Wireless ATM - An Overview

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Abstract

This paper studies the concepts and architecture of Wireless ATM (WATM). Several key design issues are addressed.

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1. Introduction

ATM (Asynchronous Transfer Mode) has been advocated as an important technology for all types of services and networks. Most people believe that ATM will be the standard for the future B-ISDN (Broadband Integrated Services Digital Network). From the service point of view, ATM combines both the data and multimedia information into the wired networks while scales well from backbones to the customer premises networks. To ensure the success of ATM, lots of the design issues have been standardized by ATM Forum.

Wireless personal communication networks (PCN) has been growing very fast in the last decade. Nowaday, laptop, cellular phone, and pagers are very popular. Many systems have been developed to provide different services, such as, Personal Communications Service (PCS), Portable Telephone Systems, and Satellite Communications System. Usually, these services do not guarantee QoS (Quality of Services) so they are not suitable for the fast growing multimedia applications.

Due to the success of ATM on wired networks, wireless ATM (WATM) is a direct t result of the ATM "everywhere" movement. WATM can be viewed as a solution for next-generation personal communication networks, or a wireless extension of the B-ISDN networks, which will support integrated data transmission (data, voice, video) with guaranteed QoS

WATM architecture and protocols are already being well discussed. An architecture for a WATM system is proposed by Dipankar and Newman [ATM Based Architecture]. In [Call Admissibility], Subir and Bhaskar proposed a call admissibility for multi-rate traffic in wireless ATM networks. The ATM Forum are currently involved in defining the baseline of WATM system. The specification for both mobility control in ATM infrastructure networks, and seamless radio extension of ATM to mobile devices are under development.

This paper is intended to outline the architectural view of WATM system, and to provide an overview of selected design issues. Since all the details of WATM system are still under development, what included in this paper may be changed in the future.

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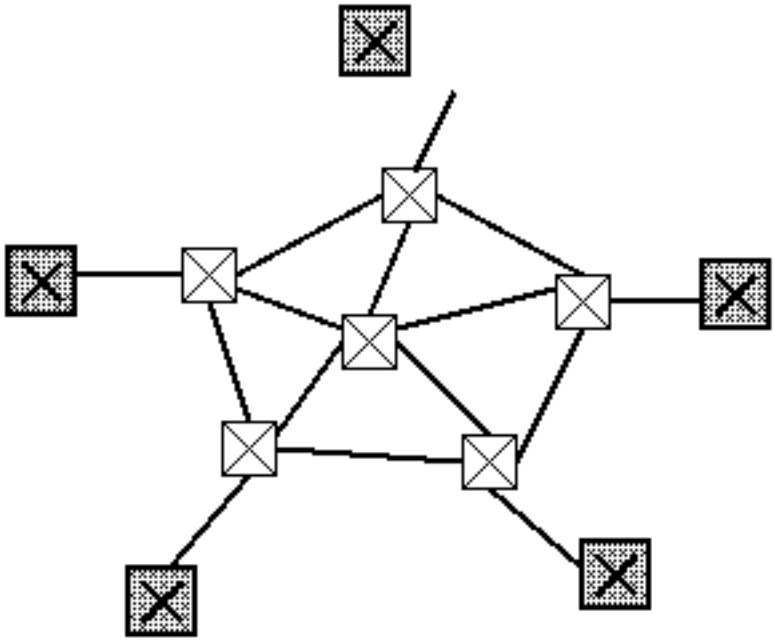
2. Wireless ATM Reference Models

A system reference model for WATM is shown in Figure 1. The overall system consists of a fixed ATM network infrastructure and a radio access segment. In the fixed ATM network, the switches, which communicate directly with wireless station or wireless end user devices, are mobility enhanced ATM switches. These switches setup connections on behalf of the wireless devices. They serve as the "entrance" to the infrastructure wired ATM networks. The other ATM switching elements in the wired ATM networks remain unchanged.

Based on the different types of wireless applications, the radio access segment falls into a number of areas which may need different solutions.



