NS-2 Enhancements for Detailed HSDPA Simulations

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ABSTRACT

The Enhanced UMTS Radio Access Network Extensions (EURANE) provided UMTS and HSDPA support in the Network Simulator (NS-2). The main components of EURANE include the Radio Link Control (RLC) layer with the Acknowledged and Unacknowledged Modes, MAC layer for the main UMTS and HSDPA transport channels and a physical-layer simulation tool for simulating the fast channel variations in HSDPA. Although it has added most of the UMTS protocol stack to NS-2, EURANE does not support multiple cells, user mobility or handover which are necessary to study the system-level performance of RLC layer, handover and Iub flow control. In this paper, we describe new extensions and a redesign of EURANE to overcome these limitations and provide additional functionality. The new simulator supports user mobility using Random Waypoint mobility models and handover. In addition, the simulator provides an enhanced signaling protocol for Iub flow control that allow adding new flow control algorithms to EURANE whenever needed.

Categories and Subject Descriptors

I.6.8 [**Simulation and Modeling**]: Types of Simulation—*Discrete event*

General Terms

Performance

Keywords

NS-2, HSDPA Simulations

1. INTRODUCTION

The Network Simulator (NS-2) is a discreet, event-driven network simulator developed initially at UC Berkeley and later supported by the VINT project [10]. NS-2 provides substantial support for TCP, routing and multicast protocols over wired and wireless networks. As an open source

software, numerous extensions have been added to NS-2, thus making it a popular simulation tool in advanced network research. Although NS-2 provides extensive support for wireless ad-hoc networks and satellite links, 3G systems such as UMTS and HSDPA have not been part of the mainstream code. Several contributed modules implemented UMTS functionality in NS-2 with varying levels of details. The most notable extension is the Enhanced UMTS Radio Access Network Extensions (EURANE) developed as part of the European Commission 5th framework project (SEACORN) which investigates enhancements to UMTS Radio Access Network and Core Network [3].

Although EURANE has added most of the UMTS and HSDPA protocol stack to NS-2, it lacks the necessary functionality to support multiple cells, mobility, handover and flow control algorithms. One of the main reasons behind this is the dependency on MATLAB for simulating the mobile fading channels in HSDPA. In this paper, we highlight the current limitations of EURANE and summarize our extensions to overcome the dependency on MATLAB and provide full mobility and handover support to EURANE. Also, we describe further modifications to EURANE to allow adding more flow control algorithms.

The rest of this paper is organized as follows. An overview of EURANE and its limitation is provided in the following section. Then, the new extensions developed on top of EURANE are introduced. A sample simulation scenario to demonstrate the new extension is described at the end along with some sample results.

2. EURANE OVERVIEW

EURANE added three node types to NS-2, namely Radio Network Controller (RNC), Base station (BS) and User Equipment (UE). These nodes support four types of UMTS transport channels: Forward Access Channel (FACH), Random Access Channel (RACH), Dedicated Channel (DCH) and High Speed Downlink Shared Channel (HS-DSCH). Most of the protocol architecture between a UE and a fixed host on the Internet is implemented in EURANE. The main protocol additions to NS-2 are the RLC Acknowledged and Unacknowledged Modes, MAC-d and MAC-c/sh support for FACH, RACH and DCH, and MAC-hs support for HS-DSCH. The overall model of HSDPA protocol architecture is shown in Figure 1 and briefly described in the following subsection.

2.1 System Model

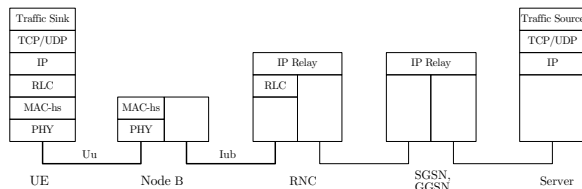We focus on the portion of EURANE that implements

Figure 1: Protocol Architecture Model

HSDPA functionality. Looking at Figure 1, only three main layers are contributed by EURANE. The first layer is the RLC layer which exists in the RNC and the UE. The second layer is the MAC-hs layer which exists in the Node B or (BS). At the bottom of the stack, there is the physical layer (PHY) which exists in the Node B and the UE. These layers implement most of the functions defined in 3GPP Release'5 [1].

