Application of Autonomous Decentralized System to the Steel Production Computer Control

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Abstract

In recent years, computer systems for information management and control have requirements for high reliable systems. Consequently hardware reliabilty has been highly increased, but system failures caused by failure of software modification or software function expansion have been increased. Therefore, online software maintainability and expandibity is highly required to fullfill the requirements of fault tolerance. In this paper, the new system architecture fullfilling the above needs called Autonomous Decentralized System is explained and its application to the real time steel production computer control systems is also presented.

1.Introduction

Nowadays, it is necessary to have information and control systems whose operation is not interrupted during software maintenance. In recent years, the reliability level of hardwares is being increased therefore most of hardware troubles and system break down are being caused by failure of software maintenance.

A new system architecture called Autonomous Decentralized System has been researched and developed to achieve the needs of the on-line software maintainability and expandability. This new architecture provides an easy way for the software modification and expansion during the system on-line operation.

The Autonomous Decentralized System is regarded as a biological organism and its mechanism is applied to engineering system. The main feature of this new architecture is that it permits to have partly damaged components in the system. This is based on the idea that the normal state of the system is, all components of the system are not perfect, while the conventional system premises that all components of the system are perfect. Therefore, this Autonomous Decentralized System is very convenient to be applied to the systems which will be continuously expanded even after the system has started its on-line commercial operation, yet without stopping the system.

In this paper, we will present an example of this system architecture and its application to real time steel plant control systems.

2.The concept of Autonomous Decentralized system

The architecture of steel process computer control system is being transferred from a centralized type to a decentralized type.

Conventional decentralized architecture is connected to the centralized computer via network and linked together among computers with communication functions of logical line. The conventional architecture makes it difficult to modify or add to the existing network system. As a result it is necessary to have a new architecture that accomodates the decentralized system.

This new idea of system architecture is called Autonomous Decentralized System which was developed to construct decentralized system easily that is reliable, maintainable and expandable.

Autonomous decentralization is constructed by the integration of basic elements of the system (subsystem) after defining each element. The configuration of architecture system is changeable, and the system that

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includes subsystem which is faulty, under expansion, or under maintenance must be considered as usual.

Coventional system premises that all components of the system are perfect, while this autonomous decentralized system is aiming non-stop system. That means even when one of the subsystems fails the other subsystems continue to act, and as a result, the whole system will not stop by itself. This subsystem is self controllable and can control its own area (Autonomous Controllability), and a system whose reliability is kept by process continuity when one of the subsystems fails (Autonomous Coordinability).

Fig.1 shows the concept of autonomous decentralized system.

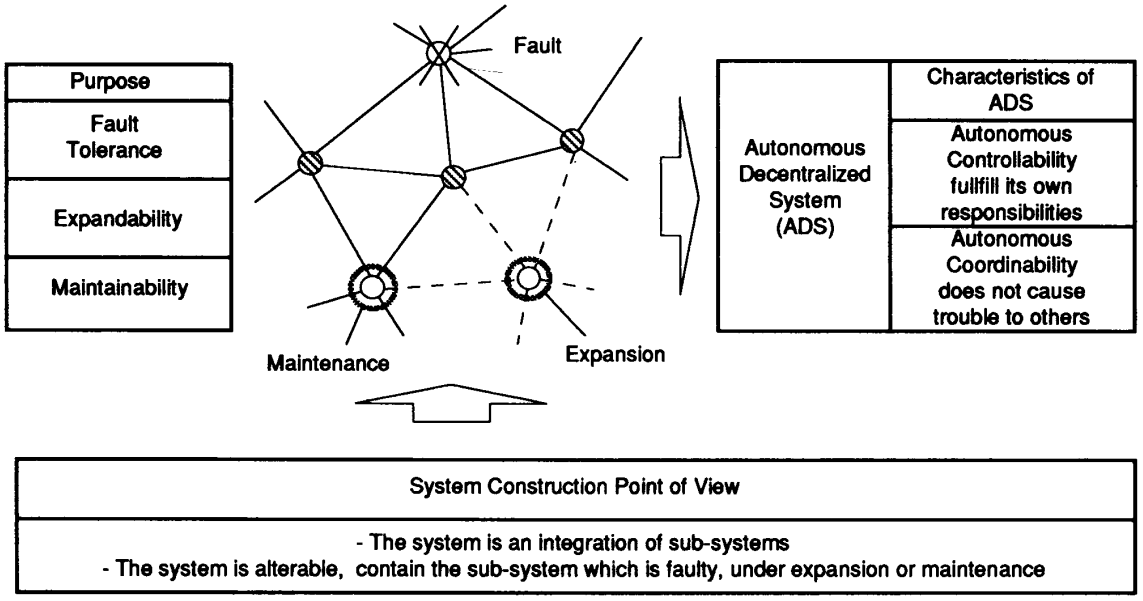


Figure 1 . The Concept of Autonomous Decentralized System

Fig.2 shows the logical system architecture which constitutes the autonomous decentralized system. Physically, each autonomous subsystem is called atom. The atom is connected to the field (called Data Field) where data is circulated. Each atom independently judges what data in the data field to accept and how to process them. Moreover, each atom broadcasts every processed resulting data into the data field without knowing which module to receive or how to process.

