Wireless ATM MAC Dynamic Control within WAND

Stéphane Decrauzat*, Christian Bonnet*, Frédéric Bauchot, Gérard Marmigère****

*****Institut Eurécom, 2229 route des Crêtes, BP 193, 06904 Sophia Antipolis Cedex, France
E-mail: {decrauza, bonnet} @ eurecom.fr

******Compagnie IBM France, CER IBM, 06610 La Gaude, France
E-mail: {fbauchot, marmiger} @ vnet.ibm.com

1. ABSTRACT

Within the scope of a high speed cellular wireless ATM system, the different MAC (Medium Access Control) dynamic control mechanisms, deployed inside or between a Mobile Terminal (MT) and its Access Point (AP), are considered. This document presents the current implementation and behaviour of the association and the data and control connections handling (establishment, maintenance and release) of the ACTS Magic WAND project, by first introducing the different control flows of the system, by presenting the WAND MAC layer called MASCARA, its address and connection identifiers and by describing the internal structure of the MASCARA dynamic control block. Finally, scenarios of association due to power-on and due to handover are explained and compared.

2. INTRODUCTION

Involved in the European ACTS (Advanced Communication Technologies and Services) research programme , the Magic WAND (Wireless ATM Network Demonstrator) project is aiming to provide a 20 Mbit/s wireless access to ATM networks and more generally to introduce ATM over the air to mobile terminals in a centralised way, in covering a wide range of functionalities, from basic data transmission, to shared multimedia applications.
The main components of the WAND system, as shown in Figure 1, are:

- *Mobile Terminals* (MTs) ; the end user equipment, which are basically ATM terminals with a radio adapter card for the air interface ;
- *Access Points* (APs) ; the base stations of the cellular environment, which the MTs access to connect to the rest of the network and plays the role of a VPI/VCI multiplexer ;
- an *ATM Switch* (SW) ; to support interconnection with the rest of the ATM network ;
- its dedicated *Control Station* (CS), containing a mobility control software to support mobility related operations, such as location update and handover, which are not supported by the ATM switch.

A more complete overview of the Magic WAND project can be found in [1].

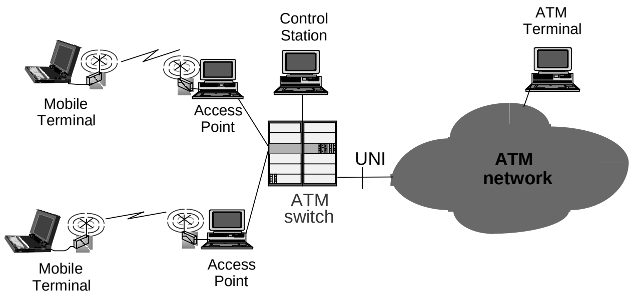


FIGURE 1: A WAND SYSTEM

3. CONTROL FLOWS

To control the WAND system from a high level such as ATM signalling, as well as low such as the MAC or the physical layer, three control flows are cohabiting:

- the Q.2931 (Q) control flow, which is conventionally used for signalling in UNI ATM,
- the Mobility (M) control flow, which is used for specific mobility signalling and whose primitives are complementing the Q.2931 control flow,
- the MASCARA control flow, which is a MAC-to-MAC peer control protocol.

Figure 2 depicts the different control flows.

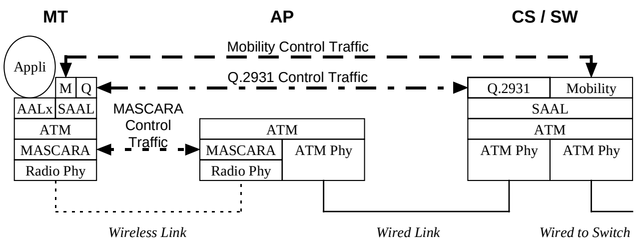


FIGURE 2: THE THREE DIFFERENT CONTROL TRAFFIC FLOWS

4. MASCARA

The TDMA-based MAC[1] included in the WAND system is called MASCARA for **M**obile **A**ccess **S**cheme based on **C**ontention **A**nd **R**eservation for **A**TM. This layer consists of the following main components :

- the Wireless Data Link Control (WDLC), which is in charge of recovering from the poor quality of the radio medium ;
- the scheduler, which sets, in accordance with connections characteristics and constraints (mainly QoS and service class), the correct pace and timing to each transmission and reception on the medium ;
- the MAC Protocol Data Unit (MPDU) handler, whose task is to build larger data units (MPDUs) in grouping data cells into cell trains (and vice versa), so as to minimise the overhead induced by the physical layer ;
- the MASCARA Control entity, monitoring the other internal MASCARA components on one hand, and communicating with its peer entity through a specific MASCARA control protocol on the other hand.

A more complete description of MASCARA can be found in [2].

