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제조 시스템과 제어기 사이의 통신알고리즘 구현에 관한 연구

(Implementation of a Communication Algorithm between Actuator Controller and Manufacturing System)

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요 약

자동화 시스템은 RS232C에 의해 제어부와 GUI 시스템사이의 통신을 이용한다. 제업부는 실린더, 모터, 센서등과 같은 장치의 처리를 담당하며, GUI 시스템은 구동부로부터 직접 통신 방식이나 RS232C에 의해 신호를 받으며, 자동화 설비의 모든 상황의 분석 데이터를 사용자에게 제시한다. 이때 RS232C를 이용한 통신방식은 매우 중요하다. 이는 비용절감을 할 수 있으며 매우 단순한 구조를 가지므로 안정된 통신상태의 유지를 위한 유지보수가 쉽다. 반면 이러한 방법은 고속의 통신에서는 데이터나 신호의 손실을 가져올 수 있다. 따라서 데이터이 손실 없는 통신 프로세스의 제공은 매우 필요하다. 본 연구에서는 이를 위한 통신 알고리즘을 제시하였으며, 제어부와 자동화 시스템 사이의 RS232C를 이용한 송수신 상황에서 데이터의 손실을 막는 통신 처리를 구현하였다.

Abstract

The manufacturing system was used to communicate between controller and GUI system by RS232C. The controller is deal with processing the equipments such as cylinders, motors, sensors, and so on. The GUI system received the signal from actuator controller by direct communication ways, RS232C, and presented the data to user to analyze the all of status for manufacturing system. In this point, it is important that communication use the RS232C. The way is helpful to be able to reduce cost, have simple structure, and easily maintain the stable communication status. Otherwise, the way has some problem to loss signal or data under the high speed communication. So it needs to complement the communication process to without loss data. In this research, we made the communication algorithm and implement the process to reduce losing data when it send or receive the signal using RS232C between controller and manufacturing system.

Keywords : Manufacturing system, Communication algorithm, Buffer processing, GUI system

Ⅰ. Introduction

The manufacturing system technique, as an illustration of the concept of performance gap, is expected to provide company with the enhancement of efficiency in labor utilization, machine operation, working environment and production management[1]. The engineering technique for manufacturing system is defined as the integrated concept of producing technique of the various mechanical components and their operating mechanism, designing of the optimal production process and the technique of using those machines and the information-oriented technique of the productivity improvements by maximizing the efficiency of the mechanical components and the process components. The purpose of widely imported

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manufacturing system is the modularization of the system components and the standardization of the modular set and their infra-structure. When the system of special purpose is developed, it could be practically composed from the standard set of the system components and the users could select and combine the system components from the set, too[2~3]. Accordingly, each module and the mutual data exchange among the system components are the most important matters in the production of the manufacturing system's machinery and its efficiency. Data cannot be processed without the data interchange among the manufacturing systems. Even after the data exchange initiates the manufacturing system, the error which occurs during the data exchange can terminated the operation at any time, which means a great economic loss in the process of the manufacturing system. Manufacturing system's design technique should be based and stabilized on the integration of proper software, hardware, communication protocol and the user interface in order to perform the static data analysis as well as the dynamic data analysis. Manufacturing system's design technique should be based and stabilized on the integration of proper software, hardware, communication protocol and the user interface in order to perform the static data analysis as well as the dynamic data analysis. Moreover, it is necessary to understand the status of the manufacturing system and reflect it in production planning[4].

In this paper, we propose the implementation of the communication algorithm without losing communication data under the high speed transformation using RS232C. It also is possible to check and analyze direct communication status between GUI system and controller in manufacturing system.

Ⅱ. Manufacturing System

1. Environment of Manufacturing System

Manufacturing system has been developed on the purpose of productivity enhancement and quality improvements since the Industrial Revolution. The system has brought the usage of all kinds of machines and actuator control instead of human labors. It means the systemization of the production process which utilizes the electronic sequence, micro processor and the manufacturing system's machine controlled by the computer in order to achieve the productivity and the flexibility. It contains the work necessary to select the proper tasks to be automated, and to choose the necessary components to execute them. It contains the various control technique as well as the connection technique among the necessary mechanical components which need to perform the proper job to be automated, compose the required components cooperatively and operate them interactively. The manufacturing system's machine could be composed of the two parts, the mechanical part which actuates the manufacturing system's machine and the control system part. It illustrated the general configuration of the manufacturing system in Fig. 1. In the figure, there are two parts, GUI system and direct communication, for control and operate the manufacture system. Between these parts, it is used RS232C generally cause of reducing direct communication cost and improving communication effect. The data communication between the two parts becomes the critical component of the overall

