APPLICATION OF GSM NETWORKS TO CONTROL THE HARDWARE OF SCIENTIFIC AND EDUCATIONAL LABORATORY COMPLEX

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Abstract: The presented paper describes a technique of remote access to the distributed information measurement and control system on basis of GSM technologies. The mechanism of remote access is implemented by means of mobile device and Siemens TC65 GSM terminal and includes developed software for transferring packets of commands between the terminal and mobile device. The terminal is connected to the distributed computer network of the laboratory complex via Atmel ATNGW 100 microprocessor board. The application protocol of the distributed information measurement and control system is proposed for interaction of mobile client and GSM server. Packets of the protocol are encapsulated in SMS messages. The access to physical equipment is realized through the standard interface servers (PXI, CAMAC, and GPIB), the server providing access to Ethernet devices, and the communication server, which integrates the equipment servers into a uniform information system. The system is used for researches in optical spectroscopy and for education at the Department of Physics and Engineering of Petrozavodsk State University.

Keywords: GSM networks, distributed information measurement and control system, GSM terminal, access equipment server, distance learning.

ACM Classification Keywords: H.3.4 Systems and Software: Distributed systems.

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Introduction

Modern laboratory complexes usually represent distributed control systems for experiment, providing access to their resources over the Internet. However, in order to improve accessibility of laboratory complexes and, at the same time, enhance their protection against unauthorized access, it is reasonable to develop alternative concepts of control for experiment. Moreover, the implementation of these concepts can serve as a standby or parallel form of access to laboratory equipment, as well as the main form. In particular, it is possible to realize the remote control for equipment through GSM networks. Usage of GSM devises provides communication between experimenter, who can be located almost everywhere, and automated laboratory complex, even if it does not have connection to the global computer network. Advantages of a such approach can be considered as an opportunity to monitor the experimental setup, as well as significant savings of time and money, that would have been spent by experimenters in case of direct service of equipment in the process of long term measurements.

At the Department of Physics and Engineering of Petrozavodsk State University the distributed information measurement and control system to support scientific and educational process was created [Гаврилов et al, 2002] – [Kiprushkin et al, 2008]. This heterogeneous system includes client programs for direct control of experiment, the communication (central) server – integrating part of the system, equipment access servers (the CAMAC server, the GPIB server, the PXI server, the Ethernet devices server, the GDS-840 digital oscilloscope server, etc), measuring and executive devices and, also, the database server. The system software was written in Java. This system was designed to research the process of excitation in the atom-atom collisions [Kurskov et al, 2008], to conduct laboratory classes on the spectroscopy of beam and plasma installations, and to study the bus interfaces for data acquisition in the course "Automated systems for research" and also in the course "The organization of remote access to automated systems for information processing and management".

Access to the system equipment has been provided via networks based on TCP/IP protocol stack.

The aim of this work is to provide access to the distributed system via GSM networks. To achieve this aim we created the GSM terminals server, which implements interaction with the communication server of the system. Also we developed a special software for mobile phones. This software ensures rapid and effective formation of command packets and forwards them to the system server by means of Short Messaging Service (SMS).

GSM Access to Laboratory Complex

To work with mobile devices (mobile phones, computers with GSM modems) the system was extended by the Siemens TC65 cellular terminal with support of a variety of technologies such as: GSM 850/900/1800/1900 MHz, GPRS Class 12, standard industrial interfaces and Java software development (Java environment allows to run applications directly on the microprocessor terminal). The terminal has a built-in TCP/IP protocol stack. The security of transmission is ensured by using HTTPS and SSL data transmission protocols.

The scheme of the interaction between a mobile phone and the distributed information measurement and control system is shown in Figure 1.

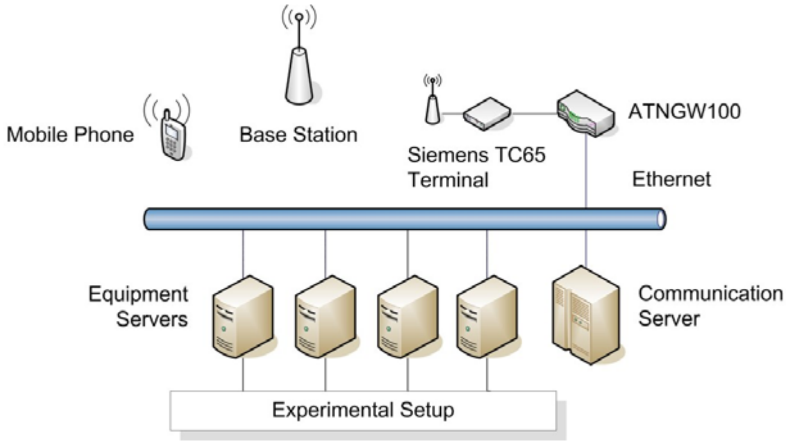

Figure 1. The scheme of the interaction between a mobile phone and the distributed information measurement and control system

In order to manage the GSM terminal and to connect it to Ethernet environment the Atmel ATNGW 100 microprocessor card was used. This card is based on AT32AP7000 32-bit microcontroller with RISC architecture.

