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学位論文題目 Performance Improvement of Mobility Management in  
IP-based Wireless Networks

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Ved Prasad Kafle's research concerns improving the performance of the mobility management in regard to the IP-based mobile networks and provides the solutions from two important aspects: network mobility (NEMO) management and overlapped heterogeneous networks.

The thesis starts by presenting the general concepts of the network mobility and heterogeneous networks in Chapter 1 and then overviews related work on them in Chapter 2. Chapters 3 and 4 provide the new network mobility management schemes while chapters 5 and 6 present an access network selection algorithm and a vertical handover scheme in heterogeneous networks respectively.

Chapter 3 addresses the mobility management of an entire network that provides an uninterrupted Internet connectivity to many mobile devices moving together in the mobile network. The existing NEMO basic support protocol has the side effect of increasing packet delivery overheads due to pinball routing and multi-layer encapsulation of data packets and the large handover latency. Therefore, a mobile router-assisted route optimization (MoRaRo) scheme is proposed to enable a correspondent node to forward packets directly to the mobile network without any tunneling. The performance evaluation of the MoRaRo scheme reveals that the scheme improves the packet delivery efficiency of the network mobility support protocol by about 100%. In addition, the packet delivery delay is significantly reduced.

Chapter 4 provides a cooperative mobile router-based handover (CoMoRoHo) scheme for long, vehicular-multihomed mobile networks. This scheme makes the packet loss independent of the handover latency by establishing a local tunnel between an access router and a mobile router of the mobile network by using only one signaling message. The performance of the CoMoRoHo scheme is compared with the Fast Handover for Mobile IPv6 protocol by formulating analytical models. The results show that CoMoRoHo outperforms in regard to the number of packet losses, signaling-message overhead, and packet-delivery overhead in the access network while CoMoRoHo has good scalability even when the access network is overloaded.

The other type of access network environment for mobility management is the overlapped heterogeneous wireless system. When there are different types of wireless networks available at a place, a mobile user with multi-mode network interfaces should be capable of effectively carrying out the following two functions: (a) select an optimal access network for a given application, and (b) gracefully transfer a connection from one access network to another when the previous one becomes suboptimal or unavailable. Chapter 5 deals with the function (a) while Chapter 6 discusses the function (b).

In Chapter 5, the bandwidth utility functions (BUF) and handover latency are formulated to derive the user satisfaction function. The analysis shows that selecting a high bandwidth access network does not guarantee higher user satisfaction if the user happens to perform a handover to a lower bandwidth network. It is also observed that after getting an estimate of the user's movement, we should assign the network with most availability to the user's call request so that the user can remain in the same network throughout the call duration. This can prevent the user satisfaction from being degraded. In accordance with the evaluation, an algorithm is proposed for selecting an access network that maximizes user satisfaction in heterogeneous networks.

In Chapter 6, a graceful vertical handover mechanism is described to optimize the connection transfer process. This scheme avoids packet losses by smoothing TCP sending rates and establishing a route to the previous access router via a relay node. Through simulations, the TCP performance with the graceful handover is proven to be significantly

better than the performance without one.

Chapter 7 summarizes the contributions of the thesis and suggests many other issues to be resolved for the full-fledge deployment of network mobility and heterogeneous networks.

## 論文の審査結果の要旨

Mr. Kafle had a presentation for his main evaluation of the thesis on performance improvement of mobility management in IP-based wireless networks and then the advisory committee members had questions to and answers from him. His main contribution includes (1) a mobile router-assisted route optimization (MoRaRo) scheme to reduce the delays and overheads associated with data delivery paths, (2) a cooperative mobile router-assisted handover (CoMoRoHo) scheme for long, vehicular-multihomed mobile networks, (3) an optimal network selection by evaluating network performances from the user's perspective, and (4) a graceful vertical handover scheme to smoothen the change in the throughput and reduce packet losses during a handover. Simulation and analysis show that the proposed schemes effectively improve the overall system performance of IP-based wireless networks.

The contributions of the thesis were condensed into 3 journal papers and presented in 5 international conference papers. The advisory committee members unanimously agreed that Ved Kafle's answers to the questions were satisfactory and his proposals and evaluations in the thesis are considered very unique and effective, having important contributions to academia and industries, and therefore deserves a PhD degree in Informatics.