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Handover Protocols in Mobile WATM Networks: An Analysis of Hard and Soft Handover

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Mobile Wireless Asynchronous Transfer Mode (WATM) networks are the means by which the next generation will enable communication due to there high data rates and conformity. It is an extension of ATM networks.

Handover is very important as it has the potential of enabling seamless uninterrupted communication over the entire globe for a mobile terminal. However, the various types of WATM networks are still in the protocol phase (i.e., not yet commercially implemented). The most popular handover protocol is the hard, backward, mobile terminal initiated handover. In this paper the analyses of these protocols were carried out via simulation.

A virtual environment was created which was tailored to match the transfer rate of ATM networks, and narrow in on the effects of handover on the entire network in terms of parameters that enable reliable connectivity. The performance of handover protocols have been evaluated in terms of delays in communication due to the switching from one base station to the next.

Further modification has been proposed and comparatively analyzed, which is based on a soft handover protocol. The algorithm developed had no need for buffering and this showed improvements in results obtained.

Keywords: *Mobile WATM, Handover, Mobile Terminal, Base Station, Cross-Over Switch, Hard Handover, Soft Handover*

1. Introduction

The requirement for a more reliable, faster mobile communication was fulfilled by the creation of mobile WATM networks. Networks of this nature offer high bandwidth in the range of tens of mega bits per second. This new generation of wireless personal communication networks is capable of supporting all forms of traffic, that is, video, voice and data, and this technology is said to have the ability to provide support for many different protocols.

For mobile WATM networks, there are two distinct areas identified. Firstly, mobility management in the fixed ATM network, and secondly, radio transmission technology for ATM cell transport over the wireless medium. Mobility management is segmented into location management and handover management.

WATM networks coverage is built up into smaller geographical groups of coverage zones. This bandwidth is spatially shared so as to limit cross-channel interference. To maintain the high bandwidth the coverage areas are reduced, and this results in an increase in handover rate. This is to show the key role this process plays in seamless communication.

This paper presents the handover protocols in mobile WATM networks, a simulation of these

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networks and from this an evaluation of the performance with respect to delays and the overall effect handover has on them.

This will be carried out by the implementation in a virtual environment. Addressed also is a proposed enhancement of handover via soft handover, which does not break the connection during handover.

2. Background

It would be appropriate to first give a short description of the ATM technology, and its basic principles in order to bring some context to Handover, followed also by a description of its derived counterpart WATM.

2.1 ATM Networks

ATM is a very fast packet switching network with fixed length packets of *53 bytes* called cells. These cells comprise of a header of length *5 bytes* and an information field (payload) of *48 bytes*. It is a single infrastructure that provides integrated services, that is, voice, video and data can be accommodated. The cells are transported via the fibre optic transmission links at bits rates of *155Mbit/s* and *622Mbit/s*, and a low bit error rate (ber) of 10^{-9}.

ATM operates in a connection-oriented mode. Network resources are first reserved, if they are available. (In this study these resources are assumed to be available). Its scheme effectively offers bandwidth on demand, and accomplishes bandwidth efficiency through statistical multiplexing (sharing) of transmission bandwidth. The advantage of ATM over other networks is its capability of carrying any kind of traffic, from circuit switched voice to bursty data traffic at any speed by changing the transmission rate of the cells. In addition, ATM fulfils more quality of service (QoS) aspects than other comparable networks.

With these characteristics and demand for performance with mobility, WATM was then considered.

2.2 Mobile WATM Networks

WATM was created by the **ATM Forum**[1] working group in 1996 [11]. Research and experiments have been conducted since but never implemented commercially. There have been no standards developed for WATM as yet, though many proposals and discussions by various researchers and companies contributing to the ATM Forum were carried out. (Research laboratories have developed several prototypes, which include WATMnet, BAHAMA/MII, Magic WAND and AWACS [12].)

Developing fast and with great potential is wireless communication, and not merely wireless but specifically mobile wireless communication. WATM is thus considered to add a nomadic access capability to ATM networks. With ATM network's advantages WATM is able to capitalise on this with its maximum bit rate numerically constrained by the access radio link speeds. Empirically a sustainable cell rate (SCR) was estimated at approximately *1.5Mb/sec* [2], which was used for the simulation of this network.

A generic WATM network configuration consists of a traditional switched ATM network and a wireless access network with wireless user terminals. These terminals can be either fixed or mobile, however only mobile terminals will be considered in this paper. The wireless mobile terminal (MT) connects to a remote host (another terminal) via a radio channel through one of the access points (AP) on a base station (BS). To support the MTs, the BSs are served by mobility-enhanced ATM switches. These mobility-supporting switches are interconnected by regular switches in the ATM backbone network.

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[1] The ATM Forum is an international non-profit organisation formed with the objective of accelerating the use of ATM products and services through a rapid convergence of interoperability specifications.

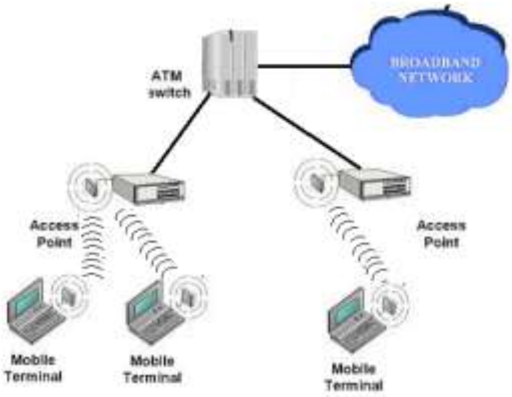

FIGURE 2-1: 1Generic WATM network [6]

Mobility management is implemented in order to track the MTs. It refers to roaming issues such as handover signalling, location management, and connection control. The principal mobility functions are however **handover** (or handoff) and location management. *Location management* is the process of keeping track of the MT so as to allow other terminals to communicate with it. *Handover* is the process of rerouting the mobile terminal connections from the old BS to the new BS (this process will be described in detail in the following section) [3].

