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

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

Framework of open data in smart cities

Recommendation ITU-T Y.4461

International Telecommunication Union

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Recommendation ITU-T Y.4461

Framework of open data in smart cities

Summary

Recommendation ITU-T Y.4461 defines a framework of open data in smart cities. It clarifies the concept of open data in smart cities, analyses the benefits of open data in smart cities, identifies the key phases, key roles and activities of open data in smart cities and describes the framework and general requirements of open data in smart cities. The use cases are also provided in an informative appendix.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4461	2020-01-13	20	11.1002/1000/14164

Keywords

Framework, open data, smart city.

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

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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1 Scope

This Recommendation defines a framework of open data in smart cities, in order to promote the sharing of data between different entities in a smart city, fully exploit potentialities of data in smart cities, and ultimately build better and smarter cities. The scope of this Recommendation includes:

– The concept of open data in smart cities;

– The benefits of open data in smart cities;

– The key phases of open data in smart cities;

– The key roles and activities in open data in smart cities;

– The framework of open data in smart cities;

– The general requirements of open data in smart cities.

2 References

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

[ITU-T Y.4900] Recommendation ITU-T Y.4900/L.1600 (2016), *Overview of key performance indicators in smart sustainable cities.*

[ISO 5127] ISO 5127:2017, *Information and documentation – Foundation and vocabulary*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 open data [ISO 5127]: Data available/visible to others and that can be freely used, re-used, re-published and redistributed by anyone.

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

3.1.3 smart sustainable city [ITU-T Y.4900]: A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural aspects.

NOTE – City competitiveness refers to policies, institutions, strategies and processes that determine the city's sustainable productivity.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CSV Comma-separated values

ICT Information and Communication Technology

IoT Internet of Things

JSON JavaScript Object Notation

KML Keyhole Markup Language

KMZ Keyhole Markup language Zipped

NGO Non-Governmental Organization

PDF Portable Document Format

QoS Quality of Service

XML Extensible Markup Language

5 Conventions

In this Recommendation:

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

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement 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.

6 Concept of open data in smart cities

Open data in smart cities refers to organizations or individuals providing machine-readable data created or collected by them to the public, so that data can be available/visible to others and that can be freely used, re-used, re-published and redistributed by anyone [ISO 5127]. Open data in smart cities can be used to promote the sharing of data between different entities in smart city (also known as smart sustainable city [ITU-T Y.4900]), fully exploit potentialities of data in smart cities, and ultimately build better and smarter cities.

The organizations mentioned above includes governments, enterprises, non-governmental organizations (NGOs), etc.

Machine-readable data means open data in smart cities is digitalized and can be retrieved, understood and processed by information systems such as computer, smart phone, etc. The data should be retrieved digitally instead of through paper media. The data should be conveniently visited through internet instead of only accessed in some limited locations such as libraries or government offices. Machine-readable data is often structured with the formats such as extensible markup language (XML), comma-separated values (CSV)/text, keyhole markup language (KML)/keyhole markup language zipped (KMZ), JavaScript object notation (JSON), etc. Data format such as portable document format (PDF) is not an ideal format for open data, because it is not easy for machines to understand and process it.

The types of open data in smart cities include both structural data, such as text and document, and non-structural data, such as image, audio and video. Streaming data can also be used as open data.

The sources of open data in smart cities include, but are not limited to, data from information and communication technology (ICT) systems, data from Internet of things (IoT) applications, social media data and data from other sources that opened to the public.

The topics of open data in smart cities include but are not limited to environment, agriculture, transportation, education, energy, health, local government, science and research, geospatial, etc.

7 Benefits of open data in smart cities

Smart cities share the end goal of achieving an economically sustainable urban environment without sacrificing on the quality of life of their citizenry. Open data plays a critical role in smart cities, and facilitates the advancement of smart cities in many aspects.

Open data in smart cities contributes to sustainability of cities by providing more data insights. City governments and companies will be able to provide services with the integration of municipal data, social media data, sensor data and data from other sources that opened to the public. For example, open data contributes to the environmental sustainability of cities by providing a full view of air pollutants in different areas, including vehicle exhaust and industrial waste gas. In addition, the relationship and effects of different pollutants can be analysed and identified.

Open data in smart cities spurs innovative business models, products and services for smart cities. Open data in smart cities is a valuable and potentially profitable resource that can fuel innovation and invention. Cities can make their public data available for businesses or community developers to re-use it in providing services and sophisticated solutions. A related use case can be found in clause I.1.

Open data in smart cities promotes economic growth by creating new business opportunities, thus bring new businesses revenue streams and jobs. Open data in smart cities helps companies to define new products and services, and improve the efficiency and effectiveness of their organizations. A related use case can be found in clause I.2.

Open data in smart cities improves the public participant in governance by enabling the access to public information that closes to citizen's daily life. Thus, citizens can be more involved in the city's decision machining process, governance transparency, participation and accountability for city policy and service delivery. A related use case can be found in clause I.3.

Open data in smart cities empowers technical solutions to improve the adaptability and resilience of cities, by enabling faster response to unpredictable city events. For example, open data can promote the response to natural and humanitarian disasters, such as earthquake, flood and epidemic diseases. Open data can also improve public emergency response by providing data-driven assessment of the problems. A related use case can be found in clause I.4.

Open data in smart cities provides smart cities to identify citizens' specific needs based on collected data from multiple sources. Thus, cities will be able to have citizen-specific and citizen-centric city development plans, make precise and reasonable decisions in terms of city's infrastructure expansion, making policies or determining the investment levels for technology or solutions, etc. A related use case can be found in clause I.5.

