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INTERNATIONAL STANDARD

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Internet of Things (IoT) – Interoperability for IoT systems – Part 3: Semantic interoperability

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FOREWORD

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

Draft	Report on voting
JTC1-SC41/233/FDIS	JTC1-SC41/244/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, available at: www.iec.ch/members_experts/refdocs and www.iso.org/directives.

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INTRODUCTION

The use of the Internet of Things (IoT) is increasing every year, in application areas such as manufacturing, healthcare, and new cross-domain applications related to smart cities (e.g. water, energy, transport, or health). Most IoT systems want to share information, which can be done by interoperability. Mechanisms are therefore needed on how to exchange information and use associated data and data description.

IoT interoperability is described as a successful interaction among entities specified in ISO/IEC 30141 [1] [1], for instance between IoT services provided by different IoT service providers. It can be achieved using the interoperability facet model defined in ISO/IEC 21823-1, which defines five facets: transport, syntactic, semantic, behavioural and policy interoperability.

IoT semantic interoperability is the facet which enables the exchange of data between IoT systems using understood data information models (or semantic meanings). According to a recently published white paper [2]:

> "Semantic interoperability is achieved when interacting systems attribute the same meaning to an exchanged piece of data, ensuring consistency of the data across systems regardless of individual data format. This consistency of meaning can be derived from pre-existing standards or agreements on the format and meaning of data or it can be derived in a dynamic way using shared vocabularies either in a schema form and/or in an ontology-driven approach."

As shown in Figure 1,

– semantic interoperability means that information in different data information models can be translated into understandable meaning and exchanged between applications;

– semantic interoperability provides the capability for applications to understand exchanged information;

– semantic interoperability for IoT is achieved by invoking services, and by using specific knowledge and concepts of IoT.

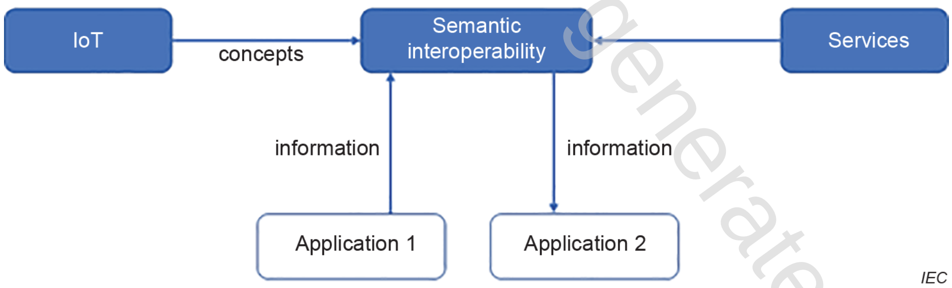

Figure 1 – Semantic interoperability facet for IoT

Semantic interoperability is achieved through the use of metadata, or descriptions of data. The approach of providing data and descriptions has been widely used in IT systems. Two examples are:

a) conceptual schemas have been used to describe database content;

b) record layouts have been used to display the content of a database record.

As shown in Figure 2, many services invoked by semantic interoperability involve metadata, thus enabling their discovery, understanding and (re)usability.

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

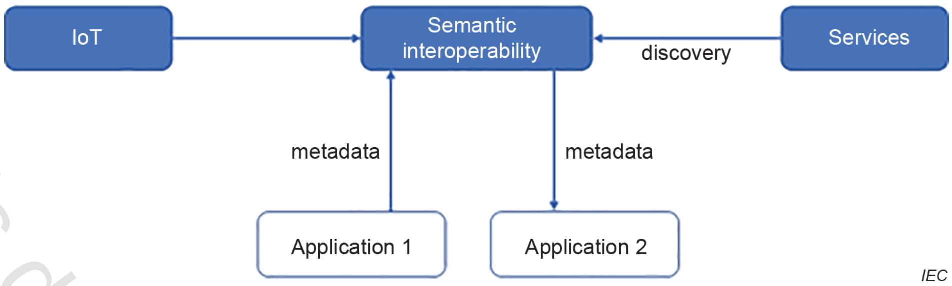

Figure 2 – Using metadata in semantic interoperability

Metadata provides IoT systems with a common understanding of exchanged data. Figure 3 shows how the meaning of data is defined by the metadata to a specific room temperature (left column) and how it is described with metadata (right column).