3. Handover

Three **handover scenarios** [1] can be distinguished:

1. The old and the new radio ports belong to the same BS. This can be handled completely by the radio-level protocols (thus, not simulated).
2. The target radio port belongs to different BSs, with the old and new BSs connected to, and supported by the one ATM switch. This switch controls the rerouting of the connections, and is called the crossover switch (COS).
3. Each of the two BSs is connected to it own mobility-enhanced ATM switch. An intermediate switch (or possibly one of the two directly connected to one of the BSs involved) acts as the COS for rerouting to be done. In this scenario discovery and selection of the appropriate COS has to be done. (COS discovery and selection was assumed in simulation).

Handover involves rerouting of connections, as well as reserving resources in switches, testing the availability of radio bandwidth, tracking terminals to perform look-ahead reservations, etc. However, the main consideration is to maintain connection quality. This quality is characterised by the following parameters [2]:

- **The speed of the entire handover process.** The buffer size can be reduced significantly if this is kept below *4ms*, according to empirical analyses.
- **Cell loss and cell sequencing**. A proper handover scheme guarantees these, and is realised by effective buffering. Only the finite buffer size[2] has the potential to result in cell loss, which was not considered.
- **Cell delay**. Buffering indicates a consequence of cell queue delay, and the challenge now for handover algorithms is to minimise this.

3.1 Handover Schemes

Though ATM networks are *connection-oriented*, in which users require connections whose path is established at setup time and remains unchanged during its lifetime, the WATM network necessitates that this path be modified as the MT roams through distinct APs (or BSs). There are two schemes for connecting the new path to the new position of the MT.

Assumed for these schemes is a hard handover procedure (described in section 3.2), where connections are handled using a "break-before-make" approach.

3.1.1 Path Rerouting

The first, path rerouting, involves changing the route of some portion of a connection from the cross-over switch[3] (COS) to the new AP. Depending on the COS selection, the new route of the connection can be close to optimal.

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[2] A significant cost of the BS is represented by the handover buffers.

[3] The cross-over switch is that ATM switch that has the shortest path to both base stations involved in handover. It manages the handover

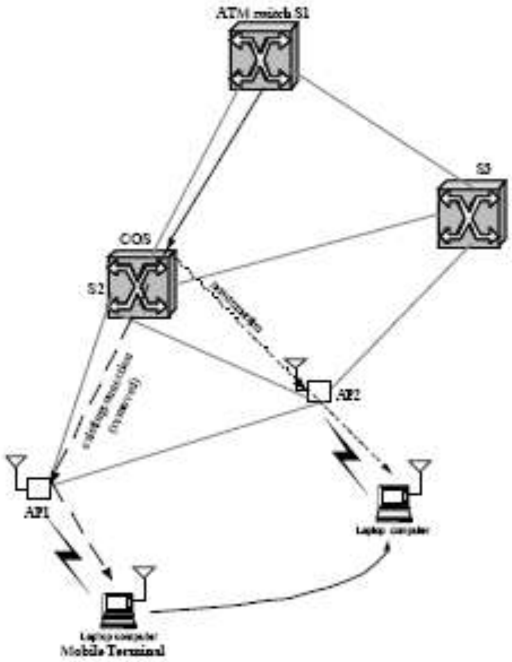

FIGURE 3-1: Path Rerouting Scheme [12]

For example, in Fig. 3-1, let the MT move from its current coverage area to a new area. Then the portion of the existing connection from the COS to AP1 is removed, and a new sub-path, from the point of detachment, is added with the remainder of the original connection path being extended to AP2.

Issues now arise with this scheme, such as COS discovery. Different methods on selecting the COS give different performance for handover control in terms of latency, data loss and resource utilisation [12].

3.1.2 Path Extension

The other approach to handover consists of extending the route of a connection from the old AP to the new AP. The key issue behind this scheme is that after handover, the new connection consists of the existing connection from the source to the old AP followed by an additional sub-path from the old to the new AP.

For example, in Fig. 3-2, let to users A and B, initialising a communication between them, being located under the coverage area of AP1 and AP2, respectively. Suppose that user A moves from AP1 to AP3. The traffic transmitted from the user A to user B will be transmitted from its current AP, AP3, to its source home AP, AP1, and from there to the current location of user B through AP2.

