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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 for data middle platform in Internet of things and smart sustainable cities

Recommendation ITU-T Y.4481

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Recommendation ITU-T Y.4481

Framework for data middle platform in Internet of things and smart sustainable cities

Summary

Recommendation ITU-T Y.4481 addresses a type of middle platform called the data middle platform (DM), which is expected to provide innovative digital data services to deliver data value. It allows the separation of the fundamental technical support capabilities from business-related services. The main purpose of a DM is to aggregate and manage cross-domain data into services.

For Internet of things (IoT) and smart sustainable cities (SSC), a DM aims at providing common data services that can be reused in diverse application domains by governments, enterprises, organizations and individuals.

History

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Data middle platform, digital transformation, Internet of things, IoT, smart sustainable cities

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1 Scope

A data middle platform (DM) is expected to provide innovative digital data services to deliver data value. For Internet of things (IoT) and smart sustainable cities (SSC), a DM aims at providing common data services that can be reused in diverse application domains by governments, enterprises, organizations and individuals.

This Recommendation introduces the concept of DM in IoT and SSCs, identifies high-level requirements of DM in IoT and SSCs and provides a related capability framework.

The scope of this Recommendation includes:

– The concept of DM in IoT and SSCs,

– Requirements for DM in IoT and SSCs,

– A capability framework for DM in IoT and SSCs.

Use cases of DM in IoT and SSCs are provided in appendix I.

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 X.1750] Recommendation ITU-T X.1750 (2020), *Guidelines on security of big data as a service for big data service providers*.

[ITU-T Y.4563] Recommendation ITU-T Y.4563 (2021), *Requirements and functional model to support data interoperability in Internet of things environments*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 city platform [b-ITU-T Y.4201]: A computer system or integration of computer systems that uses information and communication technologies (ICTs) to access data sources and process them to offer urban operation and services to the city.

NOTE – The concept is extended to a community.

3.1.2 common data model [ITU-T Y.4563]: A data model that allows the transformation of data into a single common data format from different formats that are collected from heterogeneous sources. For transformation into a common format or data model, common terminologies, vocabularies, schemes need to be followed.

3.1.3 data asset [ITU-T X.1750]: An electronically recorded data resource, owned or controlled by an organization.

3.1.4 interoperability [b-ITU-T Y.101]: The ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged.

3.1.5 metadata [b-ITU-T Y.3519]: Data about data or data elements, possibly including their data descriptions, and data about data ownership, access paths, access rights and data volatility.

3.1.6 open interface [b-ITU-T Y.4201]: A public standard for connecting hardware to hardware and software to software. Open interfaces are designed and documented for safe and easy use by third party developers and freely available to all.

3.1.7 platform [b-ITU-T X.1149]: A hardware or software system that serves as a foundation or base for realizing a certain functionality.

3.1.8 smart city platform (SCP) [b-ITU-T Y.4201]: A city platform that offers direct integration of city platforms and systems, or through open interfaces between city platforms and third parties, in order to offer the urban operation and services supporting the functioning of city services, as well as efficiency, performance, security and scalability.

3.1.9 smart sustainable city (SSC) [b-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 cultural aspects.

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

3.1.10 stability [b-ISO 23952]: The ability of a gage to arrive at the same measurements against a master value over time.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

DAG Directed Acyclic Graph

DM Data Middle platform

ELT Extract-Load-Transform

ETL Extract-Transform-Load

ICT Information and Communication Technology

IoT Internet of Things

KV Key-Value

SCP Smart City Platform

SDI Stream Data Integration

SSC Smart Sustainable City

UI User Interface

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 Introduction of data middle platform

Organizations and cities have begun adopting digital platforms to streamline both internal and customer-facing processes. These platforms are a powerful foundation for digital transformation because they bring together advanced technologies, including IoT, big data, artificial intelligence and others.

Among these platforms, front platforms provide applications and/or systems connected with end users, for example, websites, mobile and client applications or systems, while back platforms provide supporting functional blocks or systems, such as digital infrastructure utilization, network connection, computing resources scheduling, and data collection and storage, that do not directly interact with end users.

