

DEVELOPMENT OF THE REAL TIME SITUATION IDENTIFICATION MODEL FOR ADAPTIVE SERVICE SUPPORT IN VEHICULAR COMMUNICATION NETWORKS DOMAIN

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Abstract. *The article discusses analyses and assesses the key proposals how to deal with the situation identification for the heterogeneous service support in vehicular cooperation environment. This is one of the most important topics of the pervasive computing. Without the solution it is impossible to adequately respond to the user's needs and to provide needed services in the right place at the right moment and in the right way. In this work we present our developed real time situation identification model for adaptive service support in vehicular communication networks domain. Our solution is different from the others as it uses additional virtual context information source - information from other vehicles which for our knowledge is not addressed in the past. The simulation results show the promising context exchange rate between vehicles. The other vehicles provided additional context source in our developed model helps to increase situations identification level.*

Keywords

Adaptive service support, context aware, situation identification, vehicular communication networks.

1. Introduction

Today, the vehicle is a very important component of human life, so its combination with the intelligence based software and hardware equipment can improve

the level of travel safety and comfort. At the moment one of the most interesting and developed mobile technologies is the vehicular cooperation networks. In these networks vehicles communicating with each other and it open new opportunities for the vehicle industry and mobile service providers (Fig. 1). Differently from other pervasive computing devices vehicles have specific requirements and does not have strict energy constraints so it can be equipped with powerful computational resources, wireless transmitters and various sensors [1]. The vehicle must not distract drivers attention during driving, it must provide user with services autonomous and without user intervention. To provide the necessary services at the right time in the right place and in the right way it is necessary to adapt services and their support to user needs.

To solve these problems the vehicle must understand its environment and to identify current, past and possible future situations. For the situation awareness it can be used data from various sensors but this data is complex (different modality, huge amount with complex dependencies between sources), dynamic (real-time update, critical ageing) and different confidence [2]. Situation identification system must be able to recognize many different situations, to understand their relationships and context, and to control these situations. The system must be aware of simultaneous different situations and of that it cannot occur at the same moment. Considering the complex environment of system operation, high level of dynamics, imprecise data of sensors and other circumstances it is very difficult challenge to achieve a high level of situation identification.

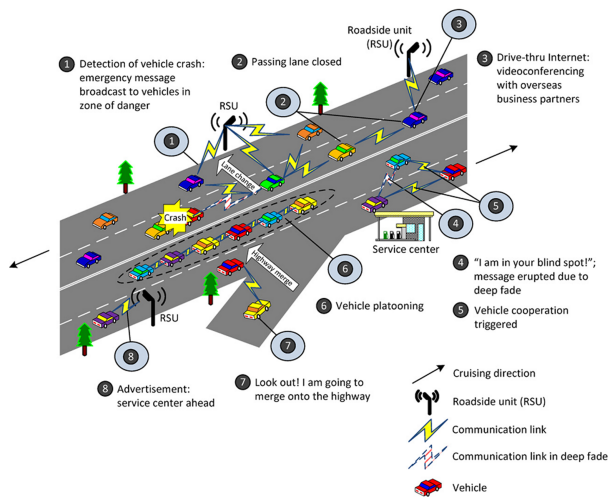


Fig. 1: Illustration of vehicular communication networks [1].

The aim of this work is to develop the real time situation identification model for adaptive service support in vehicular communication networks domain.

2. Related Works

Despite the fact that it is a huge amount of researches in situation identification in pervasive computing domain but there is very small number of researches where it is addressed the specifics of vehicular communication and cooperation.

One of the first examples of the situation reasoning in the vehicular communication networks domain was presented in [3]. This paper proposes an approach for context and situation reasoning in V2V environment. The context and situations modelling are based on Context Spaces and it is integrated with the Dempster-Shafer rule of combination for situation reasoning. This approach was applied to a context middleware framework that aims to facilitate context and situation reasoning to provide cooperative applications in V2V environment. This work does not assess the real-time requirements and virtual context sources in the proposed framework.

