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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE AND INTERNET PROTOCOL ASPECTS

Internet protocol aspects – Architecture, access, network capabilities and resource management

General architectural model for interworking

ITU-T Recommendation Y.1251

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ITU-T Recommendation Y.1251

General architectural model for interworking

Summary

This Recommendation specifies a general architectural model for interworking that can be used to analyze, categorize and describe cases of interworking between networks.

Two interworking methods are identified, namely **Service Interworking** and **Network Interworking**.

Source

ITU-T Recommendation Y.1251 was prepared by ITU-T Study Group 13 (2001-2004) and approved under the WTSA Resolution 1 procedure on 13 August 2002.

Keywords

Interworking, Network Interworking, Service Interworking.

FOREWORD

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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.1251

General architectural model for interworking

1 Scope

This Recommendation specifies a generic interworking model that can be used to analyze, categorize and describe cases of interworking between networks.

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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation I.510 (1993), *Definitions and general principles for ISDN interworking*.

[2] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

[3] ITU-T Recommendation Y.1001 (2000), *IP framework – A framework for convergence of telecommunications network and IP network technologies*.

[4] ITU-T Recommendation Y.1401 (2000), *General requirements for interworking with Internet Protocol (IP)-based networks*.

3 Definitions

For the purposes of this Recommendation the following definitions are employed. Consistency with definitions in other Recommendations has been taken into account and is noted where appropriate.

3.1 interworking: The term interworking is used to express interactions between networks, between end systems, or between parts thereof, with the aim of providing a functional entity capable of supporting an end-to-end communication. The interactions required to provide a functional entity rely on functions and on the means to select these functions.

NOTE – This definition is identical to that given in ITU-T Rec. I.510, see [1].

3.2 service interworking: In service interworking, the Interworking Function (IWF) of Figure 4 terminates the protocol used in network 1 and translates (i.e., mapping) the Protocol Control Information (PCI) to the PCI of the protocol used in network 2 for User, Control and Management Plane functions to the extent possible. In general, since not all functions may be supported in one or other of the networks, the translation of PCI may be partial or non-existent. However, this should not result in any loss of user data since the payload is not affected by PCI conversion at the service interworking IWF.

NOTE – This definition is identical to that given in ITU-T Rec. Y.1401, see [4].

3.3 network interworking: In network interworking, the PCI of the protocol used in network 1 and network 2 and the payload information are transferred transparently by an IWF of Figure 4. Typically the IWF encapsulates (known as tunnelling in some specifications) the information which is transmitted by means of an adaptation function and transfers it transparently to the other network.

NOTE – This definition is identical to that given in ITU-T Rec. Y.1401, see [4].

3.4 adaptation function: A processing function which adapts the client layer network characteristic information into a form suitable for transport over a trail[1] in the server layer network.

NOTE – This definition is taken from ITU-T Rec. G.805, see [2].

4 Abbreviations

This Recommendation uses the following abbreviations:

IP Internet Protocol

IWF Interworking Function

IWU Interworking Unit

PCI Protocol Control Information

5 Interworking – General considerations

5.1 The problem space

The objective of interworking is to provide end-to-end connectivity across two separate networks, N1 and N2, which cannot be directly interconnected due to the deployment of different protocols in each of these networks.

Simply, the problem to be solved is illustrated in Figure 1.

