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Architecture of the Resource Reservation Service for the Commercial Internet

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Status of This Memo

1. Introduction

With the development of new multimedia applications, such as voice, audio, picture, and video communication, the demands on the resource reservation service are increasing, especially as Internet traffic volume grows explosively due to these applications. Therefore, tariff systems for Internet service have tended to adopt measured rate billing, and the resource reservation setup protocol [1, 2] is increasingly important as a method for implementing measured rate billing. The resource reservation setup protocol must support billing if it is to be applied to the commercial Internet, especially measured rate billing between interconnected Internet Service Providers (ISPs) is needed.

The purpose of this document is to clarify the architecture that should be used for the resource reservation service for the commercial Internet. First, this document explains the basis of the tariff for current telecommunication and Internet services. Then it clarifies problems in the billing for Internet service, and describes

how billing can be improved by using the resource reservation setup protocol. Finally, it also studies technical and application models for a commercial resource reservation service model, and clarifies an architecture for the resource reservation setup protocol.

Incidentally, it is essential to examine billing based on business administration issues, not technical ones. For example, on a telephone service, it technically makes sense to charge the caller when the user being called is on another line. This is because,

telephone switches were in operation when they notified the caller that the number he called was busy. However, such a billing policy is contrary to the customs of business. Readers should note that the billing problems and solutions discussed in this document are not only based on the technical viewpoint.

2. The Basis of the Tariff

Basic elements that determine the network tariff are distance, bandwidth, time, and information volume. In many cases, the network tariff reflects the link cost to some extent.

In this document, distance means the distance between the regions where users call from and to, not the actual length of the physical links that connect users. In actual communication, a route depends on network situations, so a charge based on the physical link distance is inappropriate.

2.1 The Tariff in Telecommunication Services

Classifications of the basic styles of tariff systems in telecommunication services and some examples are shown below. The following classifications do not cover applied billing styles, for example contents-based charging or premium charging such as the Dial Q2 service of NTT, or the 900 telephone service.

o Flat-rate billing

- Leased line
  In most cases, the tariff is based on distance and bandwidth.

- PVC-based frame relay and ATM
  In most cases, the tariff is based on distance and bandwidth.

o Measured-rate billing

- Telephone
  In most cases, the tariff is based on distance and time.

- Circuit switching
  In most cases, the tariff is based on distance, bandwidth, and time.

- SVC-based frame relay and ATM
  In most cases, the tariff is based on distance, bandwidth, and time, or information volume.

- X.25 packet switching
  In most cases, the tariff is based on information volume.

Furthermore, measured rate billing is classified into calling- or called-party billing. The basic charge style for telecommunication service is calling-party billing.

o Calling-party billing

- Usual telephone service

o Called-party billing

- The Free Dial service of NTT and the 800 telephone service.

Basically, telecommunication service is designed for connection-oriented, point-to-point, and bidirectional communication. In the case of measured-rate billing, usually the calling or the called party pays the bidirectional communication charge. In the case of called-party billing, a function that allows incoming calls to be accepted or refused based on the calling-party address, or a function that restricts the calling-party addresses that are permitted to use called-party billing, is indispensable. This is because, the communication charge that a called party is willing to accept is usually limited.

The current tendency in telecommunication-service tariff systems is to change from measured-rate billing, which reflects link costs accurately, to flat-rate billing, which simplifies the charging system, and service tends to be provided by flat-rate billing inside a single provider. The tariff for services between provider is usually the sum of the individual providers charges. Flat-rate billing, like that within a single provider, is not currently realistic for services that cross providers.

2.2 Tariffs for Internet Service

Classifications of basic styles and examples of the tariff system for Internet service are shown below.

o Flat-rate billing

- Internet access via leased line, PVC-based frame relay, or ATM
  In most cases, the tariff is based on bandwidth.

o Measured-rate billing

  - Dialup Internet access using a modem or N-ISDN
    In most cases, the tariff is based on time.

  - Internet access via leased line, PVC-based frame relay, or ATM
    Some ISPs have adopted information-volume-based tariff systems.

Note: Dialup access charges in this document do not include the basic telephone fee.