In order to meet the continuous changing requirements of business and end users with a quick response, an increased number of services need to be provided by the front platforms, while the back platforms need to improve resource management efficiency regarding the utilization of infrastructure, network, computing and storage. However, the rapid modifications of back platforms may introduce not only a high level of costs, but also risks. On the other hand, continuing the development of similar functions for different applications make the front platforms complicated, bloated and redundant. In addition, this leads to a slow reaction of user response, degradation of user satisfaction and decline of market competitiveness.

Middle platforms, situated between front platforms and back platforms, can help to resolve the conflict between innovation-driven rapid change of front platforms and reliable-driven stable lifecycle management of back platforms. A middle platform separates the fundamental technical supporting capabilities of a back platform from services and interactions of a front platform, acting as the bridge between the front platform and the back platform, as shown in Figure 1.

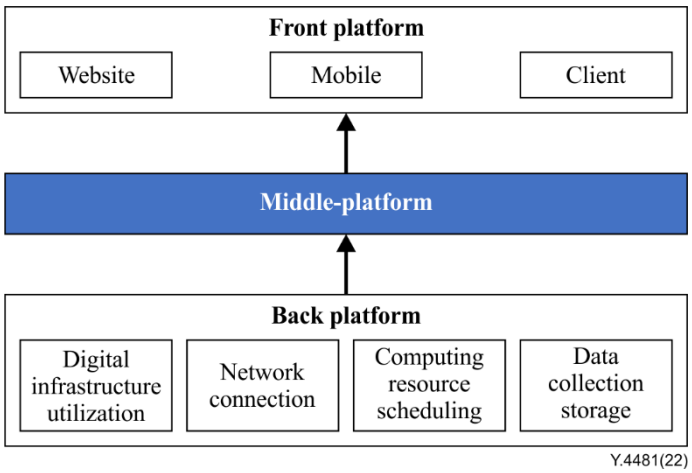

Figure 1 – Concept of middle platform

This Recommendation addresses a type of middle platform called a data middle platform (DM). This platform is specialized in delivering common data services and common data operation tools, which can be used in diverse application domains of IoT and SSCs.

7 Requirements for data middle platform in IoT and SSCs

Data is now a critical asset for organizations and cities. Massive data is generated by IoT systems, such as mobile Internet, web, billions of phones, sensors, payment systems, cameras and other sources. Making the best use of data will fuel rapid technology advances and digital transformation. However, most of the information and communication technology (ICT) developments up to now have resulted in distinct vertical systems for data processing, and this causes digital silo problems:

– Duplication of ICT system developments to support data collection from various data sources. This leads to an explosive data volume, repeated system maintenance and a high operational cost.

– Independent deployment with complicated and non-unified data collaboration strategies and data processing requirements, lack of standard data formats or schemas. These lead to a low level of data interoperability and process efficiency.

– Non-reusable data services with inflexible interaction and unclear data management rules. These lead to a low level of cooperation and lagging reaction to business innovation and requirements.

As illustrated in Figure 2, instead of building a separate system for each application from data collection to data service, a DM collects data from multiple sources with an integrated data collection component, stores all collected data in a shared data storage environment, processes data with common and reusable data processing components, and offers common and reusable data services to diverse applications through unified open interfaces.

