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NORME INTERNATIONALE

Communication network dependability engineering

Ingénierie de la sûreté de fonctionnement des réseaux de communication

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COMMUNICATION NETWORK DEPENDABILITY ENGINEERING

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The text of this standard is based on the following documents:

FDIS	Report on voting
56/1339/FDIS	56/1350/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
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- replaced by a revised edition, or
- amended.

INTRODUCTION

Communication networks are today growing in complexity to meet diverse market demands and public communication needs; networks such as mobile phones, e-commerce, intranet and Internet services.

At the same time, communication technologies are developing rapidly to provide efficient network services and dependable performance needed in worldwide communications. The essential communication services such as information exchange, data processing and network connections enable public and private communications work to be carried out cost-effectively. Business and private sectors greatly depend on these communication services that have become pivotal in their daily routines. A key factor in ensuring network performance and network service functions is dependability.

Network dependability is the ability of a network to perform as and when required and to meet users' communication needs for continuous network performance and service operation. From a user's perspective, dependability infers that the provision of network service functions is trustworthy and capable of performing the desirable service upon demand. Network dependability is characterized by its performance attributes including availability of network performance and quality of service.

The network concept is an extension of the systems concept, addressing a common framework for the interaction of network elements and interoperability of service functions that together achieve specific communication objectives.

The network requires specific performance characteristics in order to deliver both its service functions and communication services. Network dependability engineering is a specific risk-based technical discipline intended to deal with the diverse applications and deployment of essential communication services. Unlike the system life cycle where system retirement exists, a network seldom reaches retirement. A network evolves with time to accommodate innovative feature applications and provision of continual communication service needs. The network life cycle is evolutionary and has to address technology convergence issues and renewal processes as well as characterize specific dependability attributes to meet network performance objectives. The need for network dependability standardization is essential to achieve cost-effective development and implementation of communication networks.

Communication network dependability provides important performance attributes for network equipment developers and suppliers, network integrators and providers of network service functions who are mainly concerned with global competitive environments. The primary reason is that dependability can seriously impact revenue generation and affect return-on-investments. Users of network service functions and communication services rely heavily on network functions and reliable services that guarantee network security and uninterrupted network connections for voice, video and data transmission.

This International Standard provides a generic framework for communication network dependability. The communication network includes telecommunications networks, Internet and intra-networks utilizing information technology. This standard describes the influence of dependability attributes and their impact on network performance. It provides the criteria and methodology for network technology designs, security service functions, dependability assessment and quality of service evaluation. This is to guide engineering and implementation processes for realization of network dependability performance objectives.

This standard constitutes part of a framework of standards on system aspects of dependability by extending the system dependability concepts of IEC 60300-3-15 for network applications, and to support IEC 60300-1 and IEC 60300-2 on dependability management. The network performance and communication services in this standard are referenced in the International Telecommunication Union Telecommunication standardization sector (ITU-T) series of recommendations.

COMMUNICATION NETWORK DEPENDABILITY ENGINEERING

1 Scope

This International Standard gives guidance on dependability engineering of communication networks. It establishes a generic framework for network dependability performance, provides a process for network dependability implementation, and presents criteria and methodology for network technology designs, performance evaluation, security consideration and quality of service measurement to achieve network dependability performance objectives.

This standard is applicable to network equipment developers and suppliers, network integrators and providers of network service functions for planning, evaluation and implementation of network dependability.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-191, *International Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60300-3-15, *Dependability management – Part 3-15: Application guide – Engineering of system dependability*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-191 and the following apply.

3.1.1
communication network
system of communication nodes and links that provides transmission of analog or digital signals

EXAMPLES Telecommunications networks, Internet, intranet, extranet, Wide Area Networks (WAN), Local Area Networks (LAN) and computer networking utilizing information technology.

NOTE 1 A network has its boundary. All nodes at the network boundary are called ends. In some applications, the term “node” is used instead of “end” as a communication access point to the network, as well as for interconnections between the transmission links.

