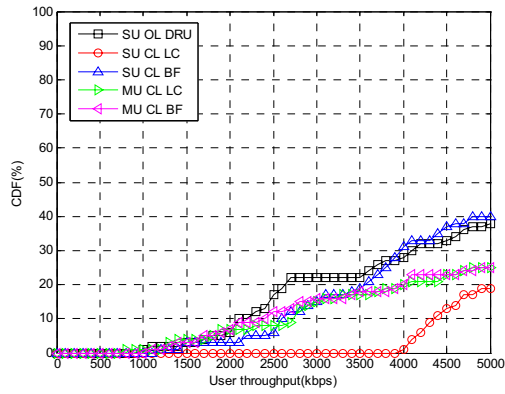


Figure 8. CDF of user throughput in DL FDD case and InH channel

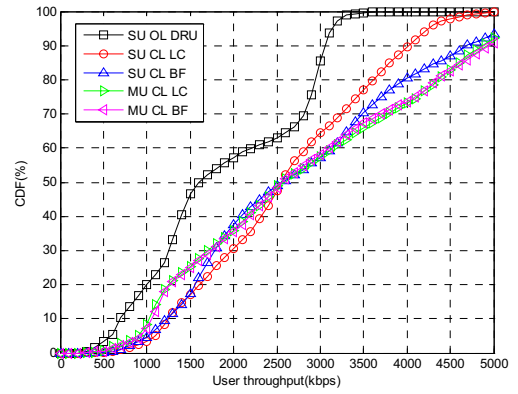


Figure 11. CDF of user throughput in DL FDD case and RMa channel

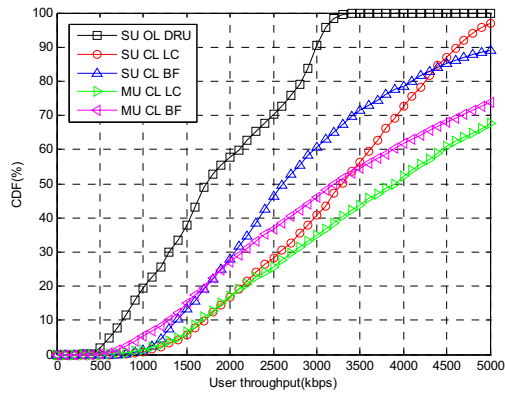


Figure 9. CDF of user throughput in DL FDD case and UMi channel

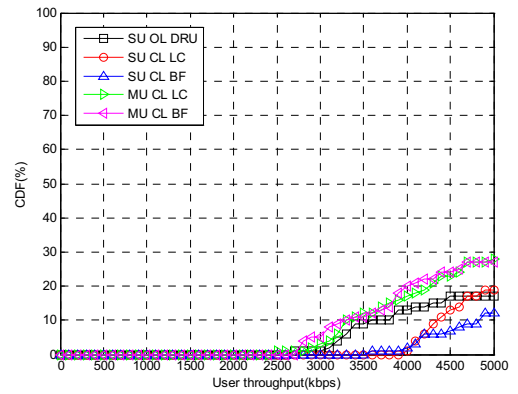


Figure 12. CDF of user throughput in UL FDD case and InH channel

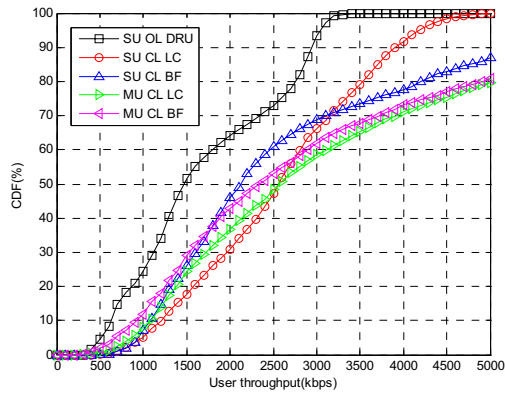


Figure 10. CDF of user throughput in DL FDD case and UMa channel

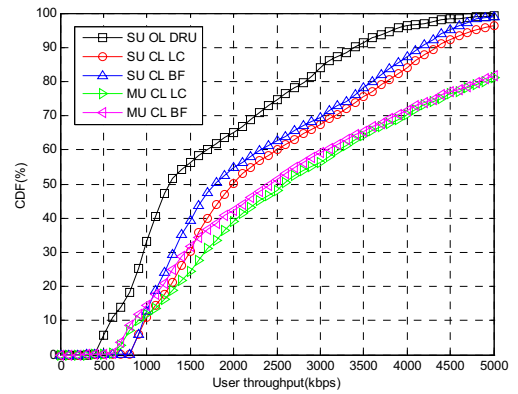


Figure 13. CDF of user throughput in UL FDD case and UMi channel

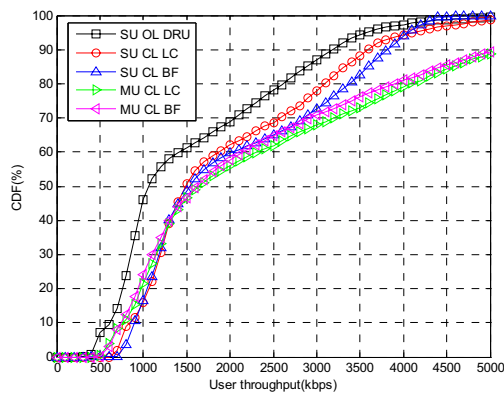


Figure 14. CDF of user throughput in UL FDD case and UMa channel

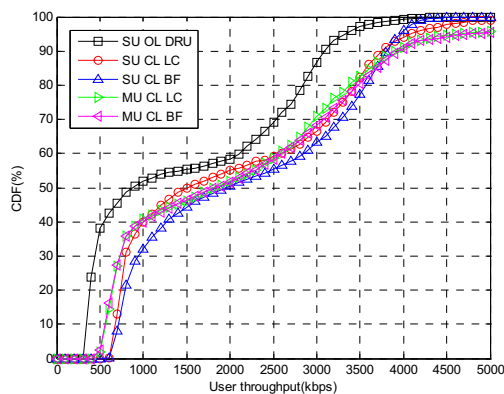


Figure 15. CDF of user throughput in UL FDD case and RMa channel

First of all, the simulation results presented by Figure 2-3. and Figure 6-7. shows general features, as we all know, such as advantages of the CL-MIMO compared to OL-MIMO and throughput enhancement of the MU-MIMO compared to the SU-MIMO from sector average spectral efficiency and user average throughput perspectives. Of course, we should remember that the implementation complexity and control overhead increase for the CL-MIMO and MU-MIMO. Also, these results can be found in Figure 8-15, i.e. CDF of user average throughput. MU-MIMO transmission scheme certainly can increase the channel capacity of the system. In cell boundary, however, SU-MIMO is more reasonable than MU-MIMO as you know in Figure 4-5. This means that to improve the link quality by using diversity gain is more efficient in terms of spectral efficiency than to increase the channel capacity by using MU-MIMO transmission scheme in case of poor channel environment such as cell boundary.

It seems that the performance difference between localized and diversity allocation is insignificant. However, we can find a feature depending on channel environments. The localized MIMO can be more efficient than the diversity MIMO in case of the channels characterized as slow mobility and low frequency selectivity(InH > UMi > UMa > RMa). In other words, diversity allocation can be more efficient than

localized MIMO in the cell edge and low quality link of channel.