At the RLC layer, the Acknowledged Mode (AM), provides segmentation and reassembly, padding and concatenation, in-sequence delivery, window-based flow control, retransmissions and duplicate PDUs detection. The basic operation of AM is as follows. Packets, or RLC SDUs, are segmented into fixed-size PDUs and sent to the peer RLC entity as long as the transmit window is less than the maximum window size. The peer RLC entity reassembles the SDUs out of the received PDUs and passes them up the stack in sequence. The receiver then sends a status report containing a bitmap acknowledgment of each sequence number it has received successfully. The status reports may be sent periodically or as a response to a poll bit in a received PDU. The sender may send a poll bit for the last PDU created from the SDU or upon expiry of the poll timer. The Unacknowledged Mode (UM) is a subset of the AM functionality described above. The employed model for UM provides segmentation and reassembly, padding and concatenation, in-sequence delivery and duplicate PDUs detection. The UM does not have ARQ so there are no status reports or acknowledgments exchanged between the sender and the receiver. Also, the sender is not bounded by a transmission window and hence can transmit PDUs whenever they are created [3].

The model for the MAC-hs which is the layer responsible of HSDPA, implements the two main features of HSDPA: fast scheduling and Hybrid Automatic Repeat Request (HARQ). The fast scheduler uses feed-backs from the UE's about their channel conditions using Channel Quality Indicator (CQI) reports. Every time slot (2 ms), the scheduler scans all priority queues and selects the candidate queue for the next transmission slot. The transmission rate is selected based on the CQI value using 3GPP's tabulated Transport Format and Resource Combinations (TFRC). Once a user is scheduled, the MAC-hs entity creates a MAC-hs PDU, or a transport block, containing multiple MAC-d PDUs and assigns it to a HARQ process. Using a Stop-And-Wait ARQ mechanism, the HARQ process persists on transmitting the block to the UE until it receives an acknowledgment or it reaches the maximum number of retransmissions. In EURANE, only chase combining is used for HARQ retransmissions. Chase combining means that the receiver does not discard the block when received in error, but combines it with the second retransmission to enhance the ability of decoding the block correctly. Chase combining is implemented

by the PHY in EURANE as will be described below.

At the bottom layer in the stack, the physical channel model uses the HARQ chase combining scheme with Acknowledgments and Channel Quality Indicator (CQI). Based on the value of the CQI, the amount of data to be transmitted in the Mac-hs frame is determined and the frame is transmitted over the air. Upon reception, a positive or a negative acknowledgment is generated depending on the received SNR value with a target Block Error Rate (BLER) of 10%. The SNR values are pre-computed for each UE using a MATLAB script that generates channel samples with distance loss, shadowing, multi-path and interference. Distance loss is calculated according to Okamura-Hata model for suburban areas. However, the channel model in EURANE is designed for the purpose of studying the effect of scheduling on nearby versus far away users and hence the distance of each UE from the BS is assumed fixed, i.e. users are assumed moving on an arc around the base station. Therefore, the distance loss remains constant throughout the simulation time. Shadowing, or slow fading, is modeled as a lognormal random process with a correlation distance. The multi-path, or fast, fading is modeled as a Rice fading process using various ITU-T channel profiles [3].

2.2   Code Design

UMTS and HSDPA functionality in EURANE are provided by the following NS-2 classes: *AM*, *UM*, *UmtsMac*, *UmtsPhy* for basic UMTS and *AM-HS*, *UM-HS*, *HsdpaMac* and *HsdpaPhy* for HSDPA. For each channel, either RLC AM or RLC UM can be used but they cannot be mixed together. Only one RNC and one BS are supported in EURANE. A single-cell HSDPA system is constructed by creating NS-2 nodes for RNC and BS and interconnecting them with an Iub link. The HS-DSCH channel is then setup in the BS node and multiple UEs are created and attached to it. The associated uplink DCH channels are created between the UEs and the BS, one per each UE. Traffic sources are then configured and mapped over the HS-DSCH channel using their flow IDs. Each UE can only have one flow, but multiple priorities can be configured for each flow. Figure 2 illustrates the class mapping and connections for two UEs attached to a HSDPA cell.

