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Digital twin - Reference architecture

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ISO/IEC 30188 has been prepared by subcommittee 41: Internet of Things and Digital Twin, of ISO/IEC joint technical committee 1: Information technology. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
JTC1-SC41/598/FDIS	JTC1-SC41/621/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, and the ISO/IEC Directives, JTC 1 Supplement available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

INTRODUCTION

The term digital twin can be used to refer to a technology domain. This is the case in the title of this document. Digital twin as a technology joins the real world and the digital world now found in many domains of manufacturing, cities, agriculture, energy, buildings, healthcare, etc., and product categories such as appliances, automobiles, machine tools, and building security. This technology is applied, for example, by the following:

– manufacturing companies to simulate and predict products and product lines, resulting in production cycle reduction and cost reduction;
– city planners to optimize city development based on simulation models, and realize visualization, convenience and intelligent city management;
– agricultural producers to monitor and optimize production operations, and perform predictive diagnosis on agricultural machinery and equipment;
– energy managers to achieve visual monitoring and management of energy production and transmission processes, as well as fault analysis and remote operation and maintenance;
– building operators to achieve energy conservation, environmental protection, lower operation cost and intelligent management of constructed buildings;
– doctors to monitor patients' real-time conditions, providing personalized medical solutions, dynamically optimizing medical resources.

Relevant application domains and standardization bodies for digital twin technology include, among others, the following:

– smart energy with IEC TC 57, IEC SyC Smart Energy;
– smart cities with IEC SyC Smart Cities, ISO/TC 268, ISO/IEC JTC 1/WG 11;
– farming with ISO/TC 23/SC 19, ITU-T;
– building with ISO/TC 59/SC 13;
– healthcare with ISO/TC 215;
– manufacturing with ISO/TC 184/SC 4, IEC TC 65/JWG 21, IEC SyC Smart Manufacturing, IEEE Computer Society Smart Manufacturing Standards Committee – Digital Representation Working Group.

Specific technical areas and related standardization bodies for a digital twin include, among others, the following:

– architecture (and lifecycle management) with ISO/IEC JTC 1/SC 7;
– modelling (and product properties) with ISO/IEC JTC 1/SC 7, ISO TC 184/SC 4, IEC SC 3D;
– simulation with IEEE 1516, SISO (Simulation Interoperability Standards Organization);
– automatic identification (and data capture) with ISO/IEC JTC 1/SC 31;
– augmented reality and virtual reality with ISO/IEC JTC 1/AG 13, ISO/IEC JTC 1/SC 24, IEEE P2048;
– Internet of Things with ISO/IEC JTC 1/SC 41;
– artificial intelligence with ISO/IEC JTC 1/SC 42;
– information technology security with ISO/IEC JTC 1/SC 27;
– privacy with ISO/IEC JTC 1/SC 27, and ISO/IEC JTC 1/SC 44;
– cloud computing with ISO/IEC JTC 1/SC 38.

The term digital twin can also be used to refer to the digital representation of a target entity. This is the case in a reference architecture description of a system of interest which involves digital twins.

Figure 1 depicts conceptual artefacts involved in the development of a system involving digital twin technologies:

– input and output items (ellipses in Figure 1):
  - stakeholder expectations and concerns as input, and
  - the system involving digital twin technologies as output;

NOTE 1 Stakeholder expectations and concerns can include requirements for governance models.

– standard items (round rectangles in Figure 1) which enable architecture processes:
  - ISO/IEC/IEEE 42010 [1][1],
  - this document, and
  - associated architecture patterns;

NOTE 2 Architecture patterns can include other reference architecture standards such as ISO/IEC 30141 [2].

– work product items or output of processes (rectangles in Figure 1):
  - stakeholder needs and requirements,
  - system requirements and
  - the architecture description;

– processes (horizontal bars in Figure 1).