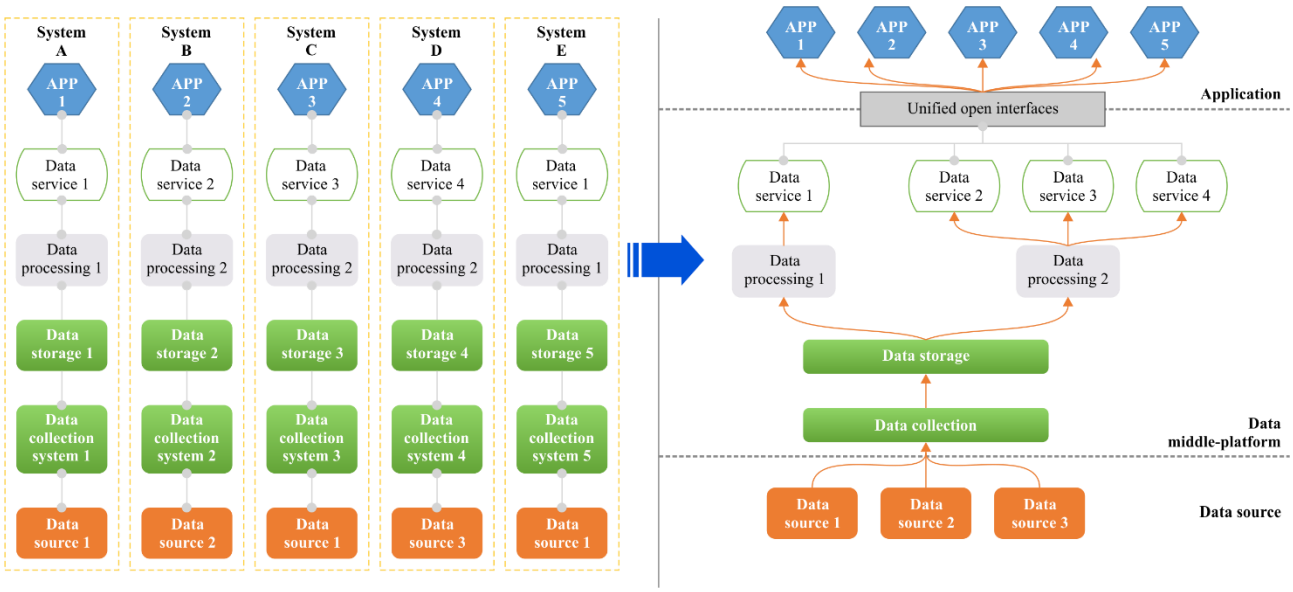

Figure 2 – Integration of vertical systems with data middle platform

In this way, a DM enables organizations and cities to break down information silos, to derive common data models [ITU-T Y.4563] and to provide unified data lifecycle management and data governance [b-FG-DPM TS D1.1]. A DM increases data processing efficiency, explores data value, promotes data openness and sharing, and delivers high quality data services. By putting a special emphasis on the reuse of common capabilities and coordination of system control, a DM also supports business development and innovation by promoting data collaboration across various systems of application domains (e.g., health, transportation, energy, education, tourism) in IoT and SSCs.

From a technical perspective, the requirements for DM can be classified in terms of data collection, data storage, data processing, data asset management, data service management, data operation, data intelligence, data governance, data access, data security and privacy, and system management and maintenance.

7.1 Data collection requirements

In order to support safe, fast and secure data collection according to data quality requirements, data collection by a DM is required to:

a) provide a data directory for data collection;

b) provide a user interface (UI) to collect data requests according to the data directory;

c) provide optional methods for the collection of data, such as APIs, files and etc.

7.2 Data storage requirements

In order to support data storage from diverse data sources, the data storage of a DM is required to:

a) support data aggregation and data storage;

b) support data storage for structured data, semi-structured data and non-structured data;

c) enable high reliability of the storage system;

d) support customized data backup strategies and different storage options for hot data, warm data and cold data.

7.3 Data processing requirements

In order to support diverse applications, data processing of a DM is required to:

a) provide data processing visualization via componentized toolbox or other methods;

b) support batch computing for high-volume, repetitive data processing tasks;

c) support streaming computing to enable the continuous analysis of massive volumes of streaming data in real time.

7.4 Data asset management requirements

In order to enable data value creation by improving efficiency, supporting decision-making, improving quality and reducing risks, the data asset management of a DM is required to:

a) support a real-time, distributed, dynamically expandable data asset catalogue service, such as local editing, remote approval and shared publishing;

b) support data asset configuration via tag and data catalogue management;

c) provide data access authentication, data operation supporting tools, data circulation and evaluation.

7.5 Data intelligence requirements

In order to explore data value based on data insights and knowledge, the data intelligence of a DM is required to provide various analytical tools and methods.

7.6 Data governance requirements

In order to provide efficient, trustworthy and traceable data management, the data governance of a DM is required to:

a) provide management of metadata, data coding and data identification in order to ensure data quality, availability, usability, consistency, integrity and security throughout the data lifecycle;

b) provide data quality management via checking the consistency of data with common data models.

7.7 Data service management requirements

In order to provide common data services which can be reused by the data consumer without additional processing, the data service management of a DM is required to provide service integration e.g., based on user requirements, business logic and usage frequency.

7.8 Data operation requirements

In order to improve coordination efficiency of system control, the data operation of a DM is required to:

a) provide offline and real-time tools and methods for data service redevelopment and commoditization;

b) provide a data sandbox service which provides a non-operational environment for testing and simulation.

