INFORMATION NETWORKS IN ELEVATOR SYSTEMS

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ABSTRACT

Today, an elevator system forms a network, which includes a group controller, remote monitoring systems and other optional intelligent equipment. Therefore, in order to improve the system, the network is forced to be wider and more complicated, so that it can deal with greater and more various types of information. To cope with the above-mentioned situation, it is desirable to introduce a network layer (NWL) protocol for elevator communication systems. In this paper, some features of an elevator network protocol are outlined together with examples of its application.

1. INTRODUCTION

An elevator control system consists of several equipment located separately, such as, the main sequence controller and traction motor controller in the machine room, the door controller on the car, switches and displays for passengers in the car and in the elevator hall. In a conventional system, all information used to control the elevator is centralized to the main sequence controller in the machine room. Recently, in order to reduce the number of wires, serial communication technology is widely adopted by equipping each component with microprocessors. Including the group control system, the monitoring system in the building central station and the maintenance center connected with public telephone network, the elevator system forms a complicated network. (Fig. 1 shows a typical communication network of a modern elevator system.)

On the other hand, some of the components need to communicate with many equipment located separately. In order to realize higher quality of maintenance, the maintenance center requires more information from each elevator component. In the same manner, in order to get higher quality of in-building monitoring and controlling, the central station requires to make closer communication with each elevator component.

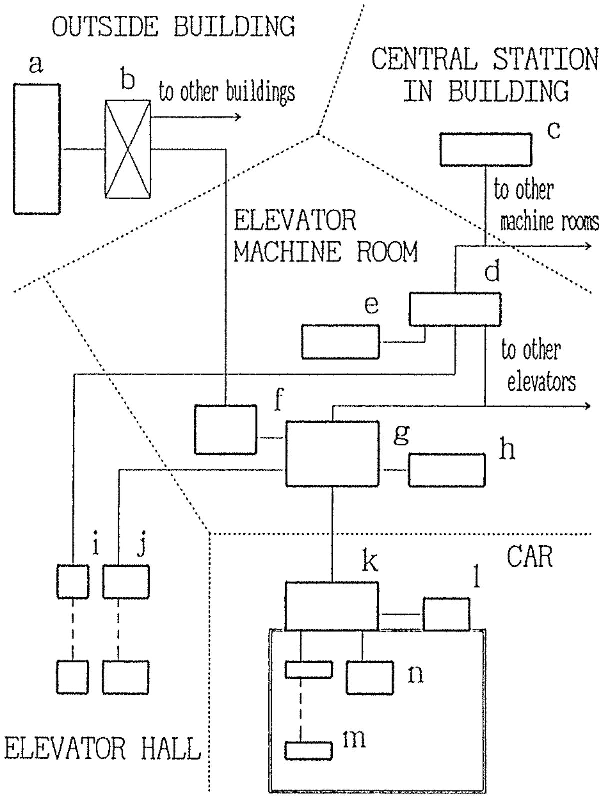
The issue is how to realize such applications efficiently in the complicated network. When, for example, in-car information display is required to deal with messages that are sent from the building central station, in addition to the messages that are sent from the on-car sequence controller according to the state of elevator, we have to re-design every intermediate relay node in the path from the central station to the display controller, in addition to both ends of the path (Fig. 2). Such a complication may prevent flexible extensions of an application.

2. INTRODUCING NETWORK LAYER ARCHITECTURE

We can think of two approaches to avoid the above complication either by :

(1) Connecting nodes directly by wires (Fig. 3)
There are no relay nodes for the messages, so we can avoid re-designing. However, there is a need for additional hardware;

