LonWorks/IP Web Server-based Virtual Device Network Management System for Predictive Maintenance

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1. Introduction

Recent trends require that access to the device/equipment information be provided from several locations or anywhere in the enterprise. One example is virtual machine/manufacturing system (VMS), which utilizes VDN[1]. In this configuration, predictive maintenance can be performed both on factory floor and in remote site through internet[2]. VMS inevitably involves the implementation of Distributed Monitoring and Control Networks (DMCN). DMCN are generally equipped with smart sensors, controllers, and other CPUs which provide very useful information if utilized properly[3].

Requirements for monitoring and control networks are different in many aspects from those of data networks[4]. Sending small packets over IP, for example, will decrease the efficiency of the IP network in terms of actual application data throughput as a proportion of overall network bandwidth. IP is, therefore, ill suited for control networks and a gateway approach needs to be implemented to leverage the advantages of both control networks and data networks. Gateways can be used to provide data access to control networks from other than fieldbus protocol.

The objective of this study is to suggest a basic framework for VDN Management System using LonWorks/IP web server (L/IP web server) to better perform predictive and preventive maintenance in a VMS environment.

2. Management of Virtual device NETWORK (VDN)

2.1 Implementation of VDN

By integrating device network with IP network, the Internet can be used for distributed control of a remote system. By connecting device network into IP, multiple sites can be simply integrated into a seamless "Virtual Device Network" (VDN)[2]. The VDN includes one or more remote sites connected with one or more monitoring/control applications located on the Internet. The general architecture of a VDN is shown in Fig. 1. The key concept to this architecture is the peer-to-peer communication, from device 2 to device 5, for example. It is also possible to monitor and control the peer devices on a remote site (client PC) through the LonWorks/IP web server (dotted line in Fig. 1

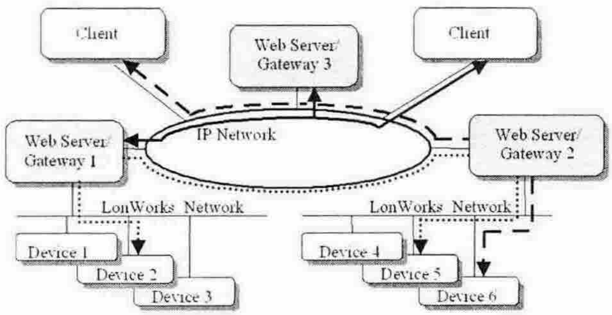

Fig.1VDN realized in distributed server-client environment using LonWorks/IP Gateway/Web server.

2.2VDNManagementSystem

A LonWorks Network Server (LNS) application program in the remote client PC interacts with the Microsoft's embedded Windows OS (Operating System) installed in the LonWorks/IP web server through data networks. This LNS application program was developed using a LNS application program development tool from Echelon Corporation. The LNS application program enables an exchangeof data/information between the individual devices within the network and manages virtual device networks in operation. Using this application utility, one can monitor and control an individual "peer"device on a remote place. The LonWorks/IP web server, which connects the data networks to the device networks, is required in order to manage virtual device networks in this fashion[5)].

2.3LonWorks/IProutingbypeertopeernetworkvariablebinding

VDN is constructed by several local device networks connected to the data network through the LonWorks/IP web server. LonWorks network devices comprise a local LonWorks network along with a LonWorks/IP web server which is a member of the data network. A LonWorks/IP web server offers the information of the network variables of the local LonWorks network devices. An authorized user or a VDN manager can access a local LonWorks network through a LonWorks/IP web server and connect it to the other LonWorks/IP web server in the network[5)].

Each device in a LonWorks network is called a node. Different nodes can communicate with each other by means of network variables. A network variable can be propagated on the network and received by other nodes. Two types of network variables, i.e., input variables and output variables are used. These variables can be bound to each other, allowing output variables to be propagated to the input variables. Fig.2 shows how an input network variable is bound to an output network variable in other node.