7.9 Data service access requirements

In order to support a unique collection of business blocks and data sets that can be reused by organizations or cities and enhance collaboration among different users, the data service access of a DM is required to enable data service access to users with unified and open interfaces and interactions, such as open data portals and open APIs.

7.10 Data security and privacy protection requirements

In order to provide data security and privacy control for data throughout the whole data lifecycle from data collection to data destruction, data security and privacy protection, a DM is required to ensure

security and privacy protection in different operating environments, including the cloud computing environment [ITU-T X.1750].

7.11 System management and maintenance requirements

In order to ensure the availability, reliability, scalability and stability of the DM, system management and maintenance of DM are required to support data and system resource management, and control for multitenant and multicluster environments.

8 Capability framework for data middle platform in IoT and SSCs

Figure 3 shows the capability framework for a DM in IoT and SSCs supporting the requirements identified in clause 7.

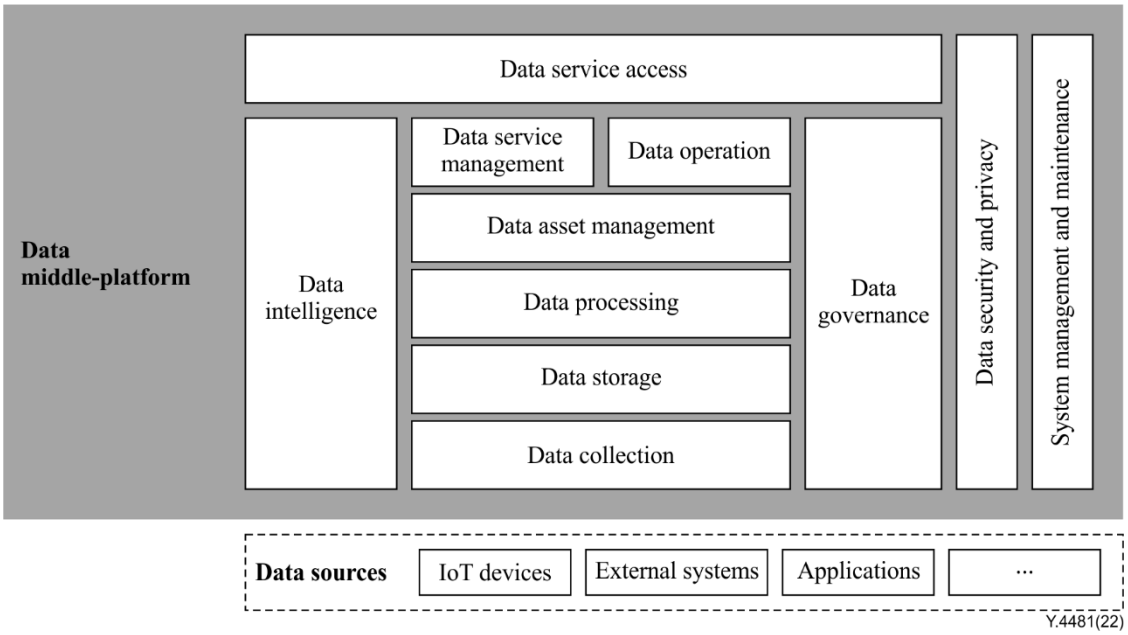

Figure 3 – Capability framework for data middle platform

Data collection is a set of capabilities to enable data collection from multiple data sources, including IoT devices, external systems and applications.

Data storage is a set of capabilities to support aggregation and storage for data collected from various sources.

Data processing is a set of capabilities to enable the transformation of raw data to data assets and provide valuable information.

Data asset management is a set of capabilities to enable the management of data as an asset, which create value by increasing efficiency, supporting decision-making, improving quality, allowing innovation and reducing risks.

Data intelligence is a set of capabilities which provide analytical tools and methods to drill down data insights and knowledge.

Data governance is a set of capabilities to ensure data quality, availability, usability, consistency, integrity and security.

Data service management is a set of capabilities to enable the delivery of data as a service to data consumers.

Data operation is a set of capabilities to improve coordination efficiency and to provide offline and real-time tools and methods in order to enable data redevelopment and commoditization.