A Packet in RLC AM mode is routed from the *AM-HS* object at the RNC to the *HsdpaMac* object at the BS then to the *HsdpaPhy* object at the BS which broadcasts it to all listening *HsdpaPhy* objects at the attached UEs. If the physical layer model determines the packet to be error-free, the UE's *HsdpaPhy* object passes the packet up in the stack to the *HsdpaMac* and the *AM* objects. The UE sends back acknowledgment packets using *UmtsMac* and *UmtsPhy* objects and their counterpart objects at the BS over a dedicated channel. The BS passes these packets to the *AM-HS* object at the RNC over the Iub link. A similar flow occurs for RLC UM mode but using *UM-HS* and *UM* objects at the RNC and UE respectively.

To implement the physical layer, EURANE uses a standard NS-2 channel object to connect the BS to the UEs. The FACH, RACH and DCH channels use the standard NS-2 error model which provides simple probabilistic packet loss. A more realistic error model is required for HSDPA to take into account the long and short term variations in link quality in order to model the fast link adaptation, fast scheduling and HARQ chase combing. Therefore, EURANE uses a
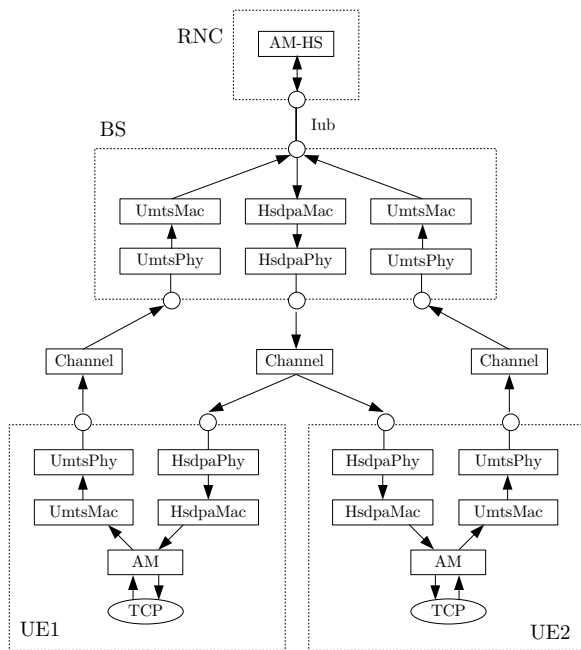
Figure 2: EURANE Setup for HSDPA with 2 UEs

pre-computed BLER/SNR performance curve and an input trace file of received powers (expressed in SNR) to generate the required error model for HSDPA. For the received powers, a separate physical layer simulation script in MATLAB is used to generate an input trace file for each UE according to the physical channel model described earlier. The file contains the SNR values of the first, second and third transmission attempts in addition to the CQI in each time slot (2 ms). The files are then attached to the corresponding flow in NS-2 using the simulation script. Basically, the *HsdpaMac* object in the BS loads all the files into a memory data structure before the simulation starts. Then, the CQI and SNR values are read on demand by the different class methods such as the scheduler and the HARQ. For the SNR/BLER curve, a single file provides mapping between a certain BLER range and the minimum SNR value required for a specific CQI. This file is also loaded into memory to be used by the receiver's *HsdpaPhy* object to determine whether an ACK or a NACK should be generated for the received SNR.

Finally, EURANE provides three scheduling algorithms and one flow control algorithm in the *HsdpaMac* class. The signaling protocol for Iub flow control is not implemented but instead, credits are allocated by calling methods in the *AM-HS* object in the RNC node from the *HsdpaMac* object in the BS node with appropriate delay representing the flow control cycle.

