International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.4121

(06/2018)

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

Internet of things and smart cities and communities – Requirements and use cases

---

Requirements of an Internet of things enabled network for support of applications for global processes of the Earth

Recommendation ITU-T Y.4121

ITU-T

International
Telecommunication
Union

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	**Y.4100–Y.4249**
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.4121

Requirements of an Internet of things enabled network for support of applications for global processes of the Earth

Summary

Internet of things (IoT) applications for global processes, such as the advanced detection of natural disasters, present demanding requirements for real-time distributed IoT networks.

Internet of things for monitoring and studying global processes (IoT GP) is an innovative concept that combines Internet of things devices distributed all over the world and one or more control and management centres (CMCs) for monitoring global natural and man-made processes.

The key idea to IoT GP is real-time consolidation of sensor data from different parts of the Earth, allowing for enhanced disaster preparedness and development of advanced models of global processes. For example, IoT GP can be used to detect areas of possible occurrence of earthquakes, floods, wildfires, heat waves, etc.

Recommendation ITU-T Y.4121 describes key IoT GP features, deployment schemes of IoT GP devices, and requirements of the IoT GP network.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4121	2018-06-29	20	11.1002/1000/13636

Keywords

Earth, global processes, Internet of things, IoT device, IoT GP, IoT GP device, IoT GP network, IoT GP service, sensors.

* 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

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.4121

Requirements of an Internet of things enabled network for support of applications for global processes of the Earth

1 Scope

This Recommendation describes requirements of an Internet of things (IoT) enabled network for support of applications monitoring and studying global processes of the Earth. This innovative concept of "Internet of things for monitoring and studying global processes (IoT GP)" combines geographically distributed IoT devices, and one or more control and management centres (CMCs) for the monitoring of global natural and man-made processes.

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

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2205] Recommendation ITU-T Y.2205 (2011), *Next Generation Networks – Emergency telecommunications – Technical considerations.*

[ITU-T Y.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things.*

[ITU-T Y.4102] Recommendation ITU-T Y.4102/Y.2074 (2015), *Requirements for Internet of things devices and operation of Internet of things applications during disasters.*

[ITU-T Y.4113] Recommendation ITU-T Y.4113 (2016), *Requirements of the network for the Internet of things.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Internet of things (IoT) [ITU-T Y.4000]: 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.

NOTE 1 – 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, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.2 device [ITU-T Y.4000]: In the Internet of things, a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 control and management centre (CMC): Entity responsible for the control and management of an IoT GP network, including data gathering from IoT GP devices and service rendering to IoT GP users.

3.2.2 global processes (GP): Phenomena of natural or man-made origin, related to a sharp deviation from the normal behaviour of everyday natural or man-made processes, which may have a significant impact on the natural, human, economic and social environment.

NOTE – Examples of global processes include earthquakes, floods, forest fires, heat waves and other environmental hazards.

3.2.3 IoT GP device: An IoT device used in an IoT GP network**.**

NOTE – This Recommendation identifies two types of IoT GP.

3.2.4 IoT GP network: A network for monitoring and studying global processes that provides reliable information delivery from geographically distributed IoT devices and trusted information exchange.

3.2.5 IoT GP service: Information and communication service rendered using the IoT GP network.

3.2.6 IoT GP user: User of an IoT GP service.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CMC	Control and Management Centre
GP	Global Processes
IoT	Internet of Things
IoT GP	IoT for monitoring and study of Global Processes
IP	Internet Protocol

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement needs not be present to claim conformance.

The keywords "can optionally" and "may" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Overview of IoT GP

The feasibility of IoT GP is based on technological breakthroughs of recent years:

– the transition to a new IP addressing technology, IP version 6, which provides increased addressing capabilities;

– network convergence, which allows for the integration of sensor networks;

– the increasing wireless access availability worldwide;

– the utilization of cloud computing technologies.

These technologies constitute the technical foundation for the deployment of IoT GP.

