



ISO/IEC 30178

Edition 1.0 2026-07

INTERNATIONAL STANDARD

Internet of Things (IoT) - Data format, value and coding for interoperability

Sample Document

get full document from standards.iteh.ai



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2026 ISO/IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search -

webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD	5
INTRODUCTION	6
1 Scope	7
2 Normative references	7
3 Terms and definitions	7
4 Abbreviated terms	10
5 Background	11
5.1 Overview	11
5.1.1 General	11
5.1.2 Sensor-related data	12
5.1.3 Source data collection	13
5.1.4 Time-resolution and sample rate	14
5.1.5 Signal-processing implications	14
5.1.6 Low-power sensors	14
5.1.7 Measurement data	15
5.1.8 Numerical component	15
5.1.9 Semantic component	15
5.1.10 Unit	15
5.1.11 Prefix	16
5.2 Sensor value metadata	17
5.2.1 General	17
5.2.2 Resolution	18
5.2.3 Precision (measurement)	18
5.2.4 Sampling time (time resolution)	18
5.2.5 Sample rate	19
5.2.6 Range	19
5.2.7 Accuracy	20
5.2.8 Unit	20
5.2.9 Data type	20
5.2.10 Physical quantity	20
5.3 Physical quantities	20
5.3.1 Overview	20
5.3.2 Occurrences	21
5.4 Examples of data models	22
5.4.1 Overview	22
5.4.2 Exchange formats	22
5.4.3 File formats	22
5.4.4 Information modelling formats	23
5.5 Interoperability challenges	23
5.5.1 System integration	23
5.5.2 Maximizing the economic value of data through reusability	24
5.5.3 Sensor lifecycle cost	25
5.5.4 Sensor data capital value	26
5.5.5 Scalability	26
5.5.6 Semantics	29
5.5.7 Symbol mapping	29

5.5.8	Sensor semantics	29
5.5.9	Representation versus presentation	31
5.5.10	Human readability	31
5.5.11	Resolving data points	32
5.5.12	Type inference and casting	33
5.5.13	Hard coupling	34
5.5.14	Machine-to-machine exchange	34
5.5.15	Representation	34
5.5.16	Presentation	34
5.5.17	Data translation	35
5.5.18	Errors and quality	37
5.5.19	Semantic mismatch	37
6	Core profile	37
6.1	Overview	37
6.2	Sensor data parameters	38
6.2.1	Unit	38
6.2.2	The "unit-word"	38
6.2.3	Dimensionless units	39
6.2.4	Range	39
6.3	Physical quantity	40
6.3.1	Overview	40
6.3.2	Canonical representation	41
6.3.3	Operations	41
6.3.4	Significance-based comparison	42
7	High-level system design	42
7.1	Overview	42
7.2	Type safety	44
7.3	Conversion mechanics	44
7.3.1	Overview	44
7.3.2	Single-step conversion	44
7.3.3	Unit resolver	44
7.3.4	Magnitude resolver	45
7.3.5	Precision estimation	45
7.3.6	Time-resolution and oversampling	45
7.4	Sanity-check mechanisms	46
7.5	Component manufacture	46
7.6	Digitized specification	46
7.6.1	General	46
7.6.2	Measurement range	46
7.6.3	Accuracy	46
7.6.4	Precision	46
Annex A (informative)	Single-step conversion	47
A.1	Overview	47
A.2	Example 1: Forward temperature conversion (Kelvin to base SI units)	47
A.3	Example 2: Forward energy conversion (nanojoules to joules)	48
A.4	List of unit-word value examples	49
A.5	Floating-point format	51
A.6	Examples on data point expression	53
Annex B (informative)	Unifying sensor data and mapping with standards	54

