



ATIS-1000037

Resource Admission Control – Overview of Relevant Standards

TECHNICAL REPORT



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### ATIS-1000037, *Resource Admission Control – Overview of Relevant Standards*

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# **RESOURCE ADMISSION CONTROL – OVERVIEW OF RELEVANT STANDARDS**

**Alliance for Telecommunications Industry Solutions**

Approved February, 2010

## **Abstract**

This Technical Report provides a high level examination of the current state of the work on resource and admission control being advanced in various Standards Development Organizations (SDO) and the challenges in implementing practical admission control solutions over Private or Public Network environments.

**Foreword**

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between providers, customers, and manufacturers. The Packet Technologies and Systems Committee (PTSC) develops and recommends standards and technical reports related to services, architectures, and signaling, in addition to related subjects under consideration in other North American and international standards bodies. PTSC coordinates and develops standards and technical reports relevant to telecommunications networks in the U.S., reviews and prepares contributions on such matters for submission to U.S. ITU-T and U.S. ITU-R Study Groups or other standards organizations, and reviews for acceptability or per contra the positions of other countries in related standards development and takes or recommends appropriate actions.

The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages. The word *may* denotes a optional capability that could augment the standard. The standard is fully functional without the incorporation of this optional capability.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, PTSC 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, PTSC, which was responsible for its development, had the following roster:

- M. Dolly, PTSC Chair (AT&T)
- V. Shaikh, PTSC Vice-Chair (Telcordia)
- P. Tarapore, Technical Editor (AT&T)
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The **SAC** Subcommittee was responsible for the development of this document.

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# RESOURCE AND ADMISSION CONTROL – OVERVIEW OF RELEVANT STANDARDS

## 1 SCOPE AND PURPOSE

The key principle driving resource and admission control is relatively straightforward and can be stated in the following three steps:

1. Determine the requirements for the call/session seeking admission into the network. Examples of such requirements include bandwidth, Quality of Service (QoS), and priority. These requirements are determined by the service type. For example, an Emergency Telecommunications Service (ETS) call would require the highest priority for admission control and stringent bandwidth requirements for acceptable voice quality.
2. Determine the availability of resources in the transport layer in order to support the requirements of the incoming call/session.
3. If the available resources can accommodate the minimum requirements, admit the call/session, else deny<sup>1</sup>.

In practice however, this process can be complex. The evolution towards “Next Generation Networks” (NGN) includes a combination of networking technologies (e.g., Ethernet, wireless, MPLS) and encompasses wireless and wire-line convergence. At the same time, new service offerings include various combinations of real-time, packet data, and multimedia services provided by an IP Multimedia Subsystem (IMS) environment.

Service providers may chose to offer certain types of services over “Private Networks” such as MPLS-based Virtual Private Networks (VPN). Alternately, they may design their networks as “Public Networks” – or “Shared Networks” - to support a wide variety of services whereby individual services compete for resource allocation during the admission process.

This Technical Report provides a high level examination of the current state of the work on resource and admission control being advanced in various Standards Development Organizations (SDO) and the challenges in implementing practical admission control solutions over Private or Public Network environments.

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<sup>1</sup> Service providers may also have provisions for admitting calls/sessions at lower QoS requirements to with appropriate charging fees. These options depend on the Service Level Agreement established with the customer.

## 2 NORMATIVE REFERENCES

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The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

### 2.1 ATIS References<sup>2</sup>

[A-0100022] – ATIS-0100022.2008, *Priority Classification Levels in Next Generation Networks*

[A-1000026] – ATIS-1000026.2008, *Sessions Border Control Functions and Requirements*

### 2.2 ITU References<sup>3</sup>

[Y.2012-Sup1] – ITU-T Recommendation Y.2012 Supplement 1 (2006), *Session Border Control Functions*

[Y.2111] – ITU-T Recommendation Y.2111 (2006), *Resource and Admission Control Functional Requirements (RACF)*

[Y.2171] – ITU-T Recommendation Y.2171 (2006), *Admission Control Priority Levels in NGN*

[Y.2174] – ITU-T Recommendation Y.2174 (2008), *Distributed RACF Architecture for MPLS Networks*

[Y.2175] – ITU-T Recommendation Y.2175 (2009), *Centralized RACF Architecture for MPLS Networks*

[Q.3301.1] – ITU-T Recommendation ITU-T Q.3301.1 (2007), *Resource Control Protocol No. 1 – Rs Interface*

