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Internet of things and smart cities and communities – Frameworks, architectures and protocols

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Framework of Internet of things based monitoring and management for lifts

Recommendation ITU-T Y.4420

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Recommendation ITU-T Y.4420

Framework of Internet of things based monitoring and management for lifts

Summary

Recommendation ITU-T Y.4420 describes a framework of Internet of things (IoT) based monitoring and management for lifts, including a protocol and a data model. Lifts need to interact with applications through communication networks to provide different kinds of services to end users. In many cases, lifts cannot connect to communication networks directly. Therefore, gateways support the interconnection of such lifts with communication networks. Correspondingly, various lift companies also apply their own data models and protocols. For this reason, interoperability problems have occurred, and therefore this framework will facilitate IoT based monitoring and management for lifts to operate in conjunction with each other.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4420	2021-07-14	20	11.1002/1000/14737

Keywords

Internet of things (IoT), lift, management, monitoring.

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FOREWORD

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Framework of Internet of things based monitoring and management for lifts

1 Scope

This Recommendation provides a framework of Internet of things (IoT) based monitoring and management for lift. The scope of this Recommendation includes:

– Overview of IoT based monitoring and management for lift;

– Architecture of IoT based monitoring and management for lift;

– Protocol and data model for IoT based lift monitoring and management.

Use cases of IoT based monitoring and management for lifts are provided in an appendix.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.4101] Recommendation ITU-T Y.4101/Y.2067 (2017), *Common requirements and capabilities of a gateway for Internet of things applications*.

3 Definitions

3.1 Terms define elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 device [b-ITU-T Y.4000]: With regard to the Internet of things, this is a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing.

3.1.2 gateway [ITU-T Y.4101]: A unit in the Internet of things which interconnects the devices with the communication networks. It performs the necessary translation between the protocols used in the communication networks and those used by devices.

3.1.3 Internet of things (IoT) [b-ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing, and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.4 sensor [b-ITU-T L.1301]: A device that transforms a physical value (e.g., temperature, current) into an electrical or logical unit. The sensor can be directly connected with a data stream to the management system or via a conversion device.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 lift: A type of vertical transportation that moves people or goods between floors (levels, decks) of a building, vessel, or other structures.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CAN	Controller Area Network
CCTV	Closed Circuit Television
CoAP	Constrained Application Protocol
ELMP-485	Elevator Monitoring Protocol over RS-485
GW	Gateway
HTTP	Hypertext Transfer Protocol
IoT	Internet of Things
LPWA	Low-Power Wide-Area
MQTT	Message Queuing Telemetry Transport
NB-IoT	Narrowband IoT
PLC	Programmable Logic Controller
RS-232	Recommended Standard 232
RS-485	Recommended Standard 485

5 Conventions

None.

6 Overview of IoT based monitoring and management for lift

A lift is a type of vertical transport device that is powered by electric motors that drive traction cables and counterweight systems like a hoist. A lift moves people or goods between floors of a building or other structures. Additionally, a lift is composed of several sensors and a control board for controlling the lift movements.

