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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet of things and smart cities and communities – Requirements and use cases

Requirements and capability framework for smart shopping mall systems

Recommendation ITU-T Y.4123

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Recommendation ITU-T Y.4123

Requirements and capability framework for smart shopping mall systems

Summary

By deploying Internet of things (IoT) devices, smart shopping malls make use of IoT technologies to collect data, control devices remotely, monitor the environment, etc. These IoT technologies can enable intelligent services such as intelligent device collaboration, indoor navigation, asset tracking etc., which can help to improve management efficiency, resulting in enhanced consumer experience and more businesses opportunities.

Recommendation ITU-T Y.4123 specifies the requirements and capability framework of smart shopping mall system.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4123	2022-01-13	20	11.1002/1000/14813

Keywords

Capabilities, IoT, requirements, smart shopping mall system.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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1 Scope

This Recommendation specifies the requirements and capability framework of smart shopping mall system.

The requirements and capability framework build on the Internet of things (IoT) reference model [ITU-T Y.4000] and the common requirements of IoT [ITU-T Y.4100]. The requirements and capabilities focus on technical aspects of smart shopping mall system.

This Recommendation can help shopping mall operators, service providers, solution and network providers, and users of the services.

The scope of this Recommendation includes:

– Overview of smart shopping mall system enabled by IoT;

– Requirements of smart shopping mall system;

– Capability framework of smart shopping mall system.

Use cases of smart shopping mall system are provided in Appendix I.

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.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of Internet of things*.

[ITU-T Y.4100] Recommendation ITU-T Y.4100/Y.2066 (2014), *Common requirements of the Internet of things*.

[ITU-T Y.4204] Recommendation ITU-T Y.4204 (2019), *Accessibility requirements for the Internet of things applications and services*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 application [b-ITU-T Y.2091]: A structured set of capabilities, which provide value-added functionality supported by one or more services, which may be supported by an API interface.

3.1.2 customer [b-ITU-T Y.2091]: The customer buys products and services from the enterprise or receives free offers or services. A customer may be a person or a business.

3.1.3 device [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.

3.1.4 Internet of things (IoT) [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 – In a broad perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.5 sensor [b-ITU-T Y.4105]: An electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic.

3.1.6 service [b-ITU-T Y.2091]: A set of functions and facilities offered to a user by a provider.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G 2nd Generation Mobile Communication Technology

5G 5th Generation Mobile Communication Technology

AI Artificial Intelligence

API Application Programming Interface

ICT Information and Communication Technologies

IoT Internet of Things

RSRP Reference Signal Received Power

RSS Received Signal Strength

RSSI Received Signal Strength Indication

SMS Short Message Service

TDOA Time Difference of Arrival

TOA Time of Arrival

UWB Ultra-Wide Bandwidth

WiFi Wireless Fidelity

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement needs not be present to claim conformance.

The keywords "can optionally" and "may" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the

network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Overview of smart shopping mall system enabled by IoT

The shopping mall is one of the most important parts of city infrastructure. It provides not only a place for shopping, but also a place for people to gather for leisure. A shopping mall may provide one-stop convenient services such as retail, catering, education, medical treatment, and entertainment. With the development of the economy, people's demand for consumer goods and cultural life is increasing. In order to improve the service quality for customers, shopping malls need to provide more intelligent and convenient services.

The smart shopping mall system uses information and communication technologies (ICTs) to provide intelligent services which can help shopping malls improve customer experience, management and competitiveness. By deploying IoT devices, e.g., temperature, humidity, air quality sensors, infrared sensors, navigation devices, shopping malls can obtain the ambient information, control the environment, acquire location of assets, etc. Based on these smart devices, a smart shopping mall system can support intelligent services, such as indoor navigation, asset tracking, intelligent device collaboration and business analysis.

Figure 1 shows an overall conceptual diagram of a smart shopping mall system. Smart shopping mall devices are deployed inside the smart shopping mall. Examples of smart shopping mall devices include environmental monitoring devices, security devices, intelligent navigation devices, and asset location devices. An IoT network is responsible for communications among devices and the platform. The platform provides intelligent services by processing and analysing the data collected by smart shopping mall devices. It can also provide application programming interfaces (APIs) for smart city systems and other users. When the user obtains the authorization of a smart shopping mall platform, it can initiate a request to obtain information from the smart shopping mall platform. The smart shopping mall platform can send the corresponding information to users.

