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Generic Aggregation of Resource ReSerVation Protocol (RSVP) for IPv4 And IPv6 Reservations over PCN domains

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Abstract

This document specifies extensions to Generic Aggregated RSVP RFC 4860 for support of the PCN Controlled Load (CL) and Single Marking (SM) edge behaviors over a Diffserv cloud using Pre-Congestion Notification.

Requirements Language

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 RFC 2119 [RFC2119].

Table of Contents

1. Introduction 4
1.1. Objective 4
1.2. Overview and Motivation 4
1.3. Terminology 7
1.4. Organization of This Document 11
2. Overview of RSVP extensions and Operations 11
2.1. Overview of RSVP Aggregation Procedures in PCN domains 11
2.2. PCN Marking and encoding and transport of pre-congestion Information 13
2.3. Traffic Classification Within The Aggregation Region 13
2.4. Deaggregator (PCN-egress-node) Determination 13
2.5. Mapping E2E Reservations Onto Aggregate Reservations 13
2.6 Size of Aggregate Reservations 14
2.7. E2E Path ADSPEC update 14
2.8. Intra-domain Routes 14
2.9. Inter-domain Routes 15
2.10. Reservations for Multicast Sessions 15
2.11. Multi-level Aggregation 15
2.12. Reliability Issues 15
2.13. Message Integrity and Node Authentication 15
3. Elements of Procedure 15
3.1. Receipt of E2E Path Message by PCN-ingress-node
(aggregating router) 15
3.2. Handling Of E2E Path Message by Interior Routers 16
3.3. Receipt of E2E Path Message by PCN-egress-node
(deaggregating router) 16
3.4. Initiation of new Aggregate Path Message By PCN-ingress-node

(Aggregating Router) 16
3.5. Handling Of new Aggregate Path Message by Interior Routers . . 16
3.6 Handling Of Aggregate Path Message by Deaggregating Router . . 16
3.7. Handling of E2E Resv Message by Deaggregating Router 17
3.8. Handling Of E2E Resv Message by Interior Routers 17

3.9. Initiation of New Aggregate Resv Message By Deaggregating Router 17
3.10. Handling of Aggregate Resv Message by Interior Routers . . . 18
3.11. Handling of E2E Resv Message by Aggregating Router 18
3.12. Handling of Aggregated Resv Message by Aggregating Router . . 18
3.13. Removal of E2E Reservation 19
3.14. Removal of Aggregate Reservation 19
3.15. Handling of Data On Reserved E2E Flow by Aggregating Router . 19
3.16. Procedures for Multicast Sessions 19
3.17. Misconfiguration of PCN node 19
3.18. PCN based Flow Termination 19
4. Protocol Elements 20
4.1 PCN object 20
5. Security Considerations 23
6. IANA Considerations 23
7. Acknowledgments 24
8. Normative References 24
9. Informative References 25
10. Appendix A: Example Signaling Flow 25
11. Authors' Address 28

1. Introduction

1.1 Objective

Pre-Congestion Notification (PCN) can support the quality of service (QoS) of inelastic flows within a Diffserv domain in a simple, scalable, and robust fashion. Two mechanisms are used: admission control and flow termination. Admission control is used to decide whether to admit or block a new flow request, while flow termination is used in abnormal circumstances to decide whether to terminate some of the existing flows. To support these two features, the overall rate of PCN-traffic is metered on every link in the domain, and PCN-packets are appropriately marked when certain configured rates are exceeded. These configured rates are below the rate of the link, thus providing notification to boundary nodes about overloads before any congestion occurs (hence "pre-congestion" notification). The PCN-egress-nodes measure the rates of differently marked PCN traffic in periodic intervals and report these rates to the Decision Points for admission control and flow termination; the Decision Points use these rates to make decisions. The Decision Points may be collocated with the PCN-ingress-nodes, or their function may be implemented in a another node. For more details see [RFC5559], [RFC6661], and [RFC6662].

The main objective of this document is to specify the signaling protocol that can be used within a Pre-Congestion Notification (PCN) domain to carry reports from a PCN-ingress-node to a PCN Decision point, considering that the PCN Decision Point and PCN-egress-node are collocated.
If the PCN Decision Point is not collocated with the PCN-egress-node then additional signaling procedures are required that are out of the scope of this document. Moreover, as mentioned above this architecture conforms with PBAC (Policy-Based Admission Control), when the Decision Point is located in a another node then the PCN-ingress-node [RFC2753].

Several signaling protocols can be used to carry information between PCN-boundary-nodes (PCN-ingress-node and PCN-egress-node). However, since (1) both PCN-egress-node and PCN-ingress-nodes are located on the data path and (2) the admission control procedure needs to be done at PCN-egress-node, a signaling protocol that follows the same path as the data path, like RSVP (Resource Reservation Protocol), is more suited for this purpose. In particular, this document specifies extensions to Generic Aggregated RSVP [RFC4860] for support of the PCN Controlled Load (CL) and Single Marking (SM) edge behaviors over a Diffserv cloud using Pre-Congestion Notification.

1.2 Overview and Motivation

Two main Quality of Service (QoS) architectures have been specified by the IETF. These are the Integrated Services (Intserv) [RFC1633] architecture and the Differentiated Services (DiffServ) architecture ([RFC2475]).

Intserv provides methods for the delivery of end-to-end Quality of Service (QoS) to applications over heterogeneous networks. One of the QoS signaling protocols used by the Intserv architecture is the Resource reServation Protocol (RSVP) [RFC2205], which can be used by applications to request per-flow resources from the network. These RSVP requests can be admitted or rejected by the network. Applications can express their quantifiable resource requirements using Intserv parameters as defined in [RFC2211] and [RFC2212]. The Controlled Load (CL) service [RFC2211] is a quality of service (QoS) closely approximating the QoS that the same flow would receive from a lightly loaded network element. The CL service is useful for inelastic flows such as those used for real-time media.

The DiffServ architecture can support the differentiated treatment of packets in very large scale environments. While Intserv and RSVP classify packets per-flow, Diffserv networks classify packets into one of a small number of aggregated flows or "classes", based on the Diffserv codepoint (DSCP) in the packet IP header. At each Diffserv router, packets are subjected to a "per-hop behavior" (PHB), which is invoked by the DSCP. The primary benefit of Diffserv is its scalability, since the need for per-flow state and per-flow processing, is eliminated.