Until now, the tariff system for Internet access has mainly been flat-rate billing, because measured-rate billing is technically difficult to implement. However, the development of new multimedia applications, such as voice, audio, picture, and video communication, has caused the traffic over the Internet to increase explosively. The cost of using the public network service is lower than when using a private network system, if users can share equipment and lines. However, if the traffic from all its users is at a steady high rate, the cost advantage of the public network service is lost. Therefore, Internet service tariff systems, although they use leased line access, tend to adopt information-volume-based tariff systems.

3. Billing in the Resource Reservation Service

3.1 Problems of Billing in Internet Service

Basically, the tariff system for Internet service seems similar to that for telecommunication service. However, note that the tariff system for Internet service based on the access method from the user site to the ISP, is not based on the end-to-end communication method. The Internet is a connection less and unreliable communication, and some users are beginning to use it for multicast communication. But, the telecommunication is basically a connection-oriented, point-to-point, and bidirectional form of communication, so telecommunication and Intrenet communication are essentially different in some ways.

Current Internet service does not allow billing based on end-to-end user site distance. This is because the structure of the IP address is flat, rather than a layered structure that contains information about the provider and region. So information about distance for billing purpose cannot be obtained from the IP address directly.

Note: In this document, an address means an identifier, such as a class A, B, or C IP address, that uniquely distinguishes an end point. It does not means a group identifier such as a class D address.

For Internet service, billing based on bandwidth can be provided, but only for the line bandwidth between the user site and the ISP; it is not based on the end-to-end user or application bandwidth, such as the bandwidth in telecommunication services.

Current Internet service, except for the dialup access, does not allow billing based on time because the IP is a connection less communication, and timing information about the beginning and ending of billing is too difficult to obtain.

Some current ISPs have adopted information-volume-based tariff systems. However, this billing is based on the information volume of IP packets that are sent to or received from the user site and the ISP. Again, because the IP is a connection less and unreliable communication, it is too difficult to provide billing based on the information volume of IP packets that are actually used between end-to-end users or applications.

It is not impossible to provide both user billing, and application provider billing over the Internet when particular services are used. These forms of billing are equivalent to calling- and called-party billing in telecommunication service. However, obtaining the timing information about the beginning and ending of application usage at the IP layer is too difficult because the IP is a connection less communication. To have billing based on usage time, the service application responsible for the bill must identify the user and monitor the usage. Also a billing process, where part of the billing is transferred from the user to the service provider, must be implemented. As a result, the billing system complexity is increased.

3.2 Improved Billing Using the Resource Reservation Setup Protocol

As explained above, billing for current commercial Internet service has many problems, but a resource reservation setup protocol may solve these problems.

For example, the resource reservation setup protocol ensures the availability of end-to-end network resources, so billing based on bandwidth (FlowSpec) between user sites may be possible. Also, the resource reservation setup protocol explicitly shows the resource acquire and release timings, so billing based on time may be feasible.

The resource reservation setup protocol also guarantees QoS based on the FlowSpec, so billing based on the information volume that is actually used between end-to-end users or applications may also be feasible. Furthermore, there is a possibility that the billing for each IP flow can be distributed to ether the sender or the receiver.

However, the resource reservation setup protocol cannot solve the problem of how billing can be based on distance because the flat structure of the IP address does not change and it is still impossible to obtain information about distance for billing from the IP address directly even when the resource reservation setup protocol is used.

4. Technical Model of the Resource Reservation Service

This section looks at an unreliable, unidirectional, and tree-structured multicast architecture as a technical model for a resource reservation service. The QoS to all receivers is assumed to be the same, and flow merging is not examined.

