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

Requirements and functional architecture of a smart street light service

Recommendation ITU-T Y.4458

International Telecommunication Union

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Recommendation ITU-T Y.4458

Requirements and functional architecture of a smart street light service

Summary

Recommendation ITU-T Y.4458 specifies requirements and the functional architecture of a smart street light (SSL) service. An SSL service is a key means to reduce energy consumption, promote maintenance management efficiency and improve the quality of municipal services as part of a smart city's services. Related SSL service use cases are provided in an appendix.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4458	2019-06-06	20	11.1002/1000/13860

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Smart street light.

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1 Scope

This Recommendation specifies requirements and the functional architecture of a smart street light (SSL) service to reduce energy consumption, promote maintenance management efficiency and improve the quality of municipal services.

The scope of this Recommendation includes:

– introduction of an SSL service;

– requirements of an SSL service;

– functional architecture of an SSL service.

NOTE 1 – The scope of this Recommendation does not cover local policy-related requirements.

NOTE 2 – Appendix I lists related use cases of SSL service.

2 References

None.

3 Definitions

3.1 Terms defined 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 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.

3.1.3 functional entity [b-ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 smart street light (SSL) service: A kind of smart city service that provides fine-grained, automatic remote management and energy-saving control for street lights.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

APP Application

EV Electric Vehicle

FE Functional Entity

GIS Geographic Information System

IoT Internet of Things

PC Personal Computer

SSL Smart Street Light

UI User Interface

Wi-Fi 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 Introduction

6.1 Overview of a smart street light service

Street lights are one of the most important parts of city infrastructure. The conventional street light service causes two significant issues as follows.

– High energy consumption

  Street lights consume large quantities of electrical power and generate a lot of heat. Usually, electrical energy consumption of street lights ranks first in total lighting electrical energy consumption.

– High maintenance costs

  Fault detection in street lights mainly depends on manual routine checks and citizen complaints. Difficulty in locating faulty street lights incurs high maintenance costs.

In order to solve these two problems, an SSL service has been introduced to provide fine-grained, automatic remote management and energy-saving control for street lights. The SSL service is extensible to provide various public services (e.g., environmental monitoring, road congestion monitoring, public information release, wireless fidelity (Wi-Fi) access and electric vehicle (EV) charging).

6.2 Features of a smart street light service

6.2.1 Automatic control based on environmental changes

The conventional street light service usually turns street lights on or off at a pre-set time. When traffic flow is low at night, street lights are still on, resulting in high energy wastage.

An SSL service can automatically turn on or off, or dim or brighten, street lights remotely based on weather conditions, illumination intensity, traffic flow, passenger flow and other environmental changes.

6.2.2 Remote control of single lights

A conventional street light service usually turns all street lights in an area on or off at the same time.

An SSL service can provide finer-grained management to help city administrators remotely control single lights.

6.2.3 Automatic fault detection and alarm

Maintenance of a conventional street light service relies mainly on manual routine checks and citizen complaints.

An SSL service can support automatic fault detection and alarm mechanisms. Once a faulty street light is detected, an alarm message is automatically sent to the relevant maintenance personnel.

6.2.4 Visualization management

To improve management efficiency, an SSL service can provide a user interface (UI) to realize map-based visualization management, including, but not limited to, display of the location and working status of street lights, fault information and energy consumption information.

6.2.5 Additional feature

An SSL service can provide various smart city services by the connection of more sensors, smart devices and application platforms.

6.3 Conceptual model of smart street light service

To support the features of an SSL service, this Recommendation provides a conceptual model of SSL service systems that consists of four parts: SSL controller; SSL platform; IoT network; and web/application (APP) client. See Figure 1.

NOTE – The IoT Network and web/APP client lie outside the scope of this Recommendation.

– An **SSL controller**, deployed for street lighting, is responsible for connecting to an SSL platform to establish communication channels, exchange data with the SSL platform and execute street light control commands.

– An **IoT network** is responsible for communications between SSL controllers and the SSL platform. It can be a cellular, short-range or wired network.

– An **SSL platform** is responsible for monitoring and managing street lights remotely, as well as providing an SSL service for city administrators.

