Remote Controlled Road Surface Networks for Enhanced ITS

Laurynas Riliskis, Evgeny Osipov, Roland Hostettler, Henrik Mäkitaavola, Wolfgang Birk and Jens Eliasson
Department of Computer Science and Electrical Engineering
Luleå University of Technology
971 87 Luleå, Sweden

Demo Abstract

Intelligent Transportation Systems (ITS) will, in the future, play a key role to improve transportation efficiency and safety. However, cost-benefit of deploying traditional ITS is retarded by expensive equipment, infrastructure, installation and maintenance. The demo presents a replica of a real world experimental ITS application using Road Surface Network architecture proposed earlier. The demonstrated "intelligent roundabout" application is intended to warning drivers about forthcoming roundabout and preventing the driving straight through accidents. We show a lab prototype system consisting of: a authentic sensor node platform enabled for car detection, secure multihop communications and the running light application, a base station and a system control center.

I. Road Surface Network Architecture

In [1] we proposed the Road Surface Network Architecture (RSN). The RSN architecture is illustrated in Figure 1. It is built upon three principle entities: road marking units (RMU), road side units (RSU) and an open platform server (OPS) for enabling new RSN services in larger ITS systems. RMUs are autonomous on-road devices that may work independently or cooperatively to carry out sensing and actuating tasks. RMUs are capable of wireless communication with RSUs as well as communicating with each other by forming a wireless sensor and actuator network. RSUs are the gateway nodes for conveying data between RMUs and the ITS backend system. The open platform provides a set of open interfaces that connects RMUs to a backend ITS and front ends.

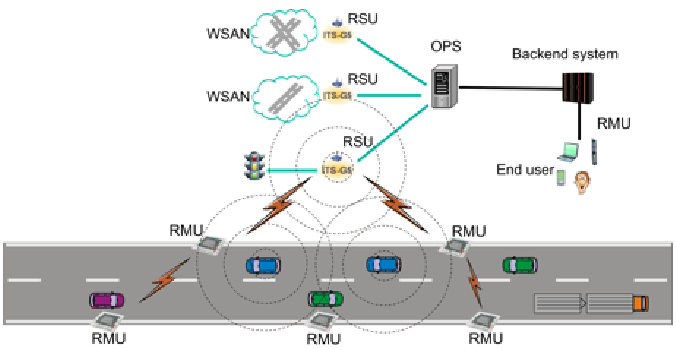

Fig. 1: The Road Surface Network Architecture.

II. Intelligent Roundabout Site in Luleå

To show the feasibility of the RSN based ITS we deploy an "Intelligent Roundabout" site close to LuleåUniversity of Technology. The schematics of the showcase installation is shown in Figure 2. The detecting RMUs are equipped with a magnetic sensor and are placed on a distance sufficient to detect an approaching vehicle and signal this event to the base station. The signal is propagated over the intermediate relay RMUs in multihop manner. When the signal reaches the base station it activates the running light application in RMUs placed on the border of the roundabout. The LEDs of these RMUs are then activated to create a visual effect of a running light in the driving direction of the roundabout.

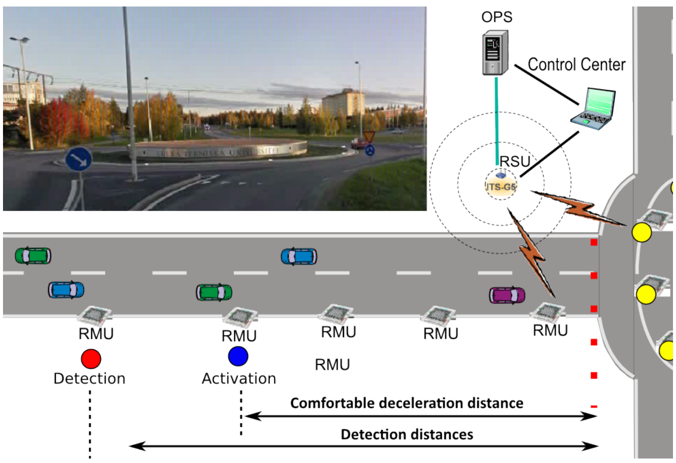

Fig. 2: The test site set up at LTU [2].

In spite of the seemingly simple application the design of the major hardware and software components of the system is far from being trivial. It is of primary importance to ensure the dependability properties of all functional blocks of the RSU, namely: availability, reliability, maintainability and security.

