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21.10.2022

EVALUATING FRMCS OVER MOBILE NETWORK OPERATORS IN FINLAND

White Paper: 21.10.2022

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1 INTRODUCTION

The modernization work of the Finnish railway train control system is in progress and the first commercial ETCS (European Train Control System) line is planned to be operational during the year 2027. The Digirail project – which is responsible for the transformation – has set an ambitious goal to be one of the first to implement ETCS over FRMCS (Future Railway Mobile Communication System). The FRMCS deployment is planned to mainly use commercially available mobile radio networks.

During the Spring of 2022, Digirail conducted a measurement campaign to assess the commercially available radio network coverage and performance throughout the entire Finnish railway. The length of the measured national railway network was approximately 6000 kilometres. The measurement targets were to verify the available coverage levels of the Finnish mobile networks, the reliability of the mobile networks and how the requirements of the narrow band FRMCS applications would be met.

The measurement setup, provided by Proxion, consisted of a Radio Frequency (RF) -scanner, multi-channel router and a software solution that generated and simulated ETCS traffic. Furthermore, a set of prioritized network subscriptions from network operators were used, ensuring a prioritized connection over ordinary subscriptions. The measurement setup is illustrated in Figure 1.

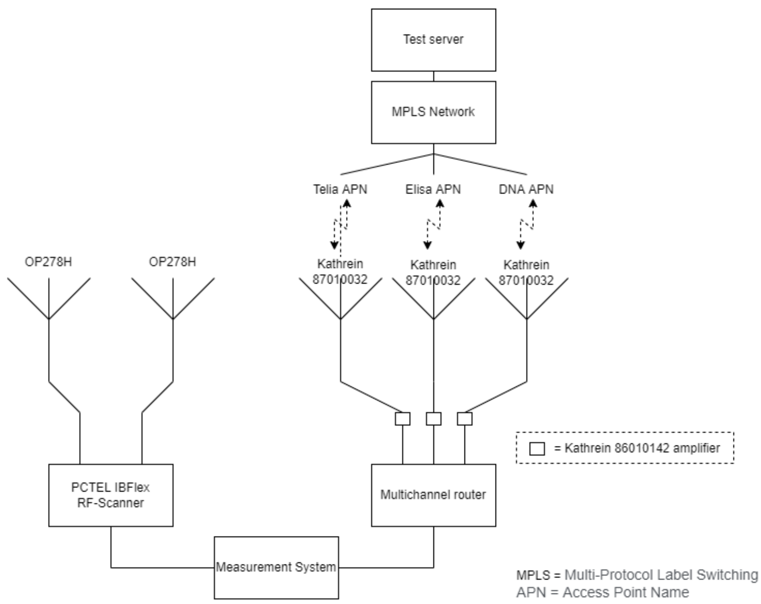

Figure 1 Measurement setup

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2 MEASUREMENT DETAILS

For the test scenarios, the multi-channel router was configured to use 4G. The RF-scanner, on the other hand, measured both 4G and 5G radio network conditions. Moreover, the measurement solution measured the times of TCP (Transmission Control Protocol) connection establishment, DNS (Domain Name System) queries, HTTP (HyperText Transfer Protocol) page loading and ETCS traffic quality and reliability, as presented in Figure 2. The ETCS Position Report and the Movement Authority messages were simulated, and the latency was analysed.

