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INTEGRATED DISTRIBUTED CONTROL SYSTEM

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Abstract. *The purpose of this paper is to discuss the opportunities for student training in control and modeling of technological plants using distributed control system with integrated data base. The initial configuration of the system comprises one programmable controller MIC 5000 Ce, two NETMASTER and server INTEL SR 2500. The latter contains the integrated data base of the system and the simulator of technological plants UniSim Design Suite R390 of Honeywell.*

Key words: *distributed control ,controllers, training, modeling*

ИНТЕГРИРАНА СИСТЕМА ЗА РАЗПРЕДЕЛЕНО УПРАВЛЕНИЕ

1. Introduction

The premises for the development of integrated distributed control system (DCS) and its feasibility are defined by the presence of several PLCs NETMASTER and a MIC 5000 Ce system including SCADA as well as a server configuration (INTEL SR 2500) suitable for the storage of an integrated data base in the department "Automation" of UCTM - Sofia. Network components are also available. Important part of the system will be the software product UniSim Design Suite R390 of Honeywell, intended for modelling and control of technological plants in real time. For the purpose it will interact through XML files with the controllers and operate as a Scenario Manager.

In this way a new effective working environment for student training and research will be developed. It will integrate heterogynous data bases and allow recipe development using Java and standard IEC 61449. The purpose of this paper is to describe the fundamental elements of the project.

2. Purpose and archirecture of the integrated distributed control system

The architecture of the system [3, 6, 8] is illustrated by Fig.1. With the term "Process Control" are identified tools and functions dedicated to plant monitoring and control, such as PLCs or DCSs. "Production Management" is a term referring tools and functions needed in order to fulfill customer orders, such as MRP systems, Decision Support Systems, etc.

The aim of this paper is to provide a view for foundation of intelligent and flexible connection between the Process Control and the Production Management.

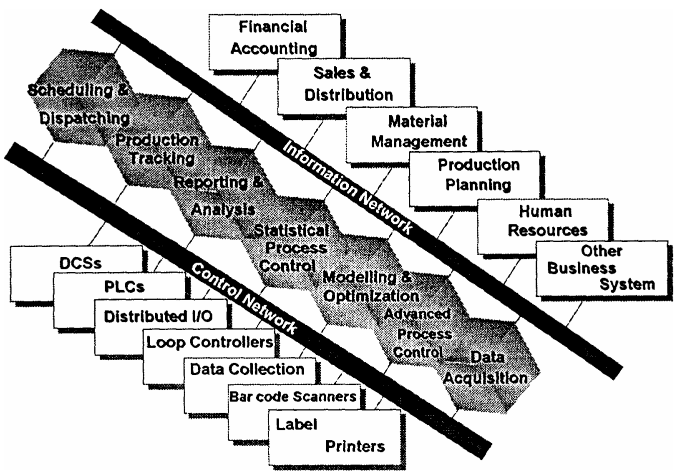

Fig. 1. Process Control and Production Management tools and functions.

Today the industry faces mounting challenges to improve profitability and reduce costs in an increasingly competitive environment. Added to this pressure is the need to comply with environmental, safety and other mandatory inspection procedures and reporting requirements. These challenges bring to the fact that most medium and large-scale facilities operate a mix of distributed control systems (DCSs), programmable logic controller (PLC) systems and supervisory systems at the Process Control level. These facilities also maintain a variety of other databases that offer decision support for Production Management. Such databases typically include financial management, monthly planning, production scheduling, inventory management, maintenance, environmental monitoring and other management systems. The goal of a modern information management system is to integrate large quantities of real-time data at the control and monitoring level with business applications at the decision support level.

The strategic choices to build such systems can be summarized as follows [3, 6, 8]:

• *Operating System*

The Operating System should include hardware/software platform with the following mandatory features: preemptive multitasking; 32 or 64 bit architecture; integrated multiprotocol networking; multiplatform; high reliability; security management; large availability of third-party software solutions.

