Interworking of B-ISDN Signaling and Internet Protocol

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Abstract. In the ITU-T and IETF, I proposed the assignment of the information field and protocol identifier in the Q.2941 GIT (Generic Identifier Transport) and Q.2957 UUS (User-to-User Signalling) for the Internet protocol. The aim is to enable B-ISDN signaling support to be used for session of the Internet protocol. The purpose of this paper is to clarify how these specifications enable B-ISDN signaling support to be used for long-lived and QoS-sensitive sessions.
Long-lived session requires that the B-ISDN signaling be capable of transferring a session identifier, which is currently supported only by proprietary protocols. By using the GIT information element, B-ISDN signaling can be used to support it.
To implement ATM VC support for QoS-sensitive session, this paper describes three approaches. In QoS-sensitive session using these approaches, the B-ISDN signaling must transfer the session identifier or IP signaling protocol. Therefore, B-ISDN signaling based on current recommendations and standards cannot support QoS-sensitive session. These problems can be solved by using the GIT or UUS information element, as I have proposed.

1 Introduction

With the development of new multimedia applications for the Internet, the need for multimedia support in the IP network, which currently supports only best-effort communications, is increasing. In particular, QoS-guaranteed communications [1,2] is needed to support the voice, audio, and video communications applications being developed. Mechanisms will also be needed that can efficiently transfer the huge volume of traffic expected with these applications.

The major features of B-ISDN are high speed, logical multiplexing using VPs and VCs, and flexible QoS management per VC, so it is quite natural to use these distinctive functions of B-ISDN to implement a multimedia-support mechanism in the Internet. When a long-lived session[1] is supported by a particular VC, efficient packet forwarding is possible by using the high-speed and

[1] The Internet protocol reference model does not contain the session and presentation layers, so communication between end-to-end applications over the Internet is equivalent to a session; the term "session" is thus used in this paper.

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logical multiplexing of B-ISDN [3,4]. The flexible QoS management and logical multiplexing functions in B-ISDN will enable QoS-guaranteed communications to be implemented on the Internet [5,6].

Currently on the Internet, N-ISDN is widely used as a datalink media. In the B-ISDN technology area, development of classical IP over ATM [7] and LAN emulation [8] technologies, which use a VC as the datalink media, has been completed. These technologies are already implemented in a large number of products. However, the development of Internet technologies that use the distinctive B-ISDN features described in above is progressing slowly. There are a number of reasons for this. One is that for applications to be able to practically use B-ISDN features, advanced functions not supported by N-ISDN must be used. However, the architecture of B-ISDN signaling is basically the same as that of N-ISDN signaling, so it does not meet the requirements of such applications.

Therefore, in the ITU-T and IETF, I proposed the assignment of the information field and protocol identifier in the Q.2941 GIT (Generic Identifier Transport) [9] and Q.2957 UUS (User-to-User Signalling) [10] for the Internet protocol [11,12,13]. The aim is to enable B-ISDN signaling support to be used for session of the Internet protocol; ITU-T recommendations and a standard track RFC based on this proposal will be published. The purpose of this paper is to clarify how these specifications enable B-ISDN signaling support to be used for long-lived and QoS-sensitive sessions.

First, this paper describes a method for implementing ATM VC support for long-lived session and explains why B-ISDN signaling must be capable of transferring a session identifier. Then it explains why the current B-ISDN signaling cannot satisfy this requirement and shows how the problem can be solved by using the GIT information element.

Next, this paper describes three approaches to implementing ATM VC support for QoS-sensitive session and compares the features and problems of these approaches. With these approaches, the B-ISDN signaling must be capable of transferring the session identifier or IP signaling protocol. Then it explains why the current B-ISDN signaling cannot satisfy this requirement and explains how the problem can be solved by using the GIT or UUS information element.

2 Long-Lived Session Signaling

2.1 ATM VC Support for Long-Lived Session

An example scenario of ATM SVC support for a long-lived session is shown in Fig. 1. First, a session is multiplexed into the default VC connecting the routers. Then, if a router detects that it is a long-lived session, the router sets up a new VC for the session. After the new VC is established, the session is moved to it [3,4].

ATM PVC support for long-lived session can be implemented as follows: PVCs connecting the routers are pre-configured, and when a router detects a long-lived session, it selects an available PVC and moves the long-lived session to it.