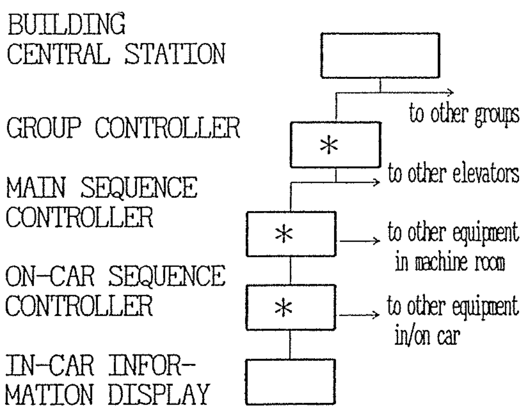
(2) Introducing network layer protocol
The fundamental facility of NWL is routing messages between such nodes which



NOTES)

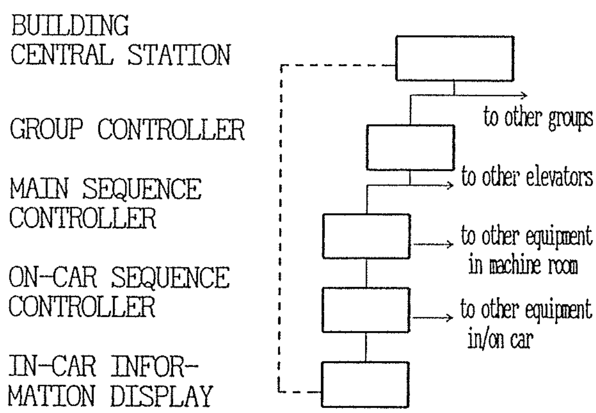
a : Maintenance center
b : Public telephone network
c : Elevator monitoring system
d : Group controller
e : Intelligent group controller
f : Elevator tele-monitoring unit
g : Main sequence controller
h : Traction motor speed controller
i : Switches and indicator controller in elevator
j : Information display in elevator hall
k : On-car sequence controller
l : Door motor controller
m : Switches and indicator controller in car
n : Information display in car

Fig.1 TYPICAL COMMUNICATION NETWORK OF ELEVATOR SYSTEM



NOTES)
* : Relay nodes in the path from central station to in-car information display

Fig.2 RELAY NODES



NOTES) --- : additional communication line

Fig.3 ADDITIONAL COMMUNICATION LINE

are not connected to each other directly by physical media. By installing the facilities to every nodes in the path, any message can be relayed to its destination node. If we base this on the concept of layered architecture described in the so-called OSI (Open systems interconnection) model, we can derive the following benefits.

(a) We can use any type of protocol in the lower layers, namely, HDLC or any of our original datalink layer protocols, RS-422 or RS-485, or any of our original physical layer protocols.

(b) We can use any type of protocol in the higher layer.

(c) The network program module is applicable to any node in elevator system, once it is designed.

Because of its capability of evolution, we have adopted the latter approach, and developed "Fujitec Information Network for Elevator system (FINE)" as a network layer architecture for our in-elevator network communication system. In section 3, the following features of FINE are described.

- Topological model of FINE (3.1).
- Selection of communication mode (3.2).
- Addressing of destination, and routing to the destination (3.3, 3.4).
- Facilities that make FINE more useful in designing elevator system
  - Segmenting and Blocking of data frame, Multiplexing of connection, Negotiation of NWL protocol version etc.(3.5 - 3.7).

3. FEATURES OF "FINE"

3.1 TOPOLOGICAL MODEL

Elevator systems have to be flexible in its communication network topology because the topology will continue to change due to endless improvements in elevator control technology, and also due to demands by customers for adding various optional equipment in various position. Of course, the design of topology is closely related to addressing and routing. By introducing a relative addressing and source routing method, FINE can be adapted to various structures of network. The details of addressing and routing of this architecture are described in 3.3 and 3.4. The following is the topological model of FINE.

The basic elements of network are the "node" and "link". The "node" is a system element that may perform both data transmission and data processing or data transmission only. The "link" is a physical route for communication, connecting two or more nodes. An elevator network is modeled as a combination of two sorts of elementary topologies, that is, "tree" and "bus".

A tree is a group of several nodes and links. In a tree, every node is linked to one node that is the parent node for that node, and also to several nodes, for which it is the parent node. As an exceptional case, in every tree there is only one node that has no parent node in the tree, which is called the root node (Fig. 4).