However, DiffServ does not include any mechanism for communication between applications and the network. Several solutions have been specified to solve this issue. One of these solutions is Intserv over Diffserv [RFC2998] including resource-based admission control (RBAC), PBAC, assistance in traffic identification/classification, and traffic conditioning. Intserv over Diffserv can operate over a statically provisioned Diffserv region or RSVP aware. When it is RSVP aware, several mechanisms may be used to support dynamic provisioning and topology-aware admission control, including aggregate RSVP reservations, per-flow RSVP, or a bandwidth broker. [RFC3175] specifies aggregation of Resource ReSerVation Protocol (RSVP) end-to-end reservations over aggregate RSVP reservations. In [RFC3175] the RSVP generic aggregated reservation is characterized by a RSVP SESSION object using the 3-tuple <source IP address, destination IP address, Diffserv Code Point>.

Several scenarios require the use of multiple generic aggregate reservations that are established for a given PHB from a given source IP address to a given destination IP address, see [SIG-NESTED], [RFC4860]. For example, multiple generic aggregate reservations can be applied in the situation that multiple E2E reservations using different preemption priorities need to be aggregated through a PCN-domain using the same PHB. By using multiple aggregate reservations for the same PHB allows enforcement of the different preemption priorities within the aggregation region. This allows more efficient management of the Diffserv resources, and in periods of resource shortage, this allows sustainment of a larger number of E2E reservations with higher preemption priorities. In particular, [SIG-NESTED] discusses in detail how end-to-end RSVP reservations can be established in a nested VPN environment through RSVP aggregation.

[RFC4860] provides generic aggregate reservations by extending [RFC3175] to support multiple aggregate reservations for the same source IP address, destination IP address, and PHB (or set of PHBs). In particular, multiple such generic aggregate reservations can be established for a given PHB from a given source IP address to a given destination IP address. This is achieved by adding the concept of a Virtual Destination Port and of an Extended Virtual Destination Port in the RSVP SESSION object. In addition to this, the RSVP SESSION object for generic aggregate reservations uses the PHB Identification Code (PHB-ID) defined in [RFC3140], instead of using the Diffserv Code Point (DSCP) used in [RFC3175]. The PHB-ID is used to identify the PHB, or set of PHBs, from which the Diffserv resources are to be reserved.
The RSVP like signaling protocol required to carry (1) requests from a PCN-egress-node to a PCN-ingress-node and (2) reports from a PCN-ingress-node to a PCN-egress-node needs to follow the PCN signaling requirements defined in [RFC6663]. In addition to that the signaling protocol functionality supported by the PCN-ingress-nodes and PCN-egress-nodes needs to maintain logical aggregate constructs (i.e. ingress-egress-aggregate state) and be able to map E2E reservations to these aggregate constructs. Moreover, no actual reservation state is needed to be maintained inside the PCN domain, i.e., the PCN-interior-nodes are not maintaining any reservation state.

This can be accomplished by two possible approaches:

Approach (1):

o) adapting the RFC 4860 aggregation procedures to fit the PCN requirements with as little change as possible over the RFC 4860 functionality

o) hence performing aggregate RSVP signaling (even if it is to be ignored by PCN interior nodes)

o) using this aggregate RSVP signaling procedures to carry PCN information between the PCN-boundary-nodes (PCN-ingress-node and PCN-egress-node).

Approach (2):

o) adapting the RFC 4860 aggregation procedures to fit the PCN requirements with more significant changes over RFC4860 (i.e. the aspect of the procedures that have to do with maintaining aggregate states and to do with mapping the E2E reservations to aggregate constructs are kept, but the procedures that have to do with the aggregate RSVP signaling and aggregate reservation establishment/maintenance are dropped).

o) hence not performing aggregate RSVP signaling

o) piggy-backing of the PCN information inside the E2E RSVP signaling.

Both approaches are probably viable, however, since the RFC 4860 operations have been thoroughly studied and implemented, it can be considered that the RFC 4860 solution can better deal with the more challenging situations (rerouting in the PCN domain, failure of an PCN-ingress-node, failure of an PCN-egress-node, rerouting towards a different edge, etc.). This is the reason for choosing Approach (1) for the specification of the signaling protocol used to carry PCN information between the PCN-boundary-nodes (PCN-ingress-node and PCN-egress-node).

In particular, this document specifies extensions to Generic Aggregated RSVP [RFC4860] for support of the PCN Controlled Load (CL) and Single Marking (SM) edge behaviors over a Diffserv cloud using Pre-Congestion Notification.

This document follows the PCN signaling requirements defined in [RFC6663] and specifies extensions to Generic Aggregated RSVP [RFC4860] for support of PCN edge behaviors as specified in [RFC6661] and [RFC6662]. Moreover, this document specifies how RSVP aggregation can be used to setup and maintain: (1) Ingress Egress Aggregate (IEA) states at Ingress and Egress nodes and (2) generic aggregation of RSVP end-to-end RSVP reservations over PCN (Congestion and Pre-Congestion Notification) domains.

To comply with this specification, PCN-nodes MUST be able to support the functionality specified in [RFC5670], [RFC5559], [RFC6660], [RFC6661], [RFC6662]. Furthermore, the PCN-boundary-nodes MUST support the RSVP generic aggregated reservation procedures specified in [RFC4860] which are augmented with procedures specified in this document.

1.3. Terminology

This document uses terms defined in [RFC4860], [RFC3175], [RFC5559], [RFC5670], [RFC6661], [RFC6662].

For readability, a number of definitions from [RFC3175] as well as definitions for terms used in [RFC5559], [RFC6661], and [RFC6662] are provided here, where some of them are augmented with new meanings:

Aggregator   This is the process in (or associated with) the router at the ingress edge of the aggregation region (with respect to the end-to-end RSVP reservation) and behaving in accordance with [RFC4860]. In this document, it is also the PCN-ingress-node. It is important to notice that in the context of this document the Aggregator MUST be able to determine the Deaggregator using the procedures specified in

Section 4 of [RFC4860] and in Section 1.4.2 of [RFC3175].

Congestion level estimate (CLE):
The ratio of PCN-marked to total PCN-traffic (measured in octets) received for a given ingress-egress-aggregate during a given measurement period. The CLE is used to derive the PCN-admission-state and is also used by the report suppression procedure if report suppression is activated.

Deaggregator   This is the process in (or associated with) the router at the egress edge of the aggregation region (with respect to the end-to-end RSVP reservation) and behaving in accordance with [RFC4860]. In this document, it is also the PCN-egress-node and Decision Point.

E2E   end to end

E2E Reservation This is an RSVP reservation such that:

(i)   corresponding RSVP Path messages are initiated upstream of the Aggregator and terminated downstream of the Deaggregator, and

(ii) corresponding RSVP Resv messages are initiated downstream of the Deaggregator and terminated upstream of the Aggregator, and

(iii) this RSVP reservation is aggregated over an Ingress Egress Aggregate (IEA) between the Aggregator and Deaggregator.

