MOBILITY SUPPORT FOR THE ACCESS TO A MONITORING SYSTEM

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Abstract: Remote access is a very important capability of a condition monitoring system. There are several types of solutions for remote access, and currently the most dominant ones are based on Web technologies. Evaluation of a Web server based solution, and a solution based on a program for remote control, resulted in low performance, especially over low bandwidth communication link. This has encouraged development of an alternative solution which is presented in this paper. The solution is built on a special TCP based protocol integrated into the monitoring applications and tested over a low bandwidth GSM communication link.

Keywords: remote access, client-server system, mobile data transmission, monitoring, protocols.

1. INTRODUCTION

The transformer monitoring system measures and estimates many transformer parameters, it recognizes incipient faults, and presents monitoring results to the user.

The system consists of sensors installed on the transformer, connected to the controller with real-time monitoring application. Controller communicates through TCP/IP communication link (Ethernet) with a computer (server) located in the control room. The server monitoring application collects, processes, archives monitoring results, and serves clients with monitoring results. The user (client) monitoring application presents monitoring results to the local or remote users [1].

There are several ways to access monitoring system equipped with computer from a remote location (via internet or directly), e.g. using a web server and web browser, Remote Desktop Connection utility in Windows, or third-party application for remote control.

2. SOLUTION REQUIREMENTS

To find a way for a proper solution of remote access to the transformer monitoring system, important facts that influence the solution should be considered, requirements for remote access should be defined, features of considered solutions should be compared, and after that the optimal solution can be chosen.

Most important fact that affects access to the monitoring system from remote location is the type of the connection available for the monitoring system in a substation. Some transformer substations have LAN infrastructure (Local Area Network). Therefore access to the system should be enabled trough the LAN/WAN infrastructure. But there are still many substations without LAN infrastructure. In this case access to the system can be achieved through a dial-up connection using a phone-line and a modem.

Phone line in a substation and on a remote location can be a standard analog phone line, an ISDN (Integrated Services Digital Network), DSL line (Digital Subscriber Line) etc. In the case when connection to the server is realized through the analog phone line (on the server side, in the substation), one can expect problems due to the low upload speed, and several users cannot be served simultaneously with acceptable speed.

After studying the specified facts, the following demands were defined for accessing the system [2]:

1. Access to the system must be safe and fast, even over connections with minimum level of quality of service, and low bandwidth (connections via analog or mobile modem).

2. System must be able to service several users simultaneously, regardless of the type of their connection to the system, and at the same time it must not block or interfere with local operation and usage of applications running on the server.

3. Client (user) must be able to overview many remote monitoring systems through the same connection infrastructure (for example through LAN/WAN). Also, he/she must be able to access a monitoring system through different links (for example from workplace through LAN/WAN, from home via modem and phone line, and from anywhere via mobile modem and mobile network).

3. REMOTE CONNECTION LINKS

3.1. Types of connection

The prerequisite for remote operation is a proper TCP connection between remote computer and TMS server. The connection can be established via:

- local area network (LAN),

- Internet (VPN – Virtual Private Network connection),

- direct dial-up, using:
  - modem - via PSTN (Public Switched Telephone Network),
  - mobile phone, or wireless card - via mobile network.

LAN connection - If the server and client computer are in the same LAN, the server application of the monitoring system is accessible from the client application. All that is necessary is to define the IP address of the TMS server.

Internet (VPN) connection - A VPN is a private network that uses a public network (usually the Internet) to connect remote sites together. Instead of using a certain connection such as leased line, a VPN uses virtual connections routed through the Internet from one to the other site [3].

To connect a remote computer with the TMS server in VPN, the remote computer must have set VPN connection, and the TMS server must be set to accept VPN connections. Also, both computers should be connected to the Internet.

Direct dial-up - Dialup is the application of the Public Switched Telephone Network (PSTN) to carry data on behalf of the end user [4].

To connect a remote computer with the TMS directly via modem, the TMS server must have a modem connected to the public telephone network and it has to be set to accept direct modem connections. Besides, the remote computer must also have a modem connected to the public telephone network and it must have set direct dial-up connection(s).

Instead of a modem and the public telephone network, the remote computer can also use a mobile phone, or a wireless card and GSM network.