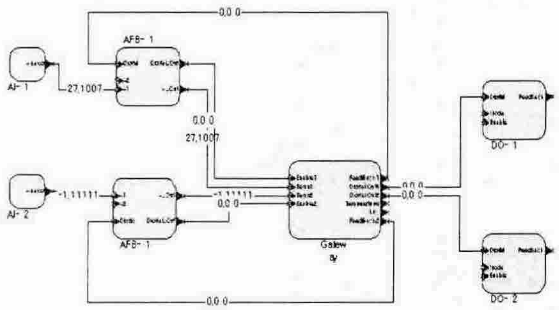

Fig.2 Network variable binding of the LonWorks network devices used for one-to-one communication.

Fig.3 shows the web page for peer to peer network variable binding through a LonWorks/IP web server. In general, LNS application software is needed to bind the network variables among different networks. The suggested method, however, gives a simple and useful peer to peer routing for small scale remote monitoring and control applications. Furthermore, the routing using LNS needs a centralized management of the network data base on the server, which is less user-oriented. On the other hand, the proposed routing method enables use of distributed network information storage, and is more user-oriented. In this case, the local device network still needs to be configured with LNS in advance.

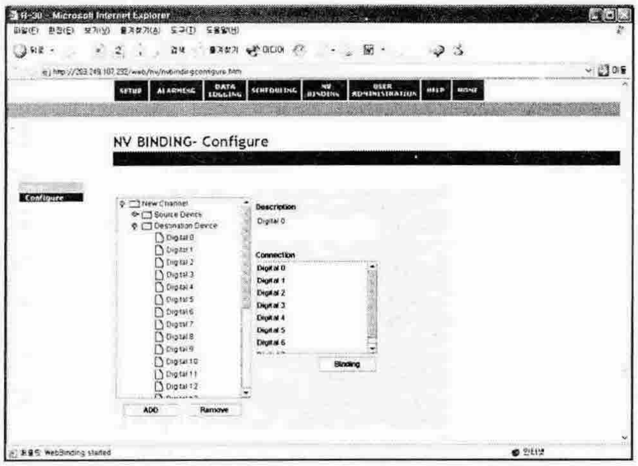

Fig.3 Peer to peer network variable binding on a LonWorks/IP web server supplied web page.

2.4Security Issues

LonWorks/IP data transmission is performed by the tunneling technique which is the core part of EIA/CEA-852 standard established by CISCO and Echelon. Fig. 4 depicts a security check logic described in EIA/ LonWorks/IP tunneling standard. A tunneling technique encodes the communication packet of LonWorks including address information device networks as well as the network variable binding information into the data packet of an IP protocol. Data (LonWorks packet) and the 128 bit secrete word are then encoded using MD 5 algorithm to construct an IP packet. This packet is transmitted to the receiving L/IP web server where the decoding process is performed. The receiving LonWorks/IP web server first encodes the transmitted data with its own 128 bitssecrete word to check if the packet is from the authorized web server. Once the security check is passed, it transmits the LonWorks data to the destination device on the lower device network according to the NV binding information it received. AnL/IP web server on virtual device networks becomes a connection pass, which can transmit and receive the data/information of device networks safely in this method.

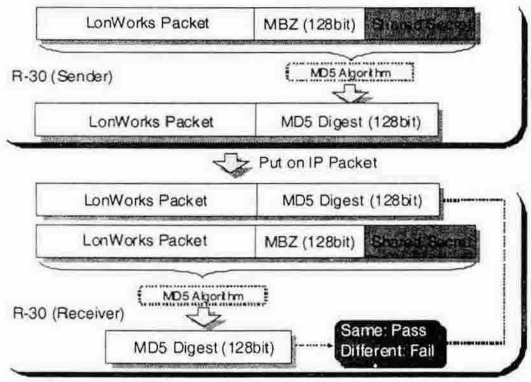

Fig.4 MD 5 authentication as specified by EIA/CEA 852 LonWorks/IP tunneling standard.

