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Information technology — Smart City ICT reference framework —

Part 2: Smart city knowledge management framework

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*.

A list of all parts in the ISO/IEC 30145 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

0.1 General

The purpose of this document is to assist city chief information officers (CIO) and other stakeholders in planning and implementing a smart city. It comprises the following three parts:

— Part 1: Smart city business process framework

— Part 2 (this document): Smart city knowledge management framework

— Part 3: Smart city engineering framework

Each of the three parts is aimed at a different role or viewpoint within the city and thus separate focus needs to be maintained. The "separation of concerns" is a principle for the development of a city as it uses ICT to deliver the vision and objectives for the city. The value of using the separation of concerns is to simplify development and maintenance of the architecture as the city both develops and delivers improved outcomes for the city stakeholders.

Figure 1 shows the components of the smart city ICT reference framework, which consist of 5 components: stakeholders, vision and outcomes, the business process framework, the knowledge management framework, and the engineering framework. This document describes the knowledge management framework. The business process framework is described in ISO/IEC 30145-1:—[1)] and stakeholders, vision and outcomes, and the engineering framework are described in ISO/IEC 30145-3 respectively.

1) Under preparation. Stage at the time of publication: ISO/IEC DIS 30145-1:2020.

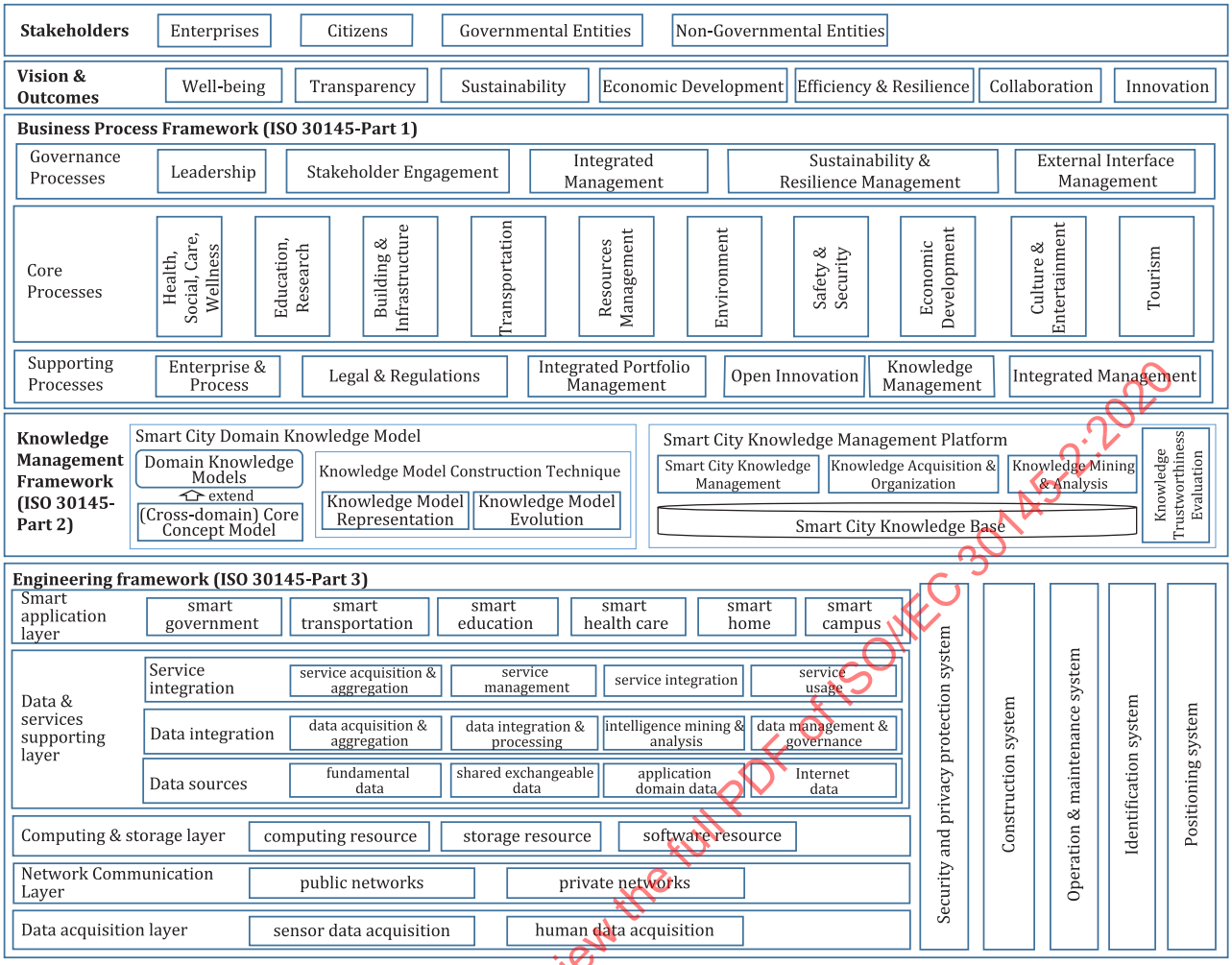

Figure 1 — Smart city ICT reference framework

0.2 Stakeholders

The stakeholders served by the smart city ICT reference framework are businesses, citizens, government organizations and non-government organizations. This stakeholder list is not exhaustive but defines the key stakeholders in a smart city and the user for the smart city ICT reference framework.

0.3 Vision and outcomes

The motivation for making a city smart is a result of a shared vision and a set of agreed outcomes from all of the city stakeholders. The vision and outcomes of the smart city ICT reference framework are well-being, transparency, sustainability, economic development, efficiency and resilience, collaboration and innovation. This vision and outcomes list is not exhaustive but defines the key vision and outcomes of a smart city. The smart city ICT reference framework articulates a vision that the smart city will be transparent in the delivery of city services which meet city sustainability ambitions. This vision uses collaboration and innovation approaches to deliver desired city outcomes. City outcomes are expected to improve efficiency and resilience of city services and promote economic development activities which enhance the well-being of citizens.

