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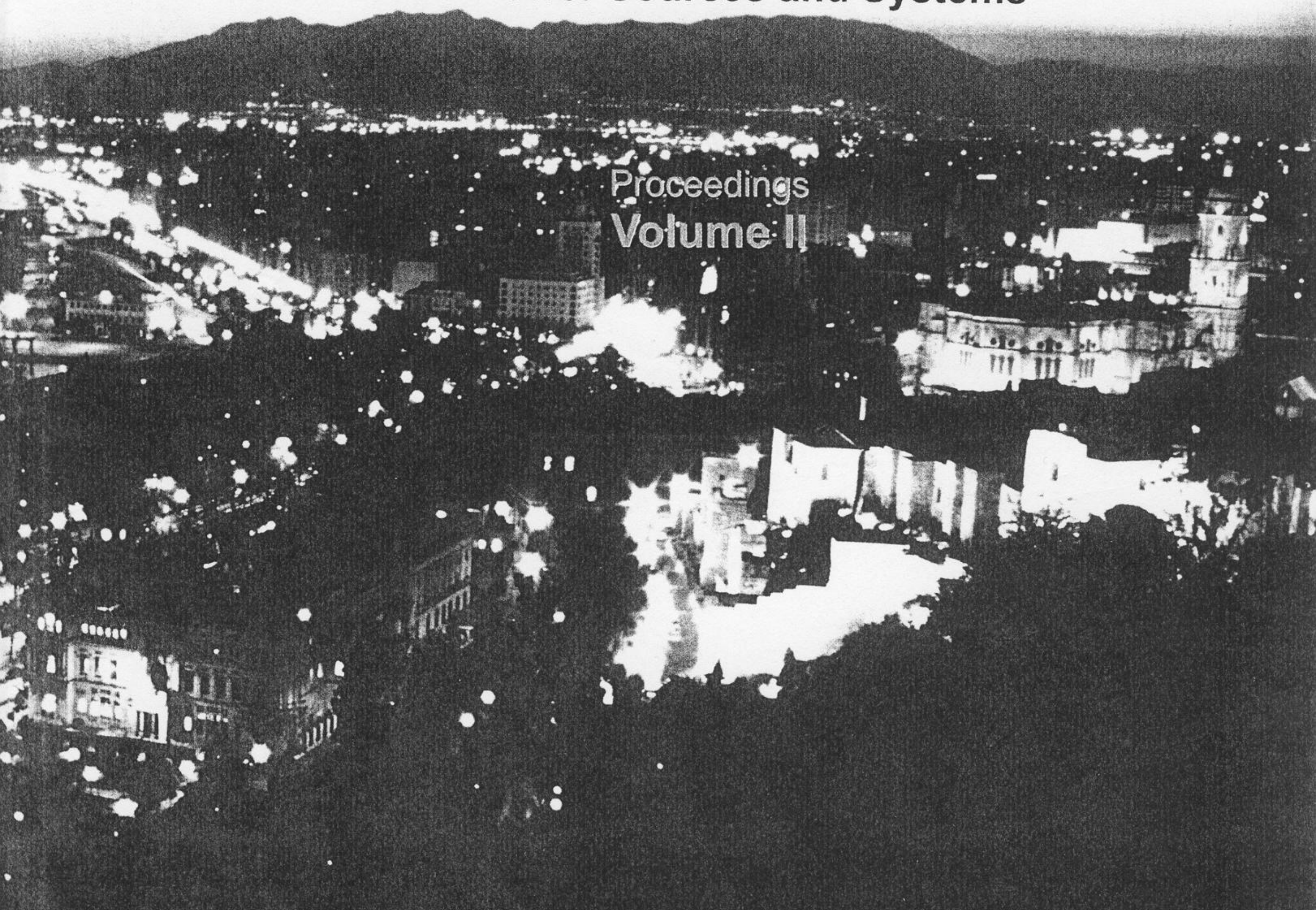

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Networking and Business Aspect

