A Fair Downlink Packet Scheduling Approach to Support QoS in HSDPA

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Contents

Introduction

- In the present scenarios, the high-speed demands are growing rapidly specially in wireless networks.
- In order to satisfy fast-growing demands in downlink, the concept of High Speed Downlink Packet Access has been proposed.
- Packet scheduler in HSDPA controls the allocation of shared resources to users.

Problem Statement

- The objective of the paper is to design and evaluate a downlink-scheduling algorithm for HSDPA based UMTS networks.
- The resulting algorithm should ensure better channel utilization and fairness among users.

Other Proposed Scheduling Algorithms

- Maximum Carrier to Interference Ratio Scheduling [1]:

$$j = max_i \, r_i(k) \tag{1}$$

  Where $r_i(k)$ is instantaneous C/I ratio

- Proportional Fair Scheduling [1, 2]:
  According to PF, user j is selected, if

$$j = max_i \frac{r_i}{R_i}, \quad i = 1, 2, ..., N. \tag{2}$$

  R_i is the average received rate for user i

- DRC Exponent Rule [3]

$$j = \max_i \frac{{r_i}^n}{R_i}, \quad i = 1, 2, ..., N. \tag{3}$$

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Other Proposed Scheduling Algorithms Contd...

- Adaptive Proportional Fair Scheduling [4]:
  In APF, the user selection criterion is given by

$$j = max_i \frac{r_i^{c_i}}{R_i} * RT_i, \qquad i = 1, 2, ..., N, \tag{4}$$

c_i are updated with

$$\begin{array}{ll} c_i = c_i + \Delta c, & if \left(\frac{R_i}{RT_i} - \frac{1}{N} \sum_{j=1}^{N} \frac{R_j}{RT_j} \right) < -\varepsilon \\ c_i = c_i - \Delta c, & if \left(\frac{R_i}{RT_i} - \frac{1}{N} \sum_{j=1}^{N} \frac{R_j}{RT_j} \right) > \varepsilon \end{array} . \tag{5}$$

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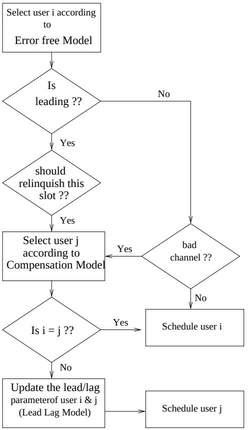
Proposed Solution Approach

Framework for developing Wireless Fair Scheduling Algorithm [5]



Main components of framework are:

- Error Free Service Model
- Compensation Model
- Lead and Lag Model

The proposed solution approach is based on the framework discussed and it replaces Internal working of Model of this framework.

Wireless Fair - High Speed Scheduling

- Proportion Fair Service Model:
  This model selects a user with

$$max_i \frac{r_i}{R_i'} * RT_i \tag{6}$$

- Compensation Model:
  The maximum limit of lead after which user will relinquishes its slot is given by

$$max\_l_i = \frac{RT_i * TTIduration}{mean\_channal\_rate_i} \tag{7}$$

  This model is also responsible for selecting user after relinquishing. Among the lagging users who perceives good channel will be scheduled.

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Wireless Fair - High Speed Scheduling Contd...

- Lead and Lag Model:

  if user i gives its slot to user j then lead-lag parameter is updated with

$$l_i = l_i - max\left(TTIduration, \frac{PacketSize_i}{RT_i}\right) \quad (8)$$

$$l_j = \begin{cases} l_j + \frac{PacketSize_j}{RT_j}, & if\ not\ lagging \\ min\left(0.0,\ l_j + \frac{PacketSize_j}{RT_j}\right), & if\ lagging \end{cases} \quad (9)$$

Performance Measure

- Link Utilization:

  Measured by Mean System Throughput (MAC-hs)
- User Level Fairness

  Long-term Fairness:
  Measured by FI by [6]

$$\frac{\left(\sum_{i=1}^{N} x_i\right)^2}{N \sum_{i=1}^{N} x_i^2}, \quad x_i \geq 0 \quad \forall i \qquad (10)$$

  Here x_i is taken as $\frac{R_i}{RT_i}$ and N is the number of users

  Short-term Fairness:
  For short-term fairness CDF of waiting time at Node B is used.

