International Telecommunication Union

ITU-T Technical Specification

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(19 July 2019)

ITU-T Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities

Technical Specification D1.1

Use case analysis and requirements for Data Processing and Management to support IoT and Smart Cities and Communities

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The procedures for establishment of focus groups are defined in Recommendation ITU-T A.7. ITU-T Study Group 20 set up the ITU-T Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities (FG-DPM) at its meeting in March 2017. ITU-T Study Group 20 is the parent group of FG-DPM.

Deliverables of focus groups can take the form of technical reports, specifications, etc., and aim to provide material for consideration by the parent group in its standardization activities. Deliverables of focus groups are not ITU-T Recommendations.

Technical Specification D1.1

Use case analysis and requirements for Data Processing and Management to support IoT and Smart Cities and Communities

Summary

This Technical Specification introduces a unified use case template for data processing and management (DPM) to support Internet of Things and Smart Cities and Communities (IoT and SC&C), and then provides common requirements for DPM as well as use case specific requirements for DPM based on the analysis of the collected use cases.

The collected use cases are listed in Appendix I.1. The detailed content of the collected use cases can be accessed as separate FG-DPM output FG-DPM-O-189.

Acknowledgements

This Technical Specification was researched and principally authored by Xiaomi An (RUC), Marco Carugi (Huawei), Wei Wei (RUC), Tetsuya Yokotani (KIT) and Martin Brynskov (OASC) under the chairmanship of Gyu Myoung Lee (Korea, Rep.of).

Additional information and materials relating to this Technical Specification can be found at: www.itu.int/go/tfgdpm. If you would like to provide any additional information, please contact Denis Andreev at tsbfgdpm@itu.int.

Keywords

Data Processing and Management; DPM; Use Cases; Requirements; Capabilities; IoT; Smart Cities and Communities

Technical Specification D1.1

Use case analysis and requirements for Data Processing and Management to support IoT and Smart Cities and Communities

Table of Contents

1 Scope

This Technical Specification provides common and use cases specific requirements for data processing and management (DPM) to support Internet of Things and Smart Cities and Communities (IoT and SC&C) based on the analysis of collected use cases.

In particular, the Technical Specification includes:

- the description of a unified use case template for DPM to support IoT and SC &C;
- key aspects for the analysis of the requirements of DPM to support IoT and SC&C;
- prominent concerns about DPM to support of IoT and SC&C based on the analysis of the collected use cases;
- common requirements and use case specific requirements for DPM to support IoT and SC&C based on the analysis of the collected use cases.

The collected use cases are listed in Appendix I.1.

NOTE – the detailed content of the collected use cases can be accessed as separate FG-DPM output FG-DPM-O-189.

Appendix I.2 provides both requirements and capabilities considerations for DPM from the collected use cases.

Appendix II provides the use case specific requirements for DPM from the collected use cases.

2 References

None

3 Definitions

3.1 Terms defined elsewhere

3.1.1 capabilities [b-ITU-T X.1601]: Quality of being able to perform a given activity.

3.1.2 city [b-ITU-T Y.4900]: An urban geographical area with one (or several) local government and planning authorities.

3.1.3 community [b-ISO 37153]: Group of people with an arrangement of responsibilities, activities and relationships, which shares geographic areas.

3.1.4 data processing and management [b-FG-DPM TS D0.1]: the combination of all activities either directly performed on or indirectly influencing data.

NOTE 1 - Directly performed activities include among others collecting/acquiring/capturing, exchanging, storing, securing, manipulating, reusing, aggregating, curating, disposing, monetizing and deleting data.
NOTE 2 - Indirectly influencing activities include among others policy and standards making, skills and innovation enhancement.

3.1.5 domain [b-ISO/IEC 19501] Area of knowledge or activity characterized by a set of concepts and terminology understood by the practitioners in that area.

3.1.6 Internet of things (IoT) [b-ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.
NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.
NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.7 requirement [b-ISO 8000-2]: Need or expectation that is stated, generally implied or obligatory.

3.1.8 scenario [b-ISO 22398]: Pre-planned storyline that drives an exercise, as well as the stimuli used to achieve exercise project performance objectives.

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

3.1.10 Smart Cities and Communities (SC&C) [b-FG-DPM TS D0.1]: Effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens.

NOTE – This definition aligns with the definition of “Smart City” in [b-ISO/IEC 30182] and with the recommendation from the IEC/ISO/ITU Smart City terminology coordination Task team [b-IEC/ISO/ITU Draft White Paper].

3.1.11 stakeholders [b-ISO GUIDE 73]: Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity

3.1.12 use case [b-IEC 62559-2]: Specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system.

3.1.13 use case template [b- IEC 62559-2]: A form which allows the structured description of a use case in predefined fields.

3.2 Terms defined in this Recommendation

None.

4 Abbreviation and acronyms

AI Artificial Intelligence

API Application Programming Interface

DPM data processing and management

GDPR General Data Protection Regulation

KPI Key Performance Indicator

ICT Information and Communication Technology

IoT Internet of things

SLA Service Level Agreement

SC&C Smart Cities and Communities

5 Conventions

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

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

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

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

In the body of this document and its annexes, the words shall, shall not, should, and may sometimes appear, in which case they are to be interpreted, respectively, as is required to, is prohibited from, is recommended, and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

6 Introduction to use case analysis and requirements for DPM to support IoT and SC&C

This clause provides an introduction to use case analysis and requirements for DPM to support IoT and SC&C, describing at first a unified use case template for DPM, then key aspects for analysis of requirements of DPM from use cases and prominent concerns about DPM to support IoT and SC&C.

6.1 Unified use case template for DPM

A unified template for the description of use cases may fulfil different purposes. In the content of this Technical Specification, two purposes are identified for the usage of a unified template for description of use cases for DPM to support IoT and SC&C: the first one is a top-down approach for abstracting requirements for DPM in predefined areas from use cases (the unified use case template in Annex A provides criteria for collecting data); the second one is a bottom-up approach for comparing use cases in order to identify common and use case specific requirements for DPM in predefined areas (see Appendixes II.2 and II.3).

Annex A provides the unified use case template for DPM used for the collection of the use cases analysed in this Technical Specification (detailed explanation of the template fields being provided for use case description compatibility). The following predefined fields are used for the use case analysis of capabilities and requirements for DPM to support IoT and SC &C:

- use case title, including: name, domain/-cross-domain, version and source;
- objectives;
- background, including: current practice, rational for use case;
- ecosystem, including: stakeholder roles and responsibilities, stakeholder relationships;

- scenario, including: context illustration, pre-requisites, pre-conditions (if any), triggers, typical operational procedure, process flow diagram, post-conditions, information exchange, considerations on publicity of results (if any);
- data characteristics, quality and formats, including: data input characteristics, data output characteristics, data quality considerations, data format;
- DPM capabilities consideration, including: data processing capabilities, data management capabilities, considerations on system capabilities, data application to the different interests;
- governance and data lifecycle considerations, including: data accountability, data isolation, personal data, IPR and licensing, SLAs enforcement, risk management, data distribution, data value chain maintenance, incident management process, continuous improvement process;
- requirements, including: functional requirements, non-functional requirements, other requirements, available international Standards supporting the requirements (if any), References (related to above standards or other useful information);
- architecture considerations，including：communication infrastructure (incl. connectivity), data consistency across systems involved in the use case, deployment considerations, interface requirements, incl. use interfaces and APIs, performance criteria;
- general remarks.

NOTE – In practice, in the collection of use cases, the usage of the unified template has not prevented that the predefined fields of the unified use case template be complemented with additional information or some pre-defined fields have not been used as not applicable fields for specific use cases.

6.2 Key aspects for analysis of requirements of DPM from use cases

This Technical Specification identifies five key aspects for the analysis of requirements of DPM from use cases. The common requirements can be then structured based on the analysis of the predefined template fields filled up from each or collected use cases, in alignment with the identified five key aspects.

The five key aspects are governance, ecosystem, data trust, data lifecycle and data commercialisation. These key aspects are intended, respectively, as follows:

- **governance** includes all the policy related matters applicable to all other aspects.
- **ecosystem** includes all factors and mechanisms that directly or indirectly impact DPM activities.