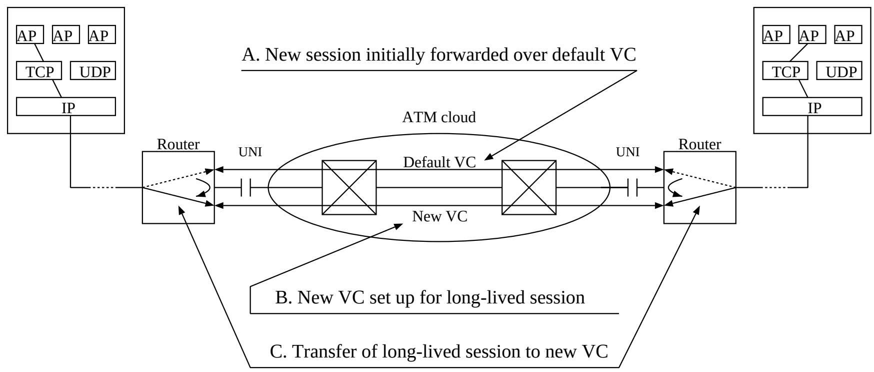

Fig. 1. Example scenario of ATM SVC support for long-lived session

ATM VC support for long-lived session was proposed by Newman and Katsube [3,4]. Support is provided by using the high-speed and logical multiplexing features of B-ISDN, which enable efficient packet forwarding. However, these proposals do not use the standard B-ISDN signaling protocol; proprietary protocols are used instead.

2.2 Requirements for B-ISDN Signaling

If the ATM SVC support for long-lived session described above is implemented using B-ISDN signaling, the B-ISDN signaling entity in the called-side router must detect that the incoming call corresponds to a session of the Internet protocol and notify the IP-layer entity. Based on this information, the IP-layer entity would move the session to the new VC. Therefore, to implement this signaling procedure, the SETUP message in the B-ISDN signaling must include a session identifier as an information element.

A session in the Internet is identified by a combination of the source and destination IP addresses, the protocol number, and the source and destination port numbers. The length of an IPv4 address is 4 octets, and that of an IPv6 address is 16 octets; the protocol number takes 1 octet, and the port number takes 2 octets, so the length of the session identifier for IPv4 is 13 octets and for IPv6 is 37 octets [14,15,16,17]. A session of the ST2+ (IPv5) is identified by the SID, which is 6 octets long [1].

Therefore, to enable ATM SVC support for long-lived session, the SETUP message in the B-ISDN signaling must be capable of transferring a session identifier of at least 37 octets long.

2.3 Problems with Current B-ISDN Signaling and Solution

Session identifier in Q.2931 and UNI 3.1. The SETUP message defined in the Q.2931 and UNI 3.1 signaling protocol specifications contains a B-HLI (broadband high-layer information) information element that could be used to transfer the session identifier [18,19]. However, when "Vendor Specific" is selected for the high layer information type in the B-HLI element, the identifier is restricted to 4 octets, and when "User Specific" is selected, it is restricted to 8 octets. Therefore, the SETUP message defined in the Q.2931 and UNI 3.1 specifications cannot hold the session identifier.

Session identifier in SCS2 and SIG 4.0. The SETUP message defined in the SCS2[2] and SIG 4.0 signaling protocol specifications contains B-HLI and GIT information elements that could be used to transfer the session identifier [9,20]. The GIT element enables the transfer of identifiers between end-to-end users in an ATM network and is an optional information element for the UNI signaling protocol. In the SCS2 and SIG 4.0 specifications, signaling messages transferred between end-to-end users may contain up to three GIT information elements, and the ATM network transfers the elements transparently.

However, in these specifications, the maximum length of the GIT element is 33 octets, so it cannot hold the IPv6 session identifier. Furthermore, they also do not assign an identifier type for the Internet protocol.

Solution using GIT. To solve these problems, I proposed the assignment of the information field and protocol identifier in the Q.2941 GIT for the Internet protocol. It is also proposed increasing the maximum length of the information element.

A GIT information element consists of a common header and identifiers. Each identifier consists of identifier type, length, and identifier value fields. The sum of the length of the common header, identifier type, and length fields is 7 octets. The maximum length of the session identifier for the Internet protocol is 37 octets, so the length of the GIT information element must be extended to at least 44 octets. In the new GIT recommendation, the length is extended to 63 octets, and identifier types for the IPv4, ST2+, IPv6, and MPLS protocols are supported.

