Approach for a Reliable Cooperative Relaying Process

Melanie Schranz and Wilfried Elmenreich (Faculty Mentor)
Lakeside Labs/Institute for Networked and Embedded Systems
University of Klagenfurt
Klagenfurt, Austria
Email: {melanie.schranz,wilfried.elmenreich}@uni-klu.ac.at

Abstract — *Cooperative relaying is a method, where nodes overhearing a communication help in forwarding this information in case the direct transmission between source and destination fails. In this paper we present a communication protocol based on cooperative relaying employing a TDMA relay selection and exchange of short control messages. To show its applicability, we implemented the described protocol on the wireless platform WARP as our testbed.*

I. Introduction

Nowadays wireless networks form a powerful area that cannot be neglected. Primarily the task of these wireless networks is to deliver data, whether it is about music, videos, sensor data or any other information. A major question is, if the data packets reliably reach its destination in a wireless network. With applications such as voice communication or distributed sensing and control, reliable communication plays a decisive role.

Wireless links typically suffer from effects such as shadowing and fading, where the latter typically can cause a wireless link to be unavailable for several 100 milliseconds. Within this timespan, retransmission attempts issued by the source will very likely have no success. A transmission via a spatially different path, however, is typically not affected by the same fading problems at the same time. Thus the concept of cooperative relaying, where a relay node is assisting the communication between a source and a destination node [1], can greatly improve the reliability of wireless communication.

Within the scope of this paper, we consider an approach where the relay node only forwards information in the case the direct transmission between source and destination fails (in contrast to relaying networks in many telecommunication applications, where the relays are used to extend the transmission range via a multi-hop approach).

In this paper we present a cooperative relaying approach for improving a wireless multi-hop communication. Besides elaborating the protocol the intention is to evaluate it on a wireless platform called WARP, which is a universal multiple-input multiple-output wireless test platform controlled by FPGA for maximum flexibility. The rest of the paper is structured as follows: Section 2 introduces to cooperative relaying concepts in more detail. Section 3 describes a self conceived simple relaying approach for 802.11-based networks while Section 4 delineates the hardware testbed we are using to implement the concepts depicted in Section 3. In the end we give a conclusion and an outlook to future work.

II. Cooperative Relaying

The term "cooperative relaying" was already explained in the introduction. The major advantage of using a relayed communication channel is that it raises the capacity of the network by implementing spatial diversity [1]. This spatial diversity establishes several independent communication paths. Researches on Multiple Input Multiple Output (MIMO) systems have depicted that the reliability of sending a data packet is enhanced the more independent paths are available [2].
Practically the simplest cooperative relaying network consists of three nodes, like shown in Figure 1. The source (S) has a direct communication (step 1) to destination (D). If the communication fails (steps 2 and 3) the relay (R) has to support D with information.

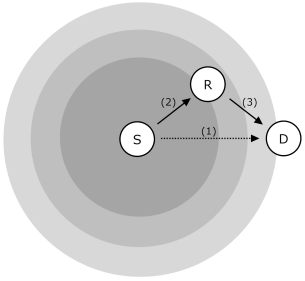

Figure 1: Cooperative relaying scheme

III. Relaying Approach

We propose the following possible solution to achieve an acceptable reliability in a wireless network: In case a packet is ready to send, the source S "asks" the destination D via an RTS (ready to send) if a transmission is possible. When S receives a CTS (clear to send), as a next step it starts with the transmission. S gets an ACK (acknowledge) if all packets are received by D. In this (likely) case we have a successful direct communication like demonstrated in Figure 2.
In the other case, so if a packet did not arrive, we have the situation illustrated in Figure 3. D sends a NACK(not acknowledge) to S and broadcasts a LOOKforGOOD-message. This message contains the header of the packet that could not be received. Attention should be paid to

