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Wireless ATM Based Network for Multimedia Personal Communication Service

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Abstract— In this paper, a multiservice, local-area, wireless access ATM system is explored from a signaling protocol viewpoint. The signaling architecture considered here follows the signaling structure of Broadband ISDN User-Network Interface, thus offering the possibility for integration of the wireless ATM access system into fixed B-ISDN. It is shown that the use of the employed signaling structure substantially simplifies the call/bearer and handover control. The evaluation of the signaling protocol architecture yields results, which fall within acceptable ATM signaling performance measures. In this paper, an ATM network is used as the backbone network due to its high bandwidth, fast switching capability, flexibility, and well-developed infrastructure. To minimize the impact caused by user mobility on the system performance, hierarchical network-control architecture is postulated. A wireless virtual circuit (WVC) concept is proposed to improve the transmission efficiency and simplify the network control in the wireless subsystem. The key advantage of this network architecture and WVC concept is that the handoff can be done locally most of the time, due to the localized behavior of PCS users.

Keywords— ATM, broadband network, multimedia, multiple access, personal communications services (PCS), spread spectrum, time-hopping

I. INTRODUCTION

The main challenge of wireless ATM is to harmonize the development of broadband wireless mobile systems with fiber optic- based infrastructure, B-ISDN/ATM and ATM LANs, and offer similar advanced multimedia, multiservice features for the support of time sensitive voice communications, LAN data traffic, video and desktop multimedia applications to the wireless user. In the described context, a number of efforts are in progress to explore this new technology. Most of them comprise wireless research systems that are implementing wireless and mobile ATM, though with different approaches and scope. In this paper, we elaborate on the signaling protocol design of wireless ATM access networks, where the main focus is put on call, bearer and handover control signaling protocols. The proposed signaling protocol structure is based on the same concepts of the fixed broadband access network configurations, currently considered in the standardization. Current trends in designing the access network part of fixed B-ISDN aim at concentrating the traffic of a number of different User Network Interfaces (UNIs) and routing this traffic to the appropriate Service Node (SN) through a broadband V interface (referred as VB), as shown in Figure 1.

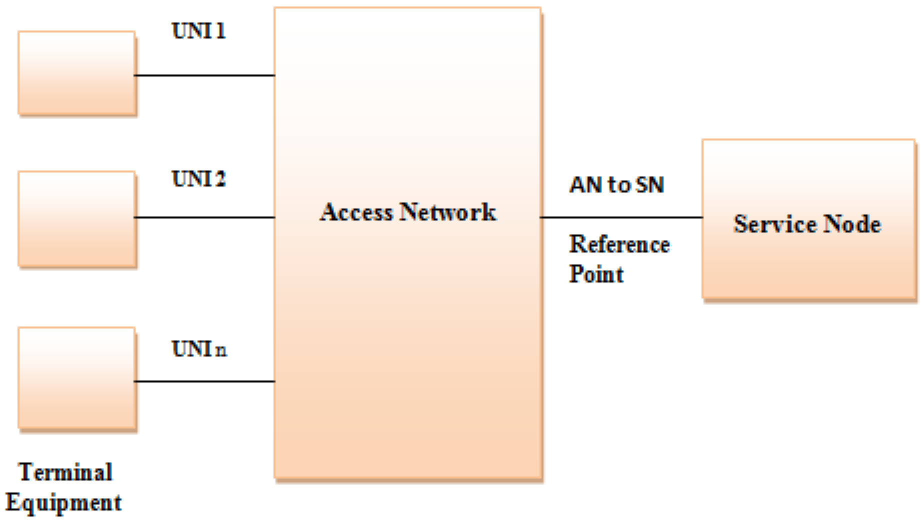

Fig. 1 Generic Broadband Access Network Configuration

II. PROTOCOL DESIGN

The most natural approach to develop a satellite system supporting ATM is to develop a MAC layer which inherently supports different QoS classes. Several constrains deriving from a NGSO satellite constellation and the ATM protocol itself influenced the design, i.e:

- the lack of a dedicated QoS field within an ATM–cell,
- variable propagation delays and swiftly changing channel error rates due to changes in the satellite's elevation angle, and
- the severe impact of rain attenuation and shadowing due to vehicular's movements.

The first is solved by an adaptive MAC framing structure and an introduced layer management entity while the latter is handled by an adaptive forward error correction scheme.