B.1	Unifying sensor data value metadata: the type of sensor, the measurement type, and the unit	54
B.2	Mapping with IEC 61360-4 [3] Common Data Dictionary (CDD)	55
B.3	Mapping with ETSI SmartM2M SAREF [4]	56
Annex C	(informative) Contextualizing sensor characteristics	58
C.1	Concerns in metrology	58
C.2	Context	58
C.3	Preserving data integrity	59
C.4	Example of contextual data conversion	59
Bibliography		60
Figure 1	– Discrimination and reduction of uncertainty of each bit within the range of an 8-bit ADC	13
Figure 2	– Sampling resolution of a signal within a given range	18
Figure 3	– Hypothetical physical entity possessing three physical quantities	20
Figure 4	– Sensors measuring a physical quantity	20
Figure 5	– Sensor attached to, and measuring, some aspect of a physical entity	21
Figure 6	– Integration of sensor (data source) and data consumer is necessary for a data stream to be possible	23
Figure 7	– Sensor and consumer interfaces not compatible	23
Figure 8	– Sensor and consumer interfaces are not compatible, but achieve compatibility through a format adapter	23
Figure 9	– Sensor and consumer already sharing the same exchange format and do not require any further adaptation	24
Figure 10	– Complete product lifecycle, from initial development to end-of-life	25
Figure 11	– Two separate integrations are made to accommodate full availability of interface A from interfaces B and C	26
Figure 12	– Three and five interfaces being integrated, requiring 6 and 20 (one-way) mappings, respectively	27
Figure 13	– 16 individual interfaces require 240 one-way mappings	27
Figure 14	– With half-step intermediary translations, the number of necessary mappings grows linearly instead of exponentially – Here 16 individual interfaces only require 32 one-way mappings	28
Figure 15	– The text-based value of 100 µm (or 0,1mm) can be represented with a big variation in both data type, value structure and scaling	30
Figure 16	– Example of consequences from change in representation	31
Figure 17	– Example of sensor measurement sample serialized as senML/JSON	32
Figure 18	– Essential properties of a physical quantity	38
Figure 19	– Sensor system overview, from electric measurement to pre-processing and transmission over typical IoT protocols	43
Figure A.1	– Breakdown and conversion of data points in a forward temperature conversion	47
Figure A.2	– Magnitude resolver parameters	48
Figure A.3	– Breakdown and conversion of data points in a forward energy conversion	48
Figure A.4	– Magnitude resolver parameters	49
Figure A.5	– Combination of base units into derived units	51
Figure A.6	– Floating-point format binary encoding	52

Figure C.1 – When applied on contextual data, QUDT schema definitions can map to a canonical representation of measurement/sensor data..... 59

Table 1 – Data source characteristics of a sensor	12
Table 2 – Examples of historical units	16
Table 3 – Prefixes of the Metric System	16
Table 4 – Costs of sensor lifecycle.....	25
Table 5 – Intermediary-representation design goals for physical quantities	28
Table 6 – JSON payload broken down into first-level objects	32
Table 7 – Data point breakdown.....	33
Table 8 – Semantic data points.....	36
Table 9 – Normalized data points.....	36
Table 10 – The "unit-word" is a compact way to store base SI unit exponents.....	38
Table 11 – Basic data types of a physical quantity	42
Table A.1 – List of unit-word value examples	49
Table A.2 – Examples on different representations of the physical quantity 0,000 1 m	53
Table B.1 – Subset of the sensor dictionary for energy (classification of sensor name, sensor measurement name, and unit)	54
Table B.2 – Sensor dictionary for energy mapped to IEC 61360 Common Data Dictionary	55
Table B.3 – Subset of the sensor dictionary for energy mapped with ETSI SmartM2M SAREF-Core and its extensions (SAREF4BLDG, SAREF4ENER)	57

get full document from standards.iteh.ai

Information technology - Internet of Things (IoT) - Data format, value and coding for interoperability

FOREWORD

- 1) ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.
- 2) The formal decisions or agreements of IEC and ISO on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC and ISO National bodies.
- 3) IEC and ISO documents have the form of recommendations for international use and are accepted by IEC and ISO National bodies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC and ISO documents is accurate, IEC and ISO cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC and ISO National bodies undertake to apply IEC and ISO documents transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC and ISO document and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC and ISO do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC and ISO marks of conformity. IEC and ISO are not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this document.
- 7) No liability shall attach to IEC and ISO or their directors, employees, servants or agents including individual experts and members of its technical committees and IEC and ISO National bodies for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this ISO/IEC document or any other IEC and ISO documents.
- 8) Attention is drawn to the Normative references cited in this document. Use of the referenced publications is indispensable for the correct application of this document.
- 9) IEC and ISO draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC and ISO take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC and ISO had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch> and www.iso.org/patents. IEC and ISO shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 30178 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-SC41/597/FDIS	JTC1-SC41/620/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

Digital transformation depends strongly on data. Within the field of Internet of Things (IoT), many leading organizations try to model physical entities and environments with structured data.