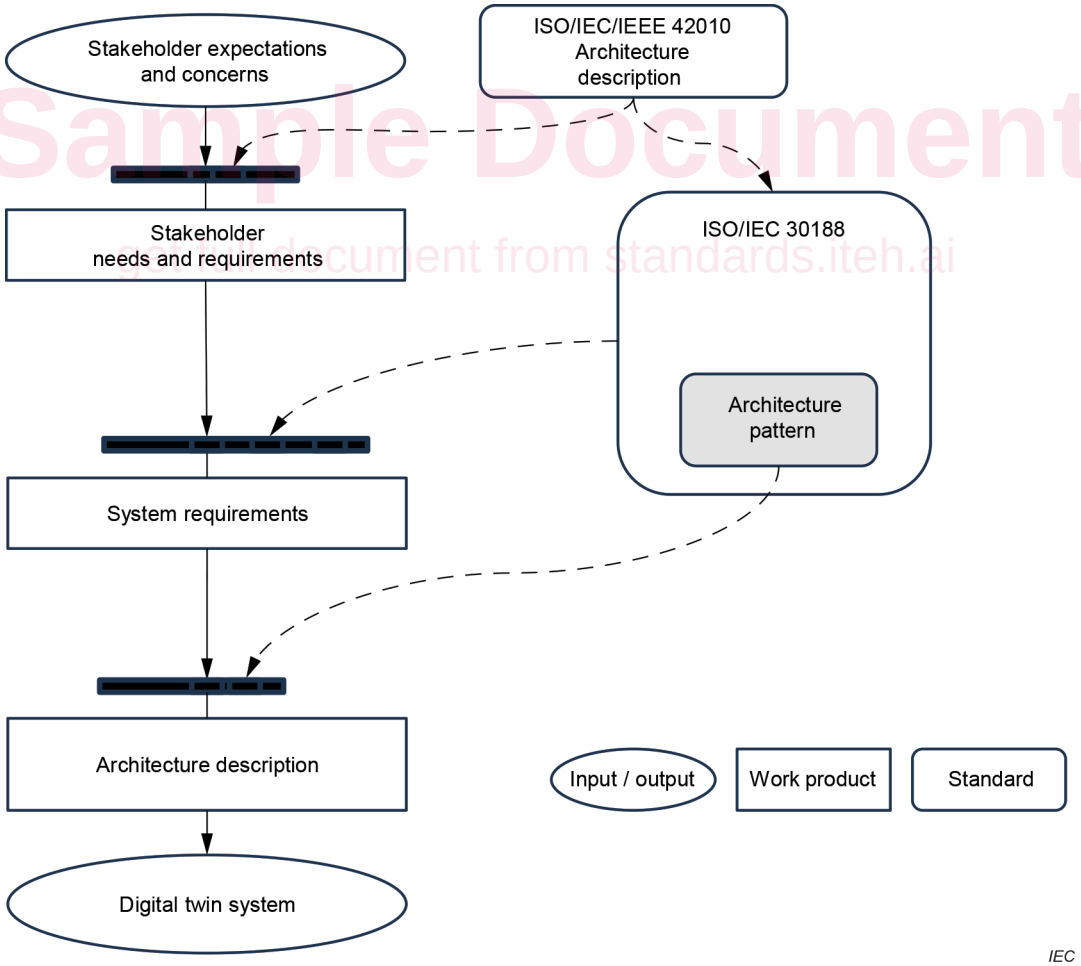

Figure 1 – How to use this document

[1] Numbers in square brackets refer to the Bibliography.

The target audience of this document are digital twin architects and engineers, digital twin project or programme managers, digital twin business managers, or digital twin owners, of all domains (application domains or technology domains).

Figure 2 shows the architecture views that are defined in this document:

– the foundational view covers the conceptual models (twinning model, synchronization model) and the lifecycle model;
– the functional view covers capabilities in the design and development, the deployment, the operation and the retirement stages;
– the implementation view covers the implementation of the usage and business interface, the implementation of interoperability, and the implementation of models;
– the architecture pattern view covers the construction model which can be used to extend an architecture.

