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Vehicle Weight Detection Sensor Development for Data Collecting in Sustainable City Transport System

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Abstract – **The technical solution for smart city concept is offered in the article. The IoT supporting new generation of control concept is developed for smart city paradigm. The offered unified wireless data transmitting concept is deployed as wireless transport vehicles weight control tool. The integrated weight sensor is developed and demonstrated in this article. The offered sensor is integrated in IoT paradigm, and aimed to obtain data from primary source and transfer it to Intelligent Transport System (ITS) in order to use those data for transport flow modeling. The data transferred to ITS will be used acquired used elements of offered the system: sensing technologies, data transferring, simulation of traffic flows and decision making. The developed solution is compatible with IoT on-line traffic management system and next generation of smart city control system.**

Keywords – **sensor development, data collecting, transport system, sensing technologies.**

I. Introduction

The freight traffic corridors are quite effective in order to organize effective freight transport flow in the very limited city conditions. The modern City transport system usually is overcrowded, and the separation of fright transport from private cars and public transport flows is a usual practice to solve traffic jam problem in city conditions. For example, there are limitations of freight transport movement in the city centre and over river Daugava bridges in the rush hours in Riga. Many technical constructions, like bridges are very sensitive for a vehicle weight. The offered solution will allow automatic finding of vehicles, which do not take into account weight limitations when cross the bridges. It will make easy work of a transport police, and will improve transport constructions reliability. For future IoT based ITS development it will be significant to receive as much as possible real data about the vehicles, aiming to plan the transport flow system more effective. This article deals with a sensor development for weight data collecting. Obtained data are used as a basis of data for modelling. It is necessary to combine at least four elements of the system: sensing technologies, data transferring, simulation of traffic flows and decision making. The weight sensor development and testing has been already preformed in a laboratory conditions. Furthermore, different additional services could be added to the system, like weight control system, etc. Using real data, it would be possible to offer a detailed concept of the on-line traffic management system.

II. IoT approach for data transferring

The joint data transferring concept have been offered during this research, and it is shown on Fig. 1. The embedded sensors are deployed in the objects of infrastructure networks and collect data about consumption, and transmit them to central control services. The transformation of collected data received from different infrastructures objects in the same format gives a possibility to create common control opportunities of existing infrastructure systems on different stages of service providing timeline. The Internet of things approach and in particular the use of Constrained Application Protocol (CoAP) provides significant benefits in terms of generalization and reimplementation of existing methods and protocols (e.g., HTTP protocol requests methods and data formats like XML and JSON).

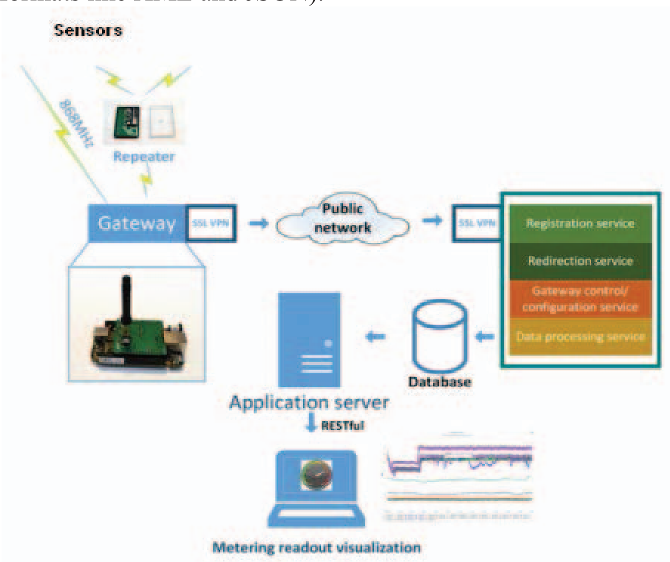

Fig. 1. Data transferring.

The collected historical and on-line data practically are used for both traffic online monitoring and forecasting tools. In typical wireless sensor network scenarios, where limited resources are designated to the prolongation of the overall systems lifetime, the basic paradigm of low-power, efficient networks architecture still is a priority. The data transmitting technology, external feeding of network as well as MESH data transmitting are the main directions to increase lifetime of a wireless network. The increase of a usage of the smart sensor [1] devices and integration into household and industrial environments provides new ways of adaptive reaction and information flow. Critical infrastructure based meter readings can be merged into the systems that have been previously operated independently. Based on this approach a new IoT concept can be implemented, where the main challenges are connecting different applications and technologies into one coherent network by providing common set of standards for interfaces, protocols, gateways and backend systems by providing a reference IoT architecture. The wide variety of possible candidate protocols [4] for IoT includes: MQTT, MQTT-S, REST API, XMPP and already mentioned CoAP:

MQ Telemetry Transport (MQTT) field devices with cellular or satellite backhaul – high traffic costs scenarios with two-way communications over unreliable networks.