Other example analyzing the context and intra-vehicular context can be found in [4]. In this work authors presents an on-board system which is able to perceive certain characteristics of the intra-vehicular context of its EgoV. It was defined a formal representation of the intra-vehicular context. The proposed system fuses the data from different vehicle sensors by means of a CEP approach to perceive two characteristics of the vehicular context, the occupancy and the places or landmarks of the itineraries usually covered by the EgoV. The real-time constrains also was not addressed in this work.

The survey of context modelling and reasoning techniques can be found at [5]. Authors described the state-of-the-art in context modelling and reasoning that supports gathering, evaluation and dissemination of context information in pervasive computing. It was showed that the existing approaches to context information modelling differ in the expressive power of the context information models, in the support they can provide for reasoning about context information, and in the computational performance of reasoning. Unfortunately authors did not take into account the specifics of vehicular communication networks domain. Most of the analyzed methods are applicable to healthcare and other pervasive systems.

3. Specifics of Vehicular Communication Networks

Vehicular communication networks have special characteristics and features that distinguish it from the other kinds of mobile communication networks. The main unique characteristics:

- High energy reserve.
- Huge mass and size of the vehicle.
- Moving by the templates.

The vehicles have much bigger reserve of the energy comparing to ordinary mobile device. The energy can be obtained from batteries and it can be recharged by the gasoline, diesel or alternative fuel engine. The vehicles are many times larger and heavier compared to ordinary mobile networks clients and it can support much larger and powerful computational and sensor components. The computers can be provided by powerful processors, huge amount of memory and fast wireless connections (3G, LTE, WiMAX, 802.11p, etc.). Vehicles can move at high speed ($160 \text{ km}\cdot\text{h}^{-1}$) or even more so it is difficult to maintain constant V2V or V2I connection and to provide necessary services. However existing statistical data about traffic such as moving together by some templates or moving in the rush hours can be used to identify some types of situations and sequences of situation occur. The situation identification is also influenced by the scenario of vehicles movement. In the rural areas there are fewer obstacles and interferences but the driving speed is higher and the number of information sources is lower. In the city there is a high level of interference and obstacles however the driving speed is lower and number of information sources is higher (see Tab. 1).

Tab. 1: Influence of different vehicles movement scenarios.

Parameter Scenario	Rural	Town	City	Highway
Average movement speed	Average	Low	Very low	Very high
Node density	Low	Average	Very high	Average/low
Interference	Low	Average	Very high	Low
Number of radio obstacles	Low	Average	Very high	Low

3.1. Sensors for the Situation Identification

To identify the situation in the vehicular environment it can be used various sensors and other sources of information. The raw data can be acquired from physical

Tab. 2: Proposed sensors for the situation recognition in the vehicular communication networks environment.

Sensor	Update rate	Information source	Data exchange
Physical			
GPS	High	Vehicle	inV
Speed	High	Vehicle	inV
Accelerometer	High	Vehicle	inV
Temperature	Low	Vehicle	inV
Fuel quantity	Low	Vehicle	inV
No of passengers	Low	Vehicle	inV
Vision	High	Vehicle	inV
Voice commands	Average	Vehicle	inV
Radar (Milimetre wave radar system)	High	Vehicle	inV
WSN	Average	Environment	V2I
Wireless interface info	Low	Wireless equipment	inV
Virtual			
Calls	Low	Smartphone	V2M
Calendar	Low	Smartphone	V2M
Reminders	Low	Smartphone	V2M
User preferences	Low	Smartphone	V2M
Road information	High	Other vehicles government environment	V2I V2V V2M
Warnings	High	Other vehicles government environment	V2I V2V V2M
Interaction with other vehicles	Average	Environment	V2I V2V V2M

sensors deployed in the vehicle: video cameras, GPS, microphones, movement dynamics, vehicle parameters, etc. and from virtual sensors: user preferences, data from Smartphone/tablet (calendar, reminders, social networks) and from other vehicles data (warnings, road information, etc.). This collected data makes vehicle user context. The context of an entity is a collection of measured and inferred knowledge that describe the state and environment in which an entity exists

or has existed [6]. This definition includes two types of knowledge: facts that can be measured by sensors (physical or virtual) and inferred data using machine learning, reasoning or applying other methods of artificial intelligence to the current of past context. Due to discussed specifics of vehicular communication networks sensors used in the vehicles covers much broader spectrum than used in the traditional ubiquitous environment. Table 2 shows the proposed sensors for the situation recognition in the vehicular communication networks environment.

