Wide-Area Optical Fiber Network Monitoring and Management System

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ABSTRACT The optical fiber cable networks that form the backbone of high-speed communications are increasingly being laid using the vacant spaces along rivers and roads, and in sewer conduits. This requires a system that can maintain and control, efficiently, accurately and on a nation-wide scale, the changing conditions of cable installation and usage for each fiber. It is to respond to this need that we have developed a wide-area optical fiber network monitoring and management system, to provide maintenance and control of optical fiber networks.

1. INTRODUCTION

The installation of optical fiber cables has proliferated with society's increased demand for telecommunications equipment, forming increasingly complex networks of lines. The areas where these are installed now cover the whole of Japan, and cables, which initially consisted of just a few optical fibers, and then a few dozen fibers each, have now reached 1000 or more fibers in each cable. This has brought massive increases in the amount of equipment.

Stable operation of these growing optical fiber networks requires efficient and accurate maintenance and control of the equipment as a whole and of each individual item. There is also a need for round-the-clock monitoring of optical fiber line networks, rapid and accurate pin-pointing of the location of any fault that might occur, and prompt restorative action. Accordingly at Furukawa Electric we have developed, as a means of maintaining and controlling optical fiber line networks, a monitoring and management system [1)~3)] which offers a monitoring function to detect faults such as increased loss, and a management function to create a database of information pertaining to optical fiber line equipment that can be easily searched.

These monitoring units and control units are mainly installed in outstations, and are primarily for operations at the individual outstation level. For this reason, in a situation in which optical fiber networks are growing and expanding throughout the country, it has become necessary to investigate several outstations as a means of determining the situation in equipment that are spread over long distances, and so to configure an optical fiber network monitoring and management system on a nation-wide scale.

Accordingly we have developed here a wide-area optical fiber network monitoring and management system that achieves, on a nation-wide scale, a grasp of the fiber usage situation in optical fiber line equipment, connection information, system information etc. for equipment control, and monitoring of fault information. This paper provides an overview of the system thus developed.

2. SYSTEM OVERVIEW

2.1 Configuration

This system comprises optical fiber line monitoring units (hereinafter referred to as monitoring units), optical fiber line control units (control units), optical fiber line central control units (central control units), and optical fiber line regional control units (regional control units). These units are connected by LANs or WANs. Figure 1 shows the overall system configuration, and each of the units is described as follows:

(1) Monitoring units: These comprise measuring units and monitoring units installed in outstations, etc., and central monitoring units installed in block stations, etc. A monitoring unit displays the location of any fault that may occur in the optical fiber line on the system diagram etc., and transmits fault information to the central monitoring unit and control units. The central monitoring unit collects monitoring results from each of the monitoring units to which it is connected, and when there is a fault, displays the fault information.

(2) Control units: These are installed in outstations. They aggregate the results of measurements from the monitoring units, and when notice of abnormality

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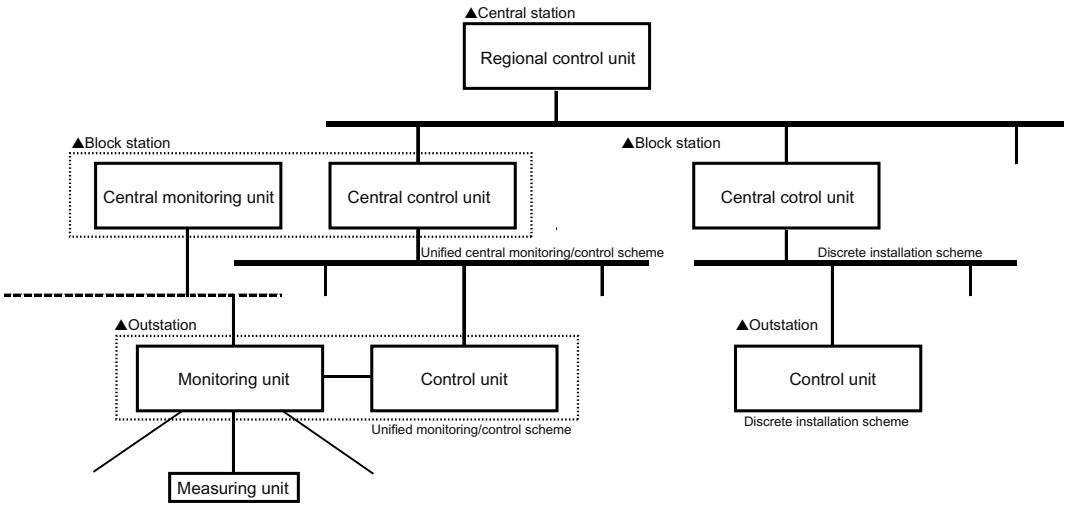