A. *Medium Access Control and Scheduling*

1) Protocol Stack: In terrestrial ATM networks, service parameters are announced during the connection set–up phase together with a unique VPI/VCI value. The only way to identify a connection's QoS parameters afterwards is through its VPI/VCI value. Therefore the MAC layer has to embed any kind of lookup table to guarantee QoS constrains for the different connections. Figure 1 depicts the protocol stack in which the layer management entity (LME) connects UNI and MAC and bypasses service parameters during connection establishment.

2) MAC Framing Structure: The up– and down–link are duplexed by FDD which is most convenient in power limited systems. Up– and down–link themselves are structured into fixed length frames. The frame length is 24 ms and is a direct result to easily support a typical voice specific data rate of 16 kbit/s. The primary goal of the MAC for the up–link direction is to reduce or even eliminate contention. This is achieved by dividing the up–link TDMA frame into two areas: a *reservation area* to transmit data of existing connections in previously assigned slots, and a *contention area* which is used for initial connection setup or bandwidth requests in case a terminal has no more resources in the reservation area. The boundary between the two areas adapts to the current link utilization and therefore reduces the contention probability within periods of low transmission activity. The reservation area is divided into slots which are assigned to each user on a frame–by–frame basis as illustrated in Fig. 2. The assignment is constrained by the fact that each user transmits all its granted slots in a burst thus reducing the number of required preamble sequences and guard times to one for each user. The delay variance introduced by this MAC scheme is flattened by a traffic shaper located in the receiving MAC to support constant bit rate (CBR) connections.

3) Up–link Scheduler: The up–link scheduler is located on board the satellite. It assigns fixed resource allocations to all CBR connections with highest priority. Remaining resources are assigned to UBR with a minimum cell rate (MCR) connections based on a weighted round robin algorithm (weights set to the MCR). Left–over resources are equally divided between all remaining UBR and UBR with MCR connections.

