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Methodology for communication network dependability assessment and assurance

Méthodologie pour l'évaluation et l'assurance de la sûreté de fonctionnement d'un réseau de communication

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CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms, definitions and abbreviations 7
3.1 Terms and definitions 7
3.2 Abbreviations 11
4 Overview of network dependability methodology 11
4.1 Need for network dependability methods 11
4.2 Network dependability objectives 12
4.3 Network service scenarios 13
4.4 Network dependability assessment strategies 13
4.5 Network dependability assurance strategies 14
5 Network dependability methodology applications 15
5.1 Network life cycle process 15
5.1.1 Life cycle process applications 15
5.1.2 Risk assessment process applications 15
5.1.3 Dependability methodology applications 16
5.2 Network dependability performance characteristics 17
5.3 Network dependability assessment methodology 18
5.3.1 Generic dependability analysis and evaluation techniques 18
5.3.2 Service scenario analysis 19
5.3.3 Network modelling 19
5.3.4 Network failure modes, effects and criticality analysis 20
5.3.5 Network fault insertion test 21
5.3.6 Failure reporting, analysis and corrective action system 22
5.4 Network dependability assurance methodology 22
5.4.1 Scope of dependability assurance methodology applications 22
5.4.2 Assurance of dependability of service 23
5.4.3 Assurance of data integrity 23
5.4.4 Assurance of network performance functions and support process enhancement 24
5.4.5 Network dependability assurance methods 24
Annex A (informative) Example of E2E network dependability assessment 27
Annex B (informative) Example of full-end network dependability assessment 33
Annex C (informative) Evaluation of network dependability performance in field operation 35
Bibliography 37

Figure A.1 – A typical example of an E2E network topology 27
Figure B.1 – A typical example of a full-end network topology 33
Figure C.1 – Network outage contributions and resultant network service impact 36

Table 1 – Summary of network dependability activities and application methods 17
Table 2 – Summary of network dependability parameters 18
Table C.1 – Summary of network failure data of a nation-wide public switched telephone network 35

INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHODOLOGY FOR COMMUNICATION NETWORK DEPENDABILITY ASSESSMENT AND ASSURANCE

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International Standard IEC 62673 has been prepared by IEC technical committee 56: Dependability.

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

FDIS	Report on voting
56/1507/FDIS	56/1514/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 stability 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

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INTRODUCTION

Communication network dependability is highly influenced by the design and implementation of the network service functions, which aim to achieve user satisfaction in service performance.

Network evolution, service growth and functional renewal in communications have long been challenges to the providers of network services, not just for the broad range of services now in existence, but also for those service-related activities experienced by the end-users.

To sustain viable business in network services, it is prudent for the communications industry to provide the

– needed network service functions,
– adequate network capacity and performance capability,
– security of service,
– quality of service, and
– dependability of service.

This International Standard addresses one of the most important issues concerning the assessment and delivery of dependability of service to ensure network service performance. It also addresses the network dependability assurance strategies and methodology applications for enhancing and sustaining network operation.

This International Standard describes a generic methodology for dependability assessment and assurance of communication networks. It also provides relevant assessment and assurance methods to support communication networks for dependability engineering application, such as those conforming to IEC 61907 and ITU-T [1] Recommendations concerning dependability.

It presents an approach for network dependability analysis and evaluation that ensures dependable network design for effective implementation.

The objective of this standard is to achieve a cost-effective solution for realizing the network dependability performance and to assure the benefits from the network dependability of service operation.

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1 ITU-T: International Telecommunications Union – Telecommunications.

METHODOLOGY FOR COMMUNICATION NETWORK DEPENDABILITY ASSESSMENT AND ASSURANCE

1 Scope

This International Standard describes a generic methodology for dependability assessment and assurance of communication networks from a network life cycle perspective. It presents the network dependability assessment strategies and methodology for analysis of network topology, evaluation of dependability of service paths, and optimization of network configurations in order to achieve network dependability performance and dependability of service. It also addresses the network dependability assurance strategies and methodology for application of network health check, network outage control and test case management to enhance and sustain dependability performance in network service operation.

This standard is applicable to network service providers, network designers and developers, and network maintainers and operators for assurance of network dependability performance and assessment of dependability of service.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 (IEV) – Chapter 191: Dependability and quality of service*

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

IEC 61907, *Communication network dependability engineering*

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 IEC 61907, as well as the following, apply.

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

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

Note 1 to entry: 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 to entry: 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
dependability
network dependability
ability to perform as and when required to meet specified communication and operational requirements

3.1.3
availability
network availability
ability to be in a state to perform as required

Note 1 to entry: Availability depends upon the combined characteristics of the reliability, recoverability and maintainability of the network and on the maintenance support performance.

Note 2 to entry: Availability may be quantified using appropriate performance measures.

3.1.4
reliability
network reliability
ability to perform as required, without failure, for a given time interval, under given conditions

Note 1 to entry: The time interval duration may be expressed in units appropriate to the network concerned.

