Paper submitted to

VTC 2001 Fall

(Full Paper)

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Title:	Supporting the Wireless Internet with a HiperLAN/2 Multi Hop Concept
Conference Topic(s):	Wireless Access, Wireless Personal Communication, Multimedia Networks/Systems

Abstract: In this paper a concept will be presented that 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, furthermore future possible enhancements are presented.

Keywords: ETSI, BRAN, HiperLAN/2, Forwarder, Wireless Base Station, Internet

Supporting the Wireless Internet with a HiperLAN/2 Multi Hop Concept

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Abstract: In this paper a concept will be further improved that 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, furthermore future possible enhancements are presented.

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.

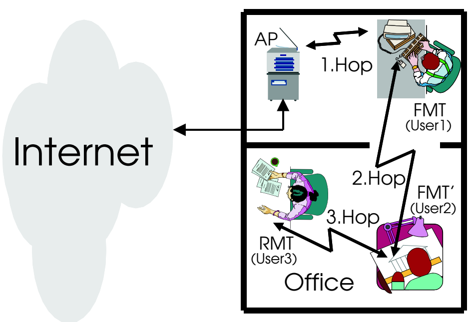

Fig. 1: Multi Hop Wireless Internet Office

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. 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 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. As further aspect the contribution presents possible extensions and improvements to the H/2 Multi Hop Concept.

2 Implementation of Forwarding in H/2

The proposed time sharing approach for forwarding employs only a single transceiver and provides a solution with minor/no modifications to the existing H/2 specification in its 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.

2.1 Medium Access Control Sub Frame

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 MAC scheme developed. In the upper part the conventional *H/2 MAC frame (MF)* is displayed with its typical BCH, FCH, ACH, downlink, uplink phase and RCH [4]. As it is a requirement to support regular MTs, a *sub frame (SF)* is generated by the FMT in its own uplink on the second hop. This SF has the same structure as the MF to allow access for conventional terminals.

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.

The block denoted as *sub frame access 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

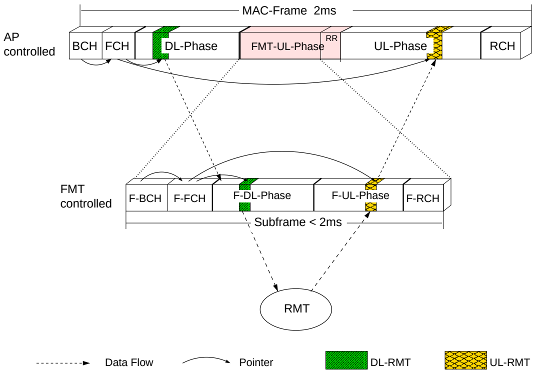

Fig. 2: H/2 MAC Frame including Forwarding Sub Frame Structures

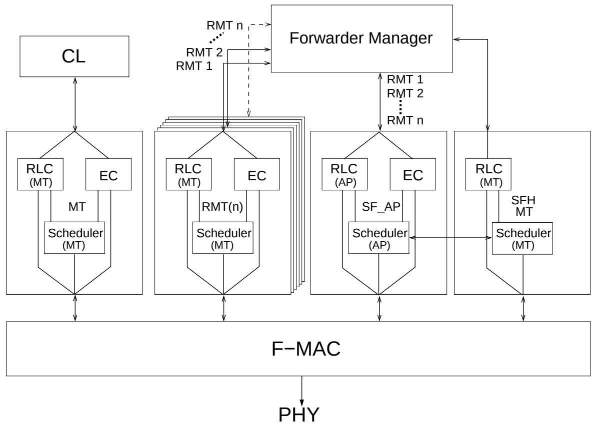

Fig. 3: FMT Software Structure

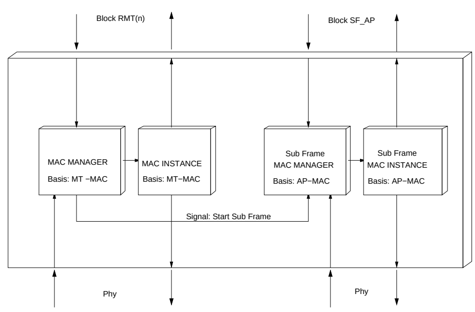

Fig. 4: FMT MAC Structure

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 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.