8 Key phases of open data in smart cities

The key phases of open data in smart cities mainly include original data generating, open data preparing, open data publishing, open data acquiring and open data utilizing phases. Figure 1 shows the main actions and output of each phase. The original data generating phase offers original data, the type of which includes, but is not limited to, document, image, audio, video and streaming. The open data preparing phase aims to make data ready for publishing. The purpose of the open data publishing

phase is to make data discoverable and available to the public. The open data acquiring phase allows consumers to find out and get the data they require. The open data utilizing phase refers to analysing and developing acquired open data to create value-add services for smart cities, such as analysis reports and applications, so that the potentialities of data in smart cities can be fully exploited.

The details of the original data generating phase and the open data utilizing phase are outside the scope of this Recommendation.

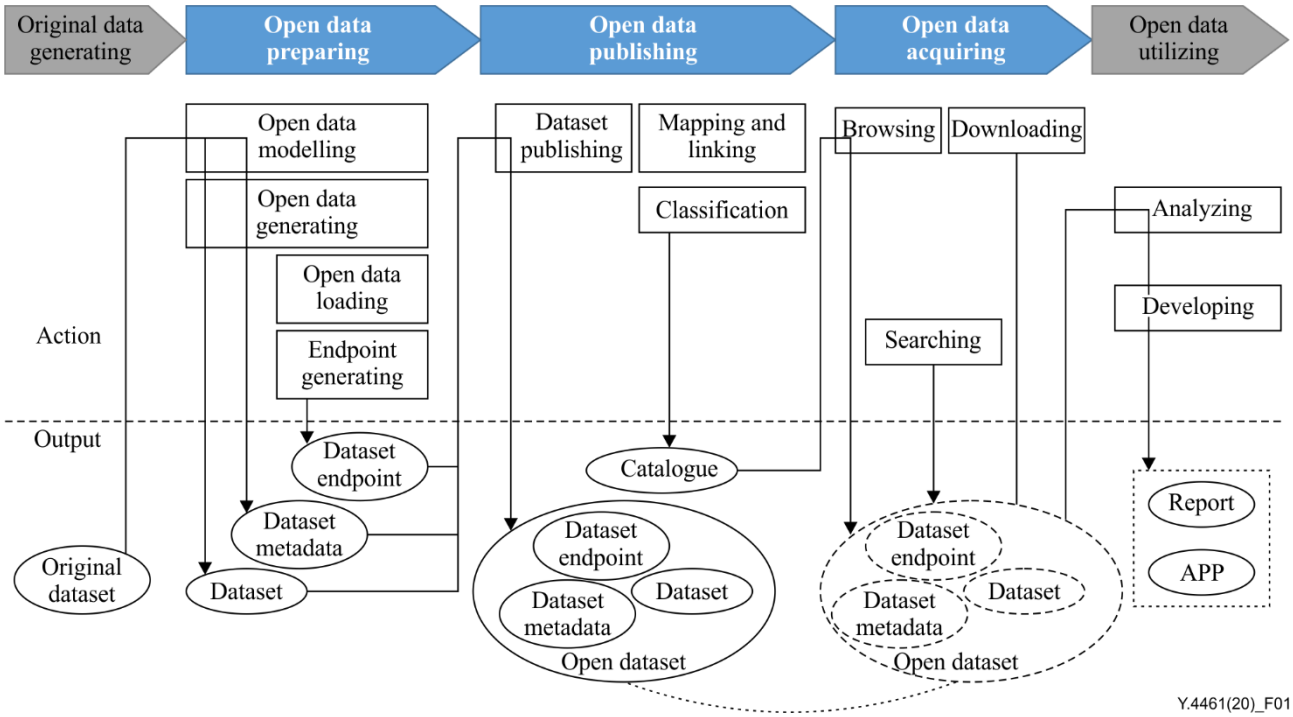

Figure 1 – Key phases of open data in smart cities

8.1 Open data preparing phase

The open data preparing phase includes the four steps shown in Figure 2. These are open data modelling, open data generating, open data loading and endpoint generating steps.