[Q.3303.3] – ITU-T Recommendation ITU-T Q.3303.3 (2008), *Protocol to Support RACF Rw Reference Point – DIAMETER*

[Q.3305.1] – ITU-T Recommendation ITU-T Q.3305.1 (2008), *Resource Control Protocol No. 5 – Rt Interface*

[NGN-C240] – NGN-GSI Contribution 240 (2009), *Transport Control Functions in NGN*

### 2.3 IETF References<sup>4</sup>

[RFC2475] – IETF RFC 2475 (1998), *An Architecture for Differentiated Services*

[RFC3175] – IETF RFC 3175 (2001), *Aggregation of RSVP for IPv4 and IPv6 Reservations*

[RFC4804] – IETF RFC 4804 (2007), *Aggregation of Resource Reservation Protocol (RSVP) Reservations over MPLS-TE/DS-TE Tunnels*

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<sup>2</sup> These documents are available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005. < <https://www.atis.org/docstore/default.aspx> >

<sup>3</sup> These documents are available from the International Telecommunications Union. < <http://www.itu.int/ITU-T/> >

<sup>4</sup> These documents are available from the Internet Engineering Task Force (IETF). < <http://www.ietf.org> >

## 2.4 3GPP References<sup>5</sup>

[TS 23.228] – 3GPP Technical Specification TS 23.228 V8.8.0 (2009), *IP Multimedia Subsystem (IMS); Stage 2 (Release 8)*

[TS 23.203] – 3GPP Technical Specification TS 23.228 V8.8.0 (2009), *Policy and Charging Control Architecture (Release 8)*

[TS 29.212] – 3GPP Technical Specification TS 29.212 V8.3.0 (2009), *Policy and Charging Control over Gx Reference Point (Release 8)*

[TS 29.214] – 3GPP Technical Specification TS 29.214 V8.4.0 (2009), *Policy and Charging Control over Rx Reference Point (Release 8)*

[TS 23.002] – 3GPP Technical Specification TS 23.002 V9.1.0 (2009), *Network Architecture (Release 9)*.

[TS 23.334] – 3GPP Technical Specification TS 23.334 V1.1.0 (2009), *IMS Application Level Gateway-IMS Access Gateway Interface: Procedures Descriptions (Release 9)*.

## 2.5 Packet Cable and Broadband Forum References

[PKT-TR-ARCH-TR] – PacketCable 2.0 PKT-TR-ARCH-FR-V06-090528 (2009), *Architecture Framework Technical Report*.<sup>6</sup>

[WT-134] – Broadband Forum Working Text 134-Rev.16.01 (2009), *Broadband Policy Control Framework*.<sup>7</sup>

[WT-203] – Broadband Forum Working Text 203-Rev.00 (2009), *Interaction between Next Generation Fixed and 3GPP Wireless Access*.<sup>7</sup>

## 2.6 ETSI/TISPAN References<sup>8</sup>

[RACS] - ETSI ES 282 003 - Telecommunications and Internet Converged Services and Protocols for Advanced Networking (TISPAN); “Resource and Admission Control Sub-system (RACS); Functional Architecture”.

# 3 DEFINITIONS, ACRONYMS, & ABBREVIATIONS

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## 3.1 Definitions

None identified in this document

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<sup>5</sup> These documents are available from the Third Generation Partnership Project (3GPP) at <  
<http://www.3gpp.org/specs/specs.htm> >

<sup>6</sup> This document is available from CableLabs, <http://www.cablelabs.com/packetcable/specifications/specifications20.html>

<sup>7</sup> This document is available from Broadband Forum, <http://www.broadband-forum.org/>

<sup>8</sup> This document is available from the European Telecommunications Standards Institute (ETSI).  
<http://www.etsi.org/getastandard/home.htm>

### 3.2 Acronyms & Abbreviations

3GPP	3 <sup>rd</sup> Generation Partnership Project
ATIS	Alliance for Telecommunications Industry Solutions
AVP	Attribute Value Pairs
BBF	Bearer Binding Function
CAC	Connection Admission Control
CMTS	Cable Modem Termination System
DSCP	DiffServ Code Point
DS-TE	DiffServ-Aware MPLS Traffic Engineering
ETS	Emergency Telecommunications Service
FMC	Fixed Mobile Convergence
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LER	Label Edge Router
MPLS	Multi-Protocol Label Switching
NGN	Next Generation Network
PAM	PacketCable Application Manager
PCC	Policy and Charging Control
PCEF	Policy and Charging Enforcement Function
PCRF	Policy and Charging Rules Function
P-CSCF	Proxy Call Session Control Function
PD-FE	Policy Decision Functional Entity
PDP	Policy Decision Point
PE-FE	Policy Enforcement Functional Entity
PEP	Policy Enforcement Point
QoS	Quality of Service
RACF	Resource and Admission Control Function
RACS	Resource and Admission Control Subsystem
RCEF	Resource Control Enforcement Function
RSVP-TE	Resource ReserVation Protocol – Traffic Engineering
SBC	Session Border Controller
SDO	Standards Development Organization
TRC-FE	Transport Resource Control Functional Entity
VoD	Video on Demand
VoIP	Voice over IP
VPN	Virtual Private Network
WT	Working Text

