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| ITU-T Study Group 20 |
| IoT and its applications including smart cities and communities (SC&C) |
| Report of ITU-T SG20 to the World Telecommunication Standardization Assembly (WTSA-16), Part I: General |

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| **Abstract:** | This contribution contains the report of ITU-T Study Group 20 to WTSA-16 concerning its activities during the 2013-2016 study period. |

TSB NOTE − The report of Study Group 20 to WTSA-16 is presented in the following documents:

Part I: **Revision 1 to** **Document 21** – General

Part II: **Document 22** – Questions proposed for study during the study period 2017-2020

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# 1 Introduction

## 1.1 Responsibilities of Study Group 20

Study Group 20 was entrusted by the Telecommunication Standardization Advisory Group (TSAG) (Geneva, 2-5 June 2015) with the study of 6 Questions in the area of Internet of Things (IoT) and its applications, with an initial focus on Smart Cities and Communities (SC&C).

## 1.2 Management team and meetings held by Study Group 20

Study Group 20 met three (3) times in Plenary in the course of the study period (see Table 1) under the chairmanship of Mr Nasser Saleh Al Marzouqi, assisted by Vice-Chairmen Mr Fabio Bigi, Ms Silvia Guzmán Araña, Ms Blanca González[[1]](#footnote-1), Mr Takafumi Hashitani, Mr Hyoung Jun Kim, Mr Abdulrahman M. Al Hassan, Mr Ziqin Sang, Mr Sergio Trabuchi and Mr Sergey Zhdanov.

In addition many Rapporteurs’ meetings (including e-meetings) took place during the study period in different locations, see Table 1-bis.

TABLE 1
Meetings of Study Group 20 and its Working Parties

| Meetings | Place, date | Reports |
| --- | --- | --- |
| Study Group 20 | Geneva, 19-23 October 2015 | COM 20 – R 1  |
| Study Group 20 | Singapore, 18-26 January 2016 | COM 20 – R 2 |
| Study Group 20 | Geneva, 25 July-5 August 2016 | COM 20 – R 3 |

TABLE 1-bis
Rapporteur meetings organized under Study Group 20 during the study period

| Dates | Place/Host | Question(s) | Event name |
| --- | --- | --- | --- |
| 2016-07-07 | E-Meeting | [Q6/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=4620&Group=20) | Q6/20 Rapporteur group meeting |
| 2016-07-05 | E-Meeting | [Q5/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=4622&Group=20) | Q5/20 Rapporteur group meeting |
| 2016-07-05 | E-Meeting | [Q2/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=4586&Group=20) | Q2/20 Rapporteur group meeting |
| 2016-06-29to2016-06-30 | E-Meeting | [Q3/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2486&Group=20) | Q3/20 Rapporteur group meeting |
| 2016-06-08 | E-Meeting | [Q2/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=4585&Group=20) | Q2/20 Rapporteur group meeting |
| 2016-06-07 | E-Meeting | [Q2/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=4584&Group=20) | Q2/20 Rapporteur group meeting |
| 2016-06-01to2016-06-02 | E-Meeting | [Q3/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2485&Group=20) | Q3/20 Rapporteur group meeting |
| 2016-05-02to2016-05-13 | Switzerland [Geneva] | [Q1/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2472&Group=20); [Q2/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2473&Group=20)[Q3/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2474&Group=20); [Q4/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2475&Group=20)[Q5/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2476&Group=20); [Q6/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2477&Group=20) | Interim Rapporteur group meetings of SG20 |
| 2016-04-14 | E-Meeting | [Q6/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2489&Group=20) | Q6/20 Rapporteur group meeting |
| 2016-04-08 | E-Meeting | [Q1/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2479&Group=20) | Q1/20 Rapporteur group meeting |
| 2016-03-30to2016-04-06 | E-Meeting | [Q2/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2482&Group=20) | Q2/20 Rapporteur group meeting |
| 2016-03-17 | E-Meeting | [Q6/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2488&Group=20) | Q6/20 Rapporteur group meeting |
| 2015-12-10 | E-Meeting | [Q5/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2375&Group=20) | Q5/20 Rapporteur group meeting |
| 2015-12-02 | E-Meeting | [Q2/20](http://www.itu.int/net/itu-t/lists/rgmdetails.aspx?id=2395&Group=20) | Q2/20 Rapporteur group meeting |

# 2 Organization of work

## 2.1 Organization of studies and allocation of work

**2.1.1** At its first meeting of the study period, Study Group 20 decided to establish two (2) Working Parties.

**2.1.2** Table 2 shows the number and title of each Working Party, together with the number of Questions assigned to it and the name of its Chairman.

**2.1.3** Table 3 lists other groups created by Study Group 20 during the study period.

During the study period, one **Joint Coordination Activity (JCA)** proposed initially by Study Group 11 and transferred to Study Group 20 by TSAG in June 2015.

- Joint Coordination Activity on Internet of Things (JCA-IoT) became the Joint Coordination Activity on Internet of Things and Smart Cities and Communities (JCA-IoT and SC&C). Highlights of achievements of the JCA-IoT and SC&C are given in 3.3.2.1.

TABLE 2
Organization of Study Group 20

| Designation | Questions to be studied | Title of the Working Party | Chairmanand Vice-Chairmen |
| --- | --- | --- | --- |
| PLEN | Q1/20 | Research and emerging technologies including terminology and definitions | Mr Sébastien Ziegler(Co-rapporteur)Mr Ramy Ahmed Fathy\*(Co-rapporteur)Ms Olga Cavalli(Associate rapporteur) |
| WP 1/20 | Q2/20; Q3/20; Q4/20 | Internet of Things (IoT) | Mr Hyoung Jun Kim (Chairman)Mr Leonel Hochman (Co-vice-chairman)Mr Abdurahman M. Al Hassan (Co-vice-chairman) |
| WP 2/20 | Q5/20; Q6/20 | Smart cities and Communities (SC&C) | Mr Flavio Cucchietti (Co-chairman)Mr Ziqin Sang (Co-chairman)Mr Ramy Ahmed Fathy (Co-vice-chairman)Mr Paolo Gemma (Co-vice-chairman)Mr Harinderpal Singh Grewal (Co-vice-chairman) |

\* Mr Ramy Ahmed Fathy was appointed as Co-rapporteur of Q1/20 during the SG20 opening plenary that took place on 25 July 2016.

