Lucent IMS and RACF Overview

How IMS and RACF provide value to Service Providers

Lucent Technologies
Bell Labs Innovations

Introduction and Business Drivers

Service providers are seeking for ways to increase their revenue and profitability for residential services. Although the revenue potential of voice, video and data services provided to residences is significant [see Figure 1], the ability to differentiate one's service offering from a competitors, and therefore to realize this revenue potential, has been hampered by a number of factors. In particular, as the attractiveness of IP or web-based services has become apparent, a multitude of competing application service providers or Internet service providers have appeared, all of whom seek to provide service as a best-effort IP flow that appears as a data service to the underlying network, requiring no specific network resources or transport-level differentiation. Consequently, since no demands are made of the network, the user can access such services with a simple broadband access service, so that the access service itself loses value and the revenue potential is dispersed to a third party for whom no service fees or network transport fees are incurred.
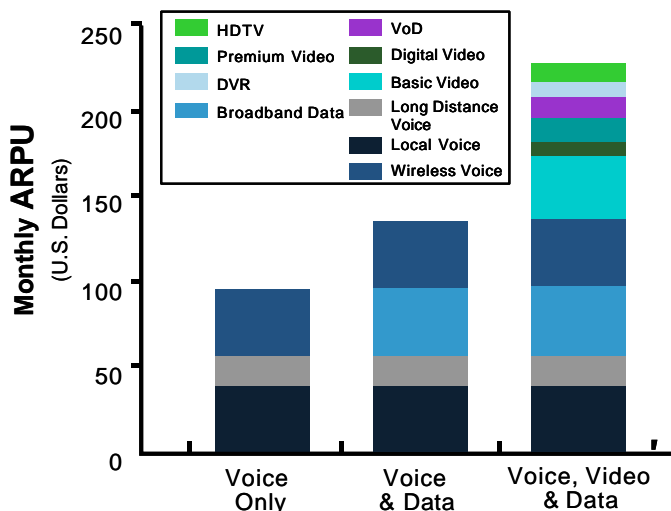

Figure 1. Monthly ARPU achievable in North America for Quadruple Play services

This model has operated successfully for a couple of reasons: I) there was excess capacity throughout the network for the services the user was trying to access and II) the services being offered were relatively simple and had few quality of service requirements (e.g. IM or e-mail). However with the addition of VoIP and IPTV, as well as myriad related services such as video telephony and gaming, to the services suite being offered to the end user, the demands on the network are increasing, both in terms of bandwidth utilization and quality of service. In short, for the first time, it is likely that the network capacity will be utilized and that there will be a need to truly differentiate multiple services running over the same network. This represents not only a significant challenge for the incumbent carrier (or the owner of the network assets) to provide the

requisite end-to-end QoS across all services, but also a great opportunity to implement per flow policing that will allow premium services to be offered by the provider with a differentiated end-user experience. The end result will be a network provider service that is perceived as superior (= of higher value) to that offered by the 'best effort' application service provider who chooses not to leverage the differentiated QoS capabilities because of the attendant increased cost of doing so (most likely in the form of access fees to the network provider for a higher tier of service).

This White Paper describes the emerging Resource and Admission Control Functions (abbreviated RACF) as an element of the ITU-T Next Generation Network architecture with a well-defined interface to IMS. This combination of IMS and RACF frameworks can form the basis of an infrastructure that can be used to address these new requirements and opportunities for deriving value-added services revenue.

The essential economic model enabled by IMS + RACF is as follows: service providers will garner more revenue per service by introducing a level of user-experience enhancing QoS control. While content and services on the worldwide public Internet will likely continue to remain available to end users on a best effort basis (pending regulatory definition), a quality service or premium content can receive preferential treatment. The benefit to the service provider is two-fold: (1) they can offer QoS-enabled services of their own, and (2) they can form partnerships with third party content and application providers for the right to access the enhanced QoS control functions. For example, RACF can be the foundation for offering network access to a 3rd party provider or internal subsidiary supporting IPTV services, broadcast Internet radio, video-conferencing, specialized content portals, or any other capability well suited for a QoS-enabled network. This allows the access network provider (or internal affiliate) to properly monetize the value of the investment in access infrastructure through business arrangements with end-users and content providers: a complete departure from commoditized best effort access.

