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Name:	Norbert Esseling*, Andreas Winkler*, Erik Weiss*, Wolfgang Zirwas+
Affiliation(*):	Communication Networks Aachen University of Technology Kopernikusstr. 16 D–52074 Aachen, Germany
Affiliation(+):	Siemens AG Werner von Siemens Ring 20 D–85630 Grasbrunn, Germany
Phone:	+49 241 80 28575
Fax.:	+49 241 80 22242
E-mail:	es@comnets.rwth-aachen.de

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Network Integration of a HiperLAN/2 Multi Hop Concept

Norbert Esseling*, Andreas Winkler*, Erik Weiss*, Wolfgang Zirwas+

(*) Communication Networks
Aachen University of Technology
Kopernikusstr. 16
D–52074 Aachen, Germany

(+) Siemens AG
Werner von Siemens Ring 20
D–85630 Grasbrunn, Germany

Phone: +49 241 80 28575, E-mail: es@comnets.rwth-aachen.de

Abstract

In this paper a concept will be further evolved which introduces a new element called forwarding mobile terminal (FMT) to the HiperLAN/2 (H/2) world. The FMT is designed to provide users in uncovered areas with access to the fixed Internet by providing an intermediate hop. The FMT is introduced in a way that it is backward compatible to existing H/2 equipment. The FMT is a modified H/2 mobile terminal which only needs different software, but no additional transceiver. The concept is evolved for the H/2 link layers and signalling flows which are analysed in more detail in this paper.

1 Introduction

The access to the Internet has become a very important factor in recent years and it will become even more important in the future. At the same time the Internet goes wireless and systems are upcoming that support high data rates for the wireless access to the Internet.

Figure 1 shows an office environment, where each user is equipped with a wireless terminal. Systems of this type include the *HiperLAN/2 (H/2) system* [1][2]. The H/2 system supports typical data rates of 25 Mbit/s. To support these data rates H/2 operates in the 5 GHz band with a bandwidth of 20 MHz per frequency channel.

The radio propagation in these frequency range is very much effected by high attenuation when line of sight can not be guaranteed in an environment, e.g., by walls in offices.

In figure 1 the access to the Internet, resp. the *H/2 access point (AP)* for user 2 and user 3 is provided by a multi hop link via user 1. In the following the equipment of user 3 is denoted as *remote mobile terminal (RMT)*. The term remote differentiates it from a standard *H/2 mobile terminal (MT)*, as the RMT does not have direct access to the AP.

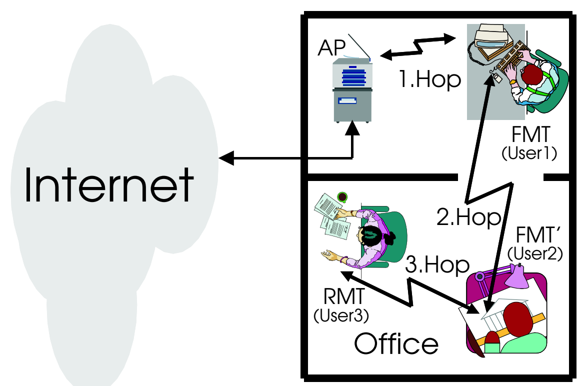

Figure 1: Multi Hop Wireless Internet Office

Users 2 and 1 are forwarding the traffic for user 3 and their equipment is therefore called *forwarding mobile terminal (FMT)*. These FMTs may also operate as conventional MTs. In the shown scenario the services requested by the users are provided by the Internet, therefore no internal traffic except forwarding traffic between the users is observed.

In this contribution the H/2 Multi Hop Concept [3] is sketched and the integration and performance of the protocols used for organising a forwarding system is evaluated.

2 Implementation of Forwarding in H/2

2.1 Medium Access Control Sub Frame

The main task when supporting forwarding is to separate the different links, i.e., the different hops. A very native approach for an FMT in H/2 would be to glue an AP together with an MT and let the terminals operate on different frequencies. Although this approach seems to be very practical it has the big disadvantage that two transceivers are necessary for an FMT which increases the terminal costs and leads to unsynchronised sub nets. These unsynchronised sub nets show problems to support hard QoS requirements in case of forwarding [4]. The reason for this is the necessity to synchronise to the different subnets that have there own time basis which is not known to a forwarder.

