ASON/GMPLS Extension for Reservation and Time Based Automatic Bandwidth Service
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Abstract

The draft presents ASON/GMPLS architecture extension for reservation and time based automatic bandwidth services. It introduces additional service intelligence function to the control plane. It describes the service scenarios and procedures for automatic bandwidth service. It also discusses the potential services enabled by the service intelligence function.

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1. Introduction

ASON and GMPLS based architectures have been developed for a long time in standard bodies. One of objectives is to allow user instantly request a bandwidth from optical transport networks using standard protocols. We refer to this model as instant bandwidth service. The user could be a customer, a client from a different network layer or from a different administration domain. This model is adopted from traditional telephony networks, where the network instantly establishes a connection path when a call request comes and takes down the connection when the call finishes. Internet technology boosts the network intelligence capability, which drives a desire of building the similar intelligence in an optical transport network and thus enabling an instant bandwidth service in which connection is instantly provided upon the service request from a user.

Although the instant bandwidth service is a prevalent mode in ASON/GMPLS control plane architecture, some dedicate bandwidth services such as private line are provided based on a reservation. For example, traditional private line services have been offered in the way that customer needs to order the service first through an administrative system, then carrier set up the circuit and work with the customer to verify the connection paths. Although this service model is rather rigid and operation intensive, for a permanent connection and a large bandwidth connection, a carrier still prefers a way to do reservation and time based bandwidth service. In addition, some customer may want to reserve the service ahead based on the future needs and wants the bandwidth to be guaranteed at a specific time it desires. We refer to this capability as reservation based automatic bandwidth service through out this document.

Another consideration is that although customer connection could be dynamic, sometimes the traffic presents a certain pattern as time, as an alternate solution for the instant bandwidth service, a connection could be managed as a function of time. We refer to this capability as time based automatic bandwidth service through out this document.

This document introduces ASON/GMPLS architecture extension to support reservation and time based automatic bandwidth service. It presents the application scenarios and service procedures. It also describes potential new components in a control plane to support the services. In addition, the comparison between instant bandwidth service and reservation based bandwidth service is discussed.
1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119].

1.2. Terminology

Client Layer: In multi-layer networks, client layer is the layer that could request a service from the server layer. For example, IP client layer request a bandwidth from OTN server layer.

Connection Manager: A entity that establish and remove a connection and maintain all existing connections.

Event Register: A entity that hold all the time related events and announce an event when its specified time arrives.

Policy Manager: A entity that manage all the policy profiles.

Policy Profile: A entity that gather all the policy rules associated with a connection or a set of connections.

Policy Rules: A rule associated with a connection. It may relate to an event or time.

Reservation based automatic bandwidth service: The connection request could be booked in carrier reservation system ahead of service time. When the service time arrives, the network could automatically build up the connection.

Reservation System: A system can book a connection reservation from a customer.

Server Layer: In multi-layer networks, server layer is the layer that could provide a service to its client layer.

Time based automatic bandwidth service: The connection path or bandwidth could be managed as a function of time.

1.3. Acronyms

AIS Alarm Indication Signal

ASON Automatically Switched Optical Network

DOM Day Of a Month
ENNI External Network to Network Interface.

GMPLS Generalized Multi-protocol Label Switching

HOY Holiday Of a Year

NE Network Element

NMS Network Management System

OTN Optical Transport Network

SDH Synchronous Digital Hierarchy

SONET Synchronous Optical Network

TDM Time Division Multiplexing

TOD Time of a Day

UNEQ-P Unequipped Path

UNI User Network Interface
2. Motivation for Reservation and Time Based Automatic Bandwidth Service

IP network success motivates people to develop network intelligence in an optical transport network. One objective is to enable automatic connection route selection, connection path establishment and removal, and connection management in an optical network and automatic interworking with other layer network such as IP network. Another objective is to allow user to instantly request a network bandwidth when it needs. The control plane based network architecture is defined by both IETF [RFC3945] and ITU-T [ITU-T G.8080]. Numerous protocols have been developed by IETF since then.

