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Sensor Web Service: A Geographical Information System (GIS) Based Model for Reliable Fire Detection in Buildings

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Abstract: Recent emergency situations in the world display the inclination that the occurrence frequency of natural catastrophes is anticipated to increase in future. Thus new approaches for Emergency management have been the hot topic in recent times. Emergency events imply all events that endanger normal functioning of services and companies, endanger lives or resources as well as events that are threatening stability of state. All situations resulting from fires, explosions, technological and traffic accidents, terrorist attacks, transport of hazardous materials all comprise hazardous events. Individuals and organizations responsible for emergency management use many tools to preserve economic assets before, during and after a catastrophic event. Correct and timely information is a critical part of any successful emergency management program. One of the greatest usages of GIS is in emergency management systems such as Natural Disasters that Impact Humans (Earthquakes, Volcanoes, Tsunamis, Landslides, Fires, Floods, Tornadoes, and Hurricanes). This paper discuss Sensor Web Service as a proposed GIS-based model for Emergency management that is GIS application has been implemented for Reliable Fire Detection in buildings.

Keywords: GIS, OGC, Sensor Web, Sensor Web Enablement (SWE), Emergency Management.

I. INTRODUCTION

Geographic Information Systems (GIS) have proven to be an important asset in Emergency Management. The ability to retrieve information on areas affected by a disaster and quickly display it on a map has proven to be a vital asset to emergency personnel. Emergency Management (EM) is the coordination and management of public and private resources before, during and after an emergency. Emergency Management does not employ cops, fire fighters, paramedics or dispatchers, yet EM coordinates the activities of public safety personnel during the four response phases (Preparation, Response, Recovery, Restoration) to an emergency. All phases of emergency management depend on data from a variety of sources. The appropriate data has to be gathered, organized, and displayed logically to determine the size and scope of emergency management program(s). During an actual emergency it is critical to have the right data at the right time displayed logically to respond and take appropriate action. A Geographic Information System (GIS) or Geographical Information System is any system that integrates, captures, stores, analyzes shares, manages, and displays data that is linked to location or so called geographic data. A geographic information system (GIS) can provide that sort of information and tools for the analysis of the spatial data and the representation of the results in spatial format [1].

Sensor Web approach [3] allows for complex behaviours and operations, such as on-the-fly identification of anomalous or unexpected events, mapping vector fields from measured scalar values and interpreting them locally, and single-pod detection of critical events which then triggers changes in the global behaviour of the Sensor Web.

SWE is the standard developed by OGC that encompasses specifications for interfaces, protocols and encodings that enable discover, access, obtain sensor data as well as sensor-processing services.

The main objective of this work is to propose an applicable Sensor Web Service architecture using GIS technology to improve emergency system, overcome the large scale spatial data problems found in traditional GIS and Finding solutions for Fire Detection in Buildings.

II. RELATEDWORK

A. Geographical Information System

A GIS is basically a computerized information system like any other database, but with an important difference: all information in GIS must be linked to a geographic (spatial) reference (latitude/longitude, or other spatial coordinates).

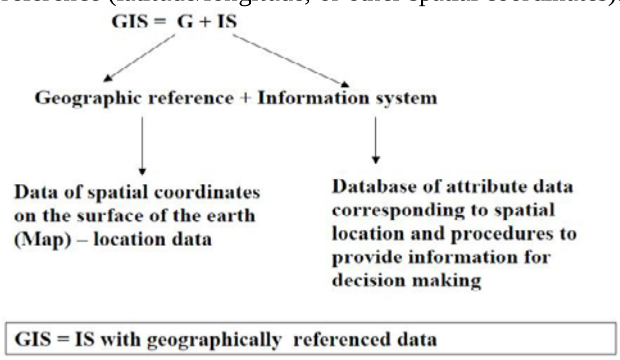

Figure 1. Definition of GIS

Geographical Information Systems or Geospatial Information Systems (GIS) is a collection of tools that captures, stores, analyzes, manages, and presents data that are linked to geographical locations and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

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GIS technology can be integrated into any enterprise information system framework [3].