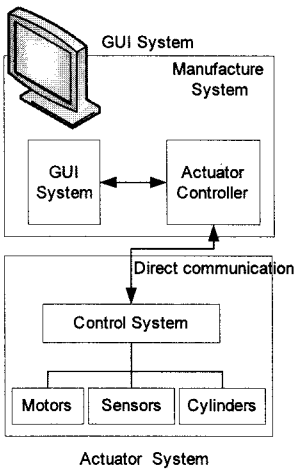

그림 1. 자동화 시스템의 일반적 구성
Fig. 1. General configuration of manufacturing system.

operation because the system cannot work normally when the error occurs in either one of the two systems.

2. Communication Network of the Manufacturing System

The manufacturing system's communication network has the following properties. First of all, industrial network can be operated in the inferior (poor) environment. Secondly it should support the necessary communication facilities and their performances in order to control and supervise the actual process. Moreover, the part which connects the communication network is the computer program with various industrial machines, not human. The industrial communication network aims to connect directly to the devices which control and supervise the manufacturing process. The tasks which are executed in the PLC(Programmable Logic Controller) in the industry computer may have some time constraints in the starting or terminating points. It can cause some disability over the operation of the system and the function of the various devices[5~6]. This kind of disabilities can be caused from the loss of the data from the difference between the data processing time and the communication time in the interface of the control system. The error state which occurs during the operation can be divided into two categories, one that can achieve the original purpose without terminating the operation and the other that requires the complete termination of the operation[7~9]. Both are critical to the operation of the manufacturing system facilities. The communication technique which are used in the industrial communication devices are Parallel Digital I/O Interface, IEEE-488 GPIB(General Purpose Interface Bus) Interface and Serial Communication Interface(RS232C). The serial interface is economic because it uses the internal slot, requires no additional board and can be easily implemented using the software to consider the necessary factors like the board rate (borate)[10]. The GUI systems based on the PC are widely used in the Industrial Manufacturing system because of the low cost, reliability and the feasibility of the maintenance[11]. The Actuator systems have used the Graphic Panel based on the GUI system and Real-time operating system. Gradually both systems are in the process of being merged into one system using the single PC. The data exchanges among the systems are essential no matter which system architecture to be built and the data processing technique is a very important part for the stability of system design.

III. A Model of Interface for Communication

The GUI system process very important works as gathering information of the manufacturing system's operation to support it to user and controlling the manufacturing system by user. The system has two parts, send and receive. Additionally, we needs initial part and buffer process to interact command signal without losing data. The system interface processes the received data at the point of the data retrieval time. The operational data from the actuator control system transferred to the GUI to be inserted into the Windows receive queue are processed by the timer or the message interrupt method after the retrieval of the data. If the received data retrieving part is combined with the processing part, the received data retrieval can be delayed because of the processing time of the formerly received data and it can cause the loss of the received data. In order to prevent the loss of the received data, it can be confirmed on the GUI system whether the transferred data has been received. This method can prevent the loss of the data, but the overhead between the sending and responding can reduce the efficiency of Factory Automation Machinery. The class diagram of the conventional received and sends data processing technique is shown in Fig. 2. In the initial part, user could set the initial command data for preparing communication. The communication part is main process that has send and receive parts. The send

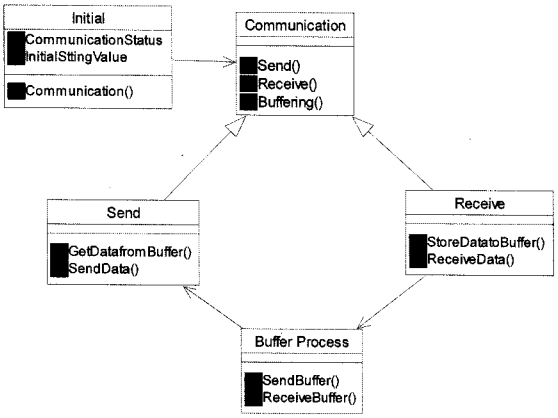

그림 2. 통신 프로세스의 클래스 다이어그램
Fig. 2. The class diagram of communication process.

part is deal with transform the operation data to actuator system. The receive part is able to get data or signal from the actuator system. Through the data we can analyze the all information of manufacturing system, what is the problem and happen the error in the system, or where is the point which the manufacturing system has problem or how many productions is in the system. And we designed the buffer process to handling data efficiently in send and receive process.

