Technologies for Robust Switches (Switching Hubs)

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Abstract

If an industrial system supporting our infrastructures is compared to a human body, a computer network would be its nervous system. Similar how healthy people are not aware of the presence of the network of their own central nervous system in daily life, people are also not aware of the presence of a computer network itself.

When any network fault occurs, such a negative effect will travel over a network's system. As such, the market demands on the reliability of more strict and higher-level network devices.

In order to offer a suitable product for an industrial computer network, we proposed a concept of our new network switch as a "robust switch" for industrial computer network. It features "an operation without stopping switch," "no missing data," and "no data transmission latency." Based on this concept, we are developing and manufacturing industrial switching hubs.

1 Preface

The duties of an industrial network are that the control data, video data, audio data, and other information can be correctly transmitted without delay. In order to maintain operation of these duties, we consider it necessary to realize the following three items:

(1) An operation without stopping switch

The operation of network equipment and communication lines must be maintained by 24/7 without causing the performance loss.

(2) No missing data in the communication network system

In industrial systems, the network gear will be placed where external conditions are challenging (negative impact by other devices emitting electromagnetic waves or by temperature.)

(3) No data transmission latency

Under the conditions of network communication lines with different communication conditions in terms of transmission distance, communication bandwidth, and communication modes, the network gear shall maintain network communication without missing data or transmission latency.

We are developing and manufacturing industrial switching hubs that play an important role in industrial networks. We realized three items in our industrial switching hub, "MEISWAY SW600" ('SW600' hereafter.) This paper introduces the features of these Meiden switching hubs.

2 Securing Real-Time Performance

In addition to the duties imposed on industrial networks as defined, Meiden industrial switching hubs newly introduced a concept of "Security of Real-time Performance."

In industrial systems, there are pressing requirements of "capturing the same phenomenon around the same time" and "make the target controlling equipment work under the same real-time performance of other equipment." For example, a power grid protection system is protected by simultaneously collecting, at an accuracy of microseconds, the current level data of the key equipment like substations distributed in the power network. Also, in order to operate a machining tool line in Factory Automation (FA) system, it is essential to make synchronizing time accuracy control.

Conventionally, this kind of information-based control had been conducted by dedicated machinery for data acquisition and data-based control. When a network technology called "Precision Time

Protocol (PTP)" is introduced to network devices, clock-accuracy control can be realized without using the large-scale dedicated special equipment.

3 Robust Switch

Since 2015, we have been developing a product series of industrial switching hubs with excellent robustness and toughness to support infrastructure systems. We have developed such products based on the concept of a "robust switch" meeting the three conditions discussed in the Preface. **Table 1** shows the outline of a robust switch.

We provide our switching hub as an industrial application product which differs from ordinary LAN products. Our products are for network systems for the mission-critical infrastructures. We aim our switching hub to maintain the high level reliability necessary for such network application. We introduce the technological elements which are required in realizing the robust switch concept products.

3.1 Network Redundancy

For industrial network devices, it is important to maintain network connectivity against the likely unplanned network outages, so we secured redundancy by making a backup communication line to make the communication system redundant and maintained the connection by swapping.

Fig. 1 shows the function of our Ring Topology Protocol (RTP) – our high-performance routing system in our switching hub. Our RTP is the revised version of Rapid Spanning Tree Protocol (RSTP) in a ring topology network.

For the ring topology network, by making a designated blocking port in advance, it can avoid loops. In case of failures in the communications link, the designated blocking port will be moved to the troubled spot (bypass) to maintain the communication. Regarding RTP functions in our switching hub, from the early design stage, we worked on shortening the bypassing time (communication break-off time.) For the latest model, the bypassing process is completed in 50ms to 200ms. This is our guaranteed value for maximum 32-node at the largest system configuration.

3.2 PTP Features

For the system to maintain stable operation, it is preferable to manage and control it under synchronized clocks instead of working under each different clock time.

For example, in tracing the log of communications failures, it is easy to check the time context of the data after the occurrence of communications failures, so long as the time information is synchro-

Table 1 Outline of a Robust Switch

We show the essential factors in making a "robust switch" as an industrial switching device.

