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# Dual-Trigger Handover Algorithm for WiMAX Technology

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# Roadmap

- Introduction
- Network model
- Proposed handover algorithm
- OPNET validation scenarios and simulation results
- Conclusions
- References

# Introduction

- IEEE 802.16e is a version of Worldwide Interoperability Microwave Access (WiMAX) technology that supports mobility
- Various handover schemes have been already proposed and developed
- We propose a new Dual-Trigger Handover (DTHO) algorithm
- DTHO depends on the computation of signal to noise ratio (SNR) received at the Mobile Station (MS) from various Base Stations (BSs)
- The proposed handover algorithm is implemented in both MS and BS nodes and improves the accuracy of handover decisions
- The handover decision is not triggered individually by the MS node or the BS node and is instead a combined decision between the two nodes
- The algorithm was implemented using OPNET Modeler v. 14 running on Windows operating system

# Introduction

- Handover occurs frequently because of:
  - channel traffic load
  - wireless environment that causes channel fading and shadowing
- Reported algorithms depend on various handover criteria (SNR)
- Handover algorithms divided into three categories
  - SNR
  - Relative SNR and the threshold
  - Relative SNR with threshold and a margin

# Introduction

- SNR:
  - Handover decision is initiated when the received signal strength of the serving BS is lower than the received signal strength of target BS
  - Repeated and unnecessary handovers may occur even if the MS receives a signal with acceptable SNR
  - Affects the performance of the system and degrades QoS of the connection
- Relative SNR and the threshold:
  - Handover decision is based on relative signal strength and the threshold
  - Prevents the repeated handovers between two BSs
  - Optimization for the threshold value is required
  - Choosing a large threshold value will reduce the handover attempts and, consequently degrade the connection quality

# Introduction

- Relative SNR with threshold and a margin:
  - Handover is initiated only when the current received signal strength from the serving BS is lower than a certain threshold and the SNR of the target BS is higher than the SNR of the serving BS
  - Ping-pong effect is prevented
  - The coverage area of the BSs is maximized
  - The drawback of this method is the optimization overhead of both the handover threshold and the margin:
    - low threshold causes degraded connections due to late handover
    - high threshold causes premature handover
  - Both affect the coverage and the system throughput

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# Network Model

- Based on the WiMAX OPNET model
- Each BS is assigned a Media Access Control address (MAC) address (BS ID) corresponding to its name: MAC i for BS_i, (i = 0, 1, 2, 3)
- MS nodes have a constant downlink traffic flow of 64 kbps to a server throughout the uplink of the target BS
- The handover messages are negotiated through the backbone links between the serving BS and the neighboring BSs
- We employ the network topology with the same object's attributes configuration for all scenarios
- BSs initially have 0.704 Msps free upload link capacity

# Network Model

- Mobility parameters configurations
  - Scanning parameters configuration

| | |
|---|---|
| Scanning threshold (dB) | 35 |
| Scan duration (N) (frames) | 3 |
| Interleaving interval (P) (frames) | 255 |
| Scan iteration (T) | 5 |
| Maximum scan request retransmissions | 8 |

  - Handover parameters configuration

| | |
|---|---|
| Handover threshold hysteresis (dB) | 6.0 |
| MS handover retransmission timer (ms) | 30 |
| Maximum handover request retransmissions | 6 |
| Multitarget handover threshold hysterias (dB) | 0.0 |
| Maximum handover attempts per BS | 3 |