NOTE 2 A “backbone” communication network consists of core network and high-speed transmission lines (national or international), connecting between major switching network nodes (interconnection of transmission lines) at various locations in a country or region.

3.1.2
(network) dependability
ability to perform as and when required to meet specified communication and operational requirements

3.1.3
(network) availability
ability to be in a state to perform as and when required, under given conditions, assuming that the necessary external resources are provided

NOTE 1 Availability depends on the combined characteristics of the reliability, maintainability, and recoverability of the item, and generally, on the maintenance support performance.

NOTE 2 Given conditions would include aspects that affect reliability, maintainability and maintenance support performance.

3.1.4
(network) reliability
ability to perform as required for a given time interval, under given conditions

NOTE 1 Given conditions would include aspects that affect reliability, such as: mode of operation, stress levels, environmental conditions.

NOTE 2 Reliability may be quantified using appropriate measures such as meantime to failure, or the probability of no failure within a specified period of time.

3.1.5
(network) maintainability
ability to be retained in, or restored to, a state in which it can perform as required under given conditions of use and maintenance

NOTE 1 "Given conditions of use" may include storage.

NOTE 2 "Given conditions of maintenance" include the procedures and resources to be used.

NOTE 3 Maintainability may be quantified using such measures as, mean time to restoration, or the probability of restoration within a specified period of time.

3.1.6
maintenance support
resources to conduct maintenance according to a given maintenance concept and policy

3.1.7
maintenance support performance
ability of an organization to complete specified network maintenance support upon demand under given conditions

NOTE The "given conditions" include those related to the maintenance organization, and to the conditions under which the item is used, maintained, and relevant maintenance policies and procedures.

3.1.8
(network) recoverability
ability to recover from a failure, without corrective maintenance

NOTE 1 The ability to recover may or may not require external actions.

NOTE 2 Recoverability may be quantified using such measures as, mean time to restoration, or the probability of restoration within a specified period of time.

3.1.9
(network) element
subsystem or component of a communication network

EXAMPLES Terminals, nodes, links and switches.

NOTE 1 A network element may involve human input to perform its service function.

NOTE 2 Network nodes and access points are connected by network links.

3.1.10
(network) link
electrical, wireless or optical connection between network nodes

3.1.11
(network) performance
ability to provide the service functions related to communications between users

[ITU Recommendation I.350]

NOTE Network dependability performance refers to the ability of the network to provide or demonstrate the dependability attributes in network operation to achieve network objectives and quality of service requirements.

3.1.12
(network) management
application of organized processes and resources to manage the performance, configuration, accounting, fault, and security activities

3.1.13
(network) service function
program or application that interacts with the network users or within the network infrastructure to transmit or exchange data and information in the network

NOTE A network service function may consist of hardware and software elements, and may involve human interactions for realizing a specific function.

3.1.14
network services
provision of network service functions and communication services to the network users

NOTE 1 Communication services are the network services subscribed by the end-users.

NOTE 2 A bearer service is a communication service function that allows transmission of user-information signals between user-network interfaces.

3.1.15
quality of service
collective effect of service performance that determines the degree of satisfaction of a user of the service

3.1.16
network failure
loss of network ability to perform its function as required

NOTE The failure may be due to, for example, equipment failure, natural disasters or human-caused disturbance.

3.1.17
network fault
state characterized by the inability of the network to perform its function as required

NOTE 1 In the context of network operation, a fault may be natural due to an abnormal condition, or malfunction resulting in a network element failure, or induced by external means such as fault insertion.

NOTE 2 A degraded state in network performance is a situation where one or more performance characteristics do not conform to requirements.

3.1.18
service provider
organization that provides communication network services

EXAMPLES Telephone companies, data carriers, mobile services, Internet service providers, and cable television operators.