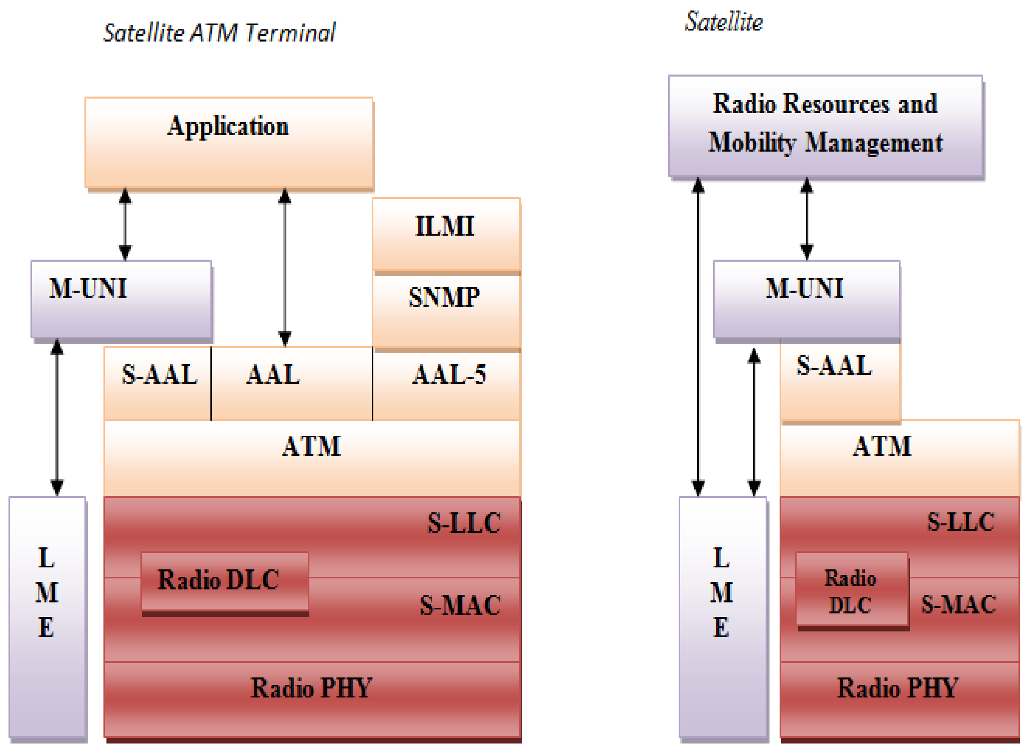

Fig. 2 ATM- Sat Protocol Stack

B. ***Forward Error Correction Schemes***

The designed satellite system utilizes the Ka–band which mainly suffers from high rain attenuation and in case of moving vehicular also from high signal shadowing due to obstacles like trees or buildings. As for this project vehicles are equipped with directional antennas, multipath fading is slight. Signal shadowing due to obstacles is too high to be compensated by forward error correction (FEC) thus leaving its focus on the attenuation caused by rain. As rain attenuation appears only from time to time and its maximum fade slope value for 0.01% of an average year is about 0.6 dB/s, adaptive forward error correction and also adaptive modulation techniques are applied to efficiently use the available bandwidth. This technique is a major improvement in contrast to traditional systems which required a rather high link margin which unnecessarily delimits up– and down– link capacity. The employed FEC scheme guarantees a fixed useful data rate by adapting the MAC packet lengths according to the used coding and modulation scheme.

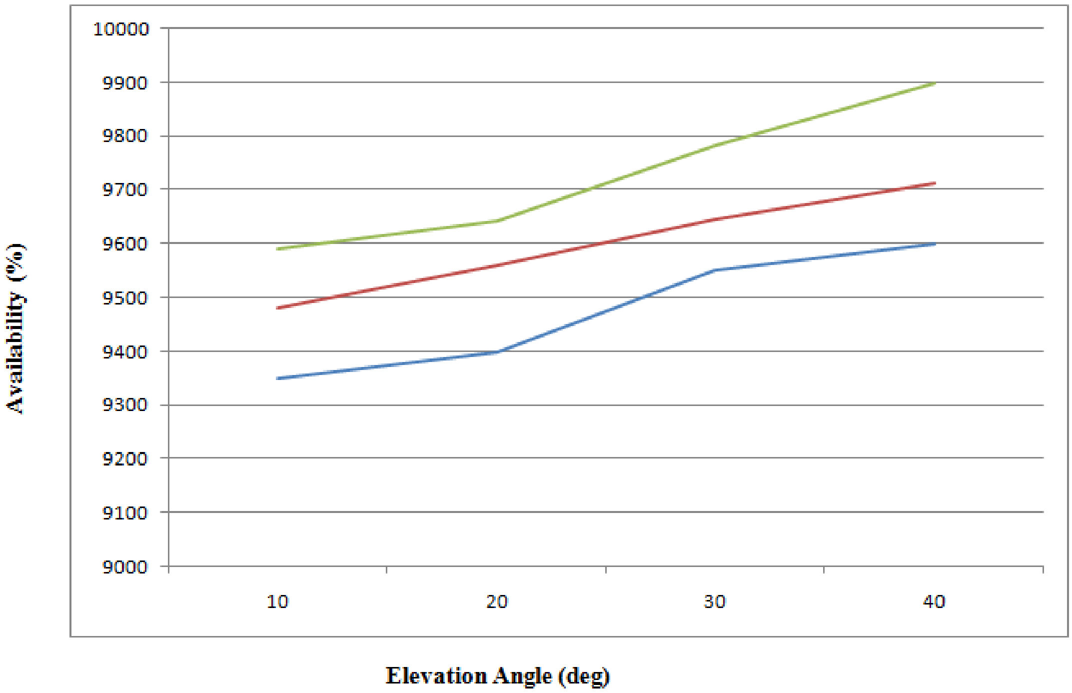

Fig. 3 TDMA Scheduler & MAC Up Down Link Frame Structure

III. WATM PROTOCOL ARCHITECTURE

All he WATM protocol architecture is based on integration of radio access and mobility features within the standard ATM protocol stack. It facilitates for gradual evolution of radio access technologies without modifying the core mobile ATM network specifications. A WATM system broadly consists of a Radio Access Layer and Mobile ATM network.