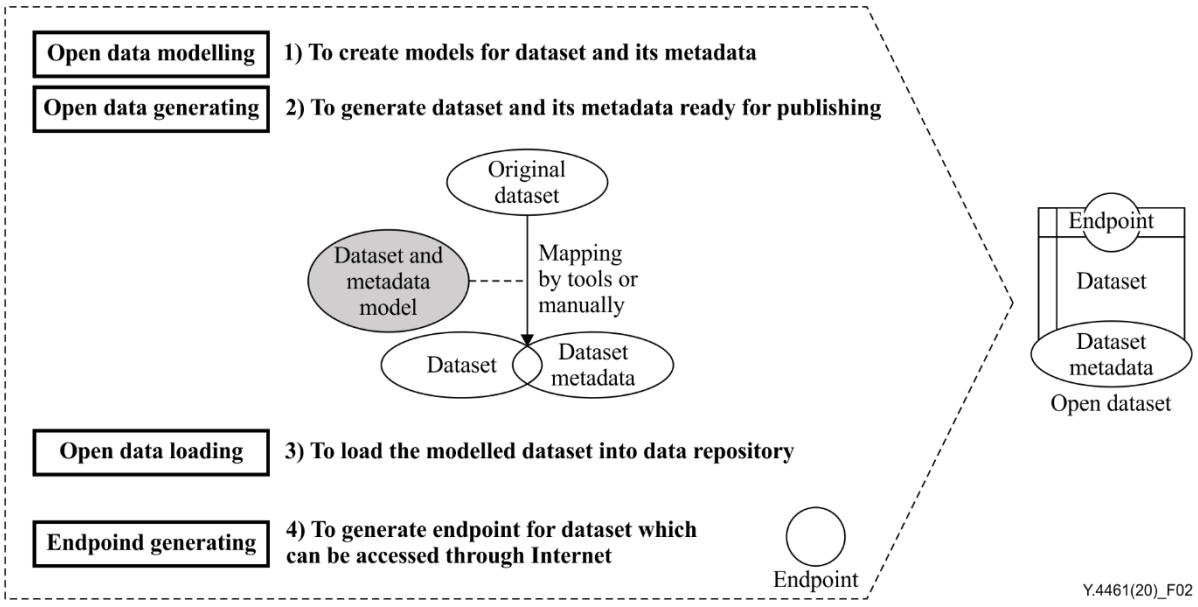

Figure 2 – Open data preparing phase

8.1.1 Open data modelling

Open data modelling aims to create models for dataset and its metadata. It consists of dataset modelling and metadata modelling. Dataset refers to the data that can be downloaded and reused after publishing. Metadata is data that describes other data, which facilitates the understanding, usage, and management of data, both by human and computers [b-ITU-T FG-SSC Anon.].

Dataset modelling defines the structure of the dataset ready for publishing, which makes the dataset machine-readable, thus promoting the reuse of open data. It unifies the data both from the syntax perspective and the semantic perspective. Dataset model includes the information such as field name, order, type, description, etc. It can also be semantics supported and use a semantics description such as ontologies (e.g., [b-ITU-T Y.4500.12]).

Different kinds of dataset models may be provided to support datasets from different domains (e.g., agriculture, education, tourism, etc.), which defines datasets by specific terms. Dataset models of the same domain may be unified or may be different if there are different open data providers.

Dataset modelling may not define the model for non-structural data such as image, audio and streaming, but a metadata model is needed for all types of dataset ready for publishing, as it facilitates the understanding of open data for both humans and machines.

Metadata modelling defines descriptive information of the dataset ready for publishing. The content of the metadata model includes, but is not limited to, basic information (e.g., name, theme, keyword, description, etc), spatial-temporal information (e.g., creation date, publication date, temporal coverage, geographic coverage, etc), provenance information (e.g. publishing organization, contact person, etc.), administrative information (e.g., version, validity period, etc.) and structural information of the dataset model (e.g., field name, order, type, description, etc).

Metadata helps consumers to find the target open data more conveniently and efficiently when browsing and searching the data. It also improves the efficiency for machines to understand and process open data. Metadata of non-structural data is particularly useful for machines since it may be difficult for machines to understand the content without additional information.

8.1.2 Open data generating

Open data generating aims to generate dataset and its metadata ready for publication according to the dataset and metadata model. It consists of dataset generating and metadata generating.

In this step, the original dataset is mapped to modelled dataset and metadata in accordance with the dataset and metadata model. The mapping can be realized either by tools or manually.

NOTE 1 – One single dataset can be generated as different formats, e.g., csv, rdf and xml for documents, and avi, mkv and rmvb for video.

NOTE 2 – Anonymization processing should be supported during open data generating if needed.

8.1.3 Open data loading

Open data loading refers to loading the modelled dataset into a data repository so that consumers are able to access the open data through the Internet.

8.1.4 Endpoint generating

Endpoint generating aims to make the dataset available to the public. It offers the access point for consumers to get the data they acquired, e.g., the download URL for the dataset, the access URL for streaming data, and an application programmable interface (API) which facilitates machines to process and reuse open data.

NOTE – Multiple endpoints may be offered for single dataset, e.g., to represent different formats.

8.2 Open data publishing phase

Open data publishing phase includes the three steps shown in Figure 3 These are dataset publishing, mapping and linking, and classification.