- **data trust** includes actions taken to safeguard security, privacy and quality of data and enhance data trustworthiness.
- **data lifecycle** includes processing and management activities conducted on data from its creation to its use and disposal
- **data commercialization** is the process of creating commercial value from data, including various activities such as monetization, valuation, pricing, licensing, distribution, marketing and sales [FG-DPM TS D0.1]

The following information is provided for tracing evidence-based analysis of prominent concerns (Clause 6.3), common requirements (Clause 7.1) and use case specific requirements (Clause 7.2) of DPM based on the collected use cases:

- Appendix-I-1- List of the collected use cases of DPM to support IoT and Smart Cities and Communities;

- Appendix-I.2 - Requirements and capabilities considerations for DPM from the collected use cases;

- Appendix II - Use case specific requirements for DPM to support IoT and Smart Cities and Communities.

6.3 Prominent concerns about DPM to support of IoT and SC&C

Four prominent concerns about DPM to support IoT and SC&C (i.e. concerns which are highlighted by multiple use cases) are identified, from the analysis of the collected use cases.

NOTE – The identified prominent concerns are based on the specific set of use cases collected by the FG-DPM. As such, it is obvious they do not represent the exclusive set of prominent concerns that can be derived from the very wide spectrum of potential DPM use cases in different IoT and SC&C related application domains.

6.3.1 Privacy and security protection

Compliance with privacy and security protection laws and regulations, and personal data anonymization is a prominent concern for IoT and SC&C.

A high level of security and inclusion of data encryption mechanism is a prominent concern for IoT and SC&C.

Compliance with the privacy laws at regional and national level is a prominent concern for IoT and SC&C.

Allowing the IoT and SC&C device user to manage (delete, restrict, modify, download) her/his personal data at any moment is a prominent concern for IoT and SC&C.

Enabling the usage of personal data with privacy policy and privacy by design tools is a prominent concern for IoT and SC&C .

(Relevant use cases: Appendix I, Use Case 1, Use Case 2, Use Case 3, Use Case 5, Use Case 6, Use Case 7, Use Case 8, Use Case 12, Use Case 15)

6.3.2 Real time support

Availability on the most recent browsers and the screen resolutions is a prominent concern for IoT and SC&C accessibility purposes.

Fast response at convenience to users is a prominent concern for IoT and SC&C for performance purposes.

Processing data in real-time (specific requirements depending on the use case) is a prominent concern for IoT and SC&C for performance purposes.

Providing online and API-based access to services is a prominent concern for IoT and SC&C for real time operation purposes.

(Relevant use cases: Appendix I, Use Case 2, Use Case 8, Use Case 12)

6.3.3 User-friendly Human Computer Interaction support

Providing and accessing data in a user-friendly way is a prominent concern for IoT and SC&C.
Supporting language localization for the user interface is a prominent concern for IoT and SC&C.
Accessibility by people with disabilities (ease of access) is a prominent concern for IoT and SC&C.
Support of the interests of the different stakeholders [b-FG-DPM TS D0.1] in terms of availability, interoperability and safety of data is a prominent concern for IoT and SC&C.
Mobility and portability are a prominent concern for IoT and SC&C for application services.
Providing intuitive and reliable experience to users is a prominent concern for IoT and SC&C for usability.

(Relevant use cases: Appendix I, Use Case 2, Use Case 3, Use case 4, Use Case 5, Use Case 8, Use Case 13, Use Case 15)

6.3.4 Data interoperability and federation support

A prominent concern in many use cases is that in order to allow data coming from different sources, including physical devices across different systems, platforms, locations and jurisdictions, to be potentially aggregated and shared to support services for IoT and SC&C, several types and degrees of interoperability must be considered. This could be in the form of ad hoc exchange of data or as more consistent alignment of operations, i.e. federation.

In order to overcome the complexity and heterogeneity of IoT and SC&C, following the principle of minimal interoperability – as adopted in the Open & Agile Smart Cities (OASC) Council of Cities as Minimal Interoperability Mechanisms (MIMs) [b-OASC], validated by the IoT Large-Scale Pilot for Smart Cities & Communities SynchroniCity [b-SynchroniCity], and promoted by the Fed4IoT project [b-Fed4IoT] toward future smart cities and communities – interoperability would at least include (1) context information management (cross-domain information meta-model), (2) shared data models (domain-specific information models) and (3) ecosystem transaction management (conditions for exchange). Related to semantic interoperability, both cross-domain and domain-specific, common information models are expected to be specified and agreed upon for this purpose.

(Relevant use cases: Appendix I, Use Cases 2-3 and 13-17).

7 Requirements of DPM from the collected use cases

7.1 Common requirements for DPM

The following clauses provide common requirements from the analysis of the requirements of DPM from the collected use cases, in alignment with the five aspects identified in clause 6.2.

7.1.1 Governance aspect: data governance requirements

The data governance requirements should address:

— Data access with secure applications ensuring appropriate authorization process;

— Limiting the costs of creation, maintenance, disposition, storage and use of data;

— Providing high quality of the data assets from cities and communities by making it trustworthy, accessible, available, usable and traceable;

— Improving digital continuity of data from information to knowledge and action;

— Providing traces of loss and leakage of data to avoid security and confidentiality problems in data access and transmission, and to ensure the security and reliability of information data.

7.1.2 Ecosystem aspect: data ecosystem requirements

The data ecosystem requirements should address:

— Providing data provenance information to enhance trust of data.

NOTE 1 – Data provenance information may include operations, environment, data type and format, responsible party information, etc.;

— Enabling interoperability across applications, platforms, domains and physical locations by providing common information models for data exchange and by supporting encoding and decoding of data provenance information.

NOTE 2 – In this Technical Specification, the meaning of encoding is the process of converting data provenance information into a specific format. Decoding is the opposite process;

— Enabling a structured and modular approach to interoperability indicating the minimal degree needed to ensure data sharing in heterogeneous ecosystems.

— Providing data provenance recording so that provenance is recorded when data is stored;

NOTE 3 – Metadata information is expected to be used for recording provenance;

— Providing cost efficient storing mechanisms for data provenance storing.

NOTE 4 – In case of recording provenance information of streaming data, for efficient storage, it is expected to designate a predetermined period of time to record provenance,

rather than recording it every time data is stored. Also, data compression techniques are expected to be considered;

— Providing data storing provenance information so that pre-storing data provenance information prior to data usage request time may be supported in order to reduce data retrieval time;

— Searching, combining, retrieving and deleting data provenance information.

NOTE 5 – Subject to data management policies and regulation, the associated data provenance information may be maintained even if the data is deleted.

7.1.3 Ecosystem aspect: application requirements

The application requirements should address:

— Being compliant with regional and/or national data protection regulation and laws;

— Having a low footprint on energy consumption;

— Supporting most of the screen resolutions and screen form reliable factor; ;Being able to run on mobile devices;

— Minimizing the amount of data exchanged between application servers and user devices;

— Be able to support graphical programming capability;

— Enabling data continuity across applications, platforms, domains and physical locations;

— Having the ability of service prioritization in order to satisfy different users' service requirements.

NOTE – Differentiated service quality is expected to be supported, so that different service level agreements (SLAs) can be provided;

— Supporting service composition to enable flexible service creation;

— Supporting autonomic services so that automatic capture, communication and processing of data can be enabled based on rules configured by service providers or customized by users;

— Providing service management capabilities so that service provisioning can be supported in a highly available and reliable way;

— Providing high reliability and security when human body connectivity services are provided.

7.1.4 Data trust aspect: activities requirements

The data trust requirements in term of activities should address:

— Eight activities, as enablers for trusted data. These activities include various actions to be taken to preserve the security and quality of data and enhance data trust, including from an

ethical perspective:

1) Data authentication
2) Data authorization (including access control)
3) Data confidentiality (anonymity, encryption, etc.)
4) Data integrity
5) Data privacy
6) Data availability
7) Data quality (from trust perspective)
8) Data ethics

— The following attributes, as condition of trusted data:

1) Quality

- Stability
- Reliability
- Scalability
- Safety
- Robustness

2) Integrity

- Accuracy
- Consistency
- Certainty
- Credibility
- Timeliness

— Measuring criteria for trusted data enablement

7.1.5 Data lifecycle aspect: data quality requirements

The data quality requirements should address:

— Providing standards for the use of data;
— Ensuring compliance with relevant data policies and regulation;
— Enabling close collaboration among stakeholders to ensure data availability, interoperability, continuity and security;
— Providing measures and tools, e.g. analytics, machine learning and other (Artificial Intelligence) AI-driven tools, for data quality audit and verification;
— Ensuring that anonymized personal data always remain anonymous unless consent is given;

— Supporting common information models for interoperability as part of quality.

7.1.6 Data lifecycle aspect: activities requirements

The activities requirements should address:

— Enabling the disposal of data so that, e.g., users can screen and delete redundant data;
— Enabling the ability of reading, querying and visualizing data;
— Enabling the ability of cleaning and filtering data;
— Enabling (re)use of data for different needs;
— Enabling access control.

