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Real-time Performance of Measurement and Control System Based on Network Environment in Automation Technology

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Abstract

With the development of society and the advancement of science and technology, automation technology has also been widely used. In computer communication and control, automation technology is widely used. Among them, automation technology is widely used in measurement and control systems. However, whether the measurement and control system based on the network environment in the automation technology is real-time is a hot issue for many scholars. The research purpose of this paper is to study the real-time performance of network-based measurement and control system in automation technology. This paper uses EFPS model to study the distributed measurement and control system based on network environment. Through simulation experiments, the real-time performance of distributed measurement and control system based on network environment is studied. This article analyzes the entire simulation experiment and finds that from the average delay curve of control-net-scenario 4 (a distributed measurement and control network based on SUNA), it can be seen that the delay is between 5ms and 6ms; while control-net-scenario 1 (based on exchange the average service delay curve of distributed Ethernet based on distributed Ethernet) is between 7.5ms and 10ms; the average service delay curve of control-net-scenario 2 (distributed measurement and control network based on bus type Ethernet) is about 10ms.

Keywords: *Automation Technology, Network Environment, Monitoring System, Real-Time;*

1. Introduction

With the continuous development of computer applications towards high-performance, networked, embedded, and intelligent directions, the demand for time-constrained application systems has become increasingly prominent, such as complex industrial control, media players, bank ATMs, etc. All have varying degrees of real-time requirements [1-2]. Specifically, for a vibration monitoring system, the detection cycle of the vibration waveform must meet the requirements of the sampling theorem; daily use of the computer, when typing the keyboard, also requires the keyboard input results to appear quickly on the display. Measurement is the information acquisition technology and the source of information technology; Control is the information utilization technology to implement the transformation of the state of the system [3-4]. Measurement and control are often conditions, influence each other, and penetrate each other. The two constitute a closed-loop feedback process, and the two technologies are organically combined to form a measurement and control system. With the rapid development of modern science and technology, especially the rapid development of computer network technology, distributed measurement and control systems interconnected by networks have become more widely used, and their complexity has also increased. This has brought great challenges to system construction and analysis. Difficulties have seriously affected the performance and application of measurement and control systems [5-6].

The centralized computer automatic measurement and control system uses a standard bus as the interconnecting bus between the computer and the measurement and control instruments or measurement and control modules in the system. Among the various standard buses, the two bus standards are VXI and GPIB. VXI is a parallel internal bus, the communication distance is limited to within 1 meter, various measurement and control function modules in the system are concentrated in one chassis; GPIB is a parallel external bus, the communication distance is usually limited to within 20 meters, and various instruments for measurement and control functions are also concentrated in a cabinet or laboratory [7-8]. In practical engineering measurement and control applications, the various types of information to be collected are geographically dispersed, resulting in scattered measurement and control nodes. It is common for each measurement and control node to be more than ten meters, tens of meters, hundreds of meters, or even thousands of meters apart. At this time, if a large number of field signals of scattered measurement and control nodes are transmitted over a long distance and concentrated into a VXI or GPIB system, not only must a large number of special cables be laid, which causes a huge increase in installation costs, but the weak analog signals are most in the transmission process. It is susceptible to field interference and greatly reduces the quality of measurement and control [9-10]. Therefore, it is very necessary to build a networked distributed measurement and control system. These systems have an objective response time requirement, which is a real-time problem that is common in the system. Computer network technology has brought profound changes to the architecture of the automatic measurement and control system. The concept of "network is an instrument" was proposed. Through network communication technology, the basic components in the measurement and control system on the computer platform are distributed to various adaptive places according to the needs of the application. It promoted the change of measurement and control system from regional centralized type to regional distributed type [11-12]. Therefore, the measurement and control system will follow open system standards, with computers as the core, software and hardware technologies as the basis, and network communication technologies as the support.At the same time, with new computing such as pervasive computing, grid computing, and mobile computing,with the emergence of models, the real-time research of measurement and control system based on network environment in automation technology is very necessary.