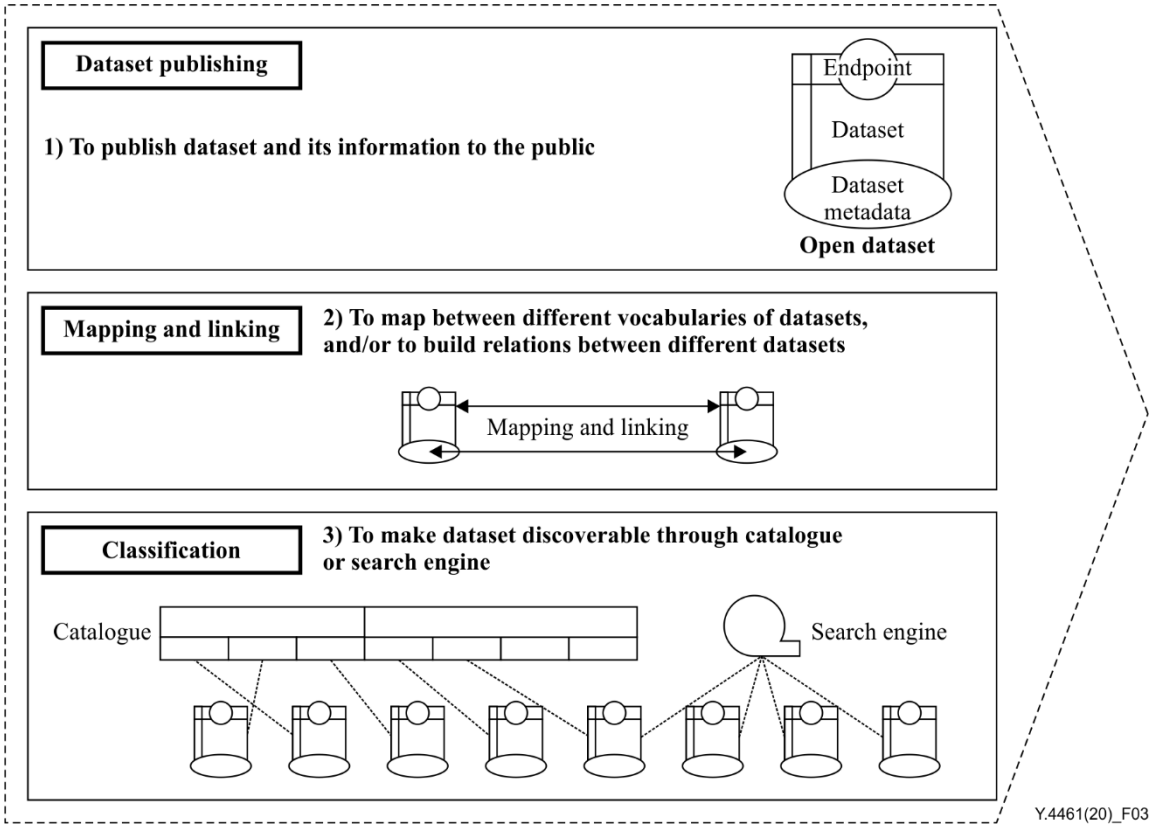

Figure 3 – Open data publishing phase

8.2.1 Dataset publishing

Dataset publishing consists of publishing the dataset and its information to the public. The information includes metadata (e.g., basic information, spatial-temporal information, provenance information, administrative information, structural information, etc.) and endpoint information. Dataset is available to the public through endpoint.

8.2.2 Mapping and linking

Mapping aims to unify the semantics of datasets from different sources. Datasets from different open data providers may use different data models. In this scenario, it is needed to keep semantic conformity of the key information of datasets by approaches such as mapping vocabularies between different datasets, so that it can promote the interoperability of open data and help consumers to find the data they require more efficiently.

Linking aims to build relations between different datasets, so that consumers can be provided with a more comprehensive view of the whole open datasets. New logic and relation could be created between different datasets by approaches such as interlinking based on keywords, interlinking based on vocabularies, etc.

8.2.3 Classification

The purpose of classification is to make dataset discoverable through catalogue or search engine.

Catalogue shows consumers the index of open data. It classifies collections of open datasets by various criteria such as theme (e.g., economy, environment, education, etc), scenario (e.g., training and employment, marriage and childbearing, retirement, etc.) and source (e.g., government department, enterprise, NGO, etc.). It shows the information of the dataset, including the dataset metadata and the endpoint to access the dataset.

Classification enables the function of filtering so that consumers can acquire the open data by filtering properties such as publisher, topic, publication date and format.

Search engine helps consumers to find target open data by keywords. The search result can be more accurate by means of linking and mapping.

8.3 Open data acquiring phase

Open data acquiring phase includes the three main steps shown in Figure 4. These are browsing, searching and downloading.

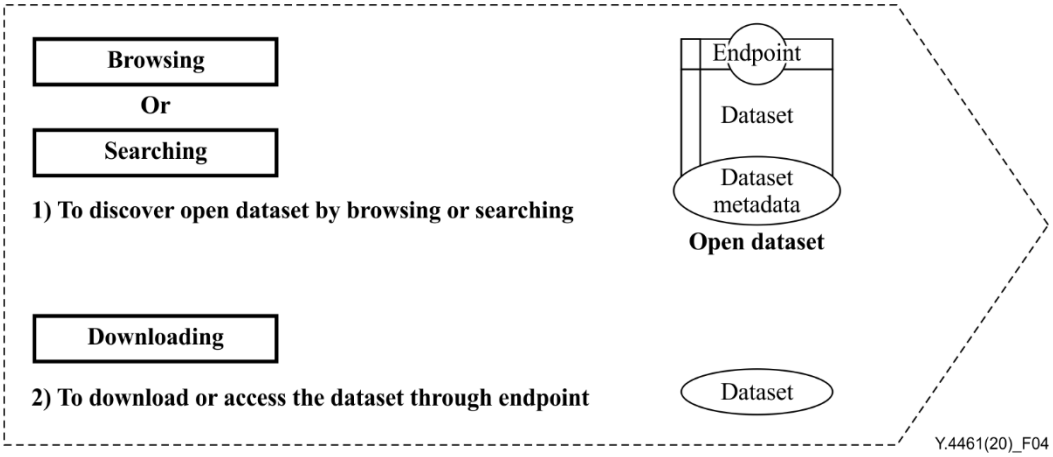

Figure 4 – Open data acquiring phase

The functions of browsing and searching helps consumers to discover the dataset they require. After finding the information of the dataset, consumers are able to get the descriptive information from the dataset metadata and get access to the dataset through its endpoint. Consumers can either download the dataset or acquire the access link to the dataset such as streaming data.

9 Key roles and activities in open data in smart cities

9.1 Key roles in open data in smart cities

Based on the key phases of open data in smart cities, three key roles, i.e., the key roles that are relevant from the operation perspective, are identified for the open data in the smart cities ecosystem. The three key roles are open data provider, open data publisher and open data consumer.

Open data provider is responsible for preparing the dataset, providing the prepared information of dataset (i.e., the information of metadata and endpoint) and the prepared dataset, if needed, to open data publisher.

Open data publisher is responsible for publishing datasets, making them discoverable and available to the public.