2.3 EURANE Limitations

EURANE provides a good tool for evaluating the key features of UMTS and HSDPA such as the RLC Acknowledged Mode, fast scheduling algorithms and HARQ. Also, the physical layer simulator developed in MATLAB provides a powerful tool for studying the characteristics of the wireless channel in HSDPA using a variety of mobile environments. However, EURANE does not support multiple

cells and hence user mobility and handover cannot be simulated. Simulating handover in HSDPA is necessary for evaluating the performance of system-level components such as the RLC layer and Iub flow control.

Another practical limitation is that the MATLAB script calculates the SNR and CQI values for all users in every time slot regardless of whether or not a user is active in that time slot. This results in two main problems. First, many large files are generated and have to be stored on disk even if only a small portion of each file is actually used by the simulator. For example, every 1 second of simulation time generates 23 KB of data for each user which means that a 10-minute simulation of 40 users would require 552 MB of storage. The situation is even worse if different simulation runs are needed. The second issue is that all these files have to be loaded into memory at the beginning of the simulation which could cause scalability issues specially when simulating larger number of users for a longer simulation time.

To overcome these limitations and to provide additional functionality, significant code redesign and modifications have been applied to EURANE as will be described the following section.

3. NEW EXTENSIONS

As described earlier, EURANE added the main functions of UMTS and HSDPA NS-2. We describe here our additions to model user mobility and handover in a multi-cell environment. We first integrated the physical layer simulator into NS-2 by porting the MATLAB code to C++ using Information Theory library (IT++) [4]. Then, we redesigned EURANE code to provide multiple cells (BSs) connected to one RNC. User mobility and handover are then implemented on top of the new system. We also implemented an algorithm-independent flow control protocol to communicate capacity-request and capacity allocations commands between the RNC and the BS over the Iub link as specified in 3GPP Release'5 [1]. This allows for implementing new flow control algorithms for performance evaluation. A brief description of the new code is given in the following subsections.

3.1 Physical Channel Simulator

In EURANE, the physical layer simulation script defines several channel parameters such as transmission power allocated to HS-DSCH, channel profile, number of users with their speeds and distances from the base station. However, these parameters remain unchanged throughout the simulation time which practically means that users are moving on an arc around the base station at a constant speed. This semi-static setup with constant distance and speed cannot be used if user mobility is to be simulated. Moreover, the input trace files are attached to a single *HsdpaMac* object in a single BS node which makes it difficult to manage in multi-cell configuration. Therefore, it was necessary to integrate the physical channel simulator into the main EURANE/NS-2 code in order to generate the SNR values dynamically depending on the current speed and location of the user with respect to its home cell.

The original physical simulation code utilizes the numerical computation power of MATLAB in linear algebra and matrix manipulation. To efficiently port the code into NS-2 which uses C++, an equivalent library at least as powerful as MATLAB should be used. The Information Theory

(IT++) library was chosen to port the code from MATLAB to native C++ code. IT++ is an open source library based on templated vector and matrix classes designed for mathematical, signal processing and communications systems [4].

A new class, *HsdpaChannel*, was developed using IT++ to compute the SNR values as in the MATLAB code but dynamically as the simulation goes on. For each user, there is one *HsdpaChannel* object responsible of generating the SNR values in every BS node, but only one object is active at a time. When the UE moves from one BS to another BS, the old *HsdpaChannel* object is disabled and the new one is enabled. Instead of reading from a file, the *HsdpaMac* object now reads from its member object *HsdpaChannel* for the specific flow ID. The interface between the new class and the *HsdpaMac* class is very similar to the interface of the original data structure but allows for changing the UE physical channel parameters such as distance and speed at run time.

The internal computation of the SNR values uses the same procedure of the original MATLAB script but includes the variation of the actual speed and distance in every time slot. It works as follows. Once the UE enters the cell area surrounding the BS according to the mobility model, the corresponding *HsdpaChannel* object in this BS reads the UE entry position, the expected exit position and the speed. It then calculates the vector of distances per time slot and the time required to move along the path from the entry to the exit points with regard to this cell. The resultant distance vector is used in the calculation of the path loss as usual.