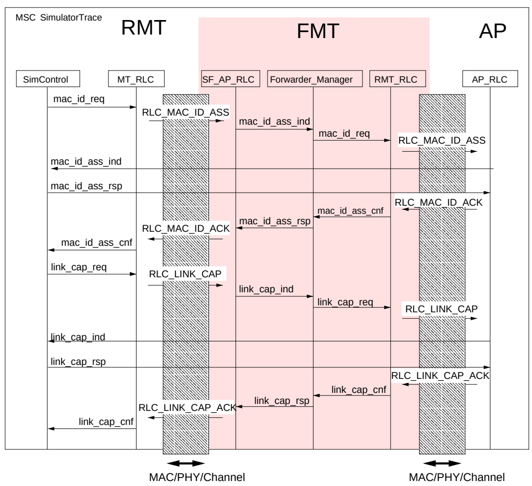

Fig. 5: MSC Trace of the RMT Association

Figure 5 shows a trace of the RMT Association.

First the MAC-Id assignment for 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 takes place. 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.

Figure 6 shows the performance of this signalling procedure, i.e. the distribution of the signalling duration. As expected the time to associate an RMT takes approximately twice the time needed for a conventional MT. Although additionally some time has to be added, because sometimes the scheduling of the SF produces additional delay.

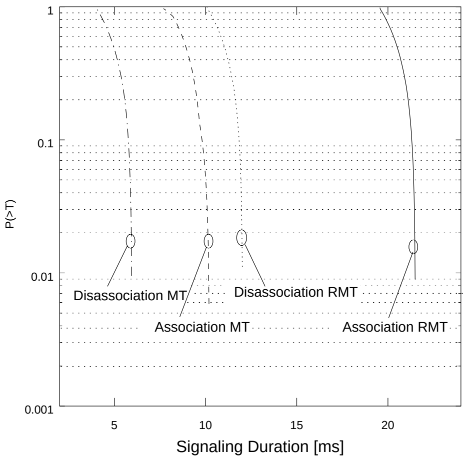

Fig. 6: Performance of Association and Disassociation

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 7 and 8 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 7 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 anymore, but a similar connection for forwarding is needed, the FMT resumes this connection with an MT-Alive-Procedure. The resumed connection is used as the first hop in the communication and needs no modification.

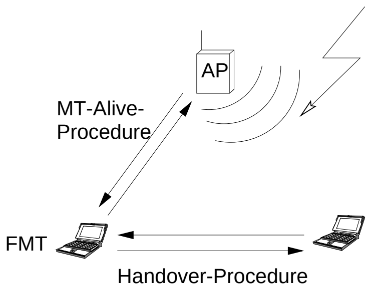

Fig. 7: Principle Handover Signalling from AP to FMT

In Figure 8 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. Further details of the handover signalling can be found in [3].

Figure 9 shows the indoor simulation scenario that was used in the following [5]. It is a scenario with a single MT that follows a polygon through the office scenario i.e. the different rooms. The characters a–d are reference points which are used in the following diagrams.

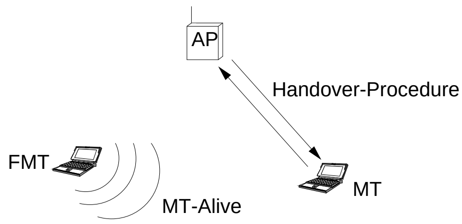

Fig. 8: Principle Handover Signalling from FMT to AP

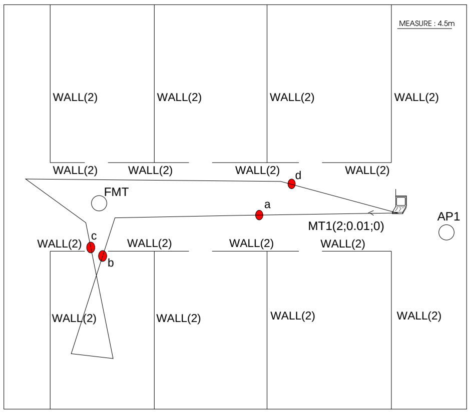

Fig. 9: Simulation Scenario for Handover

The resulting received power profile of the MT can be found in figure 10 using a multi wall model. This is the basis for the handover decision. Figure 11 shows the received power when the MT decides to do a handover if the received power from either an FMT or AP is higher. As this may lead to ineffective system performance, figure 12 shows a handover which is only performed if the first hop link is likely to break. For this algorithm the MT has to be able to distinguish between APs and FMTs for its handover decision.

