The Sum 2021

BIM-Based Description of Road Intelligent Transportation Systems

A *Summaery* of findings from the research project „digital roads“

Background and problem statement

Intelligent transportation systems (ITS) provide safer, greener, and more convenient mobility, while reducing the adverse impact on the environment. In an ITS, under-utilized on-board resources of vehicular cyber-physical systems are combined to perform traffic- and safety-related applications. Moreover, an ITS may be employed for telematics and infotainment applications. In recent years, simulation platforms have been employed to study ITS applications, mostly focusing on traffic-related simulations. Despite several research studies on ITS applications and simulation platforms, formal semantic descriptions of intelligent transportation systems have not received enough attention. Fig. 1 shows an example of how road ITS may be deployed in urban environment.

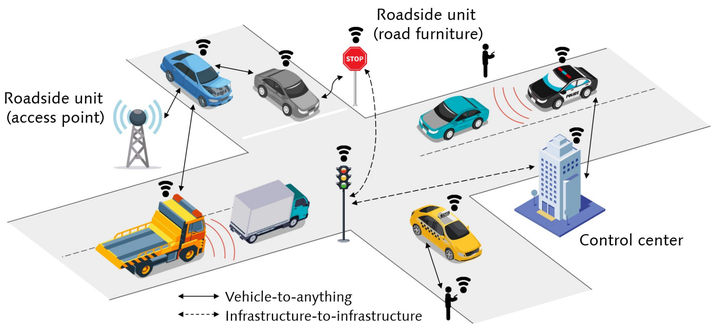

Figure 1: Example of road ITS in an urban junction

Methodology

In this project, a conceptual model describing road ITS is proposed, which is devised to provide a basis for designing ITS simulation platforms. The project process is summarized in Fig. 2. First, background information on road ITS are analyzed, and system requirements and characteristics with respect to network architecture, applications, intelligent infrastructure and communication networks are extracted. Then, based on the requirement analysis, the first conceptual model is built in form of a UML class diagram. The conceptual model is then verified according to typical scenarios in road ITS. To further standardize the proposed conceptual model, the openBIM standard schema, i.e. the Industry Foundation Classes (IFC) schema, is used as a base for mapping the conceptual model into openBIM data models. Here, the existing IFC data models were used to prepare a baseline for the formal BIM-compliant description of road ITS. Missing components were then developed in an IFC schema extension for road ITS. The IFC schema extension is verified with respect to semantic and syntax checks to be used for simulating BIM-based scenarios of road ITS.

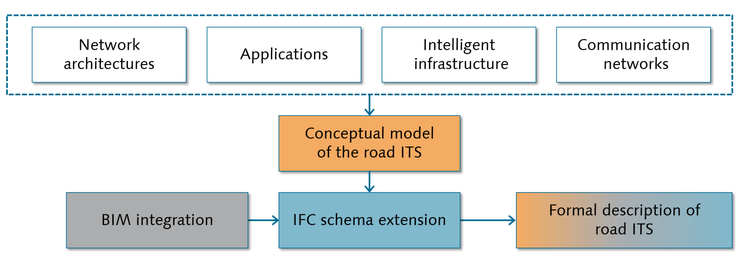

Figure 2: Towards obtaining a formal description for road ITS

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You can read our article on this topic here:

For further information about the research group, please visit:

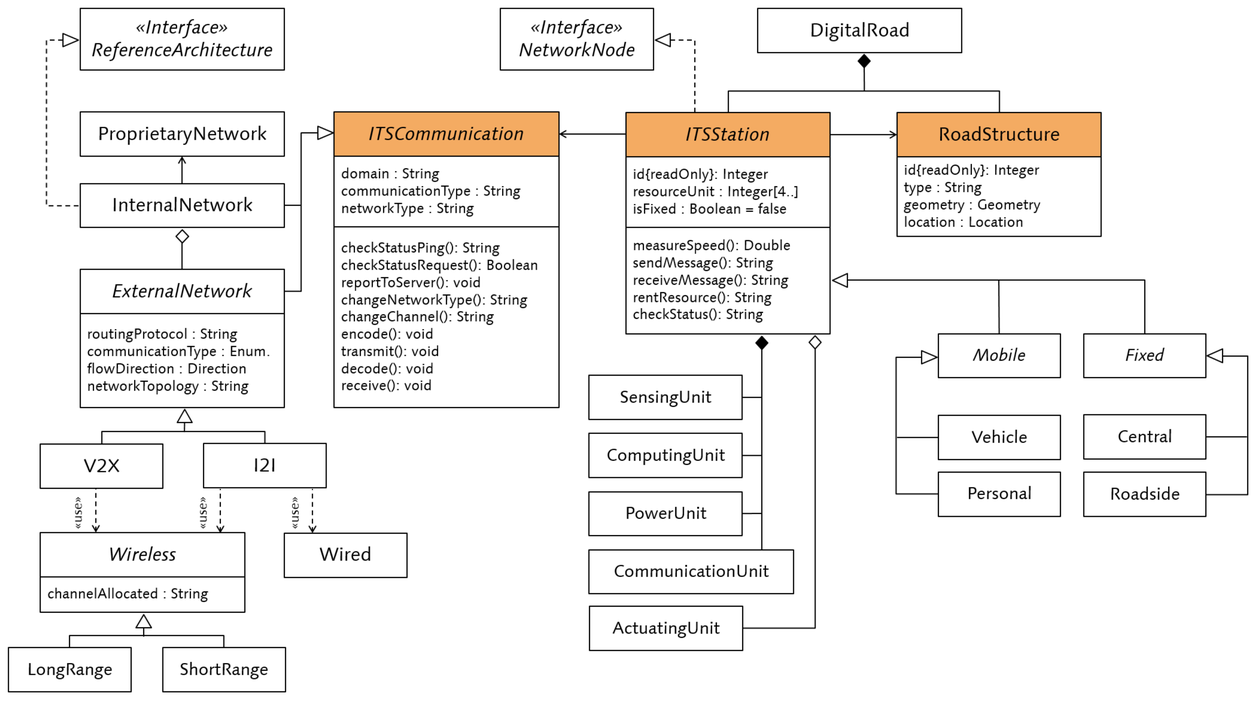

Figure 3: Extract of the proposed conceptual model for road ITS depicting three main classes in orange

The conceptual model (Fig. 3) is consisted of three main part: the *RoadStructure* class representing physical road infrastructure, the *ITSStation* class showing intelligent infrastructure of road ITS, and the *ITSCommunication* class presenting all types of communications between physical and intelligent infrastructure. The conceptual model is then verified using random ITS scenarios, concluding that the proposed model may be used to define road ITS applications and may serve as a formal basis for designing ITS simulation platforms.