7.1.7 Data lifecycle aspect: data interoperability requirements

The data interoperability requirements should address:

— Enabling application services running on different platforms to be interoperable;
— Ensuring heterogeneous infrastructure support from data interoperability perspective by indicating minimal degrees of interoperability;
— Enabling secure interoperability and data federation;
— Supporting common information models for enabling interoperability across applications, platforms, domains and physical locations;
— Enabling high data availability and reliability, in order to provide agile and user-friendly data use experience and real-time performance.

7.1.8 Data lifecycle aspect: data management requirements

The data management requirements should address:

— Data sharing agreements setting out obligations on secure and privacy enabled data processing capabilities provided by each stakeholder;
— Auditing capabilities to view and control data access according to regional and/or national data regulation and laws;
— Secure data storage, including confidentiality, meeting application requirements;
— Real time support for data updating and maintenance;
— Supporting group-based data management in efficient way;
— Providing data management supporting tools, e.g. tools for data specifications, data production procedures, technical design documentation and catalogue;
— Supporting data management software and hardware in heterogenous ecosystems.

7.1.9 Data commercialization aspect: data commercialization requirements

While data commercialization is a key aspect of DPM, no concrete common requirements are identified in the collected use cases.

7.2 Use case specific requirements for DPM

The following clauses provide relevant use case specific requirements from the analysis of the collected use cases.

They have been classified according to some application domains, and do not obviously represent the very wide spectrum of potential application domain specific requirements related to DPM for support of IoT and SC&C.

7.2.1 Transportation requirements

1) Smart parking

Smart parking requirements should address:

— User requests concerning desired destination and time of arrival;
— Destination, time of arrival and parking availability based on current status and forecasts;
— Forecasting based on current and historical parking zone related information.

2) Human-centric traffic management

a) Human-centric traffic management functional requirements should address:

— Processing data from multiple sources in real-time;
— Recognizing preconfigured traffic situations and classifying these situations in real-time;
— Performing optimal traffic light decision and actuation based on classified traffic situations in real-time;
— Performing optimal public street lighting decision and actuation based on classified traffic situations in real-time;
— Providing user identification and access control;
— Providing flexibility in terms of viewing, or having access to, certain data;
— Providing a map as the main way of interaction to superimposed data;
— Providing different views on the superimposed data;
— Providing user administration features to manage via administration panels;

— Selection of specified time window and display of corresponding aggregated data over the selected time window;
— Providing prediction based on aggregated historical data.

b) Human-centric traffic management non-functional requirements should address:

— Consuming the minimum amount of transportation resources as reasonably possible;
— Flexibility to be deployed either as an ‘on-premise’ service or as a cloud-based service.

3) Multi modal transportation

Multi modal transportation functional requirements should address:

— Providing basic features that can be accessed in an unregistered way.
— Considering real-time information (deleted rides, delays, etc.) to better plan and update the journey.
— Notifying the user in real-time about issues that affect selected route.
— Considering user related information to suggest routes based on his/her preferences.
— Providing users with a georeferenced search of parking areas.
— Permitting to search for car parks by considering user preferences (proximity of stations, bus stop, destination address, secured park, Park & Ride features, etc.).
— Indicating which transport possibilities are currently available near the selected parking area (e.g. estimated arrival times for nearby bus lines).
— Indicating in real-time where free parking lots are available and at which cost per minute.
— Estimating when and where it will be possible to find a free parking lot.
— Indicating alternative parking lots nearby when there is no parking availability (or the parking availability estimated probability is too low) on the user-selected area.
— Receiving and tracking routes, means, check- ins and check-outs by the users, to share the revenue among the different transport providers.
— Handling different subscription forms and tariffs decided by the transport providers.
— Allowing the user to pay a single periodic bill for all transportation services providers.
— Providing the user with a report of all routes and their relative costs, and the total cost.

— Providing the ability to indicate departure point, destination point and optionally other intermediates points of an itinerary on a map, including via their addresses, GPS coordinates or Point of Interest (PoI).
— Providing the ability to select among different traveller profiles (e.g., by walk, drive a car, drive a bike, use public transportation, etc.).
— Providing the ability to combine multiple transportation modes and mobility infrastructures (e.g., metro plus bike sharing for last mile instead of bus).
— Viewing on a map alternative routes and selecting the preferred one.
— Receiving the estimation of the cost (e.g. total ticket price) and arrival time (when possible) of each alternative route.
— Viewing on a map the points of interest located in an area near to the route.
— Providing GPS location and traffic flow intensity of traffic sensors.
— Providing GPS location and status of parking sensors.
— Providing transportation means information, such as speed and GPS location, by vehicle sensors.
— Providing environmental information, such as humidity, air quality, noise and wind speed, by environmental sensors or other devices..
— Providing GPS location by user devices.
— Providing user information, transport means information and GPS location by ticketing devices.
— Providing user information, bike information, GPS location and status by bike docking stations.

(Relevant use cases: Appendix II, Use Case 13, Use Case 2, Use Case 3)

7.2.2 Educational processes requirements

a) Educational processes functional requirements should address:

— Real time processing, availability of standard Key Performance Indicators (KPIs) as common normalized metrics.
— Transformation of multiple data streams from large number of data sources providing information about ongoing educational processes into high level information services

presenting integrated vision of a single educational organization contributing to the holistic vision of a city as cyber-physical urban system existing in physical and virtual worlds.

b) Educational processes non-functional requirements should address:

— Support of open source software requirements, including those applicable to data security and protection, physical protection of the analytic engines running the data models of each educational organization, and resiliency of communication networks.

c) Other educational processes requirements should address:

— Special measures and analytics for data quality audit and verification using redundant data sources, machine learning and other AI-driven tools.
— The technical support of the analytics engines by specialized certified service providers in the regions having sufficient expertise, qualifications, capacity and responsibility to support a large number of educational organizations for application setting and running.

(Relevant use cases: Appendix II, Use case 1）

7.2.3 Urban development requirements

1) Smart city administration

a) Smart city administration functional requirements should address:

— Aiming at forging more robust DPM capabilities, the ICT infrastructures have to be extensible and inclusive.

b) Smart city administration non-functional requirements should address:

— Compliance to public policies and regulations

2) Digital interface to urban processes

Digital interface to urban processes requirements should address:

— Simple and carefully designed citizen personal geographical area using web and mobile apps technologies supporting different knowledge patterns, qualifications and ages.
— Secure access from generic mobile and personal computing devices.
— Secure communications blocking intermediary data trapping.

3) Urban waste management

Urban waste management functional requirements should address:

— Edge processing, device virtualization and stream processing.

4) Citizen-made IoT applications

Citizen-made IoT applications functional requirements should address:

— Providing capability to link functions requested by citizen and IoT device wrappers;
— Providing capability to route data among functions and IoT device wrappers.

Citizen-made IoT applications non-functional requirements should address:

— Usability of programming facilities with no prior experience of programming.

(Relevant use cases: Appendix II, Use Case 4, Use Case 9, Use Case 15, Use Case 16)

7.2.4 Smart sustainable governance requirements

Smart sustainable governance requirements should address:

— Support of open source software requirements for data security and protection, physical protection of city data processing and management servers, and resiliency of communication networks;

— Providing measures enabling non-interruptible access to services.

(Relevant use cases: Appendix II, Use Case 12)

7.2.5 People finder application requirements

People finder application requirements should address:

— Edge and cloud processing, streaming data and data analysis of people attributes. (Relevant use cases: Appendix II, Use Case 14)

7.2.6 Wildlife monitoring requirements

Wildlife monitoring requirement should address:

— Outdoor sensing data collecting;
— Real time monitoring and notification capability;
— Connectivity between the application server and the sensor devices;

— Collected data is accessible by other IoT systems;

— Providing easy operations and provisioning;

— Operations for animal capture compliance with regulatory issues on protections of animals.

