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INTERNATIONAL STANDARD

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Internet of Things (IoT) – Reference architecture

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CONTENTS

INTERNET OF THINGS (IoT) – REFERENCE ARCHITECTURE

FOREWORD

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This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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INTRODUCTION

IoT has a broad use in industry and society today and it will continue to develop for many years to come. Various IoT applications and services have adopted IoT techniques to provide capabilities that were not possible a few years ago. IoT is one of the most dynamic and exciting areas of ICT. It involves the connecting of Physical Entities ("things") with IT systems through networks. Foundational to IoT are the electronic devices that interact with the physical world. Sensors collect the information about the physical world, while actuators can act upon Physical Entities. Both sensors and actuators can be in many forms such as thermometers, accelerometers, video cameras, microphones, relays, heaters or industrial equipment for manufacturing or process controlling. Mobile technology, cloud computing, big data and deep analytics (predictive, cognitive, real-time and contextual) play important roles by gathering and processing data to achieve the final result of controlling Physical Entities by providing contextual, real-time and predictive information which has an impact on physical and virtual entities.

IoT can be integrated into existing technologies. Real-time measurements generated by adding sensors to existing technology can improve its functionality and lower the cost of operations (e.g. smart traffic signals can adapt to traffic conditions, lowering congestion and air pollution). The data generated by IoT sensors can support new business models and tailor products and services to the tastes and needs of the customer. In addition to the applications, the technology needs to support supervision and adaptation of the IoT system itself.

Several forecasts indicate that IoT will connect 50 billion devices worldwide by the year 2020. There are a number of possible application areas, such as smart city, smart grid, smart home/building, digital agriculture, smart manufacturing, intelligent transport system, e-Health. IoT is an enabling technology that consists of many supporting technologies, for example, different types of communication networking technologies, information technologies, sensing and control technologies, software technologies, device/hardware technologies. This document is based on widely used enabling technologies that are defined in standards from several organizations such as ISO, IEC, ITU, IETF, IEEE, ETSI, 3GPP, W3C, etc.

Trustworthiness is recognized as an area of importance, and IoT can leverage current and future best practice. For example, monitoring and analysing deployed IoT systems is essential to maintain reliability and safety and security. Measures such as controlled access can ensure the security of the system.

This document provides a standardized IoT Reference Architecture using a common vocabulary, reusable designs and industry best practices. It uses a top down approach, beginning with collecting the most important characteristics of IoT, abstracting those into a generic IoT Conceptual Model, deriving a high level system based reference with subsequent dissection of that model into the four architecture views (functional view, system view, networking view and usage view) from different perspectives.

This document serves as a base from which to develop (specify) context specific IoT architectures and thence actual systems. The contexts can be of different kinds but shall include the business context, the regulatory context and the technological context, e.g. industry verticals, technological requirements and/or nation-specific requirement sets. For more information, see Figure 1.

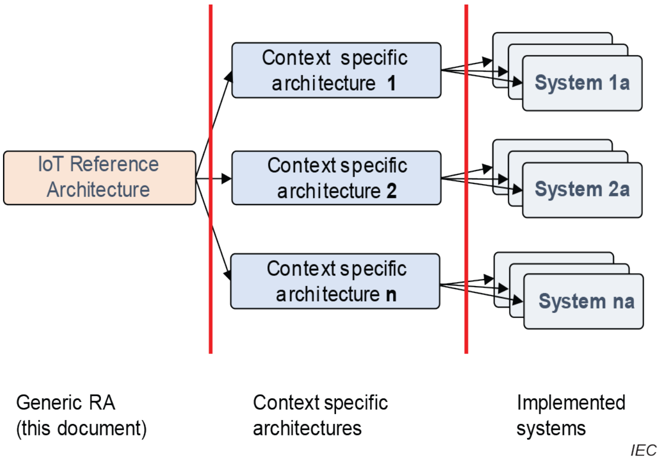

Figure 1 – From generic Reference Architecture to context specific architecture

INTERNET OF THINGS (IoT) – REFERENCE ARCHITECTURE

1 Scope

This document specifies a general IoT Reference Architecture in terms of defining system characteristics, a Conceptual Model, a Reference Model and architecture views for IoT.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 20924, *Internet of Things (IoT) – Definition and vocabulary*[1]

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 20924 apply.

