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SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Quality of telecommunication services: concepts, models, objectives and dependability planning – Objectives for quality of service and related concepts of telecommunication services

Quality of service norms for time-division multiplexing interconnection between telecom networks

Recommendation ITU-T E.847

International Telecommunication Union

ITU-T E-SERIES RECOMMENDATIONS

OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

INTERNATIONAL OPERATION	
Definitions	E.100–E.103
General provisions concerning Administrations	E.104–E.119
General provisions concerning users	E.120–E.139
Operation of international telephone services	E.140–E.159
Numbering plan of the international telephone service	E.160–E.169
International routing plan	E.170–E.179
Tones in national signalling systems	E.180–E.189
Numbering plan of the international telephone service	E.190–E.199
Maritime mobile service and public land mobile service	E.200–E.229
OPERATIONAL PROVISIONS RELATING TO CHARGING AND ACCOUNTING IN THE INTERNATIONAL TELEPHONE SERVICE	
Charging in the international telephone service	E.230–E.249
Measuring and recording call durations for accounting purposes	E.260–E.269
UTILIZATION OF THE INTERNATIONAL TELEPHONE NETWORK FOR NON-TELEPHONY APPLICATIONS	
General	E.300–E.319
Phototelegraphy	E.320–E.329
ISDN PROVISIONS CONCERNING USERS	E.330–E.349
INTERNATIONAL ROUTING PLAN	E.350–E.399
NETWORK MANAGEMENT	
International service statistics	E.400–E.404
International network management	E.405–E.419
Checking the quality of the international telephone service	E.420–E.489
TRAFFIC ENGINEERING	
Measurement and recording of traffic	E.490–E.505
Forecasting of traffic	E.506–E.509
Determination of the number of circuits in manual operation	E.510–E.519
Determination of the number of circuits in automatic and semi-automatic operation	E.520–E.539
Grade of service	E.540–E.599
Definitions	E.600–E.649
Traffic engineering for IP-networks	E.650–E.699
ISDN traffic engineering	E.700–E.749
Mobile network traffic engineering	E.750–E.799
QUALITY OF TELECOMMUNICATION SERVICES: CONCEPTS, MODELS, OBJECTIVES AND DEPENDABILITY PLANNING	
Terms and definitions related to the quality of telecommunication services	E.800–E.809
Models for telecommunication services	E.810–E.844
Objectives for quality of service and related concepts of telecommunication services	**E.845–E.859**
Use of quality of service objectives for planning of telecommunication networks	E.860–E.879
Field data collection and evaluation on the performance of equipment, networks and services	E.880–E.899
OTHER	E.900–E.999
INTERNATIONAL OPERATION	
Numbering plan of the international telephone service	E.1100–E.1199
NETWORK MANAGEMENT	
International network management	E.4100–E.4199

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T E.847

Quality of service norms for time-division multiplexing interconnection between telecom networks

Summary

Recommendation ITU-T E.847 analyses and identifies quality of service (QoS) parameters for time-division multiplexing (TDM) interconnection between telecom networks, which are needed to facilitate effective interconnections with reasonable traffic handling capacities. The proposals, as given in this Recommendation, provide a guiding framework for TDM interconnection of telecom networks and will facilitate effective monitoring of performance, QoS at point of interconnections (POIs), as well as endeavour to ensure end-to-end customer satisfaction and quality of experience (QoE). Regulators may also use this Recommendation to envision effective interconnection regulations in their respective countries.

History

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FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Table of Contents

Introduction

In multi-operator, multi-technology and multi-service environments, it is imperative to ensure effective interconnection between different operator networks in order to provide quality service to end users. To ensure effective time-division multiplexing (TDM) interconnection between networks, the network-related parameters to measure the quality of telecom services may relate to:

– network availability;

– connection establishment (accessibility);

– connection maintenance (retainability);

– optimal point of interconnection (POI) capacity provisioning and its effective utilization;

– POI congestion (no. of POIs not meeting the benchmark).

