

Supplement

ITU-T Y Suppl. 40 (11/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Supplements to the Y-series Recommendations

ITU-T Y.3600-series – Big data and data handling standardization roadmap



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Supplement 40 to ITU-T Y-series Recommendations

ITU-T Y.3600-series – Big data and data handling standardization roadmap

Summary

Supplement 40 to ITU-T Y-3600 series Recommendations provides the standardization roadmap for big data and data handling in the telecommunication sector. It describes the landscape and conceptual ecosystem of big data and data handling from an ITU-T perspective, related technical areas, activities in standards development organizations (SDOs) and gap analysis.

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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.

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

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Supplement 40 to ITU-T Y-series Recommendations

ITU-T Y.3600-series – Big data and data handling standardization roadmap

1 Scope

Data is of high value to building applications and services based on future computing. This Supplement provides the standardization roadmap for data in the telecommunication sector including not only big data but also data usage, processing, analysing, exchanging, sharing and data quality assessment in terms of data handling. It addresses the following subjects:

- landscape of data handling from an ITU-T perspective;
- conceptual model of big data ecosystems;
- related technical areas of big data and data handling;
- data activities in standards development organizations (SDOs);
- standardization gap analysis.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following term defined elsewhere:

3.1.1 big data [b-ITU-T Y.3600]: A paradigm for enabling the collection, storage, management, analysis and visualization, potentially under real-time constraints, of extensive datasets with heterogeneous characteristics.

NOTE – Examples of datasets characteristics include high-volume, high-velocity, high-variety, etc.

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AI	Artificial Intelligence
AMQP	Advanced Message Queuing Protocol
API	Application Programming Interface
AWI	Approved Work Item
BDC	Big Data service Customer
bDDN	big Data-Driven Networking
BDSP	Big Data Service Provider
CSV	Comma-Separated Values
DCAT	Data Catalog Vocabulary
DLT	Distributed Ledger Technology

DMG	Data Mining Group
DP	Data Provider
DPI	Deep Packet Inspection
DPM	Data Processing and Management
DPVCG	Data Privacy Vocabularies and controls CG
DSA	Data Sharing Agreement
ERCIM	the European Research Consortium for Informatics and Mathematics
GDPR	General Data Protection Regulation
ICT	Information and Communications Technology
IEC	International Engineering Consortium
IoT	Internet of Things
ISO	International Organization for Standardization
JSON	Java Script Object Notation
JSON-LD	JSON for Linked Data
JTC 1	Joint Technical Committee 1
LDP	Linked Data Platform
M2M	Machine to Machine
ML	Machine Learning
MQTT	Message Queuing Telemetry Transport
OASIS	Organization for the Advancement of Structured Information Standards
ODRL	Open Digital Rights Language
OGC	Open Geospatial Consortium
OWL	Web Ontology Language
PFA	Portable Format for Analytics
PII	Personally Identifiable Information
PMML	Predictive Model Markup Language
RDF	Resource Description Framework
RIF	Rule Interchange Format
SC	Subcommittee
SC&C	Smart Cities and Communities
SDO	Standards Development Organization
SG	Study Group
SHACL	Shapes Constraint Language
SMB	Standard Management Board
SPARQL	SPARQL Protocol and RDF Query Language
TC	Technical Committee
TMB	Technical Management Board

TR	Technical Report
W3C	World Wide Web Consortium
WG	Working Group
XMILE	XML Interchange Language
XML	Extensible Markup Language

5 Conventions

None.

6 Landscape of big data and data handling from an ITU-T perspective

The future relies on the wise use of data. With information and communications technologies (ICTs) everywhere, data are generated everywhere. The enormous accumulation of data has created a resource of immense productive value. In the knowledge-driven economy, data will drive innovation across all industrial sectors and public sector institutions. In this manner, the standardization of big data and data handling, such as ecosystems, data lifecycles, data security and management, and ICT applications supported by data will help make data more valuable in the following areas:

- Data powers artificial intelligence and machine learning, enabling them to come to life;
- Data analytics adds more automation, precision and dynamics to network management and control;
- The data generated by smart cities inform the improvement of public services and promote environmental sustainability;
- Advances in multimedia depend on advances in data compression and analysis;
- Cloud computing systems capture event data from systems such as aircraft, automobiles and other connected machines to identify the cause of performance anomalies associated with those systems;
- In addition, implementing security measures to protect data is crucial for building trust in ICT.

7 Technical areas of big data and data handling

7.1 Big data

[b-ITU-T Y.3600] describes the characteristics and general concepts of the big data ecosystem. Within big data ecosystem, data types include structured, semi-structured and unstructured data. Structured data are often stored in databases which may be organized in different models, such as relational model, document model, key-value model, graph model, etc. Semi-structured data does not conform to the formal structure of data models but contain tags or markers to identify data. Unstructured data do not have a pre-defined data model and are not organized in any defined manner. Within all data types, data can exist in formats, such as text, spreadsheet, video, audio, image, map, etc. [b-ITU-T Y.3600].

Big data is used in many fields, where data processing is characterized by scale (volume), diversity (variety), speed (velocity) and possibly others like credibility (veracity) or business value, if traditional methods and tools are not efficient. These characteristics, usually called v's, can be explained as following [b-ITU-T Y.3600]:

- **Volume:** refers to the amount of data collected, stored, analysed and visualized, which big data technologies need to resolve;

- **Variety:** refers to different data types and data formats that are processed by big data technologies;
- **Velocity:** refers to both how fast the data is collected and how fast the data is processed by big data technologies to deliver expected results.

NOTE 1 – Additionally, veracity refers to the uncertainty of data, and value refers to the business results from gaining new information using big data technologies. Other v's can be considered as well.

NOTE 2 – There is also an additional characteristic for big data, and it is that the data is 'behavioural', meaning that it is passively generated by natural/normal behaviour [b-GSMA].

Taking into account the described above v's characteristics, big data technologies and services can resolve many new challenges, and can also create more new opportunities than ever before [b-ITU-T Y.3600]:

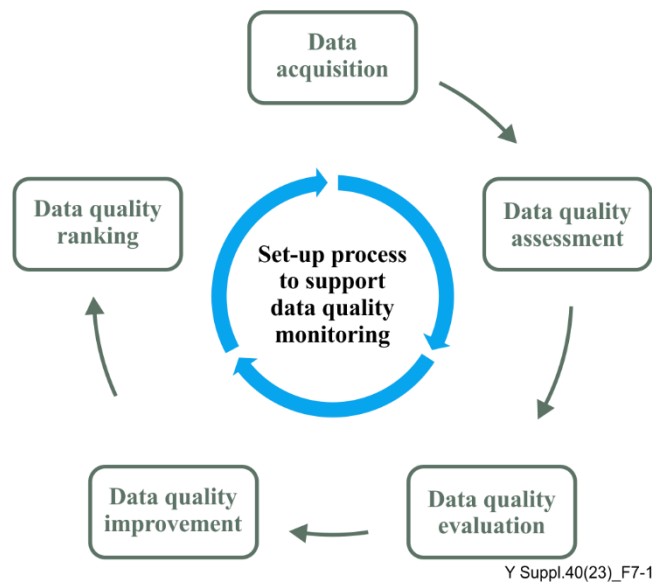
- **Heterogeneity and incompleteness:** data processed using big data can miss some attributes or introduce noise into data transmission. Even after data cleaning and error correction, some incompleteness and some errors in data are likely to remain. These challenges can be managed during data analysis [b-CRA].
- **Scale:** processing of large and rapidly increasing volumes of data is a challenging task. Using data processing technologies, the data scale challenge is mitigated by evolution of processing and storage resources. However, nowadays data volumes are scaling faster than resources are evolving. Technologies such as parallel databases, in-memory databases, non-SQL databases and analytical algorithms resolve this challenge.
- **Timeliness:** the acquisition rate and timeliness, to effectively find elements in a limited-time period that meet a specified criterion in a large dataset, are new challenges faced by data processing. Other new challenges are related to the types of criteria specified, and need to devise new index structures and responses to the queries having tight response-time limits.
- **Privacy:** data about human individuals, such as: demographic information, Internet activities, commutation patterns, social interactions, energy or water consumption, are being collected and analysed for different purposes. Big data technologies and services are challenged to protect personal identities and sensitive attributes of data throughout the entire data processing process, while respecting applicable data retention policies.

Positive resolution of the above challenges opens new opportunities to discover new data relationships, hidden patterns or unknown dependencies [b-ITU-T Y.3600].

7.2 Data quality and management

Data quality is a measure of whether data meet their requirements. In a data-driven environment led by big data and artificial intelligence, the quality of data has a profound impact on the quality of analysis results or applications. Accordingly, there is an increasing demand for standardization of procedures and methods for effectively managing data quality in an organization, along with criteria for identifying and evaluating data elements based on their intended usage.

Figure 7-1 gives an overview of data quality management.



7.3 Machine learning

Machine learning (ML) is a significant trend in the industry. There is a broad agreement about the remarkable potential of ML to lead innovation, boost commerce and drive progress among leaders in the industry, academia and governments. IMT-2020 networks, featured by diverse services, e.g., mobile Internet, Internet of things, cloud computing and other types of communication, will lead to the growth of data traffic and to the need of handling large amounts of data in the network [b-ITU-T Y.3174].

7.4 Cloud computing

Cloud computing is a paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand. Key characteristics of cloud computing are [b-ITU-T Y.3500]:

- **Broad network access:** a feature where physical and virtual resources are available over a network and accessed through standard mechanisms that promote use by heterogeneous client platforms;
- **Measured service:** a feature where the metered delivery of cloud services is such that usage can be monitored, controlled, reported, and billed. This is an important feature needed to optimize and validate the delivered cloud service;
- **Multi-tenancy:** a feature where physical or virtual resources are allocated in such a way that multiple tenants and their computations and data are isolated from, and inaccessible to, one another;
- **On-demand self-service:** a feature where a cloud service customer can provision computing capabilities, as needed, automatically or with minimal interaction with the cloud service provider;
- **Rapid elasticity and scalability:** a feature where physical or virtual resources can be rapidly and elastically adjusted, in some cases automatically, to quickly increase or decrease resources;
- **Resource pooling:** a feature where a cloud service provider's physical or virtual resource can be aggregated in order to serve one or more cloud service customers.

Big data needs on-demand high-performance data processing and distributed storage as well as a variety of tools required to accomplish activities of the big data ecosystem. The burst nature of

workloads makes cloud computing more appropriate for big data challenges such as scalability and timeliness [b-ITU-T Y.3600].

The relationship of cloud computing and big data mainly concerns two aspects:

- Cloud computing can support big data using cloud infrastructure and services;
- Big data services can provide public cloud analysis services, such as big data as a service (BDaaS).

7.5 Internet of things

The Internet of things (IoT) is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies [b-ITU-T Y.2060].

The IoT can be perceived as a far-reaching vision with technological and societal implications. From the perspective of technical standardization, the IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable ICT. Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of "things" to offer services to all kinds of applications, while ensuring that security and privacy requirements are fulfilled.

Big data in the context of IoT has some specific characteristics which do not necessarily pertain to big data in other technical areas. The prominent characteristics of big data in the context of IoT are: high variety (heterogeneity of data types and sources), high velocity (high frequency of data generation) and high volatility (data generated in a non-persistent stateless manner).

Some identified challenges concerning big data in the context of IoT are the following [b-Chen]:

- An increasing number of connected things generates huge amounts of data;
- The generated data are mainly semi-structured or even unstructured;
- The generated data may have different confidence and precision levels;
- The generated data are generally not useful until they are adequately "processed" (including pre-processing, analysis, etc.).

7.6 Security and privacy

Data security and privacy comprise the people, process and technology required to prevent destructive forces and unwanted actions [b-IBM]. From a big data perspective, security and privacy requirements are magnified by the characteristics of big data. Some identified challenges concerning big data in the context of security and privacy are the following [b-CSA]:

- Secure computations in distributed programming frameworks;
- Secure data storage and transactions logs;
- End-point input validation/filtering and data provenance;
- Real-time security/compliance monitoring;
- Scalable and composable privacy-preserving data mining and analytics;
- Anonymization and de-identification.

Additional challenges related to big data and data handling are the following [b-GSMA]:

- Locking down access to data and maintaining accountability, setting clear roles and clear documentation;
- Transparency and considering ethical issues.

NOTE – The technical area of big data in clause 7.4 and clause 7.5 also helps to solve a number of security and privacy challenges by being able to integrate vast quantities of heterogeneous log data (from firewalls, hosts, routers, etc.) arriving at network speed and apply advanced analytics to identify threat and intrusion patterns.

7.7 Deep packet inspection

Deep packet inspection (DPI) is a form of filtering used to inspect data packets sent from one computer to another over a network. Software-based DPI provides advanced traffic analysis and multidimensional reporting, showing the possibility of making off-the-shelf hardware work at actual line rates. Software-based DPI can be pervasively deployed in the network, providing much better analysis capabilities, as well as simpler mechanisms for deployment, update, testing and scaling to changing workloads [b-ITU-T Y.2774].

7.8 Big data-driven networking

Big data-driven networking (bDDN) is a group of technologies and methods to facilitate network operation, administration, maintenance and optimization, etc., based on the big data generated by the network and a series of methods and tools. That is to say, big data generated by the network is used to serve the network and make the network better. bDDN solves this problem by introducing and applying the big data technology to the framework of future networks [b-ITU-T Y.3652].

7.9 Open data

Open data is accessible public data that people, companies, and organizations can use to launch new ventures, analyse patterns and trends, make data-driven decisions, and solve complex problems. Open data typically accompanied by a clear license, provided in machine-readable formats, fostering transparency, collaboration, and innovation through its non-restrictive use and widespread availability. Open data is more focused on a horizontal scaling of big data sources.

The main technical issues for open data are as follows:

- Data publication: metadata supporting machine readability, data format, and licenses;
- Data finding: data identification, data semantics, and data access;
- Data provenance: data quality, data lineage tracking, and data versioning.

7.10 Smart city

The accelerating population density in urban areas is increasing the pressure on the existing infrastructures to meet the needs of inhabitants. Accordingly, there is an increasing demand for connected cities with pervasive embedded devices, to improve quality of IoT and Smart Cities and Communities (SC&C) services.

While traditional urban information databases and analytics architectures and infrastructures remain essential, with the growing data management demands, specific capabilities and capacities are required to be able to handle diverse and complex data streams from different sources. This data needs to be processed and managed properly to maximize its value in a secure manner, while complementing it with other information sources.

Urban areas increasingly require defined and comprehensive data processing and management frameworks and guidelines which incorporate reasonable measures to achieve a layered, data-centric paradigm to support SC&C. [b-FG-DPM]

7.11 Edge computing

Edge computing refers the computing technology to deploy processing capability at the network edge where end terminals are connected, and to perform the processing of data which is derived from and

fed to the end terminals [b-ITU-T Y.3073]. A network edge corresponds to a physical location where data is generated or consumed.

Figure 7-2 provides a conceptual diagram of edge computing.

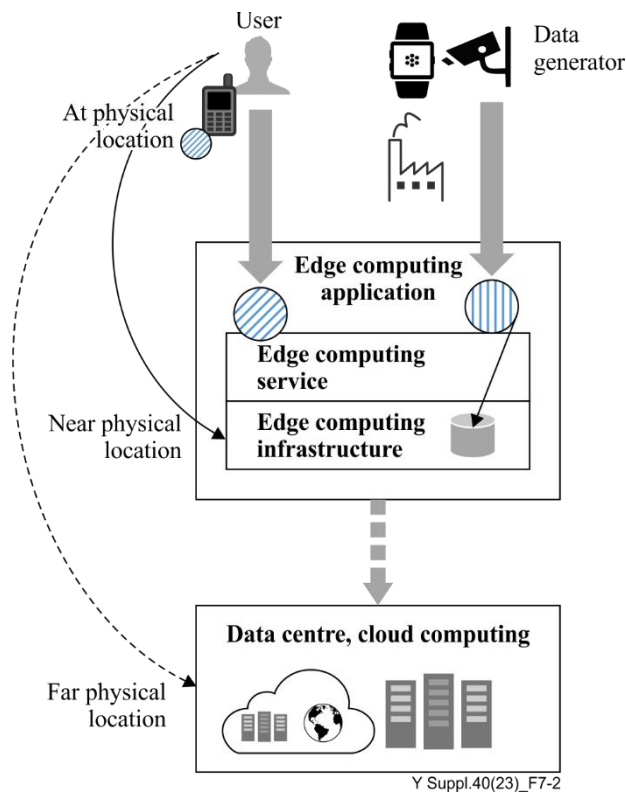


Figure 7-2 – The conceptual diagram of edge computing (from [b-ITU-T Y.3540])

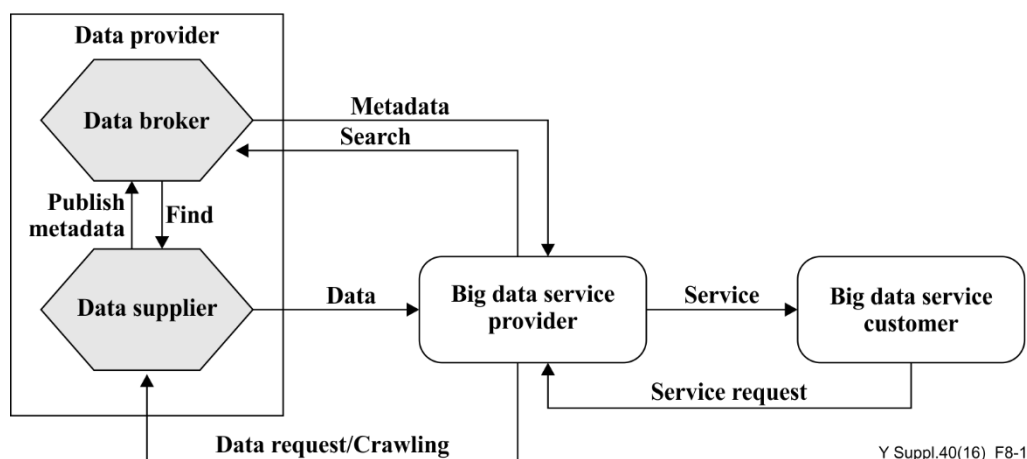
Edge computing introduces data and data management challenges encompassing diverse data type handling, quality assurance, security enforcement, latency reduction, cross-device data synchronization, constrained storage and networking resource administration, as well as regulatory adherence. The pivotal aspect lies in adeptly harmonizing the advantages of localized processing with the intricate landscape of distributed data intricacies.