These are only very basic handover schemes and it turns out that there are many additional aspects which should be taken into account (e.g. the system performance or the desired overall QoS) in the future.

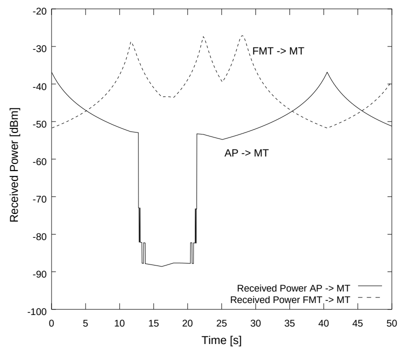

Fig. 10: Signal Power Received by the MT

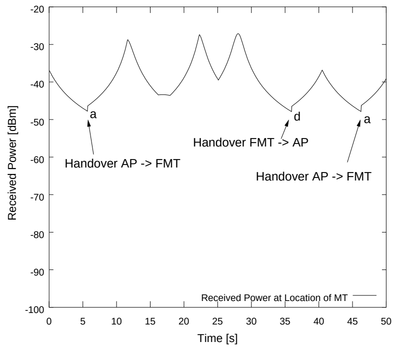

Fig. 11: Signal Power Received by the MT during Handover

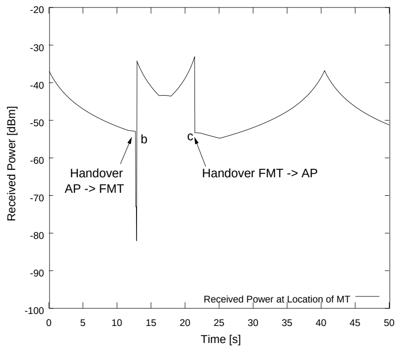

Fig. 12: Signal Power Received by the MT during Enhanced Handover

4 Improvements for Performance and Implementation

4.1 Performance Improvement

The use of FMTs [3] decreases the overall capacity available for user information. This disadvantage can be overcome by employing new SF-scheduling schemes (cf. figure 13). A very straight approach is to send only an fixed maximum number of SFs per MF. This will keep the maximum available capacity at the level as if there were only the same number of FMT present. The SF will be served one after the other in separate MFs. The number of SFs servered in one MFs is a new parameter introduced by this concept.

The gain expected from this concept is caused by a similar bundling gain as the use of non-exhaustive and exhaustive-round robin scheduling strategies for the standard H/2 system [6]. Therefore similar effects onto the transfer delay can be expected. So the system user has to decide which QoS characteristic he prefers (delay or throughput).

The above mentioned concept can be implemented when the AP knows the number of FMTs operating in a cell. There is no further need to change the existing H/2 specification.

Figure 14 shows the improved capacity available for user data depending on the number of FMTs supported in a radio cell compared to [3]. Each FMT is expected to serve one RMT, so a star configuration is formed. The graphs are

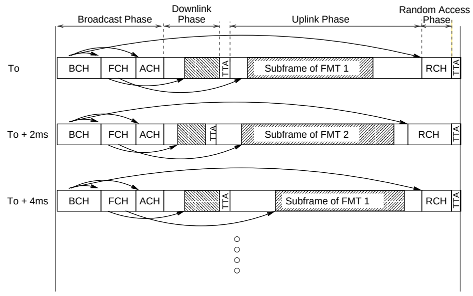

Fig. 13: Alternating SF Scheduling

parameterised with the chosen H/2-PHY mode.

The horizontal lines mark the maximum benefit for the above presented concept. The location of the horizontal lines only depend on the number of SFs allowed per MF. The number of SFs also denotes the number of additional hops which can be supported in maximum. The number of supported SFs is a compromise between the desired capacity, the QoS parameter delay/delay variance and the ability of the RMTs to cope with the new MF structure.