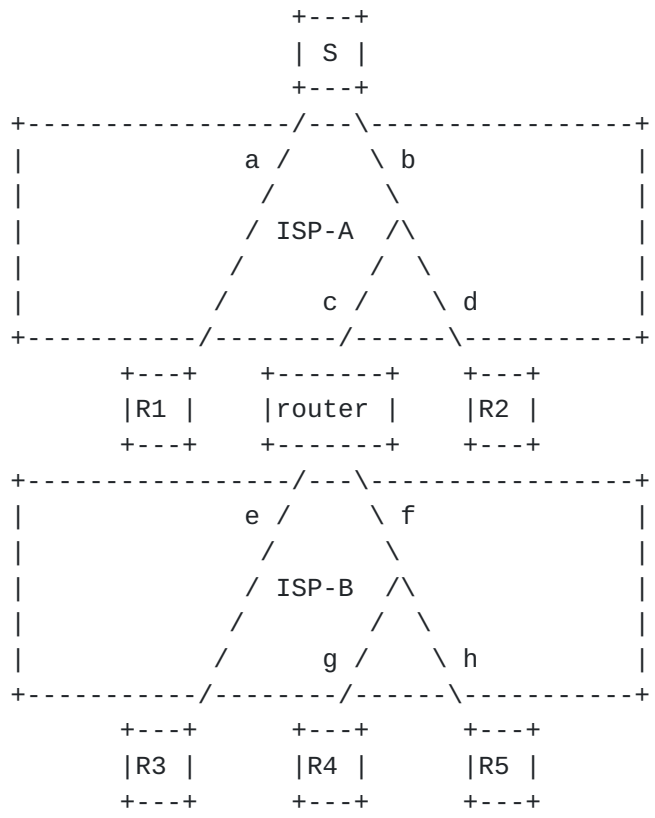

Fig. 4.1: Resource Reservation Service Model.

As shown in Fig. 4.1, ISP-A and ISP-B are interconnected, a sender S and receivers R1 and R2 belong to ISP-A, and receivers R3, R4, and R5 belong to ISP-B. The links shown in Fig. 4.1 represent the logical links that connect the regions which decide the tariff, not the physical links that connect users. This section studies the receiver billing and the sender billing resource reservation service with this model.

4.1 Receiver Billing

When the resource reservation service is provided under receiver billing, the problem is how to bill for the shared links, such as b, c, and f. The shared link cost must be distributed and billed to receivers based on some rule.

One solution inside a single ISP is to adopt a tariff system that does not depend on how the links shared between receivers. Billing that is based on the cost of the links that make up the multicast tree is equivalent to billing based on distance. Therefore, billing that does not depend on the link sharing approach is equivalent to billing that is not based on distance. This means the billing can be based on bandwidth (FlowSpec), time, and information volume.

For example, if an interconnected destination ISP is regarded as a receiver, ISP-A bills to R1, R2 and ISP-B, and ISP-B bills to R3, R4, and R5 [3]. The billing from ISP-A to ISP-B is distributed based on some rule, and is added to the base charge in ISP-B. If a large number of users join the multicast and the statistical tendency of network utilization is known, it is possible to provide this type of tariff system, although it does not accurately reflect communication costs.

Another solution is to distribute the shared link cost among the receivers that share the link. For example, the cost of link b would be shared by R2, R3, R4 and R5. This method does reflect accurate communication costs. However, in practice it is difficult to implement the billing system since the complexity of computing the cost of the shared link, located near a sender like b, is increased because the receiver can dynamically join and leave the multicast tree.

Therefore, in the case of receiver billing, if many users join the multicast and the statistical tendency of network utilization is known, billing based on bandwidth (FlowSpec), time, and information volume can be provided.

4.2 Sender Billing

When the resource reservation service is provided under the sender billing, the problem due to the shared link is avoided, because there is no need to distribute the shared link cost. In the above model, the sender would be billed for the link costs from a to h.

Therefore, with sender billing, billing based on accurate link costs can be provided. Billing based on the link cost is equivalent to billing based on distance. However, information about distance for billing cannot be obtained from the IP address directly. Therefore, a database that can extract information about distance from the destination IP address is needed to enable billing based on the link cost.

This is also true for sender billing: if a number of users join the multicast and the statistical tendency of network utilization is known, it is possible to provide billing based on bandwidth (FlowSpec), time, and information volume. That is, the sender pays for the billing to R1, R2, and ISP-B in ISP-A, and to R3, R4, and R5 in ISP-B.

Therefore, with sender billing, if a database is implemented that can extract information about distance for billing from the destination IP address, it will be possible to provide billing based on distance, bandwidth (FlowSpec), time, and information volume. And if many users join the multicast and the statistical tendency of network utilization is known, it will also be possible to provide billing based on bandwidth (FlowSpec), time, and information volume.