## 4 INTRODUCTION

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Telecommunications networks continue to evolve and support increasingly complex combinations of offered services. Access networks include a variety of technologies including wireless, DSL, and Metro Ethernet. Core backbones include MPLS, wireless, and Ethernet technologies. A single service provider may operate a number of access and core backbone technology network domains that in turn, link with other network domains operated by different service providers. Collectively, these networks constitute the “Public Network”. In this environment, many different types of services seek an end-to-end transmission path involving an access network, one or more core backbones, and an egress network, that may be operated by multiple service providers. For example, a VoIP call may originate over a wireless access network domain, gain backbone transport over an MPLS core, and finally terminate over a DSL egress domain. An appropriate end-to-end resource and admission control process across the Public Network domains, permits the determination of resource requirements for incoming calls/sessions and comparison with available resources in the network. The call/session is admitted if available resources are sufficient to meet the stated requirements.

Part of this evaluation process includes the determination of the admission control priority of the incoming call/session [Y.2171], [A-0100022]. Such priority levels are critical in the decision making process particularly under emergency/disaster conditions when networks may suffer from significant diminution of available resources. For example, admitting Emergency Telecommunications Service (ETS) under disaster conditions can be facilitated by assigning the highest admission control priority to such services. This assumes that networks are capable of recognizing priority levels and making the necessary decisions accordingly.

Alternately, service providers may chose to offer certain types of services over “Private Networks” whereby significant portions of their networks are exclusively reserved for delivery of the given service to a dedicated set of customers. For example, large Enterprise Customers have dedicated VPNs provisioned to meet their communications needs. Admission control for these cases is simplified as discussed in Clause 5.

Clauses 6 through 10 provide discussions on various aspects of the key standards and their ability to provide a practical process for Resource and Admission Control for the case involving Public Networks. Clause 11 provides some guidance on how to structure an end-to-end resource and admission control process.

## 5 RESOURCE AND ADMISSION CONTROL – PRIVATE NETWORKS

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For services offered over Public Domains, typically the traffic volume may not be sufficiently large when compared to the total service volume offered by any service provider. By contrast, private network services involve critical customers with specific needs that are captured in Service Level Agreements. In turn, significant network resources may be exclusively reserved for such customers. Two examples illustrate this:

1. Virtual Private Networks (VPN) for Enterprise Customers – Examples of such customers include:
  - a. Government Agencies: Agencies at the Federal, state, and local governments typically buy several types of telecommunications services from service providers and hence, they specify many requirements including service availability.
  - b. Private Sector: Large corporations, financial institutions, universities, etc, are examples of Enterprise Customers in the private sector. Such customers agree to very specific

requirements for the type of service desired. Service availability is a key requirement for such customers.

A service provider carves out a share of its network and “reserves” it for each Enterprise Customer. The reserved set of resources is traffic engineered to meet the agreed upon service volume with specified service availability objectives. The end points are Customer Premise locations with edge equipment (e.g., Edge Routers) controlling access into the VPN. The edge equipment provides the necessary admission control – this is a simple process that allows traffic into the VPN up to the specified amount per SLA agreements.

2. IPTV Services – This includes linear TV offerings (packages with a given set of channels) as well as Video on Demand (VoD). The underlying transport technologies may include a combination of networks such as Ethernet, DSL, and MPLS<sup>9</sup>. A service provider may design the supporting network resources to meet the demand of all customers of the service depending on the terms of individual service contracts. The only form of admission control is then carried out by the IPTV set-top boxes at the very edge of the service – the customer’s home. For example, if an IPTV customer requests VoD service that exceeds the service contract, then the request may be denied by the user’s set-top box. While this simple form of admission control is adequate for the described service, the IPTV suite of options may get enlarged to include the so-called “triple play” – Voice over IP (VoIP) and Internet service in addition to IPTV. The latter two services are partially pre-provisioned; sufficient bandwidth is assumed to be traffic engineered from the Customer Premise (user’s home) to the edge of the Public Network cloud. The latter is the collection of broad public domain networks that enable completion of voice calls as well as internet browsing. Admission control is then accomplished in two parts:
  - a. Customer Premise Control – The IPTV set-top box and the VoIP modem control the total amount of simultaneous traffic according to agreed upon limits. This form of control applies to the portion of the path from the Customer’s Premise to the edge of Public Network cloud.
  - b. Shared/Public Network Control – Admission control from the edge of the “public” cloud to the terminating end point can proceed per the discussions in Clauses 6 - 10.

