INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.1001

(11/2000)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE AND INTERNET PROTOCOL ASPECTS

Internet protocol aspects – General

IP framework – A framework for convergence of telecommunications network and IP network technologies

ITU-T Recommendation Y.1001

(Formerly CCITT Recommendation)

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ITU-T Recommendation Y.1001

IP framework – A framework for convergence of telecommunications network and IP network technologies

Summary

In order to support the development of IP-related standards, this Recommendation identifies a framework to position the telecommunications aspects with respect to IP networks. This framework serves to identify and assist understanding the IP network issues, from the telecommunications point of view, with respect to the provision of seamless services to the user between IP networks and telecommunications networks in a convergence context.

This Recommendation outlines a number of general architectures involving a mix of Telecommunication Network and Internet Protocol (IP) Network technologies. In this Recommendation, IP, the Internet Protocol, is considered in its role as a protocol purely associated with transporting connectionless packets.

Source

ITU-T Recommendation Y.1001 was prepared by ITU-T Study Group 13 (2001-2004) and approved under the WTSA Resolution 1 procedure on 24 November 2000.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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.

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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ITU-T Recommendation Y.1001

IP framework – A framework for convergence of telecommunications network and IP network technologies

1 Introduction

In order to support the development of IP-related standards, this Recommendation identifies a framework to position the telecommunications aspects with respect to IP networks. This framework serves to identify and assist understanding the IP network issues, from the telecommunications point of view, with respect to the provision of seamless services to the user between IP networks and telecommunications networks in a convergence context.

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2 Scope and terms of reference

2.1 Scope

The scope of this Recommendation includes:

a) the basic horizontal and vertical architectural principles that will be encountered in combining IP and telecommunications technologies in a variety of ways;

b) a generic protocol reference model and its application to an mixed IP/Telecommunication environment;

c) architectures for the use of the IP over telecommunications transport technologies;

d) other architectures involving the convergence, co-existence, or interworking between IP technologies and other telecommunications technologies.

NOTE – This framework will cover both the integrated and non-integrated cases. Initially, it may be envisaged that the IP and non-IP technologies will co-exist separately, and/or only loosely coupled. Ultimately, it is envisaged that IP and non-IP (telecommunication) technologies will be converged into a single, optimally integrated IP telecommunication architecture.

The scope embraces three possible types of scenarios involving networks and services based on ITU-T Recommendations, IETF RFCs/STDs, or other IP standards[1]:

e) ITU-T and ITU-R defined transport capabilities used to carry IP;

f) the use of IP to transport higher layer information whose semantics are defined in ITU-T Recommendations;

[1] Produced by a recognized standards development organization.

g) services[2] arising from standards defined by the Internet Engineering Task Force (IETF), or other recognized bodies, that are to be interworked with those defined in ITU-T Recommendations for the purposes of achieving seamless end-to-end user service.

Cases f) and g) are particular examples of scope item d) above.

2.2 Terms of reference

The types of architecture described in this Recommendation are functional in nature, covering the following aspects:

a) general architectural concepts;

b) service/protocol layering;

c) service interworking; and

d) integration.

3 References (Informative)

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; 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 published regularly.

3.1 ITU-T

– ITU-T H.225.0 (2000), *Call signalling protocols and media stream packetization for packet-based multimedia communication systems*.

– ITU-T H.245 (2000), *Control protocol for multimedia communications*.

– ITU-T H.248 (2000), *Gateway control protocol*.

– ITU-T H.323 (2000), *Packet-based multimedia communications systems*.

– ITU-T I.555 (1997), *Frame relaying Bearer service interworking*.

3.2 IETF

RFC 791 *Internet Protocol*.

RFC 1661 *The Point-to-Point Protocol (PPP)*.

RFC 1662 *PPP in HDLC-like Framing*.

RFC 2225 *Classical IP and ARP over ATM*.

RFC 2327 *SDP: Session Description Protocol*.

RFC 2364 *PPP over AAL5*.

RFC 2427 *Multiprotocol Interconnect over Frame Relay*.

[2] In this Recommendation the word "service" is used in two different ways according to the context. It is sometimes used in the architectural sense, as the abstract representation of features offered by a horizontal interface, or by a vertical (layer) interface. Alternatively, the word service is sometimes used in a more general sense, say to represent a particular telecommunications service, such the "telephone service" defined by E-series Recommendations.

RFC 2543 *SIP: Session Initiation Protocol.*

RFC 2615 *PPP over SONET/SDH.*

RFC 2684 *Multiprotocol Encapsulation over ATM Adaptation Layer 5.*

RFC 2458 *Toward the PSTN/Internet Inter-networking.*

4 Definitions

This Recommendation defines the following terms:

4.1 IP Service, IP Network Service: A data transmission service in which the data that is transferred across the interface between the user and provider is in the form of IP (Internet Protocol) packets (sometimes called datagrams). The IP (Network) Service includes the service provided by using the IP Transfer Capabilities.

4.2 IP Network[3] (or IP Layer Network): A network in which IP is used as a layer protocol.

4.3 IP Transfer Capability: The set of network capabilities provided by the Internet Protocol (IP) layer. It may be characterized by the traffic contract as well as performance attributes supported by control and management functions of the underlying protocol layers. Examples of IP Transfer Capability include basic best effort IP packet delivery and the capability provided by Intserv, and Diffserv framework defined by the IETF.

4.4 IP Based Service: The functions, facilities and capabilities implemented and executed over the IP Network Service. The IP based service utilizes the IP Transfer Capabilities offered by a network provider.

4.5 Circuit Switched Network (CSN): A network in which a fixed bandwidth channel is established for, and dedicated to the duration of a communication session. The PSTN is an example of a CSN, where a circuit is established for the duration of a telephone call.

5 Abbreviations

AAL	ATM Adaptation Layer
AP	Application Protocol
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband ISDN
CN	Customer Network
CRF	Connection Related Function
CSN	Circuit Switched Network
IETF	Internet Engineering Task Force
IN	Intelligent Network
INAP	Intelligent Network Application Protocol
IP	Internet Protocol

[3] The term "IP Network" is distinct from, and should not be confused with, the term "Internet". Many IP networks exist, each operated by different owners. Generally, individual IP networks may differ in scope and extent. They may be globally public (i.e. the Internet), totally private (i.e. with no open structure and without gateways to the Internet other private IP networks) or combinations of public and private networks (e.g. a privately run IP network with gateways and access to the Internet, but not necessarily vice versa).

ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IWU	Interworking Unit
LFC	Local functional Capability
LLC	Lower Layer Capability
N-ISDN	Narrowband ISDN
PDH	Plesiochronous Digital Hierarchy
PhDH	Photonic Digital Hierarchy
POP	Point of Presence
PPP	Point-to-Point Protocol
PSTN	Public Switched Telephone Network
QoS	Quality of Service
SCP	Service Control Point
SDH	Synchronous Digital Hierarchy
SMS	Service Management System
SS7	Signalling System No. 7
SSP	Service Switching Point
TE	Terminal Equipment
TN	Telecommunications Network
UNI	User Network Interface
WDM	Wave Division Multiplexing

6 General framework for an IP network

This clause outlines some very general high level aspects.

6.1 General model

Architecture for IP networks may consist of three parts, Application (or Service) Model, System Model and Technology Model. Relationships among the three parts for IP Networks' Architecture are as shown in Figure 1.

