Performance evaluation of EDCA MAC, Modulation and Fading Channels for IEEE 802.11p

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Abstract

This lab introduces some hands-on experience about the IEEE 802.11p protocol. The lab explored some features in the IEEE 802.11p protocol, both on the MAC and the physical aspect, for a vehicular centered transmission scenario. For the MAC side the lab is investigating the mechanisms in the sender to differentiate vehicular traffic and give priority to high emergency messages. The physical side of the lab is to evaluate the impact of channel fading and different modulation schemes in the reception performance, especially considering emergency messages. Practical experience in Virtual machines, Ubuntu, Wireshark, bash, python and c++ programming is obtained by doing this lab.

Contents

Chapter 1

Introduction

1.1 Project Scope

This lab is an exprimental/practical exercise set given to students of the MobWat course at Eurecom to get more familiar with the IEEE 802.11p, both from the MAC side and the physical side. This is the 2nd and last lab of the course. The content of the report is divided into two parts.

The first portion of the lab focuses on the understanding the impact of the mechanisms for traffic differentiation and priorities for the IEEE 802.11p protocol, while the second portion looks at how fading model and modulation schemes affects the communication.

1.2 Report Outline

The report consist of 3 main chapters.

The report consist of an introduction (1) and a chapter for each part of the lab (2)(3). The last two chapters includes everything from implementation, results and discussion.

Chapter 2

Part 1 EDCA protocol in IEEE 802.11p

In this part the EDCA protocol in IEEE 802.11p is considered. Two types of broadcast traffic is evaluated. CAM is placed at background priority and DENM is placed at voice priority.

We consider 2 scenarios:

1. Internal contention between the CAM and DENM broadcast from the same vehicle.

2. General contention from multiple vehicles.

2.1 Scenario 1 - evaluation of EDCA internal contention

A plot the variation of the packet reception rate(PRR) as a function of data rate for each priority class is shown in figure2.1. The data rate in the plot ranges from 1 Mbps to 3.6 Mbps. The PRR is defined as the number of received packets at a destination node over the number of transmitted packets.

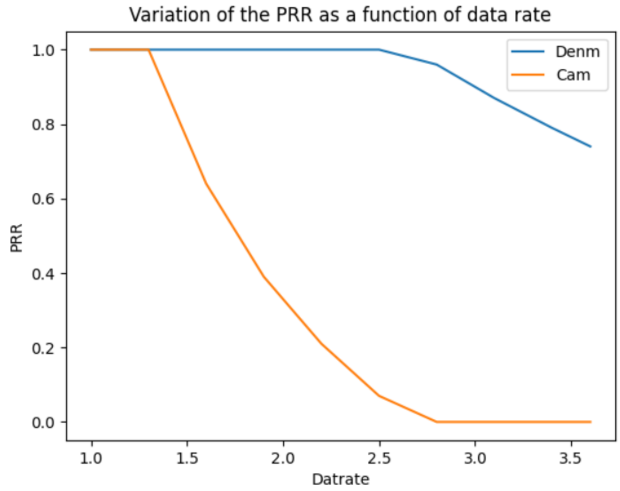

Figure 2.1: A plot of the PRR versus data rate. The data rate have a stepsize of 0.3 Mbps.

From the plot above (2.1) its possible to see that PPR for both DENM and CAM gets worse when the data rate increases. It is still a clear difference between which shrinks that fastest. When the data rate is about 1.75 Mbps the PRR of the CAM is half of what it started at, while the PRR of the Denm is still 1. The PRR for Denm starts decreasing when the data rate is about 2.6 Mbps, when this is the case, the PRR of the Cam is down to about 0.1.

A plot the variation of the average delay as a function of data rate for each priority class is shown in figure 2.2. The data rate in the plot ranges from 1 Mbps to 3.6 Mbps.

