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Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**
3.1 Edge computing 2
3.2 IoT terms 3
3.3 Real time 4
3.4 Cloud computing 4

4 Symbols and abbreviated terms **5**

5 Overview of edge computing **6**
5.1 General 6
5.2 Concepts of edge computing 6
5.3 Architectural foundations of edge computing 8
5.4 Relationship of edge computing to cloud computing 10
5.5 Relationship of edge computing to IoT 14

6 Networking and edge computing **16**
6.1 Overview 16
6.2 Proximity networks 16
6.3 Access networks 16
6.4 Services networks 16
6.5 User networks 16
6.6 Network virtualization 17
6.7 Security aspect in network virtualization 17

7 Hardware for edge solutions **18**
7.1 General 18
7.2 Hardware capabilities 18
7.3 Hardware accelerators for AI/ML in edge computing 19

8 Software considerations for edge solutions **20**
8.1 General 20
8.2 Software classifications 20
8.2.1 Firmware 20
8.2.2 Platform software 21
8.2.3 Services 21
8.2.4 Applications 21
8.3 Significant software technologies 21
8.3.1 General 21
8.3.2 Virtual machines 22
8.3.3 Containers 22
8.3.4 Serverless computing 22
8.3.5 Microservices 23

9 Edge computing deployment models, service capabilities types and service categories **23**
9.1 General 23
9.2 Deployment models 23
9.3 Service capabilities types 24
9.4 Service categories 24

10 Data in edge computing **24**
10.1 General 24
10.2 Representative data flow example 25
10.3 Data storage 26
10.4 Data processing 27

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11 Management of edge computing systems **28**
11.1 Management and orchestration fundamentals 28
11.2 Management plane, control plane and data plane 29
11.3 Cloud-based management and control of edge tier nodes and device tier devices 31
11.3.1 General 31
11.3.2 Control of services from a device 31
11.3.3 Management of devices and edge nodes from a cloud service 32
11.4 Orchestration and maintenance 32
11.5 Management of data, rights and resources 32
11.6 Security and privacy management 33

12 Virtual placement **33**

13 Security and privacy in edge computing **34**
13.1 General 34
13.2 Applying foundational security principles 35
13.3 Secure nodes and devices 35
13.4 Connectivity and network security 36
13.5 Organization of security elements 37
13.5.1 General 37
13.5.2 Network security 38
13.5.3 Data security 38
13.5.4 Application security 38
13.5.5 Node security 38
13.5.6 Security OSS 39
13.6 Privacy and personally identifiable information in edge computing 39

14 Real time in edge computing **40**
14.1 General 40
14.2 Factors influencing real time system design 41
14.3 Design approaches for real time edge computing 43

15 Mobile edge computing **43**

Bibliography **45**

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 38, *Cloud computing and distributed platforms*.

This second edition cancels and replaces the first edition (ISO/IEC TR 23188:2020), which has been technically revised.

The main changes are as follows:

— this document has been aligned with the ISO/IEC 22123 series;

— reference to ISO/IEC 17788 and ISO/IEC 17789 have been changed to the ISO/IEC 22123 series;

— verbal forms have been updated in line with the ISO/IEC Directives Part 2.

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Introduction

Edge computing is increasingly used in systems that deal with aspects of the physical world. Edge computing involves the placement of processing and storage near or at the points where those systems interact with the physical entities and users, which is where the "edge" exists. One of the trends is the development of increasingly capable Internet of Things (IoT) devices (sensors and actuators), which generate more data or new types of data. There is significant benefit from moving the processing and storing of this data closer to where the data is generated.

Edge computing is distributed computing in which data processing and storage takes place on nodes which are near to the edge. The edge is marked by the boundary between pertinent digital and physical entities, i.e. between the digital system and the physical world, delineated by networked sensors and actuators.

Pertinent digital entities mean that the digital entities which need to be considered can vary depending on the system under consideration and the context in which those entities are used.

Modern systems such as those for IoT and OT applications include both cloud services and edge services. This can include the connection of both end-user devices and edge computing nodes to centralized cloud services. It is also the case that cloud service provision is increasingly distributed. Cloud services are being implemented in nodes that are closer to the end user in order to support reduced latency or to avoid transferring large volumes of data over expensive networks.

This document aims to describe edge computing and the significant elements which contribute to the successful implementation of edge computing systems, with an emphasis on the use of cloud computing and cloud computing technologies in the context of edge computing, including the virtualization of compute, storage and networking resources.

This document is intended to be used in conjunction with ISO/IEC TR 30164, which takes a view of edge computing from the point of view of IoT systems and the IoT devices which interact with the physical world.