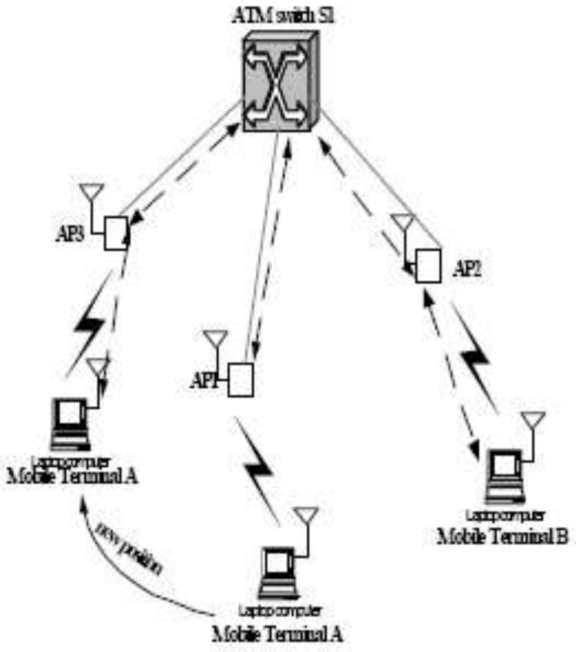

FIGURE 3-2: Path Extension Scheme [12]

The advantage of this scheme is that no COS discovery phase is required, and the existing path is maximally reused. Moreover, this approach makes it easier to implement connection handover without affecting data integrity (that is, maintaining the transmission order of the ATM cells during handover).

However, the extended path increases the end-to-end delay and also reduces network utilisation due to the creation of communication path loops (since the extended path may traverse the same link, more than once). Some form of route optimisation has to be developed so as to counter these inefficiencies. (On this basis, the previous scheme was chosen in the analysis of these networks) [12].

3.2 Handover Classes

There are various handover protocols presented, this section explains them. Identified will be the protocols included in the evaluation via simulation.

Fig. 3-3 illustrates these classes and there relationships.

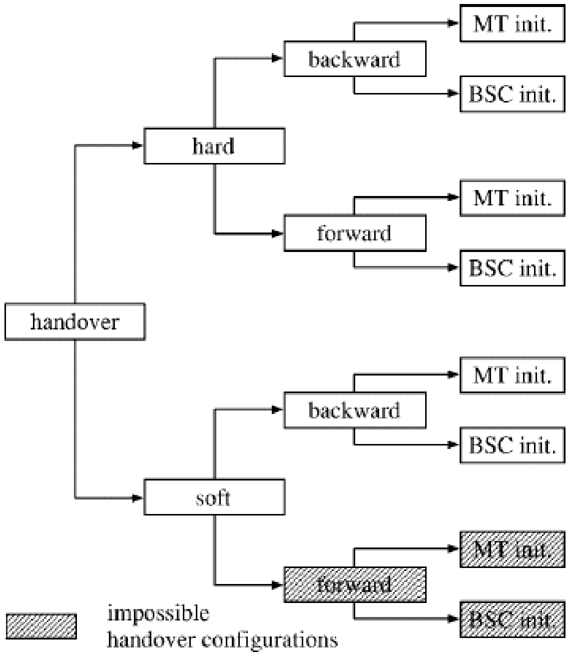

FIGURE 3-3: Handover classification tree [1]

3.2.1 Hard Handover

In a hard handover, a wireless MT has a radio connection with only one BS at any time. The disconnection is initiated, and after resources are secured. The MT disconnects from the old then connects to the new. Only in hard handover is buffering required so as to prevent cell loss and cell reordering.

Handover is required when the current radio link to the BS falls below a certain level [7]. Upon this recognition, it can be initiated either by the MT or the base station controller (BSC). More than likely this class of handover will be utilised the most.

Two well known policies to control handover buffering[4] [2] are:

DEDICATED BUFFER – A connection requiring handover is assigned to a dedicated handover buffer at the destination BS for the entire duration of the handover.

BUFFER SHARING – Connections concurrently requesting handover toward the same destination BS share a common handover buffer always available at the BS.

3.2.2 Backward Handover

In a backward handover, a fading signal is noticed and handover is either initialised by the MT or the old AP. The MT switches over to a new AP after radio resources have been reserved and all entities involved are prepared for the handover.

This is the class that is used by default, when circumstances are considered normal.

3.2.3 Forward Handover

A forward handover is characterised by a wireless MT arriving at a new AP suddenly. The handover can only be initiated after the MT has associated itself with the new AP. In this case, the new AP has to initiate and control the handover from there after. This happens when the MT suddenly loses its connection to the old AP (due to interference or a fast-moving MT), so there is no time to perform backward handover [7].

This class can be thought of as a backup. Forward handover aims at maintaining a connection in spite of unexpected link failures during a handover situation, but at the expense of losing information on the old mobile connection segment and a somewhat higher cost of resynchronisation.

This class was not considered in this paper as resources were assumed to be available.

3.2.4 Soft Handover

Soft handover supports simultaneous communication of a wireless MT with more than one AP (i.e., two APs) during handover. Buffering is not required for this class, and only backward handover can be realised.

Soft handover poses the highest requirements on the radio technology. Therefore, in the overlapping boundary region of the two cells, it enables dynamic selection of the best radio path. Provided the overlapping region of neighbouring

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[4] Buffering of cells is done at the destination BS.

cells is sufficiently large and both APs are able to maintain a sufficiently strong signal in this region, this ensures enhanced QoS for the connection as well as handover reliability [7].
In comparison, soft handover does not have such stringent timing requirements as hard handover. Also it is quite possible to attain no cell losses and cell delays, unlike with hard handover. It is seen as enhancements to the proposed handover classes above.

In summary the two basic handover mechanisms are hard and soft handover. In the case of hard handover, the handover control flow can be directed either across the current AP's air interface (backward handover) or across the target AP's one (forward handover). In all these either the MT or the AP (or BSC) can initiate the handover protocol.

