

Handover Strategies Challenges in Wireless ATM Networks

Jamila Bhar, Ridha Ouni, Kholdoun Torki, and Salem Nasri

Abstract—To support user mobility for a wireless network new mechanisms are needed and are fundamental, such as paging, location updating, routing, and handover. Also an important key feature is mobile QoS offered by the WATM. Several ATM network protocols should be updated to implement mobility management and to maintain the already ATM QoS over wireless ATM networks. A survey of the various schemes and types of handover is provided. Handover procedure allows guarantee the terminal connection reestablishment when it moves between areas covered by different base stations. It is useful to satisfy user radio link transfer without interrupting a connection. However, failure to offer efficient solutions will result in handover important packet loss, severe delays and degradation of QoS offered to the applications.

This paper reviews the requirements, characteristics and open issues of wireless ATM, particularly with regard to handover. It introduces key aspects of WATM and mobility extensions, which are added in the fixed ATM network. We propose a flexible approach for handover management that will minimize the QoS deterioration. Functional entities of this flexible approach are discussed in order to achieve minimum impact on the connection quality when a MT crosses the BS.

Keywords—Handover, HDL synthesis, QoS, Wireless ATM.

I. INTRODUCTION

THE Asynchronous Transfer Mode (ATM) is a data transport technology that supports a single high speed infrastructure for integrated broadband communication involving voice, video and data. ATM technology combines some important features: short fixed-size packets or cells, virtual circuits, statistical multiplexing, and integrated services. All these concepts together provide a uniform framework that guarantees traffic with quality of service (QoS) [8].

Wireless ATM (WATM) is mainly considered as an extension of ATM network issue. WATM will be advantageous to support the seamless delivery of multimedia flows with high Quality of Service (QoS). WATM must in all cases allow the network to guarantee a connection continuity of MT.

To support user mobility for a wireless network additional protocols are needed and are fundamental. They mainly refer to handover protocols, routing, and location management. Thus, maintaining QoS guarantees demands to integrate mobility support functions.

This paper introduces the mobility management solutions characteristics of Wireless ATM network. It presents an extended Handover technique for terminal mobility support in

WATM networks. WATM is able to deploy different Handover types, which are intended to manage different network event scenarios. For this purpose, several specific functionalities and algorithms are proposed. In our approach, improved backward and forward hard handover protocols were been developed for switching MT active connections from one base station to another. This approach aimed at defining a solution with optimal method for applying handover in WATM environment. The emphasis was especially on deploying innovative process while maintaining QoS parameters. So, some details of the proposed idea are explained and performed by synthesis and validation phase.

The paper is organized as follows. First, we give an overview of handover protocols. The second section outlines the testing approach adopted for our architecture. Technical challenges are presented and discussed. Then, Handover buffering performances are analyzed and their requirements are explained. Finally, description of our design, synthesis and simulation phases are described and conclusions are given.

II. HANDOVER PROTOCOLS SPECIFICATIONS

Handover term refer to different approaches to supporting mobility aspects. Distinctions between different propositions can be made according to the performance characteristics, diversity steps, state transitions, and control modes of handover techniques. Generally, Handover can be defined as the process by which an active MT changes its point of attachment to the network, or when such a change is attempted. The access network may provide features to minimize the interruption to sessions in progress.

There are different types of handover classified according to different aspects involved in the handover. We can then identify handover types such as backward and forward. This distinction refers to handover steps and to the BSs through which the handover signaling information will be exchanged. In backward handover, signaling messages are exchanged via the old BS (the BS the MT has been attached to during the recent past). Handover scenario, in this case is composed of two stages: setup and handoff. In forward handover, the link with the old base station is suddenly lost. Thus, the MT is forced to seek connectivity through other, neighboring BSs.

In this paper, hard backward and forward handover will be supported by WATM. Backward handover is usually used as first solution. When the radio link is suddenly degraded, the MT will be notified by the signal level, and a forward handover procedure will be initiated to recover the connection.