A Telemetry System for Sorbas gypsum karst: A new approach

F.L. Guillén, J.A. Gazquez, N.N. Castellano
Dpto. de Arquitectura de Computadores y Electrónica
Universidad de Almería
Carretera de Sacramento s/n 04120 Almería, Spain
flguille@ual.es, jgazquez@ual.es, nnovas@ual.es

J.M. Calaforra
Dpto. de Hidrogeología y Química Analítica
Universidad de Almería
Carretera de Sacremento s/n 04120 Almería Spain
jcalafor@ual.es

Abstract— **In this work, we present a telemetry system of environmental parameters installed in the Sorbas gypsum caves (Almería, Spain) destined to study the influence of the visits in the conservation of the caves and to determine the minimum time between visits. The information of parameters like the concentration in CO_2 of the air, temperature, relative humidity and human presence, are sent in real time via radio to the data management centre in the University of Almería and publish then in a web site also in real time.**

I. INTRODUCTION

The techniques of measurement and registry of variables using the classic dataloggers, presents the advantage of the system independence, it can be placed in any place and it can measure and store the data in a independent way, with the limitation of the time of autonomy of the battery and the capacity of the data memory. In the other way, these systems present the primary disadvantage of a periodic attention for the substitution of the power supply battery and the unloading of data so we can't get the acquired data in real time [1].

In some caves with certain affluence of visits (fig. 1), it's interesting to registry certain physical-environmental variables like the temperature, the concentration in CO_2 of the air, the relative humidity, etc., to be able to determine the influence of these visits in the environmental conditions of the cavity and thus to be able to evaluate the degree of incidence in the conservation of the cavity. These data in real time can be used to regulate the interval between groups of visitors.

Under the frame of a FEDER Project: Characterization of the Environmental Conditions for Tourist Visits to the Karts in Yeso de Sorbas (Feder 1FD97-1577), we have developed an intelligent acquire and telemetry specific propose system, with the capacity to detect human presence and to modify the acquisition frequency in a adaptive way and resend the data via radio link to the data management centre located in the University of Almería where they are made public through Internet web site [2].