3 QoS-Sensitive Session Signaling

3.1 ATM VC Support for QoS-Sensitive Session

The major difference between ATM VC support for long-lived and QoS-sensitive sessions is whether SVC setup or PVC selection timing is used. In the former, a setup or selection is initiated when a long-lived session is detected, but in the latter, it is initiated when resource is reserved by the IP signaling protocol such as the ST2+ and RSVP. In the latter case, the ATM network between routers must forward the IP signaling protocol.

[2] Signalling Capability Set No. 2: series of B-ISDN signaling recommendations issued by the ITU-T.

There has been little discussion of connection-oriented network support for connection-oriented protocols. Damaskos and Gavras investigated B-ISDN signaling support for the BERKOM Transport System [21], and N-ISDN signaling support for OSI connection-mode network service is mentioned in ITU-T Recommendation Q.923 [22]. However, implementation of signaling protocol support for connection-oriented protocols was not addressed completely.

Damaskos and Gavras discussed two schemes for forwarding the IP signaling protocol over an ATM network. One is to multiplex the protocol into the default VC connecting the routers or to forward the protocol through a particular VC. This scheme is called the sequential approach; resource reservation in the IP layer and SVC setup are initiated sequentially. The second scheme is to forward the IP signaling protocol as an information element in the B-ISDN signaling. This scheme is called the simultaneous approach; resource reservation in the IP layer and SVC setup are initiated simultaneously [21].

The sequential approach can be further classified into two practical schemes. One is to initiate resource reservation in the IP layer after SVC establishment; it is called the bottom-up approach in this paper. The second is to initiate SVC establishment after resource reservation; it is called the top-down approach in this paper. These sequential approaches are applicable if the ATM network supports only PVC; the simultaneous approach is not.

3.2 Comparison of IP Signaling Protocol Forwarding Schemes

This section compares the features and problems of these three approaches for forwarding the IP signaling protocol. The following figures show example procedures for enabling ATM SVC support for QoS-sensitive session based on IP and B-ISDN signaling protocols across the UNIs in the ATM network connecting the routers. In the figures, an “S” means a IP signaling entity and a “B” means a B-ISDN signaling entity. These figures do not show the VC setup procedure that forwards the B-ISDN or IP signaling protocol.

Both ST2+ and RSVP have been proposed for the IP signaling protocol, and other IP signaling protocols are likely to be developed in the future. Therefore, to generalize the discussion, the procedure for the IP signaling protocol in the figures is the general connection setup procedure using confirmed service. In the figures, N-CONNECT and N-CONNECT-ACK show the resource reservation request and response messages, respectively; these messages are issued by the IP signaling entity. The SETUP, CALL PROC, CONN, and CONN ACK show the B-ISDN signaling messages.

Overview of bottom-up approach. An example procedure of SVC support for the bottom-up approach is shown in Fig. 2. After an SVC is established, the IP signaling entity on the called side watches for the arrival of the N-CONNECT message corresponding to the SVC. When it receives an N-CONNECT message, it confirms the existence of the SVC corresponding to it. Therefore, the SETUP message in the B-ISDN signaling must contain a session identifier and notify the

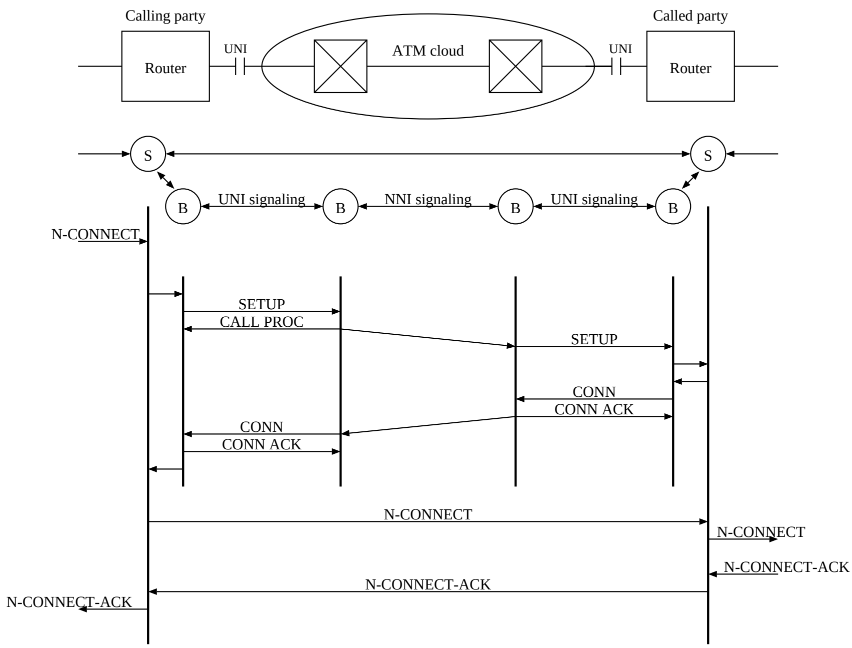

Fig. 2. Example procedure of SVC support for bottom-up approach

IP signaling entity of the arrival. If an N-CONNECT message does not arrive with a specified time from the SVC establishment, the IP signaling entity on the called side disconnects the SVC.