An E2E RSVP reservation may be a per-flow reservation, which in this document is only maintained at the PCN-ingress-node and PCN-egress-node. Alternatively, the E2E reservation may itself be an aggregate reservation of various types (e.g., Aggregate IP reservation, Aggregate IPsec reservation, see [RFC4860]). As per regular RSVP operations, E2E RSVP reservations are unidirectional.

E2E microflow   a microflow where its associated packets are being forwarded on an E2E path.

Extended vDstPort (Extended Virtual Destination Port)

An identifier used in the SESSION that remains constant over the life of the generic aggregate reservation. The length of this identifier is 32-bits when IPv4 addresses are used and 128 bits when IPv6 addresses are used.

A sender(or Aggregator) that wishes to narrow the scope of a SESSION to the sender-receiver pair (or Aggregator-Deaggregator pair) SHOULD place its IPv4 or IPv6 address here as a network unique identifier. A sender (or Aggregator) that wishes to use a common session with other senders (or Aggregators) in order to use a shared reservation across senders (or Aggregators) MUST set this field to all zeros. In this document, the Extended vDstPort SHOULD contain the IPv4 or IPv6 address of the Aggregator.

ETM-rate

The rate of excess-traffic-marked PCN-traffic received at a PCN-egress-node for a given ingress-egress-aggregate in octets per second.

Ingress-egress-aggregate (IEA):

The collection of PCN-packets from all PCN-flows that travel in one direction between a specific pair of PCN-boundary-nodes. In this document one RSVP generic aggregated reservation is mapped to only one ingress-egress-aggregate, while one ingress-egress-aggregate is mapped to either one or to more than one RSVP generic aggregated reservations. PCN-flows and their PCN-traffic that are mapped into a specific RSVP generic aggregated reservation can also easily be mapped into their corresponding ingress-egress-aggregate.

Microflow: (from [RFC2474])

a single instance of an application-to-application flow of packets which is identified by source address, destination address, protocol id, and source port, destination port (where applicable).

PCN-domain:

a PCN-capable domain; a contiguous set of PCN-enabled nodes that perform Diffserv scheduling [RFC2474]; the complete set of PCN-nodes that in principle can, through PCN-marking packets, influence decisions about flow admission and termination for the PCN-domain; includes the PCN-egress-nodes, which measure these PCN-marks, and the PCN-ingress-nodes.

PCN-boundary-node: a PCN-node that connects one PCN-domain to a node either in another PCN-domain or in a non-PCN-domain.

PCN-interior-node: a node in a PCN-domain that is not a PCN-boundary-node.

PCN-node: a PCN-boundary-node or a PCN-interior-node.

PCN-egress-node: a PCN-boundary-node in its role in handling traffic as it leaves a PCN-domain. In this document the PCN-egress-node operates also as a Decision Point and Deaggregator.

PCN-ingress-node: a PCN-boundary-node in its role in handling traffic as it enters a PCN-domain. In this document the PCN-ingress-node operates also as a Aggregator.

PCN-traffic,
PCN-packets,
PCN-BA: a PCN-domain carries traffic of different Diffserv behavior aggregates (BAs) [RFC2474]. The PCN-BA uses the PCN mechanisms to carry PCN-traffic, and the corresponding packets are PCN-packets. The same network will carry traffic of other Diffserv BAs. The PCN-BA is distinguished by a combination of the Diffserv codepoint (DSCP) and ECN fields.

PCN-flow: the unit of PCN-traffic that the PCN-boundary-node admits (or terminates); the unit could be a single E2E microflow (as defined in [RFC2474]) or some identifiable collection of microflows.

PCN-admission-state:
The state ("admit" or "block") derived by the Decision Point for a given ingress-egress-aggregate based on statistics about PCN-packet marking. The Decision Point decides to admit or block new flows offered to the aggregate based on the current value of the PCN-admission-state.

PCN-sent-rate
The rate of PCN-traffic received at a PCN-ingress-node and destined for a given ingress-egress-aggregate in octets per second.

PHB-ID (Per Hop Behavior Identification Code)
A 16-bit field containing the Per Hop Behavior Identification Code of the PHB, or of the set of PHBs, from which Diffserv resources are to be reserved. This field MUST be encoded as specified in Section 2 of [RFC3140].

RSVP generic aggregated reservation: an RSVP reservation that is identified by using the RSVP SESSION object for generic RSVP aggregated reservation. This RSVP SESSION object is based on the RSVP SESSION object specified in [RFC4860] augmented with the following information:

o) the IPv4 DestAddress, IPv6 DestAddress SHOULD be set to the IPv4 or IPv6 destination addresses, respectively, of the Deaggregator (PCN-egress-node)

o) PHB-ID (Per Hop Behavior Identification Code) SHOULD be set equal to PCN-compatible Diffserv codepoint(s).

o) Extended vDstPort SHOULD be set to the IPv4 or IPv6 destination addresses, of the Aggregator (PCN-ingress-node)

VDstPort (Virtual Destination Port)

A 16-bit identifier used in the SESSION that remains constant over the life of the generic aggregate reservation.

1.4. Organization of This Document

This document is organized as follows. Section 2 gives an overview of RSVP extensions and operations. The elements of the used procedures are specified in Section 3. Section 4 describes the protocol elements. The security considerations are given in section 5 and the IANA considerations are provided in Section 6.

2. Overview of RSVP extensions and Operations

2.1 Overview of RSVP Aggregation Procedures in PCN domains

The PCN-boundary-nodes, see Figure 1, can support RSVP SESSIONS for generic aggregated reservations {RFC4860], which are depending on ingress-egress-aggregates. In particular, one RSVP generic aggregated reservation matches to only one ingress-egress-aggregate.