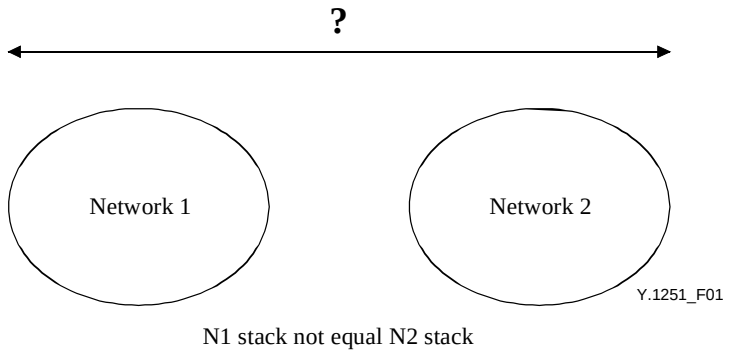

Figure 1/Y.1251 – The interworking problem

The lack of direct interconnectivity will arise when the protocol stacks in Network 1 (N1) are different from those in Network 2 (N2), and thus where one, or more protocol discontinuity will occur in an interworking path created to span both N1 and N2. This discontinuity may occur within a single given layer, some set of given layers, or within all layers between the respective networks.

5.2 Possible solutions

Two solutions are possible to achieve end-to-end connectivity.

One is to effect a semantically equivalent translation between Network 1 (N1) and Network 2 (N2). The semantic equivalence can be achieved by mapping equivalent service characteristics from N1 to N2. The basic concept is shown in Figure 2, below.

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[1] See ITU-T Rec. G.805, for further definitions of trail, etc. In this Recommendation, the use of the term "layer" or "protocol layer" is synonymous with the use of the term "layer network" in ITU-T Rec. G.805.

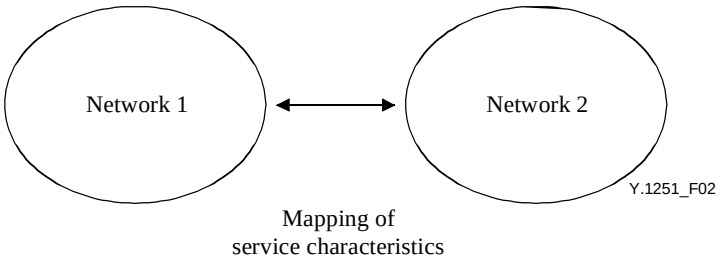

Figure 2/Y.1251 – Interworking by service mapping/translation between N1 and N2

This solution is only possible if there is sufficient similarity in service characteristics between N1 and N2. In this solution, there is a distinct discontinuity between the protocol layer(s) of N1 and N2. Thus, there is a protocol discontinuity between the user of network N1 and users of network N2. Some services of N1 may not be available to users of N2 and vice versa, due to lack of exact equivalence between all the services of N1 and all the services of N2.

This solution is known as **Service Interworking**.

The other way to achieve end-to-end connectivity is to superimpose one network on top of the other. This can be achieved by encapsulating, via an adaptation function, the relevant protocol(s), one or more, of one network on top of the protocols of the other. This is shown simplistically in Figure 3 for providing the users of N2 with access to N1. In this solution the users of N2 have to deal with the protocol layer(s) of both N2 and N1 (to some or all extent depending on the exact interworking arrangements), when intercommunication between users of N2 and N1 is required.

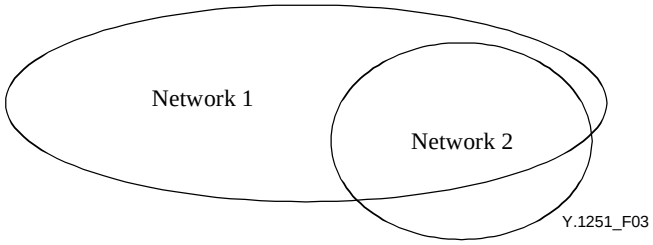

Figure 3/Y.1251 – Interworking by superimposition (Encapsulation)

This second method encapsulates the protocol(s) of N1 within the uppermost protocol of N2. Users of N2, wishing to communicate with users of N1 must use the new stack comprising the N2 stack plus the additional elements of the N1 stack used for the interworking. Theoretically, this new stack may be regarded as a new logical network N3, since users of N2 still communicate amongst themselves using the original N2 stack.

This solution is known as **Network Interworking**. It may also sometimes be called interworking by encapsulation.