Any object embedded with electronics, software, sensors, actuators and network connectivity may be considered an IoT device. Connected objects could include any living being with a networked IoT device. For example, there are IoT global processing systems used in the transportation industry that collect information from drivers calling into data centres. Based on these calls, the systems create a traffic report on road conditions. The more calls received from different parts of the city, the more information is processed to build a larger city traffic map.

The use of IoT devices and their processing abilities to manipulate the data from drivers' calls, make drivers aware of road conditions, congestion, detours and traffic collisions.

By deploying IoT devices to areas around the world, especially in disaster prone areas, these devices can monitor natural and man-made processes. Through the collected data, models can be developed to study environmental changes that could aid in predicting future cataclysmic events.

The key ideas of IoT GP are:

1) Emergency monitoring systems could benefit from utilizing data collected from various types of devices. Such data may contain hidden components of signals anticipating emergency situations that may be detected with special data processing methods. The IoT devices used for IoT GP (IoT GP devices), equipped with sensitive detection sensors, can improve the forecast capability of emergency monitoring systems. Real-time data from various sensors can improve disaster preparedness and develop advanced emergency response models. For example, IoT GP devices may be used for early detection of earthquakes, floods, wildfires, heat waves and other environmental hazards.

2) It is often difficult to differentiate signals used by IoT GP devices to forecast disasters from background noise, however, those signals may help to identify and significantly improve the disaster prediction capabilities, thereby drastically reducing loss in life and property. Connected things (including people, animals, insects, birds, bacteria, single cells, etc.) could be used to monitor various activities on Earth, to identify global changes. The evaluated data would allow for a timely reaction that would help predict negative environmental impacts.

The sensors of IoT GP devices used to forecast disasters employ common modulating signals to monitor various physical phenomena. IoT sensors may be attached to any object sensitive to environmental changes. Biogeochemists are most qualified in selecting the proper sensors for the intended purpose as they have been studying environmental changes and their effects on objects. In the early stages of a natural or man-made disaster, many signals of varying intensities may occur at the same time. It is suggested that IoT GP devices be used to correctly capture all the data in time for an early warning. For example, sensor panels, consisting of different types of IoT GP devices, are more sensitive to the detection of multiple weak prediction signals to forecast imminent disasters than other types of monitoring devices. Sensor panels can complement the sensors in monitoring systems.

Figure 1 gives an overview of an IoT GP network with a single control and measurement centre (CMC).

An IoT GP network usually consists of a set of IoT GP^{Type1} devices and a set of IoT GP^{Type2} devices. The difference between the two types of IoT GP devices is that the IoT GP^{Type1} devices are sensors providing information recorded in databases and processed, whereas, the IoT GP^{Type2} devices are users of the information obtained as a result of the processing of the data collected from the IoT GP^{Type1} devices. Therefore, the IoT GP^{Type2} devices are typically persons interacting with the IoT devices. In some cases, any IoT GP^{Type2} device may also act as an IoT GP^{Type1} device.

The CMC gathers data from the IoT GP devices and stores it in data processing unit(s). The purpose of the CMC is to enable sharing and manipulation of data with other entities through the support of cloud computing technologies and big data analysis tools.

NOTE 1 – The data processing unit(s) can be remote or within the CMC.

NOTE 2 – An IoT GP network may contain more than one CMC. In such case, the various CMCs may share control functions, or some CMCs can serve as redundant CMCs.