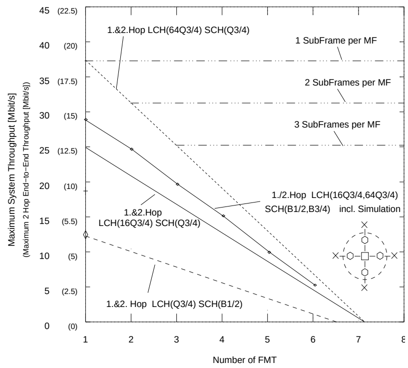

Fig. 14: Expected Performance of the Improved SF Scheduling

For RMTs the service support looks like an AP that drops every n-th MF. This may confuse the RMT, therefore it is proposed to use an extension to the H/2 specification which enables the system to use a dynamic MF-length. This concept was already proposed during the specification period of H/2 [7]. In Figure 15 the resulting MF-structure in combination with forwarding is shown. For the forwarding mode the FMT can extend the SF over multiple MF and therefore keep the H/2 protocol consistent in all aspects, namely the RCH/ACH-handling.

4.2 Implementation Improvement

In order to ease the synchronisation for RMTs onto the SF sent out by the FMT it is benifical to start the SF at the same point of time within each MF. This synchronisation can be supported by the H/2 *Fixed Slot Allocation Scheme (FSA)*. Figure 16 shows the use of FSA for FMTs and SFs.

The beginning of the SF is fixed to a prior agreed slot in

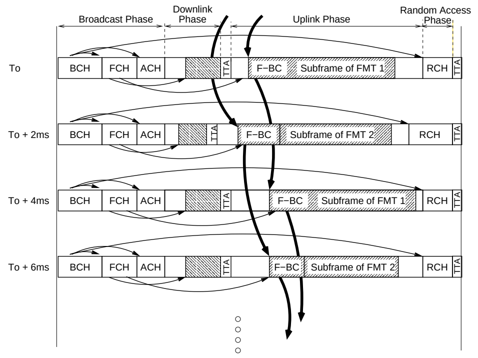

Fig. 15: Improved SF Scheduling using a dynamic MF-Length

the MF. For the use of FSA the scheduler in the AP has to support this feature. For a first implementation there is no other special signalling necessary.

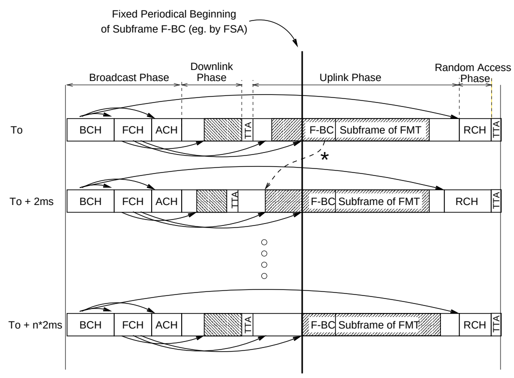

Fig. 16: Use of FSA for SFs

The disadvantage of using FSA in a simple implementation is a slightly reduced flexibility for the allocation in the MF, which has to be taken into account by the AP-scheduler, furthermore the scheduling becomes more complex. On the other hand if the FMT-scheduler operates in close co-operation with the AP-scheduler, it is possible to fix the beginning of the SF at the end of the MF and use time before this F-BCH Phase for transmission.
As this phase lies before the F-BCH, the FMT needs to have information from the AP not only for the current MF, but also for the next MF. With this the FMT is able to schedule a SF over two MF, i.e. the F-BCH points to a phase in a following MF (cf. dashed pointer marked with an asterisk in Figure 16).
The benefit of this technique is to support the synchronisation and at the same time keep the flexibility of the H/2 Forwarding System.

5 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.
In the presented concept the use of a single transceiver and the backward compatibility to already deployed equipment are the key design criterions. Besides the herein presented signalling flows further enhancements to the concept are expected and described.

6 Acknowledgement

This work was supported by the German research project COVERAGE (Cellular OFDM systems with extension points for increased transmission RAnGE) funded by the German Ministry for Education and Research (BMBF) and the SIEMENS AG Munich/Bocholt.
The authors would like to thank the members of the project for the valuable discussions.

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