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

## ITU-T Y.3600 – Big data standardization roadmap

ITU-T Y-series Recommendations – Supplement 40

International Telecommunication Union

ITU-T Y-SERIES RECOMMENDATIONS

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# Supplement 40 to ITU-T Y-series Recommendations

## ITU-T Y.3600 – Big data standardization roadmap


### Summary

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



### History

| Edition | Recommendation | Approval | Study Group | Unique ID* |
|---|---|---|---|---|
| 1.0 | ITU-T Y Suppl. 40 | 2016-07-08 | 13 | 11.1002/1000/13022 |

### Keywords

Big data, big data ecosystem, data analytics, roadmap.


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

## FOREWORD

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

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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# ITU-T Y.3600 – Big data standardization roadmap

## 1 Scope

This Supplement provides the standardization roadmap for big data area in the telecommunication sector. It addresses the following subjects:

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

## 2 References

[ITU-T Y.2060] Recommendation ITU-T Y.2060 (2013), *Overview of the Internet of things*.

[ITU-T Y.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking*.

[ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014), *Information technology – Cloud computing – Overview and vocabulary*.

[ITU-T Y.3600] Recommendation ITU-T Y.3600 (2015), *Big data – Cloud computing based requirements and capabilities*.

## 3 Definitions

### 3.1 Terms defined elsewhere

This Supplement uses the following term defined elsewhere:

**3.1.1 big data** [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:

AMQP Advanced Message Queuing Protocol

API Application Program Interface

BDaaS Big Data as a Service

BDC Big Data service Customer

bDDN big Data-Driven Networking

BDSP Big Data Service Provider

| | |
|---|---|
| CSV | Comma-Separated Values |
| DCAT | Data Catalogue Vocabulary |
| DMG | Data Ming Group |
| DPI | Deep Packet Inspection |
| HTTP | Hypertext Transfer Protocol |
| ICT | Information and Communications Technology |
| IEC | International Engineering Consortium |
| IoT | Internet of Things |
| ISO | International Organization for Standardization |
| JSON | Java Script Object Notation |
| JTC 1 | Joint Technical Committee 1 |
| KVDB | Key-Value Database Application Interface |
| LDP | Linked Data Platform |
| M2M | Machine to Machine |
| MQTT | Message Queuing Telemetry Transport |
| PMML | Predictive Model Markup Language |
| RDF | Resource Description Framework |
| SC | Subcommittee |
| SDN | Software-defined Networking |
| SDO | Standards Development Organization |
| SG | Study Group |
| TC | Technical Committee |
| URL | Uniform Resource Locator |
| W3C | World Wide Web Consortium |
| WG | Working Group |
| XMILE | XML Interchange Language |
| XML | Extensible Markup Language |

## 5 Conventions

None.

## 6 Landscape of big data from an ITU-T perspective

### 6.1 Characteristics and general concepts of big data

[ITU-T Y.3600] describes the characteristics and general concepts of the big data ecosystem.

With the rapid development of information and communications technology (ICT), Internet technologies and services, huge amount of data are generated, transmitted and stored with explosive growth. Data are generated by many sources and not only sensors, cameras, network devices, web pages, email systems, social networks and many other sources. Datasets are becoming so large and

complex or are arriving so fast that traditional data processing methods and tools are inadequate. Efficient analytics of data within tolerable elapsed times becomes very challenging. The paradigm being developed to resolve the above issues are called big data [ITU-T Y.3600].

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. [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 [ITU-T Y.3600]:

- **Volume**: refers to the amount of data collected, stored, analyzed 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 – 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.

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 [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 analyzed 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 [ITU-T Y.3600].

## 6.2 Benefits of big data

Big data technologies can provide many benefits such as data accessibility, productivity of business processes, and cost reduction to private via public sector.

Big data technology increases data accessibility by:

- Unlocking significant value by making information transparent;
- Creating and storing transactional data in digital form;
- Reducing time for finding/accessing the correct data.

Big data technology improves productivity by:

- Real-time monitoring and forecasting of events that impact either business performance or operations;
- Timely insights from the vast amount of data;
- Identifying significant information that can improve decision quality or minimize risks;
- Creating new service models using big data analytics.

Big data technology reduces cost by:

- Scale-out of data storage;
- Identifying and reducing inefficiencies.