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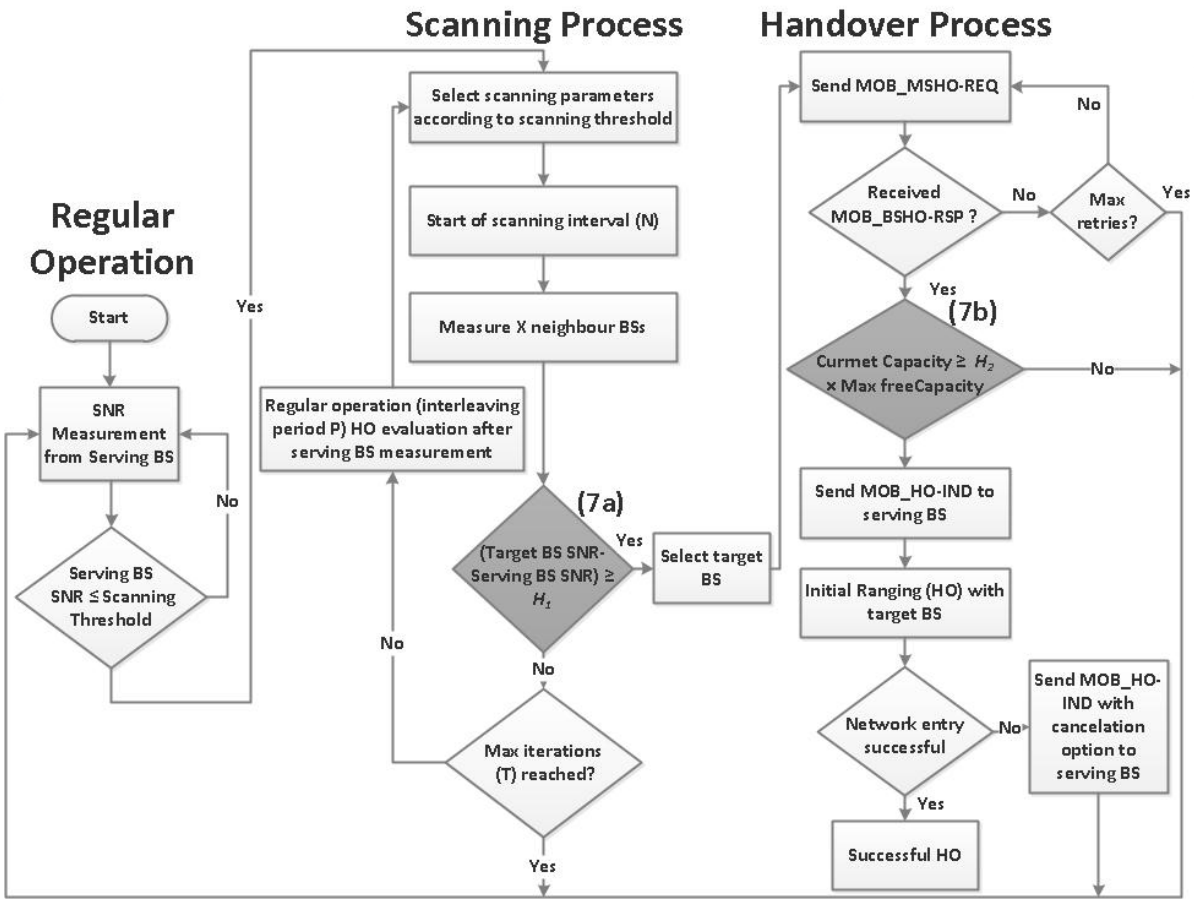
# Proposed Handover Algorithm

- The proposed triggering condition is defined as:

$$(SNR_{maxDT} - SNR_{DS}) \geq H_1 \quad (7a)$$

*AND*

$$C_{EF} \geq H_2 \times C_{max} \quad (7b)$$



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# OPNET Validation Scenarios and Simulation Results

- WiMAX OPNET model
- MS nodes have a constant downlink traffic flow of 64 kbps to a server throughout the uplink of the target BS
- The mobility parameters for simulations:

| | |
|---|---|
| Scanning threshold (dB) | 35 |
| Scan duration (N) (frames) | 3 |
| Interleaving interval (P) (frames) | 255 |
| Scan iteration (T) | 5 |
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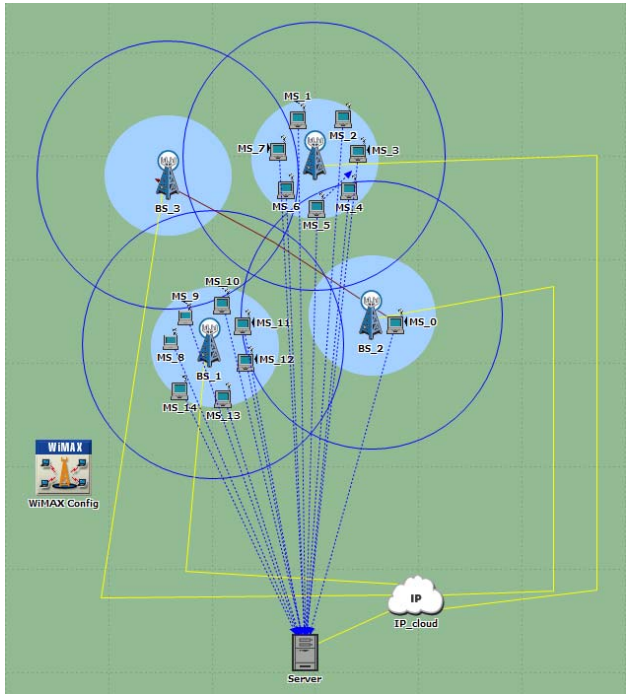
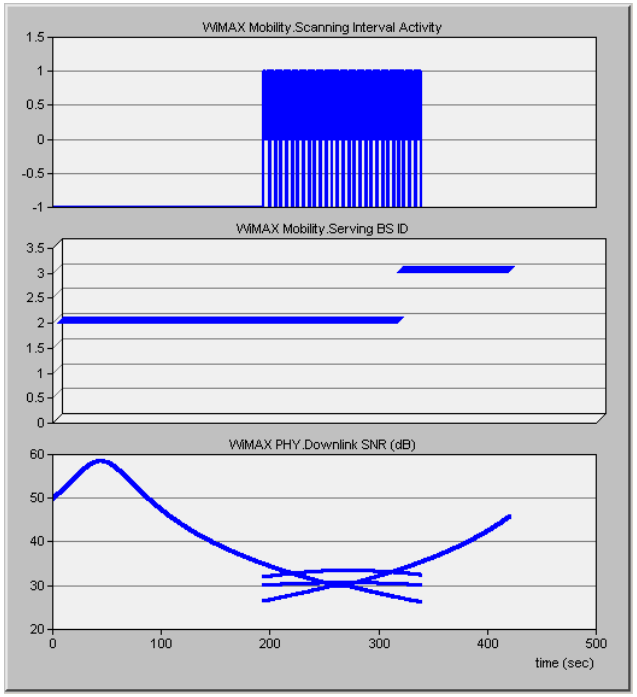
| MS handover retransmission timer (ms) | 30 |
| Maximum handover request retransmissions | 6 |
| Multitarget handover threshold hysterias (dB) | 0.0 |
| Maximum handover attempts per BS | 3 |

- Each BS initially has 0.704 Msps free upload link capacity

# OPNET Validation Scenarios and Simulation Results: Scenario A

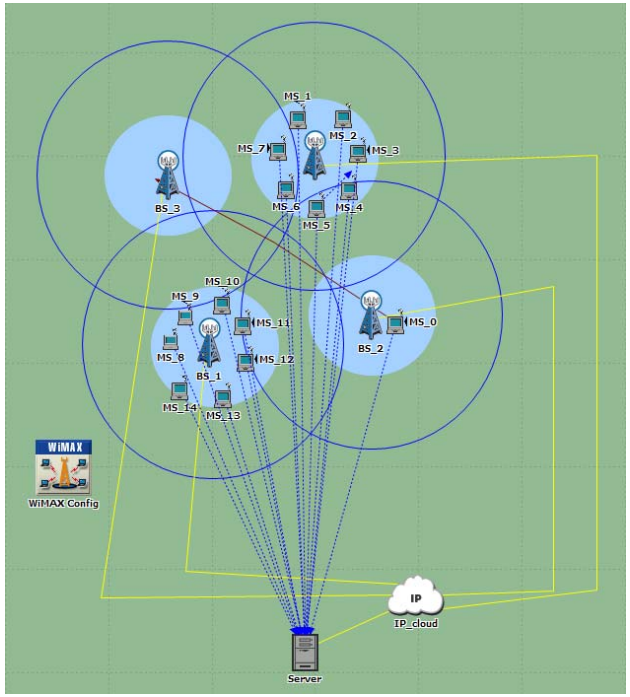
- MS_0 is moving based on a predefined trajectory between BS_2 and BS_3
- BS_0 and BS_1 are selected to have 33% free capacity (< 40%)
- MS_0 exceeds the scanning threshold (35 dB) and begins scanning at 194 s
- MS_0 does not perform handover to either BS_0 or BS_1. MS_0 performs handover to BS_3 at 317 s

