The Elevator Monitoring System with JAVA

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ABSTRACT

Conventionally, the EMS (Elevator Monitoring System) have been built with a completely closed local network structure. In recent years, networks with the TCP/IP protocol became very common for general purposes, spreading rapidly since they were used for the Internet, and thus also becoming very inexpensive. Recognizing this trend, FUJITEC has developed a TCP/IP network-based EMS using the Java language (developed by Sun Microsystems) in combination with WWW Servers. We have proved that the EMS on this LAN (Local Area Network) is more flexible and more extensible than the traditional solutions. We believe that TCP/IP and WWW with JAVA will become more and more advantageous for an EMS as LANs spread in the building.

1. GENERAL

In the past, FUJITEC had been using its original embedded computers and serial communication for the Elevator Monitor System (EMS) in buildings. For giving more customer satisfaction, we have now developed a new system using many new features:

- Ethernet+TCP/IP
- Java™
- General purpose (PC-compatible) computer
- General purpose OS (Operating System) Linux

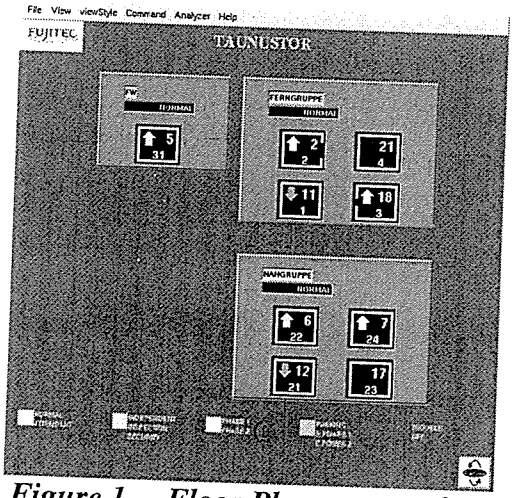

Figure 1. Floor Plan screen of EMS

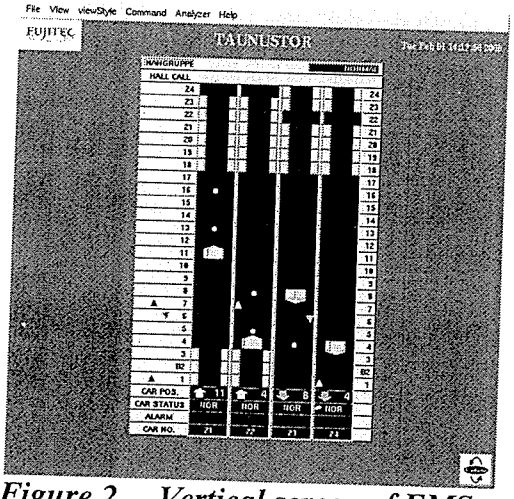

Figure 2. Vertical screen of EMS

We have already announced the main features of this system in several reports (S.Markon et al, 1997a, 1997b, 1998), and it is already shipped as a product. For instance, this new system is used as the EMS in the 'Japan Center' building in Frankfurt (Main), Germany (***Figures 1 and 2***).
Here, we present our reasons leading to the development of the new EMS. First, we describe the reasons for adopting TCP/IP as the communication protocol; next, the advantages of the new Java technology; and finally, the merits of cooperation with a WWW server.
For those people familiar with TCP/IP in the OA (Office Automation) field, it might be unclear why an exposition of TCP/IP is needed at this time. However, we think that we need to explain the necessity of TCP/IP, because we have noticed that using TCP/IP was not the *'common sense'* solution in the embedded field.

2.Adoption of Ethernet + TCP/IP as communication medium

2.1. Elevator Monitor Systems (EMS) in buildings

The EMS in buildings has an old history as part of the security system. The reasons for installing them is that a building manager want to include function such as monitoring the operating situation of elevators and escalators in the building; switching the operating mode of elevators directly; and executing schedule control by timers to the security system. They are sometimes called 'CRT Watching Boards'. These usually have closed signal path networks. RS-422 (or RS-485) is often used for the communication media of these networks. Since they use differential signals, they are resistant to noise; 100 kbps transmission speeds are possible, with the maximum transmission range at about 1 km, and the transmission rate decreasing in inverse proportion with the range. Makers using such closed designs often develop original communication protocols for these. In most cases, information on the protocol is guarded jealously. This has made it almost impossible to link up the maintenance system networks of different makers, while these systems had the advantage that security was easy to provide. Sometimes information had been forwarded by the awkward method of converting serial communication once by relay contact and optical coupler, and then by trying to convert it into serial communication again.

