Sensor Web Architecture for Data Management in Power Supply Companies through Web GIS

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Abstract **–Retrieving and managing data in real time from Supervisory Control and Data Acquisition (SCADA) systems through Web GIS applications has become a necessity for every power supply company. This paper presents one way of dealing with these requests using Sensor Web concept. The solution is given as integration of GINISED and GINISSENSE systemsinto a unique system which enables data retrieval, monitoring and visualization using power supply network elements as data sources.**

Keywords– **Sensor Web, SCADA systems, Web GIS application, Power Distribution Companies**

I. INTRODUCTION

Sensor networks gained popularity over the past few years due to technological advances in sensor technology. Sensors are smaller, lighter, more reliable and portable. They are capable of monitoring and measuring features of observed phenomena and can be placed anywhere. Networks of interconnected sensors are used for intelligent gathering of sensor measurements. Sensor measurements are sent through the network to the control centres where are being processed and analyzed. The results can indicate if there is some critical situation in the field, allowing operators to react in time and prevent or mitigate the catastrophic consequences. In order to perform more detailed and comprehensive analyzes, the process of data gathering should be based on some intelligent rules and pursued by intelligent hardware components. The Sensor Web concept precisely presents an intelligent sensor network, comprised of sensor pods which can have built-in intelligent modules enabling them to make decisions while measuring. This practically means that a sensor pod can alert control centre operator only in cases when measured values exceed critical limits. Sensor pods within such network can communicate in order to share data and check the status of other pods. Sensor Web has been very interesting exploration field to many researches and is thus very popular.

Recently, there have been attempts for adding a visual dimension to Sensor Web, by combining it with Geographic Information Systems (GIS). GIS, as an information technology, which combines geographic locations of natural and artificial objects as well as other types of data in order to generate interactive visual maps and reports, is often used in combination with Sensor Web [1]. If used as a data source in a Web-based GIS application, Sensor web gains a visual dimension. The value of information gained from different types of sensors and systems attached as data sources in Sensor Web is increased greatly by adding GIS component that contributes to it in a geographical sense.

For the needs of Power Distribution company Jugoistok Niš, CG&GIS Lab, Faculty of Electronic Engineering in Niš, with the support of Ministry of Science of Republic of Serbia, developed a geo-information system GINISED [2]. GINISEDis a specialized geo-information system which allows recording, processing, analyzing and graphic presentation of specialized information about the electric power supply network, such as spatial data, temporal data, image and multimedia [3]. Recently, we have added new functionality to GINISED, concerning data retrieval, visualization and user notification on defined parameters received from Supervisory Control and Data Acquisition (SCADA) systems. This is done by integrating GINISED with GINISSENSE. GINISSENSEis Sensor Web based architecture for monitoring real-time data, and for reacting when possible danger is noticed. It can be applied to various environmental problems, since it enables connection toheterogeneous data sources. It is based on Sensor Web concept, and it isfully designed accordingly to Open Geospatial Consortium (OGC) specifications and recommendations for Sensor Web.

The rest of the paper is organized as follows. Section 2 describes Sensor Web concept. In Section 3, GINISSENSEarchitecture is presented. One possible application of GINISSENSEarchitecture in power supply companies, for data management trough Web GIS application is presented in Section 4. Conclusion is given in Section 5, followed by list of cited papers.

II. SENSOR WEB

Sensor Web is a relatively new concept which describes a type of sensor network especially well suited for environmental monitoring. This concept was first used by Kevin Delin of NASA in 1997, who defined it as a system of wireless, intra-communicating, spatially distributed sensor pods that can be easily deployed to monitor and explore new environments[4].

The main characteristic of Sensor Web is that all data collected by one sensor can be shared and used by all other sensors in the network, enabling sensor communication and collaboration.

