A WEB-SERVICE BASED APPROACH FOR DEVELOPING INTEGRABLE NOISE MONITORING MODULES

Nguyen The Cuong, Abdellah Touhafi, Jelmer Tiete and Kris Steenhaut
ETRO, Vrije Universiteit Brussel, Brussel, Belgium
IWT, Erasmushogeschool Brussel, Brussel, Belgium

Keywords: Noise monitoring, Web services, Joomla components, Noise level visualization, Web-based applications, Sound measurement, Noise pollution.

Abstract: This paper presents a noise monitoring system based on web service technologies. By using microphones placed in certain locations, the system investigates the level of noise pollution. Sensed data are collected, processed and visualized. One of the advantages of the system is to provide monitoring modules that can be added to user websites when necessary. The objective of these modules is to display noise levels at a specific location in real time. The paper also shows the advantages and capabilities of web services in noise monitoring systems. Web service interfaces are developed to support database access, by which many users can query sound database system at the same time. It is believed that the availability of these modules promotes the participation of urban citizens in the noise monitoring task.

1 INTRODUCTION

Noise pollution is one of the main causes of health complaints by the inhabitants of urban areas today. Recent studies concluded that exposure to high levels of environmental noise can significantly increase the risk of high blood pressure, heart failure, hearing disorders and insomnia. Because of this, noise pollution is recognized as a cause of decreased productivity and disturbed social behavior (European Commission Green Paper). The European Commission recognizes this problem and has made noise avoidance, reduction and prevention their key priorities in their current policy. For this purpose, a directive has been proposed by the European Commission for all the European Member States to draw up "strategic noise maps" to assist in monitoring this environmental problem. These noise maps should provide a regular overview of detailed noise levels in agglomerations with more than 250.000 inhabitants (Directive 2002/49/EC). Via a web-interface, people would have the opportunity to consult the noise pollution situation in their neighborhood. We believe that the more users participate in the noise monitoring tasks, the more people will understand the issue of noise pollution. The question is how urban citizens can monitor noise levels when they are interested in this issue.

In this paper, we describe our approach that allows citizens to participate in noise monitoring tasks. The aim of the system is to provide internet users the capability of monitoring noise pollution. The work consists of two parts. First, we build a noise monitoring system enabling to record sound data level at some given locations. Second, easy-to-integrate modules are developed based on web service technology. Web service interfaces are used for communicating between user applications and the database system. Because almost all websites are now powered by Content Management Systems (CMSs) these modules are built following well-defined structures that makes them easily integrable into those systems.

There are different issues discussed in this paper. Firstly, we analyze the health impact of noise pollution and the role of web services in monitoring systems. Secondly, we study the related works on noise monitoring and web services. Next, we go through the description of the system and some components in detail. We then present the implementations in the system. Finally, we conclude and present plans for future works with regards to both noise monitoring and web services.

The Cuong N., Touhafi A., Tiete J. and Steenhaut K..
A WEB-SERVICE BASED APPROACH FOR DEVELOPING INTEGRABLE NOISE MONITORING MODULES.
DOI: 10.5220/0003382202950300
In *Proceedings of the 1st International Conference on Cloud Computing and Services Science* (CLOSER-2011), pages 295-300
ISBN: 978-989-8425-52-2

2 THE EFFECT OF NOISE ON THE PEOPLE HEALTH

Sound is essential in our daily life, but noise is not. Environmental noise is unwanted sound from different possible sources, including road and rail traffic, construction works, aircraft noise, sport events, leisure parks etc. Each source has different characteristics and poses specific problems. For example, noise can be irritating, disturb sleep and affect the health of people of all different age groups (Kanjo, 2010).

There is an increasing body of research linking prolonged exposure to transport noise to negative health impacts. A major impact of noise is sleep disturbance – and disrupted sleep has been linked to effects on cardiac health. A number of reports have made direct links between transport noise and cardiac health. Most work carried out has looked at impacts of aviation noise. There are links between children's concentration too. Much of this work has been carried out in Europe (NOISE PROTECTION).