TABLE I: WIRELESS ATM REQUIREMENTS

Traffic Class	**Application**	**Bit rate range**	**Q_0 S Requirement**
CBR	Voice & Digital TV	32Kbps- 2Mbps	Isochronous Low cell Loss Low Delay Jitter
VBR	Video Conferencing, Multimedia Communication	32Kbps-2Mbps (avg) 128 Kbps-6Mbps(max)	Moderate Cell Loss Low Delay Jitter Statistical Mux
ABR	Interactive data Client Server	1-10Mbps	Low Cell Loss Can Tolerate high delay

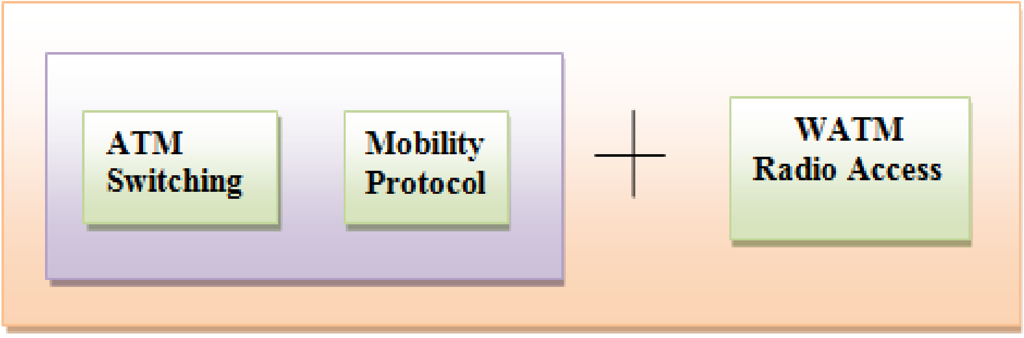

Fig. 4 Modular Protocol Architecture of WATM System

1. Radio Access Layer (RAL) 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).

2. Mobile ATM deals with control/signaling functions needed to support mobility. These include location management, handover and connection control. Location management is responsible for keeping track of the MT. Handover (or Handoff) refers to the process of rerouting the mobile terminal connections from the old to the new base station. Connection control deals with connection routing and QoS maintenance.

The Key aspects of WATM and mobility extensions, added to the fixed ATM network.

1. *Cellular Architecture*: In WATM, the geographical area is organized into small cells. The cellular organization of space potentially poses problems like increased handoff rates (due to crossings across the cells). The sharing of bandwidth and re-using of frequencies gives rise to the problem of co channel interference. Lesser the cell size accommodates greater capacity per unit area, but it increases handover rate and in turn dropping rate due to increased crossings across the cells.

2. *Resource Allocation*: QoS provisioning is an important consideration in WATM networks. An explicit resource allocation using a combination of admission, traffic shaping and policing mechanisms is used to achieve it. The connection admission mechanism must take into account possible congestion, also ensure a low rate of dropped connections as users roam among different wireless coverage areas. The admission control is based on several criteria such as: traffic and handover characteristics, call holding time statistics, desired QoS of each class of traffic and amount of radio resource available.

3. *Mobility Management*: Mobility management deals with issues such as handover signaling, location management, and connection control. Location management is responsible for locating the mobile node. It involves two-stage process: Location Registration and Call Delivery. In the first stage, the MT periodically notifies the network of its current location and allows the network to update its location profile. The second stage involves querying the network for the user location profile in order to route incoming calls to the current location of MT. Two basic location management schemes have been proposed in the Mobile PNNI scheme and the Location register scheme. The Handoff Management is responsible for rerouting the mobile terminal connections from the old to the new base station. Connection control deals with connection routing and QoS maintenance.

IV. Testing & Result Analysis

The implementation is modular in terms of separating a satellite channel emulation entity from the implementation of the MAC protocol. Therefore it is possible to run tests over various satellite constellations besides the original LEO target system.

A. *Demonstration Environment*

The demonstrator is separated into three major components: a satellite channel emulator (SCE), satellite and ground terminal DLCs (SDLC & TDLC), and a control station (CS). The ATM switch is only used for measurement purposes on ATM link level; the terminal can be any ATM–equipped computer. *1) Satellite channel emulator:* The SCE is configurable via snmp and adds the variable propagation delay and error rates depending on the current elevation angle. STK–based AER and error probability tables are used as an input file. Additionally it implements contention for terminals writing into the same MAC time slot. Its functionality is independent of the network interface used to connect DLC and SCE. Due to implementation purposes, Ethernet is used for encapsulating the actual MAC frame structure. *2) Satellite and Ground Terminal DLC:* The SDLC and TDLC units implement the MAC functionality. They are separated from the SCE in order to be independent of satellite specific network characteristics. *3) Control Station:* The CS initializes the SCE and DLC entities and acts additionally as a NTP–Server which is used by the latter two units for time synchronization.