Battery powered devices with low power consumption. Device may sleep, but not 95% of the time. The integration with other network elements (including legacy network elements) is realized via all possible level of integrations: hardware connectors, protocols or even on the level of data base integration. NAT traversal (Network Address Translation traversal) to be addressed as an afterthought – important, but not critical MQTT-S – variation of MQTT protocol aimed at embedded devices non-TCP/IP networks, such as ZigBee. Potential to scale 10% times more devices comparing to MQTT. NAT traversal might become a larger issue comparing to MQTT should be addressed during the next planning stage. REST API one-way communication from device to the cloud. NAT traversal around the globe is among the top priorities. No specific limitations to the traffic + devices themselves are not very resource constrained. "Device Cloud" for the open development communities. Home/Office CPE with good WAN connection – WLAN Routers or Home Gateways.

Internet of things concept reusing existing technologies as RESTful Web Services by implementing CoAP protocol provides an extensible system that integrates heterogeneous infrastructures and smart device environments aiding the monitoring and decision support systems for information harvesting and critical infrastructure coordination and events detection. This also implies machine-to-machine communication.

The main advantage of proposed IoT approach is its communication simplicity in general that supports very flexible environment. The digital environment must be able to handle several data streams from different inputs (such as sensors and actuators, human input, etc.) and be able to store these data into local or distributed cloud environments that are able to communicate effectively with each other. This applies to combine the data generated in the assets itself as well as the data from the multiple assets and to define digital applications which supports the enhanced communication.

III. SENSOR DEVELOPMENT FOR DATA COLLECTING

The beta prototype of developed wireless scale controller is shown on Fig. 2.

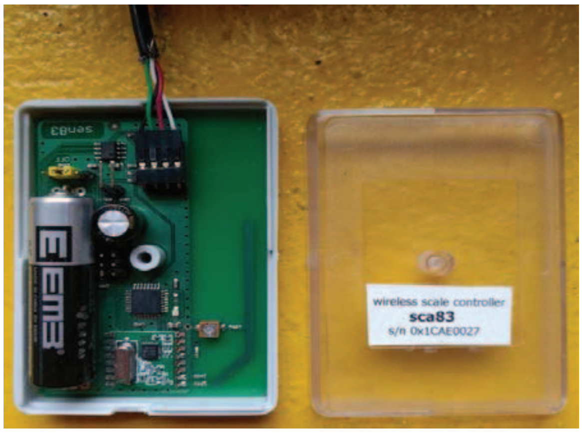

Fig. 2. Wireless scale controller.

After the sensor development it is significant to make construction elements for platform.

Proposed solution main advantages:

- Network layout can be optimized to suit environmental situation using selectable interfaces that scale with existing/legacy infrastructure;
- Modulatory offers easier extension keeping the base system components;
- Extensibility offers the possibility to expand multi interface operation by combining different communication protocols with external or third-party equipment/systems;
- Inter-system communication data exchange is provided in self-describing formats (e.g. SenML implementation) allowing easier integration and compatibility;
- Cross-system communication data exchange is provides using RESful architecture (e.g. CoAP implementation) allowing IoT convergence and Internet based data exchange;
- Core platform provides expandability for diverse sensor and metering equipment.

IV. PLATFORM DEVELOPMENT

The development of the platform is next step to develop functional model of vehicle [3] weight detection service.

Fig. 3. Platform load cell.

The base of the platform is stable construction. It is shown on figure below and has been successfully tested during the experiment.

Fig. 4. The construction of platform.

After the sensor and platform development, it was combined, calibrated and tested together for receiving the results. The connection is made to gateway node – selectable inter-system and backend communication interface architecture. This provides request and readout pre-processing and secure data delivery and queuing.

V. System solution and modeling

The roadside reader, weight station with static scale must be integrated in one system and will work together to collect real data, as it is shown below at the model.