3 THE ROLE OF WEB SERVICES

To show the role of web services in noise monitoring systems, we first summarize the capabilities of these services and then present their advantages.

Web services provide a method for distributed applications to access resources that are located on remote devices in a manner similar to local resources. Typically, a functionality available on one server is considered as a method call for an application running on remote devices (Priyantha et al., 2008).

In monitoring systems, web services offer some significant advantages besides enabling a new method for data exchange.

- *Multiple usage:* the web service enables sensed information to be shared across multiple applications in a very flexible way. The fact that one service can be consumed by many users at the same time reduces cost for duplicating copies of the application to each client.
- *Programmability:* the uses of web services improve the programmability of the system. The WSDL (Web Service Definition Language) description of the service can automatically be parsed by high-level development tools as Visual Studio and NetBeans IDE.
- *Ease of integration:* many network applications nowadays support web services. It is easy to integrate the new services into the existing system. Web service based applications can run on all kinds of machines from a desktop or laptop to a mainframe.

The aforementioned advantages prove why web services in distributed systems are so widespread.

4 RELATED WORKS AND MOTIVATIONS

Since the request of the European Union for more detailed noise data and measurements, a significant number of research has been conducted concerning noise monitoring and related subjects.

Touhafi et al., 2001 developed a software package named Euterpe to monitor noise levels in a cost efficient way. By using this software package, computer users can investigate noise pollution levels at any location. The ease of installation and usage is the significant advantage of the software. With minimum computer experience, people can set up a system that can monitor the noise level of their surroundings.

Cerniglia and Amadasi, 2006 provide a real-time noise monitoring solution. According to their work, viewers can see the noise level at a fixed position both in near real-time mode and offline mode. This website (see www.citynoise.net) provides real time video and audio streaming at a pre-determined location. Automatic warning and report sending are also considered in the system. Cerniglia proves that it is possible to monitor noise pollution on a long-term basis using a web-based application. Although almost all the objectives of a monitoring system are met by the system, an application re-using system is not implemented. Users cannot use this work for their own purposes.

When taking into account the participation of the citizen in noise monitoring, Maisonneuve et al., 2009 presents a new approach, in which urban people play a significant role in collecting and sending noise data. By using GPS-equipped mobile phones, citizens are enabled to measure noise levels in their daily environment. (Stevens and D'Hondt, 2010) provides a low cost solution for citizens to measure their personal exposure to noise in their everyday environment and participate in the creation of collective noise maps by sharing their geolocalized and annotated measurements with the community. The involvement of citizens promotes and reduces the cost of the noise-monitoring task. NoiseSpy (Kanjo, 2010) is a noise monitoring system, in which Kanjo turns mobile phones into a low-cost data logger. It allows users to explore a city area while collaboratively visualizing the noise level in real time.

A noise monitoring system has been developed around Brussels airport (www.brusselsairport.be). This system controls, measures and analyses the noise produced by the Brussels Airport and outputs a noise map around the airport. The IDEA project (see www.idea-project.be) in Belgium focuses in particular on environmental stressors that have a very local character such as (ultra) fine particulate matter and noise. They are also running sound measurement tests with a network of lower performance (and thus much cheaper) sensors.

For research based on web services, (Fuyu and Dogdu, 2006) proposed a new architecture for user management in federated database system. This approach is based on web service technologies when building the components of the system. (Zhu et al., 2004) states that web services also can be used in the integration of dynamic data. A service-oriented data integration architecture (SODIA) is developed to provide a uniform view of data coming from autonomous, heterogeneous and distributed data sources. For the purpose of software sharing over the Internet, (Yu and Daizhong, 2006) suggests an approach based on web services. It allows members of a team, who may work far away, to share their software resources.

5 STRUCTURE OF THE SYSTEM

In order to promote the participation of urban citizens in noise pollution monitoring, we propose a noise monitoring system using web service technologies. In this system web services are used to provide access to a recorded sound database. It is easy for users to query the sound database by calling defined function calls of the web service. Figure 1 shows the architecture of the system.

