Teletraffic Engineering for the IP Mobile Network

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Abstract

To develop a mobile service network allowing user mobility on a widespread IP platform, it is necessary to introduce new functions and technologies for achieving mobility, such as handoff. This article describes techniques for evaluating traffic performance and quality that are required for new systems and new implementation methods.

1. Introduction

In this article, an all-IP-based mobile service network is called an IP&Mobile network. I discuss various teletraffic engineering issues that have been studied separately for fixed IP networks and mobile networks, such as where and how traffic performance and quality problems occur and how they can be solved (Fig. 1). I shed light on these issues from the perspective of the IP&Mobile network.

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2. Teletraffic engineering issues in the IP&Mobile network

Mobile services are evolving from the initial cellular phones to terminals with a built-in browser for accessing the Internet and on to the more recent multimedia applications allowing location-free access, which are often referred to as 'ubiquitous services' [1]. In addition, new mobile applications that will run on the ITS (Intelligent Transportation System) platform are expected to be deployed on a large scale.

IP technology, which originated in the Internet, is now used not only to transfer discrete data items but also increasingly to carry streaming data traffic. It can be said to be the most widespread communications

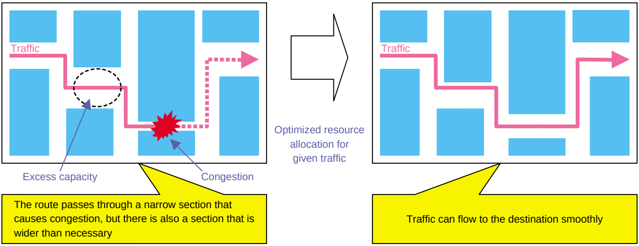

Fig. 1. How traffic engineering helps.

technology of today.

Following these trends, the migration of the mobile network from one based on circuit switching to one based on IP is being studied [2]. Furthermore, the IP&Mobile network that is envisaged will be used to offer not only public services but also enterprise solutions, such as enterprise cordless telephone systems.

Let me briefly review the advantages of the IP network regardless of whether or not it supports mobility. First, there is a rich selection of IP network products on the market, so they are widely available and prices are competitive. Second, the IP network is naturally more compatible with the IP-based services that will be increasingly provided in the future. By using the IP platform, we can build an economical network with routers and switches that have assured interoperability and are available at reasonable prices. It is easy to incorporate new products, which result from constant improvements, in a timely manner. It will also be possible to incorporate, as plug-ins on the IP platform, new functions, such as mobility, needed for new applications demanded by the market. A specific example of the second advantage is public hot spot services using wireless LANs, which were recently started throughout the world. New VPN (Virtual Private Network) services for mobile users may be provided in the future.

Thus, the IP&Mobile network assumes a multivendor environment, so it is important to evaluate performance when products based on different specifications co-exist in the network. Also, traffic from different applications, including mobile applications, with differing quality requirements, will co-exist. There will be a need for techniques and operational procedures that ensure different degrees of quality. Consequently, it is important to be able to estimate performance accurately. A case in point is whether the performance and quality assurance technologies developed for fixed networks, such as MPLS (Multi-Protocol Label Switching), are also effective for mobile applications.

Teletraffic issues specific to the IP&Mobile network must be tackled along with studies of system implementation technology.

3. Performance evaluation of handoff

Next, let's look at the handoff function, which is considered to be one of the teletraffic issues having the greatest impact on the IP&Mobile network. A cellular phone user in a moving vehicle can continue to communicate without interruption because the connection is switched every time the visiting base station changes as the user terminal moves. This switching of connections from one visiting base station area to another is called handoff (or handover).

Mobile IP is being studied in IETF (The Internet Engineering Task Force) [3], [4]. Mobile IP offers this handoff function on the IP network. This standard basically specifies only the switchover process, and leaves performance issues as implementation dependent (Fig. 2). Although voice and other streaming data services require stringent real-time transmission, in particular communication with no interruption, Mobile IP is said to be unable to achieve high-speed handoff under certain conditions. Various proposals have been made for improving the performance of Mobile IP to achieve high-speed handoff [5].

Today, there seems to be a sufficient array of implementation methods for Mobile IP. However, there is a

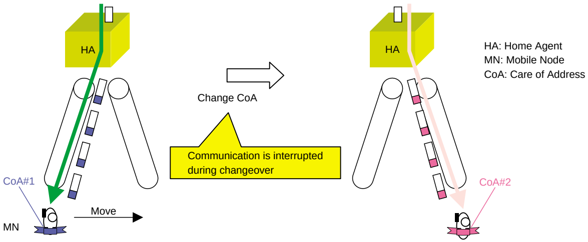

Fig. 2. Handoff in Mobile IP.

dearth of qualitative information about the performance achievable under different conditions. For example, unanswered questions remain about the extent to which a larger number of users affects switchover time, increases packet loss, and degrades user satisfaction with quality. It is necessary to understand these relationships in studying implementation and operations methods that will result in good and cost-effective performance.