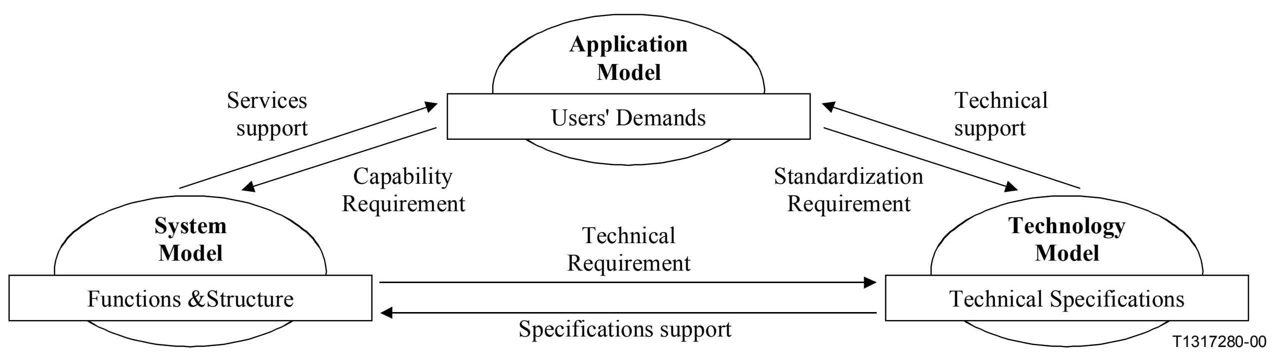
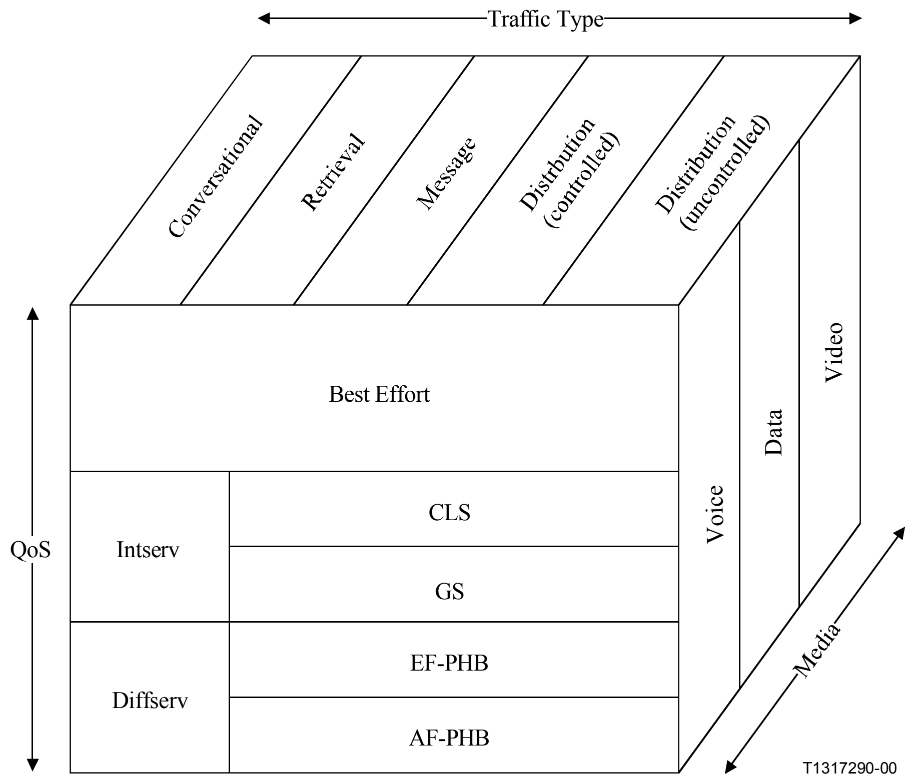


Figure 1/Y.1001 – Model relationships

6.2 Application (or Service) Model for IP Networks' Architecture

Application architecture for IP networks should reflect the relationship between customers and IP networks which provide services for the customers. It defines the applications role that an IP network should support, and describes the attributes of application services an IP network can provide for its users, such as media representation for various application services, Quality of Service (QoS) and requirements of traffic types. An application architecture model for IP Networks is shown in Figure 2.



AF Assured Forwarding
CLS Controlled Load Service
EF Expedited Forwarding
GS Guaranteed Service
PHB Per Hop Behaviour

Figure 2/Y.1001 – Application/service model

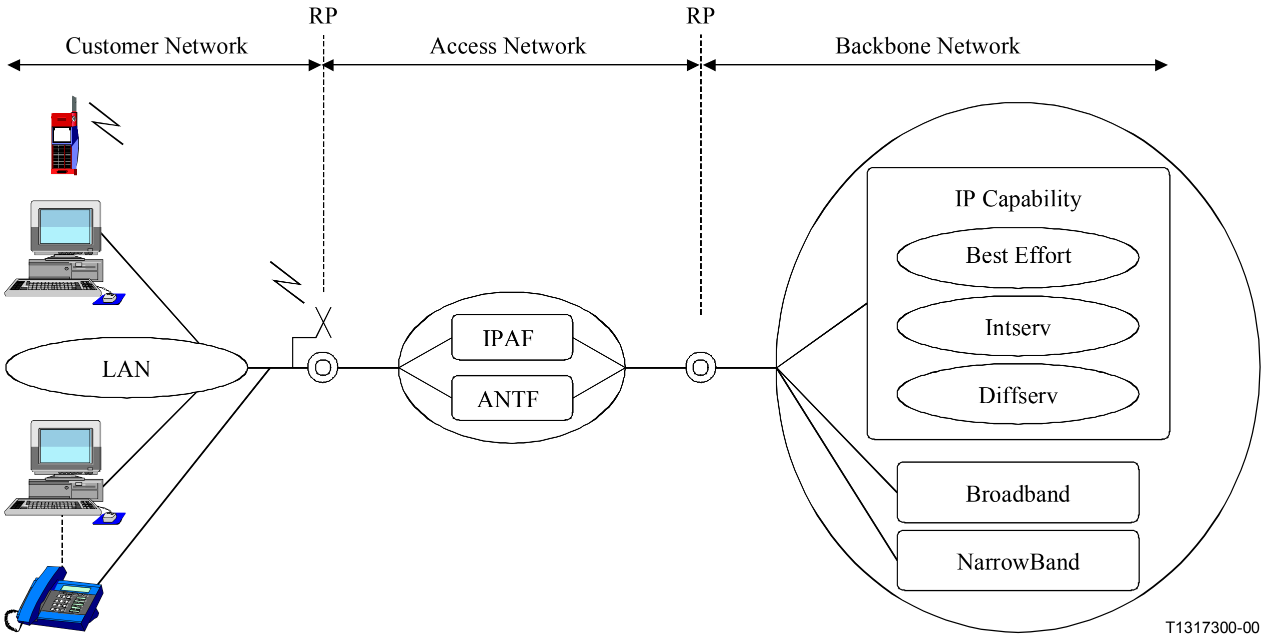
6.3 System (or functions) model for IP networks' architecture

System model for IP networks' architecture should reflect the capabilities and construction of an IP network. In this case, system function components, interconnecting entities and relationships among them for supporting various application requirements by the IP network are described, such as nodes, links, terminals and their physical connection, location and label. Performance parameters for the system and its components should also be defined in this model.

System model for IP networks' architecture can be described from, and functions divided into two planes (or directions): entities plane (horizontal direction) and logical plane (vertical direction).

6.3.1 Functions division on entities plane for system model

Functions on entities plane for System model of IP networks' architecture can be divided into three sections: core network, access network and customers' network. Each of them can be further divided in detail, for example, functions of a core network can be divided into two layers: IP layer function and telecommunication layer function. A reference configuration model for an IP Network is shown in Figure 3.



ANTF Access Network Transport Functions
IPAF Internet Access Functions
RP Reference Point

Figure 3/Y.1001 – IP network – reference framework

Examples of narrowband capabilities are 3.1 kHz audio channels, circuit and packet mode bearer services. Examples of broadband capabilities include Asynchronous Transfer Mode (ATM), channels from the Synchronous Digital Hierarchy (SDH) or Photonic Digital Hierarchy (PhDH), etc.

NOTE – The figure does not attribute any particular distribution of functions between Customer Network and Access Network, nor between Access Network and Backbone Network. Further information regarding more detailed functionality distribution can be found in ITU-T Y.1231 – IP Access Network Architecture. The architecture details for the (Telecommunications) Access Network Transport Function can be found in ITU-T G.902 – Framework Recommendation on functional Access.

