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Development of Next-generation Power Supply Information Transmission System (iQPA Network)

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SUMMARY

A power supply information transmission system essential to power system operation needs to satisfy requirements for high reliability and low delay.

Whenever implementing system renewal, Kyushu Electric Power Company conducts system reviews taking into consideration compliance with system requirements and long-term operation.

The need for renewal of the existing system due to degradation caused by aging has prompted Kyushu Electric Power Company to develop a next-generation power supply information transmission system (iQPA network).

The development comprises the two points below.

- Point 1: Change of the accommodating network

The accommodating network will be changed from the current network (ATM exchange network) to a new network (IP network for electric power systems). As well as satisfying the network requirements of the power supply information transmission system ((1) Unavailability rate, (2) Transmission delay time and (3) Maximum allowable traffic disruption time), the new network enables realization of reduced network construction costs by utilizing the existing network.

- Point 2: Development of function for switching of control to the backup facility

In addition to the function for power supply information transfer fulfilled by the existing data collection and distribution system (DX), a function will be developed for the next generation DX that unfailingly switches control from the Central Load Dispatching Center system to the Central Load Dispatching Center backup system in the event of problems such as failures in the former facility, thereby further improving the reliability of load dispatching operations.

KEYWORDS

Power Supply Information, ATM, IP, PMCN, DX (Data Collection and Distribution), Unavailability Rate, Transmission Delay Time, Maximum Allowable Traffic Disruption Time

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1. Introduction

Spurred by factors such as the increasing sophistication and standardization of information and communications technology, recent years have seen an increase in the application of IP networks in mission-critical fields, and, accordingly, Kyushu Electric Power Company has also been engaged in the construction and operation of an IP network for electric power systems since the year 2008.

Meanwhile, although, to meet time-critical requirements for highly reliable data transmission with low delay, we constructed a power supply information transmission system (iQPA) directly linked to power system operation by using an ATM exchange network as shown in Fig. 1, degradation of the exchange network due to aging prompted migration of the iQPA to the IP network for electric power systems and the development of a data collection and distribution system (DX) that centrally handles the collection and distribution of power system operation information, an overview of which is presented below.