In this case, the terminal interrupts the old connection and tries to connect to a new BS. In the following section, we present handover management strategy based on inband signaling.

III. HANDOVER MANAGEMENT STRATEGY

A. Proposal Architecture

The handover algorithm integration, in wireless ATM, presents several technical challenges that need to be resolved. This paper is focused on the handover decision making process which satisfies the objectives mentioned above. This process may lead to decide whether handover is necessary and whether additional adaptation needs to be applied. Objectives include satisfying the user's devices preferability, supporting important bandwidth for their respective applications and avoiding data loss which may affect the applications.

The integrated architecture defines the following main entities:

- Entity at base station: depending on a traffic situation, it can play a role of old or new BS.
- Entity at switch node: it is responsible to collect traffic parameters. It manages information from different BSs.
- Entity at mobile terminal: it makes final Handover decision. Terminal decides about handover type and which BS is to be selected for the handover. We use the MT because it is more scalable to make decision by itself, especially in degraded situation.

Handover entities are integrated at layer 2 when a handover appears in the same clustered area (BSs attached to the same switch). This type of handover is transparent to the routing functionalities (it requires a simply link layer reconfiguration without any mobility implications) [8].

Entities listed below are described with VHDL language. Implementing handover mechanism with VHDL description poses some specific constraints. The development of several nodes of the network (BSs, MTs) requires traffic management of simultaneous connexions. Other constraint that must be considered is to provide to mobile terminal parameter for handover decision at the right time, with most newly information about traffic conditions. For this purpose, traffic collected parameters are sent periodically to MT.

The steps for handover algorithm are detailed at the following.

B. Phases of Handover Strategy

To define our architecture while maintaining optimal resources to the mobile terminal, the following approaches are adopted:

A handover approach adopts a mobile-initiated handover type. The MT makes the initial decision to initiate the handover. However, the WATM network participates to trigger handover by informing MT about traffic management parameters in order to select suitable BS candidates.

In a prediction phase, the mobile terminal monitors traffic quality and controls signal strength indicators and error probability of the channel. It is then periodically informed

with collected information using handover cell. When receiving these parameters, MT actualizes few stored parameters for handover decision algorithm. The MT initiates Handover when the signal drops below than a threshold.

If the switch is informed through old BS about a new handover procedure, it requests BSs about information relevant to the Handover Decision. Collected information will be filtered. The switch sends, to the MT, a BSs list prioritized by the signal power of each one. The Handover Decision process at MT entity is parameterized with this information. In consequence, the MT sends via the old base station to the switch, a Handover Setup Request message notifying the intention to change to the selected BS. Otherwise, communication efforts with the current BS will be wasted. The BS list increases probability for handover successful. However, it may cause additional delay.

From these steps, we can see that this process ensures that the most up-to-date information is used for handover decision.

During handover, control messages are exchanged between different components of the WATM network. They are required to handle functions as begin, confirm, and end of the connection with network nodes. They inform nodes also about handover protocols type and QoS negotiation. Handoff signaling enables wireless terminals to move seamlessly between BSs while maintaining connections with their negotiated QoS. Bad handovers signaling lead to degraded power quality. They also have a deep impact on the transport functions and band occupancy.

In our model, resource allocation is done after the switch decision. In fact, it is not necessary to reserve resources in each BS for the connection when they receive the HOR message because only one BS will be finally chosen. Switch needs to send only one Handover message to the selected BS for resources allocation. This solution reduces the message processing time of other BSs. The efficiency of the whole network will thus be improved.