Note 2 to entry: Reliability of a network depends upon the combined characteristics of the reliability, recoverability, maintainability and maintenance support performance of the constituent network elements.

Note 3 to entry: Given conditions include aspects that affect reliability, such as: mode of operation, stress levels, environmental conditions, and maintenance.

Note 4 to entry: Reliability may be quantified using appropriate performance measures.

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

Note 1 to entry: Given conditions include aspects that affect maintainability, such as: location for maintenance, accessibility, maintenance procedures and maintenance resources.

Note 2 to entry: Maintainability may be quantified using appropriate performance measures.

3.1.6
maintenance support
network maintenance support
provision of resources to maintain a network

Note 1 to entry: Resources include human resources, support equipment, materials and spare parts, maintenance facilities, documentation, information and maintenance information systems.

3.1.7
maintenance support performance
network maintenance support performance
effectiveness of an organization in respect of maintenance support for the network

Note 1 to entry: Maintenance support performance may be quantified using appropriate measures.

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

Note 1 to entry: The ability to recover may or may not require external actions.

Note 2 to entry: Recoverability may be quantified using such measures as the probability of recovery within a specified time interval.

3.1.9
element
network element
subsystem or component of a communication network

EXAMPLES Terminals, nodes and switches.

Note 1 to entry: A network element may involve human input to perform its service function.

Note 2 to entry: Network elements are connected by network links.

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

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

[SOURCE: ITU-T Recommendation I.350:1988][1][2]

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

3.1.13
service function
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 1 to entry: 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 to entry: Communication services are the network services subscribed by the end-users.

Note 2 to entry: 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 ability of a network to perform as required

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2 References in square brackets refer to the Bibliography.

Note 1 to entry: The network failure may be due to, for example, equipment failure, natural disasters or human-caused disturbance.

3.1.17
network fault
state of inability of a network to perform as required, for internal reason

Note 1 to entry: In the context of network operation, a fault may be natural due to an abnormal condition, or malfunction resulting from a network element failure, or induced by external means such as fault injection.

Note 2 to entry: 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 service providers, Internet service providers and cable television operators.

Note 1 to entry: A 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 to entry: A user may be a source or recipient of user information, or both.

Note 2 to entry: In some circumstances, a user of a communication service is also known as a subscriber.

3.1.20
integrity
network integrity

ability to ensure that the data contents are not contaminated, corrupted, lost or altered between transmission and reception

Note 1 to entry: Throughput is the rate of successful message delivery over a communication channel of a network service.

3.1.21
dependability performance
network dependability performance
ability to provide or demonstrate the performance characteristics of dependability in network operation to achieve network service objectives

Note 1 to entry: In the context of this standard, network dependability performance refers to the provision of full-end network services.

Note 2 to entry: A full-end network service is the provision of service connectivity established for all transmission and reception ends of a communication network.

3.1.22
dependability of service
network dependability of service
effect of providing the required dependability performance for user communications services

Note 1 to entry: In the context of this standard, network dependability of service refers to the provision of end-to-end (E2E) network services.

Note 2 to entry: An end-to-end network service is the provision of service connectivity established between the transmission and reception ends of a communication network.

3.1.23
security of service
network security of service
effect of providing the required security for user communications services

3.1.24
service path
network service path
connecting path by network links and nodes to establish user communications services

3.1.25
service flow
network service flow
flow of information and data through the service path

3.1.26
service scenario
operational situation in communication network for provision of network service functions and user service applications

3.1.27
network outage
state of the network being unable to perform its primary function

3.2 Abbreviations

E2E	End-to-End
FRACAS	Failure Reporting, Analysis, Corrective Action System
FRU	Field Return Unit
HAZOP	Hazard and operability studies
MTTR	Mean Time to Restoration of Node/link
ND	Network Dependability
NFIT	Network Fault Insertion Test
NFMECA	Network Failure Modes, Effects and Criticality Analysis
OAMP	Operations, Administration, Maintenance, and Provisioning
OSI	Open System Interconnection
QoS	Quality of Service
RBD	Reliability Block Diagram
SLB	Service Logic Block

4 Overview of network dependability methodology

4.1 Need for network dependability methods

A communication network is a system of systems that interacts with other networks to achieve multiple service performance objectives. A communication network is complex and its constituent systems are constantly changing and evolving. Appropriate methodology and technical approaches are needed for dependability assessment and assurance of the network.

From a network dependability assessment perspective, the classical dependability techniques for analysis and evaluation have a limited scope in network application. Existing dependability methods are often unsuitable for modelling complex network topology and difficult for analysis of multiple network configurations and network service paths to provide confidence in the evaluation results. Selective methods such as SLB, NFMECA, and network simulation suitable for network dependability analysis and evaluation can provide effective network solutions.

They have become the essential processes to ensure sustainable network services and dependability performance.