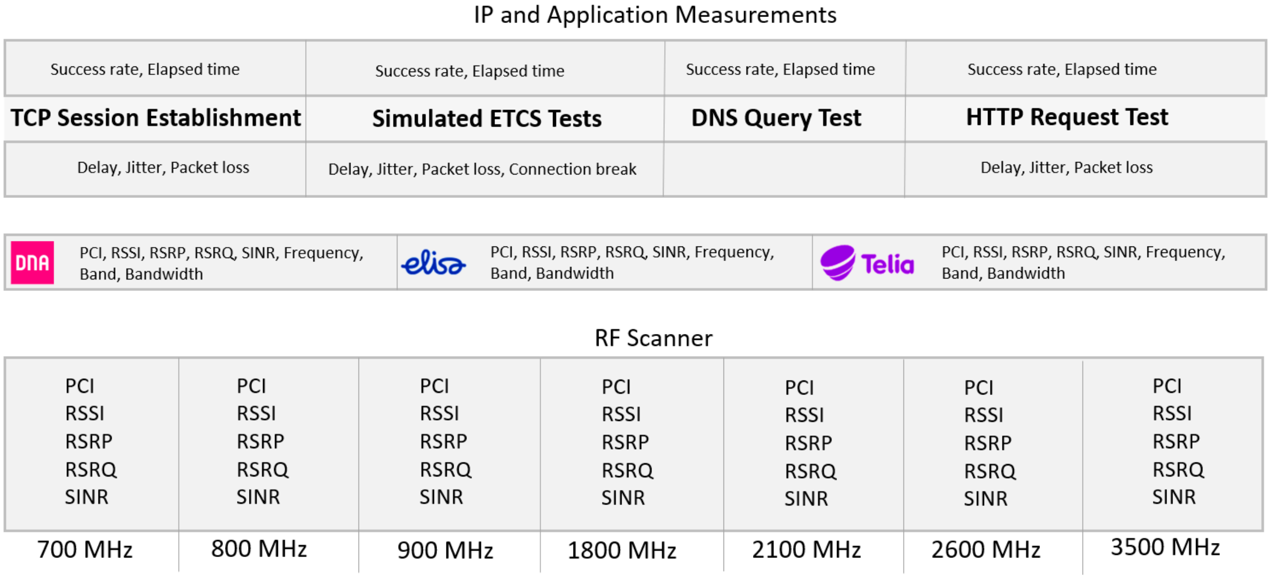

Figure 2 Measurement layers in the test setup

The measurement solution sent Movement Authority Requests every 10 seconds and accordingly the RBC (Radio Block Centre) simulator replied with the Movement Authority. The Position Reports were sent from the measurement system once per second. The actual execution time or roundtrip time for each tested application was measured.

3 MULTICHANNEL ROUTER CONFIGURATION MODES

The multichannel router had all three prioritized subscriptions simultaneously in use. Two different communication methods for the router were evaluated, Best Quality and Packet Duplication mode. When in Best Quality Mode, the router selects the best available channel based on the measured radio conditions per measurement time stamp and stays attached to the selected channel until the end of each session. When in Packet Duplication mode, data packets are sent to all three operator networks at the same time. At the infrastructure side, the first arrived packet is processed, and the later arriving packets are discarded.