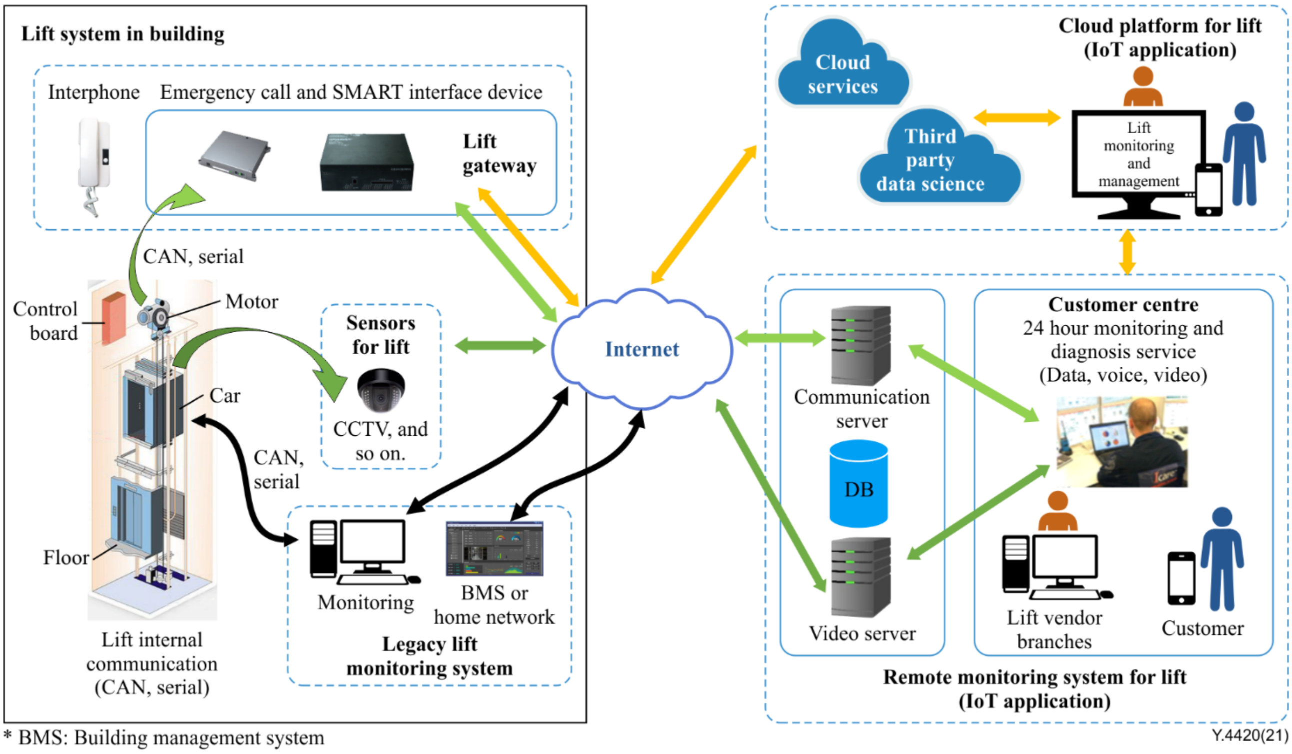

Figure 1 – Overview of lift monitoring and management system

Figure 1 describes an overview of the lift monitoring and management system. The control board and other components in the lift are connected by serial and controller area network (CAN) [b-CiA 102] communication. The legacy lift monitoring system is installed for the purpose of integrating monitoring and management of lifts in a building. In addition, it connects to lifts using serial and CAN communication. It is configured to enable network function and stores information on the remote server. Several lift vendors install remote monitoring systems for lifts. This system is operated for lift monitoring and management. Devices such as closed circuit television (CCTV) [b-ITU-T X.1114] installed in the lift are directly linked to the network and used for data transmission to a remote server or monitoring.

However, the legacy lift monitoring system has an issue with other devices or other vendor lifts interworking in the building. This is due to the lift industry using its own communication protocols and data models for communication between the lift control board and other components in the lift. In addition to this, communication methods are also used to connect with the legacy lift monitoring system. Therefore, when installing lifts in buildings for various companies, it is difficult to integrate, manage and monitor these lifts.

IoT based monitoring and management for the lift using lift gateway (GW) shown in Figure 1 have the following advantages. It can interwork with other lift vendors and other devices in the building. Moreover, it can use a variety of existing IoT applications. To this end, lifts need to interact with applications through communication networks to provide different kinds of services to end users. In many cases, lifts also cannot connect to communication networks directly. Therefore, gateways support the interconnection of such lifts with communication networks. Correspondingly, various lift companies apply their own data models and protocols. For this reason, interoperability problems have occurred. Thus, this Recommendation describes a framework of IoT based monitoring and management for lift with a protocol and data model to solve these problems.

7 Architecture of IoT based monitoring and management for lift

7.1 General architecture of IoT gateway and application for lift

Figure 2 describes a general architecture in which sensors or control boards in the lift are interworking with IoT applications. Resource constrained sensors are connected to the control board. Furthermore, the lift gateway is the connecting element between control boards and IoT applications. However, several full resource sensors or control boards can also be directly connected to IoT applications. Therefore, sensor data are transferred to the IoT application directly or collected in the IoT application through the gateway in Figure 2.