In the case of having the radio link deteriorating rapidly, what is important is to have reliability and robustness of the handover signalling protocol. However, under these circumstances the regular backward handover mechanism will not perform reliably any more. Therefore, the handover protocol has to be supplemented by a forward handover procedure, so as to avoid having handover failure and subsequent call dropping. However, for the analysis of this paper it was necessary to implement forward handover.

4. Simulation

The most popular handover protocol is in the category of hard handover. Proposed in this paper is a simple algorithm for soft handover, which will be clearly seen qualitatively as a better method for handover. This protocol allow for better performance in terms of connectivity during handover. Hard handover will be analysed first, then the improvement shown in soft handover.

The simulated topology created allowed for the inspection of handover scenarios **two** and **three**, as stated in the previous section.

The simulation was carried out with only the relevant timings of the ATM cells in mind, which is seen to be **cell delays** and **the speed of the entire handover process**. (It was confirmed that there were no cells lost or out of sequence). Also noteworthy is that the handover processes are <u>hard, backward and MT initiated</u> handovers.

The software used to create and examine these is OMNeT++. This is an object oriented discrete event simulation environment, and its primary application area is the simulation of communication networks. The name itself stands for *Objective Modular Network Testbed in C++*.

4.1 Topology

The topology implemented is illustrated in Fig. 4-1.

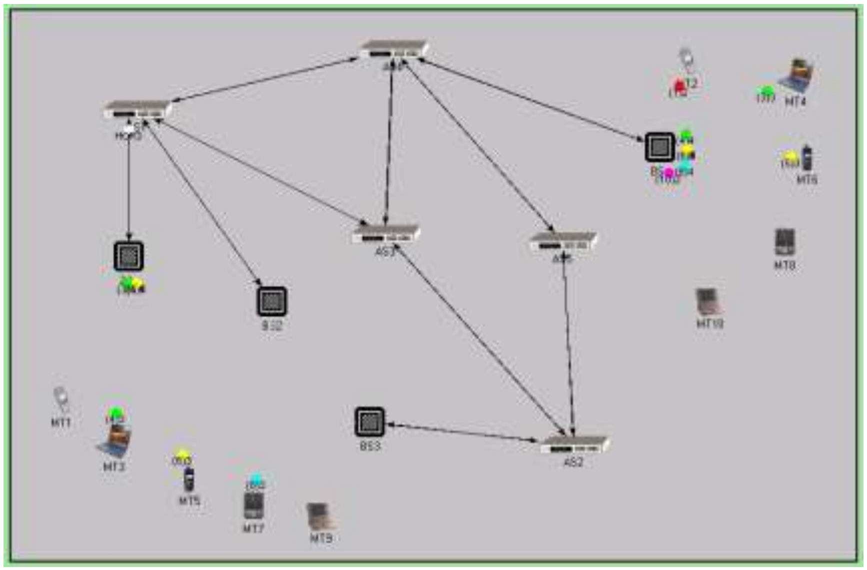

FIGURE 4-1: Network topology

4.1.1 Network Description

▦ => BS (or AP)

▭ => ATM Switch (mobility-enhanced if directly connected to BS)

📱 => MT

● (4)3 => ATM cell (displayed the same for wireless transfer). This specific cell was the third in sequence, outputted by MT4.

In the topology one MT communicates with one other through the network simultaneously along with the other MTs. MT1 communicates with MT2, MT3 with MT4, MT5 with MT6, MT7 with MT8, and MT9 with MT10. The ATM cells are colour coded accordingly. For example, ATM cells produced by MT3 and MT4 are green.

4.2 Handover Algorithm

The algorithm implemented was taken from reference [2]. The temporal diagram is shown is Fig. 4-2.