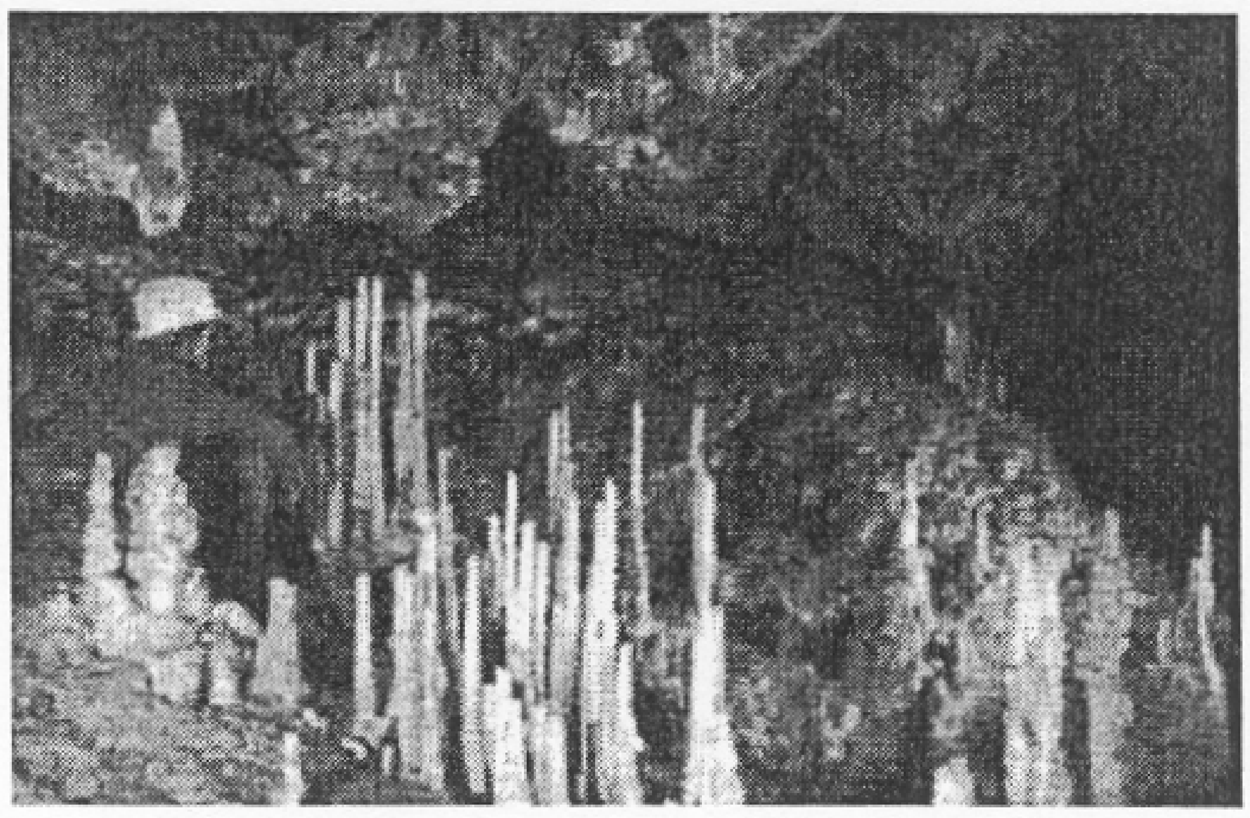

Figure 1. Gallery of the Forest (Sorbas, Almería, Spain).

The system has been working since December 2001, and the data are accessible Internet URL:

http://karst-yeso.ual.es

After more than 6 years in operation, in this article we present the improvements and results of the system to make it suitable to operate another 6 years.

II. PROJECT DESCRIPTION

The Data Acquisition and Telemetry System has been developed using distributed control architecture, and the following parts can be differentiated: Measurement Stations, Communications System and Power supply System [3].

A. Measurement Stations

The Measurement Stations acquire the value of the different sensors and transmit them to a Local Station (fig. 2). This Local Station storage this data and resend them to the Central station (fig. 3). The measurement station (fig. 4) is composed by a set of 4-20 mA current loop sensors: CO_2 sensor based on the infrared absorption method; with range from 0 to 7000 ppm, resolution of 6,9 ppm and a precision of the 1.4%; Platinum Resistance Temperature Sensor Pt100 (two wires), the measure range has established in the margin of 0 to 50° C and allows a resolution of 0,01 °C with a

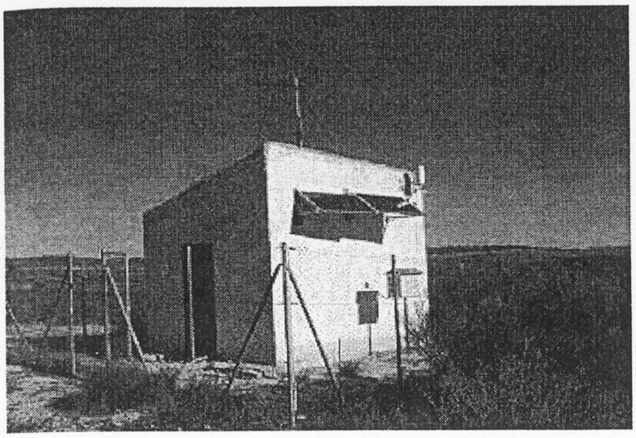

Figure 2. Caseta Estación Local.

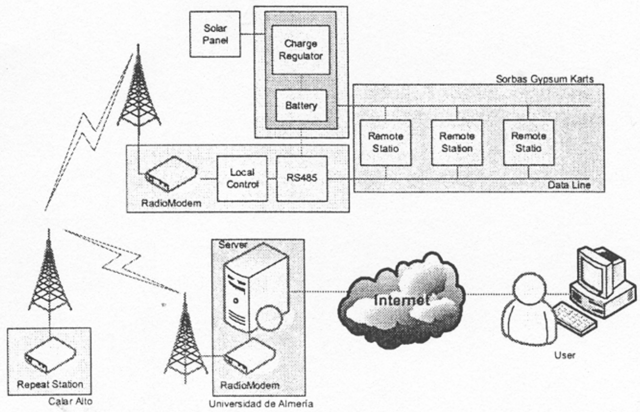

Figure 3. Overall architecture of the data-collection system.

precision of 0,3 °C; Relative Humidity sensor based on the Lithium Chloride Cell method, the range is from 5 to 100%, resolution of 0,1% and precision of 3% and a Presence Detector for the detection of visits to the caves.