While this procedure is simple straight-forward scheme, it has some problems.

– If the IP signaling protocol supports negotiation, the SVC cannot reflect the negotiated parameters because the SVC is established before resource is reserved in the IP layer.
– If an N-CONNECT message is received from a user who is not allowed to access the IP layer, communication via the SVC may be possible until access denial is received from admission control. This is because after SVC establishment, admission control in the IP layer is initiated by the IP signaling protocol. There is thus a security problem.
– In the IP signaling entity on the called side, watchdog timer processing, which supervises the arrival of an N-CONNECT message, is needed after an SVC is established.

Note that in this example, the requester of the resource reservation and the calling party of the B-ISDN signaling are on the same side. However, in practical networks, it is possible that they are on opposite sides for administrative reasons.

If so, the B-ISDN signaling uses a callback procedure from the response side of the resource reservation. This scheme has the same problems as the one above.

The difference between PVC and SVC support for the bottom-up approach is that in PVC support, when an N-CONNECT message arrives at the IP signaling entity, it selects an available PVC, and does not establish an SVC. Therefore, it has the same problems as SVC support, except for the watchdog timer processing problem.

Overview of top-down approach. An example procedure of SVC support for the top-down approach is shown in Fig. 3. After resource is reserved in the

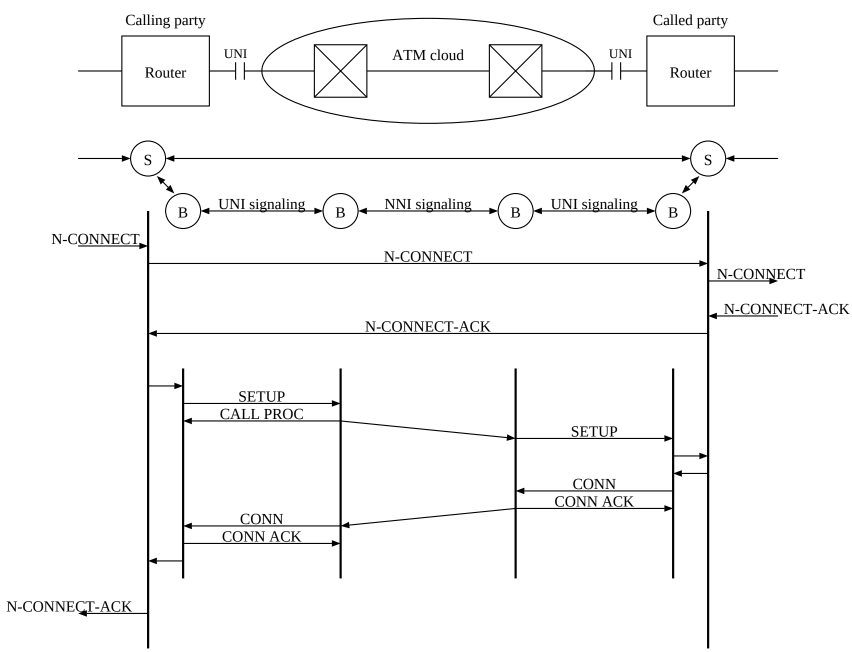

Fig. 3. Example procedure of SVC support for top-down approach

IP layer, the IP signaling entity on the called side watches for the arrival of a STEUP message corresponding to the reserved resource. When it receives a SETUP message, it confirms the existence of the reserved resource corresponding to the message. Therefore, the SETUP message in the B-ISDN signaling must contain a session identifier and notify the IP signaling entity of the arrival. If a SETUP message does not arrive with a specified time from the resource reservation in the IP layer, the IP signaling entity cancels the reservation.

This procedure has the following problems.

– If other network-layer protocols use ATM, it is possible that admission control for the ATM layer will fail due to insufficient resources, in spite of the resource reservation in the IP layer. This is because admission control for the ATM layer is initiated after the resource reservation.
– In the IP signaling entity on the called side, watchdog timer processing, which supervises the arrival of a SETUP message, is needed after resource reservation.

