

Recommendation

ITU-T Y.4228 (08/2024)

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 and framework of industrial IoT (IIoT) infrastructure for smart manufacturing

ITU-T Y-SERIES RECOMMENDATIONS

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

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Recommendation ITU-T Y.4228

Requirements and framework of industrial IoT (IIoT) infrastructure for smart manufacturing

Summary

Recommendation ITU-T Y.4228 provides requirements and reference framework of the industrial Internet of things (IIoT) infrastructure capabilities for smart manufacturing to help service providers implement their system according to the needs of smart manufacturing and merge existing and newly developed IIoT infrastructure, in order to give the stakeholders of smart manufacturing guidance for their applications. Industrial Internet of things (IIoT) infrastructure for smart manufacturing refers to common facilities based on IoT that support smart manufacturing in industries or sectors. It is independent of the products and production process in specific enterprises.

History*

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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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Recommendation ITU-T Y.4228

Requirements and framework of industrial IoT (IIoT) infrastructure for smart manufacturing

1 Scope

This Recommendation introduces the concept of industrial Internet of things (IIoT) infrastructure for smart manufacturing (SM), analyses its requirements, and provides a reference framework of the IIoT infrastructure capabilities for smart manufacturing.

The scope of this Recommendation includes:

- concept, common characteristics, and requirements of IIoT infrastructure;
- reference framework of the IIoT infrastructure capabilities for smart manufacturing.

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.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things*.
- [ITU-T Y.4003] Recommendation ITU-T Y.4003 (2018), *Overview of smart manufacturing in the context of the industrial Internet of things*.
- [ITU-T Y.4100] Recommendation ITU-T Y.4100/Y.2066 (2014), *Common requirements of the Internet of things*.
- [ITU-T Y.4401] Recommendation ITU-T Y.4401/Y.2068 (2015), *Functional framework and capabilities of the Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 factory external network [b-ITU-T Y.2623]: A network aiming to support various activities during the whole industrial life cycle and is used to connect the upstream and downstream of an enterprise, enterprise and intelligent products, as well as enterprise and users.

3.1.2 factory internal network [b-ITU-T Y.2623]: A network used for connection between the production factors, and between the corporate information technology (IT) management systems within a factory.

3.1.3 industrial Internet of things (IIoT) [ITU-T Y.4003]: An Internet of things based enabling approach for industrial transformation, by taking advantage of existing and emerging information and communication technologies.

NOTE 1 – Emerging information and communication technologies include technologies for smart machines, robots, advanced industrial networks, industrial cloud computing and industrial data processing.



NOTE 2 – The industrial transformation enabled by the industrial Internet of things empowers the industry with, but not limited to, improved efficiency, intelligent production, reduced energy consumption, advanced collaboration modes and new business models. The industrial Internet of things enables smart manufacturing providing enhanced capabilities in support of manufacturing.

3.1.4 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.

3.1.5 smart manufacturing [ITU-T Y.4003]: A generic term for advanced processes, systems, methods and organizations throughout the manufacturing ecosystem based on advanced computing and manufacturing technologies, as well as existing and evolving interoperable information and communication technologies, aiming to integrate this ecosystem, innovate the development of products and services and improve the efficiency and reliability of manufacturing's life-cycle management, together with increasing performance, safety and environmental sustainability.

NOTE – The concept of smart manufacturing encompasses all aspects of the manufacturing activities, from design, sales, production, logistics and service.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

4G	4 th Generation
5G	5 th Generation
ACL	Access Control List
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
API	Application Programming Interface
BGP	Border Gateway Protocol
BGP-LS	Border Gateway Protocol – Link State
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CoAP	Constrained Application Protocol
CRM	Customer Relationship Management
DCS	Distributed Control System
DMZ	Demilitarized Zone
DTLS	Datagram Transport Layer Security
DWDM	Dense Wavelength Division Multiplexing
E2E	End-to-End

EDP	Enhanced Device Protocol
ERP	Enterprise Resource Planning
FCS	Fieldbus Control System
Flowspec	Flow Specification
GRE	Generic Routing Encapsulation
HA	High Availability
HMI	Human Machine Interface
HTTP	Hypertext Transfer Protocol
I/O	Input/Output
IaaS	Infrastructure as a Service
ID	Identifier
IIoT	Industrial Internet of Things
IoT	Internet of Things
IP	Internet Protocol
IPS	Invasion Protection System
IPsec	Internet Protocol Security
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IT	Information Technology
L2TP	Layer 2 Tunnelling Protocol
MES	Manufacturing Execution System
MPLS	Multiprotocol Label Switching
MQTT	Message Queuing Telemetry Transport
NB-IoT	Narrowband Internet of Things
NETCONF	Network Configuration Protocol
NFV	Network Functions Virtualization
NoSQL	Not only SQL
OA	Office Automation
OAM	Operation, Administration and Maintenance
OID	Object Identifier
ORS	OID Resolution System
OSI	Open Systems Interconnection
OT	Operational Technology
OTN	Optical Transport Network
PaaS	Platform as a Service
PC	Personal Computer
PCEP	Path Computation Element Communication Protocol



