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SERIES Q: SWITCHING AND SIGNALLING

Signalling requirements and protocols for the NGN –
Resource control protocols

**Enhancement of resource and admission
control protocols to use pre-congestion
notification**

Recommendation ITU-T Q.3311



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Recommendation ITU-T Q.3311

Enhancement of resource and admission control protocols to use pre-congestion notification

Summary

Recommendation ITU-T Q.3311 defines the additions to the protocols specified for transport resource admission and control, to add the capability for resource and admission control function (RACF) to support and benefit from the use of pre-congestion notification (PCN).

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| Edition | Recommendation | Approval | Study Group |
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Recommendation ITU-T Q.3311

Enhancement of resource and admission control protocols to use pre-congestion notification

1 Scope

This Recommendation defines enhancements to resource and admission control protocols [ITU-T Q.3320] to make use of pre-congestion notification (PCN) which is defined in [IETF RFC 5559] and is a new approach to guarantee quality of service within Diffserv-controlled domains.

The basic concept of pre-congestion notification (PCN) is to measure the loading state of the network based on the experience of flow aggregates as they pass through the network. Aggregates are defined as the set of packets passing through given {ingress point, egress point} pairs. Based on the aggregate results as measured at the egress points, admission policies may be updated for flows offered to these aggregates at the ingress points to the PCN-controlled domain. The observed results can lead to one of three conclusions at a given point of time:

- a) further flows may be admitted to the aggregate;
- b) no further flows may be admitted to the aggregate; or
- c) some of the flows already admitted to the aggregate must immediately be terminated to protect quality of service for further incoming flows.

PCN distinguishes and assigns roles to ingress nodes, interior nodes, and egress nodes relative to a given PCN domain.

Ingress nodes mark admitted packets to indicate that they should be PCN-metered.

Interior nodes check the next-hop link traffic status for each PCN-marked packet before routing it. Packets are either unmarked, threshold-marked or excess traffic marked where the use of threshold marking depends on the encoding and marking schemes deployed in the network. (For definitions of the marking terminology, see clause 3.)

The egress nodes relate the packets they receive to the aggregate flows they receive from individual ingress nodes and generate traffic marking statistics at regular intervals. In principle, the egress node reports these statistics to the decision point each time they are computed, although reports may be filtered in practice to reduce the amount of messaging to be handled.

The architecture on which the IETF works has focused on has the assumption that egress nodes report directly to ingress nodes to affect termination and admission decisions, but also allows for reporting to a centralized decision point. This Recommendation defines the protocol modifications required for resource and admission control protocols to mutually enhance the operation of resource and admission control function (RACF) and PCN when both are present.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T Q.3304.1] Recommendation ITU-T Q.3304.1 (2007), *Resource control protocol No. 4 (rcp4) – Protocols at the Rc interface between a transport resource control physical entity (TRC-PE) and a transport physical entity (T-PE): COPS alternative.*
- [ITU-T Q.3304.2] Recommendation ITU-T Q.3304.2 (2007), *Resource control protocol No. 4 (rcp4) – Protocols at the Rc interface between a transport resource control physical entity (TRC-PE) and a transport physical entity (T-PE): SNMP alternative.*
- [ITU-T Q.3320] Recommendation ITU-T Q.3320 (2010), *Architectural framework for the Q.332x series of Recommendations.*
- [ITU-T Y.2111] Recommendation ITU-T Y.2111 (2008), *Resource and admission control functions in next generation networks.*
- [IETF RFC 5559] IETF RFC 5559 (2009), *Pre-Congestion Notification (PCN) Architecture.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 excess traffic marking [b-IETF RFC 5670]: Whenever the bit rate of PCN-packets is greater than its configured reference rate ("PCN-excess-rate"), its objective is to mark PCN-packets (with an "excess-traffic-mark") at a rate equal to the difference between the rate of PCN-traffic and the PCN-excess-rate.

3.1.2 threshold marking [b-IETF RFC 5670]: Its objective is to mark all PCN-packets (with a "threshold-mark") whenever the bit rate of PCN-traffic is greater than its configured reference rate ("PCN-threshold-rate").