Data service access is a set of capabilities to enable data service access with unified open interfaces and interactions.

Data security and privacy is a set of capabilities to ensure security and privacy protection for data throughout the whole data lifecycle.

System management and maintenance is a set of capabilities to ensure the functional operation of the DM itself.

8.1 Data collection capability

In support of the requirements identified in clause 7.1, data collection capability provides:

a) support for data collection with different data formats, such as data sets, logs, files;

b) support for data collection access control with different security strategies;

c) support for data format setting before collection.

8.2 Data storage capability

In support of the requirements identified in clause 7.2, data storage capability provides:

a) support for local storage, cloud storage and hybrid mix storage.

NOTE 1 – Cloud storage includes private cloud storage, public cloud storage and hybrid cloud storage;

b) support for object-oriented data query language for structured data storage;

c) support for data storage in tables, rows and columns for semi-structured data;

d) support for distributed data storage, such as supporting distributed file system, distributed object-based key-value (KV) storage, non- relational database storage;

e) support for synchronization between relational (e.g., structured query language (SQL)) database and non-relational (e.g., NoSQL) databases in order to handle various data resource types and data processing requirements.

NOTE 2 – As an example, when receiving a write data request, the analysis of the received request to obtain data needs to be stored and synchronized in relational and non-relational databases, then the response to the write data request is provided based on the analysis results;

f) support for scalable storage, such as support for dynamic data volume expansion from gigabyte (GB) to petabyte (PB), and support for non-blocking dynamic data volume expansion.

8.3 Data processing capability

In support of the requirements identified in clause 7.3, data processing capability provides:

a) support for data integration, such as extract-transform-load (ETL), extract-load-transform (ELT), data replication, and stream data integration (SDI);

b) support for data preparation in real time or at regular intervals according to customized requirements;

c) support for data conversion by translating various data formats, data enrichment by merging relevant data from multiple sources, data aggregation by providing data dashboards, and data cleaning by fixing inaccurate values;

d) support for data packing and compression with a predefined data format before the data is transmitted, and only the packed and compressed data is transmitted;

NOTE – The predefined data format includes a special field, creation time field, subpackage field and number of subpackage field. Each subpackage field should include a property field and frame field. The frame field should include a frame length field, frame compression field and frame payload field.

e) support for various computing engines and methods;

f) support for distributed memory computing framework and complex data mining algorithms and graph calculation algorithms for batch computing;

g) support for state and stateless calculations for limited data streams and unlimited data streams;

h) support for stream computing for streaming data, such as access, analysis, and visual task scheduling;

i) support for various cluster-based deployments and fast data calculation;

j) support for fast deployment for multiple real-time processing tasks.

8.4 Data asset management capability

In support of the requirements identified in clause 7.4, data asset management capability provides:

a) support for data asset classification, data theme management, catalogue registration and metadata management;

b) support for data asset catalogue publishing, catalogue query and catalogue subscription;

c) support for data asset query with detailed content based on asset tags, such as asset type, label and table;

d) support for data asset management via asset status information, such as attribute information and attribute tags of target data asset;

e) support for data asset management and assessment by setting performance indicators;

NOTE – A classification strategy is required to be identified for each data management indicator. Each data management indicator can be mapped with data asset status information to classify the corresponding data asset. A data asset management strategy can be identified by using decision model based on the asset classification result.

f) support for data blood relationship management with the obtained metadata of corresponding data asset;

g) support for data asset overview and mapping for visualization.

8.5 Data intelligence capability

In support of the requirements identified in clause 7.5, data intelligence capability provides:

a) support for defined functions to execute specific data mining and analysis algorithms;

b) support for mining and traceability analysis for key data based on the data dictionary and relationship of the database table;

c) support for the in-depth mining and analysis of data by loading machine learning and deep learning algorithms;

d) support for multidimensional analysis, including but not limited to:

   i) real-time retrieval analysis with an interactive exploration engine;

   ii) high-speed search and query with inverted search for different data fields; and

   iii) drill-down analysis for single table with billions of data with dimension combination;

e) support for federal analysis, including but not limited to:

   i) automatic data caching and copying, intelligent cache update;

   ii) cross-source data query via remote application programming interfaces.