5.1 Overview of the System

The system uses microphones, which are attached to mini computers, to record noise levels at given locations. Normally, these microphones are placed in the vicinity of busy streets, dense residences or airport fly routes. Selected sound data at the nodes

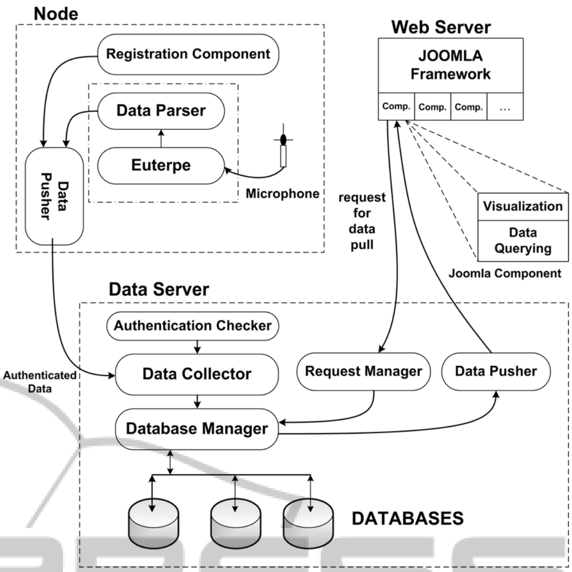

Figure 1: The architecture of the system.

will be sent to a base station (a server). In order to make the data managing convenient, sensed information is centralized in a database server where it is processed and stored.

Internet users who want to add a noise-monitoring module to their web sites can download the packed modules from the central server. The monitoring module provides a map-based interface that visualizes the sound level at a given location. These modules are developed based on the formatted structure of Joomla modules, so it is easy for Joomla users to install it on their websites. It is also possible to build a module following the module's format of other CMSs (e.g. Drupal).

5.2 System Components

The main components of the system will be described in the following sections.

5.2.1 Euterpe Software

Euterpe, a software packet developed by A. Touhafi and his team from the Erasmushogeschool Brussel, allows the implementation of a low cost sonometer with of the shelf hardware. The program records sound waves with a microphone and calculates the equivalent sound levels in decibel and other statistical parameters such as the SEL-value and L05-value. Users can also perform task scheduling of Euterpe as well as data calibration. Using a personal computer or a laptop with sound-card, a microphone and Euterpe, one can quickly monitor and analyse environmental sound levels. For professional purposes Euterpe integrates functionalities such as logging sound levels in data-sheets, monitoring and logging the value of a weather-station, sending messages via GSM and registering sound fragments.

Figure 2 shows an example output of noise levels from the Euterpe software.

```
Bandwidth: 22.39Hz - 22.39kHz
Measurement range: 20 - 140dB
Octave band: 1/3
Weighting: A-weighted Fast

31/08/2010 - 14:31:55
------------  -------   ------
 TimeStamp     Total    Status
------------  -------   ------
14:31:55.638    44.4
14:31:55.770    44.3
14:31:55.892    44.2
14:31:56.018    44.2
14:31:56.146    44.1
14:31:56.268    44.1
14:31:56.390    44.0
14:31:56.512    44.0
14:31:56.644    44.0
14:31:56.767    43.9
14:31:56.887    43.8
14:31:57.020    43.9
14:31:57.141    43.9
14:31:57.263    43.9
14:31:57.395    44.0
```

Figure 2: An example of Euterpe data file.

5.2.2 Data Parsing Component

The main tasks of the parsing program is getting significant information from Euterpe files and sending collected data to a server as quickly as possible. In order to do these tasks, first, the program must select which is the latest up-to-date file. Second, the file must be parsed into data records before being sent to the specific server. All parsed data are sent to the central station via the selected channels.

5.2.3 Data Pushing Component

After it is processed, the sound level information is pushed to a base station by the data-pushing component. Sound level information is represented as XML-based messages for ease of use and platform independence.

5.2.4 Data Collecting Component

Real-time noise monitoring applications require the data to be retrieved periodically. Because of this the sound level at the nodes must continuously be sent to a server. The data-collecting component is used to gather all the sound information which is recorded at many different nodes. Sound data authentication is checked to make sure that the data come from a registered node. This component also updates the database continuously during monitoring time. A database system installed on the server keeps the sound data for further purposes.