2.2. Features of Ethernet + TCP/IP

2.2.1 The creation of Server/Client models is easy.

TCP has the concept of 'socket' for connection.
When using TCP/IP, a Server and Clients connect by the socket, and it is just as easy to connect one node or multiple nodes. An advantage of the Server/Client model is that information can be distributed on a large scale at an fast rate by Clients becoming Servers (see ***Figure 3***).

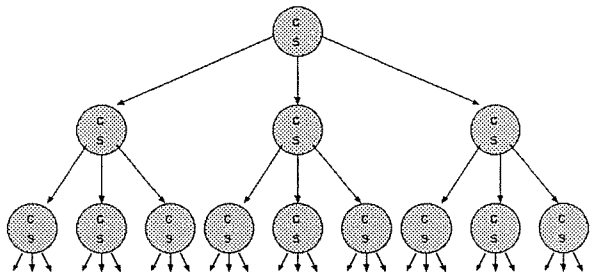

Figure 3. Hierarchical Communication protocol of service by Server/Client Model

The Server/Client model is standardized according to various usages, which are openly available (see ***Table 1***).

Table 1. Common open protocols over TCP/IP

http	File transfer for World Wide Web browser protocol
ftp	General file transfer protocol
smtp	Mail server forwarding protocol
pop	Mail client fetch protocol
ntp	Network time keeper protocol

2.2.2 The kinds of media are abundant

Ethernet is now the virtual standard for communication media, and a variety of physical media can be selected according to the usage, such as cable, wireless, optical, infrared rays etc. If a suitable media is chosen, it is possible to use communication from mobile objects such as places like the glide slope in airports, or trains. Of course, it also includes elevators. Actually, it is not novel at all to have optical cable in traveling cables.

2.2.3 Long distance transmission and high number of connected nodes

There used to be the problem that the increase of communication traffic limited the allowable number of connected nodes; but the appearance of switching hub improved this problem dramatically. Moreover, the spread of the optical cable removed the range limitation of Ethernet.

We should mention here some other communication devices and protocols, such as MODBUS etc. which use LON and RS485, which are well known for use by control equipment. Since the application of these is usually limited to the embedded field, they cannot be compared in popularity and availability with Ethernet and TCP/IP.

2.3. Examination of adoption of TCP/IP for Elevator Monitor System

The balance of merit and the drawback of basing EMS in the building on TCP/IP, considering the above, is overwhelmingly at the merit side.

The following are the main points:

- Dramatic decrease of cost
- Wide availability of the technology for TCP/IP
- Availability of new technology of signal compression in communication
- Demand for open information systems in buildings
- Demand for reduction of signal cable cost due to the increasing scale of buildings

The time for conversion from the past serial communication to Ethernet + TCP/IP has arrived.

2.4. System changes needed for the adoption of TCP/IP

There is still a drawback accompanying with the adoption of TCP/IP. It is the complexity of the protocol. The TCP/IP protocol is quite complex, and the load of implementation to embedded systems is large. Especially when using a non-standard original computer and a monitor program developed for embedded systems in-house, the cost for building in the protocol of TCP/IP is large. The conventional system of FUJITEC was just such a system, so adoption of TCP/IP would have been very difficult without changing the system hardware. We present solutions for this below.

1) Use a general purpose embedded computer

It is now possible to purchase a very compact PC-compatible single-board embedded computer at a low price. For instance, we can get one, complete with video and Ethernet interface, memory, power supply and hard disk, at a price of less than US$1000 (Advantech 1999). Thus one solution is to give up the embedded board made in-house, and adopt a general purpose OS with such an inexpensive general-purpose embedded PC.

2) Use an add-on board

It is difficult to convert all applications to general-purpose hardware, if one wants to make the best use of existing software and hardware resources. Thus, one might want to convert only the serial communication to Ethernet + TCP/IP by adding a communication converter. Various products have appeared on the market, recognizing the needs for such a converter in embedded systems. For instance, a recent card computer of the size of SIMM (Single In-line Memory Module) exists that can convert from Ethernet to serial communication, and run a WWW server program at the same time, which is available at the price of $50 (Dallas Semiconductor, 1999). An existing original product would need only a minor redesign if such a board is used as a converter device.

