Mobile and Wireless ATM (WATM)

Defense Information Systems Network (DISN)

Syed Shah
Larry Bowman
Robert Riehl
Defense Information Systems Agency
Center for Systems Engineering
Reston, VA 20191

Abstract:

In this paper Mobile and Wireless ATM DISN is introduced for providing “seamless” integrated strategic-tactical network. The DISN architecture is driven by the goal of delivering a comprehensive range of communication services to mobile users by mobile wireless enhanced ATM network. Provision of services to the mobile periphery is dependent upon the integration and interworking of heterogeneous mobile networks and fixed network entities, and the support of radio connections through the various layers of the air-interfaces. The proposed wireless DISN platform will advance the state-of-the-art of technology in several areas.

Introduction:

Worldwide demand for wireless communications continues to grow. It is expected that by 2010, half of all information sent in the world may use wireless communications media. Very recently, FCC has designated 300MHz of spectrum to Unlicensed National Information Infrastructure (U-NII) devices. The U-NII band, spanning over two blocks of RF spectrum 5.15-5.35 GHz and 5.725-5.825 GHz., is allocated for the development of Information Superhighway. New technology and services such as Universal Mobile Telecommunication Service (UMTS), Mobile Broadband Service and Local multipoint Distribution Service (LMDS), with 1,300 MHz of additional commercial bandwidth, may be able to provide wireless interactive broadband services. Significant advanced research in the Wireless ATM (WATM) to provide seamless Wideband Wireless Local Access (WWLA) is underway. Wireless ATM has become one of the “hot” topics of the ATM standardization. The ATM Forum has ranked wireless ATM high in its Strategic Planning Process (with fully accepted specifications in 3 QFY99). New end-to-end networking technologies are also being developed to support rapidly deployable information systems in the dynamically changing environments. New networking techniques that support rapid deployment and robust networking service in a hostile and dynamic environment will be critical in robust self-configuring networking technology supporting military and civilian crisis management. Solutions used in these systems are most valuable input for the development of wireless ATM systems in the DISN. ATM transmission is fundamentally a fast 53 bytes cell switching technology for fixed network assuming reliable wired fiber or copper connections. Wireless ATM intends to extend all the benefits of the ATM and therefore also the ATM signaling and virtual channels/paths into the mobile terminal raising important issues that have to be solved both in the wireless access interface and in the supporting customer premises ATM network.

The wireless ATM transmission will be subject to the specific characteristics of the radio medium and therefore special radio design measures will be required in order to offer users an adequate level of service. These measures constitute some of the major technical challenges which are being tackled within academia and industry. Current broadband RF Wireless LANs (W-LANs) can achieve data rates on the order of 2 Mbps at ranges of a few kilometers using low power commercial devices. This technology has strong military application to the mobility requirements on the battlefield. It is a good alternative to fiber technology for short distance, large bandwidth communications in the battlefield. Research in this area by the civilian sector offers the promise of increasing the data
This paper proposes a mobile and wireless ATM DISN architecture to extend the range of broadband services available to fixed users to mobile users and provide ATM Services/Network in areas of civilian disasters and military operations where Communications Infrastructures are lacking and/or destroyed. It will also address several functions implemented between an ATM switch, a mobile terminal and multiple base stations. The operations including multiple switches require the implementation of mobility specific signaling between these switches handling the distribution of the functions. The overall objective is to introduce and resolve the technical issues and problems in the development of a mobile and wireless DISN ATM network, and answer some of the questions on the future implementation of these systems.

**MOBILE/Wireless DISN Architecture:**

In a rapidly changing environment, the integration of new architectures and services into the DISN are prerequisite for keeping DISN on the competitive edge. The proposed Mobile and Wireless ATM DISN extension for the Wireless Mobility and ATM Cooperative Networks for Mobile Multimedia Communications is shown in the Figure 1, above. This is a combination of technologies derived from a number of research projects and Commercial off the shelf (COTS) products and technology. The DISN architecture is driven by the goal of delivering a wide range of personal communication services to mobile users by mobile wireless enhanced ATM network. Provision of fixed network services to the mobile periphery is dependent upon the integration and interworking of heterogeneous mobile networks and fixed network entities, and the support of radio connections through the various layers of the air-interfaces. The proposed wireless DISN extension platform will advance the state-of-the-art of technology in the following areas:

1. **Cooperative Wireless/Wireline Networking**, a new interworking concept made possible by ATM. While current approaches for integrating wireless access networks into the fixed infrastructure are based on a total separation between the two networks, this new approach provides greater visibility of the wireless channel functionality at the AAL level.
2. **Terminal Mobility based on multi-function end systems that support roaming in heterogeneous networks and offer multi-rate, multi-media services.**
3. **Nomadic Computing using mobility routing protocols, service location protocols, and location-dependent answer to user queries, in order to provide a ubiquitous mobile computing environment.**
Wireless ATM Reference Model

Mobile and wireless DISN ATM extension is built on a reference model for Wireless ATM (WATM) as shown in Figure 2. The system described by the model consists of specific ATM switches. These switches include mobility specific functions (MSF) to support terminal mobility in the system. To allow normal ATM communication between fixed and mobile users, the system is connected to a DISN, an (Private/Public) ATM network. The WATM model offers transparent connection to B-ISDN to both mobile and fixed terminals. The main goal of the WATM model is to support the mobility of standard ATM terminals. The use of standard terminals means that the wireless connection has to be transparent to the terminal. The integrated network defined by the WATM model is connected to an ATM network to allow communication with fixed B-ISDN users. The mobility specific functions necessary in the WATM model are critical for the DISN. The mobility specific functions include mobile connection management, mobility management and some security features. The signaling protocols needed to implement the functions will be identified and studied. The method for implementing a handover is one of the most important parts of any wireless system supporting mobility. Some different handover methods suited for the proposed system will be compared and the relation between the handover and the ATM fixed connection management will be studied. Extra attention needs to be placed on the Connection Admission Control (CAC) function, on the radio interface flow control, and probability of bandwidth blocking. It is expected that the implementation of these functions on top of an ATM switch will not introduce unreasonable complexity to the system.

The main benefit of wireless ATM in the DISN is that it enhances the effectiveness of warfighters in their many operations and day-to-day businesses by providing them with location independent and high capacity [20 Mbit/s] access to broadband infrastructure networks. Wireless ATM will allow users to transmit and receive data at realistic data rates and controlled service levels that match those of the wired ATM world. This assurance of service is imperative as long-haul distance DISN ATM Services are relatively expensive and critical; and users can not be expected to accept service degradation on the final (radio) link.

Technical Approach:

This proposed architecture of mobile and wireless DISN ATM Extension will be implemented as a prototype model on the ongoing DISN testbed, proof of concept service delivery node. This DISN wireless extension testbed (platform) will help us develop and deliver the proof of concept for our proposed work and also will allow to update and revise the DISN architecture. The DISN wireless ATM
extension proof of concept will serve as an experimental testbed (platform) for the development of a multimedia services and applications. This will develop a multirate/multimedia system demonstrator offering cordless and fixed access via broadband fixed wireless communication system. It has three main objectives:

1. To specify a wireless, customer premises, access system for ATM networks that maintains the service characteristics and benefits of the ATM networks to the mobile user;
2. To validate the functional and dynamic aspects of the proposed architecture of wireless ATM access as developed in this project; and to promote the standardization, notably in WATM subcommittee of the ATM Forum;
3. Demonstrate and carry out user trials with a selected user group and test the feasibility of a radio based ATM access system for multimedia applications.

Mobile and Wireless DISN ATM Extension Network covers the whole range of functionality from basic (wireless) data transmission to shared multi-media applications. The primary goal of the project is to demonstrate that wireless access to ATM, capable of providing real multi-media services to mobile users, is technically feasible. In this proof of concept we are planning to have chosen to use the 5 GHz frequency band for the Proof of Concept demonstration and perform also studies on higher bit rate operation in the higher (17/60 GHz) frequency band.

This project consists of three major phases. In the first phase, system and component design will be undertaken. In the second phase an implementation of the design will be produced. The implementation, using mobile terminals based on portable computers in combination with wireless Access Points (AP) serviced by an ATM switch, will be as close as possible to the targeted functionality defined in the design phase. In the final phase, wireless ATM access system will be tested out and demonstrated with real end users to verify the system operation. The aim of the user trials is to verify a wireless access system for ATM networks that maintains these Service characteristics and benefits of ATM networks in the five GHz (U-NNI Band) ranges allocated to wireless high speed data transmission. The feasibility of a radio based ATM access system will be demonstrated by the user trials with selected end-user groups in the field and office environments (mobile computing). This trial shows an advanced scenario, fully exploiting the wireless ATM service capabilities in the field environment. The JVTOS (Joint Video Telecommunication Operating System) will be used with a multi-party video conferencing application using both native audio and video services over ATM. In this scenario, user will be equipped with mobile terminal while roaming. With the help of wireless ATM connection, the user is able to retrieve data/information from network, conference with others and share documents. The mobile computing trial, will demonstrate legacy applications built on top of the TCP/IP protocol stack such as Internet Web-browsers over the wireless ATM link with selected group of employees as an user group.

