Feedback-Based Real-Time Streaming Over WiMAX

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Outline

- Introduction
- Background
- The MAC of WiMAX
- Feedback-Based Adaptive MAC
- Simulation Model and Results
- Conclusions

Introduction

- WiMAX (Worldwide Interoperability of Microwave Access)
  - Provides a solution of “Last Mile”
  - Avoids the prohibitive cost of wiring home and business
  - Allow a relatively faster deployment process
- WiMAX is envisioned as a solution to the outdoor broadband wireless access, and also provide rich set of features
  - PHY : OFDM technology
  - MAC : Scheduling, Data transmission, ARQ, …

Introduction

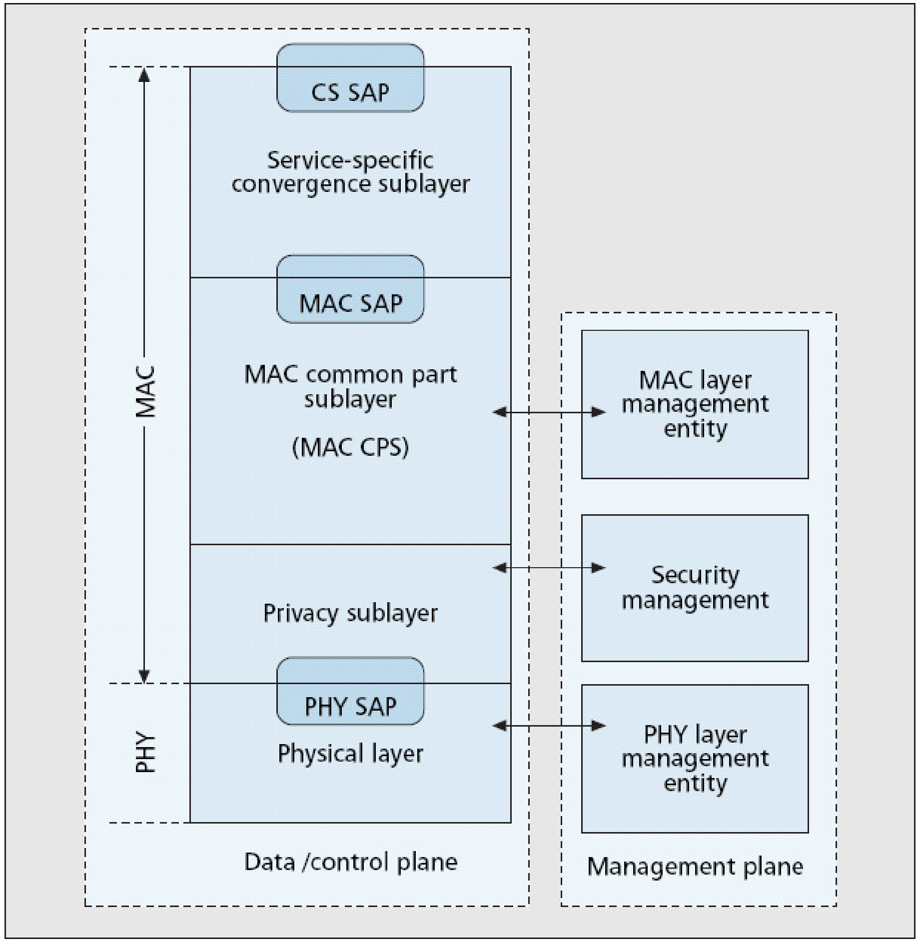
- Objectives
  - Reduction in the number of retransmission of dropped or corrupted packers lowers the delay , which is crucial for streaming applications
  - Increasing the packet restore probability, reducing data dropping probability, and increasing goodput
    - Goodput : Information bits / total bits transmitted

- This study uses Forward Error Correction (FEC) and Automatic Repeat Request (ARQ) to support real-time streaming service over WiMAX
  - Without violating what has already been standardized

Background

- ARQ schemes provide high reliability when channel is good or moderate
- For error-prone channels, Hybrid ARQ schemes are used to counter the increased frequency of retransmissions

