REMOTE MONITORING DISTRIBUTED SYSTEMS
The new generation of control systems

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Abstract: Nowadays, it is increasingly necessary and interesting to measure and control the levels of some parameters. This research and project work has been developed with the aim of creating a data acquisition and monitoring distributed system that allows the users to monitor and control easily, powerfully and flexibly any parameter interesting enough to be studied for later monitoring in real time. At the same time, it is also intended to make the system accessible to the general public and citizens, by using the most implanted and widespread network: Internet and the TCP/IP networks. As a result we present an application offering a "measurement transport layer" providing several services that will work with any kind of parameter.

1 INTRODUCTION

Nowadays, it is more and more necessary and interesting to measure and control the levels of some parameters. These measurements can be used in two ways. On the one hand, we consider real time measurement where the most interesting part is to control discrete time value of the parameter. On the other hand, we deal with the storage of all these measurements in databases with the purpose to make later analysis about the parameter time evolution.

Our research and projects have been developed with the purpose of creating a data acquisition and monitoring distributed system that allows the users in an easy, powerful and flexible way, to monitor and control any parameter that may be interesting to study for monitoring in real time and later analysis. At the same time, it is also intended to be able to make the system accessible to the general public and citizens, by using the most implanted and widespread network: Internet and the TCP/IP networks.

Due to the growing proliferation and installation of systems that work with electromagnetic emissions, we decided to apply the system to electromagnetic fields measurements because lately the society is very worried about it. This concern is owing partly to the ignorance of the consequences that radiant systems and its emissions can have in our health and on the other hand, to the necessities of controlling the emissions in the electromagnetic spectrum and their influence or interference with other systems.

The system is a distributed application based on several main servers providing support to the measurement equipment located in the monitored area, and to the users that are going to view and request the information and data captured with the measurement equipment. These measurement equipments can be static or mobile travelling around the zones that we want to monitor. The monitoring application will allow to know in real time the measurement of the electromagnetic field and spectrum at a concrete instant and place. In addition, the application will also show a series of statistics and possible alarms when the measurement levels overcome certain thresholds. And all these features work on a web environment, and are accessible and usable from a computer with TCP connectivity.

2 SYSTEM DESCRIPTION

The basic idea of the system is to have distributed measurement equipment that capture measurements and send them to data centres continually through a communication channel, typically Internet. The distributed measurement equipment can be systems specifically designed to do capturing and sending functions, or can be commercial measurement equipment connected to a computer containing specific software to do control and measurement sending tasks. Obviously there must be a channel

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from the each piece of distributed measurement equipment and the system data centre so that they are communicated.

The measurement equipment locations can be static or mobile. In case the equipment is mobile, they can have a coupled GPS system that will allow us to know their position in each instant. So that, in the server each measurement will be stored with the time and position in which it was captured.

The system core is the database, which stores and registers all the information; and the server, that coordinates and manages the accesses to the database, like an access point through which all the other elements are interconnected. The server handles the connections and requests from measurement equipments, users and administrators. To be able to assist all the tasks correctly, the Server is composed of several subservers for each function that dialogue to each other to coordinate their actions.

The users access to the system through a web interface in any browser. They can visualize the available measurement equipment, their measurements values, their position on a digital map, to monitor certain areas, their temporal and position evolution, statistical data, etc; and everything in real time, thanks the web embedded Java applications or applets, with a graphic interface and forms.

The Administrator Users can also access to the system to configure and manage the Server, the measurement equipments, etc, from any place through web interface with embedded applications and forms.

The interconnection between each one of the blocks (clients, servers and database) is over TCP/IP. The rest of the elements are located on this transport layer and they communicate to each other and request services to the servers through different protocols. The final purpose of the system is to create a layer that allows us to exchange any kind of measurement, as well as to store and consult them.

2.1 Election of technologies for system implementation

Possibly, the most appropriate programming language for the development of this system is Java. Java has some important characteristics that make it especially attractive: strongly oriented to intra and inter network applications, multi-platform, client-server applications, and distributed applications in LANs and Internet, besides providing enough reliability to the applications.

For information exchange between client and server processes, the RMI (Remote Method Invocation) package has been used, and for access to the information stored in the database the JDBC (Java DataBase Connectivity) package is used; and finally, for user-application interaction it is needed a tool to create user's graphic interfaces. This tool is the SWING package, which allows GUIs development (windows, buttons, labels, dialogs, menus, images, etc).

2.2 System Architecture

2.2.1 Introduction

The designed system is a distributed application based on the client-server model and implemented in Java programming language, following distributed objects techniques. The communication between distributed objects is over TCP/IP protocols. In Figure 2 you can see the global architectural view of the system.