7.12 Distributed ledger technology

Distributed ledger is a type of ledger that is shared, replicated and synchronized in a distributed and decentralized manner [b-ITU-T F.751.0]. Data handling within distributed ledger technology (DLT) involves intricately managing data integration, storage, and retrieval within a decentralized ledger. Ensuring data accuracy, confidentiality, and accessibility are crucial while upholding DLT's principles of immutability and decentralized governance.

8 Conceptual model of big data ecosystem

[b-ITU-T Y.3600] describes the roles and sub-roles of the big data ecosystem as shown in Figure 8-1.



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Figure 8-1 – Big data ecosystem (from [b-ITU-T Y.3600])

Data provider (DP) roles consists of two sub-roles:

- data supplier;
- data broker.

The data supplier provides data from different sources to the data broker, which can be accessed by the big data service provider (BDSP). The data supplier's activities include:

- generate data;
- create metadata information describing the data source(s) and relevant attributes;
- publish metadata information to access it.

The data broker serves as the connection between the data supplier and the BDSP. The data broker can act as a clearinghouse, open data mart, etc., and its activities include:

- providing a meta-information registry to data suppliers for publishing their data sources;
- finding on-line open-data sources and registering corresponding meta-information;
- providing a service catalogue to the BDSP for searching usable data.

The BDSP supports capabilities for big data analytics and infrastructure. The BDSP can act as a form of big data platform, extension of existing data analytics platform, etc. BDSP activities include:

- searching data sources (from data broker) and collecting data by requesting and crawling;
- storing data to a data repository;
- integrating data;
- providing tools for data analysis and visualization;
- supporting data management such as: data provenance, data privacy, data security, data retention policy, data ownership.

The big data service customer (BDC) is the end-user or a system, that uses the results or services from a BDSP. The BDC may produce new services or knowledge on consumer activities and furnish them outside of the big data ecosystem. BDC activities include:

- requesting big data services to the BDSP;
- using the outputs of big data services.

9 SDO activities

This clause describes standards development organization's (SDO's) activities with big data and data handling in order to identify the current status of standardization.

NOTE – A summary of each standard item is described in Appendix I.

9.1 ITU-T

9.1.1 SG 13

ITU-T Study Group 13 (SG13) has been studying requirements, capabilities and mechanisms of future networks.

- **Q17/13** deals with the necessary overall frameworks, definitions, and ecosystems including requirements, capabilities related to the integration or support of future computing including cloud computing and data handling in telecommunication ecosystem.
- **Q18/13** deals with the architectures, infrastructures and networking views related to the integration and support of the future computing (including cloud computing and data handling) in telecommunication ecosystems.
- **Q19/13** deals with end-to-end management, governance, and security for future computing including cloud computing and data handling from the perspective of telecommunication. The novel methods based on artificial intelligence and machine learning are essential to handle complexity of future computing management and optimally orchestrate its operation and lifecycle management.
- **Q7/13** has been studying big data driven networking (bDDN) and deep packet inspection (DPI). In terms of big data application, bDDN is one of good example meanwhile DPI has been playing an important role in collecting data from network and pre-processing the data.

Table 9-1 lists the ITU-T SG13 deliverables and work items related to big data.

Table 9-1 – ITU-T SG 13 deliverables and work items

Study group	Reference	Title	Status
SG 13	[ITU-T Y.3600]	Big data – Cloud computing based requirements and capabilities	Published 2015
SG 13	[ITU-T Y.3601]	Big data – Framework and requirements for data exchange	Published 2018
SG 13	[ITU-T Y.3602]	Big data – Functional requirements for data provenance	Published 2022
SG 13	[ITU-T Y.3603]	Big data – Requirements and conceptual model of metadata for data catalogue	Published 2023
SG 13	[ITU-T Y.3604]	Big data – Overview and requirements for data preservation	Published 2019
SG 13	[ITU-T Y.3605]	Big data – Reference architecture	Published 2020
SG 13	[ITU-T Y.3606]	Big data – deep packet inspection mechanism for network big data	Published 2021
SG 13	[ITU-T Y.3607]	Big data - Functional architecture for data provenance	Published 2023
SG 13	[ITU-T Y.bdi-reqts]	Big data – Overview and functional requirements for data integration	4Q 2024
SG 13	[ITU-T Y.cdp-reqts]	Data handling – Functional requirements of collaborative data processing in data platform	Jun. 2025

Table 9-1 – ITU-T SG 13 deliverables and work items

Study group	Reference	Title	Status
SG 13	[ITU-T Y.3650]	Framework of big data driven networking	Published 2017
SG 13	[ITU-T Y.3651]	Big data driven mobile network traffic management and planning	Published 2018
SG 13	[ITU-T Y.Sup.50]	Use cases and application scenarios of big data driven networking	Published 2018
SG 13	[ITU-T Y.3652]	Big data driven networking – Requirements	Published 2020
SG 13	[ITU-T Y.3653]	Big data driven networking – Functional architecture	Published 2021
SG 13	[ITU-T Y.3654]	Big data driven networking – Machine learning mechanism	Published 2022
SG 13	[ITU-T Y.3655]	Big data driven networking – Management and control mechanisms	Published 2022
SG 13	[ITU-T Y.bDDN-AA-RAM]	Big data driven networking – Requirements, architecture and mechanism of application awareness	Jul. 2024
SG 13	[ITU-T Y.bDDN-AM-COINO]	Big data driven networking – Architecture and mechanism for customer-oriented intelligent network operation	Mar. 2025
SG 13	[ITU-T Y.bDDN-ArchMec-KC]	Big data driven networking – Architecture and mechanism of knowledge constructing	Jul. 2025
SG 13	[ITU-T Y.bDDN-DTMec]	Big data driven networking – Data transmission mechanism	Jul. 2025
SG 13	[ITU-T Y.bDDN-NP-ReqArch]	Big data driven networking – Functional requirements and functional architecture of network programmability	Mar. 2024
SG 13	[ITU-T Y.3657]	Big data driven networking – Requirements and capabilities of network visibility	Consented (2023.11.3)
SG 13	[ITU-T Y.bDDN-RA-NPN]	Big data driven networking – Functional requirements and functional architecture of operation aspect for non-public network	Mar. 2025
SG 13	[ITU-T Y.3505]	Cloud computing – Overview and functional requirements for data storage federation	Published 2018
SG 13	[ITU-T Y.3518]	Cloud computing – Functional requirements of inter-cloud data management	Published 2018
SG 13	[ITU-T Y.3519]	Cloud computing – Functional architecture of big data as a Service	Published 2018
SG 13	[ITU-T Y.ccdm-reqts]	Cloud computing – Framework and functional requirements of cloud data mobility management	1Q. 2024
SG 13	[ITU-T Y.DSNETDN]	Data Standardization for New and Emerging Technologies in Developing Nations	Jul. 2024

Table 9-1 – ITU-T SG 13 deliverables and work items

Study group	Reference	Title	Status
SG 13	[ITU-T Y.expBDtech-frame]	Requirements and Framework for the exploitation of Big Data/Artificial Intelligence technologies in developing countries	Jul. 2024
SG 13	[ITU-T Y.3055]	Framework for Trust based Personal Data Management	Published 2020
SG 13	[ITU-T Y.fdcS]	Service model of federated data cooperation in multi-access edge computing of future networks	Jun. 2025

9.1.2 SG 17

ITU-T SG 17 is responsible for building confidence and security in the use of ICTs, and deals with the security and privacy issues of cloud computing. These activities on cloud computing can be applied to the area of big data as well. Table 9-2 lists the ITU-T SG17 deliverables and work items related to big data and data handling.

Table 9-2 – ITU-T SG 17 deliverables and work items

Study group	Reference	Title	Status
SG 17	[ITU-T X.1601]	Security framework for cloud computing	Published 2014
SG17	[ITU-T X.1603]	Data security requirements for the monitoring service of cloud computing	Published 2018
SG 17	[ITU-T X.1641]	Guidelines for cloud service customer data security	Published 2016
SG 17	[ITU-T X.1147]	Security requirements and framework for big data analytics in mobile internet services	Published 2018
SG 17	[ITU-T X.1750]	Guidelines on security of big data as a service for Big Data Service Providers	Published 2020
SG 17	[ITU-T X.1752]	Security guidelines for big data infrastructure and platform	Published 2021
SG 17	[ITU-T X.1751]	Security guidelines on big data lifecycle management for telecommunication operators	Published 2020
SG 17	[ITU-T X.1376]	Security-related misbehaviour detection mechanism using big data for connected vehicles	Published 2020
SG 17	[ITU-T X.gecds]	Guideline on edge computing data security	Mar. 2024
SG 17	[ITU-T X.guide-cdd]	Security guidelines for combining de-identified data using trusted third party	Feb. 2024
SG 17	[ITU-T X.Sup.39]	Requirements for data de-identification assurance	Published 2023
SG 17	[ITU-T X.gdsml]	Guidelines for data security using machine learning in big data infrastructure	Sep. 2024
SG 17	[ITU-T X.1410]	Security architecture of data sharing management based on the distributed ledger technology	Published 2023

Table 9-2 – ITU-T SG 17 deliverables and work items

Study group	Reference	Title	Status
SG 17	[ITU-T X.icd-schemas]	Vendor agnostic security data schemas for integrated cyber defence solutions	Mar. 2025

9.1.3 SG 20

ITU-T SG 20 is responsible for Internet of Things (IoT) and its applications, and smart cities and communities (SC&C) including Big Data aspects of IoT and SC&C, e-services and smart devices for SC&C.

- **Q1/20** addresses use cases, requirements, architectures and data sets and format to support interworking and provide interoperability between IoT and SC&C applications and services not only within but also between cities and communities.
- **Q4/20** focuses on data processing and management (DPM), data analytics and sharing including big data aspects for IoT and SC&C. This Question is developing a series of Recommendations on effective DPM, data analytics and sharing for IoT and SC&C.

Table 9-3 lists the ITU-T SG 20 deliverables and work items related to big data and data handling.

Table 9-3 – ITU-T SG 20 deliverables and work items

Study group	Reference	Title	Status
SG 20	[ITU-T Y.4114]	Specific requirements and capabilities of the Internet of Things for Big data	Published 2017
SG 20	[ITU-T Y.4461]	Framework of Open Data in Smart Cities	Published 2020
SG 20	[ITU-T Y.4484]	Framework to support web of objects ontology based semantic data interoperability of e-health services	Published 2022
SG 20	[ITU-T Y.4560]	Blockchain-based data exchange and sharing for supporting Internet of things and smart cities and communities	Published 2020
SG 20	[ITU-T Y.4561]	Blockchain-based Data Management for supporting Internet of things and smart cities and communities	Published 2020
SG 20	[ITU-T Y.4563]	Requirements and functional model to support data interoperability in IoT environments	Published 2021
SG 20	[ITU-T Y.4602]	Data processing and management framework for IoT and smart cities and communities	Published 2023
SG 20	[ITU-T Y.4603]	Requirements and functional model to support data quality management in IoT	Published 2023
SG 20	[ITU-T Y.4604]	Metadata for camera sensing information of autonomous mobile IoT devices	Published 2023
SG 20	[ITU-T Y.Suppl.62 to ITU-T Y.4000 series]	Overview of blockchain for supporting Internet of things and smart cities and communities in data processing and management aspects	Published 2020
SG 20	[ITU-T Y.Suppl.69]	Web based data model for IoT and smart city systems and services	Published 2021

Table 9-3 – ITU-T SG 20 deliverables and work items

Study group	Reference	Title	Status
SG 20	[ITU-T Y.4606]	Requirements and functional architecture of data management system for smart greenhouse service	Approved (2023.11.29)
SG 20	[ITU-T Y.4495]	Requirements and a reference model of data for smart greenhouse service	Approved (2023.11.29)
SG 20	[ITU-T Y.4498]	Framework of city-level energy data sharing and analytics among buildings	Determined (2023.9.22)
SG 20	[ITU-T Y.cii]	Requirements and reference model of IoT related data from city infrastructure	4Q 2024
SG 20	[ITU-T Y.DM-SLF]	Conceptual data model of smart livestock farming service	1Q 2024
SG 20	[ITU-T Y.CL-EDM]	Energy data model for city-level energy management platform	4Q 2024
SG 20	[ITU-T Y.DPM-alm-fra]	Functional requirements and architecture of blockchain-based activity logs management for IoT data processing and management	4Q 2024
SG 20	[ITU-T Y.nmm-isms]	Metadata model of sensing capability for disaster monitoring system	4Q 2024
SG 20	[ITU-T Y.dem-IoT]	Data exchange model for IoT devices in power transmission and transformation equipment	4Q 2025
NOTE – Clause I.1 contains a description of each cited reference.			

9.1.4 SG3

ITU-T SG 3 is responsible for tariff and accounting principles including related telecommunication economic and policy issues. It has a Question on the economic and policy aspects of big data and digital identity in international telecommunications services and networks. Table 9-4 lists the ITU-T SG3 deliverables and work items related to big data and data handling.

Table 9-4 – ITU-T SG 3 deliverables and work items

Study group	Reference	Title	Status
SG 3	[ITU-T D.princip_bigdata]	ITU-T D. policy framework and principles for data protection in the context of big data relating to international telecommunication services	2024
SG 3	[ITU-T Study_bigdata]	Technical Paper on economic and policy aspects of Big Data in international telecommunication services and networks	2024
SG 3	[ITU-T D.datatariff]	Principles for tariff regulation of Data Services	2024
NOTE – Clause I.1 contains a description of each cited reference.			

9.1.5 SG 16

ITU-T SG 16 is responsible for multimedia coding, systems and applications, including the coordination of related studies across the various ITU-T SGs. Table 9-5 lists the ITU-T SG 16 deliverables and work items related to big data and data handling.

Table 9-5 – ITU-T SG 16 deliverables and work items

Study group	Reference	Title	Status
SG 16	[ITU-T F.743.7]	Requirements for big data enhanced visual surveillance service	Published 2019
SG 16	[ITU-T F.743.20]	Assessment framework for big data infrastructure	Published 2020
SG 16	[ITU-T H.VSBD]	Architecture for Big Data Application in Visual Surveillance System	2023
SG 16	[ITU-T F.AI-RMCDP]	Requirements of multimedia composite data preprocessing	2024
SG 16	[ITU-T F.VUI-DM]	Data model for voice UI based senior health service	2024
SG16	[ITU-T F.AI-MKGDS]	Requirements for the construction of multimedia knowledge graph database structure based on artificial intelligence	2023
SG16	[ITU-T F.751.5]	Requirements for DLT-based Data Management for Power Grid	Published 2022
SG16	[ITU-T H.MDDMD-Arch]	Reference Architecture for DLT-based Multimedia Data Delivery Management System	2023
SG 16	[ITU-T F.MDAM-PR]	Procedures and requirements for multimedia data asset management	2024
SG 16	[ITU-T F.AICP-DA]	Technical specification for artificial intelligence cloud platform: Data annotation	4Q 2024
SG 16	[ITU-T F.CEC-MDG]	Requirements and framework of AI based multimedia data generation systems using core cloud and edge cloud	4Q 2025
SG 16	[ITU-T F.JSQSUDAC]	Requirements and functional architecture of joint semantic query system of unstructured data across clusters	4Q 2024
SG 16	[ITU-T F.RFDSSN]	Requirements and framework for data sharing service networks	2024
SG 16	[ITU-T H.VSDTAS-Arch]	Architecture and metadata of digital twin model assembling and interaction services for video surveillance systems	2024
SG 16	[ITU-T F.DADOCM]	Requirements for data asset development and operations capability in multimedia	2025
SG 16	[ITU-T F.FMDAV]	Framework for multimedia data asset valuation	2025
SG 16	[ITU-T H.DLT-DAS]	Technical framework for distributed ledger technology-based multimedia data asset services	2024
SG 16	[ITU-T H.DLT-DCMP]	Reference framework for DLT-based data circulation and marketplace platform	2025
SG 16	[ITU-T H.DLT-EMDGP]	General architecture for DLT-based energy metering data sharing platforms	2023
SG 16	[ITU-T H.DLT-RFCEDM]	Reference framework for carbon emission data management platforms based on distributed ledger technology	2025
SG 16	[ITU-T F.740.3]	Metadata for digital representation of cultural relics/artworks using augmented reality	Published 2023

Table 9-5 – ITU-T SG 16 deliverables and work items

Study group	Reference	Title	Status
SG 16	[ITU-T F.740.4]	Metadata for image aesthetics assessment with aesthetic attributes in mobile terminal computational photography systems	Published 2023
SG 16	[ITU-T F.740.5]	Data collection and annotation requirements for automatic white balance (AWB) enhancement in mobile terminal for digital culture	Published 2023
SG 16	[ITU-T F.CDA-RP]	Requirements and procedure for cultural data annotation	2025
SG 16	[ITU-T F.CDSS-RF]	Requirements and framework for cultural data sharing system	2025
SG 16	[ITU-T F.DC-CRATS-Meta]	Metadata for cultural relics and artworks tracing system based on blockchain	2024
SG 16	[ITU-T F.DC-MTCPS-PFM]	Processing Flow and Metadata of Mobile Terminal Computational Photography System	2024
SG 16	[ITU-T F.DEC-RM]	Requirements and metadata for digitization of ethnic costumes	2024
SG 16	[ITU-T F.MDI]	Metadata for disaster information presentation with human factors	2024
SG 16	[ITU-T H.MD-DiDRR]	Profile metadata for persons with specific needs as part of disability-inclusive disaster risk reduction	2023
SG 16	[ITU-T F.VG-DS]	Framework and requirements of the data sharing service platform for electric vehicle charging	2025
SG 16	[ITU-T H.ADSDP-spec]	Automated driving safety data protocol: Specification	Dec. 2023
SG 16	[ITU-T F.MESafFra]	Evaluation framework of safety and effectiveness of active health data collection terminal equipment	2023
SG 16	[ITU-T HSTP.MBI-UC]	Use-cases of e-health applications and services using brain data	2023
NOTE – Clause I.1 contains a description of each cited reference.			