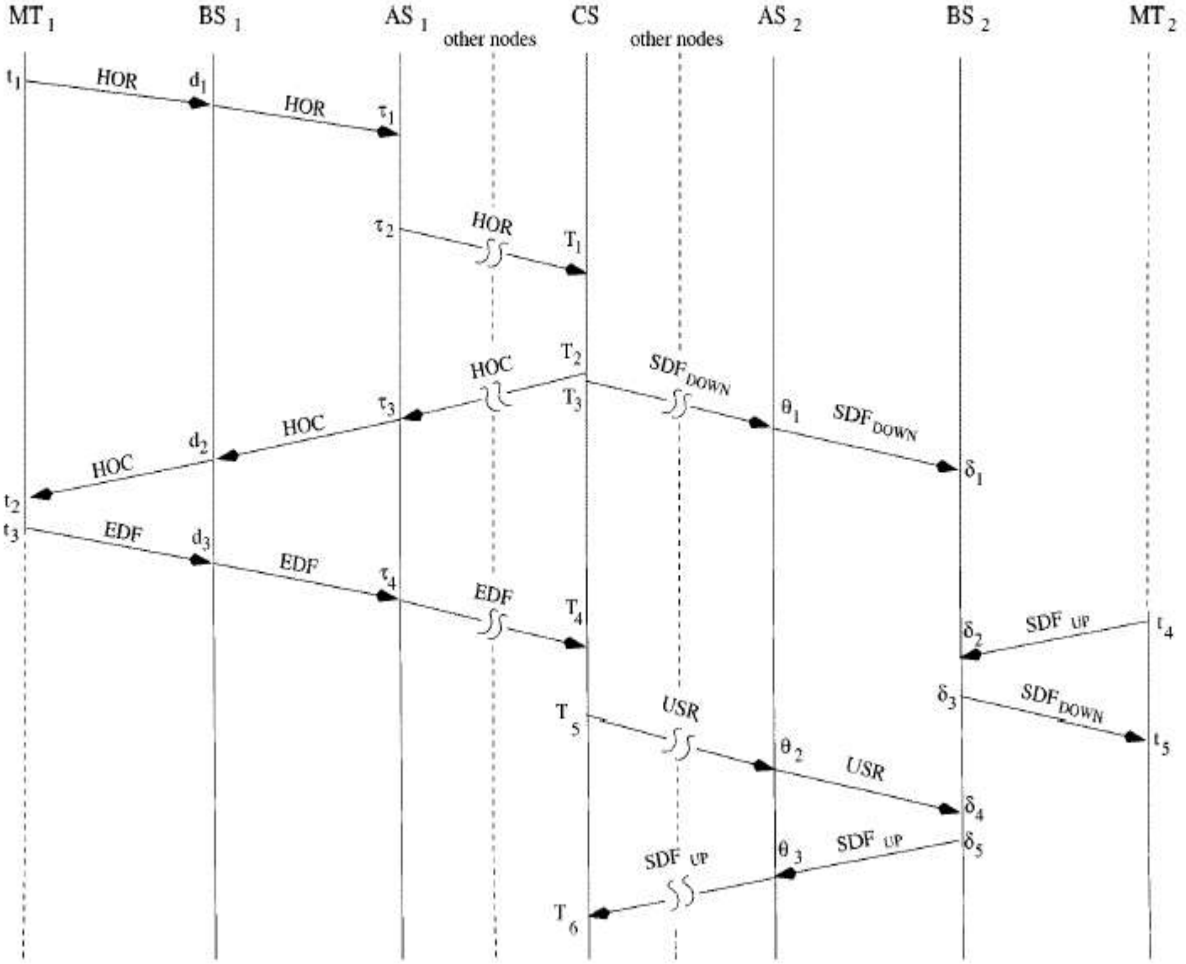

FIGURE 4-2: Temporal Diagram of the Seamless Handover Protocol [2]

Along with this algorithm, in order to focus on the effect handover has on the network in terms of the key parameters stated, the modelling assumptions were:

- Cells from the MTs were produced randomly varying from rates[5] of *5Mb/s* to *25Mb/s*, in order to simulate asynchronous transfer (or busty traffic). (The specifications of low speed wireless were used for the communication with the BSs. One with a data rate of *25Mb/s* [11]).
- The time between handover requests from the same MT is longer than the time required to complete the handover cycle.
- The propagation delay along the transmission links are only one of two categories. That is, propagation delays along all wired links are the same, and likewise along wireless links. (As stated previously, the wired links operate at a data rate of *155Mb/s* and the wireless at *25Mb/s*).

4.3 Handover Process Implemented

During simultaneous communication MT1 and MT3 requests to be handed over to other BSs. These handover processes were designed so that they have no effect on the other, since this simulates a practical case where each MT has dedicated channel.

The MTs were switched from BS1 to BS2, then from BS2 to BS3. Notice that the handover from BS1 to BS2 is in correspondence with the first scenario (BSs at same ATM switch) and the handover from BS2 to BS3 with the second scenario (BSs connected to different ATM switches).

5. Results & Discussions

Referring to the topology presented in Fig 4-1. MT5, MT6 and MT7 communicate via BS1, BS2 and BS3 respectively. During these conversations, MT1 and MT3 communicate via BS1 and then handed over to BS2 then to BS3.

Upon inspection and expectation, it was proven that *cell loss* and *cell reordering* can be avoided during handover, due to an effectively implemented algorithm.

This leaves the important parameter of *cell delay* during handover. Propagation (or end-to-end) delays were recorded and plotted for each MT in communication with its party. (The delays for MT5, MT6, MT7, MT8, MT9 and MT10 were not examined, since they had no part in the handover processes).

It was noticed that theses delays for each of the MTs all reflected similar results. Delays were taken for cells arriving at MT1, MT2, MT3 and MT4, however, because of this similarity only graphs for MT1 will be shown.

5.1 Cell Delays for Handover from BS1 to BS2

Illustrated in Fig. 5-1 is the timed delays of each cell produced by MT2 and received by MT1. Below is a table of the significant data during handover, which corresponds to the information shown in the graph above.

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[5] Typical offered loads of MTs is 1.5Mb/s [2], but in order to test the full capacity of the BSs this range was chosen.