Due to not strict requirements of energy consumption it can be used more different sensors (physical and virtual) and it can be acquired and analyzed more data. In this way using the methods of artificial intelligence the situations can be recognized more accurate and faster. In the Tab. 2 can be seen the update rate of the data, information source and data exchange ways: inV (in vehicle), V2I (vehicle to infrastructure), V2M (vehicle to mobile device), V2V (vehicle to vehicle). Different sensors provide different data types: binary, numerical and features so the software and hardware must be able to deal with all types of data.

4. Proposed Model

Our proposed system model (Fig. 2) for situation identification in the vehicle communication networks domain infers situations and associates it with other situations in the system. The system acquires the data from different sources (physical and virtual) of sensors, then it is performed the information pre-processing and de-noising procedures. The processed data is transferred to the reasoning engine which employing different methods of artificial intelligence (logic rules, expert system, ontologies) associates the context with the data from different sensors. In this way the reasoning engine infers the current vehicle situation. By using the knowledge of the current, past and possible future situation the system selects best services, adopts it to the user and provides it.

5. Experimental Results

It was created a program to test the developed system (see Fig. 3) in LabVIEW graphical programming environment. It acquires data from various sensors with the cRIO Real-Time controller. It was used 4 AI modules to acquire 16 channels of context data at 40 kS·s⁻¹ per channel. A DMA FIFO was used to pass the data to the real-time controller, which then, via an RT FIFO, passes the data to a TCP/IP consumer loop and streams the data over the network to a host PC.

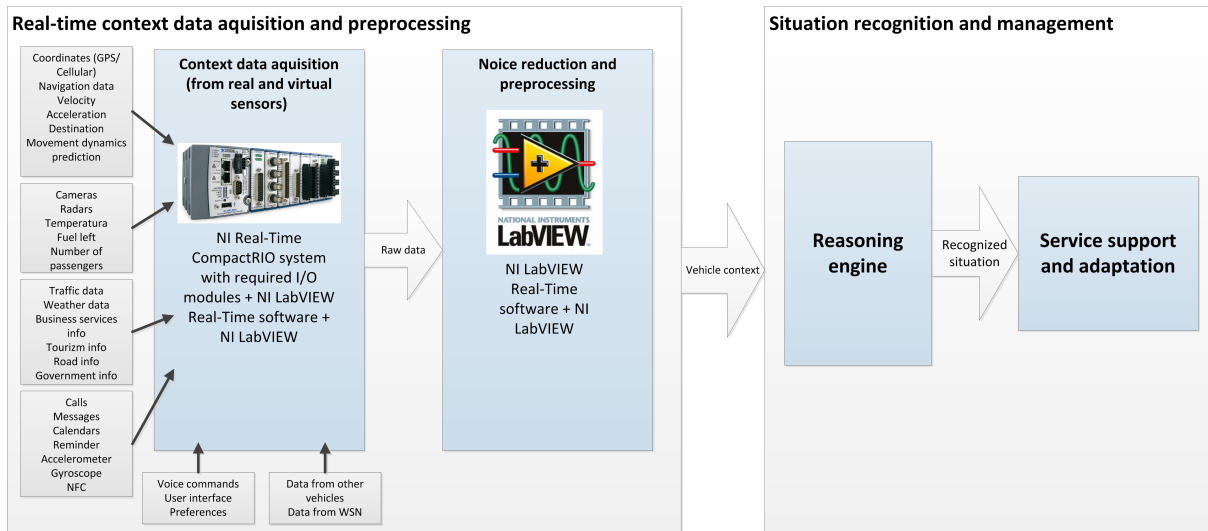


Fig. 2: Architecture of the proposed real-time situation identification model.

