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

Quality of service, network management and traffic engineering – Traffic engineering – Definitions

Reference connections for traffic engineering of IP access networks

ITU-T Recommendation E.651

(Formerly CCITT Recommendation)

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ITU-T RECOMMENDATION E.651

REFERENCE CONNECTIONS FOR TRAFFIC ENGINEERING OF IP ACCESS NETWORKS

Summary

This Recommendation provides reference connections and network configurations for IP access networks for the provision of IP telephony and TCP/IP-supported data services such as web-browsing, e-mail, file transfer and high-speed data access. Other services such as video telephony, video-on-demand, are for further study. Also, only point-to-point reference connections are considered in this release of the Recommendation.

Source

ITU-T Recommendation E.651 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

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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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The ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. The ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

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.651

REFERENCE CONNECTIONS FOR TRAFFIC ENGINEERING OF IP ACCESS NETWORKS

(Geneva, 2000)

1 Scope

This Recommendation provides reference connections and network configurations for IP access networks for the provision of IP telephony and TCP/IP-supported data services such as web-browsing, e-mail, file transfer and high-speed data access. Other services such as videotelephony, video-on-demand, are for further study. Also, only point-to-point reference connections are considered in this release of the Recommendation.

Built upon the reference connections specified herein, other Recommendations in this family contain the definitions of appropriate Grade of Service (GOS) parameters applicable to different types of IP access networks, taking into account the capabilities and limitations of different access technologies used. The intent is to facilitate the traffic-engineering tasks of developing traffic models, measurements, control and dimensioning methods for meeting Quality of Service objectives.

For the purpose of this Recommendation, an *IP access network* is an infrastructure of network components with well-defined interfaces, protocols, and network management procedures architected with a specific access technology to provide access to IP-based applications such as IP telephony and TCP/IP-supported data services. Examples of access technologies include cable-modem-based hybrid fibre/coax (HFC) systems, a variety of digital subscriber line systems, wireless systems (both mobile and fixed), and high-speed analog modems. Two-way capability must be available in an IP access network to support interactive bidirectional communication.

The first release of this Recommendation deals only with IP access networks based on HFC systems. Subsequent releases will include other access technologies.

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.726 (2000), *Network grade of service parameters and target values for B-ISDN*.

– ITU-T Recommendation E.671 (2000), *Post-selection delay in PSTN/ISDNs using Internet telephony for a portion of the connection*.

– ITU-T draft Recommendation E.hfc, *Traffic engineering considerations for IP access networks based on hybrid fibre-coaxial system*.

– ITU-T Recommendation J.112 (1998), *Transmission systems for interactive cable television services*.

– ITU-T draft Recommendation Y.1231, *IP access network architecture*.

The following references are listed here for information.

– DOCSIS1, Data-Over-Cable Service Interface Specifications, Radio Frequency Interface Specification, *Cable Television Laboratories, Inc*.

– DOCSIS2, Data-Over-Cable Service Interface Specifications, Cable Modem to Customer Premises Equipment Interface Specification, SP-RFIv1.1-I02-990731, *Cable Television Laboratories, Inc*.

3 Definitions

The following definitions given in Recommendation J.112 are repeated herein for ease of reference.

3.1 Cable Modem (CM): A modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system.

3.2 Cable Modem Termination System (CMTS): Located at the cable television system headend or distribution hub, provides complementary functionality to the cable modems to enable data connectivity to a wide-area network.

3.3 fibre node: A point of interface between a fibre trunk and the coaxial distribution.

3.4 Hybrid Fibre/Coax (HFC) system: A broadband bidirectional shared-media transmission system using fibre trunks between the headend and the fibre nodes, and coaxial distribution from the fibre nodes to the customer locations.

The following definitions given in draft Recommendation Y.1231 are repeated herein for ease of reference.

3.5 IP access network: An implementation comprising network entities to provide the required access capabilities between an "IP user" and an "IP service provider" for the provision of IP services. "IP user" and "IP service provider" are logical entities which terminate the IP layer and/or IP related functions.

3.6 IP core network: IP service provider's network, including one or more IP service providers.

NOTE – *IP access network* as described in clause 1 and used herewith for traffic engineering purposes includes a local IP network and may include an IP service provider. See Note 1 in Figure 6-1. See also Figure 7-1 for an illustrative reference architecture.

