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WWW SYSTEM SOLUTION FOR HYDROCARBON POLLUTION MONITORING AND ENVIRONMENT PROTECTION

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Abstract: The main purpose of this paper is to present the www hydrocarbon pollution monitoring system which is under development at the Warsaw University of Technology (WUT) The dedicated system server collects data from mobile GSM/GPRS accessed observation points, and delivers information on potential pollution to the authorized www clients. The emergency alarm information is planned to be send directly to palmtop/mobile phone equipped emergency teams to assure short response time to environment contamination. The moving observation points property and country wide GSM operator coverage makes the system flexible and universal.

Keywords: environmental protection, hydrocarbon pollution, WWW measurement system.

1. INTRODUCTION

The aim of the paper is to present the solution of the www system for hydrocarbon pollution monitoring and protection.

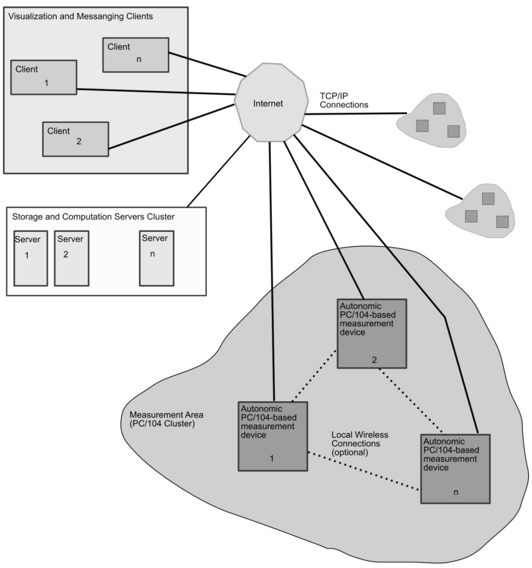

Fig. 1. WWW system structure

The system is still being under development now, and in spite of targeted application, as the www accessible system, it has more general potential implementations.

The aim of the proposed system is to protect sensitive country areas from hydrocarbon pollution with the use of GSM/GPRS accessed mobile observation points equipped with: the GPS position locator, sensitive hydrocarbon contamination probe and GSM/GPRS connection with the central www server. The server has a direct GSM/GPRS links with mobile observation points, updates his database with current observations and assures the www access to the authorized custom clients. Additionally the server, in emergency situations, can use additional direct links to inform the persons on duty on environment pollution. The described structure of WWW system is presented in Fig.1.

At the present stage of system development, the precise solution of the mobile observation point, and the general solution of the server and the custom clients software are presented in the paper.

2. SYSTEM REALIZATION

The system consist of the central server and custom clients with the www access, whose can be based on any kind of PC, any operating system (Unix, GNU/Linux, Windows) and any kind of server software (Apache, IIS or dedicated server). The server and custom clients work in comfortable, office conditions.

On the other side of the system there are numerous (few to few hundred) mobile observation points which work in heavy duty, open air field conditions, with private supplying sources (alkaline/solar batteries) and under installation/maintenance cost restrictions.

The server is not a great challenge here, as it forms a standard, but a specified task oriented solution. Two approaches to server realization are parallel developed now: one with the use of Unix or GNU/Linux environment and the Apache server with PHP module, and the other, Windows system targeted, with the IIS server.

Three versions of mobile observation points are actually build and verified:

- based on the industrial PC-104 computer,
- based on the specialized CPU (ADAM-4500),
- based on a dedicated microprocessor.

Such approach allows to build fundamentals of the flexible system from which in the final stage of development, the developer team will focus on the best subset of elaborated solutions.

2.1. Mobile observation point

Three solutions of the mobile observation point (MOP) are developed and all three are based on the same intelligent RS-485 controlled hydrocarbon contamination probe, GSM/GPRS module, and RS-232 controlled GPS receiver (Fig. 2). The standard interface of peripherals allows for easy replacement of the PC-104 CPU from the Fig. 2 with specialized CPU or dedicated microprocessor in cheaper MOP solutions.