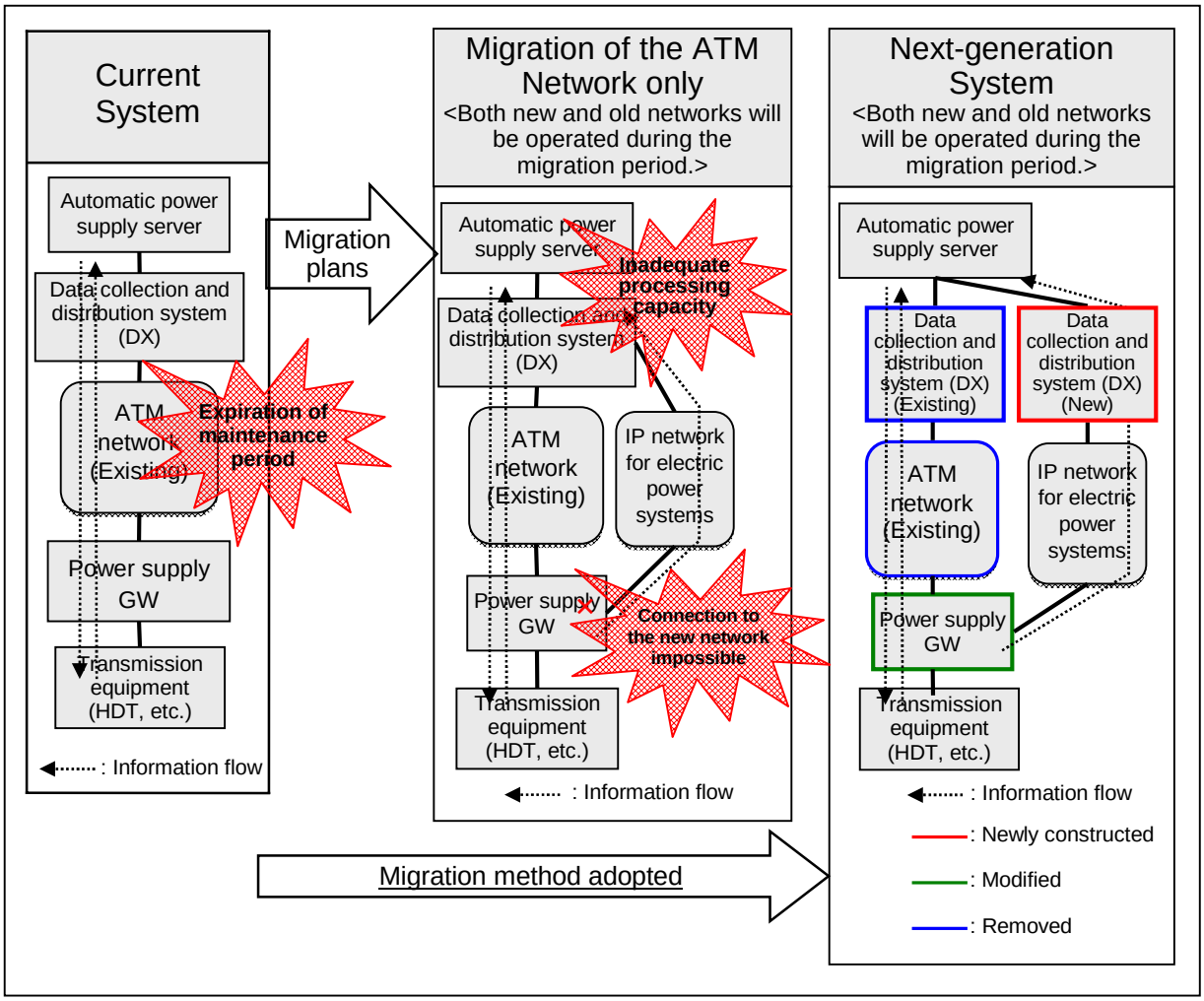


Fig. 1: Overview of Migration of Power Supply Information Transmission System

2. Migration to IP Network for Electric Power Systems

Based on the requisite of satisfying the time-critical network requirements of the power supply information transmission system, it was decided to migrate the system to the IP network for electric power systems (change in the accommodating network) because of the degradation of the ATM exchange network due to aging.

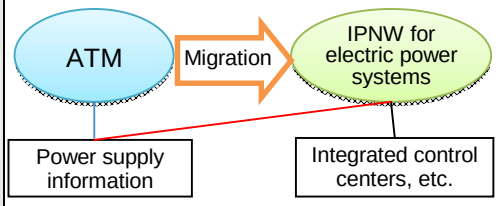
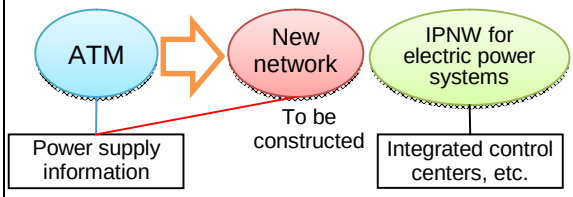
2.1 Determination of Accommodating Network

The reasons for accommodating the power supply information transmission system in the IP network for electric power systems are as follows:

(1) To eliminate the need to construct a dedicated network and hold down costs by utilizing the existing IP network for electric power systems.

(2) Even constructing a dedicated network will not enable distribution of risk in the event of a transmission path failure, because transmission media such as fiber optic cables will be shared with the IP network for electric power systems.