6.3.2 Functions division on logical plane for system model

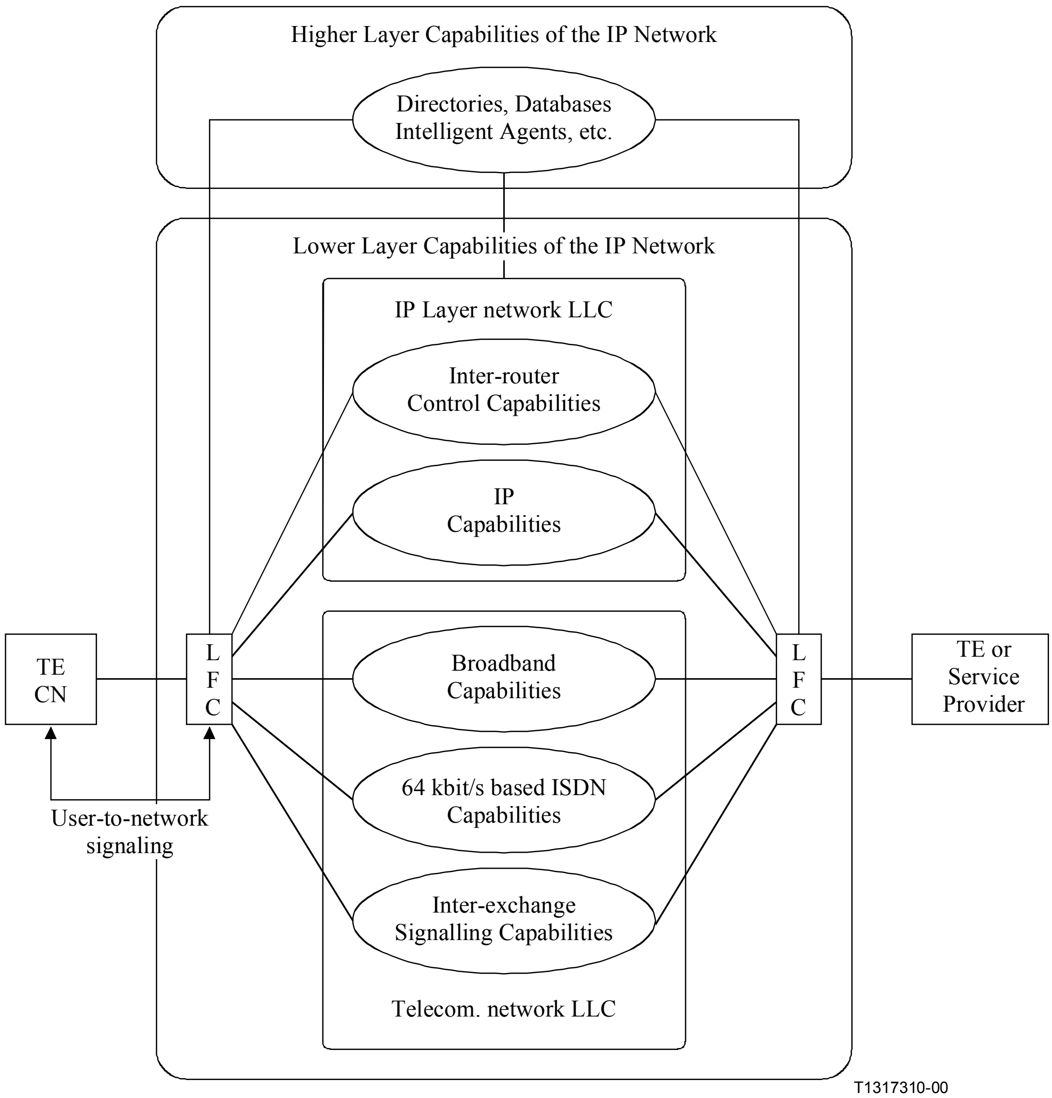
Functions on logical plane for System model of IP networks' architecture can be divided into lower layer capabilities, IP layer capabilities and high layer capabilities, as shown in Figure 4.

Information transfer between endpoints is provided by using IP packets. In the Internet, there is no fundamental difference in protocols at the IP layer used at the user-network interface, within the network and between other networks other than usage.

The user-network or network-network interfaces of the IP network may not be located in the same points as the user-network or network-network interfaces of the underlying telecommunications network.

Currently, protocols typically used at the interface between the customer and the IP service provider (e.g. dial PPP) or between IP service providers (e.g. BGP) may also be used in other parts of the network.

Regarding the high layer capabilities, normally these are involved in the terminal equipment in the telecommunication environment. In the IP based environment, several types of high layer capabilities are involved in relation to the operation of the IP network itself, e.g. name server (e.g. DNS), authentication server (e.g. AAA) and address resolution server (e.g. DNS or DHCP), etc. One or more of these services may be provided by the customer or by providers other than the access provider.



CN Customer Network
LFC Local Functional Capabilities
LLC Lower Layer capabilities

Figure 4/Y.1001 – Basic configuration model of IP network

6.3.3 End-to-end considerations

Table 1a shows some typically traditional telecommunications (non-IP) services supported by typically traditional telecommunications (non-IP) access and backbone technologies. Each row in the table represents the provision of an end-to-end service. This table is not intended to be exhaustive, but to simply illustrate that, for any given service, the range of both access and backbone technologies is quite limited and is relatively homogeneous. At the interface between backbone domains, there is rarely a substantive change of technology or characteristics.

Table 1a/Y.1001 – Characteristics of non-IP services and non-IP technologies

End User Service	Access Technology	Backbone Technology Domain 1	Backbone Technology Domain 2	Access Technology	End User Service
Voice Band and/or 3.1 kHz Audio	Analogue Loop ISDN BRI/PRI T1/E1 CAS Cellular Mobile VSAT Cable TV	DS3/SDH/ SONET/ATM	DS3/SDH/ SONET/ATM	Analogue Loop ISDN BRI/PRI T1/E1 CAS Cellular Mobile VSAT Cable TV	Voice Band and/or 3.1 kHz Audio
64 kbit/s Digital	N-ISDN	DS3/SDH/ SONET/ATM	DS3/SDH/ SONET/ATM	N-ISDN	64 kbit/s Digital
N × 64 kbit/s Digital	ISDN-PRI	B-ISDN/SDH/ SONET/ATM	B-ISDN/SDH/ SONET/ATM	ISDN-PRI	N × 64 kbit/s Digital
Leased line	T1/E1	DS3/SDH/ SONET/ATM	DS3/SDH/ SONET/ATM	T1/E1	Leased line
X.25	Various	X.25	X.25	Various	X.25
Frame Relay	Various	DS3/SDH/ SONET/ATM	DS3/SDH/ SONET/ATM	Various	Frame Relay

With the introduction of IP services and the use of IP transport capabilities (which may provide capabilities which are "pure" IP, or which are enhanced by the IP transport capability making use of the underlying layer capabilities) as backbone technology this end-to-end alignment is radically reduced.

Table 1b illustrates the support for Telecom Services by IP Networks, and Table 1c shows the support of IP services by telecom networks. In practice, elements of Table 1 and elements of Table 2 may apply, in different parts of an end-to-end path for a given communication. Consequently, the need for the development of interworking functions (IWFs) between various combinations of technology is greatly increased. IWFs may need to be applied at the network or user service level, or both, depending on the case under consideration.

Table 1b/Y.1001 – Traditional telecom services supported by IP networks

End User Service	Access Technology	Backbone Technology Domain 1	Backbone Technology Domain 2	Access Technology	End User Service
3.1 kHz Audio	Analogue Loop ISDN BRI/PRI T1/E1 CAS Cellular Mobile VSAT Cable TV IP (Note)	IP (Note)	IP (Note)	Analogue Loop ISDN BRI/PRI T1/E1 CAS Cellular Mobile VSAT Cable TV IP (Note)	3.1 kHz Audio
X.25	Various	X.25 IP (Note)	X.25 IP (Note)	Various	X.25
NOTE – It is understood that IP will run over a telecommunications network as shown in Table 1c.					

Table 1c/Y.1001 – Telecom architectures supporting IP networks/services

End User Service	Access Technology	Backbone Technology Domain 1 (Note)	Backbone Technology Domain 2 (Note)	Access Technology	End User Service
IP Best Effort	Analogue Loop, Analogue Cellular, GSM, Coax, ISDN, SONET/SDH, ATM, FR, Gigabit Ethernet, Cable, Satellite, etc.	ATM, FR, DS3, SONET/SDH, Gigabit Ethernet, 100BaseT, FDDI, Cable, Satellite, etc.	ATM, FR, DS3, SONET/SDH, Gigabit Ethernet, 100BaseT, FDDI, Cable, Satellite, etc.	Analogue Loop, Analogue Cellular, GSM, Coax, ISDN, SONET/SDH, ATM, FR, Gigabit Ethernet, Cable, Satellite, etc.	IP (Best Effort, Controlled Load, Guaranteed Load, etc.)
IP Controlled Load	Analogue Loop, Analogue Cellular, GSM, Coax, ISDN, SONET/SDH, ATM, FR, Gigabit Ethernet, Cable, Satellite, etc.	ATM, FR, DS3, SONET/SDH, Gigabit Ethernet, 100BaseT, FDDI, Cable, Satellite, etc.	ATM, FR, DS3, SONET/SDH, Gigabit Ethernet, 100BaseT, FDDI, Cable, Satellite, etc.	Analogue Loop, Analogue Cellular, GSM, Coax, ISDN, SONET/SDH, ATM, FR, Gigabit Ethernet, Cable, Satellite, etc.	IP (Best Effort, Controlled Load, Guaranteed Load, etc.)
IP Guaranteed Load	Analogue Loop, Analogue Cellular, GSM, Coax, ISDN, SONET/SDH, ATM, FR, Gigabit Ethernet, Cable, Satellite, etc.	ATM, FR, DS3, SONET/SDH, Gigabit Ethernet, 100BaseT, FDDI, MPLS, Cable, Satellite, etc.	ATM, FR, DS3, SONET/SDH, Gigabit Ethernet, 100BaseT, FDDI, MPLS, Cable, Satellite, etc.	Analogue Loop, Analogue Cellular, GSM, Coax, ISDN, SONET/SDH, ATM, FR, Gigabit Ethernet, Cable, Satellite, etc.	IP (Best Effort, Controlled Load, Guaranteed Load, etc.)
NOTE – IP may or may not take advantage of the underlying features and facilities of the underlying technologies (e.g. ATM, Frame Relay, SDH/SONET, etc.).					