Interconnection in TDM networks can be considered relatively simple and well established since all legacy telephone networks usually use the same signalling system (i.e., SS7 signalling), media transport as in TDM and numbering scheme such as that of Recommendation ITU-T E.164 and also interfaces such as E1 and T1 links that are well used depending on the region or network equipment provider.

From a regulatory point of view, the purpose of interconnection is to ensure end-to-end network service connectivity and enable consumers of interconnected operators to establish connections with one another. Access also enables service providers to utilise facilities of other providers to further influence their own business plans for providing service to customers.

Recommendation ITU-T E.847

Quality of service norms for time-division multiplexing interconnection between telecom networks

1 Scope

This Recommendation is intended to facilitate effective interconnection and support the following:

– non-discriminatory benchmarks for interconnection parameters, interconnect resources allocated to and congestion faced, if any, by outgoing as well as incoming traffic at point of interconnection (POI) of telecom networks;

– end-to-end quality of service (QoS) for users;

– prevention of under-utilization and over-provisioning of interconnect capacity and resources;

– flexibility and freedom for interconnecting parties to negotiate and finalise mutually agreeable interconnection arrangements.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; the users of this Recommendation are, therefore, encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T E.600] Recommendation ITU-T E.600 (1993), *Terms and definitions of traffic engineering*.

[ITU-T E.800] Recommendation ITU-T E.800 (2008), *Definitions of terms related to quality of service.*

[ITU-T P.10] Recommendation ITU-T P.10/G.100 (2006), *Vocabulary for performance and quality of service.*

[ITU-T Q.700 series] ITU-T Q.700-Q.799 series of Recommendations, *Specifications of Signalling System No. 7*.

[ITU-T Q.780] Recommendation ITU-T Q.780 (1995), *Signalling System No.7 test specification – General description*.

3 Definition

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 QoE assessment: [ITU-T P.10].

3.1.2 quality of service (QoS): [ITU-T P.10] and [ITU-T E.800].

3.1.3 quality of experience (QoE): [ITU-T P.10].

3.1.4 time consistent busy hour (TCBH): [ITU-T E.600].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 interconnection: The physical and logical linking of public communications networks used by the same or a different service provider to allow the users of one service provider or network to communicate with users of another service provider or network, or to access services provided by another service provider or network.

3.2.2 POI (point of interconnection): The demarcated point or the facility for exchange of traffic between networks to facilitate inter-network communication of/for respective subscribers, who are end users of such networks.

3.2.3 POI congestion: The ratio of calls failed over the POI (between two network operators) due to unavailability of free circuits to the total call requests for seizure of POI circuit.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CDR Call Data Record

DSR Dual Seizure Ratio

KPI Key Performance Indicator

MNO Mobile Network Operator

MSC Mobile Switching Center

MTTR Mean Time to Repair

POI Point of Interconnection

PSSR POI Seizure Success Ratio

QoE Quality of Experience

QoS Quality of Service

SASR Subscriber Attempt Success Ratio

SASSR Subscriber Attempts-Seizure Success Ratio

SLA Service Level Agreement

TCBH Time Consistent Busy Hour

TDM Time-Division Multiplexing

TSP Telecom Service Provider

5 Conventions

None.

6 QoS norms for TDM interconnection between telecom networks

This clause shows some parameters and their thresholds that aim to help network operators set measureable and realistic key performance indicators (KPIs) to ensure effective compliance of regulations and help them in negotiating interconnection agreements to mitigate unforeseen disputes.

The following non-discriminatory benchmark parameters are proposed to be included for monitoring/observations by national regulators, to ensure effective performance and QoS of

time-division multiplexing (TDM) interconnection, thereby resulting in improved quality of experience (QoE) for users.

6.1 Subscriber attempt success ratio for a POI

$$\text{subscriber attempt success ratio (SASR)} = y/x$$

Where:

y = No. of successful attempts/call requests for seizure of circuit at a POI

x = Total number of subscriber call attempts meant for that POI.

