Design of solution for visualization and technological process control by using WEB technologies

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Abstract
Conception of this project is based on remote technological process control by using WEB technologies. This project is pointed to design and realization of complete system structure, mainly to the server part which provides services to connect remote operators through dynamic web pages and to connect external remotes through universal interface for special applications. These external applications are built specially only for concrete technological process control. Implementation includes specific connections between controlling interface and technological device, concretely to propulsion systems and to the sensors system. Realization is divided into two parts. In the first part we verifying designed solution and in the second part we implement verified solution into real process of material interpolator placed in Faculty of mechanical engineering in Slovak Technical University, Bratislava.

Keywords: Remote technological process control, process visualization, WEB technologies, remote access management

Introduction

Remote technological processes control appears to be common in nowadays industry. Using of this type of control reduces physical presence of process operators to minimum and these operators can be used much more effectively. Advantage of this kind of centralization is also the efficiency of process workflows, control and complex outputs evaluation from depended technological processes etc. In the risk environments is using of this kind of controlling very advantageous because of the security, where the operators are protected of unsupplied influence e. g. in case of accident is happened.

The remote control of technological processes allows us to approach to the system from many different places and also the technological process is accessible for more operators who work in different places and they can control each other, communicate and complement one another, which brew up opportunities to preserve contacts to the new trends, thoughts, methods, solutions etc.

The important factor of remote technological processes control is the sensors system. Information about current states of every part of technological device, e.g. propulsion system, movements of device or position of material in actual grid storage etc., has to be available immediately, therefore the information transfer of these sensors are ordered as the highest priority.

The sensor system has to be adequately fast so that it can send the information immediately to the control system to allow evaluate all device states. Advantage of remote process control is the variability of using more software solutions. Using of software solution based on modular system allows us to control many kinds of technological processes. Efficient operator access management is the base of norm and rules observance.

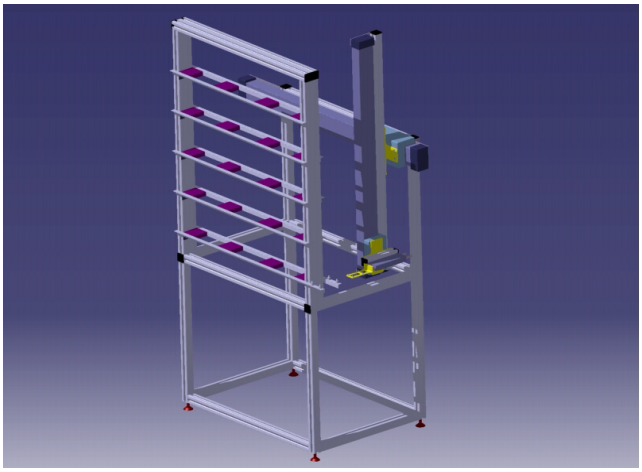

Fig.1 Technological device model design

1. Objectives

The maim objective of this project is to analyze the remote technological process control by using WEB technologies and to design a software solution for remote control of variable types of technological processes. Result of this project is design and realization of the system, which preserves standard operations associated with remote process control as his handling, programming, state watching, administration, service maintaining etc. As the system is remote controlled (through internet or intranet) there is necessary to design a client – server based system with subsystem of users (operators) access management on client side and individual partials subsystems for remote process control on server side. As result of remote control design is his imple-

mentation to the technological process of material interpolator, which is maintained through I/O PCI digital card provided by Advantech Company with CEU2 regulator. Because the project is every extensive, intension is to design modular interfaces and functionality of individual components or modules in the way of easily implementation to various technological processes.

2. Analyzes of existing solutions

Analyzed solutions have deferent functionality and also maintaining services are very individual. Some systems are built on private protocols and are designated only for one platform, which has a repercussion for some users or operators. Most of analyzed systems dispose of designing environment for building applications to control the process. That means we can create an application for concrete technological process.

Signals processing from sensors system is supported by almost every of analyzed system, but in some cases the variability of abilities was very limited and it was necessary to process the signal to needed form by own methods. Considering that most systems are commerce products, it was very difficult to make detailed analyses of transfer protocol.

As a result of analyzes is a file of conditions for the system design, which includes all indispensable elements for technological process control.