5. Application Model for the Resource Reservation Service

This section examines the following multimedia applications to develop an application model for the resource reservation service.

o Broadcast-type application model

o Advertisement-type application model

o Conference-type application model

Methods of implementing the application model using the technical model described in the previous section are also examined.

5.1 Broadcast-type Application Model

We assume that the broadcast-type application model has the following features.

- The application provider broadcasts to receivers using the multicast, and, in practice, the application is open to the public.
- Many receivers subscribe to the broadcast, and the statistical tendency of network utilization is known.
- Joining the multicast tree is initiated from the receiver.
- The receiver pays the full amount billed.
- The billing is based on information volume or bandwidth (FlowSpec) and time, and not on distance.

Features of this model correspond to receiver billing in the technical model, so it is appropriate for this model to be supported by it. Therefore, receiver billing based on bandwidth (FlowSpec) and time, or information volume can be provided.

5.2 Advertisement-type Application Model

We assume that the advertisement-type application model has the following features.

- The application provider advertises to receivers using the multicast, and, in practice, the application is open to the public.
- Many receivers subscribe to the advertisement, and the statistical tendency of network utilization is known.
- Joining the multicast tree is initiated from the receiver side.
- The application provider pays the full amount billed.
- A function that restricts the region in which the receiver is permitted to join, or a function that decides whether to accept or refuse the joining request based on the IP address of the receiver or based on the tariff to be billed, is indispensable. This is because the communication charge that is acceptable to an application provider is usually limited.

Features of this model roughly correspond to sender billing in the technical model, so it is appropriate for this model to be supported by it. But this model needs a function that restricts the region in which the receiver is permitted to join, or a function that decides whether to accept or refuse the joining request based on the IP address of the receiver or based on the tariff to be billed.

If the region that the receiver is permitted to join is simply restricted by the ISP boundary, the model can be implemented by restricting the IP flow forwarding between ISPs.

But if the decision to accept or refuse the joining request is based on the IP address of the receiver or based on the tariff to be billed, a database that can extract information about permission or distance for billing from the destination IP address is needed. In the resource reservation setup protocol, a procedure that supports this kind of processing is also needed.

However, if this procedure is processed only by the sender, and the number of receivers significantly increases, saturation of the sender protocol processing may occur. Therefore, an intermediate node is needed inside the multicast tree, and this intermediate node will decide whether to accept or refuse the joining request.

Therefore, in the advertisement-type application model, if the region that the receiver is permitted to join is simply restricted by the ISP boundary, it is appropriate for this model to be supported by the sender billing in the technical model. Thus, sender billing based on bandwidth (FlowSpec) and time, or information volume, can be provided.

If the decision to accept or refuse the joining request is based on the IP address of the receiver or based on the tariff to be billed, in addition to the sender billing in the technical model, a database, that can extract information about permission or distance for billing from the destination IP address is needed. In the resource reservation setup protocol, a procedure that supports this process is also needed. In this case, it can be provided by sender billing based on distance, bandwidth (FlowSpec) and time, or information volume.

5.3 Conference-type Application Model

We assume that the conference-type application model has the following features.

o The conference is held by a small number of participants.

- o The statistical tendency of network utilization in the conference depends on each conference style and the tendency is hard to estimate.

- o Joining the conference is initiated by each participant. That is

  - Joining the multicast tree from an existing participant or receiving information from the conference server is initiated by the receiver.

  - Construction of the multicast tree for existing participants or information sent to the conference server is initiated by the sender.

- o Management of conference participants is indispensable. A function that can decide to accept or refuse a participation request based on the IP address of the potential participant, or a similar function is needed.

To avoid establishing an unreasonably expensive tariff for short distance communications, this model needs billing based on accurate link costs, because the tendency of network utilization is hard to estimate.

Therefore, in this model, in addition to the sender billing from the technical model, a database that can extract information about permission and distance for billing from the destination IP address is needed. In the resource reservation setup protocol, a procedure that supports this process is also needed. In this case, it can be provided by sender billing based on distance, bandwidth (FlowSpec) and time, or information volume.

6. Architecture of the Resource Reservation Setup Protocol

Combinations of the billing side and the initiating side in a joining request in the resource reservation setup protocol based on the above studies are shown in Table 6.1.