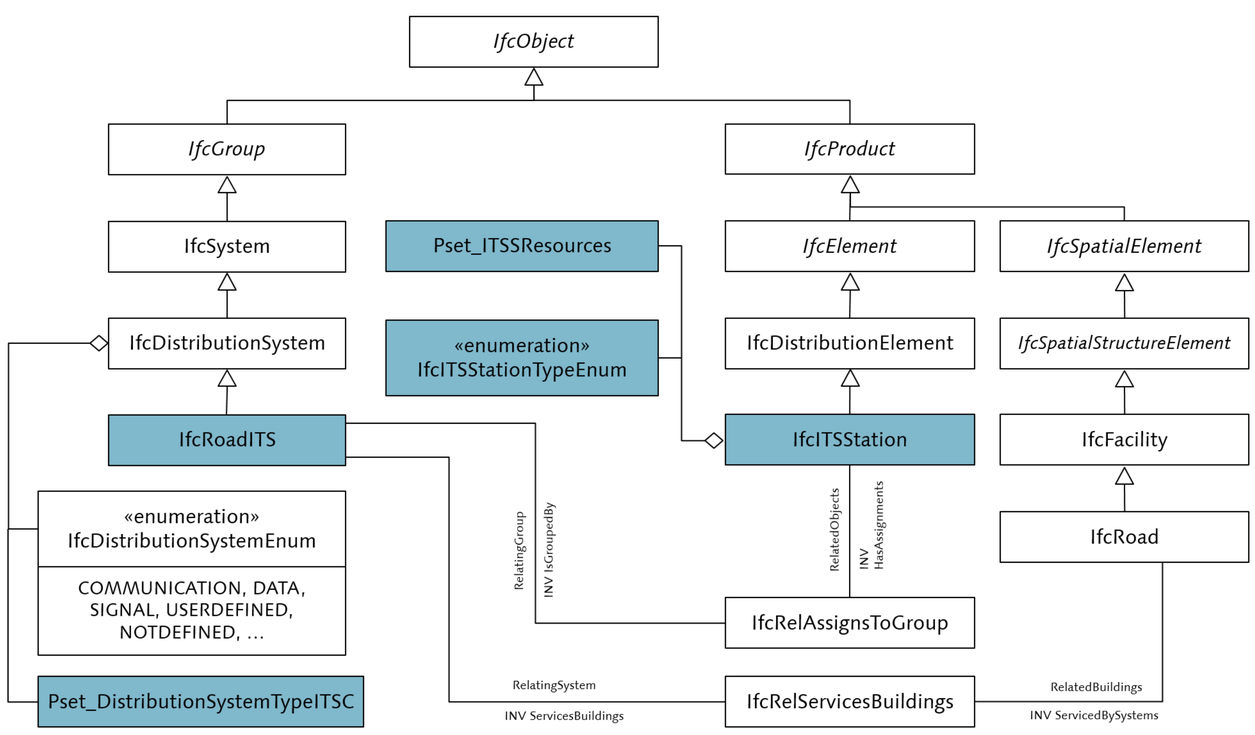

Figure 4: Extract of the proposed IFC schema extension for road ITS showing new entities in blue

The IFC schema extension (Fig. 4) introduces two new entities, one new enumeration data type, and two new property sets that facilitate BIM-based models of road ITS. The IFC schema extension is then verified using typical ITS application scenarios using the official verification software of buildingSMART.

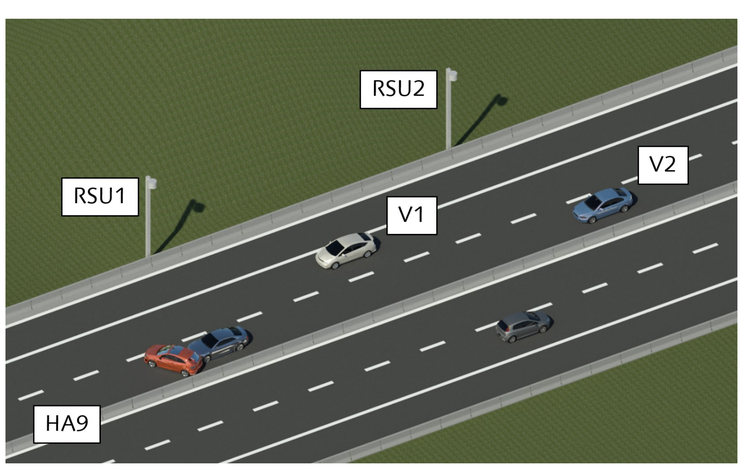

Figure 5: BIM-based simulation of a typical use case in road ITS

› Conceptual model

ITSStation
› Mobile ITS stations include vehicles and smart personal devices
› Fixed ITS stations cover roadside stations, i.e. road furniture such as traffic cameras, RFID sensors, beacons, and control devices, as well as control centres
› Each ITS station has 4 on-board units: Sensing, computing, communication, and power units
› Some ITS stations also have actuators on-board

ITSCommunication
› According to recommendations from the ETSI EN 302 665 standard
› Connecting ITS stations, which represent network nodes in an ITS
› Granting access to on-board units of different ITS stations, only to authorized users
› Resource management and application security is handled by various communication protocols

RoadStructure
› Representing spatial (infra-) structure of roads, e.g. ramps, bridges, tunnels and resting areas

› IFC schema extension

› ***IfcITSStation*** defined as IFC entity (distributed elements) representing intelligent infrastructure with the above-mentioned on-board units

› ***IfcRoadITS*** defined as IFC entity showcasing road ITS as a distributed system, combining intelligent infrastructure and spatial infrastructure

› ***IfcITSStationTypeEnum*** enumeration data type for specifying type of ITS stations in the network

› ***Pset_ITSResources*** characterizing on-board units, which are of different types, technologies and corresponding system requirements

› ***Pset_DistributionSystemEnumTypeITSC*** defined for characterizing communications in road ITS, a list of various routing protocols, standards and respective application requirements

Conclusions

An example of BIM-based model of a road safety ITS scenario is depicted in Fig. 5. The scenario was modeled using the proposed IFC schema extension and visualized using Revit. The IFC schema extension is checked against several criteria, i.e. correct assignments of entities, attributing entities, defining relationships between entities, and assigning property sets to entities.

It is concluded that the formal description attained here may provide IFC-compliant BIM models and may be used as a basis for creating a simulation platform for road ITS.

In future work, the IFC schema extension may be enhanced by integrating further ITS use cases, e.g. for decentralized data-processing scenarios, and Telematics and Infotainment applications . In addition, BIM-based simulations that consider impact of road ITS on the environment may be addressed.

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