## **6 RESOURCE AND ADMISSION CONTROL STANDARDS OVERVIEW – PUBLIC NETWORKS**

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The guiding principle behind resource and admission control was stated in the Scope as follows:

1. Determine the requirements for the call/session seeking admission into the network. Examples of such requirements include bandwidth, Quality of Service (QoS), and priority.
2. Determine the availability of resources in the transport layer in order to support the call/session requirements.
3. If the available resources can accommodate the minimum requirements, admit the call/session, else deny.

In step (1), the determination of required resources for the incoming call/session is carried out via appropriate interactions with application layer functions. The IMS domain is an example of this functionality per specifications defined in 3GPP Release 8 [TS 23.228].

Table 1 [NGN-C240] summarizes relevant resource and admission control standards defined in various Standards Development Organizations (SDO). Standards applicable to wireless networks are defined in

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<sup>9</sup> Wireless networks may also play a role in the future (e.g., Mobility TV).

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3GPP and the WiMAX Forum – the latter effort is compliant with the work done in 3GPP. Standards applicable to wire-line networks are defined in the ITU-T (RACF) and TISPAN (RACS). Cable related standards are defined in CableLabs. Policy work has also commenced in the Broadband Forum – this is discussed in Clause 9.

**Table 1– Summary of Resource and Admission Control Standards**

	ITU-T	3GPP/SAE	TISPAN	WiMax	CableLabs
Policy Decision	PD-FE	PCRF	SPDF, A-RACF (partial)	PCRF, PDF	PAM, PS
Policy Enforcement	PE-FE	PCEF	RCEF <sup>10</sup>	PCEF	CMTS
Transport Resource Control	TRC-FE	-	A-RACF (partial)	-	-

PD-FE (Policy Decision Functional Entity)  
 TRC-FE (Transport Resource Control Functional Entity)  
 PE-FE (Policy Enforcement Functional Entity)  
 PCRF (Policy and Charging Rules Function)  
 PCEF (Policy and Charging Enforcement Function)  
 SPDF (Service Policy Decision Function)  
 A-RACF (Access Resource Admission Control Function)  
 PDF (Policy Distribution Function)  
 PAM (PacketCable Application Manager)  
 PS (Policy Server)  
 CMTS (Cable Modem Termination System)

There are several aspects that are common to all standards and one significant difference as follows:

1. Policy Decision Function: All standards have a Policy Function (the names differ) that is responsible for interacting with the application layer to determine the resource requirements of the incoming call/session. This functionality serves step (1) of the resource and admission control principle stated in the scope.
2. Policy Enforcement: All standards have a Policy Enforcement Function (the names differ) that is responsible for ensuring the action needed in the underlying transport layer to admit or deny the call/session (e.g., packet policing, packet marking, QoS and priority support). This functionality is equivalent to step (3) of the resource and admission control principle stated in the scope.
3. Transport Resource Control: The wire-line standards define a dedicated Transport Resource Control function that is solely responsible for determining adequacy of available resources in the underlying transport layer. This functionality is equivalent to step (2) of the resource and admission control principle stated in the scope. The ITU-T RACF fully defines this functionality. The TISPAN RACS partially defines this as needed in access networks only; it further defines this functionality in terms of an access RACF. For wireless access networks, the 3GPP

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<sup>10</sup> Note that legacy RCEF's can only enforce pre-configured or seldom changed policies. In such cases, per session policy enforcement may involve interaction with a Border Gateway Function.

architecture invokes determination of radio access resources as part of the bearer binding association.

This Technical Report provides discussions on the use of these standards by focusing on these similarities and difference. It also touches on some architectural aspects for these functionalities.