Table 6.1: Combinations of Billing and Initiating Sides of Joining Request.

Application	Billing Side	Initiating Side
Broadcast	Receiver	Receiver
Advertisement	Sender	Receiver
Conference	Sender	Sender,Receiver

In addition to supporting all the above combinations of the billing side and the initiating side in a joining request, the commercial resource reservation service must satisfy the following requirements for sender billing.

- A function is needed that restricts the region that a receiver is permitted to join, or that decides whether to accept or refuse the joining request based on the receiver IP address and/or on the tariff to be billed.

- If the application is open to the public, an intermediate node that decides whether to accept or refuse the joining request is needed inside the multicast tree.

To achieve the combination of a sender billed and receiver initiated joining request, the resource reservation setup protocol must support a resource reservation procedure that is initiated by acceptance of a joining request from a receiver. Therefore, the following sender initiation basis protocol is a natural architecture for the commercial resource reservation service.

o The basis of the resource reservation setup protocol is sender initiation. That is, as shown in Fig. 6.1, the sender explicitly designates the receiver address, sends a resource reservation setup message (SETUP), and constructs the multicast tree.

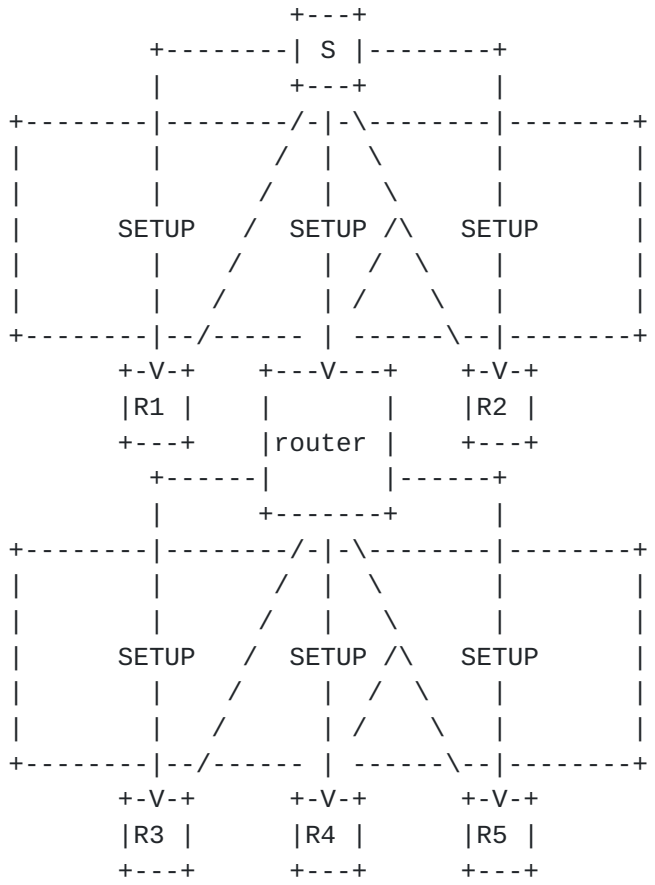

Fig. 6.1: Sender Initiation.

o In the case of receiver initiation, as shown in Fig. 6.2, the receiver explicitly sends the joining request message (JOIN), and if the sender accepts it, the sender sends a resource reservation setup message to the receiver.