The SNR values are not computed on every time slot, but instead computed in blocks of a specific time interval for better efficiency. However, the interval of each block is limited to a certain maximum value due to the extensive computation involved. Ideally, the block duration covers the whole path from entry to exit point. In case the UE changes its direction and speed inside the cell, the block duration is split to cover each movement direction separately. Moreover, SNR blocks are computed only when needed, i.e. when the *HsdpaMac* generates a query for a time slot that falls within the block duration. This saves memory usage and enhances the scalability of the simulator.

3.2 Mobility

The second major modification to EURANE is the introduction of user mobility based on the popular Random Waypoint mobility model. This model is known for its slow convergence speed where it takes long simulation time to reach steady state. In order to expedite the convergence of the model into steady state, we used the extensions of [8]. In this mobility model, we use a rectangular plane composed of 4 cells. The choice of this simplified structure is to reduce the computational complexity in NS-2. In this model, users start with initial positions, destinations and speeds drawn from the stationary distributions as derived in [8]. Then, all subsequent destinations and speeds are drawn from uniform distributions.

To implement the mobility model, the code was extended to allow for multiple BS nodes each having its own *HsdpaMac* and *HsdpaPhy* objects. Each BS is linked to the RNC node using a separate Iub link and distributed over a rectangular plane so that the inter-BS distance is equal to $2r$ where r is the required cell radius. Each UEs is attached to a specific BS node based on its starting location which

is determined by the Random Waypoint model as described earlier. Once a new movement, or trip, with a random speed and destination point is scheduled for the UE, the UE walks through the path toward the destination point and determines all possible cell changes. The UE schedules a handover for every cell change at the expected time. Once the whole path is traveled, the UE schedules a new trip at the expected arrival time at the destination point.

3.3 Handover

The handover model is based on the Serving HS-DSCH Cell Change procedure defined in [1], but with some abstractions. The handover sequence which is modeled here is illustrated in Figure 3. In this sequence, the handover signaling protocol is not implemented but associated delays are modeled as constant values depending on the accumulated link delay of all links or hops traversed by each signaling message. The processing delays are assumed negligible and equals to zero. From the sequence, only two steps are implemented. Once the handover is triggered by the UE, the RNC schedules a halt to RLC operation and hence stops transmitting PDUs once it receives the HS-DSCH Release confirmation from the source BS. Then, the actual channel switchover is executed at the activation time X which is equivalent to the time when the UE receives the Transport-Reconfiguration request plus an offset δ which is assumed 5 ms in this model. This offset is not based on the 3GPP standard but is used here to simulate a synchronized handover. The handover is synchronized meaning that UE, RNC, source Node B and target Node B all know about the activation time of the new radio link context. Nonetheless, this assumed synchronization can be easily relaxed.

For simplicity, handover decisions are not based on actual signal measurements, but instead based on distance from the basestation. During its movement, the UE checks its distance every 10 meters from all surrounding Node B's and select the closest one. If the new selected Node B is different than the current one, the handover procedure is initiated by the UE. We used this simplistic model since we are interested in system level performance at RLC and above layers specifically for flow control algorithms. A more sophisticated model is definitely required to study link level performance and handover performance in particular.

A new procedure was added to the Tcl portion of EURANE to simulate handover. In this procedure, the UE node is detached from the HS-DSCH channel in the old BS and then attached to the HS-DSCH in the new BS. The coordinates of the entry and exit points of the UE in the new cell are calculated and passed to *HsdpaChannel* object in the new BS in order to calculate the new distance vector.