In this case there is no protocol discontinuity between users of N1 and users of N2 at the superimposed interworking layer(s).

Equally possible, but not shown in the figure, protocols of N2 could be superimposed over N1.

The functions for interworking between N1 and N2, for either **service interworking** or **network interworking**, are provided by an interworking function (IWF) considered to notionally exist between the N1 and N2, as shown in Figure 4. The exact physical location of the interworking unit (IWU) containing the IWF is an implementation issue, but could be contained within N1, N2, or as an independent unit.

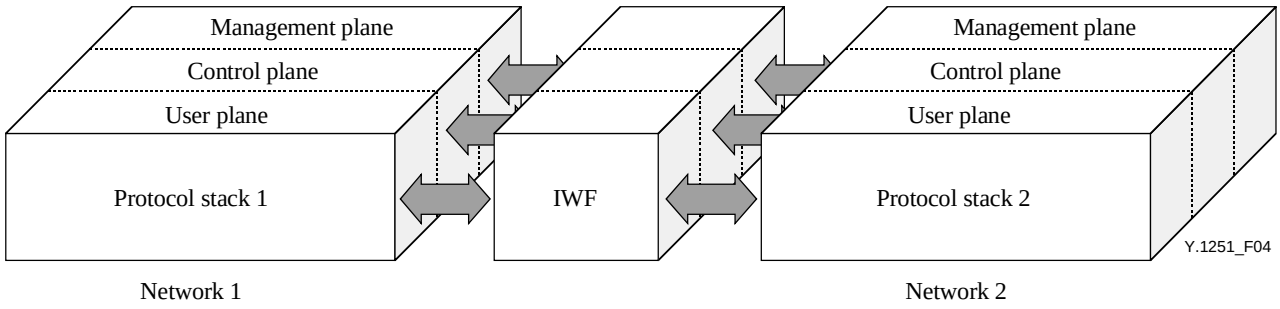

Figure 4/Y.1251 – Interworking function

6 Protocol adjacency relationships

The two methods of interworking described in clause 5 result in the need to position protocols in two different ways. The service interworking method results in the establishment of a horizontal positioning relationship between the protocols of N1 and N2. The network interworking method results in a vertical positioning relationship between the protocols of N1 and N2.

These basic positioning relationships are shown in Figure 5.

Two basic principles are involved, namely a vertical layering principle and a horizontal peering principle. Note, these principles are identical to those described in ITU-T Rec. Y.1001, see [3].