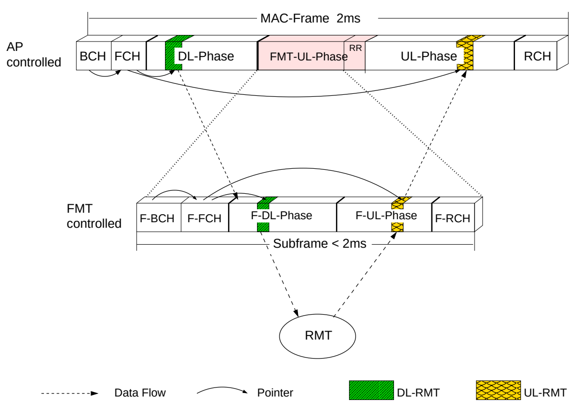

Figure 2: H/2 MAC Frame including Forwarding Sub Frame Structures

In the following a forwarding concept using a time sharing approach is presented which employs only a single transceiver and supports a synchronised access of the RMT which also helps to support QoS for the RMTs.

The proposed concept also provides a solution with minor/no modifications to the existing H/2 specification in it´s basic implementation. The FMT is simply a new element between AP and MT, which is seen as an AP by the MT and an MT by the AP. The concept operates with already existing scheduling algorithms although scheduling algorithms developed for forwarding are expected to further improve the efficiency of the concept.

The natural place to integrate a time sharing forwarding concept in H/2 is the *medium access control (MAC)* sub layer, as this layer is responsible for a time division multiple access to the shared medium.

Figure 2 shows the developed MAC scheme. In the upper part the conventional *H/2 MAC frame (MF)* is displayed with its typical BCH, FCH, ACH, downlink, uplink phase and RCH [5].

As it is a requirement to support regular MTs, a *sub frame (SF)* is generated by the FMT in it´s own uplink on the second hop. This SF has the same structure as the MF to allow access for conventional terminals. The only difference between MF and sub frame is the shortened length of the sub frame. As the AP does not know the existence of FMTs the second hop has to be placed in a phase of the MF which is neither occupied by the AP nor by other MTs. Therefore the sub frame is placed in a separate uplink phase which is controlled and re-scheduled by the FMT. The AP considers the communication of the FMT as uplink, but as the parts of the sub frame do not conform to the conventional uplink, these parts are ignored by the AP.

All parts of the sub frame are extended by the term *forward (F)*. The data of the MF is logical forwarded by the FMT to its connected (R)MTs. During F-FCH, F-ACH, F-DL, F-UL and F-RCH the communication between FMTs and RMTs takes place in exactly the same manner as for the conventional communication.

The proposed MAC frame may also be applied recursively to support far remote terminals, i.e., a new sub frame for the third hop is nested into the sub frame of the second hop.

The system performance namely throughput and delay can be found in [6].

3 FMT System Integration

Maintaining the principles for the construction of the sub frame a possible software structure for the FMT is depicted in figure 3.