3.2. Overview of mobile data transmission standards

Data transmission over digital mobile phone systems such as GSM (Global System for Mobile Communications) is done by using certain data standard. GSM is considered a second generation (2G) mobile phone system.

2G networks offer low speed data transfer such as CSD (Circuit Switched Data). This form of data transfer delivers 9,6 kb/s data transmission to the GSM Network and Switching Subsystem where it could be connected to the PSTN allowing direct calls to any dial up service [5].

Enhancement of a CSD is High-Speed Circuit-Switched Data (HSCSD) which can provide an increase of maximum transfer rate up to 57,6 kb/s and, even in bad radio conditions where a higher level of error correction needs to be used, can still provide a four times speed increase over CSD (38,4 kb/s versus 9,6 kb/s). Another upgrade of a 2G data transmission service is General Packet Radio Service (GPRS) with available bandwidth usually between 30 and 80 kb/s. GPRS service is usually charged on the basis of the amount of data transferred, while CSD and HSCD services are billed on the basis of the duration of the connection.

Next generation of mobile phone system, known as 3G (third-generation), delivers much higher data transfer speeds then second generation of mobile phone systems. Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) mobile phone technologies. UMTS supports up to 1920 kb/s data transfer rates, but user can typically expect performance up to 384 kb/s.

Modern 3G connections are still unavailable in many countries and in rural areas. Besides they are relatively expensive compared to 2G services. If the remote user wants to connect to the server using mobile phone and dial-up, he/she cannot use a UMTS or GPRS service because those services do not support dial-up connections. UMTS and GPRS can be used only when connecting to a VPN over the Internet. So user can use either CSD or HSCSD to establish dial-up connection. Since many mobile network operators do not provide HSCSD, user will must use CSD which delivers maximum transfer speed of 9,6 kb/s.

4. EVALUATION OF REMOTE ACCESS SOLUTIONS

Since all applications in our monitoring system (first running on the controller, second running on the server, and third running on the remote computer) were developed using LabVIEW as the development environment, the first logical step was to analyze possibilities of environment built-in tools.

4.1. LabVIEW web server

LabVIEW web server is simple to use. For remote access to the application developed in LabVIEW, it is necessary to define virtual instruments (application windows) that will be published as web pages, to create their html pages, to define access permission and to run the application and the web server [6].

Advantages of this solution are:

- no need for developing additional software for remote access,

- simple configuration,

- opportunity to view and to control the application on the server from a remote location,

- client uses the web browser (Internet Explorer) for accessing the server (no additional software required), what simplifies setting up the remote access to the monitoring system.

Disadvantages of this solution are:

- when accessing from a remote location, monitoring application becomes practically useless for local user and for other remote users, because the remote user takes control over it,

- weak performance on slow connections due to a huge amount of transferred data,

- verifying client's IP address is the only possible way to grant access (even IP address can be changed programmatically, this is not a good solution to serve dial-up users) [7],

- system messages from the server are not visible to the client,

- it does not support some of the LabVIEW standard functionalities.

Because of too much disadvantages, this solution is not acceptable for remote monitoring access.

4.2. Remote Desktop Connection

This application is a standard component of Windows XP Professional operating system [8], and it was our next considered solution.

Advantages of this application are:

- no need for developing additional software for remote access,

- it is well supported by the operating system because it is an integral part of OS,

- faster communication compared to LabVIEW web server,

- easy to configure,

- user authorities are restricted by user account, what is useful when connecting by dial-up,

- allows user to take over control of the entire computer (not only monitoring application), so that the user can set up parameters, install programs remotely, and download/upload files.

Disadvantages of this solution:

- during the access from remote location, the server becomes unavailable for local user and other remote users,

- it is still unable to achieve satisfying performance on connections with low transfer rates, Fig. 1., and Fig. 5.

Other third-party programs are not described in the paper, because it is obvious that using programs for remote access doesn't satisfy defined demands.

4.3. Results of solutions analysis

Specified solutions where compared from many aspects, especially concerning time needed for system overview, and amount of transferred data.

