Torsten Braun
Georg Carle
Yevgeni Koucheryavy
Vassilis Tsaoussidis (Eds.)

LNCS 3510

Wired/Wireless Internet Communications

Third International Conference, WWIC 2005
Xanthi, Greece, May 2005
Proceedings

Springer

Torsten Braun Georg Carle
Yevgeni Koucheryavy Vassilis Tsaoussidis (Eds.)

Wired/Wireless Internet Communications

Third International Conference, WWIC 2005
Xanthi, Greece, May 11-13, 2005
Proceedings

Springer

Volume Editors

Torsten Braun
University of Bern, Institute of Computer Science and Applied Mathematics
3012 Bern, Switzerland
E-mail: braun@iam.unibe.ch

Georg Carle
University of Tübingen, Department of Computer Networks and Internet
Auf der Morgenstelle 10 C, 72076 Tübingen, Germany
E-mail: carle@fokus.gmd.de

Yevgeni Koucheryavy
Tampere University of Technology, Institute of Communication Engineering
Tampere, Finland
E-mail: yk@cs.tut.fi

Vassilis Tsaoussidis
Demokritos University of Thrace
Department of Electrical and Computer Engineering
12 Vas. Sofias Str., 671 00 Xanthi, Greece
E-mail: vtsaousi@ee.duth.gr

Library of Congress Control Number: 2005925605

CR Subject Classification (1998): C.2, H.4, D.2, D.4.4, K.8

ISSN 0302-9743
ISBN-10 3-540-25899-X Springer Berlin Heidelberg New York
ISBN-13 978-3-540-25899-5 Springer Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media

springeronline.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11424505 06/3142 5 4 3 2 1 0

Preface

Welcome to the 3rd International Conference on Wired/Wireless Internet Communications (WWIC). After a successful start in Las Vegas and a selective conference in Germany, this year's WWIC demonstrated the event's maturity. The conference was supported by several sponsors, both international and local, and became the official venue for COST Action 290. That said, WWIC has now been established as a top-quality conference to promote research on the convergence of wired and wireless networks.

This year we received 117 submissions, which allowed us to organize an exciting program with excellent research results, but required more effort from the 54 members of the international Program Committee and the 51 additional reviewers. For each of the 117 submitted papers we asked three independent reviewers to provide their evaluation. Based on an online ballot phase and a TPC meeting organized in Colmar (France), we selected 34 high-quality papers for presentation at the conference. Thus, the acceptance rate for this year was 29%.

The selected papers were organized into 9 sessions:

1. Mobility Management
2. Transport Protocols and Congestion Control
3. QoS and Routing
4. Quality of service
5. Wireless Multi-hop Networks and Cellular Networks
6. Traffic Characterization and Modeling
7. Ad Hoc Networks
8. IEEE 802.11 and Other Wireless MAC Protocols
9. Energy Efficiency and Resource Optimization

We would like to thank the authors for choosing to submit their results to WWIC 2005. We would also like to thank all the members of the Technical Program Committee, the members of the Organizing Committee, as well as all the additional reviewers for their effort in providing detailed and constructive reviews. We are grateful to the two keynote speakers, Ian Akyildiz and Michael Smirnoff, for accepting our invitation; and to Springer LNCS for supporting us again this year.

We hope that all participants enjoyed the technical and social conference program, the hospitality of our Greek hosts and the beauty of the conference location. Next year's conference will take place in Bern, Switzerland. We hope to see you there again.