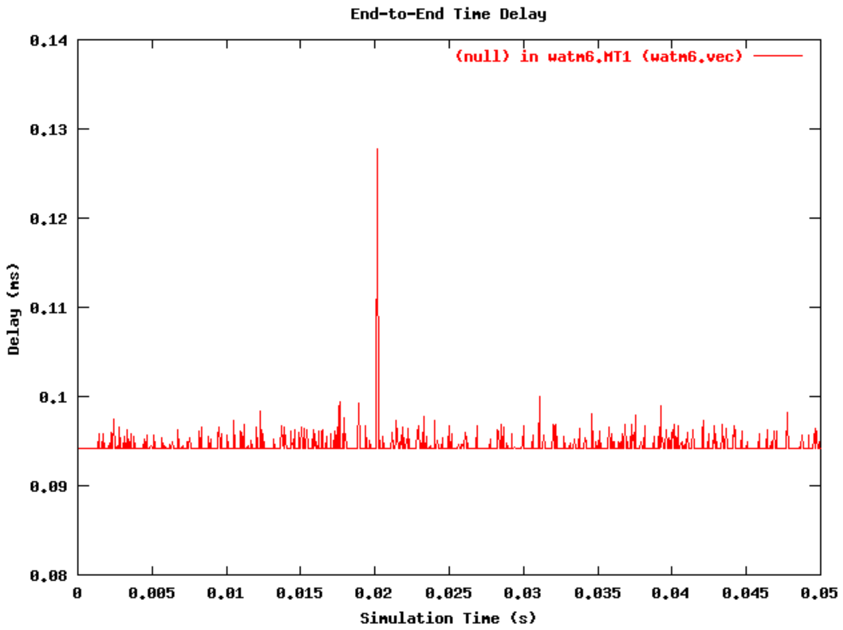

FIGURE 5-1: Cell delays from MT2 to MT 1

TABLE 5-1: Timing data for handover from BS1 to BS2

EVENT	MT1	MT3
Handover start	20.046ms	20.877ms
Handover end	20.1786ms	20.2285ms
Duration	0.132557ms	0.140796ms
Cells buffered	Upstream buffer - 1 Downstream buffer - 1	Upstream buffer - 1 Downstream buffer - 1

Noticed in Fig. 5-1 is a conspicuous spike occurring at approximately 20ms simulation time, coinciding with the handover data tabulated in Table 5-1. This is where handover occurs, as recorded in the table above. The justification for the added delay during handover is due to the fact that buffering of the cells takes place in order to prevent the cells from being lost or reordered.

In this section of the simulation, one cell was buffered per buffer, since during handover only around this amount of cells would have arrived at the destination BS (BS2) intending to traverse to its destination MT. (It is recognised that this model is a scaled down version of a practical scenario).

Contributing to this delay at handover are the control signals themselves. The control signals are expected to be encapsulated in a standard ATM cell format, which is of the same length (*53 bytes*) as the information cells. Therefore each control signal subtracts a small amount of the available resources and is shown up by added delays.

Further discussions will continue in section 5.3, after the results of both handover scenarios are shown.

5.2 Cell Delays for Handover from BS2 to BS3

As anticipated the results displayed in Fig. 5-2 gave evidence to delays being added to the network during the handover period.

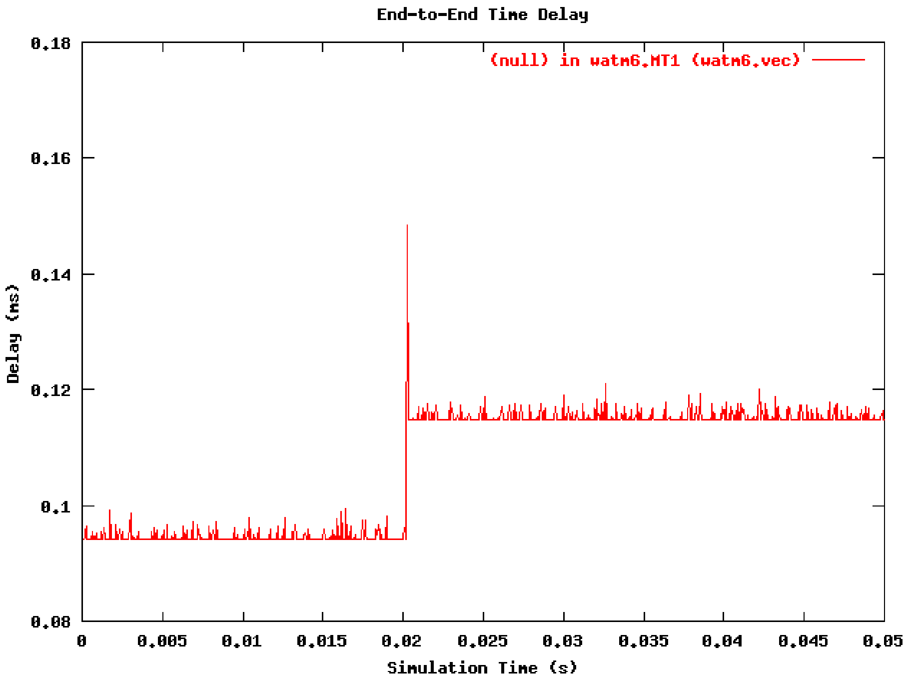

FIGURE 5-2: Cell delay from MT2 to MT1

TABLE 5-2: Timing data for handover from BS2 to BS3

EVENT	MT1	MT3
Handover start	20.0764ms	20.0229ms
Handover end	20.324ms	20.2615ms
Duration	0.247649ms	0.23867ms
Cells buffered	Upstream buffer - 1 Downstream buffer - 0	Upstream buffer - 2 Downstream buffer - 0

Shown above in Table 5-2 is the significant data for this scenario (this also corresponds to Fig. 5-4), and are much like the previous in terms of delays.

In this scenario where the MTs (MT1 and MT3) were handed over to BS3 from BS2, COS detection and selection was necessary. In the previous section the scenario did not result in the path over which the MTs communicated being altered. In this handover the path had a somewhat significant alteration, enough to result in an overall increase of all delays (this was noticed in the graph as a “step up” in delays). This can also be verified from the topology, which shows that now the communication path now has six hops, which is one extra hop more than the previous connection path.

During COS selection path optimisation took place. In that the ATM switches communicate in order to set up the optimal path for communication, which also would depend on resources[6] available.