TABLE 3
Other Groups (if any)

| Title of the Group | Chairman | Vice-Chairmen |
| --- | --- | --- |
| JCA-IoT and SC&C | Mr Hyoung Jun Kim (Co-convener)Mr Fabio Bigi (Co-convener) | - |

## 2.2 Questions and Rapporteurs

**2.2.1** The 6 Questions thatTSAG (Geneva, 2-5 June 2015) assigned to Study Group 20 are listed in Table 4.

**2.2.2** The Questions listed in Table 5 have been adopted during this period.

**2.2.3** The Questions listed in Table 6 have been deleted during this period.

TABLE 4
Study Group 20 – Questions assigned by TSAG (Geneva, 2-5 June 2015)

| Q from SG | Provisional number | Question title | Status |
| --- | --- | --- | --- |
| 2/13 | A/20 | Requirements and use cases for IoT and its capabilities  | Continuation of part of Q2/13 |
| 3/13 | B/20 | Functional architecture for IoT  | Continuation of part of Q3/13 |
| 25/16 | C/20 | IoT applications and services | Continuation of Q25/16 |
| 11/13 | D/20 | IoT user centric networking and services, including interworking  | Continuation of part of Q11/13 |
| 20/5 | E/20 | IoT in Smart Sustainable Cities and Communities | Continuation of part of New Question from SG5 |
| Q1/11 | G/20 | Signalling and protocol architectures for IoT | Continuation of part of Q1/11 |

TABLE 5
Study Group 20 – New Questions adopted and Rapporteurs

| Questions | Title of the Questions | WP | Rapporteur |
| --- | --- | --- | --- |
| 1/20 | Research and emerging technologies including terminology and definitions | PLEN | Mr Sébastien Ziegler (Co-rapporteur)Mr Ramy Ahmed Fathy(Co-rapporteur)Ms Olga Cavalli (Associate rapporteur) |
| 2/20 | Requirements and use cases for IoT | WP1/20 | Mr Marco Carugi (Rapporteur)Ms Xueqin Jia\*\* (Associate rapporteur)Mr Safder Nazir (Associate rapporteur) |
| 3/20 | IoT functional architecture including signalling requirements and protocols | WP1/20 | Ms Shane He (Rapporteur)\*Mr Ayman Elnashar Ayman (Associate rapporteur)Mr Asit Kadayan (Associate rapporteur)Mr Song Luo (Associate rapporteur) |
| 4/20 | IoT applications and services including end user networks and interworking | WP1/20 | Mr Abdulhadi AbouAlmal (Co-rapporteur)Mr Gyu Myoung Lee (Co-rapporteur)Mr Xiongwei Jia (Associate rapporteur)Mr Leng Chye Leck (Associate rapporteur) |
| 5/20 | SC&C requirements, applications and services | WP2/20 | Ms Tania Marcos Paramio (Co-rapporteur)Mr Giampiero Nanni (Co-rapporteur)Mr Jun Seob Lee (Associate rapporteur) |
| 6/20 | SC&C infrastructure and framework | WP2/20 | Ms Olga Cavalli (Rapporteur)Mr Keng Li\*\*\* (Associate rapporteur) |

\* Mr Omar Elloumi resigned as Rapporteur of Q3/20 in January 2016.

\*\* Ms Xueqin Jia moved from Associate rapporteur Q5/20 to Associate Rapporteur Q2/20 in January 2016.

\*\*\* Mr Zhen Luo resigned as Associate rapporteur of Q6/20 and Mr Keng Li was appointed as Associate rapporteur of Q6/20 during the SG20 opening plenary that took place on 25 July 2016.

TABLE 6
Study Group 20 – Questions deleted

| Questions | Title of Questions | Rapporteurs | Results |
| --- | --- | --- | --- |
|  | None |  |  |

# 3 Results of the work accomplished during the 2013-2016 study period

## 3.1 General

During the study period, Study Group 20 examined 315 contributions and generated a large number of TDs and liaison statements. It:

– consented six new Recommendations;

– determined one new Recommendation

– did not amend/revise any existing Recommendations;

– agreed nine Supplements;

– did not produce any technical papers or technical reports;

## 3.2 Highlights of achievements

The main results achieved on the various Questions assigned to Study Group 20 are briefly summarized below. Formal replies to the Questions are given in a synoptic table in Annex 1 of this report.

**a) Q1/20 - Research and emerging technologies including terminology and definitions**

Question 1/20 is currently working on six work items including: Y.HEP, Framework for Home Environment Profiles and Levels of IoT Systems; Y.SCC-Terms, Vocabulary for Smart Cities and Communities; Y.IPv6RefModel, Reference Model of IPv6 Addressing Plan for Internet of Things Deployment by Smart Cities, Public Administrations and Companies; Y.IPv6-suite, Reference Model of Protocol Suite for IPv6 Interoperable Internet of Things Deployments; IPv6-IoT Supp, IPv6 Potential for the Internet of Things and Smart Cities and Y.Req-Arch-CS, Requirements and Functional Architecture of IoT-related Crowdsourced Systems.

**b) Working Party 1/20 achievements**

**Q2/20 - Requirements and use cases for IoT**

Question 2/20 is responsible for developing Recommendations for the support of emerging services and applications for IoT, covering: use cases; ecosystem aspects taking into account business models and use cases; requirements for IoT services and applications (including for the different service interfaces that will be required).

One essential objective is the maximization of common requirements in order to provide support to a broad range of IoT services and applications in different vertical markets, in cost efficient, multi-vendor and easily deployable ways over converged infrastructures. Consideration is also given to applications and services based on the integration of the IoT services and applications with advanced information and communication technologies (ICTs).

Question 2/20 is also responsible for providing the necessary collaboration for joint activities in this field within ITU and between ITU-T and other relevant SDOs, consortia and fora.