A bus is a link that connects two or more nodes in different trees (Fig. 5). The nodes connected to each other through a bus are called as "stations" of the bus. Each of the stations constituting the bus is also an element of a tree.

3.2 CONNECTION AND CONNECTIONLESS ARCHITECTURE

Generally speaking, there are two different approaches to transmission architecture. One is "connection mode transmission", and the other is "connectionless mode transmission".

Although connection mode needs an establishment and release process in addition to data transmission process, it enables us to designate the destination node in data transmission process by a short "channel number" instead of a long full "destination address". Also, it makes flow control possible, and makes it easy to control dialogue-type communication. On the other hand, connectionless mode which needs the full expression of the destination address every time is efficient for infrequent communication.

Thinking of an elevator system, both modes are useful. Using a portable computer for regular maintenance to access the memory in elevator control microcomputer has become popular recently. Remote monitoring of the memory in the microcomputer through the public telephone network for preventive maintenance or quick response to any trouble is also widely used. Connection mode communication is useful for those purposes because a trouble shooting session using a portable computer, or a monitoring procedure through telephone circuit includes a series of reading out and writing operations. Whereas, the transmission of data from the building central station to the in-car display controller for changing the displayed message is executed sporadically. In such a case, connectionless mode communication is useful.

In FINE, both communication modes are available by introducing 3 types of NWL frames, as shown in TABLE 1.

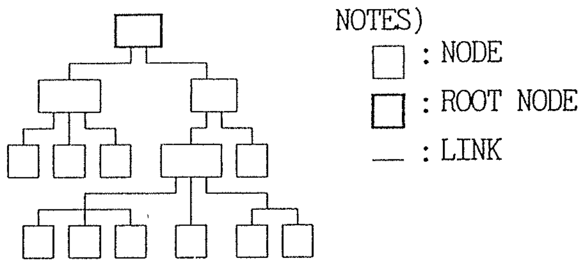


Fig.4 EXAMPLE OF ELEMENTARY TOPOLOGY "TREE"

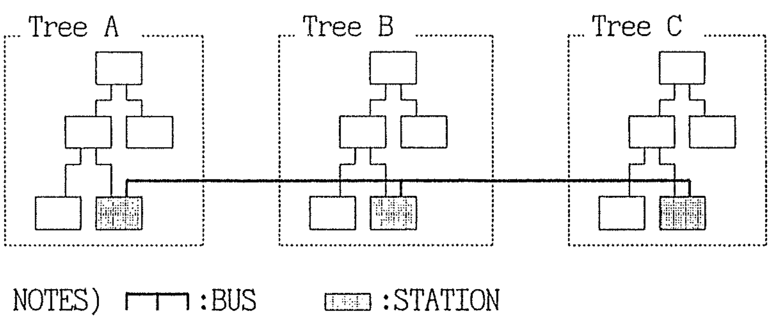


Fig.5 EXAMPLE OF ELEMENTARY TOPOLOGY "BUS"

TABLE-1 THREE TYPES OF "NWL" FRAME

FRAME CLASS / CONTENTS IN THE FRAME	CONNECTION MODE		CONNECTION LESS MODE
	CONTROLLING FRAME	MESSAGE FRAME	MESSAGE FRAME
Command (CR,ACR, etc.)	*	—	—
Destination addresess	*	—	*
Source address	*	—	*
Channel No.	*	*	—
Data	—	*	*

NOTES) * : The frame of the class includes this.
CR : Connection Request Frame.
ACR : Acceptance of Connection Request.

3.3 ADDRESSING

Addressing means the way of expression how to designate the object node.

FINE introduces "relative addressing". Nodes have neither globally known identities nor absolute addresses. Only a relative path which a message should follow is shown in the header as a designator of the object node. Then, who should determine the path and build up the relative address in the header? In both cases of connection and connection-less mode, only the node that starts a series of communication and takes the initiative in the dialogue, has to know the information about the path between the node itself and the object node. The object node, which is the passive partner in the dialogue, can find the partner's relative address only by checking the source address part in the frame header just received.

