Optimization of Distributed Control Systems Using Information Technology Assets

A. Haseltalab and M. A. Badamchizadeh

***Abstract*—By improvement of industries, the demand of using of feasible industrial control system (ICS) and optimizing the current method is growing. Distributed control system is one of the best and usual methods for controlling an industrial system. Simplicity, flexibility, extensibility, scalability, fault tolerance and accommodation are some of its features that caused this method outshine from the other methods and by using new technologies, new facilities can be added easily. Nowadays Information Technology (IT) science gives us various tools for optimization and better execution of DCS. This paper will introduce these tools and their usage and at the end a practical example including all of these tools will be presented.**

***Index Terms*—Distributed control system (DCS); information technology (IT); industrial control system (ICS); network**

I. Introduction

Industrial Control System (ICS) is a term that includes various control systems like Distributed Control System (DCS), Supervisory Control and Data Acquisition (SCADA), Programmable Logic Controller (PLC) that all are being used for controlling both batch and continuous industrial manufacturing processes. ICS are typically used in industries such as electrical, water and wastewater, oil and natural gas, chemical, transportation, pharmaceutical, pulp and paper, food and beverage, and discrete manufacturing (e.g., automotive, aerospace, and durable goods). [1]

A general ICS is consisting of three parts. Control loop that includes sensors, actuators (e.g. valve controllers, switches, pressure controllers, etc) and controller (e.g. PLC), Human Machine Interface (HMI) for adjusting set points, control algorithm and observing total process status and Remote Diagnostics and Maintenance Utilities (RDMU) for preventing, identifying and recovering from abnormal operation or failure[1]. An ICS and communication model of the parts is shown in Fig. 1.

Information Technology (IT) consists of many assets that help improving ICS, that [2] [3] includes several methods of networking and various network topologies with optimized and updated components and softwares [4], ability of system access using internet [5][6][7] and checking system condition from out world, database for storing information of real-time and past condition of system, establishing security systems and policies to protect system.

This paper with examination of DCS will use these assets for optimization of these control systems. So in the first part DCSs and their function are discussed, the second part is about IT assets and their usage methods are explained and at the end a practical system is implemented using discussed features.

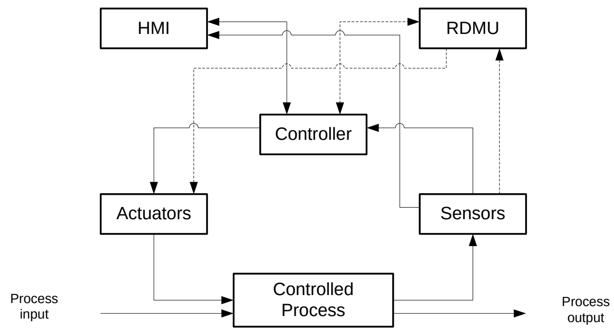

Fig. 1.A general ICS system

II. A Brief Review of DCS

DCS is an ICS that its controlling components are not centralized in a point so that they are distributed in different parts of system that each or group of them control one of system components and total system components are connected through a Local Control Network (LCN) to a node called management information system. In fact a DCS uses a centralized supervisory control loop to mediate a group of localized controllers that share the overall tasks of carrying out an entire production process [8].

A DCS consists of two working level:

1) Supervisory level
2) Field level

Supervisory level is a part of system that is connected to components of system through a LCN and its duty is about supervising whole process and components conditions and applies some of limited control actions. Control server, main HMI, Database constitute supervisory level.

Field level consists of PLCs, Programmable Automation Controllers (PAC), machine controllers, actuators, sensors, motors and etc that a group of them constitute an industrial device. In fact field level is group of industrial devices that establish process manufacturing lines in an industrial unit. A general schematic of a DCS system is illustrated in Fig. 2.

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A. Haseltalab has been graduated from University of Tabriz (e-mail: ali.haseltalab@gmail.com).
M. A. Badamchizadeh is with Control Department of faculty of Electrical and Computer Engineering at University of Tabriz (e-mail: mbadamchi@tabrizu.ac.ir).

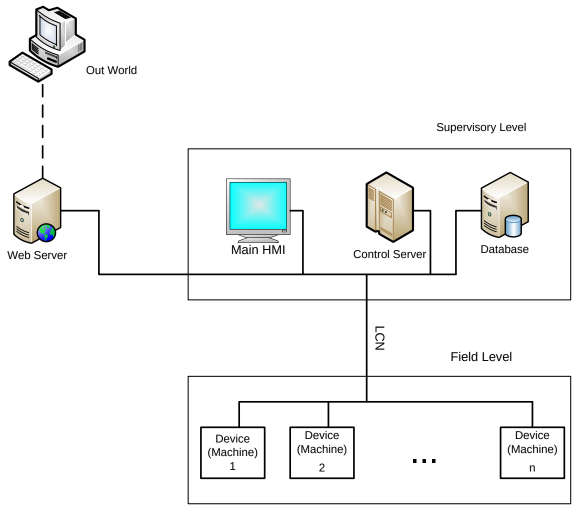

Fig. 2. A general schematic of a DCS

III. IT Assets for Optimization

By considering of DCS propagation and the need to better optimized operating of this system is growing. Feasible component communications and network architecture, availability of accessing to the system's conditional information using web server, system operation storage in database and high system security are features that assemble better functionality for DCSs. So network architecture, database, web server and security are four corners of a square that IT science presents for optimization of DCS.