Figure 1 Overall system configuration.

information is received from a monitoring unit, pinpoint the fault location and display it on the map. They have the functions of searching, displaying and updating fiber connection information, equipment information and map information.

(3) Central control units: These are installed in the block stations, etc. They have the functions of searching and displaying fiber connection information, equipment information and map information under jurisdiction within block stations. They have the function of acquiring data on the manufacturers and type designations of equipment and on the names of the companies using lines that are recorded in the regional control units.

(4) Regional control units: These are installed in the central stations, etc. They have the functions of searching and displaying fiber connection information, equipment information and map information for the whole country. They have the function of recording and updating data on the manufacturers and type designations of equipment and on the names of the companies using lines that are used in common nation-wide.

2.2 Features

(1) Enables search and display of equipment information on a nation-wide scale: The manufacturers and type designations of equipment and the names of the companies using lines that are used in common throughout the nation are recorded as unified data in the regional control units. The central control units access the regional control unit, acquire the recorded names, and then use the names at the control units where input/output operation for equipment data are carried out, thereby making it possible to use names that are in common use throughout the system, and to search equipment information on a nation-wide scale.

(2) Enables smooth search and display of information spanning outstations: A configuration has been adopted whereby jurisdictional equipment data under the jurisdiction of block stations are controlled in a unified manner at the control database of the central control unit, not of each control unit, and equipment data is not dispersed for each outstation, so that by organizing equipment data between outstations, it is possible to achieve smooth searching and display for line information spanning outstations.

(3) Aggregates fault information from each outstation: Central control units are installed at outstations and the fault information at each control unit is aggregated, making it possible for fault information to be ascertained separately for each block station.

3. MONITORING UNITS

3.1 Configuration

Figure 2 shows the configuration of a monitoring unit. Since the optical fiber being monitored is connected via a terminal box, each monitoring device is installed in close proximity to the terminal box. In outstations in which an operator is present, a monitoring unit is installed, and in a block station, a central monitoring unit is installed.

3.2 Functions

The measuring unit uses an optical time domain reflectometer (OTDR) to make measurements sequentially and at fixed intervals with respect to optical fiber losses in the route that is targeted for monitoring, which passes through the fiber switching section and was previously designated, and by comparing the difference between the normal condition and the time at which measurement faults in the optical line are detected.

The monitoring unit aggregates control and management of the measuring unit and the results of measurements taken by the measuring unit, and by previously recording the connection point information, when it receives a fault transmission from the measuring unit, quickly pinpoints the location of the fault, and