Table 1: Selection of Accommodating Network

Item	Integrated Network (**Adopted**)	Dedicated Network
Outline	• The power supply information transmission system will be accommodated by the existing IP network for electric power systems.	• A new dedicated network will be constructed to accommodate power supply information only.
Migration Method		
Costs	• Low costs for new network equipment installation and transmission path construction compared to a dedicated network • Low maintenance costs due to the small amount of additional equipment	• High costs compared to the integrated network due to the wide range of new installations • A new network monitoring system must also be developed.
Operation and Maintenance	• Migration to the IP network for electric power systems means that a high level of maintenance capabilities already in place from the operational track record to date is available.	• The new network may become a new model, and this will mean that familiarization with new knowledge and technologies will entail a certain length of time and generate costs.

2.2 Network Requirements of Power Supply Information Transmission System

The network requirements of the power supply information transmission system are shown below, all of which are satisfied by the IP network for electric power systems that has been adopted to accommodate the system.

- IP network capable of supporting the Transmission & System Operation Division system computers that will act as servers (migration to IP) in the future
- Network comprising two sides (so as to be capable of supporting PMCN[*1]) with a traffic disruption time of 2 seconds or less[*2]
- Satisfaction of the system requirements including reliability, delay time and maximum allowable traffic disruption time.
- Use of a microwave multiplex radio link as a backup line when all fiber optic lines are disrupted

*1: PMCN (Protocol for Mission Critical industrial Network use)
An industrial protocol established by the Japan Electrical Manufacturers' Association (JEMA) with strengthened recovery functions for information not received.

*2: For control information subject to the most stringent requirements. For details, see Table 2 below.

Table 2: Network Requirements of Power Supply Information Transmission System

Requirements/ Network		Unavailability Rate	Transmission Delay Time	Maximum Allowable Traffic Disruption Time
System Requirements		2.0×10^{-5} or less (Electric Technology Research Association No. 58-4)	For information transmitted to Central Load Dispatching Center: 4 sec or less For other information: 8 sec or less *For IP: 1.75 to 4.75 sec	For monitoring: 18 sec For control: 2 sec
Network	ATM Network [Existing Network]	2.14×10^{-8}	For information transmitted to Central Load Dispatching Center: SVTM: 4 sec or less Control: 2 sec or less For other information: SVTM: 8 sec or less	For monitoring and control: 0 sec (Duplex communication and packet acceptance on a first-come basis with the second discarded)
	IP Network for Electric Power Systems [Next-generation Network]	6.69×10^{-8} (When both sides-A and B are used) 2.14×10^{-7} (When only side-A is used) *Microwave radio not considered.	A few hundred msec or less *For the network only	For monitoring and control: 0 sec (Duplex communication using both sides-A and B, and packet acceptance on a first-come basis with the second discarded)

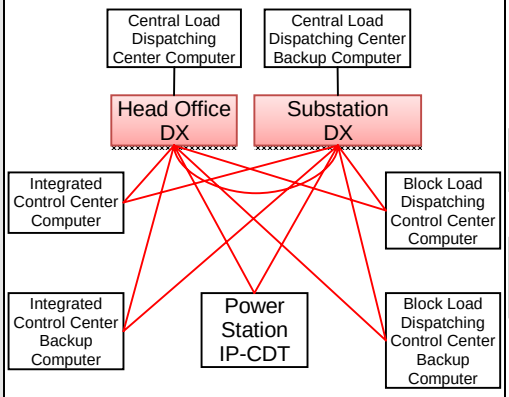
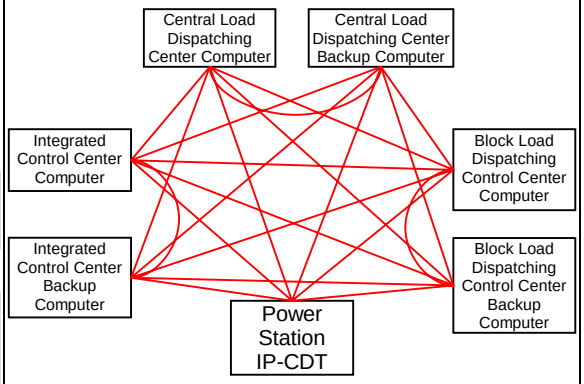
3. Development of New DX

3.1 Roles of DX

The roles of the DX in the power supply information transmission system are listed below and, taking into consideration factors such as ease of path management and processing loads of network equipment, DX is needed for data collection and distribution, as shown in Table 3.

