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Supervisory Control Sustainability of Technological Processes after the Network Failure

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***Abstract*—This article deals with information control systems, especially in view of failure of control networks and sustainability of a functional technology. The article points possible risks that may occur in the event of disruption of control system and how to avoid losses in the manufacturing process in similar cases. It includes architectural design, which ensures operation processes at the technological control level, despite the fact, that some important components in the control system fall out, or crashes the network connection. Practical verification was implemented in the laboratory of Department of Cybernetics and Artificial Intelligence, in Technical University of Kosice, on laboratory model of Smart House. The control system was built on Wonderware software components (Wonderware System Platform), with an emphasis on linking Peer-to-Peer in architecture of information control system.**

***Index Terms*—Communication networks, virtual private networks, failure analysis, error analysis, home automation.**

I. Introduction

Individual control parts of manufacturing companies (but not limited to) are linked and they create a complex management architecture with a hierarchy. Its connection is normally handled by an Ethernet network, respectively with the use of industrial control network. The functionality of whole system affects this network connection, and its failure strongly disturb control and production processes.

II. Control system architectures

The control systems today are different from original systems in several factors. One of the most important is their architecture. Time when the production company could talk about the control system came with the first elements of automation. Such a way there was created so-called islands of automation. This kind of production system has everything available what it needed to control immediately at the place. The disadvantage was that every single unit had to be managed separately. And management of the company had no direct information from the production. Management worked only with information which has been provided in reports of employees. Centralization systems were switched with decentralization systems. The control systems were switched to present form distributed control systems by several steps [1].

Standard solutions of control systems consist from nodes that are directly connected to technology - Programmable Logic Controller (PLC) using the industrial network. We can call them technology nodes. Above these systems are components of Supervisory Control Systems and Humane machine interfaces (HMI / SCADA). These nodes are linked to higher levels of control, ensuring typical tasks characteristic for Manufacturing Execution System (MES) level. It is concerned mainly about data collection and storing data and exchange of control signals between the business parts of control system and technology. The typical architecture for control systems was established. There are also located servers, which are important components in terms of information distribution and are necessary to manage production processes or historical data. The servers represent important part of information control systems and are part of distributed control systems.

III. Failure of control system parts and the possible consequences

As was already mentioned, in the control systems are a number of different elements that are interconnected and all together build complex system whereby it's possible to manage company from management to technology. Failure of any part can disrupt the individual functions of the control system. It is important that the opportunity of local control on the technological facilities was still secure, even if such a system fails. It should be noted that systems of this character have more security. Solution usually consists of detaching the system from power. In this case the device does not work and is fastened up to the elimination of failure.

IV. Distribution of important parts of control systems for technology

If we want to ensure control of technology without

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connection company control system, important application parts of control must be located directly by the technology. We called this place the technological node in control system. Technological node is directly connected to the control component, which ensures the management of technological device (PLC). Therefore technological node must to ensure local control during the failure of control network, without undermining the technological processes, technology, or injury.

Each provider of this kind of solutions has its own ways to deal with similar cases. It is mostly a similar solution based on the fact that important parts are located on servers placed in the control network (in ICS) or on technological nodes directly connected to the technological devices. These parts are necessary for control the technological process.

A. Example of technology protection before disconnecting the central part of the control system

As was mentioned above, each producer dealing with the creation of control systems has its own solutions for ICS in perspective of hardware or software deployment as well. What relates to hardware, there is recommended specific technological equipment for each station of control system and also the links between them. All at once the backup options, respectively redundancy, as the individual stations in the system, also the links between them.

A similar system was also applied on laboratory models placed in mentioned school department.

Control system has been created with stations enabling visualization of processes in technological level with possibility of their control. System also included a database server for collecting a process data and server managing the individual objects which are necessary to manage technology.

Technological level, where control system was build described in this article was model of Smart house.

B. Smart house model

Smart house model is built thus that it is possible to control lighting and temperature. It has ensured scanning of lighting and room temperature, removal of warm air and scanning of the intensity of a heating. Control is ensured through the LonWorks network.

