1-st IFAC Conference Telematics Applications in Automation and Robotics - TA 2001
Weingarten, Germany, July 24-26, 2001

REQUIREMENTS TO THE DESIGN OF LOCAL AUTOMATION SYSTEMS FOR WEB-BASED TELECONTROL

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Abstract:
The increased popularity and availability of off-the-shelf internet technologies raise a new trend for industrial tele-automation solutions. Most industrial automation systems are offered today with add-on web components for telecontrol. This offers an easy integration of these modules into existing local automation solutions and allows the use of advanced telecontrol functionality even in small size automation projects. The paper shows that the application of telecontrol functionality demands also for new automation system design aspects. Based on the analysis of experiences from conventional telecontrol system design some design requirements to web-based telecontrol systems are derived.

Keywords: telecontrol, remote control, failure detection, systems design,

1. INTRODUCTION

The integration of information technologies (IT) in automation systems provides a high potential to extend the scope of applications, but puts on the other hand additional imperative requirements to the engineering of automation solutions. This is also true for *Internet technologies*, which have become extremely popular and which offer interesting perspectives for *telecontrol* applications in *industrial automation.*

Telecontrol aspects have to be taken into account from the very beginning steps in the engineering life cycle. This means that a considerable additional workload has to be covered beside the conventional, already rather complex design decisions. In the particular design case it is however still somewhat fuzzy what particular telecontrol requirements and design considerations really have to be taken into account.

This paper reports some findings on the subject of *telecontrol* requirements to *local automation*

systems, which result from recent industrial project contracts for web-based telecontrol.

2. GENERIC TELECONTROL PROPERTIES

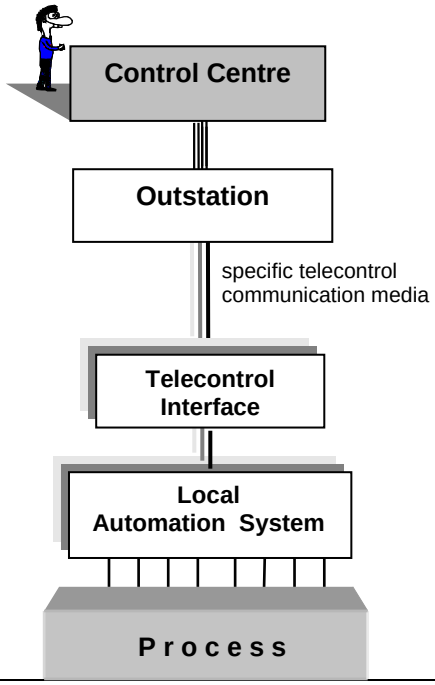
The main property of *telecontrol* is understood generally as the *far distant location* of field automation and control (operator) station. It is interesting to note, that telecontrol aspects are not unique to far distance automation topologies, but likely apparent in most process and production plants, where no "direct" contact between the operator and the process is possible (see Figure 1).
In all these cases the following two properties are governing the automation design paradigms:

- *Autonomous Failure Management* to cope with missing direct operators access to the process, e.g.
  - classification of the whole system in system components
  - situation dependent return information from any "critical" system component in the information chain (in particular any actuator, part of the communication line)
  - response time monitoring
- *Access Management* to cope with multi-operator capabilities, e.g.
  - safety critical "write access" management (remote and local).
  - security critical "read authorisation" management.

It is apparent that the failure management determines considerably the *quality of telecontrol performance*, whereas the access management determines considerably the *quality of telecontrol security*.

Thus the properties of a tele-controlled automation system can be summarised as follows:

telecontrol :=



local automation + telecontrol properties

Fig.1: Architecture of *conventional* telecontrol systems

3. CONVENTIONAL VERSUS WEB-BASED TELECONTROL

It should be emphasised that industrial implementations and solutions for telecontrol have been established in application areas such as far distance *water* and *power supply plants* already a long time before the age of Internet [DVGW 1988]. The current available solutions for such *telecontrol networks* provide remote access to on-line information on the underlying processes and automation equipment through dedicated technologies: control centres, outstations and front-end processors using task specific, standardised communication protocols and telecontrol busses, e.g. DIN EN 60870-5 (see Figure 1). These specialised telecontrol components can be added to or even directly integrated (plug-in modules) in the local automation system. Proprietary direct telecommunication lines or rented lines are being used commonly as communication media [Schüngel 1995]. Thus conventional telecontrol

systems can guarantee in most cases defined transfer rates.