The MAC of WiMAX

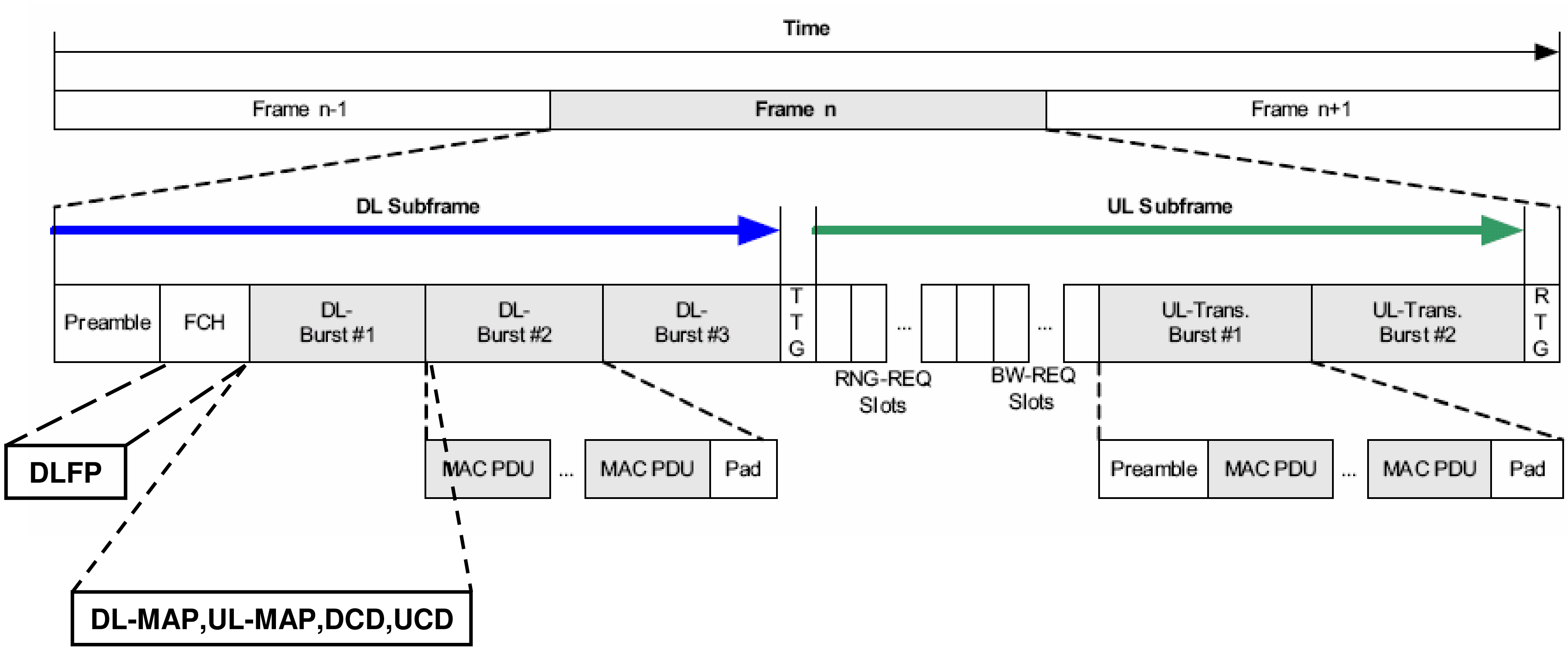


802.16a MAC layer with SAPs

- Convergence Sublayer (CS)
  - Mapping external network data into MAC SDU
- Common Part Sublayer (CPS)
  - Core MAC functionality
- Privacy Sublayer
  - Secures over wireless transmissions
  - Protects from theft of service
- PHY
  - Multiple sections
    - Appropriate to various frequency range and application