IV. ANOTHER ISSUES AND CHALLENGES IN WATM

A. Signaling Strategies

Handoff signaling enables wireless terminals to move seamlessly between BSs while maintaining connections with their negotiated QoS. Bad handovers signaling lead to degraded power quality. They also have a deep impact on the transport functions and band occupancy. [1] Presents a scheme for handover provisioning in Wireless ATM networks based on in-band signaling. Signaling information is carried using fixed cell size equal to data cell. Handover signaling message integrates control channel for some signaling functions. Therefore, in proposal [8], the handover protocol is entirely based on dedicated cells that are transmitted with the data flow. The dedicated cells, termed Mobility Enhancement Signaling (MES) cells, are Resource Management (RM) cells similar to those used in the Available Bit Rate (ABR) ATM transfer capabilities. We propose to use the in-band signaling technique as explained in [1]-[8]. The goal is to efficiently collect and manage the network information. This choice has

significant advantages such as modification requests avoidance in WATM signaling functions. It also guarantees in-sequence cell delivery over the connection during handover procedure.

B. A Survey of Buffering Issue

The main complexity of WATM arises from the functions and protocols for handover. Thus, an important issue in WATM that needs further investigation is to maintain QoS parameters for connections during handover. As WATM has these critical characteristics, a main consequence is the need for reducing data loss. An optimal handover procedure must enable the network with a guaranteed level of QoS being protected against cell loss, cell duplication, and loss of cell sequence. An optimal design of handover should give a lossless mechanism that also has low delay and delay variation. [11] Consider that the main consideration during handover is to maintain connection quality. Ensuring the completion of handover procedure by preventing any cell loss and avoiding cell duplication or cell reordering with very low delay is of primary importance.

To ensure these conditions, Handover procedure should guarantee an in-sequence cells delivery to terminals, with desired QoS parameters. Since, the connections must be handed over new BS while QoS requirements must be satisfied. For this purpose, fixing optimal handover steps are useful (Fig. 1).

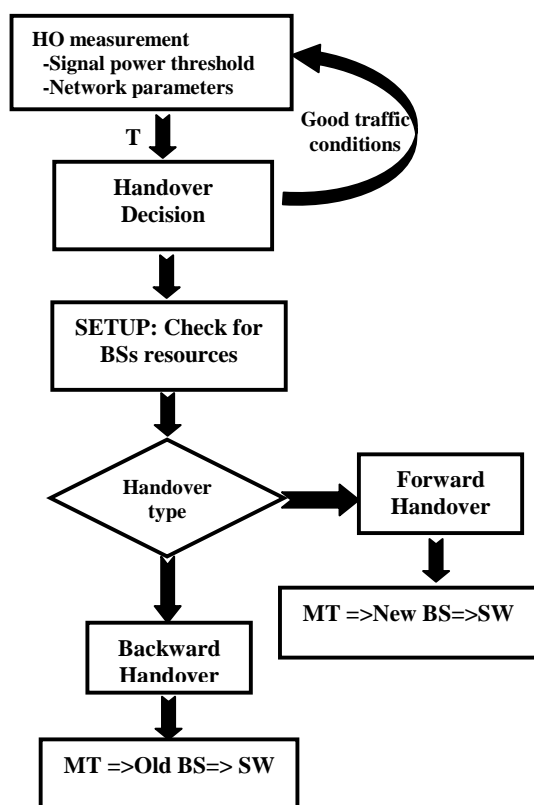


Fig. 1 Handover stages

A promising approach to meet QoS requirements is based on the storage of data cells in the selected BS buffer, while the connection is being reestablished. Indeed, until the new wireless link is created, cells cannot be transmitted between the MT and the BSs. During this time, it may be necessary to transfer stored data cells from old BS to new one. The reason is that MT is disconnected from current BS and not yet connected to the selected one. The old BS sends a handover confirmation when their buffers are being emptied. Then the switch notifies BSs that the handover is in final progress step. It informs old BS to disconnect from the MT by sending the HandOver End (HOE) message. New BS is also informed to establish a new wireless link with the MT.

