Adaptive Layer Switching for PLC Network with Repeaters

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***Abstract*—Adaptive Layer Switching (ALS) is a mechanism that allows to change the Medium Access Control (MAC) layer of the Power Line Communication (PLC) network in the runtime. According to the delay-throughput tradeoff dependencies for Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and Time Division Multiple Access (TDMA) it switches them for the corresponding network utilization. In this way the advantage of the low access delay for the low network utilization in CSMA/CA and high throughput for the high network utilization in TDMA are used. In this paper we show the operation of the ALS for the PLC network with repeaters.**

***Keywords*—Adaptive Layer Switching, Power Line Communications, PLC, MAC, Repeater.**

I. Switching with Repeaters

In the previous work the operation of ALS was shown for the network without repeaters [1]. In this case all the nodes in the network can directly communicate with each other. However, in the smart grid it is not always true. In practice some repeater levels may be necessary in order to reach all the nodes in the network. The corresponding reference physical topography is given in fig. 1.

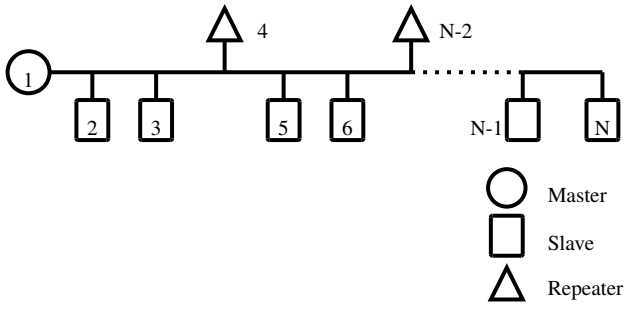

Fig. 1. Topology of network with repeaters

In this case the procedure of switching the access scheme may take longer for the whole network. This is described in the following.

II. Switching from CSMA/CA to TDMA

If network is in CSMA/CA mode the master can assess the network utilization factor ρ for the last k packets.

As in the case without repeaters if ρ reaches $\rho_t + w$ then the master decides to switch to TDMA mode. ρ_t is the utilization factor threshold, and w is the hysteresis width. The master starts the MAC cycle and sends the scheduling information as Medium Access Plan (MAP) packet (fig. 2).

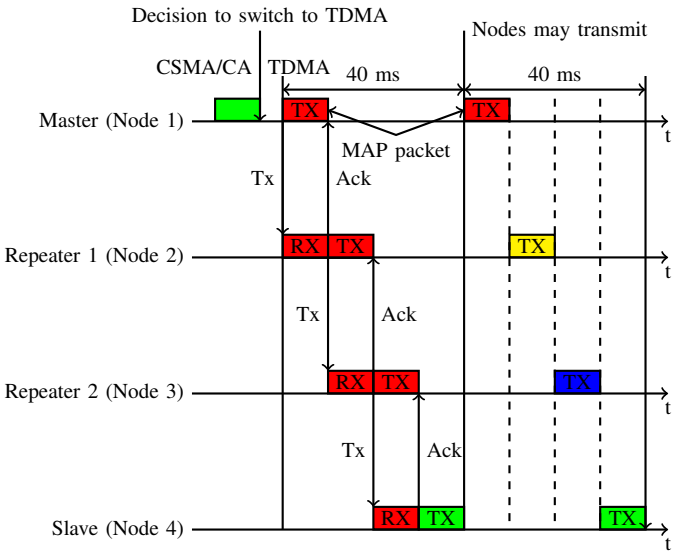

Fig. 2. Switching process from CSMA/CA to TDMA with repeaters

In difference to the case without repeaters the MAC cycle has to be used for the retransmissions of the MAP packet, which includes the switching command. Repeater 1 retransmits the MAP packet in its corresponding TDMA slot. As soon as MAP packet is successfully received by the repeater 2 it has to be acknowledged and retransmitted. The slave node may start the transmission in its TDMA slot if the switching information was correctly received from repeater 2. The switching process can be completed in the single MAC cycle.

After switching to TDMA the nodes will continue transmission according to the TDMA scheduler that is used in the specific system.

In fig. 3 the transient process of switching is shown.