It is rather obvious, that at any time new evolving technologies have to be taken into account as candidates for up-to-date engineering solutions. Therefore an automation design engineer is faced today with questions like *"Do internet technologies just substitute the conventional telecontrol technologies ?"* or *"May new qualities of telecontrol evolve through web-based solutions ?"*.

An answer to these questions may become apparent, if one looks at a typical implementation of internet technologies for telecontrol (Figure 2):

> *web-based telecontrol :=*
> *telecontrol + new qualitative properties*

This means that *web-based telecontrol* has obviously all the inherent properties of conventional telecontrol, but includes some particular additional properties:

- *Standard Commercial Equipment*
  Hardware, software, protocols for telecontrol are wide spread and common technologies with all *advantages* such as
  - ➔ high technological *familiarity* at designer and user level
  - ➔ high technological *commonality* with (at least upper level) local automation
- *Public Communication Media*
  The very large and non-deterministic number of users in wide spread public networks result in specific *problems* such as
  - ➔ multiple access of several clients because of the shared media "Internet"
  - ➔ *security* in terms of user access and loss of data
  - ➔ non-guaranteed *performances* in terms of response time and bandwidth.

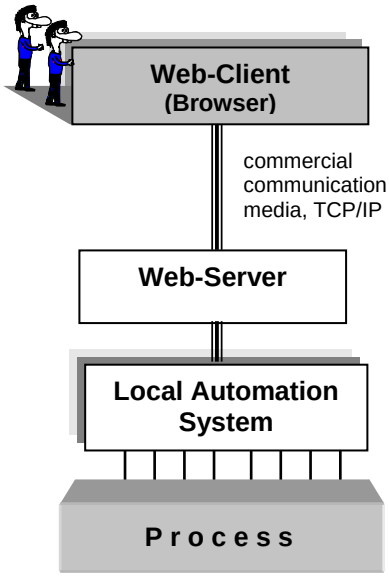


Fig.2: Architecture of *web-based* telecontrol systems

This evinces the fact, that designing internet-based telecontrol systems is much more than installing a browser and switching the PLC's to the Ethernet or just replacing the dedicated telecontrol line by a TCP/IP supported line. Internet technologies provide only the powerful and competitive *access shell* between the operators and the automation system, but the inherent telecontrol *functions* have to be allocated actually at different stages *inside* the *local automation* system [Schwarz 1999], [Hamm 2000].

Typical design questions such as the allocation of failure management functionality, the implementation of individual equipment return information or the selection of appropriate read/write access schemes are affecting directly the functional and operational architecture of the *complete* local automation system. As a consequence, the telecontrol aspects have to be understood as an integral part of the overall engineering process and have to be tackled by appropriate engineering methods [Denu 2000], [Döbrich 2000].