– A **web/APP client** allows city administrators to monitor and manage street lights at any time and anywhere via a mobile phone or personal computer (PC).

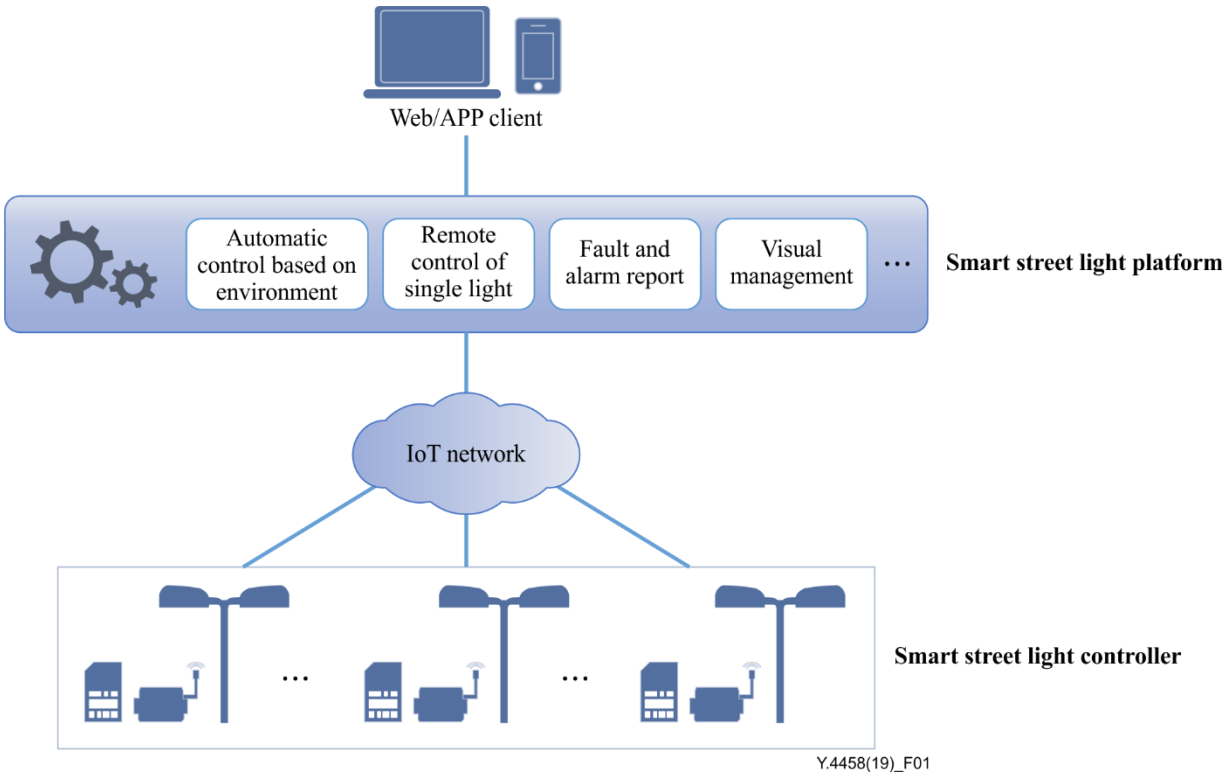

Figure 1 – Conceptual model of smart street light service systems

Therefore, an SSL service has many significant advantages over conventional street light services, including provision of on-demand lighting, reduction in energy consumption and improvement in maintenance management efficiency. Meanwhile, an SSL service also provides a vehicle for extension to more smart city applications and services in the future.

7 Requirements of a smart street light service

7.1 Requirements of a smart street light platform

An SSL platform:

– is required to support flexible street light control policies based on environmental factors, time factors, location factors and targeted levels of energy saving;

– is required to support the single light-based remote control;

– is required to support automatic or manual control modes;

– is required to support switching on or off status and adjusting brightness of street lights;

– is required to automatically detect the location of faulty and disconnected street lights, and send alarms to maintenance personnel;

– is required to analyse statistics for energy consumption and provide a report on energy-saving efficiency;

– is required to support a UI for visualization in order to display information about street lights on a map, and control the working status of street lights remotely;

– is recommended to provide interfaces for signalling interactions and data transfer with external platforms;

– may obtain information about traffic monitoring, traffic congestion and emergencies from video cameras.

