International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Series Y
Supplement 56
(12/2019)

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

ITU-T Y-series – Supplement on use cases of smart cities and communities

ITU-T Y-series Recommendations – Supplement 56

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Supplement 56 to ITU-T Y-series

ITU-T Y-series – Supplement on use cases of smart cities and communities

Summary

Supplement 56 to ITU-T Y-series Recommendations provides a set of use cases related to smart cities and communities (SC&C). The SC&C use cases described in this Supplement are in pilot or commercial phase.

The use case collection is expected to provide useful information for the definition of common requirements of SC&C and for other future studies on SC&C. It is also expected that this information will benefit the study of the relationship between city scales and SC&C solutions, and will provide examples of the social and economic benefits. The use cases in this Supplement may also help to plan the deployment of similar smart city solutions in other cities.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y Suppl. 56	2019-12-06	20	11.1002/1000/14174

Keywords

Smart cities and communities, use cases.

* 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.

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Supplement 56 to ITU-T Y-series

ITU-T Y-series – Supplement on use cases of smart cities and communities

1 Scope

This Supplement provides a set of use cases related to smart cities and communities (SC&C). Specifically, the Supplement covers the following parts:

– Recommended template for the description of SC&C use cases (clause 6);

– Classification scheme for SC&C use cases (clause 7);

– A set of SC&C use cases (collected by Q2/20 from inputs of the ITU-T membership) (clause 8).

2 References

[ITU-T Y.4200] Recommendation ITU-T Y.4200 (2018), *Requirements for the interoperability of smart city platforms*.

[ITU-T Y.4201] Recommendation ITU-T Y.4201 (2018), *High-level requirements and reference framework of smart city platforms*.

[ITU-T Y.4413] Recommendation ITU-T Y.4412/F.748.5 (2015), *Requirements and reference architecture of the machine-to-machine service layer*.

[ITU-T Y.4500.1] Recommendation ITU-T Y.4500.1 (2018), *oneM2M – Functional architecture*.

[ITU-T Y.4500.2] Recommendation ITU-T Y.4500.2 (2018), *oneM2M – Requirements*.

[ITU-T Y-Sup.27] ITU-T Y-series Recommendations – Supplement 27 (2016), ITU-T Y.4400 series – *Smart sustainable cities – Setting the framework for an ICT architecture* .

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

ABD Area Based Development

AI Artificial Intelligence

ANPR Automatic Number Plate Recognition

API Application Program Interface

AR Augmented Reality

ATCS Adaptive Traffic Control System

CCC Command and Control Centre

CCTNS	Crime and Criminal Tracking Network and Systems
CCTV	Closed Circuit Televisions
CPCB	Central Pollution Control Board
DC/DR	Data Centre/Disaster Recovery
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPON	Gigabit Passive Optical Network
GPS	Global Positioning System
IBMS	Integrated Building Management System
IC	Integrated Circuit
ICCC	Integrated Command and Control Centre
iCJS	Interoperable Criminal Justice Systems
ID	Identification
IoT	Internet of Things
IP	Internet Protocol
ISV	Independent System Vendor
KPI	Key Performance Indicators
MPLS	Multi-Protocol Label Switching
MSDG	Mobile Service Delivery Gateway
NOC	No Objection Certificate
NSDG	National e-Governance Services Delivery Gateway
OTDR	Optical Time Domain Reflectometer
OTN	Optical Transport Network
PIN	Personal Identification Number
PIS	Public Information System
RIMS	River Information Management System
TP	Transfer Protocol
PTZ	Pan–Tilt–Zoom camera
QoS	Quality of Service
R&D	Research and Development
RLVD	Red Light Violation Detectors
SCADA	Supervisory Control and Data Acquisition
SC&C	Smart Cities and Communities
SDGs	Sustainable Development Goals
SOP	Standard Operating Procedures
SIP	Session Initiation Protocol
SLA	Service Level Agreement

SNMP	Simple Network Management Protocol
SSDG	State e-Governance Service Delivery Gateway
TTZ	Taj Trapezium Zone
VaMS	Variable Message Signboard
VoIP	Voice over Internet Protocol
WAN	Wide Area Network

5 Conventions

None.

6 Recommended template for the description of an SC&C use case

Recommended template

The following is a recommended template for the description of an SC&C use case:

1. Title of the use case (title is strictly related to the application area addressed)
   a. Name of the use case
   b. Identification (ID) of the use case (IDs are given in clause 7)
   c. Version/revision history (such as no./month/year)
   d. Source (Country/ITU-T member/Organization registered with ITU)
2. Objective of the use case (aligned with title that has an explanatory content)
3. Background
   a. Current practice (current process/context which will benefit from the implementation of the use case)
   b. Need for use case
   c. Country ecosystem specifics
4. City or community of the use case
   a. City or community name
   b. Country
   c. Region
   d. Population of the city
   e. Phase of the use case (Planning phase/Pilot phase/Commercial phase)
5. Description
   a. Ecosystem description in terms of actors and business roles
   b. Contextual illustration
   c. Pre-requisites
   d. Pre-conditions (if any)
   e. Triggers
   f. Scenario

      NOTE – The basic option is to have a single scenario for each use case. However, multiple scenarios for a single use case are allowed. In such case, they are indicated in this same field as appropriate.
   g. Process flow diagram

h. Post-conditions (if any)

i. Information exchange NOTE – It is expected that the information exchange field (field i) is associated to the process flow (and process flow diagram, if any) (field g).

6. Architectural considerations

   a. Deployment considerations
   b. Geographical considerations
   c. Communication infrastructure
   d. Performance criteria
   e. Interface requirements
   f. User interface
   g. Application program interfaces (APIs) to be exposed to the application from platform
   h. Data management
   i. Data backup, archiving and recovery
   j. Remote device management
   k. Start-up/shutdown process
   l. Security requirements

7. Potential market growth forecast
8. Implementation constraints (for the support of the use case)
9. Statutory compliances and related regulations
10. Available International Standards
11. References (related to standards or other useful information)
12. General remarks

7 Classification for the SC&C use cases

Table 7-1 outlines the classification for the SC&C use cases.

Table 7-1 – Classification for the SC&C use cases

ID Category	Category of SC&C use cases	Use cases
1	Safer city	– Pedestrian monitoring for decisive disaster response – River water-level measurement system using smartphones and augmented reality (AR) – Citizens' safety services
2	Infrastructure	– e-Voucher for farmer assistance – Lift monitoring services – Infrastructure monitoring
3	e-Government	– Citizen identification system using biometric
4	City operation	– City operations Centre – Intelligent traffic management system, adaptive traffic control system, CCTV based real time public safety system, solid waste management and integrated platform with command and control centre for a smart city.

8 SC&C use cases[1]

8.1 Pedestrian monitoring for decisive disaster response

1. Title of the use case (title is strictly related to the application area addressed)
   a. Name of the use case: Pedestrian monitoring for decisive disaster response
   b. ID of the use case (IDs are given in ID category 1 (Safer city) of clause 7);
   c. Version/revision history (such as no./month/year): 1
   d. Source (Country/ITU-T member/Organization registered with ITU): Japan/NEC Corporation
2. Objective of the use case (aligned with title that has an explanatory content)

   A pedestrian monitoring system for disaster response and for accident prevention is described in this use case.
3. Background
   a. Current practice (current process/context which will benefit from the implementation of the use case)

      An area in a city with many people, such as surrounding big stations, needs immediate action in the event of a disaster, and also needs to quickly detect abnormal situations for prevention of accidents.
   b. Need for use case

      The pedestrian monitoring system facilitates the understanding of the behaviour of crowds and the detection of abnormal situations by analysing images captured by surveillance cameras. In the event of any abnormality, the system automatically provides information or instructions for evacuation from the disaster site or for prevention of accidents.
   c. Country ecosystem specifics: None
4. City or community of the use case
   a. City or community name: Toshima city, Tokyo
   b. Country: Japan
   c. Region: Asia
   d. Population of the City: 297,763 (2017)
   e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Commercial phase
5. Description
   a. Ecosystem description in terms of actors and business roles

      Toshima city is one of the eight central administrative cities in Tokyo and is the city where Japan's second largest railway station "Ikebukuro" is located. Ikebukuro station serves 2.59 million commuters a day. Control of a lot of pedestrians or commuters in the event of disasters is a big issue for the city. When the Great East Japan Earthquake hit the city in 2011, there was no system in place to immediately ascertain the number of people in the city that had no way of getting home.

      From the experience of that earthquake, Mayer and Officers of the Disaster Prevention Section of Toshima city recognized that up-to-date and reliable information for evacuation sites and traffic condition is most important when a big disaster hits the city.

[1] Collected by Q2/20 from inputs of ITU-T membership

b. Contextual illustration

- Surveillance cameras are installed throughout the city in order to capture images of the crowds.
- The image data are transmitted to a disaster control centre via broadband network.
- At the disaster control centre, the image data are analysed to detect abnormal situations. Using deep learning, this system can accurately estimate the crowd's behaviour even in a situation where people are overlapped in a captured image.
- The crowd behaviour can be analysed even if the faces of the pedestrians are not captured. It enables privacy protection.
- In the event of any abnormality, the disaster control centre provides accurate information for evacuation or information of shelters. It also provides information to prevent accidents beforehand.

Figure 8-1 – Pedestrian monitoring system [b-NEC]

c. Pre-requisites: None

d. Pre-conditions (if any): None

e. Triggers: None

f. Scenario: This use case can be used to respond not only to earthquake disasters, but also to other disasters.

g. Process flow diagram: None

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations

A total of 51 surveillance cameras were installed in the city. The cameras are connected to a broadband network to collect video information. Existing surveillance cameras can be used and the installation of new cameras is not necessary.

b. Geographical considerations

The cameras were installed throughout the city, such as major transport facilities, major roads and so on. In addition, they were installed in evacuation spots, such as schools, temporary shelters, etc.

c. Communication infrastructure

A broadband network is used in this use case. Captured video data are transmitted via the broadband network to a disaster control centre in real time.

d. Performance criteria

The cameras are designed to collect information on damaged sites in real time.

e. Interface requirements: None

f. User interface: None

g. APIs to be exposed to the application from platform: None

h. Data management: None

i. Data backup, archiving and recovery: None

j. Remote device management: None

k. Start-up/shutdown process: None

l. Security requirements

The collected data must be stored and handled in a secure environment.

Since cameras are installed with enough distance from the pedestrians as compared with conventional surveillance cameras in cities, the faces of the pedestrians are not identified. Although recorded video data are stored at the disaster control centre, personally identifiable information of the pedestrians cannot be identified from the recorded video data.

7. Potential market growth forecast: None

8. Implementation constraints (for the support of the use case): None

9. Statutory compliances and related regulations: None

10. Available International Standards: None

11. References (related to standards or other useful information): https://www.nec.com/en/case/toshima/index.html

12. General remarks: None

8.2 River water-level measurement system using smartphones and AR

1. Title of the use case (title is strictly related to the application area addressed)
   a. Name of the use case: River water-level measurement system using smartphones and AR technology
   b. ID of the use case (IDs are given in ID category 1 (Safer city) of clause 7)
   c. Version/revision history (such as no./month/year): 1
   d. Source (Country/ITU-T member/Organization registered with ITU): Japan/Fujitsu limited
2. Objective of the use case (aligned with title that has an explanatory content)

   In the current field trial, an AR marker was installed in one location in the river basin in Manado, to test whether accurate information useful in disaster prevention can be gathered. Testing is also ongoing to verify whether PU-PERA BWS Sulawesi I's (North Sulawesi province River Basin Organization Sulawesi I, Ministry of Public Works and Housing) quickly recording and sharing changes in the river's water level through this system enables effective condition assessment for river management.

   – Test the possibility of collecting highly accurate information useful in disaster prevention and mitigation.
   – Test whether PU-PERA BWS Sulawesi I's quickly recording and sharing changes in the river's water level through this system enables effective condition assessment for river management.
3. Background
   a. Current practice (current process/context which will benefit from the implementation of the use case)

      Manado, which faces the sea, has four medium-sized rivers flowing through it and is vulnerable to large disasters, such as flash floods and river flooding due to heavy rain, as was the case in January 2014, when large-scale flooding and landslides claimed a number of lives. Victims of flooding are common, not only in Manado, but across Indonesia, so the monitoring of river water levels, the rapid sharing of information by local government workers when water levels reach flood-warning levels, and providing residents with rapid and accurate evacuation instructions have become topics of interest.
   b. Need for use case

      In order to keep maintenance costs reasonable, it is necessary to use a common tool such as a smart phone.

      It is important to measure the level of water from a location at a safe distance from the river using AR technology applications installed in a smart phone in order to avoid dangerous situation like flooding and landslides.

      The JICA (Japan International Cooperation Agency) Indonesia Office felt that AR technology system would have a high probability of being used sustainably.
   c. Country ecosystem specifics

      Systems that install outdoor sensors to monitor river water levels have installation maintenance costs that make them difficult to use in Indonesia on an ongoing basis.
4. City or community of the use case
   a. City or community name: Manado city, North Sulawesi
   b. Country: Indonesia
   c. Region: Asia
   d. Population of the city: 701 390 (2014)

e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Pilot phase

5. Description

a. Ecosystem description in terms of actors and business roles

Manado, which faces the sea, has four medium-sized rivers flowing through it and is vulnerable to large disasters, such as flash floods and river flooding due to heavy rain, as was the case in January 2014, when large-scale flooding and landslides claimed a number of lives.

Systems that install outdoor sensors to monitor river water levels incurs installation maintenance costs that make them difficult to use in Indonesia on an ongoing basis.

Division of roles

1) Fujitsu and Fujitsu Indonesia

Fujitsu is handling the management of this operational trial project as a whole and developing the application and building the system, while Fujitsu Indonesia is primarily supporting system building, training the staff of PU-PERA BWS Sulawesi I, and supporting the operational trial.

The two companies developed the river information system, including the smartphone app, provided the smartphones (locally available phones), installed the AR marker in the river basin, and provided the information aggregation platform (a cloud server in a Fujitsu datacentre) to handle data accumulation and consolidation.

2) PU-PERA BWS Sulawesi I

PU-PERA BWS Sulawesi I measures the river water level with the smartphone app, and monitors river water levels. If the water level reaches flood-warning levels, they will report to Manado's municipal workers with early evacuation instructions.

b. Contextual illustration

Trial contents

1) River water-level measurement

Employees of PU-PERA BWS Sulawesi I responsible for monitoring river water levels transmit information every day, three times per day concerning water levels, as well as photos, and comments that relay the state of water-level increases with the smartphone application. They are able to measure the water levels safely using their camera's zoom function to take their measurements at some distance from the river. They can provide accurate observations because they can tap the on-screen surface of the water to fix the scale, which generates digital values.

The image processing algorithm of the AR water level measurement application is as follows (see Figure 8-2):

I. Read the AR marker on the camera image with the image recognition technology.

II. Recognize the ID number (associated to the position of the area) from the pattern of the AR marker and read the metadata (location, height, and size of the marker) which are previously set.