3.4 Flow Control Protocol

The original EURANE model for Iub flow control uses only one flow control algorithm that operates for all user buffers synchronously without modeling separate capacity-request and capacity-allocation commands per each buffer. The signaling protocol for Iub flow control is not implemented but instead, credits are allocated by calling methods in the *AM-HS* object in the RNC node from the *HsdpaMac* object in the BS node with appropriate delay representing the flow control cycle. We added new extensions to model the flow control protocol operation for each user buffer independently according to 3GPP Release'5 [2]. Each of the
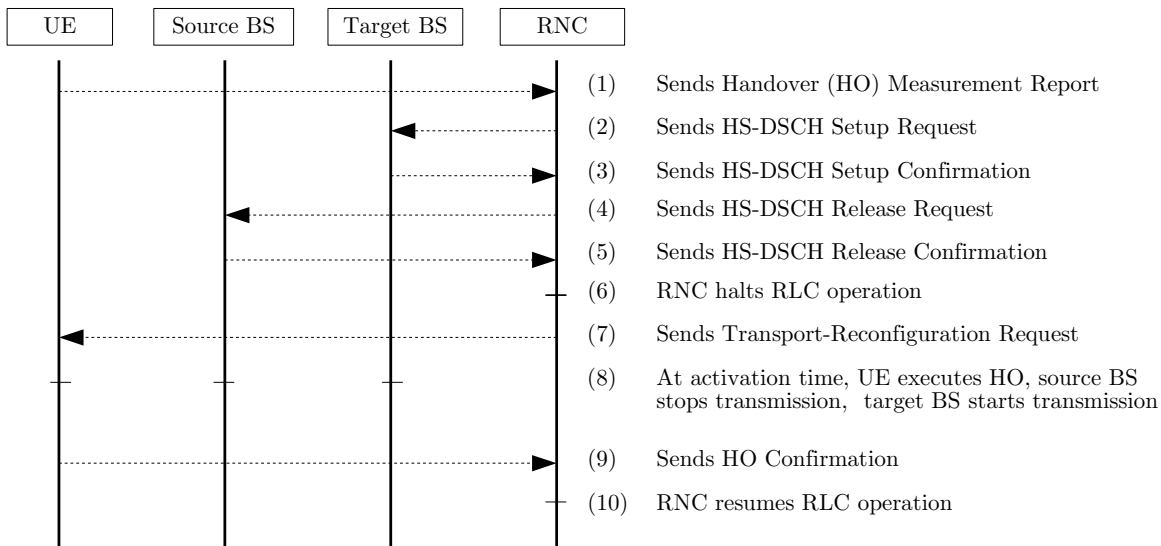
Figure 3: Serving HS-DSCH Cell Change Proceedure

flow control signaling commands is modeled as a new control packet carrying specific flags to indicate the type, i.e. capacity request or capacity allocation, number of PDUs requested or allocated, interval and repetition period. Also, the User Buffer Size (UBS) field is added to the RLC header of every data packet as defined in 3GPP Release'5. Using this protocol, EURANE can be easily extended with new flow control algorithms whenever needed. We implemented 3 algorithms: 2 from related work on HSDPA flow control in [7] and [9] and 1 from our own work.

3.5   Other Extensions

Several other extensions were added to EURANE to facilitate detailed simulation of different scenarios. One important addition is the popular Proportional Fair scheduling algorithm which is described in [6]. Another extension is the mixed mode environment which allows configuring RLC AM and UM over the same HS-DSCH channel but for different users. Finally, new instrumentation code was embedded in EURANE to collect various statistics related to mobility, handovers and flow control protocol.

4.   SAMPLE SIMULATION

In this section, we present sample results obtained using our modified EURANE simulator. Two flow control algorithms are compared here in order to illustrate some of the performance metrics that can be evaluated using this system.

4.1   Scenario Description

We used our modified EURANE code to run several simulations with different scenarios to study the impact of the Iub flow control on HSDPA performance. In this paper, we present a sample scenario to compare two flow control algorithms. Each flow control algorithm was simulated independently in 3 runs of 600 seconds each. The two algorithms are briefly described below in addition the other settings of the system.

Network Topology: There are 4 cells in the rectangular cellular plane and each cell is served by one BS node located at the center of the cell. The cell radius is 500 meters and the inter-site distance is 1 km. The four BS nodes are connected to one RNC using a 155 Mbps Iub link. The Iub delay is set to 15 ms. The RNC, SGSN and GGSN are interconnected with 155 Mbps links with 6 ms delay. The servers are connected to the GGSN with 100 Mbps links with 8 ms delay. The number of users starts with 5 users and get incremented in every run to generate different load points. The number of servers is set to a constant ratio of 1:10 users.