Open data consumer is able to find out and get the required open data by browsing, searching and downloading. Open data consumer includes individual open data consumer and open data developer. Individual open data consumer is able to use the data to improve the quality of lives. Open data developer can reuse open data to provide value-added services, such as smart city applications, so that the potentialities of data in smart cities can be fully exploited.

9.2 Key activities in open data in smart cities

The key activities of each role for open data in smart cities are shown in Figure 5 according to different open data modes.

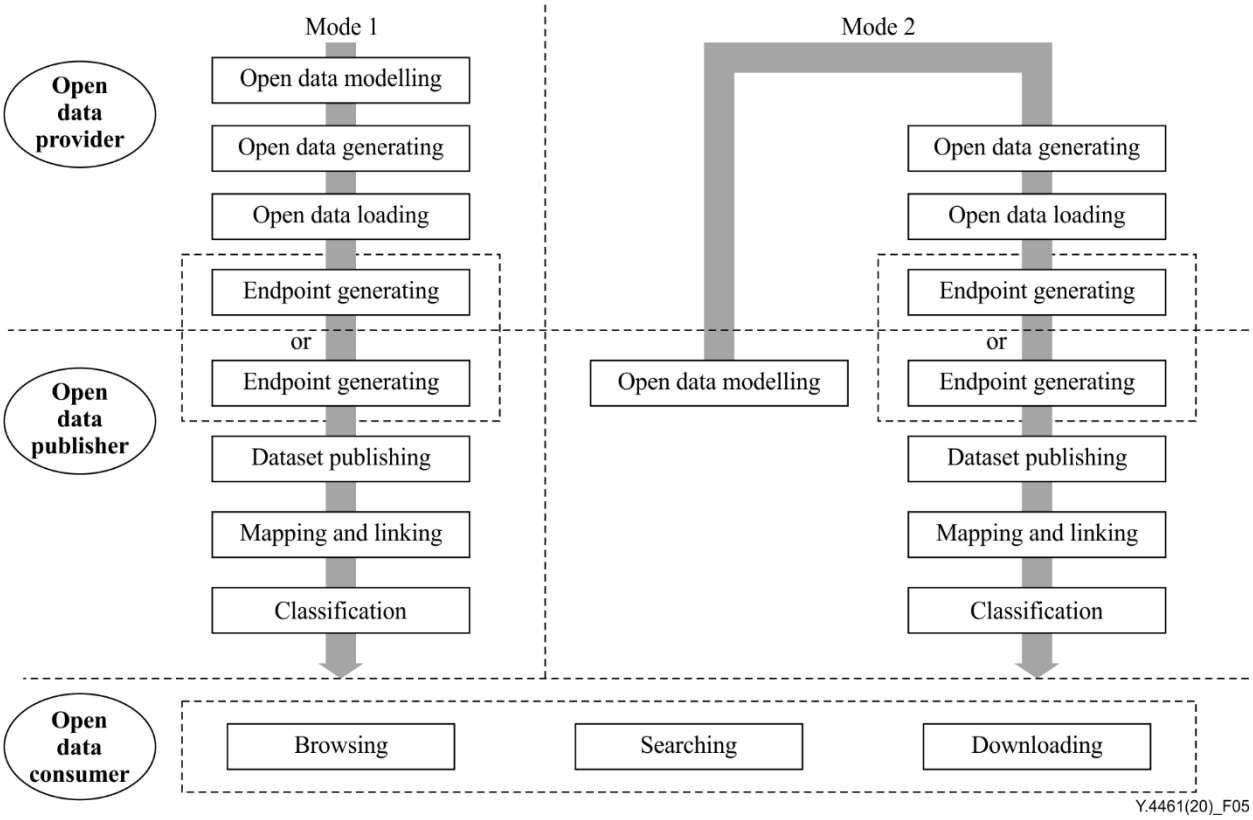

Figure 5 – Key activities of open data in smart cities

There are mainly two modes for operating open data in smart cities, depending on which role is in charge of open data modelling.

In mode 1, open data modelling is operated on the open data provider's side. In this mode, the dataset model may be different depending on the open data provider, and the open data publisher needs to unify the semantics of datasets by means of mapping and linking. Besides open data modelling, the open data provider in this mode is responsible for open data generating, open data loading and endpoint generating, if applicable. The open data publisher in this mode is responsible for dataset publishing, mapping and linking, classification and endpoint generating, if applicable.

In mode 2, open data modelling is operated on the open data publisher's side. In this mode, the open data provider generates the dataset according to the unified dataset model offered by the open data publisher, which facilitates the interoperability of open data from different sources. The open data provider in this mode is responsible for open data generating, open data loading and endpoint generating, if applicable. Besides open data modelling, the open data publisher in this mode is responsible for dataset publishing, mapping and linking, classification and endpoint generating, if applicable.

Endpoint generating can be operated either on the open data provider's side or the open data publisher's side according to the location of the dataset repository, i.e., if the dataset is located on the open data provider's side, it is the open data provider's responsibility to generate endpoint(s), and vice versa.

The key activities of the open data consumer include browsing, searching and downloading in both modes. The open data consumer is able to get the required open data either from the open data provider or the open data publisher according to the location of the dataset repository.

In deployment, a hybrid mode could exist, which means that data modelling could be conducted on both sides, the open data provider and the open data publisher.

10 Framework of open data in smart cities

To promote the development of open data in smart cities, the related infrastructure needs to be built. Figure 6 shows a framework of open data in smart cities, which includes both public open data infrastructure for smart city, and independent open data infrastructure such as city government open data infrastructure, enterprise/organization open data infrastructure, etc.