- Centralized collection, editing and distribution of power supply information
- Switching of control between the Central Load Dispatching Center and its backup by interconnection with the automatic power supply server

Table 3: Comparison of Data Collection and Distribution Methods

Item	Star Configuration with DX at its Top	Mesh Configuration between Terminals
Configuration		
Communication Section	• Upstream (IP terminals => DX) • Downstream (DX => IP terminals)	• Between IP terminals
Advantages	• Easy management of paths • Easy management of power supply information elements (through distribution of all elements)	• DXes will be unnecessary, resulting in low costs (for development, introduction and operation) • Low probability of simultaneous interruption of all information in the event of a computer or network failure
Disadvantages	• High DX processing load => To be addressed by load distribution of DXes between the Head Office and Substation (Note 1) • Stoppage of all DXes will result in total stoppage of information transmission between facilities => DXes are installed in a dual configuration at both the Head Office and Substation, ensuring a high degree of reliability.	・Very complicated management of paths ・The processing load of network equipment (routers) increases as the number of paths increases. ・Complicated management of power supply information elements

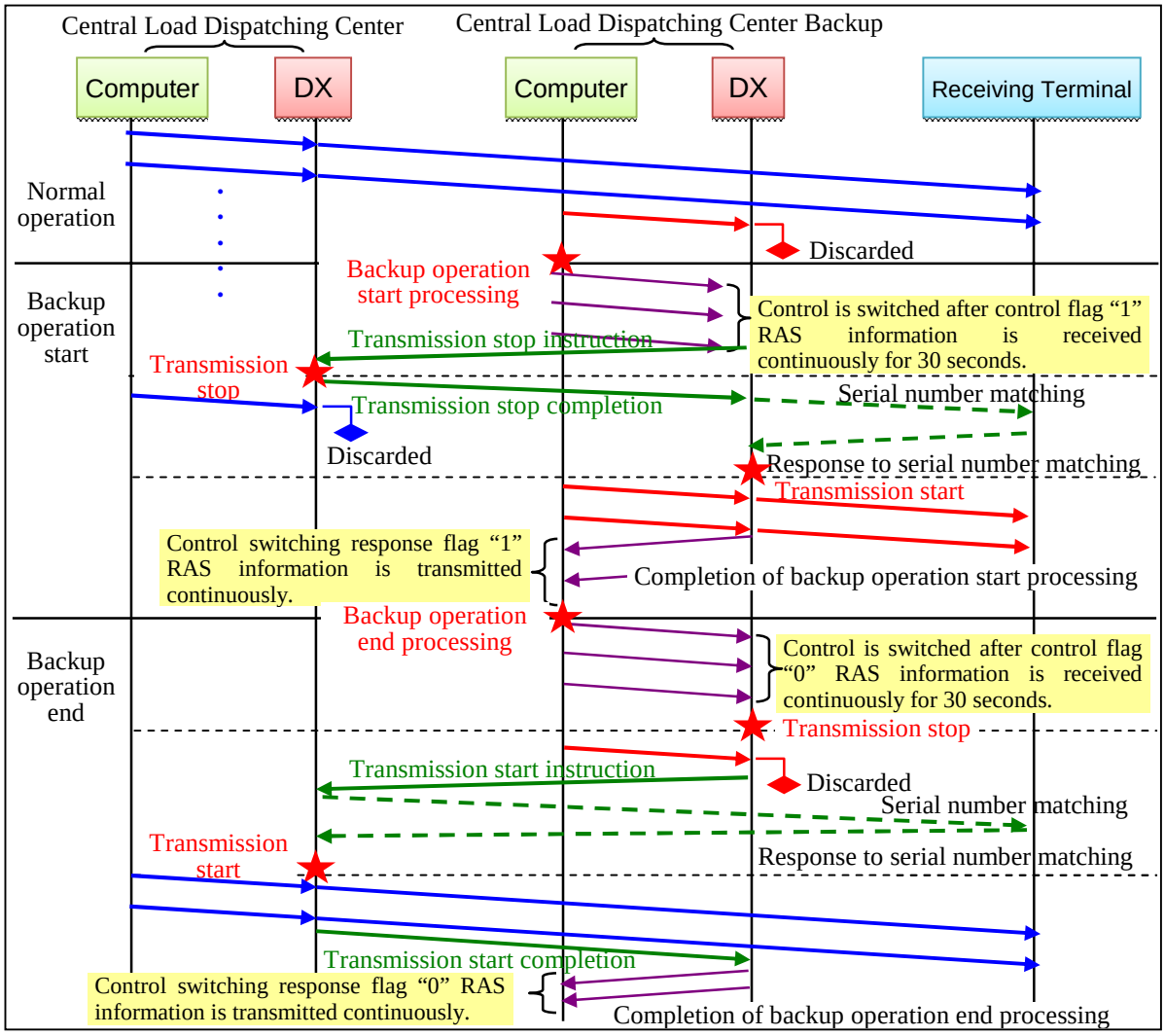
Note 1: Normally, the Head Office DX "distributes information from the Central Load Dispatching Center" while the Substation DX "distributes information from other locations," resulting in load distribution. It should be noted that, while DX duplexing is implemented at each facility, the DX at the other facility is capable of batch distribution in the event of a system stoppage at one facility.