• *Communications*

Today the capability to use multiprotocols, Local and Wide Area Networks; in particular the support of protocols like TCP/IP or PPP is mandatory. Thanks to these features the user can do queries, exchange data, perform telemonitoring or teleoperation.

• *Client/Server A rchitecture*

The Client/Server architecture offers the opportunity to target the so called "rightsizing", giving the chance to set up a distributed and well balanced system with an excellent price/performance ratio.

• *Open System*

Referring to Open Systems means the capability to:

- integrate real time devices;

In a factory there is always the need to acquire and set data to heterogeneous real time devices (PLC, DCS, Single Loop, Intelligent Sensors or other equipment).

- integrate custom applications;

Application software is normally provided by different suppliers. What is essential in order to have an easy-to-use, friendly system, is that all the HMI applications have a common look-and-feel, and the navigation is as much as possible congruent and natural.

- integrate standard productivity tools;

Every employee has on their desk a PC with a word processor or a spreadsheet, which are intended for reporting and data manipulation.

• *Availability*

A lot of procedures and data can be very critical. Loss of data or a system blackout with service interruption can cause serious damage. Particular attention must be given to the overall availability of the Process Control and Production Management system.

The basic components of the integrated system architecture are the following (Fig. 2):

Realtime Database: At the heart of the integrated system is a global, distributed, memory-resident Real-time Database through which all software modules can interact. In fact the Real-time Database functions as both an in-memory storage device and an interprocess communication for the elements of the system, which share the information in the Real-time Database by reading from or writing to its tags.

Plant Floor Device Drivers: A set of device drivers provides a common interface between the Real-time Database and a variety of monitoring and control equipment which is integrated into the system. Driver modules allow the user to configure bi-directional communication links between the Real-time Database and one or more external device.

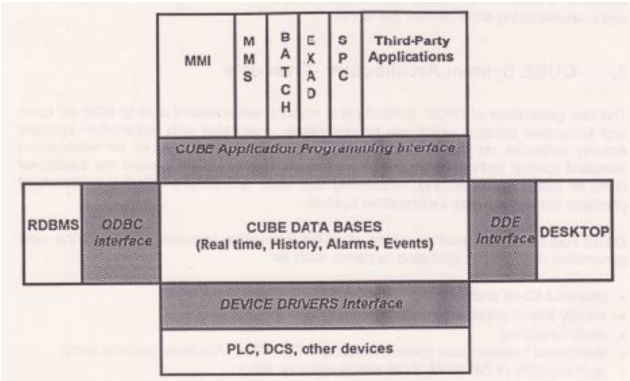

Fig. 2. Integrated system architecture

Historical Database: Historical Database is a time-based database that allows process and plant data to be stored in a compressed and optimized manner.

Relational Database Interface: The Relational Database Interface provides fully integrated access between the system environment and relational databases such as MS Access, SQL, Oracle etc. With the Relational Database Interface users may access real-time data, process data, alarms, events and relational data (i.e. production data) simultaneously employing SQL queries. Interface has to be implemented using the ODBC technology.

Human Machine Interface: The Human Machine Interface (HMI) should provide the capability to draw any kind of pictures having very high performance resolutions.

Event Manager: The Event Manager is a basic component which monitors all plant-related events (for example the end of a batch) and notifies all of the tasks concerned if these events occur. The main characteristics of the Event Manager should be the flexibility in defining new events and the possibility of associating each event to one or more actions to be undertaken.

Alarm Manager: The Alarm Manager tool should provide comprehensive monitoring, displaying, acknowledging and logging of alarms. The user specifies the Real-time Database tags to be monitored and defines the conditions under which the Alarm Manager determines when an alarm has occurred.

Programming Environment: The system should offer software standard development environment Application Programming Interface (API), which provides software libraries, tools and documentation required by programmers.

Batch and Recipe Management: The system should offer comprehensive SP88 batch control capabilities, including recipe management, production scheduling, inventory management, batch control, batch history and archiving.