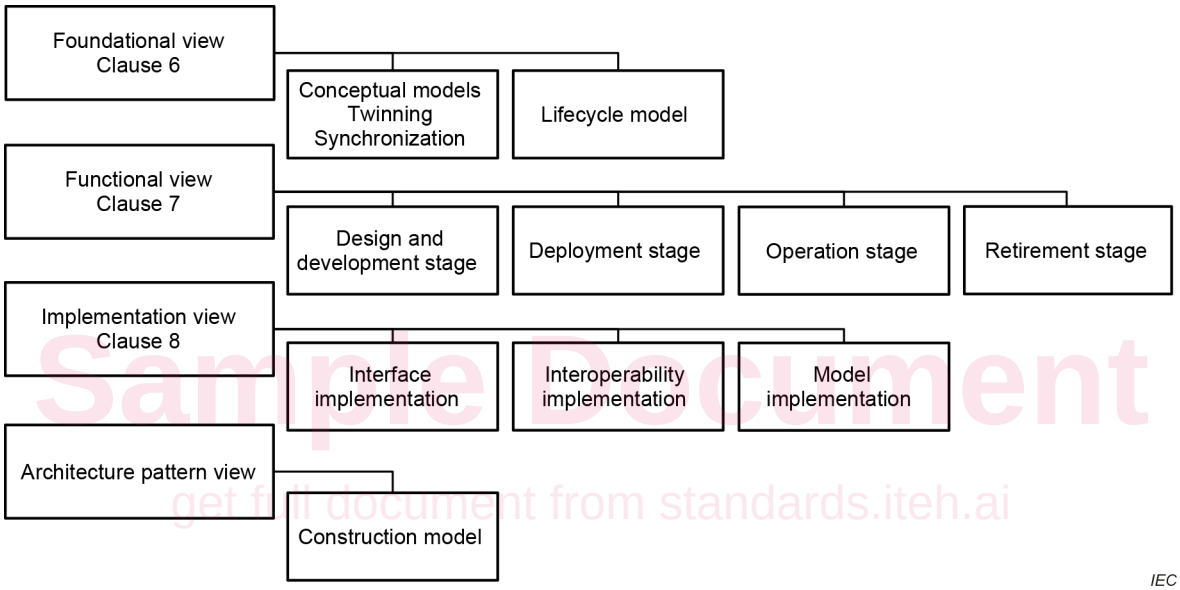

Figure 2 – Used architecture views

NOTE 3 While this document focuses on reference architecture considerations related to digital twins, it does not elaborate on concept relationships (e.g. digital twin as a technology, digital twin as a representation, digital twin in a system).

NOTE 4 This document does not address security and privacy of digital twins. These can be addressed in specific architecture patterns.

1 Scope

This document specifies a general reference architecture for a digital twin system in terms of defining system fundamentals through the use of architecture views.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/

– ISO Online browsing platform: available at https://www.iso.org/obp

3.1
digital twin
DTw
digital representation of a target entity (3.2) with data connections that enable convergence at an appropriate rate of synchronization between the state of the target entity and the state of that digital representation

Note 1 to entry: Digital twin has some or all of the capabilities of connection, integration, analysis, simulation, visualization, optimization, collaboration, etc.

Note 2 to entry: Digital twin can provide an integrated view throughout the lifecycle of the target entity.

[SOURCE: ISO/IEC 30173:2023 [3], 3.1.1, modified – In the definition, "between the physical and digital states" has been replaced with "between the state of the target entity and the state of that digital representation" and the word order has been modified.]

3.2
target entity
entity (3.11) that is of interest for a digital twin (3.1)

Note 1 to entry: The target entity can be physical, digital, or both.

3.3
entity of interest
subject of an architecture description

EXAMPLE Enterprise, organization, solution, system (including software systems), subsystem, process, business, data (as a data item or data structure), application, information technology (as a collection), mission, product, service, software item, hardware item, product line, family of systems, system of systems, collection of systems, collection of applications.

Note 1 to entry: In this document, the term entity of interest refers to the entity whose architecture is under consideration in the preparation of an architecture description.

Note 2 to entry: This document distinguishes the entity of interest from other entities which are not the subject of the architecture description.

Note 3 to entry: In this document, interest in an entity is intended to encompass interest in that entity's environment, lifecycle, architecture, requirements, design, implementation and operation. Such interests are captured via aspects, concerns and stakeholder perspectives.

[SOURCE: ISO/IEC/IEEE 42010:2022 [1], 3.12]

3.4
architecture view
information part comprising portion of an architecture description

[SOURCE: ISO/IEC/IEEE 42010:2022 [1], 3.7, modified – The example has been deleted.]

