Contribution Number: 75
Registrant's email: tblazek@nt.tuwien.ac.at

# GILBERT-TYPE VEHICLE-TO-VEHICLE PERFOMANCE MODELLING

Thomas Blazek[a]

[a]E389 - Institute of Telecommunications

## INTRODUCTION

We expect Intelligent Transport Systems (ITS) to have a strong beneficial effect on road safety. This potential stems from the ability to communicate informations about hazards, such as icy conditions or emergency braking maneuvers. Furthermore, such systems navigate dense traffic at higher speeds and fluidity than human drivers, which brings a positive impact on travelling times and fuel efficiency. A thorough understanding of the communication link performance is essential, as system failure in these applications can pose a direct threat to humans.

Our goal is to accurately model the packet-level performance of Vehicle-to-Vehicle (V2V) transmission, while retaining a manageable complexity of the model. Our model is validated using extensive real-world measurements conducted on a highway east of Vienna. A similar approach for the Vehicle-to-Infrastructure channel has been demonstrated in [1].

## METHOD

The probability of the success of a packet transmission depends strongly on the instantaneous Signal-to-Noise Ratio (SNR) during transmission. Accurate modelling of the signal strength requires intricate knowledge about multipath propagation and the associated doppler shifts, which results in complex models that are highly specific to the given situations. Instead, we restrict our modelling approach to the measured packet-error traces and per-second mean SNR.

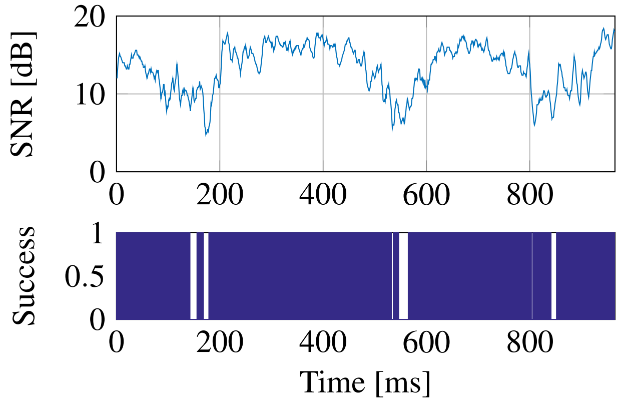


**Figure 1:** Instantaneous SNR and transmission success indicator for one second.

Within one second, the instantaneous SNR oscillates about the mean, and the packet-error behavior changes accordingly (see Fig. 1). We model this using the Gilbert model [2], which is a special case of a Hidden Markov Model (HMM). The Gilbert model allows to model a burst error process that alternates between error-free bursts and error-prone burts, using three parameters (see Fig. 2). $P_{GB}$ and $P_{BG}$ are transition probabilities that govern transitions between good and bad, while $P_e$ defines the error probability in bad state. Using this model, we are able to abstract the underlying physical processes into three parameters, while retaining the important information about Packet Delivery Rate (PDR) and burst error length.

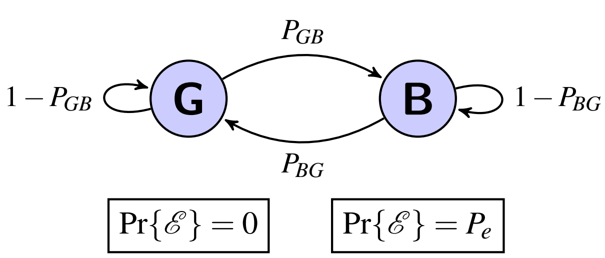


**Figure 2:** The Gilbert model has two states, good and bad. Transitions between the states as well as the packet errors are governed by the probabilities $P_{BG}$, $P_{GB}$ and $P_e$.

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From the parameters of the model, the PDR can be expressed as

$$\mathrm{PDR} = 1 - \frac{P_{GB}}{P_{GB} + P_{BG}} P_e, \tag{1}$$

while the transition probabilities $P_{GB}$ and $P_{BG}$ govern the burst behavior. The parameters for a given mean SNR can be found by using the Viterbi algorithm [3] on the packet-error traces for all times with the corresponding mean SNR.

## RESULTS AND DISCUSSION

Figure 3 depicts the results of the modelling approach, compared to the measurements. The average PDR is plotted against the mean SNR in the leftmost graph. The burst behavior is described by the probabilities of an correct transmission given the previous transmission was correct $P(C|C)$, and the probability of an error given an error $P(E|E)$. Both error and error-free transmissions are shown to be in fact bursty in their behavior, and the model we derived is able to capture this behavior.

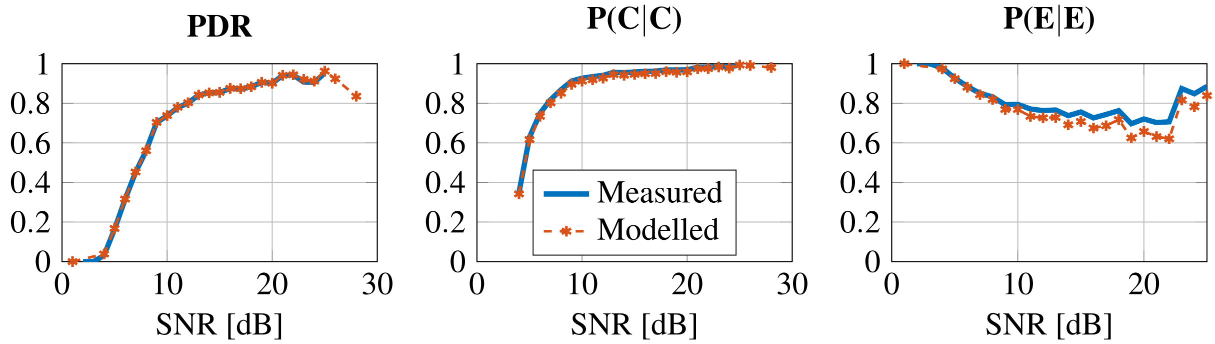


**Figure 3:** Results of the performance modelling. The figures show the average PDR vs SNR, the probability of a correct transmission given the previous was correct $P(C|C)$, and the probability of an error given the previous transmission failed $P(E|E)$.

## CONCLUSION

Transmission over the vehicular channel shows bursty behavior, due to the time-varying nature of the scenario. Intelligent transport systems will have to account for delays due to temporarily unfavorable channel conditions. In this work we provide a low-complexity model that is able to provide this behavior based on real-world measurements, allowing reproduction in simulations.

In ongoing work, we look further into the time variance of the model parameters to capture more effects on the system.

## REFERENCES

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