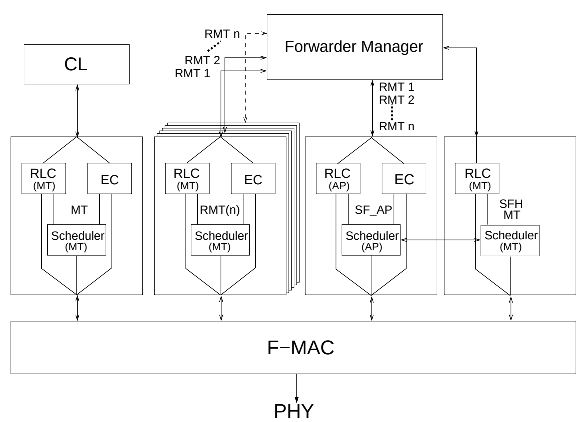

Figure 3: FMT Software Structure

The block denoted as *sub frame acceccss point (SF-AP)* is responsible for the generation of the SF. The procedures and routines used in this block are derived from the standard AP block. The only difference is the shortened MF to be used as SF. The block *sub frame handler (SFH)* is responsible for capacity allocation for the SF. As it appears to the AP as a conventional MT it is derived from an MT block. Via a link to the scheduler of the SF-AP it announces the length and starting point of the SF to the SF-AP. Each RMT(n) block is a representative for an RMT associated with this FMT and handles the traffic on the first hop towards the AP. The RMT-blocks have the same structures as conventional MTs. The Forward Manager connects all blocks necessary for the FMT functionality. Inside the Forward Manager the data and signalling flows between the blocks are coordinated. On the left in figure 3 the structure of an MT is integrated. This block is responsible for the communication for the FMT user and acts completely independent to the rest of the FMT. Therefore the FMT's own uplink phase as depicted in figure 2 is reduced to the SCHs which are used as *resource requests (RR)* for the SF.

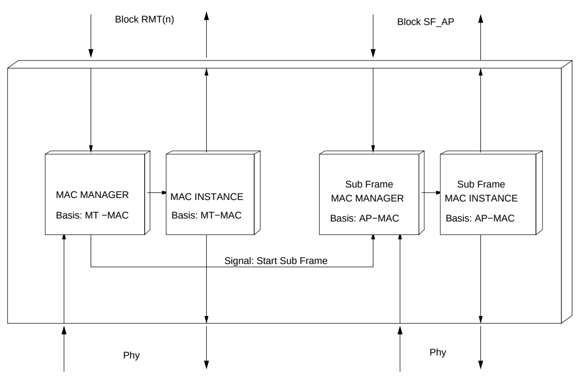

Figure 4: FMT MAC Structure

Figure 4 shows the structure of the FMT-MAC-layer. The left part of the MAC Block consists of blocks which have been derived from an MT-MAC. The modified structure is able to handle multiple MAC instances for the different parts of the FMT (i.e., the Blocks MT, RMT(n) and SFH). The Manager block uses the *Start_Sub_Frame*-Signal to inform the remaining two blocks that a SF has to be started. These two blocks are derived from an AP-MAC and are connected to the SF_AP block.

3.1 RLC Signalling

An important topic for the integration of the FMT concept is the correct handling of system signalling. The integration of signalling in the FMT is done keeping in mind the concept already applied for the DLC layer, i.e., re-using the available standard H/2 system to the extend possible. The RLC-blocks in the FMT-software structure are derived from the standard procedures available. The already introduced Forward Manager is responsible for organising these signalling flows.

The task is to connect the signalling of the first and subsequent hops. There are two basic principles to apply signalling for a multi hop system.

In figure 5 the asynchronous MAC-Id-Assign signalling is shown. It is denoted as asynchronous as the signalling and its acknowledgement are done on the hops independly.

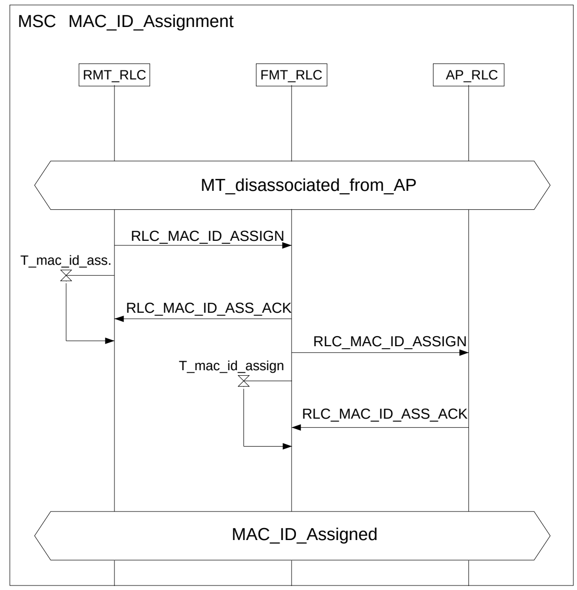

Figure 5: Asynchronous MAC-Id-Assign

As the asynchronous signalling may cause problems with the signalling and data integrity, figure 6 shows the synchronous signalling. Here the acknowledge messages are only sent when the data is consistent again, i.e., a downlink acknowledgement is sent on the second hop only after the respective acknowledgement was received on the first hop.