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

- ISO online browsing platform: available at http://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

4 Abbreviated terms

5Vs	volume, velocity, veracity, variability, and variety
API	application programming interface
ASD	Application & Service Domain
BSS	business support systems
CM	Conceptual Model
FQDN	fully qualified domain name
HMI	human machine interface
HTTP	Hypertext Transfer Protocol
HVAC	heating, ventilation and air conditioning
IaaS	infrastructure as a service
ICT	information and communication technologies
IoT	Internet of Things
IoT RA	Internet of Things Reference Architecture
LAN	local area network

[1] Under preparation. Stage at time of publication: ISO/IEC CDV 20924:2018.

LOB	line of business
OMD	Operation & Management Domain
OSS	operational support systems
PaaS	platform as a service
PED	Physical Entity Domain
PII	personally identifiable information
QoS	quality of service
RA	Reference Architecture
RAID	Resource Access & Interchange Domain
RFID	radio-frequency identification
RM	Reference Model
SaaS	software as a service
SCD	Sensing & Controlling Domain
UML	Universal Modelling Language
UD	User Domain
URI	uniform resource identifier
UUID	universally unique identifier

5 Internet of Things Reference Architecture (IoT RA) conformance

To claim conformance, the description of a concrete system architecture as provided by a vendor or system integrator should use the terminology and modelling concepts defined in this document, within the scope of their specific use case.

NOTE A separate conformity guide can be developed that can provide specific guidance to meeting and evaluating conformity to ISO/IEC 30141 to a broader set of entities beyond actual system descriptions.

6 IoT RA goals and objectives

6.1 General

The IoT Reference Architecture (IoT RA) represented in this document describes generic IoT system characteristics, a Conceptual Model, a Reference Model and a number of architectural views aligned with the architecture descriptions defined in ISO/IEC/IEEE 42010. The IoT RA outlines what the overall structured approach for the construction of IoT systems shall be by providing an architectural structure framework. In short, the IoT RA provides guidance for the architect developing an IoT system and aims to give a better understanding of IoT systems to the stakeholders of such systems, including device manufacturers, application developers, customers and users.

This document has the following descriptions:

1) the generic characteristics of IoT systems, outlining the characteristics expected from an IoT system;
2) the Conceptual Model (CM), describing the key concepts characterizing an IoT system;
3) the Reference Model (RM), providing the overall structure of the elements of the architecture;
4) a set of relevant architecture views, describing the architecture from a number of perspectives.

This document supports the following important standardization objectives:

a) to enable the production of a coherent set of standards for IoT;

b) to provide a technology-neutral reference point for defining standards for IoT; and

c) to encourage openness and transparency in the development of a target IoT RA and in the implementation of IoT systems.

Figure 2 illustrates how the IoT RA is derived from a Conceptual Model and a set of characteristics that define a Reference Model and one or more architectural views.

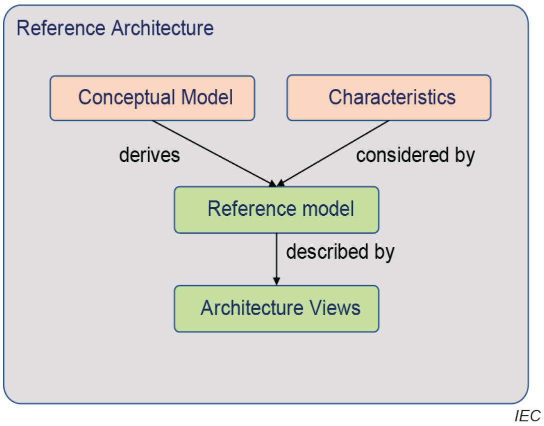

Figure 2 – IoT RA structure

Subclauses 6.2, 6.3 and 6.4 provide a summary of the characteristics, Conceptual Model and Reference Model, respectively.

6.2 Characteristics

The generic characteristics are described in Clause 7, which focuses on a number of key properties that an IoT system typically exhibits. Different application specializations can differ in terms of the actual quantification of these properties, but it is important for an IoT architect to consider how important the respective categories are for the particular system being designed. There are no characteristics that are required of any particular IoT system.

6.3 Conceptual Model

The Conceptual Model (CM) contains a number of vital concepts and describes how they relate to each other logically. Together with the generic characteristics, it provides the background and motivation for the architectural elements discussed in the architectural views in Clause 10. CM is described in Clause 8.