As in the previous example, the requester of the resource reservation and the calling party of the B-ISDN signaling are on the same side, but they may be on opposite sides. If so, the B-ISDN signaling uses a callback procedure from the response side of the resource reservation. This scheme has the same problems as the one above.

The difference between PVC and SVC support for the top-down approach is that in PVC support, when an N-CONNECT-ACK message arrives at the IP signaling entity, it selects an available PVC and does not establish an SVC. Therefore, it does not need watchdog timer processing. However, it encounters a similar problem with admission control: the IP signaling entity cannot select an available PVC due to exhaustion in spite of the resource reservation in the IP layer.

Note that in both the bottom-up and top-down approaches, if the relation between PVCs connecting routers and sessions changes dynamically, each PVC must have an identifier that is unique between routers, and the router that determines the relationship must notify the other router of the identifier. The IP signaling protocol must therefore be capable of transferring a PVC identifier.

Overview of simultaneous approach. An example procedure of SVC support for the simultaneous approach is shown in Fig. 4. In this approach, the IP signaling protocol is forwarded as an information element of the B-ISDN signaling, and the B-ISDN signaling entity on the called side notifies the IP signaling entity of the message. Therefore, with this approach, the B-ISDN signaling must be capable of transferring the IP signaling protocol. In addition, the SETUP message in the B-ISDN signaling must contain the session identifier, which is usually contained in the IP signaling protocol. This procedure is not applicable if the ATM network supports only PVC.

Comparison of approaches. While the bottom-up approach seems a natural one because it establishes the ATM connection first, it cannot support the negotiation function of the IP signaling protocol and it may have a security problem.

The top-down approach seems an unnatural one because it reserves resource in the IP layer first, but it does not have the problems of the bottom-up approach. However, it needs watchdog timer processing to supervise the arrival of a SETUP message, so its implementation is more complex.

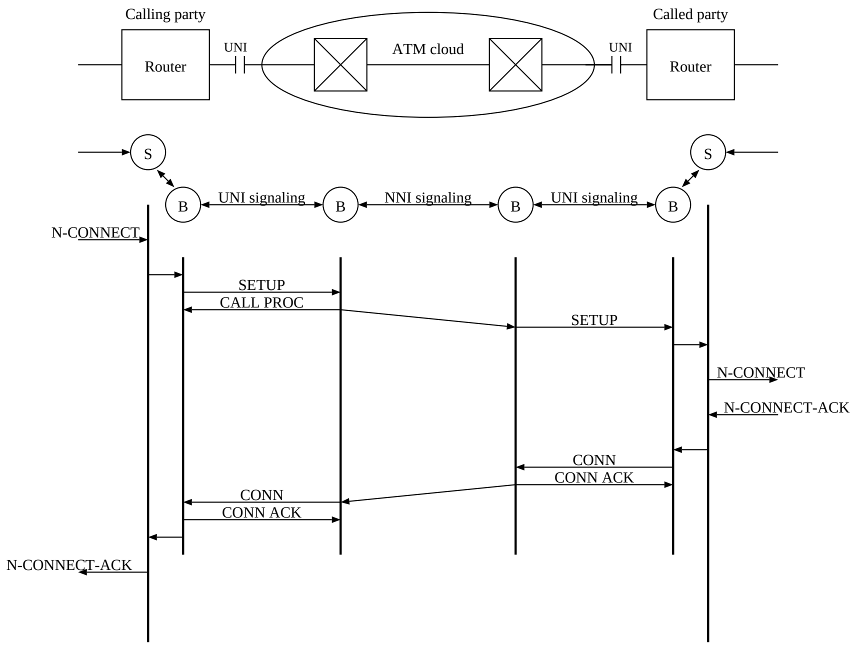

Fig. 4. Example procedure of SVC support for simultaneous approach

The simultaneous approach does not have these problems and is easier to implement than the top-down approach. However, it is not applicable if the ATM network supports only PVC.

The simultaneous approach has many features comparable to those of the top-down approach, so it is the most appropriate if the ATM network supports SVC. Therefore, QoS-session signaling should be implemented using the simultaneous or top-down approach.

3.3 Requirements for B-ISDN Signaling

Similarly to the long-lived session signaling, if ATM SVC support for QoS-sensitive session is implemented using the bottom-up or top-down approach, the SETUP message in the B-ISDN signaling must be capable of transferring the session identifier. If the simultaneous approach is used, the B-ISDN signaling must be capable of transferring the IP signaling protocol.