NOTE Network carrier or common carrier is an organization that transports a product or service using its facilities, or those of other carriers, and offers services to the general public. The term communication carrier refers to various telephone companies that provide local, long distance or value added services.

3.1.19
user
party that employs the services of a service provider for direct network access

NOTE 1 A user may be a source or recipient of user information, or both.

NOTE 2 In some circumstances, a user of a communication service is also known as a subscriber.

3.1.20
(network) integrity
ability to ensure that the data throughput contents are not contaminated, corrupted, lost or altered between transmission and reception

3.2 Abbreviations

E2E End-to-End

FMEA Failure Mode and Effects Analysis

FTA Fault Tree Analysis

IP Internet Protocol

ITU-T International Telecommunication Union Telecommunication standardization sector

LAN Local Area Network

NGN Next Generation Network

OSI Open Systems Interconnection

QoS Quality of Service

RBD Reliability Block Diagram

SLA Service Level Agreement

TCP/IP Transmission Control Protocol/Internet Protocol

WAN Wide Area Network

4 Overview of communication network dependability

4.1 Network dependability framework

A communication network consists of network elements such as switches, transmitters, computers, telephones and other devices connected by communication facilities for exchanging information electronically. The connections can be permanent via cable or temporary by means of telephone or Internet links. The transmission medium can be physical (e.g. fibre optics) or wireless (e.g. satellite). It covers many technologies such as radio, television, telephone, data communication and computer networking utilizing information technology.

The nature of network operation is multi-faceted and ever expanding and evolving such as doing business on-line via the Internet. The infrastructure connecting different types of communication systems and interacting networks is extremely complex. The integration of disparate networks and systems demands evolving establishment of interfaces and protocols for interoperability to attain viable network connectivity and service performance. Enterprise marketing and e-commerce pressures often dictate development of new techniques that change the ground rules in business and service applications.

Network related activities are unique in assuring dependable performance and quality of service. The challenge is to provide network solutions that link network designs and service function applications to realize the relevant dependability attributes. Network dependability infers that the network performance is able to maintain information integrity and capable of delivering the network service functions to satisfy user expectations as well as the service provider's needs. The strategic framework is to select and implement appropriate network elements for the network configuration to achieve dependability and integrity in network performance.

Annex A presents a generic communication network model and related concepts.

Network dependability and network service functions are influenced by the dependability attributes relevant to their specific applications in various network life cycle stages. These dependability attributes include availability, reliability, maintainability, maintenance support performance, recoverability and integrity performance characteristics, incorporated in the network designs and implemented in the network service functions for network operation and maintenance.

The communication network dependability framework consists of six main interacting areas of influence:

a) the application of dependability engineering;
b) the utilization of network technology;
c) the delivery of network performance;
d) the deployment of network service functions;
e) the integrity of network data and information;
f) the provision of quality of service.

These six interacting areas of influence form the basis for network dependability management. Implementation of network dependability processes and methods are described in Clause 5.

4.2 Network life cycle and evolution process

A network evolves and changes with time to meet the dynamic network applications and network service needs in communications. The network evolution process is reflected in the system life cycle stages described in IEC 60300-3-15 and modified for network life cycle application to include the renewal process. The following presents the network life cycle stages:

- *concept/definition* stage to identify network operating scenario;
- *design/development* stage to determine technology applications and develop network service functions;
- *realization/integration* stage to realize network operation, verification and validation to assure network performance;
- *operation/maintenance* stage to sustain network operation and provision of network services;
- *enhancement* stage:

– to optimize and improve network performance by technology evolution and service functions convergence;

– to upgrade or renew continuing network services, and launch new features in network applications;

- *retirement/decommissioning* stage to discontinue obsolete service functions.

Annex B describes the network life cycle and evolution process.