Attributes / System	**Control Web 5**	**Promotic**	**OPC to WEB**	**Web Navigator**
Client - visualization type	ActiveX HTML	ActiveX HTML	JAVA	ActiveX
Client - control method	ActiveX	ActiveX	JAVA	ActiveX
Other protocols support	Yes	Yes	No	Yes
Different HW support	Yes	Yes	No	No
Own design environment	Yes	Yes	No	Yes
Remote control building	No	No	No	No
Multi-user access	Yes	Yes	Yes	No
Own user management	No	Yes	No	No
Extern application support	Yes	Yes	Yes	No
Remote maintaining services	Yes	No	No	No
Ability for step by step control	Yes	Yes	Yes	Yes
State forcing	Yes	No	No	Yes
Process control maintaining in highest level	Yes/No	No	No	Yes/No
Receiving signals	Yes	Yes	Yes	Yes
Variability of signal processing	Yes	Yes/No	No	Yes/No

Fig.2 Analyzed solutions comparison table

3. Specification and requirements

During the descriptions of remote process control by using WEB technologies we can start by functionality and structure of real process control by using specialized software and hardware resources. By following common processes and procedures in real process we can easily specify several basic elements and sequences operated by real technological process. We could bring these specifications to our independent design of remote process control.

In the technological process we can identify operations e.g. maintaining of device movements to the sides, material lifting, material moving, back-loop response from sensors system, creation of programmer's sequences etc. In consider to basic operations there is necessary not to cross the device's technological borders. During verifying of border abilities of technological process is necessary to pay attention for sensors location to establish a protection of the system from unsupplied states. The correct locations of sensors for verifying status of technological device is ordered as a top priority in requirements to build successful control of whole system elements. Last but not least subject under consideration is dividing access levels for commands execution, whose have to be processed and filtered by the system.

4. Design of the system

Design of remote process control by using WEB technologies is based on full-duplex communication between *thin client – server – technological process* with access of *administrator's console* to the serer – *technological process* side. Communication is based on TCP/IP protocol by using HTTP, MYSQL and XML-RPC channels for fast communication between thin clients and server.

Thin client – in our project is thin client meant as ending point – user or operator – that has ability to reach the technological process through WEB application or extern application. Thin client sends data packages to the server for processing. Visualization and environment is always loaded to the client by request, so that on this side isn't necessary any kind of special software resources.

Server – introduces the main figure for data package processing and for communication between thin client and technological device. Every element of this part of system allows changing the configuration for different kinds of processes. The server is also designated as data storage, so that every information is archived for late processing and analyzing. The visuals are also kept on this server and are loaded to the thin client by request.

Administrator's console - is consider as an interface between technological process and the server. It is part of system which processes requested operations and communicates with digital hardware card. It allows also setting up the beginning states of the technological process. Watching the information packages to the hardware card is also priority of this part of system and it also has ability to change the process attributes. Information packages from technological process contain states information taken by sensors system and the console processes these states by included processing modules. In configuration of this administrator's console can operator set up every module of the system. This allows the high level process maintaining of all parts in the system. Communication design between user (thin client) and technological process is based on TAG packages exchanging between thin client and the server.

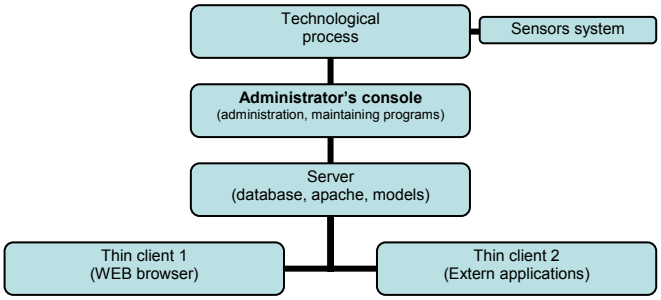

Fig.3 Scheme for remote process control

Full duplex communication between server and client allows verifying integrity of successful data packages transfer with advance user authorization verification.