Embedded system real-time measurement and representation methods are widely used in industrial CPS control systems, such as engine fault diagnosis. The fault diagnosis method filters the change of

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measurable parameters by Kalman filtering, and then maps it to the change of engine performance parameters by neural network. The disadvantages are that the neural network has a slow convergence speed and the local optimization is easy to occur. Therefore, WANG Wei once proposed a method for BP neural network optimization using genetic algorithms. This method uses a global optimization method to optimize the initial value and threshold of the neural network, reduces the number of neural network training times, thereby reducing training errors, and reducing diagnostic time. Simulation results show that the method is feasible, improves the real-time performance and error accuracy of fault diagnosis, and has high application value [13-14]. The power lithium battery assembly production line uses a CAN bus-based distributed control system and is divided into two levels, namely the station control layer (lower computer) and the production line management control layer (IPC). Each station is connected to the CAN bus as a network node. In such a multi-node, high-load system, the standard CAN communication protocol can only guarantee the real-time transmission of high-priority information in the network. The real-time performance of low-priority information will decrease as the load increases. Failure will result in an indefinite delay in the transmission of low-priority information, and even the inability to send messages, resulting in packet loss and station cards, resulting in abnormal assembly. On this basis, PAN Tianliang has proposed a hybrid scheduling algorithm with a layered structure. The DMS algorithm and the EDF algorithm are combined in the index partition to ensure the real-time performance of the system and not only improve the bandwidth utilization of the system, and improve the real-time performance of the system [15-16]. ZHOU Zhiguo once solved the problem of remote measurement and control of the launch vehicle. On the basis of analyzing the support of the space-based measurement and control system for the measurement and control of the launch vehicle, ZHOU Zhiguo proposed that the Beidou navigation satellite system can realize the real-time measurement and control of the launch vehicle. The composition and mission support capabilities of the satellite system. ZHOU Zhiguo analyzed and applied the Beidou navigation satellite system to support the communication process of space-based measurement and control of the global launch vehicle. For the Beidou global navigation satellite system, three constellation support communication schemes were designed and three groups were proposed. Network constellation to support space-based measurement and control tasks. Finally, ZHOU Zhiguo verified the feasibility of the communication scheme through simulation experiments, which provided a better solution [17-18]. GUO Xin has studied the redundancy and fault tolerance of a measurement and control system based on a compact PCI bus in order to meet the high reliability requirements of real-time measurement and control systems. GUO Xin once proposed a redundant design method that uses heartbeat detection to connect master and backup equipment. High-availability hot-swapping technology based on Vx Works real-time system is adopted to improve the system's redundant fault tolerance. GUO Xin proposed a real-time fault-tolerant scheduling algorithm based on inexact calculation theory. The algorithm is applied to the measurement and control system, and it is verified that the algorithm improves the redundancy fault tolerance performance. The simulation and experimental results of GUO Xin show that the system can meet the requirements of redundancy and fault tolerance. This design method can effectively improve the reliability of the system [19-20].

The research purpose of this paper is to study the real-time nature of network-based measurement and control system in automation technology. This paper first introduces the concept and application of real-time nature, and theoretically explains the EFPS model. The measurement and control system is studied, and the real-time performance of the distributed measurement and control system based on the network environment is studied through simulation experiments. This study found that the average delay curve of control-net-scenario 4 shows that the delay is between 5ms and 6ms; and the average service delay curve of control-net-scenario 1 is between 7.5ms and 10ms; control-net -scenario 2,the average service delay curve is around 10ms.

2.Proposed Method

2.1 Real-Time System

Real-time means that the input, calculation and output of the signal must be completed in a very short time and processed in time according to the changes in the production process. Real-time and fast here are not the same meaning. No matter how fast the processing and network transmission speed is, as long as the response action occurs within the specified response time, the system is said to be real-time. Therefore, real-time refers to the ability to perform specified functions within a limited time and respond to external asynchronous events.

A real-time system refers to a processing system that can respond to a limited time while processing external events or data, and process it quickly enough to send the processing results to the destination in a timely manner. Execution has strict time requirements, and the task must be completed or responded within the prescribed time, otherwise the execution result will be wrong or the system will fail. Specifically, for any stimulus-response system, there is a time from the stimulus input to the response output, that is, the stimulus-response period T, which represents the system's time response capability. If the response time T of the system can meet the requirement of the response time t specified by the system, that is T <= t, then the system is a real-time system.