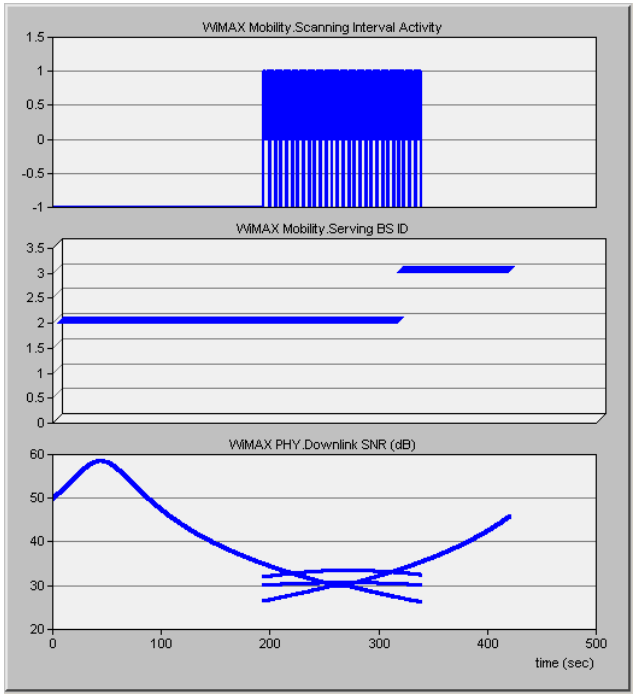


# OPNET Validation Scenarios and Simulation Results: Scenario A

- Regardless of whether or not (7a) is met, (7b) is not satisfied. Hence, MS_0 does not perform handover
- MS_0 repeatedly cancels the handover requests
- MS_0 remains in the scanning process until it reaches the BS_3 cell boundary
- Scanning interval (top), serving BS ID (middle), and downlink SNR (bottom) for MS_0