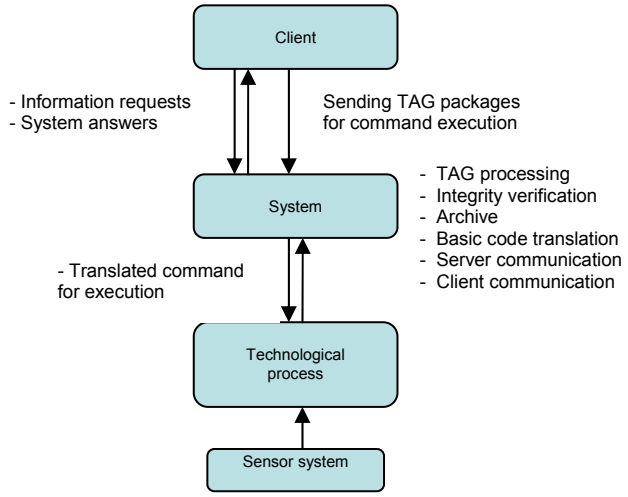

Fig.4 Scheme for TAG exchanging

4.1 Technological process – control methods

The next objective of this project is creation of modular control system that allows technological process control by using many different methods. These methods are important by point of technological process performance. Technological process control by many different methods gives operator full maintaining on system. Designed methods in our project are:

Step-by-step control (manual):

Philosophy of this control gives users ability to step by step control which means that commands are executed by sections. User is able to precede the process by steps and he can watch the technological process behavior by response to input parameters whose are entered in one step operation. This method of control allows scanning technological process collision states. This ability allows tuning the technological process. The software integrity verifying prevents the system from using of steps whose could cause a crash of the system.

Procedural control (programmatic):

Procedural control philosophy allows user to control the technological process in one cycle. Predefined package with all operational commands is sent to the system and the system sequentially executes the package with all commands. Before translation to the basic code is the program package verified by software verification. It checks the program sequences and integrity and then it evaluate values by predefined collision states. Then the system translates the program to the basic code and sends it to the technological process. The technological device responses by information from sensors system and this information is processed by software system and thereafter the user knows everything about the technological process behavior.

Autonomous control, method:

Philosophy of autonomous control method is based on selection of predefined program packages whose were successfully tested and verified and they do not contain faulty instructions. After the selection of program package is this package sent to the system and is executed. A similar way as in procedural control method also here can user watch responses from sensors system and so that he has knowledge about technological process.

4.2 Design of communication between system elements

4.2.1 Control and maintaining

Technological process control and maintaining is defined by three levels:

- Administrator's console
- Thin client 1 (web application)
- Thin client 2 (extern applications)

Administrator's console – is application for system administrator which is directly connected to the technological process and the server. This connection allows fast technological process verification, data transfer analyses, instruction compilations, program packages execution, stored programs managing and also managing relations between operators and the system. Application is also able to manage the user accounts e.g. creation of new user account, creating new relations etc. Application has communication interface. This interface is used for communicate between server and technological process. This interface also disposes of modular part of TAG translations. Translator module is used for translate the program instructions to the basic code for technological device.

Thin client 1 (web application) – web application for technological process control and maintaining is multiplatform application, undemanding for computing system, because all operations are computed and executed on the server side or in the administrator's console. Web browser works as mediator (input/output gateway) between web application working on server side and users – operators.

Through web application we can see the visualization of the technological process (JAVA visualization or CAM visualization). Web application also contains input forms. All form elements are used for TAG filling to create program packages or for selecting existing program packages. Also the operation elements (commands) for maintaining and control the process are placed on this form.

Thin client 2 (extern applications) – is specific application built for operators whose want to control the remote technical process without using web browser. This application has ability to connect to the system through gateway interface which allows full duplex communication. Communication system is based on remote call procedures (RPC) as well as response to the client. Transfer protocol is built on XML-RPC protocol which has subroutines of SOAP protocol so that all packages are transferred in universal package format. Extern applications are used for special control of technological process. External control devices could be connected to the extern application and the command signal is transferred through the gateway directly to the system.

4.2.2 Visualization

Technological process visualization is divided to three parts:

- Well arranged dynamic tables
- JAVA applet visualization model
- Real-time CAM visualization

Well arranged dynamic tables – tables are dynamically created and are reloaded in repeatedly cycles. They show actual states of the technological process based on prede-

fined model. User is able to control all incoming values from system as a response to requested instructions.

JAVA applet visualization model - the main visualization produces visual sub models based on predefined JAVA graphics configuration. Visual sub models are loaded to the client by secured channel. Visualization model is stored in server database, and is loaded to the thin clients by requests. Predefined visualization is stored in XML structure. After load to the thin client is the main visualization rendered for view and if the technological process has started, information packages are transferred to the visualization by XML-RPC channel and the visual sub models start to show system states.