RACF and IMS

The RACF is a control layer (i.e. it deals with signaling messages) that supports dynamic verification of resource availability and configuration of Policy Enforcement Functional Elements (PE-FEs) in the bearer path.

RACF as a control layer closely couples the services layer and QoS resources residing in the media path. This services-intelligent bearer control admits/denies services; manages resources as required (bandwidth, delay, etc.), and controls gates (packet filters). In addition, RACF provides a much-needed generic framework for Session Border Controllers (S/BCs) supporting the traversal of SIP (Session Initiation Protocol) through firewalls.

The IP Multimedia Subsystem or IMS is a new services control architecture, and is closely connected to RACF via the ITU-T Next Generation Network architecture (see Figure 2). The IMS is emerging as the basic framework for

services delivery in wired network environments for broadband access and PSTN replacement, 3G mobility infrastructures, as well as converged fixed/wireless applications. The IMS is defined in 3GPP (the 3rd Generation Partnership Project) focusing on GSM evolution but has been embraced by 3GPP2 (the equivalent body for CDMA) as well as ITU-T. The IMS enhances the Softswitch model of an MSC or Local Exchange by disaggregating functions over standard interfaces. The disaggregated model allows providers to mix and match best-in-class products into a complete system solution. In addition, IMS introduces two key pieces of functionality: (1) a centralized database containing user profile information known as the HSS (or home subscriber server) and (2) a set of SIP routing engines known as collectively as CSCFs (Call Session Control Functions) used to manage sessions. Application feature servers interface with the CSCF and HSS through standardized, well-documented interfaces. The HSS database contains user data made available to the CSCF and to applications feature servers to enable individualized, per-user treatment of call control information and customized application experiences. The ability to blend services – combining different individual applications into personalized experiences – is one primary element of the services value of an IMS infrastructure.

Typically, the CSCF is implemented as a distributed set of compute engines (single board processors) embedded in a blade server chassis. Backplane connectivity for these blades is typically Ethernet and layer 2/layer 3 switches are used to manage this bandwidth. A base software load ensures the addressability of each blade, basic system integrity functions such as resiliency (fail-over) and also, the basic OA&M functions. If the CSCF is designed for compute processing, the HSS is designed as a database storage engine and is often implemented as a distributed, highly available database (that in many cases also doubles as a 2G HLR for a wireless network).

The RACF and IMS are well matched for most network uses because the IMS will be the prevalent services layer for carrier-based IP infrastructure. Therefore it is likely that the leading IMS solutions will support an option to integrate a RACF control layer into the IMS core base of assets. In doing so, RACF can make use of a system integrity framework and network management framework already used for IMS. This approaches leverages commonality of assets, which results in a lower cost of operations and a lower capital expense for the service provider. This approach does not prevent RACF functionality from being made available to any Service Control Function (SCF) whether it is implemented as a direct IMS application or as an independent application server, such as today's VoD or IPTV SCFs (middleware servers).

For the RACF layer to operate, there must be network elements (NEs) that can be configured to manage QoS resources such as bandwidth. These elements are either existing and perform other primary functions (DSLAMs, PON/GPON OLTs, etc.) or are special-purpose elements often described as "bumps in the wire" which can perform deep-packet inspection, open and close gates, and also, rewrite payloads of IP packets. Good examples of the latter class of elements are S/BCs. The forward-looking network equipment providers should therefore: (a)

design and build access NEs that have bandwidth management capabilities embedded within, (b) build standard control interfaces into "bump in the wire" elements, and (c) integrate router management and control as these develop standard RACF interfaces such as the *Rw* (see figure 2).

RACF Essentials

A very simplified view of ITU-T RACF is shown in the Figure below. At the time of writing, the most recent version of RACF is TD81 Rev 2 (WP4/13) from the 2006 Geneva, WG 13 meeting (1/16 – 1/25).