(Relevant use cases: Appendix II, Use case 17)

Annex A Unified use case template for DPM

Use case title	Name	
	Domain – Cross domain	
	Version	
	Source	
Objective		
Background	Current practice	
	Rational for the use case	
Ecosystem	○ Stakeholder roles and responsibilities ○ Stakeholder relationships	
Scenario	○ Contextual illustration ○ Pre-requisites ○ Pre-conditions (if any) ○ Triggers ○ Typical operational procedure ○ Process flow diagram ○ Post-conditions ○ Information exchange ○ Considerations on publicity of results (if any)	
Detailed scenarios	(same structure than "Scenario")	
Data characteristics, quality and formats	Data input characteristics ○ Data granularity ○ Characteristics of meta data Data output characteristics ○ Data accessibility ○ Data availability ○ Data traceability Data quality considerations ○ Data authenticity ○ Data reliability ○ Data integrity ○ Data usability Data format, incl. standard, structured	

DPM capabilities considerations	Data processing capabilities o Aggregation and grouping o Cleaning and filtering o Classification and indexing o De-identification, anonymization and pseudonymization o Transfer o Pre-processing and processing o Analysis and analytics o Reading and query o Visualization Data management capabilities o Access and use o Administration o Acquisition and collection o Creation o Preservation incl. protection o Sharing o Storage o Update Considerations on system capabilities o Functions and operations o Service Level Agreements (SLAs) o Performance (incl. 5Vs of Big Data) o Data models and modelling o Data backup, archiving and recovery o Event management o System resilience o System sustainability	
	Data application to the different interests, incl. stakeholders' interests	
Governance and data life cycle considerations	Data accountability	
	Data isolation	
	Personal data (incl. sensitive personal data)	
	IPR and Licensing o Open data vs private data o Licenses of data use and reuse	
	SLAs enforcement	
	Risk management, incl. different concerns and dimensions and of risks (cybersecurity, privacy, safety, risks assessment, change management)	
	Data distribution o Technical management considerations on data distribution o Data access rights and data authorization considerations according to the different stakeholders (e.g. in a smart city scenario, (1) main groups of internal employees, (2) external business partners, (3) general public)	
	Data value chain maintenance, incl. data asset management (data asset value appraisal, identification, registration and disposition)	
	Incident management process	
	Continuous improvement process, incl. data minimization	
Requirements	Functional requirements (with respect to the different DPM capabilities indicated above)	

	Non-functional requirements, incl. ○ Availability ○ Data continuity ○ Flexibility ○ Interoperability ○ Reliability ○ Safety ○ Security and privacy ○ Trust (incl. traceability)	
	Other requirements	
	Available International Standards supporting the requirements (if any)	
	References (related to above standards or other useful information (e.g. on regulatory aspects))	
Architecture considerations	○ Communication infrastructure (incl. connectivity) ○ Data consistency across systems involved in the use case ○ Deployment considerations ○ Interface requirements, incl. user interfaces and APIs ○ Performance criteria	
General remarks		

Appendix I-1

List of the collected use cases of DPM to support of IoT and SC&C

Use case number	Title	Use case features
Use Case 1 UC#1	DPM for support of educational processes	The management procedures for education processes in the majority of city municipalities worldwide are implemented by administrations of relevant educational organizations such as kindergartens, preschools, various schools (physical, technical, musical, arts, etc), universities as well as municipality departments or organizations and national governance bodies. Their operational methods and internal controls are realized accordingly to national regulations and local governance policies
Use Case 2 UC#2	DPM for support of human-centric traffic management	With more and more people living in cities, many new challenges will emerge such as challenges around liveability, sustainability, mobility and quality of life in general
Use Case 3 UC#3	DPM for multi-model transportation	Day by day, the use of private cars in cities is having a high impact on mobility, sustainability and the overall quality of life. When using public transport, citizens would have to purchase separate tickets for each individual transport provider. Also, they are not always capable of choosing the most advantageous itinerary because of lack of information, leading to unnecessary delays, costs and a struggle to find the information needed to properly plan itineraries
Use Case 4 UC#4	DPM for support of smart city administration	The efficient running of urban systems in big metropolises relies on data interchange; whereas, urban data required is currently scattered within separate systems owned and operated by different public or private entities, which results in the prevalent problem of “data quagmire” and “data isolation”, exacerbated by the lack of data management standards as well as high-quality interchanging technologies.
Use Case 5 UC#5	DPM for support of city map	With city’s fast pace of development of public security, emergency response, intelligent transportation, urban management, environmental conservation, earthquake prevention and disaster reduction and so on, demands of the ability to maintain spatial information infrastructure are ever increasing.
Use Case 6 UC#6	DPM for support of virtual card application	city virtual card security management platform is based on virtual card holders, the application of terminal unique identification authentication, encryption and virtual CARDS in the process of transaction security barrier protection. It will greatly reduce the risk of existing information and data security threat by using of decentralized offline authentication mode, the online maintenance, security management of virtual CARDS and virtual POS greatly by reducing the overall operation cost and social cost. By these ways, a City Virtual Card application and security management Platform provide a big data source for community analysis and decision making, the mutual trust and security guarantee mechanism of community infrastructure data exchange and sharing is formed.
Use Case 7 UC#7	DPM for support of e-Heathy and assisted living for elderly people	Privacy by design to ensure data transactions, algorithms and access controls are audited in compliance with GDPR
Use Case 8 UC#8	DPM for support of smart cities	Non
Use Case 9 UC#9	DPM for support of urban process for registered legal entities	Non
Use Case 10 UC#10	DPM for support of wearables	Breaking new grounds – Entirely a new IoT application
Use Case 11	DPM for support of city public transport	Transport system applications for Public transport in a City such as Transport Licensing Management (TLS); Bus Information System (BIS), Driver Vocational Cards (DVC), Speed Governor systems, e-ticketing systems, among others

UC#11		
Use Case 12 UC#12	DPM for support of smart sustainable governance	The governance procedures in majority of city municipalities worldwide are implemented by different functional departments, having own (legacy/historic) structure, methods of work and internal controls that run accordingly to national regulations. It is common that data regarding many ongoing operations/activities and its results is not received from IoT in real time, not complete, not verified and largely provided by some third parties with significant delays (weeks, months, years). Most of the data is entered manually and its processing is made by municipality employees having specific tasks and mostly by using multiple spreadsheets. The source information validation, data verification and automatic processing and presentation of results in real time are rare. The results are aggregated mostly at the levels of departments and their heads and communicated to upper levels of governance verbally supported by presentations and reports. In reality, the majority of past decisions are not analyzed in necessary depth against its initial assumptions and actual results achieved due to complexity of evidence data access and this task in general.
Use Case 13 UC#13	DPM for support of smart parking	This number increases by a number of residents per year, with a noteworthy distribution of people among the city districts. Because of this and the capital city area, it has been detected a dramatic rise of accesses to the city center in the last years. Day by day, commuters, tourists and families traveling by car collapse the core of Murcia, wanting to park at commerce, financial and historical areas.
Use Case 14 UC#14	DPM for support of cross border personal finder	Usually, a person finding system can be deployed within a limited area/city because surveillance camera systems are set by local governments
Use Case 15 UC#15	DPM for support of waste management	A Smart City project is a regional collaborative project with local authorities and associations as partners. It aims to provide more digital facilities and applications to the citizens to make life greener and more efficient using state-of-the-art IoT technologies. The main interest of the public authority managers is to understand the way IoT technologies can benefit to citizens in urban, per-urban and rural areas and identify the sustainability model of such deployments at a time of reduced budgets and increasing constraints on data management (such as GDPR or open-data regulations). With the project, EGM is managing the whole network deployment and supporting the deployment and adoption of the waste management use case.
Use Case 16 UC#16	DPM for support of citizen-made IoT applications	The IoT infrastructure to be federated is not yet finalized; the project will likely reuse the deployment strategy of FiWARE over oneM2M, and then the infrastructure will be federated in the Fed4IoT platform. The final deployment strategy will be decided during the project lifetime.
Use Case 17 UC#17	DPM for support of wildlife monitoring	Wildlife damage is serious also in a big city (750 km 2, population 110 thousand people) in a region prefecture which is a local city on the side of the Sea of a country. In addition to damage to field crops, elderly people refrain from going out scared of wildlife showing up. As a result, there is serious problem regarding their health. On the other hand, wildlife is valuable as wild meat and fur products, and more efficient usage is desired by utilizing ICT technology.

