Methods of Interaction Between Multiprotocol Unit and Telematics Map Cloud Service

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Abstract: Continuous access to the service from the moving vehicle improves safety and provides ecological compatibility of transport infrastructure functioning in big agglomerations conditions. The lack of the guaranteed signal level of global and local networks requires new approaches to form the strategy for connection continuity provision. We offer the technology enabling to form the transport facility network by appealing multiprotocol unit and telematics map. The method suggest using external data concerning global and local wireless networks in each vehicle. The approach involves collecting networks data by means of the multiprotocol units, transmitting of these data into cloud service of telematics map, the data generalisation and to meat the query about available networks in the vehicles vicinity. The completely automatic technology of data control is designed in such a way that it can provides external data for multiprotocol routing in integrated vehicle networks. In order to check the suggested approach we performed experiments and dives the information system prototype that demonstrated its efficiency. Technical feasibility of the information system was confirmed during the experiments.

1 INTRODUCTION

Evolution of the telecommunication components of intelligent transport systems involves the continuous bidirectional communication between the vehicle and cloud services through V2V, V2I mechanisms (Zaborovskiy et al., 2013; Zaborovski et al., 2013). The stable connection at any point along the route of the vehicle performs MPU (Cheng et al., 2010; Ku et al., 2014), which supports the connection of the vehicle to multiple networks by different technologies. While driving on the highway MPU analyzes the current state of available wireless networks and connects the vehicle to the best of them (Jaworski et al., 2011).

The fundamental problem is the limited range of available networks: the vehicle can get information about available DSRC and Wi-Fi networks in the radius of 300 meters, but it is impossible to construct a map with all the connectivity options along the entire route, including the network 3G/4G (Gramaglia et al., 2011; Remy et al., 2011). On the other hand the presence of a complete list of telematic resources located on the route of the vehicle, would eliminate the costs of implementing local dynamic routing protocols that create multiple additional service traffic on the wireless network which negatively affects the bandwidth (Glazunov et al., 2013).

An alternative to the local dynamic routing can be external routing is based upon the cloud service telematics map. Telematics map shows a set of telematic resources in the region of the generalized time (Glazunov et al., 2013; Zaborovsky et al., 2011). In this case, telematics card is used as a repository of data about the location and the network access point parameters. Then the problem of data management telematics map is in continuous data collection, processing and transmission of data on telematics environment with geographic coordinates and time of each vehicle is connected to the system. Continuous interaction of a large number of mobile subscribers generates a large amount of raw data that requires adaptation algorithms for acquisition, processing and transfer between users.

The solution is to develop an adaptive algorithm interaction between multiprotocol unit and the telematics map cloud service in order to minimize the volume of service traffic and maximize the connection time to the network.

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2 THE INTERACTION ALGORITHM OF CLOUD SERVICES BETWEEN TELEMATICS MAP AND MULTIPROTOCOL UNIT

Telematics map cloud service also ensures data accumulation about potential access points to the Internet, which includes the signal level and access mode. This can be used for various technologies such as LTE, DSRC, stationary Wi–Fi, and vehicle MESH network. Figure 1 shows part of the internal description of the telematics map and its interpretation on the roads map.

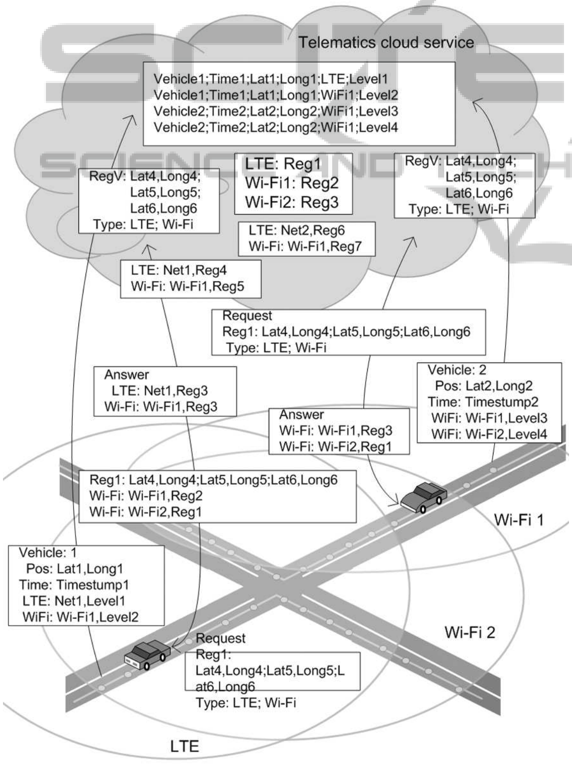

Figure 1: Access points to telematics resources and their geographic interpretation chart.