7.2 Requirements of a smart street light controller

An SSL controller:

– is required to obtain the values of environmental parameters;

– is required to automatically switch on or off status and adjust the brightness by itself, once the street light control policy pre-set conditions are reached;

– is required to regularly send electrical parameters values of street lights to the SSL platform;

– is recommended for extension to access a wide variety of sensors and devices;

– may use cameras to obtain videos and send them to the SSL platform.

8 Functional architecture of a smart street light service

As shown in Figure 2, the functional architecture of an SSL service consists of two main parts. One is the SSL platform, the other is the SSL controller. The IoT network and web/APP client lie outside the scope of this Recommendation.

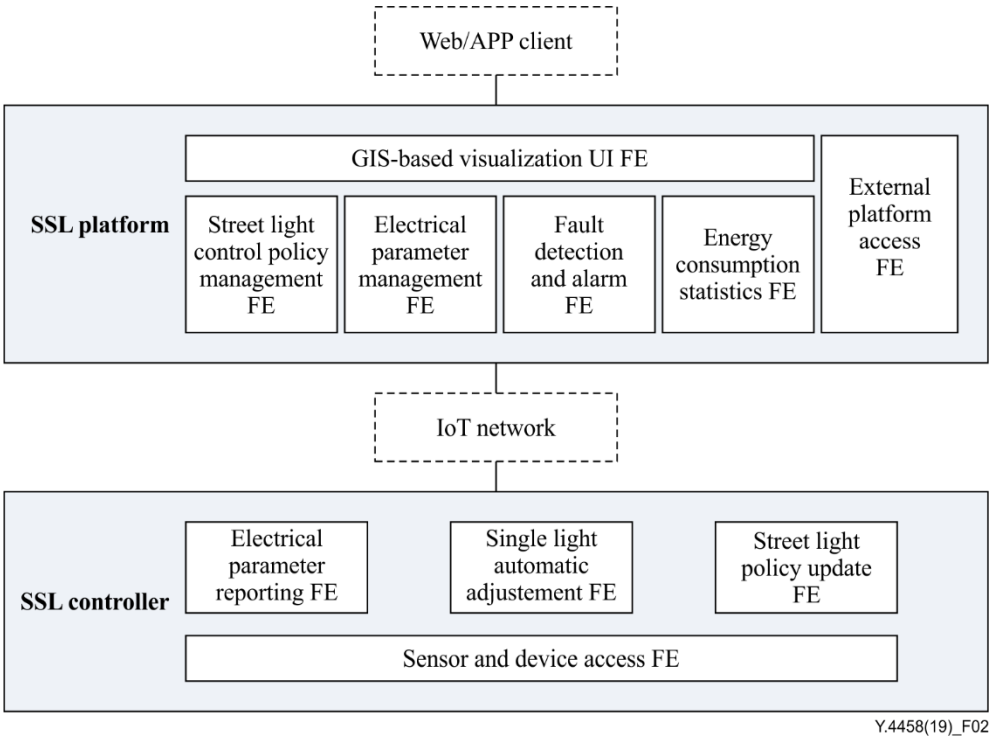

Figure 2 – Functional architecture of a smart street light service

8.1 Smart street light platform

The SSL platform includes functional entities (FEs) for: street light control policy management; electrical parameter management; detection fault and alarm; energy consumption statistics; geographic information system (GIS)-based visualization UI; and external platform access.

8.1.1 Street light control policy management functional entity

The main role of the street light control policy management FE is to manage the creation, configuration, modification and deletion of the street light control policies as follows:

– create street light control policies based on weather, illumination intensity, traffic flow and relevant environmental factors, sunrise and sunset time, location and targeted levels of energy saving;

– configure street light control levels – single light control, every other street light control, one-side street light control, group control and whole area control;
– configure street light control modes – automatic mode and manual mode;
– configure street light working status – on or off, brightness;
– configure the execution cycle of street light control policies (e.g., permanent, three times a day);
– modify and delete street light control policies;
– send street light control policies to relevant SSL controllers.