Figure 3 shows the different MASCARA components.

[1] The meaning in this document does not strictly comply with the OSI model where the term Data Link layer should be preferred instead.

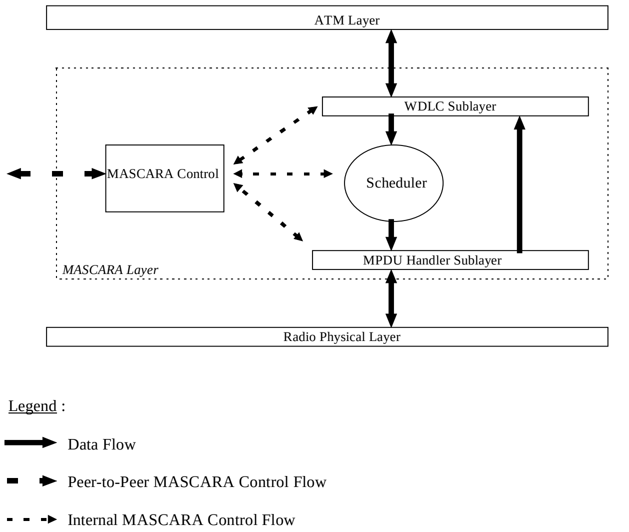


FIGURE 3: THE MASCARA COMPONENTS

5. ADDRESSES AND CONNECTION IDENTIFIERS

As already said before, in WAND, when transmitted on the air, the ATM cells are not just encapsulated. They are grouped together so as to form larger pieces of data by the MPDU handler, and their conventional ATM cell header is exchanged with a specific WDLC header. This latter still contains a CRC, the PT and CLP fields, but includes data link information (such as sequence and request numbers) and a MAC Virtual Channel identifier (MVC), which replaces the VPI ,VCI and GFC fields. This has been achieved so as to have a larger CRC field and to be able to include data link information without requiring extra time-consuming data movement operations.
Moreover, to strictly limit the use of the long MT 20-byte ATM address, a MAC address (MAC@) is used at the MAC level so as to identify both a MT or an AP.

Figure 4 shows the general case.

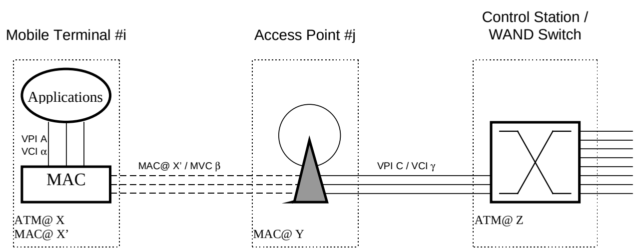


FIGURE 4: THE GENERAL CONNECTIONS MAPPINGS

A possible simplification could be to have a one-to-one mapping between a MAC address and a VPI (in Figure 5, A <-> X' and X' <-> A''), and to have another one-to-one mapping between a MVC and a VCI (in Figure 5, α <-> α' and α'<-> α''), but this is, of course, not mandatory.
Moreover, some control connection identifier differentiation has to take place at the AP. Indeed, at each MT, both mobility and Q.2931 control traffic use

predefined connection identifiers (respectively VPI = 0 / VCI = 5 and VPI = 0 / VCI = 30). As two different connections can not have the same VPI/VCI between the AP and the CS/SW (the AP uses only one switch interface) the control VPI = 0 of each MT is changed to a new control VPI value that should differ for each MT. The MASCARA control traffic does not need such mapping since it has no existence above the MAC level.

Figure 5 depicts an associated MT with its three control connections, the broadcast channel and one data connection in the WAND case.

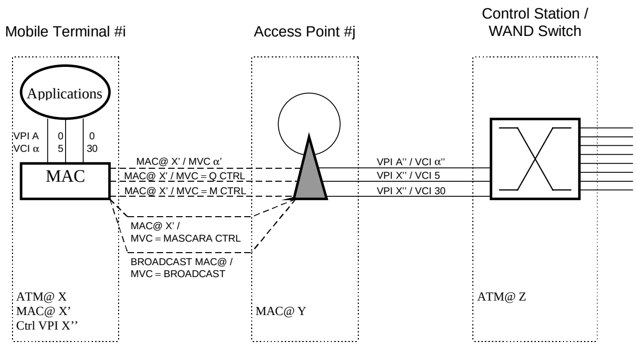


FIGURE 5: THE WAND CONNECTIONS MAPPINGS

There exist a reserved Broadcast MAC address (Broadcast MAC @) and a Broadcast MVC identifier that define a Broadcast channel. This latter conveys beacon information for associated MTs on one hand, and is used during the association phase (see later) on the other hand.
Three other MVCs are pre-defined. They respectively correspond to the MASCARA control, Q.2931 control and Mobility control.
Other MAC addresses or/and MVCs could be reserved to other dedicated services as for instance multicast diffusions.

