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SERIES X: DATA NETWORKS AND OPEN SYSTEM COMMUNICATIONS

Public data networks – Network aspects

Principles for the routing of international frame relay traffic

ITU-T Recommendation X.111

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ITU-T Recommendation X.111

Principles for the routing of international frame relay traffic

Summary

The purpose of this Recommendation is to provide network operators with the information necessary to ensure that Frame Relay data traffic can be routed effectively and efficiently across the International Public Data Network. Guidelines and general principles for the planning of Public Frame Relay Data networks and the routing of International Frame Relay Traffic are provided. In particular guidance on the incorporation of service requirements into the network routing process is provided. Principles for routing in the case of Frame Relay/ATM interworking are also provided.

Source

ITU-T Recommendation X.111 was prepared by ITU-T Study Group 17 (2001-2004) and approved under the WTSA Resolution 1 procedure on 13 February 2003.

Keywords

Frame Relay, Public Frame Relay Data Network, Routing.

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.

INTELLECTUAL PROPERTY RIGHTS

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As of the date of approval of this Recommendation, 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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ITU-T Recommendation X.111

Principles for the routing of international frame relay traffic

1 Introduction

1.1 This Recommendation provides general principles and guidelines for the routing of international frame relay data traffic. The Frame Relay Data Transmission Service as defined by ITU-T Recs X.36 and X.76 provides a wide range of services such as closed user group, reverse charging, transit network selection, transfer and discard priorities and selection of service classes. Each service must be supported by a minimum level of network capability. For each connection requested by a user, the network must provide the appropriate switching, signalling and transmission capabilities required to successfully route the call to the required destination.

1.2 The purpose of this Recommendation is to provide network operators with the information necessary to ensure that Frame Relay data traffic can be routed effectively and efficiently across the International Public Data Network. In particular guidance on the incorporation of service requirements into the network routing process is provided.

1.3 This Recommendation establishes basic principles on which to base network design and routing decisions. It provides detailed information on the mapping between Frame Relay Data Transmission services, and the network capabilities (e.g., transmission links, signalling systems, etc.) required to support and route a call. Guidance on the conveyance and use of routing information within network components is also included.

NOTE – Within this Recommendation the term Public Frame Relay Data Network can be used interchangeably with the term Public Data Network providing the Frame Relay Data Transmission Service. The term ATM Network can be used interchangeably with the term B-ISDN.

2 Scope

2.1 The scope of this Recommendation is the routing of international frame relay data traffic supported by the service capabilities defined in ITU-T Rec. X.76, "Network-to-network interface between public networks providing PVC and/or SVC frame relay data transmission service", i.e., routing principles for PVC or SVC frame relay connections. The scope of this Recommendation is limited to Public Data Networks providing the Frame Relay Data Transmission Service. Contents of this Recommendation will be reviewed/extended in order to satisfy operational needs which will arise according to the evolution of public frame relay data networks.

2.2 This Recommendation is intended to provide a single definitive reference for Frame Relay routing. It is a companion document to ITU-T Rec. X.110, "International routing principles and routing plan for the Public Data Network".

2.3 Arrangements for the routing of international frame relay data traffic between PFRDNs and the Frame Mode Bearer Service provided by N-ISDNs is outside the scope of this Recommendation.

3 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; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

This Recommendation is related to and is compatible with the following Recommendations:

– ITU-T Recommendation E.164 (1997), *The international public telecommunication numbering plan*.

– ITU-T Recommendation E.177 (1996), *B-ISDN routing*.

– ITU-T Recommendation I.555 (1997), *Frame Relaying Bearer Service interworking*.

– ITU-T Recommendation X.36 (2000), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for public data networks providing frame relay data transmission service by dedicated circuit*.

– ITU-T Recommendation X.46 (1998), *Access to FRDTS via B-ISDN*.

– ITU-T Recommendation X.76 (2000), *Network-to-network interface between public networks providing PVC and/or SVC frame relay data transmission service*.

– ITU-T Recommendation X.78 (1999), *Interworking procedures between networks providing frame relay data transmission services via B-ISDN*.

– ITU-T Recommendation X.110 (2002), *International routing principles and routing plan for public data networks*.

– ITU-T Recommendation X.121 (2000), *International numbering plan for public data networks*.

– ITU-T Recommendation X.124 (1999), *Arrangements for the interworking of the E.164 and X.121 numbering plans for frame relay and ATM networks*.

– ITU-T Recommendation X.125 (1998), *Procedure for the notification of the assignment of international network identification codes for public frame relay data networks and ATM networks numbered under the E.164 numbering plan*.

– ITU-T Recommendation X.144 (2000), *User information transfer performance parameters for data networks providing international frame relay PVC service*.

– ITU-T Recommendation X.145 (1996), *Performance for data networks providing international frame relay SVC service*.

– ITU-T Recommendation X.146 (2000), *Performance objectives and quality of service classes applicable to frame relay*.

– ITU-T Recommendation X.300 (1996), *General principles for interworking between public networks and between public networks and other networks for the provision of data transmission services*.

– ITU-T Recommendation X.301 (1996), *Description of the general arrangements for call control within a subnetwork and between subnetworks for the provision of data transmission services*.

– ITU-T Recommendation X.329 (2000), *General arrangements for interworking between networks providing frame relay data transmission services and B-ISDN*.

4 Definitions

This terms and their definitions used in this Recommendation are consistent with those defined in ITU-T Recs E.164, E.177, I.155, X.36, X.46, X.76, X.78, X.110, X.121, X.124 and X.125.