9.1.6 SG 5

ITU-T Study Group 5 (SG5) is responsible for studies on methodologies for evaluating ICT effects on climate change and publishing guidelines for using ICTs in an eco-friendly way. Under its environmental mandate SG5 is also responsible for studying design methodologies to reduce ICTs and e-waste's adverse environmental effects, for example, through recycling of ICT facilities and equipment. Table 9-6 lists the ITU-T SG 5 deliverable and work item related to big data and data handling.

Table 9-6 – ITU-T SG 5 deliverable and work item

Study group	Reference	Title	Status
SG 5	[ITU-T L.1305]	Data centre infrastructure management system based on big data and artificial intelligence technology	Published 2019
SG 5	[ITU-T L.EE-dse]	Energy efficiency metrics and measurement methods for data storage equipment	2024

Table 9-6 – ITU-T SG 5 deliverable and work item

Study group	Reference	Title	Status
SG 5	[ITU-T L.1307]	Energy Efficiency in Micro Data Centre for Edge Computing	Consented (2023.11.22)
SG 5	[ITU-T L.Energy_sav_Cloud & Edge]	Energy saving design for Data Centre considering harmonization of Cloud and Edge	2024
SG 5	[ITU-T L.Suppl.52]	Computer processing, data management and energy perspective	Published 2022
SG 5	[ITU-T L.1306]	Specification of Edge Data Centre infrastructure	Published 2023
SG 5	[ITU-T L.MM_DC]	Energy Efficiency Metric and Measurement Methodology for Data Centers and Telecommunication Rooms	2024
SG 5	[ITU-T L.thermal_DC]	Multi-level metrics for thermal environment and thermal performance of Data Centre	2025
SG 5	[ITU-T L.GHGemissions_DC]	Methodologies for accounting Greenhouse Gas Emissions of Data Centers and Telecommunication Rooms	2024
SG 5	[ITU-T L.MM&BP_DC]	Measurement methodology and Best Practices for decarbonization of Data Center and Telecommunication Room in support of Net Zero	2024
SG 5	[ITU-T L.WHR]	Specification for waste heat reuse in telecommunication rooms and data centers	2024
NOTE – Clause I.1 contains a description of each cited reference.			

9.2 ISO/IEC JTC 1

In November 2014, the ISO/IEC joint technical committee 1 (JTC 1) established the working group (WG) 9 on big data to begin big data standardization. With the establishment of the SC 42 (Artificial Intelligence) in November 2017 (confirmed in 2018 by ISO TMB and IEC SMB), WG 9's Program of the work was transferred to SC 42 and became SC42/WG 2 with the Terms of Reference on "Standardization in the relation to data in the context of artificial intelligence, big data, and data analytics".

JTC 1 subcommittee S) 27 has been developing standards for ICT security, which include generic methods, techniques and guidelines to address aspects of both security and privacy. SC 27 security and privacy are one of the cross-cutting aspect for ICT, and their methodologies are also applicable to big data security and privacy.

JTC 1/SC 38 focuses on the area of "Cloud Computing and Distributed Platforms". JTC1/SC 38 is developing ISO/IEC 19944 which describes data and their flow across devices and cloud services. Table 9-7 lists the JTC 1 deliverables and work items related to big data and data handling.

Table 9-7 – JTC 1 deliverables and work items

Sub group	Reference (Note)	Name/Title	Status
SC 42	[ISO/IEC 20546]	Information technology – Big data – Overview and vocabulary	Published 2019
SC 42	[ISO/IEC 20547-1]	Information technology – Big data – Reference architecture – Part 1: Framework and application process	Published 2020
SC 42	[ISO/IEC 20547-2]	Information technology – Big data – Reference architecture – Part 2: Use cases and derived requirements	Published 2018
SC 42	[ISO/IEC 20547-3]	Information technology – Big data – Reference architecture – Part 3: Reference architecture	Published 2020
SC 42	[ISO/IEC 20547-5]	Information technology – Big data – Reference architecture – Part 5: Standards roadmap	Published 2018
SC 42	[ISO/IEC 24668]	Information technology – Artificial Intelligence – Process management framework for big data analytics	Published 2022
SC 42	[ISO/IEC 8183]	Information technology – Artificial Intelligence – Data life cycle framework	Published 2023
SC 42	[ISO/IEC 5259-1]	Artificial intelligence – Data quality for analytics and machine learning (ML) – Part 1: Overview, terminology and examples	DIS
SC 42	[ISO/IEC 5259-2]	Artificial intelligence – Data quality for analytics and machine learning (ML) – Part 2: Data quality measures	DIS
SC 42	[ISO/IEC 5259-3]	Artificial intelligence – Data quality for analytics and machine learning (ML) – Part 3: Data quality management requirements and guidelines	DIS
SC 42	[ISO/IEC 5259-4]	Artificial intelligence – Data quality for analytics and machine learning (ML) – Part 4: Data quality process framework	DIS
SC 42	[ISO/IEC 5259-5]	Artificial intelligence – Data quality for analytics and machine learning (ML) – Part 5: Data quality governance	DIS
SC 42	[ISO/IEC 5259-6]	Artificial intelligence – Data quality for analytics and machine learning (ML) – Part 6: Visualization framework for data quality	CD TR
SC 42	[ISO/IEC 42103]	Artificial intelligence – Overview of synthetic data in the context of AI systems	AWI
SC 27	[ISO/IEC 20547-4]	Information technology – Big data – Reference architecture – Part 4: Security and privacy	Published 2020
SC 27	[ISO/IEC 20889]	Privacy enhancing data de-identification terminology and classification of techniques	Published 2018
SC 27	[ISO/IEC 27000]	Information technology – Security techniques – Information security manage systems – Overview and vocabulary	Published 2014

Table 9-7 – JTC 1 deliverables and work items

Sub group	Reference (Note)	Name/Title	Status
SC 27	[ISO/IEC 27001]	Information technology – Security techniques – Information security manage systems – Requirements	Published 2013
SC 27	[ISO/IEC 27002]	Information technology – Security techniques – Code of practice for information security controls	Published 2013
SC 27	[ISO/IEC 27018]	Information technology – Security techniques – Code of practice for protection of personally identifiable information (PII) in public clouds acting as PII processors	Published 2019
SC 27	[ISO/IEC 27555]	Information security, cybersecurity and privacy protection – Guidelines on personally identifiable information deletion	Published 2021
SC 27	[ISO/IEC 27701]	Security techniques – Extension to ISO/IEC 27001 and ISO/IEC 27002 for privacy information management – Requirements and guidelines	Published 2019
SC 27	[ISO/IEC 29100]	Information technology – Security techniques – Privacy framework	Published 2011
SC 27	[ISO/IEC 29101]	Information technology – Security techniques – Privacy architecture framework	Published 2018
SC 27	[ISO/IEC 29134]	Information technology – Security techniques – Guidelines for privacy impact assessment	Published 2017
SC 27	[ISO/IEC 29151]	Information technology – Security techniques – Code of practice for personally identifiable information protection	Published 2017
SC 27	[ISO/IEC 29184]	Information technology – Online privacy notices and consent	Published 2020
SC 27	[ISO/IEC 29190]	Information technology – Security techniques – Privacy capability assessment model	Published 2015
SC 38	[ISO/IEC 19944-1]	Cloud computing and distributed platforms – Data flow, data categories and data use – Part 1: Fundamentals	Published 2020
SC 38	[ISO/IEC 19944-2]	Cloud computing and distributed platforms – Data flow, data categories and data use – Part 2: Guidance on application and extensibility	Published 2022
SC 38	[ISO/IEC TR 23186]	Information technology – Cloud computing – Framework of trust for processing of multi-sourced data	Published 2018
SC 38	[ISO/IEC 22624]	Information technology – Cloud computing – Taxonomy based data handling for cloud services	Published 2020
SC 38	[ISO/IEC 23751]	Information technology – Cloud computing – Data sharing agreement (DSA) framework	Published 2022
NOTE – Clause I.2 contains a description of each cited reference.			

9.3 ISO/TC 69

ISO/TC 69 is responsible for standardization in the application of statistical methods, including generation, collection (planning and design), analysis, presentation and interpretation of data

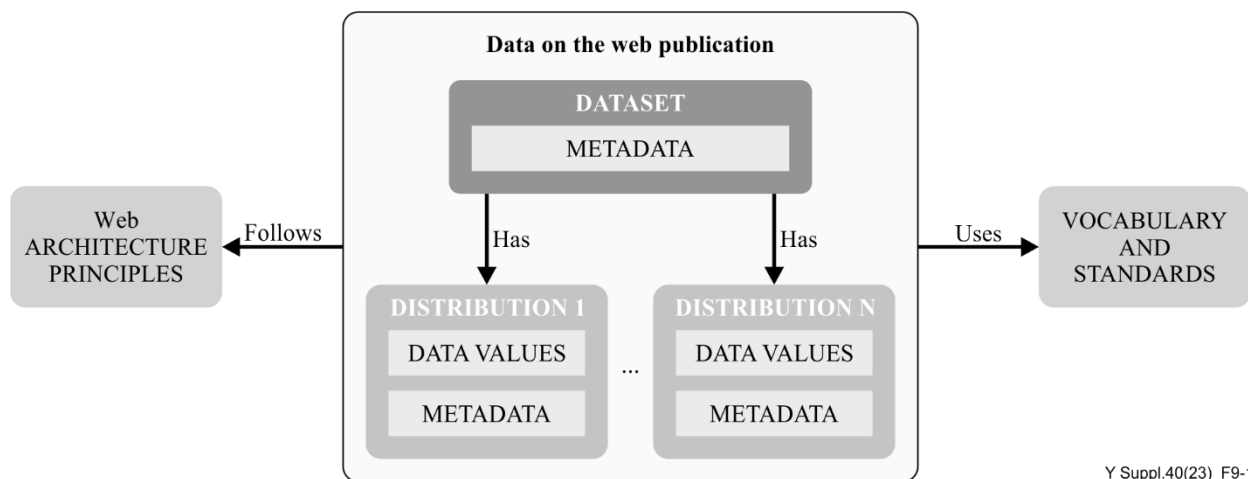
[b-TC 69]. Under the TC 69, WG 12 was initiated to cover big data analytics. Table 9-8 lists ISO/TC 69 deliverables and work items related to big data and data handling.

Table 9-8 – ISO/TC 69 deliverables and work items

Sub group	Reference (Note)	Name/Title	Status
–	[ISO 3534-5]	Statistics – Vocabulary and symbols – Part 5: Terms used in big data (predictive analytics)	AWI
WG 12	[ISO 23347]	Statistics – Big Data Analytics – Data Science Life Cycle	AWI/TR
WG 12	[ISO 23348]	Statistics – Big Data Analytics – Model Validation	AWI/TR
NOTE – Clause I.3 contains a description of each cited reference.			

9.4 W3C

W3C does not have a Big Data chartered activity, but a more general Data Activity. The mission of W3C's Data Activity is to overcome the lack of data models and common vocabularies and facilitate potentially Web-scale data integration and processing, by providing standard data exchange formats, models, tools, and guidance. This builds upon W3C's previous work on Resource Description Framework (RDF) and Linked Data, and the corresponding suite of W3C Recommendations, e.g., for RDF, Web Ontology Language (OWL), and SPARQL.



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Figure 9-1 – W3C Data activity

There is a relationship to the Web of Things, where W3C is seeking to define standards for an object model as an abstraction layer over existing IoT standards, using programming language independent descriptions of things and their relationships.

The Dataset Exchange Working Group updated Data Catalog Vocabulary (DCAT) to version 2, and JSON for Linking Data W3C Community Group updates JSON-LD to version 1.1 as a Community Group Report.

W3C recently released the results of a study on tooling and practices for web data standardization, and we gratefully acknowledge funding for the study by the Open Data Institute. The next step is further discussions on how to accelerate W3C's role as a venue for developing community standards.

The Spatial Data on the Web Interest Group, a collaboration with the Open Geospatial Consortium (OGC) has started to develop additional best practices and to evaluate technology proposals that could

improve the publication and consumption of spatial data on the Web (see on-going projects within the group)

W3C/ERCIM is participating in European projects "Boost 4.0" on big data in Industry 4.0, where we're responsible for standardization, data governance and certification. The project will field 10 lighthouse and 3 replication pilots across European manufacturers and accelerate the transition to Industry 4.0.

Data privacy vocabularies and controls CG (DPVCG) started at May 2018 to develop a taxonomy of privacy terms, which include in particular terms from the new European General Data Protection Regulation (GDPR), such as a taxonomy of personal data as well as a classification of purposes (i.e., purposes for data collection), and events of disclosures, consent, and processing such personal data [b-W3C-DPVCG].

The Permissions and Obligations Working Group recently closed after bringing to W3C Recommendation the Open Digital Rights Language (ODRL) Vocabulary & Expression and its Information Model.

Our current WG's with a connection to Big data also include: Verifiable Claims and there are plenty of existing relevant W3C Recommendations e.g., RDF core, RDF Schema, OWL, SPARQL, Turtle, JSON for Linked Data (JSON-LD), comma-separated values (CSV), Rule Interchange Format (RIF), Shapes Constraint Language (SHACL), Linked Data Platform (LDP), as well as those relating to XML, Privacy, or Web Services.

Table 9-9 lists W3C deliverables and work items related to big data and data handling.

Table 9-9 – W3C deliverables and work items

Sub group	Reference (Note)	Name/Title	Status
CSV on the Web WG	[W3C MVTB]	Metadata Vocabulary for Tabular Data	Published 2015
CSV on the Web WG	[W3C MTDM]	Model for Tabular Data and Metadata on the web	Published 2015
Government Linked Data WG	[W3C DCAT2]	Data Catalog Vocabulary (DCAT) version 2	Published 2020
Government Linked Data WG	[W3C OO]	The Organization Ontology	Published 2014
Linked Data Platform WG	[W3C LDP 1.0]	Linked Data Platform 1.0	Published 2015
RDF WG	[JSON-LD 1.1]	A JSON-based Serialization for Linked Data	Published 2018
RDF WG	[RDF 1.1]	RDF 1.1 Concepts and Abstract Syntax	Published 2014
Permissions and Obligations WG	[ODRL V&E 2.2]	Open Digital Rights Language (ODRL) Vocabulary & Expression 2.2	Published 2018
NOTE – Clause I.4 contains a description of each cited reference.			

9.5 OASIS

The following Organization for the Advancement of Structured Information Standards (OASIS) technical committees (TCs) are relevant to big data [b-OASIS]:

- OASIS Advanced Message Queuing Protocol (AMQP) TC: defines a ubiquitous, secure, reliable and open Internet protocol for handling business messaging;
- OASIS Message Queuing Telemetry Transport (MQTT) TC: provides a lightweight publish/subscribe reliable messaging transport protocol suitable for communication in machine to machine (M2M) and IoT contexts where a small code footprint is required and/or network bandwidth is at a premium.

Table 9-10 lists the OASIS deliverables and work items related to big data and data handling.

Table 9-10 – OASIS deliverables and work items

Sub group	Reference (Note)	Name/Title	Status
AMQP TC	[OASIS AMQP 1.0]	Advanced Message Queuing Protocol Version 1.0	Published 2012
MQTT TC	[OASIS MQTT 5]	Message Queuing Telemetry Transport Version 5	Published 2019
XMILE for System Dynamics	[OASIS XMILE]	XML Interchange Language for System Dynamics (XMILE) Version 1.0	Published 2015
NOTE – Clause I.4 contains a description of each cited reference.			

9.6 Data Mining Group

The Data Mining Group (DMG) is a vendor led consortium that develops data mining related standards. The DMG develops Predictive Model Markup Language (PMML) which provides a way for applications to describe and exchange models produced by data mining and machine learning algorithms, and Portable Format for Analytics (PFA); which provides a mini-language for mathematical calculations. Table 9-11 lists DMG deliverables and work items related to big data and data handling.

Table 9-11 – DMG deliverables and work items

Sub group	Reference (Note)	Name/Title	Status
–	[DMG PMML 4.4]	Predictive Model Markup Language 4.4	Published 2019
–	[DMG PFA]	Portable Format for Analytics	Published 2016
NOTE – Clause I.5 contains a description of each cited reference.			

9.7 TM Forum

The TM Forum (formerly TeleManagement Forum) is a global member association for digital business. The TM Forum published "Guide book for big data analytics" describing best practices on big data. Table 9-12 lists the TM Forum deliverables and work items related to big data and data handling.