An improved SASR means improvement in the success of subscribers' call attempts toward a particular POI and also leads to meting out of non-discriminatory treatment by telecom network/service providers to all POIs. It will also discourage intentional deterioration in QoS of a particular POI, with respect to delivery of end-to-end customer satisfaction (QoS/QoE).

6.2 POI seizure success ratio

$$\text{POI seizure success ratio (PSSR)} = z/y$$

Where:

z = No. of actual seizures at a POI

y = No. of successful attempts/call requests for seizure at POI.

Alternatively, **POI congestion** = $(y-z)/y = 1 - z/y$

POI congestion = $\frac{\text{failed call requests over the POI due to unavailability of free circuits}}{\text{(total call requests for seizure of POI circuit).}}$

NOTE – The benchmark threshold for POI congestion may be set at $\leq$0.5%, i.e., 0.005, which means that out of 200 successful call attempts or seizure requests at the POI between two operators, not more than one attempt should face congestion. Any relaxation in POI threshold above 0.5% would allow a mobile network operator (MNO) or telecom service provider (TSP) to manage with lesser provisioning of interconnection links and resources at POI but would burden them with the responsibility to ensure a higher service-level agreement (SLA) by adhering to a more stringent mean time to repair (MTTR), e.g., a relaxed POI congestion threshold of 1% would demand adherence to a more stringent MTTR to meet the expected QoS/QoE norms. Hence, while relaxing the POI threshold, a regulator has to exercise great caution and take a balanced view with the objective of ensuring delivery of an end-to-end high-quality service experience to the user.

6.3 Subscriber attempts-seizure success ratio

$$\text{subscriber attempts-seizure success ratio (SASSR)} = z/x$$

Where:

z = No. of actual seizures at a POI

x = Total number of subscriber call attempts meant for that POI.

The SASSR reflects the performance of a particular POI regarding the subscriber attempts made, so as to render end-to-end QOE to the subscriber.

6.4 Inter-operator POI efficiency (η)

$$\eta = \frac{\text{PSSR of a particular inter-operator POI}}{\text{Sum total of PSSRs of all inter-operator POIs}}$$

η = (PSSR of a particular inter-operator POI)/(sum total of PSSRs of all inter-operator POIs)

This parameter, when calculated for all inter-operator POIs, will give comparative performance of any particular inter-operator POI with respect to the other inter-operator POIs.

6.5 Time frame for activation of a new POI

The time frame for activation of a new POI is the time duration permitted for commissioning of interconnect capacity or link after confirmation or acceptance of demand for interconnect capacity provisioning and commissioning. The prescribed time limit benchmark for providing POI connectivity is 90 days, counted from the date of confirmation or acceptance of demand for POI connectivity.

6.6 Time frame for POI capacity enhancement

The time frame for POI capacity enhancement is the time frame given for the expansion of links for interconnection where a POI between networks already exists. POI capacity enhancement may be possible within 60 days from the date of acceptance or confirmation of demand, where POIs between networks already exist. However, in cases of specific situations or events, alternate POI capacity, wherever applicable or required, can be augmented temporarily by mutual agreement between service providers to maintain their utilization targets.

6.7 Interconnection route utilisation parameter

This is the POI dimensioning parameter based on traffic growth. The prescribed benchmark for the route utilisation parameter is 70%. For example, if POI route utilisation crosses 70% during time consistent busy hour (TCBH), it may trigger immediate bandwidth expansion/stream augmentation with a buffer of 10% for handling lead time traffic until the expansion/augmentation is completed. On the lower side, however, if the POI has been consistently operating for a monitoring period at less than 60% utilization, then the resource can be released up to the extent of 10%; this will avoid resource wastage and the utilization can be maintained between 60-70%. Further, as a route may have more than one interconnection link, the traffic on a route is a cumulative sum of the traffic on all interconnection links in that route.

NOTE – The suggested approach in the previous clause shall ensure operation of all POIs effectively with 60% and 80% capacity utilization as lower and upper thresholds, respectively. This approach not only discourages excess capacity allocation/wastage of resources, but also discourages inadequate buffer capacity/poor service experience during traffic surges and provides adequate lead time for augmentations.

