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

Quality of service, network management and traffic engineering – Network management – International network management

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Network management principles and functions for B-ISDN traffic

ITU-T Recommendation E.416

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION E.416

NETWORK MANAGEMENT PRINCIPLES AND FUNCTIONS FOR B-ISDN TRAFFIC

Summary

Network Management (NM) for B-ISDN traffic requires real-time monitoring of current network status and network performance. This Recommendation is intended to support and define the role of network management in the B-ISDN and broadband services. It explains the network management principles and functions. The major part of this Recommendation suggests the way traffic must be monitored and provides some indication of parameters for promptly detecting abnormal network traffic conditions. After the detection of the abnormal condition, automatic and possibly manual controls will be temporarily applied to the network to alleviate the problem until the problem is resolved. It is also necessary to frequently check the effects of the NM controls to note whether the control is actually helping with the problem and to determine when to modify or remove it from the network.

Source

ITU-T Recommendation E.416 was prepared by ITU-T Study Group 2 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 13 March 2000.

FOREWORD

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The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 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.

NOTE

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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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Recommendation E.416

NETWORK MANAGEMENT PRINCIPLES AND FUNCTIONS FOR B-ISDN TRAFFIC

(Geneva, 2000)

1 Scope

This Recommendation is intended to support and define the role of network management (NM) in the B-ISDN and broadband services. It explains the network management principles and functions. The major part of this Recommendation suggests the way traffic must be monitored and provides some indication of parameters for promptly detecting abnormal network traffic conditions. After the detection of the abnormal condition, automatic and possibly manual controls must be temporarily applied to the network to alleviate the problem until the problem is resolved. It is also necessary to frequently check the effects of the NM controls to note whether the control is actually helping with the problem and to determine when to modify or remove it from the network.

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; all 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.

– ITU-T Recommendation E.410 (1998), *International network management – General information*.

– ITU-T Recommendation E.411 (1998), *International network management – Operational guidance*.

– ITU-T Recommendation E.412 (1998), *Network management controls*.

– CCITT Recommendation E.413 (1988), *International network management – Planning*.

– CCITT Recommendation E.414 (1988), *International network management – Organization*.

– CCITT Recommendation E.415 (1991), *International network management guidance for common channel signalling system No. 7*.

– ITU-T Recommendation E.735 (1997), *Framework for traffic and dimensioning in B-ISDN*.

– ITU-T Recommendation E.736 (1997), *Methods for cell level control in B-ISDN*.

– ITU-T Recommendation E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability*.

– ITU-T Recommendation I.113 (1997), *Vocabulary of terms for broadband aspects of ISDN*.

– ITU-T Recommendation I.150 (1999), *B-ISDN asynchronous transfer mode functional characteristics*.

– ITU-T Recommendation I.311 (1996), *B-ISDN general network aspects*.

– ITU-T Recommendation I.320 (1993), *ISDN protocol reference model*.

– CCITT Recommendation I.321 (1991), *B-ISDN protocol reference model and its application*.

– ITU-T Recommendation I.356 (1996), *B-ISDN ATM layer cell transfer performance*.

– ITU-T Recommendation I.357 (1996), *B-ISDN semi-permanent connection availability*.

– ITU-T Recommendation I.358 (1998), *Call processing performance for Switched Virtual Channel Connections (VCCs) in a B-ISDN*.

– ITU-T Recommendation I.361 (1999), *B-ISDN ATM layer specification*.

– ITU-T Recommendation I.363 (1993), *B-ISDN ATM adaptation layer (AAL) specification*.

– ITU-T Recommendation I.371 (2000), *Traffic control and congestion control in B-ISDN*.

– ITU-T Recommendation I.380 (1999), *Internet Protocol Data Communication Service – IP packet transfer and availability performance parameters*.

– ITU-T Recommendation I.413 (1993), *B-ISDN user-network interface*.

– ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

– ITU-T Recommendation M.3610 (1996), *Principles for applying the TMN concept to the management of B-ISDN*.

– ITU-T Recommendation Q.822 (1994), *Stage 1, Stage 2 and Stage 3 description for the Q3 interface – Performance management*.