4. WEB-BASED AUTOMATION

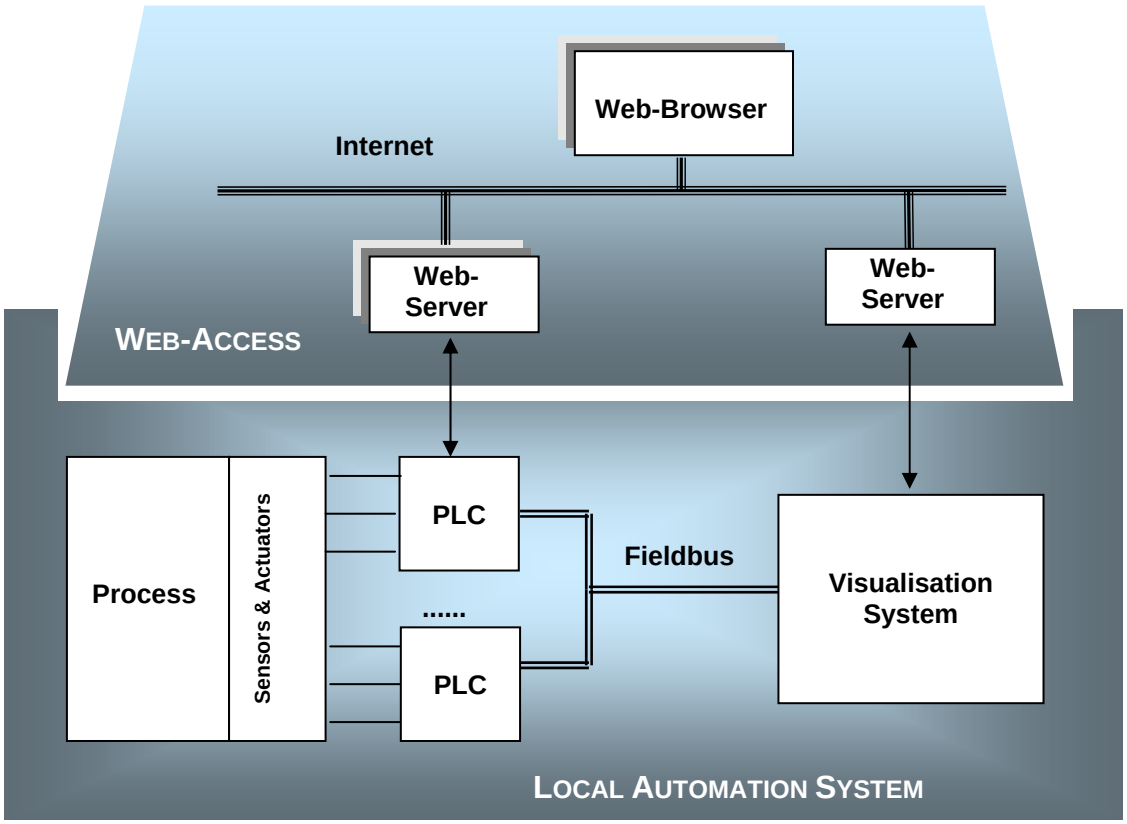


Fig.3: Upgrading variants for a Local Automation System with web-technology

Table 1: User Access Schemes for Web-based Telecontrol

PLC	VISUALISATION	REMARKS / APPLICATIONS
LOCAL	LOCAL	standard local automation configuration
LOCAL	WEB	+ low cost remote monitoring and control, needs mostly only SW extensions, no additional HW - no field level access
WEB	LOCAL	+ remote field level maintenance; remote commissioning - needs specific web-HW
WEB	WEB	+ complete remote monitoring and control access to all IT components - high cost

The basis for the subsequent considerations are standard local automation systems as sketched in Figure 3. The field level basic automation is realised by low-level (but in some cases nevertheless locally distributed) control loops implemented by PLC-systems. The high-level operator (user) access is realised by single-user visualisation systems, sometimes located off-field in separate control rooms and connected to the field instrumentation by fieldbus lines.

In general every IT-based system component (PLC, visualisation) can be supplemented by a web-server (see Table 1). This may result immediately in embedded multi-web-server configurations acting on the same technical process (Figure 3). Under such circumstances serious *access authority conflicts* may appear, which are not at all apparent in the local automation system (and therefore not tackled by the standard local automation design). The following conflicting variants of simultaneous multiple access to the automation system have to be distinguished:

- multiple remote access to one web-server

- multiple remote access to several web-servers
- local and remote access (e.g. local operator and remote operator).