The real-time system introduces the time feature, which has the following characteristics to distinguish it from other systems: The system's predictability is strong, which is the most important feature of the real-time system. The so-called predictability refers to the operation performed by the system in a predefined or determined manner, and the time for which the operation is performed is predictable; the system response time is strong, and it must be external at a certain time or within a certain time. The environment collects information, accesses the obtained information and processes the collected information in accordance with each other, and responds in a timely manner; the system must process multiple external requests at the same time and provide parallel processing capabilities, which requires good processing capabilities to achieve optimal performance; real-time systems often interact with the external environment, such as controlling machines and production processes, or monitoring chemical reactions and reporting critical situations at any time.This situation usually requires receiving data from the outside and providing output and controlling the external environment. Real-time systems often include real-time control, making control decisions from the input data received; in addition to the above characteristics, real-time systems also have features such as reliability and embeddability. In order to have a deeper understanding of real-time nature, the specific analysis is as follows.

1) Real-time and fast: The real-time of the system refers to whether the response time can meet

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the requirements of T <= t, which is different from the concept of fastness. A fast system may not be able to meet the real-time requirements of the system, and in some cases, the system's running speed is not high when the real-time requirements are met. For example, systems that meet the real-time requirements of temperature acquisition do not run at high speeds, and many high-speed systems may not meet the real-time requirements of signal acquisition of shock vibration. Fastness only reflects the real-time capability of the system.

2) The best real-time performance of the system: Fastness is the performance of the system's real-time capabilities. When the system cannot meet the real-time requirements, the system's operating speed must be increased. However, the increase of operating speed brings some negative effects of the system, such as leading to increased system power consumption and reduced electromagnetic compatibility. Therefore, when designing and optimizing a specific system, under the condition that it can meet the real-time requirements, the operating speed of the system should be minimized to meet the system's best performance in terms of power consumption, reliability, and electromagnetic compatibility. comprehensive quality.

3) Real-time distribution of the system: In the application of a real-time system, there are many process links. For example, a typical smart meter has processes such as signal acquisition, data processing, result display, and keyboard input. These processes are often performed in different time and space, and the real-time requirements of different processes are different. The keyboard input and the result display are interactive with humans, to meet the real-time requirements of human-computer interaction; signal acquisition is closely related to the dynamics of the object system, and must meet the real-time requirements of dynamic signal acquisition; and data processing will formthe time delay between signal acquisition and result display affects the real-time requirement of result display. Therefore, the design and optimization of the real-time system must study each process link in the system to meet the best real-time requirements of each process link and the entire system.

4) Real-time system classification: The real-time system has a limited response time, which makes the system predictable. According to the degree of system response time requirements, real-time systems can be divided into "hard real-time systems" and "soft real-time systems". Tasks in hard real-time systems have strict deadlines, such as process control and flight control systems. For a task in a soft real-time system, the task is completed after the deadline, and still has some value to the system. The difference between the two is that the former will cause catastrophic results if the response time limit is not met, the response is not timely, or the reaction is too early; while the latter will cause system performance degradation when the response time limit is not met, but it will not cause disastrousconsequences. The real-time system has a wide range of applications. According to the characteristics of the response time of different systems, it can be divided into three typical applications: electronic circuit systems, embedded application systems and general application systems. The electronic circuit system is a classic electronic system, which is a pure electronic circuit system without a computer. For example, measuring amplifiers, electronic counters, temperature indicators, etc. This type of system has a very short and relatively constant time period from excitation to response. Most of the real-time performance requirements are far less than the response time performance of electronic circuit systems. Most real-time systems are embedded applications. When

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the embedded application system interacts with the embedded object system, it must meet the response requirements of the event interaction process. On the one hand, due to the embedded computer, the embedded application system has a considerable incentive-response time, which leads to the reduction of the system's real-time capability. On the other hand, different embedded object systems will have different response time requirements. Therefore, in the specific design of the embedded application system, we must consider whether each task in the system can meet the real-time requirements when it is running. This is the real-time problem of the embedded system. Embedded computer systems are widely used in industrial control, consumer, communications, automotive, military and other fields. Real-time computer systems for general use belong to general-purpose computer systems, such as PCs and workstations.Because general-purpose computer systems are only used in a human-computer interaction environment, the response time requirements of the object (person) are only an expected value (as fast as possible), and this desire is expressed on one hand as endless, and on the other hand tolerability of reality. Therefore, the general-purpose computer system is a non-real-time system with low response time requirements, and fastness has become the subject of the development of general-purpose computing systems. Its typical applications, such as measurement and control computers in large-scale control systems, are usually connected to several embedded computers as their upper computer to perform overall control, coordination, and data storage of the system.