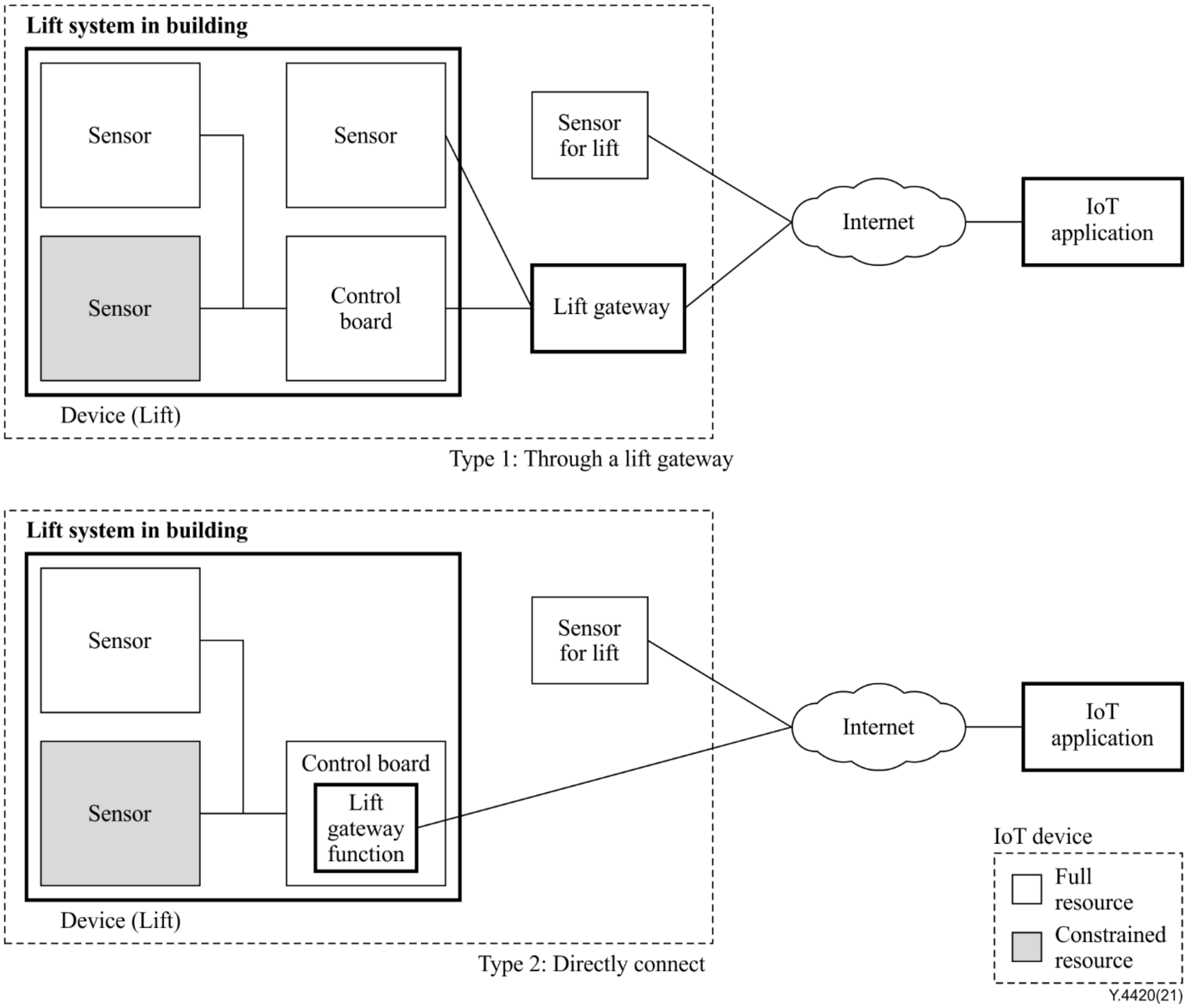

Figure 2 – IoT based monitoring and management for lift

Type 1 in Figure 2 shows a connection in which the device can be connected to IoT applications through a lift gateway. The lift consists of sensors and a control board. The control board communicates and controls the sensors. The sensors and control board shown in Figure 2 are IoT devices. The lifts are devices to which several IoT devices are connected. The amount of data generated by the sensor is small. Therefore, it communicates with the control board using serial communication such as RS-232 [b-TIA-232] and RS-485 [b-TIA-485]. Some control boards support CAN bus to communicate with sensors. Thus, the control board supports serial communication and CAN bus. Some lifts also add extra sensors for inspection and monitoring purposes. In this case, the sensor added to the lift may not be connected to the control board because unauthorized connected sensors can cause lift malfunctions or security issues.

Among the sensors installed in the lift, CCTV and vibration sensors generate a lot of data. When a lot of data are transmitted through a gateway, a problem occurs in the gateway known as data transmission error or delay. Accordingly, these IoT devices support a direct connection with IoT applications. Therefore, a gateway is required to connect the control board and sensors to the IoT applications. The information collected in the lift is transmitted to the IoT application through the lift gateway.

However, it is also possible to connect directly to the lift and IoT applications according to the user's (lift admin) requirements. Type 2 in Figure 2 describes a direct connection in which the device can directly connect to IoT applications. Therefore, some control boards support wireless or wired network environments to connect with IoT applications. In this case, the lift gateway function should be added to the control board. Also, some sensor data size is small, and the data generation frequency is low. Therefore, it can transmit data directly to IoT applications by using low-power wide-area (LPWA) [b-IEEE 802.15.4w] network or narrowband IoT (NB-IoT) [b-3GPP TR 36.802] communication. LPWA communication is capable of long-distance communication and large-scale device access while satisfying the low power required by the IoT environment.

The IoT application collects and manages the information from the lift and use the collected information. These applications include monitoring for lift safety and condition, lift emergency control, and parts management. Moreover, there is an application within the user management for accessing the lift when there are safety problems. The main function of the gateway is to collect lift information and to transmit lift control signals. If the gateway performance is sufficient, it is also possible to execute the functions performed in the IoT application at the gateway.

The gateway periodically transmits the data to the IoT application or transmits the data to the IoT application by a user (lift admin) registered event. Constrained application protocol (CoAP) [b-IETF RFC 7252], Hypertext transfer protocol (HTTP) [b-IETF RFC 7540] and message queuing telemetry transport (MQTT) [b-ISO/IEC 20922] in IoT environments are used for application protocols. Accordingly, the gateway uses these application protocols to transmit data.