To solve this problem, telematics service provides a set of low-level map management techniques to insure bidirectional exchange depending on the hardware and software features of the multiprotocol unit. The main methods should include:

1. The primary data collection about:
   - interfaces status of the telematics devices in the vehicle;
   - interfaces sharing;
   - signal levels available in networks on each vehicle interface during movement;
2. Data aggregation on the network environment in a specific geographic location.
3. Response to query about telematics capabilities in the geographic region.

The main technological challenge is to maintain the service state of the relevance of telematics environment data. The system provides to each vehicle the continuous data collection and systematisation on the network state in asynchronous mode.

Interaction multiprotocol unit vehicle and cloud service consists of three stages:

- transmitting data about telematics environment from the vehicle;
- aggregation of data about position and access time from access points;
- data about the available networks back to board the vehicle.

Interaction scheme between software modules in a telematics map and multiprotocol unit is shown in Figure 2.

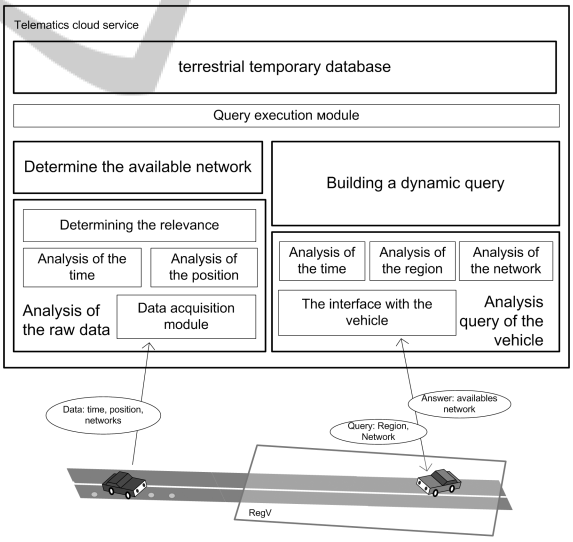

Figure 2: Modules interaction between cloud service telematics map and MPU.

Periodic polling of signal level of global and local networks is carried out continuously on multiprotocol unit. The frequency of the survey depends on the speed of the vehicle. Data is written to a local file on MPU and will be transferred to the cloud service upon the occurrence of the right moment: for example if there is a wide or free link to the cloud.

Generalisation of the transmitted data on the network state on the cloud is performed in the module based on two criteria: the network availability and the time-averaged signal level at the current point.

If necessary, each node (MPU) performs request to the cloud service, transferring data on the parameters of their technical means and the desired region to obtain data on telematics environment.

Selection of available networks is based on network's spatiotemporal database query for each network type with a vehicle's predetermined region.

The interaction of the vehicle and the cloud service for the data transmission about the available telematics resources is performed via local or global communications channels available on MPU.

Interaction algorithm between the vehicle and cloud service is implemented by means of data collection and evaluation about the network state.

Parts of the algorithm are distributed between multiprotocol node modules and analysis query module of the network status of cloud service. They provide dynamic frequency selection survey of Wi-Fi and LTE networks, depending on the speed. The flowchart is shown in Figure 3.

The proposed concept and interaction algorithms are implemented in the layout of data collection and processing of telematics environment.

3 IMPLEMENTATION OF INTERACTION BETWEEN MULTIPROTOCOL UNIT AND TELEMATICS SERVICE MAP

Implementation of algorithms interaction between multiprotocol node and cloud service is carried out by technical means of hardware and software testbed of multiprotocol nodes (Popov et al., 2014). For the experiment testbed was assembled shown in Figure 3.

Multiprotocol node is equipped with a GPS BU–355S4 receiver, built-in Wi–Fi AR9285 adapter of 802.11bgn standard and 4G M100–4 modem for data transmission.