2.2 EFPS Model Description

The EFPS model of the distributed measurement and control system is described as follows:

$$DMCS = (NE, F, P, S)(1)$$

In the formula, NE (Node Entity) represents the measurement and control node entity. It is assumed that the system has a relatively independent node entity. which is,

$$NE = \{NE_i | i = 1,2,\ldots,n, n \in N\}(2)$$

(1) where F (Functions) represents the set of action relations between node entities, that is,

$$F = \{F_{ij} | i, j = 1,2\ldots,m, i \neq j, m \in N\}(3)$$

(1) In the formula, P (Protocols) represents the protocol set of DMCS. Protocols are various specifications for communication in distributed measurement and control systems. which is

$$P = \{P_{ij} | i, j = 1,2\ldots,k, i \neq j, k \in N\}(4)$$

Among them, P_{ij} indicates the communication specification between the measurement and control node entity NE_i and the measurement and control node entity NE_j; S (services) indicates the service set provided by the entity, that

$$S_i = \{S_i | i = 1,2,\ldots,q, q \in N\}(5)$$

In an actual networked distributed measurement and control system, the relationship between NE, F, P, and S can be represented graphically in Figure 1.

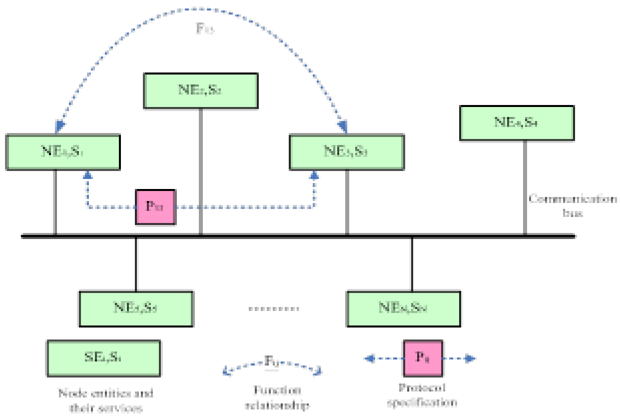

Figure 1. Description of EFPS model of distributed

measurement and control system

It can be known from FIG. 1 that the actual relationship between the nodes and entities in the actual distributed measurement and control system logic is arbitrary, and can be arbitrarily combined according to the needs of the measurement and control task.

2.3 Principles for Determining The Four Elements in The Application of The EFPS Model

As described in this paper, a description model of distributed measurement and control system can be established on the basis of EFPS model, and its description method is basically the same as that of EFPS model, so it will not be repeated here. Here, the model is analyzed in depth, and the determination principles of the four elements (E, F, P, S) in the specific application of the model are given to analyze and design the distributed measurement and control system.

(1) Measurement and control node entity NE.

From the perspective of measurement and control node entities, distributed measurement and control systems also have hardware node entities, abstract node entities, and software node entities, and their determination principles are described separately.

1) Principles of determining hardware node entities:

Exist as a realistic node of distributed measurement and control system;

Has various attributes determined by itself, including its own function body and external interface;

Unique, identified in the system by a unique identifier;

Each hardware node entity does not exist in isolation and is in contact with other nodes.

The set of all hardware node entities in a distributed measurement and control system is recorded as the actual entity set as follows:

$$RealNE = \{NE | NE \in \text{Hardware node entities in distributed measurement and control system}\} \quad (6)$$

2) Abstract node entity determination principle

The abstract node entity is an entity (model) that is abstracted from the hardware node entity and the problem to be solved, and is used to complete a certain behavior (operation, function, etc.) as needed, that is:

Extract some meaningful characteristics from the hardware node entity, and it does not need to exist in reality;

It can be seen as a finite simulation (abstraction) of hardware node entities from a certain problem perspective, so it is also called a problem node entity;

A hardware node entity can abstract multiple abstract node entities from different perspectives. That is, analysis and research can be performed by decomposing the actual hardware node entities into several abstract node entities.