DDE Interface: This interface is the bridge between the integrated data base and the applications that adhere to the DDE (Dynamic Data Exchange) standard.

3. Major Functions of the integrated system

According to the archtecture main functions provided by the integrated system should be: System Management; *Process Data Management; Alarms Management; Graphical Monitoring System; Real-time Database Management; Events Management; Relational Database Integration (ODBC Interface); Desktop Integration (DDE Interface); Programming Environment*

Integration with relational database management system forms a key part of any modern information management system, which provides a powerful, integrated and flexible environment to share data between real-time and non-real-time worlds. It should allow a transparent and on-line bi-directional integration within the system environment of any ODBC compliant application.

The idea for linking to a relational database is not confined to any particular RDBMS. With such an approach any popular relational database can be easily integrated within the environment in order to transfer selected information between the real-time database, the historical database and the relational database itself. This integration, therefore, will allow the users to build their own applications just mapping the real-time database elements to the relational database field and vice-versa.

3. Device specification in the integrated DCS

3.1. MIC 5000 Ce [7].

The basic product of the “MICONT” Ltd is the system MIC - 5000Ce. According the universally accepted terminology and for better presentation, the system is separated in two parts - DCS and SCADA (Supervisor Control And Data Acquisition). The family of the technical devices of MIC - 5000Ce includes:

- Basic Microprocessor Stations (BMS) – Multifunctional Controllers.
- Communication instruments – Standards ARCNET, CAN and Industrial Ethernet.
- Operator Stations and Servers – Functionally full SCADA system based on the family of OPC standards.

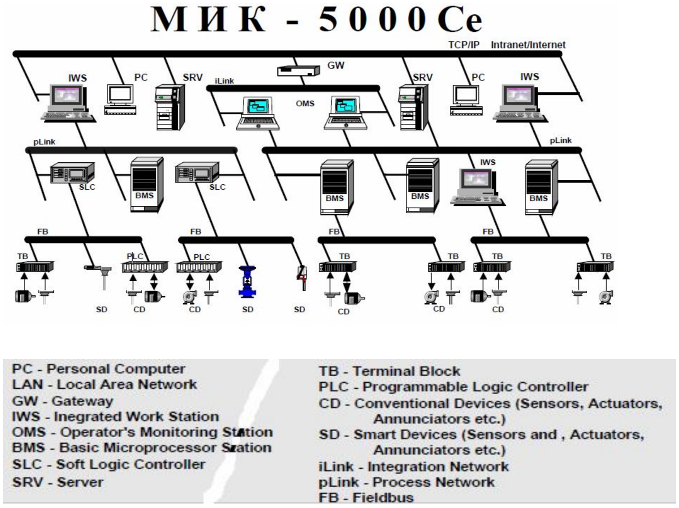

Fig. 3. Structure of MIC 5000 Ce system.

MIC-009C (Basic Microprocessor Station - BMS) is a high performance Multifunction Controller of the DCS MIC-5000Ce. It ensures: Signal conditioning, I/O conversion and linearization; Flexibility in connecting of different I/O types; High speed communication with different protocols; Remote data acquisition functions with MIC-022; Dedicated control functions: PID; POL/I – Problem Oriented Language; Logic Blocks; I/O Resources: - up to: AI-96; DI-256; AO-48; DO-160; CN-64; Int. Resources: Timers-32; Flags-256; Numerics- 999; PID - 24; Logic Blocks-256; POL/I-programs - 32; Analog Trends - 128; Digital Trends – 160.

Functional description of the BMS:

It ensures four basic functional subsystems: subsystem for sequential control; subsystem for loop control; subsystem for logical control and subsystem for input/output. BMS also ensures: information support for archives and history of the analog or digital variables, storage of mean values etc.