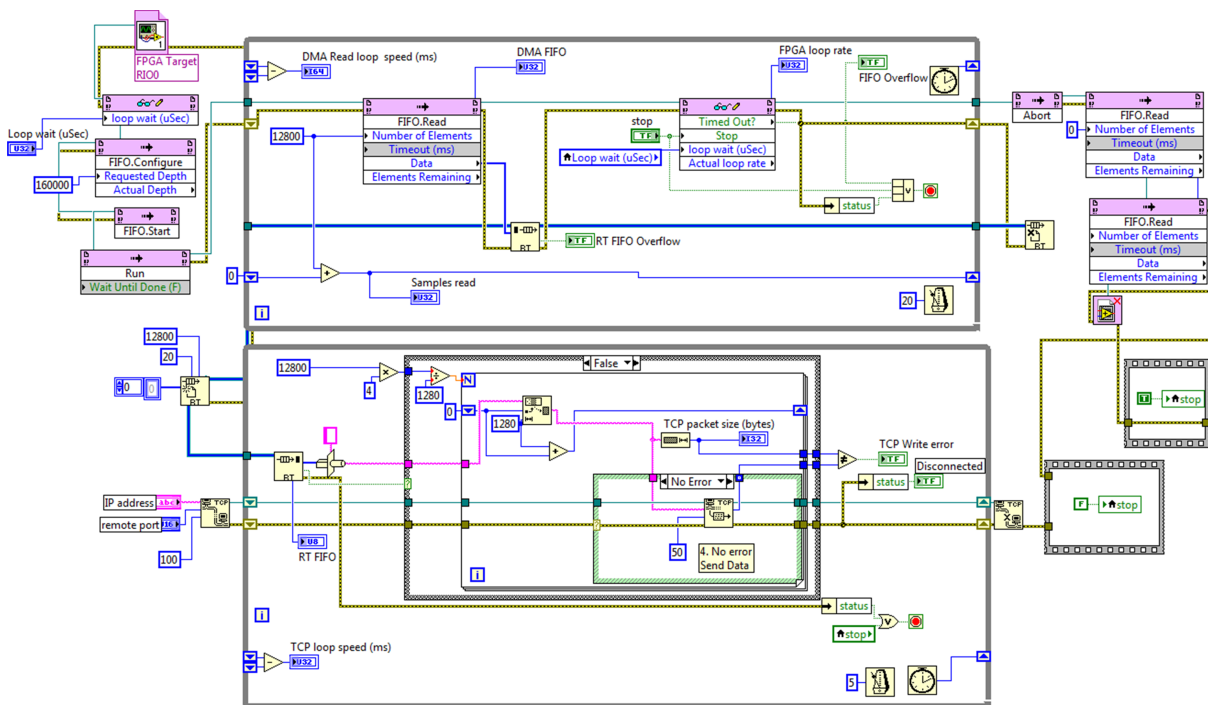


Fig. 3: LabVIEW environment program for the signal acquisition from sensors.

The PC Host program was used to get the context data to the host PC over the network (see Fig. 4). The data was pre-processed and transferred to the reasoning engine. Then the context data was transferred to the emulated mobile nodes (vehicles) in the ESTINET simulation environment. It was investigated the context data transfer capabilities in the mobile network.

The emulation were carried out in the simulation environment ESTINET 8.0 [7]. The environment was chosen as it uses the existent Linux TCP/UDP/IP protocols stack, it provides high-accuracy results; it can be used with any actual Unix application on a sim-

ulated node without additional modifications; it supports 802.11a/b/p communication networks and vehicle mobility modelling, user-friendly user interface, and it is capable of repeating the simulation results. In the experimental scenario the context data was sent from one vehicle to the other. Communication is provided via 801.11b standard interface and is used multi-hop data transmission method.

The experiment was carried out when the number of nodes in the network is from 10 to 100 - simulating different traffic congestion to determine the impact of the vehicle's number for the data-transfer ef-