May 2005

Torsten Braun
Georg Carle
Yevgeni Koucheryavy
Vassilis Tsaoussidis

Organization

Steering Committee

Torsten Braun	University of Bern, Switzerland
Ibrahim Matta	Boston University, USA
Nitin Vaidya	University of Illinois at Urbana-Champaign, USA
Vassilis Tsaoussidis	Demokritos University, Greece

Executive Commitee

General Chairs:	Yevgeni Koucheryavy (Tampere University of Technology, Finland)
	Vassilis Tsaoussidis (Demokritos University, Greece)
TPC Co-chairs	Torsten Braun (University of Bern, Switzerland)
	Georg Carle (University of Tubingen, Germany)

Technical Program Commitee

Ozgur B. Akan	Middle East Technical University (Turkey)
Bengt Ahlgren	SICS (Sweden)
Manuel Alvarez-Campana	Universidad Politecnica de Madrid (Spain)
Farooq Anjum	Telcordia Technologies (USA)
Harmen R. van As	TU Wien (Austria)
Hans van den Berg	TNO TELECOM-University of Twente (Netherlands)
Chris Blondia	University of Antwerp (Belgium)
Torsten Braun	University of Bern (Switzerland)
Andrew Campbell	Columbia University (USA)
Xiuzhen Cheng	George Washington University (USA)
Jon Crowcroft	University of Cambridge (UK)
Klaus David	University of Kassel (Germany)
Piet Demeester	Ghent University (Belgium)
Sonia Fahmy	Purdue University (USA)
Giambene Giovanni	Universita degli Studi di Siena (Italy)
Andrei Gurtov	University of Helsinki (Finland)
Peder Johannes	Norwegian University (Norway)
Daniel Kofman	ENST (France)
Yevgeni Koucheryavy	Tampere University (Finland)

Rolf Kraemer	IHP Microelectronics (Germany)
Adrian Lahanas	University of Cyprus (Cyprus)
Peter Langendoerfer	IHP Microelectronics (Germany)
Ben Liang	University of Toronto (Canada)
Pascal Lorenz	University of Haute Alsace (France)
Petri Maehoenen	University Oulu (Finland)
Christian Maihoefer	Daimler Chrysler (Germany)
Saverio Mascolo	Politecnico di Bari (Italy)
Ibrahim Matta	Boston University (USA)
Ingrid Moerman	Univ. of Gent (Belgium)
Edmundo Monteiro	University of Coimbra (Portugal)
Ioanis Nikolaidis	University of Alberta (Canada)
Guevara Noubir	Northeastern University (USA)
Fotini-Niovi Pavlidou	Aristotle University of Thessaloniki (Greece)
George Pavlou	University of Surrey (UK)
George Polyzos	AUEB (Greece)
Theodoros Salonidis	Rice University (USA)
Jochen Schiller	FU Berlin (Germany)
Andrew Scott	Lancaster University (UK)
Dimitris Serpanos	University of Patras (Greece)
Sherman Shen	University of Waterloo (Canada)
Vasilios A. Siris	University of Crete and ICS-FORTH (Greece)
Roshni Srinivasan	University of Maryland (USA)
Burkhard Stiller	ETH Zurich (Switzerland)
Ivan Stojmenovic	University of Ottawa (Canada)
Phuoc Tran-Gia	University of Wuerzburg (Germany)
Vassilis Tsaoussidis	Demokritos University (Greece)
Thierry Turletti	INRIA, Sophia-Antipolis (France)
Lars Wolf	Braunschweig University (Germany)
Adam Wolisz	Technical University of Berlin (Germany)
Miki Yamamoto	Osaka University (Japan)
Chi Zhang	Florida International University (USA)
Martina Zitterbart	TU Karlsruhe (Germany)
Michele Zorzi	University of Ferrara (Italy)

Organizing Commitee

Sotirios Kontogiannis	Demokritos University (Greece)
Lefteris Mamatas	Demokritos University (Greece)
Ieremias Ntoumpakis	Demokritos University (Greece)
Ruy de Oliveira	University of Bern (Switzerland)
Panagiotis Papadimitriou	Demokritos University (Greece)
Ioannis Psaras	Demokritos University (Greece)
Christos Samaras	Demokritos University (Greece)
Ageliki Tsioliaridou	Demokritos University (Greece)