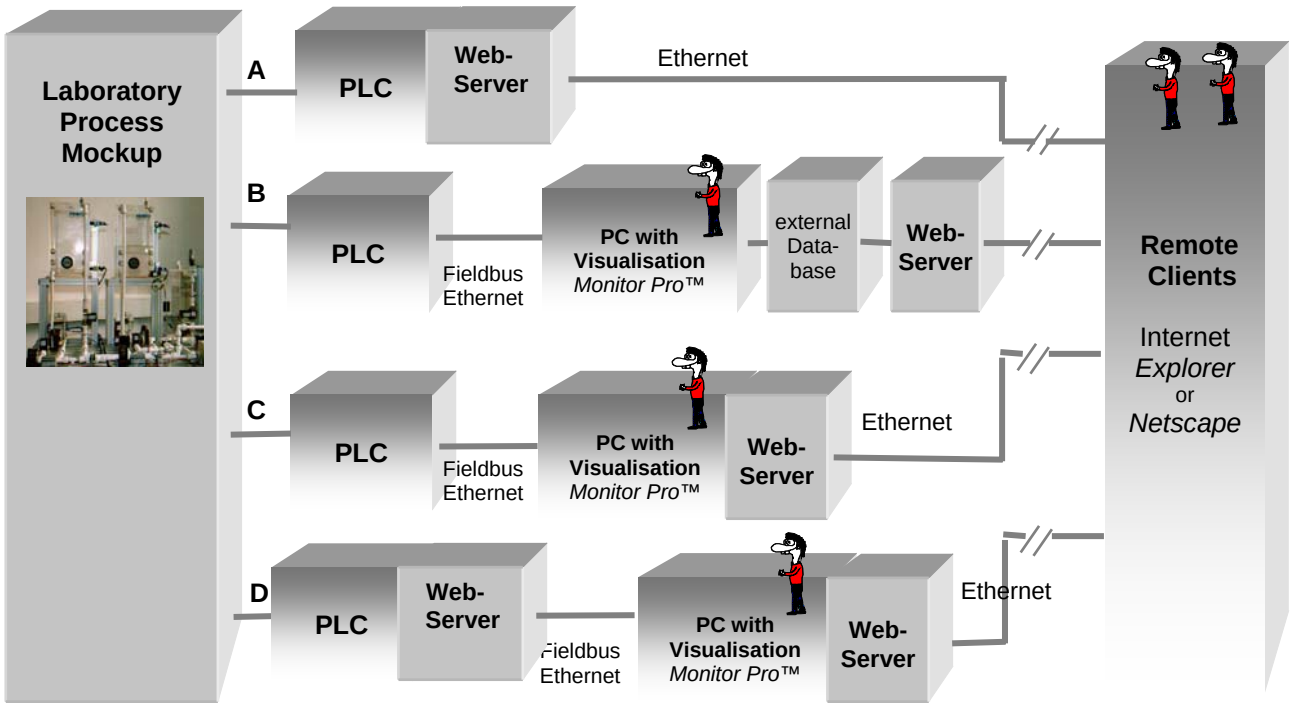


Fig.4 Web-based Telecontrol Test Configuration

5. LESSONS LEARNED

A detailed investigation of several possible telecontrol configurations (Figure 3) with state of the art automation equipment has been performed in the frame of a joint project between Schneider Automation and the Chair for Automation Engineering [Braune 1999], [Braune 2000], [Rödel 2000]. The continuous laboratory process was locally automated with a Programmable Logic Controller (PLC) and a visualisation system (see Figure 3). This basic automation solution has been designed under sole local automation aspects e.g. design exclusively for local access and inter-visibility between process, automation system and operator.

In a second step, different off-the-shelf plug-in internet/web-components have been added to the PLC and the visualisation system (Figure 4). The PLC was extended with a TCP/IP module including an embedded web-server (*Case A*). Via TCP/IP the PLC programming environment allows remote engineering end program testing, via the web-server a remote monitoring is possible with any standard browser.

For remote monitoring via the visualisation system an external web-server (*Case B*) as well as a specific embedded web-server (*Case C*) have been integrated.

Case D shows a dual web-server configuration with web-access at both PLC and visualisation level.

Some of the lessons learned with this prototype installation are reported as follows:

- Authorisation functions (e.g. by password, user specific IP-address) can be efficiently realised by standard built-in functions within the embedded servers.
- Mechanisms for multiple access security by using only one server are provided efficiently by standard built in functions of the embedded web-server.
- Multiple access security in case of multiple concurrent servers was not supported because of the autonomous operation of each web-server. .
  A multiple remote access e.g. via PLC *and* visualisation system embedded servers (*case D*) is possible, i.e. it is not prevented

due to the isolated operation of each web-server.

The co-ordination of any different access in case of autonomous internet modules is part of the local application software in the automation system.

- Mechanisms for multiple access security for local and remote access are not provided in general by built-in functionality of the web-server. It is also part of local software of the PLC or the visualisation system.
- Equipment return information about the result of a given remote write access to the actuators (e.g. remote command "close valve" and return information "valve is closed") was only partially available, due to the given hardware structure of the laboratory instrumentation, i.e. no valve had a status signal display. The use of software based functionally redundant information (derived from parallel process information and equipment) is an interesting alternative approach in the frame of re-engineering (upgrading) of existing automation implementations.
- Response time monitoring about the reasonableness of a given remote write access had to be added to the automation software solution. The valid deadlines for the different write command accesses to the process demand a further process analysis.

6. CONCLUSIONS

Due to the increasing popularity and availability of ready powerful web-technologies it becomes apparent, that already in the very near future any single automation equipment will be offered as web-compatible and telecontrol functions will be part of the standard tool-set of any industrial automation system. As a consequence it has to be recognised that the design of telecontrol functionality will become a mandatory standard practice in automation engineering. A joint effort by academia and industry (automation, IT) is therefore necessary to form the appropriate skills of automation design engineers (*education*), to develop improved design methods for information based distributed systems (*research*) and to provide ready technologies for implementation (*product development*).

Finally it should be emphasised that in the same manner as industrial automation is profiting today from IT-advances developed for existing mass markets it could be profit as well in the future from advances in new potential IT-based mass markets. Looking beyond the horizon of industrial automation reveals a rather high commonality between *industrial telecontrol* design questions and advanced concepts for *automation* of our *daily life environment* using information based interacting networks, e.g. the *Oxygen Project* at the Massachusetts Institute of Technology [MIT 2000].

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