Real-time CAM visualization - designed subsystem of CAM visualization allows operators to view the technological process in real time. Depending on latency of computer network has user ability to choose from three methods of CAM visualization:

ActiveX interface - camera view is switched through the Microsoft ActiveX technology supported by driver of used CAM. Unfortunately this method is supported only through Microsoft Internet Explorer browser.

JAVA interface – camera view is switched through JAVA technology supported by driver of used CAM. This method can be used on different platforms because of independency of JAVA technology.

Frame slide interface – camera sends pictures (frames) in predefined time to the client – this method is undemanding to the computer network but the absence of continuity view is certainly clear.

4.2.3 Access authorizations

Different types of authorizations allow full control of the technological process. User access defines abilities for different client control. Authorizations are segmented to five different levels:

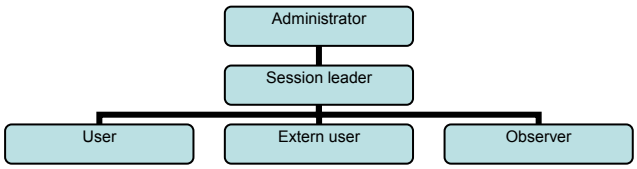

Fig.5 Access levels for process control

Administrator access allows full control of the technological process. Administrator has ability to control the data package transfer in the system. Maintaining of user accounts and the current sessions belong only for supervisor administrator as well.

Session leader access allows full control on sessions and current logged users relations. Leader is in position of observer, but if he is suspicious of something, he is able to stop the session as well as stop the technological process. Access for leaders is on the same level as users are, but with highly ability to verify transferred packages.

User access allows technological process control through the TAG packages with different methods of control (step by step, programmatic and autonomous). User is limited to enter to the system in predefined time which is defined by system administrator.

Extern user access allows technological process control through extern applications, whose are not directly connected to the system. Gateway for extern applications has authorization subroutines jointed to the main authorization modules so the policy of user access are the same as the user is logged through web application.

Observer access allows only states watching of the technological process through visual resources such as CAM visualization and JAVA visualization.

4.3 The technological process sensors system

The important step is the design of the sensors system. Correct selection of sensors and theirs placing into the device is important because the technological process operations. Our system is designed for universal use so that number of used sensors whose the system can process is depended on digital hardware card with the technological process is connected to. Software system for signal processing is limited by technological design of individual subsystems for data processing and also is limited by hardware resources. Our design is optimized for interpolator sensors system. Sensors are scan device faults e.g. propulsion system faults or electronic system faults. Sensors for arm movement scanning are placed on axes rails and are divided by boxes. These boxes are for material storing. Sensors are also placed on head of interpolator. These sensors are scanning the arm's state.

Signals for movement scanning produce states 1 or 0, where 1 is actual position of the arm. After the combination calculating of signal states the system knows where the arm position is and also if the head is outside or inside placed. Signals from propulsion system or electronic system are very specific so the processing depends on used subsystem.

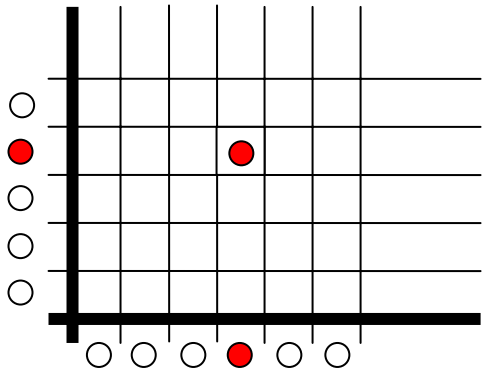

Fig.6 Interpolator sensor system

4.4 Advantages of designed solution

The designed solution allows us using different types of technological devices in the real process of remote control. With the correct design of sensor system we can have full response from technological process as we need by our requests. Modular system has ability to process signals from the sensors system independently with different kinds of methods whose we can build or predefine by using existing procedures. The design of modular subsystems allows easy implementation of the system for the process control. These subsystems could be changed or reconfigured for every specific technological process and that makes the system universal. The part of TAG configuration if very important. Creation of TAG packages is very easy and could be used by every new device which is joined to the technological process. Creation of visual model to the new technological process is very easy as well. Created sequences and visuals are stored into the database server, what allows other clients to get these visuals and attributes immediately as they are stored. Implementation of XML-RPC protocol as a gateway or interface allows extern applications to join the system. Extern applications can be based on different kinds

of platforms what can be useful for operators whose have limited resources. Other controlling devices could be connected to the external applications such as joystick, mouse, special keyboards etc. External applications could be built also for mobile devices what allows operators having connection with the technological process all the time.