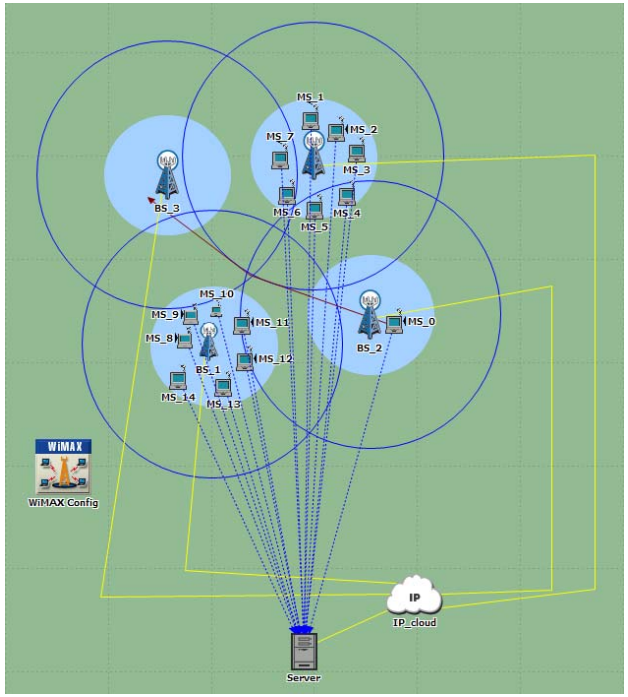


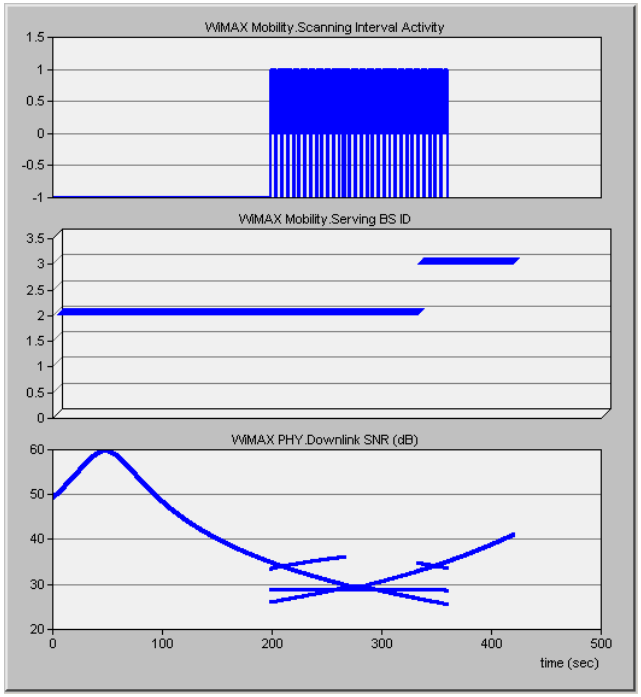



# OPNET Validation Scenarios and Simulation Results: Scenario B

- We redefined the trajectory so that MS_0 passes close BS_1 to verify that even if (7a) is satisfied, no handover will be performed unless the free capacity for the target BS is larger than or equal 40% (7b)

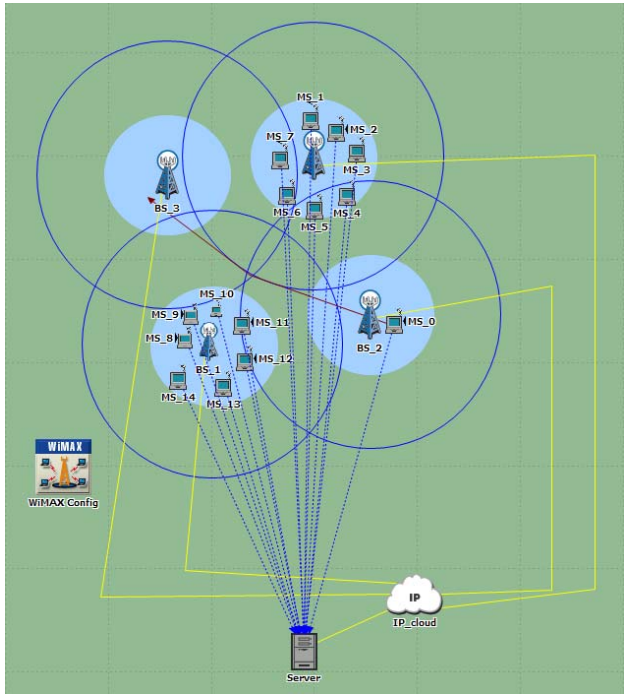
- The free capacity of BS_0 and BS_1 are identical as in scenario *A*
- $SNR_{maxDT} - SNR_{DS}$ reaches 8.9 dB
- In this scenario $SNR_{maxDT} - SNR_{DS}$ is equal or larger than $H_1$ (7a)