Digital twins, city and building information models, process industry, automation, automotive and even healthcare, are all technologies or fields in which data models are developed to accommodate domain-specific needs.

Sensors form the backbone of live data generation and help synchronize the digital world with the real world. Numerous data and information models occur in the Information Technology (IT) and Operational Technology (OT) landscape, at various layers in digital systems. Some are verbose, text-based formats (e.g. XML or JSON) that come with more or less rich metadata, while some formats contain only minimal metadata.

The huge variability in how sensory data are represented poses a problem for all parties in the value chain – not least for the data producers themselves. This variability not only affects interoperability but also has significant economic implications. This often puts the economic viability of data collection out of reach, since low data accessibility for data consumers also means poor return of economic value for the data producer.

This has often limited large-scale data collection to domains in which there is a strong need for very specific data collection (such as the automotive industry), and favoured applications where a single data producer has a direct business agreement with the data consumer, and full control over the data model. The design of the data gathering process has often been guided by a single customer's need, with one fixed requirement for data quality.

General purpose data collection remains challenging in the context of Big Data.

The variability in format and inconsistency in data quality are issues that undermine new stakeholders' trust in third-party value chains. Where data might have been accurate enough, an insufficient amount of consistent data-source documentation dissuaded any potential new data consumers – further limiting the capital value of data.

In the end, it has proven difficult for data producers to generate data that is cost-effective to produce and consume – especially with data about physical environments.

This document provides guidance by outlining principles and technical solutions for overcoming this variability and proposes a fundamental representation of data points for sensors and physical quantities that can be used everywhere in the digital landscape to improve the consistency of how both data and metadata are to be interpreted by application logic. When applied correctly, with an agnostic attitude towards application requirements, these principles also help form a baseline for data quality and accessibility.

With the perspective taken in this document, sensory data (after their collection) are regarded as descriptions of a physical entity. This also includes any other physical measurement, such as the physical parameters of real-world objects and systems. The intention is to allow for sensory data to be possible to integrate seamlessly with other data points in physical models under a shared, homogeneous interpretation.

1 Scope

This document defines common formats, values, and coding for data interoperability and exchange among systems in the Internet of Things (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) and digital twin - Vocabulary*

ISO/IEC Guide 99, *International vocabulary of metrology - Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 20924, ISO/IEC Guide 99 and the following 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

SI special names, pl.

names for compound SI units derived from the base seven SI units

EXAMPLE 1 Newton [N] equivalent to kilogram metre per second squared [$\text{kg}\cdot\text{m}/\text{s}^2$].

EXAMPLE 2 Pascal [Pa] equivalent to newton per metre squared [N/m^2] or kilogram per metre times second squared [$\text{kg}/\text{m}\cdot\text{s}^2$]

EXAMPLE 3 Joule [J] equivalent to kilogram metre squared per second squared [$\text{kg}\cdot\text{m}^2/\text{s}^2$].

Note 1 to entry: See BIPM [6] The international System of Units (SI) 9th edition (2019), 2.3.4 for further information.

3.2**data type**

named category of data characterized by a set of values, a syntax for denoting these values, and a set of operations that interpret and manipulate the values

EXAMPLE 1 uint16 – A 16-bit wide, unsigned integer capable of representing the whole-number range from 0 to 65 535.

EXAMPLE 2 bool – A Boolean value with only two states (true and false).

EXAMPLE 3 float – A 32-bit approximation of a real number.

Note 1 to entry: Standardized representation of data types is essential for cross-platform interoperability.

Note 2 to entry: The total number of bits determine the maximum number of unique values the data type can encode.

Note 3 to entry: For further information on data types see ISO/IEC 11404 [2].

[SOURCE: ISO/IEC 1539-1:2023 [1], 3.144, modified – the examples and notes have been added.]