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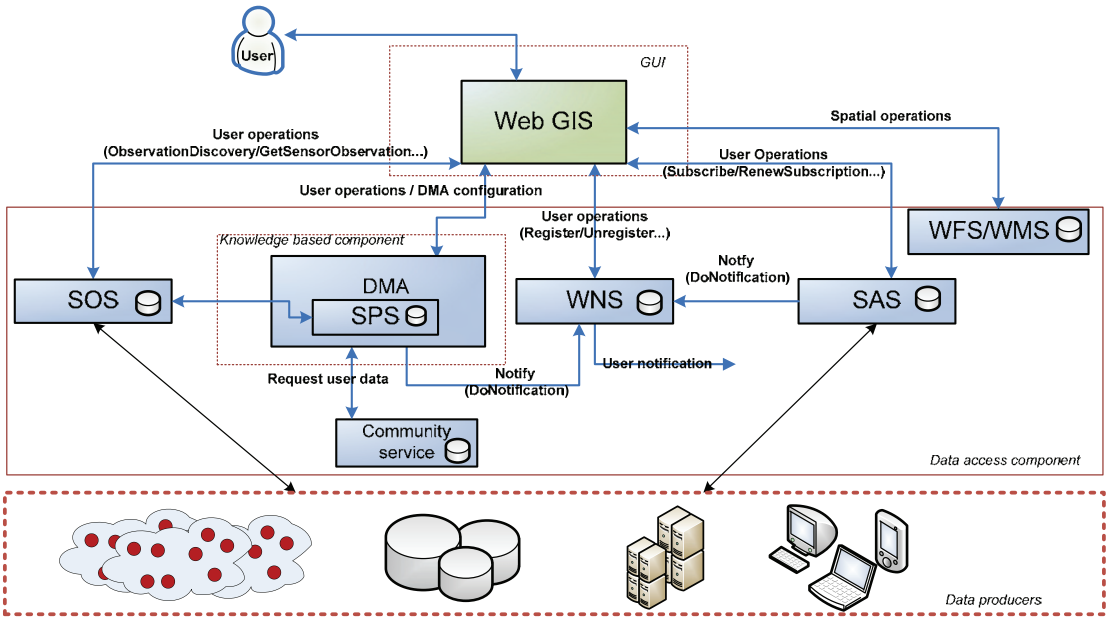

Fig. 1. GinisSenseSWE architecture

Sensor Web is thus an intelligent sensor network of collaborating sensor nodes capable of self- maintenance to some level. Another important characteristic of a Sensor Web is availability of sensors' measurements through the Web. This enables the development of Web systems for accessing and online processing of real-time sensor data. The Open Geospatial Consortium (OGC), as a leading organization in the field of developing new standards for geo-spatial and location services, has developed a set of standards and specifications named Sensor Web Enablement (SWE) [5].SWE represents a recommendation for implementing a Sensor web system and is comprised of four Web Services specifications: Sensor Observation Service (SOS), Sensor Planning Service (SPS), Sensor Alert Service (SAS) and Web Notification Service (WNS), and three modelling languages specifications: Sensor Markup Language (SensorML), Transducer Markup Language (TML) and Observations and Measurements (O&M). Web services are responsible for communicating with sensors, collecting their measurements and polling them when necessary. Modelling languages are used for modelling observations and measurements as well as for describing sensors. The proposed specifications can be applied in various situations: tracking floods, water contaminations, air pollution, traffic density, power supply networks etc.

The CG&GIS Laboratory at the Faculty of Electronic Engineering in Nis has been exploring the field of Senor Web for several years and has developed GinisSense architecture for applications in the field of environmental protection.

III. GinisSense

GinisSense is an architecture based on OGC SWE specifications [5]. GinisSenseenables creation of systems for monitoring, acquisition, control, on-demand measurements and analysis of data received from heterogeneous data sources. Data sources are typically sensors or sensor networks, set in critical areas, with ability to measure different phenomena and deliver data to other systems for the purposes of further data processing.

The GinisSenseSWE architecture has the following components (as illustrated in Fig. 1): Data producers (sensors), Data access component (Web services), Knowledge based component (DMA) and Graphical user interface (Web GIS). Components of the architecture communicate using various protocols, media, topology, etc. The most common communication means are the Internet, satellite, mobile-phone or radio networks.

Data producers are any devices (sensors) or applications, capable of harvesting or measuring physical phenomena.Typically these are sensors, but can also be databases, archives, other systems and applications, etc.

Data access component is in charge for collecting and processing data from different sources (sensors). This primarily includes real time sensor data, spatial data necessary to display sensor position and objects of interest on the map, as well as data collected by users who contribute with gathered information regarding objects of interest. For each data type, there is a separate database used for data storing. Data access component comprises of seven different Web services. SOS, WNS, SAS and SPS are responsible for planning, acquisition, analysis and notifyingusers about sensor observations. Web Map Service (WMS) and Web Feature Service (WFS) are used for accessing geographical data. Community service is an external service for gathering and retrieving data from environmental friendly users. Using this service, a user can submit a photo with a brief description about water pollution, landfills or other environmental disasters. From this service point of view, humans are data producers.