5 Abbreviations

This Recommendation uses the following abbreviations:

ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
DCE	Data Circuit-terminating Equipment
DLCI	Data Link Connection Identifier
DNIC	Data Network Identification Code
DTE	Data Terminal Equipment
FR	Frame Relay
FRDTS	Frame Relay Data Transmission Service
IDSE	International Data Switching Exchange
ISDN	Integrated Services Digital Network
IWF	Interworking Function
ND	Number Digits
NPI	Numbering Plan Identification
NSAP	Network Service Access Point (address)
PDN	Public Data Network
PFRDN	Public Frame Relay Data Network
PVC	Permanent Virtual Circuit
STE	Signalling Terminal Equipment
SVC	Switched Virtual Circuit
TON	Type of Number
VC	Virtual circuit

6 Reference configurations

6.1 Scenario 1: Routing between PFRDNs

Figure 1 provides a reference model for the most common environment in which the routing principles defined in this Recommendation apply. That is the routing of international frame relay data traffic between public data networks proving the FRDTS. Public Frame Relay Data Networks will be interconnected utilizing the network-to-network interface defined in ITU-T Rec. X.76.

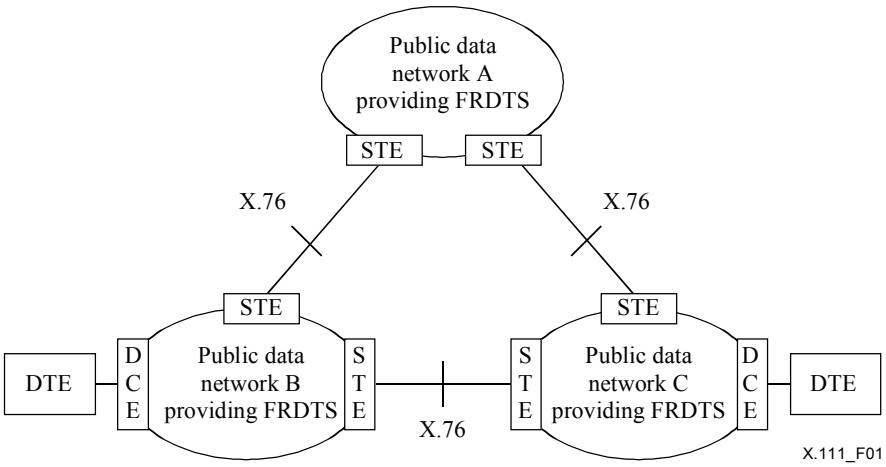


Figure 1/X.111 – General environment in which X.111 applies

6.2 Scenario 2: Interworking with ATM networks

Figure 2 is a representation of the possible interworking scenarios which may require frame relay traffic to be routed between networks. Interconnection of PFRDN and ATM networks may require an interworking function. Refer to ITU-T Rec. X.46 for detailed procedures for access to FRDTS via B-ISDN. Refer to ITU-T Rec. X.78 for detailed procedures for interworking between PFRDNs when using ATM as the backbone transit. Annex B provides guidelines and principles for routing traffic in the case of FR/ATM interworking.

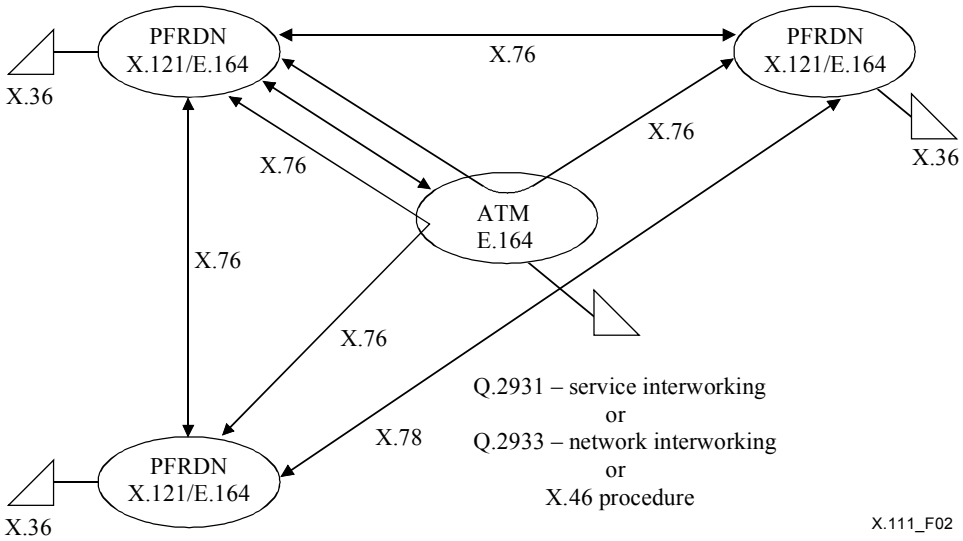


Figure 2/X.111 – Routing scenarios involving interworking with ATM networks

7 Basic principles in routing frame relay traffic

The following basic routing principles are recommended to assist in managing the trade-off between customer satisfaction and network optimization.

a) complete as many calls as possible;

b) utilize network resources efficiently:

- match network capability to service demand;
- minimize the use of "overmatching" network capability;
- minimize the number of links in a route;

c) adhere to network performance parameters:
   - delay (call set-up delay, transfer delay, call clearing delay);
   - transmission quality;
   - error rates;
   - throughput;
   - availability;

NOTE – Quality of Service parameters and objectives for Frame Relay Networks are defined in ITU-T Recs X.144, X.145 and X146.

d) minimize translation complexity;

e) minimize digit analysis and manipulation;

f) avoid "non-standard" arrangements.

8 Implications of service defined network connections for FR routing

8.1 Effective routing of Frame Relay SVC traffic is basically performed through analysis of the called address to allow selection of the chain of physical trunk routes through switching nodes to the destination. However FR encompasses the concept of customer selected service requirements for defined FR Data Link connections, (either on a predefined basis for the PVC service on a call-by-call basis for the SVC service). Each service request demands a predefined minimum level of network capability to support a connection. This requires that the routing of FR traffic must match the service request to the capability of the networks involved in routing the connection.