3.3**type safety**

software design principle that protects against representation-related errors such as unintended rounding or corruption of data by enforcing the consistent use of a *data type* (3.2) for some variable

Note 1 to entry: Type safety allows scalability by decoupling the design of separate software components while guaranteeing correctness within functional interfaces (such as APIs).

Note 2 to entry: Type safety is enforced by some programming languages.

3.4**floating-point format**

digital *data type* (3.2) representing a fixed-precision approximation of a real number with a well-defined range and precision, composed of an exponential and fractional component, and a sign

Note 1 to entry: Floating-point format is supported by all major programming languages.

Note 2 to entry: Depending on the variant, floating-point format typically features at least 6 to 7 significant decimal digits for single precision, or 15 significant decimal digits for double precision.

Note 3 to entry: Definition based on ISO/IEC 60559:2020 [9], 3.6.

3.5**floating-point representation**

unencoded member of a floating-point format, representing a finite number, a signed infinity, a quiet not a number (NaN), or a signaling NaN

Note 1 to entry: A representation of a finite number has three components: a sign, an exponent, and a significand; its numerical value is the signed product of its significand, and its radix raised to the power of its exponent.

Note 2 to entry: NaN means 'not a number' and is a special value of the floating-point representation that indicates invalid number assignments, such as when dividing zero by zero.

3.6**physical quantity**

property of some physical entity that can be measured in some physical dimension, characterized by a number and a unit

3.7**serialization format**

format of representing structured data in a serialized sequence of bits that can be exchanged between two computer systems

EXAMPLE 1 XML – Extensible Markup Language¹, a text-based format using tags to encode nested elements and structures.

EXAMPLE 2 JSON – JavaScript Object Notation², a format for representing basic values with named identities and nested structures, in cleartext. JSON is considered a less verbose alternative to XML.

EXAMPLE 3 CBOR – Concise Binary Object Representation³, a binary serialization format optimized for small code size and message size.

Note 1 to entry: Serialization format is sometimes based on cleartext for representation, with a syntax to encode structure.

Note 2 to entry: Serialization format is sometimes based on concrete data types for representation.

3.8**sensor**

Internet of Things digital device that converts a physical measurement into a digital sample carrying a quantity and a unit

Note 1 to entry: The sensor usually transmits the sample coded in some *serialization format* (3.7).

3.9**data point**

datum that carries an individual meaning regardless of representation

3.10**release-time**

period of time during which an instance of some software or hardware, such as an IoT sensor, operates after deployment

Note 1 to entry: Release-time is typically separate from, and non-overlapping with, design-time.

Note 2 to entry: Release-time constitutes part of that instance's operational lifecycle.

3.11**design-time**

period of time during which a piece of software or hardware is designed

Note 1 to entry: Design-time precedes, is typically separate from, and non-overlapping with, runtime.

Note 2 to entry: After the end of design-time, the design and its dependencies are not possible to modify.

¹ XML is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.

² JSON is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.

³ CBOR is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.

3.12

oversampling

action of collecting multiple measurement samples and averaging their values into a single sample

Note 1 to entry: Oversampling typically decreases temporal resolution.

Note 2 to entry: The number of samples converted into a single sample is called OSR, or "oversampling ratio".

Note 3 to entry: Oversampling often implies sampling at higher rates than the Nyquist (IEV 723-10-28) rate to satisfy the Nyquist criterion.

3.13

discrimination

measurement interval of a measured signal smaller than what a sensor is unable to uniquely register

Note 1 to entry: Discrimination is often expressed interchangeably with measurement resolution, which means segmenting a pre-defined measurement range into discrete steps.

3.14

context broker

middleware for exchanging contextual data

Note 1 to entry: A context broker is typically required for smart data standards like NGSI.

