# Application of Mixed-Criticality Scheduling Model to Intelligent Transportation Systems Architectures

[Extended Abstract]

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## 1. INTRODUCTION

Intelligent Transportation Systems (ITS) usage has transformed public transports' vision on operation management. However, the lack of common communication interfaces has brought redundancy within on-board applications. In this context, the European Bus System of the Future (EBSF) project has specified a common architecture based on IP standards [1]. It provides a Service Oriented Architecture (SOA) that permits the ITS applications to publish services and subscribe to others. The EBSF architecture enables Vehicle To Infrastructure communications (V2I) through a unique communication gateway, with managing needs of the different data flows depending on their priority in the network and the available communication resources (bandwidth).

In this public transport context, we are searching to model the priority management in this Mixed-Criticality environment. Either for internal data exchanges in the SOA architecture or for shared resources such as the gateway, security recording services, etc. The increasing number of embedded applications in public transport has considerably brought new challenges when it comes to mixed-criticality management. In our actual research, we consider applying Mixed-Criticality Scheduling model presented in [2] for distributed embedded applications in public transport, based on the EBSF architecture.

## 2. THE "ITS" MODEL

The constraints of ITS applications in public transport are very close to the studied scope in real-time scheduling problems. Indeed, if we focus on the shared communication gateway, we see that we have multiple applications with different criticality levels, which need to send data to off-board back-offices. The data flows contain messages that are sent sporadically, with a constraint deadline (defined as $D$) such as, there never are two messages of the same type that are ready to be sent at the same instant $t$. Moreover, the studied model is considered as a non-preemptive scheduling problem, in the sense that when a message is sent, it cannot be preempted even in the case if another message with a higher priority needs to be executed.

In that context, we are currently extending the work done in [3] in order to adapt the solution to non-preemptive problems such as network applications. The network is considered as a uniprocessor with a dedicated speed of execution, this speed is, in our case, considered as the throughput. We consider $C_i(\ell)$ the transmission time of a message $i$ at a criticality level-$\ell$. This level-$\ell$ is defined by the throughput size (or processor speed). Using this model, an extension of the worst case response time ($WCRT$) and the *Latest Completion Time (LCT)* is being adapted for non-preemptive systems.

In terms of challenges, this model needs to take into consideration a "relaxed" mixed-criticality model in order to ensure optimal transmissions to the back-offices.

## 3. EXPERIMENTAL WORK

In order to test the model, we use real life data of bus fleets operated under the authority of Vasttrafik in Sweden, where the throughput measurement have been logged along the bus journey during several weeks. As the vehicle is moving, the throughput evolves, however the deadline constraint of the messages stay identical. In that context it's of an interest to measure the $WCRT$ of the different messages depending on the level-$\ell$ of criticality. Depending on $\ell$, the lowest the throughput will be, the longest $C_i(\ell)$ will take. In this way we see the number of dropped messages and the limits of the architecture. Applying the Mixed-Criticality real-time scheduling approach to public transport architectures brings clearly a new dynamic to both research domains. It enhances also the building of new certification models for such architecture.

## 4. REFERENCES

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