7.2 Architecture of IoT gateway for lift

This clause describes the architecture of the IoT gateway for lift. IoT gateway for lift is equally applicable to both type 1 (through a lift gateway) and type 2 (direct connection) in the general architecture. IoT gateway for lift follows the reference technical framework of a gateway for IoT applications defined in [ITU-T Y.4101]. Some modules have been extended as shown in Figure 3 for the lift in IoT gateway defined in [ITU-T Y.4101]. Extended modules are device adaptation and network adaptation in the adaptation capabilities group and data processing modules in the support capabilities group.

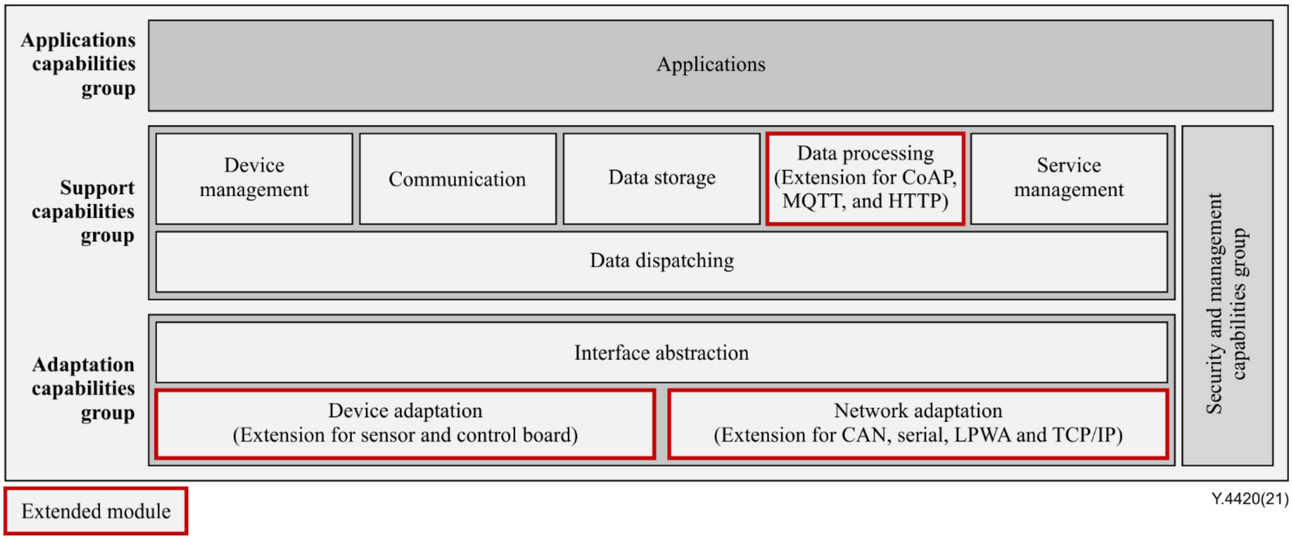

Figure 3 – Architecture of IoT gateway for lift (extended from [ITU-T Y.4101])

The extension of device adaptation is as follows:

– In the lift, various sensors or control boards are mainly composed of a programmable logic controller (PLC) [b-IEC 61131-3] system or an embedded system. Therefore, the lift gateway needs to extend the device adaptation module to support interworking with the lift. Thus, the device adaptation module of the IoT gateway must be extended to be able to connect with the lift sensor board and control board.

The extension of network adaptation is as follows:

– Lift control board and sensor board transmit data through non-IP based serial communication. Lift applications transmit data through non-IP based LPWA wireless or IP based communication. For interworking with such serial communication devices and lift applications, the lift gateway must also extend the network adaptation module. Therefore, the network adaptation module of the IoT gateway must be extended to enable non-IP (e.g., serial, LPWA, NB-IoT)/ IP communications.

The extension of data processing is as follows:

– The data processing module of the IoT gateway, encapsulates or decapsulates data based on the application protocol. The lift must also provide various IoT applications such as mobile and cloud environments. Accordingly, data processing module of the IoT gateway should be extended to support various protocols (e.g., CoAP, MQTT, and HTTP).

7.3 Architecture of IoT application for lifts

Lift applications are equally applicable to both type 1 (through a lift gateway) and type 2 (direct connection) in the general architecture. Lift applications follow the reference technical framework of a gateway for IoT applications defined in [ITU-T Y.4101]. Some modules have been extended as shown in Figure 4 for the lift in IoT application defined in [ITU-T Y.4101]. Extended modules are network adaptation modules in the adaptation capabilities group, data processing modules in the support capabilities group, and application modules in the application capabilities group.