6.4 Reference Model and architecture views

RM is described in Clause 9. The RM and architecture views contain the parts as illustrated in Figure 3.

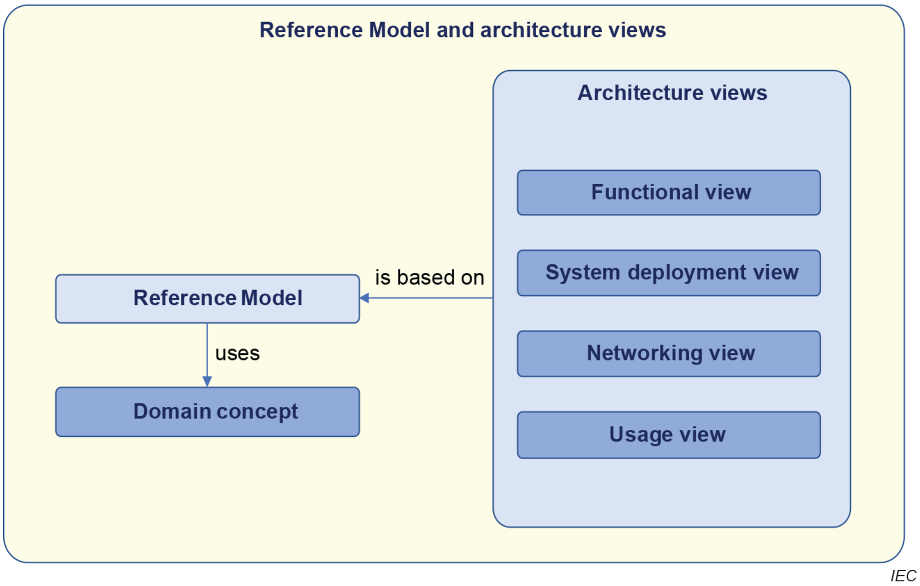

Figure 3 – RM and architecture views

Figure 3 above illustrates the relations between architecture views, Reference Model and domain concept. The domain concept is described in the CM in 8.2.1.1 and 8.2.1.3. Additionally, the RM is founded on the domain concept. A detailed description of domain based RM can be found in Clause 9.2.2.

The respective views are described in Clause 10.

7 Characteristics of IoT systems

7.1 General

Clause 7 provides characteristics of IoT systems. Functions based on all or a part of these characteristics can be implemented in IoT systems. Some of these characteristics are functional, such as network connectivity, while others are non-functional, such as availability and compliance. The characteristics are grouped and summarized in Table 1 and individually explained in 7.2 to 7.4.

Table 1 – Characteristics of IoT systems

Categories	Related characteristics
7.2 IoT system trustworthiness characteristics	7.2.2 Availability
	7.2.3 Confidentiality
	7.2.4 Integrity
	7.2.5 Protection of personally identifiable information
	7.2.6 Reliability
	7.2.7 Resilience
	7.2.8 Safety
7.3 IoT system architecture characteristics	7.3.1 Composability
	7.3.2 Functional and management capability separation
	7.3.3 Heterogeneity
	7.3.4 Highly distributed systems
	7.3.5 Legacy support
	7.3.6 Modularity
	7.3.7 Network connectivity
	7.3.8 Scalability
	7.3.9 Shareability
	7.3.10 Unique identification
	7.3.11 Well-defined components
7.4 IoT system functional characteristics	7.4.1 Accuracy
	7.4.2 Auto-configuration
	7.4.3 Compliance
	7.4.4 Content-awareness
	7.4.5 Context-awareness
	7.4.6 Data characteristics – volume, velocity, veracity, variability and variety
	7.4.7 Discoverability
	7.4.8 Flexibility
	7.4.9 Manageability
	7.4.10 Network communication
	7.4.11 Network management and operation
	7.4.12 Real-time capability
	7.4.13 Self-description
	7.4.14 Service subscription

7.2 IoT system trustworthiness characteristics

7.2.1 General

Trustworthiness is defined in ISO/IEC 20924 as follows:

> "degree of confidence a stakeholder has that the system performs as expected with characteristics including safety, security, privacy, reliability and resilience in the face of environmental disruptions, human errors, system faults and attacks."

Within the scope of this document, security is defined as the combination of availability, confidentiality, and integrity.