5 Network dependability implementation

5.1 Dependability engineering applications

5.1.1 Management of network dependability

Dependability is a technical discipline that is managed by engineering principles and practices. The dependability management systems [1][1] and guidelines [2] are used in this standard for formulation of dependability management strategies and general application of technical approaches for implementation of dependability elements and tasks. Additional management processes are introduced to address network specific management issues. Dependability management involves project planning, resource allocation, dependability task assignments, monitoring and assurance, measurement of results, data analysis and continual improvement. Dependability activities should be conducted in conjunction with other technical disciplines to attain the necessary synergistic effects and add values to the project outcomes. Project tailoring is emphasized for cost-effective management of network projects. Where applicable, life cycle cost analysis [4] and risk assessment [11] should be used for resource allocation and optimization for evaluation of acquisition and ownership costs.

From a communication network management perspective, dependability management should be an integral part of the network management process with relevant dependability activities to support development and implementation of network service functions throughout the life cycle and network evolution. Network management is the execution of the set of management processes for planning, controlling, allocating, deploying, coordinating, maintaining and monitoring the resources of a network.

From an engineering perspective, a network can be viewed as a complex system consisting of multiple interconnecting systems. The technical processes in IEC 60300-3-15 are used to describe the network life cycle stages for project implementation. The network life cycle stages are modified to accommodate the process descriptions of network evolution and technology convergence, optimization and renewal, obsolescence and retirement. Network management process and dependability related activities for each network life cycle stage are presented in Annex B.

5.1.2 Network dependability attributes

The basic set of network dependability attributes is derived from a network performance perspective. Other attributes may be added for specific applications.

a) Availability

Network availability reflects the users' requirements from three aspects:

– the network has the ability to perform as and when required;

– the network service functions should not be affected by network faults;

– the network can recover as quickly as possible when a network fault affects its service functions.

b) Reliability

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

Network reliability can be improved by using redundancy technology and protection mechanisms. For a network with high reliability requirements, the protection of multipoint faults should be considered. The manifestation of faults becomes more critical for complex network operation, especially with the continued usage of obsolete equipment that may have compatibility problems.

c) *Maintainability*

Maintainability reflects the ease of restoring a network to an operating state following a fault, or from a degraded state of network performance operation. The incorporation of redundancy in design and fault management capability into the network can affect maintainability performance. For example, remote fault management where fault identification and corrective action are carried out by remote intervention, can shorten maintenance time.

d) *Maintenance support performance*

Maintenance support performance is dependent on the provision and management of resources to perform maintenance activities. Network dependability design requires an approach to reduce the complexity of network equipment for maintenance, easy access for active maintenance during network operation, standardized maintenance procedures, network fault identification and traceability, and perfected spare parts management system. This approach applies to hardware and software as well as to human functions for maintenance support performance and design consideration.

e) *Recoverability*

Recoverability in service performance is dependent on the design of network architecture, fault-tolerant protection mechanisms, access for maintenance and self-healing features incorporated into the network functions. The means of achieving restoration may be automatic or by external actions.

f) *Integrity*

Integrity infers that the network is stable and robust, and able to maintain consistency in performance and use. Network integrity provides security and protection for information transfer in network performance and service functions.

5.1.3 Network failures and faults

5.1.3.1 Network failure criteria

Network failure criteria should be established during the concept and definition stage and continually reviewed throughout the lifecycle of the network in order to permit classification and updating of network failures.

Failure criteria should be determined by the network service provider, based on industry standards and relevant data, including the network users' inputs, so that all conceivable conditions can be covered. This information is used in:

- specification of dependability requirements to the network equipment suppliers;
- reaching agreements (such as SLA) of the network dependability performance attributes with the users of the network services.

The following should be considered when establishing failure criteria.

a) Network node and link failure: The failure of network nodes and links includes total failure and partial failure. Total failure is the loss of functionality of the entire network for a period of time. Partial failure is the loss of functionality of part of the network.

b) Quality of service (QoS) degradation failure: Degradation failure is due to an unacceptable level of QoS in the provision of network service performance experienced by the users. Network service providers routinely gather QoS data through measurements and surveys to determine the level of QoS.