B. Measurements

After an extensive simulation phase of the MAC, FEC schemes and upper layer protocols over the proposed system architecture, measurements to verify the functionality are conducted. The SCE is well capable to merge the different up–link streams coming from each TDLC into a single up–link stream going to the SDLC (including the contention handling) in real–time. The added variable propagation delay is shown in Fig. 5. The mean packet delay follows exactly the expected theoretical value; the pikes of the current cell delay are caused by the 24 ms framing (a cell may either be directly transmitted or has to wait for the next up–link frame) and the constant shift is due to processing delays.

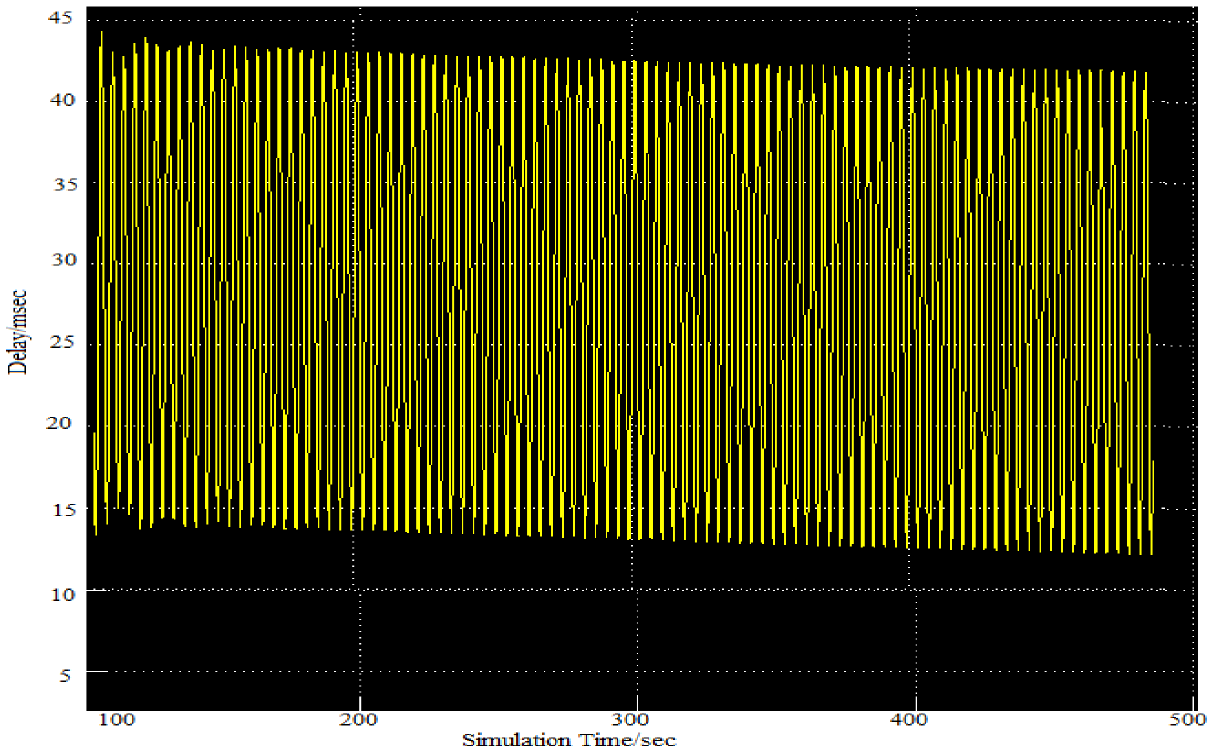

Fig. 5 Measured one cell Delay

V. Conclusions

The presented QoS aware MAC protocol suitable for ATM based NGSO satellite networks is adaptable to the changing satellite channel characteristics in terms of elevation angle dependent attenuation and the resulting BER. It allows optimal link utilization by changing its FEC scheme on the fly; dynamic MAC packet lengths guarantee a fixed useful data rate. The partial protocol implementation and measurements show the advantage of its adaptiveness. Wireless ATM provides wireless extension to ATM based ISDN networks. This paper reviews the important aspects of wireless ATM and the handoff related issues. It reviews the basic concepts and benefits of ATM. Then the important features of WATM service models, protocol model, the key characteristics of WATM and the global activities on WATM are dealt. The paper focuses on the survey of handoff techniques in WATM and related issues. The handoff requirements, various strategies and open issues are discussed.

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