3.5
architecture viewpoint
set of conventions for the creation, interpretation and use of an architecture view (3.4) to frame one or more concerns

[SOURCE: ISO/IEC/IEEE 42010:2022 [1], 3.8, modified – The notes to entry have been deleted.]

3.6
capability
measure of capacity and ability of an entity (3.11) (system, person or organization) to achieve its objectives

[SOURCE: ISO/IEC TS 5723:2022 [4], 3.3.2, modified – In the definition, “and the ability” has been replaced by “and ability”.]

3.7
observable entity
observable element
entity (3.11) in the environment (3.9) of the target entity (3.2) which can be observed and modelled in the digital twin (3.1)

EXAMPLE 1 The human body is the observable entity of a healthcare digital twin.

EXAMPLE 2 An observable manufacturing element (e.g. personnel, equipment, material, process, facility, environment, or product) is an observable entity.

Note 1 to entry: An observable entity can be physical or digital.

Note 2 to entry: A target entity is also a type of observable entity.

3.8
observation data
data resulting from the monitoring and measurement of an observable entity (3.7)

3.9
environment
context of surrounding things, conditions, or influences upon an entity (3.11)

Note 1 to entry: The environment of an entity of interest (3.3) includes external entities that can have various influences upon an entity, such as developmental, technological, business, operational, organizational, political, economic, legal, regulatory, ecological and social influences as well as external physical effects such as electromagnetic radiation, charged particles, gravitational effects, and electric and magnetic fields.

Note 2 to entry: A label attached as a qualifier to the word environment identifies a particular sub-context within that environment, such as development environment, test environment, and operational environment.

Note 3 to entry: “Influences upon” is a bi-directional relationship.

[SOURCE: ISO/IEC/IEEE 42010:2022 [1], 3.13, modified – Note 3 to entry has been added.]

3.10
architecture pattern
general, reusable solution to common architecture challenges encountered during the design of an entity of interest (3.3)

Note 1 to entry: A reference architecture is a type of architecture pattern.

3.11
entity
anything perceivable or conceivable

[SOURCE: ISO 9000:2015 [5], 3.6.1, modified – The preferred terms "object" and "item", the example and the note to entry have been deleted.]

3.12
system
arrangement of parts or elements that together exhibit a stated behaviour or meaning that the individual constituents do not

[SOURCE:ISO/IEC/IEEE 15288:2023 [6], 3.46, modified – The notes to entry have been deleted.]

3.13
stage
period within the lifecycle of an entity (3.11) that relates to the state of its description or realization

Note 1 to entry: As used in this document, stages relate to major progress and achievement milestones of the entity through its lifecycle.

Note 2 to entry: Stages often overlap.

[SOURCE: ISO/IEC/IEEE 15288:2023 [6], 3.43]

3.14
twinning
pairing a digital twin (3.1) with a target entity (3.2)

3.15
synchronization
<digital twin> action of making the states of digital twin (3.1) and target entity (3.2) synchronized

4 Abbreviated terms

AI	artificial intelligence
DTw	digital twin
IoT	Internet of Things
IT	information technology
OT	operational technology

5 Specifying an architecture for digital twins

ISO/IEC/IEEE 42010 [1] provides requirements for the structure and expression of architecture descriptions, including the following elements:

– architecture viewpoints;
– stakeholder concerns framed by those viewpoints;
– architecture views that address those concerns.

Architecture views convey aspects of an entity of interest that, together with other architecture description elements, constitute the description of the architecture of the entity of interest.

As shown in Figure 2, this document covers the following architecture views:

– the foundational view that is required;
– the functional view that is required;
– the implementation view that is required;
– the architecture pattern view that is recommended.

6 Foundational viewpoint

6.1 Stakeholders and concerns

6.1.1 General

The foundational viewpoint establishes the fundamental concepts and essential characteristics of the digital twins.

6.1.2 Stakeholders

– Software and system architect.
– Project or programme manager.
– Standards expert.
– People concerned with the fundamentals of digital twin.
– Domain experts.
– Business managers.
– System owner.

6.1.3 Concerns

The matters of relevance or importance to a stakeholder in a digital twin are the following:

– description of the interfaces with the target entity;
– description of the possible interactions between the digital twin and the target entity;
– description of the characteristics of the target entity that can be observed;
– description of the lifecycle dependencies between the digital twin and the target entity.