6. THE MASCARA DYNAMIC CONTROL

As the specification of MASCARA has been achieved in SDL (Specification and Description Language), it is therefore strongly formal and hierarchical.
MASCARA control involves several blocks, such as the radio control used to handle the radio antenna device, the steady state control in charge of the regularly issued control traffic, and the dynamic control, in charge of association and data connections handling.
We will here focus on this last block. Handover (HO) and its implications will be only considered at the MAC level. The reader interested in higher level HO is referred to [3].

The MASCARA Dynamic Control block is composed of three different kinds of SDL processes organised in a tree-oriented manner, as depicted in Figure 6.

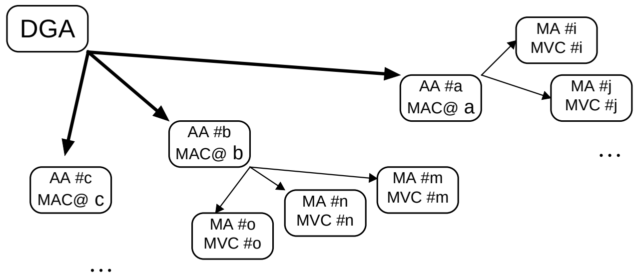


FIGURE 6: STRUCTURE OF THE MAC DYNAMIC CONTROL

6.1 THE DYNAMIC GENERIC AGENT (DGA)

In the AP, this is the static entity which dynamically creates a new AA instance when an incoming or just powered-on MT sends a request for association to the AP. More generally, the DGA manages the set of AAs, in dispatching the incoming messages to the right AA instance or terminating an AA instance.
In the MT, this entity is not necessary, since there is one unique instance of AA.

6.2 THE ASSOCIATION AGENT (AA)

In both AP and MT, this entity dynamically creates a new MA instance when a new connection is to be set up. More generally, the AA manages its set of MAs, in dispatching the incoming messages to the right MA instance or terminating a MA instance.
Moreover, this is the entity that performs the association (see later).
Per MAC address, there is one couple of AP AA - MT AA.

6.3 THE MVC AGENT (MA)

This entity controls a MVC. During its lifetime, it will make sure that all necessary resources for the connection are available and correctly set.
There exist four predefined MAs : the Broadcast MA, the MASCARA control MA, the Q.2931 MA and the Mobility MA. The first one is set and activated at power-on, whereas the three others are created and run as soon as a MT is associated.
There is one Broadcast MA in each MT and each AP, and three couples of control AP MA - MT MA (for MASCARA, Q.2931 and Mobility) per associated MT.

7. THE ASSOCIATION

In WAND, the association is the succession of actions necessary for a MT to set up the different control channels (MASCARA, Q.2931 and M) between itself and a hosting AP. This is to be differentiated from network registration (conveyed directly to the switch and CS through the Q.2931 and M channels) which is the next step to allow the MT to have data connections.

The association has the form of a MT-initiated classical four-way handshake protocol and takes place after a MT power-on, or after a backward/ forward handover.

Figure 7 shows the message sequence of the association.

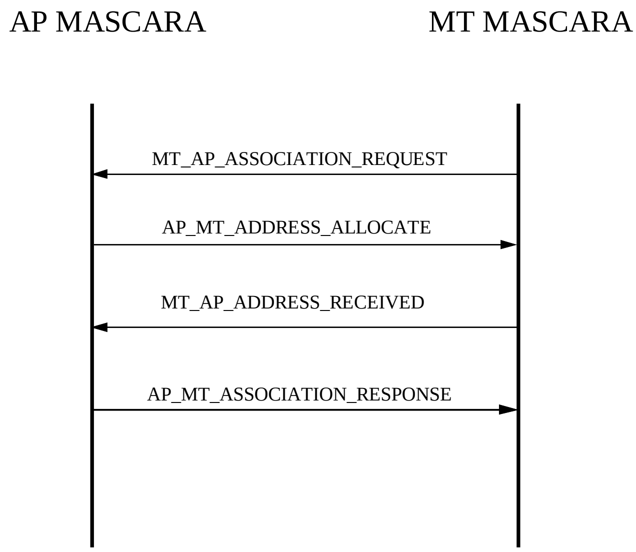
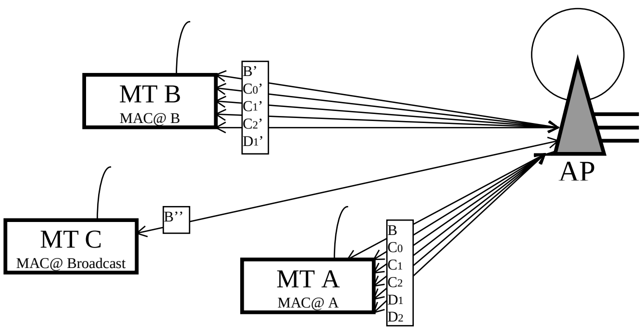


FIGURE 7: MESSAGE SEQUENCE OF THE ASSOCIATION

No security control is performed during the association phase. This is due to the fact that on one hand, security procedures are a mandatory step in the network registration and on the other hand, security in the association would not prevent a denied MT to act as a pirate or a radio jammer, i.e. to illegally use AP-cell radio resources.