Appendix I-2

Requirements and capabilities considerations of DPM from the collected use cases

Use case number	Requirements considerations	Capabilities considerations
Use Case 1 UC#1	Standard open source software requirements including those applicable to security and data protection (e.g. https, websockets, encryption AES256, 2 factor authorization, etc), physical protection of the analytic engines ruining the data models of each educational organization, redundancy of communication networks.	**Analysis and analytics** Data processing shall result in real time calculation of standard set of indicators corresponding to typical processes in educational organizations including the prime ones (learning, developing practical experiences, training, etc), and supporting ones (teachers work, supply and use of infrastructure and resources, events, transportation, quality of environment, etc). The analytics shall let both quick assessment of target process status and in depth analysis of cases to formulate optional improvements and corrective actions. The GUI formats and modalities shall support wide range of users ages and knowledge levels, provide simplicity of information presentation facilitating positive learning and improvement. It shall include use of basic mobile technology achievements and apps.
Use Case 2 UC#2	System should consume the minimum amount of resources as reasonably possible Efficiency: System should offer flexibility to be deployed either as an 'on-premise' service, or as a cloud-based service Deployment: System must process data in real-time (i.e. within a few seconds) Performance System must adhere to privacy laws Privacy System should have high up-time Reliability System should demonstrate a high level of security and include latest data encryption methods Security: System should provide intuitive and responsive experience to user Usability System should be available on the most recent browsers and screen resolutions Accessibility	**Data processing and management capabilities,** according to the reference architecture, will provide functionality about: Context Availability: represents the operations to identify which context data sources are connected to the smart city platform. Query and Subscription: synchronous data gathering based on query language, and subscriptions mechanisms, for more real-time data changes notifications. Both cases, with contextual information. Command Dispatcher: the capability of acting over devices. At the same time, and following the OASC principles, the data will be available through and Open Data Platform. a technological organisation is a good candidate to cover this requirement. This tool provides also functionality about accountability, authentication and authorization, visualization, licensing, etc.

	System should be backed up, data-loss should be prevented Accessibility System software & code base should comply with the most recent standards at time of development Compliance System should have fast response time that is not inconvenient to users Performance System should be easy, enjoyable and intuitive to use Usability System must use standard data models. General The application must be compliant with the EU GDPR (General Data Protection Regulation and national regulations)	
Use Case 3 UC#3	The application should have a low footprint on energy consumption. The application must support most of the screen resolutions and screen form factors (responsive). The application must be able to run on mobile devices. The application must provide information in a user-friendly way. The application must use standard data models. The application's interface should be accessible by people with disabilities (ease of access). The application should minimize the amount of data exchange between the servers and the user's device (to minimize data traffic consumption). The application must support language localization of the user interface. (Privacy) The application must allow the user to manage (delete, restrict, modify, download) her personal/private data and to eliminate her account at any moment. (Privacy) The application must provide the user with the privacy policy. (Privacy) The application must be compliant with the EU GDPR (General Data Protection Regulation - Official Journal of the European Union, L 119, 4 May 2016) and national regulations.	**Application** Provide user identification and access control at least by a username/email address and password basic security (log-in). Provide basic features that can be accessed in an unregistered way. Permit to plan routes by considering user preferences (panoramic itinerary, air quality, lowest cost, lowest time, etc.) and requirements. Consider real-time information (deleted rides, delays, etc.) to better plan and update the journey. Notify the user in real-time about issues that affect selected route. Consider user related information to suggest routes based on her preferences. Provide users with a georeferenced search of parking areas. Permit to search for car parks by considering user preferences. (proximity of stations, bus stop, destination address, secured park, Park & Ride features, etc.). Indicate which transport possibilities are currently available near the selected parking area (e.g. estimated arrival times for nearby bus lines). Indicate in real-time where free parking lots are available and at which cost/minute. Estimate when and where it will be possible to find a free parking lot. Indicate alternative parking lots/areas nearby when there's no parking availability (or the parking availability estimated probability is too low) on the user-selected area.

		Receive and track the routes, means, check-ins and check-outs by the users, to share the revenue among the different transport providers. Handle different subscription forms and tariffs decided by the transport providers. Allow the user to pay a single periodic bill for all transportation services providers. Provide the user with a report of all routes and their relative costs, and the total cost. User: Register an account and log-in to access features of the application that cannot be used in an unregistered way. Enter (or provide by the GPS sensor embedded in his mobile device) the departure point, destination point and optionally other intermediates points of an itinerary on a map. Enter the departure point, destination point and optionally other intermediates points of an itinerary writing their addresses, GPS coordinates or Point of Interest (PoI). Select among different traveler profiles (e.g., by walk, drive a car, drive a bike, use public transportation, etc.). Combine multiple transportation modes and mobility infrastructures (e.g., metro + bike sharing for last mile instead of bus). View on a map alternative route and select the one he/she wants to use. Receive the amount/estimation of the cost (e.g. total ticket price) and arrival time (when possible) of each alternative route. Select the preferred route she wants to use. View on a map the points of interest located in an area near to the route. IoT edge (sensors, data sources, devices) Traffic sensors must at least provide their GPS location and the traffic flow intensity. Parking sensors must at least provide their GPS location and their status. Vehicle sensors must at least provide vehicle/transportation line info, speed and their GPS location. Environmental sensors must at least provide humidity, air quality, noise and wind speed. User devices must at least provide their GPS location.

		Ticketing devices must at least provide user information, transport mean and their GPS location. Bike docking stations must at least provide user information, bike info, status and their GPS location. Mobility premises must at least provide humidity, Air quality, noise and wind speed.
Use Case 4 UC#4	Aiming at forging more robust DPM capabilities, the ICT infrastructures have to be further upgraded to be more extensible and inclusive. The success of the project largely hangs on the cooperation among the different stakeholder groups, which will to a great extent sway the availability, interoperability and also safety of the data. On the other hand, public policies and regulations are also quite important for the progress of the system construction.	**Data processing and management capabilities**: On the bottom, the project behind this use case builds on the bedrock of a renovated massive data-acquiring network covering 10 fields and commissioning over 200,000 sensing units. Recognizing the problem that varied IoT transmission manners are involved in the data acquiring process, this project manages to set up an encompassing comprehensive sensing and transmitting architecture, in a bid to integrate the various existing IoT network, supporting compatibility with the mainstream wide-band and narrow-band connecting technologies and protocols. This is to lay a sound foundation for the “digital economy” infrastructure construction. These new sensing data combined with the already existing administration data as well as the more diversified social transactional data are then interconnected by the “data pool” scheme is to support the unified transactions across at least 15 sectors or departments.
Use Case 5 UC#5	Data and system of the Use Case 5 should meet the following requirements. Usability; Data continuity; Flexibility; Interoperability: The service application running on the back end of the platform uses elegant web interactive pages to provide services through standard web protocols, ensuring that application services of different platforms can be interoperable.; Reliability; Safety; Security and privacy: In the process of spatial data exchange, the platform manages and monitors the rights of data access, provides records and traces of loss and leakage of spatial data, solves security and confidentiality issues in data access and transmission, and ensures the security and reliability of geographic information data. Co-construction and sharing: a joint construction and sharing agreement is signed among different stakeholders to cooperate with each other in data	Performance: The Use Case 5 contains tens of millions of data, and the data volume is enormous. Including map tile data, place name address data, points of interest data, and other ministries and commissions business data, such as urban management data, public security data, agriculture commission data, a district government management data, and so on. The Use Case 5 website has an average daily traffic of more than one million. For other information, please refer to "Application Services" related indicators. Economic Benefits: The construction of Use Case 5 has greatly enhanced the comprehensive management ability and service level of the municipal government, indirectly improved the economic development environment, and promoted the economic development of prefecture-level cities. It integrates administrative resources, standardize service processes, reducing overall construction costs, and reduce financial waste. Social benefits: Integrate geospatial information resources of various departments and units to make these financial investment assets effective. Promote the development of geospatial information

	sharing and exchange and system construction support.	infrastructure and provide basic data resources for e-government projects. (2) Data model: The Use Case 5 data types include land features, water systems, residential areas and facilities, transportation, realm, vegetation , soil and point of interest data. It specifies the layers, attributes, graphic expressions, and data formats for each type of data. (3) Data backup, archiving and recovery: In the data production work instructions, data submission methods and data backup are specified. Special rules and regulations documents are provided to ensure the archiving, backup and recovery of data. (4) System sustainability: Use Case 5was formally opened on September 23, 2012. It has been running for nearly six years. Its official launch provides a basic bearing platform for the spatial information of urban planning. It is an urban development and deduction platform that inherits the history of the city, bears present-day of the city, and displays the future spatial pattern of the City. Providing strong geographical information support for accelerating the management of urban refinement
Use Case 6 UC#6	Privacy by Design	**Data processing capabilities:** Data transferred from Smart Card users, entities received the payment by card using citizens etc., should be aggregated and grouped. Cleaning and filtering are necessary to these data before classifying and indexing them. The privacy and sensitive data should be identified using anonymization and pseudomymization techniques. The privacy and sensitive data include personal information, account information of citizens' who have restarted as user of the Smart Card and business' data of life services supplied entities etc. In the Smart Card application and security management Platform, all data have to be pre-processed and processed before the data analyzed, read and queried according to the internal standard protocol. **Data management capabilities:** Data are managed carefully in the Smart Card application and security management Platform. The data security is very important in data management capabilities. All data are access and use under relative security administration to control any dangers access or illegal use in accordance with the security Level of data. For data preservation and storage, security of the stored data and user's/access information should be ensured. The data producer encrypts data with public is recommended, meanwhile, data producer

