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
    | Parameter                                      | Value |
    |-----------------------------------------------|-------|
    | 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
    | Parameter                                      | Value |
    |-----------------------------------------------|-------|
    | 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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The proposed triggering condition is defined as:

\[(SNR_{\text{maxDT}} - SNR_{DS}) \geq H_1 \quad (7a)\]

AND

\[C_{EF} \geq H_2 \times C_{\text{max}} \quad (7b)\]
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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:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

- Each BS initially has 0.704 Msp/s 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
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

- \( SNR_{\text{maxDT}} - SNR_{DS} \) reaches 8.9 dB

- In this scenario \( SNR_{\text{maxDT}} - SNR_{DS} \) 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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