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SMART CITY GIS-IOT INTEGRATION AND DATA IFRASTRUCTURE

Abstract: The Smart City is a common used phrase. It could be considered as context model for data collecting and model of data usage in urban and suburban areas. The aspects of observing this phenomenon are diverse, as are the contexts in which it can be placed. To enable the existence and cohabitation of administrative procedures, hazardous situations or entertainment activities, situations resulting from urban climate or settler activity, an integration platform for data acquisition and usage is required. It is important to create a data structure or, better, an infrastructure equivalent to this phenomenon. Actually this kind of observation data, in the context of the phenomenon of IoT and GIS brings a new interpretation of data GoT Geography of Things. It support multidimensional spatial and spatial based data. Data sources are heterogeneous and anachronistic, based on individual measurement or collected as a series in real-time or off-line.

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1. INTRODUCTION

When talking about IoT and GIS, we're talking consequently about interconnectivity among devices and bringing data into a spatial context. In this way, the application of IoT concept combined with GIS relates to the use of several devices connected to a server in order to obtain a lot of data to be used to feed the information system or to use data in real-time and spatial context.

This may involve a lot of devices beyond smartphones: personal computers (mainly laptops), smartwatches or so, dedicated to work with geoprocessing, detection of weather conditions, etc. A new term also emerged from the combination of IoT with geoprocessing: Geography of Things (GoT). The Global Standards Initiative on the Internet of Things (IoT-GSI) has defined IoT as "an information society infrastructure." IoT allows objects to be spotted or controlled remotely through existing network infrastructure, allowing for the immediate integration of the physical world into computer-based systems, resulting in increased efficiency, accuracy and economic benefit, with reduced human intervention. When IoT is amplified by sensors and actuators, technology becomes an instance of a general class of cyber-physical systems, which also includes technologies such as smart grids, virtual power plants, smart homes, intelligent transportation, and smart cities. Each thing is uniquely recognizable through a nested computer system, but is also capable of interoperability within the existing Internet infrastructure.

The sharing of methods and data has been recognized by Kamilaris A. and Ostermann F. O. [1]. They bring the terms "Internet of Things", "Pervasive Computing", "Geospatial Analysis", and "Geographical Information Systems (GIS)" in common context, because the research domains of geographic information science and IoT are still relatively separated with publication patterns focusing either on one direction or the other, but not on their intersection. That intersection is our sphere of interest.

2. INTELLIGENCE AND DECISION SUPPORT SYSTEMS FOR SMART CITIES BASED ON SERVICE ARCHITECTURE

Information Infrastructure of Smart City is particularly interesting in the aspect of integrated risk management. This is the scenario we are interested in:

- An event with catastrophic consequences occurred (real-time or off-line).
- The person in charge of integrated incident management should have "everything needed to make decision".
- What needs to be provided, in terms of the functionality of a service oriented information system?
- The chosen methodology should be based on standards.
- Situations of interest to be viewed in 2D and 3D space, and be processed services characteristic of 2D, 3D and temporal data.
- Implementation to follow the relevant directives on a real space-time system.

Intelligence and decision support systems in the area of risk analysis with catastrophic consequences depend on multidimensional spatial and spatial based data. The sources of such data are heterogeneous and often anachronistic. Data formats are based on different standards: ISO, OGC, Industrial, National, Traditional, Informally agreed, or even no standards or arrangements.

Data is the product of modern, technologically advanced systems (sensor systems, GIS, various expert systems), of traditional, often outdated systems. Also the data infrastructure partly exists (2D SDI), partly does not exist (3D SDI).

It is necessary to ensure the interoperability of this data, and a way to market it in a technologically modern and highly usable way.

A particular case that has to be addressed is 3D spatial and spatially based data, their formats, appropriate data structures, interpretation and presentation, services for handling them; in other words 3D SDI [6].

The construction of spatial data infrastructure has been an important and actively followed topic in geographical research for years. A special part is the services required for 3D spatial data infrastructure, as well as the aspects that must be considered in order to build this type of infrastructure. It also concerns policy and decision-making, as well as the harmonization of technologies to reduce time and cost in the construction of spatial services for internal use, as well as for public information services. At European level, the new INSPIRE Directive 2007/2/EC intends to lay down general rules for the implementation of national spatial data infrastructure for environmental policy purposes (Figure 1). From a technical point of view, FDIs should rely on standards adopted by, among others, OGCs (WMS, WFS, WCS, OpenLS ...) [2].

