Web-based Operation of Mass Flow Rate Measuring Instruments

Reinhard Langmann
University of Applied Sciences / Department of Electrical Engineering / Duesseldorf, Germany

***Abstract* — The paper introduces a solution for a web-based operation of mass flow rate measuring instruments (LeanTMF-Net). The system is based on Ethernet link moduls for HART process data and an event-based real-time web-visualization The LeanTMF-Net can be flexibly adapted to the relevant user conditions thanks to the transparent and user-independent implementation completely based on standard Internet technology.**

***Index Terms* — Web-based operation, user interface, controller faceplate, HMI**

I. OBJECTIVES

An integral element of an industrial research project involves realizing a web-based visualization, control and evaluation for digital and analog mass flow controllers or measuring instruments used in laboratories (in short: TMF instrument). The new system is to have open structures allowing configuration in easy steps. It should be possible to use any form of web browser as operating software. The following functionalities are to be realized:

- *Visualization:* Depiction of functional blocks (controller face-plate) with setpoint value, actual value, summation counter and status, master/ slave configurati-on of various blocks with mathe-matical module, script/recipe sa-ving with time-control, binary I/O module for actua-ting valves, sen-sors etc.
- *Trend logging:* Option for saving the process variables in current formats for further processing with MS Excel.
- *Service options:* Evaluation of error codes in plain text, zero-point setting, alarm settings, setting further parameters.

All TMF instruments provide their data to a serial interface via a HART protocol or as digital and/or analog signals. A standard web-based HMI/SCADA system could not be used owing to the unfavorable cost structure and the specific technical customer requirements.

II. SCIENTIFIC TECHNICAL SOLUTION

A. Lean Web Automation as basic concept

Developed in the Process Informatics Lab (Pi-Lab) of the University of Applied Sciences Duesseldorf – the concept of Lean Web Automation (LWA) proposes, on the basis of LiveConnect, a solution for distributed automation using standardized Internet technologies [1]. This concept is also used for the web-based operating of the TMF instruments.

By the LWA concept the automation devices attached to a network (Intranet/Internet) make available only their process data (sensors/actuators). The effective control and automation functions (e.g. operating functions) are loaded and used from resources which are available in the net.

Principal item of the LWA is the fast, reliable and safe supply of the sensor and actuator data of automation equipment in the Intranet/Internet. The process data commu-nication is realized by a Java-based application model *W2<process> proxy* using Live-Connect. This model provides an interface to the process data of an external automation equipment similar to a proxy of the respective automation function in the process area of a Web client (browser) (see fig. 1).

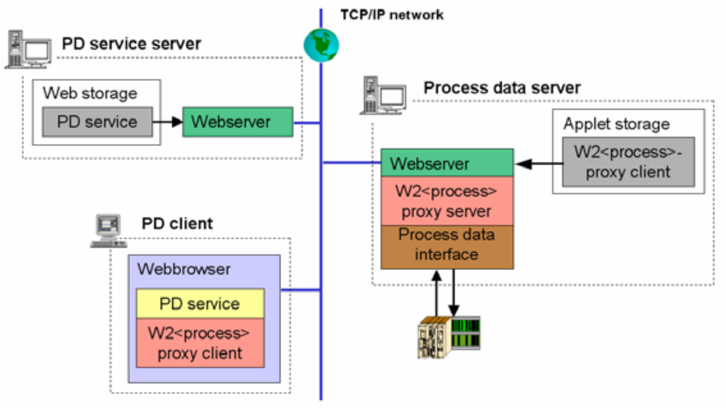

Figure 1: Distributed structure for the Web-based operation of automation devices by the LWA concept

The substitute symbol <process> stands for the practical realization of the appropriate process data interface, e.g. to an OPC server, a driver for a fieldbus system (HART fieldbus) or an embedded controller. The W2<process> proxy is equal to a distributed application following the client/server architecture. The W2<process> proxy server is an independent application which is implemented on the process data server.

The processing of process data is made by process data services (PD service) which are downloaded from a PD service server via the Web to the PD client and are executed there.

In LWA process data service describes the program code necessary for the execution of the automation functions. A PD service can contain operation and user interface functions as well as functions for the processing of process data. So it is possible to visualize e.g. current trends of analog process data by means of a suitable PD service (e.g. a graphical XY presentation service) in the PD client.

