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A simulation study of TCP over the IEEE 802.15.3 MAC

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A Simulation Study of TCP over the IEEE 802.15.3 MAC

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Abstract

This paper presents the impact of IEEE 802.15.3 MAC’s channel time allocation methods on a TCP flow’s performance. We show the importance of having super rate and appropriately sized channel time allocations (CTAs).

1. Introduction

The IEEE 802.15.3 medium access control (MAC) is designed to support bandwidth intensive multimedia applications in wireless personal area networks. The main channel access period provided by the IEEE 802.15.3 MAC is called the channel time allocation period (CTAP), which offers a TDMA approach wherein the sending device reserves a channel time allocation (CTA) from the piconet controller (PNC) in advance of its actual transmission [2].

This paper investigates how to allocate CTAs to a TCP flow given the caveat that each CTA is inherently uni-directional. This means TCP will need to be allocated at least two complimentary CTAs (dubbed as Dual-UniCTA) where one is for data packets and the other is for acknowledgement packets (hereafter referred to as sender and receiver CTAs respectively).

Figure 1 shows a TCP flow with both sender and receiver CTAs. Also shown is the growth of the TCP congestion window (signified by the number of packets transmitted) at each superframe cycle. We can see that both CTAs are grossly under utilized because, after sending a cwnd of data packets, the sender has to wait until the receiver’s CTA before it can obtain the acknowledgement packets it needs before it can queue more data. Then, it will then need to wait again, this time until its own CTA recurs in the next superframe before it is able to transmit. This example clearly illustrates the important of the duration and position of CTAs since both these parameters have a significant effect on a flow’s congestion window (cwnd) growth rate.

2. Simulation and Results

We investigate CTA methods using our ns-2 IEEE 802.15.3 MAC implementation described in [1] which uses an Ultra Wideband (UWB) physical layer modeling the DS-UWB proposal currently before the IEEE. Our topology consisted of a PNC and two other nodes where we set one of them as the FTP sender and the other the receiver. Other parameters of the simulation are shown in Table 1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superframe length</td>
<td>20ms</td>
</tr>
<tr>
<td>Duration of the CAP</td>
<td>1ms</td>
</tr>
<tr>
<td>Desired CTA time units</td>
<td>5ms</td>
</tr>
<tr>
<td>TCP flavour</td>
<td>Newreno</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>1 Gbps</td>
</tr>
<tr>
<td>TCP Packet Size</td>
<td>1460 bytes</td>
</tr>
<tr>
<td>Slow-Start Threshold</td>
<td>43 packets</td>
</tr>
<tr>
<td>Simulation runtime</td>
<td>10s</td>
</tr>
</tbody>
</table>

Table 1. Parameters used in simulation studies.

2.1. Block Sizes and Congestion Window Growth

In this experiment, we are interested in determining the impact of different CTA allocation methods on a flow’s cwnd growth. Figure 2 shows the speed at which the cwnd grows and identifies the benefit of having multiple CTAs within a superframe since each pair of sender and receiver CTAs provides an opportunity for a flow to grow its cwnd. Note that, in this experiment, TCP’s slow-start threshold is set to 43 and will therefore enter the congestion avoidance phase early in the connection.

Figure 3 shows the critical role played by TCP’s maximum congestion window with regard to CTA utilization. Utilization is defined as the number of packets that are actually transmitted over the number of packets that could possibly be transmitted in a given CTA duration. As we increase the window size, utilization increases up to the point where the flow is limited by the overheads associated with transmitting the acknowledgment packets. This is
Figure 2. This shows the effect of a 5ms time block being broken up into blocks of 250µs, 500µs, 1000µs and 5000µs. The Imme-ACK policy was used in this experiment.

because each discrete acknowledgment packet/group incurs two SIFS (10µs each), plus the transmission time of the acknowledgment itself, which limits the growth of flows.

Figure 3. This shows the utilization of CTAs when we increase TCP’s maximum congestion window size.

Figure 4. This shows the maximum throughput achieved for different CTA allocation strategies and acknowledgment policies.

3. Conclusion

In this paper, we have looked at channel allocation methods and investigated their suitability for supporting TCP flows. Our results show that super-rate allocation with appropriately sized CTAs enables a TCP flow to quickly achieve high throughput by utilizing CTAs efficiently.

References