FUJITEC uses these two methods according to the equipment and the functions, to change gradually the Elevator Information System. However, for such parts where close cooperation is needed with the control system, and where no need exists to make the information open, the transition to Ethernet would be premature.

2.6. System example of adopting TCP/IP

We introduce the application of Ethernet to a recent large scale building.

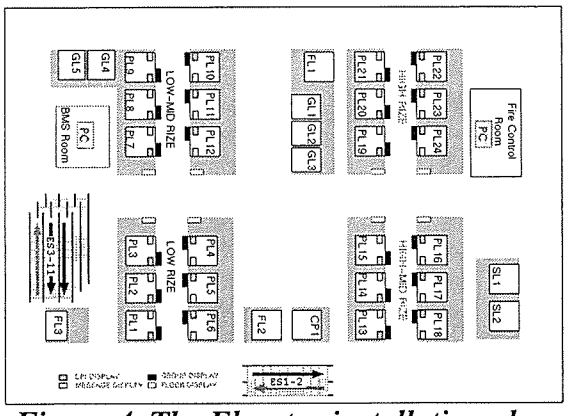

Figure 4. The Elevator installation plan

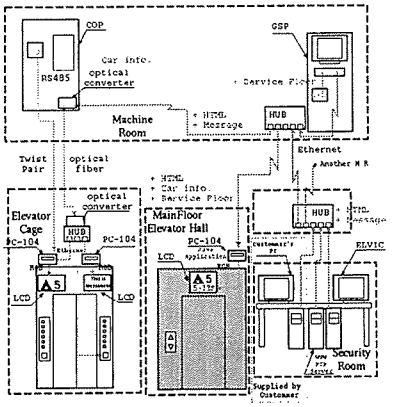

Figure 5. System when Ethernet is adopted

The building has 4 groups of elevators of six cars each, and some other elevator groups, as shown in ***Figure 4***. In each of a total of 28 cars, two displays giving information are installed in each car. There are a further 24 displays for information installed in the main lobby. ***Figures 6*** and *7* show examples of the screens planned for these displays.

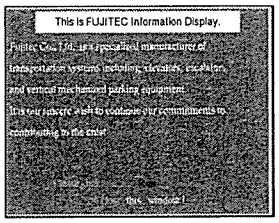

Figure 6. Information display Screen

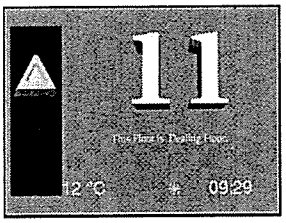

Figure 7. Car Position Indicator

Moreover, various information on all elevators and escalator is presented to the BMS (Building Management System). This necessitates the exchange of a large amount of information between the elevator/escalator equipment and the BMS equipment. There are easily more than 100 computers exchanging information directly. If we wanted to use an old-fashioned *peer to peer system* such as connecting the server and clients one by one, a huge

number of cable connections to BMS equipment would have been needed. When using Ethernet for wiring to the BMS, we need only to pass a line of small Category5 cable instead of a lot of serial cables. High-speed communication with Ethernet can achieve the simplification of the wiring system while allowing the transmission of huge amounts of information to the information terminal, and facilitates system change or expansion in the future. In addition, the maintenance costs of these communication systems can be reduced. (*Figure 5.*)

3. Adoption of Java as Programming Language

Embedded systems were usually developed using proprietary development languages, or a general language such as C. Of course, there has been a reason for adopting those languages for different equipment, and there is still enough merit in using one of those languages according to the application. However, for using TCP/IP to construct EMS in the building, or for a graphical interface, they have disadvantages. Below we explain our reasons for adopting Java, as the language which would be the most suitable for the development of this system.

3.1 The advantage of Java concerning the use of SQL(Structured Query Language).

The schedule function is indispensable in EMS. Because, for instance, the building manager will want to schedule various limits on the registration of calls at nighttime, for security reasons.

The advantage of treating this schedule data as a database was noticed through experiences with our older system, which had treated the schedule as usual data.

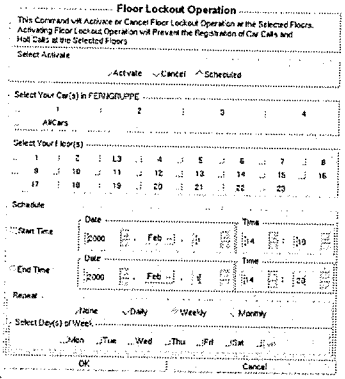

Figure 8. Input screen of schedule from EMS

Some of the advantages are the following:

1) The demand of a retrieval and statistical processing can be completely separated from EMS used from the independent application.
2) Service can be offered to two or more clients on other OS including scheduling.
3) The maintainability of the program is imploded because the database management function becomes independent.