Additional Reviewers

Evangelos Aggelakis
Marc Bechler
Fernando Boavida
Thomas Bohnert
Laila Daniel
Roman Dunaytsev
Elias Efstathiou
Peder J. Emstad
Stelios Georgoulas
Xiaoyuan Gu
Jarmo Harju
Dan He
Jeroen Hoebeke
Roy Ho
Michael Howarth
Sven Jaap
Riku Jäntti
Yuming Jiang
Verena Kahmann
Stelios Karapantazis
Sotiris Kontogiannis
Teemu Koponen
Øivind Kure
Benoit Latre
Tom Van Leeuwen
Tim Leinmüller
Lefteris Mamatas
Paulo Marques
Michael Methfessel
Dmitri Moltchanov
John Murphy
Philippe De Neve
Geir Øien
P. Papadimitriou
Thanasis Papaioannou
Liesbeth Peters
Ioannis Psaras
Wei Qian
Niky Riga
Oriol Sallent
Sergei Semenov
Siva Sivavakeesar
Dirk Staehle
Apostolos Traganitis
Despoina Triantafyllidou
Orestis Tsigas
Ageliki Tsioliaridou
Christopher Ververidis
Vasilis Vogkas
Ning Wang
Oliver Wellnitz

Table of Contents

Session 1: Mobility Management

Session 2: Transport Protocols and Congestion Control

Session 3: QoS and Routing

Session 4: Quality of Service

Session 5: Wireless Multi-hop Networks and Cellular Networks

Session 6: Traffic Characterization and Modeling

Session 7: Ad hoc Networks

Session 8: IEEE 802.11 and Other Wireless MAC Protocols

Session 9: Energy Efficiency and Resource Optimization

Impact of Link State Changes and Inaccurate Link State Information on Mobility Support and Resource Reservations

Liesbeth Peters*, Ingrid Moerman, Bart Dhoedt, and Piet Demeester

Department of Information Technology (INTEC),
Ghent University - IMEC, Sint-Pietersnieuwstraat 41,
B-9000 Gent, Belgium
Tel.: +32 9 33 14900, Fax: +32 9 33 14899
{Liesbeth.Peters, Ingrid.Moerman, Bart.Dhoedt, Piet.Demeester}
@intec.UGent.be

Abstract. The increasing use of wireless networks and the popularity of multimedia applications, leads to the need of QoS (Quality of Service) support in a mobile IP-based environment. This paper presents the framework, needed to support both micromobility and resource reservations. We present an admission control mechanism in which a mobile host can trigger reservations without performing handoff, taking advantage of link state changes caused by the handoff of other mobile hosts. We also investigate the impact of inaccurate link state information and the occurrence of simultaneous handoffs on the performance of the handoff and reservation mechanism. This impact is higher when only a small part of the mobile hosts can receive QoS service at the same time. For the simulations, we use Q-MEHROM [10]. Herein, QOSPF [11] gathers the link state information and calculates the QoS tables. However, the ideas and results presented in this paper are not restricted to these protocols.

1 Introduction

Today, wireless networks evolve towards IP-based infrastructures to allow a seamless integration between wired and wireless technologies. Most routing protocols that support IP mobility, assume that the network consists of an IP-based core network and several IP domains (access networks), each connected to the core network via a domain gateway. Mobile IP [1, 2], which is standardized by the IETF, is the best known routing protocol that supports host mobility. Mobile IP is used to support macromobility, while, examples of micromobility protocols are per-host forwarding schemes like Cellular IP [3], Hawaii [4], and tunnel-based schemes like MIPv4-RR [5]. These protocols try to solve the weaknesses of Mobile IP by aiming to reduce the handoff latency, the handoff packet loss and the load of control messages in the core network.

* Liesbeth Peters is a Research Assistant of the Fund for Scientific Research - Flanders (F.W.O.-V., Belgium).

T. Braun et al. (Eds.): WWIC 2005, LNCS 3510, pp. 1–11, 2005.

Most research in the area of micromobility assumes that the access network has a tree or hierarchical structure. However, for reasons of robustness against link failures and load balancing, a much more meshed topology is required. In our previous work, we developed MEHROM (Micromobility support with Efficient Handoff and Route Optimization Mechanisms). It shows a good performance, irrespective of the topology, for frequent handoffs within an IP domain. For a detailed description of MEHROM and a comparison with Cellular IP, Hawaii and MIPv4-RR, we refer to [6].

