Introducing MPLS in Mobile Data Networks: An High Performance Framework for QoS-Powered IP Mobility

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Abstract. Because of the evolution of portable computing, and personal communication technologies, mobile Internet connectivity is the fastest growing business in the telecommunications market, playing a vital role in shaping the 21st century communications paradigms. In this scenario, the deployment of innovative wireless data networks, the integration with the Internet and the interworking between different wireless technologies will be challenging objectives for competitive service providers. These factors, combined with the impact that mobile related traffic may have on the fixed infrastructure, and the convergence of mobile and fixed services, drive towards a rationalization of the resource allocation and management procedures and make it urgent to address the node mobility problem from a global, core-level traffic engineering point of view. We propose a framework for the integration of IP mobility and MPLS in the mobile data network focusing on the use of consolidated technology, with no major changes to standardized protocols or devices. Our model that handles wireless IP device mobility by combining local area mobility techniques at the edge and MPLS in the backbone, allows very fast handovers without the need of modifying the IP address, works with any IP version, has a low header overhead (compared to IP-in-IP tunneling), and can get the native traffic engineering and QoS benefits provided by MPLS to continuously adequate the traffic flows in the mobile data network backbone to the dynamically changing traffic requirements.

1 Introduction

In the last decade, mobile data communication and Internet connectivity services have been experiencing an explosive growth to mass-market dimensions. Experience with laptop computers and personal digital assistants (PDAs) has shown that many end users desire their portable equipment to provide essentially the same environment and applications they enjoy at their desks with few compromises thus demonstrating the singular importance of widespread coverage and anywhere/anytime access. Furthermore, with an increasing demand for the various mobile wireless data services such as wireless internet, video on demand (VoD), video telephony, multimedia mail, etc.
through the 2.5G or 3G systems, the number of subscribers to the data services would keep growing at an astonishing pace. Accordingly, mobile-related traffic is forecast to be comparable in volume with that related to fixed networks in a not too distant future. These factors, combined with the impact that mobile-related traffic may have on the fixed infrastructure, and the convergence of mobile and fixed services, drive towards a rationalization of the network architecture, resource allocation and both inter- and intra-operators’ management procedures. Consequentially, from the perspective of service providers, the increase of mobile data traffic could require enormous new investments and efforts to expand and manage their networks, which are already optimized only for static wired data or voice services. The associated dimensions of space/time dependence of this traffic demand, “hostile” operation environment, unpredictable quality, and changing user’s network attachment point represent major deviations with respect to the traditional communications paradigm. Unlike the classical pure wire-line network, the network supporting mobile data services should have different unique characteristics: enormous adaptivity in handling high-speed large traffic volumes, rapid changes of throughput variability, network congestions and re-routing, and the like. The mobile wireless service providers have started their own data services using their proprietary network and now they are trying to open their networks to the public internet domain. Thus, in the medium-term perspective, several wireless overlay networks will coexist, each with its own routing architecture, network management and support facilities, and their interworking in a unique IP-based backbone providing full support for all mobile service facilities will be a challenging objective. In this scenario, Mobile IP reveals to be the best mean to provide host mobility solution in these future converged networks and there are several proposals to incorporate IP-based technologies into the core networks of future wireless cellular systems such as UMTS [1] and Cellular IP [2]. Since the number of mobile users and terminals connected to these future systems would be very large, the scalability of the Mobile IP solution and of the whole backbone is of great concern and interest. Under the above circumstances, one of the more critical issues in mobile transport network architecture would be to build optimal traffic engineering policies to prepare for the heavy traffic growth and handle the great variability in the traffic flow distribution on the backbones generated from the increasing number of mobile users foreseen in the upcoming future. Based on this challenge, IETF (Internet Engineering Task Force) has standardized an evolutionary protocol, MPLS (Multi-protocol Label Switching), which gives us very flexible and intelligent opportunities to dynamically and efficiently route the data flows on traffic engineering and resource requirements basis, and to configure the protection paths for any resource failures. MPLS is actually playing a key role in delivering QoS and traffic engineering features in IP networks and can be considered a promising technology to enhance the ability of the network operators to control the network behavior while delivering mobile IP services, in accordance with customized service contracts (SLAs). In this paper, we propose a framework integrating the IP Mobility and traffic engineering facilities in mobile data networks backbone on a common MPLS transport stratum. The integration improves the scalability of the Mobile IP handover and data forwarding process by leveraging on the features of MPLS, which are fast switching, dynamic traffic distribution, small state maintenance and high scalability. In addition,