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Operation management of IP broadband access networks

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Abstract

The last several years have seen significant advances in broadband access technology, including greater bandwidth, improved quality of service capabilities, multicast, and better applications availability. Customers today have several choices of broadband access technologies, namely Digital Subscriber Lines (DSL), Cable, wireless, and most recently Ethernet or Fiber to the home or business, as the first/last mile access is now an emerging technology gaining significant momentum specially Europe and Asia Pacific.

Ensuring profitability from these services requires a comprehensive service management architecture that enables service providers to carefully plan, quickly provision, efficiently operate, and accurately bill these services. Once the user is connected to the network, service providers must monitor and ensure the Quality of Service. In this paper, we first provide an overview several IP broadband access technologies including Ethernet to the home/business, IP DSL, Wireless, and Cable. We then define an integrated Operation Support Systems/Network Management Systems (OSS/NMS) architecture including description of fault, configuration, accounting, performance, and security management functions. Several traffic-engineering algorithms are then discussed and simulation results are compared. Finally, an intelligent capacity allocation algorithm for IP network is introduced.

Keywords: Broadband access technology; Digital subscriber lines; Ethernet; Traffic-engineering

1. Introduction

The Internet is penetrating all aspects of society and becoming an indispensable part of our daily lives. With the enabling applications such as emails, the WWW, online shopping, banking, video-conferencing, distant learning, entertainment, which often entail exchange of large amount of data, the Internet access speed is an important issue. Internet access is in fact becoming a commodity service from a service provider perspective. It has little customer loyalty and is driven by price and quality.

There are many broadband access technologies including Ethernet-to-the-Home (ETTH) and Ethernet-to-the-Business (ETTB) (collectively known as ETTx), wireless, cable, and IP digital subscriber line (DSL).

Ethernet is the dominant technology in LAN due to its simplicity, low cost, ubiquity (300 million ports installed worldwide), and very high speeds. In the last four years the industry has seen a jump from shared 10 Mbps, to switched 100 Mbps, to switched 1 Gbps, and now up to switched 10 Gbps Ethernet. These factors have allowed LAN network managers to put more and more mission critical applications on their networks. In the WAN, service providers have used technologies such as DWDM to scale the long-haul networks. This has enabled service providers to more cost-effective by utilizing their investment in fiber. By extending Ethernet to the last mile, service providers can deliver true multi-services to the end-users. ETTx offers new opportunities for service providers. However, it entails laying fibers to the customer premises, which may be expensive.

Wireless provides mobile connection to the Internet and voice networks. Due to the noisy transmission media, it can support up to 2 Mbps in the optimal case, for the 3G (third generation) wireless systems, such as IMT-2000 and CDMA2000.3x. In practical environment, the actual speed can be much slower. However, the ubiquitous access capability has gained much market interest.

Cable access can provide connection speed up to 6 Mbps. With cable connections to most of the household in North America, it gives the cable operators quick presence into the Internet access market. The lack of switching capability in the cable network limits its two-way communications capability. Significant infrastructure upgrade is needed.

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DSL uses the current twisted copper pairs in the Plain Old Telephone Service (POTS) to provide Internet access. There are many flavors of DSL technology, e.g. Asymmetric ADSL (ADSL), G.Lite, Very-high-data-rate DSL (VDSL), etc. The downstream bit rate ranges from 1 Mbps by G.Lite to up to 52 Mbps by VDSL. The actual speed depends on the specific implementation and the distance between the customer premise and the central office (CO), i.e. the loop length. The almost 100% market penetration of the twisted pairs make DSL is strong contender in providing Internet access.

Possessing the access technology is only half of the battle for service providers. The ability to manage the network efficiently and in a timely fashion is essential in the current competitive market place. Network management can be defined as the set of operation support systems that service providers use to deploy, configure, maintain, and monitor the network and the services that are carried over it. They can also be used to study the network behavior and determine the future network expansion plans. Network management is also used for user authentication and network security to protect the network from malicious users and to maintain the network integrity. Other important issues include service order management, billing, to name a few. These are all crucial for the service providers' market penetration and profitability. The objective of this paper is to discuss the integrated management of IP (Internet Protocol) broadband access networks.