Contents of realization	Items to be realized	Method of realization	
Robust design for hardware (Tough design)	Measures against EMC Compliance	Adoption of anti-noise parts Anti-noise design (structural and electrical design)	Realize by costs
	Measures against environment (temperature)	Adoption of industrial parts Adoption of high-reliability parts	
	Measures against environment (anti-corrosion)	Adoption of sulfur-resistant parts Protection and hermetical sealing of corrosive sections	
	Redundancy (power supply)	Redundancy and maintenance in energized state	
Secure sound communication data (use of loss-free packets)	Redundancy (lines and communications)	Bypassing function by using a faster loop circuit bypassing function (reduction of loss time) Redundancy of lines (redundant configuration)	Realized by the switching function
	Priority control	Secure bandwidth based on the priority (bandwidth control)	
	Measures against environment (temperature)	Low power consumption	
Stabilization of control	Precise time protocol	Adopt IEEE 1588-compliant devices	

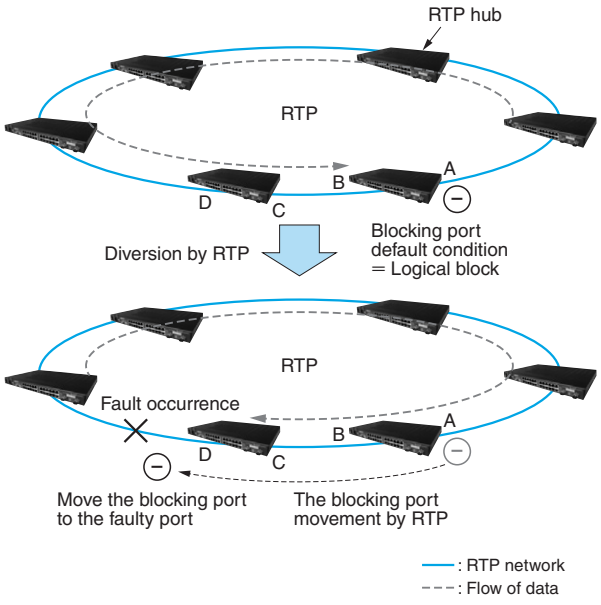

Fig. 1 Function of RTP

This diagram shows a ring topology network by RTP and the behavior of a blocking port moving from the default blocking port A to the faulty port D.

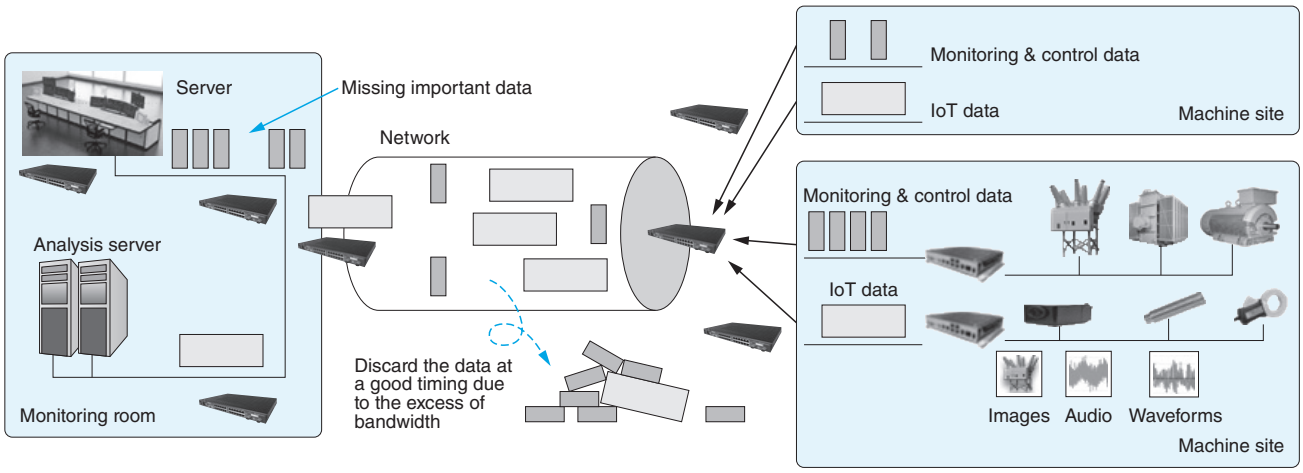

Fig. 2 State of Discarded Packets Caused by Excess of Bandwidth

In a network, bandwidth may overflow momentarily and the network may discard important data. By time-dividing the network using the time synchronization function, the bandwidth can therefore, be completely separated and important data can be prevented from being discarded.

nized. In a system where scheduled management is strict, stable system operation is possible if the clock time of each equipment is synchronized. Our PTP features are as itemized below.

(1) The PTP works as a standard clock or terminal clock.

(2) Accuracy of synchronism is kept within ±200ns (via the PTP-compliant switching hub).

(3) Clock time synchronization will be completed within 60 seconds after the power supply is ON.

(4) Pulse signal output is generated at a predetermined period.

(5) Anomaly detection will be notified when the specified accuracy cannot be maintained.