In a mobile IP-based environment, users want to receive real-time applications with the same QoS (Quality of Service) as in a fixed environment. Several extensions to RSVP (Resource Reservation Protocol) under macro- and micromobility are proposed in [7]. However, the rerouting of the RSVP branch path at the cross-over node under micromobility again assumes a tree topology and introduces some delay. Current work within the IETF NSIS (Next Steps in Signalling) working group includes the analysis of some existing QoS signalling protocols for an IP network [8] and the listing of Mobile IP specific requirements of a QoS solution [9]. In [10], we presented Q-MEHROM, which is the close coupling of MEHROM and resource reservations. By defining the resource reservation mechanism as an extension of the micromobility protocol, resources can be re-allocated at the same time that the routing tables are updated.

In this paper, we investigate how the admission control of a mobile host can take advantage of link state changes due to the handoff of other mobile hosts. We also study the impact of inaccurate link state information and simultaneous handoffs on the handoff and reservation mechanism. The rest of this paper is structured as follows. Section 2 presents the framework used. Section 3 describes a way to enhance the admission control mechanism. In Sect. 4, the impact of inaccurate link state information and simultaneous handoffs on the handoff and reservation mechanism is explained. Simulation results are presented in Sect. 5. The final Sect. 6 contains our concluding remarks.

2 Framework

Figure 1 presents the framework, used to support micromobility routing and resource reservations. A micromobility protocol updates the routing tables in the access network to support data traffic towards mobile hosts (MHs). In this paper, we consider the resource reservations for data flows towards MHs.

Micromobility Support and Resource Reservations. The central block of Fig. 1 is responsible for the propagation of mobility information and the reservation of requested resources through the access network.

For the simulations, Q-MEHROM [10], based upon the micromobility protocol MEHROM [6], is used. MEHROM is a per-host forwarding scheme. At the time of handoff, the necessary signalling to update the routing tables is kept locally as much as possible. New entries are added and obsolete entries are explicitly deleted, resulting in a single installed path for each MH. These characteristics

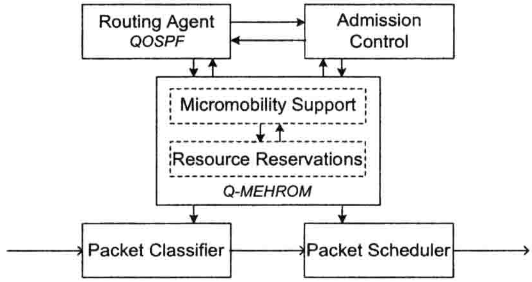

Fig. 1. Framework for micromobility and QoS support in an IP-based access network

make the MEHROM handoff scheme very suitable to be closely coupled with a resource reservation mechanism for traffic towards the MHs. During handoff, Q-MEHROM propagates the necessary QoS information as fast as possible to limit the degradation of the delivered QoS. Hereby, the signalling is restricted to the part of the new path that does not overlap with the old path and reserved resources along the unused part of the old path are explicitly released.

Topology and Link State Information. A micromobility protocol needs information about the access network topology, e.g. to find the next hop to the domain gateway (GW). A resource reservation mechanism requests information about the link states, e.g. to find a path with enough available bandwidth. The routing agent, presented by the upper left block of Fig. 1, gathers this information and computes paths in the access network that satisfy given QoS requirements. The micromobility and resource reservation mechanism, in its turn, informs the routing agent every time resources are reserved or released on a link.