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Information technology — Cloud computing — Edge computing landscape

1 Scope

This document examines the concept of edge computing, its relationship to cloud computing and IoT, and the technologies that are key to the implementation of edge computing. This document explores the following topics with respect to edge computing:

— concept of edge computing systems;

— architectural foundation of edge computing;

— edge computing terminology;

— software classifications in edge computing, e.g. firmware, services, applications;

— supporting technologies, e.g. containers, serverless computing, microservices;

— networking for edge computing systems, including virtual networks;

— data, e.g. data flow, data storage, data processing;

— management, of software, of data and of networks, resources, quality of service;

— virtual placement of software and data, and metadata;

— security and privacy;

— real time operation;

— mobile edge computing, mobile devices.

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 22123-1, *Information technology — Cloud computing — Part 1: Vocabulary*

ISO/IEC TS 23167, *Information technology — Cloud computing — Common technologies and techniques*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 22123-1, ISO/IEC TS 23167 and the following apply.

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

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

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

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3.1 Edge computing

3.1.1
distributed computing
model of computing in which processing and storage takes place on a set of *entities* (3.2.3) with activities coordinated by means of digital messages passed between the entities

3.1.2
edge
boundary between pertinent *digital entities* (3.2.2) and *physical entities* (3.2.8), delineated by *sensors* (3.2.9) and *actuators* (3.2.1)

Note 1 to entry: Pertinent digital entities means that the digital entities which need to be considered can vary depending on the system under consideration and the context in which those entities are used. For example, in a smart factory system, a cloud-based analytics platform might not be considered a pertinent digital entity for defining the edge, whereas a local edge gateway running real-time control algorithms would be. Pertinence depends on functional involvement in immediate data exchange and control processes with the physical entities.

Note 2 to entry: Pertinent physical entities can include devices other than sensors and actuators.

Note 3 to entry: The edge can be placed at the edge end or the device end of the proximity network connecting them, often depending on who owns or operates the proximity network.

3.1.3
edge computing
distributed computing (3.1.1) in which some or all processing and storage takes place at or near the *edge* (3.1.2), where the nearness is defined by the system's requirements

3.1.4
edge computing service
edge service
one or more capabilities offered via *edge computing* (3.1.3) invoked using a defined interface

3.1.5
edge computing system
system providing functionalities of *edge computing* (3.1.3)

Note 1 to entry: Edge computing systems can include capabilities for both edge computing and cloud computing

3.1.6
edge computing user
ECU
user of an *edge computing system* (3.1.5)

3.1.7
edge solution
edge computing services (3.1.4) combined and controlled to meet the *edge computing user's* (3.1.6) requirements

3.1.8
endpoint
entity (3.2.4) that exposes and uses one or more network interfaces

Note 1 to entry: An endpoint includes any hardware device that is capable of sending or receiving data over a network.

[SOURCE: ISO/IEC 20924:2024, 3.1.15, modified — In the definition, "component" has been replaced by "entity" to broaden the scope.]

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3.1.9
node
networked machine with processing and storage capabilities

Note 1 to entry: Both digital and physical entities are examples of nodes. Virtual machines or containers in cloud solution can also be nodes.

3.1.10
operational technology
OT
hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices and systems, processes and events in industrial facilities

3.2 IoT terms

3.2.1
actuator
IoT device (3.2.5) that changes one or more properties of a *physical entity* (3.2.8) in response to an input

[SOURCE: ISO/IEC 20924:2024, 3.2.2]

3.2.2
digital entity
entity (3.2.3) that exists in the digital realm

Note 1 to entry: A digital entity can exist in several forms, including a *cloud service* (3.4.2) or X-as-a-Service in a data centre, or as a network element or as an *IoT gateway* (3.2.6).

[SOURCE: ISO/IEC 20924:2024, 3.1.13]

3.2.3
entity
anything (physical or non-physical) having a distinct existence

[SOURCE: ISO/IEC 15459-3:2014, 3.1]

3.2.4
Internet of Things
IoT
infrastructure of interconnected entities, people, systems and information resources together with services which processes and reacts to information from the physical world and virtual world

[SOURCE: ISO/IEC 20924:2024, 3.2.8]

3.2.5
IoT device
endpoint (3.1.8) that interacts with the physical world through sensing or actuating

Note 1 to entry: An *IoT device* (3.2.5) can be a *sensor* (3.2.9) or an *actuator* (3.2.1).

[SOURCE: ISO/IEC 20924:2024, 3.2.11]

3.2.6
IoT gateway
entity of an *IoT system* (3.2.7) that connects one or more proximity networks and the *IoT devices* (3.2.5) on those networks to each other and to one or more access networks

[SOURCE: ISO/IEC 20924:2024, 3.2.14]

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3.2.7
IoT system
system providing functionalities of *Internet of Things* (3.2.4)

Note 1 to entry: IoT system is inclusive of *IoT devices* (3.2.5), *IoT gateways* (3.2.6), *sensors* (3.2.9), and *actuators* (3.2.1).