3.2. NETMASTER programmable controller [9].

NETMASTER is a programmable microcontroller produced by Elsist Srl, Italy. This microcontroller is cheap and compatible for use in a wide variety of distributed applications. The processors for the NETMASTER module, namely, Dallas Semiconductor's TINI and Analog Device's ADuC812 are enclosed in a DIN 43880 enclosure and equipped with a standard interfaces for serial, parallel and network communications and I/O connectivity. The base hardware module contains: 12 optoisolated digital inputs; 8 static digital outputs; 4 analog inputs (0-10 v DC); 2 analog outputs (0-2.5 v DC); LED I/O status gauges for the digital I/O's; Ethernet interface; CAN Bus or RS 422/485; RS 232C; FC interface for extending; 512 KB Flash ROM and 512 KB Static RAM backed up by battery; real time clock; keyboard – 6 keys; 2 lines of 16 character LCD display.

NETMASTER has well defined **software environment**, principally due to the TINI processor, comprising of the following components [9]: operating system and command shell, native codes that could be directly executed by the microcontroller, Java Virtual Machine (JVM).

A graphical representation of the software environment is shown in Figure 3. Following part of this section describes briefly each of these components.

Operating system of the NETMASTER module is the TINI Operating System and lies in the lowest layer of the software environment. It is responsible for managing all system resources including access to the memory, scheduling multiple processes and threads of execution and interacting with both internal and external hardware components. Unlike most small, embedded controller operating systems, TINI OS is designed to switch heavyweight tasks. Specifically, it is optimized to switch between multiple executing instances of a Java byte-code interpreter. This provides the foundation required for running multiple Java applications.

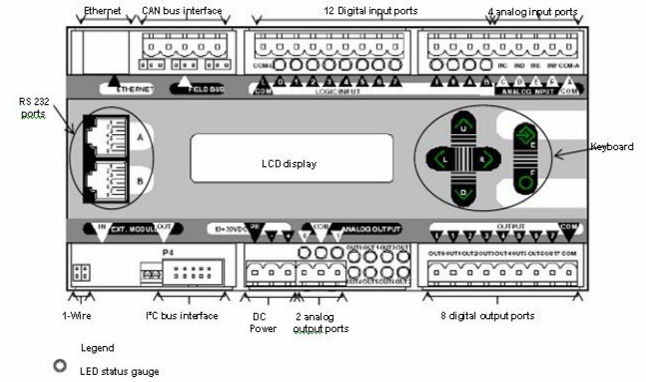

Fig. 4. NETMASTER base module.

3.3. INTEL Server SR 2500 [5].

This server is the storage for the integrated data base and SCADA system.

Form Factor: Rack-optimized 2U chassis.

HDD Carrier: Up to 6 hot-swap SAS, SCSI or SATA 3.5" HDD 1 slim-line bay: CD или USB FDD.

Intel® Server Technologies: Intel® Active Cooling; Intel® Self Diagnostic; Power Consuming Optimization.

Power Supply Modules: 750 Watt 1+0 PFC - redundant.

Options: Redundant cooling; Intel® Local Control Panel. Redundant battery for the RAID controller.

Main server components:

– Two processors INTEL XEON CPU 3.4GHz Series 5100; 3GB RAM ECC KINGSTON; RAID Controller SRCU31.

– 2 x HDD SEAGATE 36GB → RAID 1 – on this set operation system Windows Server 2008 R2 and virtualization software is installed. It is with size 36GB.

– 3 x HDD IBM 16GB → RAID 5; size 36GB.

– Intel® PRO/1000 MT Dual Port Server Adapter.

3.4. Software application UniSim® Design Suite R 390 [4].

The intensive application of **UniSim Design** is due to four key aspects: event driven operations; module operations; multy-flowsheet architecture; object oriented design.

UniSim offers unified decisions to keep high efficiency over the life cycle of the technological equipment – from the off-line design through steady state simulation, analisys of different control strategies, operators training, online usage for control and optimization, productivity control and business planning.

The software packages of the family UniSim are:

The UniSim Design suite – software product for design; **The UniSim Operations suite -** software product for operators training; **The UniSim Optimization suite: Dynamic Engineering Studies services** – software product for investigation of dynamics.