For the digitalization of these data, a commercial acquisition module is used. It has 8 channels differentials input, based on an sigma-delta analogical to digital converter 24 bits, a sampling rate of 10 data/second and the bandwidth of 15Hz, allows a precision of the 0.1%.

Stations are interrogated by an adaptive Polling protocol with a variable frequency. We use the presence detector to change the frequency of the polling protocol.

B. *Communications System*

The data are collected by the different sensors from the Remote Stations, these are sent to a Local Computer located in a Local Station near the caves, and then this data are resent Central Computer located in the data management centre, in the University of Almería. We use a mixed system to make this function: the communications of the first stage of the system (Remote stations - Local Station) are made by category 5 wire using RS-485 protocol, and in the second stage (Local Station - Data Management Centre) is necessary the use a radiomodem.

Figure 3 shows a diagram of the Communications System and Power Supply System where communication between the Local Station and the Central station is not direct, and it is made using a repeater located in Earthquake Station in Calar Alto, Almería (fig. 5).

C. *Power supply System*

The location of the local station lacks of electrical energy, thus, we used an independent power supply system. In this case, we decided to use photovoltaic supply. Figure 5 shows the solar panel in the roof of the Local Station [4].

III. SYSTEM IMPROVEMENTS

The improvements made in the system correspond to the reception and data processing system. Although the project is finalized since December 2001, it has been necessary the accomplishment these improvements to guarantee the correct operation of the system.

A. *Data Base Structure*

The data base that stores the measures of the sensors has undergone a migration to PostgreSQL v7.4.2. The data base has a table named *Sistema* that stores the information of the system; this is the main table. Using relationships, the data

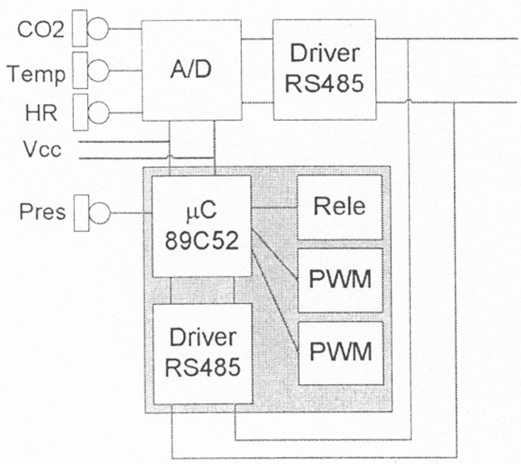

Figure 4. Block diagram of the remote unit board.

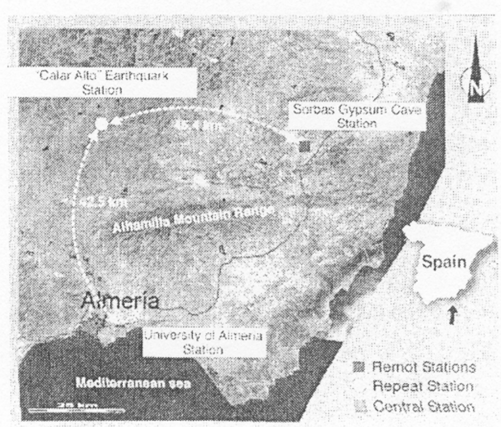

Figure 5. Radio communication between the local station and the central station.

base has another table *Incidencias* that stored the incident messages with date and hour, for example: sensors activation in the cave or in the Local Station, errors in the packages received, access to restricted sites of the Web, etc. Another table called *Sensor-Servidor* has relationship with *Sistema*, and this table stores the values of the internal sensor of the server. The *Bibliografía* table stores all the information about the articles that the project has obtained. This information can be published by the web site in real time.

The *Batería* table is the most important table of the data base, since it store the level of the charge of the batteries in the Local Station (Sorbas). *Sistema* has a relationship with *Estación* table, since *Sistema* has a set of *Estaciones (station)*. Stations are formed by sensors (Sensor table) and sensors makes measures (Medidas table).

