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Mobility Management and Packet Reordering Processing in FiWi Networks
基於光纖無線混合網的移動管理和包亂序處理研究

submitted to
Department of Computer Science
電腦科學系
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
哲學博士學位

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July 2012
二零一二年七月

Abstract

Despite the good application prospect of hybrid Fiber-Wireless (FiWi) networks, there are still lots of design challenges to provide high quality communications (e.g., high bandwidth, low latency and seamless handover) for fixed/mobile users. Specifically, to improve the quality of communication for mobile users, it is a critical issue to achieve seamless handover which means no or negligible degradation in service quality during handover. To improve the quality of communication for fixed users, it is a challenging issue to increase the bandwidth since packet reordering may be generated by employing multi-path routing protocols.

In this dissertation, we will investigate mobility management and packet reordering issues to improve the quality of communication for both fixed and mobile users in FiWi networks. Specifically, we identify two problems as our research questions: 1) design of a novel handover framework to improve the handover performance and achieve seamless handover for mobile users, 2) design of packet reordering processing mechanisms to mitigate packet reordering and improve the TCP performance for fixed users.

For the first research question, we design a novel handover framework, an efficient mobility management protocol and a packet distribution algorithm to provide seamless handover for mobile users in FiWi networks. As a candidate wireless subnetwork of FiWi networks, Mobile WiMAX (MWiMAX) is a promising technology and also one of the key candidates for 4G cellular networks. In MWiMAX networks, a fundamental issue is seamless handover, which has been investigated extensively in the literature. However, there is a lack of comprehensive handover solutions that integrate the design

of MWiMAX network, backhaul technology, and Layer-3 (i.e., IP) mobility management. In this dissertation, we address this issue and propose a novel *handover framework* to improve the handover performance of MWiMAX networks. Specifically, our framework integrates a hybrid Passive Optical Network (PON) that enables efficient multicast, localized mobility management, and direct inter-base-station communication; the framework supports both hard handover and soft handover in MWiMAX; and the framework takes advantages of Mobile IP technologies and Media Independent Handover services of IEEE 802.21. Within the proposed framework, we develop an efficient *mobility management protocol (MIH-FHMIPv6)* for hard handover, and also design an efficient *packet distribution algorithm* for soft handover. Extensive performance analysis and numerical results show that (1) our mobility management protocol can significantly improve handover performance in terms of handover latency, signaling overhead, packet loss and packet reordering, and (2) the proposed packet distribution algorithm can effectively reduce the amount of packet duplication.

For the second research question, we design an efficient packet scheduling algorithm, a dynamic bandwidth allocation (DBA) scheme and an integrated flow assignment and resequencing approach to mitigate packet reordering for fixed users in FiWi networks. In a FiWi network, multi-path routing may be applied in the wireless subnetwork to improve bandwidth. Due to different delays along multiple paths, packets may arrive at the destination out-of-order, which may cause TCP performance degradation. In this dissertation, we propose three mechanisms to improve in-order departure of packets from the OLT in a FiWi network and enhance the TCP performance. Firstly, we propose an effective *scheduling algorithm (SPCS)* at the OLT, which gives lower priorities to the packets which may potentially cause duplicate ACK (*dupack*) and reduce the congestion window size (*cwnd*). Secondly, we design a *DBA scheme (IPACT-MPR)* in the optical subnetwork (i.e., an EPON) which gives higher priorities to flows which may trigger TCP's fast retransmit and fast recovery algorithms in upstream bandwidth allocation. Finally, we propose an *integrated flow assignment and fast resequencing approach* which jointly determines the probability of sending pack-

ets along each path from the source and needs virtually zero resequencing delay at the OLT to reduce the out-of-order probability when packets are injected to the Internet from FiWi networks. Simulation results show that the proposed three mechanisms are effective in mitigating packet reordering and improving the TCP performance.

Keywords: Mobility Management, Seamless Handover, Packet Reordering, Multi-path Routing, PON, FiWi, Mobile WiMAX

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List of Acronyms

AR	Access Router
BS	Base Station
BU	Binding Update
CN	Correspondent Node
CoA	Care of Address
cwnd	congestion window size
dupack	duplicate ACK
DBA	dynamic bandwidth allocation
DRR	Deficit Round-Robin
EPON	Ethernet-PON
FBACK	Fast Binding ACK
FBSS	Fast Base Station Switching
FBU	Fast BU
F-HMIPv6	Fast Handover for Hierarchical MIPv6
FIFO	First-In-First-Out
FiWi	hybrid Fiber-Wireless
FMIPv6	Mobile IPv6 Fast Handovers

FSM Finite State Machine

HA Home Agent

HACK Handover Acknowledge

HE Handover Engine

HHO hard handover

HI Handover Initiate

HMIPv6 Hierarchical Mobile IPv6

HOL head-of-line

IPACT interleaved polling with adaptive cycle time

IS information server

LBACK Local Binding ACK

LBU Local BU

LCoA on-link CoA

LGID Logical Group ID

LLID Logical Link ID

MAP Mobility Anchor Point

MDHO Macro-Diversity Handover

MICS MIH Command Service

MIES MIH Event Service

MIH Media Independent Handover

MIHF MIH Function

MIIS MIH Information Service

MIPv6 Mobile IPv6

MN Mobile Node

MPCP Multi-Point Control Protocol

MWiMAX Mobile WiMAX

NLCoA New LCoA

NONU New ONU

OLT Optical Line Terminal

ONU Optical Network Unit

OOD out-of-order

OWI Optical Wireless Integration

PLCoA Previous LCoA

PON Passive Optical Network

PONU Previous ONU

QoS Quality of Service

RCoA Regional CoA

RTO retransmission timeout

SA Simulated Annealing

SHO soft handover

SPCS Soft Precedence Constraint Scheduling

TDM Time Division Multiplexing

UNA Unsolicited Neighbor Advertisement

WDM Wavelength Division Multiplexing