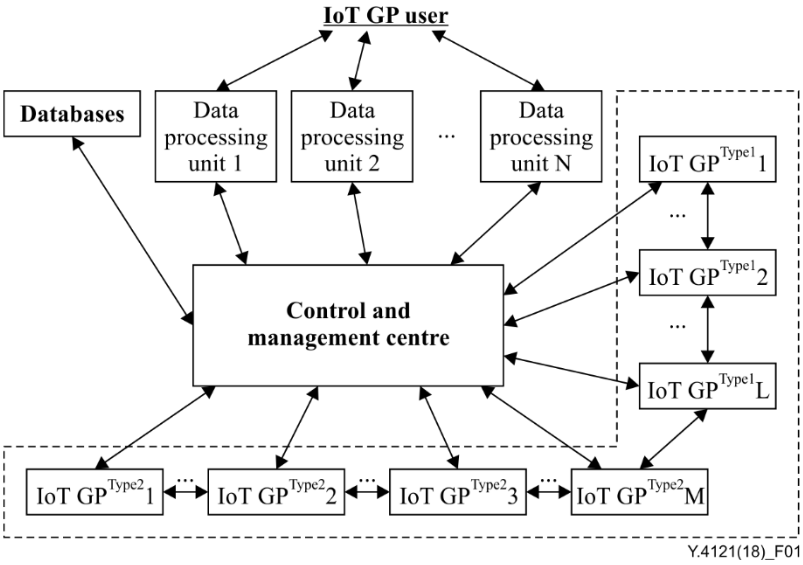

Figure 1 – Overview of IoT GP network

An IoT GP network can be used for:

1) more careful consideration of global processes, by monitoring them;
2) prediction of emergencies, both man-made and natural, via monitoring of global processes;
3) investigation of the influence of a man-made component on the natural global processes;
4) investigation of the influence of global processes on properties of objects (subjects);
5) management of global processes.

As previously mentioned, incoming data from multiple IoT GP devices may contain weak signals. Examination of these weak signals may be based either on existing data processing methods or on other techniques. A number of very sophisticated mathematical solutions exist to extract intelligence from large amounts of data in various domains of human activity.

One possible solution for the extraction of intelligence from multiple weak data signals is through comparison with existing processed data. This method relies on correctly analysing previously collected data and correlating them with new incoming data.

7 Key IoT GP features

In existing systems for the monitoring of global processes (international and domestic systems), there are a number of serious shortcomings: small number of stations, uneven arrangement of stations, complexity of processing of monitoring data.

All of this does not provide today real forecasts about global processes such as earthquakes. For example, given the global nature of the magnetic field of the Earth, it is essential to provide the most uniform and dense geographical coverage of the globe with points of supervision.

The following are key IoT GP features:

– significant increase in the number of measurement points for parameters that affect global processes by involving not only specialized measuring stations, but widely used IoT devices;
– opportunity to use IoT devices that are already involved in other applications, but which possess appropriate sensors and capabilities for monitoring global processes in parallel;
– new capabilities for predicting the evolution of global processes in real time.

8 Deployment schemes of IoT GP devices

The proposed global IoT GP network, together with existing networks of special measurement stations, will react to global processes and identify deviations from standard characteristics.

IoT GP devices (including living organisms) equipped with special sensors may help to construct acceptable global process models. In this case it becomes possible to rescue people in case of an emergency caused by an observed global process, by activating suitable instructions based on the global process model before a catastrophic phase. Information from IoT GP devices on their state and changes in their characteristics will help to increase the accuracy of the global process models, with the consequent increase of the probability of a successful rescue.

Appropriate deployment of IoT GP devices may increase the efficiency of IoT GP devices. The deployment may be recognized as effective enough if:

1) it helps with the interpretation of data from existing measuring station networks for monitoring global processes, and
2) it helps estimate qualitatively the influence of Earth's global processes on living and non-living entities.