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Part 2:
Smart city knowledge management framework

1 Scope

This document specifies a generic knowledge management framework for a smart city, focusing on creating, capturing, sharing, using and managing smart city knowledge. It also gives the key practices which are required to be implemented to safeguard the use of knowledge, such as interoperability of heterogeneous data and governance of multi-sources services within a smart city.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
data
reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing

Note 1 to entry: Data can be processed by humans or by automatic means.

[SOURCE: ISO/IEC 2382:2015, 2121272, modified — Notes 2 and 3 to entry deleted.]

3.2
information
data (3.1) that are processed, organized and correlated to produce meaning

Note 1 to entry: Information concerns facts, concepts, objects, events, ideas, processes, etc.

3.3
knowledge
collection of facts, events, beliefs, and rules, organized for systematic use

[SOURCE: ISO/IEC 2382:2015, 2123771, modified — Notes 1 and 2 to entry deleted.]

3.4
ontology
formal representation of phenomena of a universe of discourse with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their relationships

[SOURCE: ISO 19101-1:2014, 4.1.26]

3.5
management
coordinated activities to direct and control an organization

Note 1 to entry: Management can include establishing policies and objectives, and processes to meet these objectives.

3.6
smart city
city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses *data* (3.1) *information* (3.2) and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment

Note 1 to entry: A smart city also faces the challenge of respecting planetary boundaries and taking into account the limitations these boundaries impose.

Note 2 to entry: There are numerous definitions of a smart city; however, the definition that is used within TC 268 is the official one agreed to by the ISO/IEC Technical Management Board.

[SOURCE: ISO 37122:2019, 3.4]

3.7
knowledge management
combination of processes, actions, methodologies and solutions that enable the creation, maintenance, distribution and access to *knowledge* (3.3)

[SOURCE: ISO 30400:2016, 14.1, modified — deleted 'organizational'.]