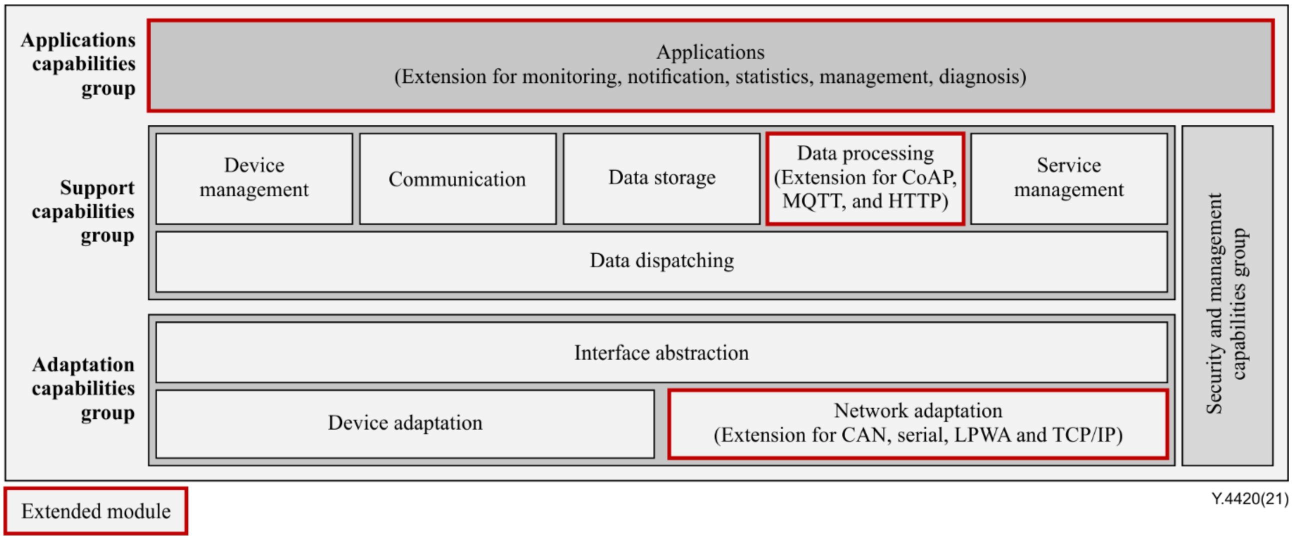

Figure 4 – Architecture of IoT application for lift (extended from [ITU-T Y.4101])

The extension of network adaptation is as follows:

– IoT applications are connected to IoT gateways or external sensors. IoT gateways or external sensors transmit data using non-IP/IP communication technology. Therefore, the network application module of IoT application must be modified to enable non-IP / IP communication.

The extension of data processing is as follows:

– The data processing module of IoT application, encapsulates or decapsulates data based on the application protocol. The lift must also provide various IoT applications such as mobile and cloud environments. Accordingly, data processing module of IoT applications should be extended to support various protocols.

The extension of applications is as follows:

– Applications capabilities group of IoT applications are capable of various application configurations for the lift. The monitoring application monitors the elevator operating condition with information related to the elevator operation and informs the notifying manager or user of the current lift status and information. It then creates statistics information based on the lift driving data. The management application calculates the timing of replacing the lift parts (lifetime) with the lift operation information and statistics information. It then performs a diagnostic mode function or checks inspection operation based on the collected information.

8 Protocol and data model for IoT based lift monitoring and management

Figure 5 shows the protocols applied in lift control panels, lift monitoring gateways (e.g., IoT gateways), and application servers (e.g., IoT servers). The data models for the protocols include basic lift information and operation state information. The elevator monitoring protocol over RS-485 (ELMP-485) supports communication between lift and the IoT gateway. The lift transmits monitoring and management data to the IoT gateway with ELMP-485, and the IoT gateway transmits monitoring and management data to the application server using IoT application protocols (e.g., CoAP, MQTT, and HTTP). The protocol conversion process occurs in the IoT gateway.