PDE	Packet Duplication and Elimination
PLC	Programmable Logic Controller
PLM	Product Lifecycle Management
PON	Passive Optical Network
QoS	Quality of Service
R&D	Research and Development
RFID	Radio Frequency Identification
RS	Recommended Standard
SaaS	Software as a Service
SCADA	Supervisory Control and Data Acquisition
SCM	Supply Chain Management
SDH	Synchronous Digital Hierarchy
SDN	Software-Defined Networking
SDO	Standards Development Organization
SD-WAN	Software-Defined Wide Area Network
SLA	Service Level Agreement
SM	Smart Manufacturing
SMPP	Short Message Peer-to-Peer
SNMP	Simple Network Management Protocol
SQL	Structured Query Language
SR	Segment Routing
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TSN	Time-Sensitive Networking
ULSIN	Unified Large Scale Industrial Network
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
VXLAN	Virtual extensible Local Area Network
WIA-FA	Wireless network for Industrial Automation - Factory Automation
WIA-PA	Wireless network for Industrial Automation - Process Automation
Wi-Fi	Wireless Fidelity
WPAN	Wireless Personal Area Network
YANG	Yet Another Next Generation

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 Recommendation 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 Introduction of Industrial Internet of things infrastructure

Smart manufacturing provides an advanced production mode based on the deep integration of advanced manufacturing technology and new generation information technology, which runs through the whole product life cycle such as design, production, sales, logistics and services. Smart manufacturing has the characteristics of self-perception, self-decision-making, self-performing, self-adaptation and self-learning, and it aims to improve the quality, efficiency and flexibility of the manufacturing industry.

IIoT infrastructure plays a crucial role in smart manufacturing, and provides supporting smart manufacturing capabilities, as presented in [ITU-T Y.4003]. This clause introduces technical aspects with regard to the IIoT Infrastructure utilized for smart manufacturing.

NOTE – With respect to smart manufacturing, the IIoT constitutes a critical foundation. As an IoT-based enabling approach [ITU-T Y.4003], IIoT is the approach to support smart manufacturing, but the IIoT infrastructure is not specifically dedicated only to the support of smart manufacturing, i.e., other applications or industries can be supported by the IIoT infrastructure. However, there is a strong crossover between "IIoT" and "smart manufacturing" (SM) in terms of public recognition by global advanced manufacturing and IoT engaged standards development organizations (SDOs), organizations and other interested groups [b-ISO/IEC TR 30166].

Figure 1 depicts a conceptual framework of the IIoT infrastructure from the Internet of things (IoT) and smart manufacturing points of view, based on the IoT reference model layering [ITU-T Y.4000]. The following clauses describe the facilities of the three layers, as well as the cross-layer facilities of this framework.