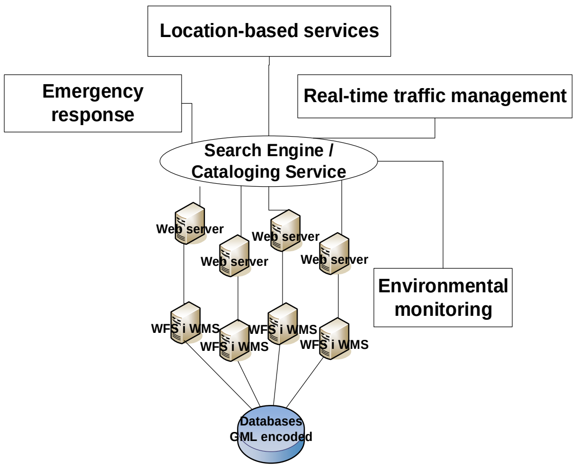

Figure 1 – Service architecture

Particularly important services are Data Interoperability Services Interoperability is the ability of two or more autonomous, heterogeneous and distributed digital components (systems, applications, procedures, or datasets) to communicate and cooperate with each other despite any differences in language, context, format or computer platform.

In the absence of interoperability, the following disadvantages are explicitly emphasized:

- Expensive conversions and data sharing
- Data redundancy
- A difficult and complex problem of updating data
- Lack of data

Interoperability is achieved through the Web service. The solution is actually the following combination:

- Service Oriented Architecture (SOA) and Web Services.
- Independent components, based on open transport protocols and XML based standards for data exchange.
- Available over TCP/IP.
- Standards provide interoperability (interface semantics, data coding ...).

Interoperability plays an important role in Web applications. They would be significantly immobilized without the ability to visualize patterns (patterns) in a critically short time. Since many systems are based on closed systems, it is difficult to achieve interoperability and solution to problems arising from syntactic, structural, and semantic heterogeneities between data sources [10]. Today, many researchers agree that adopting open standards is an important approach for realizing the interoperability of geographic information systems and sharing real-time spatial information through the Web [5].

3. IOT INTEGRATION CONCEPT

The concept of observational data is treated as data obtained by reading a property of a real-world entity. The result of the observation is the value of this property [7]. Sensors across the city also make observations, making content annotations. Annotations allow for interoperability and detection, making data easier to understand and therefore use.

3.1. W3C Semantic Sensor Network

The W3C Semantic Sensor Network (SSN) is an ontology that aims to describe sensors, observations, and related concepts, such as sensor capabilities and measurement processes. SSN is able to annotate the data so that we can determine which sensor that data is coming from, using which measurement process to read a particular property of the entity of interest. Although they are unable to describe the sensor network behind the data collected, SSN is not based on a standard approach like the W3C PROV-O. SSN is ontology and does not care about how data is transferred from their collections in terms of formats and datasets. BOnSAI and SMDO (Seasame Meter Data Ontology) are also network sensory ontologies that focus on smart buildings [3][4][9].

3.2. Human-Aware Sensor Network Ontology

Although large enough to provide scientists with enough to monitor their activities, HASNetO (Human-Aware Sensor Network Ontology) faces challenges in dealing with data collected in a large and complex environments such as urban environments. One of these challenges is that the data collected has been used not only by the city administration or the people involved in the measurements but also by citizens. Therefore, HASNetO-SC (HASNetO-Smart City) is proposed. The main objective of HASNetO-SC is to provide an efficient way of collecting, preserving and disseminating urban data with an appropriate level of contextual metadata to understand the data itself [11].

HASNet-SC focuses on smart-city features that have the greatest potential to provide data that can be collected empirically and effectively:

- Smart people
- Smart mobility
- Smart environment
- A smart lifestyle

This extension virtually refines the VSTOI concepts that are integrated into HASNetO to better suit urban data collection.

3.3. Contextualized CSV (CCSV)

Use CCSV is a CSV extension addresses content and content restrictions when handling observational data. In this approach, content and contextual metadata are required to obtain a connection between data and metadata. From a smart city perspective, it is necessary to classify the Turtle preamble of the CCSV dataset with the ontological concept of HASNetO-SC

The introduction contains the following descriptions:

- Knowledge based: To enable multi-contextual data collections and make solutions more scalable, the data set is enabled to determine what knowledge to use for validation.
- Implementation: The implementation of information enables the linking of the data transferred by the CCSV dataset to the metadata information: (1) instruments and detectors (sensors), (2) platforms, (3) all attached information, precision, location, platform, etc.
- Data collections: The use of data collection information in a CCSV introduction enables the architecture of the knowledge of a data set: it is able to know whether a particular data set is produced under the same context, or provide the user with sufficient contextual information to determine if the data is within different sets can be compared, merged or analyzed.
- Data Set: Datasets are not scientific constraints on data, but rather are data collection activities. This description links the datasets to their respective data collections.
- Measurements: Describes all measured characteristics. For each type of measurement we associate a unit description and the measured characteristics.