The functions of MPU include periodic status query for Wi-Fi and LTE networks. Data are collected into a local file, and then sent to the server via LTE channel.

The functions of the server is to receive the data file, placing the original data in the database, the implementation of a selection query in view of geographical and temporal parameters and the response to a multiprotocol unit request. To perform these functions on MPU and server the application packages are used: the database server MySQL and communication channel openvpn. Registration of Wi-Fi

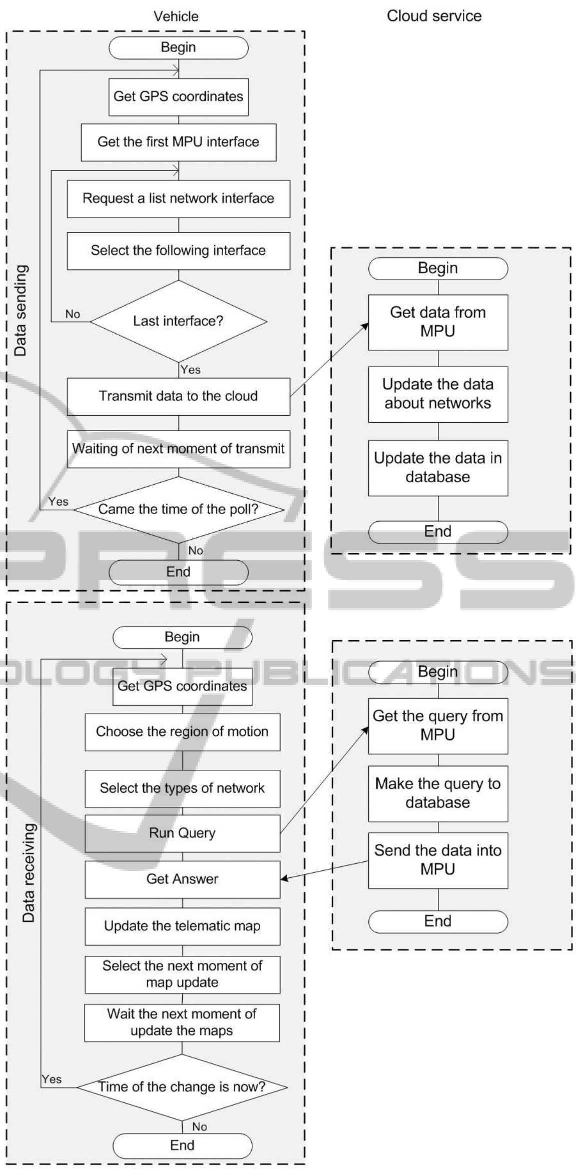

Figure 3: Interaction modules cloud service telematic maps with multiprotocol node.

parameters and GPS coordinates is carried out using the program kismet, LTE registration is performed by periodic calls of AT-command "CSQ". These packages function in the operating system Linux Debian 7.4 on both the server and the MPU.

Scheme of interaction testbed software is shown in Figure 4. Initial values for the experiment are shown in Table 1.

Frequency of coordinate obtaining from the GPS receiver is limited to 2 Hz due to the implementation constraints of the average receiver chip range. Besides, the device driver operates at a speed 4800bit/s through a local communications port.

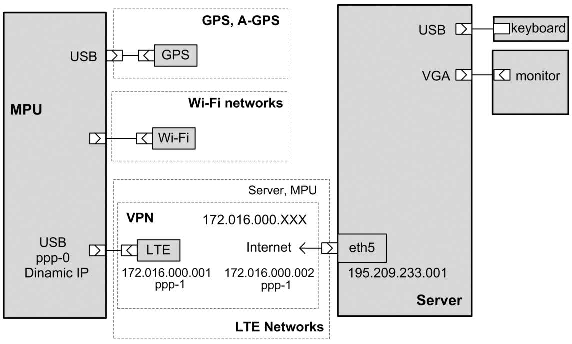

Figure 4: Hardware and software stand configuration for the experiment.

Table 1: Initial values for hardware and software environment.