The nodes are placed in the line (fig. 1) in such way that only two neighbor nodes can directly communicate with each other. Otherwise the packets should be repeated. The nodes 4, 3, and 2 send the packets with the constant interarrival time to the master node. Until the simulation time $t < 31.12$ the network operates in CSMA/CA mode. The delay in fig. 3 is given at the arrival time at master. For the CSMA/CA mode it is random because of the random backoff procedure. After the

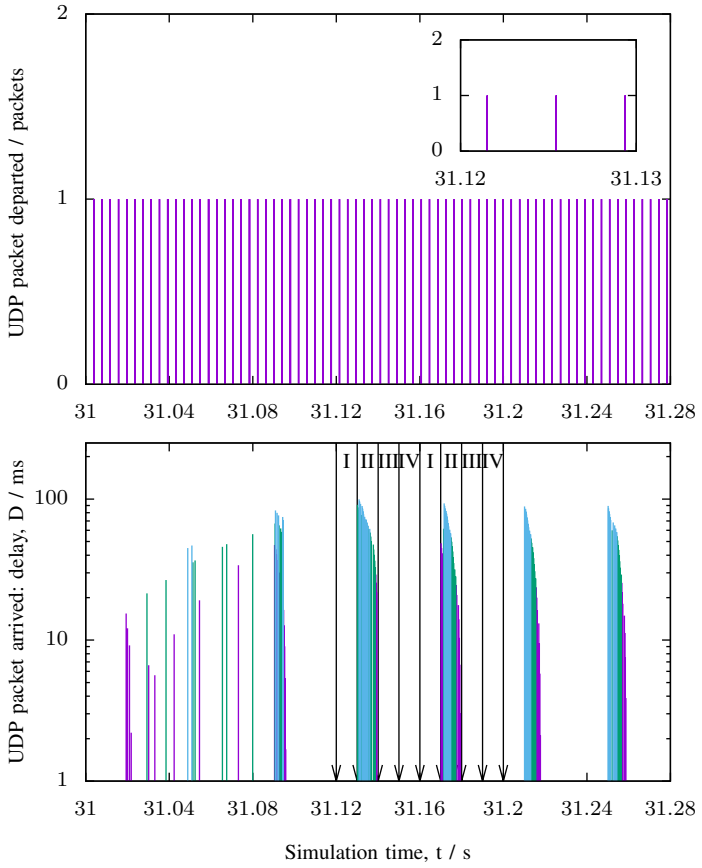

Fig. 3. Uplink delay for UDP packets with ALS and 2 repeaters, N=4, G.hn

network utilization reaches $\rho_t + w$ it switched to TDMA. It happens at $t = 31.12$. The master divides the available frame time equally for all nodes in the network. Therefore for the network with repeaters the packets come only in the time slot II, which belongs to the node 2 (repeater 1) that can be directly reached from master. As the network is not overloaded the delay decreases to the end of the slot time.

III. Switching from TDMA to CSMA/CA

In TDMA mode the scheduler is located in the master node. Therefore the master calculates ρ and decides about switching. The difference to the case without repeaters is that only transmissions which master can hear directly are counted.

The worst situation wrt. switching time happens if the next MAC cycle is already scheduled. Then in the current MAC cycle no switching happens and the network works in the TDMA mode as before (fig. 4).

In the next MAC cycle the master sends MAP packet with the switching command. This one is retransmitted until it reaches the slave. Then CSMA/CA mode starts. The transient process of switching will be given in the short paper.

IV. Conclusions

In this paper we discuss the ALS for the PLC networks with repeaters, which should be used in some smart grids in order to achieve 100% coverage. The switching mechanism is

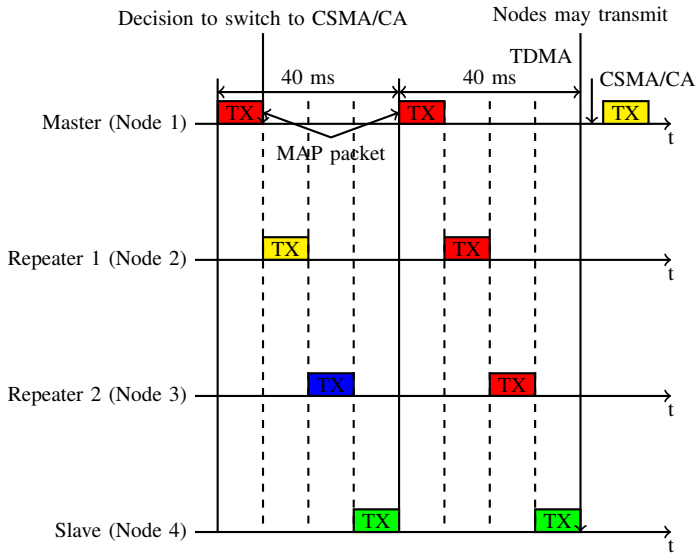

Fig. 4. Switching process from TDMA to CSMA/CA with repeaters

proposed from CSMA/CA to TDMA and back. The process of switching is tested in the ns-3 simulator with the small network with two repeaters between master and slave. The switching happens correct. Further simulation results for the networks with some 10th of nodes will be given in the short paper.

References

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