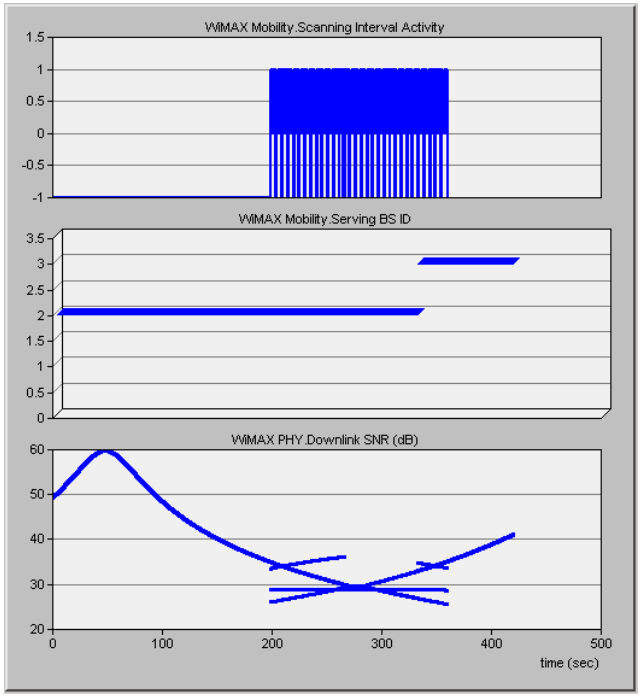


# OPNET Validation Scenarios and Simulation Results: Scenario B

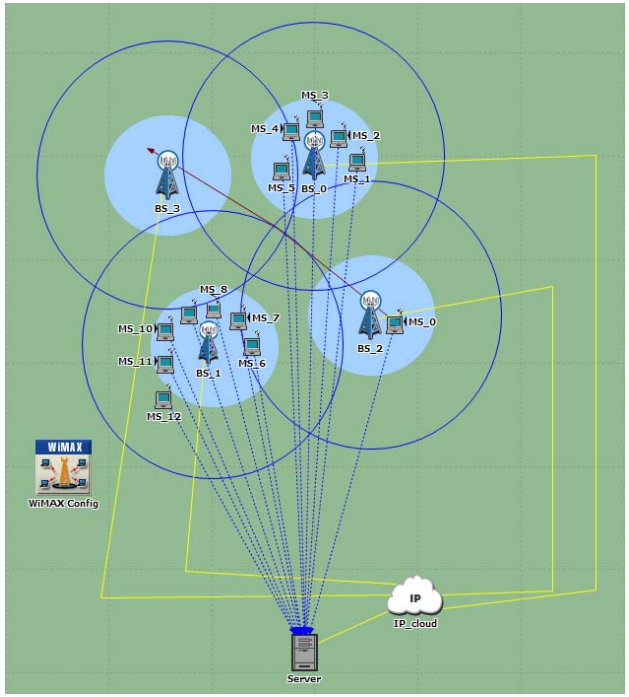
- MS_0 does not perform a handover until 333 s, when it performs handover to BS_3
- Scanning interval (top), serving BS ID (middle), and downlink SNR (bottom) for MS_0



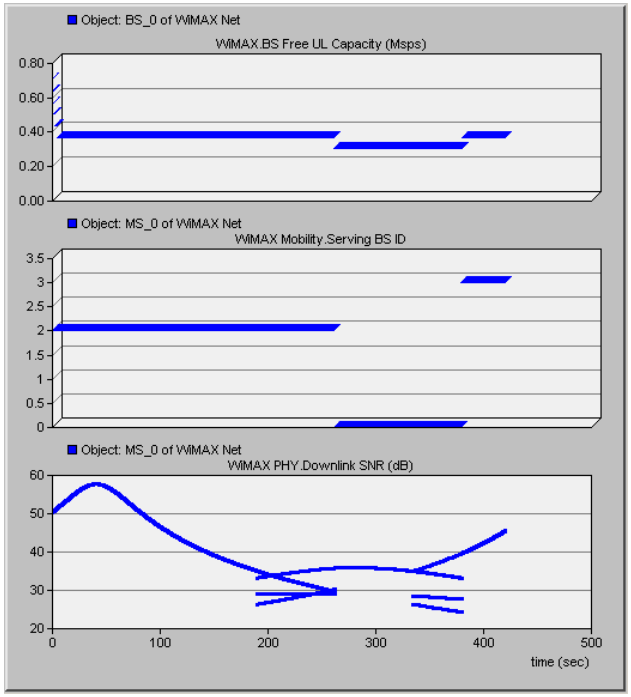



# OPNET Validation Scenarios and Simulation Results: Scenario C

- We increased the free uplink capacity of BS_0 to 52% (≥ 40%) that it may offer resources to an arriving MSs
- The trajectory has been redefined so that MS_0 passes close to BS_0
- Both (7a) and (7b) are satisfied