NOTE 1 – The devices refer to IoT devices that can collect environmental, security, navigation or location related data.

NOTE 2 – The assets are the valuable mall devices that need to be traced and monitored. Actually, some IoT devices can be also considered as assets, such as a navigation robot.

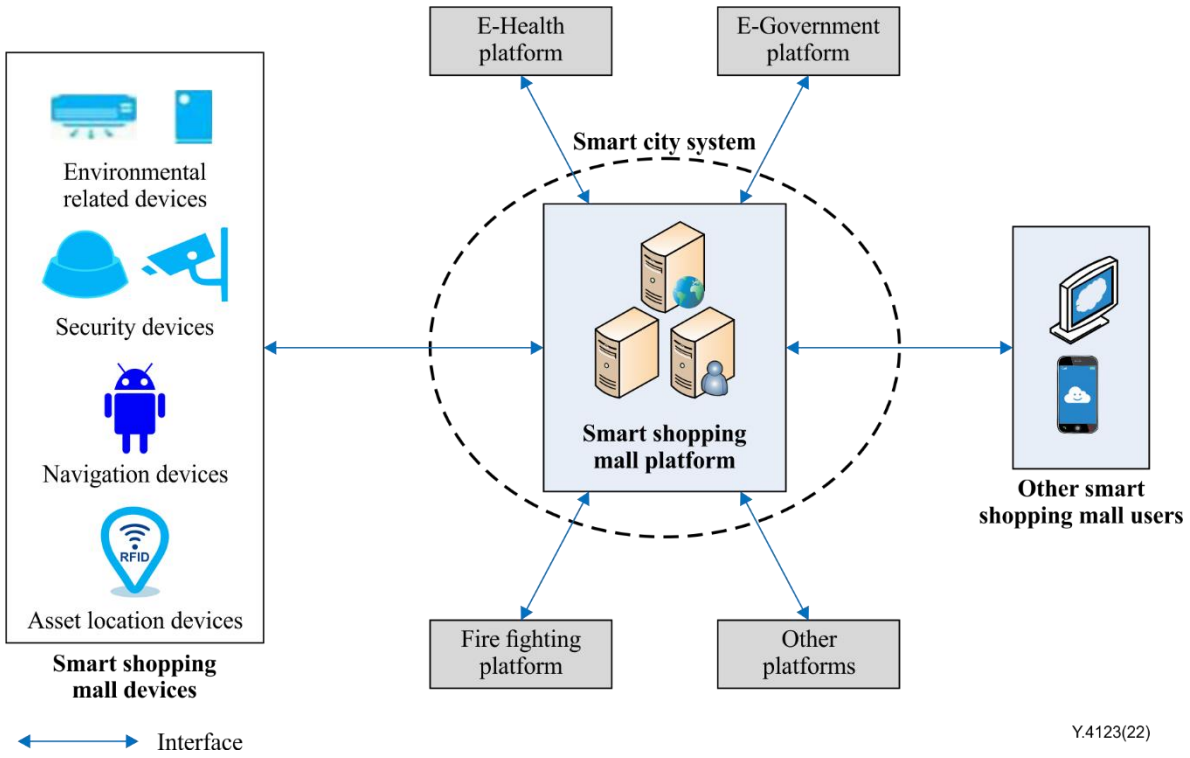

Figure 1 – Overall conceptual diagram for smart shopping mall system

7 Requirements of smart shopping mall system

7.1 Requirements of smart shopping mall platform

In addition to the common requirements specified in [ITU-T Y.4100], specific requirements for smart shopping mall platform are listed below:

7.1.1 General requirements

– Smart shopping mall platform is required to collect ambient information of the shopping mall, which includes temperature, humidity, etc.

– Smart shopping mall platform is required to intelligently process and analyse the collected data through machine learning, semantics-based technologies or other technologies so that it can implement applications such as ambient data analysis. The result of the intelligent analysis can bring benefits to the shopping mall such as energy savings, labour costs reducing, etc.