B. Open Geospatial Consortium standards(OGC):

The Open Geospatial Consortium (OGC)[7] is an international industry consortium of 384 companies, government agencies, universities, and individuals participating in a consensus process to develop publicly available geo processing specifications. Open interfaces and protocols defined by Open GIS Specifications support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT, and empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications. OGC Sensor Web Enablement Architecture to a set of use cases in the area of risk monitoring and disaster management. After introducing the OGC Sensor Web Enablement framework, use cases ranging from hydrological monitoring and measuring different types of pollution to fire fighting applications will be presented. The Sensor Web Enablement (SWE) activities of the Open Geospatial Consortium (OGC) have led to a powerful set of standards allowing the integration of sensors and sensor data into spatial data infrastructures. The OGC SWE architecture comprises standardized encodings as well as service interfaces which can be used on the application level. The SWE encodings provide data formats for encoding sensor measurements (OGC Observations & Measurements) as well as sensor metadata (OGC Sensor Model Language). Furthermore, web service interfaces for accessing sensor data (OGC Sensor Observation Service), subscribing to alerts/events (OGC Sensor Alert Service) and controlling sensors (Sensor Planning Service) are available.

C. OGC SWE Framework:

The OGC Sensor Web Enablement (SWE) working group defines standards for sensor data and sensor services.

Following Botts et al. (2007) “a Sensor Web refers to web accessible sensor networks and archived sensor data that can be discovered and accessed using standard protocols and application program interfaces (APIs)”. A Sensor Web can hence be seen as a huge internet based sensor network and data archive. To achieve the vision of the Sensor Web, the SWE initiative defines standards for encoding of sensor data as well as standards for service interfaces to access sensor data, task sensors or send and receive alerts. As the specifications are based on common OGC standards such as OWS Common and the Geography Markup Language (GML), the SWE standards enable an easy integration of sensor data into common spatial data infrastructures, which consist of already established standards such as the WMS. The SWE specifications can be grouped into the SWE information model, which defines encodings for sensor data and the SWE service model, which contains the service interface specifications for sensor data access, alerting and sensor tasking.

a. Observations and Measurements:

The Observations & Measurements (O&M) specification defines basic models and encodings for observations and measurements made by sensors. An observation can be interpreted as an act of observing a phenomenon, whereas a measurement depicts a specialized observation in which the result is a numerical value. The basic observation model contains five components. The procedure element points to the procedure (usually a sensor), which produced the value of the observation. The phenomenon that was observed is referenced by the observed Property element. The feature Of Interest refers to the real world object to which the observation belongs. The referenced feature also contains the location information of the observation. The sampling Time attribute indicates the time, when the observation was sampled. The observation value itself is contained in the result element.

b. Sensor Model Language:

The SensorML specification provides models and encodings to describe any kind of process in sensors or post processing systems. Therefore, the basic type of all SensorML descriptions is the process type. The process type is defined through its input and output elements and several optional additional parameters. Additional metadata like quality, calibration information or technical attributes can also be nested in SensorML descriptions. Different subtypes of the process type are specified which can be used to depict diverse kinds of detectors, actuators or systems of processes.

c. Sensor Observation Service:

The Sensor Observation Service (SOS) provides a standardized web service interface which allows clients to access descriptions of associated sensors and their collected observations. Like all OGC Services, the SOS offers the GetCapabilities operation to request a service description containing the spatial and temporal extent of the offered observations as well as a list of the sensors and observed features. In addition, users can request SensorML or TML encoded sensor descriptions using the Describe Sensor operation. The GetObservation operation offers access to observations and thus provides the core functionality of the SOS. Within a GetObservation request, spatial, temporal or value filters as well as sensor ids or ids of the observed phenomena can be defined in order to constrain the observation response. These three operations form the Core profile of the SOS and have to be offered by every SOS implementation. To allow registering new sensors and inserting observations, a SOS instance can implement the Transactional profile of the SOS specification. This profile contains the RegisterSensor operation for registering new sensors to the SOS by sending a SensorML or TML description of the sensor. The SOS returns an id for the sensor, which can be used afterwards to insert new observations into the SOS using the InsertObservation operation.

d. Web Notification Service:

The Web Notification Service (WNS) defines a service to enable asynchronous dialogues (message interchanges) between SWE components. This service is especially useful, if multiple collaborating services are required to satisfy a client request, and/or if significant delays occur when processing requests. Additionally, the WNS can act as protocol transducer by converting e.g. HTPP into XMPP messages. Thus, a WNS can enable the support of additional protocols like email, SMS or phone calls. The WNS specification defines two communication patterns: the one-way notification represents a simple notification, which means that the sender does not expect a response from the receiver. In contrast, in the two-way-notification the recipient has to create a response message and has to send it back to the caller. In the SWE framework, the WNS can be used in conjunction with SPS and SAS instances for allowing asynchronous messaging between service instances and clients.

e. *Sensor Planning Service:*

The Sensor Planning Service (SPS) provides a standardized interface for tasking sensors and sensor systems to acquire observations at a certain time in a certain area. Before submitting a task to the SPS through the Submit operation, the client can request the information needed to prepare a valid tasking request. Additionally, the GetFeasibility operation can be used in advance for cheking, whether the execution of a task is feasible for a certain sensor. As the SPS does not offer access to the observations gathered by the tasked sensors, it offers the DescribeResultAccess operation for determining the access points to the collected data. Furthermore, the SPS interface offers functionality for managing submitted tasks. This includes operations for retrieving the status of a task, for updating tasks or even cancelling them. Several use cases require a SPS to communicate with the client of a task asynchronously (e.g. in case of a request to a satellite system, the system might not be able to answer an a request before a human operator has taken his decision).Therefore, a SPS can use a WNS.

f. *Sensor Alert Service:*

The Sensor Alert Service (SAS) specification defines a service interface which can be used by clients for subscribing to self defined alert conditions and to receive notifications in case the conditions are matched. This corresponds to the publish-subscribe communication pattern and is obviously in contrast to the pull based approach of SOS. The SAS itself offers only operations for managing the event notification system. Thus, the implementation of the underlying messaging server (which is used for publishing and notifying) is up to the service provider (usually an XMPP server is used for messaging). The SAS offers the capability for producers to advertise alerts and to renew or cancel an advertisement. Consumers can use the Subscribe operation to subscribe for certain alerts. Also, the subscription could be renewed or cancelled. There are two ways of delivering alerts, e.g. notification of the consumer: on the one hand the notification can be based upon pure XMPP communication, on the other hand alerts can be delivered via WNS instances. The latter is called the last mile-mode because clients may not always be connected to the Internet so that the last mile between the Internet and these clients is bridged using the WNS.

III. DESCRIPTION OF THE IMPLEMENTED SYSTEM

A. *The Sensor Web concept:*

Today, it is feasible and economically viable to deploy enormous amount of low-cost, low-power in-situ sensors to continuously monitor our environment shown in fig.2. We also see more and more advanced remote sensing satellites have been or scheduled be launched. The combination of these heterogeneous sensing systems can provide enormous amount of timely, comprehensive, continuous and multi-resolution observations for applications in smart spaces, agriculture, environment monitoring, habitat monitoring, transportation, homeland security, defence to even planet exploration.

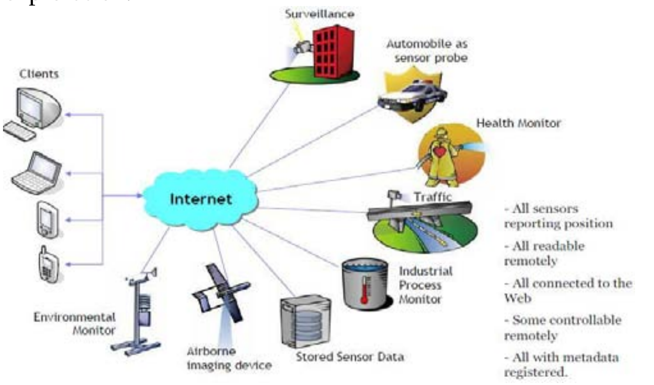

Figure 2. Service Oriented View Of Sensor Web

However, these ad-hoc networked sensors or sensor systems don‟ t connect to each other. The sensors of a sensor network connect to each other only within their proprietary network.