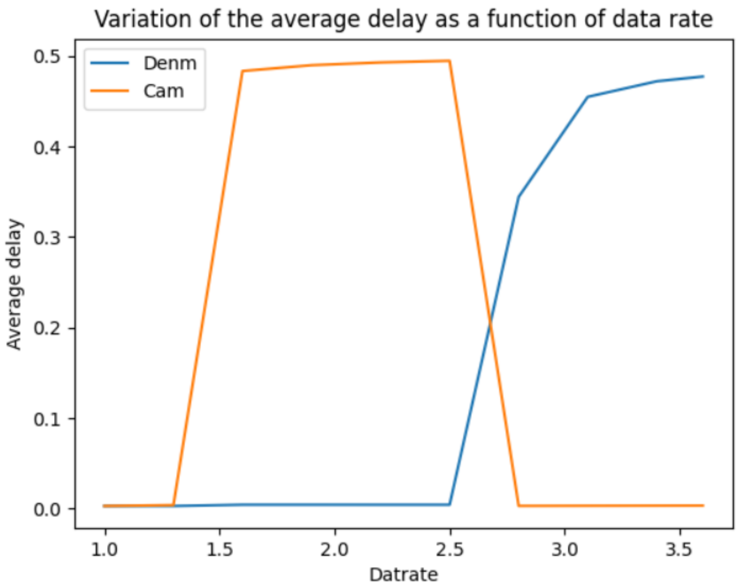

Figure 2.2: A plot of the average delay versus data rate. The data rate have a stepsize of 0.3 Mbps.

From figure 2.2 its is possible to see that the average delay for Cam increases long before the average delay for Denm. This would indicate that the protocol prioritizes Denm packets. The average delay for Denm starts to rise at 2.5 Mbps, while the average delay for Cam starts to rise at 1.3 Mbps. A possible explanation for the low delay of the Cam after 2.5 Mbps is that there were so many packets lost due to low PRR.

It is possible to inspect the Qos parameters in the 802.11 headers using Wireshark on generated pcap-traces. Figure 2.3 and 2.4 shows a couple of screenshots to exemplify this.

```
Qos Control: 0x0001
   .... .... .... 0001 = TID: 1
   [.... .... .... .001 = Priority: Background (Background) (1)]
   .... .... ...0 .... = QoS bit 4: Bits 8-15 of QoS Control field are TXOP Duration Requ
   .... .... .00. .... = Ack Policy: Normal Ack (0x0)
   .... .... 0... .... = Payload Type: MSDU
   0000 0000 .... .... = TXOP Duration Requested: 0 (no TXOP requested)
```

Figure 2.3: A screenshot from Wireshark inspecting a Cam packet.

```
Qos Control: 0x0006
   .... .... .... 0110 = TID: 6
   [.... .... .... .110 = Priority: Voice (Voice) (6)]
   .... .... ...0 .... = QoS bit 4: Bits 8-15 of QoS Control field are TXOP Duration Req.
   .... .... .00. .... = Ack Policy: Normal Ack (0x0)
   .... .... 0... .... = Payload Type: MSDU
   0000 0000 .... .... = TXOP Duration Requested: 0 (no TXOP requested)
```

Figure 2.4: A screenshot from Wireshark inspecting a Denm packet.

The figures above (2.3 and 2.4) confirms that the protocol is prioritizing. The background Qos have a value of 1 , while the Voice Qos have a value of 6.

2.2 Scenario 2 - Simulation of general contention

Similar to the previous evaluation, the PRR is an important metric. A plot of the variation of the PRR as a function of data rate and per packet category (CAM and DENM) is plotted below in figure 2.5. This time an average PRR is taken from the 10 different vehicles and the data rate ranges from 0.1 Mbps to 1 Mbps.