B. *Data Reception Daemon*

The data reception daemon received packages through radiomodem. It has been developed under Fedora Core 2 using GCC v3.3.3. We have used a scheme based on daemon. Figure 6 shows a block diagram of this daemon. First of all, we initialize all global variables (static parameters) and we create all the necessary structures (shared memory). This daemon can be used with a SCADA client, so the father process creates tow child process: one receive de data by the serial link, format it and store the data in the data base and the shared memory, and the other provide the network service to the SCADA client using Web service technology.

1) *Serial Reception Process*

This process receives data from the serial port and a dedicated radiomodem. The process uses interruptions to detect he begin and the final of a packages; when a character is received, the system generates an interruption that makes the process of storage of the received character in an Array. Whereas characters are not being received, the process is analyzing the received characters, verifying that they are in the suitable position depending on the type of received package. Two types of packages have been designed: an hour package that stores the date and hour of the remote system, the state of the battery and the alarms. The other designed package corresponds to the data, and stores the values of all the variables of the system (temperature, pressure, humidity, etc), the date and hour.

When the system detects correct and complete packages of information, it is analyzed to determine what type of package is it. A verification of the characters is made and the information is extracted to store in the data base. Appropriate SQL statements are generated using the data from the correct package, then this statements are execute and a copy of this correct package are stored in the shared memory to be used by the SCADA client [5].

All the reception processes are made in real time and they are register in the system logs, so you can know, in any time, what happened with erroneous information or attempts of access to the web site.

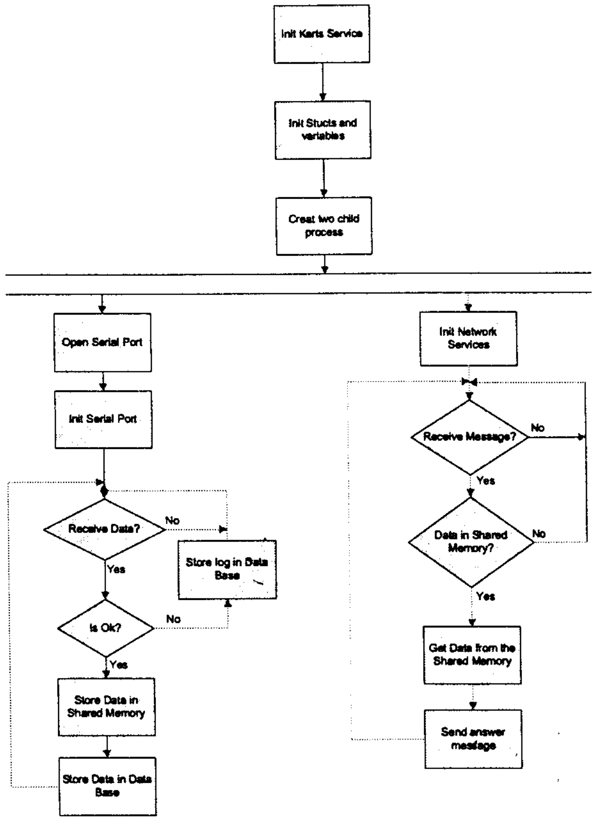

Figure 6. Block diagram of the daemon process.

2) *SCADA Service*

Service SCADA is based on a network server process. First of all, it has to initialize all the variables of the system like listening port, directions IP, etc. Next, the program enters in a loop until the arrival of a message from the client. If a message arrives, the server processes it and using WEB-Service technology replies it. If the message is correct, the daemon resend the last package of information received and closes the connection. The client uses a timer which can be configured by the user. If it expires, the client requests to the server the last package of information (fig. 7).