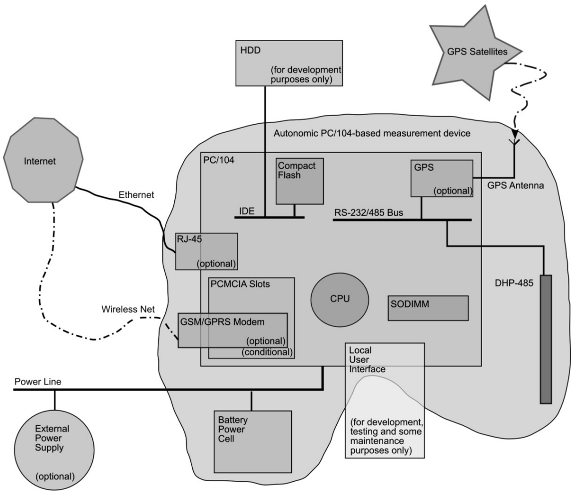

Fig. 2. The PC-104 based mobile observation point configuration

2.1.1. Measuring/communication peripherals

The central computer of MOP controls all three peripherals: hydrocarbon probe, GPS receiver and GSM/GPRS communication module

Hydrocarbon probe

In natural conditions, the measurement of concentration hydrocarbons in water is interesting in the limited range from 0 to 100 ppm. The probe should not be sensitive to other kinds of pollutions and change of temperature. Very limited number of commercially offered probes fulfils such conditions.

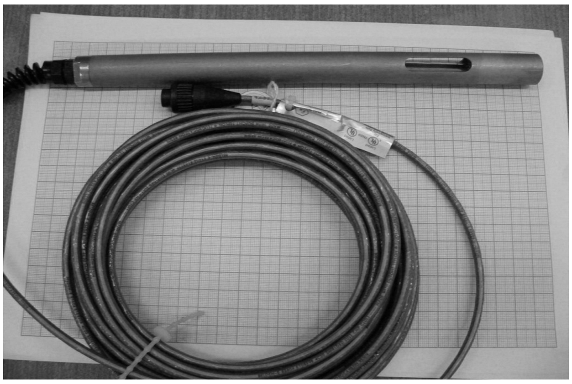

Fig. 3. Digital hydrocarbon probe DHP-485

The probe DHP-485 (digital hydrocarbon probe) made by FCI Environmental, is implemented in the project and has such parameters (Fig. 3). The probe is based on OEM patented fiber optic chemical sensor (FOCS), in which the coefficient of internal reflection changes in dependence from concentration hydrocarbons in the liquid circumjacent the measuring probe. The probe detects only those hydrocarbons which molecules posses more than six atoms of carbon: the hydrocarbons from groups BETX and petroleum hydrocarbons. The measuring range is from 0 to 2000 ppm with the resolution of 0.1 ppm with the measurement accuracy in the range 10% of reading. The power consumption is very low (200 mW). Time of measurement is smaller than 15 minutes. The probe is equipped with the RAM buffered communication RS-485 channel.

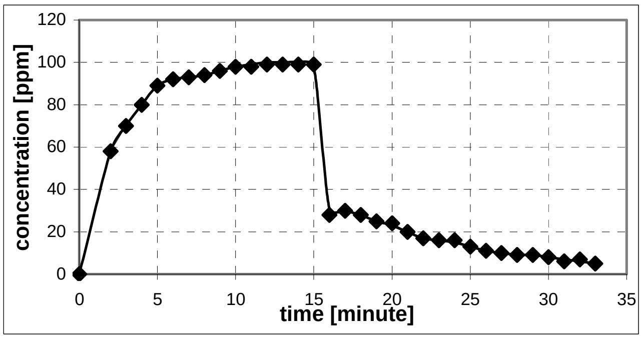

Fig. 4. Dynamic characteristic of hydrocarbon probe

The communications with the probe is based on simple command–response protocol. The initializing command send to the probe starts the measurement. In answer the probe sends information that measuring cycle has been terminated, and measured data can be read. We get exact information about concentration liquid hydrocarbon in water after about 13 - 18 minutes, The response time depends on measurements conditions (the speed of flow). Fig. 4 illustrates this situation.