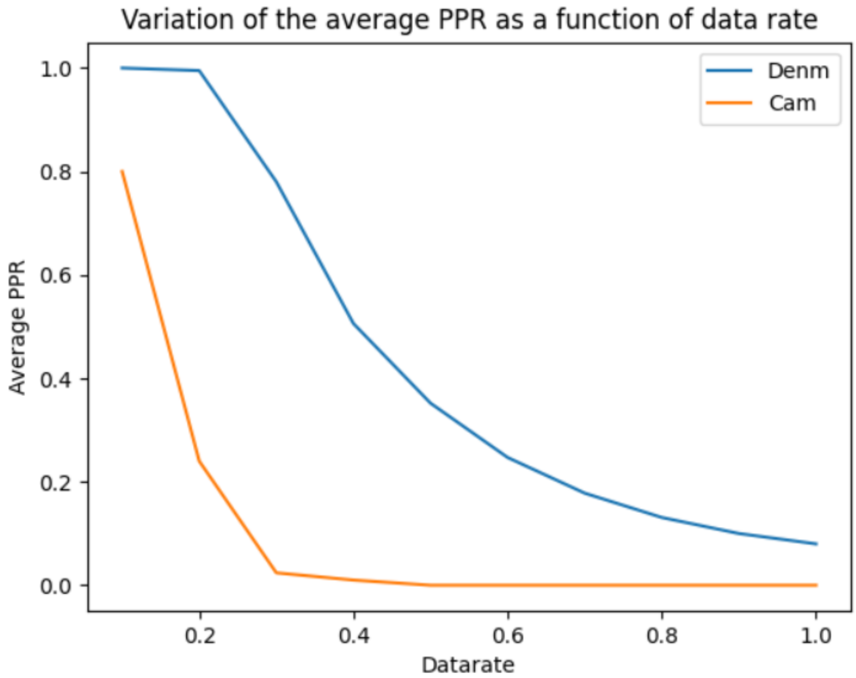

Figure 2.5: A plot of the average PRR versus data rate. The data rate have a varying stepsize of 0.1 Mbps.

From the plot above (2.5) its possible to see the similar trends from scenario 1. That the average PRR for Cam traffic decreases first and the average PRR for Denm start to decrease when the average PRR of cam is equal to 0.1. This result leads to the conclusion that even for multiple vehicles the voice packets(Denm) get higher priority than background packets(Cam).

Chapter 3

Part 2 Evaluation of different physical phenomenons of IEEE 802.11p

The effect of two different physical phenomenons are evaluated.

1. Fading based on distance
2. Modulation schemes

3.1 Fading

The figure below is a plot of the probability of reception as function of distance considering the Log- Distance fading model.(3.1)

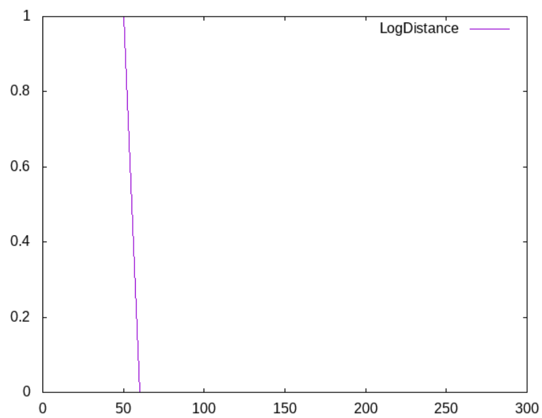

Figure 3.1: Plot of probability of reception vs distance. A Log-distance fading model is applied.

The figure above (3.1) shows that the probability massively drops of after 50 meters. The same model is plotted against it self plus a shadowing model of strength 9dB in figure 3.2.

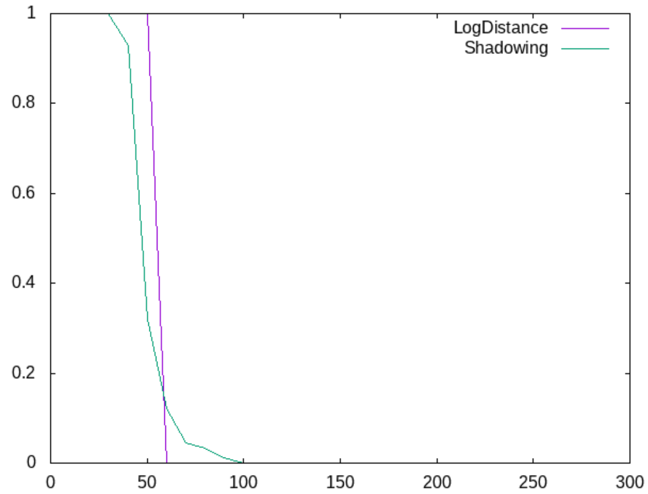

Figure 3.2: Plot of probability of reception vs distance. A Log-distance fading model is applied.

Figure 3.2 shows that the new model starts to fade at a smaller distance , but not as rapidly as the old model. The new model still have reception towards 100m. A even further expansion to the fading model can be done with Nakagami fading. The plot below (3.3) show multiple models plotted against each other. The old models are also included.

