Discuss the standard of Industry 4.0

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Abstract. Industry 4.0 is a very popular topic in recent years. Many companies want to be able to industrial upgrading by importing industry 4.0. To import Industry 4.0 it is necessary to follow the relevant standards. Many countries and international organizations have invested in the research and development of standards such as International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC). This study find out the relevant existing standards from these two international organizations and explain its contents. In addition, this study also illustrates how to integrate the use of relevant standards by using the example of IoT.

Keywords. Industry 4.0, standard, standardization

1. Introduction

With the rise of Industry 4.0, many countries have actively developed and promoted industry 4.0 in recent years. Equipment, suppliers, factories, production lines, products and customers are supposed to be linked. Therefore, there should be specific standards to allow companies to follow. For example, system architecture, data, processes, terms, etc., should have the relevant standards that companies can follow. Companies can't effectively integrate business partners or customers if they failed to follow the standards. The related methods, standards, platforms, and architecture have been gradually forming. This study wants to explore the existing standards of Industry 4.0 to understand the development of standards of Industry 4.0 so far that companies can follow. This research studies the standards of Industry 4.0, especially the international standards enacted by the IEC. Try to understand the import of Industry 4.0, in which operations need to follow standards and how to import and execute the relevant standards. Companies will be able to reduce the risk of importing failures if they follow the standards.

2. Literature review

2.1. International Electrotechnical Commission (IEC)

The IEC [1]established in 1906, is the oldest international organizations in the world for Electrotechnical Standardization. The address is 3, rue de Varembé P.O. Box 131,

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CH – 1211, Geneva 20, Switzerland. The phone number is +41 22 919 02 11. The IEC is responsible for the international standardization work in the field of electrical engineering and electronic engineering. SMB is the IEC Standardization Management Board, as the agency responsible for the overall management of the IEC technical work. SMB is also responsible for strategic planning, adjustment, execution and supervision of the activities of the Technical Committee. IEC / SMB / SG8 is the strategies working group of smart manufacturing of Industry 4.0 responsible for developing Industry 4.0 relevant standards and key technical standards In addition IEC/TC65 is also the core of the international standardization of Industry 4.0. IEC/TC65 focuses on Industrial-process, measurement, control and automation.

2.2. International Organization for Standardization (ISO)

The ISO [2] is established in 1947. The ISO also located in Geneva. The address is Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland. The phone number is +41 22 749 01 11. It is an independent, non-governmental international organization. There have 162 member states. It brings together the experts to share knowledge and develop international standards. The ISO works closely with the IEC on the development of standards. ISO/TC 184 is the core of the international standardization of Industry 4.0. ISO/TC 184 focuses on automation systems and integration.

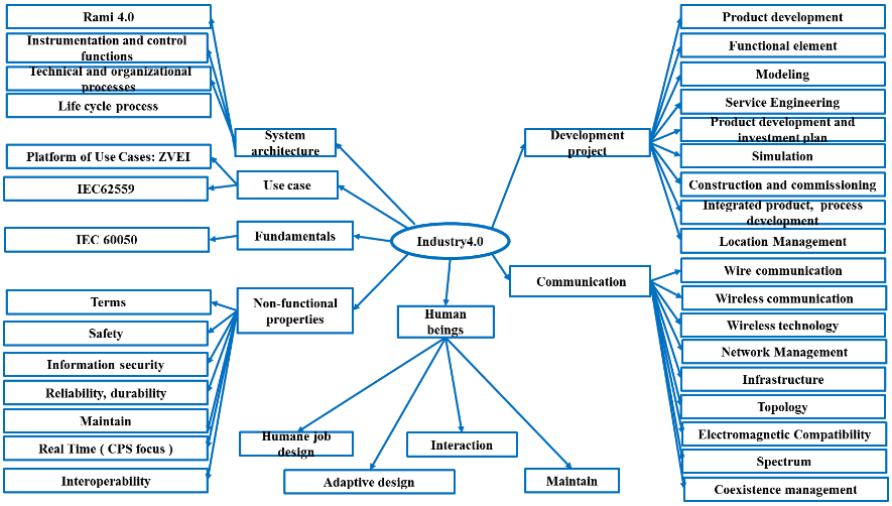
2.3. Deutsches Institut für Normung e.V. (DIN)

The DIN [3] is established in 1975. The DIN is the national standardization organization in Germany. It located in Berlin. The address is Burggrafenstrasse 6, DE-10787, Berlin. The phone number is +49 30 26 01-0. It is a very important international standardization organization. Many of the standards set by DIN will be adopted by the ISO standard and become an international standard.