– ITU-T Recommendation Q.823 (1996), *Stage 2 and Stage 3 functional specifications for traffic management*.

3 Definitions

This Recommendation defines the following terms:

3.1 Asynchronous Transfer Mode (ATM): ATM is defined in Recommendation I.113 as "a transfer mode in which the information is organized into cells; it is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic".

3.2 Virtual Channel (VC): VC is defined in Recommendation I.113 as "a concept used to describe unidirectional transport of ATM cells associated by a common identifier value".

3.3 Virtual Path (VP): VP is defined in Recommendation I.113 as "a concept used to describe unidirectional transport of ATM cells belonging to virtual channels that are associated by a common identifier value".

3.4 congestion: Congestion is defined in Recommendation I.113 as "a state of network elements in which the network is not able to meet the negotiated quality of service objective for the already established connections and for the new connection requests".

3.5 Usage Parameter Control (UPC) [Network Parameter Control (NPC)]: UPC (NPC) is defined in Recommendation I.113 as "the set of actions taken by the network to monitor and control traffic at the user network [inter-network node] interface, to protect network resources from malicious as well as unintentional misbehaviour by detecting violations of negotiated parameters and taking appropriate actions".

3.6 Quality of Service (QoS): QoS is defined in Recommendation E.800 as "collective effect of service performance, which determine the degree of satisfaction of a user of the service".

4 Abbreviations

This Recommendation uses the following abbreviations:

ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
CAC	Connection Admission Control
ECC	Egress Cell Count
ICC	Ingress Cell Count
NE	Network Element
N-ISDN	Narrow-band Integrated Services Digital Network
NM	Network Management
NPC	Network Parameter Control
QoS	Quality of Service
TMN	Telecommunications Management Network
UPC	Usage Parameter Control
VC	Virtual Channel
VCC	Virtual Channel Connection
VP	Virtual Path

5 Introduction

This Recommendation presents principles for extending the network management aspects given by Recommendations E.410, E.411 and E.412 to the Broadband Integrated Services Digital Network (B-ISDN) based on the Asynchronous Transfer Mode (ATM). Extension of these network management aspects to B-ISDN requires consideration of the diverse bandwidths associated with Virtual Channels/Paths, the various ATM transfer capabilities, the multiple Quality of Service (QoS) classes, service level agreements and automated routing control procedures that exist in B-ISDN. This Recommendation also describes functions for the network management of B-ISDN. These B-ISDN network management functions are intended to interwork with traffic and congestion controls and the measurements of traffic and performance that exist in B-ISDN exchanges for the purpose of maintaining adequate network performance under abnormal conditions.

To assure a high QoS, network management must be robust and fast enough to promptly detect any incident in the network and try to resolve it as quickly as possible. The role of manual controls must be minimized due to:

a) higher transmission and processing speeds;

b) complexity of B-ISDN due to various service categories;

c) volatility of congestion related incidents.

ATM supports various services with different requirements by allowing different virtual channels on one fast physical link to have different priorities and different bandwidth guarantees. This fact requires more NM functions such as admission control and resource management in the B-ISDN.

6 Network management principles

Network management concerns itself with the maintenance of adequate network performance under a variety of conditions, which can include exceptional traffic loads within some network portions, by the exercise of network management controls that generally provide the means to alter the flow of traffic in appropriate network portions. The overall process of network management involves the observation of relevant traffic and performance data, suitable analysis of that data, and the resulting implementation of appropriate network management controls. The effectiveness of an implemented set of network management controls is then evaluated based on new observations of traffic and performance data, which are then analysed and used as a basis to remove or further modify, if necessary, the current set of network management controls.

6.1 Network management goals

General network management goals have been described in Recommendation E.410. Such goals are still valid in the B-ISDN but may need some modifications and enhancements. In the following, some of the B-ISDN goals have been described:

- utilize all possible resources;
- keep all available resources filled with traffic which has a high probability of resulting in effective connections;
- in case of traffic overload, give priority to connections that make the most efficient use of network resources;
- inhibit traffic congestion and prevent its spread;
- when applying NM actions, connections with higher QoS needs should be given higher priority.