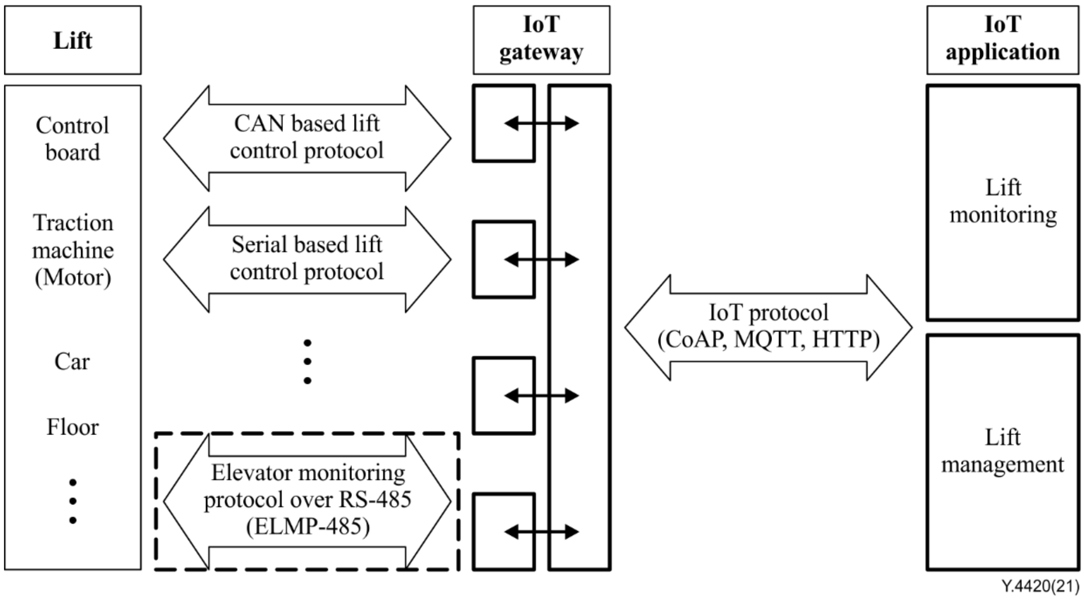

Figure 5 – Protocols for IoT based lift monitoring and management

Figure 6 shows the lift structure. The lift is functionally divided into machine, car, hall, hoistway and pit groups. The monitoring and management data model is presented for each of these groups. The machine group contains the control panel and motor. The car group contains the emergency phone and car. The pit group contains the buffer spring and stop switch. The hall group contains each hall floor and lastly the hoistway group contains the lift hoistway.

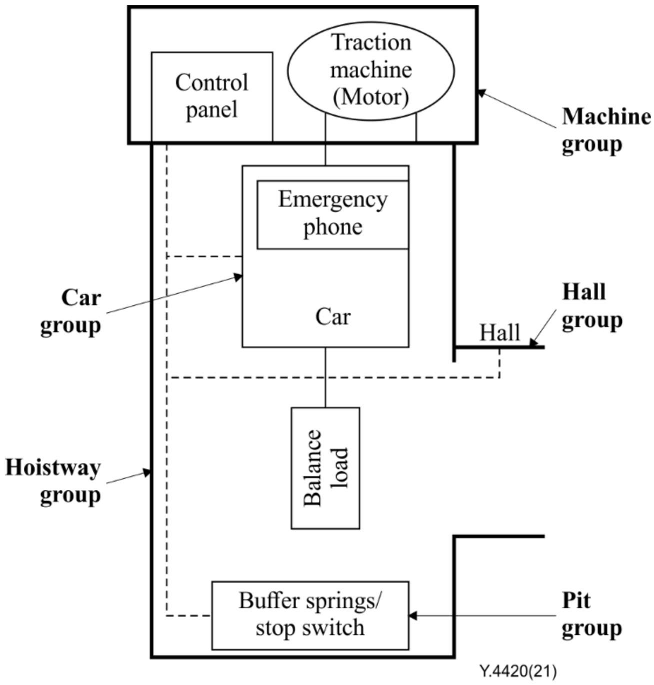

Figure 6 – Structure for lift

8.1 Protocol for lift monitoring and management

The structure of the ELMP-485 message is shown in Figure 7. This message uses a flag value to separate the start and end. The values of the start flag (SF) and the end flag (EF) used are the same and are '0x7E' of 1 byte. This flag value '0x7E' can also be used in areas other than the start and end flags.

Start flag (SF-0x7E)	Destination address (DA)	Message type (Type)	Data field length (Len)	Data field (DATA)	Cyclic redundancy check (CRC)	End flag (EF-0x7E)
1 byte	1 byte	1 byte	2 bytes	n byte	2 bytes	1 byte

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Figure 7 – ELMP-485 message structure

In the message address field, the destination address (DA) is used, and the length is 1 byte. The destination address classification is shown in Table 1.

Table 1 – ELMP-485 address classification

Classification	Address
Broadcast address	0x00
Individual address	0x01 ~ 0xF7
Reserved address	0xF8 ~ 0xFF

The message type is 1 byte and is shown in Table 2. The data length (len) and the value of the data filed are determined according to the message type.

Table 2 – ELMP-485 message type

Value	Message type
0x01	Data request
0x02	Data response
0x03	Update request
0x04	Update response
0x05~0xFF	Discard

An example of the structure of the data request and response is shown in Figure 8.

Data request	SF	DA	Type	Len	Data	CRC-16	EF
	0x7E	0x02	0x01	0x0004	0x03FFF8F0	0x16B9	0x7E

Data response	SF	DA	Type	Len	Data	CRC-16	EF
	0x7E	0x01	0x02	0x0004	0x03F80105	0x3068	0x7E

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Figure 8 – ELMP-485 message example

If '0x7E' is included in the ELMP-485 message, the escape function is used to prevent it from being recognized as SF or EF. For the escape function, the value of the '0x7D' escape flag is defined. When a value of '0x7E' is used outside the start and end flag areas or an escape flag value of '0x7D' is used, an escape flag value of '0x7D' is added before the corresponding byte. In addition, to prevent escape data from remaining in the transmitted message, the data byte value is XOR to '0x20' and transmitted.