		should update the encrypted public key irregularly to ensure the stored data security. The user's/visitor's information security can be ensured though applying for a replacement secret key, data encryption, desensitization, or fuzzification. The system capabilities of the Smart Card application and security management Platform should considerate functions and operations though the platform. The performance indicators include: To build the Smart Card System based on the identity authentication security system. To obtain the livelihood information by analysing the integrated data carried on the City almighty virtual citizen card and further to provide solid basis for the urban managers and decision makers to make refinement management decisions.
Use Case 7 UC#7	Privacy by Design (decentralised architecture)	
Use Case 8 UC#8	Efficiency System should consume the minimum amount of resources as reasonably possible System should offer flexibility to be deployed either as an 'on-premise' service, or as a cloud-based service Deployment System must process data in real-time (i.e. within a few seconds) Performance System must adhere to privacy laws Privacy System should have high up-time Reliability System should demonstrate a high level of security and include latest data encryption methods Security System should provide intuitive and responsive experience to user Usability System should be available on the most recent browsers and screen resolutions Accessibility System should be backed up, data-loss should be prevented Accessibility System software & code base should comply with the most recent standards at time of development Compliance System should have fast response time that is not inconvenient to users Performance	

	System should be easy, enjoyable and intuitive to use Usability System must use standard data models. General The application must be compliant with the EU GDPR (General Data Protection Regulation and national regulations)	
Use Case 9 UC#9	The personal devices for access to RLE personal area in SC&C system are registered prior to use The access is provided with special secure mobile apps ensuring 2 step authorizations Optional new ID methods for family members can be accommodated additionally upon availability of industrial solutions	**Data collection:** Predefined set of data includes service provider, its service cost rates, current services status, performance metrics, schedule of service breaks tests, quality of services (e.g. service non-compliances), city and national benchmarks for comparing unit costs and quality of services, claims to service provider by RLE and provider responses Data pre-processing (incl. cleaning, aggregation): Run by service providers prior to transfer to a SC&C system, verification of results on the fly by relevant processing modules in the SC&C system **Data analysis:** The available performance and quality data is presented in dashboards and widgets in time periods in charts and tables and benchmarks providing complete picture of service use, its efficiency, and quality. User can add own comments to results to be kept in a history of service use. **Data visualization:** Web apps, modern analytics, trends evaluation **Data query:** Based on use of standard user forms and options **Data transfer:** Data is owned by LTE and accessed by SC&C personnel, the data can be transferred only upon LTE instructions after changing the residence **Data storage:** As per Industry Standards; all data received from service providers and LTE actions related to service management are stored in SC&C system **Data exchange/sharing:** No sharing of personal data, but sharing aggregated data on specific community providing public metrics of quality of life
Use Case 10 UC#10	-	

Use Case 11 UC#11		**Data processing capabilities** Aggregation and grouping Cleaning and filtering Classification and indexing De-identification, anonymization and pseudonymization Transfer Pre-processing and processing Analysis and analytics Reading and query Visualisation **Data management capabilities** Access and use Administration Acquisition and collection Creation Preservation incl. protection Sharing Storage Update **Considerations on system capabilities** Functions and operations Service Level Agreements (SLAs) Performance (incl. 5Vs of Big Data) Data models and modelling Data backup), archiving and recovery Event management System resilience System sustainability
Use Case 12 UC#12	Standard open source software requirements for security and data protection (e.g. https, websockets, encryption AES256, etc.), physical protection of city data processing and management servers, redundancy of communication networks. Real time operation providing online and API access to services. Major measures enabling non-interruptible access to services.	**Processing capability** **Data collection:** Data collection shall be customizable to accommodate major set of optional data sources. It shall support linking with systems such as smart sensors / IoT (http), controllers KNX, Bacnet IP, LonWorks, M-Bus, MP-Bus, etc and various automated systems used for Pumps, Boilers, Energy Analyzers, Fuel automation and others like MetaSys, SCADA, ERP, MES, etc as well as various data bases and webs including social networks

	Special measures and analytics for data quality audit and verification using redundant data sources and machine learning and other AI-driven tools. Public visibility of performance results and audit. Legal responsibilities for proving unproven or fake data, publicity of proven cases and sources.	**Data pre-processing:** Automation systems realized in KNX, Bacnet, LonWorks, M-Bus, MP-Bus and other building and industrial automation protocols shall have gateways converting relevant data into common high level data format (such as JSON) for further transmission to data processing management systems. The local smart data verification shall be enabled in most important data sources used for management of urban processes that are critical for ensuring quality of life **System capability:** The data processing system capability shall be sufficient to transform big data streams from all sub-systems and IoT into information services that meet the objectives of the use case.
Use Case 13 UC#13	System should be available and reliable, and perform its recommendations with enough agility as to avoid users desisting from their request and making for an enjoyable experience. System should be interoperable with other smart city modules and components.	Historic and current parking occupancy information is transferred from RPZ concessionary companies and private parking sites to the system. Parking occupancy information is processed and analyzed, generating forecasts of parking availability in different time scales and time horizons. Users generate parking recommendation requests in the form of entities in the system. Users request trigger the computation of parking recommendations, which make use of parking forecasts and current status. Parking recommendations, once created, trigger the response to the user. Parking recommendations and user requests can be further analyzed to compute KPIs regarding system use and performance. All information on the system is distributed in IoT Brokers along several nodes. Centralized index of the available information stored along the IoT Brokers is stored in the IoT Discovery component. Computations in the system, take place in nodes, which can be edge physical components or cloud elements. Other elements external to the Smart Parking system, can be connected (thanks to the NGSI interface) to further enhance and extend its performance and capabilities, providing components for Open Data sharing and Big Data analysis among others. The inherently distributed nature of the system makes it resilient and flexible, adapting to changes in structure, hardware availability and user demand.

Use Case 14 UC#14	Edge and cloud processing, streaming data, and visualization the person finding responses.	In data processing capabilities, for handling the user requests, a person finding system requires to authenticate the users' requests by certifying the users' IDs to protect the data from illegal access and illegal data usage. To certify the users' IDs, the system requires a capability of accessing the data base stored the face images, matching the face images, and transmitting to the matching results to the users' devices. In addition, for processing the images/videos, the system requires to capture the images/videos from city surveillance cameras, collects the images/videos in the edge and cloud servers, and performs image processing to detect the humans, including their faces, and extract their attributes. In addition, the system requires to connect the human information to other environmental information, such as geolocations and time stamps in order to track a human's historical movement. In data management capabilities, to protect the privacy for the users, the system requires to encrypt every data exchange between the servers and the users. In addition, to reduce the video traffic volume and server processing loads, the captured images/videos are processed and stored to distributed regional edge servers. These images/videos should not be stored as raw data but intermediate processed results, such as extracted feature points.
Use Case 15 UC#15	▪ Interoperability: the data processing results are semantically annotated and interoperable with other deployment of the same use case or different use cases. ▪ Safety: the data processing results is accessible via access control Security and privacy: the personal data should always stay anonymous	**Data processing capabilities** Cleaning and filtering: the collected raw data are cleaned regularly if no pattern has been detected Classification and indexing De-identification, anonymization and pseudonymization: the collected raw data are always anonymous in the edge side Transfer: only data processing results are sent to platform Pre-processing and processing: the collected raw data are processed in the edge side Reading and query: the processing results are shared via platform interfaces for query and subscription/notification **Data management capabilities:** Access and use: the processing results are shared via platform interfaces for query and subscription/notification Administration: the platform will control the access rights to results

		Acquisition and collection: the data are collected via smart cameras following a fixed frequency Storage: the collected raw data are cleaned regularly if no pattern has been detected, and the storage is updated frequently **Considerations on system capabilities:** Functions and operations: device virtualization, image/video processing, edge computing Data models and modelling: the data include semantic annotation for interoperability purpose. Event management: an event will be recorded once an uncivil behaviour is detected
Use Case 16 UC#16	The programming facility should be usable by users with no prior experience of programming.	The system has processing capability to execute the Functions and transfer data among Functions and IoT device wrappers. In addition to the processing capability, the system provides the capability to store programs, interpret the programs, place Functions, route data among Functions and IoT device wrappers, and interface with programmers.
Use Case 17 UC#17	▪ Realtime sensing and notification of the current status shall be required. ▪ Low power consumption for collecting data shall be provided. Flexible control according to location and season shall be provided.	By sharing information such as the type and number of captured animals among the processors, restaurants, etc., it is possible to utilize materials such as gibier and furs.