3. Methodology

The methodology of this research consists of three steps. First, understand what projects need to standardization in Industry 4.0. Second, based on these projects to find out whether there are existing relevant standards and briefly describe its contents. The last, give some examples to discuss how to use these standards.

3.1. The projects need to standardization



Source: DKE

Figure 1. Standardization roadmap.

Figure 1 shows the standardization roadmap of industry4.0 [4] reference DKE Company's German standardization roadmap Industry 4.0 version 2. This figure only lists the projects that are needed standardization in Industry 4.0. It doesn't mean that these projects all have a relevant international standard for Industry 4.0 now. This figure contains 7 main project including System architecture, Use case, Fundamentals, Non-functional properties, Human beings, Communication and Development project. According to these projects, this research tries to find out the relevant standards. In 3.2 will discuss these standards.

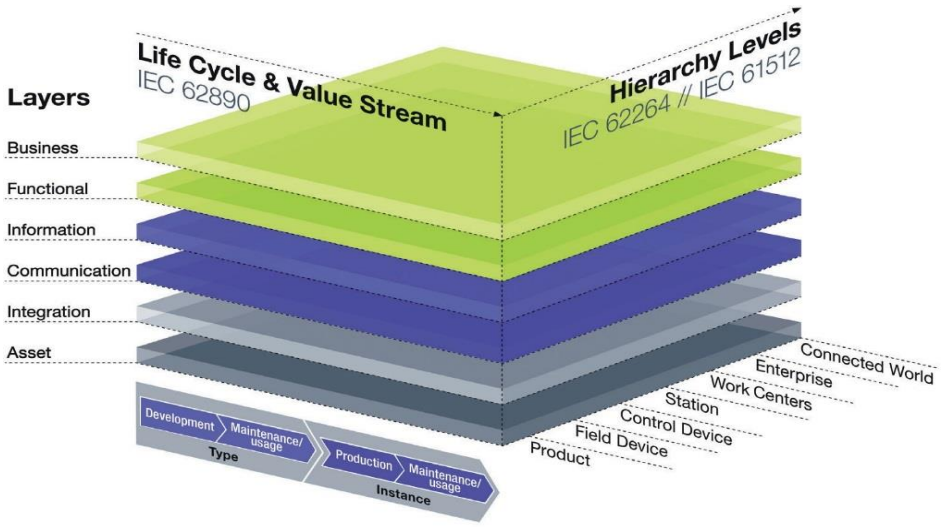
3.2. Standards

3.2.1. System architecture

System architecture is divided into RAMI 4.0, Reference Models of instrumentation and control functions, Reference Models of technical and organizational processes, and Reference Models of life cycle process. However, it doesn't have the standards about Reference Models of technical and organizational processes now.

3.2.1.1. RAMI 4.0

Figure 2 shows the Reference Architectural Model Industry 4.0 (RAMI4.0) [5] determined by German's association as the basis for development of future products and business models. This model will be phased into the current Industry 4.0. The relevant standards are the following:



Source: Platform Industry 4.0

Figure 2.RAMI 4.0 Model

- IEC 62890 Life-cycle management for systems and products used in industrial-process measurement, control and automation:

Consistent data model during the whole life cycle. Use in the value stream and life cycle level of RAMI 4.0.

- IEC 62264 [6] Enterprise-control system integration:

Define the terms and models between the enterprise business systems and factory floor control systems. It is an international standard for enterprise-control system integration. It currently has three parts including models and terminology, objects and attributes for enterprise-control system and activity models of manufacturing operations management.

- IEC 61512 [7] Batch control:

The IEC 61512 defined the models for batch control as used in the process industries and terms that help explain the relationships between these models and terms. The IEC 61512 also defined the data models that describe batch control as applied in the process industries, data structures for facilitating communications within and between batch control implementations and language guidelines for representing recipes.