4. IOT- GIS INTEGRATION WAHASTRAT CASE STUDY

The WAHASTRAT project [8] has developed a network of 8 automated monitoring stations (designated as WH1 – WH8) to provide information about environment variables: soil moisture, speed and wind direction, air temperature, air humidity and atmospheric precipitation. The data from these monitoring stations are collected and analyzed to provide information about water shortage, drought conditions and especially for urban climate. Further in this chapter, systems for monitoring of excess inland waters (Figure 2), meteorological values and urban heat islands developed by experts from the University of Novi Sad will be presented.

When station is awaken, the cell switches from sleep mode to active mode. Configuration is received after connecting to the server. If the configuration parameters are valid, the data transmission is valid. In the event of a network failure, the data is stored in the internal memory of the station and sent in the next session. The data being sent is defined as a raw data structure. The server application validates, formats, and stores the data in the database.

WAHASTRAT system specification:

- Decagon EC-5 sensor for volumetric water content determination Davis sensors
- Solar power
- Non-maintenance battery - can supply the station for 30 days when there is little or no sunlight
- GSM modem
- Communication between the station and the server is done via HTTP protocol

Figure 2 – WAHASTRAT acquisition station (wahastrat.vizugy.hu)

WAHASTRAT system, like most environmental monitoring systems uses a distributed sensor-based framework (WSN), and IoT connects them to the Internet to make data available at all times. The main roles of these systems are monitoring time series, data tracking, and recording. In WAHASTRAT system we implement IoT concept combined with GIS to feed the information system or to use data in real-time and spatial context, (Figure 3) WAHASTRAT GoT.

GoT implement for WAHASTRAT currently is used primarily to assess the risk to agricultural production. Availability of such data is invaluable to modern agriculture, and may be used to make decisions about irrigation during drought periods, or drainage needs and capability of soil to absorb excess water during the prolonged periods of rain. All those data is used mainly in off-line regime. All these assessments are also used to make business decisions in various businesses, for example about type of plants appropriate for given location, about insurance premium for crop insurance.

All this data is used after the acquisition, with more or less delay. Our idea is that by inserting new ad-hoch climatological stations without a known location in advance, and interpreting the results in real-time, we can achieve an extension of the functionality of the already installed system. In this way, the application of IoT concept combined with GIS relates to the use of several devices connected to a server in order to obtain a lot of information to feed the information system.

However, the WAHASTRAT system does not take any special action in real-time and GoT concept offer that opportunity. There are many events that should be recognized. If such events are extracted during the data analysis, it may serve as a trigger for automated recovery process. Such a process can be easily modeled, deployed and when necessary upgraded by using process aware software solution such as BPM processing engines. In [12] we discuss a BPMN model of automated response procedure triggered by error or warning events extracted during data analysis.

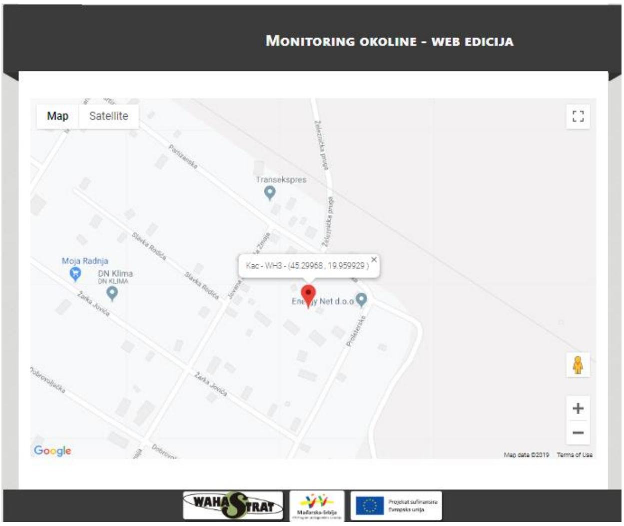

Figure 3 – WAHASTRAT GoT (wahastrat.vizugy.hu)

5. CONCLUSION

As data acquisition constantly evolving, the problem is how to use remote sensing technologies with a large number of in situ observations to get a complete picture of the environment. When this is done a general outline of a city or parts of it can be integrated with these individual measurements into the concept of a smart city.

With the expansion and growth of cities, making them smart has become crucial to increasing the quality of life for citizens. IoT was presented as the best approach to make the city smart. It can be applied in various scenarios such as the above mentioned environmental monitoring, gas concentration, water and air quality, etc. A number of related facilities are required to achieve these goals. In addition, related ICT industries need to be explored and developed in parallel to promote IoT technologies.

6. REFERENCES

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7. QUESTIONS FOR DISCUSSION WITH STUDENTS

1. What are the basic concepts of Smart City?
2. Benefits IoT approach?
3. Explain importance of data infrastructure in general?
4. Explain aspects of IoT in SMART City that are important for risk reduction.
5. Elaborate an example of Iot from your everyday experience? What could be the data structure describes that example?
6. What could be the *context model for data collecting*?
7. What are the sensor systems in your environment?
8. What is GoT?
9. What does HASNet-SC focus on?
10. Explain IoT integration concept.