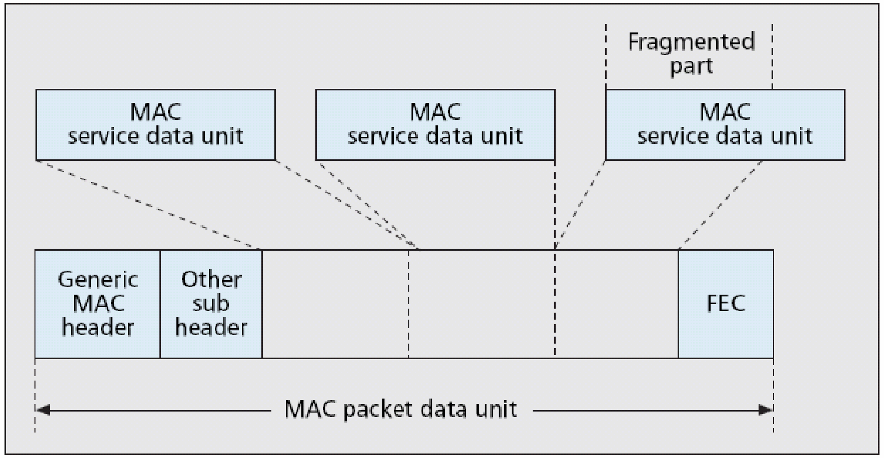
The MAC of WiMAX

TTG : Transmission Transition Gap
RTG : Receive Transition Gap
FCH : Frame Control Header
DLFP: Downlink Frame Prefix