6.8 Mean time to repair for POI ports

An MTTR is the expectation of repair time for a statistically significant number of repairs carried out from the instant a fault has been reported to the instant the service is restored for use by the customer, and is usually expressed as the arithmetic mean.

The MTTR for a POI port failure should not be greater than 72 hours. However, if all interconnect capacity is down, or congestion levels are above threshold on the following hour of a POI failure, then the restoration needs to target a shorter duration of within four hours.

6.9 Time to repair interconnection route

The time to repair (TTR) = time at which total service restoration is achieved – time at which fault is notified.

Maintenance is carried out after fault recognition and is intended to restore to a state in which it can perform the required function. This could be measured by sum of duration of each repair time in hours for all the fault incidences in a day. The TTR interconnection route should not be more than one hour from the time the fault occurred.

6.10 Dual seizure ratio

The dual seizure ratio (DSR) should ideally be zero. Dual seizure occurs if a local POI/mobile switching center (MSC) sends/receives a request to/from a corresponding POI/MSC on the other end,

to seize the same circuit simultaneously. That is, dual seizure occurs if a trunk circuit is seized by an incoming call and outgoing call simultaneously.

$$\text{dual seizure ratio} = E1/(E2+E3+E4)$$

Where:

E1 = Dual seizure times

E2 = Seizure times

E3 = Overflow times

E4 = Trunk reflection times.

E4: This measurement entity counts the number of times that second attempts are made after the first attempt to seize an outgoing trunk fails. The local POI/MSC may reselect an outgoing circuit after the first attempt to seize a circuit fails, owing to the factors such as non-controlling dual seizure.

6.11 Signalling link utilisation

This should not exceed 40% of handling capacity in case of a failure condition [ITU-T Q.780]. There should be sufficient number of signalling links provided between POIs to avoid any signalling congestion. It is, therefore, suggested to apply the above criteria for provisioning of interconnection signalling links as well. An augmentation trigger point at 35% can be followed for addressing the lead time.

6.12 Unit of time measurement and recordings in CDRs

It is desirable to have uniformity in recording and measurement of time duration in call data records (CDRs). It is, therefore, suggested that the unit of time measurement should either be in 'seconds' or 'milliseconds' in CDRs in order to avoid any inter-operator billing disputes. International practice is to measure in milliseconds.

6.13 Clock synchronisation and accuracy of switch time

The POI must have synchronised clocks in order to avoid any failure of data calls, as well as to avoid bit error or slip in pulse-code modulation (PCM). If there is no synchronisation mechanism in place, then it may also lead to differences in CDR billing. Hence, it is recommended that synchronisation may be with reference to the clock of the interconnection provider or another operator.

All POIs should have the same time stamp so that the CDR comparison/call tracing and disputes, if any, can be quickly resolved.

6.14 Acceptance testing and monitoring

It is recommended to use a uniform testing procedure (which should be reviewed from time to time) with a regular monitoring mechanism, by a governmental agency or accredited third-party, to avoid any delay in POI connectivity or augmentation.

7 Review of influences on QoS of TDM interconnection

QoS mainly refers to the perceivable quality between source and destination and is usually influenced by many factors from terminal equipments.

TDM transport techniques provide end-to-end fixed bandwidth designed to provide a guaranteed level of QoS. The POI congestion parameter, as a tool to ensure QoS of TDM interconnection, may be defined as, "The ratio of calls failed over the POI (between two operators/licensees) due to unavailability of free circuits to the total call requests for seizure of POI circuit".

However, poor quality of TDM interconnection may occur due to the following:

– insufficient capacity of the POI that may not be in accordance with the traffic flows through the interconnect links between the networks;
– insufficient or discriminatory provision or allocation of routing or control equipment resources at the receiving or transmitting end;
– growth in existing capacity of interconnection not being commensurate to the fast growing demands of the telecom services traffic on such interconnections;
– other technical reasons or issues.