All abstract node entities in a certain scope are recorded as the abstract node entity set as follows:

$$\text{Abstract}NE = \{NE | NE = \text{Real } NE \text{Abstract form in a problem} \quad (7)$$

For example, a pressure transmitter has a differential pressure calculation function and is an entity of a pressure measurement tool; it is also an entity with a communication function that transmits pressure signals to other devices. The same hardware node entity presents different entity forms depending on the perspective of the problem being discussed. Abstraction as several abstract node entities is an effective means for analyzing and synthesizing real hardware node entities. Abstract node entities are relatively independent unit entities that are easy to describe formally. Different hardware node entities may contain the same abstract node entity. For example, a pressure transmitter contains a communication entity, and a PLC also contains a communication entity, which reflects the polymorphism of the entity in software implementation. In addition, the same hardware node entity dependingon the perspective of the discussion, different abstract node entity forms are also presented. For example, a pressure transmitter has a differential pressure calculation function, is a pressure measurement tool entity, and is also an entity with a communication function that transmits pressure signals to other devices. The different functions of each measurement and control device of the distributed measurement and control system are abstract node entities from the hardware node entities. The functions completed by these devices are abstracted into different abstract entities as function executables that are visible to each other on the measurement and control network. Devices from different manufacturers need to hide the implementation methods of their specific functions, but only provide such function execution bodies, and the devices can interoperate.

3) Software node entity determination principle

A software node entity is a program entity that encapsulates data and methods (operations) together. which is:

A software node entity is a program entity generated by simulating an abstract node entity;

An abstract node entity can construct multiple software node entities;

Software node entities are polymorphic and can be changed, created, and deleted;

Software node entities and their child entities can share data and have inheritance.

All software node entities in a problem area in a distributed measurement and control network system are represented as a software node entity set as follows:

$$SoftNE = \{NE | NE = Abstact\text{Software implementation of NE}\} \quad (8)$$

(2) Function relationship between measurement and control node entities F

The relationship between the measurement and control node entities is transmitted through messages. In the distributed measurement and control system, the node entities communicate through messages.The measurement and control node entity's message transmission follows the Client / Server model. The node entity requesting the service is called the clients, the node entities that provide services are called servers. In the distributed measurement and control system, a simple intelligent sensor can be used as a server, and the monitoring equipment is the customer. And for a measurement and control node device, the status of its client or server is not fixed. A node is a client in this event and may be a server in another event. Generally, the operator workstation is the client; simple intelligent sensors, control and monitoring equipment are used as servers; and complex control equipment, such as PLC, are both clients and servers. The messages passed between node entities are generally of the following types:

1) Entity access message.

In the EFPS model, the entities that communicate with each other in the distributed measurement and control system are node entities. Nodes must read or modify various attributes of the node entities through entity access messages.

2) Alarm message.

One of the important functions that a distributed measurement and control system must

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have is to promptly report when an abnormal situation occurs in the system, and this information is passed as an alarm message between nodes. Usually, the client node and the server node define the alarm event, and the server node automatically sends an alarm message to the client node under abnormal conditions.

3) File access message.

File access messages provide messages from client nodes requesting read and write data files from server nodes.

(3) Measurement and control system protocol set P.

The protocol set is a variety of protocols for each entity of the distributed measurement and control system to communicate messages. The protocol set of the measurement and control system solves the problem of "how to do" for each entity. Its determination principle is based on the three elements of the agreement defined by the IBM dictionary.

1) Syntax: specifies the data format or signal format;

2) Semantics: the rules and data structures required for data coordination between peer processes (software entities);

3) Timing: The rate of communication matches and the correct ordering of received data.

(4) The service set S provided by the measurement and control system entity.

Its determination principle is based on the operations that can be performed on the entity, but it does not specify how these operations should be implemented. The measurement and control system service set S solves the problem of what each entity "does".

2.4 Application Method of EFPS Model

The application of EFPS model in distributed measurement and control system can be considered from analysis and design of measurement and control node entity to the entire distributed measurement and control system.

(1)Application of EFPS model to measurement and control node entities

The distributed measurement and control system hardware node entities, abstract node entities, and software node entities have intrinsic relationships. The transformation relationship between the three types of entities can be shown in Figure 2.

