Environmental sensors in the world of smart life technologies

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***Abstract*— This paper proposes the creation of sensoric network and digital platform to store and process measured data. Motivation for the research was to improve life in the city and to build capacity in Smart Life technologies. In first part we provide literature review on the sensors and their use in smart cities environment. We designed the sensoric network based on the low-cost sensors being placed on over two hundred locations over the city. We describe the parameters of the sensors used in our planned network. Then we designed the platform that will facilitate data collection, processing and interpretation. The short description of the platform and technologies used are provided. The technologies used are based on open-source principles.**

Keywords—smartlife, sensors, digital platform, smart city

I. INTRODUCTION

Smart city is a concept that is not that new. Over the years it developed into an attractive feature of modern city. There is not probably a well governed city that has not considered its smart city strategy. In European Union (EU) there are hundreds of strategies targeting smart technologies in order to improve the life in the cities and towns. These strategies range from technological innovations trough smart policy making to new forms of smart citizenship. In our proposed project we focus on use of new technology of low-cost sensor deployed trough the city in order to improve both the smart management of city and use of data to improve life of citizens.

The goal of the project is to create a network of academic workplaces, start-ups, bigger and smaller private companies that gain considerable knowledge in sensoric network from construction of sensoric points to interpretation and translation of collected data to providing people and municipalities with everyday usage of smart technology and sensors data democratization access. This capacity-building effort includes our work of building an advanced platform for processing and storing the data. This kind of research has not been realized in Slovakia up to this date and regarding the platform we did not find the relevant literature describing the architecture and principles to build one. There is a lack of skills and knowledge in the field of smart sensoric networks in scale and there is also a push for wider use of smart technology in the country.

Outcome of the research could be further used in developing heterogeneous sensoric network utilizing multiple network technology and concentrating data into one accessible place (ie smart municipality platform) in other cities and towns in the country. It is considered to be important part of building knowledge economy for the 21st century.

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II. LITERATURE REVIEW

Most people today live in the urban areas. UN report [1] predicted that 55% people lived in cities in 2018 and that by 2050 the number will increase to 68% of population. Cities have always been dynamos of innovation, development and economic, social and cultural evolution. We are presently on the verge of a civilization transition featured by the so-called Smart Cities.[2] The agenda of becoming smart city is present in such different cities as Tokyo, currently the biggest urban area in the world and small Spanish town of Santander [3]. EU funded a project on development of smart cities Smarter Together, with an objective to improve citizen's quality of life in nowadays transforming cities finding the right balance between information and communication technologies (ICT) technologies, citizen engagement and institutional governance to deliver smart and inclusive solutions [4] and its previous EU's Horizon H2020 Smart Cities and Communities Lighthouse programme [5]. According to Kim, Ramos, Mohammed [3] the main features of a smart city include "a high degree of information technology integration and a comprehensive application of information resources. The essential components of urban development for a smart city should include smart technology, smart industry, smart services, smart management and smart life". Camero, Alba [6] say that maybe it is an iterative procedure where cities get smarter in time. Most definitions of smart cities encompass the same concepts of a holistic vision of subfields, importance of CS/IT, citizens as the main target, open data, and sustainability.[6]

Smart cities provide opportunities on many levels from use of ICT technology in a form of IoT (Internet of Things) to making the cities better governed and managed. IoT usually means deployment of various sensors and collection of big amounts of data. These need to be processed, interpreted and translated to the stakeholders in the cities, including policy makers, practitioners and citizens.

The internet of things (IoT), which is known as one of the key enabling technologies of smart cities, generally refers to the network of smart objects, which are embedded with sensing, computing, networking, and actuating capabilities that all together enable them to collect and exchange data. The IoT devices are usually wirelessly networked, and they serve as a key enabling technology for many critical smart city applications, such as intelligent transportation, smart grid, smart building, and mobile healthcare. [7]

The sensors help to make cities smart in areas of mobility (ie carshares), energy (ie heating), and knowledge (decentralized fabrication). The three categories of data

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collection in cities—opportunistic sensing, ad hoc sensor deployment, and crowdsensing—can be hybridized to a various extent. [8] There are several types of network sensors, and they play several roles in smart cities: [9]

1) Electronic sensors, including environmental surveillance sensors, parking sensors, and speedometer sensors among others. They can also learn to interpret video data, and with the help of machine learning and neural networks they can learn to analyze video, image, and natural speech.

2) Chemical sensors, including carbon dioxide sensors, oxygen sensors, electronic nose and catalytic bead sensors etc.

3) Biosensors, including the ionizing and subatomic sensors such as neutron and MEMS sensors among many other biosensor devices. Biosensors mainly work in the biomedicine's field.