Appendix II Use case specific requirements for DPM

Use case specific requirements: Transportation

Main Theme	Use case code	Background	Requirements description
Smart parking	**Use Case 13** **UC#13**	**Domain**- Smart City – traffic **Objective**-This scenario exploits the needs for a more environmentally friendly traffic management by integrating the information about different sort of parking areas (private parking lots and regulated parking zones) into a service that will allow the users to reduce the time spent for a free parking spot in a specific destination **Rational**- To improve the situation, the aim of this use case is that of providing a service that tracks the state of the parking spots to provide the drivers with this information beforehand, so they can better plan where they will park. This will also lead to a more fluid traffic in the city center, because there will be less drivers wandering, looking for a parking spot in areas that do not have any available one.	**Functional requirements** The system issues parking recommendations based on user requests in which desired destination and time of arrival are specified. Parking recommendations take into consideration destination, time of arrival and parking availability based on current status and forecasts. Forecasting is computed based on current and historical information of PRZs and private parking sites. **Non-functional requirements** System should be available and reliable, and perform its recommendations with enough agility as to avoid users desisting from their request and making for an enjoyable experience. System should be interoperable with other smart city modules and components.
Human centric traffic management	**Use case 2** **UC#2**	**Domain**-Transport **Objective**- (1) Improvement of bicycle experience and (2) Improvement of infrastructure planning and policy making Rational-Aims to improve bicycle mobility in cities, in a balanced way. The initial application data-driven bicycle mobility aims to stimulate bike mobility by improving overall cycling experience, traffic safety, infrastructure planning and policy making	**Functional requirements** System must process data from multiple sources/sensors in real-time System should recognize preconfigured traffic situations and classify these situations in real-time System should select optimal traffic light decision and actuation based on classified traffic situations in real-time System should select optimal public street lighting decision and actuation based on classified traffic situations in real-time The system must provide user identification and access control at

			least by a username/password basic security The system must provide flexibility in terms of viewing, or having access to, certain data sets (e.g. through dashboard widgets) The system may provide a map as the main way of interaction to superimpose data sets The system should provide different views on the superimposed data sets The system should provide user admin features to control their teams via admin panels The system should allow selection of specified time window and display corresponding aggregated data over the selected time window The system may provide advice/prediction based on aggregated historical data The system may allow for annotation specified time windows **Non-functional requirements** System should consume the minimum amount of resources as reasonably possible System should offer flexibility to be deployed either as an 'on-premise' service, or as a cloud-based service System must process data in real-time (i.e. within a few seconds) Performance System must adhere to privacy laws System should have high up-time Reliability System should demonstrate a high level of security and include latest data encryption methods System should provide intuitive and responsive experience to user Usability System should be available on the most recent browsers and screen resolutions Accessibility

			System should be backed up, data-loss should be prevented Accessibility System software & code base should comply with the most recent standards at time of development System should have fast response time that is not inconvenient to users Performance System should be easy, enjoyable and intuitive to use Usability System must use standard data models. General The application must be compliant with the EU GDPR (General Data Protection Regulation and national regulations)
Multi-modal transportation	**Use Case 3** **UC#3**	**Domain**- Smart Cities; Transport **Objective**-Combine conventional public transports (train, bus and metro) with other transportation modes (motorized or non-motorized), new concepts of vehicle ownership (shared) and urban mobility infrastructures, to provide optimized and efficient routes **Rational**-Improved and more efficient mobility will alleviate the impact that traffic can have on cities; a way to obtain these results is to provide citizens with appropriate services and tools, which support and assist the transfer between and within the cities, providing the correct information, facilitating in the use of both public and private transports available in the cities (such as metro, buses and trains), car parking, vehicle sharing services (such as car, scooter and bike sharing), or mobility infrastructures (escalators, elevators, etc.) in a seamless way and guiding step by step in the use of different means of transportation. A multimodal assistant (mobile) application will inform citizens about their mobility options and will facilitate their journeys	**Functional requirements** (1)Application Provide user identification and access control at least by a username/email address and password basic security (log-in). Provide basic features that can be accessed in an unregistered way. Permit to plan routes by considering user preferences (panoramic itinerary, air quality, lowest cost, lowest time, etc.) and requirements. Consider real-time information (deleted rides, delays, etc.) to better plan and update the journey. Notify the user in real-time about issues that affect selected route. Consider user related information to suggest routes based on her preferences. Provide users with a georeferenced search of parking areas. Permit to search for car parks by considering user preferences. (proximity of stations, bus stop, destination address, secured park, Park & Ride features, etc.). Indicate which transport possibilities are currently available near the selected parking area (e.g.

			estimated arrival times for nearby bus lines). Indicate in real-time where free parking lots are available and at which cost/minute. Estimate when and where it will be possible to find a free parking lot. Indicate alternative parking lots/areas nearby when there's no parking availability (or the parking availability estimated probability is too low) on the user-selected area. Receive and track the routes, means, check- ins and check-outs by the users, to share the revenue among the different transport providers. Handle different subscription forms and tariffs decided by the transport providers. Allow the user to pay a single periodic bill for all transportation services providers. Provide the user with a report of all routes and their relative costs, and the total cost. (2)User Register an account and log-in to access features of the application that cannot be used in an unregistered way. Enter (or provide by the GPS sensor embedded in his mobile device) the departure point, destination point and optionally other intermediates points of an itinerary on a map. Enter the departure point, destination point and optionally other intermediates points of an itinerary writing their addresses, GPS coordinates or Point of Interest (PoI). Select among different traveler profiles (e.g., by walk, drive a car, drive a bike, use public transportation, etc.). Combine multiple transportation modes and mobility infrastructures

			(e.g., metro + bike sharing for last mile instead of bus). View on a map alternative routes and select the one he/she wants to use. Receive the amount/estimation of the cost (e.g. total ticket price) and arrival time (when possible) of each alternative route. Select the preferred route she wants to use. View on a map the points of interest located in an area near to the route. (3)IoT edge (sensors, data sources, devices) Traffic sensors must at least provide their GPS location and the traffic flow intensity. Parking sensors must at least provide their GPS location and their status. Vehicle sensors must at least provide vehicle/transportation line info, speed and their GPS location. Environmental sensors must at least provide humidity, air quality, noise and wind speed. User devices must at least provide their GPS location. Ticketing devices must at least provide user information, transport mean and their GPS location. Bike docking stations must at least provide user information, bike info, status and their GPS location. Mobility premises must at least provide humidity, Air quality, noise and wind speed. **Non-functional requirements** The application should have a low footprint on energy consumption. The application must support most of the screen resolutions and screen form factors (responsive). The application must be able to run on mobile devices.

			The application must provide information in a user-friendly way. The application must use standard data models. The application's interface should be accessible by people with disabilities (ease of access). The application should minimize the amount of data exchange between the servers and the user's device (to minimize data traffic consumption). The application must support language localization of the user interface. The application must allow the user to manage (delete, restrict, modify, download) her personal/private data and to eliminate her account at any moment. The application must provide the user with the privacy policy. The application must be compliant with the EU GDPR (General Data Protection Regulation - Official Journal of the European Union, L 119, 4 May 2016) and national regulations.

Use case specific requirements: Educational processes

Main Theme	Use case code	Background	Requirements description
Data collection and transformation for Educational processes	**Use Case1** **UC#1**	**Domain**- education in urban areas Objective- **Rational**-gradually introduced as cost-effective standardized DPM solution in the scope of IoT and SCC standard and supported by relevant economic, legal and social stimulus's, the novel educational environment can significantly improve visibility, transparency, performance and responsibilities of administrations at the levels each organization and the governance of the local, regional and national educational systems as a whole	**Functional requirements** The educational processes are required real time processing, availability of standard KPIs as common normalized metrics for all along with obligatory data collected in each organization The educational processes are required that multiple data streams from large number of data sources providing information about ongoing educational processes shall be transformed into high level information services presenting integrated vision of a single educational organization in the Stakeholder group 1 or the whole groups of educational organizations in the Stakeholder group 2 contributing to the holistic vision of a city as cyber-physical urban system existing in physical and virtual worlds. **Non-functional requirements** The educational processes are required standard open source software requirements including those applicable to security and data protection (e.g. https, websockets, encryption AES256, 2 factor authorizations, etc), physical protection of the analytic engines ruining the data models of each educational organization, redundancy of communication networks. Other requirements The educational processes are required special measures and analytics for data quality audit and verification using redundant data sources and machine learning and other AI-driven tools. The educational processes are required that the technical support of the analytics engines for Stakeholder group 1 and 2 shall be recommended to specialized certified service providers in the regions having sufficient expertise,

			qualifications, capacity and responsibility to implement and support large number of education organization for setting and running and their applications.