Table 9-12 TM Forum deliverables and work item

Sub group	Reference (Note)	Name/Title	Status
–	[TMF BDAG]	The Big Data Analytics Guidebook	Published 2015
–	[TMF DGG]	Data Governance Guidebook v3	Published 2022
–	[TMF DGMM]	Data Governance Maturity Model v3	Published 2022
NOTE – Clause I.6 contains a description of each cited reference.			

10 Gap analysis in big data and data handling standardization

This clause provides a matrix for gap analysis and the related standardization activities with data handling to identify standardization gaps.

The matrix is composed of two axes. The horizontal axis describes document categories that cover the subject of applications as follows:

- **General/definition:** the standard which provides general descriptions or terms and definitions of the technology;
- **Common requirement:** the standard which provides use cases and derived general/functional requirements;
- **System architecture:** the standard which provides a reference architecture, and functional architecture for data application;
- **Common interface:** the standard which provides a common interface, API and/or its profile;
- **Data model and format:** the standard which provides data model or protocol including scheme and/or its encoding format;
- **Guideline:** the standard which provides a guideline for data handling;
- **Informative document:** the document which provides technical and/or not normative information about data handling (e.g., service scenarios and examples).

The vertical axis describes the related technical scope to support data handling as follows:

- **Overall concept:** the common concept of data handling and related applications;
- **Data sharing and data collection:** a technical scope of data publishing, sharing, collection, and transaction, etc.;
- **Data preparation:** a technical scope of manipulating raw data into a form that can be used for certain data processing;
- **Data service:** a technical scope of service that provides data analytics, machine learning, etc.;
- **Data quality and trustworthiness:** a technical scope of data management to ensure the data quality and trustworthiness of data;
- **Security and privacy:** a technical scope of security for big data system including handling of personal identification information;
- **Data governance, management and policy:** a technical scope of data handling procedure, rules and policy within the organization level;
- **Applications:** a technical scope of applications with an enhancement of its capabilities through data-driven technology or applying data-driven technology to applications;

– **Others:** data handling related technologies which are not described above.

NOTE 1 – The items on the horizontal axis are not subordinated to the different technologies.

NOTE 2 – The items on the vertical axis can be modified with technology change.

NOTE 3 – A standard has more than one location on the matrix. In the case that one standard is included in multiple document categories (horizontal axis) or related technologies (vertical axis), it can be mapped several times.

Table 10-1 shows the standardization matrix related to big data and data handling.

Table 10-1 – Standardization matrix of big data and data handling

	General/ Definition	Requirement	System architecture	Common interface including API	Data model and format	Guideline	Informative document
Overall concept	ITU-T Y.3600 ITU-T Y.3601 ISO/IEC 20546 ISO/IEC 19944-1 ISO/IEC 8183	ITU-T Y.3600	ITU-T Y.3519 ITU-T Y.3605 ISO/IEC 20547-3			ISO/IEC 19944-2	ISO/IEC 20547-1 ISO/IEC 42103
Data sharing and collection	ITU-T Y.3601 ITU-T Y.4461 ITU-T F.740.5 ITU-T Y.bDDN- DTMec ITU-T Y.fdc ITU-T Y.4484 ITU-T Y.dem-IoT ISO/IEC 23751	ITU-T Y.3601 ITU-T Y.4461 ITU-T Y.4560 ITU-T Y.4563 ITU-T F.AI-MKGDS ITU-T Y.cdp-reqts ITU-T F.RFDSSN	ITU-T Y.4498		ITU-T Y.3603 OASIS AMQP OASIS MQTT OASIS XMLE W3C DCAT W3C JSON-LD W3C LDP W3C RDF W3C OO W3C MVT W3C MTDMW		
Data preparation	ITU-T Y.bdi-reqts	ITU-T Y.bdi-reqts ITU-T F.AI-RMCDP ITU-T Y.cdp-reqts ITU-T F.AICP-DA					
Data service	ISO 3534-5			DMG PFA	DMG PMML DMG PFA		ITU-T D.datatariff ISO 23347 ISO 23348 TMF BDAG ISO/IEC 20547-2
Data quality and trustworthiness	ITU-T Y.3602 ISO/IEC 23751 ISO/IEC 5259-1 ISO/IEC 5259-2 ISO/IEC 5259-4	ITU-T Y.3602 ISO/IEC 5259-3 ISO/IEC 5259-4	ITU-T Y.3607		ITU-T Y.3602	ISO/IEC 5259-2 ISO/IEC 5259-3	ISO/IEC TR 23186 ISO/IEC 5259-6
Security and Privacy	ITU-T X.1601 ITU-T D.princip_bigdata ITU-T X.1376 ITU-T Y.3055 ISO/IEC 20889 ISO/IEC 27000 ISO/IEC 27018 ISO/IEC 27555 IEO/IEC 29100 ISO/IEC 29184	ITU-T X.1147 ITU-T Y.3604 ITU-T X.Sup.39 ISO/IEC 20547-4 ISO/IEC 27001 ISO/IEC 27701	ITU-T X.1410 ISO/IEC 29101		ITU-T X.icd- schemas W3C ODRL V& E 2.2	ITU-T X.1603 ITU-T X.1641 ITU-T X.1750 ITU-T X.1752 ITU-T X.1751 ITU-T X.gecds ITU-T X.guide- cdd ITU-T X.gdsml ISO/IEC 20889 ISO/IEC 27002 ISO/IEC 27701 ISO/IEC 29134 ISO/IEC 29151 ISO/IEC 29190 ISO/IEC 27018	

Table 10-1 – Standardization matrix of big data and data handling

	General/ Definition	Requirement	System architecture	Common interface including API	Data model and format	Guideline	Informative document
Data governance, management and policy	ITU-T Y.4602 ITU-T Y.4603 ISO/IEC 24668 ISO/IEC 5259-5	ITU-T F.743.20 ITU-T Y.3518 ITU-T Y.4561 ITU-T F.751.5 ITU-T F.MDAM-PR ITU-T Y.4606 ITU-T Y.ccdm-reqts ITU-T Y.DPM-alm-fra ISO/IEC 5259-3	ITU-T H.MDDMD- Arch ITU-T Y.4606 ITU-T Y.DPM- alm-fra			ISO/IEC 22624 TMF DGMM	ITU-T L.Suppl.52 TMF-DGG
Applications	ITU-T Y.3606 ITU-T Y.3650 ITU-T Y.3651 ITU-T Y.3655 ITU-T Y.3654 ITU-T F.FMDAV ITU-T H.DLT- DAS ITU-T H.DLT- DCMP ITU-T H.DLT- RFCEDM ITU-T F.DC- MTCPS-PFM ITU-T F.VG-DS	ITU-T F.743.7 ITU-T Y.4114 ITU-T Y.3651 ITU-T Y.3652 ITU-T Y.3505 ITU-T L.1305 ITU-T Y.bDDN-NP- ReqArch ITU-T Y.3657 ITU-T Y.bDDN-AA- RAM ITU-T Y.4495 ITU-T Y.bDDN-RA- NPN ITU-T F.CEC-MDG ITU-T F.JSQSUDAC ITU-T F.DADOCM ITU-T F.CDA-RP ITU-T F.CDSS-RF ITU-T F.DEC-RM ITU-T F.VG-DS	ITU-T H.VSBD ITU-T Y.3653 ITU-T Y.bDDN- NP-ReqArch ITU-T Y.bDDN- AA-RAM ITU-T Y.bDDN- AM-COINO ITU-T Y.bDDN- ArchMec-KC ITU-T Y.bDDN- RA-NPN ITU-T F.JSQSUDAC ITU-T H.VSDTAS- Arch		ITU-T F.740.3 ITU-T F.740.4 ITU-T F.VUI- DM ITU-T Y.4604 ITU-T Y.DM- SLF ITU-T Y.CL- EDM ITU-T Y.nmm-isms ITU-T H.VSDTAS- Arch ITU-T F.DC- CRATS-Meta ITU-T F.DC- MTCPS-PFM ITU-T F.DEC- RM ITU-T F.MDI ITU-T H.MD- DiDRR ITU-T H.ASDP- spec	ITU-T Y.expBDtech- frame	ITU-T Y.Sup.50 ITU-T HSTP.MBI- UC
Others	ITU-T Y.Suppl.62 ITU- T L.Energy_sav_Clo ud&Edge ITU-T L.1306 ITU-T H.DLT- EMDGP ITU-T F.MESaFFra	ITU-T Y.cii ITU-T L.1307 ITU- T L.Energy_sav_Cloud &Edge			ITU-T Y.Suppl.69	ITU-T L.EE-dse ITU-T L.MM_DC ITU-T L.thermal_DC ITU-T L.GHGemission s_DC ITU-T L.MM&BP_DC	ITU-T Study_bigdata ITU-T Y.DSNETDN ITU-T L.WHR ISO/IEC 20547-5

NOTE 4 – The bold letter items in Table 10-1 are ITU-T work in progress activities.

According to the gap analysis in Table 10-1:

- ITU-T has been focusing on 'general/definition', 'requirement' and 'guideline' with each technical area described in vertical axis;
- It is expected that standardization efforts of ITU-T will be moved to 'system architecture' of each technical area;
- Consideration on standardizing 'data preparation, and data service' are needed;
- The entries under the column 'Common interface' of each of technical standardization areas are empty except 'DMG PFA'. These areas are being developed by open source projects, so ITU-T has to consider establishing relationships with them.

Appendix I

Summaries of referenced standardization work items

This appendix provides the summaries of the big data and data handling related SDO standardization items specified in clause 9.

NOTE – The summary text comes from the 'scope' or the corresponding part of each item such as 'overview', 'introduction', etc.

I.1 ITU-T references and associated summaries

[ITU-T Y.3600] **Big data – Cloud computing based requirements and capabilities**

This proposed Recommendation provides an approach to use cloud computing to meet existing challenges in the use of big data.

The scope of this proposed Recommendation includes:

Overview of big data:

- Cloud computing based big data system context and benefits;
- Cloud computing based big data requirements;
- Cloud computing based big data capabilities.

Overview of cloud computing based big data:

- Big data system context and its activities;
- Cloud computing based big data requirements;
- Cloud computing based big data capabilities;
- Cloud computing based big data use cases and scenarios.

URL: <https://www.itu.int/rec/T-REC-Y.3600-201511-I/en>

[ITU-T Y.3601] **Big data – Framework and requirements for data exchange**

This Recommendation specifies the framework and requirements for data exchange in a big data ecosystem. This Recommendation identifies general concepts, patterns, activities, and functional requirements based on the big data ecosystem and capabilities defined in [ITU-T Y.3600]. The functional requirements provided in this Recommendation are derived from use cases.

URL: <https://www.itu.int/rec/T-REC-Y.3601/en>

[ITU-T Y.3602] **Big data – Functional requirements for data provenance**

This Recommendation specifies the functional requirements for data provenance in a big data ecosystem defined in [ITU-T Y.3600]. This Recommendation introduces data provenance as well as data provenance in big data ecosystem, and also provides conceptual model, operations, logical components, and functional requirements for big data provenance. The functional requirements provided in this Recommendation are derived from use cases.

URL: <https://www.itu.int/rec/T-REC-Y.3602-202209-I/en>

[ITU-T Y.3603] **Big data – Requirements and conceptual model of metadata for data catalogue**

This Recommendation introduces metadata concept as well as its usages in a big data lifecycle. This Recommendation provides requirements and a conceptual model of metadata

for data catalogue to support a big data ecosystem defined in [ITU-T Y.3600]. The XML profiles based on the conceptual model described by UML and examples of metadata are provided in the appendix.

URL: <https://www.itu.int/rec/T-REC-Y.3603-202305-I>

[ITU-T Y.3604] **Big data – Overview and requirements for data preservation**

This Recommendation provides overview and requirements of big data preservation. It addresses the following subjects:

- Overview of big data preservation;
- Functional requirements of big data preservation;
- Use cases of big data preservation.

URL: <https://www.itu.int/rec/T-REC-Y.3604-202002-I>

[ITU-T Y.3605] **Big data – Reference architecture**

This Recommendation specifies the big data reference architecture (BDRA). The Recommendation provides a description of reference architecture concepts, user view, functional view and cross cutting aspects.

URL: <https://www.itu.int/rec/T-REC-Y.3605-202009-I>

[ITU-T Y.3606] **Big data – Deep packet inspection mechanism for big data in network**

The scope of this Recommendation includes:

- an introduction to the differences between generic deep packet inspection (DPI) and big data DPI;
- an overview of big data processing procedure;
- the relationship between deep packet inspection and big data related technologies;
- a data classification mechanism using deep packet inspection for big data in networks;
- a data pre-processing mechanism using deep packet inspection for big data in networks;
- a coordination processing mechanism for deep packet inspection for big data in networks;
- the interfaces between deep packet inspection and upper-layer big data related methods;
- other aspects of DPI mechanism for big data in network.

URL: <https://www.itu.int/rec/T-REC-Y.3606-202112-I>

[ITU-T Y.3607] **Big data – Functional architecture for data provenance**

This Recommendation provides a functional architecture for big data provenance. It specifies the following subjects:

- Functions for supporting big data provenance;
- Functional architecture of big data provenance;
- Reference points among functions for big data provenance.

In addition, this Recommendation provides relationship between the functional architecture of big data provenance and the big data reference architecture of [ITU-T Y.3605] in appendices.

URL: <https://www.itu.int/rec/T-REC-Y.3607-202301-P>

[ITU-T Y.bdi-reqts] **Big Data – Overview and functional requirements for data integration**

This Recommendation provides overview for big data integration. Compared with traditional data integration, big data needs to consider the characteristics for integration in terms of integration process. This Recommendation also provides functional requirement, which is derived from use cases.

The scope of this Recommendation is to specify overview and functional requirements for big data integration:

- Overview of big data integration;
- Functional requirements of big data integration;
- Use cases of big data.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=14074

[ITU-T Y.cdp-reqts] **Data handling – Functional requirements of collaborative data processing in data platform**

This Recommendation specifies the overview and functional requirements to support collaborative data processing in data platform. The scope of this recommendation includes:

- Overview of collaborative data processing in data platform including characteristics and roles;
- Functionalities of collaborative data processing in data platform including logical components;
- Functions requirements to support collaborative data processing;
- Use cases of collaborative data processing in data platform.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=18819

[ITU-T Y.3650] **Framework of big data driven networking**

This Recommendation specifies a framework for big-data-driven networking. The scope of this Recommendation includes the model architecture of big-data-driven networking (bDDN), the high-level capabilities of bDDN and the interface capabilities among different planes and layers.

URL: <https://www.itu.int/rec/T-REC-Y.3650/en>

[ITU-T Y.3651] **Big-data-driven networking – mobile network traffic management and planning**

This Recommendation specifies some technology aspects related to big-data-driven networking – mobile network traffic management and planning. The scope of this Recommendation includes: requirements, framework, reference points, performance and security considerations of big-data-driven networking – mobile network traffic management and planning.

URL: <https://www.itu.int/rec/T-REC-Y.3651-201812-l>

[ITU-T Y.Sup.50] **Use case and application scenario of big data driven networking**

This supplement specifies the use case and application scenario of big data driven networking.

URL: <https://www.itu.int/rec/T-REC-Y.Sup50-201811-l>

[ITU-T Y.3652] **Big data driven networking – requirements**

This Recommendation specifies requirements of big data driven networking.

The scope of this Recommendation includes:

- general requirements for big data driven networking;
- requirements of big data plane for big data driven networking;
- requirements of network plane for big data driven networking;
- requirements of management plane for big data driven networking;
- interface requirements for big data driven networking;
- security aspect requirements for big data driven networking.

URL: <https://www.itu.int/rec/T-REC-Y.3652-202006-I>

[ITU-T Y.3653] **Big data driven networking – Functional architecture**

This Recommendation specifies functional architecture of big data driven networking. The scope of this Recommendation includes:

- an overview;
- functional architecture for a big-data plane;
- functional architecture for a network plane;
- functional architecture for a management plane;
- other aspects.

URL: <https://www.itu.int/rec/T-REC-Y.3653-202104-I>

[ITU-T Y.3654] **Big data driven networking – Machine learning mechanism**

This Recommendation specifies the mechanisms of machine learning in big data driven networking, its scope includes the following aspects:

- Overview;
- Learning procedure;
- Deployment;
- Related interfaces;
- Learning and control path;
- Security considerations.

URL: <https://www.itu.int/rec/T-REC-Y.3654>

[ITU-T Y.3655] **Big data driven networking – Management and control mechanisms**

This Recommendation specifies the management and control mechanisms of big data driven networking(bDDN). Its scope includes:

- introduction of management and control mechanisms of bDDN;
- management mechanisms of bDDN;
- control mechanisms of bDDN;
- orchestration mechanisms of bDDN;
- other consideration related to management and control mechanisms of bDDN.

URL: <https://www.itu.int/rec/T-REC-Y.3655-202209-I/en>

[ITU-T Y.bDDN-AA-RAM] **Big data driven networking – Requirements, architecture and mechanism of application awareness**

This recommendation specifies the requirements, architecture and mechanism of application awareness for big data driven networking.

There are the following tasks related to the new work item:

- Study the requirements of application awareness in bDDN.
- Study the architecture of application awareness in bDDN.
- Study the mechanism of application awareness in bDDN.