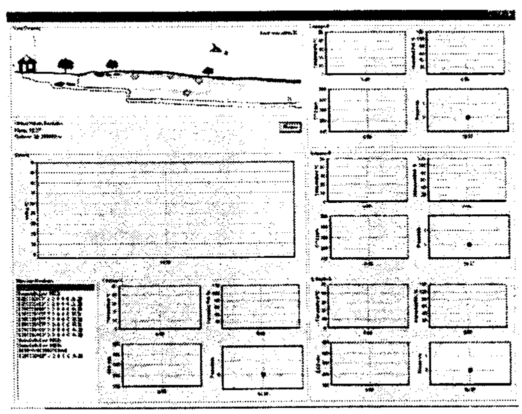

Figure 7. Main Windows of the Scada application.

This way of operation is suitable for systems in which the clients have to request often small information to the server. Software SCADA has been developed in Borland C Builder v6.0, since it offers the advantages of being powerful development tools and it is easy to program.

C. WEB Site

We have been use a Web server, called Apache v2.0.49 and script engine, PHP v4.2. Apache and PHP are GNU licence and they are integrated perfectly within the operation system and have a great power and acceptance. With this software, we can make dynamic web pages with the information required by the user. Also Flash technology is used to make menus and messages of information. Another important thing to use this GNU software is that you have a lot of information about development application and there is a huge community of user around the world (fig. 8).

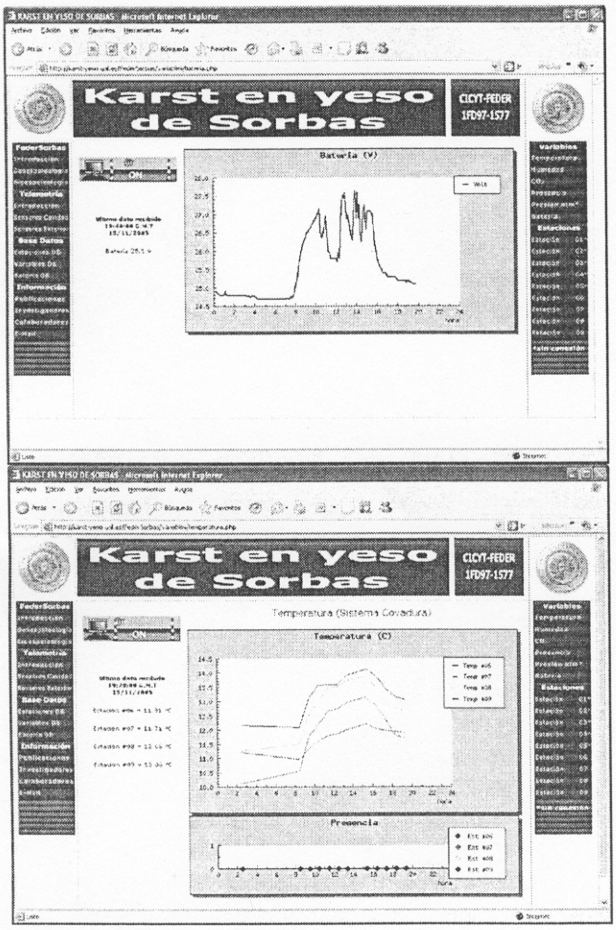

Figure 8. Web Site: Battery Graph and Variable Graph.

The Web site has two lateral menus through which you can obtain data of the project and the daily state of the climatic variables. A dynamic management content system has been introduced. With this system, the research can insert, delete or modify information about the publications that have been obtained from the project. This management system also has list of the last incident that take place in the system, like erroneous packages or attempts of access to the web site.

Data base Queries have been optimized, since after 5 years, the data base has more than 5,233,000 register. We generated the diary accumulated value graph without having to consult the complete data base. Finally, we have improved the PHP script performance to minimize time to generate a graph.

IV. CONCLUSIONS

The development of systems for specific applications requires a considerable effort compared with the installation of closed commercial systems, but allows projects to be undertaken which, because of their novelty, cannot be pursued satisfactorily with commercial systems. In the case of this project it has been possible to undertake the export of information in real time, from sensors inside a cave located in a remote place without telephone line or electrical light, to the Internet. This is thanks to the development of specific systems.

The system can be considered, in addition, as a tool for managing tourist use of the cave. Decisions about the composition of groups of visitors (number of people and frequency) can be made in real time, varying these parameters according to the intensity of the environmental effect produced.

ACKNOWLEDGMENT

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