III. Display a scale on the screen as AR based on the size of the marker.

VI. Measure the water level by finger pointing on the smartphone screen.

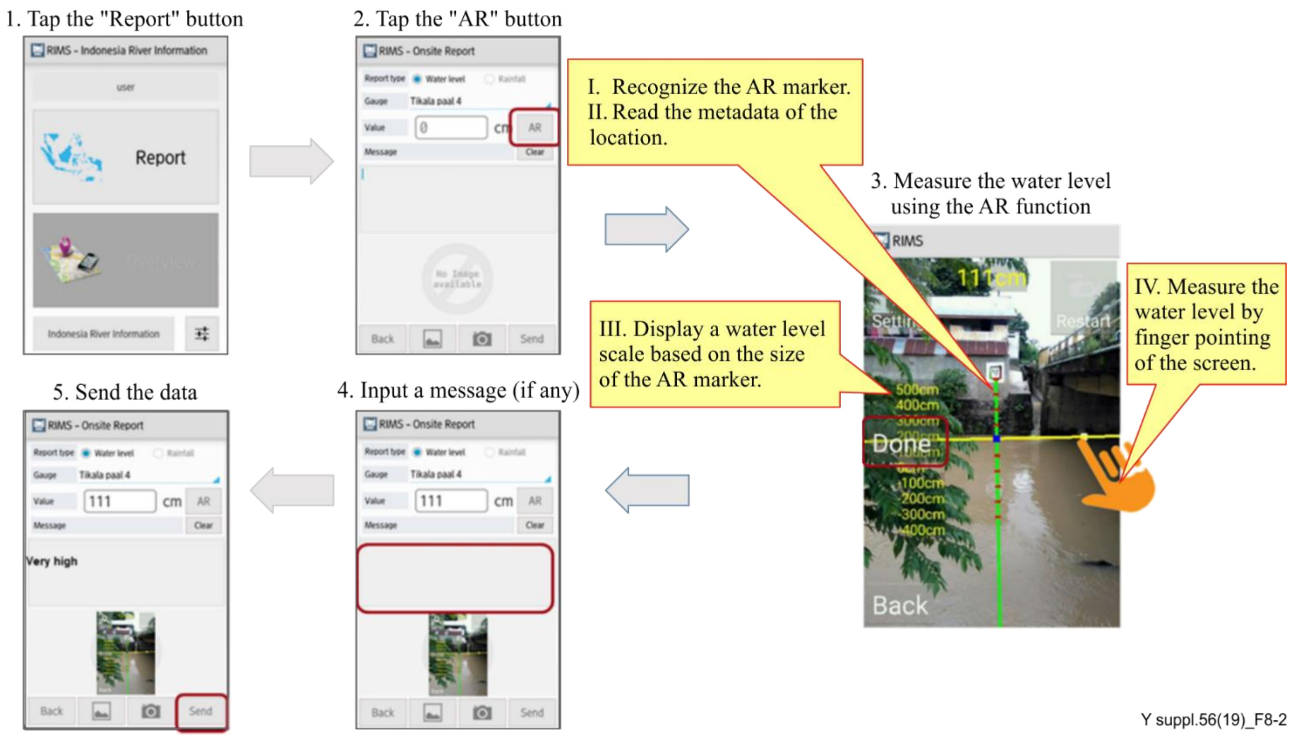

Figure 8-2 – Water-level measurement using AR technology

2) River water-level monitoring

PU-PERA BWS Sulawesi I employees responsible for managing the river, check the water level and its changes via the Internet three times per day. With this system, measured water levels, on-site photographs, and comments from those responsible for taking measurements are collected, and the changes in water level at the location are graphed. If the water reaches flood-warning levels, the system displays an alarm. In this trial, alarms are only being displayed on-screen, but it is also possible to send alarm messages to the mobile phones of local government disaster prevention and mitigation workers.

The JICA Indonesia Office expects that, as employees of PU-PERA BWS Sulawesi I can check this information via Internet-connected computers and smart devices, they can obtain reliable river data, which will be useful in issuing early evacuation orders to prepare for a flood.

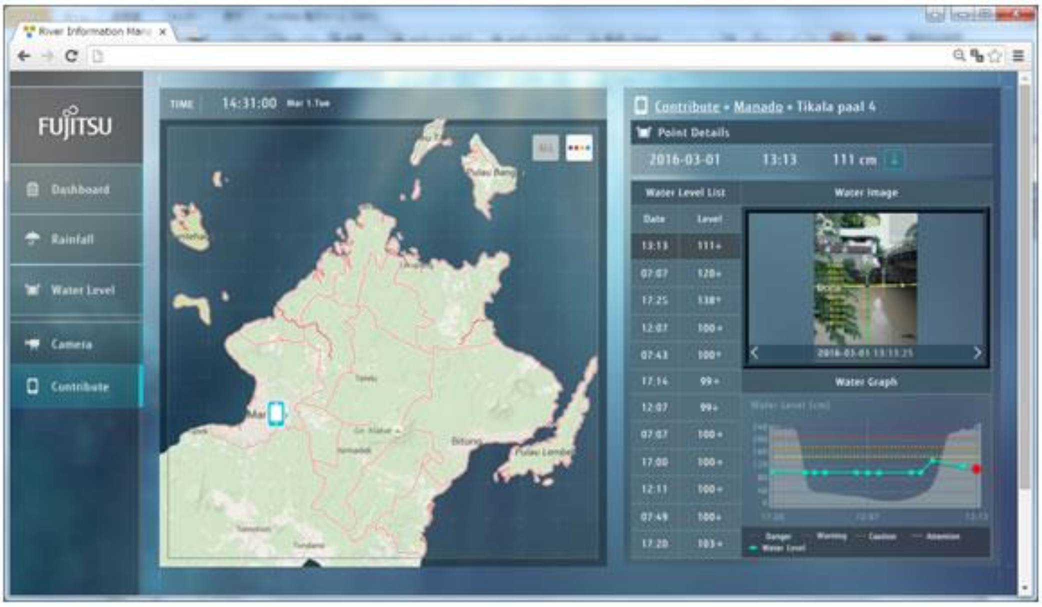

Figure 8-3 – Screenshot of the river information system website

In the current trial, the river information collected by this system is only being shared with the employees of PU-PERA BWS Sulawesi I. However, if this trial shows the system to be effective, , and if it is fully implemented in Manado by making this information public, it may also be useful in residents' voluntary, autonomous disaster prevention and mitigation activities.

Furthermore, with the continued accumulation of information in the datacentre for a number of years, it will become possible to use big data analysis, which may be useful in disaster prediction or reinforcement and repair planning for the rivers [b-Fujitsu].

c. Pre-requisites: Availability to access the signal of a base station of smart phone.

d. Pre-conditions (if any): Person will measure the level of river water by the special software in smart phone with AR marker.

e. Triggers: None

f. Scenario: To save the maintenance cost of measurement of the river water level.

g. Process flow diagram: Refer to the figure of contextual illustration.

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations: It is necessary to set the AR marker in order to be able to measure the same depth of river water than using the conventional scale.

b. Geographical considerations

An AR marker was installed in one location in the river basin in Manado.

c. Communication infrastructure

A mobile phone network is used in this use case. Measurement data are transmitted via a mobile phone network to a data centre in real time.

d. Performance criteria

A smartphone with camera is needed.

e. Interface requirements: Smart phone with camera and software river information management system (RIMS)

f. User interface: RIMS

g. APIs to be exposed to the application from platform: None

h. Data management: None

i. Data backup, archiving and recovery: None

j. Remote device management: None

k. Start-up/Shutdown process: None

l. Security requirements

The collected data must be stored and handled in a data centre.

7. Potential market growth forecast: 34 states in Indonesia

8. Implementation constraints (for the support of the use case): None

9. Statutory compliances and related regulations: None

10. Available International Standards: None

11. References (related to standards or other useful information): http://www.fujitsu.com/global/about/resources/news/press-releases/2016/0309-01.html

12. General remarks: None

8.3 Citizens' safety services

1. Title of the use case (title is strictly related to the application area addressed)

a. Name of the use case: Citizens' safety services

b. ID of the use case (IDs are given in ID category 1(Safer city) in clause 7);

c. Version/revision history (such as no./month/year: 1.0)

d. Source (Country/ITU-T member/Organization registered with ITU): Korea (Republic of)/ETRI

2. Objective of the use case (aligned with title, it has explanatory content)

This use case describes interworking between smart city operation centre and fire and police station for the citizens' safety services.

NOTE – The main role of smart city operation centre in this use case is to monitor the closed circuit televisions (CCTVs) throughout the city.

3. Background

a. Current practice (current process/context which will benefit from the implementation of the use case)

Currently, firefighters or police officers depend on the information obtained by telephone call when dispatched, so they are not able to respond efficiently in the field.

b. Need for use case

When the fire engine is dispatched, it can be dispatched promptly to the scene of a fire by providing traffic information of the road leading to the fire. The fire fighters can effectively put the fire out with the information provided in advance about the scene of a fire made possible from the CCTV footage which is monitored from the smart city operation centre.

Also, smart city operation centre can provide real time CCTV footage through wireless network for police officers to assist with the arrest of criminals for reported crimes .

c. Country ecosystem specifics: None

4. City or community of the use case

   a. City or community name: Daejeon metropolitan city

   b. Country: Korea (Republic of)

   c. Region: Asia

   d. Population of the City: 1,493,654 (September 2018)

   e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Commercial phase

5. Description

   a. Ecosystem description in terms of actors and business roles

   The smart city operation centre is connected with the fire and police station. The fire and police station request CCTV footage from the smart city operation centre and the smart city operation centre shares the CCTV footage with the fire and police station (see Figures 8-4 and 8-5).

   b. Contextual illustration

   In the case of a crime, fire, rescue, first aid, or a disaster, the smart city operation centre provides real-time CCTV images on the scene to support efficient intervention.

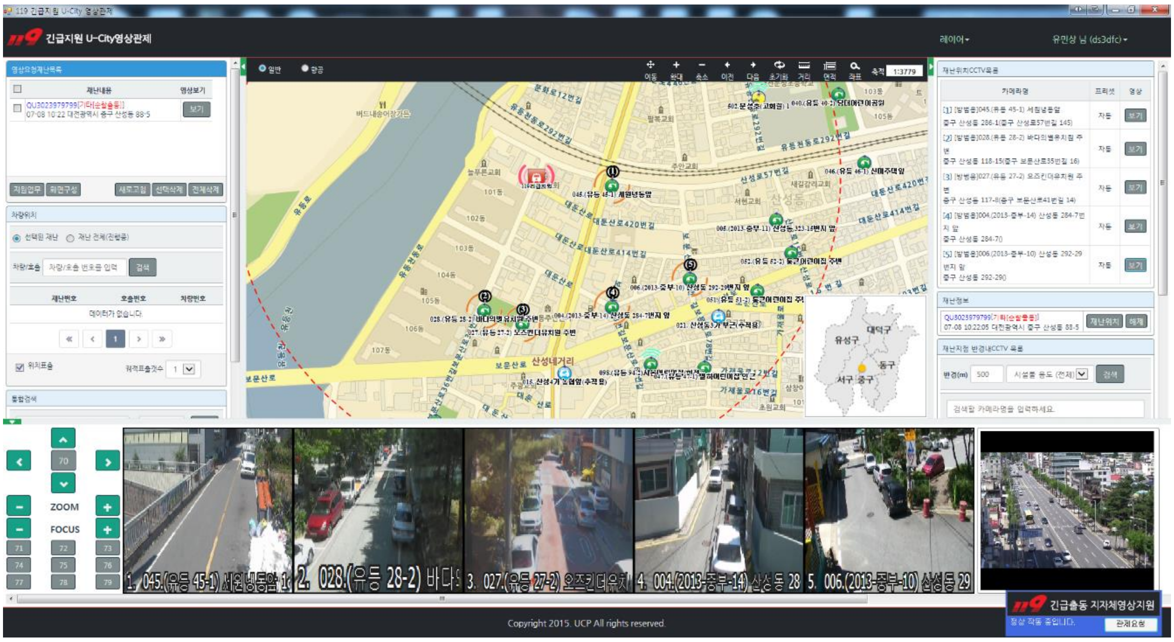

Figure 8-4 – Interworking between smart city operation centre and fire station

Figure 8-5 – Interworking between smart city operation centre and police station

c. Pre-requisites: None

d. Pre-conditions (if any): None

e. Triggers: When a crime, fire, rescue, first aid or disaster is reported.

f. Scenario

1) Interworking between smart city operation centre and fire station

– In the case of a fire, rescue, first aid, or a disaster, the fire station sends the location information of the scene and street information of the location to where fire engine is going.

– The smart city operation centre provides traffic information of the road to a fire for prompt dispatch based on the real-time CCTV images.

– The smart city operation centre provides fire fighters with information regarding the scene of a fire in advance to help them to put the fire out more effectively.

2) Interworking between a smart city operation centre and police station

– In the case of a crime, the police station sends the location information of the scene of the crime.

– The -smart city operation centre provides crime scene information based on the real-time CCTV images.

– The smart city operation centre shares CCTV images of crime scenes to help to track down the criminals.

g. Process flow diagram

1) Interworking between the smart city operation centre and the fire station

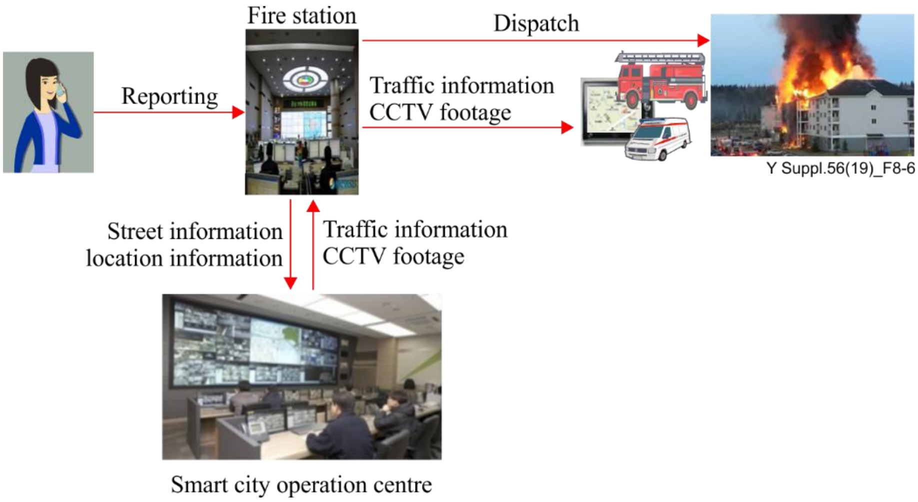

Figure 8-6 – Process flow of interworking between smart city operation centre and fire station

2) Interworking between smart city operation centre and police station

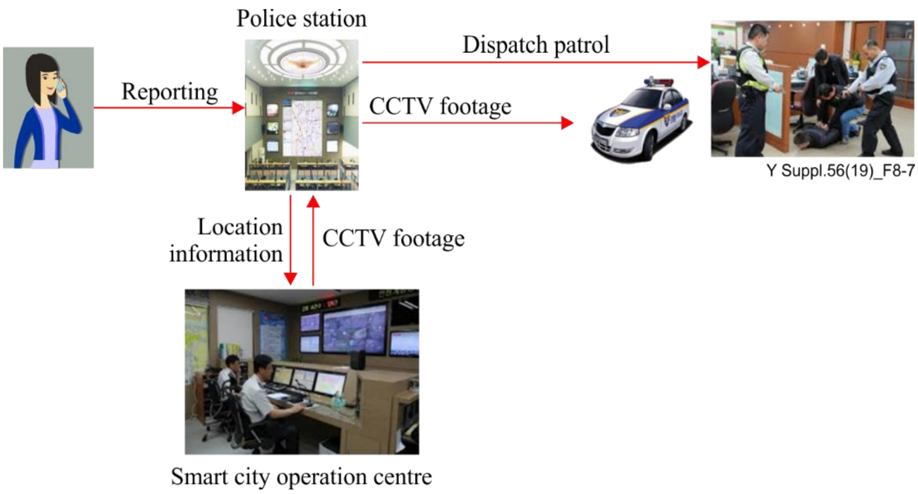

Figure 8-7 – Process flow of interworking between smart city operation centre and police station

h. Post-conditions (if any): None

i. Information exchange:

The location information of the scene, street information where the fire engine is going, traffic information and real-time CCTV footage on that location are exchanged.