However, one ingress-egress-aggregate matches to either one, or more than one, RSVP generic aggregated reservations. In addition, to comply with this specification, the PCN-boundary nodes need to distinguish and process (1) RSVP SESSIONS for generic aggregated sessions and their messages according to [RFC4860], (2) E2E RSVP sessions and messages according to [RFC2205]. Furthermore, it is considered that by configuration the PCN-interior-nodes do not intercept (nor process) RSVP messages associated with generic aggregated reservation [RFC4860], or with end to end RSVP reservations [RFC2205]. Moreover, each Aggregator and Deaggregator (i.e., PCN-boundary-nodes) need to support policies to initiate and maintain for each pair of PCN-boundary-nodes of the same PCN-domain one ingress-egress-aggregate.

```
                    -------------------------
                   /       PCN-domain        \
      |----|      |                           |      |----|
   H--| R  |\ |-----|                       |------| /| R  |-->H
   H--|    |\\|     |   |---|     |---|     |      |//|    |-->H
      |----| \|     |   | I |     | I |     |      |/ |----|
              | Agg |=====================>| Deag |
             /|     |   |   |     |   |     |      |\
   H--------//|     |   |---|     |---|     |      |\\-------->H
   H--------/ |-----|                       |------| \-------->H
                  |                           |
                   \                         /
                    -------------------------

   H       = Host requesting end-to-end RSVP reservations
   R       = RSVP router
   Agg     = Aggregator (PCN-ingress-node)
   Deag    = Deaggregator (PCN-egress-node)
   I       = Interior Router (PCN-interior-node)
   -->   = E2E RSVP reservation
   ==>   = Aggregate RSVP reservation
```

Figure 1 : Aggregation of E2E Reservations over Generic Aggregate RSVP Reservations in PCN domains, based on [RFC4860]

Both the Aggregator and Deaggregator can maintain one or more RSVP generic aggregated Reservations, but the Deaggregator is the entity that initiates these RSVP generic aggregated reservations. Note that one RSVP generic aggregated reservation matches to only one ingress-egress-aggregate, while one ingress-egress-aggregate matches to either one or to more than one RSVP generic aggregated reservations. This can be accomplished by using for the different RSVP generic aggregated reservations the same combinations of ingress and egress identifiers, but with a different PHB-ID value (see [RFC4860]). The procedures for aggregation of E2E reservations over generic aggregate RSVP reservations are the same as the procedures specified in Section 4 of [RFC4860], augmented with the ones specified in Section 2.5.

One significant difference between this document and [RFC4860] is the fact that in this document the admission control of E2E RSVP reservations over the PCN core is performed according to the PCN procedures, while in [RFC4860] this is achieved via first admitting aggregate RSVP reservations over the aggregation region and then admitting the E2E reservations over the aggregate RSVP reservations. Therefore, in this document, the RSVP generic aggregate RSVP reservations are not subject to admission control in the PCN-core, and the E2E RSVP reservations are not subject to admission control over the aggregate reservations. In turn, this means that several procedures of [RFC4860] are significantly simplified in this document:

o) unlike [RFC4860], the generic aggregate RSVP reservations need not be admitted in the PCN core.

o) unlike [RFC4860], the RSVP aggregated traffic does not need to be tunneled between Aggregator and Deaggregator, see Section 2.3.

o) unlike [RFC4860], the Deaggregator need not perform admission control of E2E reservations over the aggregate RSVP reservations.

o) unlike [RFC4860], there is no need for dynamic adjustment of the RSVP generic aggregated reservation size, see Section 2.6.

2.2 PCN Marking and encoding and transport of pre-congestion information

The method of PCN marking within the PCN domain is specified in [RFC5670]. In addition, the method of encoding and transport of pre-congestion information is specified in [RFC6660]. The PHB-ID (Per Hop Behavior Identification Code) used SHOULD be set equal to PCN-compatible Diffserv codepoint(s).

2.3. Traffic Classification Within The Aggregation Region

The PCN-ingress marks a PCN-BA using PCN-marking (i.e., combination of the DSCP and ECN fields), which interior nodes use to classify PCN-traffic. The PCN-traffic (e.g., E2E microflows) belonging to a RSVP generic aggregated reservation can be classified only at the PCN-boundary-nodes (i.e., Aggregator and Deaggregator) by using the RSVP SESSION object for RSVP generic aggregated reservations, see Section 2.1 of [RFC4860]. Note that the DSCP value included in the SESSION object, SHOULD be set equal to a PCN-compatible Diffserv codepoint. Since no admission control procedures over the RSVP generic aggregated reservations in the PCN-core are required, unlike [RFC4860], the RSVP aggregated traffic need not to be tunneled between Aggregator and Deaggregator. In this document one RSVP generic aggregated reservation is mapped to only one ingress-egress-aggregate, while one ingress-egress-aggregate is mapped to either one or to more than one RSVP generic aggregated reservations. PCN-flows and their PCN-traffic that are mapped into a specific RSVP generic aggregated reservation can also easily be classified into their corresponding ingress-egress-aggregate. The method of traffic conditioning of PCN-traffic and non-PCN traffic and PHB configuration is described in [RFC6661] and [RFC6662].

2.4. Deaggregator Determination

The present document assumes the same dynamic Deaggregator determination method as used in [RFC4860].

2.5. Mapping E2E Reservations Onto Aggregate Reservations

To comply with this specification for the mapping of E2E reservations onto aggregate reservations, the same methods MUST be used as the ones described in Section 4 of [RFC4860], augmented by the following rules:

o) An Aggregator (also PCN-ingress-node in this document) or Deaggregator (also PCN-egress-node and Decision Point in this document) MUST use one or more policies to determine whether a RSVP generic aggregated reservation can be mapped into an ingress-Egress-aggregate. This can be accomplished by using for the different RSVP generic aggregated reservations the same combinations of ingress and egress identifiers, but with a different PHB-ID value (see [RFC4860]) corresponding to the PCN specifications. In particular, the RSVP SESSION object specified in [RFC4860] augmented with the following information:

o) the IPv4 DestAddress, IPv6 DestAddress MUST be set to the IPv4 or IPv6 destination addresses, respectively, of the Deaggregator (PCN-egress-node), see [RFC4860]. Note that the PCN-domain is considered as being only one RSVP hop (for Generic aggregated RSVP or E2E RSVP). This means that the next RSVP hop for the Aggregator in the downstream direction is the Deaggregator and the next RSVP hop for the Deaggregator in the upstream direction is the Aggregator.

o) PHB-ID (Per Hop Behavior Identification Code) SHOULD be set equal to PCN-compatible Diffserv codepoint(s).

o) Extended vDstPort SHOULD be set to the IPv4 or IPv6 destination addresses, of the Aggregator (PCN-ingress-node), see [RFC4860].

2.6. Size of Aggregate Reservations

Since:(i) no admission control of E2 reservations over the RSVP aggregated reservations is required, and (ii) no admission control of the RSVP aggregated reservation over the PCN core is required, the size of the generic aggregate reservation is irrelevant and can be set to any arbitrary value by the Deaggreagtor. The Deaggregator SHOULD set the value of a generic aggregate reservation to a null bandwidth. We also observe that there is no need for dynamic adjustment of the RSVP aggregated reservation size.