In the figure below, the RACF layer is shown as standing between the service layer and the transport layer. An *Rs* standardized interface (likely to be based on DIAMETER) will enable the service layer function (e.g. IMS, IPTV, or even a web server) to request resources from the RACF layer. The specific functional component of the RACF that is accepting the interface is called Policy Decision Functional Element (PD-FE). In release 5 of the 3GPP IMS specification, the PD-FE was originally co-resident with the CSCF (specifically, the "Proxy" CSCF). Subsequent 3GPP releases and now the ITU-T, have embraced the notion of a stand-alone PD-FE.

The PF-FE interacts with Transport Resource Control Functional Elements (TRC-FE). The TRC-FEs are responsible for resource allocation in specific domains of the network. They may exist as "call admission control" functions inside network elements, or they may be located in separate servers or management systems. In the latter case, they could either keep track of network utilization through accounting, i.e. by calculating the sum of outstanding reservation requests, or though performing data monitoring in order to build a current view of network resource usage. While PD-FEs are transport technology-independent but may be closely linked to specific service control functions, TRC-FEs are just the opposite: service-independent but transport-technology dependent.

The PD-FE uses operator-specific policy rules to determine the resources (e.g. bandwidth, priority, etc.) that should be allocated to a particular service instance. In interacts with the Network Access Control Functions to determine through which access node the subscriber is reachable and with the TRC-FEs to check resource availability. Finally, it instructs the PE-FEs to perform the necessary actions on the traffic flow related to that service instance. These actions consist of one or more of the following: policing (i.e. rate limiting), filtering, QoS marking, network address and port translation (NAPT) and resource utilization collection and reporting.

The *Rw* interface between PD-FEs and PE-FEs is not yet standardized. There are three candidate protocols: DIAMETER, COPS and H.248.
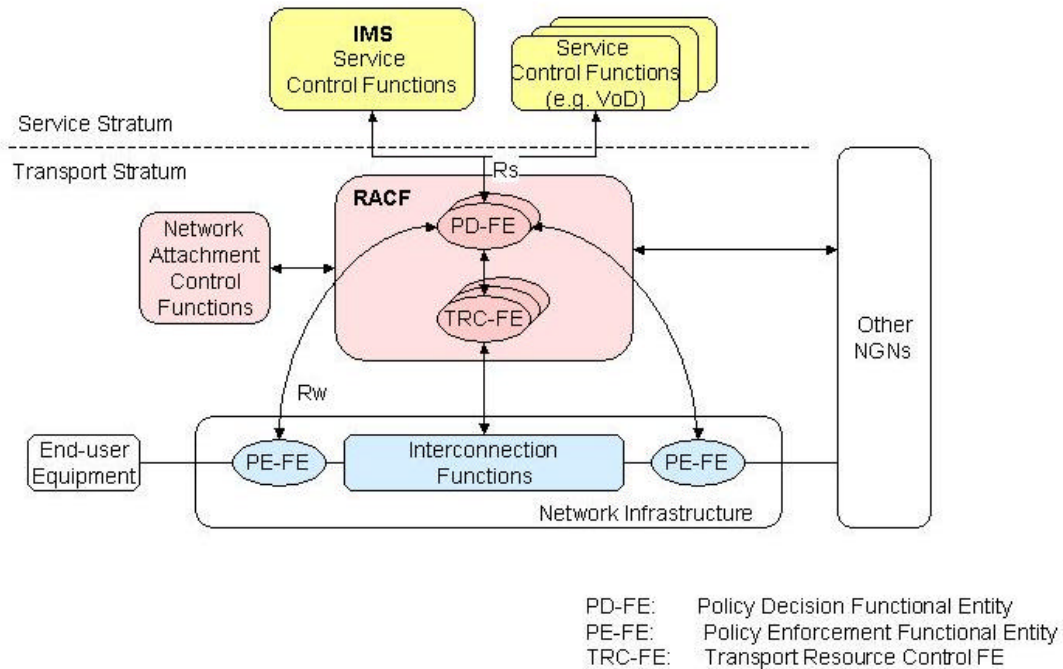
PD-FE: Policy Decision Functional Entity
PE-FE: Policy Enforcement Functional Entity
TRC-FE: Transport Resource Control FE

Figure 2: Simplified RACF model

The functions found in monolithic single integrated Session Border Controllers today are distributed in the architecture shown in Figure 2. The signaling functions are absorbed in IMS, while the data plane functions are consistent with the PE-FE functions supported by a variety of access nodes, routers and other network elements. Thus, this model acknowledges the importance of S/BCs as part of a comprehensive NGN architecture while at the same time implementing a functional separation of control and bearer functions. The latter results in better scalability characteristics as media processing functions are separated from pure transaction processing functions.