4) Smart Grid Sensors including thermal sensors, smart power meters, smart personal sensors. They are utilized in smart grids to ensure efficient generation, transmission and distribution of power from the generating source to the end users

There are many examples how the sensors can be used. [10] Sensors can be used for air quality monitoring system and object detection [11], or as parking sensors [12] [13]. They can be used in industry for industrial analytical infrastructure [14]. Other sensors can record air quality, thermal comfort and traffic indexes [13] and air pollution exposure [15] [16]. They are deployed in large quantities aimed to measure the noise pollution, or the filling volume of the bin [13]. In smart cities they can be used for detection of emergencies and for proposed emergency alerting system. [17]

III. Sensors and Platform

We plan to utilize environmental conditions sensors, noise sensors and weather sensors. Data from sensors will be gathered in the platform that will provide the processed data for mobile application for citizens, web for municipal government, and third parties, start-ups, bigger and smaller private companies.

Technical parameters of sensors to be deployed includes possibility to add modules, connection to power supply with backup battery and data connection (LoRaWAN, GSM/GPRS or 4G).

◦ Temperature: -40 ° C to + 60 ° C, accuracy ± 0.5 ° C (in the range 0 ° C to + 40 ° C)

◦ Relative humidity: 0% to 100%, accuracy ± 3% (range 20% to 80%)

◦ Acoustic noise level: 40dbA to 110dbA, accuracy ± 3dbA (without sending, storing and the possibility of audio signal reconstruction)

◦ Atmospheric pressure: 900hPa to 1100hPa, accuracy ± 1hPa (at a temperature of 0 ° C to 40 ° C in the whole range)

◦ Vibrations and magnetic fields

◦ Concentration of dust particles PM1 and PM2.5: 0 µg / m3 to 500 µg / m3, accuracy ± 10 µg / m3 (in the range 0 µg / m3 to 100 µg / m3)

◦ Concentration of dust particles PM4 and PM10: 0 µg / m3 to 500 µg / m3, accuracy ± 25 µg / m3 (in the range 0 µg / m3 to 100 µg / m3)

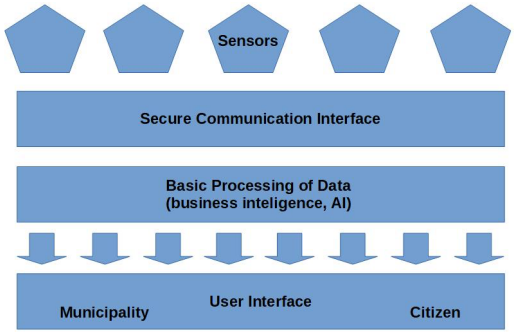
◦ Lighting intensity: 0 klx to 100 klx, resolution ± 1 lx

◦ UV index: 0 to 10 UVI, accuracy ± 2 UVI

The sensors will be placed in cooperation with the municipality at app. 200 places and will create citywide network of sensoric points. Reliability of data obtained by our sensors will be checked comparing to the national meteorological measurements from the same location. The fact that one of the partners of this project is also Slovak Technical University, participating in the sensors development, the validation of the measured data has strict scientific overview.

Various aspects of implementation of sensors into the city environment have to be taken into account. One of the challenges was to design a sensor box that could be placed in the protected historical areas of the city.

After data are collected from sensors they will end up in the municipality platform. Platform will enable us to process heterogeneous sets of data into uniform useful form for their further use in business intelligence applications, data evaluation and quality of data control. Platform will provide us with a feature to store the data in the long term. It will enable the use of executable models based on the use cases. Within the platform we will define security of data storage and transfer and the safe output interface for third parties (open data principle). We will further enable data access for start-ups, private companies, and enable democratic access to data. In future the platform will allow to connect data from other data points not related to the current project, such as traffic situation, smart waste collection and other.



Picture 1: Platform

Platform will consist of various technologies that will allow us to process, analyze, report and display data including Apache Hadoop, Kafka, Jupyter Lab, and Knowage.

Apache Hadoop – open-source framework for data storage and mass data processing

Kafka – high performance data pipeline and support for data streaming and streaming analytics

Jupyter Lab – data scientist environment

Knowage – open-source business intelligence data visualization, public access.

The goal is to build a complex platform with open architecture for connection of heterogeneous data from sensors and provide with unified interface for municipalities, citizens, organizations and commercial third parties. Inaccessible data in many cases hampers development of new business models and creation of new innovative solutions from start-up companies. Unified platform should overcome this problem and provide smart cities with competitive advantage.

The role of platform is a long-term data storage from the sensoric network and execution of data quality processes. It

will help to exclude anomalies from the datasets and provide with analytical and predictive models based on given use case scenario, testing and calibration of the models, and preservation of produced predictive data set. Another feature of the platform is the securing the data integrity and support for detection of altered data. Within platform the other data sources will be integrated with the data from the sensoric network such as 3D city map, and traffic situation. It will provide secured access to data via mobile application, city government application and for third parties for the creation of alternative hypothesis and models. The platform will scale up.

IV. Conclusion

This paper proposes a sensoric network and following platform to collect, process and interpret heterogeneous data from multiple sensor points. We used the modular system of sensors with adequate sensitivity that will allow to broaden the scope of measurement as the new sensors appear. Architecture and the parts of the system is presented. The platform has been designed according to existing knowledge base present in Slovakia. Researchers and consultants have got an experience with selected tools from previous projects. The architecture is based on open-source applications that enable project to improve existing used technologies and create open framework to add new data and make them accessible for further use.

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