From the vision of working role DCS's components are divided to different groups:

1) Supervisory components (as mentioned)
2) Controllers
3) Actuators and sensors that are connected directly to the manufacturing process.

Communication between supervisory components and controllers is established using a LCN. Also communication between controllers and actuators and sensors are being established by Fieldbus networks and protocols. (Figure 3)

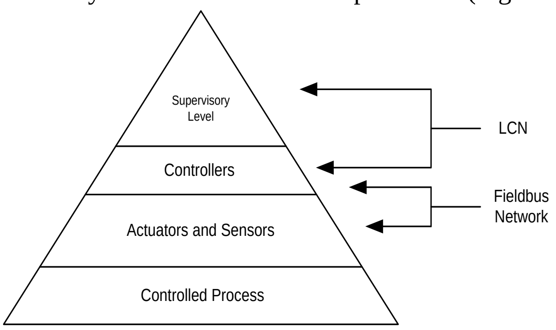

Fig. 3. Role division triangle of components and their connection methods

In order to implementing the LCN many researches have been done in the last decade and various methods have been introduced like using Ethernet technology [9][10], Controller Area Network (CAN) and neural network [11], wireless technologies[12][13][14][15] that the most of them in addition of having complicated, difficult and high cost in proportion to functionality implementation, can't function properly in industrial areas with high noise and interference. A proper method for overcoming of these problems is using fiber optic technology for linkages and networking which has good functionality in comparison to total cost and simplicity of implementing in addition because of using optic technology, it is noise robust so can be adopted in high noised and interference industrial areas. In order to implement the network we choose Tree topology (figure 4) and set of TCP/IP protocols are used, that Secure Socket Protocol (SSL) for application layer, Transmission Control Protocol (TCP) for transport layer Internet Protocol Version 6 (IPV6) for internet layer are adopted. Because of non-existence of fiber optic input on locational HMIs, fiber optic Ethernet converter can be used.

Generally a web server-based DCS from data exchange sight is divided to three tiers. Client tier, middle tier consists of web server and control server that are linked directly and data tier that includes database and devices. In order to establish communication between clients and devices OMG-CORBA standard can be adopted [5] and software and graphical user interface can be constructed using Labview [16] and Microsoft visual basic. For system access using internet a URL address is specified and a login/password based access is setup to prevent unauthorized accesses.

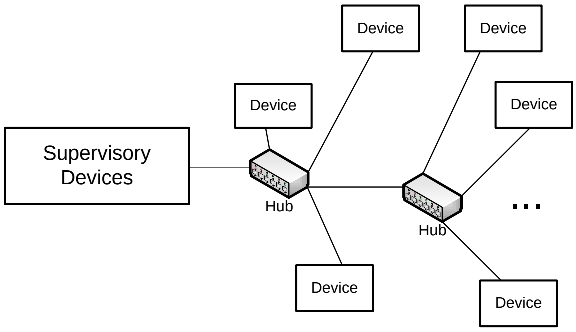

Fig. 4. LCN topology

Database consists of two parts, Real-Time DataBase (RTDB) and Historical DataBase (HDB) [17]. RTDB is consisted of real-time system information and past system information is stored in HDB (figure 5). Because of so many advantages in Relational databases, we use this database model for system. So MySQL, Microsoft SQL server, Microsoft access and etc are chosen. Important specifications for choosing a proper database management system are ability of supporting different operating systems, strong access controlling policies, data storage volume, ability of storing different data with different formats.

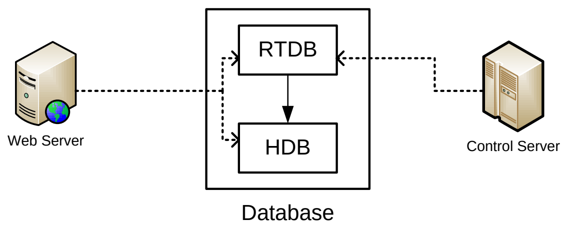

Fig. 5. Data storing and access procedure in database

Because of internet connection ability in system, security is very important so the connection to the web page is secured through the server certificates and the SSL algorithm (as mentioned). In addition Grid method can be adopted for identifying unauthorized clients and actions. [18]

IV. A Practical Prototype of Implementation

We implement the system on the manufacturing line of industrial cake. This line consists of primary mixer, secondary mixer, depositor, industrial oven, cooling multi-floor rail and packing machine. First primary cake materials are mixed in primary mixer and form cake's paste. Then in secondary mixer (Homogenizer) the paste is mixed using high speed motors in order to make it homogeny and directly it will be transferred to depositor pouring it in little moulds and by using conveyor belt the full-paste moulds will be transferred to the oven for bake. Then a multi-floor conveyor belt will carry them in order to make them cool and then cakes will be packed using packing machine.