Figure 8 represents two associated MTs with data connections and an associating MT.



Legend

B: Broadcast MVC
C_0: MASCARA Control MVC
C_1: Mobility Control MVC
C_2: Q.2931 Control MVC
D_x: Data MVC

FIGURE 8: THE WAND ASSOCIATION

7.1 POWER-ON ASSOCIATION

The following scenario sums up the first association to be initiated by a MT :

1. The MT is powered-on and MASCARA is initialised.
2. The unique MT AA has default MAC@ = Broadcast MAC@.
3. The three control MT MAs and the broadcast MT MA are created and the MT can then now listen to a potential AP.
4. The MT scans different frequencies so as to select an AP.
5. The MT AA sends an association request to the AP.
6. The AP DGA receives the request and creates an AP AA with a dynamically allocated corresponding MAC@i.
7. The newly created AP AA creates the three control AP MAs and answers the MT in giving it MAC@i.
8. The MT receives it and changes its default MAC@ to MAC@i.
9. The MT acknowledges the AP message using its new MAC@i.
10. The AP finally replies in giving some last information.
11. The MT is now associated, network registration can be initiated then data connections can be set up.

7.2 *HANDOVER ASSOCIATION OR RE-ASSOCIATION*

The following scenario describes the re-association to be initiated by a MT due to a forward handover (FHO) or a backward handover (BHO):

1. The MT experiences link outage with its old AP (FHO) or de-associates with the old AP (BHO).
2. The old AP releases all resources previously associated with the MT.
3. The unique MT AA sets its MAC@ to Broadcast MAC@.
4. The MT scans different frequencies so as to select a new AP (FHO) or knows which new AP it has to re-associate with (BHO).
5. The MT AA sends a re-association request to the new AP.
6. The AP DGA receives the request and creates an AP AA with a dynamically allocated corresponding MAC@j.
7. The newly created AP AA creates the three control AP MAs and answers the MT in giving it MAC@j.
8. The MT receives it and changes its default MAC@ to MAC@j.
9. The MT acknowledges the AP message using its new MAC@j.
10. The AP finally replies in giving some last information.
11. The MT is now re-associated, network location update can be initiated then data connections can be reactivated.

As can be seen from previous scenarios, the main difference between power-on association and handover association is the fact that, in the latter case, resources corresponding to «old» connections (mainly MAs) do not have to be destroyed and then recreated, but can be re-used. This allows simpler and quicker re-connections of MVCs (thus ATM data and control channels) so as to gain higher efficiency.
Another difference is that in case of handover association, the radio scanning step could be skipped since already done during a previous association or a previous period where the MT was associated.

8. CONCLUSION

The association and the connections handling have been presented as the main dynamic control mechanisms currently implemented in the Magic WAND project.
Those have to be as short and simple as possible to be able to be rapidly executed so data flow setting-up can immediately follow. This supposes that the SDL formal and hierarchical structure of the dynamic control block can be transcribed into efficient executable code. Early tests tend to show that it is the case, but the final results will soon be gained by the completion of the WAND demonstrator.

9. REFERENCES

[1] The Magic WAND: a Wireless ATM Access System, J.Mikkonen and J.Kruys, ACTS Mobile Communications Summit, Granada, Spain, Nov. 1996.

[2] MASCARA, a MAC Protocol for Wireless ATM, F.Bauchot, S.Decrauzat et al., ACTS Mobile Communications Summit, Granada, Spain, Nov. 1996.

[3] Description of the Handover Algorithm for Wireless ATM Network Demonstrator (WAND), H.Hansen et al., ACTS Mobile Communications Summit, Granada, Spain, Nov. 1996.

10. ACKNOWLEDGEMENTS

This work has been performed in the framework of the project ACTS AC085 “The Magic WAND”, which is partly funded by the European Community and the Swiss BBW (Bundesamt für Bildung und Wissenschaft). The Authors would like to acknowledge the contributions of their colleagues from Nokia Mobile Phones, Tampere University of Technology, Technical Research Centre of Finland, Ascom Tech AG, Lucent Technologies WCND, University of Lancaster, Robert BOSCH GmbH, University of Ulm, Compagnie IBM France, IBM Zürich Research Laboratory, Institut Eurécom, ETH Zürich, INTRACOM Hellenic Telecommunications and University of Athens.