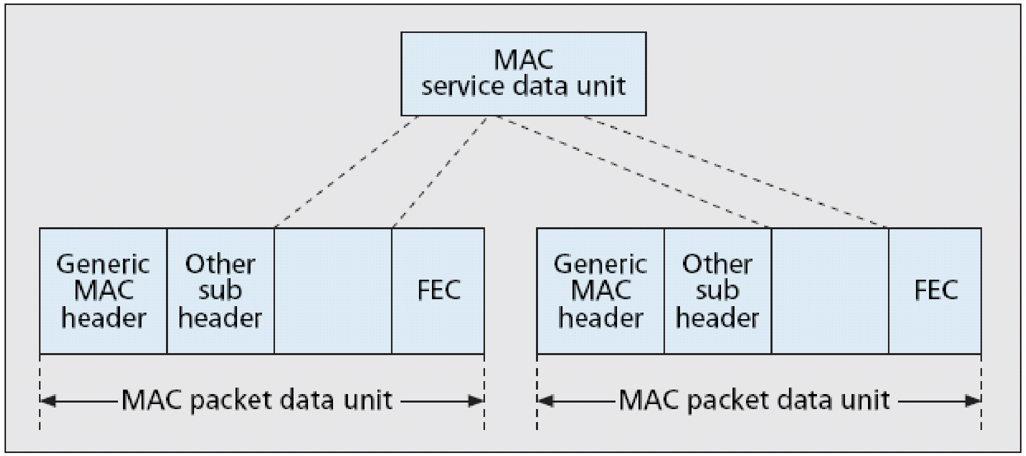


Frame Structure - TDD

The MAC of WiMAX

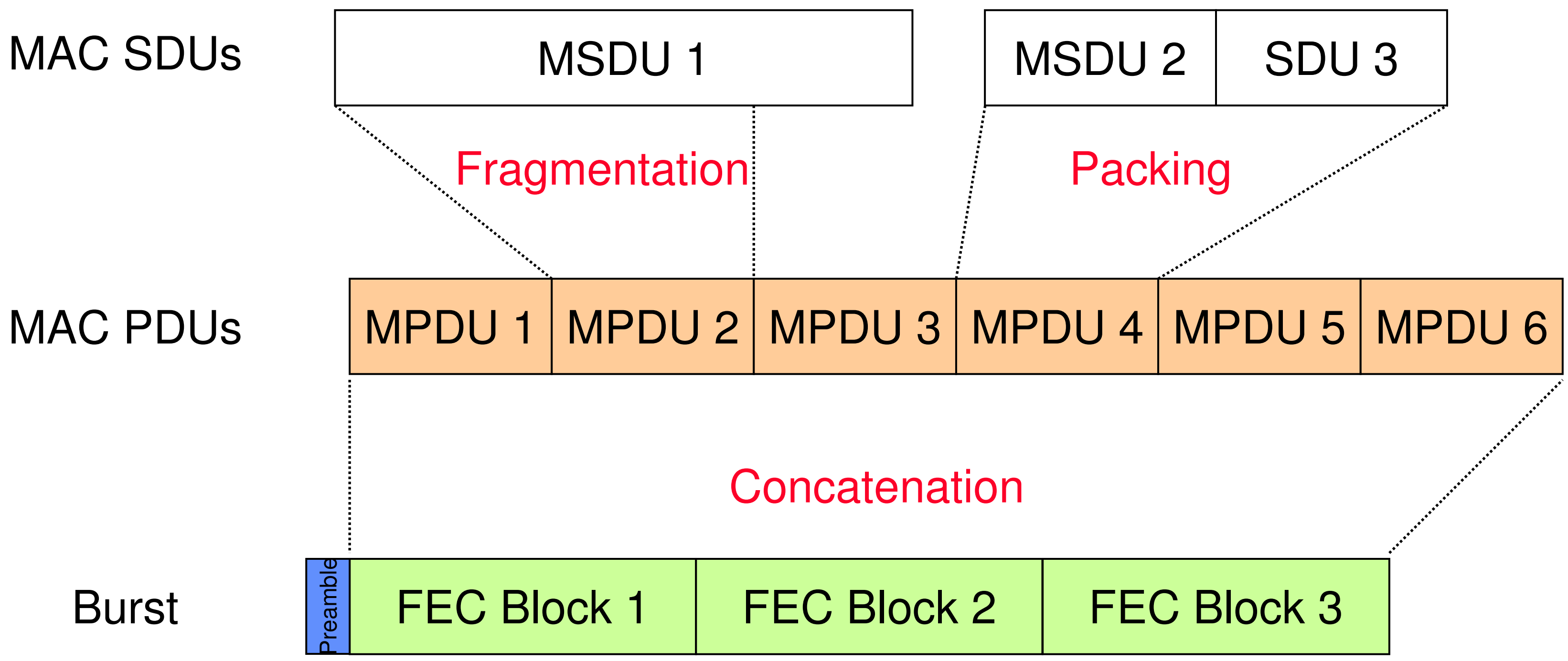


Multiple MSDUs form a MPDU



Single MSDU form multiple MPDU

The MAC of WiMAX



PDU Transmission

Problem Formulation

- Tradeoff between Goodput and Delay
  - If MPDU is large
    - Transmission time of each MPDU is large
    - Overheads of header and acknowledgement are less => higher goodput
    - MPDU dropping or corrupted rate is high if the bad channel condition persists
    - ARQ mechanism invokes a large MPDU retransmission

- Optimal MPDU Size
  - Matched size of MPDU to the channel conditions can obtain a desired level of transmission performance
  - ARQ plays a crucial role in estimating the channel condition and status of transmitted MPDU
  - Round Trip Time (RTT) would affect the size of the MPDUs

Feedback based Adaptive MAC

- A method of dynamically changing the MPDU size in response to the channel condition is proposed
- Two level classification of data
  - Important MPDU (I-MPDU)
    - E.g. I frame for MPEG-2
  - Not so important (N-MPDU)
    - E.g. B and P frame for MPEG-2
- Six types and actions of feedback

Feedback based Adaptive MAC

- Packet Restore Probability
  - Some redundant bits are applied in FEC block before transmission in
    - So that there is a probability that receiver can detect and possibly correct the errors
    - The correction capability of these codes will depend on the codes used

Feedback based Adaptive MAC

- Block code example
  - M redundancy bits are added to the N information bits

$$b = \sum_{i=M+1}^{M+N} \binom{M+N}{i} b_p^i (1-b_p)^{M+N-i} \frac{i}{M+N}$$

where b_p is the bit loss probability before decoding and b it is the decoded bit error probability

    - $P = (1-b)^{(M+N)}$, where P is restore probability of the MPDU

  - If N is decreased to N' ($N'<N$) and code size is fixed

$$b' = \sum_{i=M+1}^{M+N'} \binom{M+N'}{i} b_p^i (1-b_p)^{M+N'-i} \frac{i}{M+N'}$$

    - $P' = (1-b')^{(M+N')}$, where P' is restore probability of the MPDU

=> $(1-b) \fallingdotseq (1-b') \fallingdotseq 1$, and $N' < N$ => $p'>p$

=> Packet restore probability increases with a decrease in payload

Feedback based Adaptive MAC

- Observation summary
  - Decreasing payload keeping code fixed
    - With a decrease in payload, packet restore probability increases
  - Increasing code size keeping payload fixed
    - The resulting bit loss probability decreases and packet restore probability of MPDUs increases
  - Increasing Both payload and code
    - Increasing payload only will increase the resulting bit error probability, so it must also increase the code to compensate for the increased payload