# 7 Related technical areas of big data

## 7.1 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 [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 resources 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 [ITU-T Y.3600].

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

1) Cloud computing can support big data using cloud infrastructure and services;

2) Big data services can provide public cloud analysis services, such as big data as a service (BDaaS).

### 7.2 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 [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.).

### 7.3 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 programing 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.

### 7.4 Software-defined networking

Software-defined networking (SDN) is a set of techniques that enables users to directly program, orchestrate, control and manage network resources, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner [ITU-T Y.3300]. By abstracting the underlying infrastructure for applications and network services, SDN lets administrators dynamically adjust network-wide traffic flow to meet changing needs, while maintaining a global view of the network.

Big data processing requires agile, multi-domain, centrally managed architecture. SDN addresses the congestion and lack of scalability of current networks by [b-NEC]:

- Allowing for changing traffic patterns;
- Providing functionality to applications that access geographically distributed databases and servers through public and private clouds;
- Providing access to bandwidth on demand.

### 7.5 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 DPI].

### 7.6 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 DDN].

### 7.7 Open data

Open data is accessible public data that people, companies, and organizations can use to launch new ventures, analyze patterns and trends, make data-driven decisions, and solve complex problems. Open data includes two basic features: the data must be publicly available for anyone to use, and it must be licensed in a way that allows for its reuse [b-theguardian]. 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.

### 7.8 Standardization areas of big data

This clause describes the potential areas of standardization for big data that may be of interest to ITU-T [b-ITU-T TSAG]:

- Common requirements and use cases;
- Definition, architecture, data model and application program interfaces (APIs);
- Network-driven data analytics;
- Personalized network experience;
- Security and data protection, anonymization and de-identification of personal data;
- Framework for data quality and veracity;
- Standards and guidelines to address issues surrounding legal implications of big data in the telecommunications sector (e.g., data ownership);
- Framework and related standards for telecom big data exchange.

## 8 Conceptual model of big data ecosystem

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

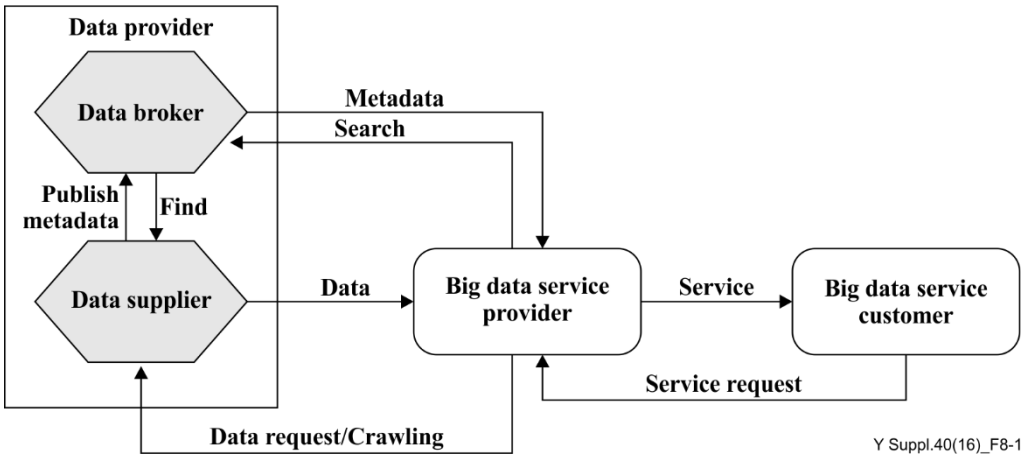


**Figure 8-1 – Big data ecosystem (from [ITU-T Y.3600])**

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 Big data SDO activities

This clause describes SDO's activities with big data 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

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

- Q17/13 deals with cloud computing and big data. In November 2015, ITU-T SG13 published [ITU-T Y.3600], "Big data – Cloud computing based requirements and capabilities".
- Q18/13 deals with cloud functional architecture, infrastructure and networking; the draft Recommendation [ITU-T Y.BDaaS-arch] describes an architecture for BDaaS.
- Q7/13 has been studying DPI in support of service/application awareness in evolving networks, and initiated draft Recommendations about DPI and bDDN for supporting big data.