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 congestion level estimate (CLE): A value derived from the measurement of PCN packets received at a PCN-egress-node for a given ingress-egress aggregate, representing the ratio of marked to total PCN traffic (measured in octets) over a short period.

NOTE – Short period is of the order of 100-300 ms.

3.2.2 pre-congestion notification (PCN) report: Information relating to the aggregate of flows between a specific ingress-egress pair of nodes, indicating either a congestion level estimate, a requirement to terminate one or more flows because of overloading, or both.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

| | |
|-------|----------------------------------------|
| CLE | Congestion Level Estimate |
| PCN | Pre-Congestion Notification |
| PD-FE | Policy Decision – Functional Entity |
| PD-PE | Policy Decision – Physical Entity |
| PE-FE | Policy Enforcement – Functional Entity |
| PE-PE | Policy Enforcement – Physical Entity |

| | |
|--------|------------------------------------------------|
| QoS | Quality of Service |
| RACF | Resource and Admission Control Function |
| TRC-FE | Transport Resource Control – Functional Entity |
| TRC-PE | Transport Resource Control – Physical Entity |

5 Conventions

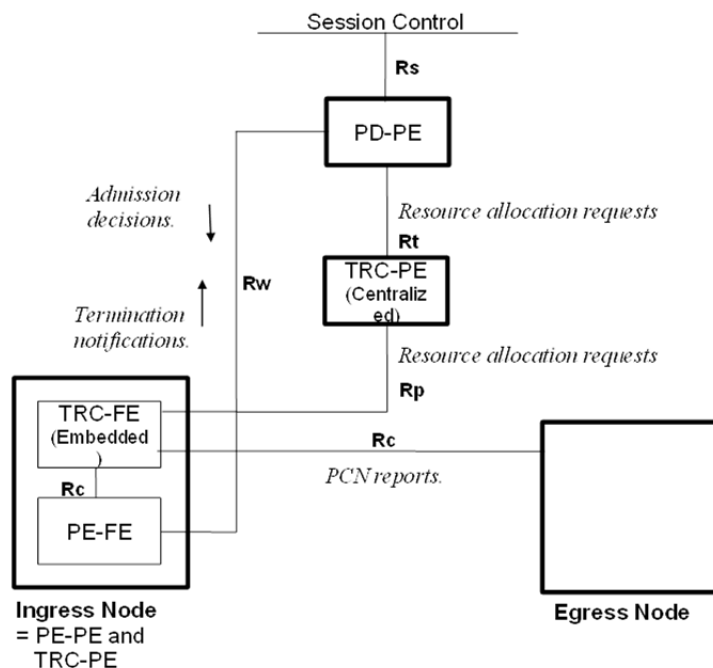
There are no specific conventions in this Recommendation.

6 Signalling architecture

This clause considers how PCN would interact with the RACF architecture. Since that resource admission control architecture is functional, various implementations are possible, depending on what elements are combined in the same physical entities. This Recommendation looks at three alternative physical architectures for deployment of PCN in a RACF environment. In all three architectures, the PD-FE is implemented in a centralized device and the PE-FE is a functional component of the ingress nodes. The architectures differ depending on where the TRC-FE is implemented.

6.1 Mixed architecture

Figure 6-1 shows an architecture in which the TRC-FE is implemented as a centralized instance, and also as a component of each ingress node of the network. The ingress node thus satisfies the definition of a TRC-PE as well as the definition of a PE-PE.



Rc interface inside Ingress Node -- The information passing across this interface is described in clause 7.

Figure 6-1 – PCN-related information flows in the mixed architecture

Each egress node transmits, via the Rc interface, the PCN report relating to a given ingress node to that node in its role as TRC-PE, via the Rc interface. This gives rise to a requirement on the Rc interface to carry the PCN reports. The PCN requirement is for a message to be transmitted to the ingress node concerned whenever the egress node computes the PCN traffic marking statistics for that aggregate. This should occur once per measurement interval (100-300 ms), though frequent

occurrences can be achieved by omitting reports when only unmarked PCN packets are observed in an interval.