3.2 Development of Function to Switch Control to Backup Facility

Concomitantly with replacement of the Central Load Dispatching Center backup, a function has been developed that switches control of power stations and substations to the Central Load Dispatching Center backup system in the event of a failure in the Central Load Dispatching Center system.

When the Central Load Dispatching Center backup is operating, control information for power stations and substations is sent from the Central Load Dispatching Center backup computer to receiving terminals. During this process, when control information from both the Central Load Dispatching Center computer and the Central Load Dispatching Center backup computer is received by the receiving terminals, a failure may occur if the information received from both computers does not match. This means that duplicated receipt of control information by the receiving terminals must be avoided and, to achieve this, the DX has been furnished with a sequence to ensure transmission of control information from only one of the 2 facilities through control switching.

The control switching flow at the beginning and end of operation of the Central Load Dispatching Center backup is shown in Fig. 2 below.



I	I	I	1	2	3	4	…	8	9	10	F1	F2	F3
			System status	Operation mode	Operation mode	Reserved		Reserved	Control flag	Control switching response flag			

Fig. 2: Control Switching Process Sequence (Above) and RAS Packet Format (Right)

3.3 Features of the Newly-developed DX

The existing DX carries out collection and distribution (transfer) functions that distribute data received from the Central Load Dispatching Center, power stations and substations to all relevant facilities and also performs the following functions.