The program code of a process data service is e.g. a makro created in an ECMA-Script-compliant programming language. In addition, a Java applet or other Web objects (ActiveX object, Flash object, …) can be used as user specific PD services.

The functions of the W2<process> proxy client are performed by a Java applet. The applet is stored in the memory of the process data server. When requested by a process data client (PD client), the applet program code is downloaded by the process data server via its Web server and processed in the Web browser of the process data client. The PD client (any computer in the net) takes over the function of the master for the automation device.

The W2<process> proxy client creates a permanent dynamic data link to the W2<process> proxy server in the process data server and – over the connection to the process data interface – to the actual process data of the automation device. The data connection between the W2<process> proxy client and server is achieved with the help of the Java technology available for the realization of dynamic communication in distributed applications, Socket API or RMI (RMI = Remote Method Invocation). The process data exchange is realized by an own OPC-like telegram protocol.

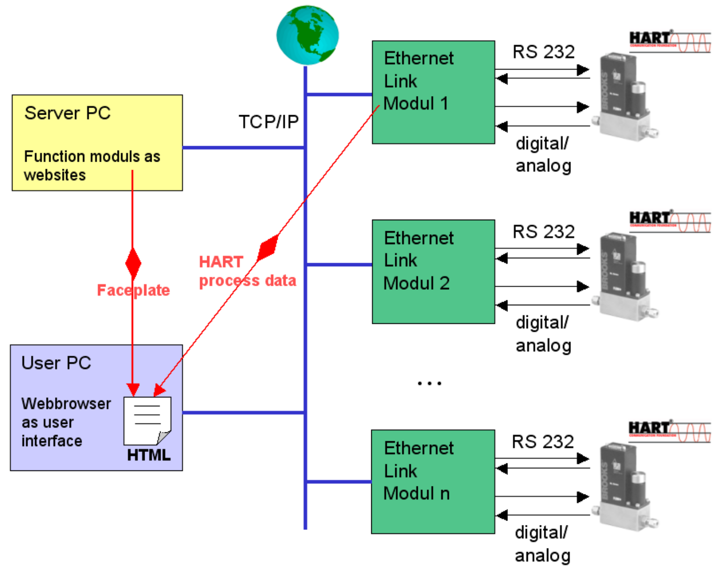

Figure 2. Overall structure of a distributed and web-based operation of mass flow measuring instruments (LeanTMF-Net)

B. Project realization

The scientific technical project realization was divided into two main phases:

- Development of an Ethernet link module as a process data server used to provide the data of the TMF instruments in the TCP/IP network,
- Development of a user interface (HMI – Human Machine-Interface) with integrated function modules as websites.

A PC with corresponding software extension or also an embedded controller can optionally be used as an Ethernet link module. An embedded web controller is used in the prototype. The advantage offered by this is that customer-specific extensions can be realized via the open real-time operating system of this controller. A corresponding protocol converter is implemented in the Ethernet link module for utilizing the HART protocol on the serial interface to the TMF instruments.

A process data proxy server is also implemented on the Ethernet link module in addition to the existing web server. This provides the process data of the connected TMF instruments in the TCP/IP network. A process data proxy client, realized as a Java applet (proxy applet), logs the process data on the HTML pages in the Web browser and enables request-based and/or event-based processing of the process data in JavaScript.

Use of these Ethernet link modules results in the overall structure shown in Figure 2 for distributed and web-based operation of the TMF instruments (LeanTMF-Net).

The websites for operation of the TMF instru-ments are stored as PD services on a central server PC and are loaded respectiv-ely into the corresponding user PCs as and when required. However, these websites can also be stored in the Ethernet link mo-dules or in the user PC itself. In this case, no central server is required.

The most im-portant element of the user interface is the graphical controller functio-nal blocks (con-troller faceplates), via which the basic operation of the TMF instru-ments occurs (Figure 3).

Corresponding to the usual distribution of the TMF instruments in different laboratory rooms, a website with maximum 12 faceplates can be started as a user interface in a browser window for each laboratory room. After calling up this faceplate browser window, the following operation can be performed:

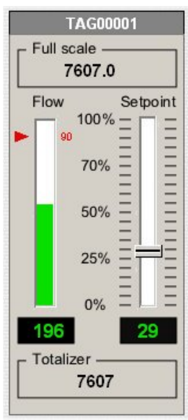

Figure 3. Controller faceplate of a TMF device

- Allocation of a TMF instrument to a faceplate,
- Operation of the TMF instrument,
- Setting alarm values.