6. Architectural considerations

   a. Deployment considerations

      It is critical to deploy CCTVs conforming to the standard. When CCTVs conforming to different standards are applied, mechanism for converting from one standard to the other standard should be added. For example, protocols and format, etc.

   b. Geographical considerations

      Consideration should be given to covering a large area with a minimal number of CCTVs.

   c. Communication infrastructure

      CCTVs communicate with monitors and/or video recorders across wired or wireless communication links.

   d. Performance criteria

      Minimum CCTV resolution to support the identified service.

   e. Interface requirements

      It is critical to effectively control multiple CCTV screens.

   f. User interface: None

   g. APIs to be exposed to the application from platform: None

   h. Data management: None

   i. Data backup, archiving and recovery

      No more CCTV footage should be stored than that which is strictly required for the stated purpose of a CCTV, and such CCTV footage should be deleted once their purposes have been served.

   j. Remote device management

      CCTVs should be capable of remote directional and zoom control from the smart city operation centre.

   k. Start-up/Shutdown process: None

   l. Security requirements

      It is critical to protect the personally identifiable information of individuals who can be exposed to CCTV screens.

7. Potential market growth forecast: None

8. Implementation constraints (for the support of the use case): None

9. Statutory compliances and related regulations: None

10. Available International Standards: None

11. References (related to standards or other useful information): http://www.daejeon.go.kr/uic/index.do (Korean only), http://www.daejeon.go.kr/dre/index.do

12. General remarks: None

8.4 E-voucher for farmer assistance

1. Title of the use case (title is strictly related to the application area addressed)

   a. Name of the use case: E-voucher for farmer assistance

   b. ID of the use case (IDs are given in ID category 2 (Infrastructure) of clause 7);

c. Version/revision history (such as no./month/year): 1

d. Source (Country/ITU-T member/Organization registered with ITU): Japan/NEC Corporation

2. Objective of the use case (aligned with title that has an explanatory content)

In Mozambique, agriculture is the main economic activity. Administration initially distributed paper vouchers to small-scale farmers to give them greater market access and to improve the quality of agricultural products. However, there were problems with this system in terms of security, traceability, and convenience.

An e-voucher system using mobile technology and contactless IC cards has been introduced with a number of partners including telecom carrier, the United Nations Food and Agriculture Organization (FAO), Nippon Biodiesel Fuel, and NEC Corporation. This solution enabled farmers to utilize subsidies more effectively and to increase their income by improving the distribution of agricultural products.

3. Background

a. Current practice (current process/context which will benefit from the implementation of the use case)

In Mozambique, where 70% of the population lives in rural areas, improvement in agricultural productivity is a key issue for national development. A means of improving agricultural productivity is the widespread distribution of high-quality seeds, seedlings and fertilizer to farmers. The FAO has been endeavouring to improve Mozambique's agricultural productivity by distributing paper vouchers that partially subsidize farmer's purchases of seeds, seedlings and fertilizer. Once the farmers have exchanged their vouchers at agricultural supply stores, , the FAO collects the vouchers from the merchants and reimburse them with the money value of the vouchers.

b. Need for use case

Given the vast expanse of Mozambique's rural regions, the collection of paper vouchers and reimbursement of merchants took a long time. Long delays between voucher redemption and reimbursement and inaccurate purchase data collection led to a problematic situation that tied up the working capital of agricultural supply merchants, with no means to accurately assess by whom and for what purposes the vouchers were being used. To resolve these issues, economic infrastructure which utilizes e-money technology was built.

c. Country ecosystem specifics: None

4. City or community of the use case

a. City or community name: None

b. Country: Mozambique

c. Region: Africa

d. Population of the City: 29,668,834 (2017)

e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Commercial phase

5. Description

a. Ecosystem description in terms of actors and business roles

NEC Corporation

The Food and Agriculture Organization (FAO) of the UN

Nippon Biodiesel Fuel (NBF)

Farmers

Accredited Merchants (Retail Stores)

b. Contextual illustration

The infrastructure has facilitated the smooth distribution of agricultural supplies while also enabling the FAO to provide more effective guidance on improving crop yields based on the purchase histories of individual farmers. Mozambique's agricultural productivity has consequently improved. The improvement has also been accompanied by growth in farmers' incomes.

The e-voucher system works according to the following steps (see Figure 8-8):

– NBF consigned by the administration provides e-vouchers (contactless IC cards) to farmers. Information of user names and remaining balance is recorded in the e-vouchers.

– The farmers can confirm the remaining balance using a tablet device (or other device for e-payment) installed at retail stores. Four digit personal identification number (PIN) number is adopted for user identification.

– The farmers can use the e-vouchers only for the required amount at the retail stores in order to buy seeds, seedlings, fertilizer, and so on. They can also buy other things from the agro-dealer by adding their capital to the remaining balance of the e-vouchers.

– Purchase information is transmitted to the FAO via stores and administration. The value of the e-vouchers is paid to the stores as a subsidy by the FAO. The FAO and the administration can monitor when, where, and for what the e-vouchers were used.

– Operations of the tablet devices at retail stores are monitored. When there is no operation for a certain period of time, maintenance staff are sent to the site of the retail store.

This digital transformation underpinned a landscape-changing e-money solution aligned with three ssustainable development goals (SDGs): No poverty, industry, innovation, and infrastructure, and partnerships for goals.

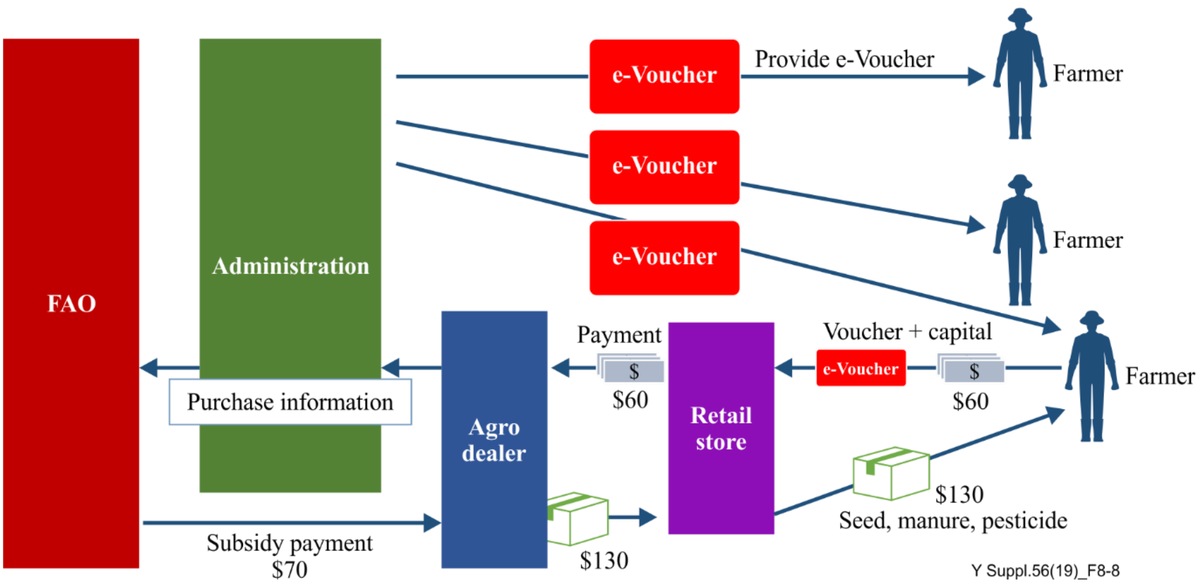

Figure 8-8 – E-voucher system for farmer assistance

c. Pre-requisites: None

d. Pre-conditions (if any): In order to transmit purchase information, Internet access at the stores is required. Since data amount is not huge, broadband network is not required.

e. Triggers: None

f. Scenario: None

g. Process flow diagram: None

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations

At the sites where the tablet devices are installed, solar panels are also installed for the provisioning of electricity.

b. Geographical considerations

For maintenance of tablet devices, location information of device installation (i.e., location of the retail stores) is managed by administration.

c. Communication infrastructure

Since purchase information (when, where, and for what the e-vouchers were used) is transmitted to the administration, the tablet devices need network connection.

d. Performance criteria: None

e. Interface requirements: None

f. User interface: None

g. APIs to be exposed to the application from platform: None

h. Data management: None

i. Data backup, archiving and recovery: None

j. Remote device management: None

k. Start-up/Shutdown process: None

l. Security requirements:

Administration securely manages the information of users and the remaining balance of the e-voucher. It enables the replacement of an e-voucher showing the existing balance should a farmer lose the original e-voucher.

7. Potential market growth forecast:

Similar financial platforms can be leveraged in many emerging countries.

8. Implementation constraints (for the support of the use case): None

9. Statutory compliances and related regulations: None

10. Available International Standards: None

11. References (related to standards or other useful information): None

12. General remarks: None

8.5 Lift monitoring services

1. Title of the use case (title is strictly related to the application area addressed)

a. Name of the use case: Lift monitoring services

b. ID of the use case (IDs are given in ID category 2 (Infrastructure) of clause 7);

c. Version/revision history (such as no./month/year): 1.0

d. Source (Country/ITU-T member/Organization registered with ITU): Korea (Republic of)/ETRI

2. Objective of the use case (aligned with title that has an explanatory content)

   This use case describes maintenance and safety services for elevators in a smart city

3. Background

   a. Current practice (current process/context which will benefit from the implementation of the use case)

      Currently, an administrator or an inspector performs lift safety inspection , danger is detected by the user's report, and emergency warning is activated.

   b. Need for use case

      When managing lifts, it is possible to conduct safety and status check remotely by using a monitoring system. It is also possible to control when an individual is trapped in the elevator, or when a problem such as failure or stoppage occurs. Therefore, smart city operators manage smart city safely and conveniently using lift monitoring systems.

   c. Country ecosystem specifics: None

4. City or community of the use case

   a. City or community name: Seoul metropolitan city

   b. Country: Korea (Republic of)

   c. Region: Asia

   d. Population of the City: 10,124,579 (December 2017)

   e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Commercial phase

5. Description

   a. Ecosystem description in terms of actors and business roles

      Smart city operation centre is connected with lift and management office. The smart city operation centre requests lift monitoring information from the lift administrator or management office and shares lift monitoring information.

      NOTE – The main role of the smart city operation centre in this use case is to monitor and control the lifts throughout the city.

   b. Contextual illustration

      For lift management and safety purposes, the smart city operation centre performs real-time monitoring, control, diagnosis, and management functions and provides statistical information.

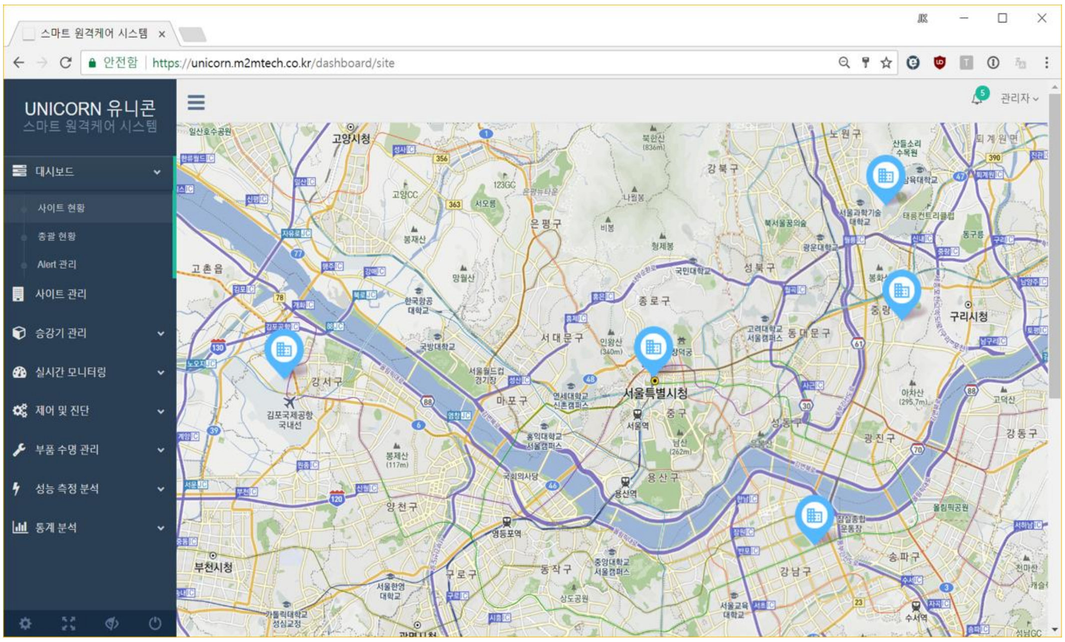

Figure 8-9 – Interworking between smart city operation centre and lift system

c. Pre-requisites: None

d. Pre-conditions (if any)

The applications used by users and engineers are different. Using the application which is made available in the users' devices, users provide location information updates to the smart city operation centre and receive nearby lift failure information. The smart city operation centre notifies the engineers located at the shortest distance from the failed lift.

e. Triggers: When an emergency alarm, out of service (fault) or fire operation is reported.

f. Scenario

1) Interworking between smart city operation centre and lift system

   – If an emergency alarm, out of service or fire operation event is detected in the elevator. An event is sent to the smart city operation centre.

   – Smart city operation centre sends events to nearby users to prevent further accidents, or to engineers to repair faults.

   – The engineers complete the inspection of the event, send a completion message to the smart city operation centre. The smart city operation centre receives messages from engineers, or receives complete events directly from the lift system.

g. Process flow diagram

1) Interworking between a smart city operation centre and a lift system (see Figure 8-10)

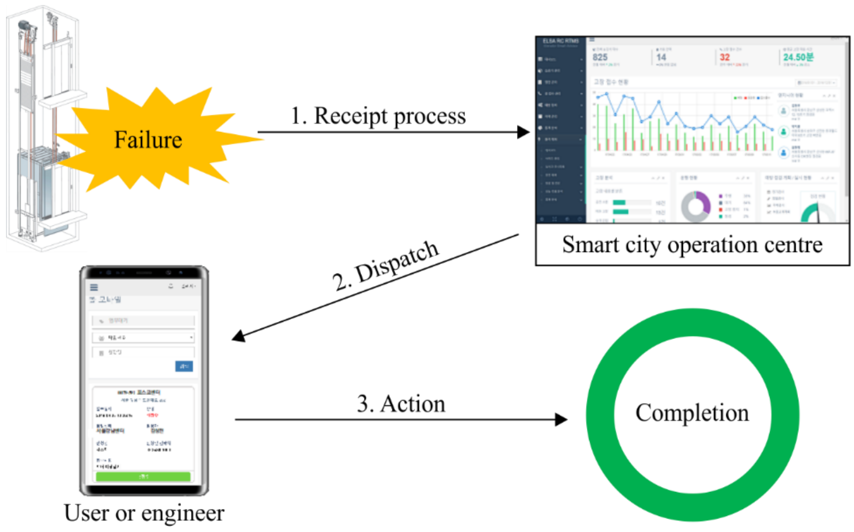

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Figure 8-10 – Process flow of interworking between a smart city operation centre and a lift system

h. Post-conditions (if any): None

i. Information exchange

The lift is managed based on the lift registration number, and the location information is stored therein. The location information of the lift system and fault related information are exchanged.