This paper is organized as follows. In Section 2, we will give an overview of the few popular broadband access technologies. The integrated network management problem is discussed in Section 3. Section 4 studies the traffic modeling and network-dimensioning problem, which is an essential component in network management. An intelligent capacity allocation algorithm is proposed. Conclusion remarks are given in Section 5.

2. Broadband Access Technologies

2.1. Wireless Access

Fig. 1 shows the wireless access architecture. A mobile terminal with IP capability establishes a wireless link to the base station transceiver (BTS). The corresponding base station controller (BSC), with IP capability provides the actual attachment to the packet-based wireless network. It can be either the GPRS (GSM Packet Radio System) or CDMA system for the 2.5G wireless systems. Alternatively, it can be the 3G wireless systems. Through an access router at the edge of the IP core, the wireless network communicates with the Internet Service Provider (ISP).

The main difference between the IP wireless access and traditional wireless access lies in the enhancement of the BSC to be IP-literate. The IP wireless network is packet-based with IP capability. For example, the GPRS system consists of the Servicing GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). GPRS uses GPRS Tunneling Protocol (GTP) to deliver IP packets to the mobile terminal. On the other hand, the 2.5G CDMA wireless system consists of the Packet Data Service Node (PDSN) and it uses Mobile IP for packet delivery.

Although the access speed through the wireless domain is limited, wireless access provides the unique tether less access to the Internet. It allows subscribers to communicate anywhere they are traveling.

2.2. IP DSL

Fig. 2 shows the IP DSL architecture. The IP DSL switch is an IP-aware DSL switch, capable of switching permanent virtual circuit (PVC's) and soft-PVC (SPVC's), yet support IP Quality of Service (QoS) and IP DSL switch. Connections to the ISP or private Virtual Private Network (VPN) are established by setting up tunnels using tunneling protocols such as Layer 2 Tunneling Protocol (L2TP). The IP DSL switch pushes the Layer 3 functionalities toward the network edge. It is a distributed architecture in the sense that it distributes the CPE aggregation and thus the L2TP aggregation among the IP DSL switches at the network edge. It makes the network more resilient to switch failure and provides better scalability.

The DSL architecture with IP DSL switches allows full IP functionalities for both consumers and businesses. These include basic Internet access, online shopping, online banking, multicast video, e-commerce, distance learning, secure Virtual Private Network (VPN) using Multiprotocol

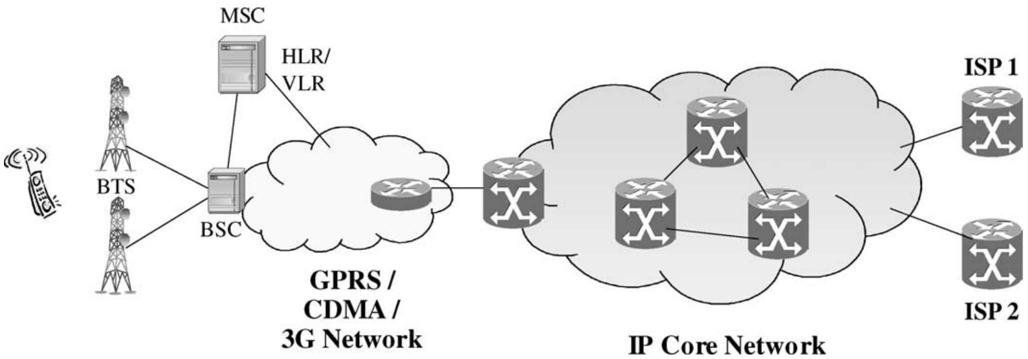

Fig. 1. Wireless Access Architecture.