5.3 General Discussion on Results

In implemented mobile wireless networks, such as cellular, the number of MTs would probably be in the range of *500* to *1000* (a rough estimate). There is a potential for many more handovers occurring simultaneously. Therefore, the number of cells buffered would be much more than that for this simulation, and then the buffer size would have to be consideration for analysis.

A buffer size of *254 cells* [2] was seen as optimal, considering that buffers contribute significantly to the cost of the BS. From this information it can be deduced that there might be cells lost due to overflow of the buffer. From simulation results it can also be deduced that approximately a maximum of half the number of mobile users connected to a BS can be accommodated efficiently for simultaneous handover.

The entire duration of the handover process was in the order of hundreds of microseconds. This could be greater depending on the distance (in number of hops) between the MT and the COS. The second scenario, where the COS was three (3) hops away from the MTs took twice as long as the first scenario, where the COS was two (2) hops away from the MTs. The handover duration is much lower than *4ms* in these cases. However, for handover between, for example, different networks the COS would be a significant distance up the hierarchical structure. In this case the total time for the handover process would have to be considered.

The average cell end-to-end delay was also in the region of hundreds of microseconds. These delays are low, and this is excellent for any communication, but they are not practical. These delays were based on a small number of hops from the sending MT to the receiving MT. Mobile communication involves many more hops, thus, the propagation delay derived in this simulation is definitely not a reflection of real world scenarios. However, the values were accurate enough to do a relative examination, which is enough to evaluate the handover protocols.

Handover does affect the performance of WATM networks, and even though connection can be efficiently maintained (given resources are available) delays were introduced. This could be significant depending on the contracted Quality of Service (QoS). In this small network, however, no significant delays were experienced.

6. Proposed Enhancement

Soft handover is thought of as an improvement to the traditional hard handover. Some of its advantages [13] are as follows:

- Smoother transition with no momentary loss or delays during handover.
- No buffer constraints.
- Less the “ping pong”[7] effect, leading to reduced load on the network signalling and overhead.

However its disadvantages [13] are:

- More complex in implementation compared to hard handover.
- Additional network resources

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[6] The intrinsic advantage of ATM is that resources are supplied on demand, depending on availability.

consumed.

Referring again to the topology of Fig 4-1, soft handover was implemented for handover of MT1 and MT3 from BS2 to BS3 simultaneously. Then the results of the delays will be examined as a comparison to that derived from the similar hard handover processes.

The Soft Handover Algorithm that was developed and implemented is explained in the following points, and displayed in the temporal diagram of Fig. 6-1:

1. Upon recognition of a signal from another BS (in this case BS3) being greater than that of the current BS (in this case BS2), a handover request (HOR) is sent to the BS2, then to the mobility-enhanced ATM switch connected to it (in this case AS1).
2. COS discovery and selection is then done. If AS1 is not the COS, which it isn't in this case, the HOR is sent to the COS selected (which is a variable distance away). In this case the COS is AS3.
3. When the COS (AS3) notices a HOR it searches and reserves resources, which are assumed to be available in this simulation. Then a handover confirmation (HOC) is sent downstream to back to the MT.
4. During this time, starting at point when the HOR was sent, the MT begins communication with the destination BS (BS3). Upon receipt of the HOR at the COS, it begins communication with both ATM switches in connection. Thus, for some time there are two established communication paths.

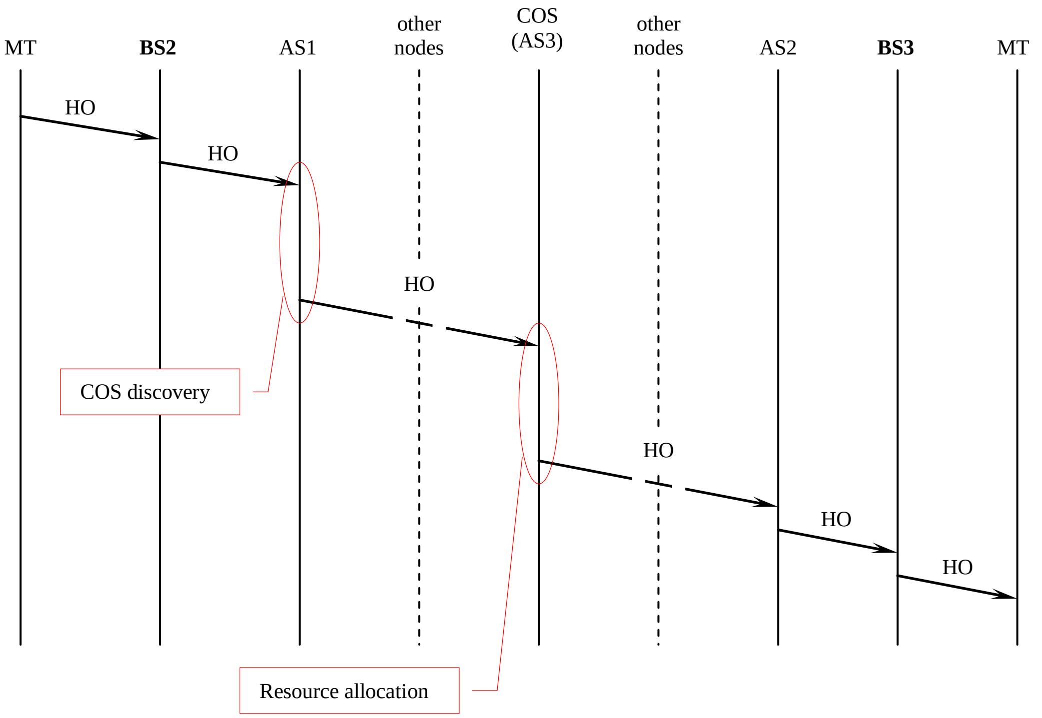

FIGURE 6-1: Temporal diagram of the Soft Handover protocol

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[7] The "ping pong" effect is the phenomenon that when a MT moves in and out of cell's boundary, frequent hard handover occurs [13].