IMS, RACF, and IPTV

Looking ahead, all the emerging applications for consumers are video intensive, whether it be IPTV, video telephony/conferencing, video mail/messaging, video gaming or video surveillance/monitoring. The basic IPTV service comprising multicast and on demand services is the third element of "triple-play" services being provided to residential wireline subscribers. In addition, since IMS can emulate an MSC (it can speak the relevant 2G/3G core signaling protocols such as GSM-MAP and ANSI-41), it also provides the option to support "quadruple-play" services that add to voice, video, and data, the extra dimension of mobility. A "quadruple-play" package of services can be offered to end-customers so that all are presented as stand-alone smokestacks, unified perhaps by a common bill. A more attractive approach, however, is to offer services so they are "blended", that is, they can interact with each other. A particular user, for example, might

wish to see caller ID on the TV prior to picking up (or rejecting) an incoming call, with correlated, automatic storage of the video stream upon call answer, or may wish to use the TV and remote as a way of managing call preferences, or as a way of sending text messages via SMS. With the ability of IMS to provide such blended services, one may have to extend the terminology further to "quintuple-play" to describe the sum of voice + data + video + wireless access + blended services.

We see two needs that must be addressed: first, from a pure business perspective, there is the requirement for a service provider to be able to "blend" the four services involved in the "quadruple-play" into compelling novel services that tightly couple and personalize the user experience, i.e. to provide the "quintuple play". Second, there is the need to ensure that every service is delivered with the network resources it needs for a positive user experience. The RACF layer operating in conjunction with the IMS and the IPTV services layer addresses this latter need.

IMS, RACF, and IPTV Services Examples

In the following, we show the interaction of IMS, RACF and IPTV servers used to supply digital multicast, voice-over-IP (VoIP) and video on demand (VOD), with guaranteed QoS.

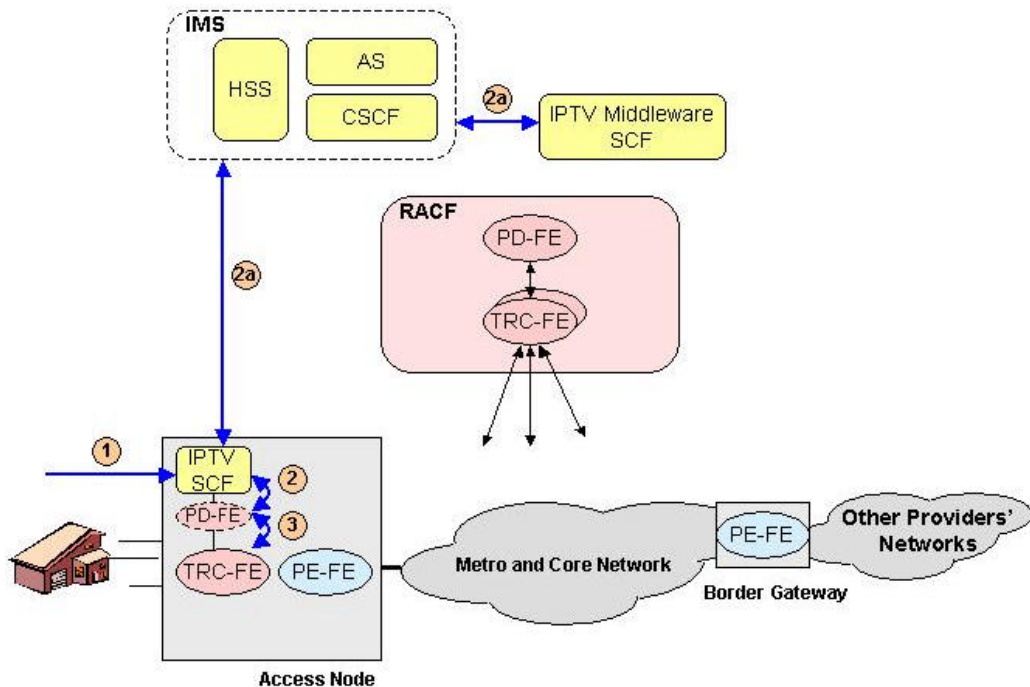To demonstrate the RACF function inter-working with IMS and multicast IPTV, we suggest the following schema:

Figure 3: IMS and IPTV Interworking

An essential element in this schema is the Access Node, which is shown as having enhanced IPTV services intelligence, composed of the IPTV service control function (SCF), a PD-FE, and a TRC-FE. The TRC-FE collects information about resource usage on the access link. There is no other element in the network better positioned to know about access resources than the Access Node itself; hence it is sensible to include a TRC-FE element in it.

As an example, we illustrate how multicast video resource control might be implemented. To begin with the IPTV subscriber selects a specific TV channel to watch using their remote control, interacting with the IPTV set top box. This results in (1) an IGMP join request to the Access Node.

To support fact channel changes, the Access Node "snoops" the IGMP join message and performs the multicast join and leave actions locally. The IPTV SCF in the Access Node checks the local IPTV policies (e.g. whether the subscriber is allowed to watch the requested channel). If the channel selection is approved, the SCF interacts, in step (2), with the PD-FE to request/verify service-level needs (e.g. channel type – SDTV, or HDTV and channel number). The PD-FE located in the Access Node is essentially a shim layer passing on requests from the IPTV SCF to the TRC-FE.

In (3), the PD-FE checks with the Access Node TRC-FE to see if there are sufficient local transport resources (bandwidth and class-of-service availability) to support the channel being delivered to the requesting user. If so, the TRC-FE grants the channel selection request and allocates the necessary downstream bandwidth throughout the Access Node.

To enable blending of services, IMS must be aware of the fact that the subscriber is watching TV and which channel he or she is watching. Therefore, the Access Node may inform the IMS/IPTV 'enhanced' middleware and HSS of the new channel state via a SIP NOTIFY message (step (2a)).

What the IMS services layer does with knowledge of the channel state information is under the control of the service provider and the suite of applications available and integrated into the IMS framework (which includes interfaces for conventional web-based applications and direct SIP-based applications). There are clear opportunities to add value by offering storage and/or control of the subscriber streams in a Network-DVR upon interruption of the user video session by other multimedia events (such as an incoming voice call, alert or text message). Similarly being able to track user channel change behavior in this way offers interesting possibilities for providing more personalized services and content (e.g. targeted advertisements).
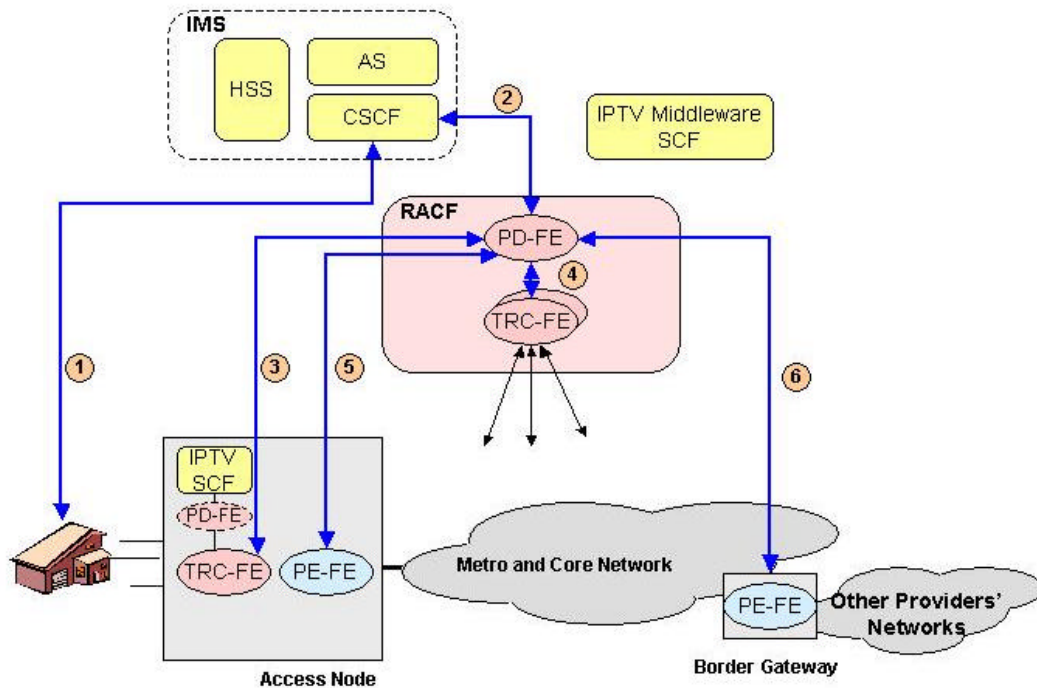
Figure 4: Voice-over-IP