Fig. 4 illustrates dynamics of the probe when it was moved from the clean water (0 ppm) to standard sample concentration (100 ppm) and after 15 minutes moved back to the clean water. As we can see probe quickly reacts to change concentration, but the stable and fine result is gets after 15 minutes.

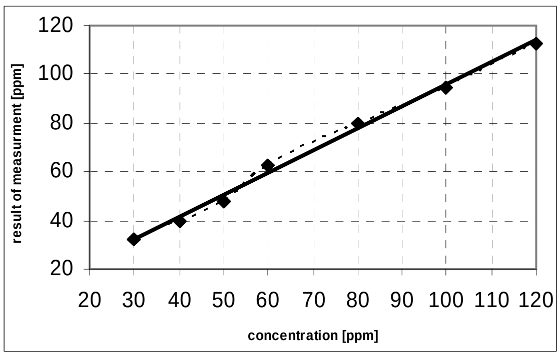

Fig. 5. Measuring characteristic of probe (linear range)

The calibration of the probe is required before the first use. It was verified that the best results were obtained when the point of calibration lies in the middle of the measuring range This situation is presented on Fig. 5. In this case probe was calibrated on value 50 ppm. The concentration of standard solution was measured in range from 30 to 120 ppm. Created in this way characteristic is linear and error of measurement in this range is smaller than 5%.

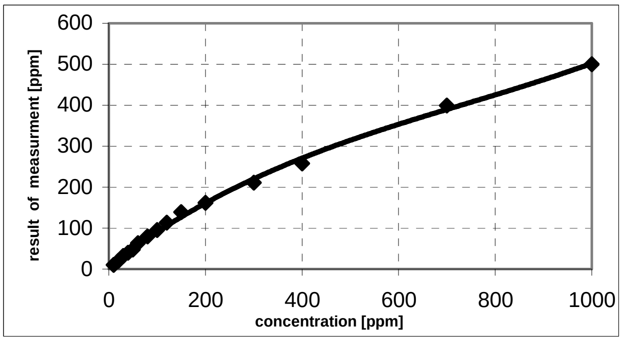

Fig. 6. Measuring characteristic of the probe

If we measure the concentration levels surpassing several times the point of calibration the response is non= linear and measurement errors can reach 50% of measured value (Fig. 6). A special linearization procedure should be implemented in such situations. In the project this problem is not really serious, as the concentrations category 200 ppm are reached very seldom, usually during ecological catastrophes.

The alternative probe 2114HCF (floating oil thickness monitor) made by Arjay Engineering Ltd. is considered. It has a capacitive sensor which is sensitive to the concentration of hydrocarbons in water. This sensor transfers measuring data to central unit across interface RS-485. Such interface permits simultaneous work of both sensors.

GPS position locator

Information of current position of measuring probe in terrain and time of measurement form complement data supplied by the GPS receiver ORCAM-20. This receiver is based on SiRFStarII technology. The best accuracy of assignment of position is 2 meters. Such this accuracy is satisfying for perspective application. The receiver communicates with central controller across the serial port under protocol NMEA-0183, which is the standard data format in text ASCII created by National Marine Electronics Association (USA) to transmission data among navigation attachments.

GSM/GPRS communication channel

Communication between server and MOPs is assured by GSM/GPRS terminals. In modular solution we use the Motorola's g20 modem. Such solution permits communication with the server with the use of TCP/UDP IP protocol, with omission the lower layer of transport data. Central processing unit communicates with g20 trough RS-232 interface. The controller orders module to log-in on remote server. After logging in the controller sends measuring data with top speed 48 kbit/s, During transmission the data to the server, the MOP works as workstation in Web. This workstation has dynamic IP address for which the GSM operator is the internet provider.

2.1.2. PC-104 MOP solution

The PC-104 based MOP solution is presented in Fig. 2. PC/104 is a well defined standard [1] used in many embedded solutions. It has a great advantage as it is in almost full compatibility with Intel's 32-bit architecture [2]. Thanks to this compatibility the same development environment and similar software solutions as in typical laboratory personal computer can be used in project development. Consequently, time to market with new features developed for embedded product is significantly shortened. It is commonly known that PC/104 based products have bigger size and power consumption as compared to other embedded solutions (like these based on ARM microprocessors for instance).. The main reason for the use of PC-104 standard is its ability to create highly scalable and easy to enrich equipment which can operate in hostile environment.