Traffic Type: In this scenario, only continuous TCP traffic is flowing in the system. Users are assumed to be always active downloading a very large file throughout the simulation time. The number of users is varied from 5 to 50 users at which the system was observed to reach its limit. TCP NewReno was used between the users and the file servers.

Transport Channels: There is one HS-DSCH channel in each cell shared by all users. Also, there is one associated uplink DCH channel for every user. The uplink DCH bandwidth is set to 64 Kbps and TTI is set 10 ms.

RLC and MAC Settings: All users' flows are routed over RLC Acknowledged Mode. All RLC and MAC parameters are left to their default values as listed in EURANE [3].

Flow Control: The two flow control algorithms are briefly described as follow:

1. Legg's Flow Control: We implemented the flow control algorithm described by Legg in [7]. The algorithm tries to maintain the buffer level below a variable threshold that takes into account the current buffer level and the outstanding credits that are allocated but are not yet consumed by the RNC. The threshold is set as an integral multiple of the maximum number of bits that can be

Table 1: Physical Channel Settings

Shadowing correlation distance	40 meters
Standard deviation of the shadow fading	8 dB
Base station transmission power	38 dBm
Base station antenna gain	17 dBi
Path loss exponent	3.52
Initial loss at 1 km	137.4 dB
Base station antenna height	30 meters
UE antenna height	1.5 meters
Carrier frequency	1950 MHz

Figure 4: Average Cell Load

Figure 5: Average Handovers per User

delivered in a single time slot. In our simulation we set the maximum bits to the largest transport block size in HSDPA minus MAC-hs header; i.e. 25558 - 21 bits. We set all other parameters as in [7].

2. Necker's Flow Control: We implemented the flow control algorithm described by Necker and Weber in [9]. The algorithm tries to adjust the buffer size for each user so that a predefined queuing time is maintained. We use an update interval of 30 ms and set the other parameters as in [9].

Scheduling: The scheduling algorithm used here is the Proportional Fair (PF) algorithm which offers a trade-off between user fairness and cell capacity [5]. We use the version of the algorithm that considers the Node B's buffer condition as formulated in [6]. The algorithm selects the user that maximizes the Relative Channel Quality Indicator; $RCQI$ defined as:

$$RCQI_i(t) = \frac{R_i(t)}{T_i(t)}$$

where R_i is the "achievable" instantaneous rate taking available data in the buffer into account. The average throughput, T_i is updated in every time slot for all active users as follows:

$$T_i(t) = (1 - [B_i(t) \overset{?}{>} 0]\frac{1}{T_c})T_i(t-1) + X_i(t)\frac{1}{T_c}R_i'(t)$$

where R_i' is the actual served rate when the user is scheduled, B_i is the current buffer size and X_i is 1 if the user is scheduled in the current slot and 0 otherwise. The exponential filter for the averaging process, T_c, is set to 1000.

Mobility: Using the Random Waypoint mobility model, we set the user speed to be randomly sampled from [20,120] km/h which yields an average speed of around 70 km/h. This speed with the relatively small cellular plane can generate a reasonable handover rate of at least one handover every 66 seconds per user.