Knowledge based component is a component used for comparing and analyzing data obtained from different sources, making action plans, running on demand or automated actions and proposing action plans to system operators.

Graphical User Interface (GUI) is a Web GIS application [6]. Besides the basic GIS functionality, the Web GIS application provides users with support for accessing Web services layer. Spatial location, from which the sensor information is obtained, is very important in the analysis, which is why GIS is used as default.

IV. Using SCADA as Data Source in GinisSense Architecture

GinisSenseSWE architecture, presented in Section 3, can be successfully applied on electric power supply network for communicating with SCADA systems, getting SCADA measurements and informing users about critical events. The CG&GIS Laboratory within the Faculty of electronic engineering in Nis has developed SCADA module, which relays on GinisSense SWE architecture, andhas integrated it withGinisEDsystem [2]. GinisED is a Web GIS solution that provides user with interactive geographical representation of electrical substations' locations and enables getting SCADA information about these substations: elements and bays connected to a substation as well as real-time measurements for selected element. A user can get a visual representation of element's measurements for a concrete date and specified time range along with spreadsheet overview. They can also subscribe for receiving notifications about certain element's measurements via email address or SMS and define subscription criteria (e.g. notify me if a value exceeds its limit).

For realization of described scenario several components should be included: SAS and WNS services within GinisSenseSWE and SCADA service and SCADA module within GinisED.

A. GinisSenseSAS: Accessing SCADA Data

SAS is by definition used for sensor advertisement and user subscription. In this usage scenario, SCADA represents primary data source and as such it should advertise its measurements with SAS. The advertising process is standardized by OGC SAS specification and it implies that data source sends a detailed document with meta-information as well as measurements information. Since SCADA elements are the components that perform measuring, they all should be listed in this document. Basic Advertise request elements are sensor description and message structure. They are both structured in accordance with SensorML specification [7]. Sensor description contains information about a data source, e.g. SCADA, which includes inputs, outputs, parameters, processes and methods, along with relevant metadata. Message structure describes data format used for data encoding. After successful data source registration SAS generates a unique identifier for the data source and creates an XMPP channel that will be used by that source for data advertising. Each time SCADA has new measurements, it will push an alert message into XMPP channel. SAS receives the message and puts data into a measurement database making it available for other system components. An example of an alert message, that shows measurement coming from an element with id 77 attached to SCADA with id 18, is given in Fig. 2.

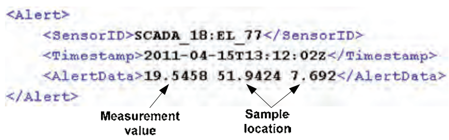

Fig. 2. Alert message

SAS enables user subscription for receiving measurements. Invoking a Subscribe request, a user sends information about SCADA elements that is interested in, as well as contact information (email address or SMS) and notification criteria (critical values, value ranges etc.). SAS then must register subscribed user with WNS in order to use this service for user notifying. Upon receiving the sensor alert message, SAS performs filteringsubscribed users upon the type of sensor or measured phenomenon andwhen the conditions are matched, it sendsnotifications via WNS.

B.GinisSenseWNS: User Notification

GinisSense Web Notification Service enables asynchronous message interchanges between clients and other GinisSense services [8]. WNS provides interface for user registrations. It is possible to register a new, single user, or to form a group of already registered users. Registered users receive notifications from WNS using email or SMS as communication protocols.WNS is invoked by some other service within the architecture; in this case by SAS when new measurements are available and user defined conditions for notification process are fulfilled.

C. GinisED: SCADA module

SCADA module enables communication with SCADA system from Web GIS. It gives a visual representation of available electrical substations on an interactive map and allows user to choose on by clicking its icon on a map. SCADA module is than induced, calling SCADA service in the background. If selected SCADA system is advertised with SAS there will be data for display. SCADA service communicates with database that contains information about bays and elements connected to SCADA and database that contains elements' measurements. It retrieves this information and returnsit to SCADA module, which than presentsit to the user. The module also enables user to retrieve measurement information from any element for a specified date and time period. In that case SCADA service gathers required information and sends it back to the module where it is presented as spreadsheet, as well as graphically in the form of chart with indicated measurement values.Fig. 3 represents one usage example of this module. SCADA service is the one responsible for communicating with GinisSense in the background. The communication is, for now, based on reading databases populated by SAS.