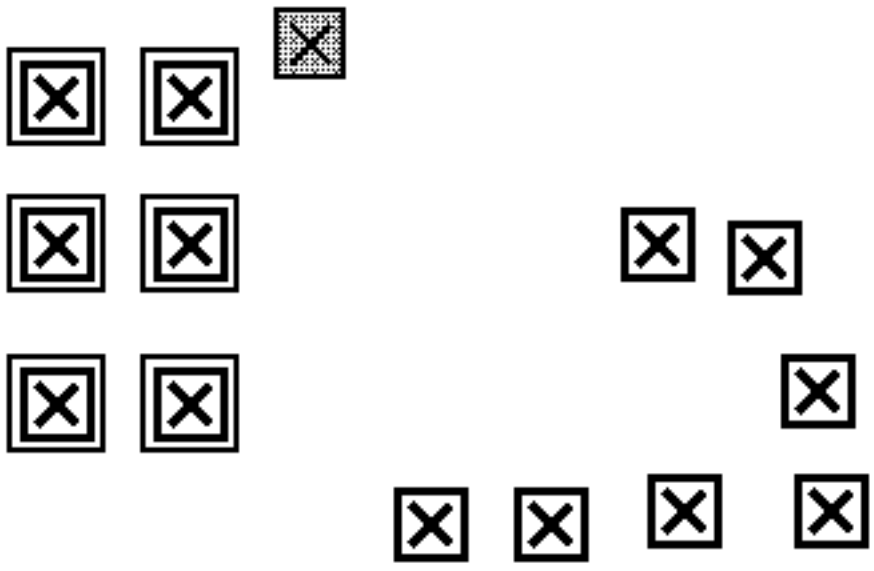


Figure 1 WATM reference model

2.1. Fixed Wireless Components

In fixed wireless LANs, or network interconnection via satellite or microwaves links, the end user devices and switching devices are fixed. They establish connections with each other via wireless channel, not through cable. In these kinds of applications, the data transmissions are wireless, yet without mobility. Since the user devices do not roam around, some design issues, e.g. handover, location management, and re-routing, are not presented.

2.2. Mobile End Users

In digital cellular, PCS, and wireless Lans, the end user devices, which are mobile, communicate directly with the fixed network switching devices via wired or wireless channels. To support the ATM connections, the end user devices are required to be equipped with a Wireless Terminal Adaptor which communicates with the Wireless Access Point in the fixed switching elements (mobility enhanced ATM switches)[Baseline for WATM].

2.3. Mobile Switches with Fixed End Users

End user devices are connected to switches via wired or wireless channels. The end user device and the switch, as a unit, are mobile. There can be more than one end user devices attach to one switch. An end user device is fixed to one switch instead of roaming around different switches. The switch is responsible to establish connections with the fixed infrastructure network component, either through wired channel or wireless channel. In this case, Wireless Access Points and Wireless Terminal Adapters are needed by the fixed mobility enhanced ATM switches and the mobile switches.

2.4. Mobile Switches with Mobile End Users

In this case, end user devices are mobile. There are also some mobile switching elements. When the end user wants to establish a connection, it first setups a connection with a mobile switch, which then setups a connection with the fixed network switches, either directly, or via another mobile switches. Wireless Access Points and Wireless Terminal Adapters are also needed to support the mobility.

2.5. Interworking with PCS

In PCS networks, the users are PCS terminals. PCS terminals send data to proper PCS base stations via wireless link, which then establish connections to the fixed network switching elements through a base station controller. The base station controller is a logical element which function as the ATM<->PCS

translator.

2.6. Wireless Ad Hoc Networks

An Ad Hoc network is the cooperative engagement of a collections of mobile terminals without the required intervention of any centralized access point. An auto-configuration of a wireless ATM network will be required for this kind of application. In wireless Ad Hoc Networks, an end user can communicate with the mobility enhanced ATM switches either directly, or via a central controller.