6.4 Technology model for IP network architecture

The technology model for IP network architecture should consist of a series of technical standards or recommendations, describing configuration, interrelation and interaction of various components in an IP network as shown abstractly in Figure 5. The technology model comprises a diversified set of referenced standards or recommendations, for services, interfaces, equipment and interrelationships.

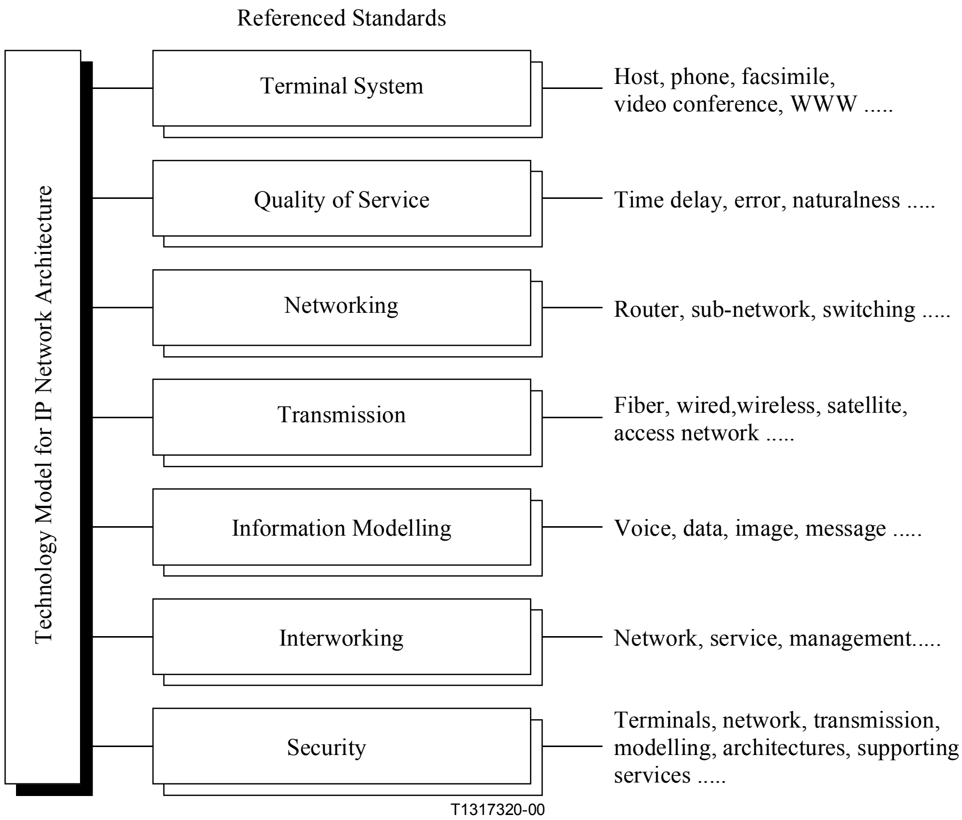


Figure 5/Y.1001 – Technology and Standards Model

7 Basic architectural principles

Figure 6 shows the two most fundamental architectural relationships that can exist between one service (and its protocol) and another service (and its protocol). These relationships will occur, to a lesser or greater extent, in the IP/telecommunications convergence architectures which are described in this Recommendation. In some of the convergence architectures these principles will occur simultaneously and multiple times.

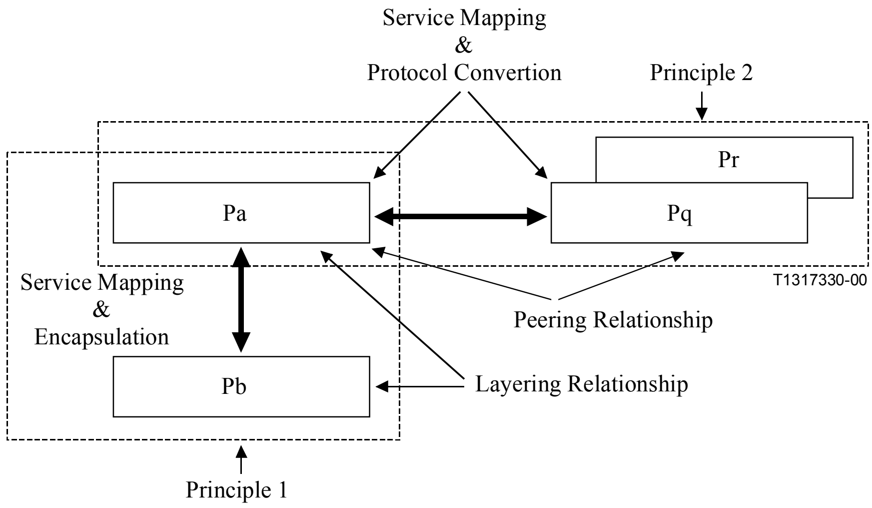


Figure 6/Y.1001 – Basic architectural principles

7.1 Principle 1 – vertical relationship

Principle 1, P1, shows the vertical relationship between protocols Pa and Pb. P1 is a layering relationship.

With respect to P1, Pa is encapsulated within Pb, and uses the service offered by Pb. No fixed relationship between the actual protocols in the role of Pa and Pb can be assumed. A given protocol may be used in either a Pa or Pb role according to a specific context. For example, we may run X.25 protocol over the IP, or the IP over the X.25, according to particular requirements.

7.2 Principle 2 – horizontal relationship

P2 shows the horizontal relationship between Pa and Pq. P2 is a peering relationship.

With respect to P2, where an end-to-end service is being provided by performing a concatenation/conversion between Pa and Pq, via some form of Interworking Unit (IWF) interposed within the path between Pa and Pq, the IWF terminates each of the protocols (Pa and Pq) and provides a mapping/matching between the service implementation provided by Pa to that provided by Pq. In the case of disparities between service implementations, some loss of features/capabilities will occur, to one or other or both of the end users.

In the case where Pa and Pq are already end-to-end in nature and, thus, both terminate within end systems, the IWF in an end system may only be required to co-ordinate the events related to Pa and Pq for the purposes of achieving synchronization and synergy between services.

NOTE – The notion of an "end" may also vary dependent on the viewpoint of the observer.

7.3 Recursion

Principles 1 and 2 may be repeated recursively, either within, or mutually between P1 and P2 structures. Some examples of this are shown in Figure 7.

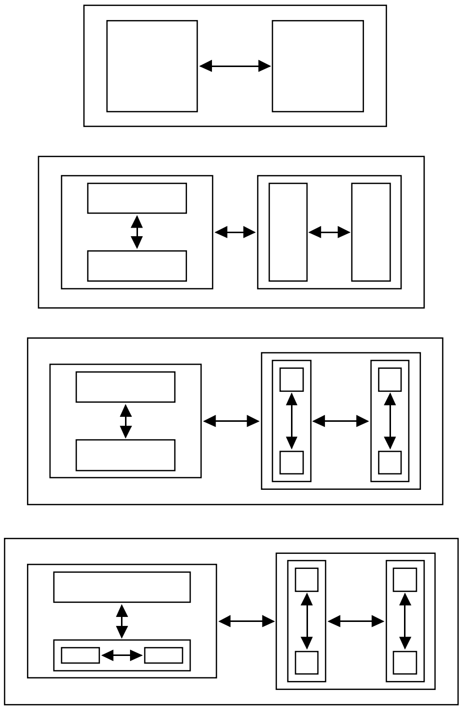


Figure 7/Y.1001 – Example of recursive application of principles 1 and 2

8 Basic reference models

8.1 Layered protocol model

Generally, the process of utilizing the telecommunication bearers is hidden from the IP service users. However, standardized mappings are required for using the IP over each and every telecommunication protocol to be deployed.

Figure 8 illustrates the layered protocol model for the provision of IP service. The area between the IP protocols and the actual telecommunication protocols (i.e. boxed area containing (a), (b), (c), etc.) represents the adaptation functions, mapping for QoS, and convergence/adaptation protocols (if necessary).

This model only depicts the IP layer and below. Layers above the IP layer would be concerned with application requirements such as those required to select/negotiate and instantiate a specific voice encoding scheme for a voice service.