A common approach for assurance of network dependability performance and dependability of service is to construct reliable network structure, establish effective routing schemes, provide efficient fault management and network maintenance support, and gather performance data and user feedback for network service evaluation and improvement. The process involves analysis of network service functions for cost-effective implementation, and evaluates value-added network service features for dependability of service enhancement. This approach, though adequate for system life cycle assessment of hardware and software network elements to ascertain dependability performance, is inadequate to deal with routing connectivity of user services in network operation. The traditional assurance approach lacks the responsiveness to react to the market dynamics of adaptive network configurations. This affects the network service objectives to ensure network dependability performance and to guarantee dependability of service in a highly competitive global network business.

There are many dependability methods developed over the years but only a selective few provide efficient methodology appropriate for effective network dependability performance and dependability of service applications. This observation is noted due to the complex nature of network evolution; the innovative topology for development of advanced network service functions, and the unique techniques required for practical dependability methodology applications. Whereas there are many factors that could influence the dependability performance in the network life cycle, the most significant impact would be during the early stages in concept/definition, design/development, and realization/integration. New additions to the existing network would involve scenario analysis of the legacy system during the concept/definition stage prior to investments in subsequent design/development and realization/integration stages. The extent of operation/maintenance, enhancement/renewal and retirement needs should be included in the scenario analysis of the legacy system. Network dependability performance and dependability of service should be continuously monitored, analysed and evaluated for optimization of network operations and provision of revenue generating network services. The network dependability assurance strategies and methodology applications are key contributing factors to enhance and sustain continued provision of network services from a viable business perspective.

4.2 Network dependability objectives

The capability of a network to provide users' communication for continual and uninterrupted service operation is highly dependent on its dependability performance. Dependability implies that the provision of network service functions is trustworthy and capable of performing the desirable service upon demand. To achieve network performance and assure network dependability of service, it is essential to utilize relevant methods for assessment of network dependability. This standard supports the engineering requirements for network design and process implementation, and provides relevant dependability methodology for analysis and evaluation of communication networks. The technical framework of IEC 60300-3-15 on system aspects of dependability and the requirements of IEC 61907 on network dependability engineering apply to this standard. Terms related to communications quality of service are referenced in ITU-T Recommendation G.1000 [2].

In the development and implementation of communication networks, there are several important influencing factors that concern the network operators and service providers to sustain a viable business. They include:

- network service functions to satisfy user needs;
- network performance capability to meet service demands;
- security of service;
- quality of service (QoS) [3];
- dependability of service.

In the assessment and assurance of network dependability, it should be noted that

a) the network functional parameters such as transmission capacity and performance connectivity will degrade with time due to failures and this will affect network dependability;

b) the robustness of the network to resist service performance violation due to external intrusion and outage interruption will affect critical network infrastructure protection.

4.3 Network service scenarios

There are two network service scenarios of interest to network dependability.

a) Dependability of service of the end-users' connections for end-to-end (E2E) network services (see Clause A.2) – the objective is to determine the network dependability performance characteristics on E2E network services from the perspective of network end-users. The E2E network service is an essential service to meet end-user needs based on the performance capability of a full-end network in service operation. In the E2E network service scenario, the dependability of service is reliant on the routing schemes and the capability of the network performance associated with the specific service paths selected for the E2E connections. Dependability of service is experienced by the end-users and reflects customer demands and user satisfaction.

b) Dependability performance of the entire network for full-end network services (see Clause B.2) – the objective is to determine the network dependability performance characteristics of the entire network from the network operator or the network service provider perspective. A full-end network can operate in a service scenario where the service provider has full control of a private network and has the responsibility to provide network dependability performance adequate for the network services. The full-end network can also operate in a service scenario with multiple service providers each controlling a designated segment of the entire network as in a public switching network. The network operator is responsible for the overall network service performance. Individual service providers are responsible for their contributions of network service performance under the network service level agreements with the network operator in provision of QoS.

The two network service scenarios associated with E2E and full-end network service operations are interdependent and complementary. It should be noted that without dependability performance capability, adequate user services could not be achieved or guaranteed; and without user satisfaction of dependability of service, the service provider would experience difficulty in sustaining user service demands and could lose subscriptions; hence affecting network service revenue generation. Relevant network user feedback information gathered and network performance data analysed from these two network service scenarios would facilitate resource planning and control of QoS provision to subscribers or users and maintain dependability of overall network services.

Network dependability performance and dependability of service reflect the network service scenarios and operation environments in doing business. This is achieved by means of dependability assessment to ensure dependability performance during network development and dependability assurance to sustain dependability of service during network operation.

The strategies for network dependability assessment and dependability assurance are outlined in 4.4 and 4.5. The dependability methodology and methods for network applications are provided in Clause 5.

4.4 Network dependability assessment strategies

Dependability assessment is an appraisal process to determine the status of network performance for delivery of dependability of service. The following describes the network dependability assessment strategies relevant to the network service scenarios.

a) E2E network dependability assessment strategy

The E2E network dependability is influenced by the network topology, the routing schemes and the selection of service paths to achieve user service connections. To assess E2E network dependability, the routing service paths associated with the service scenarios should be analysed. All the equipment and links of each service path should be evaluated