- IEC TS 62832 [8] Digital Factory:

This standard provides the model of the „Digital Factory". It discussed about the information exchange between the Digital Factory Repository and the tools such as modeling, simulation, monitoring, security, planning. It also descripted assets and installation specific properties, each asset will get a header to describe the installation specific properties.

- IEC TR 62794[9] Industrial-process measurement, control and automation - Reference model for representation of production facilities (digital factory):

Provide a reference model which comprises the abstract description for automation assets and structural and operational relationships.

3.2.1.2. Reference Models of instrumentation and control functions

The relevant standards are IEC 62264 Enterprise-control system integration and IEC 61512 Batch control.

3.2.1.3. Reference Models of life cycle process

The relevant standard is IEC 62890: Life-cycle management for systems and products used in industrial-process measurement, control and automation.

- ISO 15926 [10] Industrial automation systems and integration - Integration of life-cycle data for process plants including oil and gas production facilities:
  The ISO 15926 is the international standard for data, sharing, exchange, integration, and hand-over between computer systems. The purpose is to promote the integration of data to support the process of life-cycle activities and production facilities.

3.2.2. Use case

The relevant standard of use case is IEC 62559. In addition, the Industry 4.0 platform and ZVEI (German Electrical and Electronic Manufacturers) also have made some use cases related Industry 4.0.

- IEC 62559 [11] Use case methodology:

Use case is defining the interactions between a role and a system. The IEC 62559 defines the structure of a use case template, template lists for actors and requirements, as well as their relation to each other.

3.2.3. Fundamentals

Companies want to standardize the use of common terminology with other enterprises is necessary. The relevant standards are the following:

- IEC60050 [12] International Electrotechnical Vocabulary:
  Define the common terminology.

3.2.4. Non-functional properties

The target system of Industry 4.0 is an industrial production system. In addition to the actual function, there are some non-functional properties to meet the production of efficient, safe and stable. Non-functional properties usually have cross-cutting properties, and its related projects are terms, safety, information security, reliability/durability, maintain, real time (CPS focus), interoperability.

3.2.4.1. Terms

The relevant standards are the following:

- IEC 61360\ IEC 62683\ IEC 61987 [13] Common Data Dictionary (CDD):

Provide clear identification of classes and properties, and their relations; commonly accepted terminology and definitions based on accepted sources such as IEC International Standards, other International Standards, industry standards, or public authorities.

- IEC 61804-3\IEC61804-4 [14] Electronic Device Description Language (EDDL):

EDDL is a language that be used to describe the characteristics of devices. Device suppliers can use EDDL to create Electronic Device Description (EDD) files instead of using XML.

3.2.4.2. Safety

Following are the standards about safety:

- IEC 61508 [15] Functional safety of electrical/electronic/ programmable electronic safety-related systems:

Functional safety is a concept suitable for all industry sectors. The IEC 61508 series defined the standards for electrical, electronic and programmable electronic safety related systems. It also sets out the requirements for ensuring that systems are designed, implemented, operated and maintained to provide the required safety integrity level (SIL). SILs have 4 levels. SIL4 is the highest level that uses to protect the highest risks.

- IEC 61511 [16] Functional safety – Safety instrumented systems for the process industry sector:

IEC 61511 is a technical standard which sets out practices in the engineering of systems that ensure the safety of an industrial process through the use of instrumentation. Such systems are referred to as Safety Instrumented Systems. The title of the standard is "Functional safety - Safety instrumented systems for the process industry sector".

- ISO 13849 [17] Safety of machinery -- Safety-related parts of control systems:

ISO 13849 provides safety requirements and guidance on the principles for the design and integration of safety-related parts of control systems and establish different safety Performance Levels.

3.2.4.3. Information security

In a lot of information transmission, the information security is something that must be seriously. The relevant standards are the following:

- IEC 62443（ISA S99）[18] Security for Industrial Automation and Control Systems:

IEC62443 series of standards divided into 4 parts general, information security program, system technology and component technologies. IEC62443 series of standards used these 4 parts to achieve comprehensive security protection.

- ISO/IEC 27000-series [19] Standard for information security management systems:

Provides best practice recommendations on information security management, risks and controls within the context of an overall information security management system (ISMS), similar in design to management systems for quality assurance and environmental protection.