They are deployed for their own purposes, for specific applications, and to make it even worse, they are using proprietary network protocols, information models, and data formats. There is no resource sharing and collaboration between heterogeneous sensor networks. Today‟ s sensor networks‟ situation is just like the situation of computers without the World Wide Web (WWW). It is critical to develop a Sensor Web for the sensor networks that is similar to the WWW for the computers. The Sensor Web is an information infrastructure, a backbone that connects the heterogeneous in-situ and remote sensors over the wired and wireless networks. The vision of the Sensor Web is to allow these real-time sensor resources, such as sensor data and sensors‟ tasking capabilities, accessible from everywhere at any time. The concept of the Sensor Web is similar to the concept of the WWW. What Sensor Web is to the sensor networks is what WWW is to the computers. The WWW is an information infrastructure that interconnects heterogeneous computers on the Internet, and provides rich information, including text and multimedia files, and other network services. In a similar spirit, the Sensor Web is an information infrastructure that interconnects heterogeneous networks of sensors, and provides sensor information, including sensor metadata, sensor observations1, sensors‟ tasking capabilities and other related functions.

B. *From Sensor networks to Sensor Web:*

Sensor Networks	Sensor Web
Single purpose, one-time dedicated instrumentation	Multi-purposes, reusability, re-mix-ability
Homogeneous platforms	Heterogeneous platforms
Device centric	Network/Web enabled
Proprietary and close architecture, centrally managed	Open, Interoperable
Specialized user interface	Many different user interfaces (e.g., mashups)
Small and isolated	Large scale, Network Effects (e.g., blogging or slogging?)
Sensing	Sensing and Control
It's all about the Systems	System, Data, and Events_

Figure 3. Relation between Sensor networks to Sensor Web

C. Sensor Web Desires:

a. Quickly discover sensors (secure or public) that can meet my needs–location, observables, quality, and ability to task.

b. Obtain sensor information in a standard encoding that is understandable by me and my software.

c. Readily access sensor observations in a common manner, and in a form specific to my needs.

d. Task sensors, when possible, to meet my specific needs.

e. Subscribe to and receive alerts when a sensor measures a particular phenomenon.

D. Frame work for Reliable Fire Detection in Buildings and Tables:

The use of WSN for reliable environmental monitoring solutions can significantly improve the effectiveness and feasibility of systems thanks to the wireless and ad-hoc network capabilities of sensor nodes. Usually, geographically distributed sensors can be located in wide areas and in remote site environments. Power is a critical issue as well as nodes distance and density in order to ensure the connectivity of all the nodes and to gather sufficient information representative of particular phenomena.

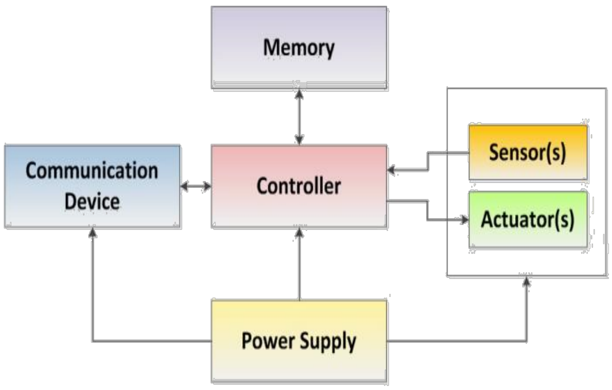

Figure 4. WSN for building fire Detection

This scenario focuses on managing fire threats in industrial facilities. A network of wireless sensors is used to detect fires with a higher reliability. A special focus is put on the avoidance of false alarms by combining various types of sensors. Smoke as well as temperature sensors are combined in order to ensure that for example cigarette smoke (smoke but no increased temperature) or high temperatures in the summer (no smoke but increased temperatures) are not interpreted as fire events. The validation of the developed system was realised in a real fire training environment at the fire department of the German city Aachen. A fire was caused within to demonstrate the fire detection capabilities of the system developed using the OSIRIS framework. The wireless sensor network consisted of three types of sensors: smoke detectors, cameras and thermometers. To allow an interoperable usage of these sensors three different SWE services were used. The SOS was used to access data gathered by the different sensors. The tasking of sensors to modify internal parameters was done via the SPS. And to allow users a registration for certain alerts and events (e.g. detection of smoke) the SAS was applied. The architecture overview of fire monitoring system shown in fig 6.consists of five components.