– Smart shopping mall platform can optionally manage the smart shopping mall device's maintenance records.

– Smart shopping mall platform is required to have the means to check and analyse the integrity and correctness of the collected data.

7.1.2 Location related requirements

– Depending on service requirements, the smart shopping mall platform can optionally record the location information of assets.

– Depending on services requirements, the smart shopping mall platform can optionally calculate the device location according to the information collected by the device or network by using a specific location algorithm.

– Depending on services requirements, the smart shopping mall platform can optionally request the location information of shopping mall assets periodically.

– Depending on services requirements, the smart shopping mall platform can optionally support location tracking.

– Depending on services requirements, the smart shopping mall platform can optionally support electronic fences. Alarm will be activated when the target asset is outside the designated area.

– Depending on services requirements, the smart shopping mall platform can optionally notify related personnel to maintain the damaged asset, when information on demolition of assets is received.

7.1.3 Routing related requirements

– Depending on services requirements, the smart shopping mall platform can optionally receive the route planning requests (examples of such requests are starting and destination locations).

– Depending on the services requirements, the smart shopping mall platform can optionally recommend route planning based on the received route planning request.

7.1.4 Environment related requirements

– Smart shopping mall platform is required to shield the heterogeneity among various sensing data, provide data fusion analysis for environmental information, and support collaboration among different devices to improve the efficiency of the devices and reduce energy consumption.

NOTE – Various sensing devices are installed in the shopping mall, and their data are a valuable input for environment control. By fully deploying these sensing data with advanced data analysis methods, better environment control and energy conservation are expected.

7.2 Requirements of smart shopping mall devices

In addition to the common requirements specified in [ITU-T Y.4100], specific requirements for smart shopping mall devices are listed below:

7.2.1 General requirements

– Smart shopping mall devices are required to provide computing capability.

NOTE – Smart shopping mall devices can optionally expose spare computing capability, enabling decentralized computing tasks.

7.2.2 Location related requirements

– Smart shopping mall devices can optionally collect location related information.

NOTE – Location related information may be acquired in real time depending on service requirements or periodically depending on the configuration of the platform.

– Smart shopping mall devices can optionally detect damage of shopping mall assets and send related information to the platform, so that the operator can maintain the damaged asset immediately.

7.2.3 Routing related requirements

– Smart shopping mall devices can optionally provide multiple interfaces for human-computer interaction to request route planning.

NOTE – The interfaces include audio, image, text, etc.

7.2.4 Environment related requirements

Smart shopping mall devices are required to collect environment information, for example, temperature, humidity, air quality, etc.

7.3 Requirements of the network

In addition to the common requirements specified in [ITU-T Y.4100], specific requirements for the network are listed below:

– The network can optionally provide location related information, i.e., measurement information of the terminal, such as reference signal received power (RSRP), time of arrival (TOA), which can be used for device location calculation.

NOTE 1 – The network layer may provide one or multiple methods that support positioning, such as 2G-5G, Bluetooth or WiFi.

NOTE 2 – The network layer obtains the information required by the positioning algorithm to achieve device positioning using location methods such as reference signal received power (RSRP), time of arrival (TOA).

NOTE 3 – This technology can locate a victim in the event of theft, violence, etc. in a timely manner. Also, the positioning service can support a route planning algorithm, which may provide the user with the fastest path to a destination.

8 Capability framework of smart shopping mall system

Based on the IoT reference model specified in [ITU-T Y.4000], Figure 2 illustrates the capability framework of the smart shopping mall system, which consists of four layers and two cross-layer capability groups.

In addition to capabilities specified in [ITU-T Y.4000], specific capabilities are required for the application layer, network layer and device layer. These specific capabilities are shown in the blue highlighted rectangles in Figure 2.