## **7 GATEWAY SUPPORT FOR POLICY FUNCTIONS**

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The Policy Decision and Enforcement functions have been defined logically for wireless and wire-line networks (see Table 1). Specifically, Gateways to network domains are embodied with a wide range of functionality to process incoming call/session initiation prior to formal admission into the underlying network. Gateways can serve as “gatekeepers” for access networks. They also provide interconnection processing between network domains over the end-to-end path of calls/sessions.

Architectural manifestations of these logical functions have also received some attention. For wireless networks, the Evolved Packet Core in 3GPP uses the Packet Data Node (PDN) Gateway. ATIS and ITU-T have defined functionality for the Session Border Controller with applications for NGNs.

### *7.1 PDN Gateway for Wireless Networks*

Two Gateways have been mentioned by 3GPP for support in wireless networks [TS 23.203], [TS 23.401]. They are:

- Gateway General Packet Radio Service (GPRS) Support Node – Gateway support for GPRS bearers
- Packet Data Node (PDN) Gateway – Gateway support for the Evolved Packet Core

The Policy and Charging Enforcement Function (PCEF) resides in these Gateways [TS-23-203]. Policy control related to QoS is enforced by this function at the Gateway in question.

The Policy and Charging Rules Function (PCRF) is depicted as an independent entity not residing in any Gateway [TS 23.203], [TS 23.401], [TS 23.402]. The possibility of locating in within any specific gateway is for further study.

### *7.2 Session Border Controller for Wireline Networks*

The Session Border Controller (SBC) Gateway functionality has been defined in ATIS [A-1000026] and the ITU-T [Y.2012-Sup1]. Signaling Path (control plane) functions provide the necessary signaling interactions with the service/application layer. Examples of Signaling Path functions include protocol translation and inter-working, call/session-based routing, and signaling encryption and decryption. Media Path functions provide interactions with the underlying transport. Examples include packet policing and marking, opening and closing of pinhole/firewall, and Connection Admission Control (CAC).

The SBC Media Path functions [A-1000026] support a host of Policy Enforcement requirements for admission control. These include access admission control, bandwidth allocation, enforcement of rules based on maximum number of simultaneous calls/sessions, monitoring bandwidth usage, support for QoS and priority, and packet policing/marking. The Policy Enforcement functions defined in various SDO's (Table 1) can then be considered to be distributed in the appropriate Media Path functions in the SBC.

To date, a function dedicated for Resource and Admission Control Policy Decision support has not been defined for the SBC. It is possible to centralize this function in a central server for a network domain. This possibility is for further study. It is also possible to distribute the functionality by dedicating

a function for this purpose in the Signaling Path of the SBC. This would enable all policy related interactions to be completed in the SBC.

### 7.3 Other Gateways

Several other Gateways have received mention in various SDO documents. They include the following:

- IMS Access Gateways [TS 23.228], [TS 23.334] – The IMS Application Level Gateway (IMS-ALG) and IMS Access Media Gateway interact via the Iq interface for the purpose of gate control and traffic policing between an IP-Connection Network (IP-CAN) and an IMS domain.
- Transition Gateway/Border Control Function [TS 23.002], [TS 23.228] – The Transition Gateway (TrGW) is located in the media path and is controlled by an Interconnect Border Control Function (IBCF). It provides functionality for network address/port translation and IPv4/IPv6 protocol translation.

The precise role of these gateways in the end-to-end admission control policy process as well as potential overlap of various functionalities (e.g., Policy Enforcement Function) across them is for further study.

## 8 WIRELESS NETWORKS – 3GPP STANDARDS

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Standards pertaining to wireless networks are advanced in 3GPP – WiMAX technology standards are stated as being 3GPP compliant. All resource and admission control development related to wireless networks should comply with 3GPP standards.

3GPP Release 8 functionality supporting admission control is described as part of the Policy and Charging Control (PCC) architecture [TS 23.203]. The Policy Decision functionality is contained in the Policy Charging and Rules Function (PCRF). The Policy Enforcement functionality is contained in the Policy and Charging Enforcement Function (PCEF). PCRF and PCEF interactions supporting Resource and Admission Control are as follows:

- Initial PCRF and Application Layer Interaction: The Proxy Call Session Control Function (P-CSCF)<sup>11</sup> which is part of the IMS Application Function layer submits a QoS authorization request to the PCRF via the Rx Reference Point. This request includes call/session bandwidth requirements, priority, media type/flow description, and event triggers. Rx Reference Point interactions are carried out via appropriate DIAMETER protocol Attribute Value Pairs (AVP) [TS 29.214].
- PCRF-PCEF Interaction: The PCRF processes the request, authorizes resources, and provisions PCC rules at the PCEF via the Gx Reference Point. The PCEF requests the establishment/modification of EPS resources. The Bearer Binding Function (BBF) associates the service flow with the appropriate bearers that can provide the desired QoS. The availability of Radio Access Network (RAN) resources is checked by the eNodeB. The E-UTRAN admits the corresponding bearer/resources only if resources are available. The PCEF performs the necessary enforcement functions such as packet policing, packet marking, and opening of pinhole. Gx Reference Point interactions are carried out via appropriate DIAMETER protocol AVPs [TS 29.212].
- Final PCRF-Application Layer Interaction: Once the PCEF completes required enforcement actions, the PCRF responds back to the P-CSCF via the Rx Reference Point indicating IP-CAN support (successful allocation of required resources provided the P-CSCF subscribes to this event) or denial (resource unavailability) of the impending media flow.

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<sup>11</sup> Note that the PCRF can interact with any application function that supports the Rx interface.

Note that while there is no dedicated Transport Resource Control Function defined in 3GPP, radio resource availability and access transport resource availability is determined as part of the bearer binding association.

## 9 WIRELINE NETWORKS – ITU-T RACF

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The ITU-T Resource and Admission Control Function (RACF) [Y.2111] standard applies to all NGN networks. Given that wireless network admission control standards are governed by 3GPP, all wire-line network admission control requirements can be specified by RACF. It was noted that TISPAN RACS is similar to RACF regarding the presence of the Policy Decision and Policy Enforcement functionality. However, the Transport Resource Control function specified in TISPAN RACS is denoted by an access RACF function. TISPAN RACS assumes that core backbone wire-line networks have sufficient resources traffic engineered/pre-provisioned and hence do not need any transport control functionality. Hence, it can be stipulated that ITU-T RACF fully governs all wire-line resource and admission control requirements – TISPAN RACS can be viewed as a subset of ITU-T RACF.

### 9.1 RACF Transport Resource Control Architecture

The Policy Decision and Enforcement Functions in RACF (and TISPAN RACS) can be supported by functionality defined – and in the case of the Policy Decision Function, proposed – for the SBC (see Clause 6). Architectures for the Transport Resource Control Function have also received some attention. Two standards have been developed for this purpose for MPLS networks.

ITU-T Recommendation Y.2175 [Y.2175] proposes a centralized Transport Resource Control Function that collects information from the Label Edge Routers (LER) on the state of availability of the underlying MPLS transport and communicates with the Policy Decision Function accordingly. This requires additional signaling interaction with the LERs and the necessary “Reference Points” are under consideration as additional protocol requirements are needed for supporting them.

ITU-T Recommendation Y.2174 [Y.2174] proposes a distributed Transport Resource Control Function that capitalizes on work done in the IETF. The functionality is distributed between the SBC Media Path Connection Admission Control (CAC) Function and the LER. It depends on the Resource Reservation Protocol with Traffic Engineering (RSVP-TE) to determine the availability of bandwidth in Label Switched Paths (LSP) and TE Tunnels between pairs of LERS in the MPLS network [RFC3175]. Bandwidth reservations can be done with RSVP-TE on a per call/session basis or on an aggregated basis. Dynamic adjustment of TE-Tunnels can also be managed via DiffServ-Aware MPLS Traffic Engineering (DS-TE) [RFC4804]. The SBC CAC Function which is part of the Transport Resource Control Function communicates with the Policy Decision Function as needed.

Note that both the centralized and distributed architectures proposed for MPLS can also be applied to other wire-line technologies such as Ethernet and DSL. The technology specific (Ethernet or DSL) interactions with either a centralized Transport Control Function or the distributed CAC Function in an SBC are for further study.

### 9.2 RACF Resource and Admission Control Process

The RACF admission control process is similar to the 3GPP process except that the Transport Resource Control Function is utilized for determining available resources in the underlying wire-line transport.

- Initial Policy Decision Function-Application Layer Interaction: The appropriate IMS function – either the P-CSCF or the Interconnect Border Control Function (IBCF) - submits an authorization request to the RACF PD-FE via the appropriate DIAMETER Attribute Value Pairs

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(AVP) as part of the Rs Reference Point [Q.3301.1]. The request includes binding information/latching indication, bandwidth, priority, media type/flow description, and event triggers.