8.2 Data model for lift monitoring and management

Basic lift information includes specification information as shown in Table 3. This specification information is determined when the lift is manufactured and installed in the building. In addition, M/O displayed in the table is an item to select mandatory/optional. Mandatory records 'M' and optional records 'O'. The selectable items in the data access mode are read (R), write (W), or both.

Table 3 – Basic lift information

Data name	Data access modes	Data type	M/O	Description
Lift no.	R	String	M	Lift unique identifier that can be identified in the network
Lift local no.	R	String	M	Lift unique identifier installed in a building
Manufacturer	R	String	M	Lift manufacturer
Model	R	String	M	Lift model
Speed	R	Float32	M	Rated speed designed for lift (unit: m/s)
Load	R	Uint8	O	Rated load designed for lift (unit: kg)
Floor	R	Uint8	M	Total number of floors that the installed lift supports (ex) The total number of lift floors operating on the second basement and fourth floors above the ground is indicated as '6')
Base floor	R	Uint8	M	The floor that is the standard for lift operation (Refers to the lobby floor, and the floor that can enter and exit from outside for firefighting purposes)

The machine group (Table 4): The machine group includes a control panel and a traction machine located at the top of the hoistway, or in a lift environment with or without a machine room. It is installed inside the hoistway to hall the functions of the existing machine room.

Table 4 – Lift operation status information: Machine group

Data name	Data access modes	Data type	M/O	Description
Machine room temperature	R	Float32	O	Current temperature of the machine room where the traction machine, electric motor, and control panel are installed
Control panel mainboard communication state	R	Boolean	O	Control panel main board status information installed in the machine room (Power and communication status is normal: true)
Control panel protocol	R	Uint8	M	Protocol information used by the control panel main board
Control panel model	R	String	M	Control panel mainboard model information
Traction machine operation signal	R	Boolean	M	Traction machine start signal (Operation: true, stop: false)

The car group (Table 5): A group of devices located in the car for transportation and convenience which also includes an emergency call device.

Table 5 – Lift operation status information: Car group

Data name	Data access modes	Data type	M/O	Description
Car operation mode	R	Uint8	M	Lift operation mode (normal, manual check, etc.), Firefighting, Evacuation (fire, earthquake detection, etc.), Dedicated driving, etc.
Car current floor	R	Uint8	M	The floor where the car is located (the lowest floor starts from 0)
Car destination floor	R	Uint8	M	The current floor from where the car moves
Car current direction	R	Uint8	M	Car driving direction (0: stop, 1: upward, 2: downward)
Car current speed	R	Float32	M	Car current running speed (unit: m/s)
Car overspeed	R	Boolean	M	Overspeed, when the rated speed set on the car exceeds 115% (Overspeed-true)
Car overload	R	Boolean	M	Exceeding the rated load of the car (Overload: true)
Car call status	R, W	BitArray	M	Provides car call status information (If the call is made from each floor, it is displayed as 1)
Car level state	R	Boolean	M	The difference in height between the car and hall is recognized, and if it is within the error of the reference value, it is considered normal.
Car door state	R, W	Uint8	M	Car door status display information conveys information about whether it is open, closed, or in progress. (Open-0, Opening-1, Closed-2, Closing-3)
Operation panel board (OPB) state	R	Boolean	M	Transmits whether the communication status of the OPB installed in the car is normal (Normal: true)

The hall group (Table 6): It is a group of devices located on each hall floor.

Table 6 – Lift operation status information: Hall group

Data name	Data access modes	Data type	M/O	Description
Machine room temperature	R	Float32	O	Current temperature of the machine room where the traction machine, electric motor, and control panel are installed
Control panel mainboard communication state	R	Boolean	O	Control panel main board status information installed in the machine room (Power and communication status is normal: true)

Table 6 – Lift operation status information: Hall group

Data name	Data access modes	Data type	M/O	Description
Control panel protocol	R	Uint8	M	Protocol information used by the control panel main board
Control panel model	R	String	M	Control panel mainboard model information
Traction machine operation signal	R	Boolean	M	Traction machine start signal (Operation: true, stop: false)

The hoistway group: It is a group of devices located on the entire hoistway where the car moves.

The pit group: It is a group of devices located in the inspection space under the lift, such as stop switches and buffer springs.

Table 7 is the data of lift operation statistics related to operation after lift construction.

Table 7 – Lift operation statistics information

Data name	Data access modes	Data type	M/O	Description
Operation count	R	Uint32	M	Total number of trips counted as one lift start and stop
Operation distance	R	Uint32	O	Total cumulative lift travel distance (unit: m)
Operation time	R	Uint32	O	Total cumulative lift operation time (unit: H)
Downtime	R	Uint32	O	Accumulated stop time due to lift failure (Unit: H)

Table 8 is the data for failure information that can be displayed in the lift control panel and in the standardized main failure information.