Current instant based bandwidth service model supported in ASON/GMPLS architecture is shown in Figure 1. The network contains a control plane and a data plane. A user or client equipment connects to a network element (node) via physical interface. This interface is called User Network Interface(UNI) [RFC4208] [ITU-T G.8080]. There is a signaling channel between a user and the network. When a user needs a bandwidth from one point to another, it can send a connection request to the control plane via the signaling channel. The request will specify the pre-defined network source and destination node addresses, port IDs, bandwidth, and other service parameters. The control plane will process the request, select connection route(s) in the network and build the connection path(s) in the data plane according the service request. After the user receives the confirmation message about the connection completion, user could start data transmission over the data plane. The data stream is then transmitted along the reserved path toward the destination. Figure 2 show the signaling flows for the connection establishment and data transmission.[RFC4208] [RFC3473]. When a user completes the bandwidth usage, it sends a disconnect request to the network, the network takes down the connection path and releases the bandwidth for reuse.
There are some differences between ASON and GMPLS architecture models regarding the UNI interface. ASON uses carrier oriented domain architecture model. UNI is used between user and a network domain; ENNI is used between two network domains. The ASON control plane supports service establishment through the automatic provisioning of end-to-end connection across one or more domains. In contrast, GMPLS has peer model and overlay model. In the peer model, it assumes a community of users with mutual trust and shared goals. There are no inherent policy or security boundaries, and routing and signaling protocols flow within the network without filtering or other constraints imposed. In the overlay model [RFC4208], it assumes that the network nodes act as a closed system, and that user nodes are not aware of the topology of the network, though network and user nodes may have a routing protocol interaction for the exchange of reachability information to other user nodes.

Regardless of the architecture differences in ASON and GMPLS, both models share the same service characteristics in which the service is requested at the time the connection needs. In other words, service request and service time are tightly coupled. This service model may raise concerns for carriers to offer all the bandwidth services in optical transport networks in this manner. Here are the major concerns:

1) It is hard for carriers to predict user demand and guarantee the dedicated bandwidth when user needs it. Some user may want to book the bandwidth ahead to ensure the bandwidth availability.
2) For some Permanent Connection (PC) or a high bandwidth connection, carriers may want to let a customer book in advance and automatically provision the connection when service time arrives. This way gives carriers a chance to plan the network resource ahead of service time if necessary.

3) Having user directly request the bandwidth from network through the signaling channel that directly communicates with the optical control plane could potentially introduce a big security concerns for carrier. Since the control plane is the network brain, it can not tolerate any possibility of outsider attack. Thus, the special security function for the signaling channel at UNI is required.

4) A carrier may not want to expose its network to its customer. To support UNI, carrier has to define a separated node address, port ID for customer to use, and the advertisement of customer reachability in the control plane, which adds the complexity and cost for a carrier.

5) Some optical data plane takes time to have a path run clean even the connection path already established from optical control plane. Therefore, user may get a lot of corrupted payloads initially.

6) The service model presents a big challenge for service operation and back office system integration.

Today this instant bandwidth service model has been rarely deployed in a real network although the protocols have been standardized in the standard body for a while. It is believed due to two major reasons: 1) most of bandwidth services offered by optical networks are relatively static and could be reserved ahead of service time; 2) the service model and its benefits are still under carrier investigation because of these concerns.

The questions are raised: could ASON/GMPLS architecture support reservation based automatic bandwidth service? could ASON/GMPLS architectures support time based automatic bandwidth service as an alternate solution for bandwidth on demand service. Furthermore, how could we enhance the control plane to be of service intelligence?

These questions motivate this draft to discuss the possibility of ASON/GMPLS architecture extension to support reservation and time based automatic bandwidth services.

* The reservation based automatic bandwidth service is that the connection service could be booked in carrier reservation system ahead of service time. When the service time arrives, the network could automatically build up the connection path.
* The time based automatic connection is that an existing connection or bandwidth can be managed as a function of time.
3. ASON/GMPLS Architecture Extension for Reservation and Time Based Automatic Bandwidth Service

3.1. Architecture

The great advantage of ASON/GMPLS is to have network intelligence for network discovery, route selection, path establishment, connection management. The question is how to utilize the intelligence for a reservation based bandwidth request. Figure 3 illustrates a possible architecture model for a reservation based automatic bandwidth service. In this model, it is assumed that user equipment has been connected to network with a physical interface such as SONET or Ethernet; there is no signaling channel between user and network. The control plane enabled network is able to automatically select a route and set up the connection path. A reservation system is provided by a carrier.