- Policy Decision-Policy Enforcement Interactions: The PD-FE determines the ability of the SBC to carry out admission control processing and initiate the desired RACF Policy Enforcement actions in the SBC Media Plane (e.g., packet policing and marking, opening of pinhole, etc) [Y.2111]. This interaction is carried out via appropriate DIAMETER AVPs as specified in the RACF Rw Reference Point [Q.3303.3].
- Policy Decision-Transport Resource Control Interaction: The PD-FE submits a DIAMETER message per RACF Rt Reference Point [Q.3305.1] to the Transport Resource Control Function (Media Path CAC Function in the SBC in the distributed case). The Transport Control Function determines the availability of sufficient resources in the underlying transport network. The Transport Control Function responds back to the PD-FE with the desired information.
- Final Policy Decision Function-Application Layer Interaction: Once the Policy Enforcement and Transport Control Functions complete the required actions, the PD-FE responds back to the appropriate IMS Function (P-CSCF or IBCF) via the Rs Reference Point indicating support or denial of the impending media flow.

It should be noted that the Q Series DIAMETER protocol requirements listed above for the Rs, Rw, and Rt Reference Points were based on 3GPP Release 7. These requirements need to be updated to conform to 3GPP Release 8.

The processing functionality for the TISPAN RACS is similar to this process. The one difference is that instead of a Transport Resource Control Function, RACS lists the use of an Access-RACF for this purpose. This assumes that sufficient bandwidth will always be Traffic Engineered in core backbone networks.

## 10 CABLE LABS AND BROADBAND FORUM EFFORTS

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This clause describes standards work in CableLabs and in the Broadband Forum.

### 10.1 CableLabs Standards

Packet Cable network architecture Release 2.0 for multimedia services has outlined the following functional entities to support QoS based admission control policies[PKT-TR-ARCH-TR]:

- PacketCable Application Manager (PAM): The PAM receives messages from a P-CSCF and prepares appropriate responses to the Policy Server. The interaction between the PAM and the P-CSCF is done via the Rx interface – this is the same interface between a 3GPP PCRF and a P-CSCF.
- Policy Server: The Policy Server receives the messages from the PAM and determines the appropriate Cable Modem Termination System. Note also that the PAM can be packaged with the Policy Server in which case it is equivalent to the 3GPP PCRF.
- Cable Modem Termination System (CMTS): The Termination System resides in the Resource Control Domain and enforces resource requests from the Application Manager via a Policy Enforcement Point (PEP). The CMTS is responsible for admission control and resource control management via DOCSIS Service Flows.

When access to cable networks is via wireless access, then access policies are aligned with 3GPP Technical Specification 23.203 Annex D [TS.23.203].

## 10.2 Broadband Forum Standards

Admission control policy work in the Broadband Forum has been progressing on the following two efforts.

- WT-134 [WT-134] – This Working Text (WT) seeks to develop physical network architectures and element-specific requirements for policy management and control in Broadband multiservice networks. The WT also attempts to define the relationship between the Broadband Forum approach and various external Standard Development Organizations (SDOs) policy and NGN efforts as well as the integration of features to allow the broadband multiservice network to work with generic NGN architectures. The goal is to develop an architecture for these features via an appropriate information model. Congestion control is a key objective for policy definition and initial drafts for WT-134 have defined two key logical functions in support:
  - Policy Decision Point (PDP)/Policy Server – A logical function or entity that makes policy decisions for network elements that request such decisions. The PDP architecture may be centralized whereby a single operator is responsible for decision making for both network access as well as Internet Service Provider (ISP) services. Alternately, it may be distributed whereby multiple PDPs have operational responsibility for predefined portions of the network/domain. In this case, the PDPs are required to communicate with themselves to support various service types and provide end-to-end control. The PDP is assumed to be located within a Policy Server for both the centralized and distributed cases.
  - Policy Enforcement Point (PEP) – A logical function or entity that is responsible for traffic policy enforcement of unicast and multicast traffic types in any functional node element. Policy Enforcement may be applied at an IP Session, IP Flow, as well as at an aggregate level.
- WT-203 [WT-203] – This WT seeks to address the inter-working between wireless and wireline technologies - Fixed Mobile Convergence (FMC). FMC is a technology trend impacting almost all telecommunication and Information industries providing the subscribers access to services anywhere anytime regardless of the Access network type they are connected to and providing the Service Providers with the flexibility to ensure transparency of services to the end user. The purpose of WT-203 is to develop architecture and requirements that facilitate FMC between BBF and 3GPP architectures supporting policies related to admission control among other aspects. This WT is a “work in progress”.