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3. WATM Design Issues

WATM adopts ATM to provide the data communications services so the overall architecture is based on the ATM protocol stack. A WATM protocol architecture is showed in session 3.1.

To support mobility, appropriate extensions need to be added to the ATM protocol stack. The wireless segment of the network will require new mobility functions . The key design issues of WATM networks are presented in 3.2 and 3.3.

3.1 Wireless ATM Protocol Architecture

The protocol architecture currently proposed by ATM Forum [3] is shown in Figure 2.

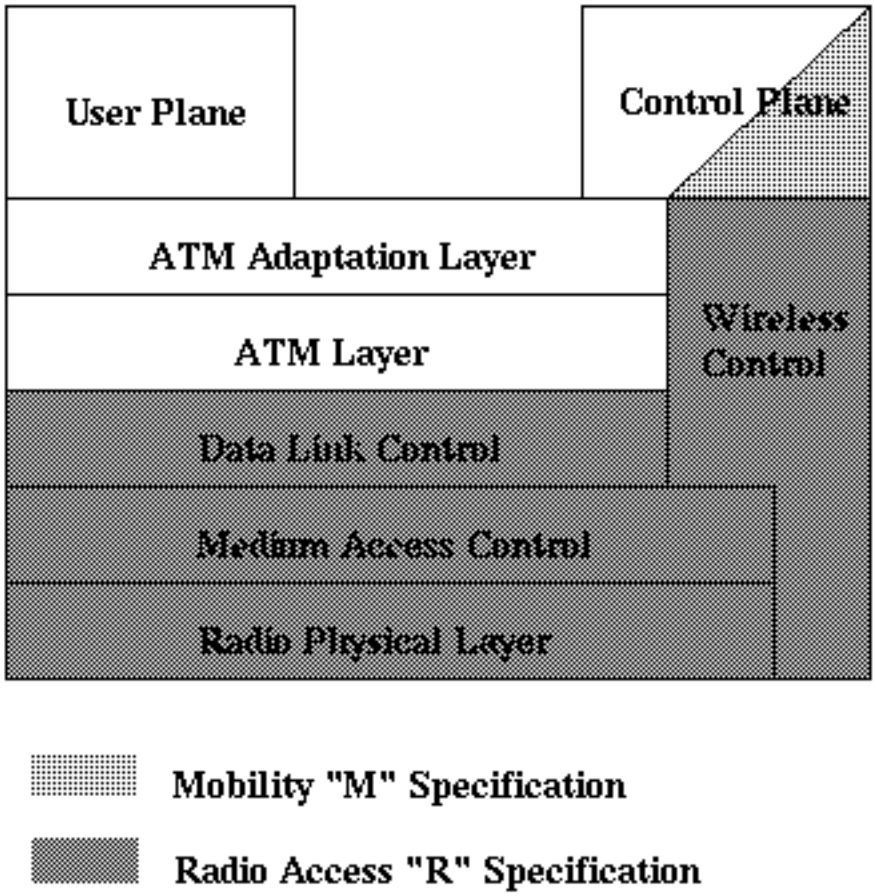

Figure 2 WATM Protocol Architecture

The WATM items are divided into two distinct parts: Mobile ATM (Control Plane, as showed in Figure 3), and Radio Access Layer (Wireless Control, as showed in Figure 3). Mobile ATM is dealing with the higher-layer control/signaling functions needed to support mobility. These control/signaling include handover, location management, routing, addressing, and traffic management. Radio Access Layer is responsible for the radio link protocols for wireless ATM access. Radio Access Layers consists of PHY (Physical Layer), MAC (Media Access Layer), DLC (Data Link Layer), and RRC (Radio Resource Control). Up to now, only PHY and MAC are under consideration. The protocols and approaches for DLC and RRC have not been proposed yet.

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3.2 Radio Access Layer

To support wireless communication, new wireless channel specific physical, medium access and data link layers are need to be added below the ATM network layer. These layers are called Radio Access Layer in the WATM network. The following sections address the design issues of the Radio Access Layer.