In general, absolute addressing is used widely, and it seems to be a simple one. However, introducing absolute addresses makes it necessary to have a total and fixed topological design of the network. The main reason why we have introduced relative addressing is that a fixed topological design obstructs flexible extension and development of elevator system.

It may seem that building up the full path to the object node is very complicated. In practice, only a few equipment such as the central station in building, the maintenance center and portable computers for maintenance, will start the communication, take the initiative of dialogue, and should have the ability of building up the path. It is relatively easy to revise the algorithm of building up the path in these equipment, because they are not embedded computers but stand-alone ones.

3.4 ROUTING

Routing methods can be classified into the following three ways:

(1) adaptive routing — the path that a NWL message has to follow is determined from real time information of traffic or circuit failure.

(2) routing by fixed routing table in each node.

(3) source routing — the path that a NWL frame has to follow is described in the header of the frame.

Communications of critical use in an elevator system should be realized by directly connected physical media, and also form dual systems if necessary. In other words, the network system with relay nodes is of supplementary use in an elevator system. Thus the first method would be an overspecification for elevator networks, considering the complexity of design.

In case of the second method, every node in the network has to have a routing table, namely, it has to know the whole structure of the network in which the node is included. It means that the routing table in every node has to be rewritten when any node is added to or removed from the network. This conflicts with the aim of flexibility in extending applications that use communication between microcomputers.

FINE adopts the third method because such a system is very flexible. Even when any new node is added to or removed from the network, only a few nodes need to update the selecting algorithm. (A node determines to which link should a NWL frame be sent out by the frame header and the algorithm.) Namely, those nodes that are adjacent to the changed node, and those that want to communicate through it, need to know the change of network structure.

In FINE the routing information in the NWL frame is the destination address itself (see 3.3). In case of connectionless mode, the header size of NWL frame might be long in all frames because of the address. In case of connection mode, it need to be long in "connection request (CR) frame", and "acceptance of connection request (ACR) frame" in the same way. However communication in the former mode is not used so frequently, and the CR and ACR frame in the latter mode are used only at the starting and ending stage of a series of communication. Thus, NWL frames being longer has a negligible effect on transmission efficiency.

3.5 SEGMENTING/REASSEMBLING AND BLOCKING/DEBLOCKING

The NWL protocol should be available to various types of higher layer protocols, that is, to various types of applications. The length of a higher layer message frame may be longer or much shorter than the maximum of NWL frame. The NWL facility has to transfer both of these types of higher layer message frame efficiently. In FINE we have introduced a segmenting/reassembling facility and a blocking/deblocking facility (Fig. 6).

At the source node, such higher layer frames which are longer than the longest NWL frame, are segmented into two or more parts and one NWL frame is built for each part. At the destination node, the fragments of the higher layer frame in these NWL frames are reassembled (segmenting/reassembling).

If several frames of extremely short length are given by the higher layer in a short period, the NWL gathers two or more these frames and builds one NWL frame in the source node. At the destination node, the higher layer frames in one NWL frame are deblocked to their original frames (blocking/deblocking).

In the same way, generally speaking, similar facilities are desirable in the data link layer. A NWL frame may be available to various types of data link protocols that depend on the physical characteristics of the communication hardware.

3.6 MULTIPLEXING/DEMULTIPLEXING

Two or more simultaneous requests of accessing through one network link or accessing one node is likely to occur. For example, an accessing to the on-car sequence controller as a daily monitoring from the maintenance center can occur simultaneously with the accessing to the main sequence controller in the machine room from the in-car connector by a portable computer as a monthly maintenance. It is undesirable to reject the later accessing.

FINE enables such a simultaneous accessing by introducing a multiplexing/demultiplexing facility. The multiplexing/demultiplexing facility means that two or more connections can be established simultaneously through a single link. Each of the multiplexed connections is distinguished by a channel number. Fig. 7 shows an example of using this multiplexing facility in the case described above.