There may be an alternative way of PCN report in the Ethernet case. The egress node may check the pre-congestion status change for the ingress-egress aggregate. Once the status changes from pre-congestion to non pre-congestion or vice versa, the PCN report sent from the egress node to the ingress node or the TRC-PE should carry the indication of the status change. The indication can be path ID carried in the PCN report in the Ethernet network.

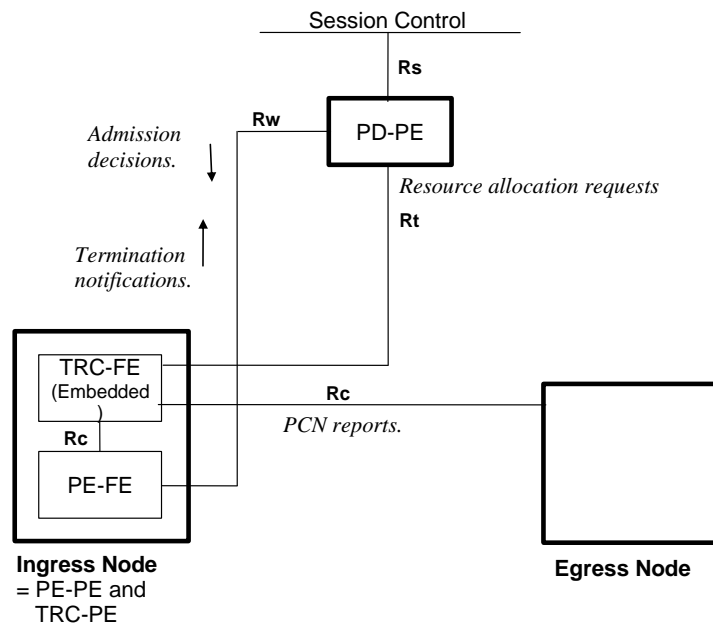
The TRC-FE instance embedded in each ingress node retains the information sent to it by different egress nodes. If an indication of requirement to terminate flows is received by the ingress node, it is handled according to the procedure described in clause 9.1.2.2.2 of [ITU-T Y.2111]. Details are shown in clause 7. When the PD-PE wishes to make a flow admission decision, it requests allocation of the required QoS resources from the centralized TRC-PE over the Rt interface. The centralized TRC-PE passes the request on to the ingress node via the Rp interface to which the flow is offered, in its role as TRC-PE. The ingress node checks to see whether the flow is admissible according to the congestion level estimates derived from the statistics received from the egress node through which the flow will pass, and responds accordingly. If the flow is to be admitted, the PD-PE then sends a message across the Rw interface to the ingress node in its role as PE-PE setting up the admission of the flow.

Note the following requirements in this architecture for knowledge of the network routing information:

- The egress node must be able to match each outgoing packet to the ingress node it came from, both to assign it to the right ingress-egress aggregate for derivation of PCN traffic marking statistics, and to route the resulting reports to the right ingress node.
- The centralized TRC-PE must know which ingress node to contact when routing resource allocation requests across the Rp interface.
- The PD-PE must know which ingress node to contact when transmitting flow admission decisions across the Rw interface.

6.2 Fully-distributed architecture

Figure 6-2 shows an architecture where the TRC-FE is fully distributed, with an instance embedded in each ingress node. As in the previous architecture, the ingress node satisfies the definitions of both a PE-PE and a TRC-PE.



Rc interface inside Ingress Node -- The information passing across this interface is described in clause 7.