This software application will be used for simulation and real-time control of technological plants with MIC and NETMASTER controllers. It is installed as a virtual machine on the server.

4. Communications in the integrated distributed control system

The system has a WAN interface - router, which is configured to receive automatically Internet parameters - real IP /defined by the ISP/. This allows remote connections with the system. The router is configured with DHCP to distribute the addresses in the private network. The reserved region is from 10.10.10.100 to 10.10.10.124, which means 25 dynamic hosts. The rest part of the IP addresses is free for configuring by hand.

The server needs static IP, which is – 10.10.10.2. This requirement comes from the fact that its exact address should be known. With the real IP a connection with the stations outside the university can be established using the function „Port Forwarding".

Three virtual machines are configured in the server. Network connection with them is realized using the functional connectivity type „bridge". So the network interface of the server is a bridge to the virtual network cards, so they can be configured with IP.

For the moment a wireless connection to MIC 5000 Ce is used. Its parameters are satisfactory: throuput of 54 Mbps on channel 7 at 2.442GHz and WPA Personal, TKIP. For the future for higher speed and reliability the usage of special wireless NanoStation2 LOCO is stipulated. This is a network device intended to be mount outside. It functions like Wireless Access Point or Bridge. To reach the possible span of 5 km a system of 4 antennas is built in the NanoStation2 LOCO. The hardware is intended for work from -20C up to +70C. The Operating system was developed specially for it - OS of Ubiquiti Networks.

As the programmable controller NETMASTER uses CAN protocol for communications its connection with the integrated data base should be made using CAN OPC server. It is a Windows application operating as a gateway between devices attached to CAN (Control Area Network) segment and OPC clients (typically SCADA systems). Server supports OPC Data Access specification v. 2.0.

Fastwel CAN OPC Server [1, 2] that will be used, has the functions as follows:

- Sending CAN communication objects (messages) with the given friequency.
- Receiving CAN communication objects (messages).
- Mapping CAN messages data to OPC tags (8, 16, 32- bit signed and unsigned integers, float and double types are supported).
- Hierarchical OPC address space.
- OPC data quality calculation using expiration period assigned to a message.
- CAN network monitoring.
- Automatic message list creation using CAN monitor statistics.

RTR data acqusition currently is not supported.

5. Conclusion

The development of the integrated DCS, which will be based on the MIC 5000 Ce scada, demands integration of devices of different producers. That is why specific interfaces for communication among variety of protocols are needed.

The integrated data base and the DCS ensure in principle a new environment for training and research. For the purpose they need a specific important functions that has to be developed: System Management; Process Data Management; Alarms Management; Graphical Monitoring System; Real-time Database Management; Events Management; Relational Database Integration (ODBC Interface).

Important part of the project is the application of the software package UniSim Design Suite R390. It will be used for simulation and control of technological plants. Advantage of the package is the presence of a variety of prepared models, which have only to be adapted to concrete installations, for example: distillation of natural gas; crude oil distillation; sour water stripper etc. In addition these models can be connected to the PLCs through XML-files for the investigation of the applicability of different control strategies.

ЛИТЕРАТУРА

1. Джиев Ст., Индустриални мрежи за комуникация и управление, Технически университет – гр. София, 2003.
2. Fastwel CAN OPC server, User's Guide
3. Honeywell, Scan 3000 Specification Data, 1996.
4. Honeywell, UniSim® Design, Tutorials and Applications, April 2009 R390.
5. support.intel.com" – Сайт за поддръжка и асемблиране на компютърни системи.

6. Love J., Process Automation Handbook, Springer-Verlag London Ltd, 2007.
7. MicSK User-Pack-User Manual, 2007.
8. ORSI, The CUBE System - Management Overview, BT037/01E, 1996.
9. Tanvir H., Georg F., IEC 61499 SIFBs for the NETMASTER network-enabled controllers, JPA Technical Report 01/2004.

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