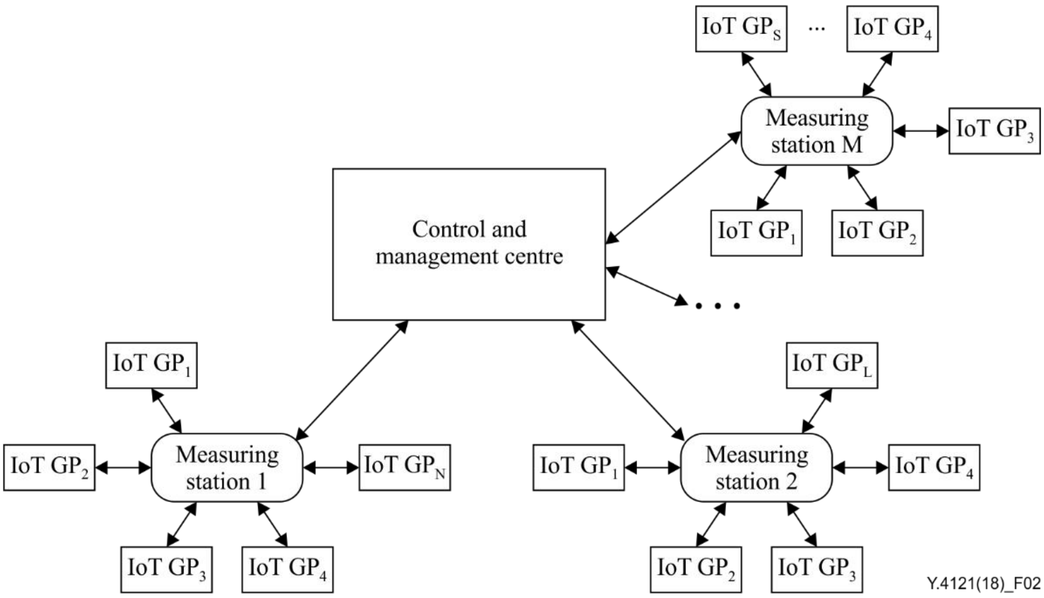

Figure 2 – IoT GP devices placement

Figure 2 shows a block diagram of a hybrid network for global process monitoring. The figure shows the interaction between IoT GP devices equipped with sensors and existing measuring stations. The physical conditions of the deployment area of IoT GP devices and related communication capabilities may imply additional limitations on the deployment scheme.

9 IoT GP network requirements

9.1 IoT GP network operation and maintenance requirements

Global processes are difficult and multi-sided processes. They cannot be generally studied operating only with one geological criteria and indicator. Different types of indicators, e.g., medical sanitary and socio-economic indicators, may be necessary. Only their cumulative use allows the estimation of the influence of various factors on global processes.

An IoT GP network may aggregate information from various sources to make available a wide range of data for studying global processes. To provide good measurement results, an IoT GP network needs to meet basic requirements for its operation and maintenance, both from the networking capability and the IoT GP device perspectives [ITU-T Y.4113]. These requirements also address the implementation of IoT GP network operation modes during and after disasters [ITU-T Y.4102].

9.2 IoT GP device selection requirements

Depending on the appropriate type of the monitoring network for a specific kind of studied global process(es), the IoT GP devices are selected according to their ability to detect the necessary phenomena and to their sensitivity. The list of measured physical parameters is unique for each global process. The selection is carried out as a result of research and changes of the measurement characteristics of IoT GP devices, depending on the studied global process and its signals.

NOTE – Compliance with identified parameters will be specific to each deployment and shall not supersede national policies and regulations.

The information related to the IoT GP devices selection is stored in the databases of the control and management centre (CMC) together with the information on the geolocation of the IoT GP devices. All this information is taken into account during the process of monitoring and study of global processes.

When selecting IoT GP devices, it is important to identify the periodic processes that are reproduced in the objects represented by the IoT GP devices, and which can be modulated by the signals anticipating the emergency situations, which may indicate an early stage of the impending disaster.

The specific IoT GP devices selected as sensors (IoT GP devices type 1) should have a noticeable sensitivity to changes in the parameters of the external environment. They can be living objects – for example, animals that change their common behaviour when global disasters approach – or non-living objects – for example, a change in the conductivity of the atmosphere or a change of colour of the water in reservoirs or rivers. Geochemists, biologists and geophysicists are well aware of such objects. Experimental studies of such objects, transformed into IoT GP devices with continuous monitoring and processing of data in real time, simultaneously and synchronously with the data of existing monitoring systems, will make it possible to select and further certify them as sensors for prediction of earthquakes and other natural or man-made disasters.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2018