There was created a supervisory control using the Wonderware visualization software. This control allows displaying the technological processes using graphical symbols, set the parameters of process variables. It allows remote control in real time and providing historical data. Visualization of smart house model shows the Fig. 1.

Information level was created on basis of server computers. These servers provide a historical data, which are being used later.

The smart house model consists of two rooms one above the other. The lower room is used to simulate of lighting in the room (bulb and window blind). The upper room is used to simulate heating in the room. Heat source is bulb and our task is to control the room temperature. Two embedded fans are used for cold air intake provide air circulation.

There is a temperature sensor, heater (bulb), LCD display for displaying the temperature, light sensors, blinds and stepper motor for blinds control.

Control system of technological level consists of control modules SAMO automation and communication card PCLTA-20 for LonWorks communications network.

Fig. 1. Visualiation of smart house model (created in InTouch 10 with using of graphical components of ArchestraIDE).

C. Control system architecture

As the communication software was used FactorySuite Gateway, between the server and computer that reads the value of LonWorks network with using the LonServer Gateway. As supervisory control software was used InTouch. Industrial database was created by InSQL and SuiteVoyager Portal. Used communication protocols were SuiteLink (data collection in InSQL using FactorySuite Gateway as well as SuiteVoyager portal communication with InTouch program) and TCP/IP (for communication of thin client with SuiteVoyager portal).

Smart house model is connected to the control system created on Wonderware platform [2], [3], through LonWorks network.

Higher control levels contain a number of applications: InTouch (in which was created visualization of processes), ArchestrA Integrated Development Environment (environment for creating control systems), Wonderware Application Server (WAS), (runtime environment that performs the automation objects).

Configuration database Galaxy is a set of configuration data for Wonderware Application Server. This database is used for developing and editing of applications and also for their subsequent deployment into production.

Visualization represents node in a network which runs InTouch visualization program. Historian server is relational database that is used as a source of historical data. Active Factory is software for data analysis.

The visualizations, which were made by using InTouch and direct communication with I/O Server by Gateway were modified to a distributed architecture through WAS.

D. Peer-to-Peer in control architecture

Application server uses the object-oriented approach. Each object has defined characteristics as alarms, historization, I/O communication, scripts and security. Complete logic is thus clearly positioned in one place. New objects are generated from patterns of parental objects. Template of each supported objects inherit all the features into subsidiary objects, including additional change.

In online mode, it is necessary to ensure that objects implemented in the complete architecture are performed. It is also possible without application server. It is necessary that there was element placed in the network to provide their implementation. It is a part of the WAS, known as Bootstrap and also there has to be located MSSQL database. This is because the object information is stored in the database. There are two equivalent computers (in terms of runtime control, not development) in created architecture. This is a link Peer-to-Peer.

Our goal was not only to maintain functional control system without the WAS, but we wanted to keep control system by failure of Ethernet networks. The individual components are installed on the computer which represents technology node. Implemented architecture is showed in the Fig. 2.

From the perspective of created application is necessary to ensure that objects managing technology were deployed on technological node. This is doing from Archestra development environment.

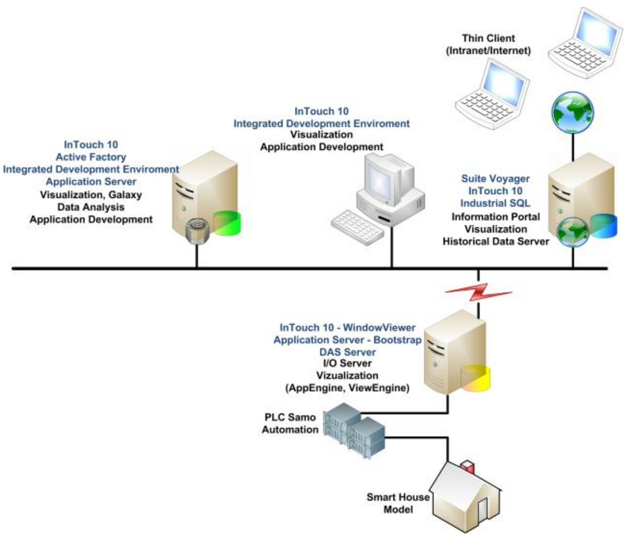

Fig. 2. Realized control system architecture. The figure contains only deployed components of WSP.

