Open position PhD 36 months- Université Gustave Eiffel, Campus Lille, France – start: 01/09/2023
Dependability analysis of the wireless communication system for Virtual coupling of automatic trains – The case of platooning

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1) Context, objectives and ambition

The VCTS (Virtual Coupling Train Set) concept is currently under development in the framework of the Shift2Rail [1]. The platooning strategy consists of assigning trains to different platoons, determining when and where to join and leave the platoon, managing stopping at stations, etc. In this context, the process will be based on wireless communication system to ensure exchange of information between two vehicles (V2V). The safety and availability of the link are crucial for correctly setting and managing the virtual coupling operation.

Several wireless communications systems can be considered to answer the need of virtual coupling of two trains and preliminary studies exist. No choice has been yet decided. Taking advantage of ITS frequency bands in the 5.8 GHz band [2,3], it is possible to consider systems coming from the automotive world like ITS-G5. It is also possible to consider the millimetric waves band (60 GHz), allocated for safety applications since 1992, particularly for V2V communications. In this case we can consider the 5G technology in the millimetric band for V2V or M2M communications [4,5]. A third solution could be to consider the LTE-A system (Long Term Evolution-Advanced), which is also considered for other railways applications, particularly Train-to-Ground links in the case of TCMS and the wireless backbone [6,7,8].

The PhD will be conducted in the framework of the European project Academics4Rail
The objectives of this PhD work are twofold. First, it is necessary to focus on the analysis of the impact of the wireless communication system key performance indicators (KPI) in railway environments, such as the end-to-end delay and the packet error rate, on the performance of the VCTS operation in view of some targeted safety integrity level. The impact of parameters, such as, for instance, the size of the platoon will be also considered in our analysis. The outputs of our study will support the choice for an appropriate communication system to be used in the virtually coupled train set (VCTS) context. Whatever is the chosen system to address the virtual coupling needs, the failures of the wireless link jeopardize the safety level. Thus, it is essential to guarantee a level of trust for the communication system achieved by the wireless link. This guarantee is expressed by the railway safety standards (EN 50126, 50129, 50159) according to the operating safety parameters RAMS (Reliability, Availability, Maintainability, Safety). The second objective of the PhD is to develop a methodology for a preliminary dependability analysis then seeks to identify and characterize all sources of errors or failures that may degrade the wireless communication link in order to evaluate, in view of these disturbances, the quality and the associated risk with the transmission system.

1) Methodology

As mentionned previsouly, different works exist in the litterature. The PhD work will start with a litterature review in order to identify the missing points, particularly for the evaluation of the wireless links. In the next step of the work, the methodology will rely both on simulations and possibly experimental works in lab in order to evaluate some key performance indicators (KPI) of various wireless links (different frequency bands) in the context of VTCS and platooning of trains in railway environments. Differences with the road context will be highlighted. The main difficulty of this research lies in the estimation of the degradation suffered by the radio signals, the impact of the traffic load of the system and in particular the impact of the choices concerning the architecture. Different communication strategies (both multihop or single-hop) will be envisaged.

In the third part of the work, based on the different strategies and the most suitable technology, we will propose a methodology and evaluation strategy to analyze the impact of different communication parameters such as “transmission error”, “transmission latency” and “Platoon Size (VCTS units inside a Virtually Coupled Platoon)” on dependability. Considering, previous works in the literature and in the

research team [9,10,11], a solution to perform the proposed evaluation will be model- based and will consider Stochastic Colored Petri Net; therefore, if there is any change of parameter values or any other scenario, which is reducible to this form (holds the same assumptions), we can use the same model for evaluation by changing parameter values.

Bibliography

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Required diploma and skills:

Master degree or equivalent in informatics, automatics
knowledge on Petri Nets or discreet events simulation, English, autonomy, hard work, interest for the railway domain

To candidate: Send CV, motivation letter, master grades and references to marion.berbineau@univ-eiffel.fr