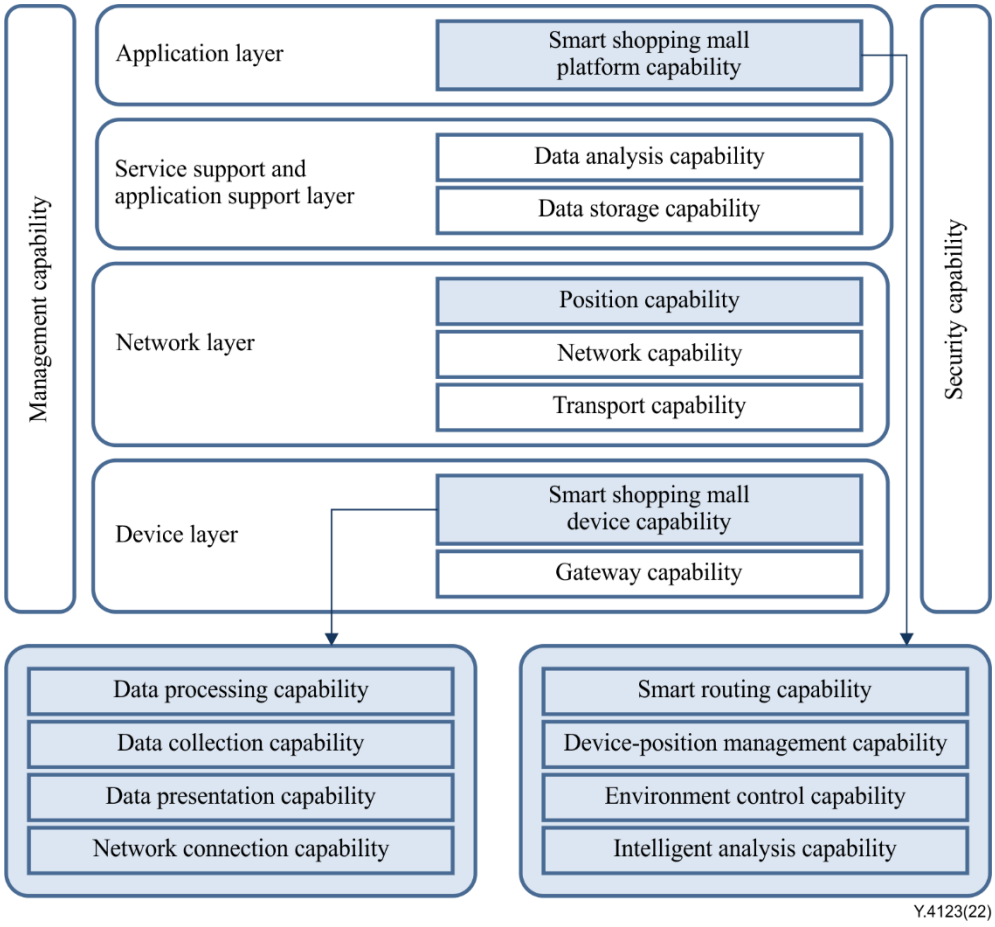

Figure 2 – Capability framework of smart shopping mall system

8.1 Capabilities of the application layer

According to the smart shopping mall platform requirements described in clause 7.1, the application layer supports the smart shopping mall platform capabilities, including smart routing, indoor positioning, knowledge graph and intelligent analysis capabilities. Details of these capabilities are provided in the following clauses.

8.1.1 Smart routing capability

According to the requirements described in clause 7.1.3, the following features of smart routing capability are identified:

– to provide a 3D display of the shopping mall environment. The physical location of assets and related areas in the mall is presented in an intuitive way;

– to provide route planning. The route is planned according to user's preferences (e.g., shortest route, or least crowded). The starting point of the route defaults to the location of the asset, or can be input manually;

– to update the routing algorithm. When the shopping mall layout changes, the routing algorithm needs to be updated accordingly.

8.1.2 Device-position management capability

According to the requirements described in clause 7.1.2, the following features of device-position management capability are identified:

– to provide anti-theft capability for devices;

NOTE – This includes set up of an electronic fence, i.e., when the positioning information of the device shows that the device has crossed the fence, an alarm is triggered.

– to provide asset management capability. Recording and requesting of the location information of assets, with location tracking support, is provided. In cases of asset damage, notification to the maintenance personnel about the damaged asset is also provided.