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Simulation Environment

- Simulation Tools
  Network Simulator-2 [7] and Enhanced UMTS Radio Access Network Extensions to NS2 [8]

- Simulation Topology

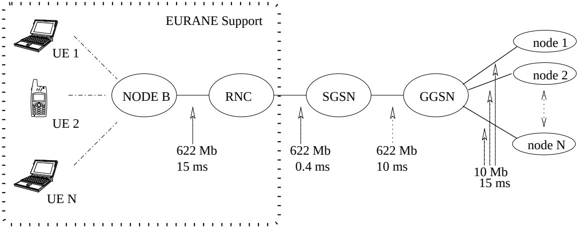


Figure: Topology used in simulation

Simulation Environment

- Simulation Parameters

Parameters	Value
Cell Radius	600 m
Number of codes used	15
Link Adaptation Delay	6 ms
HARQ Cycle	6 TTI
Node B Transmission Power	38 dBm
Node B Antenna Gain	17 dB
Shadowing Standard Deviation	3 dB
Max. number of HARQ transmission	3
Number of parallel HARQ processes	6
RLC Acknowledgement Mode	AM
RLC Buffer Level	500 PDU's
MAC Buffer Level	250 PDU's

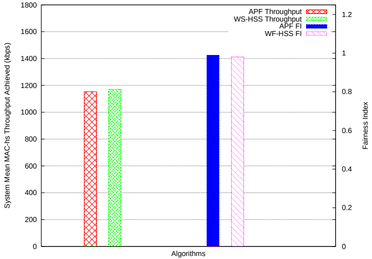
Simulation Results

Simulation Scenarios

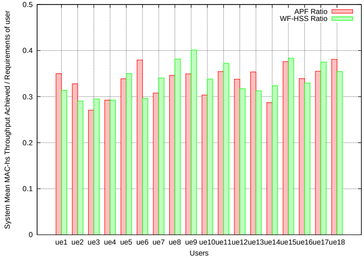
- Web Traffic Scenario
  - Average Load Distribution Scenario - Users are uniformly distributed in the cell area
  - Worst Load Distribution Scenario - High requirement users are in bad channel condition
- FTP-Web Traffic Scenario
- Load Analysis

Simulation Results - Web-Traffic

Pedestrian Environments - Users are uniformly distributed in the cell area



(a) System Parameters



(b) Users Analysis

Figure: System & Users Analysis

Simulation Results - Web-Traffic

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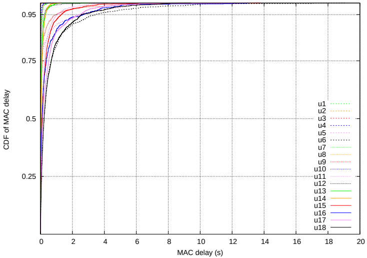

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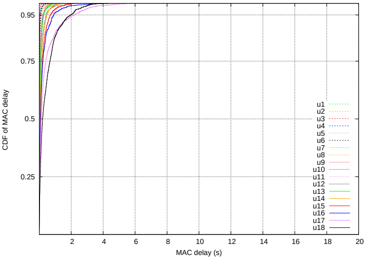

(b) WF-HSS

Figure: CDF of MAC-hs delay.