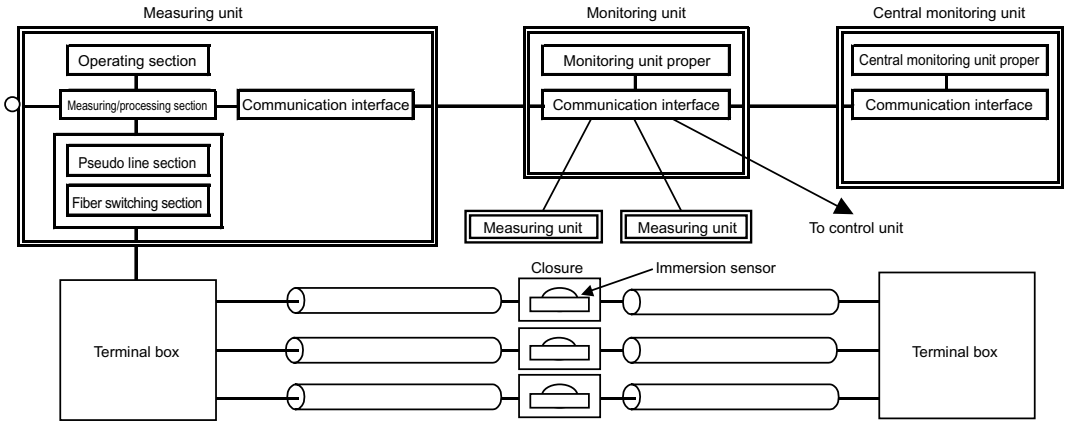

Figure 2 Configuration of monitoring unit.

Table 1 Main functions of monitoring units.

Function	Description
Automated monitoring	Automated monitoring at specified intervals
Fault detection and pinpointing	Display of information on position of fault
Manual monitoring	Monitoring of any desired line by manual operation
Contact point output	Route, unit abnormality

Table 2 Main display functions of central monitoring unit.

	Description
1	System diagram
2	Names of equipment (block station, outstation, etc.)
3	Fault route, fault point distance, fault history

transmits the fault information to the central monitoring unit and the control units. Table 1 shows the main functions of the monitoring units.

The central monitoring unit carries out periodic monitoring of each of the monitoring units connected to it, aggregates the monitoring results, and, when there is fault information, collects the route of the fault and displays the fault information. Table 2 shows its main display functions.

4. CONTROL UNITS

4.1 Configuration

Table 3 shows the specifications for each type of control unit. The central and regional control units use the highly reliable RAID 5 server. DAT is provided as standard for the backup of important data.

Figure 3 shows the structure of control unit software. The operating system used is Windows NT/2000, and Furukawa Electric Information Technology's EyeKernel-X is used as the map engine. The database engine is Oracle. In this environment a newly upgraded version of Furukawa Electric Information Technology's Eyepack-NET fiber control software is used. The central and regional

Table 3 Minimum specifications of control uit hardware.

Hardware item		Control unit	Central control unit	Regional control unit
Memory		512 MB	512 MB	512 MB
CPU		32 bits	32 bits	32 bits
Hard disk		18 GB	100 GB	100 GB
CRT monitor		17-inch	17-inch	17-inch
Storage device	DAT	12 GB*	12 GB	12 GB
	MO	640 MB*	640 MB*	640 MB*

* Add-on

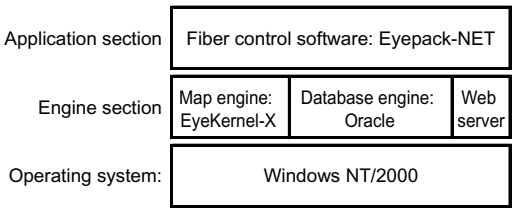

Figure 3 Structure of control unit software.

control units are provided with a web function, enabling search and display from operating terminals that can be connected by LAN.

4.2 Functions

The control data can, depending on its attributes, be modeled in three groups--equipment installation information, system diagram information and attribute information. Equipment installation information consists of data on line equipment installation--manholes (MH), pylons, conduits, etc. System diagram information consists of data on closures other than that which is related to geographical position, cables, and the connection conditions of each. Attribute information is information on each individual fiber and data on the condition of each connection point. Each of these levels is connected by a relational key.