Figure 6-2 – PCN-related information flows in the fully-distributed architecture

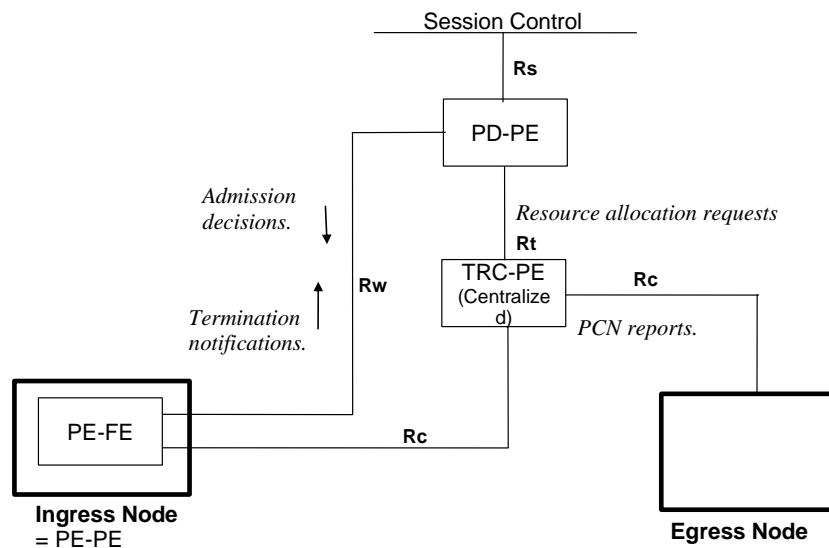
In this architecture, the egress node behaviour is the same as in the first architecture, and the Rc interface is again required to carry PCN reports. The basic difference is that the PD-PE and the ingress node in its role as TRC-PE communicate directly via the Rt interface rather than indirectly via the Rp interface. The requirements for knowledge of routing information thus change slightly from those of the previous architecture, to become as follows:

- [No change] The egress node must be able to match each outgoing packet to the ingress node it came from, both to assign it to the right ingress-egress aggregate for derivation of PCN traffic marking statistics and indications that flows should be terminated, and to route the resulting reports to the right ingress node.
- [Modified] The PD-PE must know which ingress node to contact when routing resource allocation requests across the Rt interface.
- [No change] The PD-PE must know which ingress node to contact when transmitting flow admission decisions across the Rw interface.

The removal of the centralized TRC-PE reduces the possibilities for how the necessary topological information is collected and shared.

6.3 Fully-centralized architecture

Figure 6-3 shows an architecture where the TRC-PE is fully centralized, so that the ingress nodes implement only the PE-FE.



Rc interface between Ingress Node and centralized TRC-PE --
The information passing across this interface is described in clause 7.

Figure 6-3 – PCN-related information flows in the fully-centralized architecture

In this architecture, the egress node sends its PCN reports for all ingress nodes to the TRC-PE via the Rc interface. The messages may thus contain PCN reports pertaining to multiple ingress nodes rather than just one. The centralized TRC-PE calculates the congestion level estimate for each ingress-egress pair based on the PCN traffic statistics it receives from the egress nodes, and also determines whether flow termination is required. If so, the TRC-PE requests the ingress node for the aggregate concerned (i.e., the PE-PE) to provide it with an estimate of the current rate at which PCN traffic is being admitted to the aggregate. Based on the returned estimate and the traffic statistics provided by the egress node, it determines how much traffic to terminate. It selects flows to terminate based on the flow descriptors it received from the PD-PE, and handles flow terminations according to the procedures of clause 9.1.2.2.2 of [ITU-T Y.2111].

When the PD-PE requests allocation of QoS resources for a flow over the Rt interface, the TRC-PE determines admissibility based on the congestion level estimate it has stored for the ingress-egress aggregate involved. As always, the PD-PE completes admission by sending the necessary message over the Rw interface to the ingress node in its role as PE-PE.

Requirements for knowledge of routing information are somewhat different from the requirements in the first architecture:

- [Modified] The egress node must be able to match each outgoing packet to the ingress node it came from, in order to assign it to the right ingress-egress aggregate for derivation of PCN traffic marking statistics. Routing of reports is now a simple matter of knowing the address of the TRC-PE.
- [New] The centralized TRC-PE must know which ingress-egress node pair will carry the flow described by the request it receives over the Rt interface. It must also know which ingress node to contact when flow termination is required for a given aggregate.
- [No change] The PD-PE must know which ingress node to contact when transmitting flow admission decisions across the Rw interface.