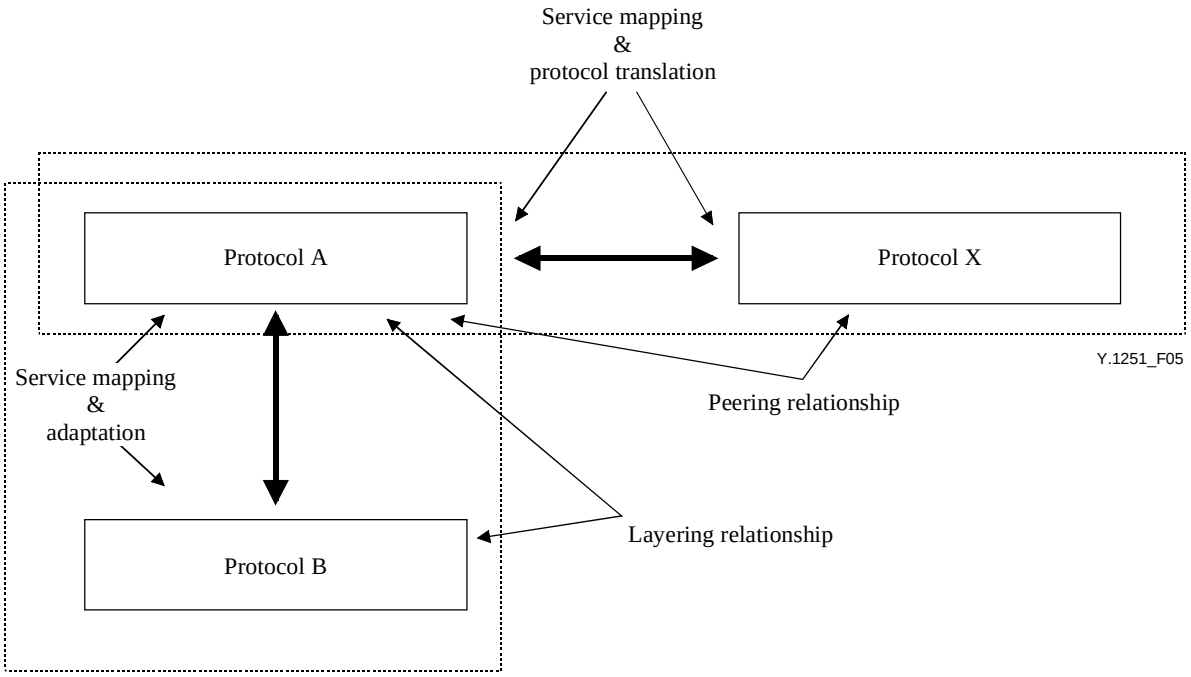

Figure 5/Y.1251 – Protocol adjacency relationships

6.1 Layering principle

In this case, there is a vertical relationship between Protocol A and Protocol B. This is a layering relationship.

Protocol A is encapsulated within Protocol B, and uses the layer service offered by Protocol B. In general, no fixed relationship between the actual protocols playing in the role of Protocol A or Protocol B can be assumed. In general, protocols can be combined in arbitrary ways. For, example,

Frame Relay can be operated over IP, or IP may be operated over Frame Relay according to the circumstances pertaining.

As far as the adaptation is concerned, an adaptation protocol may or may not involve additional protocol control information (PCI) of a shim layer format, depending on the type of mapping required. In some cases, the adaptation may simply be a question of a mapping procedure with no additional PCI being required. In other cases, additional PCI may be required to effect the encapsulation process.

6.2 Peering principle

In this case, an end-to end service is being provided by performing a translation and conversion function between Protocol A and Protocol X, via some form of IWF interposed between Protocol A and Protocol X. The IWF terminates each protocol (Protocol A and Protocol X) and performs a mapping between the services offered by Protocol A and Protocol X.

7 Generic interworking model

The cases described above apply in general to a variety of complex protocol arrangements. Generally, all these cases can be specified in terms of horizontal and/or vertical relationships between adjacent protocols. In this regard, for modelling purposes, it is only necessary to consider two adjacent horizontal protocols and two vertical protocols as shown in Figure 6. All cases, can be fully described by such a model either by degeneration for the case of single layer, or recursive application of the model to the other adjacencies that would exist in a multi-layer situation. This principle applies to the user, control and management planes.