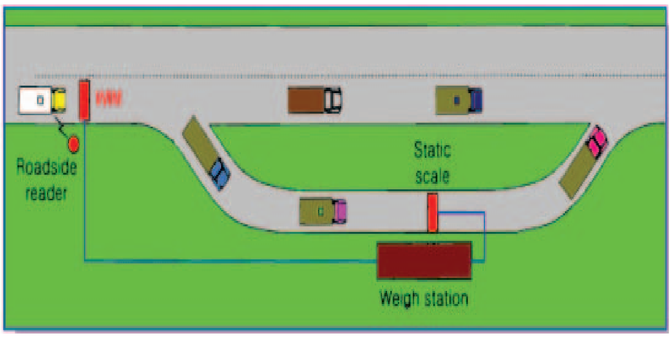

Fig. 5. Model and data transferring.

Next step is real experiments to check sensors and platform work. Offered sensor and platform can be used in real traffic condition in the way, which is shown using specially developed model (Fig. 5).

VI. Experiments how to collect real data

Experimental results are positive. It is possible to conclude, that developed sensor and platform can give precise results about weight and successfully transfer data for obtaining and usage.

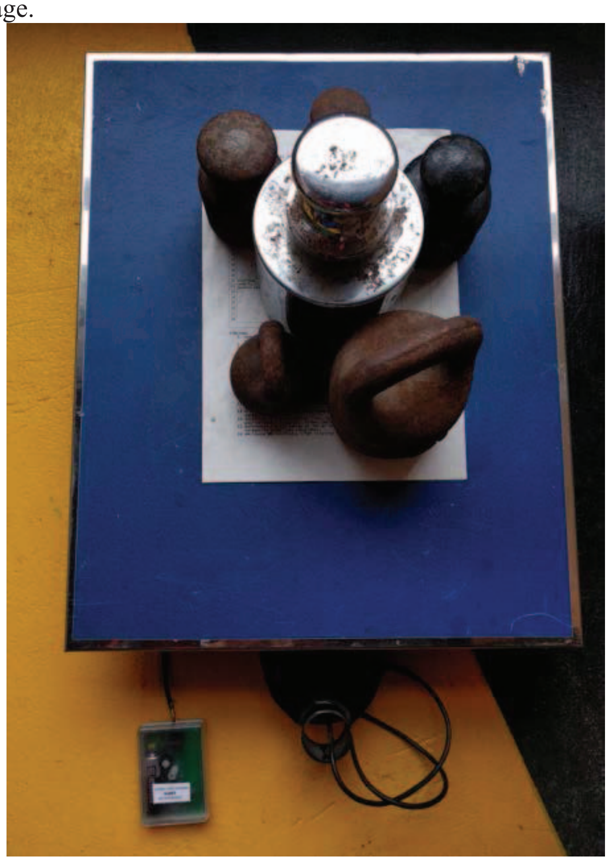

Fig. 6. Experiment.

Modeling results are shown on figure below.

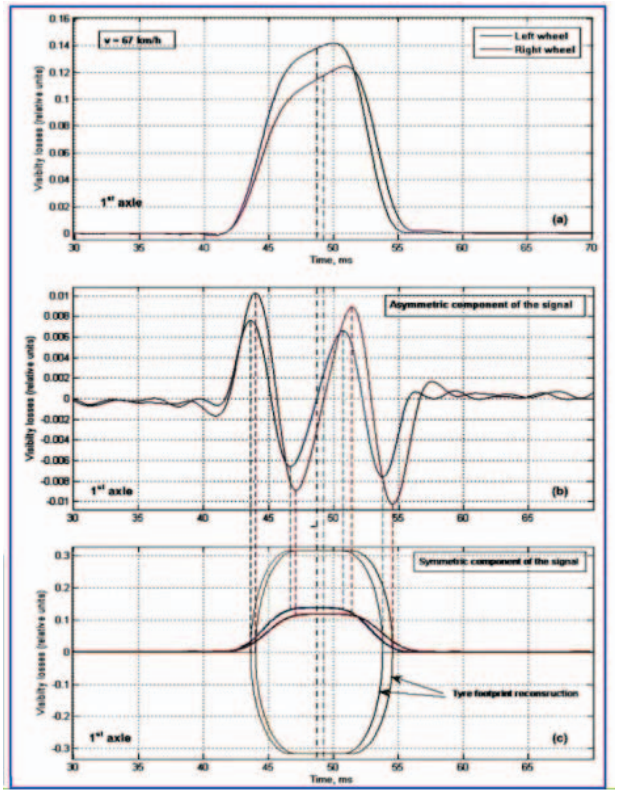

Fig. 7. Modeling results.