Irrespective of the solution type, remote access begins with connection initialization (connection establishment). As the initialization is necessarily for any type of remote access, and it is the same when using any solution, its time duration, amount of transferred data and other parameters needed for connection establishment are not observed in the paper, in order to make differences between solutions for remote access clearly visible.

Tests were carried out for all solutions in the same extent, inspecting current signal values. Server and client computer where linked over direct dial-up connection. Server was connected with analog modem to PTSN, while client used mobile phone and CSD.

Measurements show that overview of remote monitoring system, performed using solution based on a LabVIEW web server tool, last for an hour and 42 minutes, and transfers data amount of 4200 kB.

Overview of remote monitoring system using solution based on a Remote Desktop Connection lasts for 54 minutes, and transfers data amount of 700 kB.

Testing a solution based on a Remote Desktop Connection tool, which has many advantages and only two disadvantages, indicates that the problem can be solved only by defining a protocol, and by developing server and client communication tools that transfer minimal amount of data. These tools should be integrated into server and client applications. Important requirements for this protocol are: serving multiple clients at the same time, including local and remote operation, even on connections with low transfer rates.
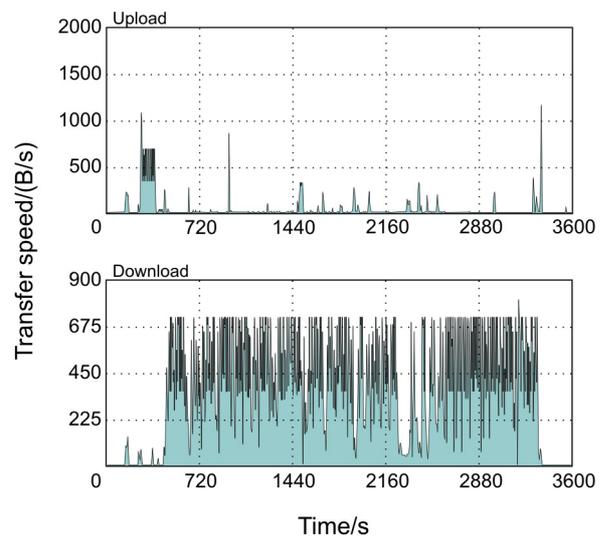

Fig. 1. Network traffic between TMS server and client computer using Remote Desktop Connection application

5. E-TRAFO REMOTE ACCESS SOLUTION

5.1. Monitoring system software

Software of the TMS consists of three major applications:

- e-Trafo Origin – monitoring application which runs on a controller (PAC), provides data acquisition and signal processing.

- e-Trafo Spot – monitoring application which runs on a server computer (PC), provides long-term storage of acquired data, additional signal processing, logging of alarms and events, and serving data for client applications.

- e-Trafo Anywhere – monitoring application which runs on a client (remote) computer (PC) enabling

user to access monitoring results from server application.

All three applications were developed in LabVIEW development environment.

5.2. Communication in monitoring system

e-Trafo Origin and e-Trafo Spot applications communicate using TCP/IP protocols via Ethernet 10/100 link.

The communication between e-Trafo Spot and e-Trafo Anywhere is one of the points of this paper. This communication was realized by defining TCP/IP based protocol, and by developing sever and client tolls. These tools support the defined protocol, and they are integrated into server and client applications of monitoring system.

It is possible to run e-Trafo Spot and e-Trafo Anywhere on the same computer (usually on the server computer situated in the substations control room) or to access e-Trafo Spot application from a different (remote) computer that runs e-Trafo Anywhere application.

5.3. Attributes of solution for remote communication

e-Trafo Spot can serve one or more clients at the same time (Client 1...N, Fig. 2). Client applications can connect and disconnect at random times to access monitoring results. This multi-client server can dynamically accept and service many incoming connections. This is a significant advantage compared with the usage of Remote Desktop utility in Windows, which allows only one user at a time to get access to server application.

e-Trafo Anywhere is a client application with graphical user interface (GUI) which enables user to access monitoring results and presents them in an appropriate form (chart, numerical, etc.). User can switch through different monitoring systems with a single mouse click and the connection with the new server is automatically established (if client and server are part of the same VPN).

Communication between server and client applications is fully encrypted, even if both of them are installed on the same computer.