PLC is used as a controller in machines and devices that is installed on each of them separately. In addition each of them is consist of a HMI that indicates information and condition of the machine and control actions are applied. All the machines are networked using fiber optic LCN in order to machine's operating conditions and information can be seen from one point (engineers work station) and some limited control actions to be applied. Microsoft SQL server is adopted for data management and storage. In database each device has two tables. One for the current status (RTDB) and the other one consists of history of device conditions and application of it in past (HDB) (figure 6). By using SSL algorithm and login password, internet access is secured. General schematic of industrial manufacturing line and implemented system are shown in figure 7.

Device ID	Device Name
102	Homogenizer

Date and time	Current status	Motor speed (rpm)	Pump speed (rpm)	Output paste temperature (‘c)	Output paste pressure (bar)
07/05/2010 14:31:39	On	90	105	11	3

Date and time	Status	Motor speed (rpm)	Pump speed (rpm)	Output paste temperature (‘c)	Output paste pressure (bar)
07/05/2010 12:34:12	on	90	105	10	3
07/05/2010 10:20:54	on	102	105	10	3
07/05/2010 09:01:11	on	95	105	10	3

Fig. 6. Database data storage model

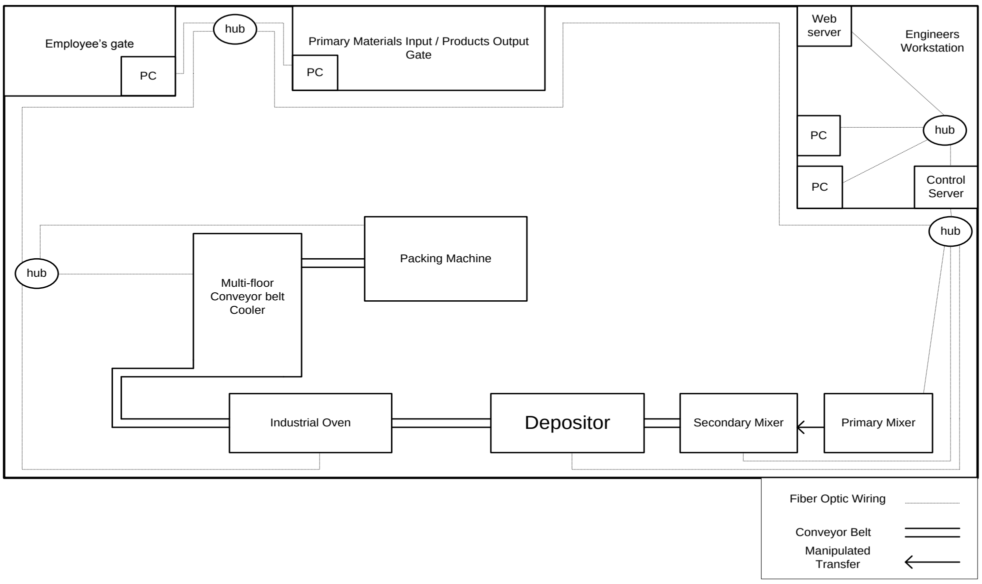

Fig. 7. Industrial cake manufacturing factory and DCS implementation

V. Conclusion

In this paper after discussing about ICS and DCS, the tools that IT science avail to optimize DCSs are introduced and some methods for obtaining better optimization are presented and at the end a practical example that contains all these tools featuring less cost implementation, flexibility, compatibility, ability to operate in high noised industrial areas, ease of implementation are represented.

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Ali Haseltalab was born in Tehran, Iran in 1996. He received his B.S. degree in Control Engineering from University of Tabriz, Iran in 2009 His research interests are Automatic systems, PLC, DCS and fuzzy control.

Mohammad Ali Badamchizadeh was born in Tabriz, Iran, in December 1975. He received the B.S. degree in Electrical Engineering from University of Tabriz in 1998. He received the M.Sc. and Ph.D. degree in Control Engineering from University of Tabriz in 2001 and 2007, respectively. He is now assistant professor in the Faculty of Electrical and Computer engineering at University of Tabriz. His research interests include Hybrid dynamical systems, Stability of systems, Adaptive Control and intelligent systems.