a. Sensor nodes(motes):

A sensor node (or mote) is a device in a WSN that gathers information from the external environment, can process the acquired information and perform decisional tasks, and communicates with other connected nodes in the network.WSN nodes have specific hardware characteristics and limitations. Most WSN nodes have limited vailableenergy: some rely on batteries and some implement environmental energy harvesting techniques (e.g. solar panels or vibration-powered generators). Therefore WSN nodes tend to be small embedded systems with few processing resources and low bit rate capable of establishing limited low range radio links. Cost and size restrictions impose similar constraints.

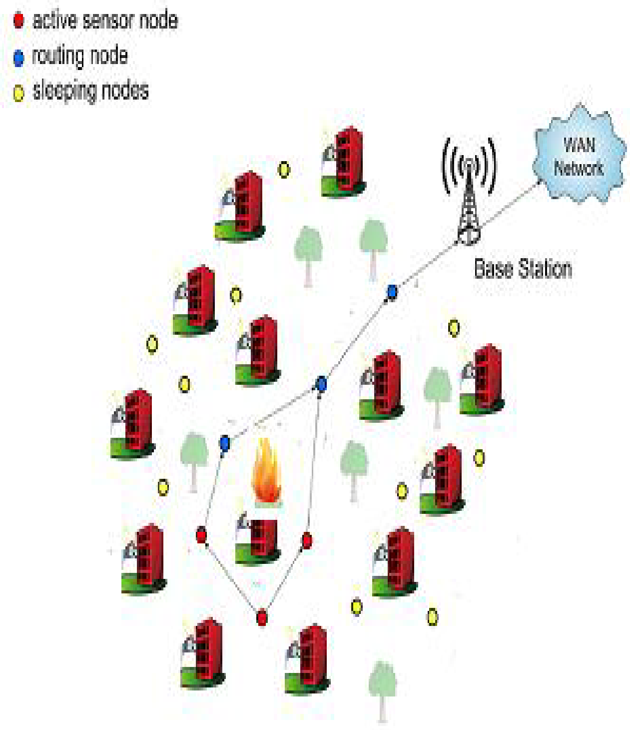

Figure 5. Architecture of Sensor node

b. SPS:

Service to help users build a feasible sensor collection plan and to schedule requests for sensors and sensor platforms.

c. SOS:

A service by which a client can obtain observations from one or more sensors/platforms (can be of mixed sensor/platform types). Clients can also obtain information that describes the associated sensors and platforms.

d. SAS:

A service by which a client subscribes for specific and/or self-defined alert conditions and gets notified in case the condition is matched. The specified SAS specifies an interface that allows nodes to advertise and publish observational data or its describing metadata respectively.

e. WNS:

Service to manage client sessions and notify the client about the outcome of the requested service using various communication protocols.

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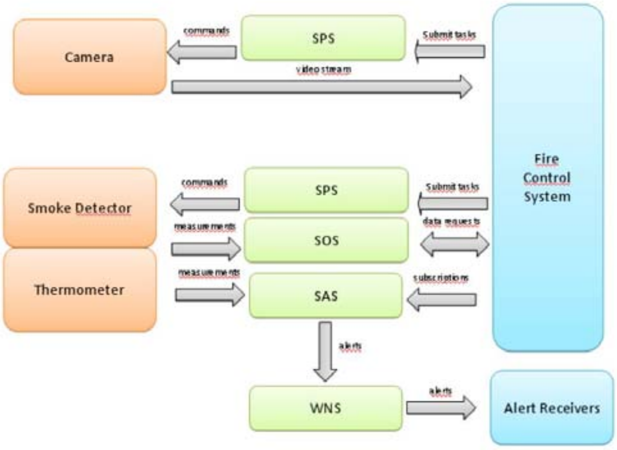

Figure 6. Architecture overview of the fire monitoring system

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