Simulation Results - Web-Traffic

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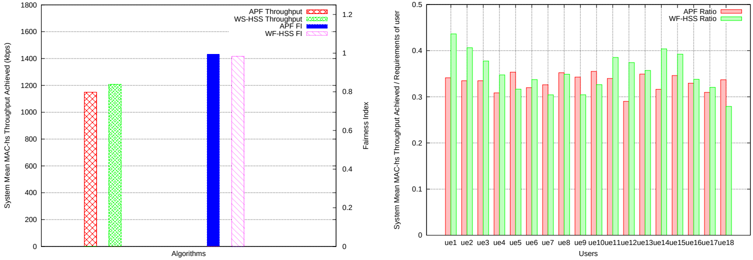

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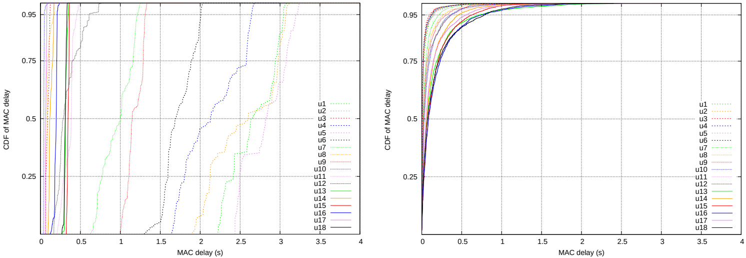

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Simulation Results - FTP-Web Traffic Scenario

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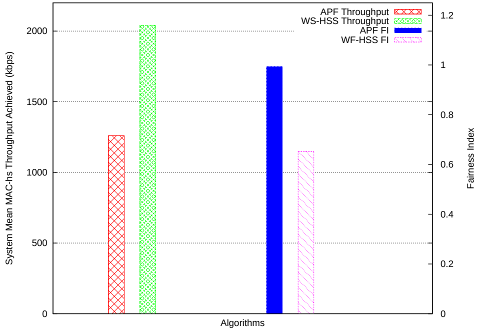
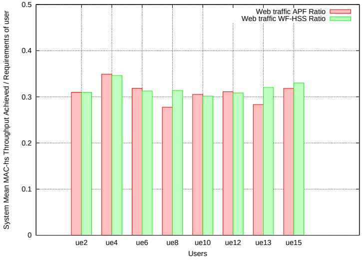


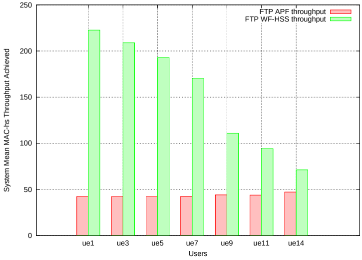
Figure: Mean System Throughput (MAC-hs) Achieved and Fairness Index.

Simulation Results - FTP-Web Traffic Scenario

Pedestrian Environments



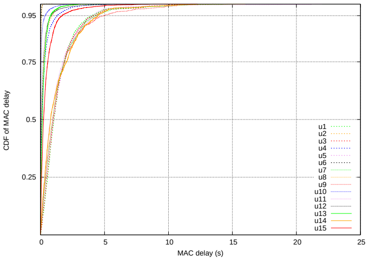
(a) $\frac{R_i}{RT_i}$ for Web traffic



(b) MAC-hs Throughput Achieved for FTP users

Figure: Users analysis

Simulation Results - FTP-Web Traffic Scenario
Pedestrian Environments



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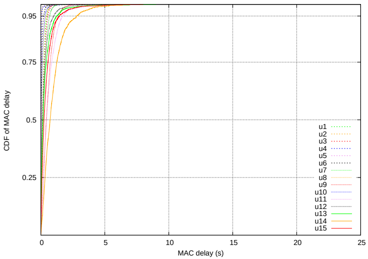
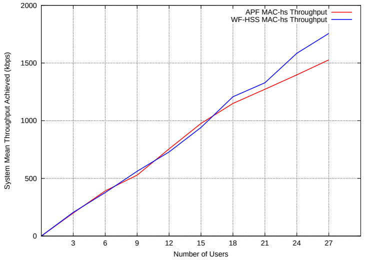


(b) WF-HSS

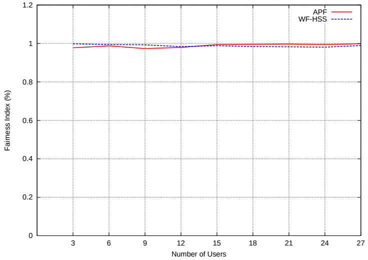
Figure: CDF of MAC-hs delay

Simulation Results - Load Analysis

Pedestrian Environment



(a) Mean System Throughput(MAC-hs)



(b) Fairness Index

Figure: System Parameters by varying load on system

Summary

- In averagely distributed load, both APF and WF-HSS algorithm provides good balance between link utilization and long-term fairness.
- In worst load conditions, WF-HSS provide better performance in terms of link utilization in comparison to APF algorithm.
- CDF of waiting time at Node B shows that WF-HSS algorithm provides short-term fairness among users for all traffic scenarios, while APF algorithm fails to do so.