There are different choices with which MT should establish the new connection. Discussions about the deployment of efficient buffering mechanisms have taken place. In [5] data is sent simultaneously to MT from old and new BS. This approach minimizes buffer occupancy but it needs more resources. This approach is called Make-before-break (MBB). However, in [3] MT can wait for current BS to send all buffered cells to new one. This is a Break-before-make (BBM) approach. This is a good choice for connections without critical timing requirements. However, when there is no end buffering confirm message, data loss can appear. Thus, we think that it is important to indicate the number of cell buffered in the old BS. Else, a cell transfer in old BS to new one may be not guaranteed. Here we assume that MT can wait for current BS to send all buffered cells. Old BS transmits to the switch end buffering information allowing the new BS to start transmission so that the cell order is maintained (figure 2). Old BS informs the switch about the last quantity of the data stored in the buffer. Data are measured in multiple NRM user cells followed by a numbered RM cell. However, [7] considers that MT should establish connection with new BS before disconnecting from the old one. In this way, old BS can be asked for another handover if MT cannot establish the new radio link, thus ensuring a lossless handover. This approach minimizes also buffer occupancy but it needs more resources.

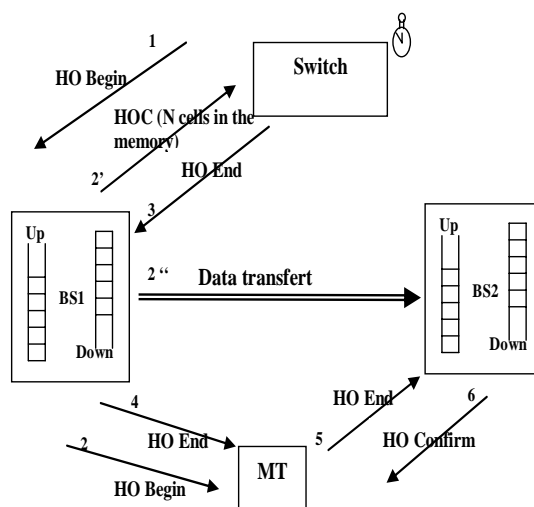


Fig. 2 Handover buffer occupancy issue

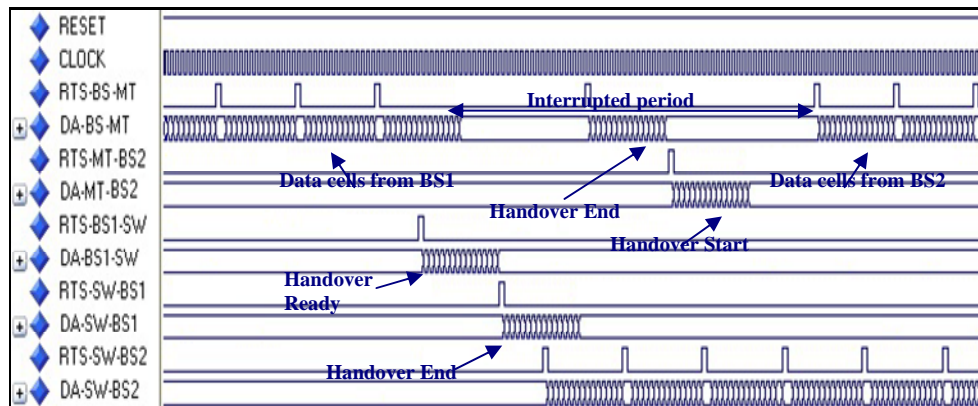


Fig. 3 Handoff from BS1 to BS2

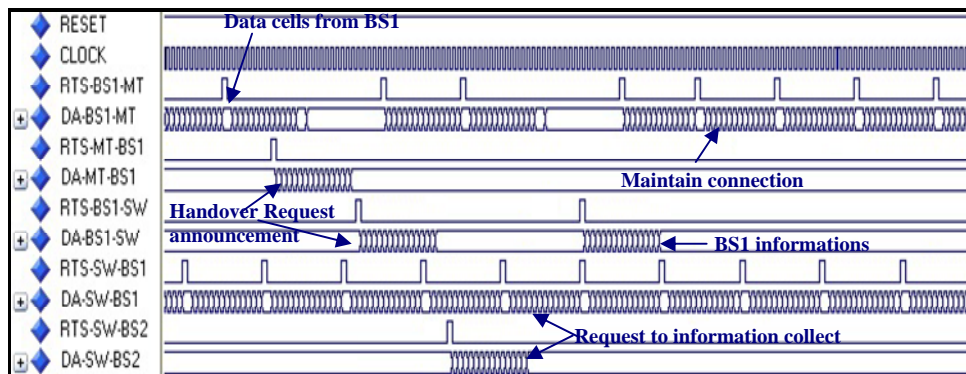


Fig. 4 Handoff Setup stage

In a successful Handover case, MT and new BS exchange cells via the newly established wireless link. Otherwise, the switch sends a HandOver Denied (HOD) message, and the handover procedure can be re-initiated by the Terminal. One of the disadvantages of an incremental re-establishment handover algorithm is that all nodes in a network have to support the augmented signalling protocol.

V. CONTRIBUTION OF THIS PAPER

This paper proposes a handoff solution for a WATM environment. The proposed solution has for goal to meet the challenges of wireless ATM and to reduce the number of control signals required for handoff and the volume of buffered information packets during handoff. It tries to significantly improve the radio link transmission accuracy. Performance results reported in the literature are mostly obtained via analytical models [5]. Simulative study is planned and it leads to characterize the effectiveness of the handover protocols by testing several network situations.