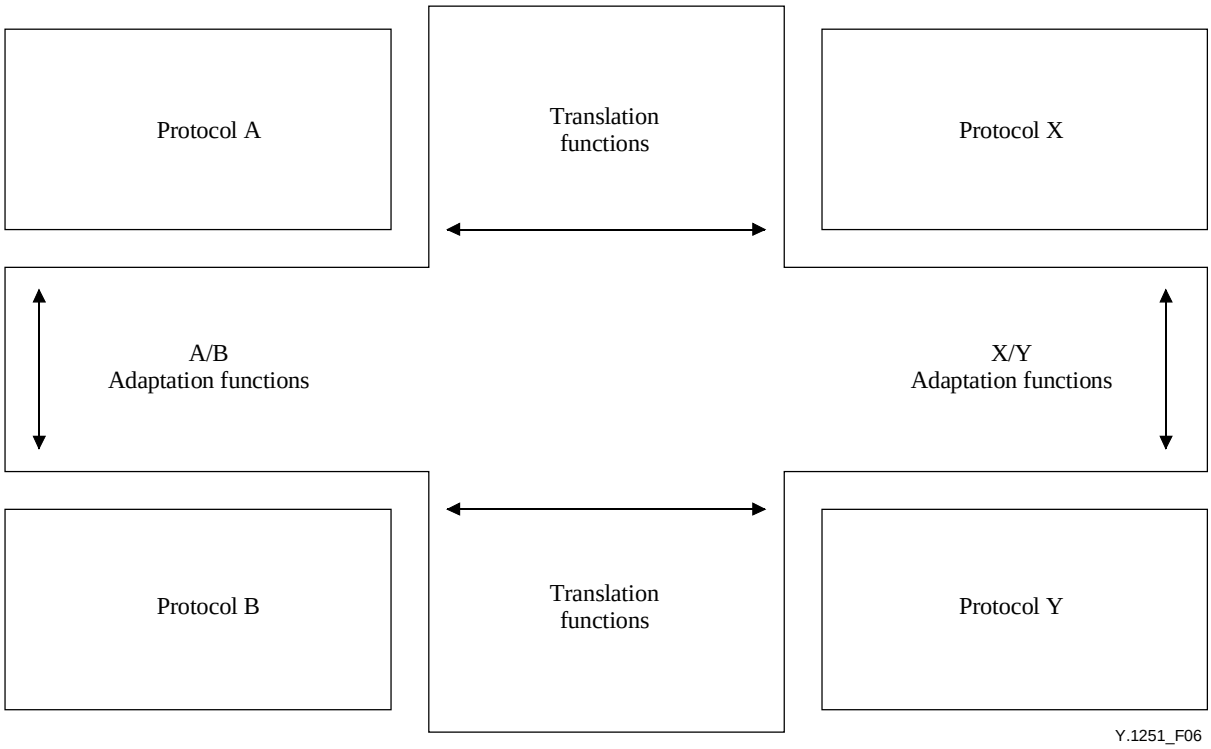

Figure 6/Y.1251 – Generic interworking model

Every interworking arrangement can now be described by comparing the horizontal protocol adjacencies, A-X and B-Y, and vertical adjacencies A-B and X-Y. The model can be re-applied to all pairwise adjacencies, to analyze the entire relationship and possible solutions for between any two disparate protocol stacks belonging to different networks.

For example, if protocol A is not equal to protocol X, but sufficient semantic equivalence exists, protocol A could be translated to X by a semantic functional mapping elements of the interworking functions contained in an interworking unit. This case also embraces the concept service interworking case, where end-to-end semantics across the IWF are preserved by service mapping.

Alternatively, if this is not possible or desirable, then a common protocol, say protocol A, must be used on both sides (i.e., protocol X becomes the same as protocol A) and is encapsulated within protocol Y by some interworking adaptation function. This is the case of superimposing N1 over N2, interworking by encapsulation. An adaptation protocol may or may not involve additional protocol control information (PCI) of a shim layer format, depending on the type of mapping required. This embraces the concept of network interworking.

It should be noted that in this Recommendation the use of the term peer-to-peer will not be associated with any given protocol, for the following reasons:

a) All protocols that generate formats (i.e., specific and explicit syntax) are peer-to-peer, in that there is always source for generating the protocol format and sink for receiving the protocol in a given stratum of operation (in the same layer or sub-layer). This fact says nothing about the specific role of any specific protocol itself, i.e., what it is being used for, or anything about its type.

b) Some interworking adaptation protocols do not generate any format (syntax) as such. This is true of many interworking protocols which provide mapping functions from one layer to a lower layer. These are still be peer-to-peer, i.e., implicitly operating between corresponding remote peer entities. For example, Fragmentation and Reassembly procedures fall into this category, in that they have defined procedures but generate no format for transmission and/or reception.

c) It is not possible to label a protocol as being of a particular absolute kind. Any given protocol can play many different roles in different contexts. There are numerous examples, where protocols may play different roles in different contexts.