For the simulations, we use QOSPF, as described in [11]. QOSPF advertises link metrics, like available bandwidth and delay, across the access network by link state advertisements. As a result, all routers have an updated link-state database. To provide useful information to the micromobility and resource reservation mechanism, QOSPF calculates, in each router, several QoS routing tables from the database. Q-MEHROM uses information from the following QoS tables:

- The Delay table of a router has this router as source and an entry for every access router (AR) as destination. Therefore, the router calculates the path with smallest delay to a specific AR. The next hop to that AR is then put in the Delay table.
- A Bandwidth table is used to reserve resources for a new traffic flow or to switch from best-effort to QoS service. Here, the available bandwidth on the links of the access network as well as the hop count are taken into account. As we consider traffic towards the MHs, a router calculates a Bandwidth table with the GW as source and itself as destination. For a certain value of the hop count, the path with at most this amount of hops and with maximum bandwidth is calculated. The Bandwidth table gives the last node on the path before reaching the router.

– A Reuse-Bandwidth table is used for the handoff mechanism of flows with QoS service. After handoff, it is possible that the new path partly overlaps with the old path. Resources along this common part should be reused and not allocated twice. Therefore, QOSPF must consider the resources, reserved for the MH before handoff, also as available resources. Using this additional information, the Reuse-Bandwidth table is calculated.

Admission Control. The upper right block of Fig. 1 represents the admission control policy. We have chosen for a simple admission control priority mechanism: priority is given to handoff requests above new requests. When a new request for resources is made by a MH, its AR decides whether the access network has enough resources to deliver the required QoS. If not, the request is rejected. If, at the time of handoff, the required resources for an existing connection can not be delivered via the new AR, the handoff request is not rejected, but the delivered service is reduced to best-effort. At the time of a next handoff, the availability of resources is checked again and reservations can be made.

When the micromobility and resource reservation mechanism of an AR must decide how to treat a new request or handoff request, the admission control mechanism gives the routing agent information about the resources that were reserved by the MH before handoff. The routing agent in its turn provides information about paths with sufficient resources in the access network. The admission control then informs the micromobility and resource reservation mechanism about the availability of resources.

3 Impact of Link State Changes on Admission Control

The simple admission control mechanism, explained in Sect. 2 and used in [10], has an important drawback: as long as a MH, receiving best-effort service, does not perform handoff, its service remains best-effort. Even if enough resources became available due to the handoff of other MHs.

In order to overcome this important drawback, we propose to extend the admission control policy. In this extended admission control mechanism, the AR must check whether enough resources became available for one of the MHs in its routing cache that still receive best-effort service. This check can be triggered periodically or after the receipt of a link state advertisement, indicating that the available resources on a link are increased. However, both of these trigger mechanisms can not avoid that the AR starts the resource reservation mechanism while the MH performs handoff to another AR, possibly leading to router inconsistency in the access network. Therefore, we propose a solution in which the MH itself triggers the link state check by the AR, by sending a new Mobile IP Registration Request. The MH sends this trigger when it receives a new beacon, i.e. a Mobile IP Agent Advertisement, from its current AR, if it receives best-effort service and is not performing handoff soon. To make an estimation about the next time of handoff, it can be very useful to use link layer (L2) information, e.g. the signal strength of the beacons. If the AR detects that enough resources became available, the AR starts the resource reservation mechanism, and the delivered service is switched back from best-effort to QoS. We will call the reservation of resources without performing handoff, the switch mechanism.

4 Use of Inaccurate Link State Information

As the state of the access network changes constantly, e.g. as a result of handoffs, the QoS tables need to be recalculated as time passes by. Several approaches for these recalculations can be used. A QoS table can be recalculated either:

- Periodically at given time intervals P, irrespective of the number of link state changes;
- After an amount of N_{ads} received link state advertisements or interface changes, proportional to the number of link state changes;
- On demand, depending on the number of times information is requested from the QoS table.

For an increasing value of P and N_{ads}, the number of calculations in the routers of the access network decreases at the cost of possible inaccurate information in the QoS tables. If the information is calculated on demand, the most accurate link state information, available by the router, is used to calculate the QoS tables.