6.2 Network management concerns

Network management concerns are resolved by automatic or manual detection of the problem, and when necessary, followed by the network manager taking appropriate actions in resolving the problem. Detecting and correcting any problem in a B-ISDN network must be done in the shortest time possible by the network manager or preferably by a support system. The following are some of the major concerns of B-ISDN network management.

6.2.1 Transmission medium failure

Due to various reasons, a transmission medium can be interrupted (e.g. when a cable is cut or extremely damaged). Unless automatic detectors can quickly determine the existence of the failure and find an alternate path, the QoS could be degraded.

6.2.2 Network element/equipment failure

There may be occasions when an NE (e.g. multiplexer, switch module) can fail due to malfunctioning of some electronic circuits or some other failures possibly impacting adversely the QoS. In such cases, network managers require real-time status of network availability thus enabling the effected node to be quickly identified and if possible, the traffic rerouted in a very short period of time.

6.2.3 ATM exchange overload

An exchange can be overloaded, because:

- more cells are entering the ATM exchange than can be effectively processed (for example, queue overflows);

- more connections are being offered to the ATM exchange than can be supported by the ATM exchange switching fabric (for example, insufficient number of junctors);
- more signalling messages are being offered to the ATM exchange than can be processed. (for example, CPU degradation).

6.2.4 Network overload

There are occasions when the network becomes overloaded, for example:

- when the capacity of the network has been exceeded from the demand;
- peak days, natural disasters or focused overloads;
- some other causes of network overload which could be: software error, failure in an NE or in part of an NE, and/or signalling failure.

6.2.5 Interference among services

Since various services will share the ATM transmission facilities and the cells are statistically multiplexed, it is likely that an unexpected surge of traffic will use an inordinate amount of network resource, thereby degrading other services. This can happen despite the fact that the network will drop the lower priority cells. As a result, crucial services must be assured of receiving prompt attention.

7 Network management functions

Network management encompasses all of the activities necessary to identify conditions that may adversely affect network performance and service to the customer, and the application of network controls to minimize their impact. The following are some of the NM functions:

- **Status and performance monitoring on a real-time basis**

  This task is based on the utilization of periodically collected measurements, alarms, and notifications. Alarms (e.g. critical, major, minor) and notifications (e.g. Explicit Forward Congestion Notification) are generated upon occurrence of significant events either defined by the operator or by the network, based on, for example, Operation and Maintenance functions. Status and performance monitoring may be based on statistics elaborated in the NM centre from collected data. Relevant measurements and parameters at the cell level have already been defined for B-ISDN performance and traffic engineering and control (see Recommendations I.356 and I.371). Examples of such parameters are delay, loss and discards and cell rate. Operation and maintenance principles and functions are defined in Recommendation I.610.

- **Detecting abnormal conditions**

  This is performed through analysis of the previously presented parameters and events, or through high-level aggregated parameters, and with the help of statistical algorithms, and thresholding procedures.

- **Investigating and identifying abnormal network conditions**

  This task should provide a diagnosis on the situation that may lead to a corrective control (see below). The diagnosis is expressed in terms of service or traffic streams identifiers with their traffic characteristics.

- **Initiating corrective actions and/or controls**

  Once an abnormal situation has been detected and its causes identified, traffic control actions should be executed. Examples of traffic control actions can be found in Recommendation I.371. Additional actions may also include routing control at the connection level, for example to bypass a congested portion of the network.

- **Cooperating and coordinating actions with other NM centres**

  Different applications (e.g. telephony service) may have distinct NM centres. Cooperation between the centres may be of great interest to meet a global, regional and/or customer QoS.

- **Cooperating and coordinating with other work areas (e.g. maintenance)**

  As in N-ISDN, information coming from equipment surveillance and maintenance is important. As the purpose of ATM is to mix heterogeneous traffics coming from different customers, a strong cooperation must be established with the customer support centres.

- **Issuing reports of abnormal network situations**

  As in N-ISDN, these reports are important for managers training and network performance improvements.

- **Providing advance planning for known or predictable network situations**

  This planning should take into consideration the need of particular service and traffic categories.

Telecommunications Management Network (TMN) Recommendation M.3000 provides a framework to implement the functions described in this clause. Data collection aspects are treated in Recommendations Q.822 and Q.823.