The smart city operation centre sends a fault alarm to users near a broken lift, and sends information regarding the fault to the engineers closest to the lift.

6. Architectural considerations

a. Deployment considerations

Equipment such as Internet of things (IoT) gateways for remote monitoring in lifts should be supported. Standard protocols and data formats for event transmission should be defined.

b. Geographical considerations: None

c. Communication infrastructure

Lifts communicate with monitoring system across wired or wireless communication links.

d. Performance criteria: None

e. Interface requirements: None

f. User interface: None

g. APIs to be exposed to the application from platform: None

h. Data management: The lift number is unique and consists of seven digits. The first two digits indicate the area and lift type. Then, the rest of digits is allocated in order and match with the specific address information and other lift related information such as lift specification.

i. Data backup, archiving and recovery: None

j. Remote device management: None

k. Start-up/Shutdown process: None

l. Security requirements

The collected data must be stored and handled in a secure environment.

7. Potential market growth forecast: None
8. Implementation constraints (for the support of the use case): None
9. Statutory compliances and related regulations: None
10. Available International Standards: None
11. References (related to standards or other useful information): https://unicorn.m2mtech.co.kr (Korean only)
12. General remarks: None

8.6 Citizen identification system using biometrics

1. Title of the use case (title is strictly related to the application area addressed)
   a. Name of the use case: Citizen identification system using biometric.
   b. ID of the use case (IDs are given in ID category 3 (e-Government) of clause 7)
   c. Version/revision history (such as no./month/year):1
   d. Source (Country/ITU-T member/Organization registered with ITU): Japan/NEC Corporation
2. Objective of the use case (aligned with title that has an explanatory content)

   As reported by the UN e-Government Survey 2018, providing legal identities can help by expanding financial inclusion and preventing fraud and corruption in the delivery of social services. Digital identities have been offered as a means to effectively expedite the process. A unique identity and digital platform can authenticate citizens anytime, anywhere. It enables that every single person can equally have access to education, healthcare, social welfare, banking, and other public and financial services.
3. Background
   a. Current practice (current process/context which will benefit from the implementation of the use case)

      In India, the Aadhaar program is providing digital identity to the entire population and serves as the basis for interacting with the government at various levels. Once a person registers for the system, he or she receives an individual 12-digit identification number. The 12-digit number is used for fair provision of social services, such as food distribution, government subsidy, and so on. This helpsto avoid duplicate provision or fictitious claims of the subsidy. The number is also required when a person opens his/her new bank account or contracts a new mobile phone. A payment system using fingerprints is also available. In April 2016, one billion people registered for the system. It is the largest system of its kind in the world.
   b. Need for use case

      As with any identification system, it must be robust enough to prevent duplicate registrations, and to stop people from impersonating others and committing fraud. This is essential in order to maintain the integrity of the system and the trust of the people registered to the system. Furthermore, with so many citizens to register, the registration procedure needs to be as simple, accurate and efficient as possible.
   c. Country ecosystem specifics: None
4. City or community of the use case
   a. City or community name: None
   b. Country: India

c. Region: Asia

d. Population of the City: 1,210,854,977 (2011)

e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Commercial phase

5. Description

a. Ecosystem description in terms of actors and business roles

NEC Corporation

UIDAI (The Unique Identification Authority of India)

b. Contextual illustration

– In the Aadhaar programme, when a person registers his or her information (name, address, and biometric information), a 12-digit number is given to the person if the person did not register before.

– For the biometric information, fingerprints, face images, and iris images are collected (see Figure 8-11) and used for preventing people from being registered twice.

– After the registration, the 12-digit number is used for social services.

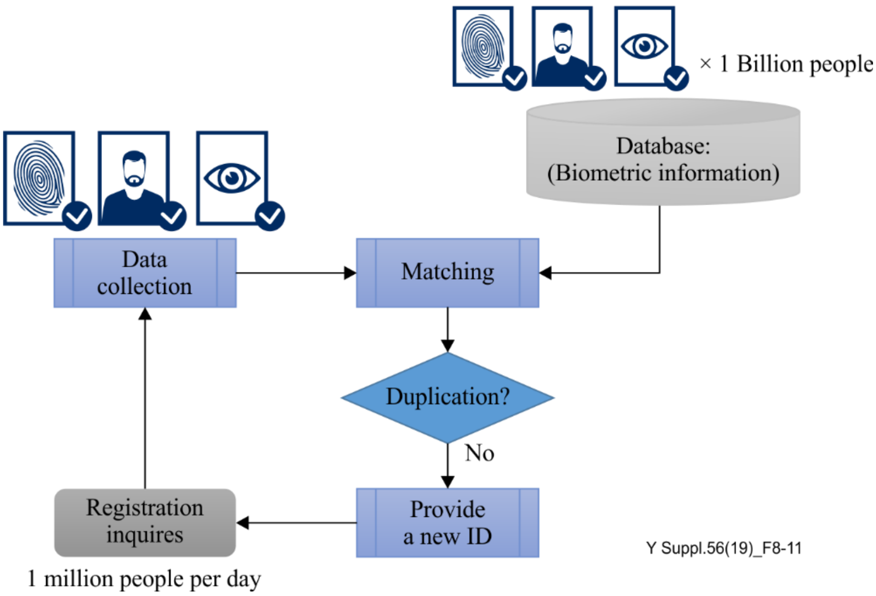

Figure 8-11 – Citizen identification system using biometric

c. Pre-requisites: None

d. Pre-conditions (if any): None

e. Triggers: None

f. Scenario: None

g. Process flow diagram: None

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations

The quality of information also depends on the manual operation of biometric data collection. Trained and experienced staff members should be deployed at the data collecting sites.

b. Geographical considerations: None

c. Communication infrastructure

   Since collected biometric information is compared with the data of people who are already registered to the system and stored in a database, the registration sites need network connection for the comparison and accumulation.

d. Performance criteria:

   This system can handle more than one million registrations per day by checking the registered biometric information for more than one billion people and comparing it to the biometric information of people seeking to register.

e. Interface requirements: None

f. User interface: None

g. APIs to be exposed to the application from platform: None

h. Data management: None

i. Data backup, archiving and recovery: None

j. Remote device management: None

k. Start-up/Shutdown process: None

l. Security requirements: None

7. Potential market growth forecast:

   This citizen identification system is aligned with Target 16.9 of the SDGs on identity, which states that "By 2030, provide legal identity for all, including birth registration" and can be applied to various cities and communities including those with large populations.

8. Implementation constraints (for the support of the use case): None

9. Statutory compliances and related regulations: None

10. Available International Standards: None

11. References (related to standards or other useful information): None

12. General remarks: None

8.7 City operations centre

1. Bristol Operations Centre

   a. Bristol Operations Centre

   b. ID of the use case (IDs are given in ID category 4 of clause 7)

   c. Version 1, November 2019

   d. United Kingdom

2. Objective of the use case (aligned with title that has an explanatory content)

   The Bristol Operations Centre is a key element of Bristol's smart city programme aimed at improving the quality of living standards of citizens by providing integrated, city-wide management and service delivery.

3. Background

   a. Current practice (current process/context which will benefit from the implementation of the use case)

      With a focus on the needs of citizens and improving the quality of living standards of citizens, Bristol required a solution to bring together a variety of functions such as traffic management, public transportation, and services such as telemedicine in one place. To do this, a city operations centre was created.

b. Need for use case

A variety of stakeholders including government, industry, and public services were providing city management and service delivery roles, however, coordination and collaboration could be improved to better address the needs of the citizen. Although not the only driver, by bringing together and integrating citizen services and increasing business efficiency, there is a direct financial benefit to the city through saved cost and commercial revenue.

c. Country ecosystem specifics: None

4. City or community of the use case

a. City or community name: Bristol

b. Country: United Kingdom

c. Region: Europe

d. Population of the City: 463,000

e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Operational

5. Description

a. Ecosystem description in terms of actors and business roles

Industry, local government, and social services all have roles in providing citizen-centric services in Bristol. Notably, the operations centre brings together actors such as private sector public transportation providers, emergency services (blue light agencies), Bristol City Council, Bristol is Open (a joint venture aimed at the development of a smart city), University of Bristol and telecare agencies. The operations centre is being deployed in stages, which started with the traffic management integration.

b. Contextual illustration

A connected operations centre for Bristol was created. The operations centre connects actors in the public and private sector both digitally and physically (i.e., within one office) which is fundamental to the delivery of essential services for the city and its citizens.

c. Many of these actors are housed in the same building allowing for greater contact and coordination, resulting in a better environment for citizens. This includes the city council's Emergency Control Centre, Traffic Control Centre, and Community Safety Control Rooms.

Staff from transport providers, such as bus companies, also have a space in the centre to work with the city council's traffic management team. Not all of the value is derived from connected technologies. For example, the city's bus drivers also provide timely and valuable information that may then be shared with appropriate teams in the operations centre.

c. Pre-requisites: None

d. Pre-conditions (if any): None

e. Triggers: None

f. Scenario

The operations centre is also the main hub for managing large scale events in the city such as festivals.

Dedicated teams of actors including festival managers can be located together in the operations centre and facilitates cross-service coordination to improve citizen's experience. This may include managing traffic flows before, during, and after events, ensuring emergency services can reach their destination in a timely manner, or, using information provided by staff across the city (e.g., bus drivers) to feedback real-time information that may not be observed by the city's various connected systems.

This coordination helps to address the needs of citizens in a number of ways, such as improving their access to services as well as their experience in the city or at an event.

g. Process flow diagram: None

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations

Many actors were digitally connected through technology and physically by moving into the same building. Depending on the actors and their roles, permanent and temporary collaborations may be considered.

Public and private actors were brought together to improve city management and service delivery to address the needs of citizens. It is considered best practice for stakeholders like city managers to consider the needs of the citizens and the actors across sectors that are most appropriate to bring together to improve collaboration.

Bristol focused on traffic management as its first area of collaboration in the operations centre. It is considered best practice for stakeholders such as city managers to identify a deployment plan that will best address the needs of the citizens and improve collaboration across actors and sectors.

b. Geographical considerations

Cities may identify priority areas to focus their initial efforts, such as city centre traffic. Cities may also identify new priority areas as the project develops. For instance, Bristol identified their harbour side as a key area requiring better infrastructure and collaboration to improve safety for citizens. There is ongoing work to improve emergency service response if an individual falls into the water.

c. Communication infrastructure

Bristol city invested in infrastructure for the operations centre including its own fibre network that provides connectivity for some services throughout the city including the operations centre, emergency services, and traffic lights. While connectivity supports the operations centre, it is not necessary for a city or municipality to have a dedicated fibre network to benefit from the coordination of city managers and service providers or digital technologies.

d. Performance criteria: None

e. Interface requirements: None

f. User interface: None

g. APIs to be exposed to the application from platform: None

h. Data management

Data is managed in accordance with relevant regulations, including national and European regulations. To support coordination and integration across city services and managers, data may be shared as appropriate and relevant and in accordance with applicable regulations and information security best practices.

i. Data backup, archiving and recovery

j. Remote device management

k. Start-up/Shutdown process

l. Security requirements

7. Potential market growth forecast
8. Implementation constraints (for the support of the use case)
9. Statutory compliances and related regulations
10. Available International Standards
11. References (related to standards or other useful information)
12. General remarks

8.8 Intelligent traffic management system, adaptive traffic control system, CCTV based real time public safety system, solid waste management and integrated platform with command and control centre (ICCC) for a smart city

1. Title of the use case
   a. Name of the use case: Implementation of intelligent traffic management system, adaptive traffic control system, CCTV based real time public safety system, solid waste management and integrated platform with command and control centre (ICCC) for a smart city
   b. ID of the use case: 4
   c. Version/revision history: 2/Nov/2019
   d. Source: India/MoC/TEC
2. Objective of the use case

   The description of this use case is essentially related to Agra city, India, as this use case is based on project work being carried out in Agra smart city. However, the use case is being considered for a more general applicability to other cities.

   The key objective of this project is to establish a collaborative framework where inputs from different functional departments of Agra Municipal Corporation and other stakeholders such as transport, water, fire, police, e-governance, etc., can be assimilated and analysed on a single platform; consequently, resulting in aggregated city level information. Furthermore, this aggregated city level information can be converted to actionable intelligence, which would be propagated to relevant stakeholders and citizens.

   The following results are expected to be achieved by the proposed interventions:
   1) Efficient traffic management
   2) Efficient transport management
   3) Enhanced safety and security
   4) Better management of utilities and quantification of services
   5) Asset management
   6) Disaster management and emergency response
   7) Integration with all existing, proposed and future services as identified by a smart city including but not limited to (with provision for future scalability):
      i. CCTV based real time public safety system
      ii. Adaptive traffic control system
      iii. Intelligent transport management system
      iv. Solid waste management
      v. Smart parking
      vi. Panic button/emergency call box
      vii. Public address system

viii. Environmental sensors
ix. GIS based system
x. Citizen application mobile app and Web portal

Future services

i. Smart poles
ii. Smart lighting
iii. Smart governance
iv. City network
v. City Wi-Fi
vi. Water supervisory control and data acquisition (SCADA) and smart meters
vii. Sewerage
viii. Storm water drainage
ix. e-Medicine/Health
x. e-Education
xi. Disaster management
xii. Grievance management
xiii. Fire
xiv e-Governance – Including service delivery gateway like NSDG, SSDG, MSDG etc.

Smart policing and integrated module

i. Crime and criminal tracking network and systems (CCTNS)
ii. e-Prison
iii. e-Courts
iv Interoperable criminal justice systems (iCJS)
v. It is critical to be able to integrate directly or through bridge with all available applications which are launched by smart cities from time to time.

3. Background

a. Current practice:

Agra City is lacking complete IT and ICT elements with entire infrastructure. All the processes in terms of solid waste, managing city traffic and public awareness is manual and respective institution driven.

b. Need for use case: One of the primary objectives of Agra under its smart city mission is to enhance the safety and security for citizens of Agra and worldwide tourists visiting Agra to see its heritage monument, the Taj Mahal, which is one amongst the Seven Wonders of the World.

Other objective caters to bring law enforcement and public awareness among citizens of Agra on various horizons of traffic rules, safe driving, solid waste, and improved sanitation, to promote a better quality of life for residents and to also enhance and improve the efficiency of municipal services.

In order to achieve these objectives, it is critical to develop robust ICT infrastructure that supports digital applications and ensures seamless steady state operations, transport and traffic management, emergency response mechanisms, and real time tracking of services and vital city metrics throughout the city and in government departments.

c Country ecosystem specifics: None

4. City or community of the use case
    a. City or community name: Agra, Uttar Pradesh
    b. Country: India
    c. Region: Asia
    d. Population of the City: > 1.5 Million
    e. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Commercial phase
5. Description
    a. Ecosystem description in terms of actors and business roles

       Agra is a major tourist hub with a number of monuments like Agra Fort and Fatehpur Sikri Fort, other than the Taj Mahal, which have been listed as a UNESCO World Heritage site.