4. Approach

NTT Service Integration Laboratories are taking two approaches to finding solutions to these problems.

4.1 Theoretical approach

To understand the intrinsic behavior of a system and evaluate system performance, we are developing a mathematical model for a network under study and conducting theoretical analysis. For example, we have developed a queuing model for a Mobile IP network, and have applied queuing theory to analyze network performance [6]. As shown in Fig. 3, in Mobile IP the "care of address" (CoA) of a mobile node (MN) is registered with a home agent (HA). Each time a mobile node moves and visits a different area, the home agent is notified of a new CoA. This process is called Binding Update. While it is in progress, communication is usually interrupted. We can apply queuing theory to determine the quantitative relationship between the handoff occurrence rate, which means how often Binding Update requests occur, and the packet loss ratio around a handoff (Fig. 4). This kind of approach can clarify the relationships among various traffic parameters.

In developing a model, it is important to extract the essential properties related to performance from the actual network architecture. Efficient development of a model requires not only knowledge of mathematical theory but also rich experience with, and deep insight into, real networks. We are therefore pursuing not only mathematical theories but also surveys of the latest network technologies.

4.2 Computer simulation

A drawback of the theoretical approach is that some simplification is inevitable during the process of developing a model. In a real network, a large number of factors usually interact in an intricate manner, affecting the overall performance. As a result, it is worthwhile simulating the behavior of different factors on a computer, to narrow down the range of values of different parameters and to understand the possible problems that may arise, before implementing specific functions in a device or network. For these reasons, we are using traffic simulation.

We are also conducting R&D into simulation techniques themselves. Well-known generic simulation tools include OPNET*1 and ns-2*2. OPNET includes, for example, built-in software models of the major nodes sold by different vendors. Therefore, even engineers without specialist skills in simulation can easily build simulation models by dragging and dropping icons from a pallet on a GUI. So, this tool can be

*1 OPNET: An off-the-shelf tool developed by OPNET Technology Inc. (http://www.opnet.com/).

*2 ns-2: A freeware tool developed by the University of California Berkley (http://www.isi.edu/nsnam/ns/).

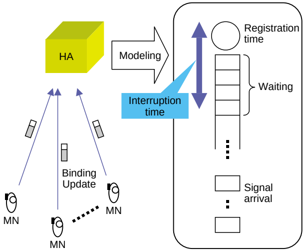

Fig. 3. Queuing model for Mobile IP.

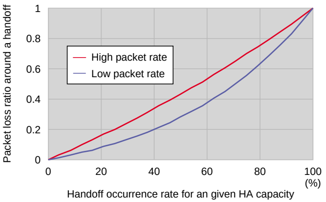

Fig. 4. Examples of performance analysis by queuing model.

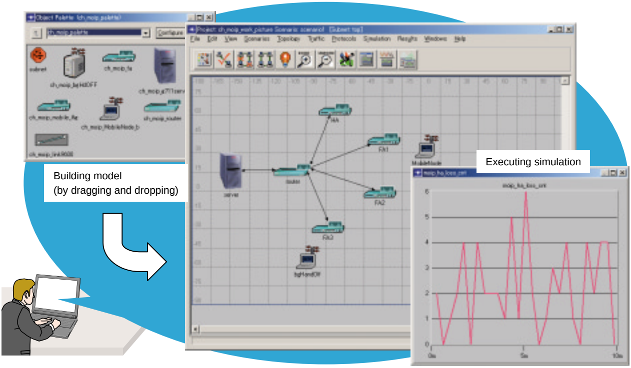

Fig. 5. Examples of simulation tool's GUI display.

used easily by people in NTT operating companies (Fig. 5). However, the models incorporated in generic tools are limited to ones for general-purpose devices that are commonly used. To evaluate the performance of a real IP platform, it is desirable to be able to simulate proprietary devices while utilizing standard functions available in the tool. We are therefore studying modeling techniques that enable newly required functions to be added to the tool's standard library. We are also investigating the performance and validity of the tools themselves to build a model that truly simulates the real network.

5. Conclusion

Using the approaches described above, we are studying traffic performance and quality evaluation techniques for the IP&Mobile network. Knowledge obtained from performance evaluation can provide guidelines for system implementation, and contribute to the establishment of standards for the network design and provisioning processes.

Mobile IP is expected to find its way into various devices. We will conduct performance evaluations that reflect actual implementation, including evaluations using a test bed. We will also study methods of network operation and traffic measurement for application to real networks.

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