To date, Question 2/20 has conducted studies (including those inherited from SG13) on different areas, including: 1) network requirements of the IoT; 2) requirements for IoT supporting capabilities such as enhanced gateway, device management, accounting and charging, Big Data enablement and things description supporting capabilities; 3) requirements for IoT vertical markets such as wearable devices and related services, smart manufacturing, transportation safety, cooperative Intelligent Transport Systems (ITS), monitoring of global processes of the earth; 4) other IoT scenarios including those for IoT implementation in networks of developing countries, wireless power transfer application service and user-centric work space service.

Question 2/20 is also working towards a common IoT use cases description template, with the intention to propose the generalization of its usage for any future contribution on IoT use cases.

Question 2/20 is working on the following work items:

**- Common requirements and capabilities of a gateway for IoT applications (Y.2067-Rev)**

The revised version of this Recommendation is expected to provide the common requirements and capabilities of a gateway for Internet of things (IoT) applications. The provided common requirements and capabilities are intended to be generally applicable in gateway application scenarios.

**- Requirements for accounting and charging capabilities of the IoT (Y.IoT-AC-Reqts)**

This Draft Recommendation specifies accounting and charging requirements for IoT. Building on the requirements and framework for accounting and charging capabilities in NGN [ITU-T Y.2233], the Draft Recommendation provides specific requirements derived from the analysis of business use cases specific to the IoT. Based on the identified requirements, an IoT accounting and charging capability framework is then specified.

**- Specific requirements and capabilities of the IoT for Big Data (Y.IoT-BigData-reqts)**

The purpose of this Draft Recommendation is to specify requirements and capabilities of the IoT for Big Data. This Draft Recommendation complements the developments on common requirements of the IoT [ITU-T Y.2066] and functional framework of the IoT [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. Additionally, it constitutes a basis for further standardization work (e.g. functional entities, APIs and protocols) concerning Big Data in the IoT.

**- Requirements of things description in the IoT (Y.IoT-things-description-reqts)**

As the number of IoT devices, services and users increases faster and faster, the requirements of IoT applications on automatization, interoperability and composability, among others, become more and more urgent. The “things description” is a tool to realise the representation of “things” as objects of the information world to facilitate automatization, interoperability and composability for IoT applications. The goal of this Draft Recommendation is to specify requirements for an effective way of describing things as far as possible in a homogeneous way.

**- Requirements and capabilities of IoT for support of wearable devices and related services (Y.IoT-WDS-Reqts)**

Emerging wearable devices and related services place specific requirements on the IoT. The purpose of this Draft Recommendation is to investigate characteristics of wearable devices and related services, and to provide specific requirements and capabilities of the IoT in order to support them. This Draft Recommendation builds on the common requirements of the IoT [ITU-T Y.2066], to provide specific requirements and capabilities for the support of wearable devices and services.

**- Overview of smart manufacturing in the context of Industrial IoT (Y.SmartMan-IIoT-overview)**

This Draft Recommendation provides an overview of Smart Manufacturing in the context of the Industrial IoT. The scope covers, but is not limited to, the concepts of smart manufacturing in the context of the Industrial IoT, the fundamental characteristics, the general requirements and reference models applicable in smart manufacturing in the context of the Industrial IoT, business models and use cases of smart manufacturing in the context of the Industrial IoT.

**- Requirements of transportation safety service including use cases and service scenarios (Y.TPS-req)**

This Draft Recommendation addresses requirements for providing transportation safety services based on IoT technologies. The use cases and related service scenarios which are used to extract requirements for various IoT services and applications are expected to be described in the Draft Recommendation.

**- Framework of Cooperative Intelligent Transport Systems based on the IoT (Y.IoT-ITS-framework)**

Cooperative ITS based on the IoT are advanced systems which, without embodying intelligence as such, aim to provide innovative individual, personalized services relating to different modes of transport and traffic management, to enable users to be better informed and to make safer, more coordinated, and “smarter” use of transport networks.

This Draft Recommendation provides a Framework of cooperative Intelligent Transport Systems (ITS) based on the IoT.

**- Requirements for an IoT enabled network to support applications for global processes of the earth (Y.IoT-GP-Reqts)**

This Draft Recommendation describes special requirements for IoT for the monitoring and study of Global Processes (IoT GP). This innovative concept combines IoT devices distributed all over the world and one or more Control and Management Centers (CMCs) for monitoring of global natural and man-made processes, including disasters.

This Draft Recommendation describes the main features of IoT GP, deployment schemes of IoT GP devices and requirements of the IoT GP network.

**- Supplement on Scenarios of Implementing IoT in networks of developing countries (Supp-Y.IoT Scenarios for Developing Countries)**

This Draft Supplement addresses scenarios related to the implementation of IoT in networks of developing countries.

**- Use cases of Wireless Power Transfer Application Service (Y.wpt-usecase)**

WPT (Wireless Power Transfer) can be defined as “a method of getting useful electricity from one place to another without the need for electrical conducting media. Usually, this process involves a phenomenon known as electromagnetic induction.” WPT can be used in various areas such as homes, vehicles, offices, public spaces, etc. WPT technologies can be applied to electrical devices such as mobile phones, smart pads, electric cars, moving robots, wearable devices, healthcare equipment, etc. WPT can be used to provide electrical power to IoT devices in constrained environments. This Draft Recommendation describes service framework, use case, requirements, and basic service flows for WPT application service.

**- Accessibility requirements for the Internet of things applications and services (Y.Accessibility-IoT)**

This Draft Recommendation is to provide accessibility requirements of IoT applications and services. Existing accessibility standards were mostly developed through specific technology or specific service platforms. This recommendation complements existing recommendations specifically defined for certain platforms in case when such platforms are applied as a part of IoT applications and services.

**- Requirements and reference model of IoT applications for smart retail stores (Y.IoT-Retail-Reqts)**

This Draft Recommendation provides requirements and reference model of IoT applications for smart retail stores fully incorporated with IoT technologies. The scope will cover, but not limited to, the concepts, requirements and reference model applicable to IoT applications for smart retail stores. Use cases of IoT applications for smart retail stores are also provided.