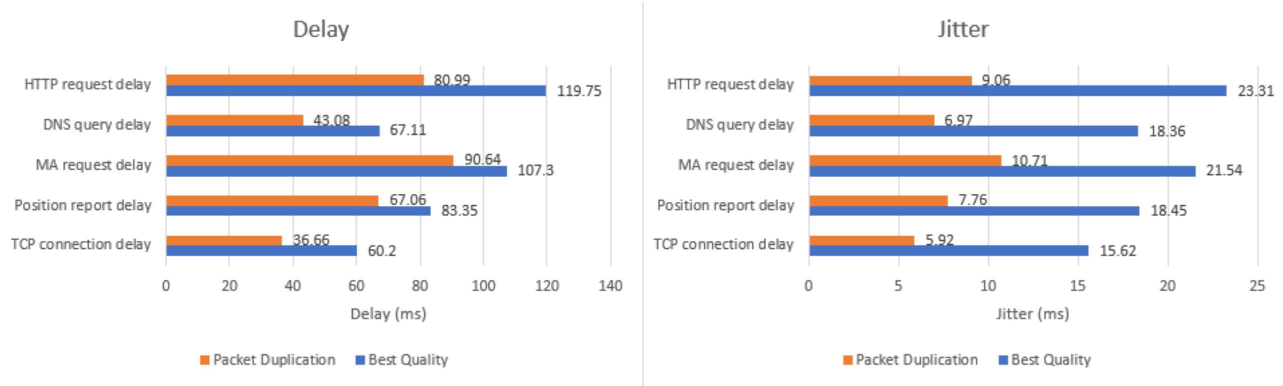

Figure 3 Delay and jitter with Best Quality and Packet Duplication modes

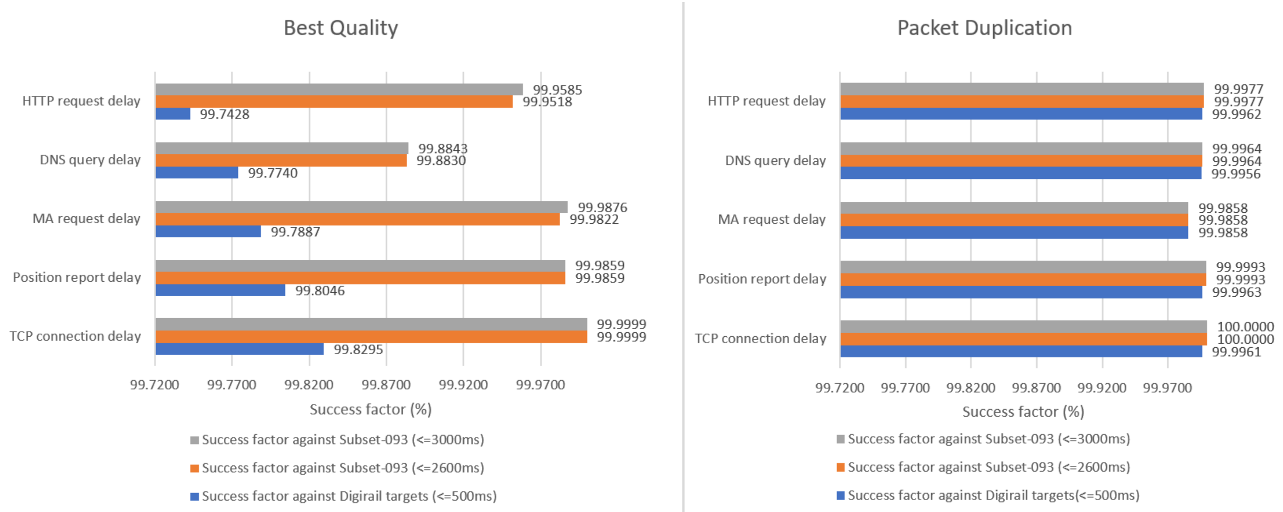

Figure 4 Test success factories based on different criteria with Best Quality and Packet Duplication modes

As highlighted in Figure 3 and 4, the measurement results with Best Quality mode were promising. Based on the results, both the Subset -093 tolerance level and the Digirail delay threshold of 500 ms or better ("Critical Data Legacy Applications", 3GPP TR 22.989 V18.5.0) were met with a success rate of more than 99%. However, communication delay peaks were occasionally noticed when the radio conditions clearly decreased. Significant improvements were achieved while using the Packet Duplication mode. Similarly, the Packet Duplication mode results fulfilled both the Subset -093 tolerance level and the Digirail delay threshold of 500 ms or better ("Critical Data Legacy Applications", 3GPP TR 22.989 V18.5.0) and were met with a success rate of more than 99.9%. The measurement results demonstrated that while using Packet Duplication mode, the serving network changed more frequently, hence achieving a better level of service throughout the measurements.

4 CONCLUSION

The main motivation of this study was to evaluate how feasible it would be to rely on commercial mobile networks for ETCS over FRMCS. Based on the conducted Digirail measurement of spring 2022, the results are clearly encouraging for an ETCS over FRMCS solution using commercial mobile networks. Furthermore, as illustrated in Figure 5, the measurement results have shown that the coverage levels and the reliability of the Finnish commercial mobile networks are sufficient for a large scale FRMCS deployment when used simultaneously.

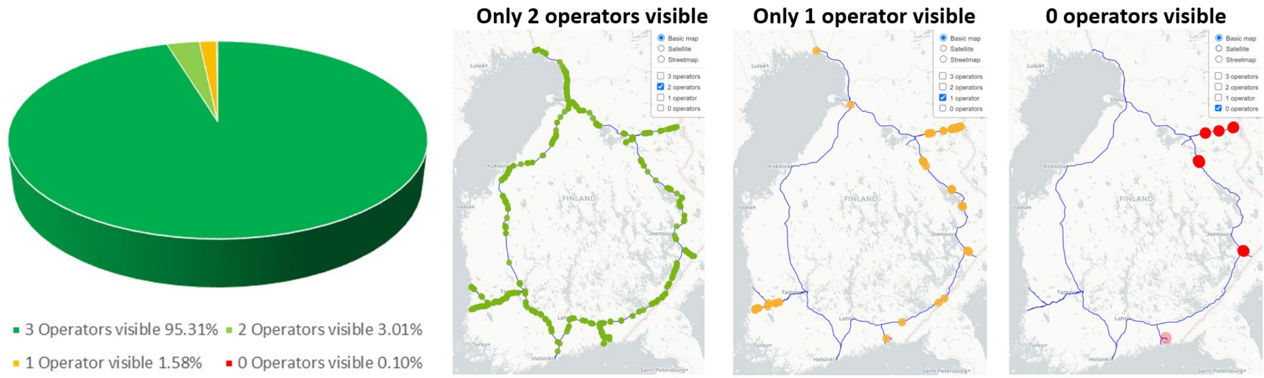

Figure 5 Network coverage test drive with Packet Duplication mode

It is worth noting that the measurement campaign was conducted using a router that used a proprietary routing technique (Best Quality and Packet Duplication), which is not yet defined by TC RT of ETSI. ETSI has yet to define the standardized FRMCS multipath routing technique (with reference to an RFC or similar). As the results have shown, the selected multipath function technique will have an impact on the results. Therefore, once ETSI TC RT has defined the approved routing technique, a verification measurement campaign would be required to evaluate the impact.

The main identified benefits in using commercially available radio networks in Finland are the achieved level of redundancy when using multiple radio networks and the FRMCS deployment speed and cost efficiency as the commercially available radio networks and chipsets for the UEs are already available.