       Although the spatial growth has been considerable, disproportionate spatial development has led to pockets of high density in terms of employment and population, putting pressure on the infrastructure of the city. A phenomenal increase in commercial activities witnessed during the post-independence period with the associated industrial development and establishment of industrial estate, resulted in the increase of city population.

       In 1998 the Ministry of Environment and Forests, Government of India notified an area of 10400 square kilometres as Taj Trapezium Zone (TTZ). The CPCB delineated the Taj Trapezium Zone on the basis of the weighted mean wind speed in twelve directions from Agra to Mathura and Bharatpur. The boundaries of the zone were established bearing in mind the possible effect of pollution sources in this zone on the critical receptor- the Taj Mahal. It banned the use of coal/coke in industries located in the TTZ with a mandate for switching over from coal/coke to natural gas, and relocating them outside the TTZ or shutting them down. Promoting bicycling is critical to support this objective by adding a green, non-polluting mode of transportation.
    b. Contextual illustration:

       Smart ICT interventions required to make the city smart are as given in Table 8-1.

Table 8-1 – ICT components in a smart city

Sr. No.	Components	Scope of work – brief description
1	City communication network	• It is critical that the city uses optical fibre cable (OFC) and the cellular network of the telecom service providers for the smart city project. • Make a detailed survey of available OFC network of telecom service providers and electrical supply network availability and GIS mapping of proposed locations of all CCTV cameras, smart bus stops, IoT sensors (environment, etc.), display signage, traffic lights, solid waste management infrastructure, etc., in order to complete the various components of smart city projects.

Table 8-1 – ICT components in a smart city

Sr. No.	Components	Scope of work – brief description
2	Integrated command and control centre (ICCC)	• It is critical that the city command and control centre be the central repository for management and monitoring of all ICT based smart city components such as solid waste management system, smart street lighting control system, Wi-Fi, smart transport, smart bus stops, CCTV surveillance, digital signages, IoT sensors (environment, etc.), and public information system (PIS) and all other smart city applications will be integrated, centrally monitored, tracked and managed from the operations command centre. • It is critical that the CCC be ergonomically designed with an area for video wall, operators, offices, conference room, all other amenities, etc.
3	Data centre and disaster recovery	• It is critical that the city setup owned data centre, disaster recovery centre and data backup storage facility may be in the cloud.
4	City and enterprise GIS solution	The broad objective of the work is to develop a comprehensive GIS application for planning, management and governance in the context of the entire functioning of the organization. The major activities of the departments to be supported by the system are as follows: • Creation and updating of geospatial data – Area based development (ABD) supply of enterprise GIS platform suit – Pan-City; • Design and develop enterprise Web GIS municipal application for all departments in the Pan-City; • Design and develop Geo-enabled mobile application for the Pan-City.
5	CCTV based real time public safety system	• CCTV based real time public safety system is a security enabler to ensure public safety. • Install CCTV cameras at various locations across the city for safety along with public address system and variable message signboard (VaMS), emergency/panic box system, etc.
6	Intelligent traffic management solution	• Install CCTV cameras and traffic violation sensors at various locations across the city for traffic management and enforcement system like RLVD/ANPR, speed detection, etc.
7	Environmental sensors	Smart environmental sensors will gather data about pollution, ambient conditions (light, noise, temperature, humidity and barometric pressure), weather conditions (rain), levels of gases in the city (pollution) and any other events on an hourly and subsequently on a daily basis. It is for the information of citizens and administration to further take appropriate actions during the daily course/cause of any event.
8	ICT enabled solid waste management	Install GIS/GPS enabled solid waste management system to provide end-to-end management and monitoring of garbage collection and processing.

Table 8-1 – ICT components in a smart city

Sr. No.	Components	Scope of work – brief description
9	Adaptive traffic management system	Install system for control and management of traffic by controlling the traffic signals on certain stretch of road with sensor based automation of signals.
10	Integration Components	Integrate the following system with the integrated command and control centre (present and in future): • e-Governance system; • Smart LED lighting; • Smart bus stops; • SCADA system; • Sewage system; • Wi-Fi hotspots; • Citizen engagement applications for a smart city.
11	Interoperability	Interoperability should be available at device, network, application and platform functional level. It is critical that platforms have the feature of common service layer for sharing of data across verticals. It is expected that smart city platforms be interoperable with other smart city platforms and use open interfaces for sharing of data [ITU-T Y.4200], [ITU-T Y.4201[and [ITU-T Y.4413].

c. Pre-requisites: City approval and acceptance wherever required in terms of permissions, no objection certificates (NOC) and formal documentation process and procedures.

d. Pre-conditions (if any): None

e. Triggers: None

f. Scenario

Table 8-2 – End-to-end scenario of various sensors/gateways

Gateways/Type of sensors	End-to-end scenario and integration capabilities
Environmental sensors	CCC dashboard will display and monitor the environmental sensors for its reading. If the reading of any of environmental sensor is above threshold, a new incident will be reported in CCC incident management module and predefined standard operating procedures (SOPs) will follow for action.
Video management system	Following functionalities can be accessed on ICCC: • Live video • Virtual tour • Playback • PTZ/Presets • VA alerts – Incidents can be opened and SOP made to close such alerts • Export video clips • Start/Stop recording

Table 8-2 – End-to-end scenario of various sensors/gateways

Gateways/Type of sensors	End-to-end scenario and integration capabilities
Adaptive traffic control system (ATCS)	CCC dashboard will display and monitor the key performance indicators (KPIs) set along with other information related to ATCS. If any KPI is breached, a new incident will be reported in CCC incident management module and predefined SOPs will follow for action. It will also help in managing the traffic congestion and serve green corridor in case of emergency.
Intelligent traffic management system	CCC will integrate with ANPR/RLVD and e-Challan solutions to provide alerts to CCC: • Receive number plate event • Receive breach events • Get plate image • Active alarm output • De-active alarm output • Acknowledge object in alarm state • Reset an object in alarm state
ICT enabled solid waste management	CCC dashboard will display and monitor the KPIs set along with other information related to waste management. If any KPI is breached, a new incident will be reported in CCC incident management module and predefined SOPs will follow for action.
GIS system	1) Use GIS maps from customer GIS server. 2) Plot various devices/assets on GIS maps with different layers.
Smart public transport system	CCC dashboard will display and monitor the KPIs set along with other information related smart public transport solution. If any KPI is breached, a new incident will be reported in CCC incident management module and predefined SOPs will follow for action. Location to be plotted on map. Traceroute of each bus with GPS to be stored for analysis.
Public addressing system	Public addressing system can monitor the health of the public announcement subsystem as well as the edge devices connected to it. The system enables an operator to play pre-recorded announcement to specific zone. The announcements should be recorded and stored within the public announcement subsystem. The zones should be defined within the public announcement subsystem. Operator can trigger the announcement manually, directly from the map or automatically as part of the business process. Activation of audio path for live microphone announcement should be done from the desk console of the public announcement system.
Panic/Emergency call button (ECB)	Location of these ECB will be plotted on C&C maps. C&C will display the status of these ECBs and when a user uses it by pressing the push button; new incident will be triggered, and the user will be shown on one of the monitors of C&C. Camera around should be popped up and focus on the ECB as presets.
Variable message signboard (VaMS)	VaMS will be plotted on the CCC map for identification of its location under the zone management module. VaMS status will be displayed on the map. Pre-defined messages will be displayed on one/many VaMS using the CCC.

Table 8-2 – End-to-end scenario of various sensors/gateways

Gateways/Type of sensors	End-to-end scenario and integration capabilities
AI analytics	Receive alerts based on incident occur like vandalism, graffiti, face recognition system, loitering, unidentified object detection, etc. Show video associated with the alert and track the last movement.
Social media	The gateway to social media monitoring software will support: • Creating a new incident • Closing an existing incident An alert to be generated if total number of tweets per day are greater than XX number, etc.
Integrated building management system (IBMS)	CCC dashboard will display and monitor the KPIs set along with other information related to IBMS. If any KPI is breached, a new incident will be reported in CCC incident management module and predefined SOPs will follow for action.
Unified communication system	Soft licenses and session initiation protocol (SIP) based voice over Internet protocol (VoIP) switch to manage end-to-end calling system.

g. Process flow diagram

It is critical that each of the above mentioned scenarios to has its predefined process flow diagram based on engagement from the stakeholder responsible to engage and manage the incidents and workflows as per standard operating procedures.

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations

The overall functional design of the city network backbone is indicative in nature and is envisaged to be implemented in a three-tier architecture as described below.

It is critical that the network be designed on a layered principle with ring-based architecture having the following value propositions:

- Single homed/dual homed
- Better link utilization
- Dedicated and predefined path for critical applications
- Easy insertion of new nodes
- Quality of service (QoS) for critical data
- Segregation of critical and non-critical traffic

The envisaged layers of the city network backbone (see Figure 8-12) integrating key elements at edge are as follows:

- **Core layer**: The core layer forms the backbone of the entire network, which consists of compute, storage, application, links and connectivity to be established at the data centre and disaster recovery site. It is critical that this layer enables all applications hosted to be accessed over the backbone for consumers and users. It is critical that the core layer forms the point of aggregation for all the traffic coming from the aggregation layer and beyond.

- **Aggregation layer**: It is critical that the traffic coming from the respective access layer gets aggregated at the aggregation level. A ring architecture is proposed to be formed to establish the required redundancy. It is critical that the aggregation layer further connects to the core layer in order to forward the traffic to the core layer.
- **Access layer**: It is critical that the access layer be formed based on the similar types of devices gathered at the service layer. It is critical that the entire access layer in the respective region/location/junction forms individual rings to establish redundancy. There can be multiple rings within the respective region/location/junction. It is critical that the access layer enables the smart city solutions to connect to the network backbone. It is critical that the aggregation switch of the respective smart city solution taps into the respective access layer devices.
- **Common service layer**: It is critical that the service layer enables smart city solutions such as city surveillance, ICT enabled solid waste management, ATCS, and ITMS to connect to the devices/gateways through the network backbone. It is critical that the aggregation switch of the respective smart city solution connects on the access layer devices to connect to the network backbone. A common service layer is critical to avoid the silos between various verticals of the smart city. Data received from the devices can be shared across verticals. It is expected that the smart city platforms have the features of a common service layer [ITU-T Y.4413], [ITU-T Y.4500.1] and [ITU-T Y.4500.2].

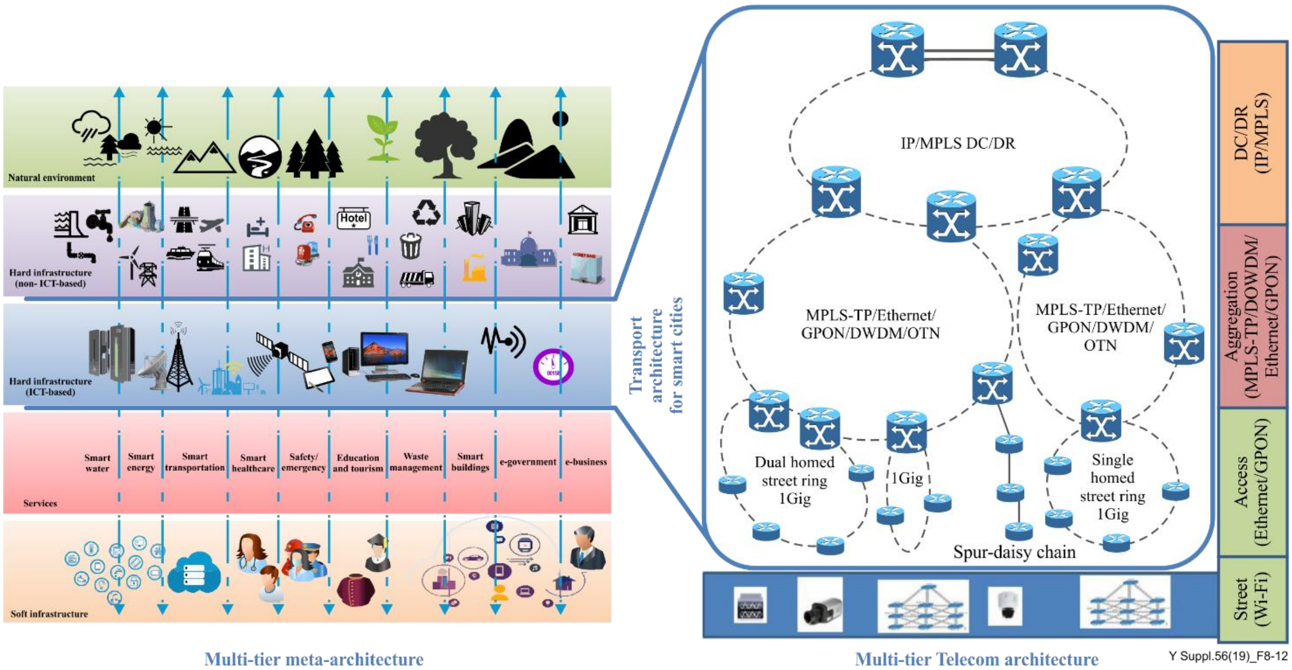

Figure 8-12 – City network backbone [based on ITU-T Y. 27 Supplement to Y.4400 series Recommendations]

b. Geographical considerations: It is important that city data and infrastructure is well maintained and secured through a data centre and disaster recovery site. It is important that one site is built within the city with the standard specifications of Tier II or Tier III (a classification in data centre building standards developed by Uptime Institute [b-Uptime]) and the recovery site is on cloud service provider in separate seismic zone to have complete security and integrity of data.

c. Communication infrastructure

The city network backbone is planned on OFC in ring so that it provides the secure, reliable, scalable, manageable, interoperable, capable and resilient network connectivity for all the requirements of Agra Smart City initiative. Cameras for city surveillance and the devices for adaptive traffic management have been planned to be connected on OFC. For vehicle location tracking services, cellular connectivity is used. In waste management, QR code and the smart phones are used.

Design considerations applied for developing the network backbone are:

- High performance: The network should provide better user experience while connecting with citizens, government, business, and communities. The system should be up and running without any single point of failure as per the demands of various mission critical applications running on the network. Hence, the uptime of 99.982% is required for the availability.
- Scalability: It is critical that the network be scalable to future growth such as all smart city initiatives. It is critical that the network infrastructure (routers, switches, servers, etc.) supports these scalability requirements. Similarly, the last mile connectivity is expected to be also upgradable to meet the future requirements.
- Security: It is critical that the network has built-in security features so that network access is controlled. Access control is critical to be implemented at all levels. Firewall, intrusion protection system and VPN solutions are critical to be employed to prevent attacks from hackers and secure the systems effectively.
- Manageability: It is critical that the entire network be seamlessly managed with a centralized network management software. It is critical that all the network components be manageable using open standard management protocols such as simple network management protocol (SNMP).
- Fault tolerance and resiliency: The network is expected to have built-in redundancy features to provide high availability. Redundant connectivity is critical to be proposed for all locations to ensure that single link failure does not affect the functionality. Similarly, equipment level redundancy is critical at DC, DR and aggregation level.
- Intelligence: It is critical that the network be configured with the required QoS features to prioritize traffic based on the application and that it handles the traffic accordingly.
- Interoperability: It is critical that all products be open standards based and it is expected that they are interoperable with different vendors' products following industry standards in order to avoid vendor lock-in.