Data consists of content code (called function code) and data itself. The function code specifies the contents of the data, rather than by using an address which designates the receiving stations and other such devices.

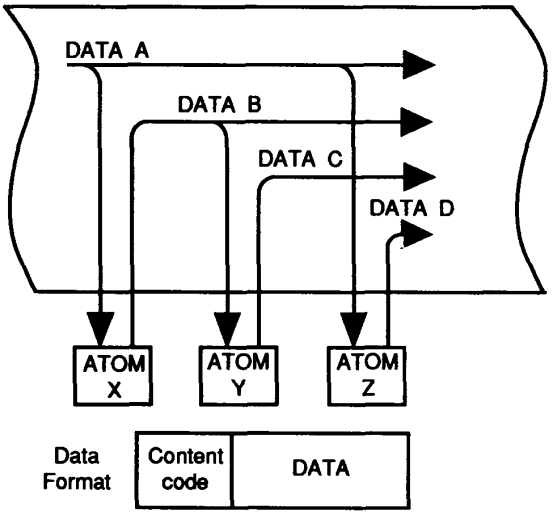
In this way, all atoms have an interface with the data field only, and it will start executing an asynchronous parallel process as soon as it gathers all necessary data.

As each atom independently acts without having a fixed place in the data field, it will immediately operate in any moment that it is accessed. The autonomous decentralized system operates according that every atom controls itself and coordinates with the others without having global information about the entire system or other conditions of atom but having only the data in the data field and local information about the function code necessary for the module in the atom itself. In order to make the logical structure possible hardware and autonomous decentralized OS were developed.

In more detail, the multiple computers corresponding to atoms are connected to the network corresponding to data field. The autonomous decentralized OS supports the function code

communication on the network and actuates the process in the computer when all the necessary data are gathered.

A practical example of autonomous decentralized system is presented as follows.



Each Atom collects the necessary DATA, execute and return the results to the Data Field.

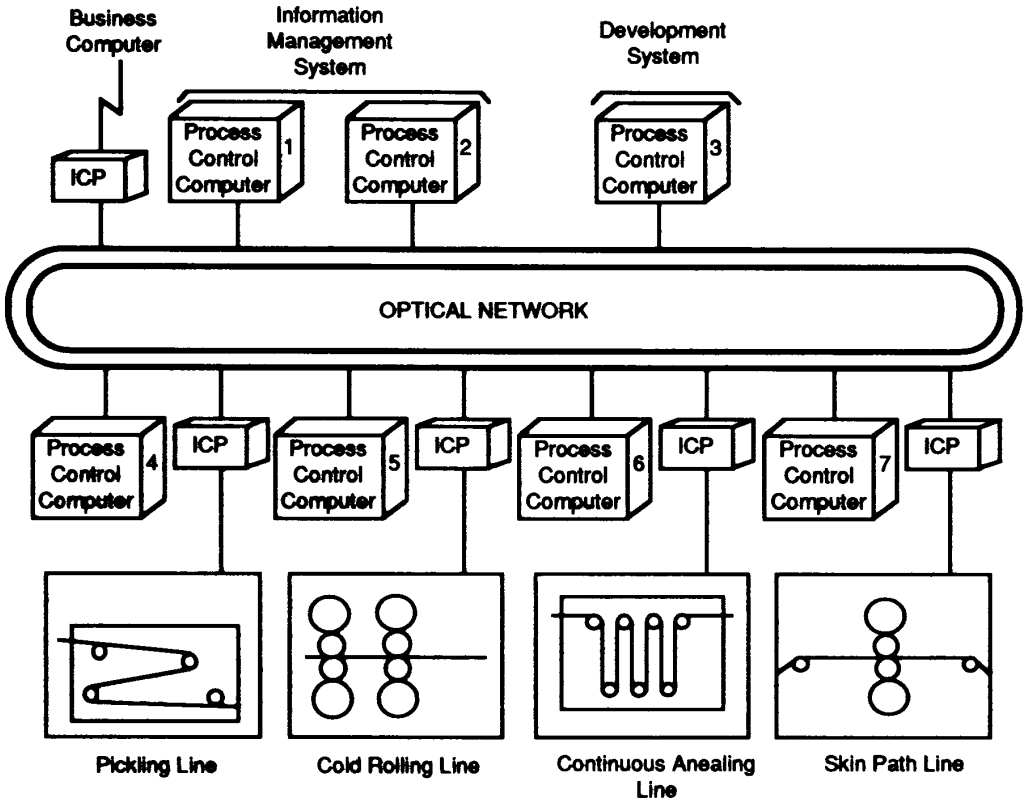
Figure 2. The Logical Structure of Autonomous Decentralized System