In this work, each of the components is designed using a hardware description language and synthesized to an FPGA. A HDL description defines details of each of the different components. Network architecture includes Switch, BSs and

MTs. The performance of the entire system is also dependent on the interactions of these components when they are being used by different traffic patterns. For this purpose, we introduce a flexible architecture that supports dynamic behavior of the system.

The objective of our methodology is to provide a rigorous design flow for high-performance processing networks. For accuracy, we have designed and implemented our components using the VHDL hardware description language. To evaluate system performances, we have synthesized our VHDL design. The synthesis tool performs a detailed timing analysis and reports a maximum clock frequency.

VI. SIMULATION AND SYNTHESIS RESULTS

Our approach of handover has been transposed on a concise description which supports different Wireless ATM simulation scenarios. The efficiency of this description for several network situations evaluates the Handover algorithm performances. Handover algorithm has been implemented in an FPGA environment based on simulation and synthesis tools. This algorithm has been integrated, in three parts, on the base station, the MT and the switch according to their specific tasks. Simulation environment contains two base stations

(BS1, BS2), one mobile terminal (MT) and one switch (SW). This architecture is based on two channels that could be established from the switch to the MT. Our proposed handover model is extensible for multi-channel architecture based on multi-hierarchical level (MTs, BSs, SWs).

In Fig. 3 multiple Handover messages are omitted, we give here an overview of critical sequences of Handover process. Fig. 3 shows a network scenario that we consider for performance evaluation of handover procedures. It presents a BS switching through which a terminal receives data. The BS converts cell data in order to adapt ATM and WATM cell formats. Data cell transmission is initialized by Request To Send (RTS) signal. Data are transmitted over (32 bits) port accompanied with four control bits. A control bit is set to '1' to indicate delimiter and special characters and '0' to indicate data bits. Fig. 4 shows that for some traffic condition, handover setup algorithm can maintain the current base station as more suitable to support the requested MT connection. In this case, handover procedure is interrupted.