Conclusion

During this project we analyzed few different kinds of solutions for remote control and maintaining of technological process by using WEB technologies. Mission of this project was creation of system model, elaboration of function model of design and realization of individual designed modules.

Designed modules includes specifications and descriptions of basic attributes. Description of all structures determines general specification for individual partial realization. During the design we mainly focused to the ability of connections for external applications to the system. The important point was suitable selection of universal interface for communication between external clients and the server. As a result of this project is designed system framework for technological process control by using WEB technologies with implementation to the real process.

In the realization and implementation was verified a propriety of used technologies, global philosophy of designed solution and the architecture of the system. Some tests were made to confirm our rightness of used technologies in project realization. In practice could designed solution be used as a backup control for variously technological processes or also for implementation to the risk environments, whose have limited access for operators.

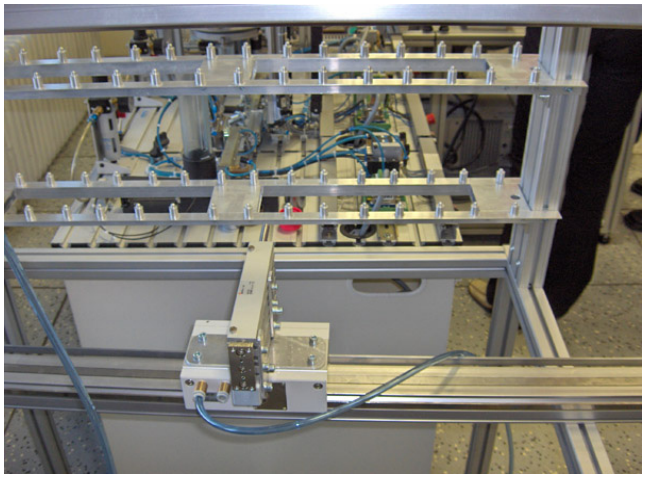

Fig.7 Technological device in real process

For the future is planned a realization of designing module as an extended module, which could be beneficial for operators or the process designers whose could modify or change the visualization and function modules of their technological processes. Also the extension of programmer's syntax for programming and building process sequences is important to help to expand the universality of the system. In case of extending programmer's syntax we could think about implementation of software regulators whose could be set by parameters of designed functions and could be implemented to the process sequences.

References

[1] Control Web 5. http://www.mii.cz/

[2] Promotic. http://www.microsys.cz

[3] OPC to Web. http://www.opcdatahub.com/

[4] WinCC/Web Navigator. http://www.automation.siemens.com/hmi/

[5] XML-RPC client pre C#: http://www.wordtracker.com/docs/api/ch03s04.html

[6] ZOLOTOVÁ, I., FLOCHOVÁ, J.: Vizualizačné prostriedky, systémy SCADA/HMI (1).

[7] SMC Corporation.: Brake Position Determination System's User Guide CE2: Monosashi-kun Measuring Cylinder With Brake, CEU2: Controller

[8] ADVANTECH: User's Manual, PCI-1753/1753E 96/192-bit Digital I/O Card, Part No. 2003175300 1st Edition,

[9] Bc. Ľudovít Fülöp, Virtuálna univerzita, Diplomová práca, Máj 2005

[10] XML-RPC implementation http://ws.apache.org/xmlrpc/

[11] Simon St. Laurent, Joe Johnston & Edd Dumbill: Programming Web Services with XML-RPC, O'REILLY, June 2001

[12] XML-RPC protocol, http://www.xml-rpc.net/

[13] MySQL database, http://www.mysql.com/

[14] PHP - general-purpose scripting language - http://www.php.net/

[15] Apache web server - http://httpd.apache.org/

[16] XML-RPC for PHP - http://phpxmlrpc.sourceforge.net/

[17] KARDOŠ, J.: Pružné výrobné systémy. STU Bratislava, 1999

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