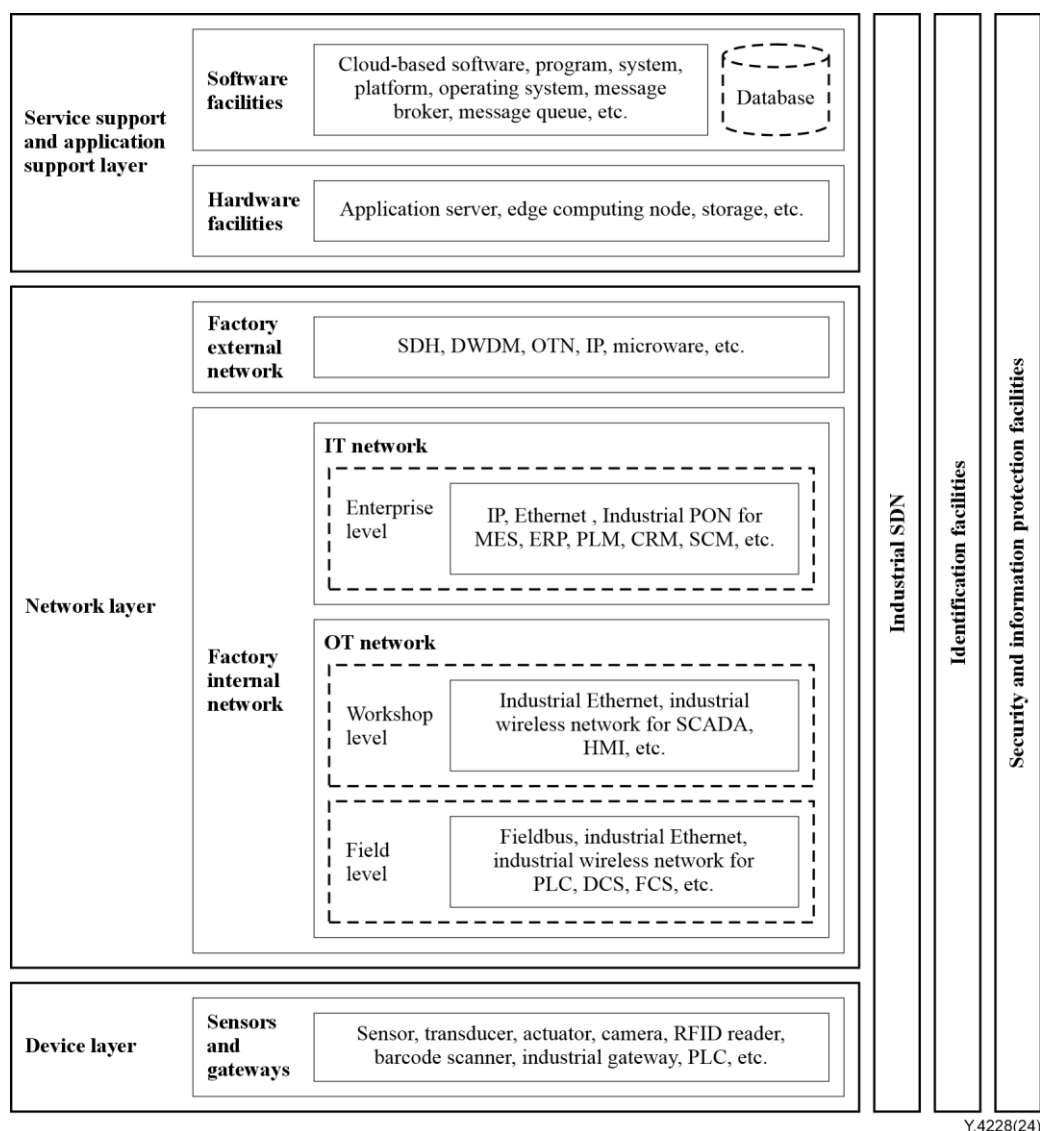


Figure 1 – Conceptual framework of the IIoT infrastructure from the IoT and smart manufacturing points of view

6.1 Device layer

Due to the many communication technologies in the industrial network, the relevant communication media in the IIoT infrastructure physical layer are very diverse. The devices connected in the industrial network are not only personal computers (PCs), printers and other equipment, but also industrial control and management equipment, such as industrial PCs, human machine interface (HMI), programmable logic controllers (PLCs), motion controllers, remote terminals, and radio frequency identification (RFID) equipment. These devices work at different layers or across multiple layers of the open systems interconnection (OSI) [b-ITU-T X.200] reference model, provide data in standardized or non-standardized format, receive control and adjustment signals from the upper layers, and perform comprehensive sensing and control of relevant hardware and processes in the industrial production environment.

These devices can be distinguished into sensors and gateways, which directly interact with machines, robotics, environment equipment and other field facilities for smart manufacturing production.

6.1.1 Sensors

They belong to different categories, such as sensors of resources, security, presence, lighting, motion, environment and position, and are installed on the physical facilities for smart manufacturing. These devices make it possible to collect and track the status of smart manufacturing machines, operations, environment, etc., in order to help the facilities in the upper layers in gathering, processing, analysing and eventually generating valuable information throughout services for smart manufacturing.

6.1.2 Gateways

The manufacturing-specific gateways connect manufacturing facilities such as sensors, PLCs, machines and robotics which have open data interfaces. This is to sense and identify data upward from different resources and help control and execute decision flows downward from the upper layer facilities. Gateways translate and transform information coming from devices and sensors into formats and structures suitable for applications and systems in the upper layer, and transport them using suitable network protocols, and vice versa.

In the industrial environment, services are not only deployed in the cloud, but also likely to be deployed in both the industrial field and the cloud. The industrial field equipment and machines will produce extensive data at the edge of the network, and the edge network equipment such as gateways at the industrial field will require interoperable data processing capability and flexible service carrying and forwarding capability.

6.2 Network layer

The network provides comprehensive interconnection of people, machines and things, in order to transport data among them, this being a basic function to fulfil the requirements of industrial applications. It promotes seamless flowing and integration of diverse industrial data.

The IIoT network connections involve different technical fields inside and outside the enterprise. Many networking technologies are used in the industrial field with related performance advantages in specific scenarios. However, these technologies with specific capabilities (such as many kinds of industrial fieldbuses) are designed and applied only in specific scenarios, and cannot meet the requirements of IIoT in terms of data interoperability and seamless integration.

The overall goal of the network connectivity is to promote the interconnection between systems, unlock data from isolated systems or networks, and make data play a greater value for industry and cross industry applications.

The network layer consists of two sub-layers, the factory internal network sub-layer and the factory external network sub-layer [b-ITU-T Y.2623].

6.2.1 Factory internal network

The factory internal network is the network inside the factory or the enclosed area for production, which is used to connect smart manufacturing related industrial resources [b-ISO/IEC TR 30166]: personnel (such as production personnel, designers and external personnel), machines (such as production equipment and office devices), materials (such as raw materials, semi-finished and finished products), processes (such as exchange of materials and control of production), environmental assets (such as instruments and monitoring equipment), etc. Through the factory internal network, these resources are interconnected with the enterprise data centre and application servers to support services and applications.

From the smart manufacturing point of view, the factory internal network encompasses an operational technology (OT) network and an information technology (IT) network [b-ITU-T Y.2623].