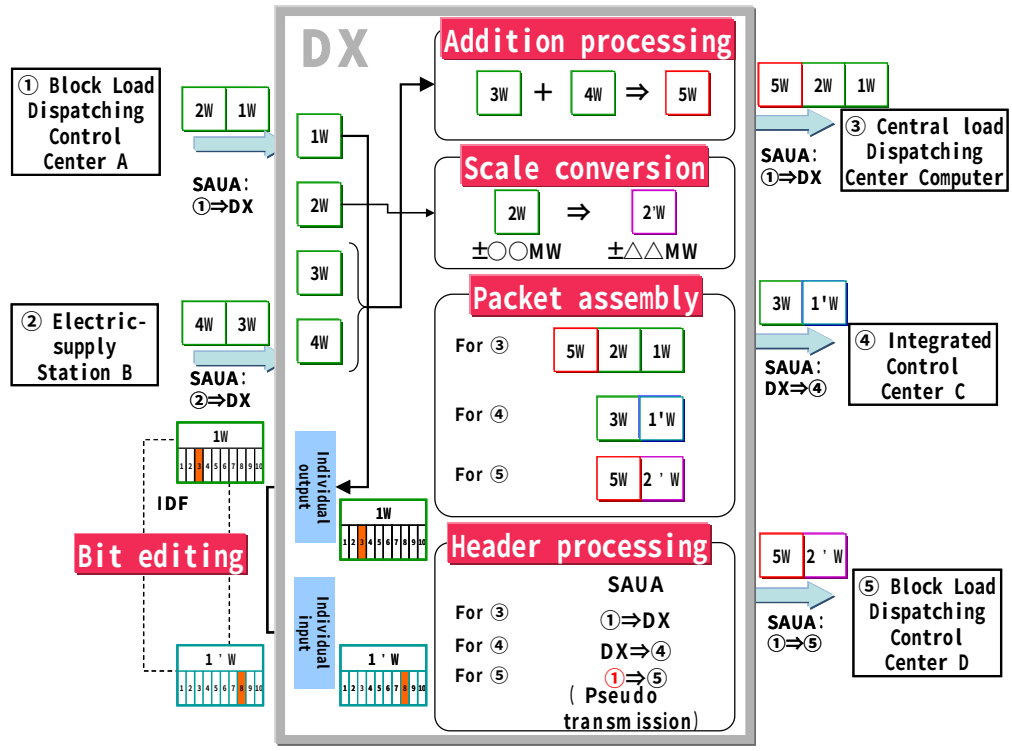
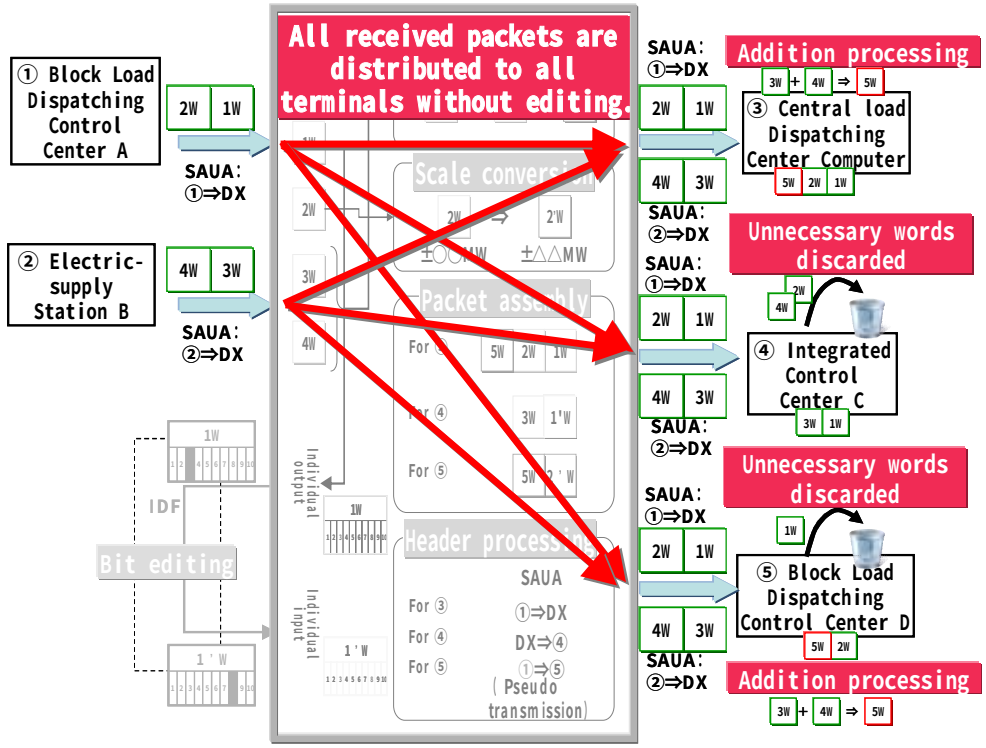
- Word editing: Creation of packets by combining words required for each receiving terminal
- Bit editing: Bit position shifting matched to the receiving terminal position definition
- Pseudo transmission: Packet transmission with the DX substituting for other sending terminals (Conversion of the originating SAUA*)
- Addition processing: Formation of different words (telemeter values) by adding multiple words (telemeter values)
- Scale conversion: Conversion of the telemeter value scale matched to the receiving terminal scale