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.

ITU-T SG 20 is responsible for IoT and its applications, with an initial focus on smart cities and communities (SC&C). In November 2015, Q2/20 initiated a draft Recommendation [ITU-T Y.IoT-BigData-reqts], "Specific requirements and capabilities of the Internet of Things for Big Data" which describes the characteristics of big data in the context of IoT. Table 9-1 lists the ITU-T deliverables and work items related to big data.

**Table 9-1 – ITU-T deliverables and work items related to big data**

| Study group | Reference (Note) | Title | Status |
|---|---|---|---|
| SG 13 | [ITU-T Y.3600] | Big data – Cloud computing based requirements and capabilities | Published 2015 |
| SG 13 | [ITU-T Y.BigDataEX-reqts] | Big data exchange framework and requirements | 2Q 2017 |
| SG 13 | [ITU-T Y.BdaaS-arch] | Functional architecture of Big data as a Service | Dec. 2016 |
| SG 13 | [ITU-T Y.bDDN-req] | Requirement of big data-driven networking | Dec. 2018 |
| SG 13 | [ITU-T Y.bDDN-fr] | Framework of big data driven networking based on DPI | Jul. 2018 |
| SG 13 | [ITU-T Y.dsf-reqts] | Requirements and Capabilities for Data Storage Federation | 2Q 2018 |
| SG 13 | [ITU-T Y.bDPI-Mec] | Mechanism of deep packet inspection applied in network big data context | Dec. 2018 |
| SG 13 | [ITU-T Y.SDN-ARCH] | Functional architecture of software-defined networking | Jul. 2017 |
| SG13 | [ITU-T Y.bdp-reqts] | Big data – Requirements for data provenance | 4Q 2018 |

**Table 9-1 – ITU-T deliverables and work items related to big data**

| Study group | Reference (Note) | Title | Status |
|---|---|---|---|
| SG 17 | [ITU-T X.1601] | Security framework for cloud computing | Published 2014 |
| SG 17 | [ITU-T X.CSCDataSec] | Guidelines for cloud service customer data security | Dec. 2016 |
| SG 20 | [ITU-T Y.IoT-BigData-reqts] | Specific requirements and capabilities of the Internet of Things for Big data | 4Q 2016 |
| 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 working group (WG) 9 [b-JTC 1] on big data to:

- Serve as the focus of, and proponent for, big data standardization;
- Develop foundational standards for big data – including reference architecture and vocabulary standards – for guiding big data efforts throughout JTC 1 upon which other standards can be developed;
- Develop other big data standards that build on the foundational standards when relevant JTC 1 subgroups, that could address these standards, do not exist or are unable to develop them.
- Identify gaps in big data standardization;
- Develop and maintain liaisons with all relevant JTC 1 entities as well as with any other JTC 1 subgroup that may propose work related to big data in the future;
- Identify JTC 1 (and other organization) entities that are developing standards and related material that contribute to big data, and where appropriate, investigate ongoing and potential new work that contributes to big data;
- Engage with the community outside of JTC 1 to grow the awareness of and encourage engagement in JTC 1 big data standardization efforts within JTC 1, forming liaisons as is needed.

JTC 1 subcommittee (SC) 27 has been developing standards for the protection of information and ICT, which include generic methods, techniques and guidelines to address aspects of both security and privacy. Security and privacy is one of the cross cutting aspect on ICT, and the activities of SC 27 can be applied to the area of big data as well.

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 9-2 lists the JTC 1 deliverables and work items related to big data.

**Table 9-2 – JTC 1 deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| WG 9 | [ISO/IEC 20546] | Information technology – Big data – Overview and vocabulary | Aug. 2017 |