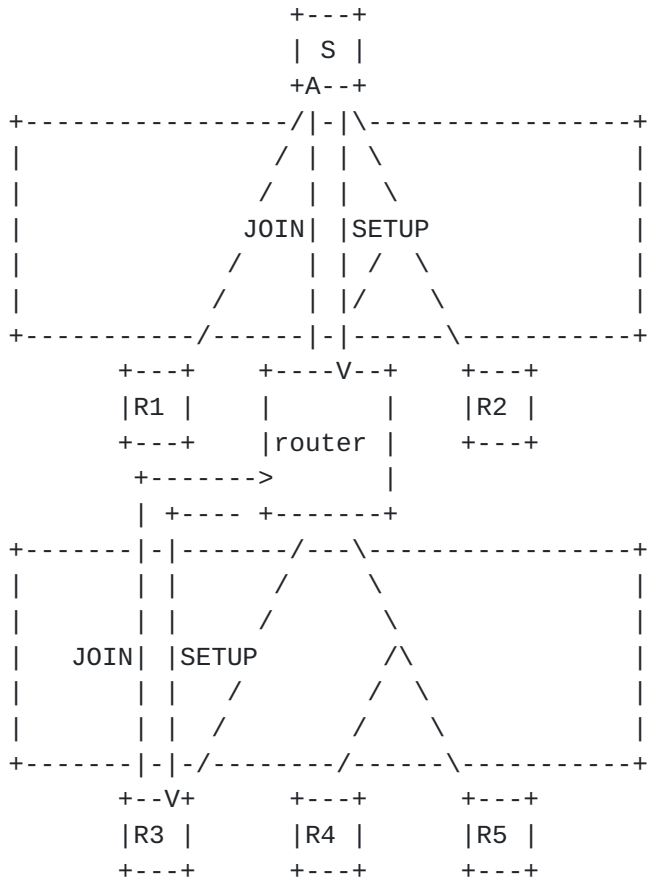

Fig. 6.2: Receiver Initiation.

o However, if the application is open to the public, as shown in Fig. 6.3, the intermediate node inside the multicast tree that decides whether to accept or refuse the joining request, may send a resource reservation setup message as a response to the joining request message.

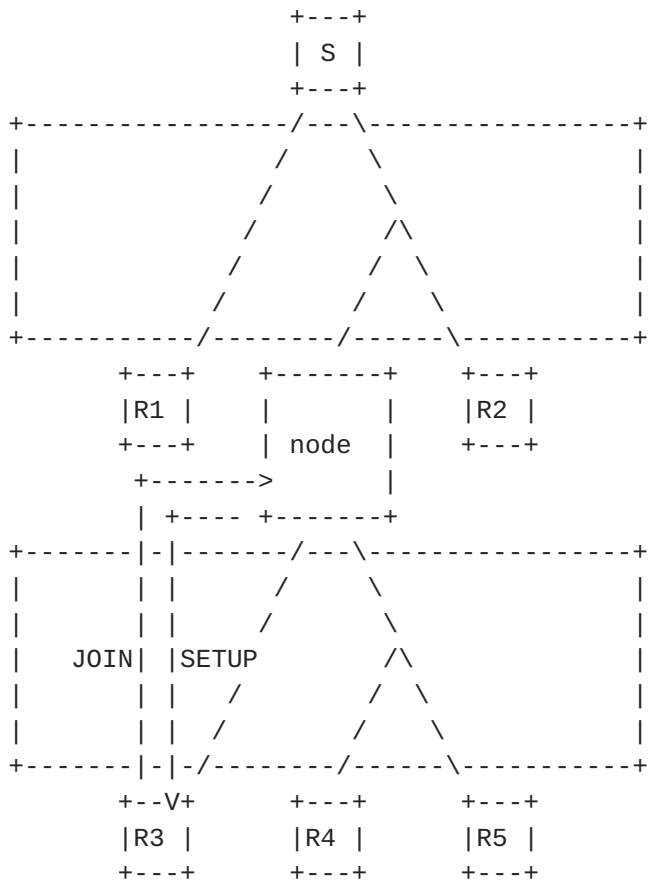

Fig. 6.3: Intermediate Node.

7. Conclusions

This document studied technical and application models of the resource reservation service, and clarified the followings in terms of an architecture for the resource reservation setup protocol.

o The basis of the resource reservation setup protocol is sender initiation. That is, the sender explicitly designates the receiver address, sends a resource reservation setup message and constructs a multicast tree.

o In the case of receiver initiation, the receiver explicitly sends a joining request message; if the sender accepts it, the sender sends

a resource reservation setup message to the receiver.

- However, if the application is open to the public, an intermediate node inside the multicast tree decides whether to accept or refuse the joining request, and may send a resource reservation setup message as a response to the joining request message.

Finally, if the billing policies of ISPs are fundamentally different from each other in the commercial resource reservation service, it will be difficult to achieve smooth interconnection. Therefore, the author believes that ISPs need to conclude agreements or to clarify recommendations concerning minimum common billing policies for the resource reservation service, especially on the definition of distance for billing purpose.

References

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Acknowledgments

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