Simultaneous Mobility: Probability of Lost Binding Updates and Mean Time to Occurrence

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ABSTRACT

To realize the full potential of mobile multimedia, mobility protocols are needed to handle situations when nodes move while in a multimedia session. Many mobility protocols have been proposed for IP-based networks. In some important cases in using these mobility protocols such as mobile IPv6 with route optimization, a problem can arise when both nodes are mobile and move simultaneously. The problem is that both sides’ binding updates could be lost. A few solutions have recently been proposed. A crucial indicator of the importance of the simultaneous mobility problem, and of its solutions, is the probability of its occurrence. However, previous articles have used only a simple analytical model to estimate the probability of the simultaneous mobility problem occurring. In this article, we present new and more accurate results on the variation of this probability with a number of critical variables.

Keywords: binding updates; handoffs; handovers; IP mobility; mobile IP; mobile multimedia; simultaneous mobility

INTRODUCTION

Mobile multimedia applications are one of the most exciting classes of applications that are appearing these days and are an area with tremendous growth potential. These applications are fueling the growth of the wireless Internet (Wong, 2004). Various kinds of research have been conducted in mobile computing and communications, including data mining for mobile users (Goh & Taniar, 2005) and mobility management for cellular networks (Abondo & Pierre, 2005). In this article, however, we focus on a specific problem related to mobility management. The motivation for mobility management is that, for flexibility and convenience, mobile multimedia applications have to work even when users move around and bring their terminals (laptops, PDAs, smart phones, etc.) with them. Indeed, one of the most serious issues that needs to be dealt with to ensure the success of mobile
multimedia is the following: there may be ongoing multimedia communications sessions between a mobile node and one or more correspondent nodes. When a mobile node moves and changes its point of attachment to the network (also known as handoff), these sessions need to be efficiently redirected to the appropriate new location, from the first network attachment point to the other. Various network protocols have been proposed to handle handoff. Some of these protocols do not correctly handle the case when both sides of a communications session are mobile, so the session may break when both sides simultaneously move roughly.

**Background on Simultaneous Mobility**

IP networks are expected to provide the foundation for most of the mobile multimedia applications of the future (or at least, the foreseeable future). Many network protocols have been proposed to handle the problems of mobility such as efficiently redirecting traffic to the new point of attachment—in IP networks.

In particular, solutions have been proposed at the network layer (mobile IP (Perkins, 2002) and its variants, mobile IPv6 (Johnson, Perkins, & Arkko, 2004), mobile IP with location registers (Jain et al., 1999; Jain, Raleigh, Graff, & Breschinsky, 1998), etc.), at the transport layer (MSOCKS (Maltz & Bhagwat, 1998), MSCTP (Dreibholz, Jungmaier, & Tuxen, 2003), TCP migration (Snoeren & Balakrishnan, 2000), etc.), and at the application layer (SIP mobility (Schulzrinne & Wedlund, 2000), etc.). In these solutions, typically some location update information needs to be sent by a mobile node about its latest location so traffic can be directed there. We refer to this type of information in general as binding updates (for example, in mobile IP, these are the registration messages; in SIP mobility, these are the re-INVITE messages).

To optimize the network path taken by packets from a correspondent node to a mobile node, the correspondent node could be directly informed about the mobile node’s latest location. Then, traffic need not pass through a forwarding element (like home agent in mobile IP, SIP server in SIP mobility, etc.). Thus, a binding update can be sent directly from the mobile node to the correspondent node. This is sometimes known as route optimization. Unfortunately, using route optimization can lead to the so-called simultaneous mobility problem. This is the problem when a correspondent node is also a mobile node, and both of them move at roughly the same time; the binding updates that they send to each other may be lost. One definition of the simultaneous mobility problem is that “end hosts should be able to move simultaneously without breaking an ongoing session between them” (Zhuang, Lai, Stoica, Katz, & Shenker, 2003). A more precise definition (Wong, Dutta, Schulzrinne, & Young, 2006) is:

The simultaneous mobility problem occurs when there are two mobile nodes in a communications session in normal state, and they both move such that the binding updates that they send to each other are both lost through belated arrival, and such that the communications session never returns from interrupted state to normal state, but is ended.

A communications session may be in a normal state or interrupted state. It is in a normal state when data from one node is arriving at the right location for the other node, and vice versa. It is in an interrupted state otherwise.