While the routers in the access network use the QoS tables to find the next hop towards the old AR or towards the GW, the ARs use the information also during admission control. Even though an AR decided that enough resources, e.g. bandwidth, are available to make reservations for a MH, still the following can occur during the handoff or switch mechanism:

- When a router requests information from a QoS table, no longer a next hop on a path with enough available bandwidth may be found;
- When a router wants to make reservations on a link, the available bandwidth on the link may no longer be sufficient.

When such an error is detected, the delivered service is switched to best-effort. These errors can occur when the QoS tables of the AR are not up to date. This is the case when the AR has not the most recent link state information, due to the fact that the propagation of link state information through the network requires some time. Even when the correct link state information is already available, the AR may not have recalculated the QoS tables yet, due to the fact that these tables are calculated periodically or after a number of link state changes.

Moreover, even when the QoS tables are up to date at the moment of handoff, errors can occur as several MHs can perform handoff more or less at the same time. Especially in the case of mobility, the latter reason causes the major part of the errors. If ARs broadcast beacons to trigger handoff at the MHs, the sending of beacons influences the occurrence of errors:

- MHs newly arriving in the same cell, send a handoff request when a beacon from that AR is received, resulting in simultaneous handoffs;
- MHs in different cells, performing handoff more or less at the same time, can cause errors on the links of the access network.

5 Evaluation

The statements in Sects. 3 and 4 are supported by the evaluation results in this section. The network simulator ns-2 [12] is used, with Q-MEHROM as micromobility and reservation mechanism and QOSPF as routing agent [13]. However, the conclusions are not restricted to these protocols. In what follows, the results are average values of a set of 200 independent simulations of each 1800 s, i.e. there is no correlation between the sending of beacons by the ARs, the movements of the MHs and the arrival of data packets in the ARs.

The following parameter values are chosen: *1)* The wired links of the access network have a delay of 2 ms and a capacity of 2.5 Mb/s. For the wireless link, IEEE 802.11 is used with a physical bitrate of 11 Mb/s. *2)* Every AR broadcasts beacons at fixed time intervals of 1.0 s. These beacons are Mobile IP Agent Advertisements. The distance between two adjacent ARs is 200 m, with a cell overlap d_o of 30 m. All ARs are placed on a straight line. Eight MHs, labeled 1 to 8 in Fig. 3, move at a speed v_{MH} and travel from one AR to another, maximizing the overlap time to d_o/v_{MH}. *3)* CBR (constant bit rate) data traffic patterns are used, with a bitrate of 0.5 Mb/s and a packet size of 1500 bytes. For each MH, one UDP connection is set up between the sender (a fixed host in the core network) and the receiver (the MH). The requested resource is thus an amount of bandwidth of 0.5 Mb/s. *4)* Tree, mesh and random topologies are investigated. The simulated topologies are given in Fig. 2.

Using these values, the access network is highly loaded and the accuracy of the information in the QoS tables becomes important. As the wired links have a capacity of 2.5 Mb/s and a small part of this bandwidth is reserved for control traffic, only 4 reservations of 0.5 Mb/s can be made on a link. In the tree topology, the link capacities closest to the GW form the bottleneck for the number of MHs that can make a reservation. In the meshed and random topology, Q-MEHROM is able to take advantage of the extra links to offer QoS

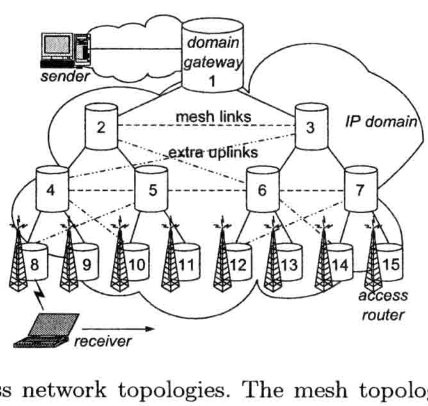

Fig. 2. Simulated access network topologies. The mesh topology consists of the tree structure (full lines) with the indicated additional mesh links (dashed lines). The random topology is formed by adding extra uplinks (dotted lines) to the mesh topology