8.1.3 Environment control capability

According to the requirements described in clauses 7.1.1 and 7.1.4, the following features of environment control capability are identified:

– to integrate the environmental information of the mall (such as temperature, humidity, light, etc.), and automatically adjust the related facilities in the mall.

8.1.4 Intelligent analysis capability

According to the requirements described in clause 7.1.1, the following features of intelligent analysis capability are identified:

– to provide intelligent analysis reports for departments in the mall as appropriate, such as customers flow, sales, safety reports, and marketing strategy recommendations;

NOTE – For customer complaints and suggestions, analysis algorithms can intelligently classify them and provide related reports.

– to detect abnormal behaviours and trigger alarms;

– to predict alarm events;

– to predict maintenance requirements based on smart shopping mall devices' managed maintenance records;

– to check and analyse the integrity and correctness of the collected data.

8.2 Capabilities of the device layer

According to smart shopping mall device requirements described in clause 7.2, the device layer supports the smart shopping mall device capabilities, including data processing, data collection, data presentation and network connection capabilities.

8.2.1 Data processing capability

According to the requirements described in clause 7.2.1, the following features of data processing capability are identified:

– to provide data analysis capability such as knowledge graph and AI. For some basic control operations, such as temperature adjustment, lighting device control, the collected data can be analysed and processed on the device layer to reduce network overload;

– to provide decentralized computing capability for data processing and analysis in order to speed up the calculation and utilize idle computing resources.

8.2.2 Data collection capability

According to the requirements described in clauses 7.2.2, 7.2.3 and 7.2.4, the following features of data connection capability are identified:

– to collect environmental information, such as temperature, humidity, light, etc.;

– to collect critical events in shopping malls, such as customers accidentally falling down and crowds gathering;

– to collect interactive information of multiple forms, such as visual, audio, haptic, etc. Considering the requirements of persons with disabilities, persons with age related disabilities and those with specific needs, multiple forms of interactive information are enabled [ITU-T Y.4204].

NOTE – The assets need to be equipped with necessary functional modules such as a microphone, touch screen, manual call button, etc.

8.2.3 Data presentation capability

According to the requirements described in clause 7.2.3, the data presentation capability is mainly used in human-computer interaction, and only required for interactive devices. The following features are identified:

– to present interactive information of multiple forms. Considering the requirements of persons with disabilities, persons with age related disabilities and those with specific needs, multiple forms of interactive information are enabled [ITU-T Y.4204].

NOTE – Examples of interactive information forms include touch screen, motion sensors, , wearable devices that incorporate vibration, smart speakers and so on.

8.2.4 Network connection capability

According to the requirements described in clauses 7.2.2 and 7.2.3, the following feature of network connection capability is identified:

– to provide measures in support of locating capability in case locating capability is provided by the network.

8.3 Capabilities of the network layer

According to the requirements described in clause 7.3, the following capability of the network layer is identified in addition to the networking and transport capabilities defined in [ITU-T Y.4000]:

– position capability.

NOTE 1 – As far as indoor positioning is concerned, different positioning technology methods can be used, including but not limited to time of arrival (TOA), time difference of arrival (TDOA), received signal strength (RSS), etc.

NOTE 2 – As an example, with respect to the following widely used networking technologies, the network layer may provide network-based locating capability using the following methods:

– WiFi: the wireless local area network (WLAN) uses the location information of access points and a combination of empirical and theoretical signal propagation models to locate the connected devices.

– Bluetooth: Bluetooth indoor positioning is based on the value of the received signal strength indication (RSSI), and the location is performed through the principle of triangulation.

– Ultra-wide bandwidth (UWB): the positioning technology uses pre-arranged anchor nodes and bridge nodes with known locations to communicate with newly added blind nodes and, using triangulation or "fingerprint" positioning methods, determine the location.

Appendix I

Use cases of smart shopping mall

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

I.1 Equipment anti-theft service

Smart shopping mall platform uses the positioning function of the device to provide anti-theft monitoring. The positioning module transmits the position information to the smart shopping mall platform. The platform stores the positioning data on the platform and analyses its trajectory information. If the track information is abnormal, the smart shopping mall will send an alarm message to the administrator to prevent the device from being stolen.