Realization of the faceplates is object-oriented in JavaScript and only via the use of HTML and dynamic GIFs. All faceplates are dynamically generated, so that any number of faceplates per operating page and also any number of operating pages for the runtime can be generated or used in principle. This allows a simple extension and distribution of the overall system on different server computers. In example, figure 4 shows an operating panel website with faceplates for 12 TMF instruments.

Figure 4. Web-based operating panel for 12 TMF instruments

Each TMF instrument has a specified amount of process data, with the result that a process data proxy applet is used for each instrument. Each proxy applet incorporates a listener function, which receives changed process data by server push and Live Connect [1]. The process data for the relevant faceplate are visualized in real time using a further JavaScript function

The complete interactive behavior of the faceplate is implemented in encapsulated form within the faceplate object. Specified JavaScript functions each serve as an external interface to the HTML page.

III. RESULTS

The LeanTMF-Net can be flexibly adapted to the relevant user conditions thanks to the transparent and user-independent implementation completely based on standard Internet technology. Additional TMF instruments are easily integrated in the HTML pages via a supplementary parameterization using further proxy applets. Changes or amendments to the individual web-based function modules can also be realized rapidly without any problem using an HTML editor.

TABLE I. TRANSMISSION TIME FOR PROCESS DATA VIA THE INTERNET

	Transmission time of 10 process data, these values are changed at the same time [ms]
Intranet	20 … 50
Internet	800 … 1500

Naturally, time performance is an important characteristic of an automation system. The time performance of the described LeanTMF-Net is mainly determined by the following aspects:

- Transmission time inside the network (Internet/Intranet),
- Processing time of the visualization and operating functions in the HMI websites

First studies concerning the time performance of the process data transmission between TMF instruments and Web client including the data transfer to an event receiver by means of W2HART proxy applet resulted in values specified in table 1.

The processing time of the HMI functions in the Web client depends on how it is realized. In each case the communication between the LiveConnect interface of the W2HART proxy applet and the HMI functions (realized in JavaScript) requires a defined time. Depending on the parameter transfer and browser type, a simultaneous change of 10 process data needs a time range of 1 to 10 ms.

In summary, the reaction time of the complete system HMI interface ←→ TMF instruments is approximately 200 ms via the Internet and approximately 30 ms in the Intranet.

IV. SUMMARY AND FUTURE WORKS

With its flexiblity and transparency, the described solution for a web-based operation of mass flow rate measuring instruments on the basic of Lean Web Automation will meet future requirements for individuality and openness of instrument automation in laboratories and simultaneous cost reduction in operation and maintenance. A strong focus is on Web-based remote visualization and operating.

In future the parameterization envisages creating a web-based parameterization editor in a more advanced development, which generically creates the websites using a web application. In this way, the available TMF instruments of a user can optionally be grouped by the user himself and called up via individual websites (laboratory room 1, laboratory room 2, ...), whereby these websites can be saved on any web servers in the Intranet/Internet, depending on requirements.

Till now the development of the required web pages for the user interface of the TMF instruments was carried out under use of classic web tools with source code coding (HTML, JavaScript). Related to the otherwise usual graphic-interactive tools in the area of the process visualization and HMI construction, however, this procedure is user unfriendly and difficult manageable for an automation engineer. In a new R&D project of the Process Informatics Lab shall therefore be created an engineering environment (toolkit) within the next two years on the basis of a web-oriented architecture, which makes possible a user friendly configuration and generation of web-based automation systems.

REFERENCES

[1] R. Langmann:, “Web-based Remote Control by LiveConnect,” *International Journal of Online Engineering*, 1. Edition, Villach, Oct. 2005, http://www.i-joe.org

AUTHOR

R. Langmann is with the University of Applied Sciences, Department of Electrical Engineering, Josef-Gockeln-Strasse 9, D-40474 Duesseldorf, (email: reinhard.langmann@fh-duesseldorf.de)

Manuscript received July 6, 2007.

Published as submitted by the author(s).

Paper presented at REV2007 conference, Porto, Portugal, June 2007.