Parameter	Value
The path length, km	3,21
Coordinates source	GPS
Data storage method	In local file
Coordinates polling rate, Hz	2
Wi-Fi polling rate, Hz	10
LTE polling rate, Hz	2
Traffic type	UDP
Channel type	Tunnel over LTE

The advantage of the installed software is the polling frequency of local and global networks does not depend on the GPS devices polling frequency, which enables to run these processes in different threads of the operating system and improves the signal representation accuracy. Scheme of software interaction to survey local and global networks on MPU is shown in Figure 5.

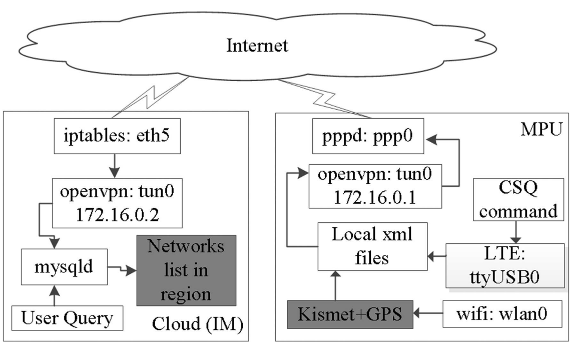

Figure 5: Software interaction chart for scanning the local and global wireless networks.

4 TESTING OF SCANNING TECHNOLOGY FOR WIRELESS NETWORKS AVAILABLE FROM THE VEHICLE

To verify the algorithm operability and data management technology of telematics map, we've conducted a series of field experiments in the driving conditions of the vehicle with different average speed in a real radio situation of a large city. Main goal of these experiments was to demonstrate the operability of proposed algorithm during collection, processing and transmission of data about global and local wireless networks while driving the vehicle in city traffic conditions. For this purpose the multiprotocol unit prototype was installed on the vehicle which moves on predefined ring route. In motion, the multiprotocol unit collects data with signal level of available global and local wireless networks. Vehicle's trajectory is shown on Figure 6.

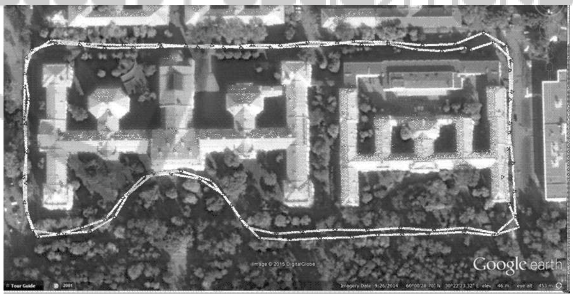

Figure 6: Vehicle's driving route.

Experiment, which shows the operability of the data collection technology, consisted in continuous screening of global and local wireless networks for availability and signal level from the vehicle. For each stage of experiment we determined average speed and calculated driving time, number of GPS points, number of global and local networks polls, number of registered local networks, average signal level at given point and the network working range. Summary results of this experiment are shown in Table 2.

During our experiments consisting of collection and transmission of data about available wireless networks we've revealed the dependencies of transmitted data size and number of networks on the average vehicle's speed under stable radio conditions. Figure 7 shows charts with dependencies of number of networks and transmitted data size on the average vehicle's speed. Charts show that the number of registered stationary wireless networks drops with increase of average speed, which is explained by decrease in polling rate due to route length. Transmitted data

Table 2: The parameter values.

Parameters	Vehicle speed						
	10	15	18	20	23	26	28
The driving duration, min	16	10	8	7	6	5	4
Data amount, KB	697	504	480	457	354	274	200
Average signal level LTE, dB	-59	-64	-65	-67	-67	-68	-69
Number of registered networks Wi–Fi, num	215	181	179	164	159	159	155
Average visibility time of Wi–Fi networks, s	28	19	10	7	6	4	3

size dramatically drops too with increase of average speed owing to decreasing number of registered networks and decreasing polling rate, which is caused by shortening the time spent on the route. This allows to draw a conclusion about the multiprotocol unit's operational efficiency for the purposes of signal level registration of global and local networks. Figure 8 shows dependency between visibility time of stationary wireless network by the vehicle's multiprotocol unit and vehicle's average speed by the example of four wireless networks.