On the other hand the asynchronous signalling is much faster, as the signalling can be done in parallel. The asynchronous signalling will be interesting if the number of hops increases and therefore the signalling delay increases, which may lead to problems with the signalling timers depending on the implementation.

In the following the key signalling procedures are presented and analysed to verify the signalling concepts.

In the MAC-Id assignment the MAC-Id to be used between an RMT and the FMT and the MAC-Id for the RMT representative in the FMT which is used for the communication between AP and FMT is assigned. The procedure is triggered by the RMT with a request to assign a MAC-Id.

In a second step the radio link capability procedure is executed. The structure of this procedure is similar to the MAC-Id-Assignment, therefore it is not shown.

Figure 7 shows the performance of these two sig-

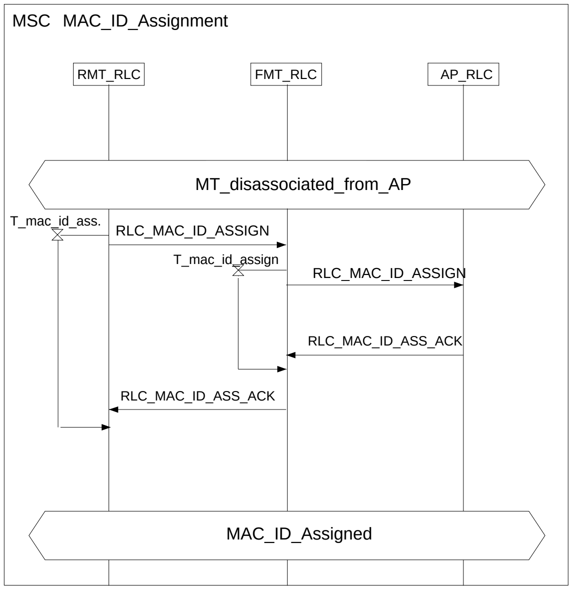

Figure 6: Synchronous MAC-Id-Assign

nalling procedures, i.e., the distribution of the signalling duration of an MT association comprising MAC-Id assignment and link capability procedure. As expected the time to associate an RMT takes approximately twice the time than with a conventional MT. Additionally some time has to be added, because the scheduling of the SF produces additional delay.

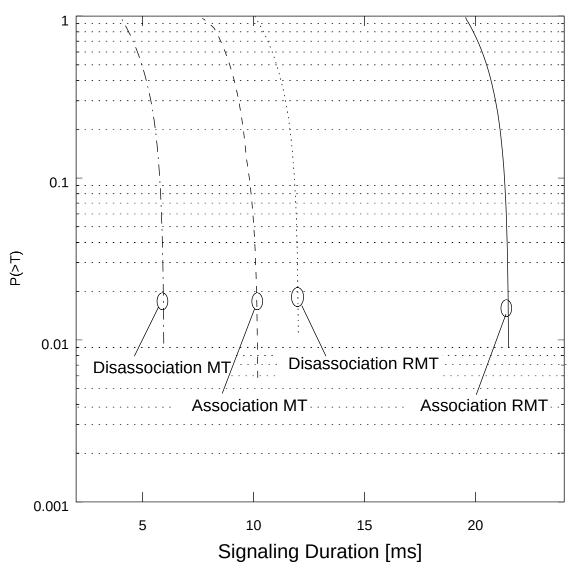

Figure 7: Performance of Association and Disassociation

Figure 8 shows the signalling procedure for a connection setup. This time three messages have to be transferred. The setup of connections for an MTs is faster than the association. This becomes logical keeping in mind that the association needs four messages. The release of connections is similar to the disassociation. This behaviour can be explained with the very similar signalling procedures namely the number of messages exchanged.