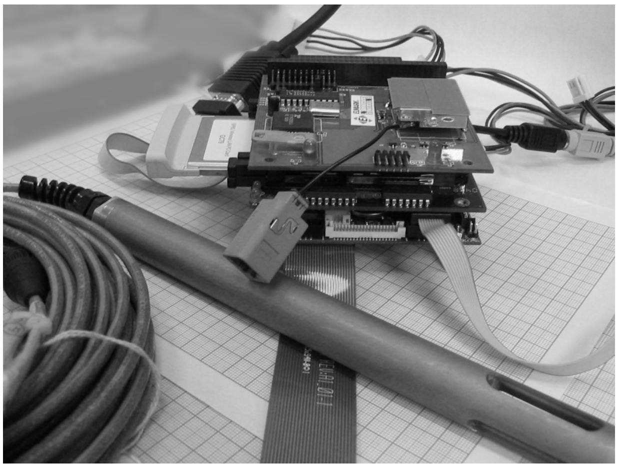

Fig. 7. Mobile Observation Point set based on PC/104

In the early stage of development, basis of this version of described facility was PC/104 all-in-one single board computer. Later on we had to switch to PC/104+ which supports 32-bit bus. The change had to be done due to bus of an GPRS card which was 32-bit PCMCIA card. Now we are using PC/104+ all-in-one single board computer PCM-3370 with low power consumption microprocessor: Intel ULV Celeron 650. The processor works with clock rate about 650MHz, which is much more than it is needed for this design. Spare computing power can be used to provide distributed solutions of any kind, not particularly related to our problem. Chipset of this board supports Ethernet and video graphics on LCD or CRT. These two capabilities can be used in laboratory development as local user interface or in branching the product to a different, more complex tasks.

As in a typical computer there are two main memory types: RAM and hard disk. RAM is exactly the same as that used in laptops: popular SDRAM SODIMM up to 256 MB in size. There are two types of a nonvolatile storage which can be used as hard disk and both are accessible via an IDE bus. One of them is typical hard disk for personal computers but due to its spinning parts, disk-on-chip is preferred in this sort of design. PCM-3370 supports Compact Flash which have no spinning parts and has good performance. Industrial type of the Flash is going to be used in this project. Size of this media will be as small as possible in order to reasonably lower costs but will depend on end user's needs. Tests of this device made with hdparm tool presented that “Timing buffered disk reads” are about 5.96 MB/s and that “Timing cached reads” are about 344.00 MB/s, which is comparable to the same characteristics of disks in personal computers. Fig. 7 shows Mobile Observation Point set which is based on PC/104. Standard ext2/3 filesystem will be used but collected data files will be compressed. In this device Linux kernel and some additional software will be embedded. Some of the software is under development especially for this project. Final system is being designed as a specialized distribution, but some design concepts will be taken from Slackware Linux. The distribution is intended to fulfill embedded Linux standards [5]. The kernel will be recompiled to only fit the needs. Software will be recomplied against uClibc. A prototype of GPS-NMEA parser written in Perl and then rewritten in C language as a final version wiil be available very soon. Main application which will manage data flow in PC/104 based device is designed. Working versions of all needed software will be done till June 2006 and will be presented on Congress. In tests we were able to send chosen information from GPS device through the network to server and store it in database.

End user will have to define area of measurements in which he is interested. In this area many devices will work as distributed system. Wireless connections must be used instead of Ethernet supported by PCM-3370 for the area will be on the water and every device will float as an independent buoy. This device is developed for shores, rivers and lakes which are places where GSM is or should be available. Authors decided to create connections between nodes of the system via GPRS, which is an overlay network for GSM networks [3]. It is quite cheap solution to set up TCP/IP connections in rural areas where designed device will work. There are GSM/GPRS modems in PCMCIA standard sold widely in retail market for reasonable price. With GPRS support, devices have access to Internet so acquired data will be presented with flexible web service, for example. More complex or dedicated application can be developed too. Thanks to the pcmcia-cs and ppp package distributed with Linux, starting communication with chosen modem is very easy. There was no problem with drivers because in the modem popular Ricoh chipset is used.