Very significant is to organize data transferring for further obtaining the information. From the collected data it is possible to analyze the lost data packet distribution on the timeline. It shows 2 or more ratio transmitter data packet collisions, that can happen when the microcontrollers frequency coincides with high precision. For 5 sec. transmission interval the ratio would be 1/100, that is 1%. For short transmission intervals the probability of collisions is high. But in real life scenario the ratio would be 50ms/60000ms, that is 0.012% by so the collision probability is very low and can be considered non-important for the selected application. The initial registration server can send a redirect to another registration server or direct the gateway to post received messages to a specific server. The gateway polls its radio interface for received data, validates the telegrams and prepares there for sending. It the send operation fails, the gateway moved to offline mode, where data is stored into a local database until network connection is available, if no writable data storage is available.

VII. Practical Usage: traffic online forecasting tool

Possible usage of developed sensor in real traffic system conditions shown on figure below.

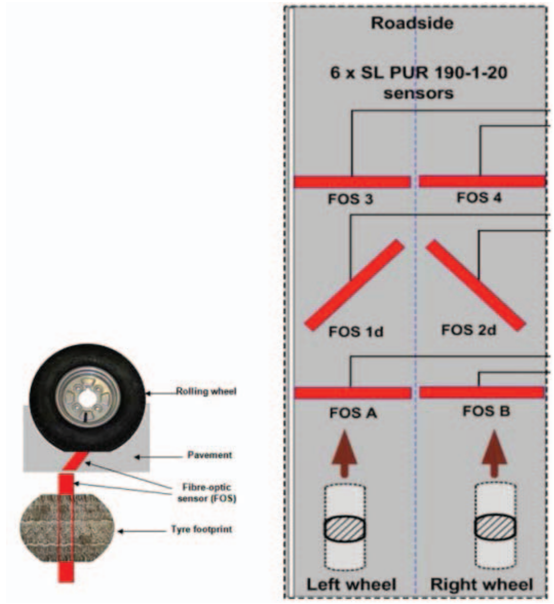

Fig. 8. Possible usage of developed sensor.

Traffic online forecasting tool consist of three main parts: data sources, data processing model (core) and results publishing. Figure above shows traffic online forecasting tool in more details. The possibility to manage traffic and future smart city control tool development are supported with this solution. IoT approach helps to integrate different city infrastructure cervices and supports of critical infrastructure control approach. Critical infrastructure [3] is an asset or system which is essential for the maintenance of vital societal functions. The IoT paradigms allows to integrate existing infrastructure control methodology and realize system of system control requirements as well as gives guidelines for definition of self sustainable and energy independent region paradigm.

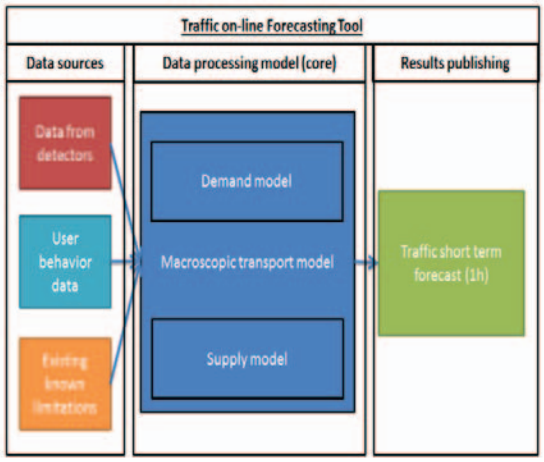

Fig. 9. Traffic online forecasting tool.

This methodological approach in particular in development of data transmission paradigm for large distributed infrastructure system is fully supporting sustainable region paradigm with autonomous critical infrastructure control possibility on dedicated region.

VIII. Conclusions

The control of large scale dynamical systems is one of the biggest challenges facing control engineers today. At the end of the current research it is possible to conclude that experimental results are positive and offered sensor can be used in the frame of offered model, as well as in other cases.

Furthermore, Wi-Fi rooters or any kind of gateways, which enable link with partner's servers, will be used. The output of gateway could be Ethernet and TCP/IP protocol. The requirements to the gateway interface, to output data and protocols are necessary in order to ensure sensors measurement delivery to the partner's servers.

Acknowledgment

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