**- IoT Use Cases (Y.IoT-Use-Cases)**

This Draft Supplement provides a set of Use Cases related to different application domains of the IoT. Specifically, the Supplement will cover:

Part 1- Recommended Template for the description of IoT Use Cases (clause 6);
Part 2 - Classification scheme for IoT Use Cases (clause 7);
Part 3 - A set of IoT Use Cases (collected by Q2/20 from inputs of the ITU-T membership) (clause 8)

**Q3/20 - IoT functional architecture including signalling requirements and protocols**

Question 3/20 is responsible for developing Recommendations on IoT functional architecture including signalling requirements and protocols. One essential objective is to address the requirements of IoT devices, networks, and applications, analyse related architectures and frameworks, in order to provide a common IoT functional architecture, which could be widely applied for different IoT applications, platforms, and systems. Question 3/20 is also responsible for developing Recommendations on other aspects based on this architecture, including but not limited to protocols, APIs, identification and management mechanism.

Question 3/20 is also responsible for providing the necessary collaboration for joint activities in this field within ITU and between ITU-T and other relevant SDOs, consortia and fora.

To date, Question 3/20 has progressed on IoT framework and architecture in terms of framework of constrained device networking, architecture of the IoT based on NGNe, etc., as well as IoT device and gateway related topics. Question 3/20 is also developing technical protocols under IoT functional architectures.

**- Framework of self-organization network (Y.IoT-son)**

This Draft Recommendation specifies the framework of self-organization networking in the IoT environments in terms of the communications of IoT devices. This Draft Recommendation describes the concept of self-organization networking and common characteristics of self-organization networking in the IoT environments. It also describes the architecture of self-organization networking, common requirements, and common functionalities of mechanisms for self-organization networking.

**- Functional architecture of gateway for IoT applications (Y.IoT-gw-arch)**

This Draft Recommendation studies the functional architecture of gateway for IoT application. The scope of this Draft Recommendation includes functional architectures of gateway for IoT applications, functional entities of gateway for IoT applications, and reference points of gateway for IoT applications.

**- Reference architecture for IoT network capability exposure (Y.IoT-NCE)**

The IoT network capability exposure (IoT NCE) mainly aims to dig into the relation between network capability and IoT applications and services optimization. The objective of Y.IoT-NCE is to optimize user experience, improve network efficiency, and expose network capability in order to optimize IoT applications and services. This Draft Recommendation clarifies the concept of the IoT NCE, identifies its general characteristics and common requirements, and provides the reference architecture and relevant capabilities for the IoT NCE.

**- Reference architecture for IoT device capabilities exposure (Y.IoT-DE-RA)**

This Draft Recommendation specifies reference architecture for IoT device capability exposure. The scope of this Draft Recommendation includes the concept of IoT device capability exposure, general characteristics and requirements of IoT device capability exposure, and the reference architecture for IoT device capability exposure. One of the objectives of IoT device capability exposure is to ensure that the consumers are able to use their smart terminals (e.g., smart phones, PCs, and tablets) to manage their own IoT devices.

**- Architecture of the Internet of Things based on NGNe (Y.NGNe-IoT-arch)**

This Draft Recommendation provides an architecture of the Internet of Things (IoT) based on extensions and enhancement to NGNe functional entities, reference points and components as described in ITU-T Y.2012, Y.2301, Y.2302, and other related Recommendations. The proposed architecture is related with the IoT reference model specified in Recommendation ITU-T Y.2060, the IoT common requirements specified in Recommendations ITU-T Y.2066, and the IoT functional framework and capabilities specified in Recommendation ITU-T Y.2068. Security considerations for the extensions and enhancement specified in this Draft Recommendation are also expected to be provided.

**- Functional architecture of Service Discovery for Interworking between Heterogeneous IoT Platforms (Y.IoT-sd-arch)**

This Draft Recommendation builds on the framework of service discovery for interworking between heterogeneous IoT platforms. The scope of this Recommendation will include:

– Introduction of service discovery for interworking between heterogeneous IoT platforms

– Functional requirements of service discovery for interworking between heterogeneous IoT platforms

– Functional architecture of service discovery for interworking between heterogeneous IoT platforms

– Reference interfaces of service discovery for interworking between heterogeneous IoT platforms

**- Requirements and functional architecture of Open IoT identity correlation service (Y.IoT-ics)**

This Draft Recommendation provides:

– Concept and Requirements of the Open IoT identity correlation service

– Functional architecture of the Open IoT identity correlation service

– Basic capabilities, relevant reference points and procedures of the Open IoT identity correlation service.

**Q4/20 - IoT applications and services including end user networks and interworking**

Question 4/20 is responsible for developing Recommendations on IoT applications and services, taking into consideration the whole process of communications such as configuration of resources, provision of capabilities and management, whilst maintaining the required privacy and security. Question 4/20 is also responsible for developing Recommendations on end user networks (e.g., enhancement of home networks, personal area networks, wireless sensor networks, etc.), taking into account their specific IoT applications and services in end users perspective as well as interworking for IoT applications and services in end user, heterogeneous networks.

To date, Question 4/20 has progressed on various IoT applications such as transportation safety services, smart green house, e-health, energy efficiency, etc. including privacy and trust issues. Question 4/20 is also developing technical frameworks for IoT devices with home network solutions.

**- Identity of IoT devices (Y.IoT-IoD-PT)**

The “Identity of IoT” is a set of the characteristics, determining what the Internet of Thing is. Y.IoT-IoD-PT provides the methods and scenarios of IoT devices identification. The methods and scenarios of IoT devices identification are given to IoT device, based on passive tags, and complex IoT devices, which are based on microcontrollers or microprocessors.

**- Architectural framework for transportation safety service (Y.TPS-afw)**

Y.TPS-afw addresses the transportation safety management model and architectural framework for transportation safety services based on IoT technologies.

**- Delegation service for IoT devices (Y.del-fw)**

Y.del-fw specifies the framework of the delegation service in the IoT environments in viewpoint of the ownership of IoT devices. It describes the concept of the delegation service and its scenarios in the IoT environments. It also describes requirements and architecture of the delegation service.

**- Performance evaluation frameworks of e-health systems (Y.IoT-EH-PFE)**

Y.IoT-EH-PFE specifies performance evaluation frameworks of e-health systems in the IoT for e-health services. From information and communication technologies point of view, e-health services are classified. Performance evaluation factors applicable for e-health systems in the IoT are specified. Then performance evaluation frameworks are normalized for the classified e-health services.