Based on the design objective, geographical spread and the expected usage, the following technical features are envisaged for the network backbone:

- A protocol independent network, designed to carry multi-protocol traffic;
- Capability to offer hierarchical QoS for real-time traffic (voice and video) and guaranteed bandwidth for business critical applications. City network backbone governance backs it up by service level agreements (SLAs) from the service provider;
- Support by design of IPv6 transport, IPv6 networking and IPv6 MPLS VPN services in addition to the similar facilities based on traditional IPv4.

Design, implementation, management and control are such that service provisioning is internal to the network even though leased from telecom service providers for "raw" bandwidth or fibre is likely to be leased:

- Support by design of multicast enabled VPN for running multicast applications, both in IPv4 and IPv6;
- Management capable of handling provisioning for the central services;

- Access provided to secure integrated command and control centre with information assurance;
- Enabled provisioning of innovative new services unavailable from services providers, should the user agencies demand.

In short, the network backbone is expected to be more like a dedicated owned IP-MPLS network in the core from Internet service provider.

It is critical that the design, planning, implementation, operations and management of the city network backbone has an institutional mechanism that is agile and responsive. The design principles enable seamless expansion of the network as well as topological alterations.

d. Performance criteria: Covered as part of design and architecture considerations.

e. Interface requirements: Required from each of the independent system vendor (ISV).

f. User interface: As all the applications are integrated with command and control centre platform, it is critical that the user has only a single interface that helps the city to monitor with the single eye view.

g. APIs to be exposed to the application from platform: It is critical that all the independent system vendors expose the APIs to integrate with the centralized command and control centre platform, which is critical to help to correlate data, understand the incident and take appropriate action to resolve issues.

h. Data management: A large amount of data is collected from various sensors deployed in the city (see Figure 8-13), which is critical to become the basis for the stakeholders to take action against the violators. It is important to have multiple copies of data stored at various locations in order to manage data integrity and duplicity in case of any disaster. It is also important to understand the dynamics of stakeholders in the context of data responsibility, ownership and for the use of data in the right context.

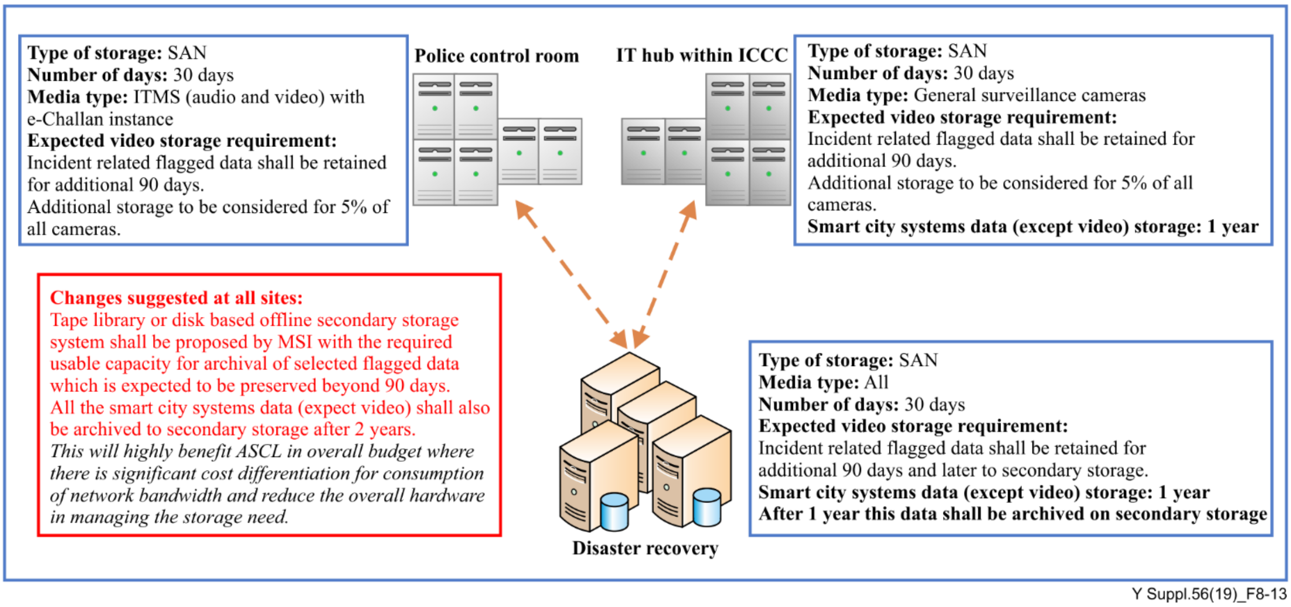

Figure 8-13 – Data management

i. Data backup, archiving and recovery

j. Remote device management

k. Start-up/Shutdown process

l. Security requirements

7. Potential market growth forecast: Successful intervention from the first phase can be spread in to further ABDs or Pan-City deployment.

8. Implementation constraints (for the support of the use case)

9. Statutory compliances and related regulations: TBD

10. Available International Standards: TBD

11. References (related to standards or other useful information): TBD

12. General remarks: None

8.9 Infrastructure monitoring

1. Title of the use case (title is strictly related to the application area addressed)
   a. Name of the use case: Infrastructure monitoring
   b. ID of the use case (IDs are given in ID category 2 (Infrastructure) of clause 7)
   c. Version/revision history (such as no./month/year): 1
   d. Source (Country/ITU-T member/Organization registered with ITU): Japan/Oki Electric Industry Co., Ltd.

2. Objective of the use case (aligned with title, it has explanatory content)

   Monitoring of aging infrastructure by using sensors would support inspection, diagnosis, confirmation of repair effect, status check after disaster, etc.

3. Background
   a. Current practice (current process/context which will benefit from the implementation of the use case)

      Generally, inspection and diagnosis need to be carried out periodically to maintain the condition of the infrastructure. In Japan, a close visual inspection is required once every five years. However, the diagnosis results may vary depending on the person in charge of the inspection, and advanced skills and extensive experience is required in order to maintain the uniformity of inspection quality and appropriateness of diagnosis. In addition, it is necessary to perform the same inspection on both healthy and suspicious parts, which tends to become expensive and inefficient.
   b. Need for use case

      Infrastructure aging is a common subject not only for Japan but also for each country, and this use case will help as a reference for introducing an infrastructure monitoring system.
   c. Country ecosystem specifics: None

4. City or community of the use case
   d. City or community name: None
   e. Country: Japan
   f. Region: Asia
   g. Population of the Country: 127,094,745 (2015)
   h. Phase of the use case (Planning phase/Pilot phase/Commercial phase): Pilot phase

5. Description
   a. Ecosystem description in terms of actors and business roles

      For infrastructure monitoring, these are the following three management sites.
      1) Field site: A site where whole or a part of the infrastructure to be monitored is installed.

2) Monitoring site: A site that manages monitoring work for one or multiple field sites. Analysis and visualization of the monitoring data may also be performed at monitoring sites.

3) Storing and utilizing site: A site that performs medium to long-term storage of data collected from multiple monitoring sites and performs big data analysis by combining multiple stored data and other data, such as weather, traffic, inspection records, etc.

b. Contextual illustration

The following four use cases demonstrates experiments for monitoring infrastructure.

1) Crack monitoring with camera images

In this demonstration experiment, the current state of crack damage on the bottom surface of the floor slab is grasped from the image taken by the camera from the ground under the floor slab, the progress of deterioration is monitored, and the damage state is evaluated.

– Using a digital camera, take pictures of the floor slab from the ground under the bridge.
– Determine the reference points using physical marker, structural feature points, or laser projection.
– Convert the captured image into an orthographic projection image based on the reference point.
– Combine multiple images to create a floor slab image.
– Decipher the crack shape and width from the combined image.
– Compare crack density and distribution at different times to understand the progress of cracks.

The relationship between the functional blocks constituting this demonstration experiment and the monitoring architecture is shown in Figure 8-14.

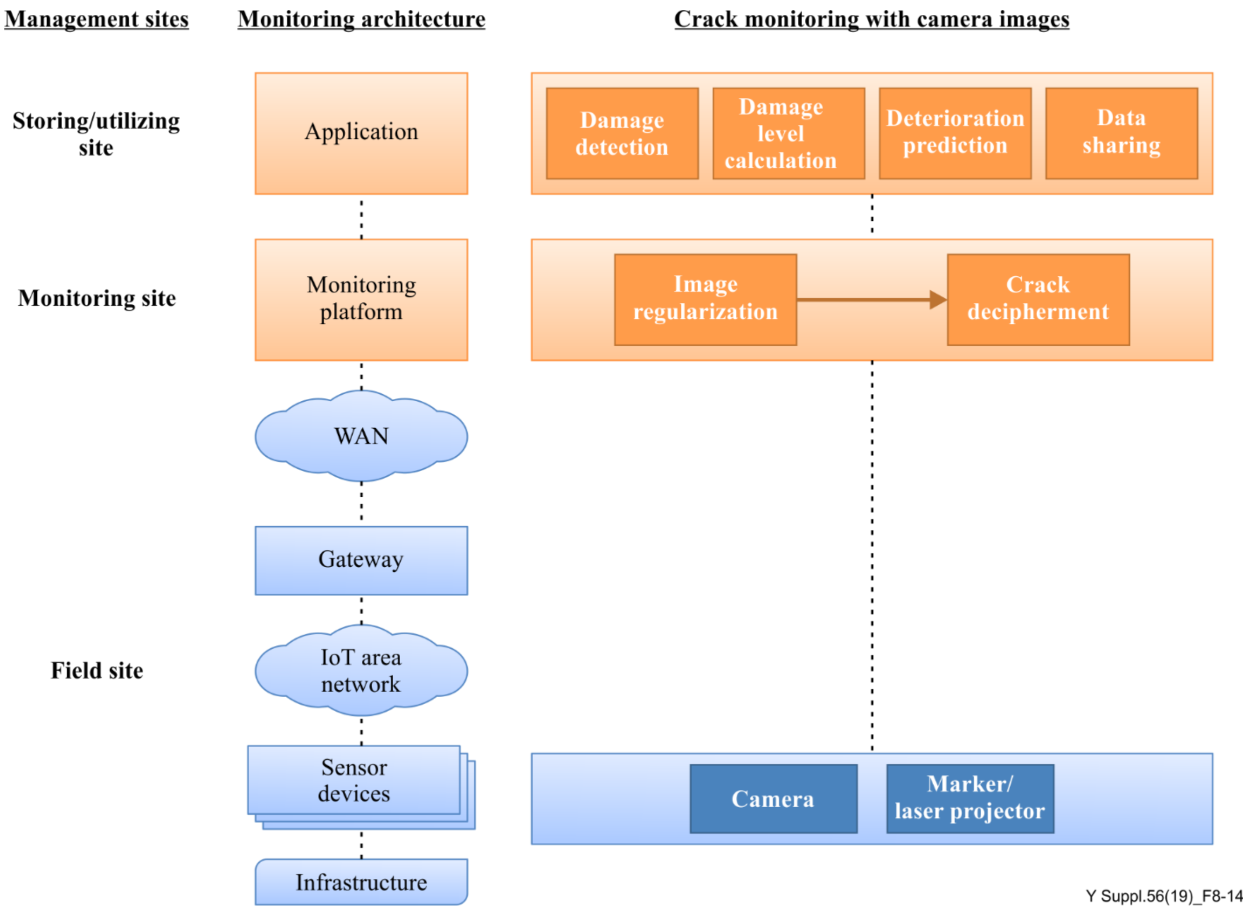

Figure 8-14 – Crack monitoring with camera images

2) Crack monitoring with a displacement meter

When the floor slab is found to be excessively damaged by regular inspections, maintenance and repair work may not be able to start immediately due to the budget and traffic disturbances. In this demonstration experiment, the displacement of the floor slab is measured with a displacement meter attached to a fixed beam and the damage is monitored.

The relationship between the functional blocks constituting this demonstration experiment and the monitoring architecture is shown in Figure 8-15.

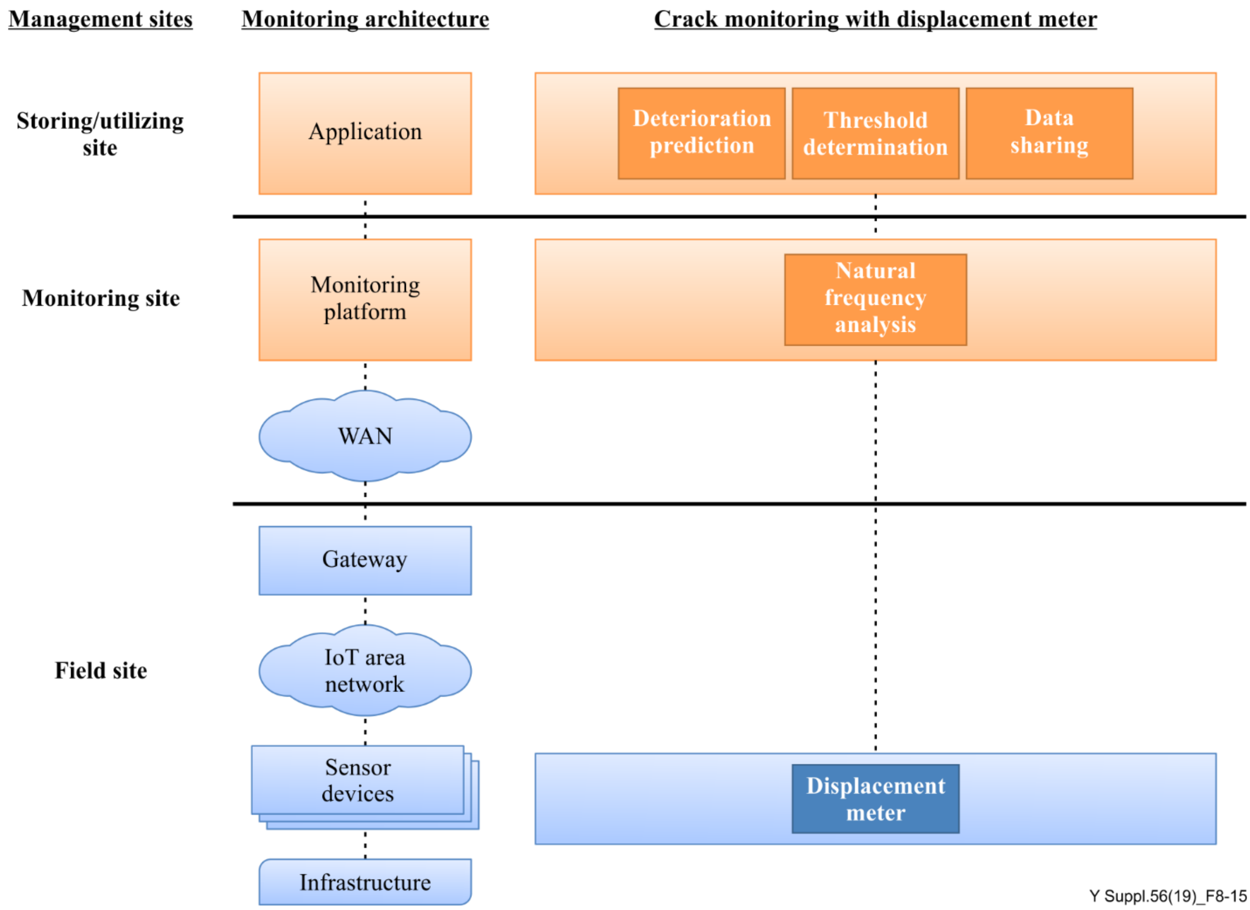

Figure 8-15 – Crack monitoring with a displacement meter

3) Crack/Strain monitoring with optical fibres

– By fixing the optical fibre comprehensively to the bottom of the floor slab and measuring the change in the amount of transmitted light, the level difference on the crack surface that leads to the floor slab falling off is monitored.