Summary Contd....

- WF-HSS scheduling provides benefits of TCP window resizing to the FTP users without affecting performance of other users, while APF algorithm doesn't do so.
- In comparison to APF algorithm, WF-HSS provides better link utilization without affecting fairness among users in heavy load conditions.

Conclusion

WF-HSS algorithm ensures long as well as short time scale fairness among users, according to their QoS requirements, while seeking to maximize link utilization.

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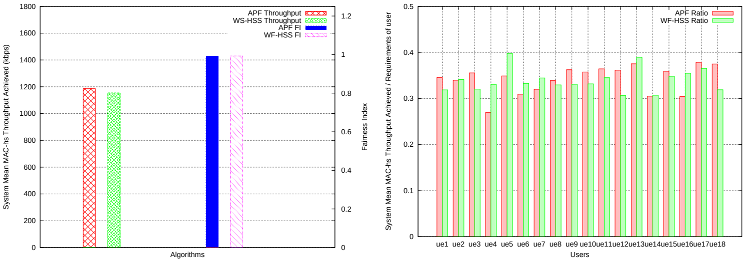
- EURANE patch for clean ns 2.28 and its documentation is available on http://www.ti wmc.nl/eurane/.

Thank You

Backup Slides

Simulation Results - Web-Traffic

Vehicular Environments - Users are uniformly distributed in the cell area



(a) System Parameters

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Figure: System & Users Analysis

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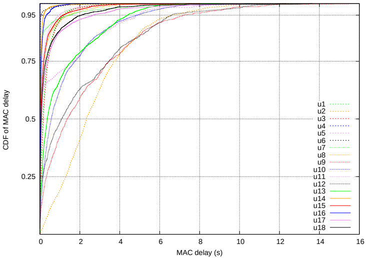

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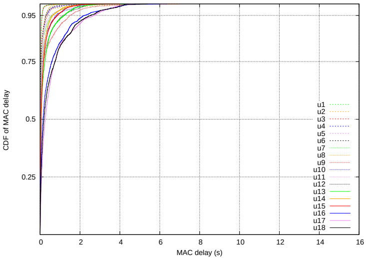

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Figure: CDF of MAC-hs delay.

Simulation Results - Web-Traffic

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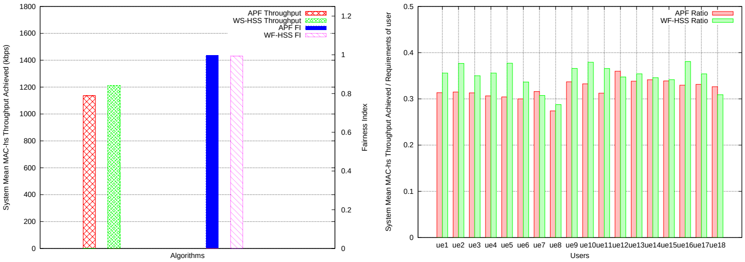

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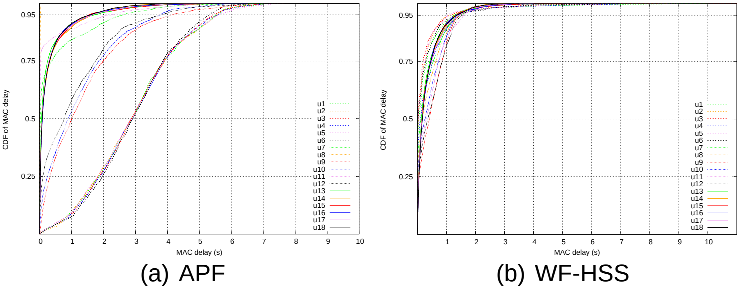


Figure: CDF of MAC-hs delay.