8 Application of the model to service interworking and network interworking

The following two clauses show application of the generic model to the Service Interworking and Network Interworking cases.

8.1 Service interworking

Figure 7 shows an example of service interworking by service mapping. In this example, there is a protocol discontinuity at the interworking layer, since protocol A and protocol X are not identical. Mapping and translation functions are used to convert the services provided by protocol A into formats and services provided by protocol X.

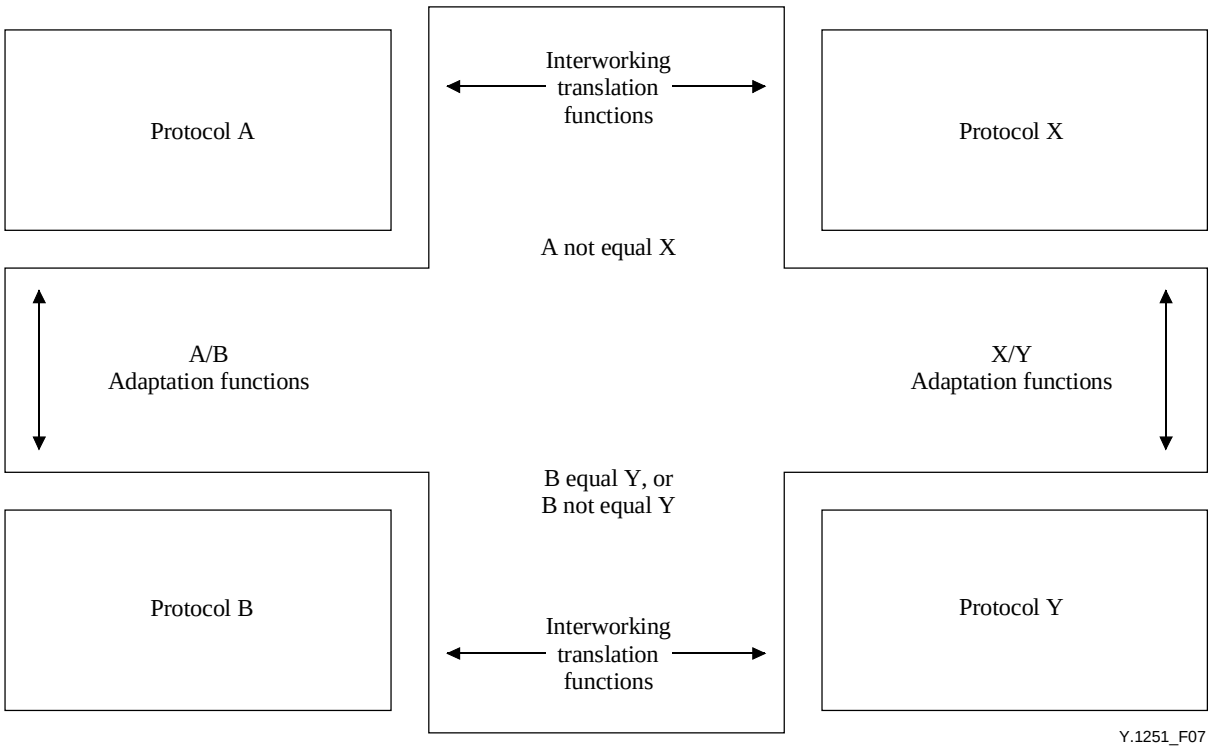

Figure 7/Y.1251 – Application of model to service interworking

8.2 Network interworking

Figure 8 shows the case where the protocol of N1 is superimposed over the protocol of N2 to effect interworking. In this case, protocol A is transferred across the IWF to become protocol X. Thus it is, in fact, protocol A, which now has to be encapsulated over protocol Y, via some suitable adaptation function and may be an additional adaptation shim layer protocol. In this case, there are protocol discontinuities at layers B and Y, but no protocol discontinuity at the upper layer since protocol X is identical to protocol A, i.e., there is a single common protocol across N1 and N2 (for interworking purposes).