In Figure 8, the following specific cases are shown:

Combination (a) IP Network scenario over FR (access)

Combination (b) IP Network scenario over FR (access) over ATM (backbone)

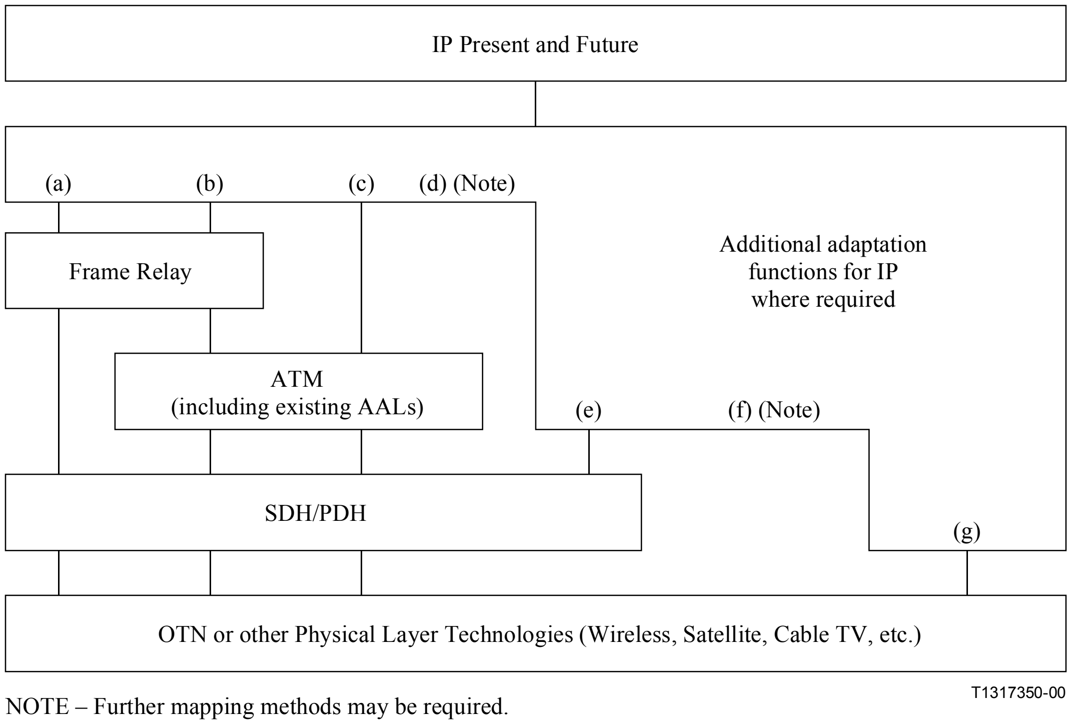
Combination (c) IP Network scenario over ATM (access)

Combination (e) IP Network scenario over SDH/PhDH (existing mapping)

Combination (g) IP Network scenario over Optical/WDM Transport Network or other physical layer technology, including cable TV.

NOTE – Further mappings for combinations (d) and (f) may be required and are left for further study.

The layered protocol architecture shown in Figure 8 is a straightforward example of the application of principle 1.



NOTE – Further mapping methods may be required.

Figure 8/Y.1001 – Layered protocol model for IP network

8.2 General protocol reference model – potential U-, C- and M-plane relationships

In addition to the hierarchical relationship shown in Figure 8, each protocol layer can be considered to have its user (U), control (C) and management (M) planes.

An IP network operates via the IP layer protocol and its associated protocols (e.g. ICMP) with the telecommunication infrastructure as underlying supporting layers. IP was designed without a distinct concept of Control, User transport and Management planes, although it and its associated protocols do provide these functions. In some cases, these functions are implicitly included in the IP protocol. In cases where separate protocols for control and management of an IP network have been defined, these may be conveyed over IP. They may or may not be conveyed over the same logical and physical path as the customer's user data. This is an operational decision.

Some components within the totality of equipment constituting an IP network will usually include control and management protocols not operating over, or directly associated with IP. This would apply, for example, to the equipment supporting the transport of IP.

In any event, where the two technologies converge there is a need to ensure appropriate mappings between the respective user (U), control (C) and management (M) planes. Mappings are required both between adjacent layers and between peer layers (in the case of service interworking). From this point of view, there is always a need to establish a protocol reference model (PRM) of an IP network to specify the relationship between an IP network and the telecommunication network U, C and M planes in order to adequately and comprehensively specify the overall service provision, control and management aspects. Figure 9 shows a PRM as applied to an IP network.

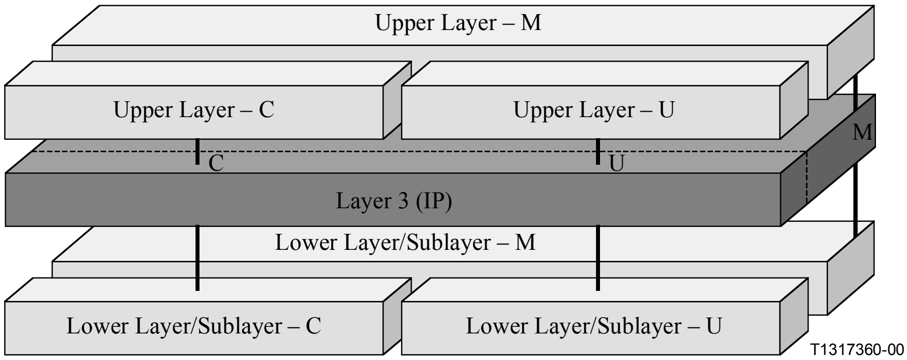
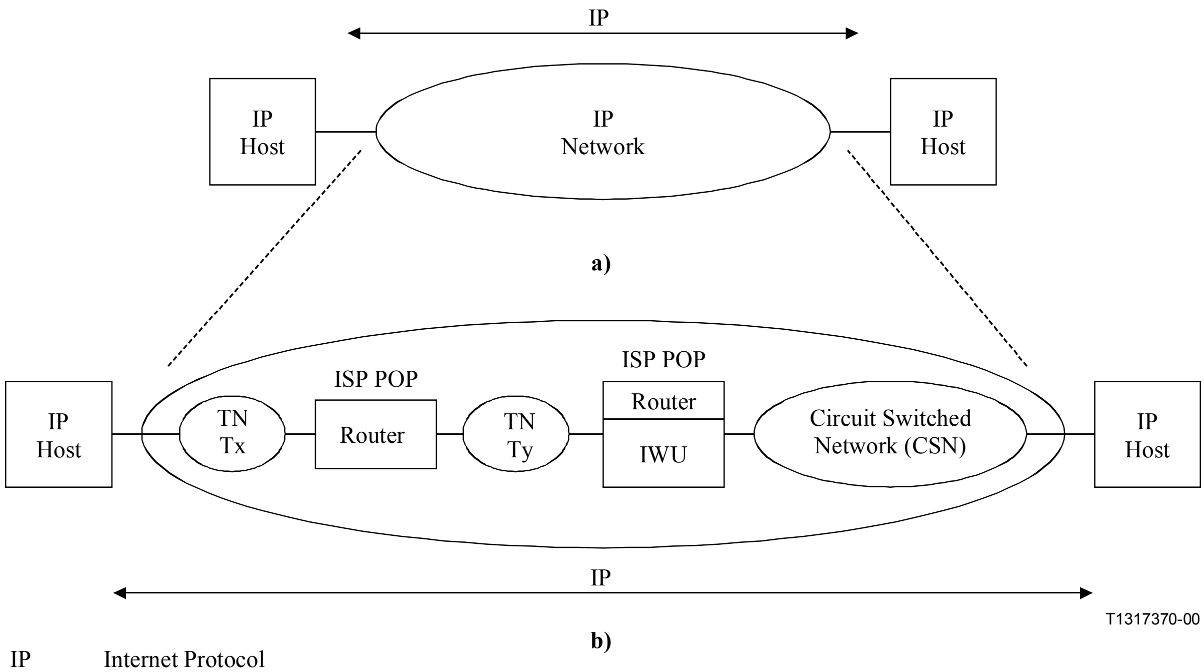


Figure 9/Y.1001 – Protocol reference model for an IP network

9 IP network overlay architecture

In this case IP is conveyed end-to-end, i.e. from IP host to IP host[4], as shown in Figure 10. IP is overlaid on any underlying telecommunication protocol such as X.25, Frame Relay, ATM, ISDN, etc. Different telecommunication protocols may be used in different parts of the IP-based n Network itself, i.e. between routers, using the concepts of 8.1 and 8.2 for each inter-router link.

[4] The term "IP host" is used as defined in RFC 1122 and 1123. According to the context, an IP host may be a computer, a terminal, or some type of specialized information appliance (e.g. phone, TV) or other equipment with network access for control/monitoring (e.g. heating and/or refrigeration equipment, household appliances, etc.).



IP Internet Protocol
ISP Internet Service Provider
IWU Interworking Unit
POP Point of Presence
TN Tx Telecommunications Network technology type x
TN Ty Telecommunications Network technology type y

Figure 10/Y.1001 – IP Network overlay architecture

NOTE – The use of a CSN to access an IP POP is a special case, due to the dynamic/transient nature of the access arrangements and the use of IP and PSTN/ISDN addressing schemes. However, once the customer is connected to the POP the CSN case is the same as the other cases. This case is elaborated further in 10.2.1.