3.2.1 Physical Layer (PHY)

While a fixed station may own an 25 Mbit/s up to 155 Mbit/s data rate ATM link, a 25 Mbit/s data link in a wireless environment is currently difficult to implement. A several GHz spectrum would be required to provide high speed wireless transmission. Currently, 5 GHz band is considered to be used to provide 51 Mbit/s channel with advanced modulation and special coding techniques. Although 155 Mbit/s is unreachable due to the limitation of today's techniques, people believe that it will soon be available in the 60 GHz band and 622 Mbit/s would be reached in the not-too-distant future. Based on this belief, two separate PHY layer specifications are recommended, one for 5 GHz band, one for the 60 GHz band since they will require different operations.

The suggested specific requirements for the PHY layers are showed in Figure 3 [PHY ATM Forum/96-0785].

	Low Speed Wireless PHY	High Speed Wireless PHY
Frequency Band	5.15 – 5.35 GHz, 5.725 – 5.875 GHz	59 GHZ – 64 GHZ
Cell radius	80 m	10 – 15 m
Transmit power	100 mW	10 – 20 mW
Frequency reuse factor	up to 12	7
Channel bandwidth	30 MHz	150 / 700 MHz
Data Rate	25 Mbit / s	155 / 622 Mbit / s
Modulation	16 tone DQPSK	32 tone DQPSK
MAC interface	parallel, transfer speed 3.127 Mbyte / s	parallel, transfer speed 87.5 Mbyte / s
Fixed packet length	PHY header + MAC header + 4 * ATM cells	

Figure 3 Specific requirements for PHY layer

3.2.2 Media Access Control (MAC)

WATM MAC is responsible for providing functionally point to point links for the higher protocol layer to use. To identify each station, both IEEE 48 bit address and local significant address, which is assigned

dynamically within a cell, are allowed. Each station registers it's address to it's hub during a hub initiated slotted-ALOHA content period for new registration so that make itself know by others.

In a shared environment, there must be some control over the usage of the medium to guarantee QoS. An extended TDMA, which satisfies PCR (Peak Cell Rate), SCR (Sustainable Cell Rate), and MBS (Maximum Burst Size) requests, is suggested. Each station may use the media only when it's informed by the central control elements (hub). Each can send out several packets at a time. To minimum overhead, the MAC should support multiple ATM cells in a packet.

Another design issue of MAC layer is to support multiple PHY layers. Currently, people are interested in different wireless bands, which includes infra-red medium, 5 GHz radio band, and 60 GHz band. Different PHY will be need for different medium. WATM MAC should support all of them. Some other design issues like error recovery, support for sleep are also under consideration[MAC ATM Forum/96-0786].

3.2.3 Data Link Control (DLC)

Data Link Control is responsible for providing service to ATM layer. Mitigating the effect of radio channel errors should be done in this layer before cells are sent to the ATM layer. In order to fulfill this requirement, error detection/retransmission protocols and forward error correction methods are recommended. Currently, the DLC protocol and syntax, interface to MAC layer, and interface to ATM layer have not been proposed yet.

3.2.4 Radio Resource Control (RRC)

RRC is needed for support of control plane functions related to the radio access layer. It should support radio resource control and management functions for PHY, MAC, and DLC layers. The design issues of RRL will include control/management syntax for PHY, MAC and DLC layers; meta-signaling support for mobile ATM; and interface to ATM control plane.

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3.3 Mobile ATM

To support mobility, new higher layer control/signaling functions are needed to handling handover, location management, routing, addressing, and traffic management. The item, which defines the design the functions of control/signaling, are called Mobile ATM.

3.3.1 Handover

In WATM networks, a mobile end user establish a virtual circuit (VC) to communicate with another end user (either mobile or ATM end user). When the mobile end user moves from one AP (access point) to another AP, proper handover is required. To minimize the interruption to cell transport, an efficient switching of the active VCs from the old data path to new data path is needed. Also the switching should be fast enough to make the new VCs available to the mobile users.

