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Mobility management and control in intelligent wireless ATM networks

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Abstract

This paper shows how the Asynchronous Transfer Mode (ATM) signaling and the Intelligent Network (IN) concept can be exploited to support mobility in an ATM-based network with wireless access parts and mobile users. The proposed architecture exploits the enhanced service control processing features offered by the IN technology to support location management. The access signaling protocol structure is based on the principles of separation between call and bearer channel control, employed in fixed broadband access networks. The design objective is to minimize the changes required to the wired network signaling, by taking advantage of the well-developed capability sets. This allows the easy introduction of the wireless ATM technology (W-ATM) into the real world. It is shown that the proposed signaling protocol model provides cost-effective implementations without degrading the agreed Quality of Service (QoS) and the system's performance. A comparative signaling performance evaluation is carried-out to demonstrate the impact of the proposed signaling protocol architecture onto various performance measures and to quantify the relative gains. The obtained results can be used for network design purposes in a large-scale private installation supporting many users. The signaling protocol architecture aims for private W-ATM networks, but can be readily extended to fulfill the signaling requirements of public environment broadband wireless systems.

Keywords: Wireless ATM; Signaling; Mobility management; Intelligent Networks

1. Introduction

The emergence of wireless communications networks, based on new digital technologies, is paving the way to providing multiservice capabilities to mobile terminals. This motivates the integration of wireless access systems with the Asynchronous Transfer Mode (ATM) based fixed network. Wireless ATM (W-ATM) has been proposed as one candidate solution for providing wireless broadband services [1]. Its main challenge is to consolidate the wireless and wired ATM technology into a seamless network infrastructure, capable of providing qualitatively similar service attributes to the mobile terminal user, even if the complete quantitative equivalence with the fixed ATM network may not be feasible [2]. In this context, a number of efforts have been deployed to explore this new technology (see Refs. [2–14,21,23] and the references therein). Most of them [2–9] comprise wireless research prototypes that are implementing wireless and mobile ATM, though with different approaches and scope. Others [10–14,21,23] focus on the design of broadband wireless Personal Communication Systems (PCS) with similar ATM-type service capabilities.

The W-ATM technology necessitates the introduction of new features into signaling and control protocols. In the wired ATM environment, the User-Network Interface (UNI) is a fixed port that remains stationary throughout the connection lifetime. The current Broadband ISDN (B-ISDN) UNI protocol stack [15,16] uses a single protocol over fixed point-to-point or point-to-multipoint interfaces, which does not cater for terminal movement. On the other hand, in W-ATM systems, users' mobility causes the terminals' access point to the wired network to change constantly. This calls for the employment of location management mechanisms, required to determine (whenever needed) the location of a mobile terminal, and handover schemes required to transfer the connections of an active terminal (i.e. involved in a call) from access point to access point. These two topics have gained particular research attention, and various location management mechanisms and handover schemes have been proposed [3–14,17–38,59,63–65].

This paper elaborates on the design of signaling and control protocols for W-ATM, deployed as extensions to

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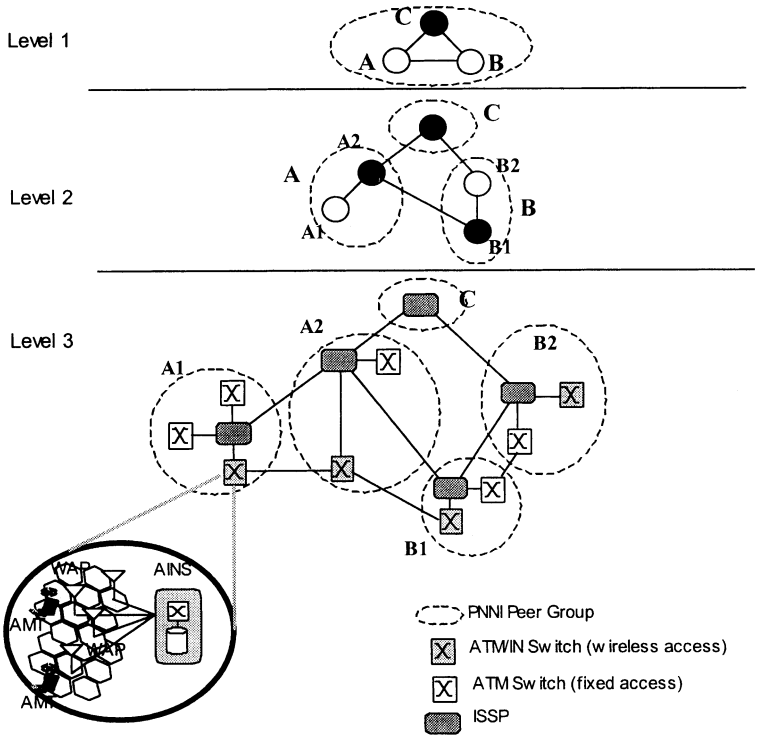

Fig. 1. Network architecture for wired and wireless access assuming the PNNI hierarchy.

the standard broadband signaling capabilities to cater for mobility. In an attempt to generalize and extend results and experiences obtained from the specification, design, and implementation of fixed ATM networks, we employ an enhanced version of the broadband V interface (referred to as VB) [39,53] for application to W-ATM systems. The introduction of the VB interface in ATM-based access systems intends to provide cost-effective implementations without degrading the agreed Quality of Service (QoS), while achieving high utilization of network resources. The selection of a low-level operating access network forces the establishment of internal mechanisms that are used to unambiguously identify the connection an ATM packet belongs to, and to convey only those connection parameters that are absolutely necessary for traffic handling. This task forms part of the fixed bearer handling procedures in the access network, and it is undertaken by the VB interface control protocol. The latter cooperates with a mobility-enhanced version of the existing ATM Call Control (CC) UNI signaling, which is employed to provide the basic call control and to support handover [3,14,27,40]. These features allow us to minimize the changes required to the signaling infrastructure used in the wired network, and, in this respect, they can guarantee the integration of the W-ATM access system with fixed ATM.

The signaling protocol architecture takes advantage of the Intelligent Network (IN) service control to support location management. The IN approach leads to an implementation framework, which enables the support of both fixed network services and mobility features in the same infrastructure, thus offering flexibility in service provisioning and tailoring [42]. The use of IN in wireless multimedia networking has lately become an important research topic [13,43–47] due to its convenience and flexibility in introducing new service features independently regarding to the underlying access network. In this way it provides a common mobility management framework for different network environments. In particular, the IN signaling control is highly feasible for the future PCS, which demand a sophisticated network signaling control mechanism for user-network interaction and mobility [48,49]. A specific application of the IN concept for W-ATM systems can be found in Ref. [13] for the design of the Wireless Intelligent ATM (WIATM) network, based on ITU Capability Set 1 (CS-1). An enhanced Basic Call State Model (BCSM) was proposed therein to cater for mobility as an extension of the CS-1 BCSM.

The design presented here is based on the IN CS-2 [50], which inherently permits for call-unrelated user-to-network service control processing, advanced call-related signaling, service customization and management, and provides the potentiality to support multimedia/multiparty communication. The support of these service features has been described in detail in Ref. [51], where it is shown how the IN technology complements and enhances the standard fixed ATM/B-ISDN control functionality in a generic way. This paper extends the ATM/IN integration scenario to cater for location management in a W-ATM network environment. The signaling protocol design aims for private environment W-ATM Customer Premises Network (CPN)