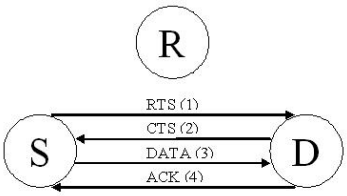

Figure 2: Packet exchange scheme for successful direct transmission

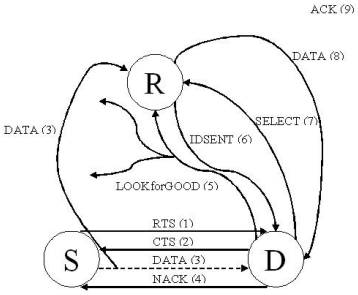

Figure 3: Packet exchange scheme for failed direct transmission

the source S. In the case of a none received packet, also S works as a relay node as assistance for the data transmission. All the relay nodes (in our figure the situation is demonstrated with only one relay node R) look for the packet in their buffers. If the packet is in the buffer the relays send their ID (IDSENT) in an *a priori* defined TDMA schedule, so each node has its own time slot. In the next step D selects one relay node according to measures of the channel quality by sending a SELECT-message that contains the ID of the chosen relay node. The data will then be transmitted. In the case of an failed transmission again, the process would start once with choosing a relay node by sending a LOOKforGOOD message.
The messages CTS, RTS, ACK, NACK, LOOKforGOOD, IDSENT and SELECT are coded with BPSK (Binary Phase-Shift Keying). These messages are considerably shorter than the data packet. The BPSK modulation scheme is less vulnerable to noise, so we assume that the control messages can be transmitted even in case of fading problems. The data packet is coded with 16QAM (16 Quadrature Amplitude Modulation), which is more efficient than BPSK, but requires a better Signal-to-Noise ratio than BPSK.

IV. Testbed

To evaluate the described relay approach, we use a wireless platform called WARP board[1]. The WARP board consist of a Virtex II Pro FPGA of Xilinx for the processing of the developed communication protocol, two radio boards for the transmission over radio frequency of 2.4 GHz, two antennas and respective circuitry needed for realizing a communication. Figure 4 depicts a WARP board, which has been set up to use both transmitters emulating two different wireless nodes.

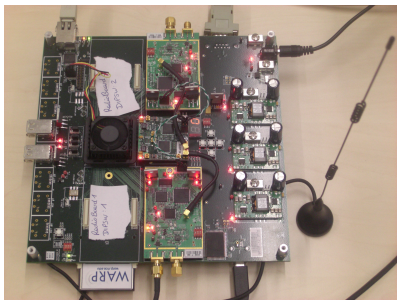

Figure 4: WARP-Board: Wireless platform for implementing the relay approach

With these boards we have the possibility to modify physical layer as well as MAC layer. All programming work is done in C. With the comfortable detail of a serial output we have a chance to track the communication channel status with every sent packet for debugging purposes. Current test configuration consists of two WARP Boards, where each of the two wireless transmission units per board is programmed separately, forming a network of four logical nodes.

V. Conclusion and Outlook

The proposed protocol on the basis of cooperative relaying promises increased reliability for wireless networks by mitigating small-scale fading effects. A preliminary version of the protocol has been implemented on the WARP platform, but further tests have to be done to achieve expedient results. Though, for an efficient evaluation we are going to evaluate the approach on a larger wireless network. Further future work will also include researching alternative ways for relay selection, since the proposed TDMA approach comes with considerable complexity for large networks.

Acknowledgments

This work was supported by the European Regional Development Fund and the Carinthian Economic Promotion Fund (KWF) under grant 20214/15935/23108 within the Lakeside Labs project.

References

[1] W. Elmenreich, N. Marchenko, H. Adam, C. Hofbauer, G. Brandner, C. Bettstetter, and M. Huemer. Building blocks of cooperative relaying in wireless systems. *Springer e & i Journal*, October 2008.

[2] H. Adam, W. Elmenreich, and S. M. Senouci. A protocol for cooperative relaying in wireless networks. *submitted to EURASIP Journal on Wireless Communications and Networking*, 2008.

[1]For further information: `http://warp.rice.edu`