ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 1998
Seria: INFORMATYKA z. 34 Nr kol. 1381

Waldemar GRABSKI, Artur KRYSTOSIK
Wiktor B. DASZCZUK, Jerzy MIEŚCICKI
Politechnika Warszawska, Instytut Informatyki

INTEGRATION OF INDUSTRIAL DCS WITH A PLANT MANAGEMENT NETWORK

Summary. The paper describes general requirements and design decisions made in the implementation of Plant Monitoring System which makes data from Distributed Control System available for the users of Management Information Network. The brief description of two working examples is given

INTEGRACJA PRZEMYSŁOWEGO ROZPROSZONEGO SYSTEMU STEROWANIA Z ZAKŁADOWĄ SIECIĄ ZARZĄDZANIA

Streszczenie. W artykule opisano podstawowe wymagania projektowe i decyzje podjęte przy implementacji Systemu Nadzoru Eksploatacji Bloków Energetycznych, który udostępnia dane z sieci sterowania w sieci zarządzania. Jako przykłady podano krótkie opisy wdrożeń.

1. Introduction

Both industrial systems, DCS (Distributed Control System) and MIN (Management Information Network), are used in industrial plants, but their purpose and construction differ. Industrial DCS systems support acquiring and processing of large amounts of real-time data related to plant's performance. However, it is rather difficult to make such a system display or otherwise provide the data for the users situated outside the installation site itself, for example in an management department. Moreover, usually many DCS systems bought from various vendors are used in the same factory. These systems can be incompatible with each other, and also with MIN. Of course, DCS system vendors can easily offer the transmission of data to

This paper was supported by Warsaw University of Technology as a part of PATIA Research Project.

management department, but this generally requires expensive hardware and software, and the solution is still incompatible with MIN. Offered DCS systems are usually closed and do not offer a standardised interface for user's own applications.

This paper describes the Plant Monitoring System (PMS) which was developed in the Institute of Computer Science (Warsaw University of Technology) with co-operation of Institute of Heat Engineering (the same WUT) and installed in two Polish power plants. PMS safely integrates DCS with MIN making any data from DCS available for MIN users in a quasi real-time mode

2. Project features

2.1. 'Off-line monitoring'

A concept of "off-line monitoring" was elaborated to establish an access to data from DCS by MIN nodes. Because of significant differences between a DCS and MIN, it is practically impossible to implement a direct, safe and reliable connection between them.

Indeed, DCS is built to transfer data in a real time with high reliability. DCS is oriented to transfer a large number of short messages. Fault tolerance is achieved by duplication of passive and active network elements. Pieces of data are distributed among nodes of the network. Expiration time of data validity is very short. Token-passing protocols (with no collision) or multiplication of data channels are typically used. Meanwhile, MIN is typically used for data base management. MIN is oriented to transfer large as well as small pieces of data and the traffic of messages is rather irregular. Fault tolerance is achieved by retransmission of messages (this is useless in DCS because of quick loosing of interest of data). Typically network elements solve collisions of access to the network instead of preventing them. Pieces of data are centralised in specific nodes working as application servers. The organisation of MIN does not allow for broadcasting data as in DCS.

Another important difference between DCS and MIN is, that DCS is mission-critical while MIN is not. Any interference to DCS operation, caused by external software or hardware is potentially harmful and can lead to a damage of controlled system.

The idea of the 'off-line monitoring' was to introduce an intermediate data server which is connected to the DCS through the hardware/software interface as one of its real-time units while it is seen by the MIN - as a general purpose data server with random access from MIN nodes. A few seconds delay caused by this intermediate layer was acceptable for the system user.

Moreover, if several DCS types have to be integrated with a plant's MIN, the off-line monitoring also would make the system operation independent from a particular DCS features.

2.2. Model of an application layer

The organisation of PMS follows the rules for the implementation of a general, 'three-dimensional' system model discussed in [1]. The application layer of the system is built of three main components, which may be considered as three software 'levels'.

The bottom one, i.e. Data Acquisition Level (or more generally Data Stream Level) is implementation-dependent and must be, in general, constructed individually for given DCS system. The software that implements this level is called **DataSource**. Its task is to pick up the specified data from the DCS and transmit it to the data server placed in a middle level.

The middle Data Organisation Level contains a cyclic data base management system called **SigData,** developed in C++ and thus fully portable in a source code.

The top Application Processing Level contains the software components for data visualisation and processing. A typical program which purpose is visualisation of state of an industrial systems is a **SigScr** module while a module called **SigComp** represents user-defined computations (via DLL modules).

