Analyzing Buffer Requirement for Wireless Enhancement of TCP in Network Mobility

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ABSTRACT
On-board TCP (obTCP) has been shown to address the dual wireless link related issues in network mobility (NEMO) effectively. obTCP uses agents at both base station (BS) and mobile router (MR). The agents store incoming TCP packet in a buffer for future possible retransmissions over the wireless links. Since the number of TCP connections passing through the MR could be very large, the amount of memory space required for the buffers may become very high. This may put the deployment of obTCP in question. So, in this paper, the authors investigate the buffer requirement problem of obTCP at MR for each TCP connection. For this purpose, they describe a Markov model to keep track of the packet transmission process of MR. The buffer size for each TCP connection is represented as a function of loss probability of the wireless links. Interestingly, from the numerical results, the authors find that the buffer size requirement at MR is significantly low for each TCP connections. This observation claims possible implementation of obTCP in NEMO.

Keywords: Markov Model, Network Mobility (NEMO), On-board TCP (obTCP), Pack Transmission process (TCP), Wireless Enhancements

INTRODUCTION
In telecommunication, the term mobility refers to the ability to move around here and there and at the same time remain reachable to others irrespective of current location. Though wireless medium encourages mobility, providing seamless mobility in the Internet is a major issue. Mobility can be divided into two categories: terminal mobility and network mobility. Terminal mobility allows a device (or a terminal, e.g., mobile phone, laptop etc) to move from one location to another, while maintaining connectivity to the network it belongs to. To support terminal mobility, the Internet Engineering Task Force (IETF) has standardized protocols like mobile IPv4 (MIPv4) (Perkins, 2002) and mobile IPv6 (MIPv6) (Perkins, Johnson, & Arkko, 2011). On the other hand, network mobility (NEMO) occurs when a group of mobile hosts (MHs) form a network, moves and changes point of attachment to the Internet together (Figure 1) (Devarapalli, Wakikawa, Petrescu, & Thubert, 2005; Lee & Ernst, 2011; Lee, Ernst, & Chilamkurti, 2012). Example of such networks include network of sensors and computers deployed in a vehicle. One common

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feature of these systems is that their journeys mostly last for hours or even days. People riding a high-speed train or a non-stop flight (e.g., from Mumbai to New York) may want to use these long hours to read/send emails, browse the Internet, or catch up with their office intranet.

To support NEMO it is still possible to use MIP. However, this would require all MHs (e.g., PDAs) to be MIP capable and be able to process a storm of control packets to perform MIP functions. Moreover, all MHs within the moving network may not be sophisticated enough (e.g., sensors) to run such a mobility protocol. These problems are addressed by the NEMO working group with the IETF. The IETF has recently standardized NEMO basic support protocol to provide mobility support to a moving network without any kind of help from MHs within the moving network (Devarapalli, Wakkawa, Petrescu, & Thubert, 2005). The NEMO basic support protocol is an extension of MIPv6 and backward compatible with MIPv6. A mobile router (MR) connects the entire moving network to the Internet (Figure 1). The NEMO basic support suggests using a bi-directional tunnel between the MR and its HA. The MR’s HA intercepts all packets destined for MHs within the moving network and tunnels them towards MR. On the other hand, the MR tunnels all packets from the MHs to the HA. In this case, the HA decapsulates the packets and forwards them to the fixed host (FH). This mechanism is simple and provides complete and transparent mobility support to MHs within the moving network.

While NEMO gracefully extends the Internet services onboard a moving vehicle, it raises several performance issues of its own, primarily due to the mobility of the entire network and the existence of double wireless links (Baig, Libman, & Hassan, 2006; Chan, Chunq, Hassan, Lan, & Libman, 2005; Petander, Perera, Lan, & Seneviratne, 2006; Sardar, Chand, & Saha, 2006; Sardar, Saha, & Hassan, 2009). It is well known in the context of terminal mobility that TCP (Postel, 1981) cannot distinguish between...

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**Figure 1. NEMO connectivity model**

![NEMO Connectivity Model](image-url)
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Dario Di Zenobio, Massimo Celidonio, Lorenzo Pulcini and Arianna Rufini (2013). 
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