This work item focuses on bDDN, and the special network such as Internet is out of the scope of the work item.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18427

[ITU-T Y.bDDN-AM-COINO] **Big data driven networking – Architecture and mechanism for customer-oriented intelligent network operation**

This draft recommendation specifies the big data driven networking - architecture and mechanism for customer-oriented intelligent network operation. The scope of the draft Recommendation includes:

- Overview of architecture and mechanism for customer-oriented intelligent network operation based on bDDN;
- The architecture of each plane for customer-oriented intelligent network operation based on bDDN;
- The mechanism for customer-oriented intelligent network operation based on bDDN;
- The interface abilities of mechanism for customer-oriented intelligent network operation based on bDDN.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18646

[ITU-T Y.bDDN-ArchMec-KC] **Big data driven networking – Architecture and mechanism of knowledge constructing**

This document specifies the architecture and mechanism of knowledge constructing for big data driven networking. The scope of the draft Recommendation includes:

- Overview of knowledge constructing of bDDN;
- The architecture to realize knowledge constructing of bDDN;
- The mechanism of knowledge constructing in each plane of bDDN;
- The interfaces ability related to mechanism for knowledge constructing of bDDN;
- Security considerations.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18817

[ITU-T Y.bDDN-DTMec] **Big data driven networking – Data transmission mechanism**

This Recommendation specifies the data transmission mechanism of bDDN. It includes:

- overview of data transmission mechanism of bDDN;
- data transmission mechanism between different entity inside big data plane of bDDN;
- data transmission mechanism between network plane and big data plane in bDDN;
- data transmission mechanism between management plane and big data plane in bDDN;
- Security consideration.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18816

[ITU-T Y.bDDN-NP-ReqArch] **Big data driven networking – Functional requirements and functional architecture of network programmability**

This Recommendation specifies the functional requirements and functional architecture of network programmability for big data driven networking. The scope of this Recommendation includes:

- Overview of network programmability for big data driven networking;
- Functional requirements of network programmability for big data driven networking;
- Functional architecture of network programmability for big data driven networking.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18137

[ITU-T Y.3657] **Big data driven networking – Requirements and capabilities of network visibility**

This recommendation aims to study requirements and capabilities of network visibility for big-data-driven networking, which focuses on network visibility for bDDN in the scenario where network infrastructure layer of bDDN corresponds to IP bearer network. The scope of this Recommendation includes:

- Overview for network visibility of bDDN;
- Requirements and capabilities for network visibility of control aspect of bDDN;
- Requirements and capabilities for network visibility of forwarding aspect of bDDN;
- Requirements and capabilities for network visibility of management aspect of bDDN;
- Interface requirements for network visibility of bDDN;
- Security considerations.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18122

[ITU-T Y.bDDN-RA-NPN] **Big data driven networking – Functional requirements and functional architecture of operation aspect for non-public network**

This Recommendation specifies big data driven networking- functional requirements and functional architecture of operation aspect for non-public network.

The scope of this Recommendation includes:

- Overview of operation aspect for NPN based on bDDN;
- Functional requirements of operation aspect for NPN based on bDDN;
- Functional architecture of operation aspect for NPN based on bDDN;
- Security considerations.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18645

[ITU-T Y.3505] **Cloud computing – Overview and functional requirements for data storage federation**

This Recommendation provides overview and functional requirements of data storage federation including benefits, configuration for logical components, and ecosystem of data storage federation as well as cloud computing based data storage federation. The functional requirements provided in this Recommendation are derived from use cases.

URL: <https://www.itu.int/rec/T-REC-Y.3505>

[ITU-T Y.3518] **Cloud computing – Functional requirements of inter-cloud data management**

This Recommendation provides the overview and functional requirements of inter-cloud data management. This Recommendation consists of:

- the overview of inter-cloud data management;
- functional requirements for inter-cloud data policy;
- functional requirements for inter-cloud data isolation and protection;
- functional requirements for inter-cloud data management.

This Recommendation also provides an appendix describing use cases aimed at deriving the corresponding functional requirements.

URL: <https://www.itu.int/rec/T-REC-Y.3518-201812-I/en>

[ITU-T Y.3519] **Cloud computing – Functional architecture of Big Data as a Service**

This Recommendation provides an overview of the big data as a service (BDaaS) functional architecture and defines the BDaaS functional architecture and cross-cutting aspects by specifying the functional components for the support of BDaaS.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=13627

[ITU-T Y.ccdm-reqts] **Cloud computing – Framework and functional requirements of cloud data mobility management**

This draft Recommendation provides the framework and functional requirements of cloud data mobility management, including in inter-cloud, intra-cloud and multi-cloud environments. It covers the following aspects:

- overview of cloud data mobility management;
- framework of cloud data mobility management;
- functional requirements of cloud data mobility management;

This Recommendation also provides an appendix describing use cases aimed at deriving the corresponding functional requirements.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18106

[ITU-T Y.DSNETDN] **Data Standardization for New and Emerging Technologies in Developing Nations**

The scope of this recommendation is in undertaking studies for the standardization of data for new and emerging technologies in developing nations thereby allowing studies and reporting of use cases.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18419

[ITU-T Y.expBDtech-frame] **Requirements and Framework for the exploitation of Big Data/Artificial Intelligence technologies in developing countries**

In view of the optimal exploitation of the data produced by current and future information systems deployed in the context of the digital transformation of the agri-food sector and existing initiatives in this sector, it is time to think about using Big data coupled with Artificial Intelligence to process and analyse trends, provide alternatives in normal and crisis times to ensure food security at national, regional and global level.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18420

[ITU-T Y.3055] **Framework for Trust based Personal Data Management**

To increase benefits from personal data utilization with the balance of privacy protection, it is important to support trust-based personal data management that considers trust in personal data utilization processes. Therefore, this Recommendation provides a framework for trust-based personal data management. More specifically, this Recommendation covers the following:

- The necessity of trust-based personal data management;
- Requirements considering personal data management comprising various stakeholders;
- Framework architecture specifying related functional blocks and reference points;
- Information flows describing interactions between/among functional blocks.

Details of prospective technologies for personal data management and a trust evaluation model with a specific use case are described in informative appendices.

URL: <https://www.itu.int/rec/T-REC-Y.3055-202009-I>

[ITU-T X.1601] **Security framework for cloud computing**

This Recommendation analyses security threats and challenges in the cloud computing environment, and describes security capabilities that could mitigate these threats and address security challenges. A framework methodology is provided for determining which of these security capabilities will require specification for mitigating security threats and addressing security challenges for cloud computing.

URL: <https://www.itu.int/rec/T-REC-X.1601-201510-I>

[ITU-T X.1603] **Data security requirements for the monitoring service of cloud computing**

This Recommendation describes data security requirements for the monitoring service of cloud computing. The Recommendation analyses data security threats and challenges associated with the monitoring service in a cloud computing environment, and describes data security requirements of the monitoring service including data scope, data lifecycle, data acquisition and data storage. This Recommendation can be used by cloud service providers (CSPs) who provide monitoring services to cloud service customers (CSCs).

URL: <https://www.itu.int/rec/T-REC-X.1603-201803-I>

[ITU-T X.1641] **Guidelines for cloud service customer data security**

This Recommendation provides guidelines for cloud service customer (CSC) data security in cloud computing, for those cases where the cloud service provider (CSP) is responsible for ensuring that the data is handled with proper security. This is not always the case, since for some cloud services the security of the data is the responsibility of CSCs themselves. In other cases, the responsibility may be mixed.

This Recommendation identifies security controls for CSC data that can be used in different stages of the full data lifecycle. These security controls can differ when the security level of the CSC data changes. Therefore, this Recommendation provides guidelines on when each control should be used for best security practice.

URL: <https://www.itu.int/rec/T-REC-X.1641/en>

[ITU-T X.1147] **Security requirements and framework for big data analytics in mobile internet services**

This Recommendation provides security framework and requirements for big data analytics in mobile internet services. The intent of this Recommendation is to study the challenges brought forward by big data analytics, and the specific security requirements for the mobile

internet services as well as the security framework. The scope of this Recommendation will focus on security threats analysis, security requirements, and a security framework.

URL: <https://www.itu.int/rec/T-REC-X.1147-201811-I>

[ITU-T X.1750] **Guidelines on security of big data as a service for Big Data Service Providers**

This Recommendation analyses security challenges faced by big data as a service (BDaaS) and provides guidelines for big data service providers (BDSPs) to secure BDaaS. It identifies security roles and responsibilities of BDaaS components and specifies a security framework for a big data infrastructure, including platforms, applications, analytics, interfaces and the BDaaS ecosystem. This Recommendation also specifies security protection measures that should be taken for activities or components related to BDaaS. This Recommendation is a high-level description of security requirements for BDaaS implementation that focuses on BDaaS. BDaaS involves big data infrastructure providers (BDIPs) and big data application providers (BDAPs). Guidelines for BDIPs and BDAPs, as well as detailed guidance on BDaaS implementation lie outside the scope of this Recommendation.

URL: <https://www.itu.int/rec/T-REC-X.1750-202009-I>

[ITU-T X.1752] **Security guidelines for big data infrastructure and platform**

The Recommendation describes the big data infrastructure and platform from existing standardization works in relevant fora. This Recommendation develops a threat assessment methodology and specifies security guidelines to protect the big data infrastructure and platform. This Recommendation also provides a mapping between threats and security guidelines.

URL: <https://www.itu.int/rec/T-REC-X.1752-202201-I>

[ITU-T X.1751] **Security guidelines on big data lifecycle management for telecommunication operators**

This Recommendation describes security vulnerabilities and establishes lifecycle management guidelines for telecommunication big data services. This Recommendation:

- introduces characteristics of telecommunication big data services and data categories;
- analyses security vulnerabilities of lifecycle management for telecommunication big data services;
- specifies security guidelines for data lifecycle management for telecommunication big data services.

When telecommunication operators provide big data services, the basic prerequisite is that the explicit consent of subscribers has been obtained. In addition, for telecommunication operators, provision of necessary data protection measures is recommended throughout the entire big data service process. Protection mechanisms for various data categories lie outside the scope of this Recommendation.

URL: <https://www.itu.int/rec/T-REC-X.1751-202009-I>

[ITU-T X.1376] **Security-related misbehaviour detection mechanism using big data for connected vehicles**

This Recommendation describes a security-related misbehaviour detection mechanism for connected vehicles. The mechanism includes the following steps:

- Data capture. Definition of the types of data and information that can be captured from different sources, including automotive, infrastructure, original equipment manufacturers (OEMs) and suppliers, for misbehaviour detection. Data capture methods and procedures lie outside the scope of this Recommendation.

- Detection. Analysis of the data captured to detect misbehaviour.

This Recommendation applies to connected vehicles to detect misbehaviour by designers and security solution providers. Notification utilization methods lie outside the scope of this Recommendation.

URL: <https://www.itu.int/rec/T-REC-X.1376-202101-P>

[ITU-T X.gecds] **Guidelines on edge computing data security**

This recommendation:

- introduces characteristics of the framework of edge computing and the reference architecture of edge computing integrated with 5G network. Additionally, to analyse how the reference architecture affects data security at the edge;
- analyses security challenges and threats for edge computing, especially for different edge computing service scenarios;
- specifies security guidelines for edge computing for various roles who are related with edge computing application.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=18025

[ITU-T X.guide-cdd] **Security guidelines for combining de-identified data using trusted third party**

This Recommendation describes security guidelines for combining de-identified datasets from different organizations in a secure manner. It describes various use cases, identifies entities, and defines two models and necessary procedures for combining de-identified datasets from different organizations such as data controller and data processor. It also provides organizational and technical controls for trusted third party which is responsible for combining de-identified datasets for ICT service providers.

This Recommendation does not address issues related to regulation.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18022

[ITU-T X.Sup.39] **Requirements for data de-identification assurance**

This Recommendation defines data de-identification assurance. It also provides a set of requirements for managing data de-identification assurance, including data risk assessment, risk assessment of data use environment, and using and managing de-identified data.

URL: <https://www.itu.int/rec/T-REC-X.Sup39-202309-P>

[ITU-T X.gdsm] **Guidelines for data security using machine learning in big data infrastructure**

This draft Recommendation establishes guidelines for data security using machine learning in big data infrastructure. This recommendation:

- analyses data security threats in big data infrastructure and specifies data security threats that can be monitored, analysed, early warned, and responded using machine learning;
- proposes a reference model of using machine learning to dynamically protect data security in big data infrastructure.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18351

[ITU-T X.1410] **Security architecture of data sharing management based on the distributed ledger technology**

This Recommendation specifies a security architecture for data sharing based on blockchain. This Recommendation includes:

- design of security architecture for data sharing based on distributed ledger technology (DLT);
- specification of the logical functions of the data-sharing security architecture;
- specification of the interfaces between the logical functions of the security architecture;
- specification of the procedures for data sharing based on DLT.

URL: <https://www.itu.int/rec/T-REC-X.1410-202303-I>

[ITU-T X.icd-schemas] **Vendor agnostic security data schemas for integrated cyber defence solutions**

This scope of this recommendation is the definition of the vendor agnostic security data schemas that products may use to either produce security data or consume security data in the context of an Integrated Cyber Defence (ICD) solution.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17986

[ITU-T Y.4114] **Specific requirements and capabilities of the IoT for Big Data**

Recommendation ITU-T Y.4114 specifies requirements and capabilities of the Internet of things (IoT) for big data. This Recommendation complements the developments on common requirements of the IoT described in Recommendation ITU-T Y.4100/Y.2066 and the functional framework and capabilities of the IoT described in Recommendation ITU-T Y.2068 in terms of the specific requirements and capabilities that the IoT is expected to support in order to address the challenges related to big data. This Recommendation also constitutes a basis for further standardization work such as functional entities, application programming interfaces (APIs) and protocols concerning big data in the IoT. The scope of this Recommendation includes:

- Overview of big data in the IoT;
- Requirements of the IoT for big data;
- Capabilities of the IoT for big data.

URL: <http://www.itu.int/rec/T-REC-Y.4114>

[ITU-T Y.4461] **Framework of Open Data in Smart Cities**

This Recommendation defines a framework of Open Data in Smart Cities, in order to promote the sharing of data between different entities in 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.

URL: <https://www.itu.int/rec/T-REC-Y.4461-202001-I/en>

[ITU-T Y.4484] **Framework to support web of objects ontology based semantic data interoperability of e-health services**

In e-health services, semantic data interoperability will enable the various systems to combine received information with other information resources and to process it in a manner

that preserves meaning. The lack of semantic data interoperability between e-health systems is one of the major obstacles in the provision of cross-border and cross-sector e-health systems. [ITU-T Y.4563] identifies the requirements and functional model to support data interoperability in Internet of things (IoT) environments.

In accordance with [ITU-T Y.4452] and [ITU-T Y.4563], this Recommendation describes a framework to support web of objects (WoO) ontology based semantic data interoperability of e-health services by presenting:

The concept of Open Data in Smart Cities.

- An overview of semantic data interoperability in e-health services;
- Requirements to support WoO based semantic data interoperability in e-health services;
- A functional model to support WoO ontology based semantic data interoperability;
- WoO based semantic data interoperability provisioning in e-health services.

URL: <https://www.itu.int/rec/T-REC-Y.4484-202208-I>

[ITU-T Y.4560] **Blockchain-based data exchange and sharing for supporting Internet of things and smart cities and communities**

This Recommendation provides descriptions of blockchain-based data exchange and sharing in Internet of things (IoT) and smart cities and communities (SC&C) application domains.

The scope of this Recommendation includes:

- Overview of blockchain in data exchange and sharing;
- Requirements for blockchain-based data exchange and sharing;
- Functional models of blockchain-based data exchange and sharing;
- Platform of blockchain-based data exchange and sharing;
- Deployment modes for blockchain-based data exchange and sharing.

URL: <https://www.itu.int/rec/T-REC-Y.4560-202008-I>

[ITU-T Y.4561] **Blockchain-based Data Management for supporting Internet of things and smart cities and communities**

This Recommendation provides technical descriptions and specifications of the blockchain-based data management in Internet of things (IoT) and smart cities and communities (SC&C) application domains.

The scope of this Recommendation includes:

- Requirements of blockchain-based data management;
- Generic reference model of blockchain-based data management;
- Common capabilities and procedures of blockchain-based data management.

In addition, this Recommendation provides two data management approaches based on blockchain in Appendix I.

URL: <https://www.itu.int/rec/T-REC-Y.4561-202008-I>

[ITU-T Y.4563] **Requirements and functional model to support data interoperability in IoT environments**

This Recommendation addresses the requirements and functional model for data interoperability in IoT environments. The scope of this Recommendation covers several key

requirements with respect to data interoperability in IoT environments and many important elements to fulfil these requirements. Specifically, this document covers the followings:

- Overview of data interoperability in IoT environments;
- Requirements to support data interoperability;
- Functional model to support data interoperability;
- Functional components of the semantic mediation function;
- Functional components of the syntactic mediation function;
- Functional components of the object abstractions representation mediation function;
- Functional components of the interoperable data repositories.

URL: <https://www.itu.int/rec/T-REC-Y.4563-202111-I/en>

[ITU-T Y.4602] **Data processing and management framework for IoT and smart cities and communities**

This Recommendation is expected to cover the following:

- A high level DPM framework in IoT and smart cities and communities from a capability perspective;
- Identification of related data processing and management concepts and their relationships;
- Common considerations of DPM in IoT and smart cities and communities.

This Recommendation is intended to be used by:

- Those who are engaged in Data Processing and Management activities;
- Those who are involved in data related standardization activities;
- Data processing and management policy makers and regulators.

