Study on the Control Strategy of Network Control System

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Abstract. As a symbolic achievement of the third scientific and technological revolution, computer network has penetrated into various fields of modern society and become one of the important infrastructures in the information age. The background of the network control system is put forward and the basic problems of the control system are discussed in this paper, taking the network delay problem as the main analysis object and proposing the solution strategy.

Introduction

A networked control system is a control system that exchanges data by the components of a control loop through a communication network. It is characterized in that the command and feedback of the control system are transmitted in a packet in the network. Computer network foundation, network architecture and interconnection technology, fieldbus control network, control network equipment and wiring installation, distributed network control system, network control system implementation and application. The most important feature of networked control systems is the connection of cyberspace and physical space, so many tasks can be performed over long distances. Moreover, the signals of networked control system are transmitted through the shared network, eliminating unnecessary wiring, reducing system complexity or the cost of designing and erecting the system. To add sensors, controllers, or actuators to adjust or update the system, it can be achieved at a lower cost without changing the main architecture of the system.

Background of the Network Control System

As early as the late 1970s, the distributed control system was born. The computer control network was also introduced into the control system for the first time with the development of technology, resulting in DCS. Prior to the advent of DCS, early computer control systems were direct digital control. All sensors and actuators perform the point-to-point connection with a computer in such a control system. In the case where the computer was expensive at the time, generally, the system adopts a centralized one-type architecture, and the entire production process and control strategy are completed by one computer.

Problems with the Network Control System

Network information transmission delay.

For networked control systems, the impact of random, time-varying network information transmission delay on control system performance is a primary challenge for control system analysis and synthesis. The influence of network transmission delay on the performance of network control system has already attracted extensive attention. The research results show that under normal circumstances, the network transmission delay will deteriorate the transient performance of the control system, which has special influence on increasing the overshoot of system response, extending the transition process of the system. The more serious is that the network transmission delay will reduce the stability margin of the control system and even make the control system unstable. In the network control system, the data transmission between different nodes and the random delay introduced during the sensor node and controller node calculation process have become the most important factors affecting the control quality of the control system.

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Clock synchronization.

There may be errors in the system clock signals of different network nodes. The purpose of clock synchronization is to give the internal clocks of two or more nodes the same value. Whether it is a time-driven node or a timestamp technology, there is a clock synchronization problem. Clock synchronization methods include hardware synchronization, software synchronization, and hybrid synchronization. Hardware synchronization generally transmits synchronization signals through actual media between nodes. It is costly, especially for large-scale network control system where nodes are widely distributed. Software synchronization is to synchronize by the clock control algorithm, the workload is large, and the synchronization deviation is easy to accumulate, resulting in reduced accuracy.

Packet loss and out-of-order.

In the network control system, due to buffer overflow of network node, router congestion and connection interruption, the data packet will be lost in the network transmission. Lost data packets are affected by factors such as network protocols and load conditions, and are usually random. In an actual network control system, only a certain amount of data packets can be tolerated. When the packet loss rate reaches a certain value, the control system will become unstable. The general processing method for packet loss is to use the data when the packet loss did not occur last time or to give a certain constant value.

Network scheduling.

Network scheduling refers to the sending order priority, sending time and time interval of the specified node when the system node collides in the shared network. The purpose is to make full use of network bandwidth under the condition of limited bandwidth resources, and reasonably schedule various data in the network control system to meet different real-time requirements, effectively control network load, improve network operation performance, and reduce network transmission delay. The occurrence probability of packet loss and out-of-order weakens the negative impact on the control system due to the involvement of information transmission network.

Single packet transmission and multi-packet transmission.

In a networked control system, data is transmitted over the network in the form of data packets. Single-packet transmission means that data is encapsulated and sent in one data packet; multi-packet transmission means that data is separately encapsulated and sent in multiple data packets. There are two main reasons for using multi-packet transmission: First, subject to the significant digits of a single data packet, the data to be transmitted exceeds the capacity of a single data packet, and the data must be split into multiple packets. Second, the sensor nodes and executor nodes of network control system are often distributed in a wide range of physical spaces. It is impossible to physically encapsulate all the information of the same kind into a single data packet. The acquisition and transmission of information can only be realized by multiple data packet transmissions.

Communication constraints.

In networked control systems, communication rates are bounded due to the limit of network bandwidth and the number of system nodes. It constitutes the control problems of band communication constraints that how to obtain the upper bound of the transmission rate of each network control system while ensuring the stability of a system or satisfying some other performances, and how to perform state estimation, controller design, etc. in the case of communication upper bounds. Communication constraints are divided into two types: bit rate constraint and information rate constraint. Bit rate constraint problems exist in networks with limited word length and often with noise interference. The main problem that needs to be solved is to determine what code the sensor node uses to send data, how the controller node decodes, and how fast the communication rate is needed.

Network Control System Delay Analysis

Characteristics of network transmission delay.

In the network control system, when information is exchanged between the proximity controllers

and the remotely controlled object's sensors and actuators through the communication network, the transmission delay of information in the network, which is referred to as network transmission delay, is inevitable due to the reasons, including the information flow from the multiple devices changing irregularly, and multiple packets transmission, multi-path transmission, packet collision and retransmission, network congestion, packet loss and out-of-order and connection interruption, etc.,. In addition, the data transmitted on the network, including periodic data and burst data, is generally short.

Network control system delay stability.

The existence of network transmission delay makes the analysis and synthesis of the control system more complicated and difficult. At the same time, the network transmission delay is often the source of control system instability and control performance deterioration. In essence, due to the time-varying and uncertainty of network transmission delay, networked control system is the time-delay system with time-varying and uncertainty time-delay. They can be analyzed and synthesized by relevant theories of time-delay systems. In the existing stability conditions of time-delay systems, based on whether depending on the size of time-delay in the control system, the stability conditions can be divided into two categories: time-delay-free stability condition and time-delay-related stability condition.

Processing method of delay.

The first problem encountered when adding a communication network to the feedback loop is the network induced delay. Sensor—controller delay and controller—actuator delay issues occur when data is exchanged between devices that share media. This delay can be either constant or time-varying. For example, when designing the control system, such delays will reduce the performance of the control system and even destabilize the system. There are three ways:

① Set the receive buffer between devices. This method converts the random delay into a fixed delay, so that the compensation controller can be designed using the predictive control method.

② Assuming that the delay conforms to a certain statistical law, the controller that stabilizes the system is designed by means of stochastic control theory in the case of knowing the statistical law of delay.

③ Think of time delay as a time-varying, bounded value. This assumption fits a large part of network. From the two perspectives of control technology and communication technology, the convergence of network technology and control technology is taken as the starting point to explore the delay problem in NCS, and the method of average delay window is improved. The network technology is incorporated to propose the most recent matching method.

Conclusion

With the rapid development of computer networks and communication technologies, the control system has gradually become networked and intelligent. The network control system, that is, transmits signals through network, has become one of the research hotspots. As the controlled objects and control systems become more and more complex, more and more information needs to be exchanged between various components of the control system. Compared with the traditional control system of point-to-point structure, the network control system is more in line with the trend of modern control. The traditional control system of point-to-point structure has a complicated structure, and it is difficult to maintain, upgrade, and improve the control system. In addition, this control system structure is not suitable for some new control requirements such as modularization, decentralization, comprehensive diagnosis, fast and easy maintenance, and low cost. In the network control system, the signal from the sensor to the controller and the signal from the controller to the actuator for each point are transmitted through the network, thus making up for the shortcomings of the above-mentioned conventional control system.

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