**Table 9-2 – JTC 1 deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| WG 9 | [ISO/IEC 20547-1] | Information technology – Big data – Reference architecture – Part 1: Framework and Application Process | Apr. 2017 |
| WG 9 | [ISO/IEC 20547-2] | Information technology – Big data – Reference architecture – Part 2: Use Cases and Derived Requirements | Dec. 2016 |
| WG 9 | [ISO/IEC 20547-3] | Information technology – Big data – Reference architecture – Part 3: Reference architecture | Dec. 2017 |
| WG 9 | [ISO/IEC 20547-5] | Information technology – Big data – Reference architecture – Part 5: Standards roadmap | Apr 2017 |
| SC 27 | [ISO/IEC 20547-4] | Information technology – Big data – Reference architecture – Part 4: Security and privacy fabric | May 2018 |
| SC 27 | [ISO/IEC 27000] | Information technology – Security techniques – Information security manage systems – Overview and vocabulary | Published 2014 |
| 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 29100] | Information technology – Security techniques – Privacy framework | Published 2011 |
| SC 38 | [ISO/IEC 19944] | Information technology – Cloud computing – Data and their flow across devices and cloud services | Oct. 2017 |
| NOTE – Clause I.2 contains a description of each cited reference. | | | |

## 9.3 W3C

The World Wide Web Consortium (W3C) big data community explores emerging big data pipelines and discusses the potential for developing standard architectures, APIs, and languages that will improve interoperability, enable security, and lower the overall cost of big data solutions. In addition, this group will also develop tools and methods that will enable:

- Trust in big data solutions;
- Standard techniques for operating on big data; and
- Increased education and awareness of accuracy and uncertainties associated with – applying emerging techniques to big data [b-W3C-BDCG].

The W3C Open Government Community Group's mission is to discuss and prepare data and API specifications relating to open government information. This group defines various serializations of the specifications, including but not limited to resource description framework (RDF) and Java script object notation (JSON) [b-W3C-OGCG].

Furthermore, W3C has the following data activities related to big data:

- RDF WG;
- Linked data platform (LDP) WG;
- Data on the Web best practices WG;
- CSV (comma-separated values) on the Web WG.

Table 9-3 lists the W3C deliverables and work items related to big data.

**Table 9-3 – W3C deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| CSV on the Web WG | [W3C MVTD] | 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 DCAT] | Data Catalog Vocabulary (DCAT) | Published 2014 |
| 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 1.0 | A JSON-based Serialization for Linked Data | Published 2014 |
| RDF WG | RDF 1.1 | RDF 1.1 Concepts and Abstract Syntax | Published 2014 |
| NOTE – Clause I.3 contains a description of each cited reference. | | | |

## 9.4 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 Key-Value Database Application Interface (KVDB) TC: defines an open application programming interface for managing and accessing data from database systems based on a key-value model;
- 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;
- OASIS XML Interchange Language (XMILE) for System Dynamics TC: defines an open XML protocol for sharing interoperable system dynamics models and simulations.

Table 9-4 lists the OASIS deliverables and work items related to big data.

**Table 9-4 – OASIS deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| AMQP TC | [OASIS AMQP 1.0] | Advanced Message Queuing Protocol Version 1.0 | Published 2012 |

**Table 9-4 – OASIS deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| MQTT TC | [OASIS MQTT 3.1.1] | Message Queuing Telemetry Transport Version 3.1.1 | Published 2014 |
| NOTE – Clause I.4 contains a description of each cited reference. | | | |

## 9.5 Data Mining Group

The Data Mining Group (DMG) is a vendor led consortium that develops data mining related standards. The DMG develops the Predictive Model Markup Language (PMML), which is an XML-based file format to provide a way for applications to describe and exchange models produced by data mining and machine learning algorithms. Table 9-5 lists the DMG deliverables and work items related to big data.

**Table 9-5 – DMG deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| – | [DMG PMML 4.2.1] | Predictive Model Markup Language 4.2.1 | Published 2014 |
| NOTE – Clause I.5 contains a description of each cited reference. | | | |

## 9.6 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 9-6 lists the TM Forum deliverables and work items related to big data.

**Table 9-6 TM Forum deliverables and work items related to big data**

| Sub group | Reference (Note) | Name/Title | Status |
|---|---|---|---|
| – | [TMF BDAG] | The Big Data Analytics Guidebook | Published 2015 |
| NOTE – Clause I.6 contains a description of each cited reference. | | | |

# 10 Gap analysis in big data standardization

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

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

- **General, definition**: the standard which provides general descriptions or terms and definitions of the technology;
- **Common requirements, use cases**: the standard which provides use cases and derived general/functional requirements;

- **Architecture**: the standard which provides reference architecture;
- **API, interface, profile**: the standard which provides common interface, API and/or its profile;
- **Data model, format, schema**: the standard which provides data model or protocol including scheme and/or its encoding format;
- **Others** (e.g., guidelines, technical reports).