3.4 Problems with Current B-ISDN Signaling and Solution

The Q.2931 and UNI 3.1 signaling protocol specifications do not contain an information element that could be used for transferring the IP signaling protocol.

The SCS1[3] and SIG 4.0 protocol specifications contain a UUS information element, which could be used for transferring the IP signaling protocol [10,20]. The UUS element enables the transfer of information between end-to-end users in an ATM network; it is an optional information element in the UNI signaling protocol. In SCS1 and SIG 4.0, signaling messages transferred between end-to-end users may contain a UUS element, and the ATM network transfers this element transparently.

These specifications do not assign a protocol discriminator for the Internet protocol. Therefore, I proposed the assignment of the information field and protocol identifier in the Q.2957 UUS for the Internet protocol. In the new UUS recommendation, a protocol discriminator for the Internet protocol is assigned. (The problems and solution for the session identifier were described in section 2.)

4 Discussion

Depending on the IP signaling protocol architecture, if the IP signaling protocol supports uni-directional multicast communications, the simultaneous approach using the Q.2957 UUS element may have a problem.

A multicast tree consists of a sender, receivers, and routers corresponding to the root, leaves, and nodes, respectively. An ATM SVC connecting a sender and a router or two routers corresponds to a session, and this session may support several receivers. Because the UUS element transfers user-to-user information by using a B-ISDN signaling message, once an SVC is established, it cannot support transferring information until just before it is disconnected. Therefore, once an SVC connecting a sender and a router or two routers is established, this branch cannot support transferring the IP signaling protocol for additional receivers.

This problem does not occur if the IP signaling protocol architecture is as follows: when adding a new receiver to a session, if a router between the sender and receiver does not need to reserve a new resource, like RSVP, the IP signaling protocol is terminated at the router. This is because a branch between the sender and a router or two routers whose resource is already reserved, i.e., an SVC has been established, need not transfer the IP signaling protocol for the new receiver.

However, this problem occurs if the architecture is as follows: when adding a new receiver to a session, like ST2+, the IP signaling protocol must be exchanged between the sender and the receiver. Needless to say, this problem does not occur in a branch that supports only one receiver, i.e., an ATM SVC connecting the sender and a receiver or between a router and a receiver.

The UUS service 3 category may solve this problem. The Q.2957 UUS recommendation describes three service categories: service 1 transfers user-to-user information by using B-ISDN signaling messages, service 2 does it during the call-establishment phase, and service 3 does it while the call is active. However,

[3] Signalling Capability Set No. 1: covers ITU-T Recommendations Q.2931, Q.2951.X, Q.2955.1, and Q.2957, which are the basis of B-ISDN signaling.

Q.2957 provides detailed specifications for service 1 only, it does not specify services 2 and 3. Once the UUS protocol for service 3 is specified, this problem is solved because the IP signaling protocol can be transferred after call establishment.

The APM (application transport mechanism) may also solve this problem. The APM enables message exchange between any signaling entities; Q.2765 [23] describes an APM protocol between the NNIs in an B-ISDN. If an APM protocol between the UNIs of a B-ISDN is specified, this problem is solved because the IP signaling protocol can be transferred after call establishment.

5 Conclusion

In this paper I explained how the specifications, I proposed in the ITU-T and IETF, enable the B-ISDN signaling support to be used for long-lived and QoS-sensitive sessions.

Long-lived session requires that the B-ISDN signaling be capable of transferring a session identifier, which is currently supported only by proprietary protocols. By using the GIT information element, B-ISDN signaling can be used to support it.

To implement ATM VC support for QoS-sensitive session, I described three approaches: resource in the IP layer is reserved after the VC corresponding to the resource is established, the VC is established after the resource is reserved, or the resource is reserved and the VC is set up simultaneously. The first two approaches are applicable to SVC/PVC ATM networks, while SVC networks only support the third approach, whose implementation is the simplest.

In QoS-sensitive session using the first two and final approaches, the B-ISDN signaling must transfer the session identifier and the IP signaling protocol, respectively. Therefore, B-ISDN signaling based on current recommendations and standards cannot support QoS-sensitive session. These problems can be solved by using the GIT or UUS information element, as I have proposed. However, depending on the IP signaling protocol architecture, if the IP signaling protocol supports multicast communications, the final approach may not transfer the IP signaling protocol for additional receivers, and solutions using the UUS service 3 category or APM were discussed.

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