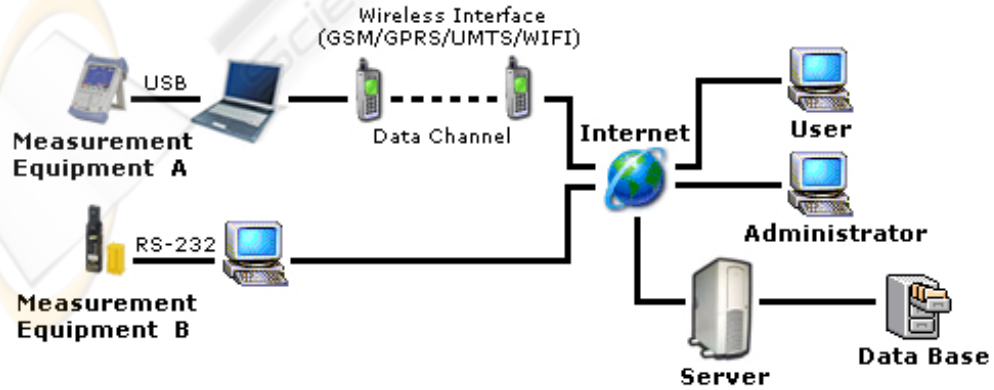

Figure 1: System Description.

2.2.2 The server and the database, brains of system

In our system, data are the most important thing, because the main function of the system is data collecting and data offering. So we decided to use a relational database manager system software that supports a huge volume of information. MySQL provides a robust solution to users with powerful multi-user tools, interface access to the data normalized through (Structured Query Language) SQL language, multi-threaded. It is a very quick, robust and easy to use language, apart from being open source.

As important as the database, it is the Java Server, in charge of controlling all the interactions with the database. The Server has been divided into three small servers, with the purpose to give service and assist to each one of the client applications of each one functionality area.

- **Measurements Server:** it gives support to the remote measurement equipment of the Client Application in the Measurement Equipment Control Area. The server subscribes the measurement equipment in the database (indicating all their characteristic data), stores the measurements, alarms and configuration, unsubscribes the equipment, indicates the state in which the equipment is, etc. Also, if there are errors in the connections with measurement equipment, the server is able to re-establish the connections automatically when the network service will be up again.
- **Users Server**: gives support to the Remote Measurement Equipment Monitoring Applet on the web client in the User Area. The server will monitor the geographical situation of the equipment and the measurements that it is capturing in real time, wherever it is. It requests to the database to obtain a list with the current data and measurements of each one of the connected meters, in a periodic and constant interval, to view the measurement in almost real time.
- **Administrators Server**: gives support to the Remote Control Applet on the web client in the Administration Area, where an authorized administrator can control remote equipment connected to the Server, and manage the system.

2.2.3 Client Applications

The access to the server can be different depending on which client application is accessing to the server. There are three different working planes or functional areas:

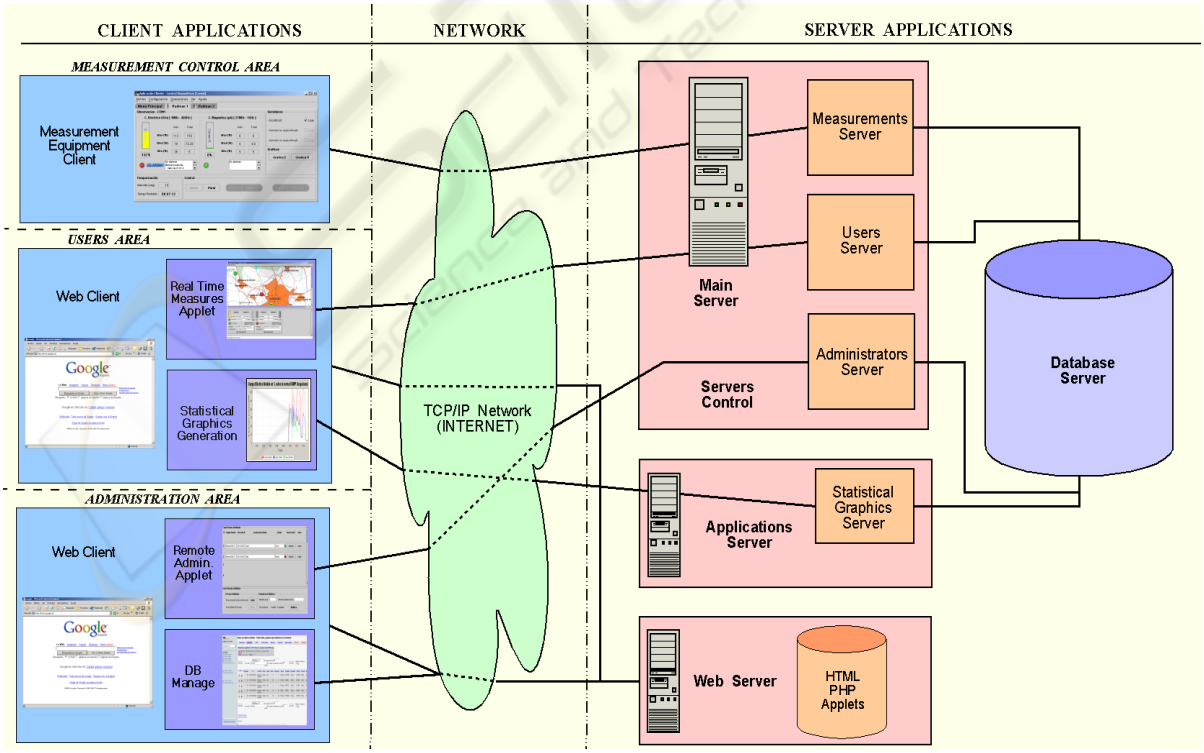

Figure 2: System Architecture

- **Measurement Equipment Control Area**: it is a Java application that allows to install and configure a measurement equipment, and subscribe it on the system, control the equipment, establish measuring parameters such as time length, capture and sending data interval, measurement type, equipment position, etc. Also it allows visualising the measurements captured, and the alarms indicators. It will be connected, through Internet, to the Measurement Servers that you indicate, being able to be connected and to be sending data simultaneously to several servers.

- **Users Area**: offers consulting services to the users, like real time monitoring applet, or some forms to request statistical graphics of the stored information. The first service is an applet composed of a panel for the geographical localization of the equipment and another panel for the real time monitoring of the measurements captured by the located meters. This application is connected the Users Server with an RMI connection to upgrade the data in almost real time. With the consultation forms, the user can curse petitions to the Statistical Graphic Server about the stored information. The return result will be html pages with the data in graphical format, containing the measurements obtained by the selected meter during the specified time period.
- **Administration Area**: it offers administration services to authorized administrators users. In this area we can make remote control of the measurement equipment that is subscribed in the system and of other managing tasks like the database administration, etc. For Equipment Remote Control it offers an applet that is connected with the Administrators Server through a RMI connection to obtain the list of current subscribed equipment. In this way, the configuration parameters can be viewed and remotely controlled, without needing anybody in the place where the equipment is located.

2.2.4 Other elements

To give support to all the elements of the architecture, it is necessary some other elements like web servers, Apache in this case, dynamic pages scripting technologies, for example PHP, and application servers or servlet engines like it can be Apache Tomcat.

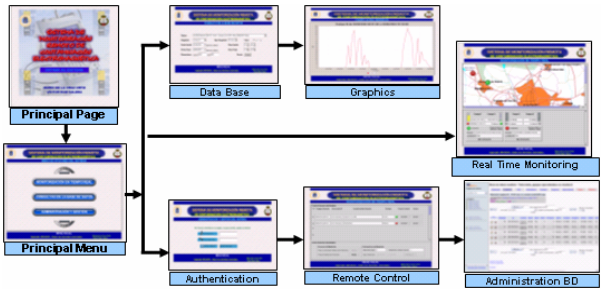

Figure 3: Served Pages Schema

2.3 System Capabilities

2.3.1 Measurement Equipment Access Capabilities

In the start menu, you can add the measurement equipment to the system and configure them correctly. For each piece of equipment we can define if the equipment is static or mobile, position (long, lat, alt and location description or GPS option), connection port, measurement parameters like interval between samples (s), measurement period, type of parameter (the value in the discrete instant or the average along the interval) and the server list where we want to connect and the measurements that will be sent.