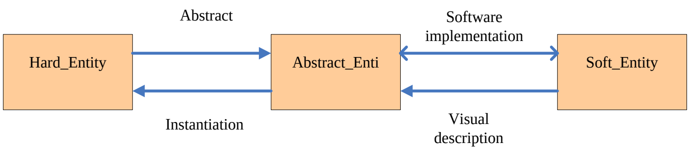

Figure 2. Transformation relationship between hardware node entities, abstract node entities, and software node entities

It can be known from Figure 2 that for a distributed measurement and control system that includes both hardware and software and has a complicated topology, FIG. 2 provides an effective analysis and design method. The forward transformation between entities in the figure is the analysis and design of a real system (software and hardware) using the EFPS model; the reverse transformation between entities in the figure is the application of the EFPS model to a system to be implemented (soft, Hardware) design and implementation and analysis of software systems. Among them, the abstract node entity abstracts the problem from the hardware node entity and makes a formal description, which is the key to design and analyze the system. There are four cases of the application of the EFPS model in the measurement and control node entity:

1) The design and implementation of the

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hardware system follow the order from the abstract node entity to the actual hardware node entity.

2) The analysis of the existing hardware system follows the order from the actual hardware node entity to the abstract node entity.

3) The design and implementation of software systems follow the order from real hardware node entities to abstract node entities to software node entities.

4) The analysis of existing software systems follows the order from software node entities to abstract node entities.

(2) Application of EFPS model in analysis and design of distributed measurement and control system. Based on the EFPS model, a method for analysis and design of distributed measurement and control system can be obtained, which is discussed in two cases.

1) Analysis of existing distributed measurement and control systems

In engineering, it is often necessary to evaluate the performance of an existing measurement and control system. Based on the EFPS model, the system is divided into a service part and an application part in a bottom-up order. The specific steps are:

Services section. The real node entity is determined through system structure analysis. The real node entity is the on-site measurement and control node equipment in the distributed measurement and control system.

Application Part. Based on the problem described, the system is functionally decomposed, and the abstract node entities are abstracted from each real hardware node entity, so as to determine the abstract entities, the principles to be followed when decomposing:

Abstract node entities complete specific functions that are relatively independent;

Abstract node entities are connected to other entities in the form of messages through interfaces (including FO interfaces), and the transmission of messages should be as small as possible;

Abstract node entities cannot span two or more hardware node entities, that is, there is a one-to-many relationship between hardware node entities and abstract node entities.

Through the function analysis of the distributed measurement and control system, the relationship between each measurement and control node entity is determined, that is, the various application interfaces in the application part are determined. Specific to the relationship between each measurement and control node entity, draw the system EFPS diagram.

2) Design of the distributed measurement and control system yet to be established

For the analysis and design of a distributed measurement and control system that has not yet been implemented, starting from the EFPS model theory, it should follow a top-down sequence, starting from the function of the system, constructing abstract node entities, and then following the actual conditions of the distributed measurement and control system. The condition maps the abstract node entity to a real node entity, and determines the topology of the distributed measurement and control system, etc., thereby completing the design of the entire distributed measurement and control system.

3.Experiments

3.1 Real-Time Simulation Experiment of Measurement and Control System

(1) Experimental environment

The hardware test environment is 4 measurement and control devices (device0, device1,

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device2, device3); 3 workstations (wk-station0, wk-station1, wk-station2), configured as Pentium II (clocked at 800MHz), memory 132M, each A 10 / 100Mbps network card is inserted into the computer, and the network card is connected to the hub through a twisted pair; a monitoring server (main server) and a shared hub. Each device is a separate node that can send and receive messages.

(2) Parameter setting

In the network simulation software Opnet Modeler, various data services in the network are configured through the application tool. Set the device to initiate requests at an exponential distribution interval with a parameter of 50.The measurement and control time of the simulation experiment is set to 2.8 hours (about 10,000 seconds).This setting takes into account the completeness of the experiment; because the response time in the OPNET simulation experiment software. Set it as seconds, and set the time order as milliseconds according to the communication of the actual measurement and control network.

(3) Experimental content

A total of five simulation experiments were performed, so there are five experimental project scenarios, which are:

1) Switched Ethernet measurement and control network model (control-net-scenario 1);

2) Bus-type Ethernet measurement and control network model (control-net-scenario 2);

3) Distributed measurement and control network model with router (control-net-scenario 3);

4) Distributed monitoring and control network model based on SUNA (control-net-scenario 4);

5) SUN-based distributed measurement and control network model (control-net-scenario 5) with router.

4.Discussion

4.1 Comparison of Simulation Results Between Bus-Type Ethernet Measurement and Control Network and Switched Ethernet Measurement and Control Network.

