**ezCar2x®: Streamlined Development of Reliable Networked Vehicle Applications**

Even in the automobile sector, the growth of connected electronic devices is taking on more importance. Future vehicles will be able to immediately share information with one another and with the road infrastructure using wireless communication technology. Referred to as Car2X communication, this technology is making a major contribution to improved traffic safety and efficiency while enabling a broad range of innovative services:

- **Cooperative driver assistance systems:** improved driving comfort and safety through automated danger warnings, by expanding the driver’s field of view (cooperative perception) and cooperative driving manoeuvres (e.g. platooning)
- **Intelligent traffic systems:** improved traffic safety through personalized routing, green wave assistance and precise tracking of the traffic situation

For such applications, developers require not only a communication platform, but other services as well. Through the integration of digital map data, the local street topology and the navigation information can be factored in. Sensors track and capture the ambient environment of the vehicle or road side unit and deliver data that is important for further algorithms. Processes for the reliable modeling and analysis of the current traffic and driving situation provide the consolidated basis for context-based applications.

With this in mind, Fraunhofer ESK developed the flexible ezCar2x® software framework, which provides the key components needed to rapidly create prototype applications for networking vehicles. This allows vehicle manufacturers, suppliers and road infrastructure providers the opportunity to rapidly implement new concepts and evaluate them in a real world setting.
Rapid Prototyping

The ezCar2x® framework features components for the following functions:

- ETSI ITS-compliant communication services
- GeoNetworking and IPv6-over-GeoNetworking via ITS-G5 and LTE
- Adaptive hybrid network layer with optimal network selection in real time
- CAN bus system connectivity, including quick vehicle integration
- Connectivity to external sensors such as GPS, odometry or radar and lidar
- Integration of digital map data
- Facilities such as CAM and DENM management and Local Dynamic Maps
- Integration of security services
- Connectivity to various HMI devices such as tablets or touch screens

The framework is structured as a collection of C++ libraries that are available under Linux and Windows operating systems. Extensive API documentation and various examples help accelerate the learning curve for first-time users. With its flexible, modular and portable design, the framework can be deployed in a variety of environments such as in common onboard and roadside units, as backend server components or directly in simulation environments.

The consistent utilization of abstraction concepts and known design patterns leads to a high degree of modularity. Single functions can be swapped out and if needed, replaced by other implementations without modifying the remaining systems. External platform-specific dependencies were minimized to allow the framework to be used on different target platforms. The high degree of abstraction means that hardware-dependent functions, such as direct access to the wireless modules, can be easily adapted. Even with the achieved portability, performance is not impacted since the framework has access to native compilers and platform-specific optimizations. ezCar2x® requires no additional middleware or environments at runtime.

Proven Solution

The framework has already been deployed in various prototypes. One example is a predictive headlight control assistant that relies on periodic CAM messages, combined with digital map data.

Furthermore it was demonstrated, how existing ITS applications on the basis of CAM and DENM can be implemented using mobile communications (LTE) with low latencies. With the help of the framework, a GeoService was realised for this that coordinates the intelligent distribution of information in the back end or directly on the base station.

Simulation Environments

When developing innovative technical systems, engineers generally rely on simulation tools to evaluate system behavior and effectiveness in the early design stages. Especially in the area of networked vehicles, it can be difficult, if not impossible, to implement comprehensive and reproducible field tests. With its modular design, the ezCar2x® framework can be incorporated directly into a simulation environment consisting of a road traffic and network simulator. As a result, it can be installed in an unlimited number of virtual vehicles. This allows developers to test and continuously enhance ezCar2x® applications and protocols under realistic conditions with minimal effort. The same source code can then be used directly on the embedded target platform without modifying it, thus eliminating additional development effort and preventing glitches when porting it over.

Besides the ezCar2x® software framework, Fraunhofer ESK offers other tools for the development and analysis of networked functions, such as the ERNEST analysis framework and model-based DANA platform. Thus providing a comprehensive package for a complete and integrated solution from the modelling to simulating and prototyping of networked applications in intelligent transport systems.