3.7 NEGOTIATION OF PROTOCOL AND OPTIONAL CAPABILITIES

Of course, there is a possibility that this NWL protocol will be improved in the future. And also, there is a possibility that nodes of old and new versions are linked to each other, for example, when:

(1) Optional equipment with new version is installed in an existing elevator with old version;

(2) Some part of an elevator system is modernized.

FINE has negotiation facility of protocol version and optional capabilities. Specific protocol version and optional capabilities are presented in the CR frame by the node that starts a series of communication. The CR frame is passed on through relay nodes one after another to the destination node with description of protocol version and optional capabilities being modified to the greatest common level. In the return trip as an ACR frame, the results are confirmed by every relay node. Fig. 8 shows an example.

4. APPLICATION

This section shows JOB-SITE MAINTENANCE WITH PORTABLE COMPUTER, and REMOTE MAINTENANCE SYSTEM in Fujitec elevator system as examples of FINE. These application can be realized by installing FINE in the following (1) to (4) computers (Fig. 9).

(1) Microcomputer for main sequence control in machine room. (MSC)

(2) Microcomputer for on-car sequence controller on car.(CSC)

(3) Portable maintenance computer.(PMC)

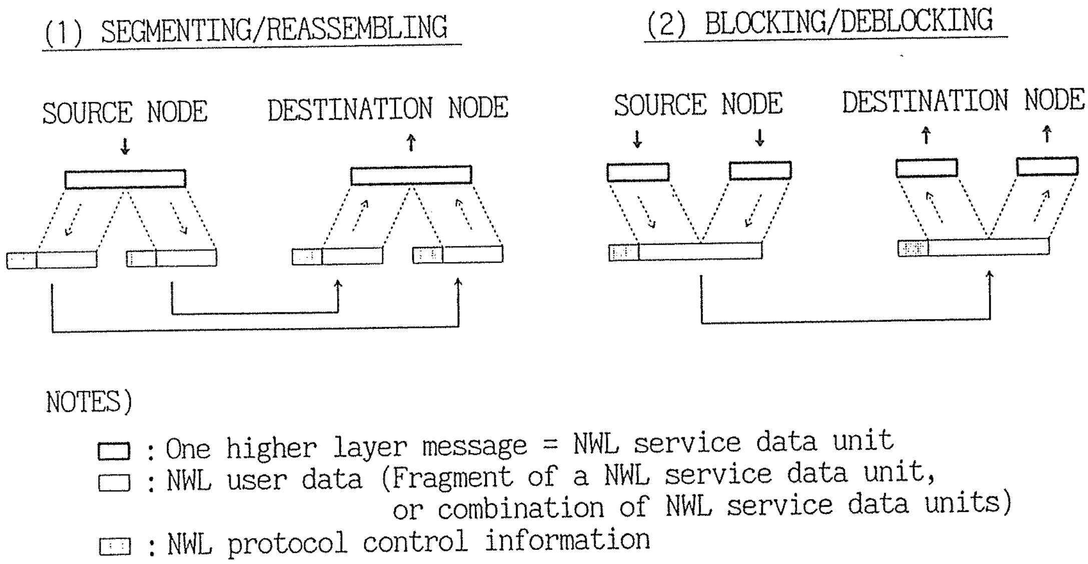


Fig.6 SEGMENTING/REASSEMBLING AND BLOCKING/DEBLOCKING

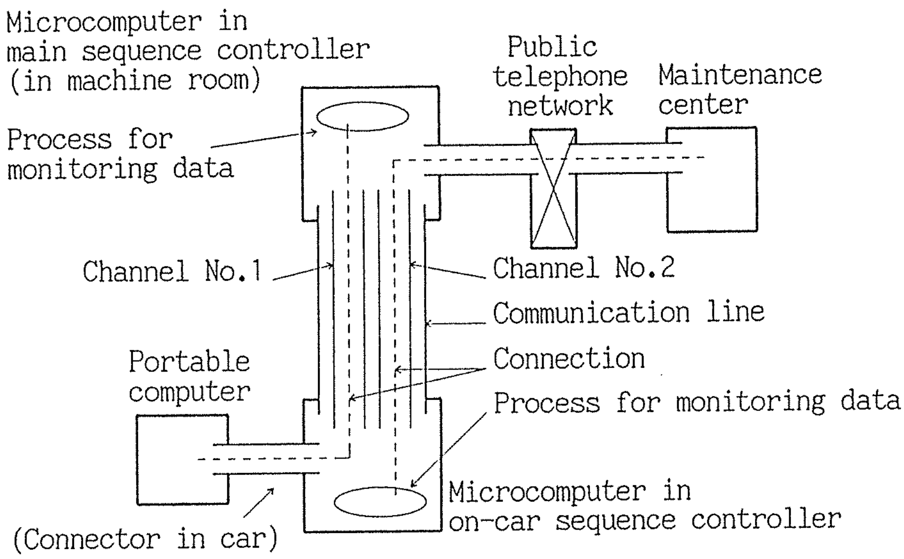
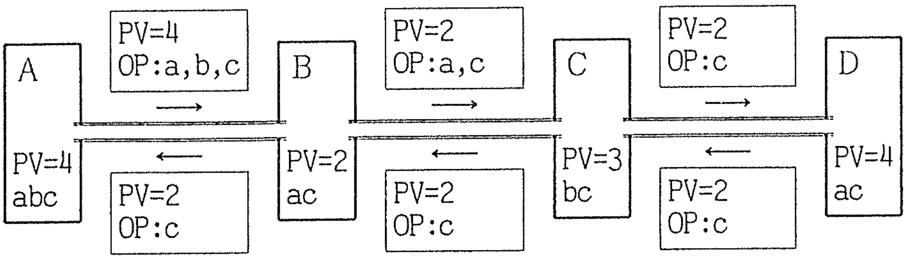


FIG.7 EXAMPLE CASE OF MULTIPLEXING/DEMULTIPLEXING



NOTES)

: a Link.

: a Node. · "PV=" means the maximum protocol version that the node can follow.
· "a","b" and "c" means the optional NW facilities that the node has.

: a CR Frame. · "PV=" means the protocol version designated in the frame.
: an ACR Frame. · "abc" means the optional NW facilities designated in the frame.

- The Node "A" is trying to establish a connection with the node "D".
- In this example, the connection between "A" and "D" will be established in protocol version "2" with optional facility "c".

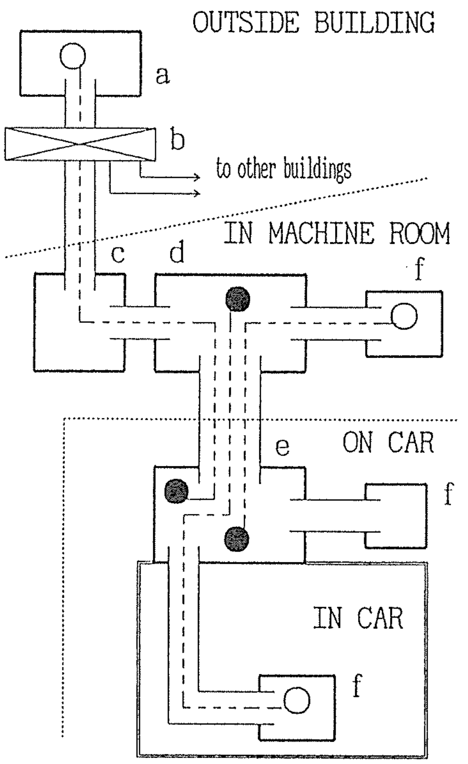
Fig.8 NEGOTIATION OF PROTOCOL VERSION AND OPTIONAL CAPABILITIES

(4) Maintenance center (MCT) computer for remote monitoring of elevators through public telephone network.