Feedback based Adaptive MAC

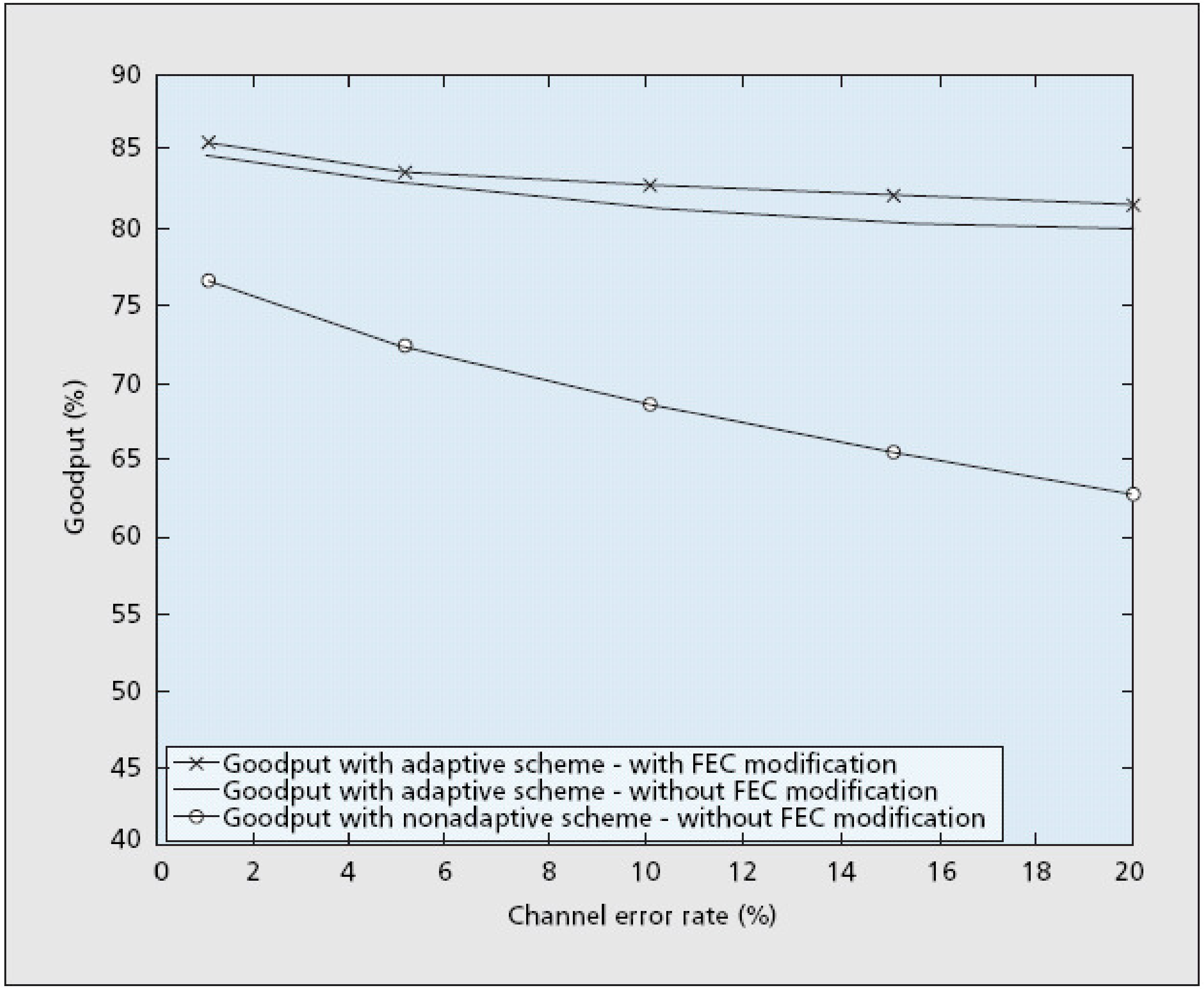
- Connection Setup and Transmission
  - Phase 1: subscriber station requests connection
  - Phase 2: base station confirms connection
  - Phase 3: base station starts transmission of MPDUs