**- Web of objects enabled virtual home network (Y.WoO-hn)**

The Web of Objects (WoO) supports a framework to simplify application deployment, maintenance and operation of IoT service infrastructure. The WoO will support a coherent architecture applicable to heterogeneous and dynamic environments embedded in home network. Y.WoO-hn identifies the service framework of WoO enabled virtual home network defined in the ITU-T Recommendation H.622.

**- IoT-based Smart Greenhouse (Y.ISG-ra)**

IoT-based Smart Greenhouse (ISG) is an IoT-based approach towards food production. The goal of Y.ISG-ra is to provide and maintain optimal conditions for growing crops in greenhouse environment.

**- Service Functionalities of Self-quantification over Internet of things (Y.IoT-SQ-fns)**

This Draft Recommendation provides service functionalities of self-quantification over Internet of things with the purpose of fostering interoperability of different platforms.

More specifically, the following elements are within the scope of this Recommendation.

- Concept and technical overview of self-quantification

- Requirements

- Functionalities

Usage scenarios of self-quantification services is provided in Appendix I. Gap analysis on standards activities in relation to self-quantification services is provided in Appendix II.

**- Security capabilities supporting safety of the Internet of Things (Y.IoT-sec-safety)**

This Draft Recommendation identifies security threats that may affect safety and security capabilities based on the Recommendation ITU-T Y.2068.

Firstly, this Recommendation determines security threats with a possible impact on safety. Secondly, it identifies which security capabilities can be applied to mitigate these threats.

Internet of Things poses specific security challenges, which may be not covered by existing security objectives (such as confidentiality, integrity, availability) completely. Further elaboration of specific security countermeasures relies on an interpretation of security capabilities according to the identified threats.

This Recommendation is mostly applicable to safety-critical IoT systems, such as industrial automation, automotive systems, transportation, smart cities, however, it has no specific restrictions and may be used for any domain area of IoT.

**- Information Management Digital Architecture to combat counterfeiting in IoT (Y.IoT-DA-Counterfeit)**

The intent of this Recommendation is to provide solutions to deter the spread of counterfeit IoT devices worldwide.

This Draft Recommendation covers Digital Architecture based systems, such as:

- Digital Object Architecture (DOA) based system. The recommendation will cover:

– General description of the IoT-DOA-based systems for combating counterfeiting

– Compatibility with other anti-counterfeit systems

– Principles of products identification.

– Universal identification system.

– Verification procedures of product’s identifiers

- Other approaches can be developed, where relevant, based on input contributions to the future SG20 meetings

**- An Interoperability framework for IoT (Y.IoT-Interop)**

ITU-T X.1255 is based on the Digital Object Architecture (DOA). Recommendation ITU-T Y.2066 describes Common requirements of the Internet of things. The intent of this recommendation is to provide the features DOA and its capabilities to meet those requirements. Therefore, this Recommendation covers the following:

– Digital Object Architecture (DOA) Overview.

– Key components of Digital Object Identifiers Resolution System.

– The DOA’s overarching model’s ability to provide a general IoT interoperability framework.

– Security and privacy requirement for IoT interoperability framework

**Q5/20 - SC&C requirements, applications and services**

Question 5/20 intends to study: SC&C related ecosystem, applications, services and use cases; studies that are directly related to SC&C including, inter alia, smart grids, water, mobility, logistic, waste, healthcare, e-government, emergency telecommunications, education, transport, utilities, etc.); basic and high-level requirements, characteristics, and general capabilities of SC&C; ICT requirements and the related communications technologies to be taken into account when designing smart city services; efficient service analysis, strategic planning, deployment and implementation of SC&C, taking into account different needs of developed and developing countries; and security, privacy and trust of IoT systems, services and applications for SC&C.

**- Overview of smart cities and communities (Y.SC-Overview)**

ITU-T Y.SC-Overview gives an overview of smart cities and communities and the role of information and communication technology (ICT). Smart cities and communities in general, have the end goal of achieving an economically sustainable urban environment without sacrificing on the quality of life of citizenry. It strives to create a sustainable living environment for all its citizens using IoT, capacitated by ICTs. An IoT-based infrastructure, enabled using ICTs, continues to play a pivotal role in smart cities and communities by functioning as the platform for aggregation of information and data to enable an improved understanding of how the city is functioning in terms of resource consumption, services, and lifestyles.

**- Identifier service (Y.SC-Interop)**

ITU-T Y.SC-Interop explores the set of requirements for identifier services used in smart city. An identifier service for smart city should be scalable and secure, and not only promote interoperability among different smart city applications, but also be compatible with any existing practices in the application domain.

**- Open data (Y.SC-Opendata)**

ITU-T Y.SC-Opendata provides a framework of Open Data in smart cities. It clarifies the concept and types of Open Data in smart cities, analyses the relationship between Open Data and smart cities, identifies the requirements of Open Data in smart cities and describes the functional architecture for Open Data in smart cities.

**- Smart residential communities (Y.SC-Residential)**

As an important part of the smart city, smart residential community has two roles. Outwardly, it carries information interconnection between the residential community and the city to meet the requirement of collecting and managing internal information needs for the residential community, government, enterprises and individuals. On the other hand, smart residential community is responsible for the sensor layer information collection, conversion, processing and fully connected, integrated with the network layer to meet the high efficiency, energy saving and environmental protection needs during the residential community construction and operation.

Y.SC-Residential studies Smart Residential Communities to describe the concept, scope and goals, generalize common requirements of Smart Residential Communities management and service, and list typical use cases of Smart Residential Communities management, service and operation.

**- Smart port (Y.smartport)**

Y.smartport presents smart management of the provision of multiple services in smart ports, including energy services, and also to interact with the city where the port is located. The new potential of communications and data exchange between service provision channels will enable the city to improve services, monitor and control resource use and thus react to information provided by port remote management systems in real time.

**- Smart farming (Y.pops and Y.psfs)**

Y.pops and Y.psfs present production services of smart farming. The two work items were transferred from ITU-T SG13 to ITU-T SG20.

**- Requirements for deployment of smart services in Rural Communities (Y.SRC)**

The scope of this Draft Recommendation is to develop a minimum set of requirements to enhance the deployment of smart services (e.g. e-government, health, education, etc.) in rural communities.