– The strain distribution at the floor slab joint is monitored by the optical fibre installed in the bridge axis direction.

The relationship between the functional blocks constituting this demonstration experiment and the monitoring architecture is shown in Figure 8-16.

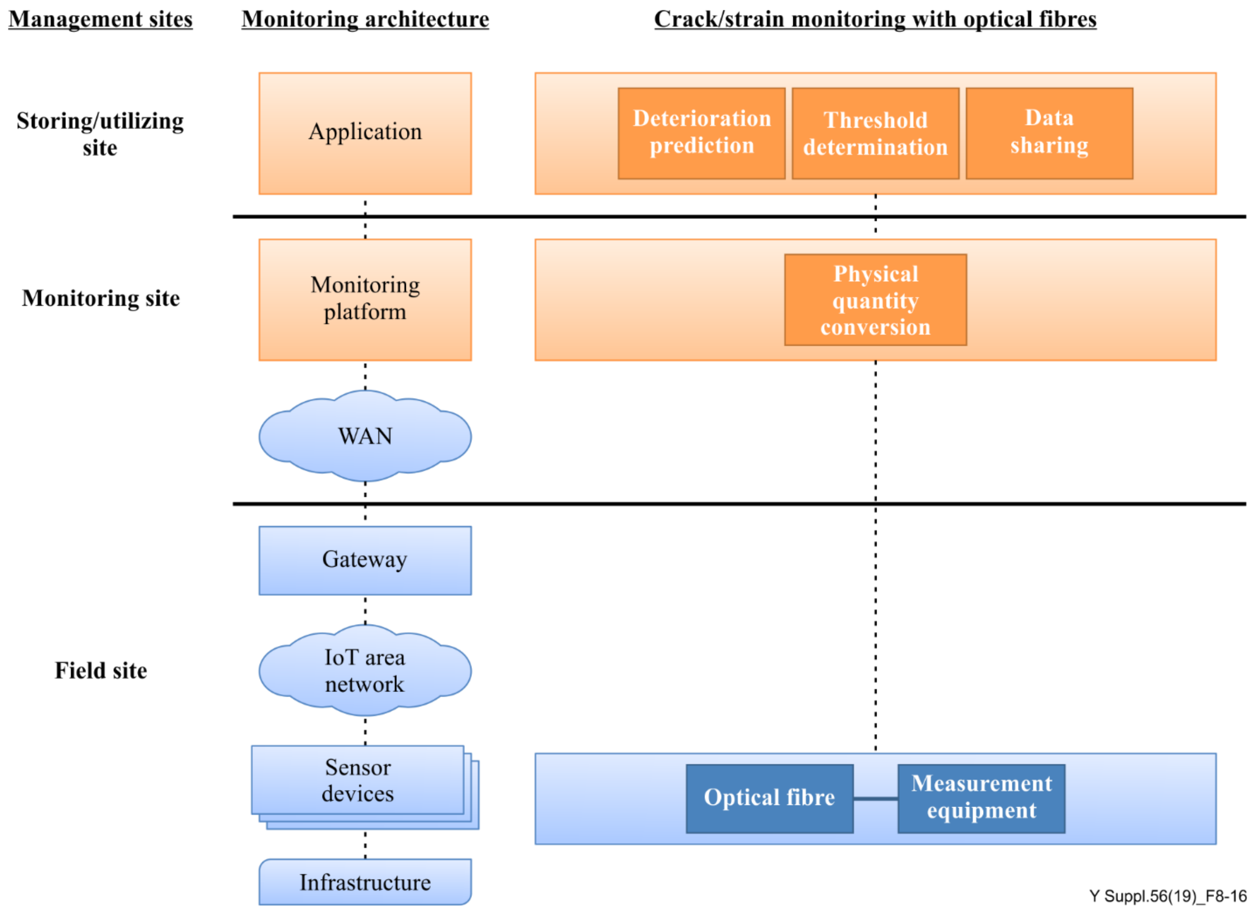

Figure 8-16 – Crack/Strain monitoring with optical fibres

4) Deformation monitoring with accelerometers

In this demonstration experiment, multiple accelerometers are installed at the bottom of the slab, and changes in structural performance due to deformation such as peeling or dropping are evaluated from the frequency spectrum or vibration mode unique to the bridge.

The relationship between the functional blocks constituting this demonstration experiment and the monitoring architecture is shown in Figure 8-17.

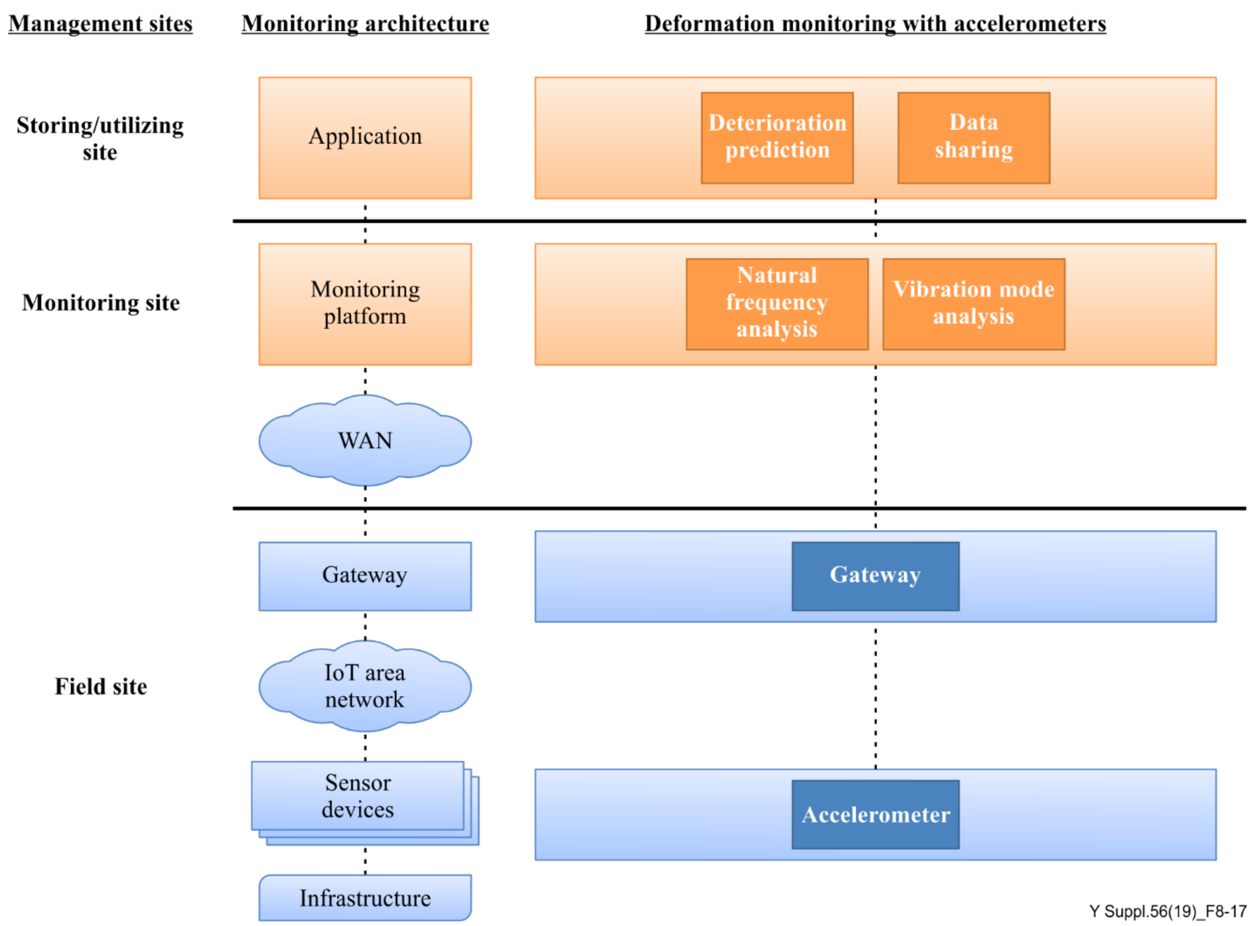

Figure 8-17 – Deformation monitoring with accelerometers

c. Pre-requisites: None

d. Pre-conditions (if any): None

e. Triggers

   – Continuous measurement

   – Periodical measurement

   – When determined necessary by an administrator after an emergency such as a natural disaster.

f. Scenario

   1) Monitoring: Anomaly detection due to exceeding threshold

   2) Maintenance and analysis: Deterioration prediction by big data analysis and artificial intelligence (AI) analysis

   3) Storing and data management: Centralized data management, utilization for analysis, sharing with others, determination of notification threshold from past data

g. Process flow diagram

1) Crack monitoring with camera images

The process flow of crack monitoring with camera images is shown in Figure 8-18.

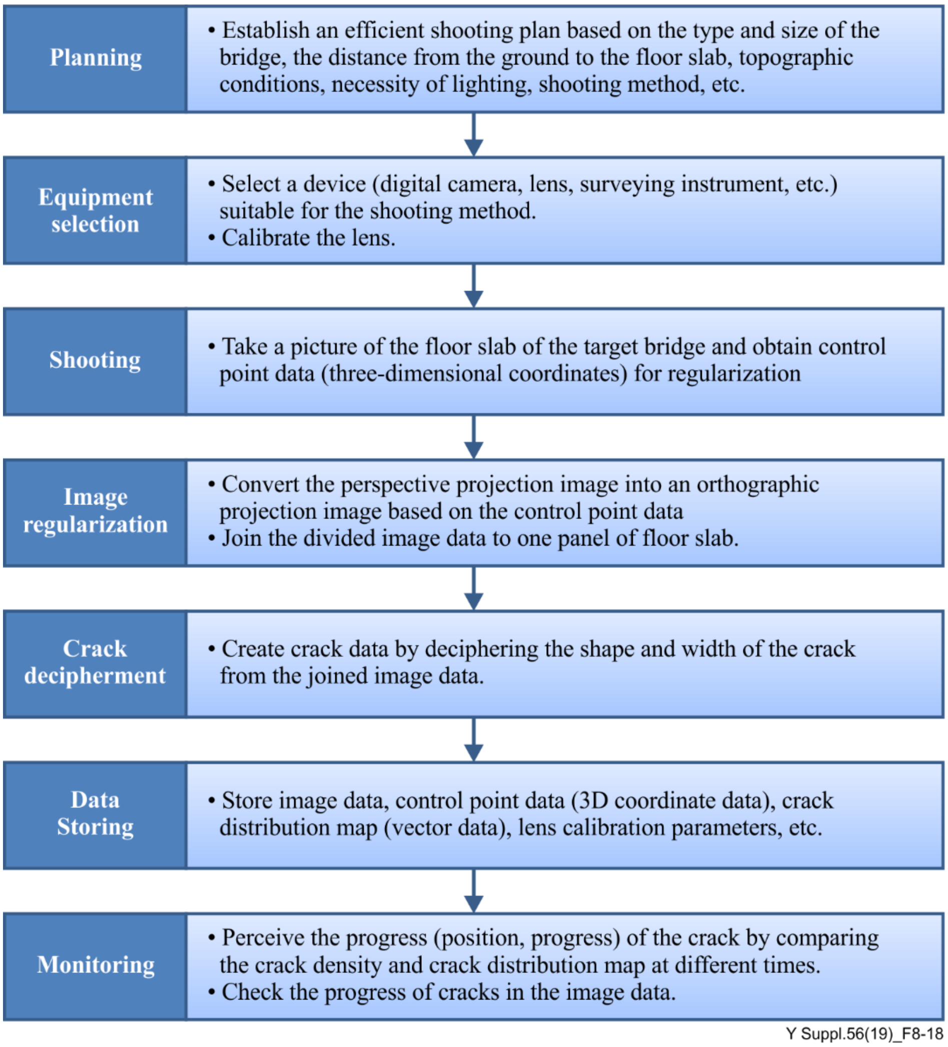

Figure 8-18 – The process flow of crack monitoring with camera images (see ([b-RAIMS])

2) Crack monitoring with a displacement meter

The process flow of crack monitoring with a displacement meter is shown in Figure 8-19.

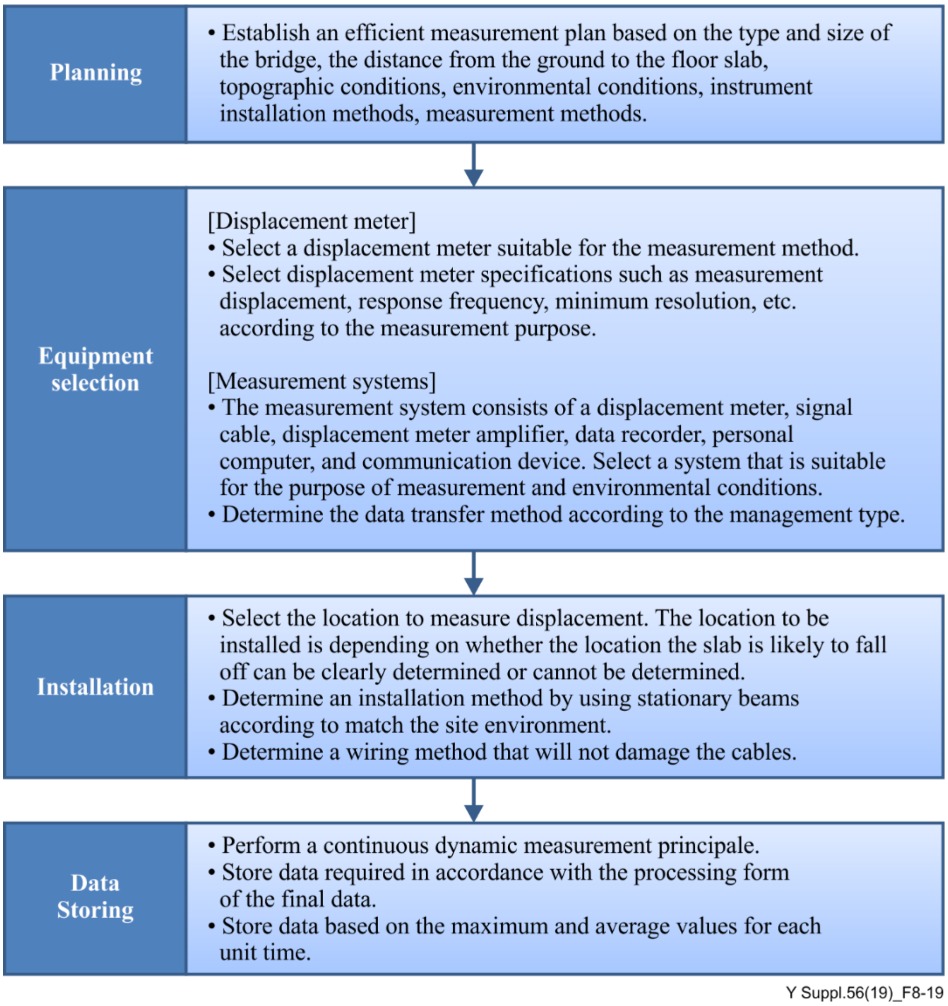

Figure 8-19 – The process flow of crack monitoring with a displacement meter (see ([b-RAIMS])

3) Crack/Strain monitoring with optical fibres

The process flow of crack/strain monitoring with optical fibres is shown in Figure 8-20.