URL: <https://www.itu.int/rec/T-REC-Y.4602-202303-I>

[ITU-T Y.4603] **Requirements and functional model to support data quality management in IoT**

This draft Recommendation identifies the followings to provide requirements and functional model for data quality management in IoT. The scope of this document covers several key requirements with respect to data quality management in IoT, many important elements to fulfil these requirements and the functional model. Specifically, it covers the following:

- Overview of data quality management;
- Data quality management in IoT;
- Requirements of data quality management in IoT;
- Functional model to support data quality management.

URL: <https://www.itu.int/rec/T-REC-Y.4603-202303-I>

[ITU-T Y.4604] **Metadata for camera-sensing information of autonomous mobile IoT devices**

This draft Recommendation defines the metadata elements and format for autonomous mobile IoT devices and describes metadata characteristics of camera-sensing-based information working on IoT devices. In particular, the scope of this draft Recommendation includes:

- Introduction of metadata for camera-sensing information (MCSI);
- Metadata and Features of MCSI;
- Use case of MCSI.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=17956

[ITU-T Y.Suppl.62] **Overview of blockchain for supporting Internet of things and smart cities and communities in data processing and management aspects**

This Supplement provides an overview of blockchain related to data processing and management (DPM) for supporting Internet of things (IoT) and sustainable smart cities and communities (SC&C).

The scope of this Supplement includes analysis of:

- the advantages, challenges, key features and a common reference model of blockchain from the DPM perspective for supporting IoT and SC&C;
- key issues for blockchain to support IoT and SC&C from the DPM perspectives;
- the effects when using blockchain to support IoT and SC&C from the DPM perspective.

URL: <https://www.itu.int/rec/T-REC-Y.Sup62-202007-I>

[ITU-T Y.Suppl.69] **Web based data model for IoT and smart city systems and services**

This Supplement to ITU-T Y-series Recommendations provides a web-based data model for Internet of things (IoT) and smart city systems and services including:

- a general discussion on data formats and metadata;
- basic concepts and types of data model;
- microdata formats for web data management; and
- procedural metadata for semantic web of things (WoT).

URL: <https://www.itu.int/rec/T-REC-Y.Sup69-202105-I>

[ITU-T Y.4606] **Requirements and functional architecture of data management system for smart greenhouse service**

This draft Recommendation addresses data management for smart greenhouse service including the follows:

- overview of data management system for smart greenhouse service;
- requirements of data management system for smart greenhouse service;
- functional architecture of data management system for smart greenhouse service;
- consideration on deployment in various service environment.

The general requirements and functions of data management system are not under scope of this draft Recommendation.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18464

[ITU-T Y.4495] **Requirements and a reference model of data for smart greenhouse service**

This draft Recommendation addresses of requirements and a reference model of data for smart greenhouse service including the following:

- Overview of crop-growth-related data for smart greenhouse service;
- High level requirements of data model for smart greenhouse service;

- Reference model of data for smart greenhouse service.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=17957

[ITU-T Y.4498] **Framework of city-level energy data sharing and analytics among buildings**

This draft Recommendation presents a framework of city-level energy data sharing and analytics for city energy services and intelligent energy applications among buildings in smart cities.

The scope of this draft Recommendation includes:

- Overview of city-level energy data sharing and analytics among buildings;
- Requirements for energy data sharing and analytics for city energy services and intelligent energy applications;
- Architectural models, specification of functions and interfaces;
- Energy data processing and operation for city energy services.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=17946

[ITU-T Y.cii] **Requirements and reference model of IoT related data from city infrastructure**

This Recommendation specifies requirements and reference model of IoT related data from city infrastructure.

The scope of this recommendation includes:

- Overview of IoT related data from city infrastructure;
- Requirements of IoT related data from city infrastructure;
- Reference model of IoT related data from city infrastructure.

All content related to data collection, storage, retrieval and delete covered in this document is recommended to be conducted in accordance with the laws and regulations of the country or region where the standard is used.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17900

[ITU-T Y.DM-SLF] **Conceptual data model of smart livestock farming service**

This draft Recommendation addresses of data model required for smart livestock farming (SLF) service:

- Overview of SLF service in the perspective of data;
- Data entities for SLF service;
- Relationship between data entities; and,
- Conceptual data model for SLF service.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18470

[ITU-T Y.CL-EDM] **Energy data model for city-level energy management platform**

This draft Recommendation addresses of data model required for This draft Recommendation specifies an energy data model of the city-level energy management platform (CL-EMP) to support building energy services and integrated city energy services in a smart sustainable city.

The scope of this draft Recommendation includes:

- overview of city-level energy data model for building energy services and integrated city energy services;

- requirements of city-level energy data model;
- description of city-level energy data model.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18463

[ITU-T Y.DPM-alm-fra] **Functional requirements and architecture of blockchain-based activity logs management for IoT data processing and management**

This draft new Recommendation introduces blockchain-based activity logs management (ALM) for IoT data processing and management (IoT DPM), and specifies its characteristics, functional requirements and architecture.

The scope includes:

- Concept, use cases and characteristics of blockchain-based activity logs management for IoT data processing and management;
- Functional requirements and architecture of blockchain-based activity logs management for IoT data processing and management.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18467

[ITU-T Y.nmm-isms] **Metadata model of sensing capability for disaster monitoring system**

This Recommendation presents the Sensing Capability Metadata Model (SCMM) for Disaster Monitoring System (DMS). The scope of this Recommendation includes:

- Overview of SCMM for DMS;
- Metadata categories of SCMM for DMS;
- Metadata elements of SCMM for DMS.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17883

[ITU-T Y.dem-IoT] **Data exchange model for IoT devices in power transmission and transformation equipment**

This Recommendation provides the data exchange model for IoT devices in power transmission and transformation equipment: Overview of SCMM for DMS

- The metadata of data exchange model from IoT devices;
- The data flows of data exchange for IoT devices.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18743

[ITU-T D.princip_bigdata] **Policy framework and principles for data protection in the context of big data relating to international telecommunication services**

This Recommendation proposes a policy framework and a set of principles for data protection in the context of big data relating to international telecommunication services.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18189

[ITU-T Study_bigdata] **Technical Paper on economic and policy aspects of Big Data in international telecommunication services and networks**

The aim of the technical paper is to study the economic and policy aspects of big data in international telecommunication services and networks.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18183

[ITU-T D.datatariff] **Principles for tariff regulation of Data Services**

In view of the increasing usage of the data services by the consumers, the time has come to enunciate the principles for tariff regulation for data services as the regulatory prescriptions

hitherto, on non-discrimination and transparency in tariff offers were more focused to address the regulatory concerns in voice telephony.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18188

[ITU-T F.743.7] **Requirements for big data enhanced visual surveillance services**

This Recommendation specifies Requirements for big data enhanced visual surveillance service.

The scope of this recommendation includes:

- Application scenarios;
- Service requirements;
- Functional requirements;
- Performance requirements;
- Security requirements.

URL: <https://www.itu.int/rec/T-REC-F.743.7-201905-I>

[ITU-T F.743.20] **Assessment framework for big data infrastructure**

This Recommendation specifies the requirements in assessment methods for big data infrastructure system. The scope of this Recommendation includes:

- Operation and maintenance management requirement in big data infrastructure;
- High availability requirement in big data infrastructure;
- Functional requirement in big data infrastructure;
- Compatibility requirement in big data infrastructure;
- Performance requirement in big data infrastructure;
- Security requirement in big data infrastructure;
- Multi-tenant requirement in big data infrastructure;
- Extensibility requirement in big data infrastructure.

URL: <https://www.itu.int/rec/T-REC-F.743.20-202008-I/en>

[ITU-T H.VSBD] **Architecture for big data application in visual surveillance system**

This Recommendation specifies the reference architecture for big data application in visual surveillance system. The scope of this Recommendation includes:

- Reference architecture for big data application in visual surveillance system;
- Reference point for big data application in visual surveillance system;
- Service flow for big data application in visual surveillance system;
- Key Parameter for big data application in visual surveillance system;
- Interworking for legacy visual surveillance system and big data analytics system.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17475

[ITU-T F.AI-RMCDP] **Requirements of multimedia composite data preprocessing**

This Recommendation makes a framework for multimedia composite data (mainly text, image, audio and video) preprocessing, which is suitable for guiding the data preprocessing of the related artificial intelligence system in the training stage.

It addresses the following subjects:

- Data cleaning;
- Data annotation;
- Data transformation;
- Data association.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=17544

[ITU-T F.VUI-DM] Data model for voice UI based senior health service

This Recommendation describes data model for voice UI based senior health service.

URL: https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=17506

[ITU-T F.AI-MKGDS] Requirements for the construction of multimedia knowledge graph database structure based on artificial intelligence

This recommendation makes a standard for the construction of knowledge graph, which is suitable for guiding the construction of knowledge graph.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17570

[ITU-T F.751.5] Requirements for distributed ledger technology-based power grid data management

This Recommendation defines requirements for DLT-based power grid data management, including:

- requirements for infrastructure layer;
- requirements for service layer;
- requirements for application layer; and
- requirements for data governance.

This Recommendation can be used as a guideline for power grid data management with DLT technologies.

URL: <https://www.itu.int/rec/T-REC-F.751.5-202212-P>

[ITU-T H.MDDMD-Arch] Reference Architecture for DLT-based Multimedia Data Delivery Management System

This Recommendation specifies the reference architecture for DLT-based multimedia data delivery management systems including the general architecture, management function and management process. The following aspects are within the scope of this Recommendation: Overall functional architecture of DLT-based multimedia data delivery management systems, DLT-based multimedia data delivery service management domain, multimedia data management domain and DLT management domain.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17638

[ITU-T F.MDAM-PR] Procedures and requirements for multimedia data asset management

This Recommendation specifies the procedures for multimedia data asset management, and provides the detailed requirements and use cases for multimedia data asset management procedures. The scope of this Recommendation includes, but is not limited to:

- Overview;
- General procedures for multimedia data asset management;
- Requirements for each part of the multimedia data asset management procedures.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18601

[ITU-T F.AICP-DA] **Technical specification for artificial intelligence cloud platform: Data annotation**

AI cloud platform is designed for the development of AI models. Data annotation, because of its ability to improve the quality of AI models, is a core part of the AI model development process. This Recommendation provides functional requirements and a reference architecture for such a platform. With the satisfactory function requirements mentioned in this Recommendation, the AI cloud platform can better help model development. This Recommendation provides the minimum and recommended functional requirements that the data annotation section should satisfy. From the perspective of the whole process of artificial intelligence data annotation, this Recommendation mainly focuses on the evaluation of data annotation capabilities and levels.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18649

[ITU-T F.CEC-MDG] **Requirements and framework of AI based multimedia data generation systems using core cloud and edge cloud**

This Recommendation clarifies the requirements and reference framework of AI-based multimedia data generation systems using core cloud and edge cloud. The scope of this Recommendation includes:

- Overview;
- Requirements;
- Reference framework.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=19023

[ITU-T F.JSQUADAC] **Requirements and functional architecture of joint semantic query system of unstructured data across clusters**

This draft Recommendation provides an overview of joint semantic query of unstructured data across clusters, and defines the requirements and functional architecture of joint semantic query system of unstructured data across clusters.

The scope of this Recommendation includes:

- Framework of system for joint semantic query of unstructured data across clusters;
- Functional requirements of system for joint semantic query of unstructured data across clusters.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18660

[ITU-T F.RFDSSN] **Requirements and framework for data sharing service networks**

This recommendation proposes a system of data sharing service network (DSSN), and provides the scenario requirements and framework of DSSN.

The scope of this Recommendation includes:

- Overview of data sharing service network;
- Scenario requirements of data sharing service network;
- Framework of data sharing service network;
- Technical requirements of data sharing service network.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18527

[ITU-T H.VSDTAS-Arch] **Architecture and metadata of digital twin model assembling and interaction services for video surveillance systems**

The digital twin model assembling and interaction services for video surveillance system are to establish the digital twin mapping relationship between the video surveillance system and digital 3D models of surveilled objects and surveillance devices, and enable the users to understand and interact with the video surveillance system through the digital twin models. This Recommendation specifies the requirements, architecture, functions, and metadata of digital twin model assembling and interaction services for video surveillance system.

The scope of this Recommendation includes:

- Requirements of digital twin model assembling and interaction services for video surveillance system;
- Architecture of digital twin model assembling and interaction services for video surveillance system;
- Functions of digital twin model assembling and interaction services for video surveillance system;
- Metadata of digital twin model assembling and interaction services for video surveillance system.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17630

[ITU-T F.FMDAV] **Framework for multimedia data asset valuation**

This Recommendation defines the framework for multimedia data asset valuation, which is applicable to guiding relevant enterprises or departments to carry out the evaluation of multimedia data assets value. The scope of this Recommendation includes:

- Process of data asset valuation;
- Objectives of data asset valuation;
- Principles of data asset valuation;
- Objects of data asset valuation;
- Organization of data asset valuation;
- Dimensions and indicators of data asset valuation;
- Methods for calculating indicators in data asset valuation;
- Data asset valuation implementation;
- Guarantees of data asset valuation.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18992

[ITU-T H.DLT-DAS] **Technical framework for distributed ledger technology-based multimedia data asset services**

This document specifies technical framework of for distributed ledger technology based multi-media data asset service. It includes technical architecture, functional components, technical flows, functional requirements, and security requirements for DLT-based data asset services.

This document can be used as guidance by the relevant parties to research, develop, test, deploy and manage the distributed ledger technology based multi-media data asset services.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18609

[ITU-T H.DLT-DCMP] **Reference framework for DLT-based data circulation and marketplace platform**

This Recommendation specifies a framework for DLT-based data circulation and marketplace platform covering:

- Overall architecture;
- Roles of participating entities;
- Technical requirements.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18997

[ITU-T H.DLT-EMDGP] **General architecture for DLT-based energy metering data sharing platforms**

This Recommendation defines a general architecture for DLT-based energy metering data sharing platform. The general architecture includes the overall framework, functional structure, and basic process of DLT-based energy metering data sharing platform, the requirements of trusted collection, DLT-based energy metering data sharing platform and applications.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17642

[ITU-T H.DLT-RFCEDM] **Reference framework for carbon emission data management platforms based on distributed ledger technology**

This Recommendation specifies a reference framework for carbon emission data management platforms, which defines the main layers including infrastructure layer, data integration layer, DLT service layer, common service layer, industry application layer, security layer, and operations management layer, and specifies the technical requirements of the framework.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18998

[ITU-T F.740.3] **Metadata for digital representation of cultural relics/artworks using augmented reality**

This Recommendation describes the metadata for digital representation of cultural relics/artworks using augmented reality.

The scope of this Recommendation includes:

- Information flows of augmented reality cultural service;
- Metadata of augmented reality cultural service system.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17514

[ITU-T F.740.4] **Metadata for image aesthetics assessment with aesthetic attributes in mobile terminal computational photography systems**

This Recommendation defines metadata for image aesthetics assessment (IAA). The scope of this Recommendation includes:

- The structure of metadata for IAA.
- The dimensions of metadata for IAA.
- Requirements for sample collection.
- Requirements for labelling equipment and environment.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17606

[ITU-T F.740.5] **Data collection and annotation requirements for automatic white balance (AWB) enhancement in mobile terminal for digital culture**

This Recommendation describes the procedure and the requirement for data collection and annotation on automatic white balance (AWB) enhancement under uniform illumination condition in mobile terminal, which includes:

- Requirements of the data collection procedure.
- Requirements of the data annotation.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17605

[ITU-T F.CDA-RP] **Requirements and procedure for cultural data annotation**

This document specifies procedure for cultural data annotation, which include seven activities: data collection activity, data processing and screening activity, annotation scheme design activity, annotation tool selection activity, annotator recruitment activity, annotation result output activity, and annotation procedure management activity. In the meantime, this document specifies requirements that should be fulfilled at each activity.

This document targets cultural data existing in forms such as text, images, audio, video, and 3-D models. It carries out operations such as classification, recognition, segmentation, and boundary delineation on its inherent constituent elements, and performs semantic annotation to form specialized datasets. These datasets are used for machine learning, semantic search, and data visualization related to cultural applications.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=19005

[ITU-T F.CDSS-RF] **Requirements and framework for cultural data sharing system**

This draft Recommendation defines the requirements and framework for cultural data sharing system (CDSS). The following aspects are within the scope of this draft Recommendation:

- overview of CDSS;
- framework of CDSS;
- functional requirements of CDSS, including user management, cultural data management, and cultural data sharing service;
- the interfaces related to CDSS.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=19007

[ITU-T F.DC-CRATS-Meta] **Metadata for cultural relics and artworks tracing system based on blockchain**

The scope of this draft Recommendation includes: metadata based on cultural relic artwork traceability system, basic elements of text information and image information, according to the different categories of cultural relics art divided identity information data unit, as the target of cultural relics identity information and data in unified metadata standards. It can be applied to the modelling and data communication interaction of cultural relics and artworks, such as traceability, restoration, identification, and AR/VR, etc., including API metadata, metadata integration, middleware metadata, grid metadata, etc., taking the whole life cycle of art identity information chain into the blockchain application system.

- Cultural Relics and Artworks Tracing System: Operation Flow;
- Metadata for a Cultural Relics and Artworks Tracing System.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17547

[ITU-T F.DC-MTCPS-PFM] **Processing Flow and Metadata of Mobile Terminal Computational Photography System**

This draft Recommendation includes the following contents:

- Imaging control flow and image processing flow of computational photography system;
- Control metadata definitions and formats of computational photography system;
- Image metadata definitions and formats of computational photography system.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17608

[ITU-T F.DEC-RM] **Requirements and metadata for digitization of ethnic costumes**

This draft Recommendation identifies the requirement for traditional ethnic costume digitalization (shorten as DEC-RM, e.g., clothing, costume, pattern, symbol, etc.); it identifies metadata for digital storage and application in DEC-RM; it defines a set of shared metadata for digitization of ethnic costumes, which satisfies two requirements, one is protection and inheritance of integrity and authenticity requirement and the other is data generic requirement.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17479

[ITU-T F.MDI] **Metadata for disaster information presentation with human factors**

This Recommendation specifies metadata for disaster information presentation, including the natural disaster information presentation, and the social disaster information presentation.