**- Requirements and Reference Framework for Smart Parking Lots in smart city (Y.SPL)**

This Draft Recommendation specifies requirements and framework for Smart Parking Lots. The scope of SPL is to refine the granularity and enhance the degree of informatization for parking lots, provide the rich functions for people to improve the convenience of city life, support the unified standard for the vendors to produce the better products.

The scope of this Recommendation includes:

– Requirements for Smart Parking Lots

– Framework for Smart Parking Lots

– Interfaces for Smart Parking Lots

**- Requirements and Reference Architecture of Smart Environmental Monitoring (Y.SEM)**

This Draft Recommendation specifies Reference Architecture of Smart Environmental Monitoring. As a smart application of ICT in the field of environmental monitoring and protection, smart environmental monitoring is an important means to enhance environmental management level and develop environmental protection industry. Three essential environmental factors (air, water, and soil) are considered in the proposed smart environmental monitoring. A unified standard for smart environmental monitoring is needed to specify what services the users want and what functions should be realized.

The scope of this Recommendation includes:

– Definition of smart environmental monitoring

– Requirements of smart environmental monitoring

– Reference architecture of smart environmental monitoring

**Q6/20 - SC&C infrastructure and framework**

Question 6/20 intends to study: general reference models of SC&C; spatio-temporal modeling for SC&C; frameworks to identify the architectural and service compositions and views on SC&C; identification of entities, their functions, and reference points required to provide support to SC&C applications and services; ICT use for physical infrastructure, including but not limited to: telecom networks, underground pipelines, capillary network, intelligent building system, building information modeling (BIM), traffic system and other facilities.

**- City infrastructure (Y.infra and Y.SC-infra-TS)**

Y.infra presents the concept and classification of city infrastructure as well as its intelligent improvement in smart city establishments. ITU-T Y.SC-infra-TS presents the classification and concept of Telecommunication systems as urban infrastructure.

**- Framework of smart cities and communities (Y.frame-scc and Y.SC-platform)**

ITU-T Y.frame-scc presents the framework and high-level requirements of smart cities and communities. The SCC framework is the foundation supporting all the work of building SCC, including: using ICTs and other means, improving infrastructure, improving quality of life, providing urban operation and services, improving economic competitiveness, ensuring environmental sustainability, and ensuring social inclusion.

**- Integrated management (Y.ism-ssc and Y.isw-ssc)**

ITU-T Y.ism-ssc specifies a technical framework of Integrated Sensing and Management (ISM) for SSC. It clarifies the background, goal, significance, and intended effects of ISM for SSC, proposes a technical framework, and lists the key technologies, components, information models, management interface and service operations used in ISM.

ITU-T Y.isw-ssc provides a Metadata Model of ISM for SSC. It clarifies the concept and types of ISM for SSC, analyses the basic metadata components of ISM for SSC, identifies the requirements of integrated sensor web resources in SSC and describes the structure and contents of ISM for SSC.

**- Framework and service scenarios (Y.FSN)**

ITU-T Y.FSN presents framework and service scenarios for smartwork. This work item was transferred from SG13 to SG20.

**- Reference Model for Smart Tourist Destinations: platform interoperability and functionalities (Y.STD)**

The scope of this Draft Recommendation is to develop a reference model for Smart Tourist Destinations including the requirements for the platform interoperability and description of functionalities, in order to provide a comprehensive system for tourist destination management.

**- Open Data Indicator (Y.ODI)**

This Draft Recommendation establishes how to measure a City's Open Data.

Specifically, the Recommendation will cover,

– Dimensions and Sub-dimensions for the Indicator of Open Data in smart sustainable cities.

– Levels of measurement

– Indicator of Open Data in smart sustainable cities.

## 3.3 Report of lead study group activities, GSIs, JCAs and regional groups

### 3.3.1 Lead study group activities on Internet of Things (IoT) and its applications, with an initial focus on Smart Cities and Communities (SC&C)

– Lead study group on Internet of Things (IoT) and its applications

– Lead study group on Smart Cities and Communities (SC&C)

### 3.3.2 GSIs/JCAs

ITU-T SG20 does not have a global standards initiative (GSI) under its responsibility during this study period. One Joint Coordination Activity (JCA) under the auspices of ITU-T SG20 underscores the lead study group functions given to ITU-T SG20.

#### 3.3.2.1 JCA-IoT and SC&C

The establishment of the Joint Coordination Activity on Internet of Things (JCA-IoT), has been approved by [ITU-T TSAG](http://www.itu.int/itu-t/tsag) in February 2011. In June 2015, TSAG approved the creation of [ITU-T Study Group 20 on IoT and its applications including smart cities and communities (SC&C)](http://www.itu.int/en/ITU-T/studygroups/2013-2016/20/Pages/default.aspx) and decided that the parent group of JCA-IoT would be transferred to the new ITU-T SG20.

In light of this, the terms of reference of the JCA-IoT have been revised and agreed upon during the first meeting of ITU-T Study Group 20, which took place from 19 to 23 October 2015. It was also agreed to change the title from JCA-IoT to Joint Coordination Activity on Internet of Things and Smart Cities and Communities (JCA-IoT and SC&C).

The scope of the JCA-IoT and SC&C is to coordinate the ITU-T work on the “Internet of Things and Smart Cities and Communities” and provide a visible contact point for IoT and its applications including smart cities and communities (SC&C) activities within ITU-T. This would also help to coordinate with external bodies working in the field of IoT and SC&C and enable effective two-way communication with these bodies. External bodies include representatives from relevant SDOs such as IEC, ISO or relevant academia, consortia or fora.

### 3.3.3 Regional Group

None.

# 4 Observations concerning future work

ITU-T Study Group 20 is the Standardization Sector’s lead study group on IoT, its applications including smart cities and communities (SC&C). A foundation of IoT and SC&C Recommendations has been established, collaboration arrangements with other bodies are in place, and an ongoing work program of IoT and SC&C Questions for the next study period is proposed in Part II of the ITU-T Study Group 20 report.