Feedback based Adaptive MAC

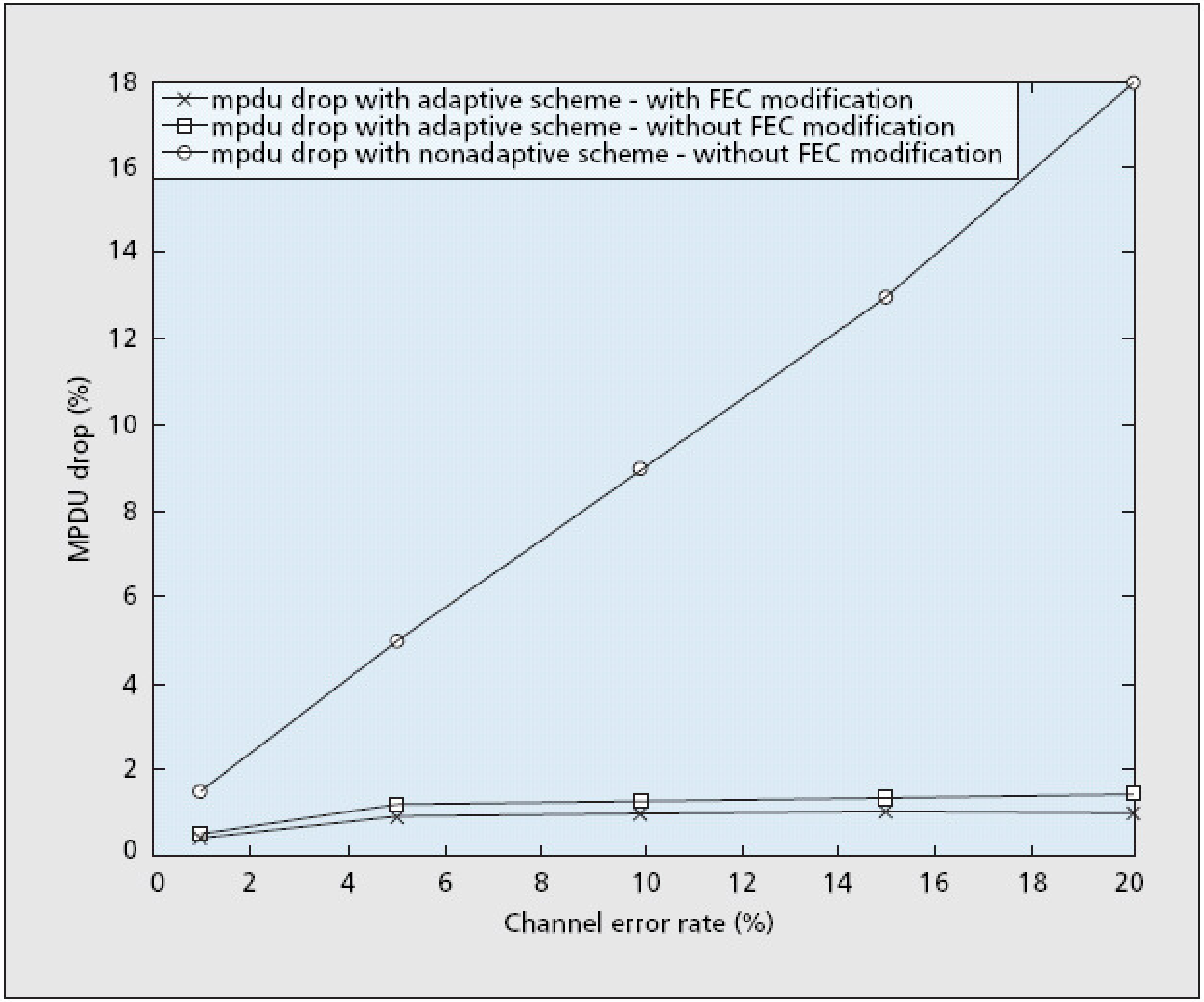
- When a feedback is received, the next awaiting MPSU is formed depending on the type of feedback received.
- Upon the reception of each of the six feedbacks, the payload and code size are changed.
  - Action 1 : increase MPDU payload; decrease code size for not so I-MPDU
  - Action 2 : increase code size for I-MPDU; keep payload and code fixed for N-MPDU
  - Action 3 : decrease payload of MPDU; increase code size of MPDU
  - Action 4 : same as action 3, but increment/decrement is more
  - Action 5 : stall transmission until further request received
  - Action 6 : skip transmission of N-MPDUs; I-MPDUs are transmitted