As shown in the Figure I.1, the positioning module is responsible for collecting the location information of the device, and then transmitting it to the smart shopping mall platform, and the platform performs trajectory analysis based on the collected positioning information. When an abnormality occurs, the administrator can receive a warning about the abnormality of the device on his/her PC and/or mobile applications.

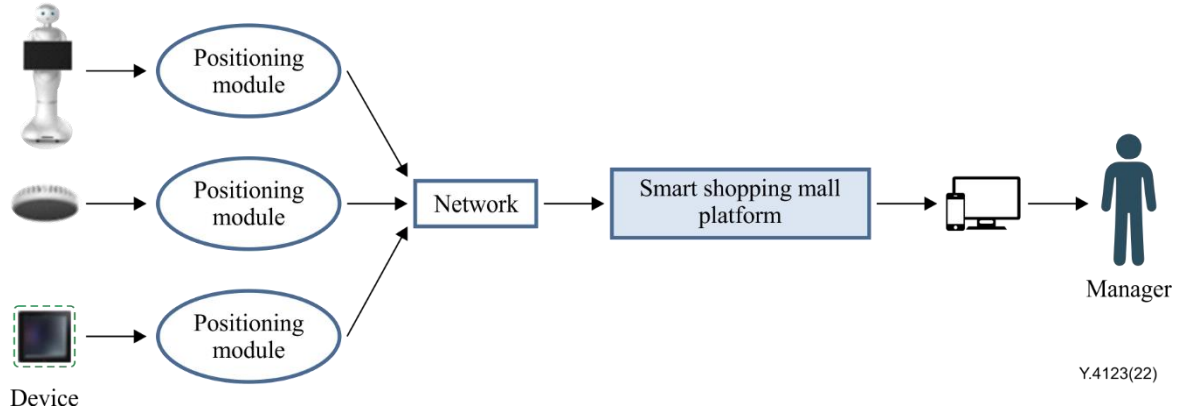

Figure I.1 – Use case of anti-theft service for device

The anti-theft service for device has the following functions:

1) Information collection: The positioning module collects the location information of the device, so that the platform can monitor the specific location of the device in real time. Provide managers with the ability to monitor and query.

2) Alarm service: Trajectory analysis of the positioning information on the smart shopping mall platform. When the trajectory is abnormal, the abnormal device number and location information will be sent to the management staff by short message service (SMS), email and app push.

3) Data management and analysis: The smart shopping mall platform will save the device collected data and provide the data to researchers for statistical analysis. The smart shopping mall platform can then help to provide better planning and management solutions.

I.2 Intelligent environment control

The smart shopping mall platform provides automated control of the environment in the shopping mall through digital analysis. Environmental monitoring devices such as thermometers and hygrometers arranged in the mall will upload the environmental data to the smart shopping mall platform. According to the analysis result, the air conditioner, humidifier and other device in the shopping mall are automatically controlled.

As shown in Figure I.2, the monitoring device in the shopping mall is responsible for collecting environmental information in the shopping mall and sending it to the platform. The platform analyses the environment based on the uploaded information, and reversely controls the environmental changing devices in the shopping mall based on the analysis results. The platform will periodically output analysis reports to managers.