Now, turning to consider the analogous example for Voice-over-IP, shown in Figure 4. First, in step (1), a subscriber sends a SIP INVITE to IMS. At some point during the call setup process, the CSCF requests resources from RACF. In step (3), the PD-FE in the centralized RACF module communicates with the Access Node TRC-FE to request/set the resources required to support the requested stream. Assuming that the flow is admitted, the resources within the Access Node are allocated and the queuing and scheduling settings in the Access Node are adjusted accordingly.

In step (4), the core PD-FE interacts with other TRC-FEs responsible for the sub-networks on the path from source to destination to determine if sufficient bandwidth is available[1]. If resources are available for the end-to-end call, the PD-FE instructs - in step (5) - the PE-FE function in the Access Node to apply the required QoS marking, perform policing and, if necessary, other functions like NAPT.

If the terminating side of the VoIP call is in another service provider's network, the PD-FE may also instruct - in step (6) - a gateway at the peering interface to perform QoS marking, NAPT and other functions.

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[1] If the metro and core networks are sufficiently over-provisioned, an operator may decide that resource control in those domains is not necessary. In that case, the TRC-FE is a NULL function. The RACF model provides the flexibility to let the operator decide which parts of the network to manage, thus avoiding any unnecessary complexity in other parts of the network.
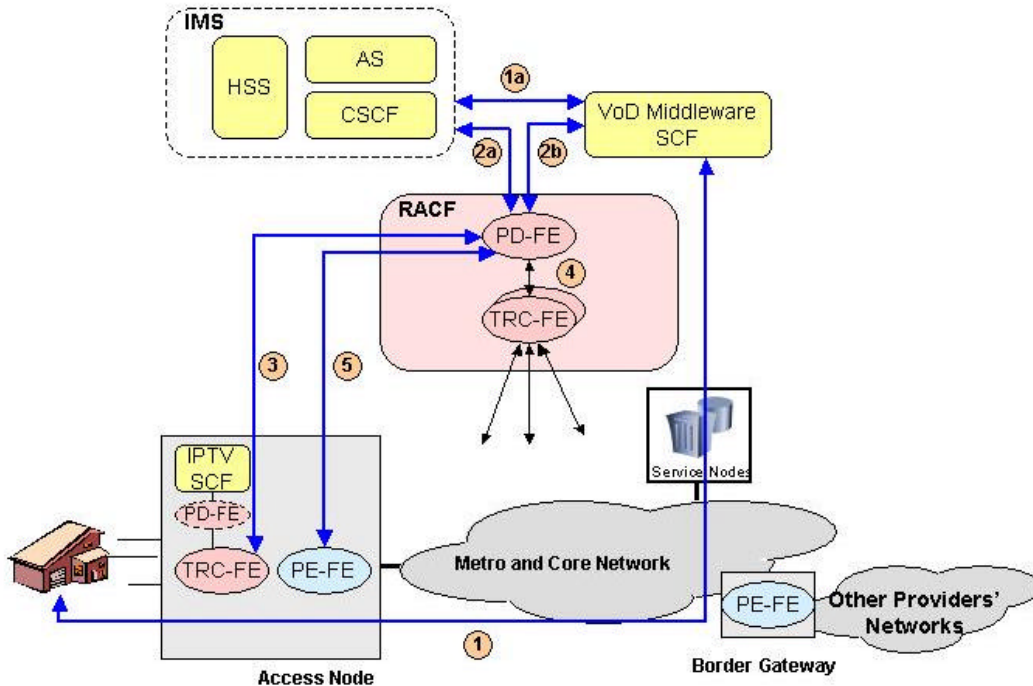
Figure 5: IMS and VOD