Feedback type	Feedback classification
1	MPDU received correctly
2	MPDU received with errors, but correctable
3	MPDU received with errors, and uncorrectable
4	MPDU dropped, timeout in receiver MAC occurred
5	Receiver MAC buffer full, last stored frame is important
6	Receiver MAC buffer full, last stored frame is not so important

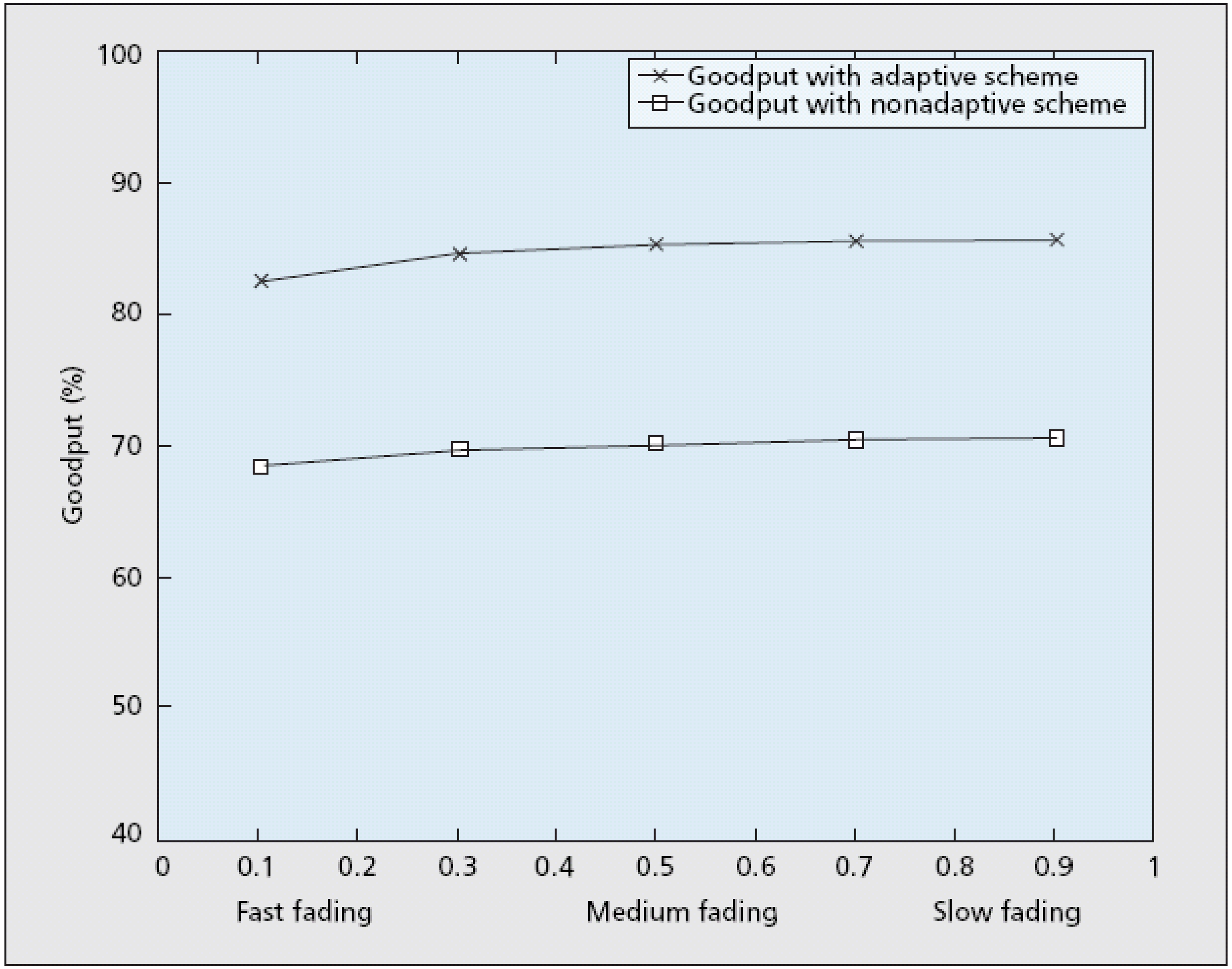
Goodput Comparison



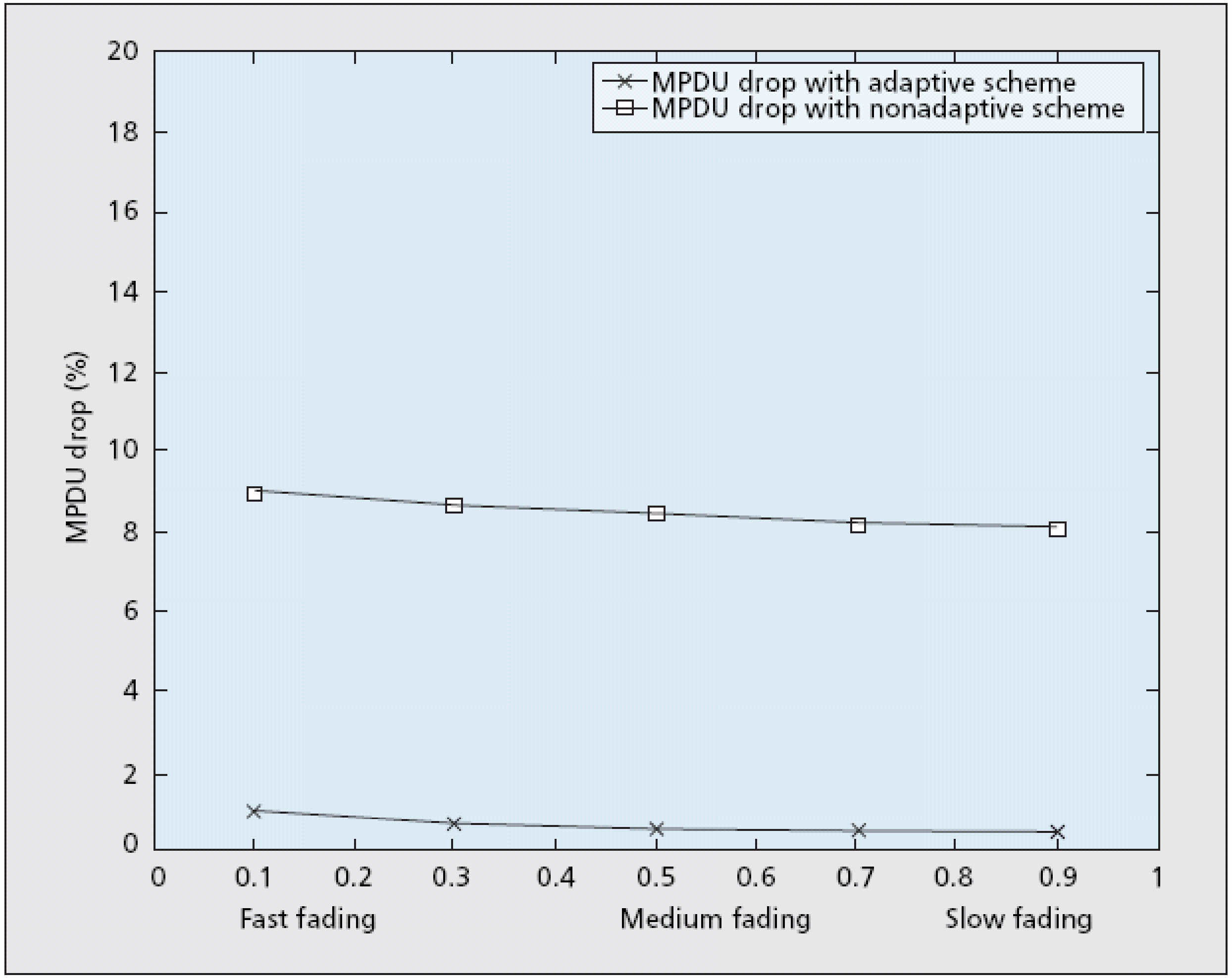
MPDU Drop Comparison



Goodput for Different Channels



MPDU Drop for Different Channels



Conclusions

- WiMAX is a broadband wireless technology designed to provide “Last-Mile” connectivity
- Problem of real-time streaming over WiMAX is discussed in this article
- The sizes of MPDU can be made adaptive to feet dynamic wireless channel conditions
- Based on the type of feedbacks received, variable-size MPDUs can be transmitted after packing or fragmenting for increasing goodput and decreasing drop probability