## 11 END-TO-END RESOURCE AND ADMISSION CONTROL PROCESS FOR SHARED NETWORKS

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As stated above, resource and admission control can be invoked for a wide variety of service types (real-time VoIP calls, data and multimedia sessions) to be setup over multiple domains of different wireless and wire-line technologies end-to-end. For example, a VoIP call may originate over a wireless access network domain, gain backbone transport over an MPLS core, and finally terminate over a DSL egress domain. To determine an end-to-end admission control process, two questions require further discussion.

### 11.1 Per Call/Session Admission Control Versus Aggregated Admission Control

It is possible to administer Resource and Admission Control on a Per Call/Session basis or on an Aggregated Admission Control basis. For the per call/session case, every call/session seeking entry into a network undergoes examination for resource demands (e.g., bandwidth, QoS, priority) and resource availability. The required resources are then specifically reserved “on demand” to support this call/session. These resources are released upon the termination of the call/session. This is the most optimal process in terms of resource utilization. There are two drawbacks to incorporate a per call/session process:

- To carry out such a process, it is necessary to have a Transport Resource Control Function operational in all domains in the end-to-end path of the call/session. That is the only way to correctly determine the availability of required resources followed by the ability to reserve – and release - the specified amount of bandwidth in each domain. As discussed earlier, wireless networks currently do not have such a function and, going forward for LTE work, may not plan for a Transport Resource Control Function. Without some form of Transport Control functionality end-to-end, the ability to correctly determine resource availability followed by the reservation and release of the required resources becomes problematic.
- Per call/session reservation processing demands on network elements (e.g., routers, switches, cross-connects, etc) could be prohibitively excessive, particularly for large service providers who handle hundreds of millions of calls/sessions every day.

For these reasons, per call/session admission control may not be a practical process.

In the case of Aggregated Admission Control, resource (bandwidth) allocation is done in aggregated chunks for agreed upon service types. The allocation can be Accomplished in two ways:

- Static Allocation: Transport capacity can be pre-provisioned based on traffic forecasts (time of day, day of week). Resources are then expected to be “always” available for all service types. This mitigates the need for a Transport Resource Control Function.
- Dynamic Allocation: Resources can be reserved in aggregated chunks when traffic demands increase. The size of the reserved chunk can be adjusted as needed. The resources can be released epr traffic patterns. An example of dynamic resource reservation is the use of RSVP-TE based reservations for MPLS-TE tunnels [RFC3175], [RFC4804] as described in [Y.2174]. Such dynamic allocation mechanisms can then be seen as a form of Transport Resource Control functionality.

Network element processing at the transport layer is also significantly simplified. Aggregated Admission Control may not optimize resource utilization. However, it is much more practical and efficient to administer.

### 11.2 End-to-End Admission Control Process

Per the above discussion, it can be stated that the end-to-end Resource and Admission Control process requires the following:

- a. The application layer (e.g., IMS domain) is needed for all network domains in the path of the call/session. Appropriate signaling initiates the admission control process in the application layer, triggering the policy requests to relevant policy decision functions in each network domain over the path of the call/session.
- b. Policy Decision Functions in each network domain (wire-line and wireless) interact with the application layer to derive the resource requirements of the incoming call/session.

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- c. Policy Enforcement Functions in each domain carry out the enforcement tasks in the transport layer per instructions from the appropriate Policy Decision Function.
- d. At a minimum, adequate transport resource is traffic engineered/pre-provisioned to “guarantee” availability of required resources in the underlying transport layer. The presence of a Transport Resource Control Function, while not inherently necessary, may assist in making aggregated reservations that could be altered dynamically.

Given that wireless and wire-line SDO’s have defined the two key Policy Functions, two options for achieving the end-to-end objective are as follows:

1. Harmonize Policy Functions – This option envisions all pertinent SDO’s to harmonize the Policy Decision and Enforcement Functions such that they are identical in all domains. This also needs to be followed by achieving agreements on the role of the DIAMETER AVP’s that will be utilized in communications between these functions and the application layer. This could lead to identical functionality being installed in the relevant Gateways (PDNs for wireless and SBCs for wireline) such that the same policy process is invoked in all domains end-to-end. The same set of Gateway functions effectively control the admission process for all domains over the path of the call/session.
2. Harmonize Information Exchange – This option envisions all pertinent SDO’s to reach agreement on the necessary admission control related information (e.g., QoS and priority classifications) that needs to be determined in each wireless and wire-line domain in the responsible SDO’s. This may require a mapping scheme between wireless and wire-line classifications and may require the use of DiffServ Code Points (DSCP) [RFC2475] at the media path to facilitate the required treatment over various network domains.

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