4 Abbreviations

This Recommendation uses the following abbreviations:

CM	Cable Modem
CMTS	Cable Modem Termination System
CPE	Customer-Premises Equipment
CPN	Customer-Premises Network
GOS	Grade of Service
HFC	Hybrid Fibre/Coax system
IP	Internet Protocol
ISDN	Integrated Services Digital Network
MTA	Multimedia Terminal Adapter
PSTN	Public Switched Telephone Network

QOS Quality of Service

TCP Transmission Control Protocol

UNI User-Network Interface

VOIP Voice Over IP

5 Introduction

IP-based networks are being used to develop integrated broadband networks for the delivery of diverse types of IP-based voice and data services. To gain access to such services efficiently on a mass scale, IP access networks are provisioned according to customer demands. To meet Quality of Service (QOS) objectives to customers of IP access networks, network operators use Grade of Service (GOS) parameters and their associated target values as internal design objectives. This Recommendation provides reference connections and access network configurations so that network GOS parameters can be defined and their associated target values specified. The appropriate GOS parameters applicable to different IP access network types based on different access technologies are specified in other Recommendations of this family. These Recommendations may also contain relevant traffic principles such as user demand models, traffic models, measurements, control and dimensioning methods for the planning, operation, and management of the particular IP access networks.

In addition to this Recommendation, the family of IP access network traffic-engineering Recommendations currently consists of Recommendation E.671 and draft Recommendation E.hfc. Recommendations for IP access networks based on other access technologies are to be added in the future.

6 Reference connections

This clause specifies generic reference connections that are independent of access technology. Interworking with PSTN/ISDN is also considered.

Three categories of reference connections are specified:

- national, local area;
- national, long distance;
- international.

The term "national local area" refers to a connection whose UNI-to-UNI straight-line geographic distance is relatively short. This distance is usually of the order of 150 kilometres or less (see Notes 1 and 2 below); typically this would be within a greater metropolitan area.

The term "national long distance" refers to a connection whose UNI-to-UNI straight-line geographic distance is more than the value for "national local area", and is within a single country. Typically, though not necessarily, a "national local area" connection is supported by a single public network provider, while a "national long distance" connection is supported typically by one to three public network providers.

NOTE 1 – Annex B/J.112 specifies "a maximum optical/electrical spacing between the cable modem termination system and the most distant cable modem of 100 miles, although typical maximum separation may be 10-15 miles".

NOTE 2 – Recommendation E.726 specifies a "national local area" connection to be one whose UNI-to-UNI straight-line geographic distance does not exceed 100 kilometres.

NOTE 3 – The category of "national, long distance" connections may include a sub-category of connections referred to as "national, intermediate distance" connections. The UNI-to-UNI straight-line geographic distance of these connections does not exceed 1000 kilometres, but exceeds that for "national, local area" connections.

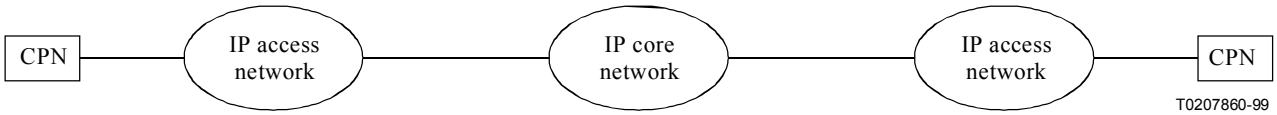
6.1 All-IP connections

Figure 6-1 shows the above types of reference connections in the case of an all-IP connection on an end-to-end basis. The *IP core network* "cloud" in the diagram is intended to denote a combination of national intermediate-distance, national long-distance and/or international IP service provider networks, and may thus consist of several IP-based networks in tandem. IP core network provides interconnection between domains.

In these reference connections, a customer-premises network (CPN) may consist of a combination of the following: one or more telephones, customer-premises equipment such as personal computers (PCs), Macintoshes, workstations, network computers, and other electronic equipment (see DOCSIS2).

The distinction between the above types of connections is important from a traffic engineering perspective. Depending on the structure of the IP access network as well as that of the IP core network, the target values for delay grade of service parameters such as packet transfer delay and packet delay variation will be different. The specification of these values is the subject matter of other Recommendations in this family, such as draft Recommendation E.hfc.

a) National, local area connection



b) National intermediate-distance, national long-distance, or international connection

NOTE 1 – As described in the Note in 3.6, an IP service provider is included in the IP access network of a) above, but may be included in the IP access network or in the IP core network of b) above.

NOTE 2 – Since the two types of reference connections in a) and b) above generally have different performance characteristics in terms of delay or blocking, their distinction is important from a traffic engineering perspective.

Figure 6-1/E.651 – End-to-end all-IP connections

6.2 Interworking with PSTN/ISDN

In the transition period (which may take a long time), three scenarios are possible, all involving the interworking between PSTN/ISDN and IP-based networks.