When the handover occurs, the current QoS may not be support by the new data path. In this case, a negotiation is required to set up new QoS. Since a mobile user may be in the access range of several APs, it will select the one which can provides the best QoS.

During the handover, an old path is released and a new path is then re-established. There is a possibility that some cells will get lost during this process (when the connection is broken). In case no cell lost is allowed. Cell buffering is used to guarantee that no cell is lost and cell sequence is preserved. Cell buffering consists of Uplink Buffering and Downlink Buffering. If VC is broken when the mobile user is sending cells to APs, Uplink Buffering is required. The mobile user will buffer all the outgoing cells. When the connection is up, it send out all the buffered cells so no cells are lost unless the buffers is overflowed. Downlink Buffering is performed by APs to preserve the downlink cells for sudden link interruptions, congestion, or retransmissions. It may also occur when handover is executed. There are sever options for downlink buffering based on different handover situations. More details are discussed in [4].

3.3.2 Location Management

When a connection is needed to be established between an mobile ATM end point and another ATM end point, the mobile ATM end point is needed to be located. There are two basic location management schemes: the mobile PNNI scheme and the location register scheme.

In the mobile PNNI scheme, when a mobile moves, the reachability update information only propagates to the nodes in a limited region. The switches within the region has the correct reachable information for the mobiles. When a call is originated by a switch in this region, it can use the location information to directly establish the connection. If a call is originated by a switch outside this region, a connect is established between this switch and the mobile's Home Agent, which then forward the cells to the mobile. This scheme decreases the number of signaling messages during a local handover[ATM Forum/97-0087].

In the location register scheme, an explicit search is required to prior to the establishment of connections. A hierarchy of location registers, which is limited to a certain level, is used.

3.3.3 Routing

Due to the mobility feature of mobile ATM, routing signaling is a little bit different from that for the wired ATM network. First, mapping of mobile terminal routing-id's to paths in the network is necessary. Also rerouting is needed to re-establish connection when the mobiles move around.

3.3.4 Addressing

Addressing issue of WATM focuses on the addressing of the mobile terminal (or mobile end user device). The current solution is that each mobile terminal has a name and an local address. The name of the mobile terminal is a regular ATM endsystem address. It's constant and doesn't change while the terminal moves. When a terminal is up, it's name is advertised by the switch it attaches to other switches. An local (or temporary) address is assigned when the mobile terminal attaches to a different switch during roaming. This switch will assign a local significant address to the terminal.

A mapping have to be take place in order to map the terminal's name to it's temporary address. Several mapping methods have been proposed [ATM Forum/97-0322].

3.3.5 Traffic and QoS Control

The mobility feature puts additional impact on traffic control and QoS control. Currently a reference model for resource allocation in WATM is still unavailable. Support for dynamic QoS renegotiation and extensions to ABR control policy to deal with handover and other related design issues have not been proposed yet.

3.3.6 Wireless Network Management

In wireless networks, the topology is changing in time. This, as well as other mobility feature, present a unique set of network management challenges. A specific methods must be designed to maintain the dynamic nature of the network topology. Other issues, like network and user administration, fault identification and isolation, and performance management, are also need to be considered.

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4. WATM Projects and Status

Wireless ATM is a topic that raises a lot of interest at the moment and there are a lot of research activities going on. Many of the activities are done within the universities and corporate research laboratories. Some examples are: NTT AWA (Advanced Wireless Access system), Olivetti Research Laboratory, Lucent Technologies. There are several projects which are focusing on or related to WATM. They are:

- Magic WAND (Wireless ATM Network Demonstrator)
  http://www.tik.ee.ethz.ch/~wand/
  Magic WAND is a joint European project which intend to develop a demonstration of mobile terminals for multimedia information access using a fast and wireless ATM network. The 5 GHz band is used to provide communications between mobile devices and the ATM switches.
- MEDIAN (Wireless Broadband CPN/LAN for Professional and Residential Multimedia

Applications)
http://www.imst.de/mobile/median/median.html
The main objective of MEDIAN is to evaluate and implement a high speed wireless customer premises local area network pilot system for multimedia applications. The desired system will support wireless ATM network extension. 60 GHz band is used to provide bit rates up 155 Mbit/s.