Finally, we consider VoD, shown in Figure 5. First, in step (1), a subscriber starts a VoD session by having the STB signal to the VoD middleware SCF, which is located in a centralized location (e.g. with the streaming video servers). To enable blended services, the VoD server can notify IMS (1a) of the session SETUP.

Now, in step (2) the IMS CSCF issues a bandwidth request to the PD-FE (2a), or, optionally, the VoD middleware SCF can interact directly with the PDF (2b) if the VoD SCF is not integrated into the IMS framework.

The subsequent steps are analogous to the VoIP example and don't require further explanation.

We have seen in the previous examples, a clear indication of how RACF, interacting with IMS and with intelligent access nodes that are IMS/RACF enabled can provide service guarantees that will effectively ensure a premium user experience for all services.

Summary

In this paper, we have briefly covered the essential business drivers for the RACF. In essence, RACF elements and standards are being developed to meet the need for more intelligent control of packet-based network infrastructures. By overlaying session-based control of QoS resources, the RACF enables service providers to derive greater value from their networks, over and above what

traditional IP-based networks and services frameworks can support. Moreover, by limiting access to the RACF functions associated with service provider-owned network elements, so that only trusted partners and provider-owned applications can support QoS guarantees, anonymous or competitive services offered by ISPs and ASPs will be prevented from eroding the value out of the network.

While performing separate functions from RACF, the IMS core hardware assets should be able to also accommodate an RACF layer for use by the IMS core, as well as by other service control frameworks. The RACF layer can use exactly the same platform assets as the core IMS CSCF and in fact, can co-exist with IMS. This feature allows a service provider to deploy IMS functionality today and then upgrade (via software and incremental compute server blades) to include a RACF. Moreover, there is great value in the integration of elements of the RACF layer into access nodes; we have shown how a PD-FE and a TRC-FE can be embedded in the access nodes for communication with core RACF functions, whilst also allowing autonomous local control of resource allocation. This latter point underscores a feature of RACF: it consists of a loosely coupled federation of pieces of network control that together superimpose a QoS framework on an IP infrastructure, with varying degrees of flow granularity (from the per-user flow level, to the aggregate service-level).

In summary, RACF, deployed with IMS and used in conjunction with intelligent access nodes will allow service providers to better monetize their investment in broadband access, and derive long-term value from their networks.

Acronyms

2G **2ⁿᵈ Generation**
Name by which IS-95 and GSM radio technologies are known.

3G **3ʳᵈ Generation**
Name by which UMTS and the evolved CDMA radio technologies are known

3GPP **Third Generation Partnership Project**
Ad-hoc standards body defining 3G wireless standards evolved from GSM.

3GPP2 **Third Generation Partnership Project 2**
Ad-hoc standards body defining 3G wireless standards evolved from IS-95 (classic CDMA).

5-tuple

Refers to specific fields in an IP packet that provide a combination of source IP address, destination address, source port number, destination port number, and protocol type.

B2BUA **Back-to-back User Agent**
A SIP entity comprised of two serial user agents. B2BUAs typically implement manipulations in the header and in the SDP payload.

BGF **Border Gateway Function**
Functionality defined in RACF (but not formally part of RACF layer) performing deep packet inspection and other media manipulations.

CDMA **Code Division Multiple Access**
Name for spread-spectrum technology used in IS-95 based 2G systems

cPSB **Compact-PCI Packet Switched Backplane**
The conventional name for the PICMG 2.16 set of standards defining blade server architecture.