6.2.1 IP-to-PSTN/ISDN or PSTN/ISDN-to-IP

A connection with an IP access network at one end and PSTN/ISDN at the other, the IP core network may or may not be present.

NOTE – The diagrams below apply symmetrically for traffic in both directions, i.e. either from IP access to PSTN/ISDN, or from PSTN/ISDN to IP access.

In the first case, i.e. when the IP core network is not present, the PSTN/ISDN portion of the end-to-end connection may be either local or long distance. In the second case with IP core network, the PSTN/ISDN portion of the connection is typically local.

In Figure 6-2, the PSTN/ISDN gateway provides the interworking function required between an IP access network and a PSTN/ISDN.

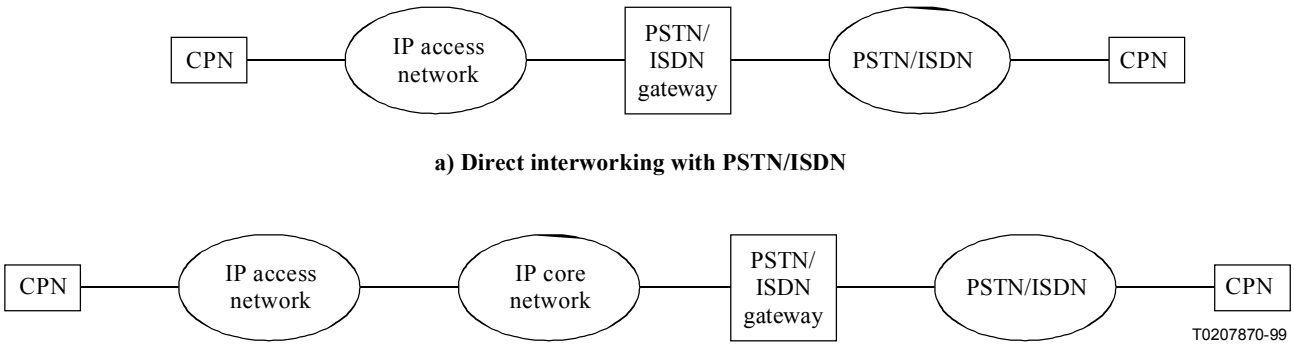


Figure 6-2/E.651 – IP and PSTN/ISDN interworking

6.2.2 IP-to-IP via PSTN/ISDN

This scenario, as shown in Figure 6-3, may be used in the interim to provide call features that are only available in the PSTN/ISDN. However, this interworking arrangement may be suboptimal as it requires two operations of packetization/depacketization.

Figure 6-3/E.651 – IP-to-IP connection via PSTN/ISDN

NOTE – Although not shown in Figure 6-3, it may be possible for an IP access network to be connected to IP core network and then through a PSTN/ISDN gateway to a PSTN/ISDN.

6.2.3 PSTN/ISDN-to-PSTN/ISDN via IP

IP-based networks may be used to substitute for a portion of an end-to-end circuit-switched PSTN/ISDN connection. This is the case considered in Recommendation E.671.

In Figure 6-4, the Voice Over IP (VOIP) gateway denotes the interworking function required between an IP core network and a PSTN/ISDN. In this arrangement, a PSTN/ISDN together with its VOIP gateway provides the access function to an IP-based network. Thus, strictly speaking, this is not a reference connection for IP access network as defined in clause 3. However, it is included here as some of the traffic engineering considerations related to IP networking, such as packet delays, are similar.

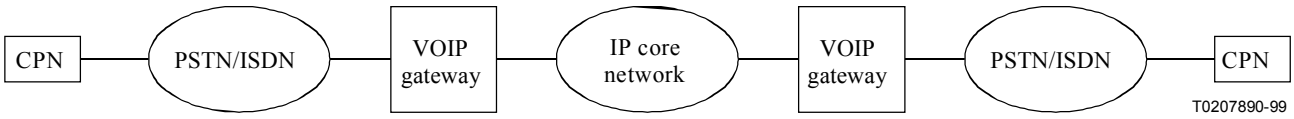


Figure 6-4/E.651 – PSTN/ISDN-to-PSTN/ISDN connection via IP

NOTE – There may or may not be a difference in the functionality between a PSTN/ISDN gateway and a VOIP gateway in Figure 6-4. This issue is for further study.

7 Reference architectures

As different access technologies have different capabilities and limitations, IP access networks based on different technologies may have different requirements. In this section, generic reference architectures are used to illustrate the different network components that may need to be considered from a traffic-engineering perspective.