The public open data infrastructure supports open data from all sources, and offers functions such as open data preparing and open data publishing to the public, so that open data providers who do not have the related infrastructure can also publish the data to the public. The independent open data infrastructure provides open data from specific sources such as government and enterprise. Open data in smart cities from different infrastructures can be shared from each other to promote the interoperability.

The framework of open data in smart cities consists of data source layer, open data integration and storage layer, open data portal layer and open data application layer.

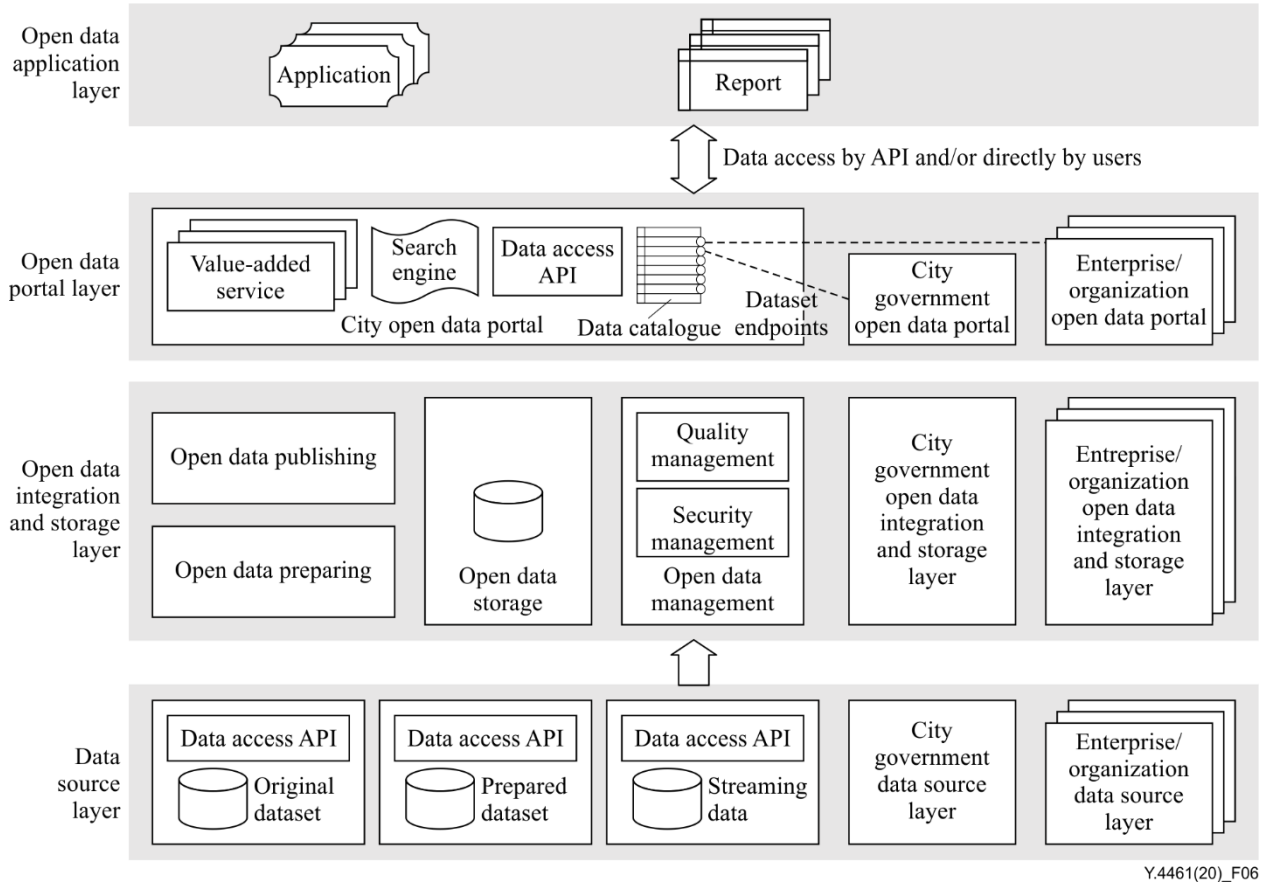

Figure 6 – Framework of open data in smart cities

10.1 Data source layer

The data source layer includes original dataset, prepared dataset and streaming data, if applicable.

Original dataset refers to the data that needs to be prepared as an open dataset before publishing. It needs to be uploaded to the open data integration and storage layer for the preparation, which includes open data modelling, open data generating, open data loading and endpoint generating as described in clause 8.1.

Prepared dataset refers to the data that is ready for publishing, which means the data has been generated according to the open data model. The prepared dataset can be stored either on the local side or at the open data integration and storage layer according to the specific scenarios. The endpoint is generated according to the location of the storage.

The uploading of the data source, including the original dataset and prepared dataset, can be periodical and/or event triggered. It is supported to push the data source to the open data integration and storage layer, and/or pull the data as requested.

The original dataset and prepared dataset can be uploaded through methods such as data access API and manually.

Streaming data can also be used as open data, which makes it possible for users to acquire the real time or near real time streaming data publicly. The streaming data provider supports to generate the endpoint and sending the endpoint information to the open data integration and storage layer (including public open data infrastructure for smart city and/or independent open data infrastructure). It is also supported to upload the streaming data to the open data integration and storage layer through data access API upon receiving the request.

10.2 Open data integration and storage layer

The open data integration and storage layer includes open data preparing, open data publishing, open data storage and open data management.

The open data integration and storage layer is responsible for open data preparing for the uploaded original dataset, which includes open data modelling, open data generating, open data loading and endpoint generating as described in clause 8.1. It is supported to transfer the original dataset to the open dataset in real time.

