interview

Vincent Savaux

‘Knowing the outage capacity allows the designers of communications systems to foresee how many users can share a transmission band’

Dr Vincent Savaux from b<>com Institute of Research and Technology, France, talks to us about the work behind the paper ‘Optimal non-outage probability maximising the outage rate in Rayleigh channel’, page***

Can you give us a brief overview of the outage capacity?

The outage capacity is one of the most important metrics used for the design of communications systems and networks. In short, it provides an upper bound on the amount of data that can be properly received by a wired or wireless device. Therefore, knowing the outage capacity allows the designers of communications systems to foresee how many users can share a transmission band, given a target data rate, and what kind of data can be transmitted, depending on the quality of service (QoS).

Can you explain how the outage capacity is calculated?

The outage capacity is defined as the maximum data rate that can be achieved given a specified outage probability, *i.e.* the probability that a signal is not properly decoded. Although the outage capacity value mainly depends on both the outage probability and the signal-to-interference plus noise ratio (SINR), it can be expressed as a product of two functions of the outage probability. When one of the two functions increases, the other one decreases, and *vice versa*. This feature leads to the usual bell curve of the capacity versus the outage probability. Therefore, there is an optimal outage probability value which maximises the outage capacity. The outage capacity was developed by Claude E. Shannon, the father of information theory, in the middle of the last century, in order to describe the mutual information between the input and the output of the noisy transmission channel.

What makes your method novel?

The originality of the paper lies in the mathematical description of the achievable maximum outage capacity in function of the non-outage probability. In fact, previous works solved the problem through simulations only, which depends on the considered systems and parameters. The general formulation that we provide is independent of a given context, and then can be used to find the optimal outage probability for any considered problem. Furthermore, we have shown that optimal non-outage probability is upper bounded by one when the SINR tends to infinity (i.e. when the noise is null). Conversely, it is lower bounded by 1/e, not zero, when the noise level increases. This is a very interesting result, since it is not intuitive.

What have you reported in your *Electronics Letters* paper?

In the paper, we provide an expression of the outage capacity in function of the non-outage probability, and we derive the maximum capacity in function of the W Lambert function. Furthermore, the series expansion of the outage capacity allows us to deduce the upper and lower bounds of the optimal non-outage probability. The theoretical results are supported by detailed mathematical developments, as well as three illustrations.

What is the significance of this?

The results presented in the paper may interest any researcher who analyses, optimises, or designs a communications system, based on outage capacity. Thus, the significance of our work is not limited to the scientists working on information theory. In fact, the proposed general formulation of the maximum outage capacity avoids performing multiple simulations each time a parameter changes. More precisely, knowing the transmitter and receiver devices, one can directly choose the best wave form, modulation order, channel coding rate, transmission power and so on, which leads to the optimal non-outage probability.

What new opportunities will this present?

The method proposed in our Letter could be used as a base for further works. In the paper, we carry out our analysis by using the log-normal path loss model, which provides a good idea of the achievable maximum outage capacity. One of the pending challenges is to perform the same analysis for a more general channel model, including shadowing and multipath fading, such as Rice, Rayleigh, or Nakagami channel models.