* SAUA (Station Address Unit Address) is a unique 4-digit address given to each of the terminals comprising the power supply information system. The first and second digits (SA) of the 4-digit address represent the electric-supply station at which the terminal is installed and the last two digits (UA) represent the terminal unit at the electric-supply station.

Since the above are processed by the DX, the Transmission & System Operation Division needs to coordinate with the Telecommunications Dept. when tasks such as changing elements are performed, and the latter must also provide table maintenance for the above whenever required, resulting in disadvantages for both departments.

Based on the future image of the power supply information transmission system and the above issues, the future image of the DX is of a data collection and distribution system with specifications that will enable specialization exclusively on collection and distribution and allow distribution of all received data to all terminals without editing.

Table 4: Summary of Changes in DX Specifications

	Overview of DX Specifications
Current	 Furnished with editing functions* in addition to data collection and distribution capabilities *Addition processing, scale conversion, packet assembly, header processing and bit editing
Future	 Specialized exclusively on data collection and distribution with editing functions provided by the Transmission & System Operation Division system (IP terminals)

3.4 Measures during the Period of Migration of all Power Supply Information Terminals to IP

To realize the future image of DX described above, all power supply information terminals (Transmission & System Operation Division system) must be migrated to IP.

However, taking into account factors such as the fact that the Central Load Dispatching Center system and the Integrated Control Center system have not yet been long in place as well as the costs of migrating terminals to IP, the functions of the newly-developed DX are as follows.

(1) Processing for existing (non-IP) terminals

- Current approach of distributing data to receiving terminals after implementing processing such as word editing within the DX

(2) Processing for IP terminals to be installed in the future

- Distribution of all received data to all IP terminals without processing such as word editing within the DX