8.2 From a network routing perspective, the physical requirements of a network connection may be determined through analysis of connection configuration parameters. Bearer service definitions dictate the minimum capability for information transfer between Frame Relay access points. The service aspect of FR routing is based primarily on the bearer service requested by the customer. The Frame Relay Data Transmission Service, its service parameters and service quality and data link transfer control procedures are defined in ITU-T Rec. X.36, clauses 7, 8 and 9.

9 Overview of the routing process

9.1 General

This clause describes the FR routing process. The routing process is the sequence of functions required to establish a VC connection between the originating DTE (calling user) and the terminating DTE (called user) via a transit network. The conventions used for a routed FR connection are shown in Figure 3.

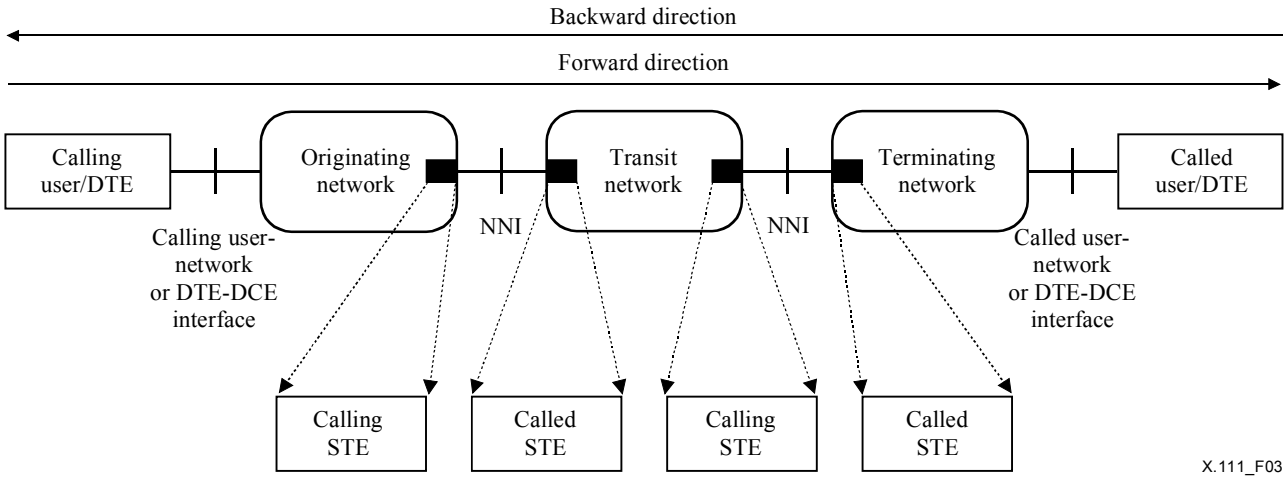


Figure 3/X.111 – Convention used in an international routed FR connection

NOTE – A transit network may be configured as a single switching node.

9.2 DTE-DCE interface

9.2.1 For permanent virtual circuits (PVCs), connections are established under the control of network operators by invoking management capabilities to reflect subscription parameters. For switched virtual circuits (SVCs), the user initiates a service request through a FR capable DTE, connected to the network via the X.36 DTE-DCE interface. The calling DTE provides the following information:

– called and calling addresses;

– service request parameters: (frame transfer or discard priority, committed burst size, excess burst size, committed information rate, etc.);

– other information required for call set-up: closed user group, reverse charging indication, transit network selection.

9.2.2 The terminal equipment converts this information into an X.36 Setup message which is transmitted to the originating local switch for processing.

9.3 Originating local switch

9.3.1 The originating local switch performs the most critical function in FR call routing. That function is to assemble essential call routing information, which is uniquely available to it, into an information element that will be used by all subsequent exchanges to make the required routing decisions.

9.3.2 The originating local switch uses:

– call specific information provided in the X.36 call setup message;

– customer subscription profile data in exchange memory;

– network environmental and administrative conditions;

to establish:

– the route treatment of that specific call (i.e., route selection, block, etc.);

– the routing parameters which are associated with the call for use at subsequent exchanges in the connection.

9.3.3 The originating switch therefore defines the minimum network resources (switching, signalling, transmission) which are needed to support the service request. These call/routing parameters are transported through the network via the call Setup Message.

9.3.4 The incoming and outgoing Setup Message contains the following parameter fields which may be used for routing purposes: The parameters listed generally contain all the signalling information needed to perform routing in the national and international network:

– Bearer capability;
– Data Link Connection Identifier;
– Closed user group;
– Link layer core parameters;
– Link Layer protocol parameters;
– Priority and service class parameters;
– Reverse charging indication;
– Calling party number;
– Calling party subaddress;
– Called party number;
– Called part subaddress;
– Transit network selection.

9.4 Transit networks and switches (national and international)

9.4.1 Each transit switch in the route sequence will receive the Setup Message (containing the routing parameters), generated by the previous switch. These parameters will be used as the basis for selecting an appropriate outgoing route. In addition, routing parameters may be added to or modified to update such information as connection history.

9.4.2 This process continues until either the terminating local switch is reached or the call is failed due to conditions encountered in the network.

9.4.3 International outgoing and incoming gateways (IDSE or STEs) should be capable of switching VCs to provide basic routing functionality (i.e., information analysis for routing purposes, e.g., digit analysis).

9.4.4 While many parameters are potentially involved in selecting a FR route, most calls can be successfully completed (assuming a route exists across the transit network) by matching the service request with idle facilities which are capable of supporting it.

9.4.5 In order to achieve cost effective allocation of network resources, use may be made of OAM capable nodes to obtain and analyse network operational status information (e.g., network congestion and network failure) in order to react to the network operational status.