As a control device, it completely replaces the personal computer with the clock frequency 133 MHz and several gigabytes of disk space. The Atmel ATNGW 100 board has a large set of interfaces (USB 2.0, RS-232, Ethernet, etc) and also 62 general purpose I/O ports. It runs Linux kernel based operating system.

The GSM terminal server for this board was written in Java. The main function of the server is to provide packet exchange between a GSM client and the communication server of distributed system. The functionality of the server also includes check of packets integrity, access control based on clients' phone numbers, forming answers in a readable format and sending them to clients, etc. In fact, it is a link between experimenter and the distributed information measurement and control system. The server connects to the terminal via RS-232 interface.

Command packets, which are formed, for instance, by mobile phone, consist of instructions for equipment servers of the distributed system. Response messages contain various information, e. g. current system state and results of packet processing.

The terminal receives instructions from mobile devices via SMS messages, which can be typed on mobile phone manually or with help of special software, including support of encryption. Further, the terminal informs the server about received message (in a single frame or packet). The terminal server receives frames and transmits them to the central server of the system. Thus, the terminal server plays a role of standard client of the automated system. Feedback is also performed by means of SMS messages. So the state of claims to the command processing and the progress of experiment can be observed on the fly.

The terminal server (as any server with access to the system equipment) has a typical structure and the only difference is a library of methods, which realize interaction with the GSM terminal. The server processes requests sequentially. The server includes such classes as:

- GSMS is the main server class. It implements "listening to the network", connects to the communication server, ensures terminal initialization and sets the terminal to waiting for message mode;
- CServerProtocol defines operation codes, error codes and other constants of the communication protocol;
- QueryToEServer describes "request frame to server" object and methods of access to this object;
- ReplyFromEServer defines "response frame" object and methods of access to this object;
- GSMLib includes library of methods of access to the terminal. These methods implement AT commands delivery, as well as data receiving and data sending. I/O operations with COM port are implemented by means of external methods, written in C ("native" methods in Java).

During testing of earlier versions of the server (for personal computer, not for the ATNGW 100 microprocessor board) we discovered several deficiencies. Both the server and the client lack security. The possibility of packages interception and substitution was not taken into account. Another issue concerns ineffective use of the transmission medium.

For elimination of these disadvantages the software unit responsible for reception and transmission of messages has been significantly updated and modified. In particular, now the content of SMS message is ciphered and compressed with usage of progressive algorithm that allows to increase a quantity of the helpful compressed information in a message with comprehensible duration of process of compression.

In the packet mode ([Кипрушкин et al, 2007] and [Kiprushkin, Korolev et al, 2008]) the short sequence of integrated commands is transferred to the system, then the client is disconnected from the system. After the "start packet" command the communication server saves all subsequent commands to the file until it receives the "end of the package" command. Further, the server sequentially reads commands from the file and sends them to the appropriate equipment servers for execution. On the completion of all commands, the client receives a notification of the possibility of obtaining results. When equipment failure occurs the client, in accordance to the application protocol of the system, will receive an error message. In case of a fatal error the package execution will be stopped, and the client will get an appropriate message.

The developed software for a mobile phone forms packets of instructions for remote control of equipment. Each package consists of a frame collection defined by the protocol of the distributed information measurement system. The frame of the protocol for data exchange between a mobile device and the communication server contains an address array, function code, data type, a key (it is intended for system administration) and data [Gavrilov et al, 2002]. User interface enables sequential input of frames by selecting them from the list with further saving them as a package. The "transfer ready" command initiates the encryption of the package and the process of sending SMS message. The penultimate frame of the SMS message sets the value of time interval between the messages informing the experimenter about the state of the experiment. The package reception is confirmed by the communication server.

This special software was written in Java and intended for phones that support Java2ME platform.

Conclusion

The realized access method to resources of the distributed system has a special value for remote training and performance of some laboratory works in the course of full-time education. When computer classes, buildings and laboratories change their configuration and network security policy, the offered approach allows to bypass local area networks and provides uninterruptible access to the system.

Besides, the ATNGW 100 board allows to use computing system resources more rationally, increases period of offline work of the terminal server (with help of uninterruptible power supply), and also reduces cost and sizes of the GSM subsystem. This implementation of mobile segment of the system (perhaps with minor modifications) can be interesting not only for the remote control of experiment, but also for solution of other applied tasks.

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