2.7. E2E Path ADSPEC update

To comply with this specification, for the update of the E2E Path ADSPEC, the same methods can be used as the ones described in [RFC4860].

2.8. Intra-domain Routes

The PCN-interior-nodes are neither maintaining E2E RSVP nor RSVP generic aggregation states and reservations. Therefore, intra-domain route changes will not affect intra-domain reservations since such reservations are not maintained by the PCN-interior-nodes.

Furthermore, it is considered that by configuration, the PCN-interior-nodes are not able to distinguish neither RSVP generic aggregated sessions and their associated messages [RFC4860], nor E2E RSVP sessions and their associated messages [RFC2205].

2.9. Inter-domain Routes

The PCN-charter scope precludes inter-domain considerations. However, for solving inter-domain routes changes associated with the operation of the RSVP messages, the same methods SHOULD be used as the ones described in [RFC4860] and in Section 1.4.7 of [RFC3175].

2.10. Reservations for Multicast Sessions

PCN does not consider reservations for multicast sessions.

2.11. Multi-level Aggregation

PCN does not consider multi-level aggregations within the PCN domain. Therefore, the PCN-interior-nodes are not supporting multi-level aggregation procedures. However, the Aggregator and Deaggregator SHOULD support the multi-level aggregation procedures specified in [RFC4860] and in Section 1.4.9 of [RFC3175].

2.12. Reliability Issues

To comply with this specification, for solving possible reliability issues, the same methods MUST used as the ones described in Section 4 of [RFC4860].

2.13. Message Integrity and Node Authentication

To comply with this specification, for message integrity and node authentication, the same methods MUST be used as the ones described in Section 4 of [RFC4860] and [RFC5559].

3. Elements of Procedure

This section describes the procedures used to implement the aggregated RSVP procedure over PCN. It is considered that the procedures for aggregation of E2E reservations over generic aggregate RSVP reservations are same as the procedures specified in Section 4 of [RFC4860] except where a departure from these procedures is explicitly described in the present section. Please refer to [RFC4860] for all the below error cases:

- o) Incomplete message
- o) Unexpected objects

3.1. Receipt of E2E Path Message by Aggregating router

When the E2E Path message arrives at the exterior interface of the Aggregator, (also PCN-ingress-node in this document), then standard RSVP generic aggregation [RFC4860] procedures are used.

3.2. Handling Of E2E Path Message by Interior Routers

The E2E Path messages traverse zero or more PCN-interior-nodes. The PCN-interior-nodes receive the E2E Path message on an interior interface and forward it on another interior interface. It is considered that, by configuration, the PCN-interior-nodes ignore the E2E RSVP signaling messages [RFC2205]. Therefore, the E2E Path messages are simply forwarded as normal IP datagrams.

3.3. Receipt of E2E Path Message by Deaggregating router

When receiving the E2E Path message the Deaggregator (also PCN-egress-node and Decision Point in this document) performs the regular [RFC4860] procedures, augmented with the following rules:

o) The Deaggregator MUST NOT perform the RSVP-TTL vs IP TTL-check and MUST NOT update the ADspec Break bit. This is because the whole PCN-domain is effectively handled by E2E RSVP as a virtual link on which integrated service is indeed supported (and admission control performed) so that the Break bit MUST NOT be set, see also [draft-lefaucheur-rsvp-ecn-01].

The Deaggregator forwards the E2E Path message towards the receiver.

3.4. Initiation of new Aggregate Path Message by Aggregating Router

To comply with this specification, for the initiation of the new RSVP generic aggregated Path message by the Aggregator (also PCN-ingress-node in this document), the same methods MUST be used as the ones described in [RFC4860].

3.5. Handling Of Aggregate Path Message By Interior Routers

The Aggregate Path messages traverse zero or more PCN-interior-nodes. The PCN-interior-nodes receive the Aggregated Path message on an interior interface and forward it on another interior interface. It is considered that, by configuration, the PCN-interior-nodes ignore the Aggregated Path signaling messages. Therefore, the Aggregated Path messages are simply forwarded as normal IP datagrams.

3.6. Handling Of Aggregate Path Message By Deaggregating Router

When receiving the Aggregated Path message, the Deaggregator (also PCN-egress-node and Decision Point in this document) performs the regular [RFC4860] procedures, augmented with the following rules:

o) When the received Aggregated Path message by the Deaggregator contains the RSVP-AGGREGATE-IPv4-PCN-response or RSVP-AGGREGATE-IPv6-PCN-response PCN objects, which carry the

PCN-sent-rate, then the procedures specified in Section 3.18 of this document MUST be followed.

3.7. Handling of E2E Resv Message by Deaggregating Router

When the E2E Resv message arrives at the exterior interface of the Deaggregator, (also PCN-egress-node and Decision Point in this document) then standard RSVP aggregation [RFC4860] procedures are used, augmented with the following rules:

o) The E2E RSVP session associated with an E2E Resv message that arrives at the external interface of the Deaggregator is mapped/matched with an RSVP generic aggregate and with a PCN ingress-egress-aggregate.

o) Depending on the type of the PCN edge behavior supported by the Deaggregator, the PCN admission control procedures specified in Section 3.3.1 of [RFC6661] or [RFC6662] MUST be followed. Since no admission control procedures over the RSVP aggregated reservations in the PCN-core are required, unlike [RFC4860], the Deaggregator does not perform any admission control of the E2E Reservation over the mapped generic aggregate RSVP reservation. If the PCN based admission control procedure is successful then the Deaggregator MUST allow the new flow to be admitted onto the associated RSVP generic aggregation reservation and onto the PCN ingress-egress-aggregate, see [RFC6661] and [RFC6662]. If the PCN based admission control procedure is not successful, then the E2E Resv MUST NOT be admitted onto the associated RSVP generic aggregate reservation and onto the PCN ingress-egress-aggregation. The E2E Resv message is further processed according to [RFC4860].

The way of how the PCN-admission-state is maintained is specified in [RFC6661] and [RFC6662].

3.8. Handling Of E2E Resv Message By Interior Routers

The E2E Resv messages traversing the PCN core are IP addressed to the Aggregating router and are not marked with Router Alert, therefore the E2E Resv messages are simply forwarded as normal IP datagrams.