PMC is a portable size computer, with a keyboard including ASCII characters, an LCD screen, and an RS-232-C interface. MSC and CSC have also RS-232-C interfaces. After connecting the PMC to MSC with the RS-232-C interface, a serviceman can read out records and indications of failure as a result of self-diagnosis feature in the MSC, the states of MSC I/O-interface, and so on. He can also adjust parameters of speed regulator, rewrite data for selecting elevator options related to MSC's facility. Connecting PMC to CSC in the same way, the serviceman can read out, adjust and rewrite similar items in CSC.

Without NWL facility, the serviceman in the machine room would have to go to the car to get the information in CSC, and a serviceman who wants to adjust the riding comfort by adjusting the speed regulation parameter in MSC has to run between the machine room and the car. As a result of installing NWL facility, the serviceman can read out the result of self-diagnosis done by CSC etc. from inside the machine room, without climbing on top of the car, or entering the car. In the same manner, when operating the elevator from inside the car, he can adjust the parameters of traction motor speed regulator.

The tele-monitoring-unit, which is the interface between the Elevator controller and the public telephone network with MODEM, NCU, and speech communication device between the MCT and passengers in the car, is connected to MSC with serial communication interface.



NOTES)
a : Maintenance center
b : Public telephone network
c : Elevator tele-monitoring unit
d : Main sequence controller
e : On-car sequence controller
f : Portable maintenance computer
○: Node which has initiative in dialogue
●: Node which is passive in dialogue
--- : Established connections as an example

Fig.9 CONFIGURATION OF FUJITEC ELEVATOR SYSTEM RELATED TO PMC AND MCT AS AN EXAMPLE OF "FINE"

Without the NWL facility, CSC transmits constantly to the MSC all data that might be useful for the MCT, and the MSC has to have a large memory to store them. As a result of installing the NWL facility, the MCT can read out information both in MSC and CSC when accessing them for daily preventive maintenance, or in case of any failure of an elevator, without additional data transmission or additional memory.

In addition to the fundamental effects described above, we have the following benefits by means of the facilities described in section 3.

(1) PMC and MCT will be available for any structure of networks in the future, only by adding addresses for the new network.

(2) Connection mode transmission enables communication with the least overhead in transmission.

(3) The segmenting/reassembling and blocking/deblocking facility enables the PMC and the MCT to use their own higher layer protocol without restrictions on their frame length.

(4) The multiplexing/demultiplexing facility enables concurrent accessing by the MCT and PMCs.

(5) Even if the NWL protocol is revised in the future, the negotiation facility enables equipment with the new protocol to communicate with those with the earlier protocol.

5. CONCLUSION

Introducing network layer protocol based on layered architecture is very useful for information networks in elevator systems. It provides advatages especially in fields of remote monitoring and controlling of elevator for maintenance and building management, and controlling displays in cars or in the hall. Furthermore, once a program module of NWL facilities is developed, it can be applied to various types of applications in the higher layer and to different conditions in the lower layer.

Points to be considered in designing NWL protocol for elevator system are:

(1) applicability to various types of topology;

(2) no limitation to specific application protocol;

(3) no limitation to specific lower layer protocol and physical media;

(4) interconnectability among equipment of different protocol versions.

We have described some features of the NWL protocol used in Fujitec elevator systems that we designed taking these points into consideration.

Future demand and development of technology in elevator management and elevator control systems will require larger quantity and higher quality of information flow in elevator systems. Introducing a NWL protocol will be helpful to elevator systems in avoiding excessively complicated structures, and will encourage flexible and smooth development. Thus the network architecture itself will be developed according to the requirements of real time control and fault-tolerant techniques.

Biographical notes

The author received the M.S. degree from Kyoto University and joined Fujitec Co.,Ltd. in 1979. In 1989, he entered Fujitec Research Center Ltd. He has been engaged in development of software technologies for elevator control.