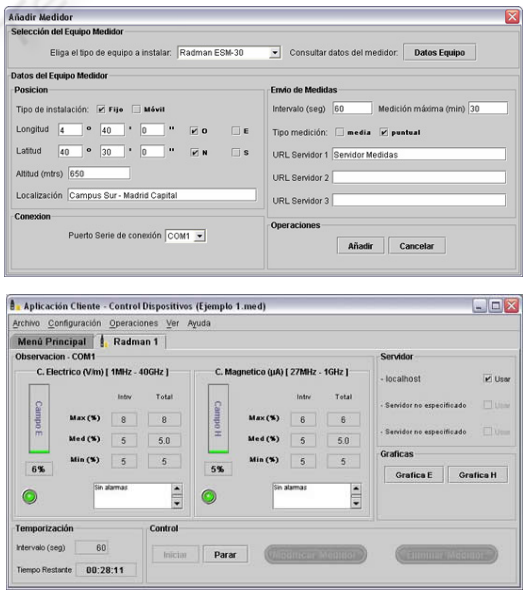

Figure 4: Config and Monitor Equipment Panels

For each added equipment, a panel appears with a tab and the tools to control the equipment locally. In the panel there are some bars with the values of

the measurements in real time (E and H), alarm indicators (registered value, date, time), state of connections with servers, the interval, and real time (line) graphics with the E and H representation.

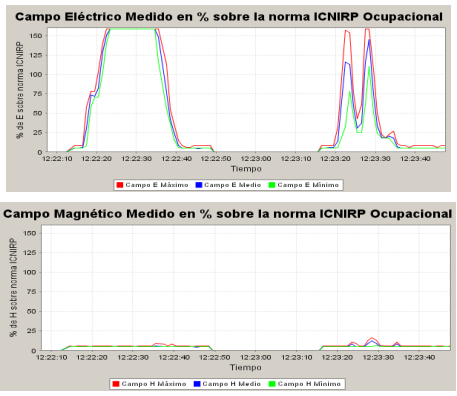

Figure 5: Real Time E and H measurements, in Graphical Format

We can change and update all the explained parameters and of course, we can delete equipment from the system.

2.3.2 User Access Capabilities

The user access provides these capabilities:

- **Real Time Monitoring**: It is the embedded application in a web page dedicated to real time monitoring of the measurements that the distributed equipment in different areas are sending to the server. This applet is continuously requesting to the Users Server the last version of the list with the equipment and its measurements, to be represented on the screen. At top there is a

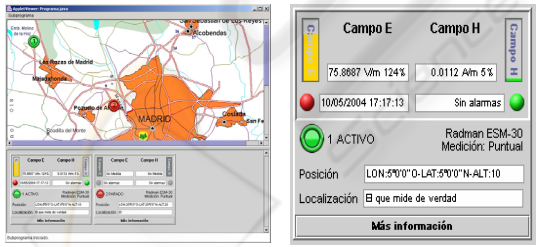

Figure 6: Real Time Monitoring Application and panel detail

map where the applet represented the geographical information of the equipment, and at bottom there are some panels with the measurement values in real time, meters bars, alarms indicators and other information.

- **DB Information Request**: using web forms, a user can request and extract information from database. For example, the equipments list, data historical, alarms historical and much more.

- **Statistical Graphics Generator**: using web forms we can obtain all the information but in a statistical graphic format, with any parameter and in the range of specified time.

2.3.3 Administrator Access Capabilities

The administrator can access to the system control options but must be previously authenticated with login and password:

- **Remote Control**: it is an embedded applet on a web page that permits to make remote control on any equipment from any place. This applet is refreshing continuously the measurement equipments list through a RMI connection with the Administrators Server, which obtains the information from the database.

- **Database administration**: the administrator user has permission to manage the database with tools like PHPMyAdmin, a web interface database managing system.

3 CONCLUSIONS AND POSSIBLE APPLICATIONS OF SYSTEM

At first, about electromagnetic emissions theme, we cannot affirm that are dangerous for human (when the levels are down of limits allowed by laws) because doesn't exist evidences about it. But we cannot neither say that are innocuous because there are not enough studies about it and we don't know their long time effects. So it is recommended to protect sensible zones like schools, hospitals, etc.

One of the final objects of project is to make a "measurement transport layer" providing several services that will work with any kind of parameter, and can be used to create a lot of different measurement system with the same philosophy.

Some possible cases to use this kind of systems are:

- Investigation groups that need to work from different places in the world, but they need to work with the same data simultaneously. For example, a scientist in Barcelona that needs other opinion about some measurements, but the other person is in

Sidney. Both can view in their browsers the same data at the same time.

- Creation of data repositories to make later analysis. For example, to work with parameters that currently we don't know enough, and to have a lot of data to research later if these measurement levels are related with others events or facts.
- The control of certain parameters that are important to the general public and citizens, like for example contamination parameters, or traffic report data. For example, it is possible to use the system with "cars counters" and offer to the citizens a map with traffic congestion information in real time.

There are a lot of more possible applications for this kind of systems, and the only limit is your imagination.

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