In order to prevent the loss of data where the data receiving part is combined with the processing part we propose the technique of dividing it into two processes and inserting the circle wait array between them. When the data transferring message arrives, the data receiving part inputs the received data into the right position of the circle wait array, increases the receiving pointer which indicates the right position and terminates the receive process. Data processing part retrieves periodically the process pointer which indicates the current data processing point of the circle wait array and the receiving pointer. When the values of the two pointers are identical, the data receiving process has not occurred since the last one. Otherwise, the data has arrived to be processed. Even when the received data take time to be processed, the loss of the data to be processed can be prevented since they are safely inserted into the circle wait array.

IV. A Model of Interface for Communication

The GUI system proposed in this paper could be used under Windows XP environment and coded with Visual C++. Window Create message (WM_CREATE), Receive message (WM_COMMNOTIFY) and Timer message (WM_TIMER) has been used for the implementation. First of all, the initial setup for the communication port has been required as the followings.

```
Class Initial
Algorithm Main()
  Input UserStartSignal
Begin
  Call OpenComm(communication port, receive buffer
       size, send buffer size)
  if(communication port opens successively) {
    Select the communication port by communication
    setup value;
   }
  After communication port has been selected, the
  GUI system uses Message Interrupt Method to set
  up the data initiation part;
  In the WM_CREAT, Call EnableCommNotification
       (communication ID, buffer-size)
  Call SetTimerStart(timerParameter)
  Register wmCommunication
  Call main()
  Return CommunicationStatus
End

Algorithm SetTimerStart ()
  Input timerParameter
Begin
  SetTimer(timerParameter)
  WTimer()
  Return true
End

Algorithm WTimer()
  Input timerParameter
```

```
Begin
  if(value of data receiving pointer = value of data
        processing pointer) {
  function call for the received data processing
  Increases the pointer value of circle wait array by
   the processed data length
   }
End
```

Data processing part initiates the timer as described in the following to use the GUI process for the first time. And the timer message calling part (WM_TIMER) retrieves the received data, processes them and terminates the operation of the data processing part.

The communication contains the data receive part which actually receives the message in the following. It inputs the received data through the communication port into the circle wait array. In order to retrieve the received data in the data processing part it increases the data receiving pointer by the length of the received data and terminates the task of the data receiving part to be ready for the next data arrival.

```
Class Communication
Algorithm Main()
Begin
   Call Send()
   Call Receive()
   Call Buffering()
End

Algorithm Send()
Input SendUserCommand
Output Boolean Sendresult
Begin
   Call GetDatafromBuffer()
   Analyze the Data from Buffer;
   If Data α∈ A then α = SetupCommand
   Else Data α = ControlCommand
   Inhere A = {Set of SetupCommand for initial
        manufacture } and B = {Set of
        ControlCommand to control manufacture }
   Sendresult = Call GetDatafromBuffer(Data α)
   If Sendresult = false then repeat all process
End

Algorithm Receive()
Output ReceiveData , Boolean Receiveresult
Begin
   ReceiveData = Call ReceiveData()
   Get Current buffer-input-pointer from the buffer
        process
   Receiveresult = Call StoreDataBuffer(Receive -
        Data)
   Check the buffer-input-pointer and the
        buffer-output-pointer
   If Receiveresult = false then repeat all process
End

Algorithm BufferProcess()
Begin
  Call SendBuffer()
  Call ReceiveBuffer()
  Check the buffer-input-pointer and
        the buffer-output-pointer
  if it request data from the receivebuffer then
        increase the buffer-output-pointer
        get data from the buffer
  if it request to store data to the receivebuffer then
        increase the buffer-input-pointer
        store data to the buffer
  Check the buffer-input-pointer and the
        buffer-output-pointer
End

Class wmCommunication
Algorithm Commnotify()
  Output ReceiveDataFlag
Begin
  /* actual receiving task processed */
    if(data receiving message appeared) {
      Inputs the received data into the circle wait
```

```
        array.
        Increases the data receiving pointer by the
          length of the received data.
        }
    Return ReceiveDataFlag
End
```

After the processing of the data receiving part described above has been terminated, it calls the WM_COMMNOTIFY on the GUI whenever the receiving data has been arrived from the communication network.

In this application result, we can get data as shown in Fig. 3.

For this result, we prepared 40 data and tested it under exist method and proposal method by 30 time each per 100ms.

In this section, existing method means to process without buffer process. That is, we could know proposal method needs more time than existing one cause of buffering process in buffer. But proposal method has no losing data during the direct communication process as shown in Fig. 4. In this result, the more data increase, send part of exist method has losing data. That situation is same to receive part. But proposal method include send and receive part has no losing data even though it needs more processing time.