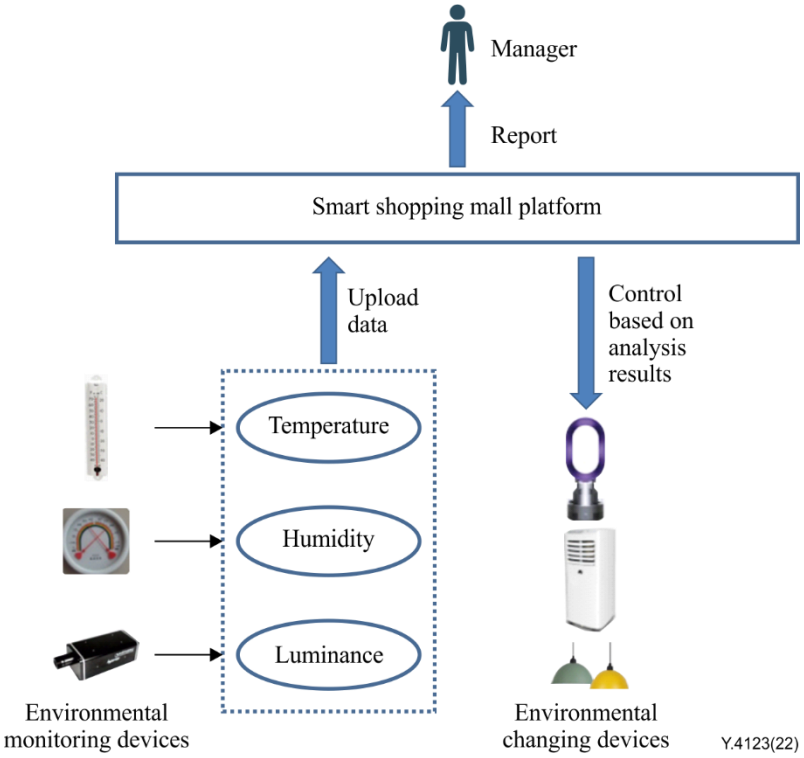

Figure I.2 – Use case of intelligent environment control

Intelligent environment control includes the following functions:

1) Intelligent temperature control: The thermometer in the mall will report the current temperature in the area in real time. When the temperature is detected to exceed the set suitable temperature threshold, the air conditioner will work and report the working status to the smart shopping mall platform.

2) Humidity intelligent control: The hygrometer in the shopping mall will report the humidity in the area in real time. When the humidity is detected to exceed the set suitable temperature threshold, the humidifier or dehumidifier will work and report the working status to the smart shopping mall platform.

3) Intelligent brightness control: The light sensing device in the mall will report the current luminance in area in real time, automatically control the lights in the mall according to the luminance and weather, and report the working status to the smart shopping mall platform.

I.3 Automatic navigation

In the smart shopping mall, machines with human-computer interaction capability will be placed to realize the function of intelligent navigation. The customer enters where he/she wants to go through the display screen of machine. The platform calculates the best route through the smart routing algorithm and displays it to customers on the display screen of machine. The default starting position of the path planning is the location of the machine, which can also be entered manually by the customer.

As shown in Figure I.3, the machine is responsible for interacting with customers and acquiring customer needs. Additionally it uploads the navigation origin (location information or input information) and destination to the smart shopping mall via the network. The platform plans the route and returns the result to the interactive machine. The machine presents the route to the user through the display screen.

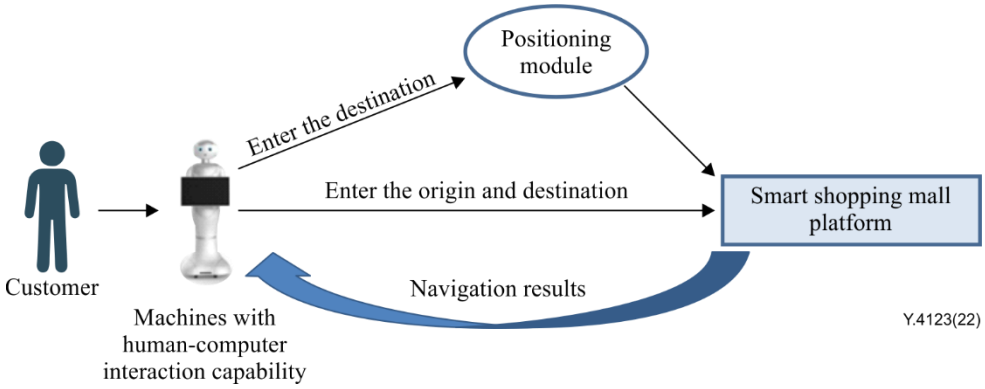

Figure I.3 – Use case of automatic navigation

Bibliography

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[b-ITU-T Y.4105] Recommendation ITU-T Y.4105/Y.2221 (2010), *Requirements for support of ubiquitous sensor network (USN) applications and services in the NGN environment*.

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