The vertical axis describes the related technologies for supporting big data as follows.

- **Fundamental**: concept of big data and its applications;
- **Data exchange**: for supporting big data publishing, sharing, transaction, etc.;
- **Data integration**: with heterogeneous data sources;
- **Analysis/visualization**: for mining model description, etc.;
- **Data provenance/metadata**: for data quality, history tracking, data management, etc.;
- **Security/privacy**: for big data, especially personal identification information;
- **Other**: big data 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.

**Table 10-1 – Standardization matrix of big data**

| | **General/ Definition** | **Common requirement/ Use case** | **Architecture** | **API, Interface and its profile** | **Data model, format, schema** | **Others (e.g., guideline)** |
|---|---|---|---|---|---|---|
| **Fundamental** | **ITU-T Y.3600**<br>ISO/IEC 20546<br>ISO/IEC 20547-1 | **ITU-T Y.3600** | **ITU-T Y.BDaaS-arch**<br>ISO/IEC 20547-3 | | | |
| **Data exchange** | **ITU-T Y.BigDataEX-reqts** | **ITU-T Y.BigDataEX-reqts** | | | OASIS AMQP 1.0<br>OASIS MQTT 3.1.1 | |
| **Data integration** | | | | | W3C DCAT<br>W3C JSON-LD 1.0<br>W3C LDP 1.0<br>W3C RDF 1.1<br>W3C OO | |
| **Analysis /Visualization** | | | | | DMG PMML 4.2.1 | TMF BDAG |
| **Data Provenance /Metadata** | **ITU-T Y.bdp-reats** | **ITU-T Y.bdp-reats** | | | W3C MVTD<br>W3C MTDMW | |
| **Security /Privacy** | **ITU-T X.1601**<br>ISO/IEC 27000<br>IEO/IEC 29100 | ISO/IEC 20547-4 | | | ISO/IEC 27002<br>ISO/IEC 27018 | **ITU-T X.CSCDataSec**<br>ISO/IEC 27001 |

**Table 10-1 – Standardization matrix of big data**

| | General/ Definition | Common requirement/ Use case | Architecture | API, Interface and its profile | Data model, format, schema | Others (e.g., guideline) |
|---|---|---|---|---|---|---|
| **Others** | **ITU-T Y.bDPI-Mec**<br>**ITU-T Y.bDDN-fr** | **ITU-T Y.IoT-BigData-reqts**<br>**ITU-T Y.dsf-reqts**<br>**ITU-T Y.bDDN-req**<br>ISO/IEC 20547-2 | **ITU-T Y.SDN-ARCH** | | | ISO/IEC 19944<br>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', 'common requirement/use cases' with each technical area described in vertical axis;
- It is expected that standardization efforts of ITU-T will be moved to 'architecture' of each technical areas;
- Consideration on standardizing 'analysis/visualization' is needed;
- The entries under the column 'API, interface and its profile' of each of technical standardization areas are empty. 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 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.bDPI-Mec] Mechanism of deep packet inspection applied in network big data context

This proposed Recommendation specifies mechanism of DPI for network big data. The scope of this proposed Recommendation includes:

– overview of big data processing procedure;
– analysing role of DPI in big data processing procedure;
– data classification mechanism used for DPI for big data;
– data pre-processing mechanism used for DPI for big data;
– coordination processing mechanism of DPI in network big data context;
– interfaces between DPI and the upper-layer big data related method.

URL: http://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10966

[ITU-T Y.bDDN-req] Requirement of big data-driven networking

This proposed Recommendation specifies the requirements of bDDN. bDDN, aims at solving the problem where the valuable information from the network can't effectively be used by the network, through making full use of big data generated by the network itself; this can provide the data intelligence to facilitate network management, operation, control, optimization and security, etc. The scope of this work includes:

– requirements for bDDN;
– requirements of big data plane for bDDN;
– requirements of network plane for bDDN;
– requirements of management plane for bDDN;
– interface requirements for bDDN;

URL: http://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10967

[ITU-T Y.bDDN-fr] Framework of big data driven networking based on DPI

This proposed Recommendation specifies the framework of data-driven networking based on DPI.