- AWACS (ATM Wireless Access Communication System)
  http://www.uk.infowin.org/ACTS/ANALYSYS/PROJECTS/AC228.htm
  AWACS's main objective is to develop a system concept and testbed demonstration of wireless public access to B-ISDN services. 19 GHz band is used to provide bit rates up to 34 Mbit/s.
- ORL Radio ATM
  http://www.cam-orl.co.uk/radio/
  ORL (The Olivetti & Oracle Research Laboratory) has been developing a wireless ATM system for about 5 years. The system is designed as an extension to existing ATM LANs. The system is based on pico-cells. Each cell has a base station. The mobiles setup communicate with each other via base stations which are constructed as an ATM network.
- RDRN (Rapidly Deployable Radio Networks)
  http://www.tisl.ukans.edu/RDRN/
  The goal of RDRN is to design high-speed ATM-based wireless network architecture and protocols which will be adaptive at both the link and network levels to allow for rapid deployment and automatic reconfiguration in a changing environment.

While wireless ATM research has already been active for some time, not until October 1995, the wireless ATM subject has been brought to ATM forum. In 1996, ATM Forum establish a new working group named Wireless ATM (WATM) to undertake the work related to wireless ATM. Since then, a lot of contributions have been proposed. WATM Working Group currently is working on "Baseline Text for Wireless ATM specifications". The latest version of this draft was released on July 20, 1997. As showed in the work plan outline, this specification will be final ballot in December 1998.

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5. Summary

While the wired network has been going towards B-ISDN with ATM concepts for high data rate, wireless personal communication networks are also experiencing fast development. People are expecting an exciting future of portable and mobile computing which is not tethered to a fixed point by a wire and which has a wide range of services and wide availability. The quality of services is close to today's fixed networks. WATM has the potential to bring wireless networks a new generation. Both ATM and wireless communities have put a lot of attention on Wireless ATM.

While WATM is showed to be a promising area, the success of WATM will be highly relies on the success of ATM/B-ISDN in wired networks. If ATM network are to be a standard in the wired area, the success of WATM would be seen in the very near future.

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Reference:

(descriptions are about to be added)

- Baseline Text for Wireless ATM specifications, ATM Forum/btd-watm-01.03.txt, July 1997.
  This document specifies the ATM Mobility Extension Service (AMES) from a user's perspective. It also provides the basis for subsequent development of the architecture and protocols need to support this service.
- K. Rauhala, "Living List Document of Wireless ATM Working Group", ATM Forum/ltd-watm-01.01, February 1997
  The reference configuration and the design issues of WATM are presented in this document
- J. Deane, "WATM PHY requirements," ATM Forum/96-0785, June 1996
  This document addresses the specification and design issues in PHY of WATM.
- J. Deane, "WATM MAC requirements," ATM Forum/96-0786, June 1996
  MAC layer design issues are addressed in this document
- D. Raychaudhuri and N. Wilson, "ATM Based Transport Architecture for Multiservices Wireless Personal Communication Network", IEEE J. Selected Areas in Comm., Oct. 1994, pp. 1401-1414.
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  A call admission algorithm is proposed in this paper.
- L. Dellaverson, "Proposed Charter, Work Plan and Schedule for a Wireless ATM Working Group," ATM Forum/96-0712, June 1996.
  This document provides a charter, scope, and work plan outline for the WATM working group with the ATM Forum
- K. Duault, "Location Management for Mobile Networks", ATM Forum/97-0087, Februray 1997
  This paper discusses the location management issues associated to mobile networks.
- G. Bautz, "Addressing in Wireless ATM Networks", ATM Forum/97-0322, April 1997
  This contribution talks about the addressing of mobile terminals.

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