Using this relational key, information on the cables and closures accommodated in equipment such as

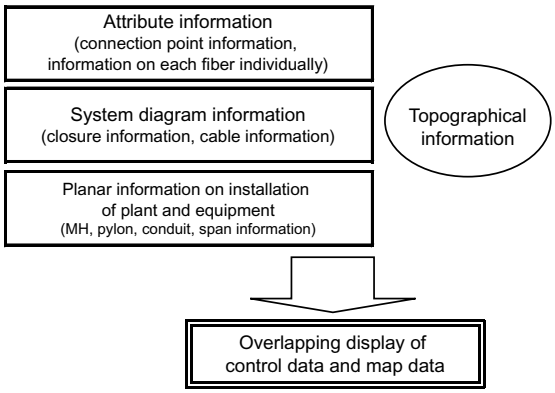

Figure 4 Relational diagram of data.

Table 4 Main functions of control units.

Function and Description
Update functions
Updating the equipment diagram and installations of equipment in the system diagram
Updating attribute information for each item of equipment
Updating fiber connection configurations for junction boxes
Search & display functions
Searching point of installation by means of the equipment diagram
Searching & displaying line equipment by means of the equipment diagram
Searching equipment passed by a specific fiber
Searching circuit (route), searching dark fiber
Searching junction box fiber connection configurations
Searching fibers in use
Searching desired conditions (search by name or specification)
Searching & displaying dark fibers and routes by setting for start and end points
Outputting CSV data for search results

manholes or conduits can be searched at the control units, and further searching is possible, even to fiber information. And superimposing these search results and topographical map information produces an easily understood display of the conditions of line installation. Figure 4 is a relational diagram of the data, and Table 4 shows the main functions of the control units.

4.3 Coordination Between Monitoring and Control Units

When a line fault occurs in the line being monitored, the control unit is notified via the monitoring unit of the fault information, together with an alarm, and a variety of information is displayed on the map by operation, including display of the location of fault occurrence.

Figure 5 shows an alert screen at the time of occurrence of fault trouble. Clicking on the “confirm” button causes the location of the line fault to be displayed on the map (Figure 6). From the screen displaying the fault location it is possible to confirm the location of fault occurrence, the name of the conduit (between manholes)

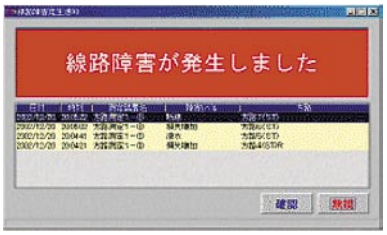

Figure 5 Display to alert of occurrence of fault.

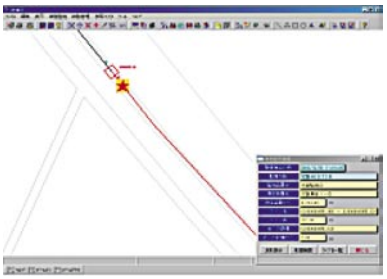

Figure 6 Display of fault location.

or of the span (between pylons) containing the cable in which the fault is thought to have occurred, and the length of that conduit or span, the name of the accommodating equipment nearest the fault location (name of manhole or pylon), the distance from that location, and so on. Thus when the fault occurs in a conduit, it can immediately be ascertained how far past which manhole should be investigated, and in addition it is possible to display the waveform measured by the measuring unit, the extent of the effect when it is determined that all fibers have broken in the cable incorporating the fiber in which a fault was monitored, and to display a listing of the cables incorporating the location of the equipment incorporating the fault concerned.

4.4 Functions of Central Control Unit

The central control unit treats the central control unit as a database server and the control unit as a client, and operates as a client server system. In this system, in order to process the maximum amount of data, attention is paid to the response time with respect to screen displays, and when in construction, etc., data entry or updating is frequent and is dispersed or distributed, equipment data, the organizing of which is difficult, is loaded to the central control unit and subjected to unitary management, and detailed map data, for which updating opportunities are rare and data volumes large, are loaded to the control unit, thereby improving response. Figure 7 is a conceptual diagram showing the data flow between a central control unit and a control unit.