10 Structure/topology of the international frame relay network

Figure 3 shows the conventions used in an international frame relay connection. The end-to-end connection consists of an originating national network, one or more transit networks and a destination national network. The network structure for PFRDN is consistent with the hypothetical reference connection for public data networks defined in ITU-T Rec. X.92. The maximum allocations of switching nodes and links for frame relay connections is shown in Table 1.

10.1 National network parts

10.1.1 In accordance with ITU-T Rec. X.110, the planning of the originating and destination national network parts is a national matter. However, in general national networks should be planned to ensure that the achieved quality of service (e.g., transfer delay frame loss ratio, etc.) provided on international connections meets the performance objectives defined in ITU-T Rec. X.146. For example, the number of switching nodes and the transmission bearer capabilities

used within a national network in order to route a call to the International Data Switching Equipment (IDSE) (or STE) will impact the achievable transfer delay (see Note).

NOTE – Appendix II/X.146 presents information to illustrate the effects which the choice of frame size and transmission trunk speed have on Frame Transfer Delay performance. These effects occur in both the access circuit section, and also in the inter-node trunk transmission links and may influence the design of the network topology.

10.1.2 It should also be noted that the introduction of multiple switching nodes in conjunction with the use of high-speed inter-node transmission trunks will not significantly diminish the achievable performance. Accordingly, this Recommendation places no limits on the maximum number of switching nodes and links used within a national network in order to establish an international frame relay connection. (See Table 1.)

10.1.3 Network operators are free to change their call routing arrangements provided they are still within the guidelines outlined in this plan.

10.2 International Network parts

10.2.1 The planning of international data traffic routes is the responsibility of the Network Operators concerned and is subject to bilateral agreements between the network operators involved. In accordance with ITU-T Rec. X.110, it is recommended that international transit section of an international frame relay data connection should be so planned as to encompass no more than four international data links in tandem. (See Table 1.) These limits may be exceeded in the case where high-speed switching nodes in conjunction with the use of high-speed inter-node transmission trunks are deployed in international transit networks .

10.2.2 The following points should also be taken into planning considerations and may impact route provision or selection:

– number of VC switches and links on an end-to-end VC;

– number of simultaneous VCs supported on inter-node transmission links;

– propagation delay of an end-to-end VC;

– transit network arrangements.

10.2.3 Network operators are free to change their call routing arrangements provided they are still within the guidelines outlined in this plan.

Table 1/X.111 – Maximum allocation of nodes and links in an international frame relay connection

Originating national network		International transit network		Terminating national network	
Nodes	**Links**	**Nodes**	**Links**	**Nodes**	**Links**
Unspecified	Unspecified	3	4	Unspecified	Unspecified

11 Network numbering and identification and the relation to routing

Public Frame Relay Data Networks may be numbered under either the X.121 or the E.164 numbering plan.

11.1 Networks numbered under X.121

Those networks number under X.121 will be allocated a DNIC. The DNIC is embedded within the X.121 number and uniquely identifies the network to which it has been assigned. For Networks numbered under X.121, the originating and destination networks are already identified within the calling and called DTE terminal addresses, and therefore do not require any additional identification at the time of the call establishment.

11.2 Networks numbered under E.164

Networks numbered under E.164 would not necessarily have a DNIC. A protocol specific mechanism has been defined within ITU-T Recs X.36 and X.76 in order to uniquely identify a specific Public Frame Relay Network numbered under E.164. These identifiers are known as an International Network Identification Code and are allocated according to procedures defined in ITU-T Rec. X.125. Use may be made of the International Network Identification Code for selecting a transit network.

NOTE – The use of an X.125 International Network Identification Code for routing across Frame Relay Networks numbered under E.164 is for further study.

11.3 Number plan interworking

Specific details and procedures on numbering plan interworking between Public Frame Relay Data Networks and ATM networks for the E.164 and X.121 numbering plans are outlined in ITU-T Rec. X.124. Transit cases are considered in ITU-T Rec. X.124. Escape codes are not used within the Frame Relay (X.36, X.76) and ATM signalling protocols (Q.2931) for the purposes of number plan interworking as these protocols utilize a TON/NPI mechanism for number plan interworking.

11.4 Identification of transit networks

Any network involved in providing transit IDSE(s) for an international frame relay data call should be identified at the time of the call establishment by means of the DNIC allocated to that Network (see Note 1).

NOTE 1 – Exceptionally, a DNIC or International Network Identification Code may need to be allocated to a network that would offer transit only and no direct subscriber access, for the purpose of identifying the transit IDSE(s).

There may be more than one IDSE provided by the same Network Operator. Also several independently operated networks may be provided by the same Network Operator. Independently operated networks may need to be identified even when the same Network Operator is concerned. Two or more IDSEs provided within the same independently operated network should be identified by the same DNIC (see Note 2).

NOTE 2 – The provision of one DNIC, one International Network Identification Code for an E.164 numbered Frame Relay Network, or one International Network Identification Code for a transit, (independently operated), network is considered to be sufficient for covering the international accounting requirements, and for avoiding unexpected loops of calls between independently operated networks. The identifications needed for tracing the exact path of a call for maintenance are outside the scope of this Recommendation.

Annex A

International Routing plan for PFRDNs – Examples of typical FR routes

A.1 Introduction

Network Operators will generally be constrained by both financial and technical considerations in the provision of routes. Accordingly, when high volumes of traffic are forecast, a direct route with no intermediate transit network is likely to be planned. Routes with low traffic volumes may be more economically switched through one or more transit networks. Transmission links between networks will be appropriately dimensioned to take account of traffic levels and required capabilities to be supported. The choice of routes may also depend on the capabilities provided by the transit networks. In assessing expected traffic volumes, it would be necessary to take into consideration both the static transmission and switching capacity and the dynamic utilization aspects of the overall traffic route. Network operators should provide alternative routes over which the traffic will be carried when the direct route is unavailable due to either capacity constraints or an equipment failure conditions. The priority order for selection of routes would normally be: high usage route (direct), alternative route 1, alternative route 2, etc. The actual number of alternative routes provided is subject to the bilateral agreements between Network Operators. Network Operators can make use of their agreed routes by offering them to a third party. In general, care should be taken to ensure that no routes planned in this way would involve inclusion of any more than 4 international links; that is the transit traffic should pass through a maximum of three intermediate transit networks or switching Nodes.