Figure 3: ASON/GMPLS Architecture Extension

The service Reservation System (RS) allows user to book the service request ahead of service time. User could specify the service start time and end time if available, source and destination, bandwidth, and other service parameters. The RS needs go through the service validation processes including customer account, connection points, service quality, etc. To accomplish these steps, the RS needs to communicate with some back office systems (OSS) such as account, inventory system. After completing the validation processes, the RS converts the request to a connection order in a database, and send a confirmation message back to the customer.

For bandwidth reservation, a provider could use booking information
in the database to prepare network resource ahead. Since some services may use the bandwidth over the same network segment in different time period, they could use the same bandwidth resource at different time. In TDM network, the bandwidth refers to "timeslot". Thus, the resource planning is to estimate a bandwidth pool in network to ensure that all booked services can get the bandwidth at its service time. If a "special" service really requests to book and allocate network resource ahead service time, it should be allowed under some condition such as the ahead period prior to the service time and/or price.

3.2. Reservation Service Activation and Deactivation Procedures

When the service time arrives, the RS generates a connection request to the network source node of the connection, the source node will select route(s) first and then establish the connection path toward destination node using GMPLS signaling protocol. The signaling flow for the connection establishment shows in Figure 4. The RS may provide the explicit route list depending on the implementation, then the network only needs to establish the connection path.

Although the network already allocates bandwidth for the connection, user may not generate traffic yet; unequipped path(UNEQ-P)or alarm indication signal(AIS-P)could be generated by SONET/SDH or OTN data plane. Thus, the control plane needs to inform the nodes that the path is in waiting payload period and starts a waiting period timer; the nodes should not start the path monitor at this time. Administrative Status Information object in GMPLS signaling may be used in cooperation on this step. For an advanced situation, the network could enable an automatic data path verification process before getting into the waiting period.
When user begins to generate the traffic, both ingress and egress nodes could detect the payload and inform the control plane. The control plane at the source node will stop the timer, inform the node to start monitor the path. The administrative status information object may be used to inform the connection status.

If the waiting timer is expired, the control plane may take down the connection path and inform the RS about service cancellation. The waiting time can be selected by user or a default timer provided by carrier.

To tear down the connection, there could be two scenarios. First, a customer does not specify the end time of its connection, it simply asks network to take down the connection when it stops sending traffic. Second, a customer specifies the ending time in the service scheduler system.

In the first scenario, customer stops sending data stream when it finishes, the nodes at ingress and/or egress detect the payload missing, the ingress node informs the control plane. The control plane waits for certain period (configurable or defined in service profile), then the source node initiates the teardown message toward the destination node. It will send a service completion message to the reservation system. The system will go through the service completion process. It is necessary that the nodes at ingress and egress differentiate a link or equipment failure from payload missing and inform the control plane with different status changes.

In the second scenario, the RS sends a disconnection request to the control plane when the service period expires. The control plane informs the source and destination nodes to inject UNEQ-P signaling toward user if the interface is SONET or OTN. Then, the source node sends a path teardown message toward the destination node and send a service completion message to the RS. The RS will go through the service completion process.

The solution suggested here provides an alternate way to automatically establish a connection path in ASON/GMPLS network. Once the connection is established, the control plane can manage the connection based on the service request such as service protection requirement.

### 3.3. Time Based Automatic Bandwidth Service

The reservation based automatic bandwidth service solution allows carrier further implementing event driven service such as a time
based bandwidth service. A time based service means that the connection path could be automatically setup, taken down, or modified based on the pre-scheduled time. For example, a connection will be setup two hours every day for three months or 600Mbps during the day and 150Mbps at night. In this case, the reservation system allows customer to specify time based connection request.

For this advanced application, the RS could convert the reservation into a connection request associated with a policy profile. When an initial connection time arrives, it will send a connection request with the policy profile to the control plane. The control plane will maintain the policy profile and execute the policy rules specified in the policy profile. Figure 5 shows some policy rules but not limited to. How the control plane supports the time based connection request will be discussed in the section 3.5.