The unification of interfaces allows to define sources of real-time data other than the actual process signals. For example, in a SigComp performing boiler thermal stress calculations the data feedback is implemented. The data feedback is a situation, where an application acting as a DataSource calculates new values and inserts them back into the data base. These pieces of data are not obtained from the DCS system - they are prepared in real time by some iterative processes acting concurrently with SigData.

Interfaces between above-mentioned software modules are standardised to make the system components easily portable and reusable. The interface between all components is based on BSD sockets - wide used standard of communication - to simplify creating new programs for using real-time data, ever by the user himself.

The real-time data base is organised in a cyclic manner. Every signal is stored as a fixed number of last samples (a trend) in a given period (with fixed time slice) in a cyclic buffer. Now, following types of trends are available: 1 min., 10 min., 1 hour, 8 hours, 1 day, 10 days. The data buffers are organised like in an energy or water counter: one full turn of a lower-order circle makes one elementary step of a higher-order circle..

2.3. Customisation

Customisation for user's needs is easy to achieve on each level of the system. For SigData we can define a set of points collected from DCS. Each point is identified by its name and source of origin and has set of attributes like: unit, precision, collected trends, range. To make database management easier, points can be split into separate groups e.g. points from boiler or turbine etc. Each SigScr is an MS Windows application. For a particular SigScr the user can define his own form of visualisation diagrams. Each diagram consists of a bitmap which usually represents a particular industrial device and a set of visualisation points placed on the bitmap which show a current state of particular process points. User can choose from a following display types of visualisations:

- **Value** displays a numerical value of a point.
- **Bar graph** displays a numerical value in a form of coloured bar graph.
- **Active schema** displays a state of a device (e.g. pump on, off, damaged) via a set of small bitmaps switched according to the value of one or more process points which represents the state of the device.
- **Trend** displays trends of a set of process points.
- **Moving plot** displays plot of dependence between two process points.

To facilitate the design of such graphics, a graphic builder software - called **SigGraph** - has been developed. This program allows to construct graphics by selecting bitmap, process points and type of visualisation, placing its on the bitmap and testing overall view. After construction, a ready-to-use graphics is stored in a file and can be used by any SigScr anywhere in MIN. Example implementations

By now, PMS is used in two Polish power plants. Further sections describe architecture of these implementations.

2.4. The Siekierki Power and Heat Plant

The overall view of PMS architecture installed in Siekierki Power and Heat Plant in Warsaw is given in Fig. 1 below. The central point is SigData, placed on a NT server, which contains the database of all process points in power plant Siekierki. There are about 2500 points. SigData is connected to a few DataSources which serve separate industrial networks. The oldest one are BLOK_9 and BLOK_10 directly connected to TELEPERM ME made by Siemens. The second NT server acts a DataSource KOCIOL_1 connected to ABB system based on VMS. The most interesting, however, is software for Block 7. These software work on NT server and communicates bi-directionally via OLE with Hartman & Brown-made UNIX. Single SigComp module carries out a computation of boiler thermal stress. In the future, this system is planned to be extended. New module for long term data storing will be added.

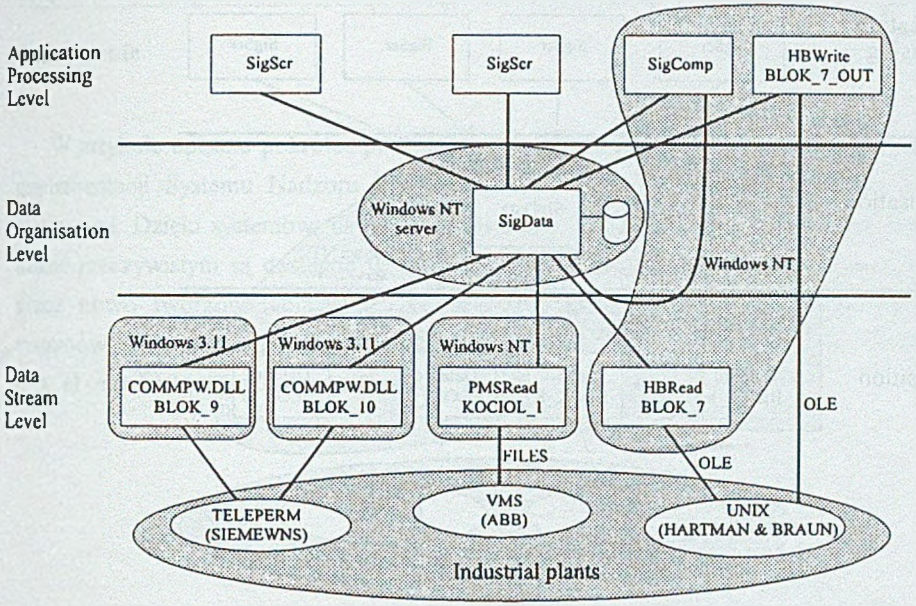

Fig. 1. PMS architecture for Siekierki Heat and Power Plant

Rys. 1. Architektura systemu w Elektrociepłowni Siekierki w Warszawie

2.5. The Polaniec Power Plant

The overall view of PMS architecture implemented in Polaniec is given in Fig 2.