4 Abbreviated terms

ADC	analog-to-digital converter
AI	artificial intelligence
API	application programming interface
BIM	building information model
CBOR	concise binary object representation
CPU	central processing unit
DTw	digital twin
GIS	geographic information system
GNSS	global navigation satellite system
I2C	inter-integrated circuit
I3C	improved inter-integrated circuit
IT	information technology
IoT	Internet of Things
JSON	JavaScript object notation
LPWAN	low power wide area network
LSB	least significant bit
MEMS	micro-electromechanical systems
ML	machine learning
OPC	open platform communications
OPC-UA	OPC unified architecture
OSR	oversampling ratio
OT	operational technology
PCB	printed circuit board
QUDT	quantities units dimensions and data types

RMS	root mean square
SenML	sensor measurement lists
SI	SI-unit (<i>Le Système International d'Unités</i>)
SiP	system in package
SPI	serial peripheral interface
XML	extensible markup language

5 Background

5.1 Overview

5.1.1 General

Today's increasingly digitized technology is founded on sensory measurement. Among the IT/OT environments underpinning an information-based society, there is a wide range of structured and semi-structured data models that characterize the data shared between IoT-based systems.

While the sensors that operate out in the field measure physical quantities according to well-defined specifications, most often the measurements and the specification are not fully available in the digital context.

Sensors operating in the field also have a limited interoperability with most other sensors – either in other domains or other digital ecosystems. Sometimes this limited interoperability is due to an inherent lack of data overlap, or even a lack of data completeness.

The range of IoT sensors varies in many respects, and a core assumption that can be made is that, at runtime, no one sensor has complete compatibility with every other sensor. This is both due to the actual information content (i.e. meaning) of data, and a lack of consistent interpretation. When IoT sensors operate in separate ecosystems as individuals, they very often adhere to different conceptual domains or product families. It is therefore necessary to ensure that a baseline for interoperability⁴ can be created, and relied on, when embarking on system or data integration projects.

Reducing the engineering cost revolves to a significant degree around predictability. Being able to plan ahead allows system architects to reduce development and integration costs over long timespans.

Many IoT-based exchange formats define semantics and data types to cover the most essential primary data, and accompanying metadata to some degree. For sensory data, this often includes some representation of the sensory value (magnitude) itself and its unit of measurement, which can belong to any standard or non-standard choice of scale.

Variations in how data are encoded, structured, or serialized, bring with them a need for data to be translated or adapted (through interpretation) before they can be used by a third party. This is sometimes hampered by how data are recorded, which can limit how much useful information it can carry.

Common drawbacks of many clear text-based serialization formats include arbitrary rounding or truncation of measurement values (which can permanently strip away numerical precision), and a lack of unambiguous representation of measurement units.

⁴ In practice this means establishing a set of universally applicable principles that provide inherent interoperability when adhered to.

Translating data between different formats therefore often requires ad-hoc integrations that perform custom one-time conversion with or without safeguards for data integrity.

Variations in data representation in general can also constitute a challenge, since aggregating a heterogeneous set of data sources (e.g. combining sensor data from weather stations and traffic sensors with differing sampling rates and units) requires many separate conversions.

Taken together, it is therefore hard for IoT data models, which often are very well defined within their own domain (or scope of application), to make assumptions about what data points:

- a) it is necessary to provide to satisfy any future integration with a third-party data model,
- b) will be available for import from third-party data sets,
- c) meet the quality requirements for every specific implementation.

Essentially, the lack of universally available data points (e.g. unit, range, accuracy) in an arbitrary sensor's data output is limiting its potential value to future applications. Consequently, it will be necessary for any applications to which its data will be reusable to assess the data sources' suitability – often through human intervention.

This is a costly process, and scales in proportion to the number of integrations with that data source. For data with indefinite lifecycles (such as statistical, historic data about environments) that should be kept for posterity, this is a cost that accumulates over time.

Reducing the cost of each integration beforehand is therefore in the interest of every involved party.

5.1.2 Sensor-related data

While IoT data models vary greatly in characteristics and scope depending on domain and application, every sensor with a digital interface that measures a physical quantity constitutes a data source with some universally applicable characteristics, as summarized in Table 1.