A.2 Examples of typical routes

Figures A.1 to A.9 depict some typical Frame Relay routes that Network Operators are likely to plan. Network operators are free to implement other routing scenarios that are not described in this annex.

A.2.1 Direct route (high usage route)

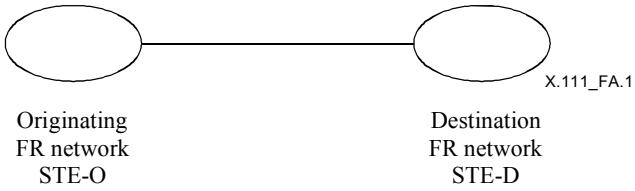


Figure A.1/X.111 – Connection established via Direct Route

A.2.2 Routes via intermediate transit networks

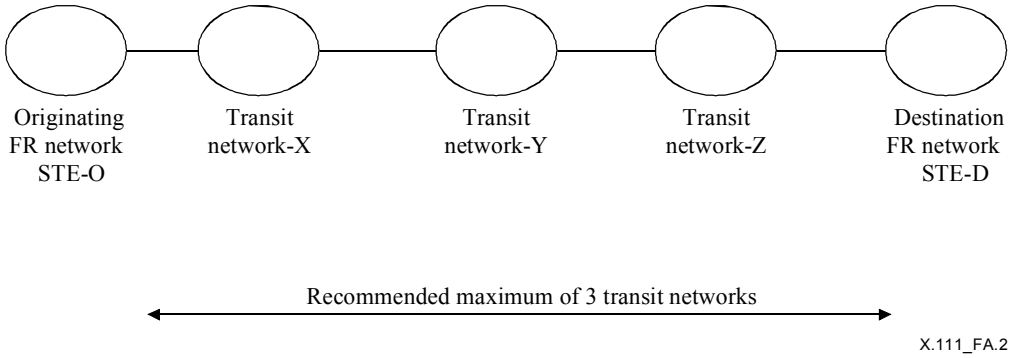
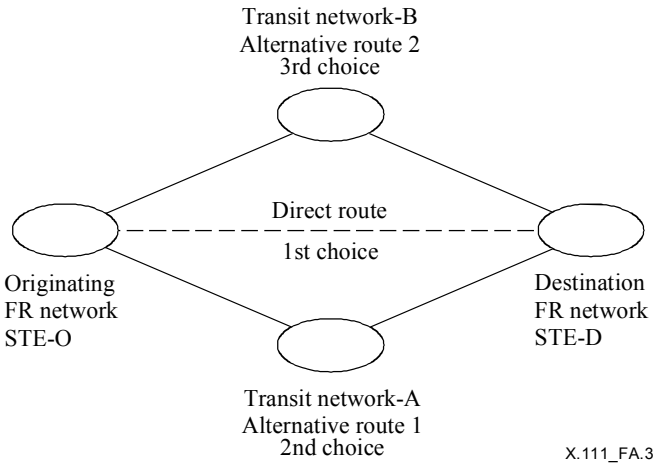


Figure A.2/X.111 – Limiting Condition: Frame Relay connection established via 3 intermediate transit networks

A.2.3 Use of Alternative routes



NOTE 1 – Likely routing selection process:

First choice – Direct route.
Second choice – Alternative route 1 via Transit Network-A
Third choice – Alternative route 2 Transit Network-B.

NOTE 2 – A similar routing algorithm may exist at intermediate Transit Network and care should be taken to ensure that the call is not routed using more than four links.

Figure A.3/X.111 – Interconnection of Frame Relay Networks by direct and alternative routes

A.2.4 Routing plan in cases where direct routes are provisioned

In those cases where a direct route is provisioned between the originating and the destination network, but cannot carry the Frame Relay connection due to either equipment failure or traffic congestion conditions, use should be made of transit networks. Within the economic and political constraints of a country, the alternative routes should be selected with the sequences illustrated in Figures A.4 to A.6.

The first alternative route selection would be made in the originating Frame Relay Network to a transit network which has a direct route/s to the destination Frame Relay Network (see Figure A.4).

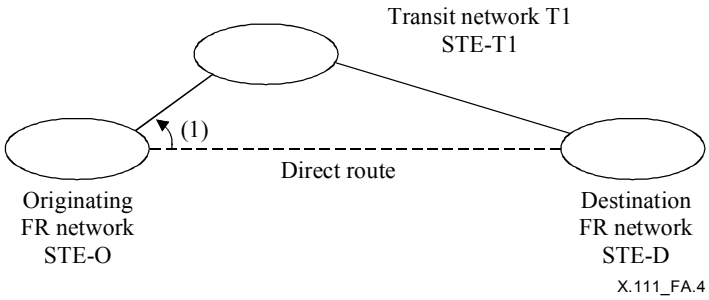


Figure A.4/X.111 – First choice alternative route

If there is no direct route (capable of supporting the traffic parameters) from Transit Network T1 to the destination, it will then be necessary to route the traffic via a second transit network. Accordingly, the second alternative routing will be made in the first Transit Network (T1) to either route the connection via the second Transit Network T2 or via a direct route to the destination Network (see Figure A.5).