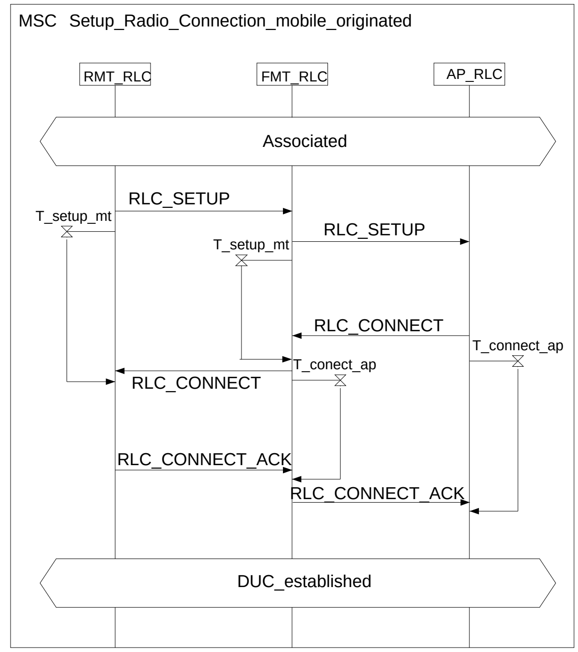

Figure 8: Signalling Connection Setup

The signalling over the second hop shows similar effects as the signalling for association and disassociation. The duration over the second hop takes twice the time as for the basic signalling.

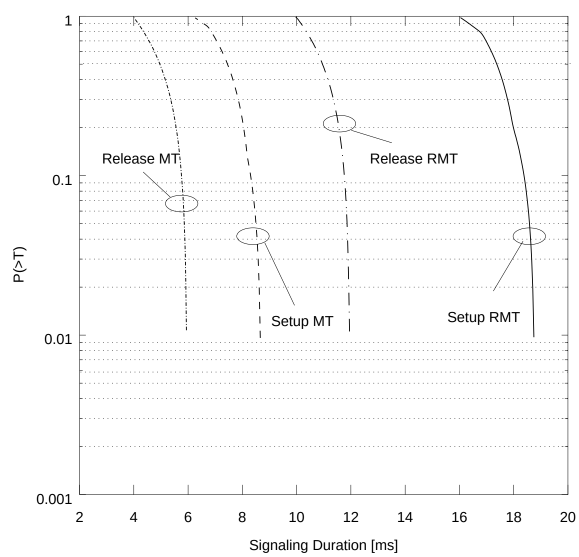

Figure 9: Performance of Setup and Release

Another important system aspect is the support of handover with this concept. Apart from the handover scenarios also known to the standard H/2 system a set of new handover types apply. These new handover types result from the handovers when an MT is becoming an RMT or vice versa. Figure 10 and 11 show the principle signalling of an MT becoming an RMT (i.e., the handover from an AP to an FMT) and the way reverse. The FMT is assumed to continuously generate a sub frame.

In figure 10 the MT loses its connection towards the AP and starts a handover procedure towards the FMT. As the connection between AP and MT is not used any more, but a similar connection for forwarding is needed, the FMT resumes this connection with the MT-Alive-Procedure. The resumed connection is used as the first hop in the multi hop communication and needs no modification.