3.PREDICTIVEMAINTENANCEUsingLonWorks/IPWebServer

Equipment utilization measures the fraction of total operating time in an observation period, hence the overall effectiveness of equipment[2)]. Factors that affect the equipment utilization include time lost due to breakdown and setup adjustment losses. A key factor in calculating a reliable equipment utilization time is to perform a proper process parameter logging. The monitoring node in this case is a digital input node, as shown in Fig.5. If this device has no real-time clock in it, any change of state sensed by the sensor has to be propagated in the LonWorks network to the web server or further to the client over IP network for data logging.

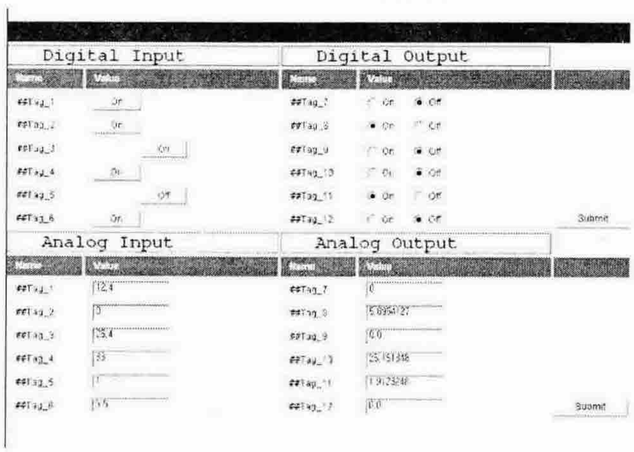

Fig.5 Web browser screen to monitor digital I/O data. This page was written in Java applet.

4. Experiments

Fig.6 shows that the experimental set up of the DCS on VDN where VDWorks'Distributed Control Modules (LonWorks devices) DI-20, AI-20, AO-20 and IS-30 LonWorks/IP Web Server were used. DC servo motor system by ED engineering was used as the plant.

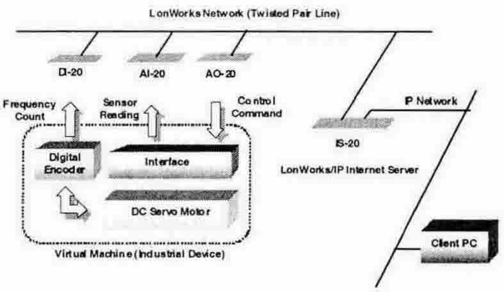

Fig.6 The experimental set up of the DCS on VDN

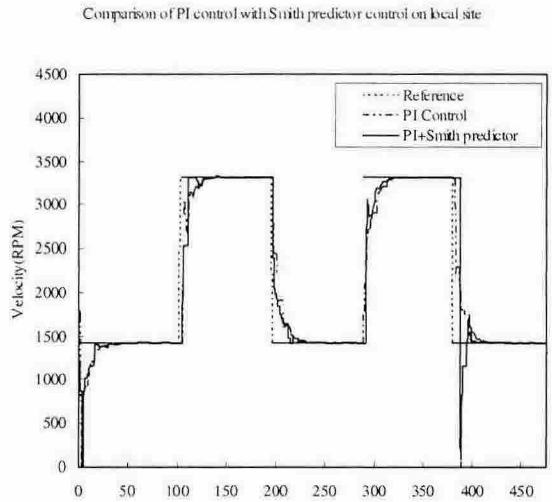

Fig.7 Comparison of PI control with Smith predictor-based control for step reference input on local site.

Fig.7 show the results of both PI control and PI+Smith's Predictor-based control on step reference tracking application[9]. In the figures, the performance of LonWorks/IP Web Server is shown to be acceptable in terms of the time delay involved in the network transmission.

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