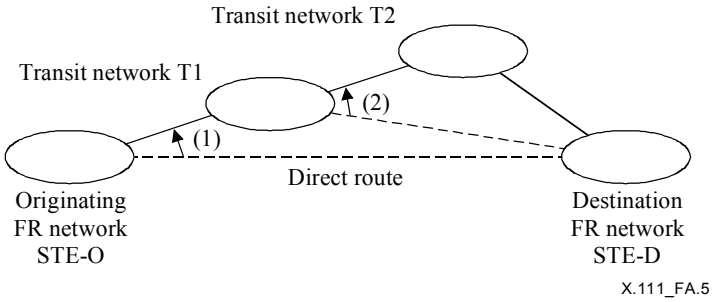


Figure A.5/X.111 – Selection of route at the first transit

The third alternative routing should be made in the same way, indicated in Figure A.6.

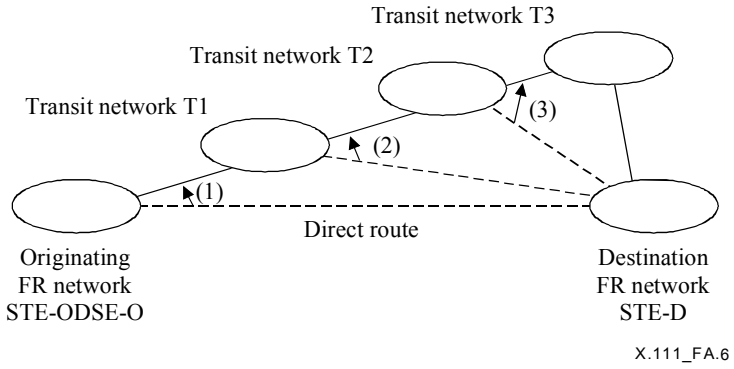


Figure A.6/X.111 – Selection of route at the second transit

A.2.5 Routing plan in cases where direct routes are not provisioned

In the case where no direct route between the originating and destination network is provisioned, use must be made of transit networks. In the case of traffic congestion or equipment failure, between STE-O and Transit Network T1 (STE-T1), or in the case where T1 does not support the requested capabilities, the first choice would be to route the call via Transit Network T2 (STE-T2) which has a direct route to the destination Network (STE-D) (see Figure A.7).

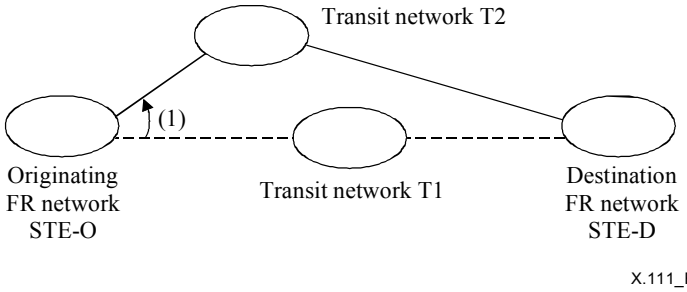


Figure A.7/X.111 – Routing of calls to destination via 2nd choice transit network

In the case where the originating network (STE-O) must select a route via Transit Network T2 (STE-T2) which also has no direct route available to the destination network (STE-D), the subsequent choice of transit by Transit Network T2 may be Transit Network T1 (STE-T1) (see Figure A.8). Alternatively the route may be established via Transit Network T3 (STE-T3) if no direct route is available between Transit Network T2 and the Destination Network (STE-D) (see Figure A.9).

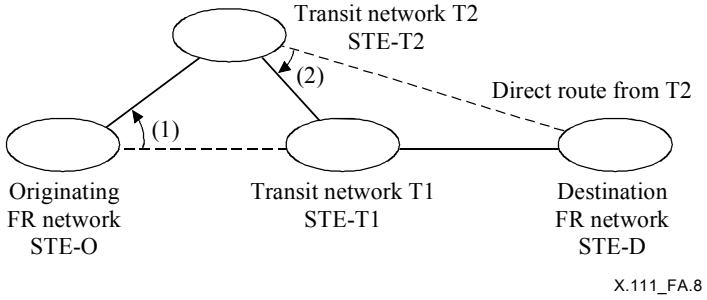


Figure A.8/X.111 – Establishment of route by alternative Transit

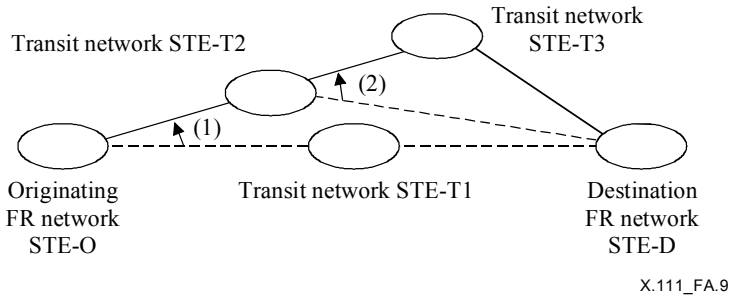


Figure A.9/X.111 – Establishment of route by additional Transit

The routing plan for the connection from Transit Network 1 (STE-1) to the Destination Network (STE-D) would be the same as the plan indicated in A.2.4 above.

A.3 Rerouting due to call set-up failure

The concept of re-routing of calls that fail at an intermediate transit networks (STEs) during call set-up is not supported within the Frame Relay protocols. Under the procedures defined in ITU-T Rec. X.76, if an STE is unable to provide a connection to reflect the lowest acceptable traffic parameters, the call will be rejected and the call cleared back to the calling DTE.

Annex B

Frame relay routing in the case of interworking with ATM networks

B.1 Introduction

This annex provides guidelines and principles for the routing of data traffic between Frame Relay Networks and ATM networks. This annex describes a number of scenarios involving FR/ATM interworking, which Network Operators are likely to plan. Network operators are free to implement other routing scenarios that are not described in this annex.