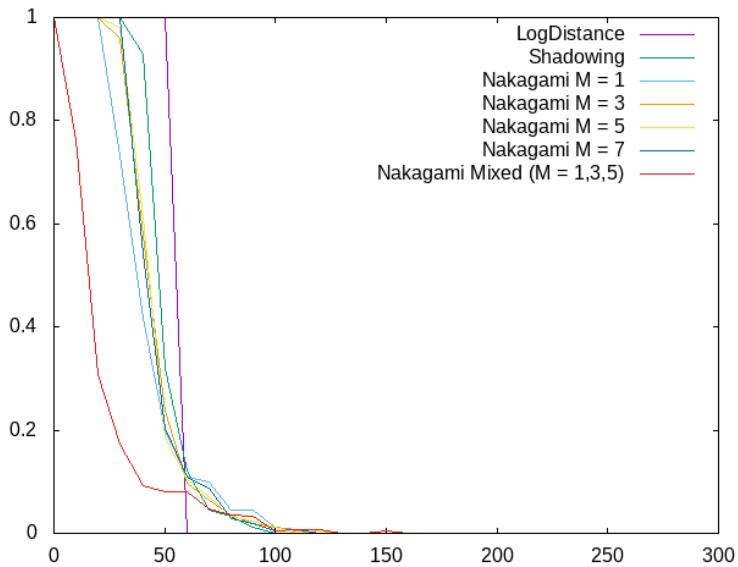

Figure 3.3: Plot of probability of reception vs distance. A mixture of models are displayed.

Figure 3.3 shows that the more complex fading models (Log-distance + Shadowing + Nakagami) starts decreasing earlier and last longer, depending on distance. A real wireless link would have serious trouble receiving packets if the distance is larger than 150m.

3.2 Modulation schemes

A plot of the PRR as function of distance for each modulation schemes is plotted in figure 3.4 in order to evaluate modulation schemes available in IEEE 802.11p and their sensitivity to distance and fading.

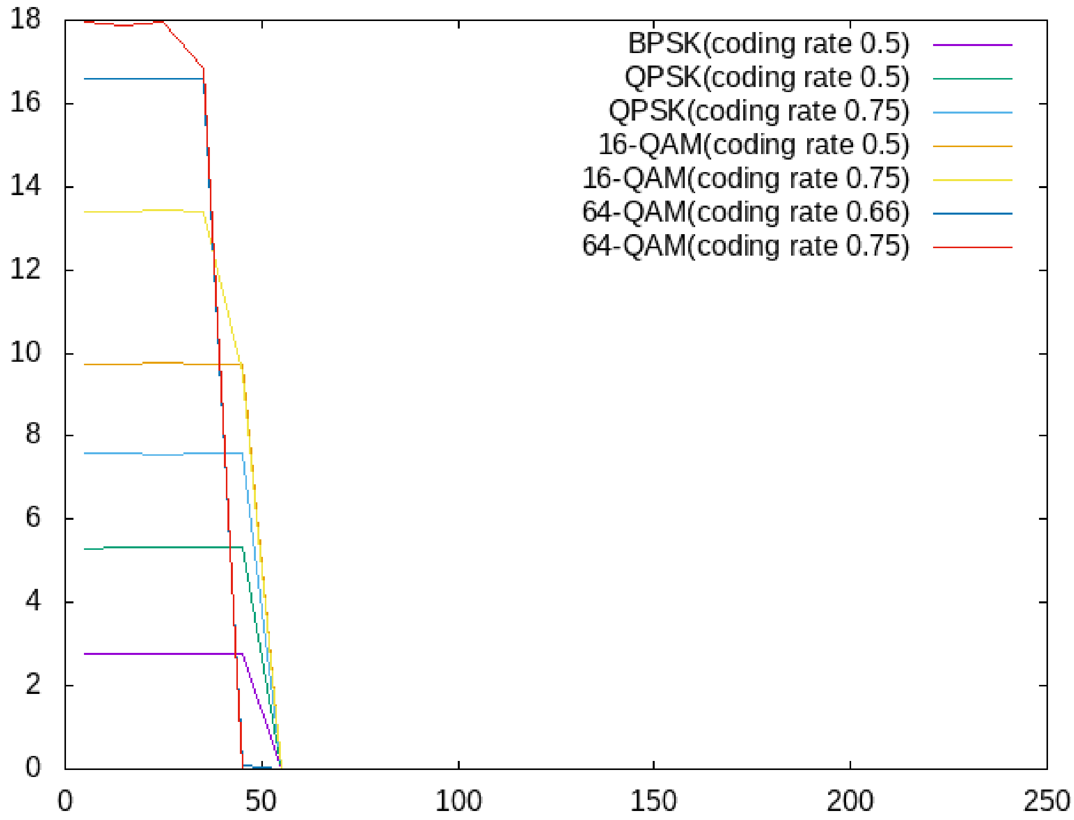

Figure 3.4: Plot of PRR vs distance. Multiple modulation schemes.