5.4. Information flow during remote access

When user requests data from a certain server, e-Trafo Anywhere attempts to make connection with that server. After connection with the server has been established, e-Trafo Anywhere sends a specific command with log-in parameters to the server. New Connection Monitor module of server's Connection Manager verifies log-in data and sends information to the User Request Parser. If the user is allowed to access data, Connection Manager stores context information of that connection and provides an API (Application Programming Interface) to access that connection. After that server sends a command to the client, using Information Sender, which confirms that user has successfully logged-in. In case that the user doesn't have rights to access this server the connection will be banned and the client will be notified.

When e-Trafo Anywhere receives a confirmation of successful log-in, it begins to send commands based on user activities using User Request Sender (requests for certain data). A new command will be sent only if user requests different data. Connection manager receives incoming command and stores it as context information (property) for that connection. User Request Parser loops through all active connections and examines their requests (commands) and routes that information to the appropriate loop in the Information Server.

Central Application provides all monitoring tasks from high priority tasks such as: data acquisition and signal processing, to medium priority tasks such as servicing client requests, alarms and events logging and data archiving. It receives clients requests and parameters from the Information Server and serves them. Requested data is sent to the client only if data has changed from the last iteration, or if the client has sent a new request in the meanwhile. This significantly reduces traffic between the server and clients.
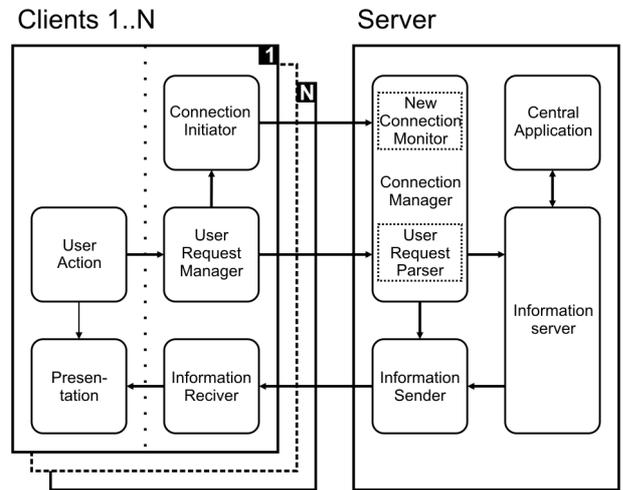

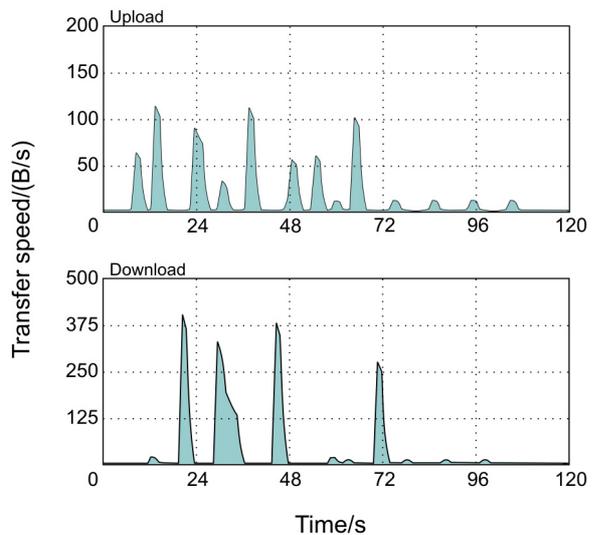**Fig. 2. Architecture of solution for remote communication in monitoring system**

Fig. 3. Network traffic between TMS server and client computer using TMS/TCP protocol and e-Trafo Anywhere application