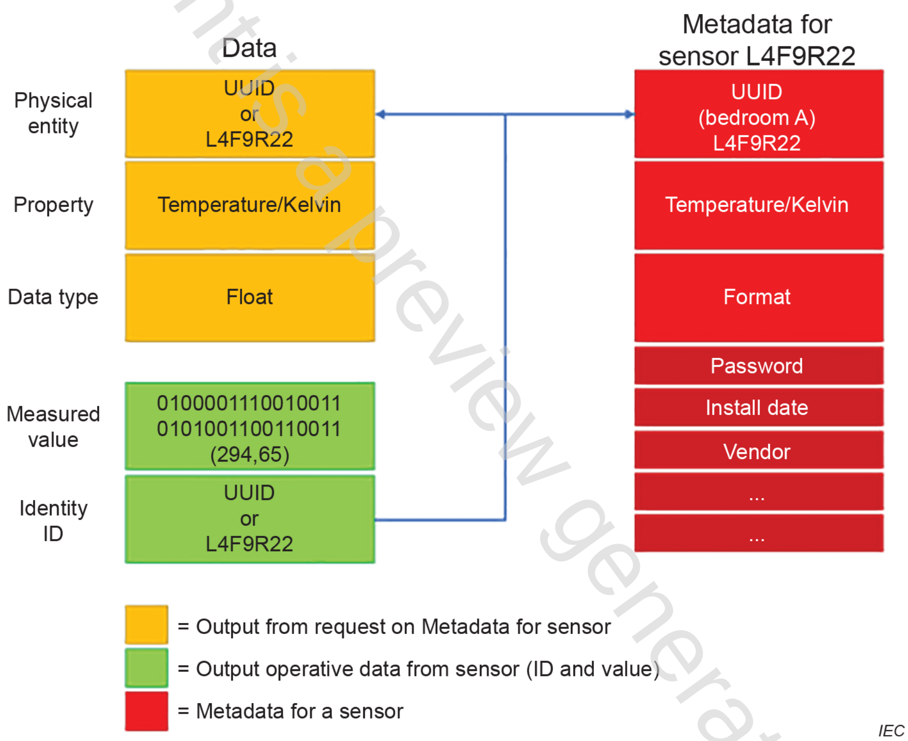

Figure 3 – Meaningfulness of the data, described with metadata

Knowledge that metadata represents can be described using ontologies. In other words, semantic interoperability needs shared, unambiguous, machine-understandable metadata, to be able to perform exchange of information using metadata. The application of semantics in IoT has still been limited because most metadata are developed independently, making it difficult for IoT entities or applications to interoperate semantically. In this document, an ontology-driven approach for semantic interoperability is specified to design and specify metadata, so that the sensors, devices, systems and services can express metadata information and data by applying the ontologies to achieve semantic interoperability. Stakeholders targeted by this document include ontology engineers and IoT system engineers who are building semantic interoperability capabilities for IoT systems.

This document also specifies methods and techniques to build semantic interoperability for IoT systems. Clause 5 focuses on the IoT semantic interoperability process. Clause 6 focuses on the IoT semantic interoperability life cycle management.

Informative annexes provide additional information and guidance. Annex A, Annex B and Annex C provide guidance on how to learn IoT semantic interoperability, develop IoT semantic interoperability, and manage IoT semantic interoperability life cycle, respectively. Annex D provides ontological specification of the IoT Reference Architecture specified in ISO/IEC 30141 [1]. Annex E provides related existing ontologies that are applicable for IoT semantic interoperability.

INTERNET OF THINGS (IoT) – INTEROPERABILITY FOR IoT SYSTEMS –

Part 3: Semantic interoperability

1 Scope

This document provides the basic concepts for IoT systems semantic interoperability, as described in the facet model of ISO/IEC 21823 -1, including:

– requirements of the core ontologies for semantic interoperability;
– best practices and guidance on how to use ontologies and to develop domain-specific applications, including the need to allow for extensibility and connection to external ontologies;
– cross-domain specification and formalization of ontologies to provide harmonized utilization of existing ontologies;
– relevant IoT ontologies along with comparative study of the characteristics and approaches in terms of modularity, extensibility, reusability, scalability, interoperability with upper ontologies, and so on;
– use cases and service scenarios that exhibit necessities and requirements of semantic interoperability.

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) – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 20924 and the following apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

3.1
semantic interoperability
interoperability so that the meaning of the data model within the context of a subject area is understood by the participating systems

[SOURCE: ISO/IEC 19941:2017, 3.1.5, modified – In the term, "data" has been deleted.]

3.2
metadata
data that defines and describes other data

[SOURCE: ISO/IEC 11179-3:2013, 3.2.74]