3.2.4.4. Reliability/Durability and Maintain

In order to not interrupt the production, lower production costs, the reliability of the machine is very important, the relevant standards are as follows:

- DIN EN 60300-3-10:2015-01 [20] Reliability Management- Application guide - Maintainability and Supportability:

The application guide can be used to implement a maintainability programme covering the initiation, development and in-service phases of a product. It provides guidance on how the maintenance aspects of the tasks should be considered in order to achieve optimum maintainability.

3.2.4.5. Interoperability

In Industry 4.0, it’s important that have good communication between machines and machines. The relevant standards are as follows:

- IEC 62769 [21] Field Device Integration (FDI):

FDI technology is a device integration technology, which plays a key role in the device addressing and management in factory. IEC 62769 specifies the FDI client, FDI server, FDI packages, information model that reflect the topology of the automation system, FDI technology mapping, and FDI communication devices.

- IEC 62541 [22] OPC UA:

OPC standard is to solve interoperability problems. Specifically for M2M communication. Between the machine and the machine needs to have a bridge, so we can use IEC 62541.

3.2.5. Communication

Communication is an important part of the IoT. Communication can be divided into wired and wireless communications.

3.2.5.1. Wire communication

The relevant standards of wire communication are as follows:

- IEEE802.3 [23]

IEEE 802.3 is a working group and a collection of IEEE standards produced by the working group defining the physical layer and data link layer's media access control (MAC) of wired Ethernet.

3.2.5.2. Wireless communication and technology

The relevant standards of wireless communication are as follows:

- EN 300 328/ EN 300 440 [24]

Define the requirements and conditions of the industrial radio communication.

- IEC61784-2 [25] Industrial communication networks - Profiles - Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3

Define the performance indicators supporting classification schemes for Real-Time Ethernet (RTE) requirements.

- IEC 62591 [26] (WirelessHART) Industrial communication networks - Wireless communication network and communication profiles - WirelessHART™:

Define physical layer service definition and protocol specification, data-link layer service and protocol, application layer service and protocol, network management, security, communication profile, wireless procedures and Gateway.

- IEC62601 [27] (WIA-PA) Industrial networks - Wireless communication network and communication profiles - WIA-PA:

Define the system architecture and the communication protocol of Wireless networks for Industrial Automation - Process Automation (WIA-PA)

3.2.5.3. Coexistence management

There are many different devices, systems in a factory, how to maximize the benefits is important. Therefore, companies should follow the standards of coexistence management.

- IEC62657-2 [28] Industrial communication networks - Wireless communication networks - Part 2: Coexistence management:

Specifies the fundamental assumptions, concepts, parameters, and procedure for wireless communication coexistence; provides guidelines, requirements, and best practices for wireless communication's availability and performance in an industrial automation plant; it covers the life cycle of wireless communication coexistence and provides a common point of reference for wireless communication coexistence for industrial automation sites as a homogeneous guideline to help the users assess and gauge their plant efforts.

3.3. Discuss how to use these standards

IoT:
Companies want to import IoT to be followed some standards. First, must use the common terminology. IEC 61360、IEC 61987 (sensors types) 、IEC 62683 (switch gears types), these three standards includes the related terminology of IoT. The equipment interoperability standards are also the key to IoT can use IEC 61804 (Electronic Device Description Language EDDL) is an electronic device description language. Besides between machines and machines need to have a bridge, use the IEC 62541 (OPC UA), is designed for M2M communication protocol. Also very important is communication with a wireless transmission standard, the communication can be IEC 62591 (WirelessHART) and IEC 62601 (WIA-PA). Once you have the transmission, security information is important to note, IEC 62443 and ISO 27000 series of standards define information security. Finally, to complete the relevant installation and build can reference IEC 62794 and IEC 62832. Both standard describes how to complete the related installation and build [29].

4. Conclusion

There are many standards associated with Industry 4.0. This study cannot list all the relevant standards. Different industries might have different standards need to follow. To import Industry 4.0 is not able to happen overnight. Enterprises must be gradual to achieve their goals. Industry 4.0 is the opportunity of business transformation. Enterprises should set out targets based on their own situation, and then import Industry 4.0 in accordance with international standards. However, the relevant standards of Industry 4.0 are at the stage of vigorous development. Some matters that need to be standardized may not have relevant international standards now. This study only discuss existing Industry 4.0 standards. There will be more standards that must be followed with time passing.

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