There are some interesting results. The SU_OL_DRU scheme is more efficient than the SU_CL_BF in the InH channel. The reason for this is because the scheduler selects, in many cases, the SM-rank2 mode for data transmission in the InH with the high received SINR.

V. CONCLUSIONS

In this paper, we confirmed the performance evaluation results by the system simulation of the IEEE 802.16m technology. The evaluation results showed that what MIMO transmission scheme can be efficient from various perspectives. The evaluation result can be helpful to decided MIMO transmission schemes on various environment.

Although we only covered the FDD case, the results of the performance evaluation of the TDD case are not much different from the FDD, too.

ACKNOWLEDGMENT

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APPENDIX

ACRONYMS

- A-MAP: Advanced MAP
- AMC: Adaptive Modulation and Coding
- BLER: Block Error Rate
- BRCH: Bandwidth Request Channel
- BS: Base Station
- CC: Chase Combining
- CDF: Cumulative Density Function
- CDR: Conjugate Data Repetition
- CL-MIMO: Closed Loop MIMO
- CP: Cyclic Prefix
- CQI: Channel Quality Indicator
- CTC: Convolutional Turbo Code
- DL: Downlink
- DLRU: Distributed Logical Resource Unit
- FBCH: Feedback Channel
- FDD: Frequency Division Duplex
- HARQ: Hybrid Automatic Repeat Request
- InH: Indoor Hotspot
- IoT: Interference over Thermal Noise
- IRC: Interference Reduction Combining
- MIESM: Mutual Information Effective SINR Mapping
- MIMO: Multi Input Multi Output
- MMSE: Minimum Mean Square Error
- MS: Mobile Station
- MU-MIMO: Multi User MIMO
- NI: Noise and Interference
- NLRU: Miniband Contiguous Logical Resource Unit
- NUS: Non User Specific
- OL-MIMO: Open Loop MIMO
- OLPC: Open Loop Power Control

- PF: Proportional Fair
- PMI: Precoding Matrix Index
- RBIR: Received Bit Mutual Information
- RMa: Rural Macro
- SFBC: Space Frequency Block Coding
- SF: Super Frame
- SFH: Super Frame Header
- SINR: Signal to Interference and Noise Ratio
- SLRU: Subband Contiguous Logical Resource Unit
- SM: Spatial Multiplexing
- SU-MIMO: Single User MIMO
- TDD: Time Division Duplex
- TTI: Transmission Time Interval

- UL: Uplink
- UMa: Urban Macro
- UMi: Urban Micro

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