Then, we decided on the adoption of SQL, which is widespread as databases processing. Recently, a free SQL server became available (PostgreSQL 1999) which has highly developed functions. Using SQL increase the advantage of adopting Java, because the database access library called JDBC, which can the handle SQL, had been enhanced in Java.

3.2 Advantage concerning cooperation with WWW servers

Various functions required for cooperation with WWW servers are implemented in Java. Let us think about the utility of 'applets'. An 'applet' is a mechanism by which a program is run via a WWW server. Because the computers of each user execute the 'applet' by themselves,

the load on the server is kept to the minimum, even when an increasing number of clients execute the applet,. After a program has been developed as a stand-alone application, it can be easily remodeled as an applet. It is possible to confirm the functions and the looks of an applet by simulating the behavior of the program to be remotely executed as shown in the figure below.

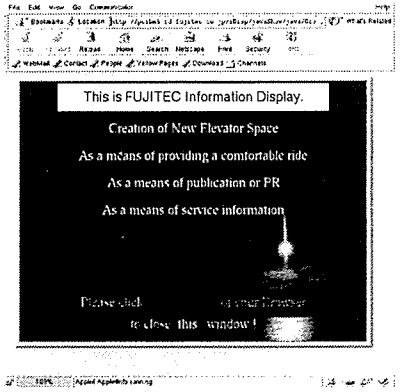

Figure 9. Information via WWW

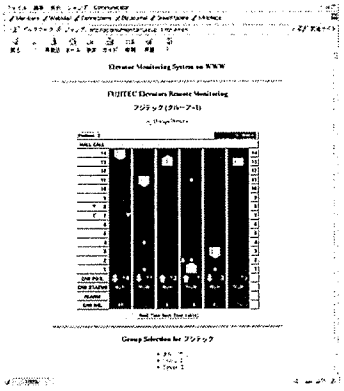

Figure 10. EMS via WWW

Applets are most useful in displaying information which changes time by time. Another way is using the 'Form' feature of the browser, together with CGI (Common Gateway Interface) and so-called *server push,* but without using Java the possibilities are considerably limited, compared with Java; though good-looking web pages can also be achieved this way.

3.3 Some further advantages

The following advantages were also found important.

1) Java has libraries for network programming as standard.
2) Java has automatic memory management, called 'garbage collection', so memory leaks, which are a common problem using C++ etc. are easier to avoid.
3) Java has high portability, which can reduce the cost of the porting work in the future.

4.Cooperation of Elevator Monitor System (EMS) in building and WWW Server

4.1 Use of WWW Browser which became a common tool in all the world

WWW browsers, for example, Netscape Navigator and Microsoft Internet Explorer, are becoming the most common standard GUI (user interface) tools, and now their operation method is generally understood. Because people are daily using such browsers, no special explanation is needed for their operation. Browsers are bundled with most OS (operating systems), and new functions are added almost daily. People can access all sorts of information as documents in HTML (Hyper Text Markup Language) form, all over the world, by using these browsers. Already many kinds of services are offered, and many new services are being added on the web sites. All such applications on the computer need the cooperation with WWW Server which offer this service, and EMS is not an exception. Our new system now has this function, and in the future it will be able to answer to a variety of demands that can not be realized yet.

4.2 Server/Client model makes flexibility in demand of users in the future

Let's think about the operation mode of EMS in the building. Only the building manager was able to monitor the elevators so far. However, the demand of opening up the information is now spreading to all kinds of systems. There are a lot of users who want to have the elevator information available near to themselves. Let's think about ***VIP Operation*** as an example. The

VIP Operation is an operation to give the elevator priority temporarily to an important user in the building. When this command is issued, a specific elevator arrives on the specified floor and waits for passenger's boarding. The elevator automatically returns to the usual operation when the passenger boards and the first trip is completed. This operation is designed to minimize the degradation in service to the entire elevator group, while at the same time trying to achieve convenience to a specific user (who might be an important visitor, or the owner of the building etc.). In a traditional system, a switch or an operating terminal was placed in the room of building manager. However, this method would have problems when for instance

1) There are several floors where the visitor might come, or the floor changes.
2) There are several visitors at the same time, or they go to different places.