8.1.2 Electrical parameter management functional entity

The main role of the electrical parameter management FE is to manage the electrical parameters of street lights as follows:

– receive and store electrical parameter values reported by SSL controllers;
– create electrical parameter reporting policies;
– configure the reporting cycle of electrical parameters;
– modify and delete the electrical parameter reporting policies;
– send the electrical parameter reporting policies to SSL controllers.

8.1.3 Fault detection and alarm functional entity

The main role of the fault detection and alarm FE is to provide the fault and alarm information for quick trouble shooting as follows:

– monitor the working status of street lights based on electrical parameter values;
– identify faults in street lights, once the pre-set fault conditions are reached;
– identify street light disconnection, once the pre-set disconnection conditions are reached;
– generate a fault report, once a street light is identified as faulty or disconnected;
– automatically trigger an alarm and notify maintenance personnel via web/APP client.

8.1.4 Energy consumption statistic functional entity

The main role of the energy consumption statistic FE is to provide energy consumption relevant reports for better maintenance as follows:

– obtain real-time energy consumption information about each street light;
– analyse statistics of energy consumption;
– provide a report on energy-saving efficiency.

8.1.5 Geographic information system-based visualization user interface functional entity

The main role of the GIS-based visualization UI FE is to display street light information intuitively on a map and control each street light directly as follows:

– display the physical distribution of each street light on a GIS-based map;
– display the working status of each street light – on or off, brightness, connected or disconnected, faulty;
– manually control each street light working status on demand – turning on or off, adjusting the brightness;
– display the electrical parameter values of each street light;
– display fault and alarm information about street lights;
– display statistical information about energy consumption and energy-saving efficiency.

8.1.6 External platform access functional entity

The main role of the external platform access FE is as follows:

– connect with the external platforms via interfaces;

– exchange relevant information or content with external platforms.

8.2 Smart street light controller

The SSL controller includes FEs for electrical parameter reporting, single light automatic adjustment, street light policy update, as well as sensor and device access.

8.2.1 Electrical parameter reporting functional entity

The main role of the electrical parameter reporting FE is to report electrical parameter values of street lights to the SSL platform as follows:

– collect the electrical parameter values of the street light – electrical current, voltage, active energy, reactive energy, active power, reactive power, apparent power, power factor, frequency;

– regularly send the electrical parameter values of the street light to the SSL platform, according to electrical parameter reporting policies.

8.2.2 Single light automatic adjustment functional entity

The main role of the single light automatic adjustment FE is to ensure that each street light can adjust working status by itself, as follows:

– receive and store street light control policies sent by the SSL platform;

– regularly monitor and obtain various environmental parameter values via weather sensors, illumination intensity sensors, traffic density sensors, etc;

– automatically turn on or off a single light or adjust the brightness of a single light, once the street light control policy pre-set conditions are reached.

8.2.3 Street light policy update functional entity

The main role of the street light policy update FE is as follows:

– receive street light control policies from the SSL platform and replace existing policies inside the SSL controller;

– receive electrical parameter reporting policies from the SSL platform and replace existing policies inside the SSL controller.

8.2.4 Sensor and device access functional entity

The main role of the sensor and device access FE is as follows:

– extend to connect with various smart city sensors and devices (e.g., closed circuit television cameras, weather sensors, illumination intensity sensors, traffic density sensors, air quality sensors, noise detectors, Wi-Fi hotspots, advertising screens and EV charging infrastructure);

– exchange relevant information or content with sensors and devices.

Appendix I

Use cases

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

This appendix provides some use cases to better understand SSL service.

As shown in Figure I.1, SSL is a new urban infrastructure that can connect to a wide range of sensors and devices to support various smart city applications. SSL has the ability to access the IoT network and the service platform that can provide on-demand lighting and energy-saving services to city administrators. Clauses I.1 to I.6 describe SSL service use cases.