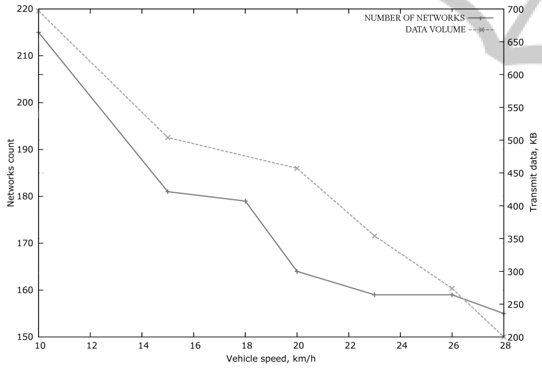

Figure 7: The number of detected networks and the volume of data for different the average speeds of the vehicle.

The volume of transmitted data decreases linearly with the increase in the average speed as a consequence of reducing the number of registered networks. As a smaller number of polls to the network is caused by a decrease in travel time, which leads to the conclusion about the effectiveness of the multiprotocol node in signal level registration of local and wide-area wireless networks.

Figure 8shows the dependence of the availability of fixed wireless network access point from multiprotocol node with the average vehicle speed for the four networks.

The graph shows that for all achieved average vehicle speeds range,networks availability is reduced by no more than 35%, which reliably provides their registration by technical means from multiprotocol nodes.

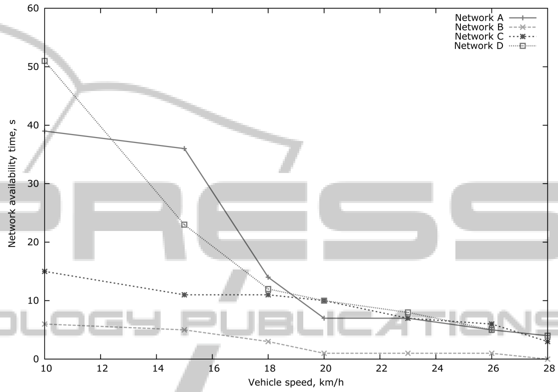

Figure 8: availability duration of the wireless networks for different average speeds of the vehicle.

Study of the dependence of LTE signal levels shows a trend to some reduction in the ratio "signal to noise" at higher speeds, but that does not disconnect link or reducing the speed of data exchange between the multiprotocol unit and the hardware-software testbed of telematic map cloud service. To demonstrate the efficiency of data obtaining from the telematics maps a series experiments was carried out. In each experiment in each vehicle position the query in of telematics maps cloud service was executed. The results are compared with the radio environment.

To this end, the vehicle moving along the path as shown in Figure6, polls the GPS sensor, runs the queries to the telematic maps database, registering current values of radio environment, and checked their compliance with the data obtained from the telematics service.

Figure 9 shows the results of comparison with wireless networks identifiers that are received directly on multiprotocol unit and those from cloud telematics map database. The histogram shows sustainable coincidence of the networks lists derived from cloud service and those directly found in the air. This suggests the applicability of the proposed technology for obtaining wireless networks lists from cloud telematics service at all vehicle's speeds.

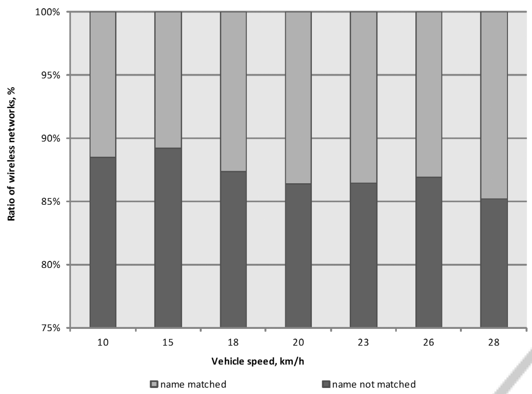

Figure 9: The histogram of the number of coincided wireless networks names between cloud and the multiprotocol unit.

5 CONCLUSIONS AND FUTURE WORK

The described technological environment of telematic maps cloud service and multiprotocol unit interacting with it provides data management of local and wide area wireless networks in the moving vehicle. This expands the of multiprotocol routing possibility in heterogeneous vehicles networks by increasing the visibility scope of the vehicle networks. Further development of the work should be the realization of user's uninterrupted access to the network, by forecasting the most suitable moments and data channels inside the software procedure of the routing multiprotocol node.

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