Simulation Results - FTP-Web Traffic Scenario

Vehicular Environments

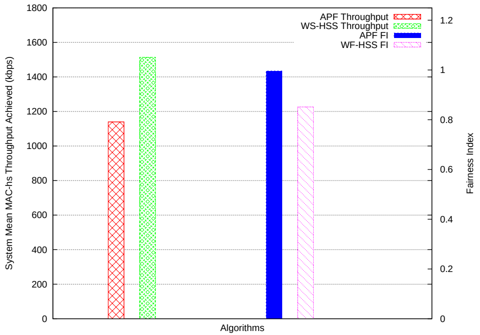
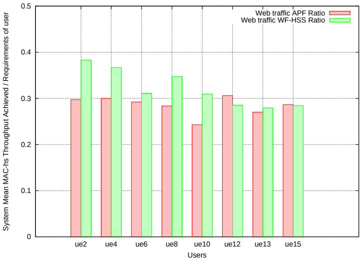


Figure: Mean System Throughput (MAC-hs) Achieved and Fairness Index.

Simulation Results - FTP-Web Traffic Scenario

Vehicular Environments



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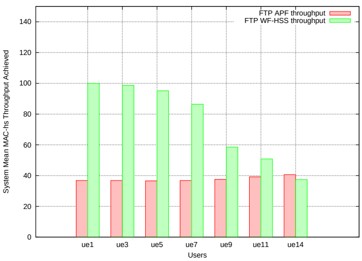
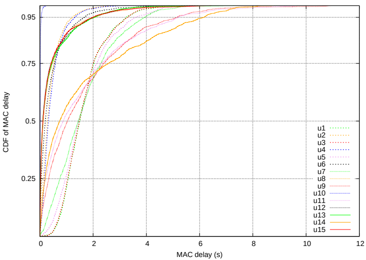


(b) MAC-hs Throughput Achieved for FTP users

Figure: Users analysis

Simulation Results - FTP-Web Traffic Scenario

Vehicular Environments



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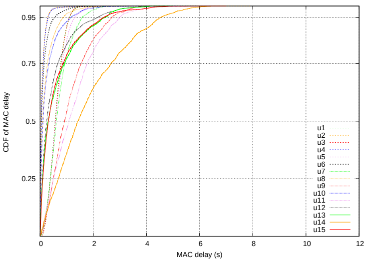

(b) WF-HSS

Figure: CDF of MAC-hs delay

Simulation Results - Load Analysis

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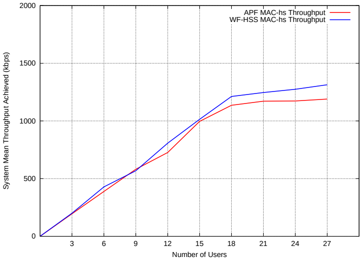

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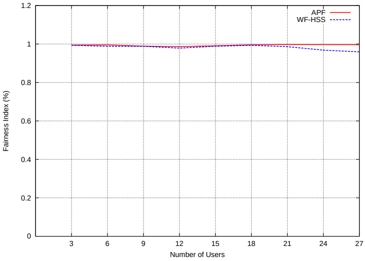

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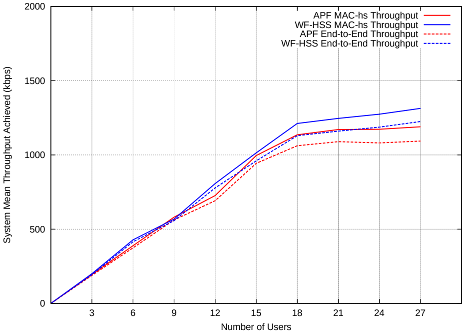
Back to Pedestrian Results

Simulation Results - Load Analysis
Pedestrian Environments



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