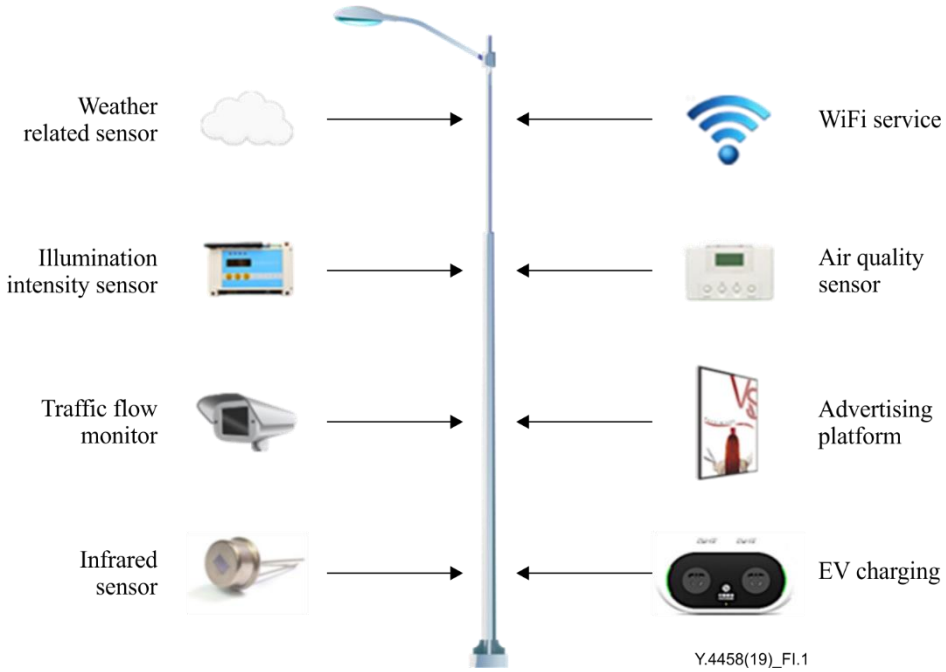

Figure I.1 – An example of a smart street light

I.1 Automatic control based on environment

Compared with a conventional street light service, the SSL service can turn on or off or dim or brighten street lights based on environment (e.g., weather conditions, illumination intensity, traffic flow and passenger flow).

If there is high traffic flow with low illumination intensity, street lights will be turned on automatically.

If there is low traffic flow during the night, street lights will be dimmed automatically.

I.2 Remote control of single light

A single street light or every other street light can be turned on or off or adjusted up or down by remote control as shown in Figure I.2.

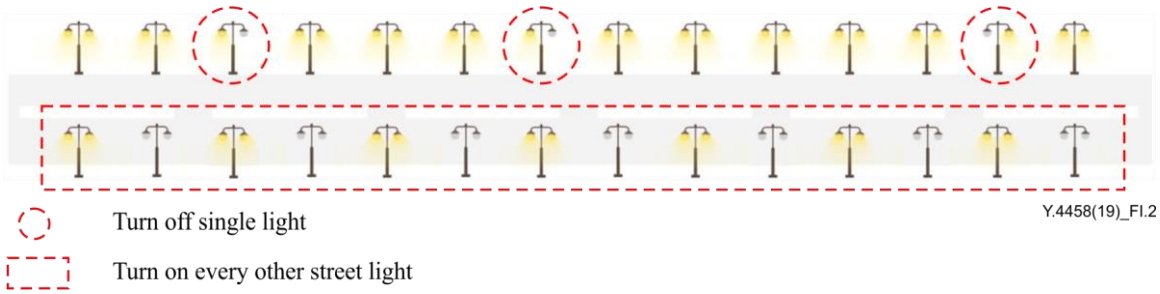

Figure I.2 – An example of remote control of single light

I.3 Automatic alarm

If a lamp or circuit does not work properly, the SSL platform generates an alarm message and sends it immediately to maintenance personnel.

I.4 Visualization management portal

The operators of an SSL service can monitor the running status of the street lights of a whole city via a visualization management portal, as shown in Figure I.3.