8 Network status and performance data

Network status and performance data is needed to establish a rational basis for guiding the application of network management controls, and to provide a means for evaluating the effectiveness of previously applied network management controls.

8.1 Network status of ATM traffic

A significant difference between the B-ISDN packet switching and the traditional circuit switching is that when the call is established in the circuit switch, the path is reserved for the duration of the call. In ATM networks, cells from different calls may use the same path or parts of the same path simultaneously. As a result, monitoring the ATM traffic must be done at both call level and cell level.

A network manager may be directly involved in acting upon failures, errors or alarms to resolve the problem immediately. It is however assumed that most problems are detected and resolved automatically.

Monitoring the network is one of the primary tasks of network management that should be done in real time to observe and protect network performance. This monitoring function should provide the network managers with the current operational status of the network and its components, the traffic load and the resulting performance.

The following are some of the issues relating to monitoring of ATM traffic:

- verifying the contract agreement parameters in a per customer basis (connection and cell level traffic);
- the ability to take appropriate action by the network manager in cases of contract violation;

- monitoring the fluctuations of the call-level traffic;
- monitoring the fluctuations of the cell-level traffic in order to optimise resource utilization.

NM controls (see clause 9) must also be reviewed in conjunction with current network status data by network managers to observe whether the problem has gone away or lessened in severity. Based on such review, a network manager can determine whether to retain, modify or remove previously applied NM controls. Network managers must also review duration of controls. It is also necessary to investigate the amount of affected traffic to verify that traffic is properly controlled.

8.2 Measurements

To detect and isolate a problem, various data must be collected at each node. These measurements can assist network management in controlling the traffic and safeguarding network performance and service level agreements. For example, exchange status, information on destination-based performance, information on the performance on each Virtual Path/Virtual Channel (VP/VC), and effectiveness of NM actions can be relevant. Measurements can be defined at various parts of the network such as access, transport and backbone.

Measurements are also needed pertaining to the customer's negotiated parameters that are reflected in the contract agreement. Such measurements give a real-time view of the customer performance in order to analyse customer's qualification for renegotiation. The number of modifications that have been made to the contract is also registered for future renegotiations.

In this subclause, we have categorized the measurements into three different areas: the *end-to-end*, the *link-level* and the *exchange-level* areas. The measurements within each of the three areas can be further subcategorized into the following:

- traffic measurements (e.g. average cell count);
- performance measurements (e.g. number of dropped cells);
- fault measurements (e.g. rate of non-conforming cells);
- service-specific measurements [e.g. per customer events such as per cent of down Permanent Virtual Circuits (PVCs)].

The traffic and performance categories comprise measurements such as loss, delay and delay variation (jitter).

8.2.1 Some end-to-end measurement examples

End-to-end measurements provide data between the source and destination nodes. Some examples may include:

– *Attempted call count*: total number of call attempts made to the network.

– *Accepted call count*: the number of calls that are accepted to the network by the CAC.

– *Failed call count*: number of calls that are not accepted to the network due to limited resources or any other reason.

– *Usage (occupancy)*: appropriate measures of the volume of calls or the volume of cells on the network.

– *Average expected cell rate*: this parameter provides the load on the network by calculating the expected network's cell rate based on the Sustainable Bit Rates (SBR) of connections on the network.

NOTE – The time unit for the above must be defined.

8.2.2 Some link-level measurement examples

Link-level measurements provide information about the inter-nodal activities. By having such parameters available to the network management, a possible problem can be isolated to the node or the link with abnormal parameters. Some examples of the link-level measurements may include the following:

– *Attempted call count*: total number of calls accessing the exchange.

– *Accepted call count*: the number of calls that are successfully sent out of the exchange.

– *Failed call count*: number of calls that are not established due to failures, overloads, queue overflow or other reasons.

– *Usage (occupancy)*: measures of the volume of calls or the volume of cells on a particular exchange.

– *Average cell count*: this parameter provides the average number of cells entering the exchange in a unit time.

NOTE – The time unit for the above must be defined.