Overlay the simulation results of the bus-type Ethernet measurement and control network with the simulation results of the switched Ethernet measurement and control network

The statistical output is shown in Figure 3.

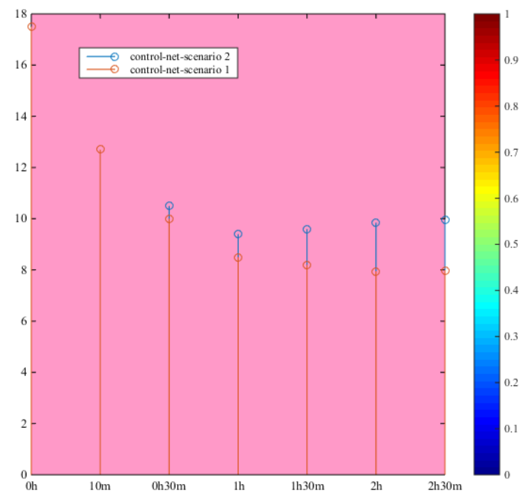

Figure 3. Comparison of average delays under the two network structures of device 0

From Figure 3, it can be seen that the average service delay of the measurement and control device device 0 under the traditional Ethernet measurement and control network model and the switched Ethernet measurement and control network model can be seen. The scenario 1 curve) is smaller than the bus-type Ethernet measurement and control network model (control-net-scenario 2 curve), and the average response time of device requests is also lower than that of the bus-type Ethernet.

4.2 Comparison of Simulation Results of Distributed Measurement and Control Network and Switched Ethernet Measurement and Control Network Based on SUNA

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The simulation results of distributed measurement and control network based on SUNA and the simulation results of switched Ethernet measurement and control network are superimposed and output.

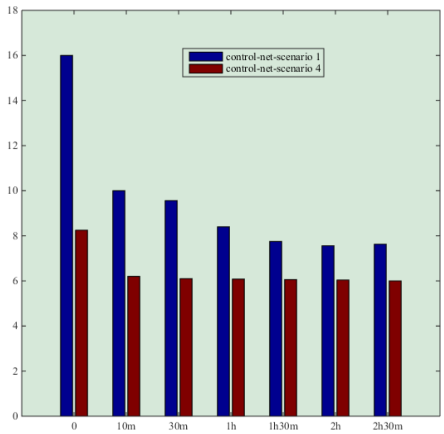

Figure 4. Comparison of time delay between distributed measurement and control network based on SUNA and switched Ethernet measurement and control network.

It can be seen from Figure 4 that the average service delay of the measurement and control device under the two architecture models is compared. It can be seen that the data transmission delay (control-net-scenario 4 curve) of the measurement and control network based on SUNA is better than the current delay performance. Some switched Ethernet measurement and control networks (control-net-scenario 1 curve), this is because the TCP / P protocol stack used in switched Ethernet is hierarchical, and any application layer data must go through UDP / TCP → IP → Ethernet. The MAC encapsulation process; and the distributed measurement and control network based on SUNA is a hierarchical network structure, and a specific service meta sequence can be configured according to the requirements of the application layer. As a non-hierarchical network architecture, SUNA uses service elements as network functional units to provide network services in combination.There is no strict hierarchical relationship between each service element, which has good scalability and reduces processing redundancy.These measures, all are conducive to improving the real-time performance of the distributed measurement and control network based on SUNA.

4.3 Comparison of Simulation Results of Distributed Measurement and Control Network with Router Based on SUNA and Switched Distributed Measurement and Control Network with Router

If the network is modified with reference to the model with routing functions in Ethernet, a network-scenario 5 control-net-scenario curve of the extended measurement and control network based on SUNA is obtained, which is compared with the extended switched Ethernet average service delay (control-net-scenario 3 curve), the results are shown in Figure 5.

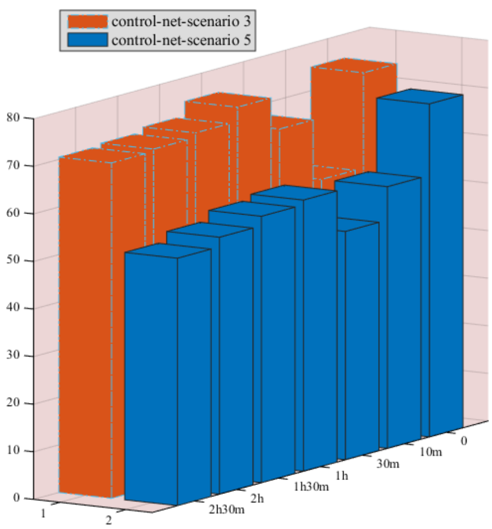

Figure 5. Comparison of extended SUNA-based distributed measurement and control network delay and extended switched Ethernet delay.