The above prescribed identification of parameters and their corresponding thresholds intend to provide a guiding framework for effective TDM interconnection of telecom networks and is expected to facilitate effective monitoring of performance as well as QoS of POIs, thereby helping to ensure end-to-end customer satisfaction or QoE for users. However, the level of interconnection may need to be reviewed at regular intervals in view of technological advances in the telecom services sector and migration of networks towards IP networks as handing over of inter-connection traffic may be feasible at alternate locations, thereby leading to savings for both the parties to interconnect.

Annex A

Guiding regulatory framework for interconnection

(This annex forms an integral part of this Recommendation.)

The term 'interconnection' refers to physical or logical linking between telecom networks and 'interconnection agreement' refers to the commercial and technical arrangement which facilitates TSPs to interconnect their equipment, networks and services so that subscribers of a TSP have access to the subscribers, services and networks of another TSP. An interconnection agreement must endeavour to ensure fair, reasonable and non-discriminatory terms and conditions of interconnection between TSPs keeping in view the technological, market, licensing, regulatory and legal developments in the telecommunication sector.

All TSPs should register with their administration's regulatory authority, the interconnect agreements that they are party to. This interconnection agreement may, among other things:

– meet all reasonable demands for the transmission and reception of messages between interconnected systems;

– establish and maintain such POIs as are reasonably required with sufficient capacity and in sufficient number to enable transmission and reception of messages by means of the applicable systems;

– connect and keep connected, to their applicable systems.

While interconnection is purely a matter of mutual agreement between interconnecting parties, any interconnect capacity creation, augmentation and/or disconnection of the interconnect capacity may have to be mutually agreed upon. However, it is desirable for administrations to have ex-ante regulatory guidelines for establishing a proper environment to facilitate effective and expeditious interconnection in the interest of consumers. For this purpose, they may prescribe broad guidelines based on fair, reasonable and non-discriminatory principles and leave the details of interconnection agreement to be mutually decided by the interconnecting TSPs in a time-bound manner. Alternatively, they may prescribe a standard interconnection agreement, which must be entered into between interconnecting TSPs, in case they are unable to mutually agree upon terms and conditions of the interconnection agreement between themselves in a specified timeframe.

The broad guidelines suggested above are a sort of model reference interconnect offer (RIO) (describing, among other things, the technical and commercial conditions for interconnection) which may form the basis of all interconnection agreements to be entered into. However, if the parties fail to amicably negotiate a mutually beneficial interconnection arrangement in a prescribed period or a specified timeframe, then the default option of a standard template can be pursued in a transparent, fair and non-discriminatory manner to serve the larger interest of consumers and the telecom sector as such.

Interconnection between networks of different service providers for carrying circuit-switched traffic may be as per standards of common channel signalling (CCS) No. 7 protocols defined in the [ITU-T Q.700 series] series of Recommendations as amended from time to time and also subject to technical feasibility and technical integrity of the networks and shall be within the overall framework of interconnection regulations, directions and orders issued by respective administrations. A media gateway switch will be installed for internetworking between circuit-switched and IP-based networks.

The interconnection tests for each and every interface may be carried out by mutual arrangement between the connecting parties. In case of a disagreement for rectification of deficiencies or deviations in conducted interconnection tests, reference could be made to the concerned administrative authority.

The regulatory framework for interconnection may periodically be reviewed, keeping in view the market and technological changes to ensure a level playing field for orderly growth on the basis of reciprocal, fair, reasonable and non-discriminatory terms and conditions.

The network resources, including the cost of upgrading or modifying interconnecting networks to meet service requirements, may be mutually negotiated. The general principle followed in these negotiations is that each party may bear the incremental costs incurred for the additional ports required for meeting the QoS standards relating to its outgoing traffic to the other party. The cost of upgrading and modifying interconnecting networks should be shared by both the interconnection seeker as well as the interconnection provider as both are benefiting from interconnection.