III. Demo Description

In our installation we will demonstrate the following:

1) Samples of LED-guides, the enabling hardware technology for the proposed RSN architecture.
2) A lab version of the whole system prototype.
3) An online demonstration of the real installation's functionality in real time.

A. LED-guides - the RMU

A road marking unit, depicted in Fig. 3, situated on the road surface endures the toughest of conditions: being overrun by cars, trucks, heavy vehicles, and harsh weather with rain and snow. The RMUs are composed of a number of subsystems including sensing and signal processing blocks, actuators and low power wireless communication components [3].

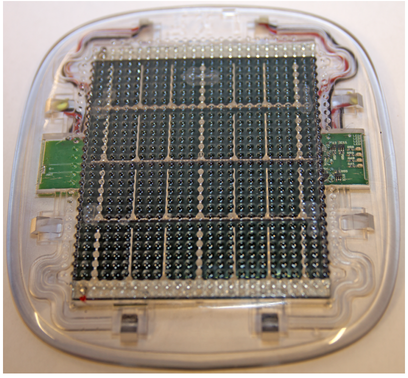

Fig. 3: Road Marking Unit - LED-guide.

B. Car Detection Technique

Figure 4 illustrates the detection algorithm used in sensor nodes. Vehicle detection is achieved by using a magnetometer that measures the change in the magnetic earth field induced by a magnetized metallic mass passing the sensor. Work flow of the detection algorithm: firstly, the static offset from the measured magnetic field strength is removed and the disturbance is derived. Secondly, the magnitude of the disturbance is calculated and thresholded. If the threshold is exceeded for a longer time period the disturbance is accounted to a vehicle and the detection flag is set to 1. In order to prevent double-detections of a single vehicle, a dead-time is added after each detection in which no detections are allowed.

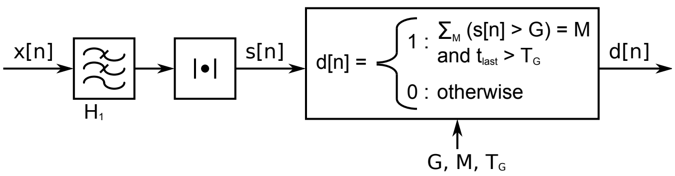

Fig. 4: Car detection.

C. A lab prototype of the system

The lab prototype of the system demonstrates car detection, secure multihop communications, and the running light application. During the demonstration the RSU, the backend server and the control center are shown as an entity on a single laptop. The car detection is done on a miniature race track with a RMU equipped with a magnetic sensor. We demonstrate the remote system configuration and management of the intelligent roundabout ITS. We also will demonstrate resistance of our RSN communication architecture to jamming and replay attacks.

D. Online demonstration of ITS functionality in real time

During the demonstration we will show a real time report on the number of vehicles entering the roundabout in Luleå. We also show video of the test site in operation.

E. Demo Execution

The demo runs in four processes: The car detection mechanism is shown on miniature race track and the running light application. Moreover, the system parameters can be set by user from laptop containing control center and deployed to the network. Independently from the main system functionality we show the resistance of the communication architecture to security threats.

F. Requirements

For the demonstration we will bring the following equipment with us: twelve sensor nodes including LED-guides, nodes equipped with magnetic sensor; the miniature race track with a metal car model; three laptops; a video projector. One of the laptop will play a role of the base station, the same laptop will act as the control centre. Other laptops will demonstrate car detection algorithm and security features.

G. Additional Requirements

Power access is necessary for the three laptops, the beamer and the race track. The equipment works with standard 220V power supply. The demonstrator need a horizontal area of about 1.5 x 1.5 meter to deploy RMUs and the miniature race track. Also a table for setup and demonstration of the control center and the detection algorithm. A vertical area would be needed for a video presentation. A big screen TV set can be used instead of the video projector. The setup time is rather short and is about 20 minutes.

H. Wireless Access

For the demonstration of real-time car detection at the installation site an Internet access is needed. The rest of the demo works without the Internet access. The sensor nodes communicate in 868 MHz frequency band, therefore other demos operating on the same frequency could be a subject to interferences.

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[3] J. Eliasson and W. Birk, "Towards road surface monitoring: Experiments and technical challenges," in *Control Applications, (CCA) Intelligent Control, (ISIC), 2009 IEEE*, July 2009, pp. 655–659.