3.8
information and communication technology
ICT
technology for gathering, storing, retrieving, processing, analysing and transmitting *information* (3.2)

[SOURCE: ISO/IEC 9241-20:2008, 3.4, modified — replaced '/' by 'and' in the term.]

3.9
trustworthiness
ability to meet stakeholders' expectations in a verifiable way

Note 1 to entry: Depending on the context or sector, and also on the specific product or service, *data* (3.1) and technology used, different characteristics apply and require verification to ensure stakeholders' expectations are met.

Note 2 to entry: Characteristics of trustworthiness include, for instance, reliability, availability, resilience, security, privacy, safety, accountability, transparency, integrity, authenticity, quality, usability and accuracy.

Note 3 to entry: Trustworthiness is an attribute that can be applied to services, products, technology, *data* (3.1) and *information* (3.2) as well as, in the context of governance, to organizations.

3.10
city model
set of *data* (3.1) which models those physical and social aspects of the city that are relevant for its objectives

Note 1 to entry: Preference should be given to city models that conform to open standards.

4 Background

The sharing of data and services for the benefit of all stakeholders is a fundamental requirement of smart city applications and operations. A smart city consists of organizations from all sectors (public and private) and the work these organizations do should rely on the sharing of interoperable data and common knowledge of the city. Smart city data and services are shared based on a common description of their semantic meaning. Smart city knowledge provides the basis for understanding multi-source data and the support for data interoperation.

Smart city knowledge is created, captured, shared, used and managed by an infrastructure for knowledge management. This document specifies the framework of knowledge management to provide guidance on how to build such infrastructure.

5 Aims of the knowledge management framework

The knowledge management framework aims to give an instruction on how to build infrastructure for knowledge management, define activities related to knowledge management and give an instruction on how to apply the knowledge in the smart city.

The framework provides a way in which the city can extract, manage and apply knowledge to operate city services for the benefit of the citizen. It also provides the basis for understanding and utilizing heterogeneous data and services in the smart city.

6 Overview of the smart city knowledge management framework

The framework gives a conceptual vision of the activities of knowledge management in the smart city and the usage of the framework is to improve decision-making processes and enhance the added-value of the business processes of the smart city.

The framework comprises a core concept model and its domain-specific extensions (such as knowledge models for citizen livelihood, knowledge models for smart transportation, etc.), the techniques of constructing domain knowledge models, the knowledge base, the acquisition and organization of knowledge, the mining and analysis of knowledge, and knowledge trustworthiness evaluations.

Figure 2 illustrates the framework of smart city knowledge management. As shown in Figure 2, from an ICT point of view, there are two layers in the knowledge management framework for smart cities: one is the smart city domain knowledge model and the other is the smart city knowledge management platform, which will be the basis on which a city implements the ICT technical solution. The smart city domain knowledge model layer provides the foundations, and supports knowledge acquiring, mining, use and evaluation. The smart city knowledge management platform layer collects feedback throughout the phases of knowledge practices and returns them to the smart city domain knowledge model layer to help it to evolve and meet the development of the smart city.

Annex A shows use cases for a smart city knowledge management framework.