8.6 Data governance capability

In support of the requirements identified in clause 7.6, data governance capability provides:

a) support for data quality management;

b) support for common data model management.

8.7 Data service management capability

In support of the requirements identified in clause 7.7, data service management capability provides:

a) support for service integration to meet various business and service requirements;

b) support for cloud hosting for data services;

c) support for the data service engine, including service registration, service publication, service authentication, service discovery;

d) support for the analysis of received read data request to obtain query conditions, then response to the read data request based on the queried data;

e) support for various query conditions, such as high-frequency access conditions and complex access conditions.

NOTE 1 – High-frequency access conditions refer to query conditions matched with predefined routeing fields. Complex access conditions refer to query conditions which contain more routeing fields compared with predefined routeing fields.

NOTE 2 – To improve query efficiency, as data has been stored in both relational or non-relational databases, it is required to search in a non-relational database if the high-frequency access conditions are met, and search in a relational database if the complex access conditions are met.

8.8 Data operation capability

In support of the requirements identified in clause 7.8, data operation capability provides:

a) support for the collection of metadata sets, including technical metadata and business metadata.

NOTE 1 – Technical metadata indicate technical data which is generated and used during business-related processing. Business metadata indicate context descriptive information which is generated and used during business-related processing;

b) support for perform business data analysis based on importance categories of metadata sets;

c) support for tracking and assessment for data usage during business-related processing;

d) support for data use requirement management, the analysis results of which can further guide data collection, data governance and data integration of DM;

e) support for extraction of metadata features to form metadata feature sets according to data business value, which indicate the states of business management operation via technical metadata and business metadata;

NOTE 2 – Technical metadata features extracted from technical metadata should include the technical statistical indicators corresponding to business scale and business visits; business metadata features extracted from business metadata should include the descriptive statistic indicators corresponding to business attributes and business process definitions.

NOTE 3 –The metadata feature set is obtained from technical metadata features and business metadata features by using at least one feature processing method, including feature normalization, feature transformation, and feature selection;

f) support for metadata categorization based on the relevance of the assessment results of the metadata feature sets by using training results from tagged feature sets.

8.9 Data service access capability

In support of the requirements identified in clause 7.9, data service access capability provides:

a) support for user customized content and subscription management;

b) support for unified and open data service access interfaces, such as website interfaces, mobile application interfaces, microservice interfaces and APIs.

8.10 Data security and privacy capability

In support of the requirements identified in clause 7.10, data security and privacy capability provides:

a) support for data auditing for data access records;

b) support for data anonymization and data encryption for personal information and other sensitive data.

8.11 System management and maintenance capability

In support of the requirements identified in clause 7.11, system management and maintenance capability provides:

a) fault tolerance management control and design to ensure fast recovery;

b) system monitoring and alarm management and control, including but not limited to unified system monitoring, service state monitoring, task alarm, failure recovery and job directed acyclic graph (DAG) visualization;

c) task configuration and job scheduling capability;

d) multitenant and multicluster management and control, including but not limited to:

   i) unified identity authentication and access control;

   ii) storage resource allocation and computing resource isolation;

   iii) task scheduling and load balancing, cross-cluster batch migration;

   iv) unified data security and access control.

Appendix I

Use cases of data middle platform in IoT and SSCs

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

I.1 Data middle platform for online multimedia and entertainment service

Online multimedia and entertainment services provide streaming video and digital content to the public via the Internet. Users access such services via official websites and mobile APPs. Such a service has a wider range of end users with different preferences and habits. These bring more challenges in terms of concurrent access performance, personalized information recommendations and data security issues. The data processing technologies to support such services require extremely high capacity, availability, reliability and scalability.

First, the multimedia DM should be able to collect data with a diverse data format, including application account data, interactive data, live broadcast data, media asset data, video station editing data, hot topic data on the Internet, and future social data, and so on. In addition, it needs to process hundreds of billions of data collection log records per day. The real-time calculation engine of the platform needs to process levels greater than 1 TB of APP reports every day, including report quality, user events and abnormal data. It also needs to process approximately GB levels of interactive data, video media metadata and other related data. The offline computing engine and storage need the potential to undertake a PB level of data processing and storage, and the archive media library should be able to store a PB level of publicly available digital content.