Backup is achieved by continual replication of the control data in the central control unit by the control unit. Thus if there is a circuit fault or the like between the control unit and the central control unit rendering the control database of the central control unit inaccessible, there is the capability of switching over to the backup data

and continuing operation, so that no interference with the operations at the outstation level will occur.

The central control unit also has a search and display function with respect to the optical fiber line equipment under the jurisdiction of block stations that is similar to that of the control units. It is, for example, possible to make the name of a road or river into a single key, and perform search and display for a road that runs between outstations. Figure 8 is a typical search screen.

Here the equipment concerned are displayed in a listing. By clicking on the attribute buttons, equipment diagram buttons and system diagram buttons for the equipment that are to be displayed from this screen, it is possible to display a equipment diagram on which attribute information such as the conditions of use of the fibers connected to the plant or equipment, connection information and route information, and the situation in which the equipment are installed are shown graphically on a map, and a system diagram in which the situation of cable connections are shown linearly.

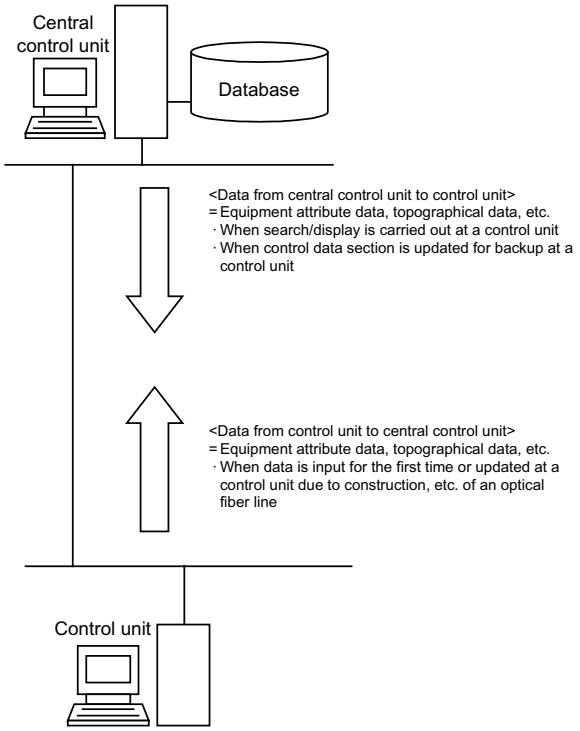

Figure 7 Data flow between central control unit and control unit.

Figure 8 River name search screen.

4.5 Regional Control Unit Functions

The regional control unit allows the recording and updating of data on the manufacturers and type designations of equipment and on the names of the companies using lines that are used in common throughout the nation. These names are recorded at the regional control center as unified master data. From the unified master data of the regional control unit, the central control unit generates pseudo unified master data, and when data is entered at a control unit, it accesses the central control unit and selects the required data from the pseudo unified master data, so that its content is unified throughout the nation and searching on a nation-wide scale is possible.

The regional control center is also able to perform search processing for line equipment nation-wide, but when the search is carried out at the regional control unit, it automatically determines the central control unit on which the control data to be searched is loaded, and directs the server of the central control unit to generate the required data. By receiving this control data, it is possible to perform search and display for line equipment nation-wide.

5. CONCLUSION

The system presented here has been delivered to the Ministry of Land, Infrastructure and Transport, and has begun operation. It is intended to investigate the extent to which updated equipment data can be efficiently applied to the system, and to improve performance to respond effectively to users' needs.

REFERENCES

1) Yamashita and Hasemi; Supporting System for Optical Fiber Installation Work, Furukawa Electric Review, No. 103, 1998, 13. (in Japanese)
2) Sakemi et al.; Application of GIS to Management Supporting System of Optical Fiber Transmission Line, Furukawa Electric Review, No. 107, 2001, 45. (in Japanese)
3) Umezaki and Sato; Development of Management and Supervisory System of Optical Fiber Transmission Line. (in Japanese)