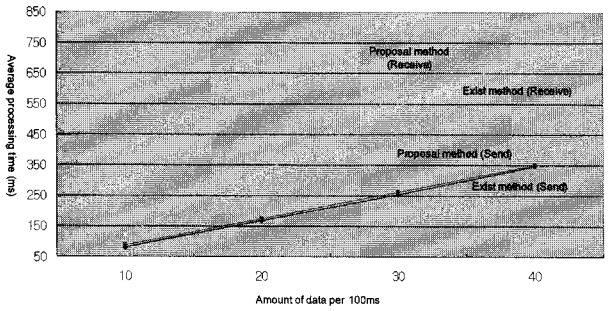

그림 3. 30회 테스트에 의한 평균 처리시간
Fig. 3. The average processing time by testing 30 times.

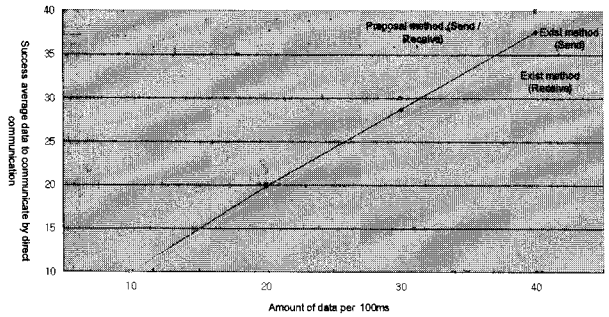

그림 4. 30회 테스트에 의한 평균 성공 데이터
Fig. 4. The average success data by testing 30 times.

V. Conclusions

The stability becomes very important issue for the interface method between the actuator systems which control the industrial manufacturing system and the GUI systems which provide the data output and the operational information. The loss of data in the manufacturing system in the real industrial field can cause critical damage to the production line as well as the termination of the operation of the manufacturing system in the worst case. That means the damage can drastically harm the productivity enhancement and efficiency improvement which the manufacturing system has been expected to bring in the first place.

Therefore, we propose the improved data processing technique to prevent the loss of data by dividing the conventional data processing part into two - the data receiving part and the data processing part. By separating the data receiving part from the data processing part the received data can be managed efficiently and the chance of error occurrence during the data transfer can be reduced. The operation of the manufacturing system had been terminated by the loss of the operational data by the conventional method. The communication emulator has been used for the communication data retrieval with the proposed technique. We have observed some data delay on the GUI system because of the received data which required a lot of time to process, but there had not been a un-processed data caused by the loss of data. Consequently, we have applied the technique to the Handler of the Semiconductor Manufacturing Machine System which Sam Sung

Semiconductor Company and UTC(Co) in Taiwanarecurrentlyusing.

The proposed method can provide the better stability-oriented base when the interface technique is combined with the real-time processing technique where the integrated production system is to be automated with the computer.

참 고 문 헌

[1] R. H. Hayes and S. C. Wheelwright, "Restoring Our Competitive Edge: Competing through Manufacturing," New York : John Wiley & Sons, 1984.

[2] P. M. Noker, "CNC's Fast Moves," Manufacturing Engineering, 1995, 5.

[3] J. V. Owen, "Open Up Control Architecture," Manufacturing Engineering, 1995.

[4] Kazuhiro Kusunki, Isao Imai, Tomonori Negi, Nori Matsuda, and Kazuo Ushijima, "Proposal and Evaluation of a Method of Remote Access to FA Controllers via the Internet", Electronics and Communications in Japan, Part 1, Vol. 85, No. 6, 2002.

[5] http://www.industry.net

[6] http://islsun20.snu.ac.kr/technology/rain.html

[7] D. A. Handelman and R. F. Stengel, "Combining Expert System and Analytical Redundancy Concept for Fault-tolerant Flight Control," Journal of Guidance, Control, and Dynamics, vol 12, 1989.

[8] J. J. Gertler and K. C. Anderson, "An Evidential Reasoning Extension to Quantitative Model-based Failure Diagnosis," IEEE Transaction on System, Man and Cybernatics, vol 22, 1992.

[9] R, J, Patton and J. Chen, "Review of Parity Space of Approaches to Fault Diagnosis for Aerospace Systems," Journal of Guidance, Control, and Dynamics, vol 17, 1994.

[10] Michael F. Hordeski, "Control System Interfaces / Design and Implementation using Personal Computers," Prentice Hall, 1992.

[11] Kevin Borthwick, Pardip Thind, and Philip Fransen, "PC-Based Operator Interface," IEEE Industry Application, 4(4), July/August 1998.

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