ITU-T SG20 provides government, industry and academia with a unique global platform to engage and collaborate in the development of international IoT standards. An important aspect of the group’s work is the development of Recommendations that leverage IoT technologies to address urban-development challenges.

ITU-T Study Group 20 is working to build the cohesive model of behavior necessary to the coordinated development of IoT and smart sustainable cities. The group is taking an innovative approach to IoT standardization by placing ITU’s technical expertise in IoT standardization at the service of national and local governments, city planners and a wide range of vertical industries. This multi-stakeholder approach intends to pave the way to trusted IoT technologies that fully address and anticipate end-user and market expectations.

Its future work may include new or further studies in the following areas (but not limited to):

– Identification and addressing aspects in IoT

– Security, privacy and trust of IoT/SC&C systems, services and applications

– Accessibility of IoT

– Data centric capabilities for IoT, including Big Data:
It is expected that in the future the quantity of connected things and things related data will be so huge that these data will constitute the predominant part of the data carried by networks. Connecting huge number of physical and virtual things is a core capability of the IoT and its applications, including smart cities and communities. Exploring hidden patterns of data, uncovering correlations and developing new insights, decisions, and conclusions are some of the crucial benefits that Big Data and Big Data analytics can bring to the stakeholders of IoT and smart cities ecosystems in terms of management and development, including reduction of operational costs and new revenue opportunities. Big data is arriving from multiple sources at varying mega levels of velocity, volume and variety.
One promising working direction for the benefits of IoT and smart city applications is the development of a standardized set of Big Data capabilities and platforms which can be delivered as a service to IoT applications and smart city services. However, the critical nature of various applications and services entails that extreme measures become essential to store, process, and analyze the data in real time and in a secured fashion. This could be a rather conflicting set of requirements since ensuring that privacy and security measures are effectively applied in general needs processing time and power. More generally, from a security and privacy perspective, Big data can bring significant challenges in the various phases of the data life cycle, in particular with respect to the treatment of personal data.
Requirements such as real-time analytics in industrial environments or for disaster monitoring and prevention systems are, on the other hand, driving new Big Data architectures with the distribution of capabilities at different levels of the data value chain.
ITU-T SG20 is currently considering developing measures to effectively tackle the Big Data challenges in IoT and its applications, including in smart cities. Future work includes developing standardized efficient architectures, analytics protocols, data exchange capabilities, data dimensionality reduction, pattern reduction, features selection, distributed computing architectures, privacy preservation processing, real time big data encryption, and much more.

– Semantic and syntax aspects of IoT

– IoT management and provisioning

– Quality of service and end-to-end performance for IoT and its applications

– IoT and cloud computing

– IoT and end user networks

– IoT applications and services

– Connected vehicles and intelligent transportation

* Industrial Internet and smart manufacturing

– Retail stores

– Use cases and requirements in other application domains

– IoT functional architectures (in different application domains)

– APIs and protocols for IoT

– Network evolution for smart city services (5G & IoT)

– Platforms interoperability for smart cities and communities

– Integrated management for smart cities, including smart residential communities, smart port, tourist destinations, smart building etc.

– Metadata and modelling for smart cities

– IPv6 potential for the Internet of Things and Smart Cities

– ICT use for city infrastructure

– Key performance indicators for smart sustainable cities

– Global smart sustainable cities index

– Open data and/or open source data

– Artificial intelligence

– E-smart services

– Applications for SSC

# 5 Updates to the WTSA Resolution 2 for the 2017-2020 study period

Annex 2 contains the updates to WTSA Resolution 2 proposed by Study Group 20 concerning the general areas of study, title, mandate, lead roles and points of guidance in the next study period.

ANNEX 1

List of Recommendations, Supplements and
other materials produced or deleted during the study period

The list of new and revised Recommendations approved during the study period is found in Table 7.

The list of Recommendations determined/consented at the last meeting of Study Group 20 is found in Table 8.

The list of Recommendations deleted by Study Group 20 during the study period is found in Table 9.

The List of Recommendations submitted by Study Group 20 to WTSA-16 for approval is found in Table 10.

Tables 11 onwards list other publications approved and/or deleted by Study Group 20 during the study period.

TABLE 7
Study Group 20 – Recommendations approved during the study period

| Recommendation | Approval | Status | TAP/AAP | Title |
| --- | --- | --- | --- | --- |
| [Y.4553](http://handle.itu.int/11.1002/1000/12779) | 2016-03-15 | In force | AAP | Requirements of smartphone as sink node for IoT applications and services |
| [Y.4702](http://handle.itu.int/11.1002/1000/12780) | 2016-03-15 | In force | AAP | Common requirements and capabilities of device management in the Internet of things |
| [Y.4113](http://www.itu.int/ITU-T/recommendations/rec.aspx?id=13025&lang=en) | 2016-09-13 | In force | AAP | Requirements of the network for the Internet of Things |
| [Y.4451](http://www.itu.int/ITU-T/recommendations/rec.aspx?id=13026&lang=en) | 2016-09-13 | In force | AAP | Framework of constrained device networking in the IoT environments |
| [Y.4452](http://www.itu.int/ITU-T/recommendations/rec.aspx?id=13027&lang=en) | 2016-09-13 | In force | AAP | Functional framework of Web of Objects |
| [Y.4453](http://www.itu.int/ITU-T/recommendations/rec.aspx?id=13028&lang=en) | 2016-09-13 | In force | AAP | Adaptive software framework for IoT devices |

TABLE 8
Study Group 20 – Recommendations consented/determined at the last meeting

| Recommendation | Consent/Determination | TAP/AAP | Title |
| --- | --- | --- | --- |
| Y.4454 | Determined | TAP | Platform Interoperability for Smart Cities |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

TABLE 9
Study Group 20 – Recommendations deleted during study period

| Recommendation | Last version | Withdrawal date | Title |
| --- | --- | --- | --- |
| None |  |  |  |

TABLE 10
Study Group 20 – Recommendations submitted to WTSA-16

| Recommendation | Proposal | Title | Reference |
| --- | --- | --- | --- |
| None |  |  |  |