Data will be transferred from nodes to central server and visualization clients. Authors are considering SOAP supported by World Wide Web Consortium with specific binary encoding to decrease transmission time and data processing time. For now data was transferred as simple XML in ASCII due to early development stage of client-server applications.

Software for presented PC/104-based solution is not the lightest one although authors will do their best to have applications and system as small as possible. It does not have to be, because mentioned standard is compatible with common personal computers. Facility build with this paradigm can and probably will perform much more task than simple measuring, collecting and sending data. This version of design could be treated not only as a final solution but also as a possible field of tests. Developed and matured applications could be fit in other versions of smaller and cheaper autonomic devices for measuring hydrocarbon pollution thereafter. Another such a kind of design is derived from specialized ADAM controllers.

2.1.3. Specialized CPU solution

The Mobile Observation Point is adapted to running with many CPU and probes and sensor. These solution is different but general MOP functions are always kept. Now they will be presented alternative solution to PC-104 CPU.

Controller ADAM 4500 made by Advantech is one of there alternative solutions. This computer is fully functionally stand-alone controller to work in hard climatic conditions. ADAM4500 has 80180 processor and 404KB memory for users, and three communication ports. First port is dedicated for RS-232, the second one is dedicated for RS-485, the third one can be configured for RS-232 or RS-485. Communication of measuring devices with controller is very simple because measuring probe communicates with users across interface RS-485 and the receiver GPS and the modules GSM/GPRS connect with controller across interface RS-232. Additionally, ADAM 4500 has low power consumption and possibility of simple applications execution. Fig. 8 shows Mobile Observation Point set based on ADAM 4500.

Fig. 8. Mobil Observation Point set based on ADAM4500

Another alternative CPU is Embedded Controller I-7188E. This controller has parameters comparable with ADAM4500. It has 80180 processor and 512KB memory. This CPU has Ethernet port, two RS-232 ports, one RS-485 port and one port that can be configured for RS-232 or RS-485, additionally CPU has analog/digital converter. Large number of ports and a/d converter, give the expendability the MOP for new sensors and probes. The Ethernet port can be used for direct transport of measuring data to server.

Another proposition of CPU is ADAM6500 made in Advantech. This computer has larger possibilities than ADAM4500 or I-7188 but it needs there times more power and is more expensive. It implements 32-bit Intel StrongArm 206 MHz processor and 32 MB memory and has one Ethernet port and five communications ports 3xRS-232 and 2xRS-485. For transfer data from CPU to server we can use Ethernet port and TCP/IP protocol. Large size memory is very important because it can be used to the data acquisition when the system GSM will break-down or if the MOP will work for short time.

2.1.4. Dedicated microprocessor solution

Dedicated microprocessor solution implements PHYTEC's phyCORE-LPC2294 single board microcomputer on Philips LPC2294 processor. LPC2294 is 60 MHz clock, 16/32-bit ARM family RISC processor with real-time emulation and embedded trace support, 16 KB on-chip static RAM, 256 kB of high speed flash memory, 32-bit timers, 8-channel 10-bit ADC, 4 advanced CAN channels, two serial RS-232 channels, PWM channels, up to nine external interrupts and 76 general purpose I/O lines. LPC2294 has high instruction throughput, fast real-time interrupt response, low power consumption and high reliability for real time applications in hard climatic conditions. Single board microcomputer adds 2 MB of flash memory, 1 MB of RAM, Real-Time clock, and Ethernet interface. Connection to the elements of observation point will be made through RS-232 interfaces and converters to RS-485 standard [8], [9].