6. RESULTS

Measurement results are given in Fig. 4. and Fig. 5. for three types of remote access: e-Trafo remote access solution, Remote Desktop Connection and LabVIEW web server. It is obvious that the developed solution has much better results and much better fulfills the defined requests.
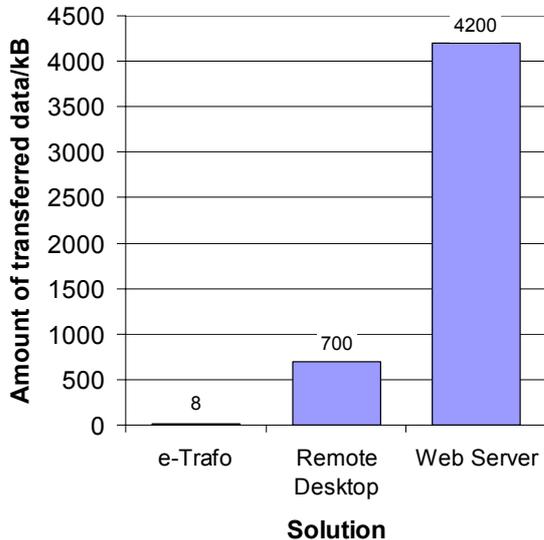

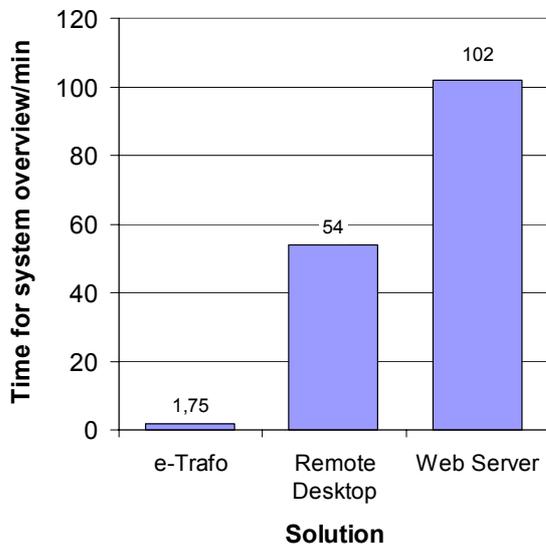**Fig. 4. Amount of data transferred during system overview**

Fig. 5. Duration of system overview

Compared to other solutions, this solution works several times faster than Remote Desktop Connection and even more times faster than LabVIEW web server. This is achieved by developing tools for server and client that recognize user need (requests), and transfer only data needed to fulfill user requests, significantly minimizing amount of transferred data, and time for system overview (Fig. 5.)

The time for system overview depends on transfer speed. At lower speed the time required for system overview is longer, and the differences between solutions are bigger. Accordingly, at higher transfer speed the required time is shorter, and differences between solutions are lower. Listed results are measured at direct dial up connection with maximum transfer speed of 9,6 kbps.

7. CONCLUSIONS

Since many substations provide links with relatively low bandwidth for remote accessing to a monitoring system (usually modem connected to PSTN) it is relatively difficult to access such systems from remote location. This is especially indicative when remote user wants to use a mobile phone to access monitoring system.

Tests that were carried out showed that solution for remote access based on a program for remote control along with the solution based on a web server has very poor performance. Since none of the two considered solutions satisfied all the desired requirements (serving multiple clients at the same time without affecting local operation of server, providing smooth operation even on the slowest connections), a special TCP based communication protocol along with the server and client tools was developed. These tools recognize user needs (requests), and transfer only the data needed to fulfill user requests, significantly minimizing amount of transferred data, and time required for system overview.

REFERENCES

[1] M. Banović, Z. Godec, and V. Cindrić, "The Value of Information Obtained Through Transformer Monitoring System", 10th IMEKO TC10 International Conference on Technical Diagnostics, Budapest, June 2005.

[2] M. Banović, S. Keitoue, "Enhanced Remote Access to the Monitoring System", International Conference on Condition Monitoring and Diagnosis, Changwon, April 2006.

[3] J. Tysson, "How Virtual Private Networks Work", http://computer.howstuffworks.com/vpn.htm.

[4] Cisco Systems Inc., "Dial-Up Technologies", http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/dialup.htm

[5] Wikipedia contributors, "Circuit Switched Data", Wikipedia, The Free Encyclopedia, http://en.wikipedia.org/w/index.php?title=Circuit_Switched_Data&oldid=43517596

[6] LabVIEW Function and VI Reference Manual, National Instruments, January 1998.

[7] LabVIEW Help: Networking in LabVIEW

[8] Windows XP Help: Networking and the Web, http://www.microsoft.com/resources/documentation/windows/xp/all/proddocs/en-us/default.mspx, Microsoft Corporation, 2006.