Table 8 – Lift error information

Data name	Data access modes	Data type	M/O	Description
Main_ErrorCode	R	Uint16	M	Each manufacturer's error code is used.

Appendix I

Use cases of IoT based monitoring and management for lift

(This appendix does not form an integral part of this Recommendation.)

I.1 Lift emergency notification

The manager of the building should notify the people and quickly evacuate in the event of an earthquake, fire, or disaster. In case of a disaster, the lift is operated in an emergency operation mode, and not in a normal operation mode. Thus, lifts are used to evacuate or rescue people. Moreover it is also necessary to add sensors and devices to detect disasters such as fires and earthquakes that may occur in buildings, and these sensors and devices must be linked to the lift. If not, this information must be collected and delivered to the lift disaster-related external information for fires and earthquakes. Moreover, in case of an emergency, the lift operation mode should be changed. Therefore, IoT-based management technology is required to monitor and manage lifts using additional sensors, devices, or external information. As shown in Figure I.1, the fire detector or seismograph installed in the building is connected to the lift through the IoT gateway, and the cloud server (IoT application) and IoT gateway that informs the earthquake and fire information are also interconnected.

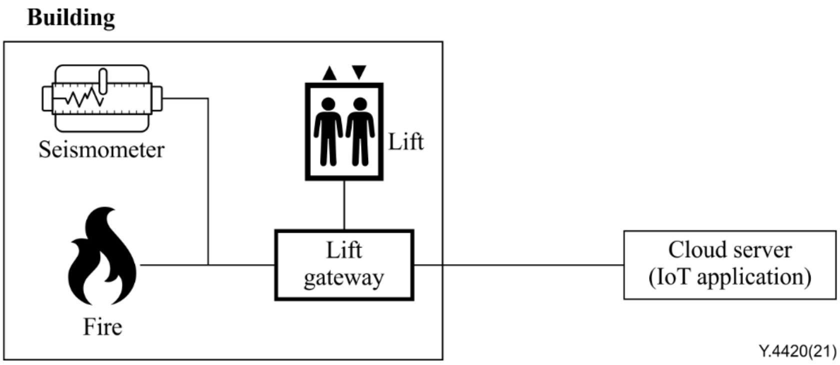

Figure I.1 – Lift emergency notification

I.2 Lift monitoring in smart building

As shown in Figure I.2, there are various IoT devices present in smart buildings. The lift is one of them. In an existing building with multiple lifts installed, the lifts will stop according to the initial setting regardless of the number of people waiting. When one of the nearest lifts arrives, the other lift calls are cancelled, or the other lift arrivals are also stopped. Thus the lift runs inefficiently. However, in smart buildings, the number of people waiting is monitored using CCTV and based on this information, one or several lifts arrives. In addition, it is possible to make only a specific floor accessible to a specific user or disable access to a specific floor by interworking with a security system in a smart building.

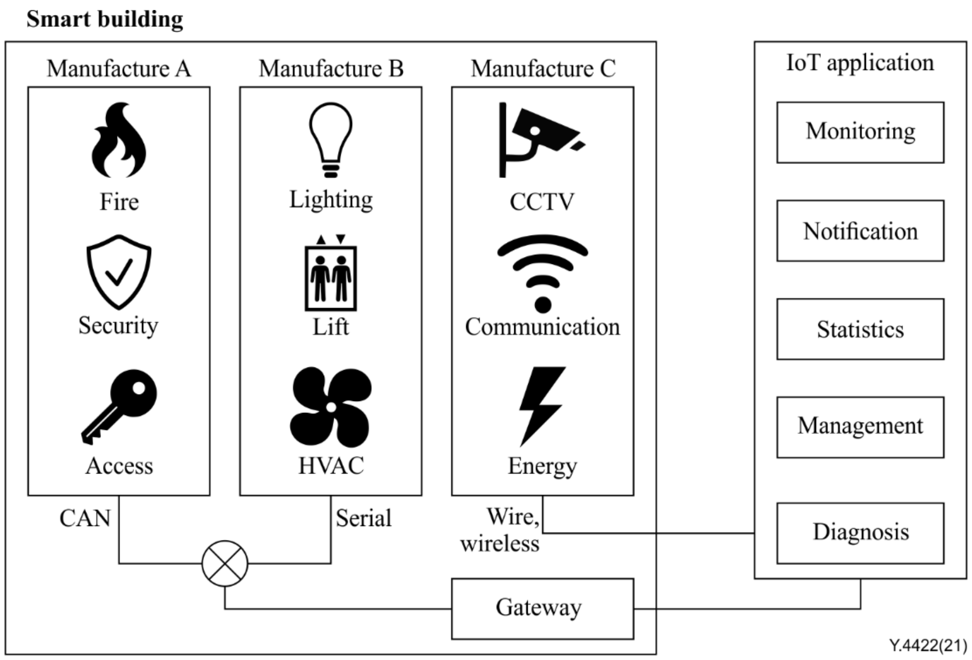

Figure I.2 – Lift monitoring in smart building

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