<table>
<thead>
<tr>
<th>Rule Type</th>
<th>Time Duration</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOD</td>
<td>8AM-5PM</td>
<td>Maintain Connection</td>
</tr>
<tr>
<td>Time of Day</td>
<td>Other</td>
<td>Terminate Connection</td>
</tr>
<tr>
<td>DOW</td>
<td>M - F</td>
<td>Maintain 600MBW</td>
</tr>
<tr>
<td>Day of Week</td>
<td>Sa-Su</td>
<td>Maintain 200MBW</td>
</tr>
</tbody>
</table>

Figure 5: Policy Rules

Followings are some potential service features that could be implemented through the reservation based bandwidth service but not limited to.

1) Bandwidth service is specified in time pattern, for example, time of day, day of month, holiday of year, etc. If the connection is taken down during the break time, it is possible that the new connection path differs from the old but the service quality remains the same. The carrier needs to plan the network resource ahead to ensure the bandwidth availability.

2) Bandwidth modification for an existing connection. Customer specifies bandwidth variance to the time for a connection. In this case, the control plane can modify the connection bandwidth without service disruption.
3) One reservation for a group of connections among a set of client ports. The set of client ports could share a same profile. Time based traffic pattern can be specified among the ports. For example, there are 10 ports, the first four ports need 200 Mbps and last six ports need 100 Mbps in day time; two ports need 500Mbps, the rest needs 50 Mbps at night.

4) Service extension for an existing connection. Customer could extend the service time through the reservation system.

5) Combined above services. The combined service offers a lot of flexibility for the bandwidth service. Thus, it may serve as a bandwidth on demand service.

3.4. Protocol between Reservation System and Control Plane

There are some protocols needed between the reservation system and the control plane. It is recommended to use existing signaling protocol, i.e. extend GMPLS signaling protocol to the RS. In this case, the RS acts as GMPLS signaling agent. The RS can send a connection request to the source node using GMPLS protocol. Since the RS and network belong to the same carrier administrative domain, RS can directly use network internal address and port information in the connection request. Thus, it is like a user interface in GMPLS peer model. For the time based service, there will be additional enhanced objects in GMPLS protocol to carry the time based service information. Another way to implement is to develop Management Information Base (MIB) modules between RS and control plane to carry the connection request information. This implementation requires control plane to convert MIB into signaling message for an end-to-end path establishment.

3.5. Time Based Connection Path Management

A control plane is expected to manage a connection in an event driven policy. For example, when a failure happens [POLICY], it can select another route for user or allocate the reserved protection path in shared mesh configuration. To support time based connection management, the control plane needs to have a time trigger and event register function.

Figure 6 shows a possible connection controller structure to manage a scheduled event. There are three components plus a time ticker. The connection manager (CM) is responsible for connection establishment and maintenance. The policy manager (PM) manages all the connection rules. These rules may be associated with an network event and/or time event. The Event Register (ER) can table all time related events that will be triggered when the time arrives. When a connection
request comes from RS, CM in the source node processes the request and establishes the initial connection by using GMPLS protocol. If there is a time based policy profile associated with the connection, CM sends the connection ID and policy profile to PM. PM processes the policy profile and registers the time based events into the ER. When an event is on time, EM notifies PM on the event. PM sends the action with connection ID to CM. Then CM executes the action on the connection. Such time based function empowers a control plane to actively manage the connection path. It is possible that a time based connection may be routed through different paths during different connection time but the service quality remains the same. How to keep a time based connection in the same route needs future study.

Connection Controller

| Connection +---------------------------------------+
| Request | +------------------+ +------------------+ |
| from RS | | Connection +-----+ Policy |
| --------> | | Manager <----- Manager |
| | +------------------+ +-------+ |
| | | Time Ticker | Event Register |
| +------------------+ +------------------+ |

Figure 6: Connection Controller Structure

There is a debate whether the time based connection management should reside in the control plane or management plane, i.e. Network Management System (NMS). NMS is a centralized system. It responds to collect fault alarms and performance data from network, provide equipment configuration and service provisioning, and support all the operation activities. It is possible to implement time based connection management function in NMS. In this case, NMS keeps tracking all connections created by the control plane and maintain the time based policy profiles. When an event arrives, NMS finds out the associated connection ID and its source node, then sends the event to the control plane. The control plane executes the event. In the model, both control plane and NMS manage the connections. Who has the connection ownership is questionable. The model may create a lot of communications between the NMS and control plane for a large network or frequent connection changes, which could cause a scalability problem and infrastructure challenge. In contrast, using
control plane to manage time based connection provides the distributing management in the control plane and the control plane fully manages and maintains the connections, which presents some advantages.
4. Multi-Layer and Multi-Domain Networks