The scope of this Recommendation includes:

- Overview of disaster information presentation with human factors;
- Metadata for the natural disaster information presentation;
- Metadata for the social disaster information presentation.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17523

[ITU-T H.MD-DiDRR] **Profile metadata for persons with specific needs as part of disability-inclusive disaster risk reduction**

This (draft) Recommendation describes Profile metadata for persons with specific needs as part of disability-inclusive disaster risk reduction.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17454

[ITU-T F.VG-DS] **Framework and requirements of the data sharing service platform for electric vehicle charging**

This draft Recommendation specifies the Framework and requirements of the data sharing service platform for electric vehicle charging, which guarantees efficient data interactive and sharing between multiple entities in the charging network and supports the applications such as charging guide, charging station planning, safe charging, and V2G.

The draft Recommendation is applicable to the architecture design, research and development of the data sharing service platform among electric vehicles, charging stations, and power grid.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=19002

[ITU-T H.ADSDP-spec] **Automated driving safety data protocol: Specification**

This draft Recommendation define an Automated driving (AD) safety data protocol, which is specifically designed for post-hoc monitoring of driving behaviour.

The AD safety data protocol specification defines the minimum set of data elements (DEs) and data frames (DFs) required for analysing the safe interaction of road users over space and time.

This Recommendation defines a protocol for communicating, storing and processing the safety data in real-time which enables safety monitoring onboard the vehicle, at the edge or in the cloud.

The AD safety data protocol specification defines a standardised data output from automated and assisted driving systems.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18621

[ITU-T F.MESafFra] **Evaluation framework of safety and effectiveness of active health data collection terminal equipment**

The proposed recommendation is focused evaluation framework of safety and effectiveness of active health data collection terminal equipment. This recommendation specifies physical interface, information security, electrical security, battery and power consumption characteristics, environmental adaptation and reliability, material security, electromagnetic compatibility, SAR, OTA, terminal interoperability, functional application.

The framework is evaluated from following aspects:

- physical interface;
- information security;
- electrical security;
- battery and power consumption characteristics;
- environmental adaptation and reliability;
- material security;
- electromagnetic compatibility;
- SAR;
- OTA;
- terminal interoperability;
- functional application.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17565

[ITU-T HSTP.MBI-UC] **Use-cases of e-health applications and services using brain data**

The main objective of this document is to describe use cases of e-health applications and services involving the usage of brain information. The use-cases are categorized into two typical types:

- brain status monitoring; and
- brain health intervention.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17455

[ITU-T L.1305] **Data centre infrastructure management system based on big data and artificial intelligence technology**

This Recommendation describes specifications of a data centre infrastructure management (DCIM) system based on big data and artificial intelligence (AI) technology. The system will

manage all infrastructure in the data centre at the same time through a comprehensive platform.

The scope of this Recommendation includes:

- network infrastructure of management systems;
- standardization of data collection of the installed module;
- interconnection among various kinds of monitoring sub-systems;
- requirements for different functions in a DCIM.

URL: <https://www.itu.int/rec/T-REC-L.1305-201911-I/en>

[ITU-T L.EE-dse] **Energy efficiency metrics and measurement methods for data storage equipment**

The Recommendation will define new energy efficiency measurement methods and metrics KPIs to support data storage. To define measurement methods for: 1) online storage, 2) nearline storage including HW and system.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17689

[ITU-T L.1307] **Energy Efficiency in Micro Data Centre for Edge Computing**

In order to achieve energy efficiency of micro data centres, which can be facilitated for edge computing, the scope of the Recommendation is as follows.

- Requirements on micro data centre for edge computing: deployment, configuration including redundancy, components;
- Energy efficiency in micro data centre: management functions including energy saving and operation perspective;
- Energy efficiency in edge computing: management functions including energy saving and operation perspective.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17702

[ITU-T L.Energy_sav_Cloud & Edge] **Energy saving design for Data Centre considering harmonization of Cloud and Edge**

This Recommendation will be focused on energy saving design for Data Centre considering harmonization of Cloud and Edge, such as definition, classification of energy-saving, characteristic requirement, specification of energy-saving structure design considering harmonization of Cloud and Edge, specification of location choosing and deployment, energy-saving requirement of architecture, energy-saving design of cooling system, energy-saving design of power supply system, energy-saving design of ambient monitor and smart management system.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17699

[ITU-T L.Suppl.52] **Computer processing, data management and energy perspective**

This Supplement presents a set of well-adopted energy efficiency practices for cyber-physical system classes and applications – enabled by artificial intelligence (AI), big data, Internet of things (IoT), and other innovative technologies.

To do so, a set of relevant and significant use cases are first introduced; Secondly, system classes are identified. Finally, according to a circular value-chain model, the system efficiency practices are specified and mapped to the components of the cyber-physical systems.

URL: <https://www.itu.int/rec/T-REC-L.Sup52-202210-I>

[ITU-T L.1306] **Specification of Edge Data Centre infrastructure**

This Recommendation focuses on the specification of edge data centre infrastructure, such as principles, basic components, technical specification of power feeding systems, cooling systems (design, maintenance, operation and energy consumption), monitoring systems and others.

URL: <https://www.itu.int/rec/T-REC-L.1306-202302-I>

[ITU-T L.MM_DC] **Energy Efficiency Metric and Measurement Methodology for Data Centers and Telecommunication Rooms**

This draft Recommendation will focus on data centres and telecommunication rooms (excluding radio base station sites), provides a systematic and complete energy efficiency metric and measurement methodology. Including energy, carbon, water, etc., it will provide specific methods. The metric to be developed will go further than traditional metrics such as PUE, and will consider the useful output of the IT equipment.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18964

[ITU-T L.thermal_DC] **Multi-level metrics for thermal environment and thermal performance of Data Centre**

This recommendation provides an introduction of evaluation indicator system defined from different perspectives, such as, depending on the region of the thermal environment room-level overall flow organization evaluation, rack-level thermal performance and flow organization evaluation, cabinet-level thermal performance and energy utilization efficiency. Guidelines on how to set and use the evaluation indicator system for a specific DC are proposed to:

- locate potential safety hazards of the thermal environment in the DC and make targeted improvements;
- judge the advantage and disadvantage as well as to assess the energy utilizing efficiency of the DCs with different thermal management strategies implemented;
- provide a standard for designing an energy-saving refrigeration system for a new DC and guide the optimization of existing DCs;
- provide a general and unified identification of the degree of energy-saving potential and energy consumption status, and hence specific the energy conversion direction for a better DC cooling system;
- offer basis on comparability of thermal performance of DCs with different sizes, layouts, and airflow organization patterns, etc.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18965

[ITU-T L.GHGemissions_DC] **Methodologies for accounting Greenhouse Gas Emissions of Data Centers and Telecommunication Rooms**

This Recommendation will provide the methodology for GHG emissions accounting in Data Centers and Telecommunication Rooms, which includes ICT equipment, as well as equipment for power supply, cooling system, energy storage, etc. About GHG emission, it will mainly consider GHG emission from scope1 and scope 2 which were defined in ISO14064-1, while other indirect GHG emissions scope 3 (value chain) followed by GHG Protocol is also be considered.

Following aspects are taken into consideration in this Recommendation:

- The boundaries of GHG emissions accounting in data center and telecommunication rooms.

- The specific methods on GHG emissions accounting in data center and telecommunication rooms, especially on direct emissions and indirect emissions.
- The accounting report of GHG emissions accounting in data center and telecommunication rooms.
- The quality assurance of accounting data of GHG emissions accounting in data center and telecommunication rooms.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17742

[ITU-T L.MM&BP_DC] **Measurement methodology and Best Practices for decarbonization of Data Center and Telecommunication Room in support of Net Zero**

This Recommendation will investigate how GHG emissions of Data Center and Telecommunication Room could be reduced during operation and maintenance to establish guidance on measurement of energy consumptions and best practices. It will also provide examples of best practices applied in different parts of the World.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17747

[ITU-T L.WHR] **Specification for waste heat reuse in telecommunication rooms and data centers**

This Recommendation will focus on technologies for the reuse of waste heat in telecommunications rooms and data centers and is described in terms of

- Current use cases and benefits of waste heat reuse;
- Development issues currently encountered with waste heat reuse;
- Technical specifications for waste heat reuse technologies, with recommendations for the establishment of relevant indicators.

URL: https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18399

I.2 ISO/IEC JTC 1 References and associated summaries

[ISO/IEC 20546] **Information technology – Big Data – Overview and vocabulary**

This document provides an overview of big data along with a set of terms and definitions. It provides a terminological foundation for big data-related standards.

URL: <https://www.iso.org/standard/68305.html>

[ISO/IEC 20547-1] **Information technology – Big data reference architecture – Part 1: Framework and application process**

This technical report (under development) describes the framework of the big data reference architecture and the process for how a user of the standard can apply it to their particular problem domain.

URL: <https://www.iso.org/standard/71275.html>

[ISO/IEC 20547-2] **Information technology – Big data reference architecture – Part 2: Use cases and derived requirements**

This document provides examples of big data use cases with application domains and technical considerations derived from the contributed use cases.

URL: <https://www.iso.org/standard/71276.html>

[ISO/IEC 20547-3] **Information technology – Big data reference architecture – Part 3: Reference architecture**

This International Standard (under development) specifies the big data reference architecture. The reference architecture includes the big data roles, activities, and functional components and their relationships.

URL: <https://www.iso.org/standard/71277.html>

[ISO/IEC 20547-5] **Information technology – Big data reference architecture – Part 5: Standards roadmap**

This document describes big data relevant standards, both in existence and under development, along with priorities for future big data standards development based on gap analysis.

URL: <https://www.iso.org/standard/72826.html>

[ISO/IEC 24668] **Information Technology – Artificial Intelligence – Process management framework for Big data analytics**

This document provides a framework for developing processes to effectively leverage big data analytics across the organization irrespective of the industries/sectors.

URL: <https://www.iso.org/standard/78368.html>

[ISO/IEC 8183] **Information technology - Artificial Intelligence – Data life cycle framework**

This document provides an overarching data life cycle framework that is instantiable for any AI system from data ideation to decommission. This document is applicable to the data processing throughout the AI system life cycle including the acquisition, creation, development, deployment, maintenance and decommissioning. This document does not define specific services, platforms or tools. This document is applicable to all organizations, regardless of type, sizes and nature, that use data in the development and use of AI systems.

URL: <https://www.iso.org/standard/83002.html>

[ISO/IEC 5259-1] **Artificial Intelligence – Data quality for analytics and ML – Part 1: Overview, terminology, and examples**

This document provides an overview of data quality for analytics and machine learning. It also discusses associated technologies and examples (e.g., use cases and usage scenarios).

URL: <https://www.iso.org/standard/81088.html>

[ISO/IEC 5259-2] **Artificial intelligence – Data quality for analytics and ML – Part 2: Data quality measures**

This document provides a data quality model, data quality measures, and guidance on reporting data quality in the context of analytics and machine learning (ML). This document builds on ISO 8000 series, ISO/IEC 25012 and ISO/IEC 25024. The aim of this document is to enable organizations to achieve their data quality objectives and is applicable to all types of organizations.

URL: <https://www.iso.org/standard/81860.html>

[ISO/IEC 5259-3] **Artificial Intelligence – Data quality for analytics and ML – Part 3: Data quality management requirements and guidelines**

This document specifies requirements and provides guidance for establishing, implementing, maintaining and continually improving the quality for data used in the areas of analytics and machine learning.

URL: <https://www.iso.org/standard/81092.html>

[ISO/IEC 5259-4] **Artificial Intelligence – Data quality for analytics and ML – Part 4: Data quality process framework**

This document provides general common organizational approaches, regardless of type, size or nature of the applying organization, to ensure data quality for training and evaluation in analytics and machine learning.

URL: <https://www.iso.org/standard/81093.html>

[ISO/IEC 5259-5] **Artificial Intelligence – Data quality for analytics and ML – Part 5: Data quality governance**

This document provides a data quality governance framework for analytics and machine learning to enable governing bodies of organizations to direct and oversee the implementation and operation of data quality measures, management, and related processes with adequate controls throughout the data life cycle. This document can be applied to any analytics and machine learning. This document does not define specific management requirements or process requirements specified in 5259-3 and 5259-4 respectively.

URL: <https://www.iso.org/standard/84150.html>

[ISO/IEC 5259-6] **Artificial Intelligence – Data quality for analytics and ML – Part 6: Visualization framework for data**

This document describes a visualization framework for data quality in analytics and machine learning. The aim is to enable stakeholders using visualization methods to assess the results of data quality measures. This visualization framework supports data quality goals.

URL: <https://www.iso.org/standard/86532.html>

[ISO/IEC 42103] **Artificial Intelligence – Overview of synthetic data in the context of AI systems**

This document provides an overview of synthetic data concepts methods, uses and considerations in the context of AI systems.

URL: <https://www.iso.org/standard/86899.html>

[ISO/IEC 20547-4] **Information technology – Big data reference architecture – Part 4: Security and privacy fabric**

This International Standard (under development) specifies the underlying Security and Privacy fabric that applies to all aspects of the big data reference architecture including the big data roles, activities, and functional components.

URL: <https://www.iso.org/standard/71278.html>

[ISO/IEC 20889] **Privacy enhancing data de-identification terminology and classification of techniques**

This document provides a description of privacy-enhancing data de-identification techniques, to be used to describe and design de-identification measures in accordance with the privacy principles in ISO/IEC 29100. In particular, this document specifies terminology, a classification of de-identification techniques according to their characteristics, and their applicability for reducing the risk of re-identification. This document is applicable to all types and sizes of organizations, including public and private companies, government entities, and not-for-profit organizations, that are PII controllers or PII processors acting on a controller's behalf, implementing data de-identification processes for privacy enhancing purposes.

URL: <https://www.iso.org/standard/69373.html>

[ISO/IEC 27000] **Information technology – Security techniques – Information security manage systems – Overview and vocabulary**

This International Standard provides the overview of information security management systems, and terms and definitions commonly used in the ISMS (Information Security Management System) family of standards. This International Standard is applicable to all types and sizes of organization (e.g., commercial enterprises, government agencies, not-for-profit organizations).

URL: <https://www.iso.org/standard/63411.html>

[ISO/IEC 27001] **Information technology – Security techniques – Information security manage systems – Requirements**

This International Standard specifies the requirements for establishing, implementing, maintaining and continually improving an information security management system within the context of the organization. This International Standard also includes requirements for the assessment and treatment of information security risks tailored to the needs of the organization. The requirements set out in this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size or nature.

URL: <https://www.iso.org/obp/ui/#iso:std:iso-iec:27001:ed-2:v1:en>

[ISO/IEC 27002] **Information technology – Security techniques – Code of practice for information security controls**

This International Standard gives guidelines for organizational information security standards and information security management practices including the selection, implementation and management of controls taking into consideration the organization's information security risk environment(s).

URL: http://www.iso.org/iso/catalogue_detail?csnumber=54533

[ISO/IEC 27018] **Information technology – Security techniques – Code of practice for protection of personally identifiable information (PII) in public clouds acting as PII processors**

This document establishes commonly accepted control objectives, controls and guidelines for implementing measures to protect Personally Identifiable Information (PII) in line with the privacy principles in ISO/IEC 29100 for the public cloud computing environment. In particular, this document specifies guidelines based on ISO/IEC 27002, taking into consideration the regulatory requirements for the protection of PII which can be applicable within the context of the information security risk environment(s) of a provider of public cloud services. This document is applicable to all types and sizes of organizations, including public and private companies, government entities and not-for-profit organizations, which provide information processing services as PII processors via cloud computing under contract to other organizations. The guidelines in this document can also be relevant to organizations acting as PII controllers. However, PII controllers can be subject to additional PII protection legislation, regulations and obligations, not applying to PII processors. This document is not intended to cover such additional obligations.

URL: <https://www.iso.org/standard/76559.html>

[ISO/IEC 27555] **Information security, cybersecurity and privacy protection – Guidelines on personally identifiable information deletion**

This document contains guidelines for developing and establishing policies and procedures for deletion of personally identifiable information (PII) in organizations by specifying:

- a harmonized terminology for PII deletion;

- an approach for defining deletion rules in an efficient way;
- a description of required documentation;
- a broad definition of roles, responsibilities and processes.

This document is intended to be used by organizations where PII is stored or processed. This document does not address:

- specific legal provision, as given by national law or specified in contracts;
- specific deletion rules for particular clusters of PII that are defined by PII controllers for processing PII;
- deletion mechanisms;
- reliability, security and suitability of deletion mechanisms;
- specific techniques for de-identification of data.

URL: <https://www.iso.org/standard/71673.html>

[ISO/IEC 27701] Security techniques – Extension to ISO/IEC 27001 and ISO/IEC 27002 for privacy information management – Requirements and guidelines

This document specifies requirements and provides guidance for establishing, implementing, maintaining and continually improving a Privacy Information Management System (PIMS) in the form of an extension to ISO/IEC 27001 and ISO/IEC 27002 for privacy management within the context of the organization. This document specifies PIMS-related requirements and provides guidance for PII controllers and PII processors holding responsibility and accountability for PII processing. This document is applicable to all types and sizes of organizations, including public and private companies, government entities and not-for-profit organizations, which are PII controllers and/or PII processors processing PII within an ISMS.