It is recommended to quantify and prescribe:

– timeframe for entering into an interconnection agreement;
– criteria to ensure that inflated demand for ports (at E1 or synchronous transport module level-1 (STM1) level) is not made by the interconnection seeker;
– minimum number of interconnection ports required for start of service;
– maximum time period permissible for issuance of payment demand note by the interconnection provider;
– maximum time period for payment for demanded ports by the interconnection seeker;
– time permitted for intimation of provisioning of requested ports by the interconnection provider;
– space allocation for collocation of transmission equipment;
– maximum time period for establishment of transmission links by the interconnection seeker;
– maximum time period for acceptance testing;
– maximum time period for issuance of the final commissioning letter by the interconnection provider; and
– maximum time period for start of traffic in the POI after provisioning/augmentation of ports for which payment has been made. In cases where the interconnection seeker agrees to bear the total cost of equipment required for augmentation in advance, the interconnection provider may give the requested ports irrespective of the volume of traffic at the POI.

The prescribed time periods for provisioning of ports may be different for:

– fixed-line networks; and
– mobile and IP networks.

Financial disincentive may be imposed on TSPs for:

– not entering into an interconnection agreement within the stipulated timeframe;
– not providing the initial POI;
– not augmenting the POI within the stipulated timeframe;
– violation of any prescription in the regulations.

The regulatory framework may also prescribe, if there is a need, bank guarantee to securitize payment of interconnection usage charges in the interconnection agreement and the basis for determining the amount of the bank guarantee. Once the interconnection has been in operation for a prescribed time period, the bank guarantees to securitize payments of applicable interconnection usage charges (IUC); if initially taken on a fixed amount basis, they may subsequently be made on a net-off basis and any such payment should be reciprocal. Though interconnection providers may intend to place reliance on their own billing records or CDRs, settlement of wrong/excess billing may be equitable, transparent and fair.

Any infrastructure taken for interconnection under one license may be allowed to be shared for all services authorised for provision under that license. The interconnection and interconnection agreement should be license specific and service-agnostic (i.e., a TSP can send any type of traffic on a POI which is allowed under the terms and conditions of the license) as all TSPs are equipped with CDR-based billing systems. However, for such integrated POIs, a suitable mechanism for discovery, prevention and penalization of any traffic manipulation by TSPs (whereby higher IUC traffic is recorded as lower IUC traffic in the CDR of the originating TSP) can be put in place. For TSPs having implemented an IP-based core transport network for carrying voice and data traffic, by deploying IP/ Ethernet elements extending into access and aggregation networks, there is apparently, a need to establish appropriate policy and regulatory framework/measures for encouraging TSPs to migrate to interconnection at the IP level, as well as to evolve terms and conditions for inter-connection at the IP level.

To solve many interconnection related problems by eliminating bilateral interconnection issues and to ensure effective interconnection, one option could be to establish an interconnect exchange. The interconnect exchange may provide interconnection ports to all variety of TSPs and, in turn, it may reduce the number of POIs. Under such a scenario, the existing peer-to-peer interconnection may continue as before; however, all new augmentation of ports may be mandated to be done through the interconnect exchange. Thus, there is a need to establish a framework for an interconnect exchange and to explore options to operate such an interconnect exchange.

Sometimes TSPs, unilaterally, disconnect POIs in certain circumstances, based on their interpretation of terms and conditions for non-payment of dues etc., thus resulting in the blockage of services to consumers. Subsequently the interconnection seekers have to resort to court proceedings, injunctions etc., to restore services. Thus, there is a need to define the circumstances under which a TSP can disconnect POIs and procedures which need to be followed before disconnection of a POI.

Since seeking and providing interconnection is an ongoing process, issues related to interconnection keep surfacing at various stages, even when formal interconnection agreements between TSPs are in place. Therefore, there may be a need to have a coordination committee with a defined constitution and operating framework to facilitate effective and expeditious interconnection.

Appendix I

Further guidance to regulators

(This appendix does not form an integral part of this Recommendation.)

Failure of calls during the setup phase or dropping of calls after they are established, deteriorate subscribers' QoE and result in customers' dissatisfaction. Therefore, there definitely is a strong need for having regulations concerning cause codes for call failures during the process of establishment of calls.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	**Overall network operation, telephone service, service operation and human factors**
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
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Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
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Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
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