ASON architecture supports a multi-layer and multi-domain configuration. [MLN/MRN] The solution described here works for multi-layer networks as well. Figure 7 illustrates a multi-layer network in general. Customer equipment physically connects to an ASON network at client layer, for example, through Ethernet interface, the network ingress and egress have client layer interfaces; the network side interfaces have server layer interfaces. The customer could book a connection request from client layer without knowing the network topology and architecture at all. When the service time arrives, the scheduler system will send the connection request to the control plane, the control plane will select the path route over client layer adaptation and server layer to establish the connection path. If the server layer path is already existed, the control plane could also build a connection path over the existing tunnel in server layer depending on the service request or control plane policy.

In the similar way, when tearing down a connection, if there are multiple connections in client layer such as multiple VLANs, client layer will only tear down the VLAN path in the client layer. When tearing down the last VLAN path in a tunnel, the control plane could take down the tunnel as well depending on the service request or control plane policy.

The reservation-based service model allows providers to manage the server layer connection separately from the client layer connection. Based on the customer needs, the reservation system could let server layer to establish a tunnel that connects to ingress and egress at client layer first. For example, set up a SONET connection and use GFP at ingress and egress to map to Ethernet port. Thus, when customer wants a P2P connection at Ethernet, the connection can be built directly over end-to-end client layer through the server layer tunnel. Multiple P2P connections may be built over a tunnel. As a result, client layer connections could be very dynamic while a server layer connection is relative static.
The solution could apply to multi-domain configuration as well. In this scenario, there could be one reservation system to support multi-domains or each domain has its own reservation system. If customer needs to build a connection across multi-domains, it can book through one system or several systems. A reservation system will use the same semantics to build connection path through the control plane. External Network to Network Interface (ENNI) will be used between domains.
5. Architecture Advantages

The architecture model for reservation and time based automatic bandwidth services adopt ASON/GMPLS architecture model and combine with Web application technology. It de-couples service request time and service time, which provides a great value for carriers and customers. It provides a practical architecture to a bandwidth on demand service in an optical transport network. It has following advantages compared to UNI based instant bandwidth service.

1. Reservation based automatic bandwidth service can provide better bandwidth guarantee for the customer. Carrier can observe reservations and plan the network resources.

2. It does not need a signaling channel between user and network, i.e. no UNI interface. This simplifies the service model. To support UNI, carrier has to work out separated node address and port ID for customer to use, and the advertisement of customer reachability in the network.

3. Since there is no signaling channel between user and network control plane, it eliminates the possibility that a control plane is attacked from UNI signaling channel.

4. This allows network to pre-verify the data plane path by using an embedded tool or automatically tune a data plane path to ensure the path running clean.

5. This service model is more close to the private line services that carrier offer today. It could co-exist with existing ASON/GMPLS architecture.

6. Advanced reservation system could be designed to offer very flexible and dynamic service for customers as mentioned above.

7. The architecture model allows carrier easier to implement the services in term of service operation and back office system support.

Internet technology enables many WEB based reservation applications. Integrating ASON/GMPLS architecture with the reservation based system boosts optical control plane capability to support automatic bandwidth service and open potentials for other advanced services such as L1VPN and bandwidth trading.
6. Other Architecture Solution

The architecture solution discussed in this document is one way to implement the reservation and time based automatic bandwidth service. The separation between the reservation system and control plane provides a realistic way for the implementation from many perspectives. The reservation system can be interwork with other back office systems to provide customer account management, inventory verification, resource management, and security management. The control plane only responses for the connection management.

Another solution is to directly implement reservation and time based automatic bandwidth service through UNI interface, i.e. enhance the GMPLS signaling protocol between user and network interface to allow carrying these time based service information and let control plane interwork with back office system to perform all the validation processes and manage the services. Authors think this architecture design is not a practical design for carrier and it will add more concerns about the service models over UNI beyond mentioned in this document.
7. Security Considerations

This implementation eliminates the security concern at UNI and requires security management in the scheduler system. Each user needs to have a private account and security procedure before it can summit its service request. The architecture presents little possibility to attack the network.
8. IANA Considerations

There is no IANA actions requested in this specification.
9. Acknowledgements

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10. References

10.1. Normative References


10.2. Informative References


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