3.9. Initiation of New Aggregate Resv Message By Deaggregating Router

To comply with this specification, for the initiation of the new RSVP generic aggregated Resv message by the Deaggregator (also PCN-egress-node and Decision Point in this document), the same methods MUST be used as the ones described in Section 4 of [RFC4860] augmented with the following rules:

o) The size of the generic aggregate reservation is irrelevant, see Section 2.6, and can be set to any arbitrary value by the PCN-egress node. The Deaggregator SHOULD set the value of a RSVP generic aggregate reservation to a null bandwidth. We also observe that there is no need for dynamic adjustment of the RSVP generic aggregated reservation size.

o) When [RFC6661] is used and the ETM-rate measured by the Deaggregator contains a non-zero value for some ingress-egress-aggregate, see [RFC6661] and [RFC6662], the Deagregator MUST request the PCN-ingress-node to provide an estimate of the rate (PCN-sent-rate) at which the Aggregator (also PCN-ingress-node in this document) is receiving PCN-traffic that is destined for the given ingress-egress-aggregate.

o) When [RFC6662] is used and the PCN-admission-state computed by the Deaggregator, on the basis of the CLE is "block" for the given ingress-egress-aggregate, the Deaggregator MUST request the PCN-ingress-node to provide an estimate of the rate (PCN-sent-rate) at which the Aggregator is receiving PCN-traffic that is destined for the given ingress-egress-aggregate.

o) In the above two cases and when the PCN-sent-rate needs to be requested from the Aggregator, the Deaggregator MUST generate and send an (refresh) Aggregated Resv message to the Aggregator that MUST carry one of the following PCN objects, see Section 4.1, depending on whether IPv4 or IPv6 is supported:
   o) RSVP-AGGREGATE-IPv4-PCN-request
   o) RSVP-AGGREGATE-IPv6-PCN-request.

3.10. Handling of Aggregate Resv Message by Interior Routers

The Aggregated Resv messages traversing the PCN core are IP addressed to the Aggregating router and are not marked with Router Alert, therefore the Aggregated Resv messages are simply forwarded as normal IP datagrams.

3.11. Handling of E2E Resv Message by Aggregating Router

When the E2E Resv message arrives at the interior interface of the Aggregator (also PCN-ingress-node in this document), then standard RSVP aggregation [RFC4860] procedures are used.

3.12. Handling of Aggregated Resv Message by Aggregating Router

When the Aggregated Resv message arrives at the interior interface of the Aggregator, (also PCN-ingress-node in this document), then standard RSVP aggregation [RFC4860] procedures are used, augmented with the following rules:

o) the Aggregator SHOULD use the information carried by the PCN objects, see Section 4, and follow the steps specified in [RFC6661], [RFC6662]. If the "R" flag carried by the RSVP-AGGREGATE-IPv4-PCN-request or RSVP-AGGREGATE-IPv6-PCN-request PCN objects is set to ON, see Section 4.1, then the Aggregator follows the steps described in Section 3.4 of [RFC6661] and [RFC6662] on calculating the PCN-sent-rate. In particular, the

Aggregator MUST provide the estimated current rate of PCN-traffic received at that node and destined for a given ingress-egress-aggregate in octets per second (the PCN-sent-rate). The way this rate estimate is derived is a matter of implementation, see [RFC6661] or [RFC6662].

o) the Aggregator initiates an Aggregated Path message. In particular, when the Aggregator receives an Aggregated Resv message which carries one of the following PCN objects: RSVP-AGGREGATE-IPv4-PCN-request or RSVP-AGGREGATE-IPv6-PCN-request, with the flag "R" set to ON, see Section 4.1, the Aggregator initiates an Aggregated Path message, and includes the calculated PCN-sent-rate into the RSVP-AGGREGATE-IPv4-PCN-response or RSVP-AGGREGATE-IPv6-PCN-response PCN objects, see Section 4.1, which that MUST be carried by the Aggregated Path message. This Aggregated Path message is sent towards the Deaggregator (also PCN-egress-node and Decision Point in this document) that requested the calculation of the PCN-sent-rate.

3.13. Removal of E2E Reservation

To comply with this specification, for the removal of E2E reservations, the same methods MUST be used as the ones described in Section 4 of [RFC4860] and [RFC4495].

3.14. Removal of Aggregate Reservation

To comply with this specification, for the removal of RSVP generic aggregated reservations, the same methods MUST be used as the ones described in Section 4 of [RFC4860] and Section 2.10 of [RFC3175]. In particular, should an aggregate reservation go away (presumably due to a configuration change, route change, or policy event), the E2E reservations it supports are no longer active.
They MUST be treated accordingly.

3.15. Handling of Data On Reserved E2E Flow by Aggregating Router

The handling of data on the reserved E2E flow by Aggregator (also PCN-ingress-node in this document) uses the procedures described in [RFC4860] augmented with:

o) Regarding, PCN marking and traffic classification the procedures defined in Section 2.2 and 2.3 of this document are used.

3.16. Procedures for Multicast Sessions

In this document no multicast sessions are considered.

3.17. Misconfiguration of PCN-node

In an event where a PCN-node is misconfigured within a PCN-domain, the desired behavior is same as described in Section 3.10.

3.18 PCN based Flow Termination

When the Deaggregator (also PCN-egress-node and Decision Point in this document) needs to terminate an amount of traffic associated with one ingress-egress-aggregate (see Section 3.3.2 of [RFC6661] and [RFC6662]), then several procedures of terminating E2E microflows can be deployed. The default procedure of terminating E2E microflows (i.e., PCN-flows) is as follows, see i.e., [RFC6661] and [RFC6662].

For the same ingress-egress-aggregate, select a number of E2E microflows to be terminated in order to decrease the total incoming amount of bandwidth associated with one ingress-egress-aggregate by the amount of traffic to be terminated, see above. In this situation the same mechanisms for terminating an E2E microflow can be followed as specified in [RFC2205]. However, based on a local policy, the Deaggregator could use other ways of selecting which microflows should be terminated. For example, for the same ingress-egress-aggregate, select a number of E2E microflows to be terminated or to reduce their reserved bandwidth in order to decrease the total incoming amount of bandwidth associated with one ingress-egress-aggregate by the amount of traffic to be terminated. In this situation the same mechanisms for terminating an E2E microflow or reducing bandwidth associated with an E2E microflow can be followed as specified in [RFC4495].