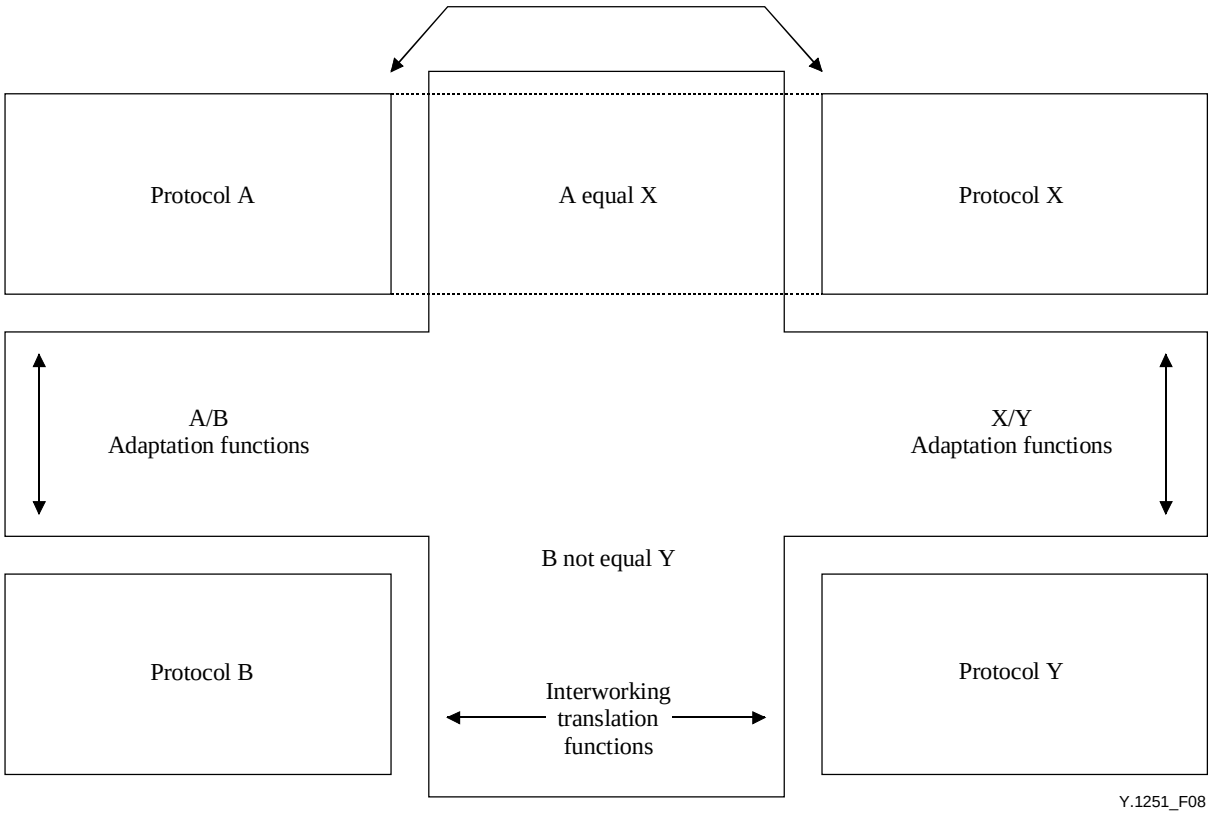

Figure 8/Y.1251 –Application of model to Network Interworking

A common usage/application of this method involves three physically separate networks, where two similar networks N1 and N3 are interconnected via a third dissimilar network N2, as shown in Figure 9.