TABLE I
 SYNTHESIS SUMMARY RESULT

	MT	BS	SW
I/O put ports	154	224	224
Number of cells	6783	16208	15350
Total area (mm²)	3.706	8.192	7.567

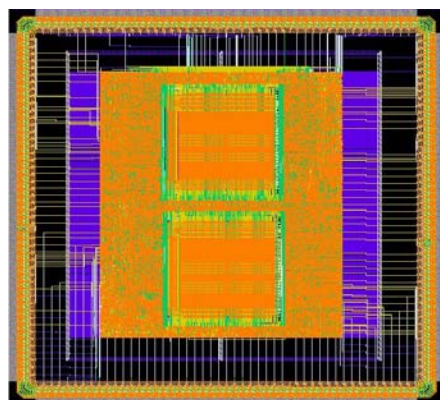
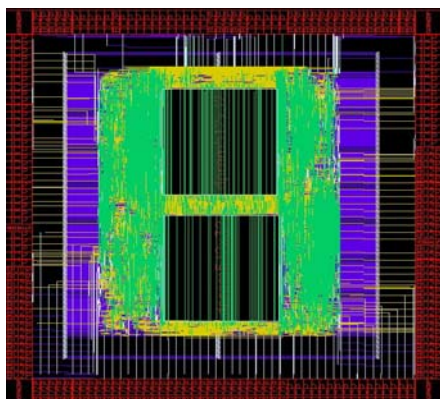


Fig. 5 Layout of BS entity

Table I summarizes implementation parameters for the handover contribution in each system (MT, BS and SW). It contains synthesis results obtained by synopsys tool. Implementation parameters are explained with the needed in/out put ports, the integrated equivalent cell number and the occupied area. At this design level, a powerful tool for placing and routing outlines the layout of the designed systems (Fig. 5).

Finally, results obtained from handover protocol implementation reveal that implementing mechanism is feasible, as it maintains the QoS characteristics and fails at higher data rates. Since, it is essential to evaluate the handover protocol in an environment with multiple mobile terminals. It is also important to apply routing algorithm to provide a robust handover mechanism.

VII. CONCLUSIONS AND FUTURE DIRECTIONS

This paper has presented a work for designing, synthesizing and simulating networks service. By using a hardware design flow, each component can be designed and characterized separately. By using FPGAs technology, we have presented performance results. The hardware synthesis tools provide a maximum frequency of the device, and from simulations we can determine the latency in terms of clock cycles.

This work has involved the impact of handover protocols in a wireless ATM environment. For this purpose, developed algorithms collect information to allow mobile nodes to execute handover decisions in an optimal way. These algorithms explain also a complexity of implementing handover mechanism with VHDL description language.

To increase the efficiency of handovers, a survey of buffering issue is considered when MT switches from BS to another. The proposed architecture shows that necessary signalling information must be available at the right place and at the right time to reduce handover failure.

In fact, intelligent handover decisions are important in mobile networks with different capabilities. Our solution ensures not only that it handles diverse, and dynamic traffic situation but also a hardware feasibility.

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Jamila Bhar received her Engineering diploma in Electric and her DEA in Communication system from the National School of Engineering of Tunis (ENIT), Tunisia in 2001 and 2002, respectively. Currently, she is a PhD student. Her research interests include protocol adaptation in heterogeneous networks, traffic management and Quality of Service for high speed networks. Her recent work has been in traffic control in WATM network.

Ridha Ouni received his doctoral degree in physic (2002) from the Science Faculty of Monastir, Tunisia He is currently an assistant Professor at the Preparatory Institute of Engineering Study of Monastir (IPEIM), Tunisia. His research interests include computer networks, flow and congestion control, interoperability and performance evaluation. He is interested in many areas of hardware/software protocol verification and design for distributed systems.

Salem Nasri received his Doctoral degree in automatic control and computer engineering from the National Institute of Applied Sciences of Toulouse France, in June 1985. His research interests are in the fields of computer networks, communication systems and multimedia applications. In May 2001 he obtained the diploma of "Habilitation universitaire". Since then he has been a professor. He developed collaboration with many laboratories in France such as LSR (Grenoble), CRAN (Nancy), and some other laboratories in Tunisia. Currently he is a professor in the Computer Science Department, Qassim University in the Kingdom of Saudi Arabia.