4. Protocol Elements

The protocol elements in this document are using the ones defined in Section 4 of [RFC4860] and Section 3 of [RFC3175] augmented with the following rules:

o) the DSCP value included in the SESSION object, SHOULD be set equal to a PCN-compatible Diffserv codepoint.

o) Extended vDstPort SHOULD be set to the IPv4 or IPv6 destination addresses, of the Aggregator (also PCN-ingress-node in this document), see [RFC4860].

o) When the Deaggregator (also PCN-egress-node and Decision Point in this document) needs to request the PCN-sent-rate from the PCN-ingress-node, see Section 3.9 of this document, the Deaggregator MUST generate and send an (refresh) Aggregate Resv message to the Aggregator that MUST carry one of the following PCN objects, see Section 4.1, depending on whether IPv4 or IPv6 is supported:

- o) RSVP-AGGREGATE-IPv4-PCN-request
- o) RSVP-AGGREGATE-IPv6-PCN-request.

o) When the Aggregator receives an Aggregate Resv message which carries one of the following PCN objects: RSVP-AGGREGATE-IPv4-PCN-request or RSVP-AGGREGATE-IPv6-PCN-request, with the flag "R" set to ON, see Section 4.1, then the Aggregator MUST generate and send to the Deaggregator an Aggregated Path message which carries one of the following PCN objects, see Section 4.1, depending on whether IPv4 or IPv6 is supported:

- o) RSVP-AGGREGATE-IPv4-PCN-response,
- o) RSVP-AGGREGATE-IPv6-PCN-response.

4.1 PCN objects

This section describes four types of PCN objects that can be carried by the (refresh) Aggregate Path or the (refresh) Aggregate Resv messages specified in [RFC4860].

These objects are:

- o RSVP-AGGREGATE-IPv4-PCN-request,
- o RSVP-AGGREGATE-IPv6-PCN-request,
- o RSVP-AGGREGATE-IPv4-PCN-response,
- o RSVP-AGGREGATE-IPv6-PCN-response.

o) RSVP-AGGREGATE-IPv4-PCN-request: PCN request object, when IPv4 addresses are used:
Class = 248 (PCN)
C-Type = 1 (RSVP-AGGREGATE-IPv4-PCN-request

```
+-------------+-------------+-------------+-------------+
|     IPv4 PCN-ingress-node Address (4 bytes)           |
+-------------+-------------+-------------+-------------+
|     IPv4 PCN-egress-node Address (4 bytes)            |
+-------------+-------------+-------------+-------------+
|     IPv4 Decision Point Address (4 bytes)             |
+-------------+-------------+-------------+-------------+
|R|     Reserved                                        |
+-------------+-------------+-------------+-------------|
```

o) RSVP-AGGREGATE-IPv6-PCN-request: PCN object, when IPv6 addresses are used:

Class = 248 (PCN)
C-Type = 2 (RSVP-AGGREGATE-IPv6-PCN-request

```
+-------------+-------------+-------------+-------------+
|                                                       |
+                                                       +
|                                                       |
+     IPv6 PCN-ingress-node Address (16 bytes)          +
|                                                       |
+                                                       +
|                                                       |
+-------------+-------------+-------------+-------------+
|                                                       |
+                                                       +
|                                                       |
+     IPv6 PCN-egress-node Address (16 bytes)           +
|                                                       |
+                                                       +
|                                                       |
+-------------+-------------+-------------+-------------+
|                                                       |
+                                                       +
|                                                       |
+     Decision Point Address (16 bytes)                 +
|                                                       |
```

```
+                                                        +
|                                                        |
+-------------+-------------+-------------+-------------+
|R|     Reserved                                         |
+-------------+-------------+-------------+-------------+
```

o) RSVP-AGGREGATE-IPv4-PCN-response: PCN object, IPv4 addresses are used:
Class = 248 (PCN)
C-Type = 3 (RSVP-AGGREGATE-IPv4-PCN-response)

```
+-------------+-------------+-------------+-------------+
|     IPv4 PCN-ingress-node Address (4 bytes)           |
+-------------+-------------+-------------+-------------+
|     IPv4 PCN-egress-node Address (4 bytes)            |
+-------------+-------------+-------------+-------------+
|     IPv4 Decision Point Address (4 bytes)             |
+-------------+-------------+-------------+-------------+
| PCN-sent-rate                                         |
+-------------+-------------+-------------+-------------+
```

o) RSVP-AGGREGATE-IPv6-PCN-response: PCN object, IPv6 addresses are used:
Class = 248 (PCN)
C-Type = 4 (RSVP-AGGREGATE-IPv6-PCN-response)

```
+-------------+-------------+-------------+-------------+
|                                                       |
+                                                       +
|                                                       |
+     IPv6 PCN-ingress-node Address (16 bytes)          +
|                                                       |
+                                                       +
|                                                       |
+-------------+-------------+-------------+-------------+
|                                                       |
+                                                       +
|                                                       |
+     IPv6 PCN-egress-node Address (16 bytes)           +
|                                                       |
+                                                       +
|                                                       |
+-------------+-------------+-------------+-------------+
|                                                       |
+                                                       +
|                                                       |
+     Decision Point Address (16 bytes)                 +
|                                                       |
+                                                       +
|                                                       |
+-------------+-------------+-------------+-------------+
| PCN-sent-rate                                         |
+-------------+-------------+-------------+-------------+
```

The fields carried by the PCN object are specified in [RFC6663], [RFC6661] and [RFC6662]:

o the IPv4 or IPv6 address of the PCN-ingress-node (Aggregator) and the IPv4 or IPv6 address of the PCN-egress-node (Deaggregator); together they specify the ingress-egress-aggregate to which the report refers. According to [RFC6663] the report should carry the identifier of the PCN-ingress-node (Aggregator) and the identifier of the PCN-egress-node (Deaggregator) (typically their IP addresses);

o Decision Point address specify the IPv4 or IPv6 address of the Decision Point. In this document this field MUST contain the IP address of the Deaggregator.

o "R": 1 bit flag that when set to ON, signifies, according to [RFC6661] and [RFC6662], that the PCN-ingress-node (Aggregator) MUST provide an estimate of the rate (PCN-sent-rate) at which the PCN-ingress-node (Aggregator) is receiving PCN-traffic that is destined for the given ingress-egress-aggregate.

O "Reserved": 31 bits that are currently not used by this document and are reserved. These SHALL be set to 0 and SHALL be ignored on reception.

o PCN-sent-rate: the PCN-sent-rate for the given ingress-egress-aggregate. It is expressed in octets/second; its format is a 32-bit IEEE floating point number; The PCN-sent-rate is specified in [RFC6661] and [RFC6662] and it represents the estimate of the rate at which the PCN-ingress-node (Aggregator) is receiving PCN-traffic that is destined for the given ingress-egress-aggregate.

5. Security Considerations

The same security considerations specified in [RFC2205], [RFC4230], [RFC4860], [RFC5559] and [RFC6411].