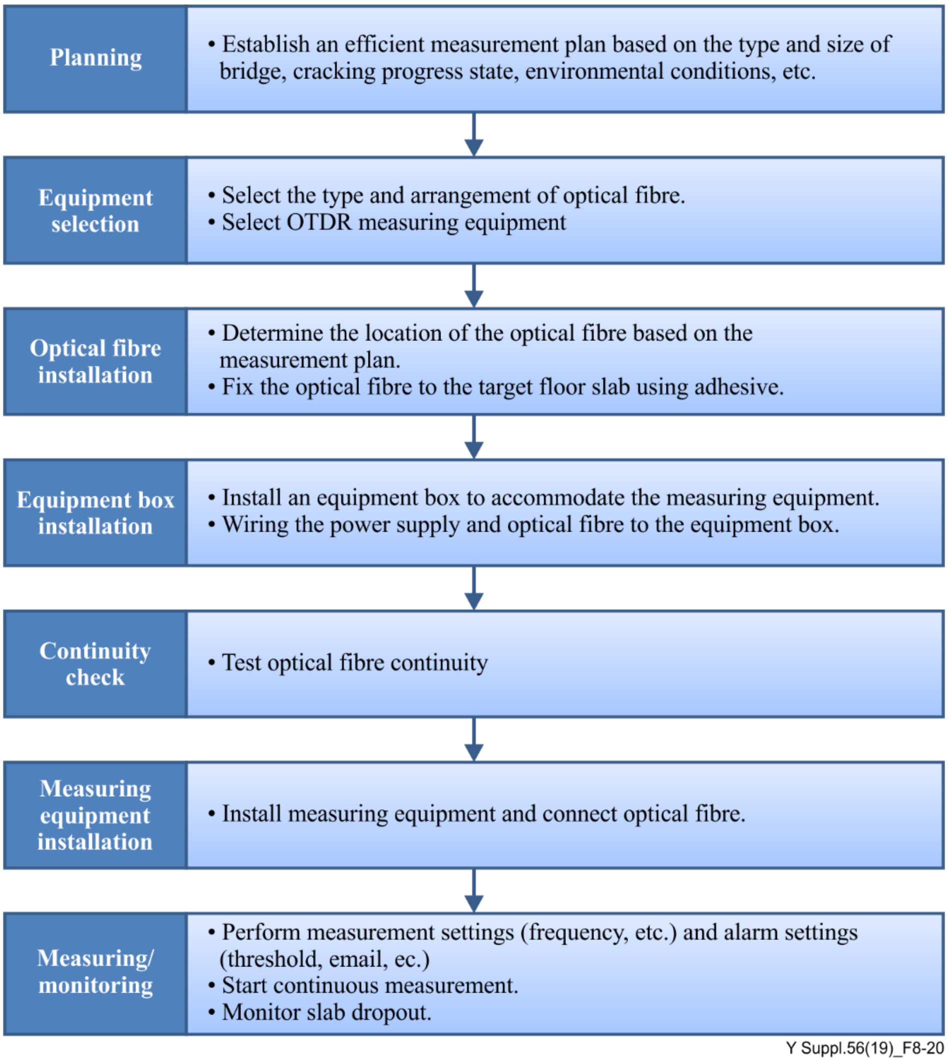

Figure 8-20 – The process flow of crack/strain monitoring with optical fibres (see [b-RAIMS])

4) Deformation monitoring with accelerometers

The process flow of deformation monitoring with accelerometers is shown in Figure 8-21.

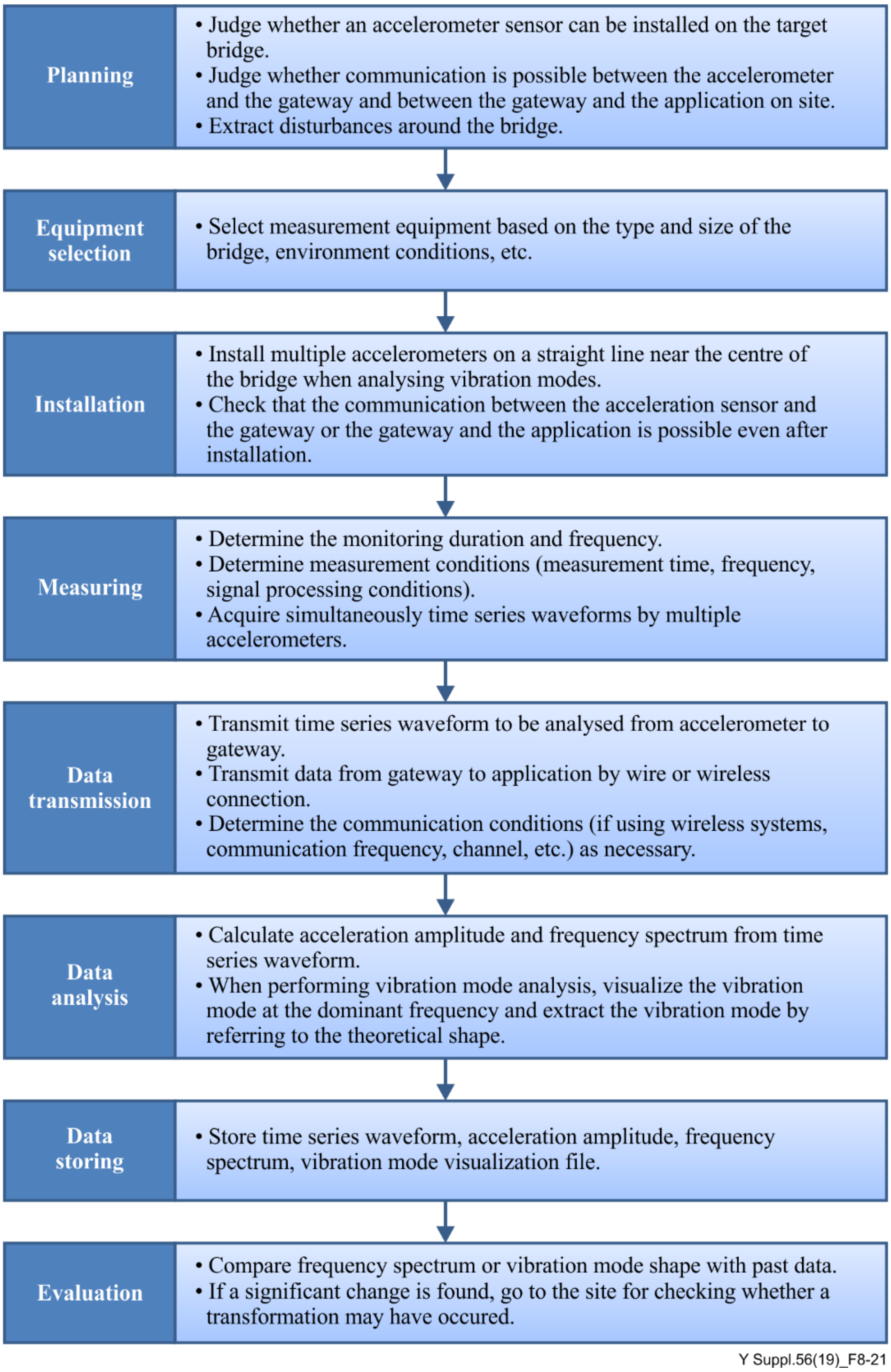

Figure 8-21 – The process flow of deformation monitoring with accelerometers (see ([b-RAIMS])

h. Post-conditions (if any): None

i. Information exchange: None

6. Architectural considerations

a. Deployment considerations

The infrastructure monitoring architecture consists of:

– Sensor devices installed in the infrastructure
– Gateway that aggregates data from multiple sensors
– Monitoring platform that monitors the collected data
– Application that stores and uses the collected data

Monitoring architecture and example of data collection and utilization flows regarding infrastructure monitoring are shown in Figure 8-22.

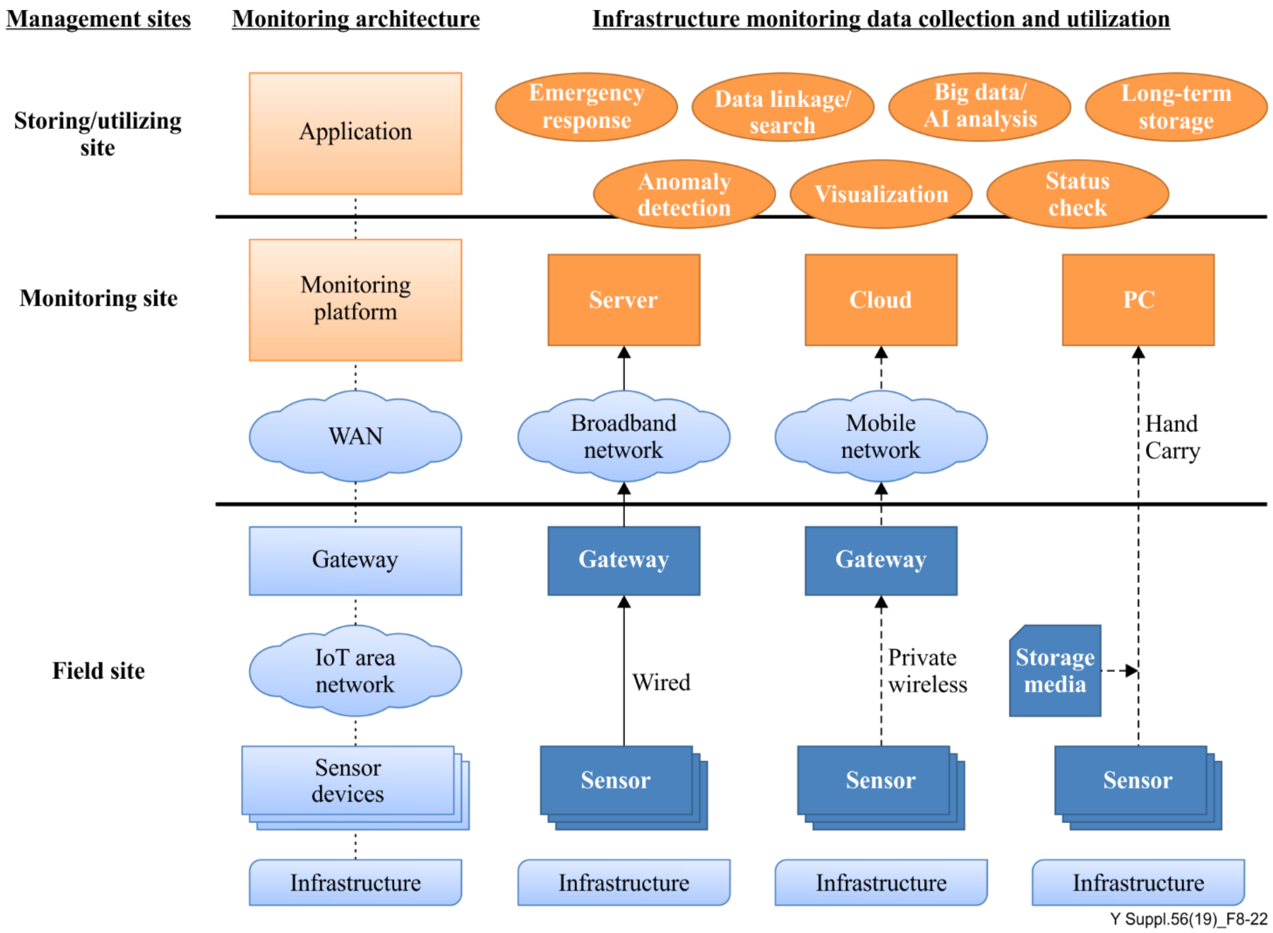

Figure 8-22 – Monitoring architecture

b. Geographical considerations

Except for some sensors that can be driven by batteries, many sensors and devices require power supply.

c. Communication infrastructure

When a sensor is permanently installed and remotely operated and monitored, a communication infrastructure is required, but it is necessary to construct an appropriate communication environment according to the purpose, such as a broad line, mobile data line, or hand carry. It does not depend on a specific communication infrastructure.

d. Performance criteria

1) Crack monitoring with camera images

Traditional periodic visual inspection requires that cracks with 0.2 mm width or more should be displayed on the crack distribution map.

As a result of shooting multiple bridges with different distances to the bottom of the slab in the demonstration experiment, in order to decipher cracks with 2 mm width or more on digital data, it was necessary to secure an image quality that could recognize cracks with about 1 mm width, that is, the resolution higher than 4 mm per pixel.

2) Crack monitoring with a displacement meter

The measurement range and resolution of the displacement meter must have specifications with enough margins for deformation of the infrastructure structure to be measured.

The measurement range should be 1.5 times or more of the expected displacement, and the measurement resolution should be 1/100 or more of the measurement range.

3) Crack/Strain monitoring with optical fibres

Perform measurement management by setting a threshold based on the amount of change in light transmission.

Although the threshold varies depending on the environment, in the demonstration experiment, a threshold of -5 dB was set as the threshold because a level difference occurred in the floor slab and the amount of transmitted light was halved.

4) Deformation monitoring with accelerometers

In the demonstration experiment, there was no special performance condition for the accelerometer.

e. Interface requirements: None

f. User interface: None

g. APIs to be exposed to the application from platform: None

h. Data management

It is recommended to store the data acquired from the sensor in a general format independent of the device or its manufacturer.

Since the deformation of the infrastructure structure is affected by the natural environment and traffic volume, if there are other measuring devices and environmental measuring devices in the vicinity, it is desirable to manage these measurement data as well.

i) Data backup, archiving and recovery

As infrastructure structures change very slowly, the acquired data must be stored for decades. However, when the amount of data becomes large as in the case of continuous measurement using a displacement meter or an accelerometer, the measurement data may not be stored and only the comparison with the threshold value may be performed.

Future technological advances will enable more accurate or highly efficient data acquisition, but compatibility with data acquired in the past must be ensured.

j. Remote device management

When a sensor or device is permanently installed, its status must be monitored remotely, and it must be immediately replaced, if a failure occurs, so it is necessary to manage the device remotely.

k. Start-up/Shutdown process: None

l. Security requirements: None

7. Potential market growth forecast

In Japan, there are 700,000 bridges, 10,000 tunnels, and approximately 3,100 m2 paved roads, and many of them have an average age of more than 30 years, and are aging. Infrastructure maintenance and renewal costs are estimated to be approximately 3.6 trillion yen, and are expected to increase 1.5 times over the next 20 years.

Infrastructure monitoring is an important issue not only for Japan but also for other countries, and is expected to contribute to reduce inspection costs and extend the life of infrastructure.

8. Implementation constraints (for the support of the use case): None

9. Statutory compliances and related regulations: None

10. Available International Standards: None

11 References (related to standards or other useful information)

"Guidelines for using monitoring system for civil engineering structures", Research Association for Infrastructure Monitoring System (RAIMS), 2019, https://raims.or.jp/ (Japanese only)

12. General remarks

– A part of the work in this contribution has been carried out under a research consignment with "research and development and standardization on collaboration between infrastructure 3D model and IoT sensor information model in infrastructure monitoring" under "Strategic Information and Communications R&D Promotion Programme (SCOPE)" of Ministry of Internal Affairs and Communications.

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Printed in Switzerland
Geneva, 2020