B.2 Bilateral agreements/interworking units

In general the routing of data traffic that involves interworking between PFRDNs and ATM networks will require bilateral agreement particularly in regard to the establishment of Frame Relay/ATM Interworking units. It is not mandatory to provide interworking facilities or capabilities within networks.

B.3 Number-plan Interworking

Since Frame Relay Networks may be numbered under either the X.121 or E.164 numbering plans, and ATM Networks are numbered under either the E.164 numbering plan or an AESA (NSAP Format), SVC interworking between Frame Relay and ATM networks may involve number plan interworking plan. Arrangements for number plan interworking are described in ITU-T Rec. X.124.

B.4 Use of transit networks/location of interworking units

End-to-end connections may be established over PVCs or SVCs. If required transit networks may be utilized to establish the connection. It is recommended that a maximum of 3 transit networks (or switching nodes) be used to establish an end-to-end connection. The principles defined in Annex A should be applied in the case where Frame Relay networks are used to provide the transit. The principles and guidelines defined in ITU-T Rec. E.177 should be applied to route traffic across any ATM networks utilized as a transit network

In routing a connection to/from an ATM terminal with frame relay capabilities on an ATM Network from/to a frame relay terminal on a PFRDN, the location of the Interworking units may determine the point at which the connection crosses from the ATM network environment to the Frame Relay network environment. Traffic volumes and QoS considerations may also influence the choice of the route and the use of transit networks.

B.5 Signalling procedures

Detailed signalling and connection establishment procedures for FR/ATM interworking are described in ITU-T Recs X.46, X.78 and I.555.

B.6 Interworking scenarios

Interworking between PFRDNs and ATM Networks will generally involve the following scenarios, which are illustrated in Figures B.1 to B.3.

a) Network interworking between a PFRDN (using X.36/X.76) and an ATM Network using Q.2933 procedures. (Figure B.1)

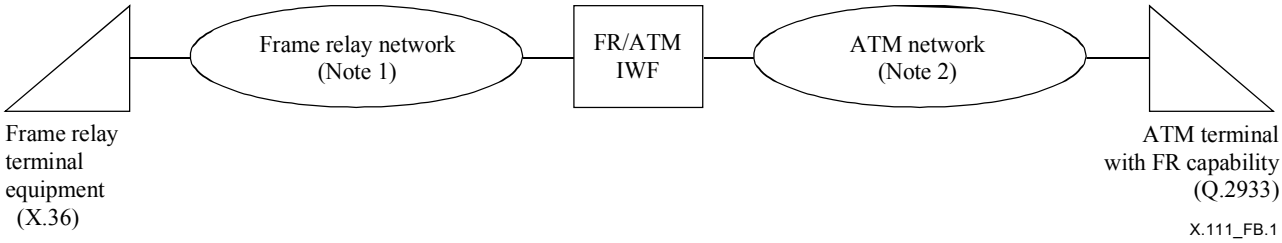
b) Network interworking between two PFRDNs (using X.36/X.76) with an ATM Network using Q.2933 procedures as a transit network. (Figure B.2)

c) Service interworking between a PFRDN (using X.36/X.76) and an ATM Network using Q.2931 procedures. (Figure B.3)

NOTE – Figures B.1 to B.3 do not imply any particular physical location for the FR/ATM IWF. The IWF may be functionally located in either a Frame Relay Network or an ATM network or be a physically separate entity. The IWF is shown as a separate entity for illustrative purposes only.

B.6.1 Network interworking

This interworking scenario (Figure B.1) describes the transport of Frame Relay data units between a Frame Relay user on a Frame Relay Network and an ATM user on an ATM Network. The ATM user utilizes the Frame Mode Bearer Service capability of the ATM network and accordingly the ATM terminal must have a built-in Frame Relay capability.

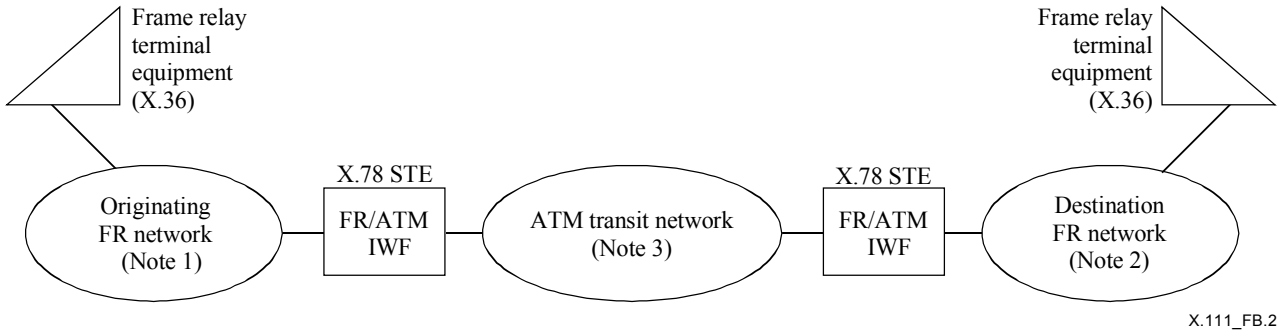


NOTE 1 – The FR connection between the originating FR Terminal Equipment and the FR/ATM IWF may involve one or more transit networks.
NOTE 2 – The FR connection between the FR/ATM IWF and the destination ATM Terminal Equipment may involve one or more transit networks.
NOTE 3 – A total maximum of 3 transit networks is recommended for the end-to-end connection.

Figure B.1/X.111 – Frame relay/ATM network interworking

B.6.2 Network Interworking between two PFRDNs using an ATM Network as a transit

This interworking scenario (Figure B.2) represents the case where the ATM network is used to provide a backbone interconnection capability (between the Frame Relay Networks). The backbone interconnect may consist of one or more ATM networks. In this scenario the Frame Relay networks are simply users of the end-to-end connectivity provided by the ATM transit network and are generally unaware of the underlying ATM backbone due to the isolation provided by the interworking functions at each interface to the ATM network. Routing across the ATM transit network should be in accordance with the principles defined in ITU-T Rec. E.177.