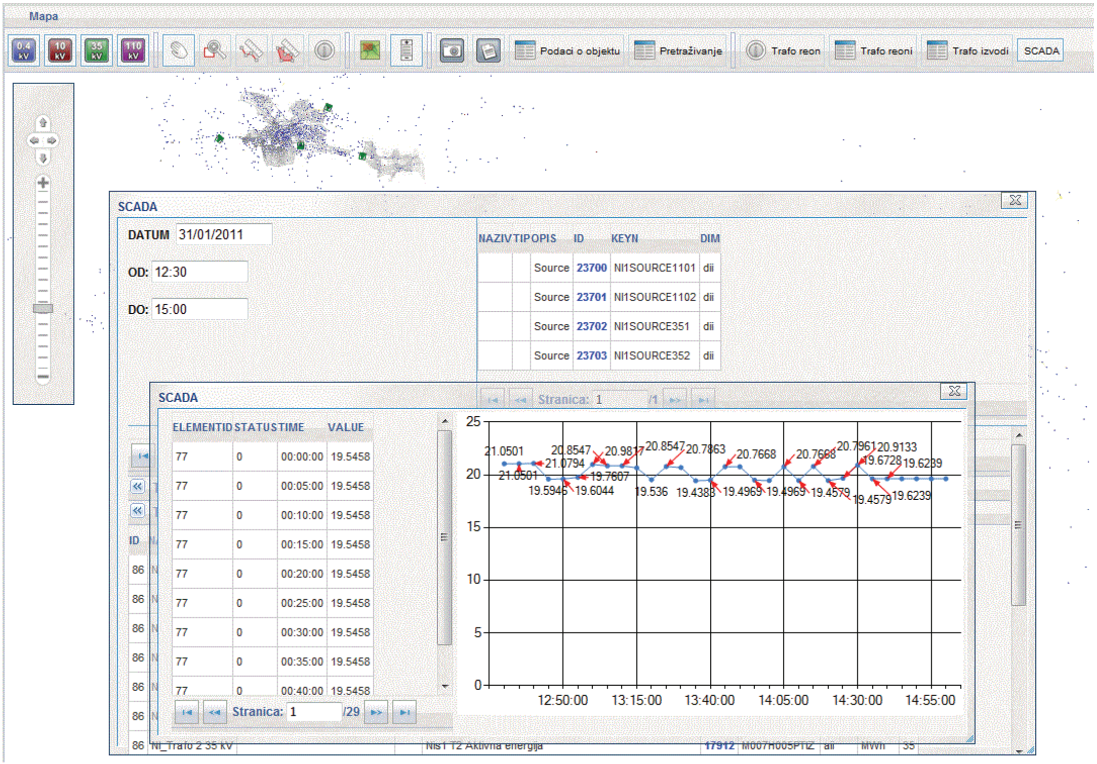

Fig. 3. GINISEDSCADA module

V. CONCLUSION

The technology today provides possibility of developing efficient monitoring systems that can be installed anywhere and used for all types of environmental issues. Sensor Web has become a primary concept in this area and a standard for developing such systems.On the other hand, visual representation of all types of data on interactive maps is crucial in monitoring applications. Combining GIS and Sensor Web we can develop powerful applications in this area.Power Supply Companies have a necessity to track, collect, analyze and visualize data and measurements coming from electrical network, especially to have an insight into elements' behaviour over certain period. GINISSENSE architecture provides possibility to use electrical network as data sourceand apply all Sensor Web based functionalities to data retrieved from components attached to electrical substations in the network. That further means that we can use GINISSENSE in GINISED system in order to collect measurements obtained by SCADA components, perform different kinds of analyses and visualize their changes using charts or other graphictools.

In this paper, we have presented GINISEDsystem integrated with GINISSENSE resulting in a powerful application for visualization and monitoring of data retrieved from SCADA systems and provided an efficient data management tool for Power Supply Companies.

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