5.2.5 Database Managing Component

The noise-monitoring task produces a large amount of data. To get this data efficiently processed, it is necessary to have a good database design and a strong database system. A MySQL database system (see www.mysql.com) is a good choice that meets the database management requirements. Because MySQL is open and free for download and use, this database system is suitable for developing the open systems at a minimum cost and for the maximum number of users. Combined with a Java-based framework, MySQL becomes the first choice when developers want to build internet-based applications. The query-speed of this database system is high enough to use it for a real time monitoring system.

5.2.6 Network Services

Web services are used when developing the data displaying component. These services are deployed on the server and are used to answer users' queries on demand. By using defined standard calls (Pierce et al., 2008) users can access the database system. Only a simple web services client is needed to consume deployed web services. Remote access clients are not necessary in this monitoring system.

6 IMPLEMENTATION

The main tasks for implementation of the system consist of developing a noise monitoring system and building components that consume web services deployed in the system. The development of the modules undertaking that tasks is described below.

6.1 The Implementation of Data Parsing and Data Sending Modules

The data files produced by Euterpe, contain relevant information, but some of it may be redundant. To reduce network traffic, only the necessary information will be transferred through the Internet. Therefore, these files must be parsed in order to eliminate the redundancy. To do so, a small program is developed and runs at the client-side computers.

The program accesses a directory (is set default by the users) to find what the current working file is. Making a comparison between the timestamp information of the file-name and the current timestamp of the system determines which file was last created by Euterpe – this is also the current data file. After the working file is selected, it is accessed every 10 seconds to get new data. Each line of the text file is divided into two fields, timestamp and sound value. These data fields are formed to an XML-based message that will be sent to the server immediately via the internet.

```
<? xml version="1.0" encoding="UTF-8" ?>
<data>
    <records> <idnode>IDEAErasmus</idnode>
    <timestamp>10:39:00</timestamp>
    <value>47.0</value>
    <datestamp>24-09-2010</datestamp>
 </records>
 <records>
 <idnode>IDEAErasmus</idnode>
 <timestamp>10:39:01</timestamp>
 <value>47.1</value>
 <datestamp>24-09-2010</datestamp>
 </records>
</data>
```

Figure 3: An example of a data message.

6.2 The Implementation of Data Collecting Module

On the node, sound data is represented as an XML-message before being transferred. Each data message contains information about the location of the microphone where the noise is recorded. Based on this clue, a program running on the server can find the sensor node that the message belongs to.

When a message comes in, the server will check if it is a data message according to the message header. After that, the remaining part will be broken into segments based on user-defined tags. From these segments, all necessary information will be collected and sent automatically to a database management system.

6.3 The Implementation of Database System

The database of the system has two tables, of which one table is used to keep information related to nodes. The other is used for storage of measured data. The node table is updated whenever the topology of the system changes. The measurement table keeps all data sent by sensing nodes. Because the noise level is continuously monitored, the amount of noise data that is made by this process becomes bigger and bigger day after day. It is estimated that each node produces approximate the number of 31.5 million records per year (one record is created per second). Therefore, to increase the performance of the database system in accessing and querying, a good management mechanism must be applied when implementing the database system. MySQL database system provides a table partition mechanism that is aimed to reduce amount of data read for SQL operations so that the response time is reduced as well.

There are two major types of partitioning: horizontal partitioning which forms of partitioning segments table rows and vertical partitioning based on collections of certain columns of the table. The database system is implemented based on a horizontal partitioning method, by which the measurement table is divided into partitions corresponding to the year when the data was collected.

6.4 The Implementation of Noise Level Displaying Component

Joomla, *a free and open source content management system for publishing content to World Wide Web and Intranets*, is widespread, which motivates us to build a Joomla component that can get noise information from the database system and show it on a web page. This component can easily be installed on websites that are powered by Joomla.

To visualize node locations, a web-based map-interface plug-in like Google maps is added to the module. A marker is used to present a node with a microphone on the map. Markers are placed on the Google map corresponding to the location where the real microphones are located.