10 Use of specific telecommunication bearers

This clause outlines the use of specific telecommunication bearers. Two subcases may be identified:

a) use of a telecommunication bearer service between IP routers; and

b) use of a telecommunication bearer service to access an IP network.

Typically, the Internet does not draw a hard distinction between user-network and network-network and intra-network in its use and choice of transmission bearer services. Thus, there may be little if any difference between the use of a leased line within an IP network and for the access to an IP network. Mostly, the difference lies in the policy (e.g. security, QoS) applied to routing and admission control. For example, although most people think of PSTN/ISDN dial-up as a method for accessing an IP network, there are cases in which PSTN/ISDN dial-up is used within an IP network to interconnect two routers.

10.1 Use of a telecommunication bearer service between IP routers

10.1.1 IP on ATM

Currently, carriers utilize point-to-point ATM PVCs for interconnecting their IP routers using RFC 2684 ("Multiprotocol Encapsulation over ATM Adaptation Level 5") or RFC 2225 ("Classical IP and ARP over ATM AAL5") using either LLC/SNAP or direct encapsulation. ATM PVCs are used to provide interconnectivity and traffic engineering in the network. In the future, the integrated use of IP and ATM using MPLS is expected, enabling MPLS-enabled ATM switches to switch ATM cells on the basis of IP routing information.

10.1.2 IP on SDH

In current practice, carriers support IP over SONET or SDH using RFC 2615 ("PPP over SONET/SDH").

10.1.3 IP on frame relay

RFC 2427 ("Multiprotocol Interconnect over Frame Relay") is used to carry IP over Frame Relay between routers.

10.1.4 IP on leased lines

Carriers use IP over TDM-based leased lines using RFC 1661 ("The Point-to-Point Protocol (PPP)") and RFC 1662 ("PPP in HDLC-like Framing").

10.1.5 IP on WDM

This area is for further study.

10.1.6 IP on satellite (VSAT or TV data channels)

This area is for further study.

10.2 Use of a telecommunication bearer service to access an IP network

10.2.1 Use of circuit switched network

Figure 10 b) shows the extension of IP over a dial-in or dial-out Circuit Switched Network (CSN) connection used to gain access to an IP point-of-presence, as is currently provided by many Internet Service Providers (ISPs) today. A discrete three-stage process is required, firstly to establish the telecommunication bearer between the ISP POP and the end user, secondly to authenticate and authorize the dial-in (or dial-out) user and finally to route the IP packets.

For voice support over such a dial-in service, the voice service is digitally encoded and conveyed as a payload of the IP network transparently to the CSN. This may be contrasted with the service interworking approach elaborated in clause 12.

10.2.1.1 Dial-in to the ISP POP

This case is relatively simple, being identical to existing dial-in access, i.e. set up the PSTN/ISDN connection to ISP, using a PSTN/ISDN number to access the interworking unit. Once the PSTN/ISDN connection is established the Point-to-Point Protocol (PPP) is invoked for the carriage of the IP containing the encoded voice information.

10.2.1.2 Dial-out from the ISP POP

Dial-out is supported in different ways by current ISPs. The user on the PSTN/ISDN is generally reachable from the user on the IP network using a standard IP address as the destination address for the PSTN/ISDN user. The user on the IP network may only be required to know the host name of the user on the PSTN/ISDN, thus letting DNS determine the correct IP address to use. In either case, the IWU has to determine the PSTN/ISDN address required for dial-out, from the IP address assigned to the PSTN/ISDN user (or the host name), through address translation/mapping mechanisms. For example, a static configuration could be used in the IWU to map the IP address to a PSTN/ISDN address, or a more dynamic method may be used (e.g. DNS, RADIUS, etc.). Standard mechanisms for performing this function have not been defined.

Other cases may be possible, perhaps, by directly conveying the destination E.164 address across the IP network.

Other requirements include locating a specific IWU optimally located for a given PSTN/ISDN destination.

10.2.2 Use of PSDN/frame relay

Users access the Internet via frame relay by utilizing RFC 2427 ("Multiprotocol Interconnect over Frame Relay").

10.2.3 Use of ATM/B-ISDN

Users typically access the Internet using ATM by utilizing RFC 2684, RFC 2364 or RFC 2225. Other methods are for further study.

10.2.4 Use of xDSL bitstreams

Different DSL technologies may be used for accessing the Internet.

In the case of ADSL and VDSL, users accessing the Internet use the same methods as listed for the use of ATM/B-ISDN.

In the case of IDSL, HDSL, or SDSL, users accessing the Internet use RFC 1661 and RFC 1662.

10.2.5 Use of leased lines

Uses accessing the Internet via leased lines use RFC 1661 ("Point-to-Point Protocol (PPP)") and RFC 1662 ("PPP in HDLC-like Framing").

10.2.6 Use of satellite (VSAT or TV data channels)

For further study.

10.2.7 Other access mechanisms

Other access mechanisms are in use or under investigation for access to the Internet. These include mobile wireless, fixed wireless, cable, Gigabit Ethernet (over fibre), cable TV or Satellite TV, etc. Some of these are not normally considered a telecommunication bearer services.

11 Interworking within the underlying telecommunication infrastructure

It is conceivable that interworking may be required/possible between two dissimilar telecommunication technologies without the presence of an intervening IP router, as shown in Figure 11.

In the case where two different telecommunication network technologies are interworked, the interworking function may need to be aware of the adaptation/convergence protocols, and be prepared to provide appropriate interworking functions, if necessary, at the adaptation layer.

Figure 11 shows the use of two different transport technologies, Tx and Ty, with corresponding adaptation functions AFx and AFy encapsulated within Tx and Ty. Two cases may be distinguished.

In case 1, the adaptation protocol AFx is identical to AFy. In this case the interworking unit can transparently pass the adaptation protocol. In this case the adaptation protocol can simply be un-encapsulated from one side and re-encapsulated on the other side without change.

Case 2 is required when AFx is not identical to AFy. In this case, the interworking unit must terminate both AFx and AFy and provide the necessary mapping functions. In this case, the adaptation protocol must be un-encapsulated and terminated on one side, and translated to a different adaptation protocol for subsequent encapsulation on the other.

NOTE – ITU-T I.555 and ITU-T X.46 are examples of specifications for the interworking of two dissimilar telecommunication technologies, i.e. ATM and Frame Relay.

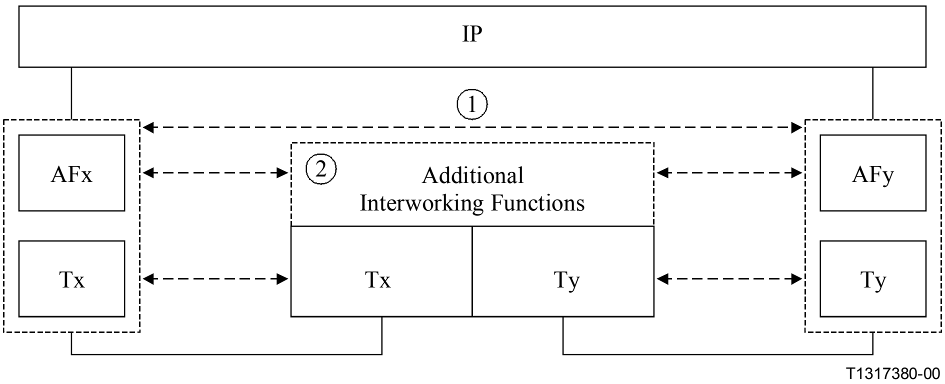


Figure 11/Y.1001 – Interworking within the underlying telecommunication infrastructure

Case 1 is an example of the application of principle 1. Case 2 is an example of both principle 2 and principle 1. Principle 2 applies to the interworking between the adaptation functions AFx and AFy, and principle 1 applies to the carriage of AFx over Tx and AFy over Ty.

12 Telephony service interworking

12.1 General considerations

In this case interworking is achieved at the service level via an intermediate gateway or Interworking Unit (IWU) for the provision of an end-to-end voice service. All protocols terminate on the respective side of the Interworking Function (IWF). There is no end-to-end protocol in this case. The IP stack is terminated at the IWF. This is shown in Figure 12.

