Adaptive Wireless Reliability Measurements

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***Abstract*—In 5G, reliability will play a crucial role. The reliability should not only be estimated in advance, but also be measured in practice. Such measurements can be carried out by transmitting a predefined number of packets over the channel. However, to test for high reliability many packet transmissions are necessary. To reduce the necessary transmissions, we propose a reliability measurement method where the number of packet transmissions depends on the results of the ongoing measurements. We show that the expected number of packet transmissions is lower than that of the conventional method. In the future, methods such as the proposed one are needed to efficiently measure the reliability of wireless networks when communication is important.**

In this paper, we describe a sequential hypothesis test for the reliability r of a wireless transmission channel by repeated transmission of individual packets. In contrast to earlier work [2], here the number of required packet transmissions n is not fixed before the test. Instead, n depends on the results of the measured transmissions. The general idea is to stop transmitting packets as soon as a result is sufficiently certainty. This is an application of the sequential probability ratio test (SPRT) for binomial distributions [3].

We use the following mathematical model: Repeated packet transmission constitutes (under certain assumptions) a Bernoulli process. The success probability r of this process is the reliability of the system. We select reliability thresholds t and s with $t < s$. We apply the SPRT with null hypothesis $r = s$ and alternative $r = t$. We then test if the reliability of the system is below t or above s. We select confidence thresholds α for the null hypothesis and β for the alternative.

Suppose that n packets were transmitted over the channel and $X(n) \in \{0, \ldots, n\}$ denotes the number of successful transmissions. According to the SPRT, the test statistic

$$\mathcal{L}_n = \frac{t^{X(n)}(1-t)^{n-X(n)}}{s^{X(n)}(1-s)^{n-X(n)}}$$

yields the following decision rules:

(1) If $\mathcal{L}_n \geq \frac{\beta}{1-\alpha}$, the channel is not reliable ($r < t$).
(2) If $\mathcal{L}_n \leq \frac{1-\beta}{\alpha}$, the channel is reliable ($r > s$).
(3) Otherwise, continue transmitting packets.

These inequalities can be solved to obtain decision bounds $N_u(n)$ and $N_l(n)$ such that for $X(n) \geq N_u(n)$ (resp. $X(n) \leq N_l(n)$), the null hypothesis (resp. alternative) is accepted with significance level α (resp. β). Figure 1 shows an example. To execute the test, we transmit packets until one of these cases occurs, or $n = n_{\max}$. Here $n_{\max}$ is a fixed maximal number of packet transmissions. We propose to set $n_{\max}$ to the number of transmissions determined from the measurement method outlined in earlier work [2]. If $n = n_{max}$ and no decision is reached, no definitive statement about the reliability can be made and therefore the claim of reliability should be rejected.

To evaluate the proposed method, Figure 2 shows the expected number of packet transmissions $\mathrm{E}[\#n]$ dependent on the real reliability r in an example [1].

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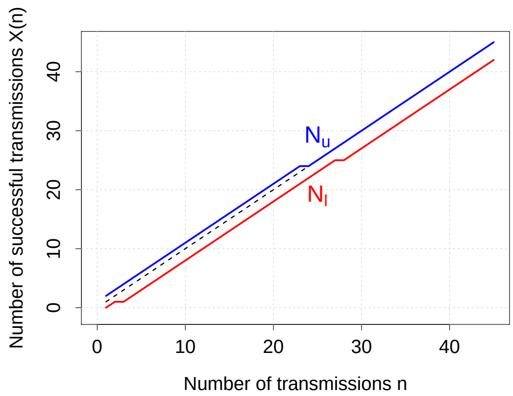

Fig. 1. Decision bounds for $t = 0.9, s = 0.99$ and $\alpha = \beta = 0.1$. The dashed line represents a transmission with no packet loss.

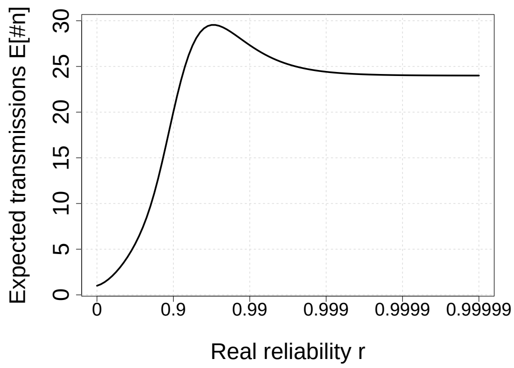

Fig. 2. Expected transmissions for $t = 0.9, s = 0.99, \alpha = \beta = 0.1, n_{\max} = 38$

References

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