7 Flow termination

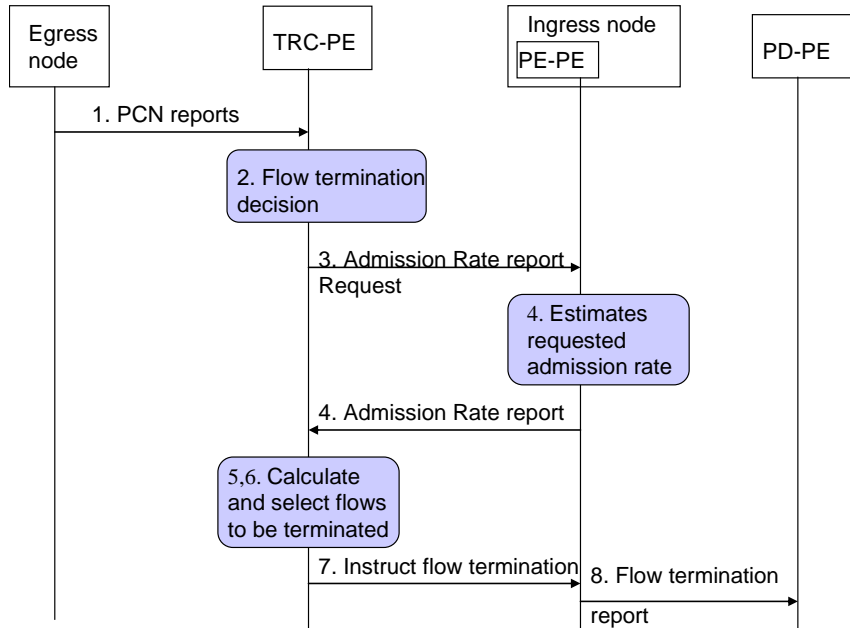


Figure 7-1 – Flow termination process

The following steps describe the process of flow termination. The term TRC-PE below refers to the centralized TRC-PE in the fully centralized case, and to the embedded TRC-PE in the other two cases.

- 1) The TRC-PE receives a report from the egress node for a given ingress-egress aggregate.
- 2) The TRC-PE determines from the report that flow termination is required.
- 3) The TRC-PE sends a request to the PE-PE at the ingress node to report the rate at which it is currently admitting PCN traffic to the given ingress-egress aggregate.
- 4) The PE-PE at the ingress node estimates and reports the requested admission rate.
- 5) The TRC-PE uses the information from the ingress and egress nodes to calculate how much traffic has to be terminated.
- 6) The TRC-PE selects flows to be terminated based on flow characteristics.
- 7) The TRC-PE instructs the PE-PE to terminate the selected flows.
- 8) The PE-PE reports that the flows have been terminated to the PD-PE via the Rw interface.

8 Summary of interface-specific requirements

8.1 Requirements on the Rw interface

No change to the Rw interface described in [ITU-T Y.2111].

8.2 Requirements on the Rt interface

No change to the Rt interface described in [ITU-T Y.2111].

8.3 Requirements on the Rp interface

No change to the Rp interface described in [ITU-T Y.2111].

8.4 Requirements for the Rc interface

8.4.1 General requirements

Reliable delivery of messages carrying PCN reports is required. The basic Rc interface protocol is defined in [ITU-T Q.3304.1] and [ITU-T Q.3304.2].

In the mixed and fully-distributed architectures, the edge nodes of the network are required to be capable of supporting multiple active Rc interfaces.

8.4.2 Content of PCN reports

Two types of PCN report are required: the egress node measurement report, and the ingress node measurement report.

The egress node measurement reports the following:

- the octets per second of unmarked PCN traffic received at the egress node (PD-PE);
- the octets per second of threshold-marked PCN traffic received at the egress node;
NOTE 1 – In some deployments of PCN, no threshold marking occurs so that this value is always zero.
- the octets per second of excess-traffic-marked traffic received at the egress node;
- optionally, the congestion level estimate (CLE), calculated as the ratio of octets in PCN-marked packets to total octets of PCN traffic received;
- identity of flows experiencing excess-traffic-marking (only in certain deployments).

The ingress node measurement report is required when flow termination is needed. It contains:

- the octets per second of PCN traffic admitted to a given ingress-egress aggregate.

NOTE 2 – Identification of marked flows is required only when equal cost multipath (ECMP) routing is in effect in the PCN domain.

9 Security considerations

There are no security-related issues identified in this Recommendation.

Bibliography

[b-IETF RFC 5670] IETF RFC 5670 (2009), *Metering and Marking Behaviour of PCN-Nodes*.

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