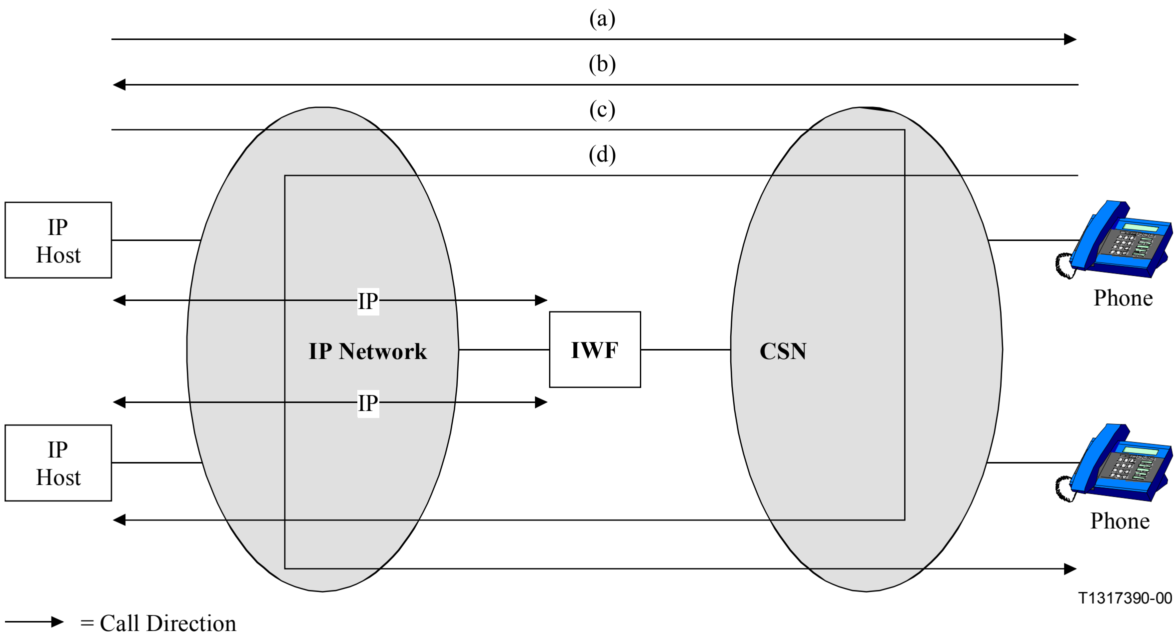


Figure 12/Y.1001 – Telephony service – basic interworking architecture

The connection patterns are classified into four scenarios (a) – (d), according to the point of origin and destination of the call, as follows:

(a) from audio capable IP Host on an IP network to a phone on the CSN (PSTN or ISDN);

(b) from a phone on a CSN to an audio capable IP Host on an IP network;

(c) from audio capable IP Host on an IP network to another audio capable IP Host on an IP network, via an intervening CSN;

(d) from a phone on a CSN to another a phone on a CSN, via an intervening IP network.

The following figure outlines the mappings that are required in general for service interworking cases.

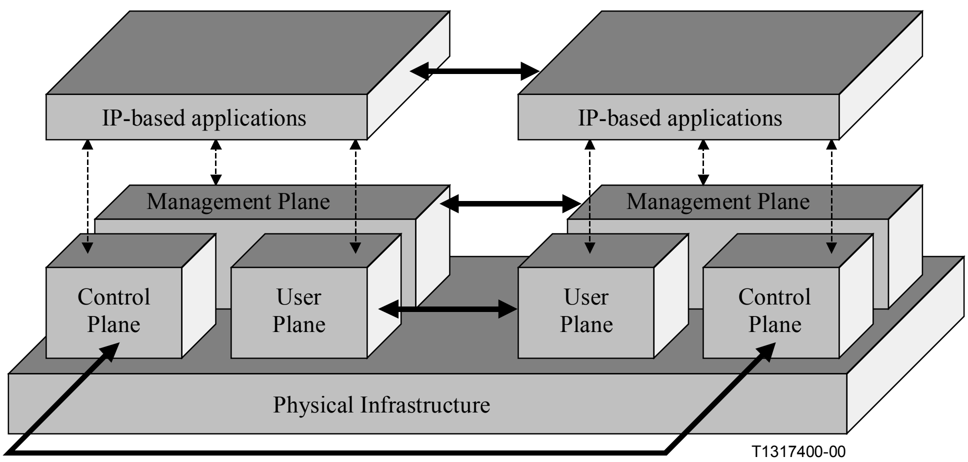


Figure 13/Y.1001 – Mappings for service interworking

The horizontal arrows represent the application of principle 2. The vertical arrows represent the application of principle 1.

12.2 Interworking functions

12.2.1 C-plane aspects

12.2.1.1 Conversion of call connection procedure

In scenario (a), the functions are required for converting from the call connection procedure for the IP network section to that for the CSN section, to establish the end-to-end connection between the IP host and phone. The functions may be implemented in a gateway at the border between the IP network and the CSN.

In scenario (b), the functions are required for converting from the call connection procedure for PSTN/ISDN CSN section to that for the IP network section to establish the end-to-end connection between phone and the IP host. The functions may be implemented at the border between the IP based network and the CSN.

In scenarios (a), (b) and (c), the functions dealing with the call connection procedure for the IP network section may be required. The functions may be implemented at adapters attached to the IP host and/or in the gateway at the border between the IP network and the CSN.

In scenarios (c) and (d), the functions for converting from the call connection procedure for the IP network section to that for CSN section, and vice versa, may be required or not, since in this case the call connection protocol may be transmitted transparently across the PSTN/ISDN/CSN or the IP network.

12.2.1.2 Numbering and addressing

In scenario (a), the address resolution functions are required to convert from the address used on the IP network section to that required for the CSN section for the designation of the called terminal.

In scenario (b), the address resolution functions are required to convert from the address used on the CSN section to that required for the IP network section for the designation of the called terminal.

In scenarios (a) and (c), PSTN directory functions may be required to designate the called terminals.

12.2.2 U-plane aspects

12.2.2.1 Conversion of voice coding methods

In each scenario, the functions are required for converting the voice encoding methods used for voice services over an IP network to those used for analogue voice over the PSTN or to those used for voice encoding over ISDN and digital trunk sections of PSTN, and vice versa.

NOTE – The presence of different voice encoding systems is not peculiar to the IP network, and many existing ITU-T standards are applicable to this issue.

12.2.2.2 QoS for IP services

Specifications for various classes of IP service, characterized by different qualities of service will be required in order to select IP services suitable for specific types of application. Voice and other real-time sensitive applications are examples of applications which have specific QoS requirements. The specifications for these classes of IP service will include values for transmission delay and packet loss and other relevant QoS parameters.

12.2.2.3 Security

Specification for the provision of security in the IP network section will be required.

12.2.3 M-plane aspects

12.2.3.1 Accounting

IP networks do not include the concept of calls, and therefore have not included the concept of call-based accounting. Accounting capabilities that can support any and all scenarios in Figure 9 will need to be determined to support accounting principles and requirements defined by the appropriate ITU Study Group. Special attention may need to be given to permanent connection to PUSH services.

12.3 Interworking gateway architecture

Figure 14 shows a hypothetical and generic functional architecture of an interworking unit or gateway.

Four functional components are shown:

a) Media Gateway (MG);

b) Media Gateway Controller (MGC);

c) Signalling Gateway (SG); and

d) Intelligent Databases (ID).

The MG will handle the real-time operations associated with interworking, voice encoding conversion, etc. An MG terminates the circuit switched network (CSN) facilities (trunks, loops), packetizes the media stream, if it is not already packetized, and delivers packetized traffic to the IP network. It performs these functions in the reverse order for media streams flowing from the IP network to the CSN. The MG will interface with the CSN as per PSTN/ISDN requirements and specifications. The MG will interface with the IP network, using IP packets as the payload bearer, using Real-Time Protocol for voice transmission.

The MGC will handle call control aspects associated with interworking. The MGC controls the operation of the Media Gateway function. Where these functions are packaged in separate devices, a protocol is needed between them. It is envisaged that the interconnection between the MGC and the MG will be over an IP network. The MGC interfaces to the IP network for the purposes of conveying call control information to peer entities on the IP network using either the IETF's Session Initiation Protocol (SIP) family of protocols, or the ITU-T's H.323 family of protocols (H.225, H.245, etc.). An MGC-MG control protocol is required and one candidate for this is H.248 (or its IETF equivalent).

The SG will handle any necessary interactions between the interworking functions and the SS7 network. The SG is a signalling agent that receives/sends CSN native signalling at the border between the IP network and telecommunication network. In particular the SG function may relay, translate or terminate SS7 signalling in an SS7-Internet Gateway.

The ID will be used to acquire any necessary information required, e.g. for credit card usage, 800 services, directory services, etc.

Although all the illustrated functions may be packaged into one physical box, it is likely that the relative scale of operation of each of the component functions and the nature of multi-vendor equipment provision will result in the realization of separate physical units with the interconnection interfaces shown in Figure 14.

The interworking functions between the IP network and the CSN require the application of principle 2. The other interfaces are various cases of the application of principle 1.