This application is less complicated than in Siekierki power plant because of smaller number of different DCS systems to be integrated. However, database served by SigData is much bigger as it contains 13000 points collected. To cope with such large number of points we had to set up a NT server with 128 MB of RAM and 166 MHz Pentium processor.

3. Conclusions

The experience gained from operation of a system has proved that the idea of "off-line monitoring" is successful. Centralisation of data taken from DCS and access to data on demand allows to use the MIN effectively. Irregularities in traffic in MIN are not critical for the system.

A practical experience shows also that delay between data appearance in DCS and the time when it is available in MIN is about a few seconds, which is completely acceptable for all users.

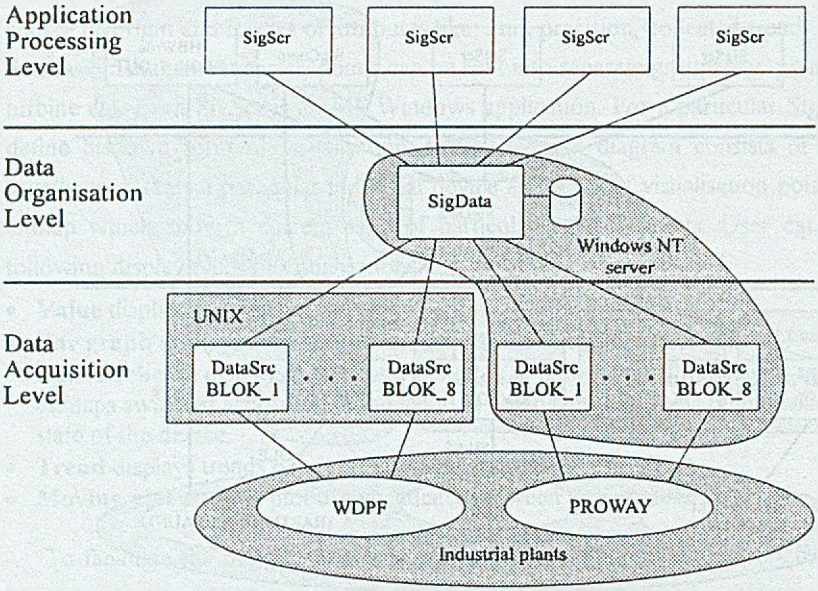

Fig. 2. PMS architecture for Połaniec Power Plant

Rys. 2. Architektura systemu w Elektrowni Połaniec

In a case of power plant, heat plant or other industrial plant the integration of DCS and MIN opens new, practically unlimited computational possibilities and provides practically unlimited access to information from process. This makes a base for a system that implements new, sophisticated control, optimisation or management tasks.

The advantage of proposed system organisation is also that its cost is several times lower as compared with the similar systems offered by vendors of typical commercial Distributed Control Systems.

BIBLIOGRAPHY

[1] Mieścicki J., Daszczuk W.B., Grabski W., Krystosik A.: Practical Approach to Distributed Systems' Design, Zeszyty Naukowe Politechniki Śląskiej, Seria Informatyka,1998

Recenzent: Dr hab. inż. Tadeusz Czachórski, Prof. Politechniki Śląskiej

Wpłynęło do Redakcji 8 stycznia 1998 r.

Streszczenie

W artykule opisano pokrótce podstawowe wymagania projektowe i decyzje podjęte przy implementacji Systemu Nadzoru Eksploatacji Bloków Energetycznych dla kilku polskich elektrowni. Dzięki systemowi dane z rozproszonego przemysłowego systemu sterowania w czasie rzeczywistym są dostępne w zakładowej sieci zarządzania i mogą być przetwarzane przez nowo tworzone aplikacje. Jako przykłady przytoczono krótkie opisy organizacji systemów pracujących już w ruchu ciągłym w Elektrociepłowni Siekierki w Warszawie (rys. 1) oraz Elektrowni Połaniec (rys. 2).