Mobility over Heterogeneous Wireless Networks

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INTRODUCTION

Accessing wireless services and application on the move has become a norm among casual or business users these days. Due to societal needs, technological innovation, and networks operators' business strategies, there has been a rapid proliferation of many different wireless technologies. In many parts of the world, we are witnessing a wireless ecosystem consisting of wide-area, low-to-medium-bandwidth network based on access technologies such as GSM, GPRS, and WCDMA, overlaid by faster local area networks such as IEEE 802.11-based Wireless LANs and Bluetooth pico-networks. One notable advantage of wide-area networks such as GPRS and 3G networks is their ability to provide access in a larger service area. However, a wide-area network has limited bandwidth and higher latency. 3G systems promise a speed of up to 2Mbps per cell for a non-roaming user. On the other hand, alternative wireless technologies like WLAN 802.11and Personal area network (PAN) using Bluetooth technology have limited range but can provide much higher bandwidth. Thus, technologies like WWAN and WLAN provide complementary features with respect to operating range and available bandwidth. Consequently, the natural trend will be toward utilizing high bandwidth data networks such as WLAN, whenever they are available, and to switch to an overlay service such as GPRS or 3G networks with low bandwidth, when coverage of WLAN is not available. Adding to the existing public networks, some private institutions (i.e., universities) have joined the fray to adopt wireless infrastructure to support mobility within their premises, thus adding to the plethora of wireless networks. With such pervasiveness, solutions are required to guarantee end-user terminal mobility and maintain always-on session connections to the Internet. To achieve this objective, an end device with several radio interfaces and intelligent software that would enable the automatic selection of networks and resources is necessary (Einsiedler, 2001; Moby Dick, 2003).

Related Technical Challenges

While this article focuses on how an IP-based mobile node can remain connected to the Internet as it moves across different network technologies, for practical and commercial Internet deployment, functions such as access authentication, security, and metering (for charging purposes) also need to be integrated with these mobility functions. In addition, in order to support the needs of cost-savvy users and future real-time applications such as VOIP and video conferencing, functions such as intelligent interface/network selection, fast and seamless hand-over, context transfer, QoS provisioning, differentiation, and others yet to be thought of need to be integrated. Moreover, specific variants of each of these functions, tailor-fitted to specific access technologies, may have to co-exist on mobile stations equipped with multiple access technologies.

In the remainder of this article, the various technical challenges are elaborated upon through a number of commercially available and research solutions presented in detail.

POSSIBLE SOLUTIONS

In general, a seamless mobility solution can be achieved by using two main approaches. The first is based on Mobile IP Technology. The second approach is a

Central Server Based solution. In the Mobile IP-based solution, there are specific solutions for IPv4 and IPv6 (Deering, 1998), respectively. To provide a comprehensive review of these solutions, the rest of this article is organized as follows: first, the mobile IPv6 solution is explained (Johnson, 2003); this is followed by two IPv4 solutions, namely the mobile IPv4 and central server based solution.

Mobile IPv6-Based Solutions

In the current state of the art, Mobile IPv6 (Johnson, 2003; Koodli, 2003) makes it possible for an IPv6 mobile node (MN) to remain connected to the Internet as it changes its network point of attachment. However, from a network provider's point of view, in addition to the mobility function, the system needs to be integrated with additional functions that allows them to authenticate, provision/select, and maintain suitable network resources, charge the MN for usage of their infrastructure, and so forth. From a network user's point of view, the MN needs to be smart enough to automatically select and hand off to networks that best suit its policies as and when they become available. Additionally, in the case of multi-homed MNs, it should be smart enough to automatically route traffic through the interface that best suits its policies (Kenward, 2002; Loughney, 2003; Thomson, 1998). All these need to be done in a seamless manner by the MN, where possible.

An example of a IPv6-based mobility solution is the AMASE (Advance Mobile Application Support Environment) project (Jayabal, 2004). It is aimed at providing a middleware for mobile devices that will allow users to move from one network to another and still have access to rich multimedia services in a seamless manner. One of the key features of this middleware is the intelligent abstraction of the underlying networks and network resources that are handled by a module called UAL (Universal Adaptation Layer). This entity is the client part of a mobility and resource management framework, which provides the mobility function in AMASE while, at the same time, facilitating the other additional functions to be carried out, as mentioned previously. The components of AMASE are elaborated in the following section:

The Mobile Node (MN)

The MN is a physical entity installed with the following AMASE logical components:

- **Universal Aadaptation Layer (UAL):** The UAL consists of the Mobility Management (MM) framework and a simple user –policy-based local network resource and handover management function (SLRM). It is responsible for the automatic link/network discovery and for IPv6 roaming mobility of the MN. The MM framework is designed so that it can be extended to facilitate other additional functions such as the URP, while managing the IPv6 mobility of the MN. The DHC6C module provides programmatic interfaces to the MMC for triggering DHCPv6 procedures, receiving DHCPv6 events, and sending and receiving MM and MM function-specific messages. The LM consists of network device-specific components that abstract the control, status reporting, and parameters of available links in each of the network devices governed by the UAL to present a uniform programmatic interface to MMC or other MMC extended functions. Presently, a generic LM module for single-link interfaces (i.e., wall-plug Ethernet or GPRS) and a signal strength and hysteresis-based LM for 802.11 interfaces (LM80211) are implemented.
- **DHCPv6 Client (DHC6C):** AMASE-enabled mobile node implements the Dynamic Host Configuration Protocol for IPv6 (DHCPv6) (Droms, 2003) to achieve stateful address autoconfiguration. Apart from obtaining IPv6/v4 address(es) from the network, DHCPv6 provides a flexible mechanism for the mobile node to request configuration parameters from the server, which is the underlying signaling protocol used in AMASE to obtain several AMASE-specific configurations. The design of the DHCPv6 client allows AMASE-modules (e.g. URP, MM) or applications to react according to specific DHCPv6-specific events. The design also allows AMASE-modules to have control of the behavior of the DHCPv6 state-machine.