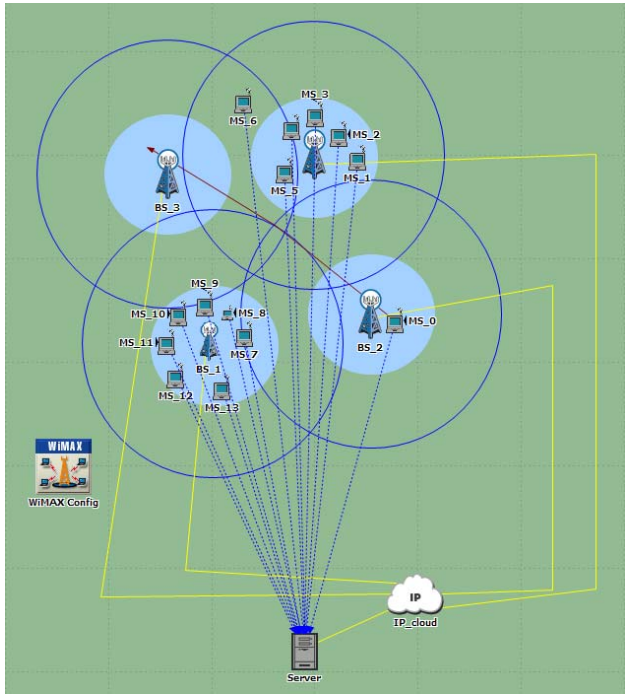


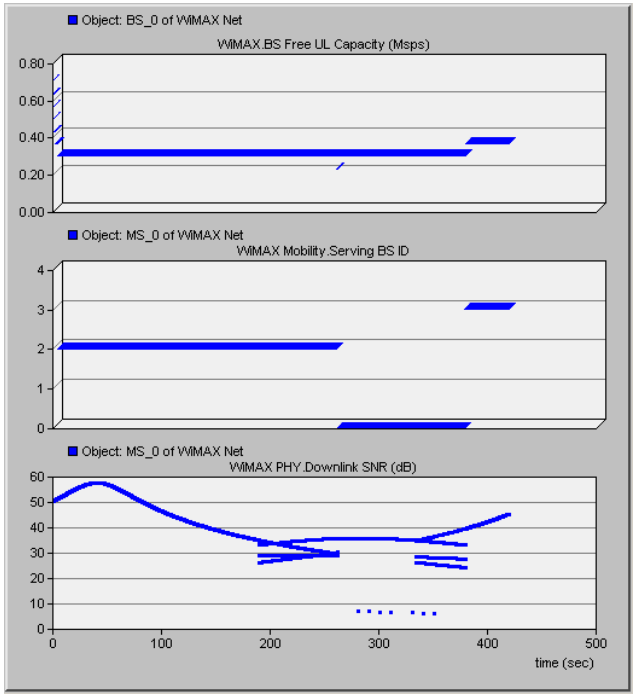

- MS_0 performs handover at 262 s and 380 s to BS_0 and BS_3, respectively
- Upload free capacity of BS_0 changes from 0.368 Msps (0.52%) to 0.3008 Msps (0.43%) and back to 0.368 Msps (0.52%) as MS_0 arrives and departs



# OPNET Validation Scenarios and Simulation Results: Scenario D

- In this scenario, we increase the free capacity of BS_0 to 42.7% (≥ 40%) by assigning MS_1, …, MS_6 to BS_0
- BS_0 may handle only one additional MS. However, its free capacity falls below 40% (32.2%)
- The BS_0 performs the *capacity handover* and forces MS_6 to perform handover to BS_3
- BS_0 Free Upload Capacity (top), serving BS ID (middle), and downlink SNR (bottom) for MS_0



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# Conclusions

- We employed OPNET Modeler as a simulation tool for testing and developing WiMAX handover algorithms
- The proposed handover triggering algorithm was validated in various simulation scenarios
- We demonstrated that the proposed handover triggering algorithm for mobile WiMAX shows significant improvement in system performance
- The SNR measurements for handover triggering mechanism combined with estimation capacity reduces the probability of call loss and maximizes the overall system throughput
- We also introduced predefined heuristic values to avoid repeated handovers while trying to balance users across the cells
- The future work calls for implementation of an adaptive mechanism for optimizing thresholds of the handover hysteresis values

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