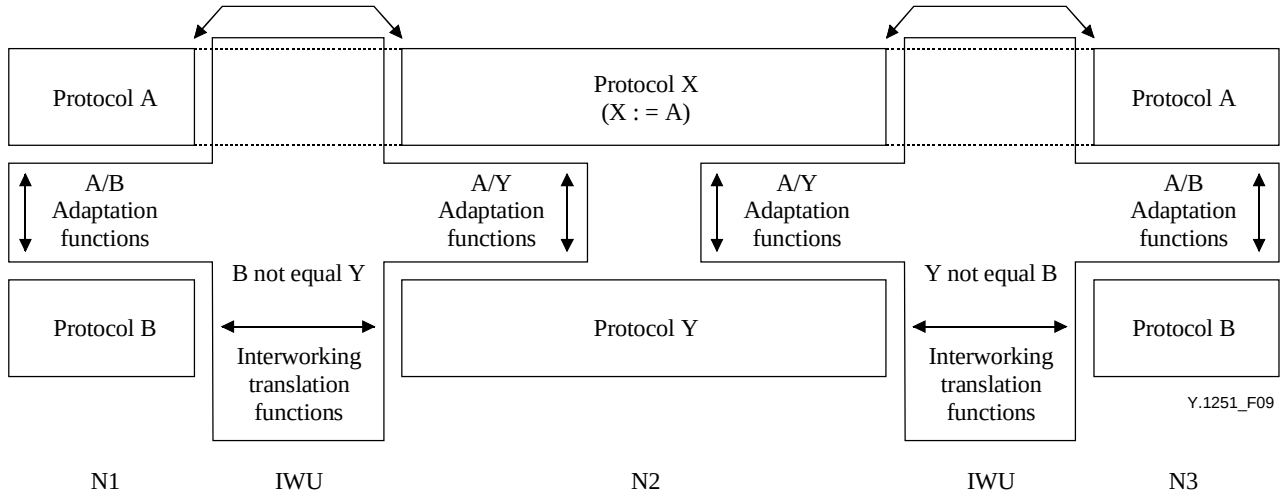

Figure 9/Y.1251 – Example of Network Interworking

In such a case we have application of two IWUs. Both the IWFs apply adaptation functions, i.e., encapsulation and decapsulation at the border between N1 and N2 and at the border between N2 and N3 for the bidirectional carriage of the common N1/N3 protocol over N2. In this case, the protocol of N1/N3 is carried transparently over N2. When only two dissimilar networks are involved one of the end systems could be regarded as constituting a third network handling the common protocol.

9 Related principles

In general, it can be stated that whenever any protocol stack difference exists between two networks, interworking is required to interconnect the two networks. This general principle is independent of the method used to achieve such interworking, i.e., irrespective of whether the service interworking method of 8.1 or the network interworking of 8.2 is used to effect such interworking.

Any protocol discontinuity between N1 and N2, at any layer of their respective stacks, constitutes interworking. For example, if N1 were IP over a Local Area Network and N2 was IP over Frame Relay, interworking is taking place between the Local area Network and the Frame Relay network because of the layer 2 discontinuity, even though there is no discontinuity at layer 3 (the IP layer). Adaptation functions are required for IP over the LAN layer 2 protocol and for IP over the Frame Relay protocol.

If layer N is the uppermost layer from the interworking standpoint, there must be at least one layer protocol discontinuity between the protocol stacks of networks N1 and N2 for their interconnection to be considered as an interworking case. This discontinuity may occur at layer N itself, or at any other layer N–j (for j less than N; j greater equal 1), or at several layers simultaneously including or excluding the layer N itself. It should also be noted that the number of layer protocols in each stack may be different.

In general, mappings between features may span several layers. It cannot be assumed that mappings performed purely at a peer level are sufficient, or that each peer layer is independent of the underlying layer(s). For example, a particular feature at layer N in N1 may be required to be mapped to non-peer layer in N2. These considerations may apply particularly to QoS related features and/or aspects.

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