3.Application to the field of steel plant control

The organizational system chart in fig.3 shows a typical example of the latest steel system. Namely, in a steel system, the network is introduced at an early stage. Several computers are arranged separately and, in large field, information and control processing of production facilities are carried out. In the system described in fig.3, production instructions are given to each of the production facilities based on a business computer production plan which will be used by the production management. And at the same time it reports actual result of production to the business computer. Therefore, in a central computer room, there is a total management process computer that easily performs information exchange between the business computer and the satellite computer. Important programs are handled by these two computers in order not to have any hindrance on the operation in case of any trouble in either computer. It also gives high reliability to the system. A direct interface with the facilities is done by the ICP (Input/output Control Processor). ICP is a computer that deals specially with I/O. It accepts I/O interfacing by function code without using commands toward I/O directly from the application program. The example in fig.3 shows that the satellite computer copes with each facility such as, cold rolling mill, continuous anealing line and skin path line. Adding a new function to the satellite computer, it will process the expanded facility by connecting the satellite computer to the network. Moreover, in the central computer room, the system has a development computer, and all application programs or parts of application program are available for test. At this time, the input message used for online control which is the same message as used by the satellite computer, is sent to the network that fullfill the conditions required by the data field. Therefore, the test program can be run on the development computer under the same situation as the online satellite computer. This is called online parallel run test. In this way, when a test for software expansion or maintenance is executed in advance, it becomes possible to have an enormous reduction of expansion and maintenance works of the system. It occurs due to the fact that the online data test is available without stopping the control operation. On the other hand while the parallel run test is not carried out, it is possible to load the same system as the satellite computer in the development computer. Based on it, when the satellite computer goes down, the development computer takes responsibility to the corresponding task. This improves the reliability of the total system. The features of the system which applied autonomous decentralized system to the real process are as follows :

3.1. Features of the system

(1) Reliability : The autonomous decentralized system has a high reliability. It is comprised of independent subsystem functions and its structure prevents all the other parts from the influence of partial functional



ICP : Input/output Control Processor
The upper part of the diagram corresponds to the central computers and the lower part of the diagram corresponds to the satellite computers.

Figure 3 . Steel Production Process Control System

hindrance. Also, by adding the most important functions into the backup computer and connecting it to the data field, allows for an easier system of high reliability.

(2) **Expandability** : As fig.3 shows, expansion is easily accomplished by adding satellite computer to the same network according to the expansion of the facility. The conventional system found some difficulties in expansion work because parts as common memory among computers or multi access control mechanism were adopted between the computers.

(3) **Developability** : Features of the autonomous decentralized system in software development are different from the intensive method of the conventional system, but the clear definition of input and output data in each of the function module and the design phase proceeds self-conclusively. In general, as the developed program gets bigger, the time and complexity of its production also increases rapidly. Some efforts have been made to reduce the complexity, for example, dividing the program into several small programs (Modules). However, the efficiency of the production increases according to the independency of each module. The data flow of function module is more independent than the module division of subroutine call. Therefore, productivity is improved.

(4) Maintainability : In this autonomous decentralized system, all information is broadcasted to all computers. These allows online parallel run test without special handling in the development computer. The actual effects are described as follows :

a) Registering the programs to be tested into the software development computer, allow an easy testing by the online parallel run test function.

b) When the memory margin becomes too small in a conventional computer, a memory must be added. However, in the autonomous decentralized system, it is very easy to transfer programs to other computer which has an available spare memory space at that particular moment.

c) Interfacing in the whole system is accomplished by the function code method. This makes it easier to gather all information by the development computer and also to analyze any troubles.

Applying autonomous decentralized system to the steel plant control system, improves expandability, developability and maintainability.

4.Conclusion

As the autonomous decentralized system is comprised of subsystems which have autonomy in each, even if, a part of the system fails or an extension and/or maintainance is being done, the other parts will continue to work, making it possible to have fault tolerance, online expandability and online maintainability.

Applying this system to the steel production process control system, it was possible to attain software and hardware fault tolerance of the aimed architecture.

Furthermore, as the system including both software and hardware is being constructed by building blocks, it becomes possible to have more dynamic and flexible system of fault tolerant nature.

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