Physical Channel: Except for the user speed and distance from the base station, the physical channel parameters are identical to the settings in the original MATLAB script for EURANE physical layer simulations as listed in Table 1.
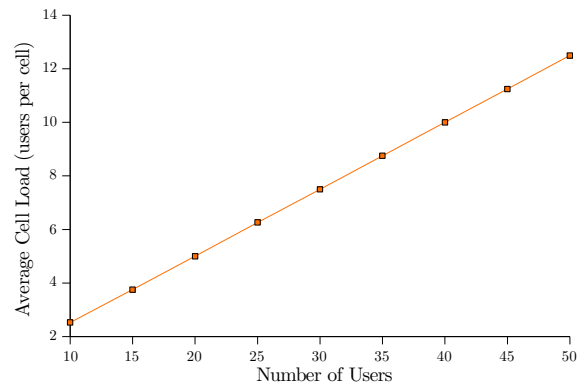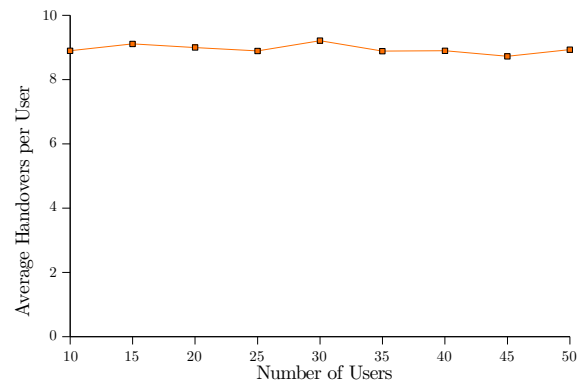
4.2 Sample Results

Some sample results obtained from this simulation are presented here. Since the purpose of this scenario is to highlight the benefits and the new simulator, the results of the two flow control algorithms are presented as is with no further analysis. We focus on the aspects related to our newly developed extensions in mobility, handover and flow control.

We first look at some mobility statistics which are independent of the performance of the flow control algorithm. The average cell load is depicted in Figure 4. This represents the time average of the number of active users per cell. Also, the average number of handovers per user is shown in Figure 5. This represents the activity of each user during the 600-second simulation time.

Next, we quickly examine the performance of the two flow control algorithms. The primary target of the Iub flow control in HSDPA is to control the amount of traffic buffered at the Node B in such a way that reduces data loss during handovers. In the same time, sufficient traffic has to be available at the Node B for the scheduler to efficiently utilize the air interface. The average packet loss during handover is compared for the two algorithms in Figure 6.

Finally, the signaling load generated by the flow control protocol has to be within an acceptable limit for cost and bandwidth reasons. Figure 7 indicates that Necker's algorithm generates much more signaling load than Legg's algorithm.
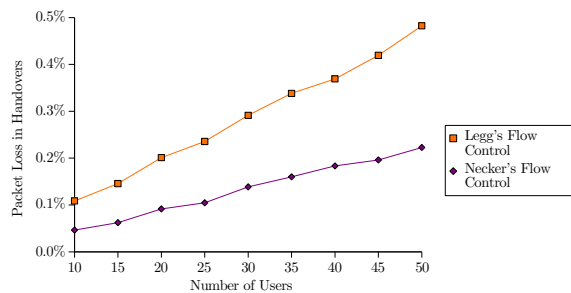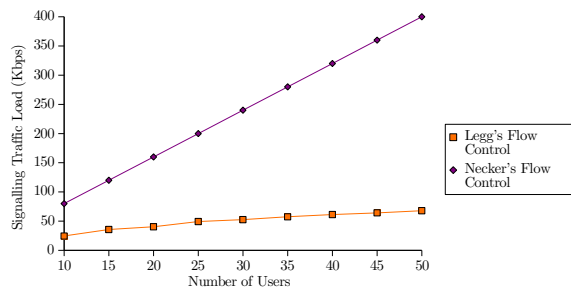
Figure 6: Average Packet Loss during Handover

Figure 7: Flow Control Signaling Traffic Load

5. CONCLUSIONS

In this paper, we described the functionality of the Enhanced UMTS Radio Access Network Extensions (EURANE) which provides UMTS and HSDPA support to the Network Simulator (NS-2). We identified the current limitations of EURANE which are mainly the lack of mobility and handover support and the dependency on MATLAB for physical layer simulations. New extensions have been developed with significant code redesign to overcome these limitations and to add additional functionality. The new modified simulator supports user mobility using Random Waypoint models and handover. Also, the physical layer simulation has been integrated with NS-2 which eliminates the dependency on MATLAB in EURANE. In addition, the simulator provides an enhanced signaling protocol for Iub flow control that allow adding new flow control algorithms to EURANE whenever needed.

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