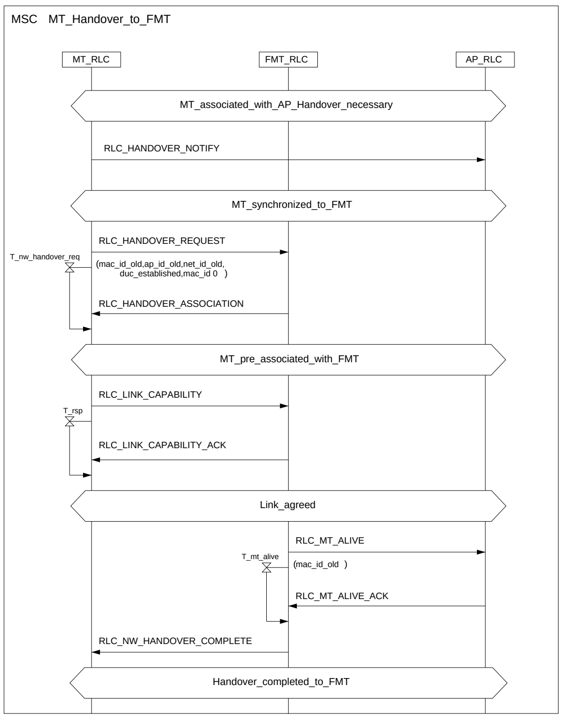

Figure 10: Handover Signalling from AP to FMT

In Figure 11 the MT detects the AP to be a better communication partner. In this situation it associates with the AP using a network handover procedure. If the FMT is not informed it will continue the MT-Alive-Procedure and will get no answer. In this situation the FMT frees the context it had with the (R)MT and the handover is completed.

Figure 12 shows the simulation scenario that was used in the following [7]. It is a scenario with a single MT that moves between an FMT and an AP. The MT changes between AP and FMT based on the power received from the AP and the FMT. In the simulated scenario the MT stays half the time at the AP and the other half at the FMT.

This ratio is also reflected in the delay of the transmitted data packets. At 0.5 a significant shift of the delay distribution from the curve known from standard H/2 systems to the known distribution of the multi hop system can be observed. This shift is only

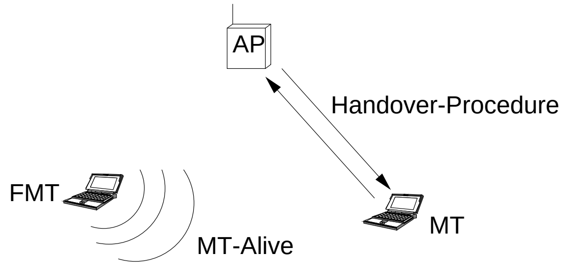

Figure 11: Principle Handover Signalling from FMT to AP

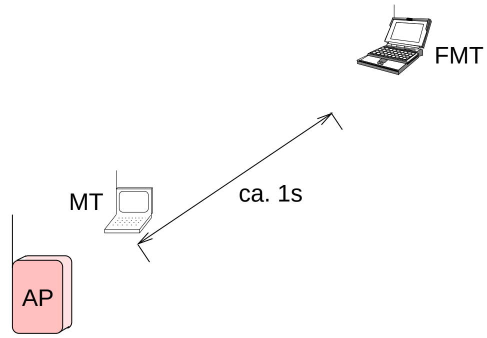

Figure 12: Simulation Scenario for Handover

found in the uplink as the scheduler used preferred the downlink direction especially on the sub frames.

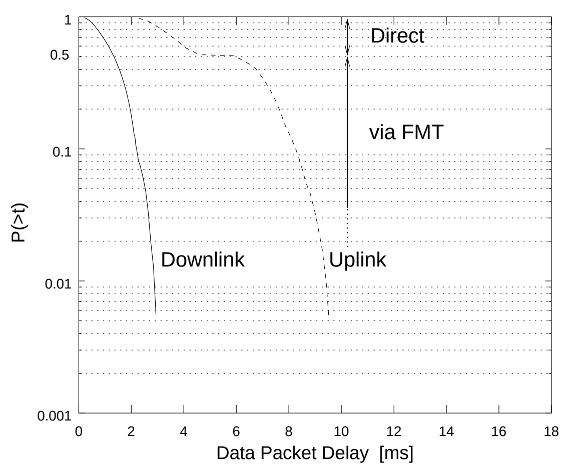

Figure 13: Delay Distribution for Paket Transfer

The used handover scheme is a very basic one and it turns out that there are many additional aspects which should be taken into account for the handover decision (e.g. the system performance or the desired overall QoS) in the future.