Figure 3.4 shows that the higher tier modulation schemes have the higher PRR for smaller distances, while the opposite is true for higher distances.

The trade-off in this case that engineers have to take into consideration the required distance versus the require data rate. If they want the system to transmit for a larger distance they need to select a lower coding scheme, while if they need PRR they need the receiver and sender to be close and choose a high coding scheme.

Figure 3.5 is a similar plot to the plot in figure 3.4, but with a mixed fading model (Log-distance + Shadowing + Nakagami) applied.

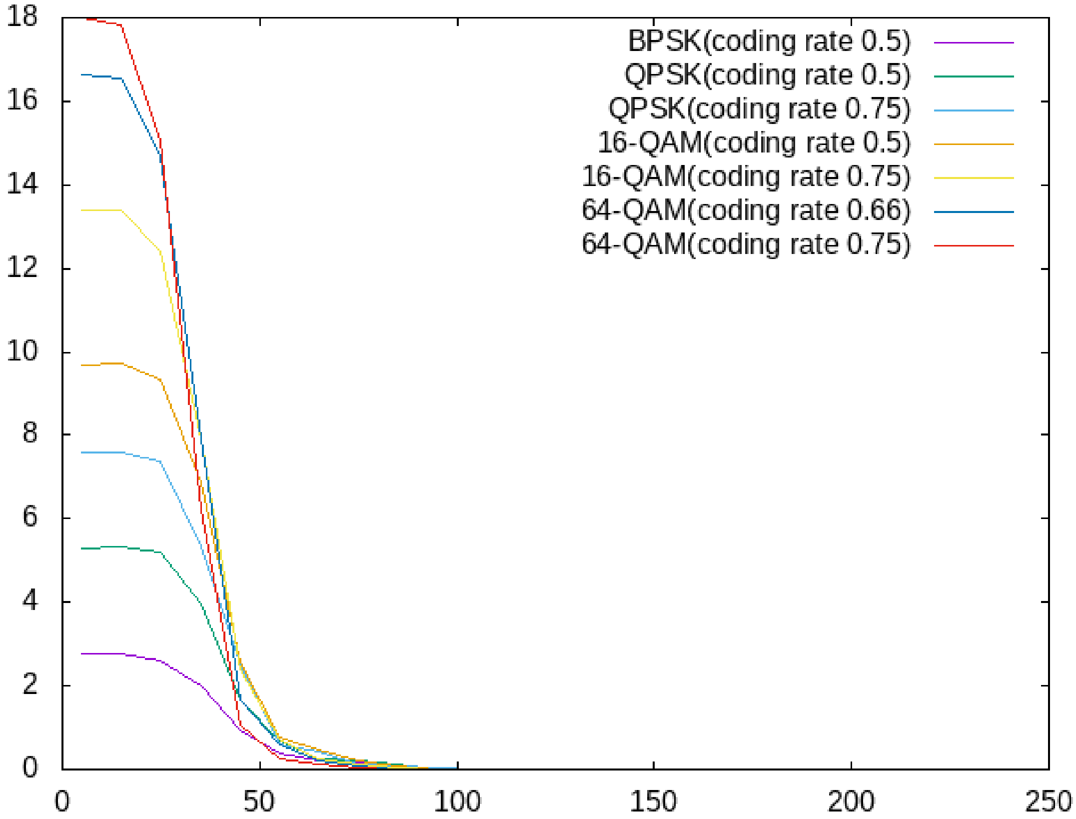

Figure 3.5: Plot of PRR vs distance. Multiple modulation schemes. Mixed fading model applied.

Figure 3.5 shows that every modulation scheme still have some PRR after 50m , this is not the case with figure 3.4. Another observation is that the PRR curves are a lot smoother for every modulation scheme.