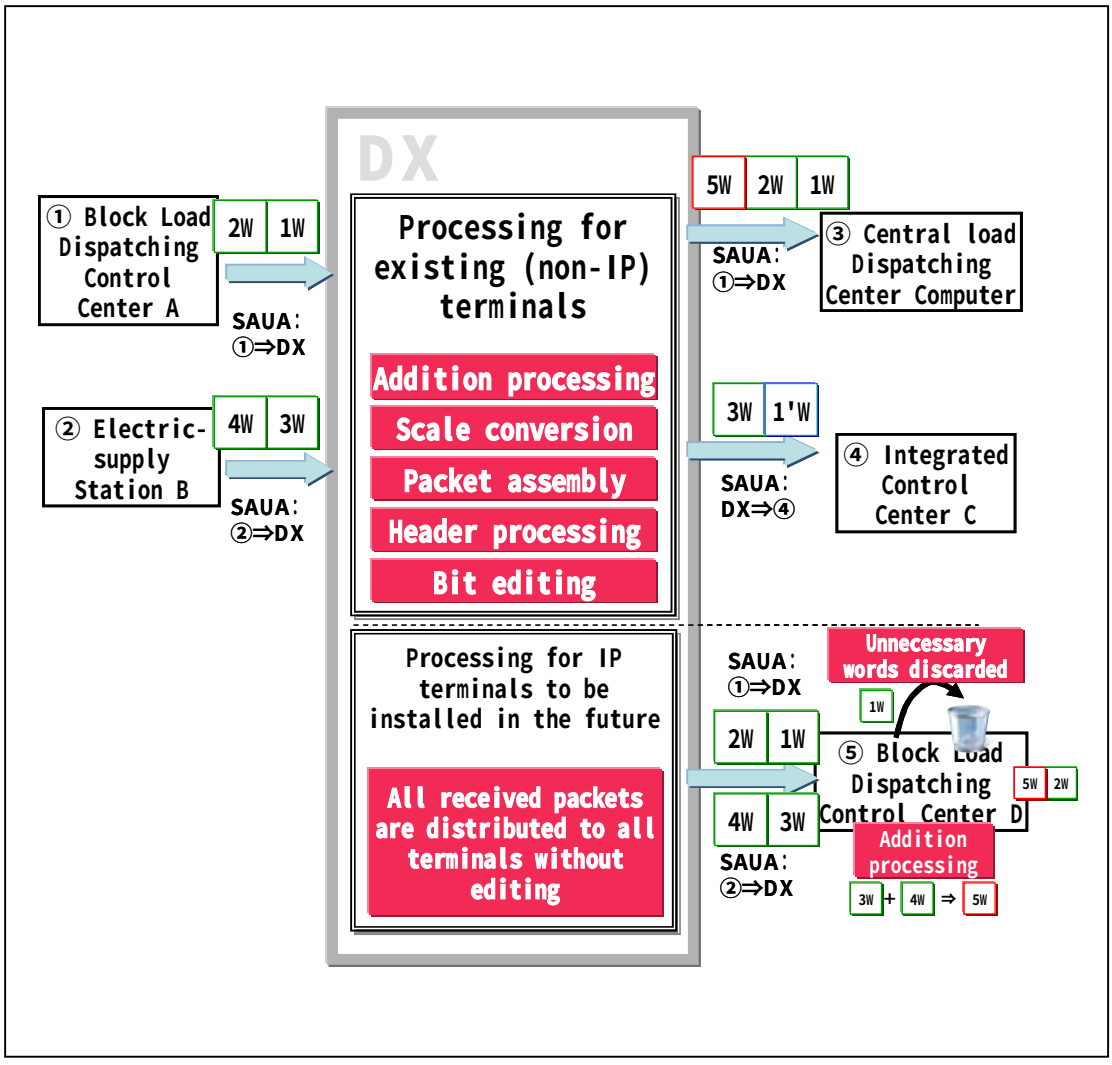


Fig. 3: Functions of Newly-developed DX

4. Conclusion

The power supply information transmission system is essential to the accurate transmission of power system equipment operation information required for the stable supply of electric power, and this means that it must be highly reliable and capable of low delay.

The newly-developed DX will undergo integration testing at the manufacturer's plant connected to the Transmission & System Operation Division system as well as field testing to fully assess aspects such as reliability and performance and verify compliance with the requirements of the power supply information transmission system.

While interconnection of renewable energy (e.g., photovoltaic and wind power generation) with power systems will grow in the future, renewable energy power sources are comparatively unstable with generated power varying due to factors such as differing amounts of sunlight available during the day and at night and weather conditions compared to power sources such as nuclear and thermal power that produce stable volumes of power. Therefore, it is anticipated that increases in power generated by renewable energy sources will give rise to a situation in which measures will need to be taken to cope with sudden fluctuations in the amount of power generated and the number of load dispatching instructions (control information) issued will be increased to suppress or urgently increase the amount of power generated by base-load power sources. In addition, considering the growing importance of the power supply information transmission system and its role in transmitting power supply information (monitoring information) needed for load dispatching instructions, we believe that the newly-developed system described in this paper will fully satisfy system requirements and contribute to the stabilization of power systems.

BIBLIOGRAPHY

- Joint Research on Electric Technology, Vol. 58, No. 4 (p. 100: Table 4-1-1 List of Requirements)