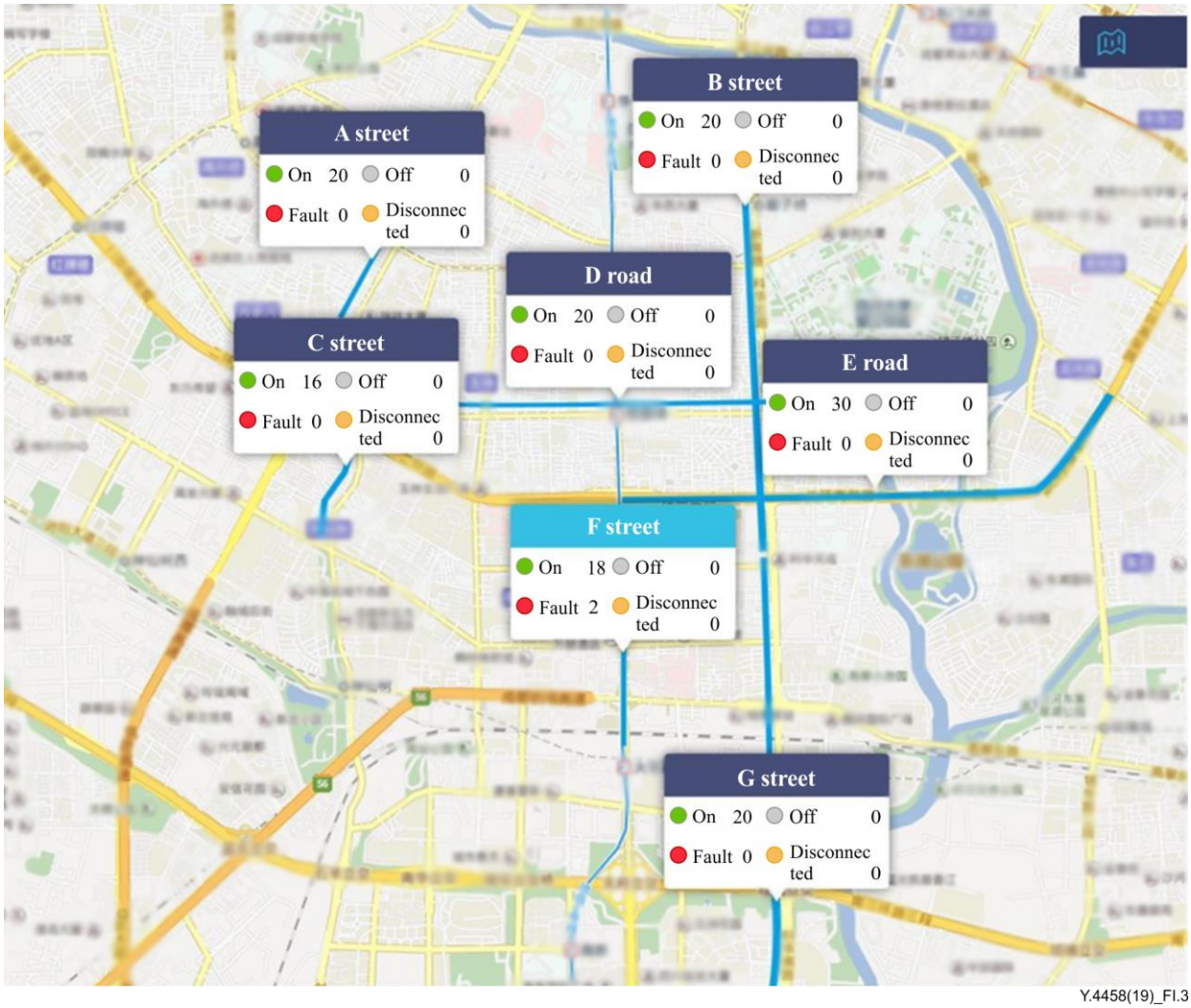

Figure I.3 – An example of a visualization management portal

I.5 Proactive maintenance

Based on electrical parameter values of street lights, an SSL service can analyse these data, provide predictive information, and notify whether lamps are approaching end-of-life. Then replacements can be scheduled proactively.

I.6 Additional use case

Besides the major function of light management, an SSL service is also extensible and supports the connectivity of other sensors or devices. With this extensibility of an SSL service, operators can add additional smart city applications (e.g., air quality monitoring, Wi-Fi hotspot, advertising or EV charging).

I.6.1 Video monitoring

An SSL service may use monitor cameras to check traffic conditions, flow congestion and emergencies. Videos may be sent to the monitoring centre, so that personnel can check videos from different street lights to process related events in a timely fashion.

Bibliography

[b-ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks*.

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

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