(6) The present status of synchronism is notified.

3.3 Bandwidth Control Function

With the trend of various types of data going through the industrial network, prioritization is made against each data type. Formerly, we mostly managed the control data but from now on, real-time data of video, audio, and Internet of Things (IoT) will be on the network.

In order to handle such various data, it is essential to add a bandwidth control function to "secure the important data by ensuring the booked bandwidth at the synchronized clock time." Conventional bandwidth control technique depended on performance of dedicated network device with switching engine but from now on, as our future option, we are also working on to adopt PTP as mentioned above as per IEEE 802.1 Time-Sensitive

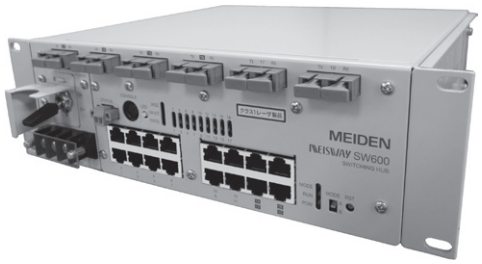

Fig. 3 SW600

This is a gigabit layer-2 switch conforming to the B-402 electrical standards of The Japan Electric Association (Digital Protection Relays and Protection Equipment.) It is replaceable as a successor machine for the SW500.

Networking (TSN). In this IEEE 802.1 TSN, it applies PTP and is a method to secure the bandwidth just like Time-Division Multiplexing (TDM) method. Fig. 2 shows the state of Discarded Packets Caused by Excess of Bandwidth.

4 Commercialization of Robust Switches

We adopted a new switching engine for our robust switching hub products. We released the SW600 with new switching engine in February 2015. Fig. 3 shows an external appearance of the SW600. This product is a successor model of our previous industrial switching hub, "MEISWAY SW500" ('SW500' hereafter.) Our SW600 was designed to serve as a platform of robust switches with new-generation switching engines. Table 2 shows

Table 2 Transmission Specifications of SW600

Maximum 16 ports of 10/100/1000BASE-T and maximum 6 optical ports of 100BASE-FX or 1000BASE-LX can be installed.

Item			Transmission specification
Switching mode			Store and forward
Switch capacity			13.7Gbps 2.66Gbps (for full duplex/full port 100Mbps)
Transmission system			Full-duplex/half-duplex
Port configuration	10/100/1000 BASE-T		16 ports (4 ports for optical ports and combo ports)
	6 optical ports Max.	100 BASE-FX	Connector used: SC Multi-Mode Fiber (MMF) applicable Single-Mode Fiber (SMF) applicable
		1000 BASE-LX	Connector used: LC SMF applicable 10km and long distance (40km) applicable
Error output terminal			1 contact
MAC address capacity			8000 pcs.
Flow control			IEEE 802.3x (full duplex) Back pressure (half duplex)
VLAN			IEEE 802.1Q conforming tag and port base VLAN
Error packet filtering function			Short packet, long packet, FCS error packet, symbol error packet
Network control			SNMPv1 (conforming to RFC1157), MIB Ⅱ
Network operation			telnet・http・ICMP・IP
Storm prevention			Revocation enabled by setting for broadcast, multicast, and address unknown packet
Serial console port			By round connector conforming to EIA/TIA-232-E
Setup saving, writing, firmware updating			Via Web (http) or serial port

transmission specifications of SW600 and **Table 3** shows environmental specifications of SW600. (The precise time protocol function is optional. The function of bandwidth control will be provided in the future.)

Table 3 Environmental Specifications of SW600

The top panel of this product is free from ventilation holes and the operating temperature range is −20 to 55℃. Compared with the SW500, the power consumption is reduced by 30% and the total mass is approximately 30% less.

Item	Environmental specification
Type	UT226/***A (***changeable with type description)
Power connector	3P inlet type (AC)/ 3P terminal block (DC)
Input power voltage range	AC85～242V 47～63Hz/DC80～143V
Power consumption (in operation)	25W or less
Operating temperature range	−20～55℃
Isolation voltage (Source primary – FG or SG)	AC 2000V for 1 minute
Insulation resistance (Source primary – FG or SG)	DC 500V 5MΩ or above
Power noise immunity	Impulse noise 2kV, 50ns/1μs
Mass	Approx. 4kg
External dimensions	W255 × H88 × D250mm (protruded parts excluded)
Applicable standards	B-402 Standards-compliant (except inrush current)

5 Postscript

As an industrial network device in support of good network connection of industrial infrastructure, we will provide our switching hub products with high-level functions as previously mentioned. In doing so, we will keep providing network devices which realizes higher reliability.