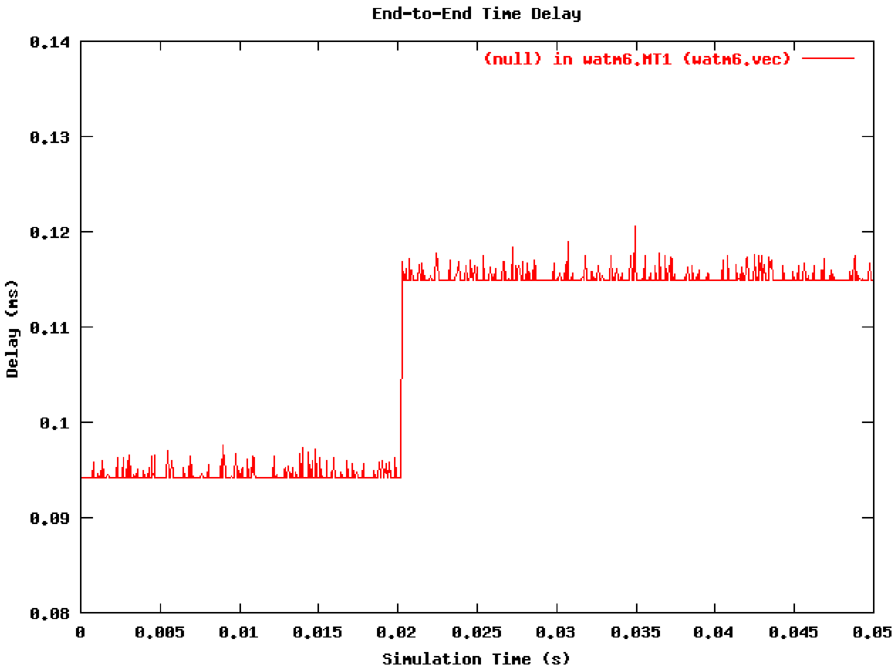

FIGURE 6-2: Cell delay from MT2 to MT1

Key to note is that during handover duplicate cells are avoided by algorithms implemented in the MT and the COS. Duplicate cells were created by the MT and also by the COS. The MT will filter the duplicated downstream cells from the connection it is moving away from (BS2), and the COS will also filter those upstream cells from the old path.

Fig. 6-2 is a graph of the cell delays of the cells received from each MT2 at MT1, during and around soft handover.

It is quite clear in Fig. 6-2 that the general shapes of the graphs are similar in comparison to that of scenario three’s hard handover between BS2 and BS3. The same step up is seen, which signifies the extra hop in the communication link after handover.

However, even more noticeable is the fact that there is no longer evidence of relatively large delays caused by the handover processes. This is the improvement to the system, in that instead of breaking the connection (as in hard handover), it is maintained. This is done via the MT communicating with BS2 and BS3 during handover.

Therefore, with a soft handover procedure there are still no cells lost, no cells reordered or duplicated, and the delays added during handover are now eliminated.

7. Discussion

As discussed thoroughly throughout the previous sections it is clearly seen that handover does have an effect on the network. In hard handover delays were introduced during handover, which was avoided via soft handover. However, it should be understood that this paper did not consider a limit to network resources (they were assumed to always be available).

No discrepancies were evident in this study, but it is expected that a more accurate representation of a real world case could have been realised if more intricate parameters were included. Such as a radio signal that fades depending on distance from the base station, also the buffer size overflowing due to more mobile terminals reengaging in handover than can be accommodated. In a practical case there are possibilities of mobile terminals requesting resources for handover and being denied, this would result in that mobile losing its connection. It is recognised that it is a judgement call to compromise between profit and reliability of service providers.

Evident is that soft handover is much more efficient, given that resources suffice, which is more than likely the case in the near future. A recommendation is that this handover class is a much more reliable one and it also reduces the cost of the base station, since no buffering policies is required. However, in the design of these networks the radio coverage has to be powered enough to overlap. This kind of handover may not seem feasible at first but at the rate at which personal mobile communication is growing it will be, so sacrifice now for a greater benefit in the future.

8. Conclusion

WATM networks fulfil the communication needs of this generation. In the light of high expectancy and productivity this type of mobile communication is no longer a luxury but a requirement.

The handover protocols were studied, with special attention to the various schemes and classes. These were seen to have inherent similarities and differences, and actually implemented protocols are a combination of these. (For example the most popular is hard, backward, mobile terminal initiated handover).

The simulation WATM network was created using OMNeT++. From this, the more pertinent parameters of connectivity were examined with the results obtained. Noticed is that simulators can never perfectly model real world applications, but can give one an insight. The more parameters incorporated the more accurate the results reflect what they should.

An enhancement was proposed which eliminates the problems of delays during handover. This soft handover protocol had no need for buffering, so it was seen as advantageous according to the analysis done. The result obtained showed that where there were delays during hard handover, they were not seen during soft handover.

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