For streaming data, it is responsible for the endpoint storage, caching and distributing of the streaming data to users when receiving the request, if supported. It is also supported to provide a media player to users, which helps them to play the streaming data.

The functions of open data publishing include dataset publishing, mapping and linking, and classification as described in clause 8.2. This function applies to all kinds of open data source, after they are prepared for publishing.

Open data storage includes temporary storage/cache and permanent storage. It is supported to store the data on the open data infrastructure side (including public open data infrastructure for smart city and/or independent open data infrastructure) temporarily or permanently according to specific requirements.

Open data management includes quality management and security management. Quality management is responsible for ensuring the quality of the open data both before and after publishing. The functions of quality management include checking the integrity of open data, updating the data timely as requested, ensuring the traceability of open data, etc. It is also responsible for the control of the quality of service (QoS) of streaming data, if applicable.

The functions of security management include authorization of the data provider, protecting the confidentiality of sensitive information by means of technology such as anonymization and verification of the open data.

NOTE – If the value-added service from the third party is available on the open data portal, the related functions need to be supported on the open data integration and storage layer such as service provider management, service management and service publishing.

10.3 Open data portal layer

The open data portal layer makes open data and its related service discoverable and available to the public. It offers functions such as data catalogue, search engine and value-added services, if applicable. Users can browse, search and download the open data and/or value-added services as they require. Users can acquire the open data and/or value-added services either through data access API or by themselves.

Users can download the open dataset through its endpoint. The dataset endpoints offered by the open data portal (including the public city open data portal and independent open data portal) point to the dataset either from the local open data infrastructure or other open data infrastructure, which ensures the interoperability of open data. If the dataset endpoint points to other open data infrastructure, it can link to either the specific dataset as required or the portal of its related open data infrastructure.

Value-added services include both the value-added services such as statistics and visualization information of open data, and the services from third parties such as applications based on open data, analysis reports, etc.

10.4 Open data application layer

Open data can be accessed either through a data access API or directly by users. After acquiring the open data, users can analyse and develop the data to create open data services for smart cities such as analysis reports and applications. Open data services can be uploaded to the open data portal and available to the public, thus enhancing the value and promoting the utilization of open data.

11 General requirements of open data in smart cities

The following are the requirements of open data in smart cities.

11.1 Common requirements of open data in smart cities

1) It is recommended to access open data in smart cities without mandatory registration, which enables users to use open data without being required to identify themselves.

NOTE 1 – A registration mechanism can also be supported to provide functions such as recording the information of the visited data, which helps to understand users' interests and preferences.

2) It is required to access open data in smart cities without restriction of time and location. The data is required to be conveniently accessed through Internet instead of only accessed in some limited locations such as libraries or government offices. The data is also required to be available any time.

3) It is recommended to support that open data in smart cities be reused, republished and redistributed by users.

4) It is recommended to support providing open data in smart cities and its related information through a web portal, so that it will be convenient for people to access.

5) It is recommended to support providing open data in smart cities and its related information through API(s), so that it will be convenient for information systems to process it.

6) It is recommended to support access of historical data and real-time data.

7) It is recommended to support browsing of open data in smart cities by theme and/or metadata types.

8) It is required to support search functions of open data in smart cities by key words. It is recommended to support search functions based on natural language description.

9) It is recommended to support data visualization functions to help users have a better understanding of the data.

10) It is recommended to provide visualization tools to users, which helps developers to create new applications and enables users to analyse the data and find the insights and tendency of the data with their specific requirements.

11) It is recommended to support applications for open data in smart cities on the web portal, which enables users to browse, search and use the applications they need.

12) It is recommended to support a feedback mechanism for users of open data in smart cities. The content of feedback may include the requirement for new content of open data, the improvement of existing data, etc.

13) It is recommended to support linking different kinds of data of open data in smart cities, so that the related data can easily be found.

NOTE 2 – Open data could be linked by methods such as using identifiers, labels, etc.

14) Open data in smart cities is required to be machine-readable, so that it can be retrieved, understood and processed by information systems.

15) It is recommended to provide open data in smart cities in different types of date, including structured data (e.g., CSV, XML, etc) and media data (e.g., images, audio, video, etc).

16) It is recommended to support a catalogue functions that enables open data in smart cities to be classified and better displayed.

17) It is recommended to support that catalogue information be accessed through an API and/or a web portal.

18) It is recommended to support statistics and analysis functions related to the visiting behaviour of open data in smart cities, such as the hot topics of open data in smart cities.

19) It is recommended to support developers to upload the applications for open data in smart cities or the links of applications for open data in smart cities to the web portal.

20) It is required to assure the accuracy of open data in smart cities, such as identification and exclusion of the abnormal data after data cleaning, or retaining the abnormal data with an explanation.

21) It is required to publish and update open data in smart cities to keep the data up to date.

22) It is recommended to provide open data in smart cities as comprehensive as possible. Explanation is needed if related data is missing.

23) It is recommended to provide original data as much as possible, which enables users to process the data under their own considerations.

24) It is recommended to support modified data with description of what changes have been made.

25) It is required to indicate the information of open data in smart cities, such as the name of the provider and the time of publication, which enables the traceability of the data.

26) It is recommended to provide metadata of open data in smart cities including datasets and streaming data. The description of metadata is recommended to be available in human- and machine-readable formats.

27) It is recommended to support the interoperability of open data in smart cities from different infrastructures.

11.2 Security and privacy of open data in smart cities

1) It is required to verify the identity and authority of data providers before publishing their provided or uploaded open data in smart cities.
2) It is required to verify the data as open data in smart cities before publishing.
3) It is required to protect data confidentiality of sensitive information when publishing open data in smart cities.