TABLE 11
Study Group 20 – Supplements

| Recommendation | Date | Status | Title |
| --- | --- | --- | --- |
| [Y Suppl. 27](http://handle.itu.int/11.1002/1000/12753) | 2016-01-26 | In force | ITU-T Y.4400 series – Smart Sustainable Cities - Setting the framework for an ICT architecture |
| [Y Suppl. 28](http://handle.itu.int/11.1002/1000/12754) | 2016-01-26 | In force | ITU-T Y.4550 series – Smart Sustainable Cities - Integrated management |
| [Y Suppl. 29](http://handle.itu.int/11.1002/1000/12755) | 2016-01-26 | In force | ITU-T Y.4250 series – Smart Sustainable Cities - Multi-service infrastructure in new-development areas |
| [Y Suppl. 30](http://handle.itu.int/11.1002/1000/12756) | 2016-01-26 | In force | ITU-T Y.4250 series – Smart Sustainable Cities - Overview of smart sustainable cities infrastructure |
| [Y Suppl. 31](http://handle.itu.int/11.1002/1000/12757) | 2016-01-26 | In force | ITU-T Y.4550 series – Smart Sustainable Cities - Intelligent sustainable buildings |
| [Y Suppl. 32](http://handle.itu.int/11.1002/1000/12758) | 2016-01-26 | In force | ITU-T Y.4000 series – Smart sustainable cities - A guide for city leaders |
| [Y Suppl. 33](http://handle.itu.int/11.1002/1000/12759) | 2016-01-26 | In force | ITU-T Y.4000 series – Smart Sustainable Cities - Master plan |
| [Y Suppl. 34](http://handle.itu.int/11.1002/1000/12760) | 2016-01-26 | In force | ITU-T Y.4000 series – Smart Sustainable Cities - Setting the stage for stakeholders' engagement |
| [Y.Suppl. 42](http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13024) | 2016-08-05 | In force | ITU-T Y.4100 series - Use cases of User-Centric work Space (UCS) Service |

TABLE 12
Study Group 20 – Technical Papers

| Recommendation | Date | Status | Title |
| --- | --- | --- | --- |
| None |  |  |  |

TABLE 13
Study Group 20 – Technical Reports

| Recommendation | Date | Status | Title |
| --- | --- | --- | --- |
| None |  |  |  |

TABLE 14
Study Group 20 – Other publications

| Others | Date | Status | Title |
| --- | --- | --- | --- |
| Flipbook | January 2016 | In force | [Shaping smarter and more sustainable cities: Striving for sustainable development goals.](http://wftp3.itu.int/pub/epub_shared/TSB/ITUT-Tech-Report-Specs/2016/en/flipviewerxpress.html) |
| Flipbook | July 2016 | In force | [Unleashing the potential of the Internet of Things](http://wftp3.itu.int/pub/epub_shared/TSB/2016-07-11-ITU-T-Compendium/index.html) |

ANNEX 2

Proposed updates to the Study Group 20 mandate and Lead Study Group roles

**(WTSA Resolution 2)**

The following are the proposed changes to the Study Group 20 mandate and Lead Study Group roles agreed at the last Study Group 20 meeting in this study period, based on the relevant portions of [WTSA-12 Resolution 2](http://www.itu.int/dms_pub/itu-t/opb/res/T-RES-T.2-2008-MSW-E.doc).

#### PART 1 ‑ General areas of study

**ITU-T Study Group 20**

**IoT and its applications including smart cities and communities (SC&C)**

Study Group 20 is responsible for studies relating to Internet of Things (IoT) and its applications, with an initial focus on Smart Cities and Communities (SC&C).

#### PART 2 ‑ Lead Study Groups in specific areas of study

SG20 Lead study group on Internet of Things (IoT) and its applications
Lead study group on Smart Cities and Communities (SC&C)

Annex B
(to WTSA Resolution 2)

Points of guidance to study groups for the development
of the post-2016 work programme

ITU-T Study Group 20

ITU-T SG 20 will work on the following items:

– Framework and roadmaps for the harmonized and coordinated development of Internet of things (IoT), including M2M communications, ubiquitous sensor networks and smart sustainable cities, in ITU‑T and in close cooperation with ITU-D and ITU‑R SGs and other regional and international standards-development organizations (SDO) and industry forums;

– Requirements and capabilities of IoT and its applications including SC&C;

– Definitions and terminology for IoT;

– IoT infrastructure/ services available in smart sustainable cities/ architecture framework and requirements of IoT for SC&C;

– Efficient service analysis and infrastructure of IoT use in smart sustainable cities and communities to assess how the use of IoT has an impact on the smartness of cities;

– Guidelines, methodologies and best practices related to standards to help cities (including rural areas and villages) deliver services using the IoT, with an initial view to address city challenges;

– IoT end-to-end architectures;

– Data sets that will enable data interoperability for various verticals, including smart cities, e-agriculture, etc.;

– High-layer protocols and middleware for IoT systems and applications including SC&C;

– Middleware for interoperability between IoT applications for different IoT verticals;

– Quality of service (QoS) and end-to-end performance for IoT and its applications including SC&C;

– Security of IoT systems, services and applications;

– Database maintenance of existing and planned IoT standards.

Annex C
(to WTSA Resolution 2)

List of Recommendations under the responsibility of the respective
study groups and TSAG in the 2017-2020 study period

Study Group 20

ITU-T Study Group 20

ITU-T F.744, ITU-T F.747.1 – ITU-T F.747.8, ITU-T F.748.0 – ITU-T F.748.5 and ITU-T F.771

ITU-T H.621, ITU-T H.623, ITU-T H.641, ITU-T H.642.1, ITU-T H.642.2 and ITU-T H.642.3

ITU-T Q.3052

ITU-T Y.4000-series, ITU-T Y.2016, ITU-T Y.2026, ITU-T Y.2060 – ITU-T Y.2070, ITU-T Y.2074 – ITU‑T Y.2078, ITU-T Y.2213, ITU-T Y.2221, ITU-T Y.2238, ITU-T Y.2281, ITU-T Y.2291

NOTE – Recommendations transferred from other study groups have double numbers in the Y.4000-series.

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1. Ms Gonzalez was appointed Vice-chairman of SG20 in place of Ms Silvia Guzman Araña during the SG20 opening plenary that took place on 25 July 2016. [↑](#footnote-ref-1)