NOTE 1 – The FR connection between the originating FR Terminal Equipment and the originating FR/ATM IWF may involve one or more transit networks.

NOTE 2 – The FR connection between the destination FR/ATM IWF and the destination FR Terminal Equipment may involve one or more transit networks.

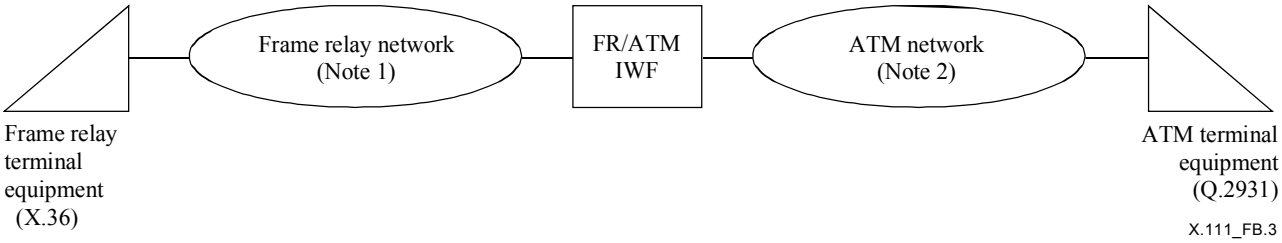
NOTE 3 – The ATM transit network may consist of one or more networks.

NOTE 4 – A total maximum of 3 transit networks is recommended for the end-to-end connection.

Figure B.2/X.111 – Network interworking between two PFRDNs with one or more ATM Networks acting as a transit network

B.6.3 Service interworking

This interworking scenario (Figure B.3) represents the case where a Frame Relay service user interworks with an ATM service user. The ATM service user performs no Frame Relay service specific functions, and the Frame Relay service user performs no ATM service specific functions. The ATM terminal has no knowledge that the distant terminal is connected to a Frame Relay Network and likewise, the Frame Relay terminal has no knowledge that the distant terminal is connected to an ATM Network. All interworking is performed by the interworking function.



NOTE 1 – The FR connection between the originating FR Terminal Equipment and the FR/ATM IWF may involve one or more transit networks.
NOTE 2 – The ATM connection between the FR/ATM IWF and the destination ATM Terminal Equipment may involve one or more transit networks.
NOTE 3 – A total maximum of 3 transit networks is recommended for the end-to-end connection.

Figure B.3/X.111 – Frame relay/ATM service interworking

Annex C

Analysis of information required for routing

This annex lists the information that requires analysis for VC connection routing purposes. The information will vary depending on the progress of the call through network. Consequently this may place different requirements on the network nodes as shown in Table C.1.

NOTE – The traffic parameters utilized in the routing of Frame Relay Virtual Connections between networks are formally defined in ITU-T Rec. X.76. They are only repeated here to improve the overall readability of this annex.

C.1 Calling party number

Depending on the calling party's service arrangement, a check of authorized and unauthorized service requests will be performed before the outgoing route is selected.

C.2 Incoming route DLCI

Identifies the incoming VCs.

C.3 Called party number

The called number uniquely identifies a destination, on which an outgoing route choice is based. Either an X.121 or E.164 number is used for this purpose.

C.4 Bearer capability: Link Layer core parameters

Bearer Capability is contained in the signalling information received from the calling party at the originating VC switch. The BC contains bearer class information. This information will possibly be analysed at each VC switch to select appropriate route and allocate resources.

Table C.1/X.111 – Application of routing information at network nodes

Information used to establish the VC route	Information to be taken into account (Note 1)				
	Originating VC switch	**National transit VC switch**	**International VC switch**	**National transit VC switch**	**Terminating VC switch**
Calling party	X	X	X	X	
Incoming route DLCI		X	X	X	X
Called number (Note 2)	X	X	X	X	X
Bearer capability: Link Layer core parameters	X	X	X	X	X
Priority & Service Class Parameters	X	X	X	X	X
Maximum end-to-end transit delay	X	X	X	X	
Transit network identification & selection	X	X	X	X	X
Network management conditions	X	X	X	X	
Time, event and state conditions	X	X	X	X	

NOTE 1 – This Table identifies the data normally used to route Frame Relay Virtual Connections in many fundamental circumstances. The use of data not marked with a cross is not precluded at any routing stage in special circumstances.

NOTE 2 – The called number includes NPI/TON information if present.

C.5 Priority and service class parameters

Priority and Service Class parameters are specified in the signalling information received from the calling party at the originating VC switch. The frame transfer and discard priority allows networks the possibility to apply different priorities to virtual circuits. Frame relay service class allows frame relay networks the possibility to apply different quality of service classes to frame relay virtual circuits to meet delay and loss requirements for different applications on a consistent basis between different networks. During the data transfer phase, frames will be processed such that the performance characteristics of the subscribed or requested service class will be met. Support of Priority and Service Class is a network option. Networks should endeavour to route calls to meet the requested priorities or service classes.

C.6 Maximum end-to-end transit delay

This parameter is generated from end-to-end transit delay information at the originating VC switch. The purpose of the end-to-end transit delay is to request & indicate the maximum transit delay for the FR connection.

C.7 Transit network selection

The purpose of the transit network selection information element is to identify a requested transit network. The transit network selection may be repeated in a message to select a sequence of transit networks through which the FR VC must pass. Support of this capability is a network option.

C.8 Network management conditions

There may be cases where network management control activation will require modification to normal network routing decisions

C.9 Time, event and state conditions

There may be cases where routing decisions will be updated periodically or a periodically, predetermined, depending on the state of network or depending on whether calls succeed or fail.

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