URL: <https://www.iso.org/standard/71670.html>

[ISO/IEC 29100] Information technology – Security techniques – Privacy framework

This International Standard provides a privacy framework which:

- specifies a common privacy terminology;
- defines the actors and their roles in processing personally identifiable information (PII);
- describes privacy safeguarding considerations; and
- provides references to known privacy principles for information technology.

URL: <https://www.iso.org/standard/45123.html>

[ISO/IEC 29101] Information technology – Security techniques – Privacy architecture framework

This document defines a privacy architecture framework that:

- specifies concerns for ICT systems that process PII;
- lists components for the implementation of such systems; and
- provides architectural views contextualizing these components.

This document is applicable to entities involved in specifying, procuring, architecting, designing, testing, maintaining, administering and operating ICT systems that process PII.

URL: <https://www.iso.org/standard/75293.html>

[ISO/IEC 29134] Information technology – Security techniques – Guidelines for privacy impact assessment

This document gives guidelines for

- a process on privacy impact assessments; and
- a structure and content of a PIA (Privacy Impact Assessment) report.

It is applicable to all types and sizes of organizations, including public companies, private companies, government entities and not-for-profit organizations. ISO/IEC 29134:2017 is relevant to those involved in designing or implementing projects, including the parties operating data processing systems and services that process PII.

URL: <https://www.iso.org/standard/75293.html>

[ISO/IEC 29151] Information technology – Security techniques – Code of practice for personally identifiable information protection

ISO/IEC 29151:2017 establishes control objectives, controls and guidelines for implementing controls, to meet the requirements identified by a risk and impact assessment related to the protection of personally identifiable information (PII). In particular, this Recommendation | International Standard specifies guidelines based on ISO/IEC 27002, taking into consideration the requirements for processing PII that may be applicable within the context of an organization's information security risk environment(s). ISO/IEC 29151:2017 is applicable to all types and sizes of organizations acting as PII controllers (as defined in ISO/IEC 29100), including public and private companies, government entities and not-for-profit organizations that process PII.

URL: <https://www.iso.org/standard/62726.html>

[ISO/IEC 29184] Information technology – Online privacy notices and consent

This document specifies controls which shape the content and the structure of online privacy notices as well as the process of asking for consent to collect and process personally identifiable information (PII) from PII principals.

This document is applicable in any online context where a PII controller or any other entity processing PII informs PII principals of processing.

URL: <https://www.iso.org/standard/70331.html>

[ISO/IEC 29190] Information technology – Security techniques – Privacy capability assessment model

ISO 29190:2015 provides organizations with high-level guidance about how to assess their capability to manage privacy-related processes. In particular, it:

- specifies steps in assessing processes to determine privacy capability;
- specifies a set of levels for privacy capability assessment;
- provides guidance on the key process areas against which privacy capability can be assessed;
- provides guidance for those implementing process assessment; and
- provides guidance on how to integrate the privacy capability assessment into organizations operations.

URL: <https://www.iso.org/standard/45269.html>

[ISO/IEC 19944-1] Cloud computing and distributed platforms – Data flow, data categories and data use – Part 1: Fundamentals

This document:

- extends the existing cloud computing vocabulary and reference architecture in ISO/IEC 17788 and ISO/IEC 17789 to describe an ecosystem involving devices using cloud services,
- describes the various types of data flowing within the devices and cloud computing ecosystem,
- describes the impact of connected devices on the data that flow within the cloud computing ecosystem,
- describes flows of data between cloud services, cloud service customers and cloud service users,
- provides foundational concepts, including a data taxonomy, and
- identifies the categories of data that flow across the cloud service customer devices and cloud services.

This document is applicable primarily to cloud service providers, cloud service customers and cloud service users, but also to any person or organization involved in legal, policy, technical or other implications of data flows between devices and cloud services.

URL: <https://www.iso.org/standard/79573.html>

[ISO/IEC 19944-2] Cloud computing and distributed platforms – Data flow, data categories and data use – Part 2: Guidance on application and extensibility

This document provides guidance on the application of the taxonomy and use statements from ISO/IEC 19944-1 in real world scenarios, and how to develop extensions to the data taxonomy, data processing and use categories and data use statements.

URL: <https://www.iso.org/standard/79574.html>

[ISO/IEC TR 23186] Information technology – Cloud computing – Framework of trust for processing of multi-sourced data

This document describes a framework of trust for the processing of multi-sourced data that includes data use obligations and controls, data provenance, chain of custody, security and immutable proof of compliance as elements of the framework.

URL: <https://www.iso.org/standard/74844.html?browse=tc>

[ISO/IEC 22624] Information technology – Cloud computing – Taxonomy based data handling for cloud services

This document:

- describes a framework for the structured expression of data-related policies and practices in the cloud computing environment, based on the data taxonomy in ISO/IEC 19944;
- provides guidelines on application of the taxonomy for handling of data based on data subcategory and classification;
- covers expression of data-related policies and practices including, but not limited to data geolocation, cross border flow of data, data access and data portability, data use, data management, and data governance;
- describes how the framework can be used in codes of conduct for practices regarding data at rest and in transit, including cross border data transfer, as well as remote access to data;
- provides use cases for data handling challenges, i.e., control, access and location of data according to ISO/IEC 19944 data categories.

This document is applicable primarily to cloud service providers, cloud service customers (CSCs) and cloud service users, but also to any person or organization involved in legal, policy, technical or other implications of taxonomy-based data management in cloud services.

URL: <https://www.iso.org/standard/73614.html>

[ISO/IEC 23751] **Information technology – Cloud computing – Data sharing agreement (DSA) framework**

URL: <https://www.iso.org/standard/76834.html>

I.3 ISO/TC 69 References and associated summaries

[ISO 3534-5] **Statistics – Vocabulary and symbols – Part 5: Terms used in big data (predictive analytics)**

Defines terms used in the statistical analysis of very large data sets and may be used in the drafting of other International Standards.

More specifically, it defines terms used in the field of statistics dealing with data sets that occur in the realm of so-called Big Data applications. The data sets can be large owing to one or more of the characteristics of volume, variety, velocity, and variability of the data. Volume refers to the size of the data set, which typically could exceed the storage capacity of the analyst's personal computer. Variety 23751

indicates that the data could reside in diverse domains within distinct data repositories while consisting of diverse data types (e.g., continuous, discrete, categorical, ordinal, images, and so forth). Velocity is tied to the rate of generation and transmission of the data that could be expanding at a rate beyond the analyst's ability to process and to assess the data in a timely fashion. Finally, variability suggests that the previous three "V's" (volume, variety and velocity) could be deviating over time.

URL: <https://www.iso.org/standard/75373.html?browse=tc>

[ISO 23347] **Statistics – Big Data Analytics – Data Science Life Cycle**

URL: <https://www.iso.org/standard/75289.html?browse=tc>

[ISO 23348] **Statistics – Big Data Analytics – Model Validation**

URL: <https://www.iso.org/standard/75290.html?browse=tc>

I.4 W3C references and associated summaries

[W3C MVTD] **Metadata Vocabulary for Tabular Data**

Validation, conversion, display, and search of tabular data on the web requires additional metadata that describes how the data should be interpreted. This document defines a vocabulary for metadata that annotates tabular data. This can be used to provide metadata at various levels, from groups of tables and how they relate to each other down to individual cells within a table.

URL: <http://www.w3.org/TR/tabular-metadata/>

[W3C MTDM] **Model for Tabular Data and Metadata on the web**

This document outlines a data model, or info set, for tabular data and metadata about that tabular data that can be used as a basis for validation, display, or creating other formats. It also contains some non-normative guidance for publishing tabular data as CSV and how that maps into the tabular data model.

URL: <http://www.w3.org/TR/2015/REC-tabular-data-model-20151217/>

[W3C DCAT2] **Data Catalog Vocabulary (DCAT) – Version 2**

This revision of DCAT has extended the previous version to support further use cases and requirements. These include the possibility of cataloging other resources in addition to datasets, such as data services. The revision also supports describing relationships between datasets as well as between datasets and other cataloged resources. Guidance on how to document licenses and rights statements associated with the cataloged items is provided.

URL: <http://www.w3.org/TR/vocab-dcat-2/>

[W3C OO] **The Organization Ontology**

This document describes a core ontology for organizational structures, aimed at supporting linked data publishing of organizational information across a number of domains. It is designed to allow domain-specific extensions to add classification of organizations and roles, as well as extensions to support neighboring information such as organizational activities.

URL: <http://www.w3.org/TR/vocab-org/>

[W3C LDP 1.0] **Linked Data Platform 1.0**

LDP defines a set of rules for Hypertext Transfer Protocol (HTTP) operations on web resources, some based on RDF, to provide an architecture for read-write Linked Data on the web.

URL: <http://www.w3.org/TR/ldp/>

[W3C JSON-LD 1.1] **A JSON-based Serialization for Linked Data**

Linked Data is a way to create a network of standards-based machine interpretable data across different documents and Web sites. It allows an application to start at one piece of Linked Data, and follow embedded links to other pieces of Linked Data that are hosted on different sites across the Web. JSON-LD is a lightweight syntax to serialize Linked Data in JSON. Its design allows existing JSON to be interpreted as Linked Data with minimal changes. JSON-LD is primarily intended to be a way to use Linked Data in Web-based programming environments, to build interoperable Web services, and to store Linked Data in JSON-based storage engines. Since JSON-LD is 100% compatible with JSON, the large number of JSON parsers and libraries available today can be reused. In addition to all the features JSON provides, JSON-LD introduces:

- a universal identifier mechanism for JSON objects via the use of IRIs,
- a way to disambiguate keys shared among different JSON documents by mapping them to IRIs via a context,
- a mechanism in which a value in a JSON object may refer to a JSON object on a different site on the Web,
- the ability to annotate strings with their language,
- a way to associate datatypes with values such as dates and times,
- and a facility to express one or more directed graphs, such as a social network, in a single document.

URL: <https://www.w3.org/2018/jsonld-cg-reports/json-ld/#introduction>

[W3C RDF 1.1] **Resource Description Framework 1.1**

The Resource Description Framework (RDF) is a framework for representing information in the Web. This document defines an abstract syntax (a data model) which serves to link all RDF-based languages and specifications. The abstract syntax has two key data structures:

RDF graphs are sets of subject-predicate-object triples, where the elements may be IRIs, blank nodes, or datatyped literals. They are used to express descriptions of resources. RDF datasets are used to organize collections of RDF graphs, and comprise a default graph and zero or more named graphs. RDF 1.1 Concepts and Abstract Syntax also introduces key concepts and terminology, and discusses datotyping and the handling of fragment identifiers in IRIs within RDF graphs.

URL: <https://www.w3.org/TR/rdf11-concepts/>

[W3C ODRL V&E 2.2] **The Open Digital Rights Language Vocabulary & Expression 2.2**

The Open Digital Rights Language (ODRL) is a policy expression language that provides a flexible and interoperable information model, vocabulary, and encoding mechanisms for representing statements about the usage of content and services. The ODRL Vocabulary and Expression describes the terms used in ODRL policies and how to encode them.

URL: <https://www.w3.org/TR/2018/REC-odrl-vocab-20180215/>

I.5 OASIS references and associated summaries

[OASIS AMQP 1.0] **Advanced Message Queuing Protocol Version 1.0**

The AMQP is an open Internet protocol for business messaging. It defines a binary wire-level protocol that allows for the reliable exchange of business messages between two parties. AMQP has a layered architecture and the specification is organized as a set of parts that reflects that architecture.

URL: <http://docs.oasis-open.org/amqp/core/v1.0/os/amqp-core-overview-v1.0-os.html>

[OASIS MQTT 3.1.1] **Message Queuing Telemetry Transport Version 3.1.1**

MQTT is a client server publish/subscribe messaging transport protocol. It is light weight, open, simple, and designed so as to be easy to implement. These characteristics make it ideal for use in many situations, including constrained environments such as for communication in M2M and IoT contexts where a small code footprint is required and/or network bandwidth is at a premium.

URL: <http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html>

[OASIS XMILE 1.0] **XML Interchange Language for System Dynamics (XMILE) Version 1.0**

XMILE is an open XML protocol for the sharing, interoperability, and reuse of system dynamics (SD) models and simulations. The document defines the XMILE language and format for anyone who wishes to use SD models or embed them in their applications, such as vendors of SD software, big data, cloud, mobile, and social media solutions.

URL: <http://docs.oasis-open.org/xmile/xmile/v1.0/os/xmile-v1.0-os.html>

I.6 Data Mining Group references and associated summaries

[DMG PMML 4.4] **Predictive Model Markup Language 4.4**

PMML is XML-based file format to provide a way for applications to describe and exchange models produced by data mining and machine learning algorithms. It supports common models such as logistic regression and feed forward neural networks.

URL: <http://dmg.org/pmml/pmml-v4-4.html>

[DMG PFA] **Portable Format for Analytics**

PFA is a mini-language for mathematical calculations that is usually generated programmatically, rather than by hand. A PFA document is a string of JSON-formatted text that describes an executable called a scoring engine. Each engine has a well-defined input, a

well-defined output, and functions for combining inputs to construct the output in an expression-centric syntax tree.

URL: <http://dmq.org/pfa/index.html>

I.7 TM Forum references and associated summaries

[TMF BDAG] The Big Data Analytics Guidebook

The guidebook provides guidance to a communication service provider on the major components that are needed for the implementation of real-life big data analytics use cases. It defines a reference model, use cases, business value roadmap, building blocks and the analytics big data repository for big data analytics. It also includes addendums, which are:

- Big data analytics use cases – Best practice;
- Big data analytics building blocks – Best practice;
- Big data analytics privacy risk score details – Best practice;
- Big data analytics big data repository – Best practice.

URL: <https://www.tmforum.org/resources/collection/gb979-big-data-analytics-solution-suite-r15-5-1/>

[TMF DGG] Data Governance Guidebook v3.0.0

The Data Governance Guidebook has been created to provide guidance of the process and steps to implementing a data governance program. The goal of the guidebook is to enable organizations, at all levels of data maturity, to take steps to define a data governance program specific to the organizations business and data strategy. The Data Governance Guidebook is a guide not only for those contemplating transforming their current data situation but also those that have recognized that data, just as any other organization asset, is tangible and valuable to the enterprise that must be leveraged in a secure, responsible manner. The Data Governance guidebook provides information to assist the transition to a data-driven enterprise and address the resistance and impacts of cultural change.

URL: <https://www.tmforum.org/resources/standard/gb1023-data-governance-guidebook-v2-0-0/>

[TMF DGMM] Data Governance Maturity Model v3.0.0

The purpose of this guide is to provide a detailed description of the Process, People and Technology-related aspects for each criteria at each level of maturity of the Data Governance subdimension – as defined in the Data dimension of TM Forum's Digital Maturity Model. It provides further context, along with additional explanatory text to clarify the scope of the criteria. It is strongly recommended to use the Digital Maturity Model (DMM) as part of a progressive capability rollout led by certified DMM practitioners who have deep knowledge of the model structure and contents.

URL: <https://www.tmforum.org/resources/how-to-guide/gb1025-data-governance-maturity-model-v3-0-0/>

Bibliography

- [b-ITU-T D4.4] ITU-T Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities, Technical Specification D4.4, July 2019, *Framework to support data quality management in IoT*.
- [b-ITU-T F.751.0] Recommendation ITU-T F.751.0 (2020), *Requirements for distributed ledger systems*.
- [b-ITU-T Y.2060] Recommendation ITU-T Y.2060 (2013), *Overview of the Internet of things*.
- [b-ITU-T Y.2774] Recommendation ITU-T Y.2774 (2019), *Functional Requirements of deep packet inspection for future networks*.
- [b-ITU-T Y.3073] Recommendation ITU-T Y.3073 (2019), *Framework for service function chaining in information-centric networking*.
- [b-ITU-T Y.3174] Recommendation ITU-T Y.3174 (2020), *Framework for data handling to enable machine learning in future networks including IMT-2020*.
- [b-ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014), *Information technology – Cloud computing – Overview and vocabulary*.
- [b-ITU-T Y.3540] Recommendation ITU-T Y.3540 (2023), *Edge computing – Overview and high-level requirements*.
- [b-ITU-T Y.3600] Recommendation ITU-T Y.3600 (2015), *Big data – Cloud computing based requirements and capabilities*.
- [b-ITU-T Y.3652] Recommendation ITU-T Y.3652 (2020), *Big data-driven networking – Requirements*.
- [b-Chen] Min Chen, Shiwen Mao, Ying Zhang, et al. (2014), *Big Data: Related Technologies, Challenges and Future Prospects*, Springer.
- [b-CRA] Challenges and Opportunities with Big Data (2012), *Computing Research Association*, November.
- [b-CSA] Cloud Security Alliance (2012), *Top Ten Big Data Security and Privacy Challenges*.
- [b-FG-DPM] ITU-T Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities
<<https://www.itu.int/en/ITU-T/focusgroups/dpm/Pages/default.aspx>>
- [b-GSMA] GSMA, *Big Data Analytics and Artificial Intelligence for Impact Course*.
<<https://www.gsma.com/>>
- [b-IBM] IBM Data Security and Protection, *What are data security and data privacy?*
<<http://www-01.ibm.com/software/data/security-privacy/>>
- [b-OASIS] OASIS Committee Categories: *Big Data*.
<https://www.oasis-open.org/committees/tc_cat.php?cat=bigdata>
- [b-TC 69] ISO/TC 69
<<https://www.iso.org/committee/49742.html>>
- [b-W3C-DPVCG] W3C, Data Privacy Vocabularies and Controls Community Group.
<<http://www.w3.org/community/dpvcg/>>

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