Whereas Application server is located in the network (represents development station), applications are distributed on the control nodes from this environment. It is necessary to distribute components AppEngine and ViewEngine to ensure the control. Deployment is realized through so-called WinPlatform. WinPlatform entails rules for objects operating.

In case of WAS failure, or network failure it is possible to continue in managing the technology. Of course, the condition is that the application server components (Bootstrap) must be located in the control network. Together with AppEngine and ViewEngine (for the technological process) and MSSQL database system.

V. PRACTICAL USAGE IN INDUSTRY

Distributed control systems that are using the Peer-to-Peer link are widely used in practice, mostly in cases with plenty of so-called islands of automation, in fact the companies, which encompasses a number of places where technological process is carried out. These technological workplaces are linked and are part of the architecture of information control system. In practice, there is a place where technological workplaces are driving from, called the control room. In the case of network failure is control disrupted and company has losses especially due to downtime in the operation. However, if there is a way to manage technology directly in the technological process, production can continue.

Example how our solutions can be implemented in practice is illustrated in the Fig. 3. It is an oil refinery with oil wells. Pumping is provided directly by borehole pump and it is controlled from one place. In the case of network failure, the pumping stops. But if there is possibility to control a pump locally, it is possible to continue with pumping. There is no loss from downtime.

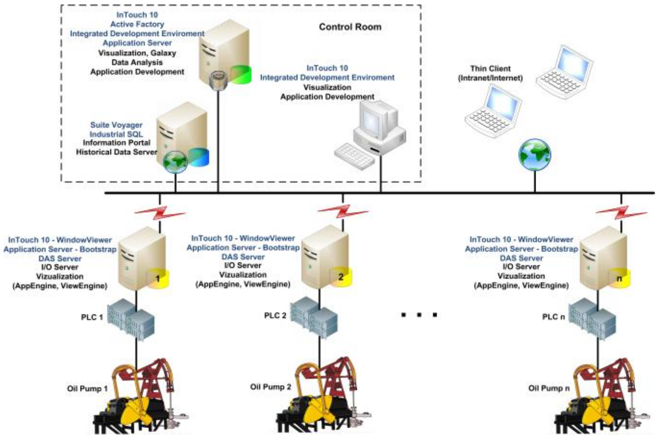

Fig. 3. Control system architecture for oil refinery. The figure contains only deployed components of WSP.

The figure shows the Ethernet network failure or disconnection from the network. Objects relating to a specific technological operation of the automated island are carried out on the corresponding computer station. Thanks to this it is possible to use less efficient equipment and again save costs.

VI. CONCLUSIONS

The aim of our study was to create a control system in laboratory that would not depend on control network functionality. So the operator can control technological system directly in technology. This control network was successfully realized and its functionality was by using software components of WSP.

For this purpose, as the technological process has been selected one of the models located in the laboratory, the Smart house.

Control network was simulated in laboratory conditions. Smart house model represent technological level. For real conditions it’s not very good example but for our purpose is sufficient. For this reason, was mentioned practical usage in industry. Article presents solution for Oil refinery. Important parts of control system are deployed on technological nodes to allow control of oil pumps, either one or more on certain place of oil field.

There are more possibilities of usage, for example in

Electric power plant, manufacturing plants of various kinds, etc. In fact, we can use this solution for control when is possible to look on technology as an island of automation or group of islands of automation.

Thanks to this design of information control system can industry facilities continue in productions, without stopping, if network failure occurs. This is very important for those factories, because there is no financial loss from the discontinued production.

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