Sound information is displayed by using graphic form. On this graph, the y-axis (vertically) shows the level of sound in decibels (dB), the x-axis (horizontally) is used for presenting the timeline. Sound information during monitoring duration is represented by a zigzag line, which shows the change of sound level at that location.

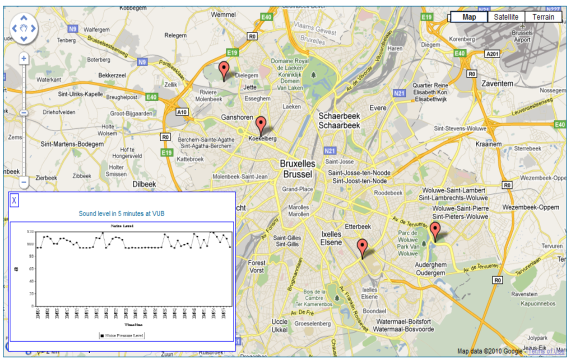

Figure 4: An example of real time data displaying.

7 CONCLUSIONS AND FUTURE WORK

In this paper, we presented a noise monitoring system using web services. The contributions of this work are two-fold. First, we proposed the architecture and the system components and described their functionality and their implementation in detail. Second, we have defined a web service approach for data sharing between the server and remote clients and data visualizing. Web service interfaces are used for controlling database accessing. Web services technology offers many advantages for autonomous and distributed systems like a noise monitoring system.

In the near future, improving the participation of citizens in noise monitoring is one objective for developers. The main goals are not only providing internet users interfaces to access the sound database, but also enabling them to contribute with their own sound data. This helps to reduce the cost for the amount of deployed devices and allows developers to widen the sensed area. Based on this work, users will get a better and clearer overview on noise pollution.

REFERENCES

Cerniglia, A. & Amadasi, G. (2006) Use of Web based real time noise data transmission for acoustic investigation and mapping. *The Thirteenth International Congress on Sound and Vibration.* Vienna, Austria.

Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of Environmental noise. Official Journal of the European Commission, July 2002.

European Commission Green Paper of 4 November 1996 on Future Noise Policy.

Fuyu, L. & Dogdu, E. (2006) A User Management System for Federated Databases Using Web Services. *Computational Science and its Applications.* Glasgow, UK.

Kanjo, E. (2010) NoiseSPY: A Real-Time Mobile Phone Platform for Urban Noise Monitoring and Mapping. *Mobile Networks and Applications,* 15**,** 562 - 574.

Maisonneuve, N., Stevens, M., et al. (2009) Citizen Noise Pollution Monitoring. *The 10th Annual International Conference on Digital Government Research.* Cholula, Puebla C.P. 72820, Mexico, Digital Government Society of North America.

Noise Protection http://www.environmental-protection.org.uk/noise/environmental-noise/health/.

Pierce, M., Fox, G., et al. (2008) The QuakeSim Project: Web Services for Managing Geophysical Data and Applications. *Pure and Applied Geophysics,* 165**,** 635-651.

Priyantha, B. N., Kansal, A., et al. (2008) Tiny Web Services: Design and Implementation of Interoperable and Evolvable Sensor Networks. *ACM/IEEE Conference on Embedded Networked Sensor Systems.* Raleigh, NC, USA, Association for Computing Machinery, Inc.

Stevens, M. & D'Hondt, E. (2010) Crowdsourcing of Pollution Data using Smartphones. *Workshop on Ubiquitous Crowdsourcing, UbiComp2010.* Copenhagen, Denmark.

Touhafi, A., Courdon, B., et al. (2001) Euterpe: An integrated low cost sonometer. *17th International Congress On Acoustics.* Rome, Italy.

Yu, X. & Daizhong, S. (2006) A Web-Service Based Approach for Software Sharing. *Lecture Notes in Computer Science.* Springer Berlin / Heidelberg.

Zhu, F., Turnera, M., et al. (2004) Dynamic Data Integration Using Web Services. *IEEE International Conference on Web Services.* California, USA, IEEE Computer Society Washington, DC, USA.