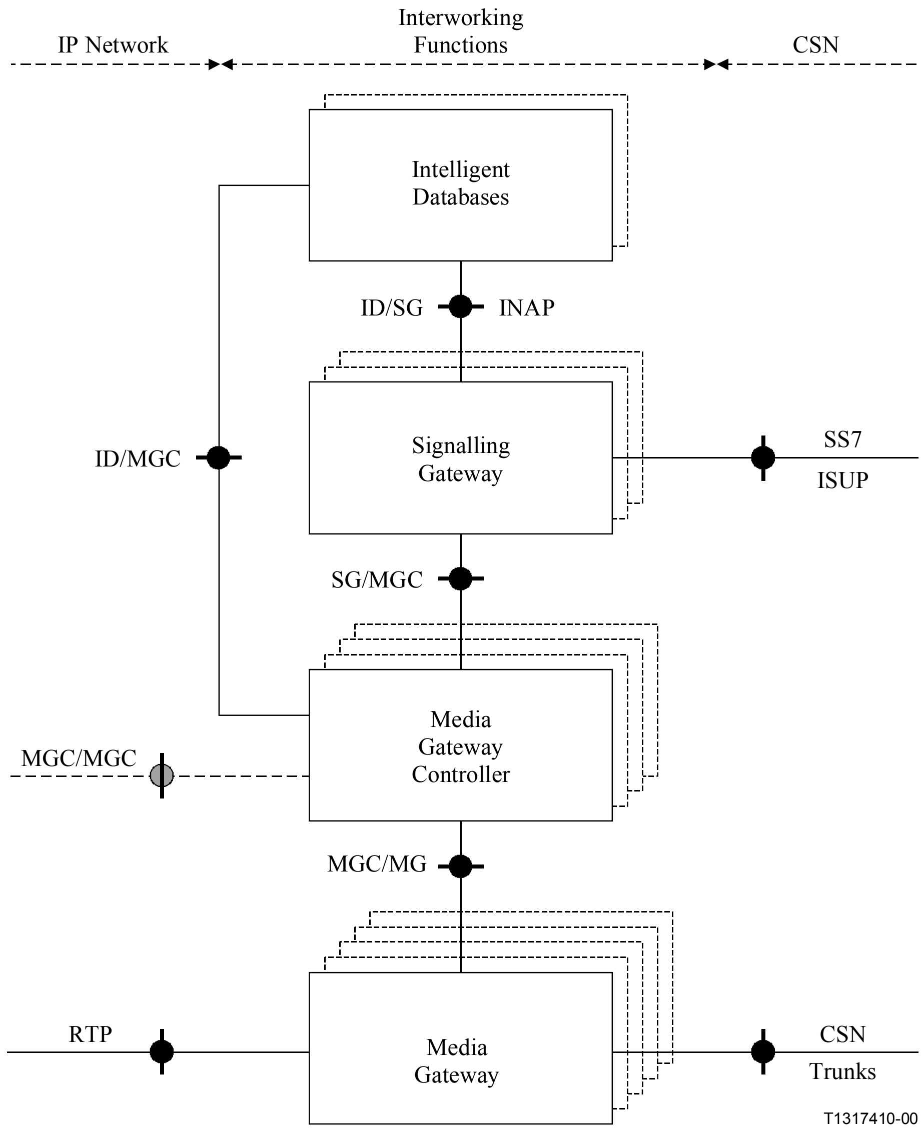
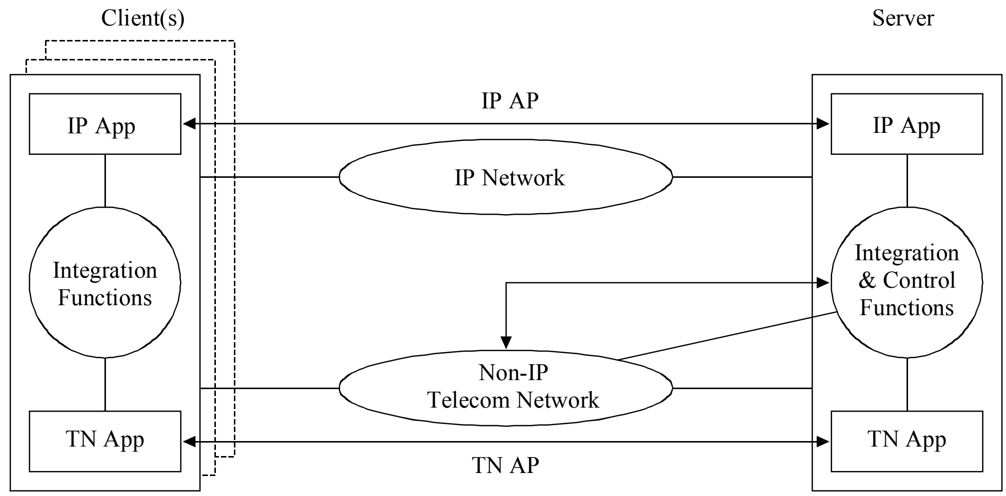


Figure 14/Y.1001 – Telephony gateway architecture

13 Native IP services interworking with services defined in ITU-T Recommendations

In this case both the IP network and the telecommunication networks are used to provide services, via their inherent applications, in a complementary and synergistic fashion. For example, IP data services may be used in parallel with telecommunication voice and/or facsimile (fax) services. In this architecture, however, the establishment of the telecommunications-based services is triggered and controlled by a server on the IP network. Figure 15 depicts such an arrangement, where the actual services are deemed to exist in parallel universes but with coordinated or integrated control mechanisms.

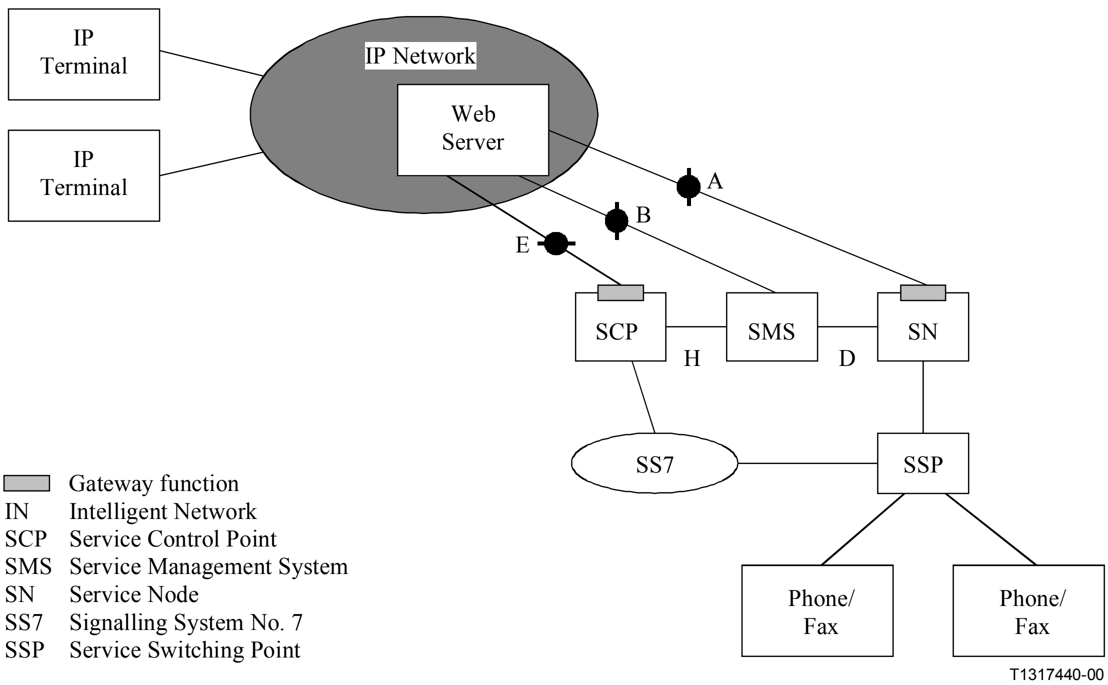


IP App IP Application
TN App Telecommunication Network Application

Figure 15/Y.1001 – Parallel service architecture

Figure 16 shows a specific example of such an arrangement. The synergy between the two networks is achieved by the link between the server, in this case an IP Host (for example a Web server) of the IP network and the IN Service Node (SN) or Service Control Point (SCP) of the telecommunication network. It is possible that the IP host and the SCP or SN will be co-resident on the IP network providing services to IP hosts and to the telecommunication network.

The **P**STN/**Int**ernet Interworking (PINT) activity developed jointly by IETF and ITU-T is an example of such an architecture. Other architectures are possible.



Gateway function
IN Intelligent Network
SCP Service Control Point
SMS Service Management System
SN Service Node
SS7 Signalling System No. 7
SSP Service Switching Point

Figure 16/Y.1001 – PINT – An example of parallel service architecture

The interfaces A, B and E correspond to those defined in RFC 2458 "Toward the PSTN/Internet Inter-networking".

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