6. IANA Considerations

IANA has modified the RSVP parameters registry, 'Class Names, Class Numbers, and Class Types' subregistry, to add a new Class Number and assign 4 new C-Types under this new Class Number, as described below, see Section 4.1:

```
Class
Number  Class Name                                         Reference
------  ----------------------                             ---------
248 PCN                                                this document

        Class Types or C-Types:
1 RSVP-AGGREGATE-IPv4-PCN-request                      this document
2 RSVP-AGGREGATE-IPv6-PCN-request                      this document
```

```
   3 RSVP-AGGREGATE-IPv4-PCN-response                   this document
   4 RSVP-AGGREGATE-IPv6-PCN-response                   this document
```

When this draft is published as an RFC, IANA should update the reference for the above 5 items to that published RFC (and the RFC Editor should remove this sentence).

7. Acknowledgments

We would like to thank the authors of [draft-lefaucheur-rsvp-ecn-01.txt], since some ideas used in this document are based on the work initiated in [draft-lefaucheur-rsvp-ecn-01.txt]. Moreover, we would like to thank Bob Briscoe, David Black, Ken Carlberg, Tom Taylor, Philip Eardley, Michael Menth, Toby Moncaster, James Polk, Scott Bradner and Lixia Zhang for the provided comments. In particular, we would like to thank Francois Le Faucheur for contributing in addition to comments also to a significant amount of text.

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10. Appendix A: Example Signaling Flow

This appendix is based on the appendix provided in [RFC4860]. In particular, it provides an example signaling flow of the specification detailed in Section 3 and 4.

This signaling flow assumes an environment where E2E reservations are aggregated over generic aggregate RSVP reservations and applied over a PCN domain. In particular the Aggregator (PCN-ingress-node) and Deaggregator (PCN-egress-node) are located at the boundaries of the PCN domain. The PCN-interior-nodes are located within the PCN-domain, between the PCN-boundary nodes, but are not shown in this Figure. It illustrates a possible RSVP message flow that could take place in the successful establishment of a unicast E2E reservation that is the first between a given pair of Aggregator/Deaggregator.

```
      Aggregator (PCN-ingress-node)     Deaggregator (PCN-egress-node)

    E2E Path
   ----------->
                (1)
                           E2E Path
                   -------------------------------->
                                                   (2)
                    E2E PathErr(New-agg-needed,SOI=GApcn)
                   <-----------------------------------
(3)
                         AggPath(Session=GApcn)
                   -------------------------------->
(4)
                                                      E2E Path
                                                     ----------->
                                                   (5)
                         AggResv (Session=GApcn) (PCN object)
                   <--------------------------------
(6)
                     AggResvConfirm (Session=GApcn)
                   ------------------------------->
(7)
                                                      E2E Resv
                                                     <---------
                                                   (8)
                           E2E Resv (SOI=GApcn)
                   <------------------------------
                (9)
      E2E Resv
   <-----------
```

(1) The Aggregator forwards E2E Path into the aggregation region
  after modifying its IP protocol number to RSVP-E2E-IGNORE

(2) Let's assume no Aggregate Path exists. To be able to accurately
    update the ADSPEC of the E2E Path, the Deaggregator needs the

ADSPEC of Aggregate Path. In this example, the Deaggregator elects to instruct the Aggregator to set up an Aggregate Path state for the PCN PHB-ID. To do that, the Deaggregator sends an E2E PathErr message with a New-Agg-Needed PathErr code.

The PathErr message also contains a SESSION-OF-INTEREST (SOI) object. The SOI contains a GENERIC-AGGREGATE SESSION (GApcn) whose PHB-ID is set to the PCN PHB-ID. The GENERIC-AGGREGATE SESSION contains an interface-independent Deaggregator address inside the DestAddress and appropriate values inside the vDstPort and Extended vDstPort fields. In this document, the Extended vDstPort SHOULD contain the IPv4 or IPv6 address of the Aggregator.

(3) The Aggregator follows the request from the Deaggregator and signals an Aggregate Path for the GENERIC-AGGREGATE Session (GApcn).

(4) The Deaggregator takes into account the information contained in the ADSPEC from both Aggregate Paths and updates the E2E Path ADSPEC accordingly. The PCN-egress-node MUST NOT perform the RSVP-TTL vs IP TTL-check and MUST NOT update the ADspec Break bit. This is because the whole PCN-domain is effectively handled by E2E RSVP as a virtual link on which integrated service is indeed supported (and admission control performed) so that the Break bit MUST NOT be set, see also [draft-lefaucheur-rsvp-ecn-01]. The Deaggregator also modifies the E2E Path IP protocol number to RSVP before forwarding it.

(5) In this example, the Deaggregator elects to immediately proceed with establishment of the generic aggregate reservation. In effect, the Deaggregator can be seen as anticipating the actual demand of E2E reservations so that the generic aggregate reservation is in place when the E2E Resv request arrives, in order to speed up establishment of E2E reservations. Here it is also assumed that the Deaggregator includes the optional Resv Confirm Request in the Aggregate Resv message.

(6) The Aggregator merely complies with the received ResvConfirm Request and returns the corresponding Aggregate ResvConfirm.

(7) The Deaggregator has explicit confirmation that the generic aggregate reservation is established.

(8) On receipt of the E2E Resv, the Deaggregator applies the mapping policy defined by the network administrator to map the E2E Resv onto a generic aggregate reservation. Let's assume that this policy is such that the E2E reservation is to be mapped onto the generic aggregate reservation with the PCN PHB-ID=x. The Deaggregator knows that a generic aggregate reservation (GApcn) is in place for the corresponding PHB-ID since (7). At this step the Deaggregator maps the generic aggregated reservation onto one ingress-egress-aggregate maintained by the Deaggregator (as a

PCN-egress-node), see Section 3.7. The Deaggregator performs admission control of the E2E Resv onto the generic Aggregate reservation for the PCN PHB-ID (GApcn). The Deaggregator takes also into account the PCN admission control procedure as as specified in [RFC6661] and [RFC6662], see Section 3.7.

If one or both the admission control procedures (PCN based admission control procedure and admission control procedure specified in [RFC4860]) are not successful, then the E2E Resv is not admitted onto the associated RSVP generic aggregate reservation for the PCN PHB-ID (GApcn). Otherwise, assuming that the generic aggregate reservation for the PCN (GApcn) had been established with sufficient bandwidth to support the E2E Resv, the Deaggregator adjusts its counter, tracking the unused bandwidth on the generic aggregate reservation. Then it forwards the E2E Resv to the Aggregator including a SESSION-OF-INTEREST object conveying the selected mapping onto GApcn (and hence onto the PCN PHB-ID).

(9) The Aggregator records the mapping of the E2E Resv onto GApcn (and onto the PCN PHB-ID). The Aggregator removes the SOI object and forwards the E2E Resv towards the sender.

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