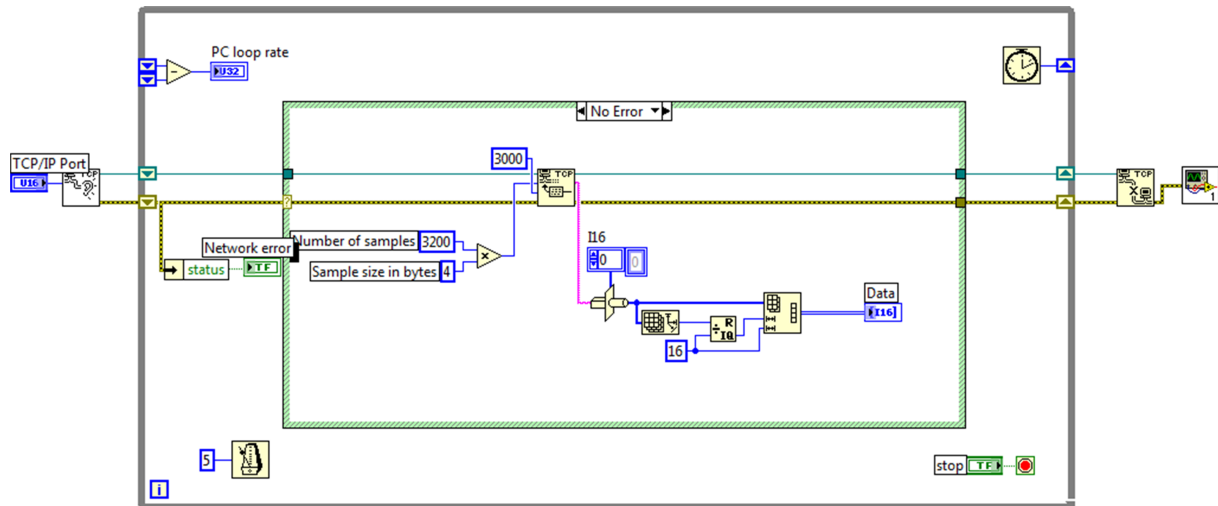


Fig. 4: PC Host program to get the context data to the host PC over the network.

iciency. Senders and receiver’s nodes are moving at high speed ($130 \text{ km}\cdot\text{h}^{-1}$) in the opposite directions. The remaining vehicles are moving at different speeds from $90 \text{ km}\cdot\text{h}^{-1}$ to $150 \text{ km}\cdot\text{h}^{-1}$, and their speed and directions of movement are spread evenly. These parameters are chosen to simulate the realistic movement of cars on highway conditions.

During the experiments the average data uplink and downlink throughput was measured (Fig. 5). In this case, the highest mean transfer rate achieved by the network operating 20 vehicles, while the meanest - 30. The maximum average data rate of downlink - 100 vehicles, while the meanest - 50. The data rate is sufficient for the real implementation of the solution.

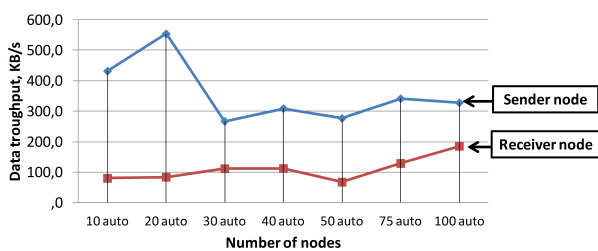


Fig. 5: The average context data downlink and uplink throughput with a different number of vehicles on the network.

Also it was found investigated collision’s dependence on sender and receiver nodes with a different number of vehicles (Fig. 6). Collision rate is directly proportional to the number of vehicles. Up to 40 vehicles, collisions rate at the receiver and sender nodes is similar, but from 50 vehicles, collision is greater in sender node because of unsuitable channel access mechanisms.

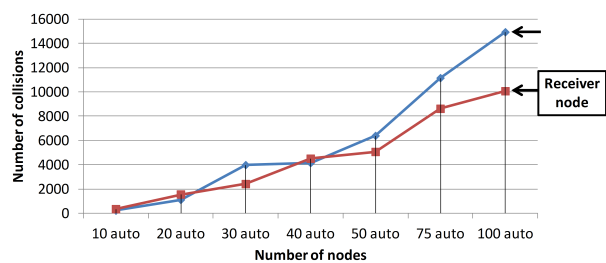


Fig. 6: Collisions rate dependence on receiver and sender nodes with a different number of vehicles on the network.

6. Conclusion

In this work we present our developed real time situation identification model for adaptive service support in vehicular communication networks domain. We have tested our solution during various experiments. The results showed that the solution is able to work in the real-time vehicular communication networks environment. There are still many problems in the field of routing protocols with a huge number of nodes. Future plans are to extend the study and to test the system in real life vehicular environment.

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