URL: http://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10629

[ITU-T Y.dsf-reqts] Requirements and Capabilities for Data Storage Federation

This proposed Recommendation specifies requirements and capabilities of data storage federation which is based on the collection of use cases

within telecommunication ecosystem, analyses of gaps with different technologies and identification of related documents in cloud computing and big data area.

The scope of this proposed Recommendation includes:

– Overview of data storage federation;
– Requirements of data storage federation;
– Capabilities of data storage federation;
– Use cases of data storage federation.

URL: http://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10972

[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.BigDataEX-reqts] Big data exchange framework and requirements

This proposed Recommendation specifies the big data exchange framework and requirements, which is based on the collection of use cases and scenarios, analyses of gaps with different application areas and identification of functional requirements within telecommunication ecosystem.

The scope of this proposed Recommendation consists of:

– Overview of big data exchange;
– Framework of big data exchange;
– Functional requirements of big data exchange.

URL: http://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10542

[ITU-T Y.BDaaS-arch] Cloud computing - Functional architecture of Big Data as a Service

This proposed Recommendation specifies the functionalities, functional components, functional architecture, and reference points of BDaaS.

The scope of this proposed Recommendation includes:

– Overview of BDaaS functional architecture;
– Functional components of BDaaS;

– Functional architecture of BDaaS;
– Reference points of BDaaS functional architecture.

URL: http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=10548

[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.CSCDataSec] Guidelines for cloud service customer data security

This proposed Recommendation provides guidelines for cloud service customer 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 proposed Recommendation, also, identifies security controls for cloud service customer data that can be used in different stages of the full data lifecycle.

URL: http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=10273

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

Building on the identified specific requirements of the IoT for big data, the capabilities of the IoT for big data are specified.

The scope of this proposed 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/itu-t/workprog/wp_item.aspx?isn=10258

ITU-T Y.SDN-ARCH Functional architecture of software-defined networking

This proposed Recommendation describes the functional architecture SDN by providing components of the architecture and appropriate interfaces

URL: http://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=10233

[ITU-T Y.bdp-reqts] Big data – Requirements for data provenance

This proposed Recommendation specifies the overview and requirements of big data provenance.

The scope of this proposed Recommendation includes:
– Overview of big data provenance concept including characteristics, application area, and functional framework;
– Requirements of big data provenance;
– Use cases of big data provenance.

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

[ISO/IEC WD 20546] Information technology – Big Data – Definition and Vocabulary

This International Standard (under development) 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: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=68305

[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.

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

This technical report (under development) would decompose a set of contributed use cases into general big data reference architecture requirements.

[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.

[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.

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

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

[ISO/IEC 19944] Information technology – Cloud computing – Cloud services and devices: data flow, data categories and data use

Establish common and functional ways of understanding and describing the breadth of the cloud service ecosystem.

Enumerate and define the types of connections that can exist between cloud services and customers where their devices are mobile.

Provide foundational concepts necessary to enable others to provide guidance concerning data locality, mobile ecosystem issues, and identity issues.

Identify the types of data that flow across the customers and cloud services ecosystem and that can help cloud customers'

URL: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=66674

[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 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: http://www.iso.org/iso/catalogue_detail?csnumber=63411

[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 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:
http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=45123

## I.3 W3C references and associated summaries

[W3C DCAT] Data Catalog Vocabulary (DCAT)

The DCAT is an RDF vocabulary designed to facilitate interoperability between data catalogs published on the Web. This document defines the schema and provides examples for its use.

By using DCAT to describe datasets in data catalogs, publishers increase discoverability and enable applications easily to consume metadata from multiple catalogs. It further enables decentralized

publishing of catalogs and facilitates federated dataset search across sites. Aggregated DCAT metadata can serve as a manifest file to facilitate digital preservation.

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

[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 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 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 infoset, 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/

## I.4 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

## I.5 Data Mining Group references and associated summaries

[DMG PMML 4.2.1] Predictive Model Markup Language 4.2.1

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://www.dmg.org/v4-2-1/GeneralStructure.html

## I.6 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/

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<http://www.w3.org/community/bigdata/>

[b-W3C-OGCG] W3C, *Open Government Community Group*.
<http://www.w3.org/community/opengov/>

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