CSCF **Call Session Control Function**
Session control functionality defined by 3GPP IMS standards.

DVR **Digital Video Recorder**
Device to store IPTV or VoD traffic for subsequent play-back

GPON **Gigabit Passive Optical Networks**
A fiber-to-the-home technique that uses generic framing procedure to manage bandwidth.

GSM **Global System for Mobile**
Time-division multiplexed 2G wireless standard.

HLR **Home Location Register**
The database storing user profile information in a 2G/3G circuit switched wireless network.

HSS   **Home Subscriber Server**

The name of the IMS database defining the user profile data store.

IGMP   **Internet Group Multicast Protocol**

Signaling protocol used for multicast control of digital broadcast channels in IPTV.

IMS   **IP Multimedia Subsystem**

3GPPP defined reference architecture prescribing standard functions and interfaces to enable a standardized model for next generation services delivery.

IPTV   **Internet Protocol TV**

Service capability that refers to delivering television services on an IP access infrastructure (DSL or PON). An access vehicle (such as an OLT or DSLAM) delivers digital broadcast channels switched under signaling control to an access link where a set top box decodes into a television.

ITU-T   **International Telecommunications Union**

MSC   **Mobile Switching Center**

The name of the telephony switch function in cellular networks.

NAPT   **Network and Port Address Translation**

A firewall technology that allows the use of private IP addresses inside the firewall by using a table of network and port address to correlate traffic inside the firewall to traffic outside of it.

NAPT   **Network Address and Port Translation**

A firewall function designed to eliminate the need for all IP addresses protected by it, to have public identities known across the Internet. A NAP/PAT firewall will use a table matching 5-tuples used inside the firewall to those used outside the firewall.

NE   **Network Element**

NGN   **Next Generation Network**

OA&M   **Operations, Administration, and Maintenance**

OLT   **Optical Line Terminal**

Host terminal for PON/GPON.

PD-FE   **Policy Decision Functional Element**

Functional element of the RACF architecture that applies policy. PD-FE uses information generated by the TRC-FEs to create policy. The PD-FE is consulted through a standard interface (Gq') by a SCF as to the availability of resources to support a call/session. It is the arbiter of admission control even though the specific SCF is in charge of notifying the user of a call admission decision.

PON   **Passive Optical Network**

Technique that uses passive fiber splitting and broadcast to reach downstream subscribers and TDMA for upstream to reach the network.

QoS   **Quality of Service**

RACF **Resource and Admission Control Function**
An ITU-T initiative to specify a standardized framework for fine-grained services-based control of network resources

RTP **Real Time Protocol**
IETF framing protocol capable of delivering synchronized data to a media processor.
RTP typically operates over UDP.

S/BC **Session Border Controllers**
These are "bump-in-the-wire" elements that are used to enable SIP traffic and the associated media streams to traverse NAPT-based firewalls.

SCF **Service Control Function**
RACF term that refers to a services layer in an NGN

SDP **Session Description Protocol**
Protocol used in SIP to describe bearer media streams.

SIP **Session Initiation Protocol**
IETF protocol used in VoIP and for NGN session control.

STB **Set Top Box**
Decodes digital video into a television and signals into the network for content requests.

TDMA **Time Division Multiple Access**
Time-slotting technique used for sharing bandwidth in a shared media.

TRC-FE **Transport Resource Control Functional Element**
Functional element of the RACF architecture that is in charge of collection knowledge of network resources on a per domain basis and making that knowledge available to the PD-FE. The TRC-FE also directly knows how to set and configure QoS in a domain. The TRC-FE knows NEs but has no knowledge of network services. There are multiple domain specific TRC-FEs in any given network. A TRC-FE domain can be comprised of a single NE, or a sub-network domain.

UAC/UAS **User Agent Client / User Agent Server**
Types of SIP end-points

USDS **Universal Subscriber Data Server**
The trade name for Lucent's HSS implementation (which integrates 2G HLRs).

VOD **Video on Demand**

VoIP **Voice over IP**