8.2.3 Some exchange-level measurement examples

Exchange-level measurements provide the intra-nodal activities. Such measurements provide information that will be helpful in isolating possible problems inside the switch. Some examples of the exchange-level measurements may include the following:

– *Ingress cell count (ICC)*: total number of cells arriving at the exchange.

– *Egress cell count (ECC)*: total number of cells departing from the exchange.

– *Percent cell loss:* $[1 - (ECC/ICC)] \times 100$.

– *Average exchange delay*: the average difference between the time that a cell enters an exchange and the time that it leaves the same exchange.

NOTE – The time unit for the above must be defined.

9 Network management controls

To resolve network traffic management problems in the network, a network manager should be able to apply appropriate NM controls, or such NM controls should be applied automatically. If controls are applied automatically, then for some critical controls, the network manager must have the capability to remove or modify them manually. This is feasible only if proper tools are built in the network or are available to the network management team. Such tools can be utilized to, for example, set parameters, add or remove a faulty node from the network, reroute the traffic or modify various tables. Recommendation E.412 covers NM controls for N-ISDN. A comparable set of NM controls for B-ISDN need to be developed. Some considerations and issues pertaining to the development of NM controls for B-ISDN are now described. We introduce three categories for controls and leave this issue open for further study. The three categories introduced here are information-transfer-based, routing-based and address-based controls.

The need for NM controls operating at the information transfer level does not exist in N-ISDN, but have been found to be necessary for B-ISDN. The great speed with which such controls need to be applied, modified and removed generally precludes direct human interaction. A fully automated set of such controls has been specified by Recommendation I.371.

An important class of NM controls for N-ISDN includes the alterations to normal call routing procedures, and such controls are based upon a thorough knowledge of the underlying approaches for N-ISDN call routing under normal conditions. However, the underlying approaches for B-ISDN call routing have not yet been fully established through appropriate ITU-T Recommendations.

The development of appropriate NM controls for B-ISDN will need to address both controls operating at the information-transfer-based level and controls affecting the routing procedures used in call establishment. The development of appropriate NM controls for B-ISDN will likely extend those controls from N-ISDN that are based upon the destination address (e.g. code blocking and call gapping). Such controls are categorized here as address-based controls.

In the following, some examples of possible NM controls for B-ISDN are discussed.

9.1 Information-transfer-based controls

A set of controls at the information-transfer level has been defined for automated application by Recommendation I.371. At a functional level, these controls are broadly grouped into traffic control functions and congestion control functions. The traffic control functions include the following:

- Connection Admission Control (CAC);
- Usage Parameter Control (UPC);
- Network Parameter Control (NPC);
- Priority Control;
- Traffic Shaping;
- Fast Resource Management.

The congestion control functions include the following:

- Selective Cell Discarding;
- Explicit Forward Congestion Indication;
- Reaction to UPC/NPC Failures.

With additional research and B-ISDN operating experience, it is possible that a basis can be established for modifying these information-transfer-based controls to better support network management of the B-ISDN.

9.2 Routing-based controls

NM controls that alter the normal B-ISDN call routing procedures in response to congestion or to non-typical traffic loads can be valuable tools for network management. Such controls would be developed after normal B-ISDN call routing procedures are appropriately established. Since such controls have the potential for automatic application, they would be developed in a manner compatible with future updates to Recommendation I.371.

To the extent that normal B-ISDN routing procedures may incorporate dynamic route selection, expansive NM routing controls would be inherently provided. Even when expansive NM routing controls are available, it is useful to also provide a set of restrictive NM controls.

9.3 Address-based controls

B-ISDN will require restrictive NM controls that are based upon destination address. Examples from N-ISDN of such address-based NM controls include code blocking controls, which are generally percentage-oriented, and call gapping controls, which are generally rate-oriented. Call gapping control may incorporate the leaky bucket algorithm.

Address-based controls limit the number of calls accepted by a switch for forwarding to a specified destination address, or a specified set of destination addresses. It will be necessary to consider B-ISDN address-based NM controls in the context of enhanced numbering plans being formulated for B-ISDN.

9.4 Other NM controls

B-ISDN being relatively new, it is likely that additional NM control techniques such as modification of VPs and VCs may be proposed in the future. Other NM controls are for further study.

10 History

This is the first issue of Recommendation E.416.

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