4 Conclusion

In this contribution a concept for an integrated multi hop communication for the *HiperLAN/2 (H/2)* system and the wireless Internet is presented. The concept is intended to be used for the infrastructure mode of H/2 as it aims to provide far remote users with a cost efficient access to the Internet without the need to invest into fixed infrastructure. The concept is especially beneficial for indoor environments where high attenuation by walls can be expected. Similar condition can be found in street canyons.

In the presented concept the use of a single transceiver and the backward compatibility to already deployed equipment are the key design criterions. In this contribution we describe the signalling concept and its performance.

5 Acknowledgement

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References

[1] B. Walke, *Mobile Radio Networks.* New York, USA: Wiley & Sons Ltd., 1. ed., 1999.

[2] B. Walke, N. Esseling, J. Habetha, A. Hettich, A. Kadelka, S. Mangold, J. Peetz, U. Vornefeld , "IP over Wireless Mobile ATM – Guaranteed Wireless QoS by Hip erLAN/2," *Proceedings of the IEEE*, vol. 89, pp. 21–40, Jan. 2001.

[3] N. Esseling, A. Winkler, "Integrated 2-Hop Communication for the HiperLAN/2 Infrastructure Mode," in *Proc. of 53th VTC 2001 Spring*, (Rhodes, Greece), May 2001.

[4] J. Peetz, "A Concept for Interconnecting HiperLAN/2 Ad Hoc Subnets Operating on Different Frequency Channels," in *Proc. of the European Personal Mobile Communication Conference 2001*, (Vienna, Austria), Feb. 2001.

[5] Broadband Radio Access Networks (BRAN), "HIPERLAN Type 2; Functional Specification; Data Link Control (DLC) Layer; Part 1: Basic Data Transport Functions," TS 101 761-1, ETSI, Apr. 2000.

[6] N. Esseling, "Extending the Range of HiperLAN/2 Cells in Infrastructure Mode using Forward Mobile Terminals," in *Proc. of the European Personal Mobile Communication Conference 2001*, (Vienna, Austria), Feb. 2001.

[7] A. Kadelka, N. Esseling, S. Mangold, *Wireless Access Radio Protocol 2 - Simulator (WARP2).* URL: http://www.warp2.de/, 1999/2001.

6 Biographies

NORBERT ESSELING
(es@comnets.rwth-aachen.de) received his Diploma in Electrical Engineering in 1994 from the Aachen University of Technology. From 1994 to 1996 he worked at T-Mobil, Bonn/Germany, in the Department for Signaling Specifications for the German D1-GSM-Network. During this time he was responsible for the ISUP specification. He was also involved in the GSM core net signaling specification and extensions (e.g. convergence GSM to fixed and satellite). In 1996 he joined the Chair for Communication Networks, where he is working towards his Ph.D. He participated in the ACTS Project SAMBA (wireless ATM) where he was involved in the implementation and integration of the SAMBA trail platform. Areas of research interest are protocols to support wireless broadband packet networks. Currently his focus lies on aspects extending the range of the HiperLAN/2 System.

ANDREAS WINKLER
(awi@comnets.rwth-aachen.de) received his Diploma in Electrical Engineering in 2001 from Aachen University of Technology. In his diploma thesis he developed and analysed the network integration of H/2.

ERIK WEISS
(erw@comnets.rwth-aachen.de) studies Electrical Engineering at the Aachen Unversity of Technology. In his Diploma thesis he analyses and simulates the interference situation for multihop H/2 with respect to internet traffic.

WOLFGANG ZIRWAS
(wolfgang.zirwas@icn.siemens.de) received the Diplomingenieur degree in electrical engineering from Technical University Munich, Germany. He joined Siemens AG, Munich, in 1987. First, he worked in the field of high-bit-rate fiber-optic communication systems. Later, he focused his work on broad-band access technologies (xDSL, HFC) for both residential and business users. He is now working in the field of broad-band wireless systems.