7.1 HFC systems

Figure 7-1 shows the reference architecture of an HFC-based IP access network for traffic engineering purposes.

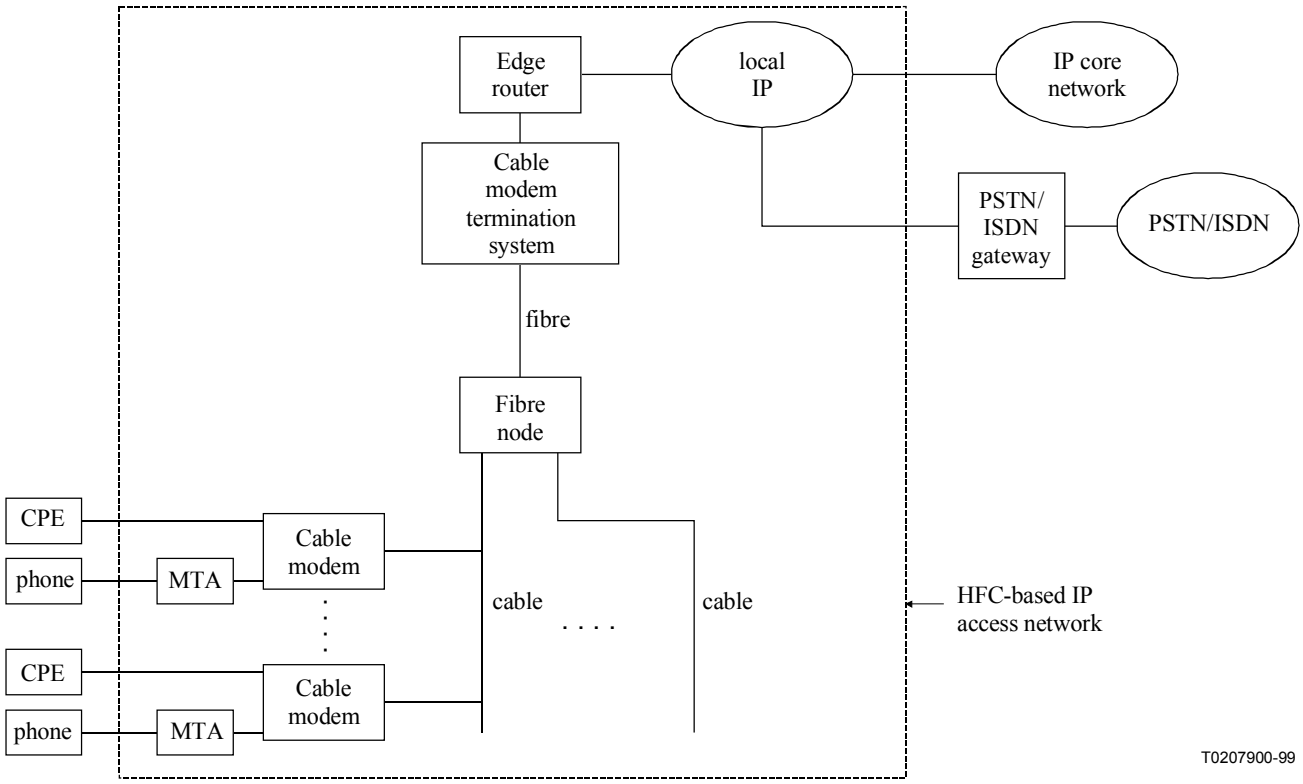


Figure 7-1/E.651 – Reference architecture of an HFC-based IP access network

NOTE 1 – The functionalities of cable modem termination system (CMTS) and edge router may be combined and implemented as a single integrated physical entity.

NOTE 2 – A customer-premises equipment such as a personal computer can interface directly with a cable modem (CM). A telephone is usually interfaced through a multimedia terminal adapter (MTA) to a CM. The MTA function may or may not be integrated with the CM.

NOTE 3 – The "local IP" cloud contains all the network elements/servers (not shown in Figure 7-1) required for connection management and call processing.

NOTE 4 – Equipment associated with broadcast television that shares bandwidth on the HFC network is not shown in Figure 7-1.

NOTE 5 – As specified in Annex B/J.112, a coaxial-based access network may take the form of either an all-coax or hybrid fibre/coax network. The generic term "cable network" is used therein to cover all cases. For an all-coax network, there is neither fibre link nor fibre node in Figure 7-1.

7.2 Other access technologies

IP access networks may be built using digital subscriber line systems, wireless systems (both mobile and fixed), high-speed analog modems, and possibly others. Reference architectures for these types of networks are for further study.

8 History

This is the first issue of Recommendation E.651.

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