It can be known from Figure5 that at this time, the delay of the remote monitoring equipment receiving the measurement and control data is also greatly reduced, and the extended measurement and control network service delay based on SUNA is also better than the extended switched Ethernet average service delay.

4.4 Comparison of Average Delays Based on SUNA, Switched Ethernet, and Bus Ethernet

Suna-based distributed measurement and control network service delay curve (control-net-scenario 4 curve), switched Ethernet measurement and control network service delay curve (control-net-scenario 1 curve), and bus-type Ethernet measurement and control network average service delay. Comparison of the curves (control-net-scenario 2 curves), the results are shown in Figure 6.

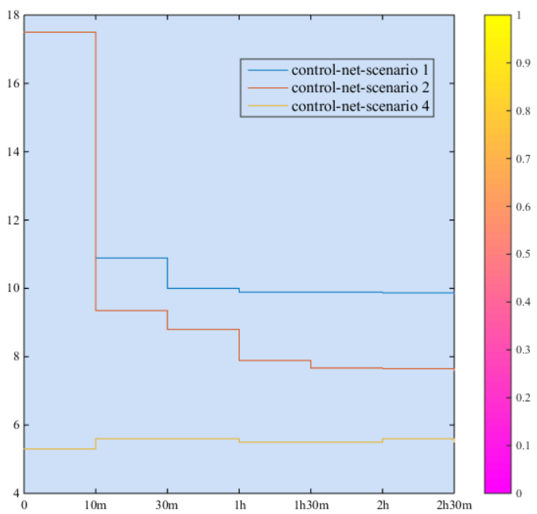

Figure 6. Comparison of average delays based on SUNA, switched Ethernet and bus type Ethernet

As can be seen from Figure 6, when analyzing the entire simulation experiment, it can be seen from the average delay curve of control-net-scenario 4 that the delay is between 5ms and 6ms; while the average service delay curve of control-net-scenario 1 is between 7.5ms and 10ms; control-net-scenario 2 average service delay curve is around 10ms.

5.Conclusions

The research purpose of this article is to study the real-time nature of the measurement and control system based on the network environment in automation technology. We know that the traditional Ethernet uses the CSMA / CD mechanism and is a random access protocol. Due to the randomness of the frame and the back-off algorithm and other uncertain impact factors, and due to the limitations of hierarchical networks, the average service delay of the network is large, so it is difficult to meet the requirements of modern real-time measurement and control; similarly, switched Ethernet has better network performance than traditional Ethernet, to a large extent, the real-time performance of shared Ethernet is solved, but under a large amount of data, a large number of frames need to be queued in the switch buffer, and there are still some problems with its real-time performance. Therefore, further exploration of new resolution mechanisms is needed. In this paper, simulation experiments are performed on a traditional bus Ethernet measurement and control network model, a switched Ethernet measurement and control network model, a distributed measurement and control network model with a router, and a SUNA distributed measurement and control network model with a router.

The simulation experiments in this article compare the service delays of the bus Ethernet measurement and control network and the switched Ethernet measurement and control network respectively. Based on the SUNA distributed measurement and control network and the switched Ethernet measurement and control network service delay, the SUNA distributed measurement and control network with routers and the distributed measurement and control network service delay.Finally, the average service delay of the measurement and control network based on SUNA, switched Ethernet and bus type Ethernet is simulated and analyzed, and the end-to-end permanent virtual circuit based on SUNA is calculated and analyzed. The results show that the scheme is correct and feasible, and can improve the real-time performance of distributed measurement and control system.

The research results of this paper show that from the perspective of average delay, only the distributed measurement and control system network based on SUNA has better real-time performance on average service delay. The distributed measurement and control system based on SUNA can use the permanent virtual circuit to achieve real-time performance of the distributed measurement and control system in the range of 200km, which can reach the millisecond level, which can better meet the real-time requirements of the distributed measurement and control system.

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