Use case specific requirements: Urban development

Main Theme	Use case code	Background	Requirements description
Smart city administration	**Use case 4** **UC#4**	**Domain** - Urban management **Objective** - To strengthen the urban administration suited to expansive metropolises by virtue of smart ICT solutions consisting of big data technologies and IoT **Rational** - realize coherent and effective converging of data from varied origins on way to the formation of an infinitely flexible data carrier for the development of "digital economy'	**Functional requirements** Aiming at forging more robust DPM capabilities, the ICT infrastructures have to be further upgraded to be more extensible and inclusive. **Non-functional requirements** Smart city administration is required the success of the project largely hangs on the cooperation among the different stakeholder groups, which will to a great extent sway the availability, interoperability and also safety of the data; Smart city administration is required that public policies and regulations are also quite important for the progress of the system construction.
Digital interface	**Use Case 9** **UC#9**	**Domain** - **Objective** - **Rational** -	Digital interface to urban processes is required simple and carefully designed citizen personal area using web and mobile apps technologies supporting different knowledge patterns, qualifications and ages Digital interface to urban processes is required secure access from common mobile and personal computing devices Digital interface to urban processes is required secure communications blocking intermediary data trapping Digital interface to urban processes is required standards for data to be provided to SC&C systems by service providers regarding use of such services by legal entities in community

Urban waste management	**Use Case 15** **UC#15**	**Domain** - Smart City – Urban life **Objective** - to provide easy deployment of garbage site monitoring devices and services to detect uncivil behaviours for necessary actions and improve urban life experience **Rational** - The main interest of the public authority managers is to understand the way IoT technologies can benefit to citizens in urban, peri-urban and rural areas and identify the sustainability model of such deployments at a time of reduced budgets and increasing constraints on data management (such as GDPR or open-data regulations). With the Grasse Smart City project, EGM is managing the whole network deployment and supporting the deployment and adoption of the waste management use case.	**Functional requirements** Edge processing, device virtualization and stream processing **Non-functional requirements** Urban waste management is required interoperability: the data processing results are semantically annotated and interoperable with other deployment of the same use case or different use cases; Urban waste management is required safety: the data processing results is accessible via access control; Urban waste management is required security and privacy: the personal data should always stay anonymous.
Citizen-made IoT Applications	**Use Case 16** **UC#16**	**Domain** - Home and Regulated Smart City Environment **Objective** - The objective of this use case is to make the IoT systems programmable so that the owners and the users of IoT systems can integrate different IoT devices and let them work together to implement variety of services. **Rational** - The idea for citizens to develop their own application is part of the activities to re-vitalize the city by attracting more international visitors as well as the visitors from other part of Japan. In order to ensure the accessibility by citizens to the system, the city plans to develop IoT application components to be combined to form citizen-made IoT applications. Fed4IoT platform provides IoT device sharing capability among citizens to the system.	**Functional requirements** GUI to provide graphical programming capability; Capability to link Functions and IoT device wrappers by data flow; Capability to place Functions in processing facilities; Capability to route data among Functions and IoT device wrappers. **Non-functional requirements** The programming facility should be usable by users with no prior experience of programming.

Use case specific requirements: Smart sustainable governance

Main Theme	Use case code	Background	Requirements description
Smart sustainable governance	**Use Case 12** **UC#12**	**Domain** - Sustainability status of urban area **Objective** - Supporting smart transparent governance and sustainability of cities as increasingly complex and dynamic urban systems by digital transformation and IoT Rational- the level of local communities, the complexity of interdependencies between causes and impacts may result in combinations of trends that lead to long term negative impacts which democratically elected or nominated governors may not be able to mitigate due to lack of knowledge about actual processes, performance transparency and capacity to cope with growing nexus of challenges during their governance intervals. The challenge can and shall be mitigated by changing the existing legal and organization frameworks to allow and foster applying latest cost-effective digital transformation solutions enabling Automatic collecting of vital data about urban processes received from large number of diverse IoT domains in real time Making the detailed results available to governance bodies and business entities which support life processes (utility providers, health, education, leisure, social status, etc.) Presenting generic information related to quality of life and its sustainability to all stakeholders in real time Providing access to this information easy understandable modalities (online performance scoreboards, reports, animated avatars, gamification, 2D/3D,	**Non-functional requirements** Smart sustainable governance is required standard open source software requirements for security and data protection (e.g. https, websockets, encryption AES256, etc.), physical protection of city data processing and management servers, redundancy of communication networks; Smart sustainable governance is required real time operation providing online and API access to services; Smart sustainable governance is required major measures enabling non-interruptible access to services;

		AR/VR, AI-enabled voice assistants, etc.) Enabling possibility to go into necessary details for analysis of causes, events, and traceability of consequences and dependences Introducing well defined and validated AI-driven assistance to let smart governance at each level of urban management and operations including maintenance, condition monitoring, predictive & prescriptive analytics supporting variable level of qualifications and knowledge and learning	

Use case specific Requirements: People finder application

Main Theme	Use case code	Background	Requirements description
People finder	**Use Case 14** **UC#14**	**Domain** - Smart City – Cross domain **Objective** - To notify authorized users (e.g., security authority, parents) about the presence of a given person in a specific place/area. This functionality can be used for instance to find a lost child or an elderly person, expanding the automatic search over different EU or JP regions **Rational** - This use case seeks to enable extending such systems throughout other smart cities in an interoperable way.	**Functional requirements** Edge and cloud processing, streaming data, and visualization the person finding responses.

Use case specific Requirements: Wildlife monitoring

Main Theme	Use case code	Background	Requirements description
Wildlife monitoring	**Use Case 17** **UC#17**	**Domain-** **Objective**- Real-time monitoring of the wildlife intrusion to farms. Sharing of the information of trapped wildlife among farmers, food/furs processors, restaurants, hunters, and other smart city platforms.	**Functional requirements** Outdoor sensing data must be collected; Real time monitoring and notification capability is required;

		Rational- These problems can be solved with the IoT technology. By attaching a communication function to surveillance cameras, sensors, etc., people can know the status of traps remotely in real time without having to physically reach each one of them.	Connectivity between the Cloud and the sensor device must be guaranteed; Collected data is accessible by other IoT systems. On easy operations and provisioning. Operations for animal capture shall complied with regulatory issues on protections of animals

Bibliography

[b-ITU-T X.1601] Recommendation ITU-T X.1601 (2015), *Security framework for cloud computing.*

[b-ITU-T Y.2091] Recommendation ITU-T Y.2091 (2011), *Next Generation Networks – Frameworks and functional architecture models: Terms and definitions for next generation networks.*

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

[b-ITU-T Y.4900] Recommendation ITU-T Y.4900/L.1600 (2015), *Overview of key performance indicators in smart sustainable cities.*

[b-ISO 22398] ISO 22398:2013, *Societal security — Guidelines for exercises.*

[b-ISO 37153] ISO 37153:2017, *Smart community infrastructures — Maturity model for assessment and improvement.*

[b-ISO 8000-2] ISO 8000-2:2017, *Data quality — Part 2: Vocabulary.*

[b-ISO/Guide 73] ISO/Guide 73:2009, *Risk management — Vocabulary.*

[b-IEC 62559-2] IEC 62559-2:2015, *Use case methodology - Part 2: Definition of the templates for use cases, actor list and requirements list.*

[b-IEC/ISO/ITU Draft White Paper] IEC/ISO/ITU Smart City Coordination Task Group: 2019 Draft White Paper: *Suggested Priority Terms in Need of Common Definitions to Support Standards Activities for Smart city, Barcelona, World Smart City Forum, April 17, 2019.*

[b-ISO/IEC 19501] ISO/IEC 19501:2005, *Information technology — Open Distributed Processing — Unified Modeling Language (UML) Version 1.4.2*

[b-FG-DPM TS D0.1] Draft Technical Specifications D0.1, "Data Processing and Management *for IoT and Smart Cities and Communities: Vocabulary*".

[b-OASC] Open & Agile Smart Cities (OASC) Minimal Interoperability Mechanisms (MIMs) as adopted by the OASC Council of Cities January 16, 2019, https://oascities.org/

[b-SynchroniCity] SynchroniCity: IoT Large-Scale Pilot for Smart Cities & Communities

[b-Fed4IoT] Fed4IoT Project, https://www.fed4iot.org