2.2. Web system organization

Web application can control most of distributed system. Measurement devices are terminals which are independent for the system although they can be controlled by central server in some manner. These facilities works autonomously most of the time but server can order them to perform particular duties from time to time. Realization of the server is based on web server free and open-source applications stack called LAMP (Linux, Apache, MySQL, PHP). According to tests performed by Coverity project in collaboration with Stanford University on contract with US Department of Homeland Security, LAMP code has significantly less errors than other tested software [6].

2.2.1 Unix or GNU/Linux system approach

This configuration has great possibilities based on PHP programming language power used to integrating LAMP stack elements with the help of many libraries (modules). This concept provides a very good reliability for work of the server in a real time. Generally, the web server is responsible for accepting HTTP requests from clients- web browsers, and serving them dynamical web pages (HTML documents created on demand). In this system server realizes function of integrator of all system elements.

Server communicates with distant probes by modems over GSM network. Communication is simplified and standarized by underlaying GSM with GPRS and TCP/IP. This manner we have flexible connection with all mobile observation points. MOPs can initialize communication with the server in the event of extreme pollution or after collecting particular amount of data. But also the server can perform certain tasks on MOP in time windows. For example it can switch MOP to maintain continuous communication and real-time data flow. So then database mainframe and autonomic facilities are considered as nodes pushing or pulling data equally. Synchronization problems are being solved with standardized [4] and well known Unix style and thanks to the XML-based protocol. Simple solution is based on timestamp included in each entry of data. Every data packet will have also information about source – from which device it came. Additionally, MOPs append precise location and a highly accurate time reference information from GPS receivers for each communication session. This time information will be used to synchronize local clocks in measuring terminals, database server and clients.

Server application commands the whole system, provides remote monitoring of system status and collects all information in SQL-based database. MySQL will be used due its popularity and ease of use but using more advanced database like Postgres is not prevented. The state of all system is presented in reports as a HTML documents generated dynamically on server by PHP language. This manner, information from system can be accessed in any place having connection to the Internet. For archiving purpose for the system work a PDF documents are created using ClibPDF library. The security measures are taken to provide access to information with authentication to authorized personnel using login and password implementing HTTP Authentication or nowadays popular authentication based on database entries. Alert information about certain level of pollution is supplied directly to the emergency groups and authorized persons using SMS messages on GSM network and e-mail messages on Internet using mail network protocols SMTP and POP3. Of course whole communication can and will be cyphered with commonly used secured layers for security reasons. Of course whole communication for security reasons can and will be cyphered with commonly used secured layers.

Format of the reports from the system can be dynamically modified according to the questions send from recipient of information to server. Web application can generate reports in graphical mode easing this manner receiving huge volume of data using specialized libraries such as GD or GraPHPite for example. Thanks to the GPS the exact location for every measure is available just as the timestamp is. Integration of these informations from database and its graphical visualization on map will make results of system work more useful and readable.

2.2.2 Windows system approach

The Windows Visual Studio 2005 offers great flexibility in web applications development with the use of ASP.NET.

The Windows Visual Studio IDE forms the interesting alternative to Unix web development tools as it has direct access to the Windows GUI and databases. The web IIS server which runs the application can be installed on Windows XP as well as Windows Server 2003 operating systems.

The additional advantage of Windows approach to server realization is the Visual Studio ability to program web services on mobile platforms. With the ASP Mobile Application Development the alarming situations can access mobile phones and palmtops to assure quick response to abnormal situations.

The authentication and authorization measures assure security of web applications.

3. CONCLUSION

The presented paper described the www hydrocarbon pollution monitoring system which is under development at the Warsaw University of Technology. The idea of designed system based on collecting data from mobile GSM/GPRS accessed observation points (MOP), and delivering information on potential pollution to the authorized www clients. Data transfer between MOP and clients is controlled by the www server. Three types of dedicated MOPs were described, based on: microcomputer PC 104+, microcontroller ADAM 4500/6500 and phyCORE-LPC2294 single board microcomputer.

Two approaches to server realization were discussed: one with the use of Unix or GNU/Linux environment and the Apache server with PHP module, and the other, Windows system targeted, with the IIS server. On the current stage of the project both approaches are parallel realized. The final selection depends on the end-user expectations and economic restrictions.

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