Appendix I

Use cases of open data in smart cities

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

I.1 Creating business innovations in weather-related industry by means of open data

Open data can be used to create economic benefits and business innovations. Open weather-related data, for example, could be cited as a typical use case which both brings huge profits to related private sectors and improves weather-related industry, such as the agriculture industry, by providing more accurate climate forecasts and more timely warnings of adverse weather.

With the help of opening weather-related data, innovative business can be created, such as providing customizable weather insurance services. By means of analysing huge amounts of weather-related open data, it is able to predict weather patterns more precisely, for instance, showing how much rain falls on a given farmer's field in a day. Service providers can offer services such as weather monitoring, agronomic modelling, and high-resolution weather simulations, which helps farmers improve profitability by making better informed operating and financing decisions.

Open data in smart cities helps to create a win-win proposition for both the service provider and the businesses it insured. Since the weather patterns can be predicted more accurately, farmers can make better preparation when facing climate change and increase their crop yields. Meanwhile, cities can make their public data available for businesses or community developers to re-use it in providing services and sophisticated solutions.

I.2 Creating new business opportunities for small business by means of open data

Open data in smart cities promotes economic growth by creating new business opportunities. For instance, open data in smart cities can be used to drive small business growth by helping small businesses explore business conditions in the neighbourhood and help them make business decisions like where to open a new business or what type of shop makes sense in a particular area.

New insights to small businesses can be provided from a diversity of sources of open data, which could be not only from government, but also from enterprise. The content of the open data includes, but not limited to, business-filing data, sales tax data, demographic data and traffic data.

The conditions in the neighbourhood can be displayed by catalogues, such as citywide map layers, population and demographics, and business conditions. Map layers display data for the entire neighbourhood tabulation area. Population and demographic data is based on the closest census tract. Business conditions data include all businesses in the neighbourhood tabulation area. The open data of population and demographic could include total population, average household size, median household income, population distribution by age, the percentage of households that have children, etc. The open data of business conditions could include taxable sales revenue, land use, etc.

Besides, this use case shows the possibility of open data from just releasing data to the public to providing a solution to a targeted, user-centred requirement. Although much of the open data has already been available to the public, it was often in fragmentary form and lack of sophisticated analytics and visualization. Therefore, it is difficult for users to transfer these data into real value and help them make decisions. The impact of open data can be amplified when providing analytics tools and results to the public with specific requirements.

I.3 Empowering citizens by means of open data

Open data in smart cities can empower citizens by letting them make better decisions and thus improve their qualities of lives.

For instance, in some cities, health care is delivered through a mixed public-private framework, with private insurers and hospitals working alongside a public health care infrastructure, and citizens have the option to change their health service providers in an open enrolment period.

An open data portal can be provided to the users, which offers both the searchable open dataset and visualized infographics based on open data, allowing them to select their location and view the satisfaction score of local health care providers from the aspect of formalities, availability of medicines, rights information, complaints, etc. The detail information of health care providers can also be get from the portal, such as structure information, care goals, prices, rights and user satisfaction, etc. The open data can help citizens make better decisions when choosing their health care providers, help health providers improve the quality and responsiveness of service, and help the public health system improve the efficiency, transparency and accountability.

Besides, the open data portal can also be used to give citizens the ability to report on hospital incidents and provides them with essential information for filing formal complaints, which improves the awareness and engagement of citizens.

I.4 Handling natural and humanitarian disasters by means of open data

Open data plays a very important role in handling natural and humanitarian disasters, such as earthquake, flood and epidemic diseases. Open data can be used to improve public emergency response by providing data-driven assessment of the problems.

For instance, in order to confront epidemic disease such as Ebola crisis, open data and visualized data based on open data can be shown to illustrate the situation and related information of Ebola. Users can get the information such as cases number, deaths number of different areas, data for Ebola recovery, funding coverage of the Ebola virus outbreak emergency, financial tracking of private sector contributions, Ebola community care centre, etc.

By means of open data, it can give both policymakers and citizens a better understanding of conditions on the crises, and thus contribution to planning recovery efforts.

I.5 Handling public service requests from citizens by means of open data

Open data can be used to improve the handling of public service requests from citizens such as broken streetlights, graffiti removal, pothole in street, etc.

With the help of open data, it enables governments to handle these public service issues more cost-effectively, efficiently and collaboratively. Today, an email or phone-call report of public issues will typically be received by a public servant and then dispatched manually to relative department to consider and action. Now, with the improvement of ICT infrastructure, this report could be sent directly from a citizen and routed automatically into the electronic to-do list for the relative local government team. Moreover, the difference from a traditional report is that this information is available for anyone to see and it allows anyone to contribute more information. By enabling collaboration on these issues, it is easier to collect and organize more information about important problems.

Public services can offer citizens with more open channels and diversified ways to provide their messages as open data. For instance, with the help of open APIs, it enables citizens to send requests, messages and problem reports to local governments through mobile devices or computers. Citizens can not only send text messages, but also upload a photo about the problem at a given location.

Besides, it can also provide issue-tracking function. This enables citizens informed of the whole procedure and improves the participation, because it improves the transparency and let citizens know that their voices are being heard. By specifying the required service request id, service code, or other conditions like start date and end date, the relative requests and their status can be indicated.

This use case shows an example that individuals can not only acquire open data from smart cities, but also provide data to smart cities. It encourages citizens to better engage with their city and get connected to their community, and it also improves transparency and accountability for those responsible for civic issues.

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