Table 1 – Data source characteristics of a sensor

Sensor characteristic	Data analysis impact	Example
Sensors measure a physical quantity, which by definition will include a numerical magnitude and a unit	Determines the dimension of measurement in which an observed variable can vary	A thermometer measures temperature in degrees Celsius, Kelvin or Fahrenheit
Sensors have an inherent accuracy of measurement	Determines the minimum error of a sample's value from the actual value	A GNSS device with ± 3 m accuracy
Sensor measurement samples are recorded with some numerical precision	Determines the smallest possible variation of a sample's value	A scale that records weight to the nearest 0,1 kg
Sensors are able to make distinct measurement samples by some minimum sensitivity	Determines the measurement sample's highest sampling resolution	A voltage sensor with an effective measurement resolution of 0,5mV
Sensor measurements are collected over some period of time	Determines the maximum time-resolution ^a of the sample's value	A heart rate monitor collecting data every second
Sensors output measurement samples at some maximum sample rate	Determines the time spacing between measurements	An accelerometer sampling at 100 Hz (100 measurements per second)
Sensors perform measurements within some maximum measurement range	Determines the range within which a sample's value can be considered valid	A temperature sensor measuring from -50 °C to 150 °C
Sensors transform the input signal in a certain way	The transformation outputs a scalar value in a given physical dimension	A pressure transducer voltage being converted into kPa

^a When multiple samples are combined into an average value, the time resolution of the average is constructed from the sum of the time resolution of all the samples. In contrast, when the median value is extracted, it retains the time resolution of its original sample.

Each of these characteristics helps implementers determine how well a sensor suits a given application and, by extension, also how well its data do. The requirements imposed by the application are carried over to the physical design of the system at design-time. For one-off implementations, the characteristics of the data are merely determined to be sufficient for their application, and often just implicitly guaranteed by the design of the system itself.

Data without an explicit quality and characteristics benchmark make any quality guarantees implicit to the design of the system. This in turn makes a retrospective analysis of the system's quality metrics necessary to extract any quality guarantees downstream in the value-chain. Only by explicitly specifying quality and characteristics in digitally accessible metadata can it allow for future suitability analysis decoupled from the system's design.

To retain a high interoperability for a sensor and its data long-term, metadata should be easily accessible for authorized evaluation when necessary (see Annex B).

5.1.3 Source data collection

It is not unusual for IoT data to be collected by microcontroller devices – sometimes also with real-time computing requirements.

Measurements performed by peripheral circuits of such devices typically implement analogue-to-digital conversion with raw measurement values expressed as an integer value, where the least significant bit (LSB) corresponds to a step-wise discrimination (small fixed steps in measurement) between segments of the measurement range and the measurement resolution, as shown in Figure 1. This equates to an upper bound on the level of theoretical precision that is possible.

get full document from standards.iteh.ai

Manufacturers should consider these limits when defining sensor characteristics.

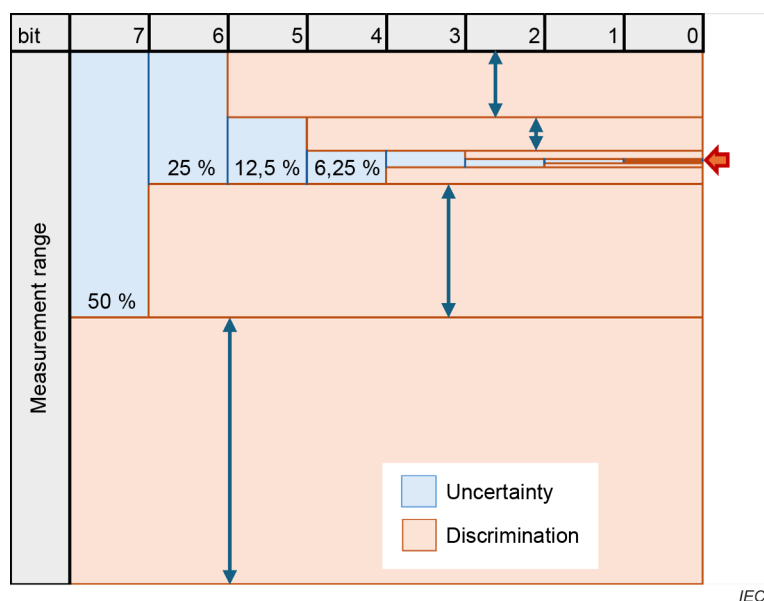


Figure 1 – Discrimination and reduction of uncertainty of each bit within the range of an 8-bit ADC