At the same time, the multimedia DM provides diverse data services, such as data analysis and exploration for user operations, data services for video search, intelligent recommendation services, hotspot services for integrated operating platforms, performance analysis for video editing, and central data statistics service of video number.

I.2 Data middle platform for financial institutions

A financial institution usually has multiple business systems, such as a saving account system, loan systems and credit card systems. The financial institutions usually build data warehouse systems to store and analyse data collected from their businesses. However, traditional data warehouses generally have problems such as low efficiency, poor data timeliness, low level of data quality assurance, non-standard data models and single data service forms. Thus, it is difficult to rapidly adapt to changing business needs.

The DM can solve the above problems to a large extent. The purpose of building a DM is to store, manage and use the data assets owned by financial institutions. Its value is mainly reflected in the more efficient use of data to assist customer marketing, risk control, operational efficiency improvement and internal management aspects.

1) Through a unified data collection platform, the DM can aggregate structured, semi-structured and unstructured data for storage. This solves the problem that traditional data warehouses can only store structured data. At the same time, through real-time data collection and analysis, the timeliness of data is improved.
2) Through a unified data development platform, the development methods of different types of codes and scripts can be unified in a single environment, which solves the problem of the multitool and multiplatform switching required in the data development process and affecting development efficiency.
3) Data services are delivered through a unified portal in the form of files or APIs, thus improving the response efficiency of data services for quick business development support.

As an example, based on the information collected by the DM from various data sources, the platform supports a financial institution to build its own unified and comprehensive internal indicator system, such as credit indicators, risk assessment indicators, etc. In addition, the DM can also support multiple businesses of the financial institution, such as load approval and credit issuance. In this way, there is no need to repeatedly build different indicator systems for each specific business.

I.3 Data middle platform for the manufacturing industry

The manufacturing industry is the pioneer industry to achieve automation and thus has gained significant experience in digital transformation. During the digitalization of the manufacturing industry, the usage of big data technology met the following challenges.

1) Industrial production processes generate large amounts of data every second that can be collected, processed and analysed.
2) The development of technologies such as sensors and the Internet of things (IoT) has further expanded the scope and format of data. In addition to traditional structured data, there are also files, audio and video, and so on.
3) The data in the manufacturing industry has the characteristics of multimodality, including offline, online and even real-time streaming data with delay sensitive requirements.
4) The data quality requirements for data processing need to be aligned with different production systems, and the right data needs to be selected and modelled with domain knowledge so that real-time and effective data analysis and decision making can be supported.

DM for manufacturing industry supports various forms of data access and collection connection among various production lines, equipment and systems. At the same time, fast and backlog-free writing for real-time data is supported. In addition, various types of collected and aggregated data from heterogeneous systems and heterogeneous devices need to be processed, stored, managed and reorganized according to a systematic and unified approach with clear data processing and management specifications with ready to use domain experience and insight models. Moreover, to better improve manufacturing production efficiency and reduce production risks (e.g., device failure or product defective rate), a DM supports the visualization of production and operation with analysed data, real-time alarm and report.

With a DM, the manufacturing enterprise is also able to achieve data collection and analysis of the whole production process with transparency and accuracy. Through real-time analysis of the power consumption, energy consumption and other data of various equipment sensors in the production line, equipment operation and maintenance analysis and fault prediction can be realized, thereby reducing downtime, improving equipment operation and maintenance efficiency, reducing maintenance costs and contributing to carbon emission reductions.

Bibliography

[b-ITU-T X.1149] Recommendation ITU-T X.1149 (2020), *Security framework of an open platform for FinTech services*.

[b-ITU-T Y.101] Recommendation ITU-T Y.101 (2000), *Global Information Infrastructure terminology: Terms and definitions.*

[b-ITU-T Y.3519] Recommendation ITU-T Y.3519 (2018), *Cloud computing – Functional architecture of big data as a service.*

[b-ITU-T Y.4201] Recommendation ITU-T Y.4201 (2017), *High-level requirements and reference framework of smart city platforms*.

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

[b-FG-DPM TS D1.1] ITU-T Technical Specification D1.1 (2019), *Use case analysis and requirements for Data Processing and Management to support IoT and Smart Cities and Communities*.

[b-ISO 23952] ISO 23952:2020, *Automation systems and integration – Quality information framework (QIF) – An integrated model for manufacturing quality information*.

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