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# Optimized topology control in mobile IP networks using a new parametric routing algorithm☆

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ABSTRACT

When some intermediate nodes fail or are suddenly removed in a mobile IP network, a node failure can disconnect paths and decrease network efficiency due to loss of some packets. In this case, the movement of the remaining nodes must be controlled such that to prevent further network efficiency drop. In the present research, we will study the intermediate node failure and changing foreign networks in mobile IP networks when the Mobile Node (MN) moves. Then, a new optimal routing algorithm is proposed to make up the node failure and changing Foreign Agent (FA). For this purpose, an Optimal Parametric Topology Control Routing (OPTCR) algorithm is introduced based on parametric linear programming formulation (LPF). Since OPTCR can handle the handover latency, it is supposed that both destination and intermediate nodes can move but just intermediate nodes may fail. Simulation results show that OPTCR algorithm is superior to some algorithms appeared in the recent literature.

## 1. Introduction: IP and mobile IP differentiation

This paper is an ongoing work of handover latency problems in Mobile IP networks. Today's computers are smaller and handier and connectivity to the Internet is now easier and more diverse.

A user may now disconnect his computer in the office and reconnect from another site within the same office or elsewhere. Connectivity may be achieved through established networking technologies such as Ethernet, dial-up lines, or wireless networking. In the last case, the point of attachment may change even while the user is connected since the user may travel between base stations of a wireless local area network (LAN) or a mobile phone system. Mobile IP is a solution for mobility support in the global Internet [1–5].

When a host or mobile node moves, its point of attachment in the network changes; this situation is called a handover. Trying routers for re-finding mobile node wastes the time, leading to Hand over Latency (HoL). It has to be noted that HoL is different from the delay between nodes. The present study deals with HoL and offers some methods to overcome this problem.

In this following, some mobile IP terminologies are defined first [6–8]:

- Mobile Node (MN): a system (node) that can change the point of connection to the network without changing its IP address
- Home Agent (HA): a system in the home network of the MN, typically a router, that registers the location of the MN and tunnels IP

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datagrams to the COA

- Foreign Agent (FA): a system in the current foreign network of the MN, typically a router, that forwards the tunneled datagrams to the MN and also the default router for the MN
- Care-of Address (COA): the address of the current tunnel end-point for the MN (at FA or MN), the actual location of the MN from an IP point of view, that can be chosen, e.g., via DHCP
- Correspondent Node (CN): the communication partner of MN
- Mobile IP Operation: consists 3 steps: Agent discovery, Registration, and Rout-ing/Tunneling as follows:

- Agent discovery: consists of two functions:

(1) HA and FA periodically send advertisement messages to their subnets (2) MN reads a COA from the FA advertisement messages

- Registration (always limited lifetime): consists of two following functions (Fig. 1)

(1) MN signals COA to the HA via the FA, HA acknowledges (2) Messages need to be secured by authentication

- Routing/Tunneling: consists of three functions

(1) HA advertises the MN IP address (as for fixed systems), (2) routers adjust their entries, (HA is responsible for a long time), and (3) all packets to MN are sent to HA

Fig. 1 shows stages of registration of node MN when it arrives in a new FA. For further information, see Mobile IP RFC 2002 (Section 2.4.2.2). MN does not require any mobility capabilities when it returns back to the home network. Fig. 2 shows stages of handover latency and routing in Mobile IP networks. The upper part of the figure shows a data communication between the home network and foreign network without any handover latency (HoL) mechanism. The lower part of the figure shows the steps of HoL mechanism for improving data communication including 4 steps.

It is of great note that when one of the routers in HA, FA, or CN suddenly fails, the addresses of their networks will be removed and efficiency of Mobile IP networks will be decreased, leading to an increase in the handover delay. In this paper, we present a new optimal algorithm for controlling topology of IP Mobile network for the case that some nodes suddenly fail. Also, when an MN travels from an FA to another FA, the HoL is reduced by our algorithm.

The remainder of the paper is organized as follows. Section 2 formulates and models parameters and variables of the network using graph theory. In Section 3, we review the works related to handover latency, mobile IP challenges, and routing optimization. In Section 4, we formulate and discuss a parametric linear programming optimization model, which considers path computation with additive metrics and topology control conditions. We propose and evaluate a mathematical and formal algorithm in Section 5. In Section 6, we present numerical results obtained for several scenarios with optimal routing. Furthermore, an applicability assessment of the formal optimization approach is included. Finally, we summarize and conclude the paper in Section 7.

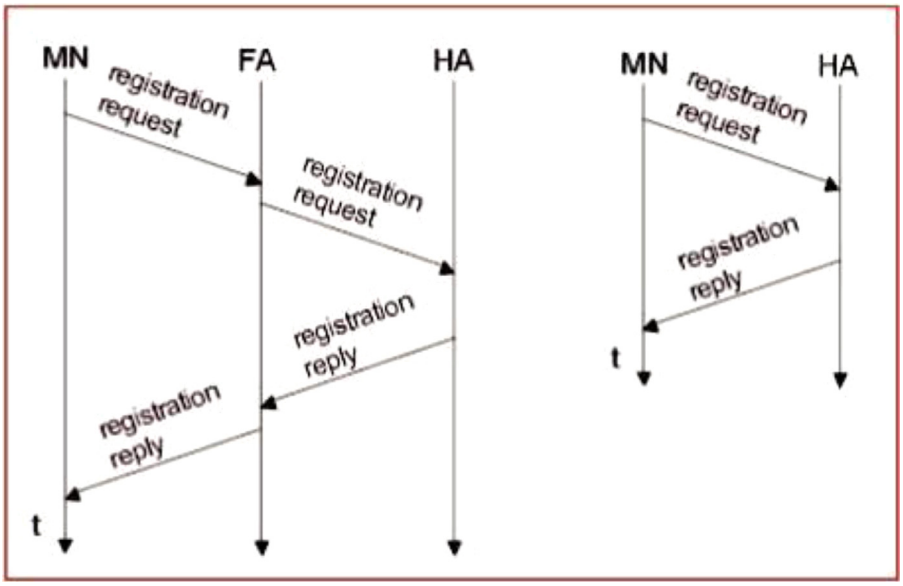


**Fig. 1.** The stages involved in the registration of MN consisting of an FA and without an FA [6,8].