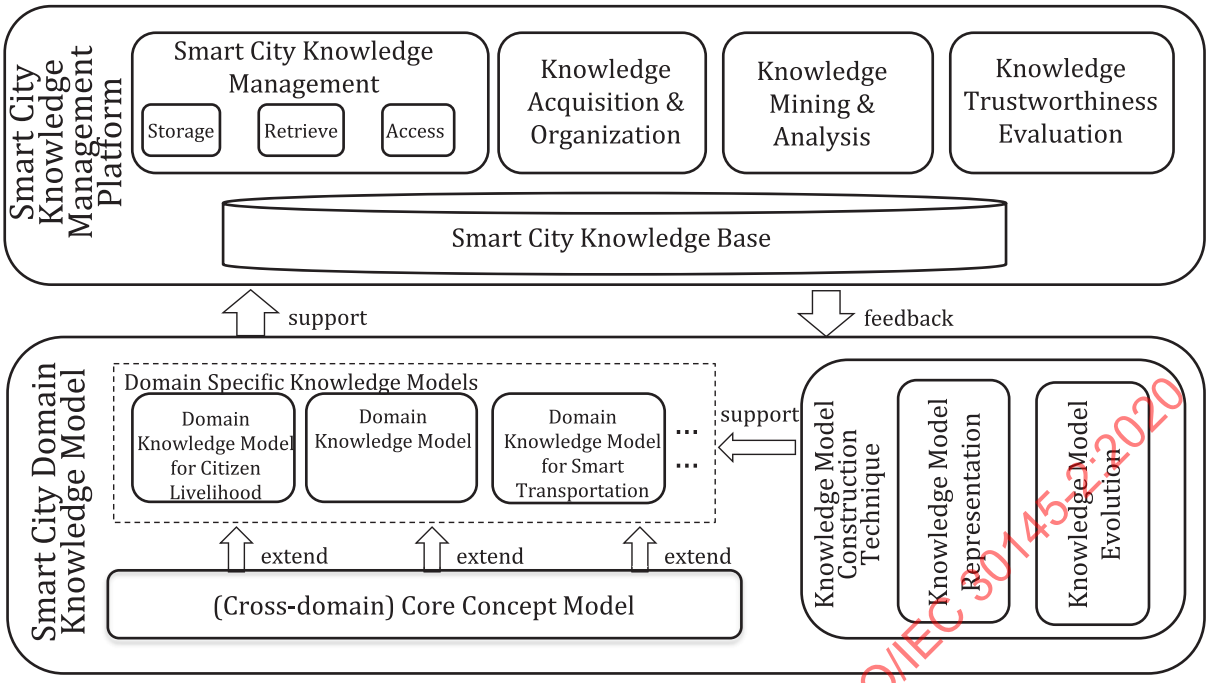

Figure 2 — The framework of smart city knowledge management

7 ICT implementation components in the knowledge management framework

7.1 Smart city domain knowledge model

7.1.1 Smart city related models

In the smart city domain knowledge model layer, there are two parts: the smart city (cross-domain) core concept model (CCM) and its extensions in different areas. The CCM is an abstract representation of common concepts, attributes, and relationships in different business areas in a smart city. It provides a common framework for describing the concepts and the relationships in the domain knowledge model needed to provide data or services for citizens in the city. The CCM should also provide extension mechanisms which can be used to construct domain-specific knowledge models. Furthermore, the CCM provides the basis for communication and interoperability among various domain knowledge models which represent different domains and different cities.

The domain-specific knowledge models extend the core concept model by complementing specific knowledge in various domains. The domain-specific knowledge models can use the concepts defined in the smart city core concept model and focus on a specific domain, such as transportation, healthcare, citizen livelihood, etc. Each city can build its own smart city knowledge base using the domain knowledge models through their own customizations.

7.1.2 Knowledge model construction technique

The common techniques for constructing the domain knowledge model (including the core concept model and domain-specific knowledge models) include techniques of knowledge model representation and knowledge model evolution. Knowledge model representation can adopt various knowledge representation technologies, such as ontology-based techniques (semantic web, knowledge graph etc.), to support the formalized description and representation of a shared concept model of relevant knowledge in the smart city. The knowledge model evolution aims to build a continually evolving specification and a unified knowledge management process of evolution. It will also provide the continually evolving mechanisms of quality evaluation and assurance to guarantee the usability and effectiveness of the domain knowledge model. Furthermore, when there are new data or new knowledge

models that need to be merged, the ontology alignment or matching algorithms can use metadata and the concepts and relationships defined in the core concept model to carry on semantic matching. Thus, it can help either the core concept model or domain knowledge models to be evolved automatically. The smart city knowledge management platform will collect the feedback from the qualitative (e.g. from human comments) and quantitative (e.g. from the machine measurement) sources and send it to the model layer to help the domain knowledge model to evolve.