The DISN Wireless ATM extension project will continue to work on gaining knowledge on the wireless ATM radio design and its medium access control functions as well as wireless ATM specific Control and signaling functions. These results will be further used to enhance the DISN ATM Specifications and contribute to the ATM forum in order to influence relevant standards for DISN Mobile and Wireless ATM systems.

The DISN Technology Solutions:

The migration of multi-media services from fixed to mobile terminals requires mobile systems capable of supporting broadband integrated services. Since the present (second generation) systems were essentially developed to support narrow-band voice with limited data transmission capabilities, the progressive migration to the next generation must be pursued while ensuring a relatively seamless, attractive and natural evolution. DISN exploits the unique flexibility of the ATM transmission and switching technology, in order to allow for a smooth integration of long-haul regional-area, wide-area, metropolitan-area, campus-area, in-building, and in-room wireless networks.

ATM Wireless/Wireline Cooperative Networks:

The concept of Cooperative Wireless and Wireline Networks is being illustrated with the development of an ATM/WATM Interworking Unit and Mobile Terminals within the DISN framework. The key element is represented by a
"wireless ATM Adaptation Layer (AAL)", capable of coping with the increased latency and poor reliability of wireless links. Terminal Mobility will be supported by the advanced B-ISDN signaling and Intelligent Networking (IN) features for end-to-end connections between a mobile and a fixed ATM terminal. In the long term, this development will offer the scientific and technological base for a "Seamless Multimedia Multimode Personal Communication System" which will have a number of programmable AAL interfaces capable of supporting ATM applications over different wireless and wireline physical layers and allow universal roaming.

**Overlay Networks for Mobile Computing:**

Future mobile information systems will be built upon heterogeneous overlay networks, extending traditional wired and internetworked processing "islands" to hosts on the move over a wide area. Overlays vary in bandwidth, latency, coverage, and application-level performance visibility. Mobile terminals will have to operate across a wide range of network performance, and choosing among alternative overlays for best performance. Diverse wireless and wired networks are integrated through software that mediates between the mobile terminal and the networks it could possibly connect to, supporting the mobile as it roams among the multiple wireless networks.

The proposed approach for the seamless integration of overlay networks is based on mobility routing protocols, which support multiple networks and where the cells may utilize different air interface technology (IEEE 802.11, GSM, IR, HyperLAN, etc.) Network control is performed in a distributed fashion, driven by mobile nodes, and based on a common protocol to support mobility, Mobile-IP. The gateways from the wireless islands to the broadband ATM backbone provide support for mobility routing, while the mobile hosts integrate a Mobile Router device.

The Mobile IP functionality is based on the IETF work on Mobile IP and on migration from IP to IP-next-generation (IPng). The use of IP and TCP/UDP greatly simplifies the base station design, by distributing complex control, management and processing functions across servers attached to the high speed ATM backbone network. This allows the design of low-cost base stations, suitable for attaching the emerging inexpensive "network appliances" which will in the medium term help interconnect and control security systems, home appliances, electronic car guidance systems, etc.

**Concluding Remarks:**

The DISN Advanced Communications solutions are advancing the state-of-the-art of information systems at the large scale in DOD. Several Key technical issues such as mobile connection management, mobility management and security requirements in the fixed network side of the DISN, still need to be resolved. The challenge will be the retrofitting the ATM switches in the DISN Service Delivery Node (SDN) with special call set-up and re-routing features into the Control and Signaling functions developed for the wired broadband world. The fixed switching (wired) technology has to be enhanced in order to be able to cope with mobile ATM users. The DISN platform will accommodate the transition from home base (fixed) networking and computing to the wireless/nomadic networking and computing. There is a significant demand for mobile applications, the missing link is a network architecture allowing the migration of popular applications (such as email, data based inquiry, Internet connectivity, video conferencing) into a the mobile environment. In the long term new applications based on the Wireless Application Protocol will be developed, which will be able to adapt to the huge variability of the wireless mobile links. The DISN wireless ATM extension proof of concept will serve as an experimental testbed (platform) for the development of a multimedia services and applications. This will result in a multirate/multimedia system demonstrator offering cordless and fixed access via broadband fixed wireless communication system.

U.S. Government work not protected by U.S. copyright