Under these situations, the users would need to phone the building manager and ask him to issue the command; also, the number of switches and wiring could be quite large.
In addition, the building manager might want to observe the status of elevators at two or more location, or in a hierarchical structure. It is necessary to use the Server/Client model and LAN which allows building manager to freely change the number of connections of clients and their position, to deal with this flexibly. As for the clients that receive service, the number is not limited in the Server/Client model. If LAN is used, usually there is no need even to change the wiring. In addition, even the installation work of the program in the client computer can be avoided by using Java applets, which we developed. The operating environment of client should not be limited. Users want to receive service with the computers that they are using now. Conventional systems which need special terminals have poor flexibility.
In addition, in case of the new EMS, all users will get a benefit from a new function only by changing the program of the server side, which is a great advantage of the World Wide Web service, as explained in Section 4.1. In case of the old model, changes could influence the entire system.

4.3 Integration with Other Systems

Using the service of EMS by way of WWW Server will facilitate the integration of other systems and EMS.
For instance, we developed a system which can display a video camera system "SECURIA". This device *OpennetView* (MegaChips 1998) can show the image on the World Wide Web screen.

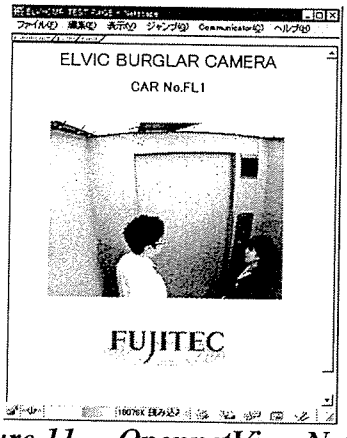

Figure 11. OpennetView Network

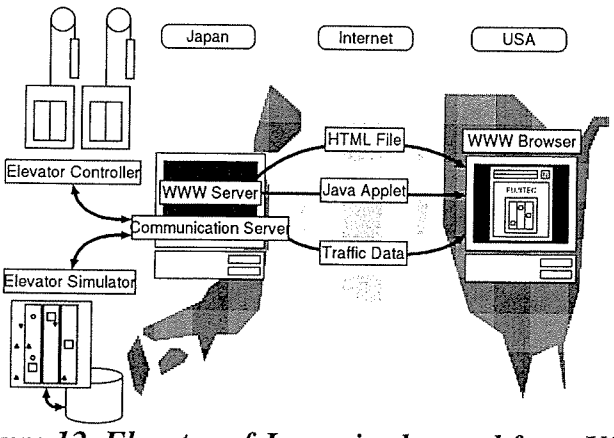

Figure 12. Elevator of Japan is observed from US.

Such a function can be easily integrated with our EMS. The image of the elevator interior can be displayed next to the operating status of the elevator if the EMS is combined with this system. While there are limits on what an elevator maker can develop in-house, being able to offer a product which quickly incorporates the technology developed in other fields provides a

great advantage for the user. This includes not only image, but also voice, etc., which will become more and more useful in the future if cooperation with World Wide Web is considered.

4.4 Extensions to the Internet

When the EMS is able to cooperate with the WWW Server, offering service toward outside of the building by using the Internet becomes easily possible. This service will become especially advantageous in a BMS which should monitor two or more buildings. We have already succeeded in connecting Japan and US, and confirmed the feasibility of elevator monitoring at an intercontinental distance without trouble. (see ***Figure 12.***)

5. Conclusions

Ethernet + TCP/IP is a system with great flexibility and in an advanced stage of development, and it is found that the network cost also become inexpensive. In addition, by adopting Java as the program language, and cooperating with WWW servers, we could improve the quality of the service of EMS and its functions rapidly. Finally, we should give a warning: in our system, we have considered the network security of such an open system which uses Ethernet + TCP/IP. As the system becomes more powerful, the danger of invasion from the outside increases. Connecting the network of the EMS directly with other LAN and WAN without any security measures could becomes a suicide act concerning the security of the system. However, it is not necessary to fear unduly the 'cracking' the EMS network, as long as abundant technologies to control network safety exist.

We expect that in the future all monitor systems inside and outside the building will change into a form which looks like our system, using Ethernet + TCP/IP. This will be the story of the opening of the elevator monitoring system in new information technology age.

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