7.2 Smart city knowledge management platform

7.2.1 The platform of smart city knowledge management

This component of the knowledge management framework is the ICT implementation layer for better understanding and utilizing heterogeneous data and services in a smart city. It defines the smart city knowledge base and uses industry standard techniques for the management of the city knowledge, techniques for knowledge acquisition and organization, techniques related to knowledge mining and analysis, and techniques for knowledge trustworthiness evaluation. The knowledge management platform shall meet the requirements of an information management system, e.g. security (ISO/IEC 27001) of privacy (ISO/IEC 27701).

7.2.2 Smart city knowledge base and its interface

The knowledge base is designed for storing various domain knowledge models and their knowledge instances and for providing support for knowledge sharing. For example, one knowledge instance should be a City Model (sometimes called the 'common operating picture' or 'virtual city'). A City Model is a set of data which represents those physical and social aspects of the city that are relevant for the city's objectives. It could be a fully three-dimensional model of the physical city or simple lists of identified features. ISO 19101-1 and related standards provide a framework for such models; there are a number of open standard models built on that family of ISO standards, such as OGC CityGML and the European Commission's INSPIRE theme specifications. ISO/IEC 30146 establishes indicators for their availability and use.

The knowledge base is the fundamental infrastructure in knowledge management in the smart city. It not only supports the developer in utilizing and reusing the knowledge of the smart city to develop applications, but also in collecting feedback to improve the knowledge models and knowledge instances.

The smart city knowledge management interface provides the unified and standardized interface for storing, retrieving and displaying the knowledge base of the smart city and supports the development of applications of the smart city.

7.2.3 Smart city knowledge acquisition and organization

Knowledge acquisition and organization is the process of extracting, structuring and arranging knowledge from the city. It includes the activities that involve classifying, mapping, indexing and categorizing knowledge for navigation, storage and retrieval. The technique adopts collaborative crowd-sourcing related techniques to acquire and supply different types of knowledge for the smart city and supports for the development and improvement of the smart city knowledge base. It will utilize the cross-domain core concept model to define and arrange the boundary of domain knowledge to support the distinction between domain knowledge and cross-domain knowledge.

7.2.4 Smart city knowledge mining and analysis

Knowledge mining and analysis is the process of extraction of useful, often previously unknown knowledge from large databases or data sets. The process includes inspecting, cleansing, transforming and modelling data with the goal of discovering knowledge. The technique utilizes all kinds of data in the smart city to extract and concise knowledge and enriches knowledge in the smart city knowledge base. In addition to this, it is the process to use representation techniques, ontology engineering and a reasoning system to solve complex tasks. The technique is used to define the forward and backward

reasoning rules for knowledge inference and supports the construction and development of various applications for the smart city.

7.2.5 Smart city knowledge trustworthiness evaluation

There are many application scenarios in smart cities, such as urban planning management, a citizens' livelihood service, and economic development decision-making, that have significant differences in the demand for knowledge trustworthiness. There are two trustworthiness viewpoints in a smart city knowledge management system:

— Trustworthiness of the knowledge (i.e. is it accurate?). This is managed by the knowledge trustworthiness evaluation component of the framework.

— Trustworthiness of the knowledge management system (i.e. is it secure? Does it meet privacy requirements? etc.). This is managed by requirements regarding the knowledge management system and their enforcement. These requirements can be the outcome from smart city engineering framework processes.

The evaluation of knowledge trustworthiness includes the definition of the knowledge trustworthiness attribute model, the acquisition and storage of trustworthiness evidence, the measure of trustworthiness and the knowledge retrieval technology for different trustworthiness requirements. Knowledge trustworthiness evaluation technology can effectively support the construction of smart city applications with different trustworthiness needs in different domains.