[SOURCE: ISO/IEC 20924:2024, 3.2.15]

3.2.8
physical entity
entity in the physical world that can be the subject of sensing and/or actuating

[SOURCE: ISO/IEC 20924:2024, 3.1.25]

3.2.9
sensor
IoT device (3.2.5) with the capability of sensing

[SOURCE: ISO/IEC 20924:2024, 3.2.20]

3.3 Real time

3.3.1
real time
processing of data by a computer in connection with another process outside the computer according to time requirements imposed by the outside process

[SOURCE: ISO/IEC 2382:2015, 2122900, modified — "pertaining to" has been removed to improve substitutability of definition; Notes 1 to 3 to entry have been removed.]

3.3.2
real time system
system in which processing meets *real time* (3.3.1) requirements

3.3.3
hard real time
real time system (3.3.2) whose operation is incorrect if results are not produced according to specified timing requirements

3.3.4
soft real time
real time system (3.3.2) whose operation is degraded if results are not produced according to specified timing requirements

3.4 Cloud computing

3.4.1
cloud computing
paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on demand

[SOURCE: ISO/IEC 22123-1:2023, 3.1.1, modified — Notes 1 and 2 to entry have been deleted.]

3.4.2
cloud service
one or more capabilities offered via *cloud computing* (3.4.1) invoked using a defined interface

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4 Symbols and abbreviated terms

AC	alternating current
BYOD	bring your own device
CDN	content delivery network
CPU	central processing unit
CSC	cloud service customer
CSP	cloud service provider
CSU	cloud service user
DDoS	distributed denial of service
DevSecOps	development, security, and operations
ECU	edge computing user
EPG	electronic programme guide
EPROM	erasable programmable read only memory
FPGA	field programmable gate array
GPS	global positioning system
GPU	graphics processing unit
ID	identity
IETF	internet engineering task force
IoT	internet of things
IP	internet protocol
IPTV	internet protocol television
LAN	local area network
MDM	mobile device management
OS	operating system
OSS	operations support system
PC	personal computer
PII	personally identifiable information
RAM	random-access memory
RFC	request for comments
ROM	read only memory
SIM	subscriber identity module

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TPM	trusted platform module
VM	virtual machine
VoIP	voice over internet protocol
VPN	virtual private network
WiFi	wireless fidelity

5 Overview of edge computing

5.1 General

Over time, the forms of computing have varied between centralized and distributed, depending on the nature and capabilities of the computing devices and of the networks used to connect them.

Mainframe computers represent a form of centralized computing, where the main computer systems are placed in a data centre, containing processing and storage units. Originally, almost the whole of the computing system was situated within the data centre. Gradually, time-sharing terminals were located in remote locations to provide user access to the mainframe systems. Terminals were typically little more than a display with a keyboard for input and the associated network connection had limited bandwidth, perhaps involving a dial-up modem.

The personal computer (PC) represents a distributed form of computing. The PC has significant processing and storage capabilities and can be used very effectively in a standalone mode. However, PCs are more typically used in a networked mode. Initially, the networks were used for simple communications such as (text based) email, but as the network bandwidth increased over time, increasingly sophisticated activities took place, with file transfer and eventually peer-to-peer capabilities being used.

The availability of higher bandwidth networking encouraged the development of the client-server architecture, with the PC used for the clients, connected to a centralized server which performs the main processing and storage. Clients can include quite substantial software elements performing significant processing activities. Data can also be stored locally for faster access, although the main database(s) are held centrally.

The advent of the internet and the World Wide Web (WWW) represents the appearance of another form of computing. In this form of computing, web servers serve up web pages and related material which are accessed through client's web browsers. Devices running web browsers can be relatively low in compute power, while the web servers for some of the more popular and high demand web sites can involve massive compute power spread over many machines in a large data centre.

Cloud computing is a computing paradigm that provides various types of computing resources on demand in a highly scalable manner through cloud computing services. In practice, it relies on a highly centralized architecture, with computing resources concentrated in large data centres. However, cloud computing also incorporates certain features of distributed computing. It is common for cloud service providers to operate multiple physically separated data centres, and for cloud service users to use applications and data that are distributed across these centres for resilience, reduced latency and disaster recovery. In addition, the favoured design paradigm for cloud native applications is to distribute multiple instances of each application component across different machines within the cloud computing system. This design paradigm and the technologies that support it are of significance to edge computing.

5.2 Concepts of edge computing

Edge computing is distributed computing in which data processing and storage takes place on nodes which are near to the edge. The edge is marked by the boundary between pertinent digital and physical entities, i.e. between the digital system and the physical world, delineated by networked sensors and actuators. The concept of edge computing is shown in Figure 1.

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