Analysis on Technologies Supporting Resource Management in Next Generation Networks

Pavlina H. Koleva, Ivaylo I. Atanasov, and Evelina N. Pencheva

Abstract – **Next generation networks accommodate different quality of service (QoS) mechanisms including resource reservation and admission control. Resources can be requested through service control function and through service platform. The paper investigates the support of Session Initiation Protocol (SIP) in procedures concerning resource reservation and admission control. The QoS management capabilities of technologies providing open access to network functions are analysed.**

Keywords – **Next generation network, Session initiation protocol, open service access, resource and admission control**

I. Introduction

Next Generation Network (NGN) is a concept of network providing all kind of multimedia services. Different services have different characteristics and properties which determine specific quality of service (QoS). To increase service performance, different QoS control mechanisms could be used, corresponding to different technologies. The QoS support mechanisms have a strong influence on the architecture that may be needed to provide them as to ITU-T Rec. Y.1291. In case the QoS is requested by the service, the user terminal or home gateway does not itself support native QoS signaling mechanisms. It requests an application-specific service by sending a service request to a Service Control Function (SCF). It is then the SCF's responsibility to determine the QoS needs of the requested service, to request network authorization from the network resource controller which then requests resource reservation to network. According to the QoS architecture, the mechanisms dealing with the pathways through which user traffic travels include admission control, QoS routing, and resource reservation. The admission control mechanism controls the traffic to be admitted into the network and is policy driven. QoS routing concerns the selection of a path satisfying the QoS requirements of a flow. The mechanism of resource reservation sets aside required network resources on demand for delivering desired network performance as to [3].

The functional architecture and requirements for the resource and admission control functions (RACF) in NGN are defined in ITU-T Rec.Y.2111. The RACF should provide real-time application-driven and policy-based transport resource management in support of end-to-end QoS.

Pavlina H. Koleva, Ivaylo I. Atanasov and Evelina N. Pencheva are with the Faculty of Telecommunications, Technical University of Sofia, Kliment Ohridski 8, 1000 Sofia, Bulgaria, E-mail: p_koleva@tu-sofia.bg, iia@tu-sofia.bg, enp@tu-sofia.bg

The paper presents analysis on resource management capabilities of Session Initiation Protocol (SIP) as a control protocol for multimedia sessions. Technologies providing open access to network functions for QoS management are also discussed. The second section presents the required functionality for resource and admission control. The next sections discuss the supported functionality and how it can be implemented using SIP, Open Service Access Connectivity Manager and Parlay X Web Services Application-driven quality of service.

II. Resource and Admission Control

The control functions in NGN are classified in two general sets, as shown in Fig.1. The service control functions (SCF) are related to the control of services (e.g., functions such as user authentication, user identification, service admission control, application functions). The transport control functions include network attachment control functions and resource and admission control functions (RACF). The RACF include network admission control, network resource/policy control, and dynamic connectivity provision.

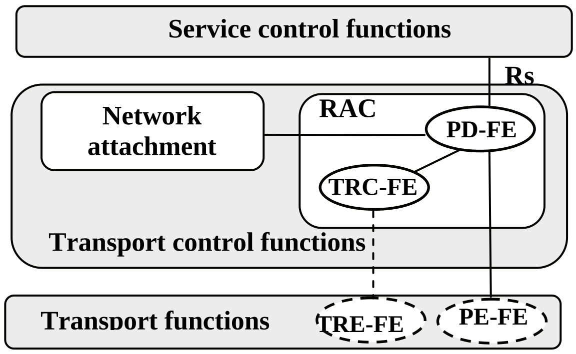

Fig.1 Resource and admission control in NGN

The RACF consists of two types of control functional entities: the Policy Decision Functional Entity (PD-FE) and the Transport Resource Control Functional Entity (TRC-FE).

The PD-FE handles the QoS resource request. This request may be received from the SCF via the Rs reference point or from transport functions. PD-FE checks the QoS resource request based on service information, transport network information and transport subscription information. This way PD-FE makes the final policy decision. The policy decision provides sufficient information to make the Policy Enforcement Functional Entity (PE-FE) to perform the resource control operation.

The TRC-FE is responsible for transport technology dependent resource control. The TRC-FE collects and maintains the network information and resource status information. On receipt of the resource request from PD-FE, the TRC-FE performs admission control based on the QoS and priority requirements received from the PD-FE. The TRC-FE coordinates the resource requests from PD-FEs and takes into account transport dependent policy rules to decide if the resource requests can be supported.

In order to make authorization and resource control decision, the PD-FE needs to communicate with SCF via reference point Rs. The information exchange requirements for the Rs reference point include the following:

- SCF must be able to request a transaction to be performed by the PD-FE and get a response in return.
- PD-FE must be able to notify the SCF about asynchronous events.
- The SCF must be able to determine capabilities when requesting resources and other transport plane functions via the PD-FE.

A SCF shall be able to communicate with multiple PD-FEs which might be in different administrative domains. Because the control protocol in NGN is SIP, it is important to assess the capabilities of SIP to transfer information components for resource control request processing.

III. SIP AND QOS CONTROL MECHANISMS

The control protocol for setting up, modification and release of multimedia sessions in NGN is SIP. The capabilities for integration of resource management and SIP are considered in RFC 3312. That document defines a generic framework for preconditions for establishment of sessions initiated by SIP. These preconditions require network resource reservation before continuing with the session. The RFC 3313 defines a SIP extension that can be used to integrate QoS admission control with session signaling and help guard against denial of service attacks. The use of this extension is only applicable when both the SIP proxy authorizing the QoS, and the policy control of the network providing the QoS, belong to that administrative domain or federation of domains.

SIP supports the mechanism of INVITE transactions to request resource reservation. The ability of SIP to request asynchronous notification of events needed for cooperation between SIP entities is defined in RFC 3265 The general concept is that entities in the network can subscribe to resource or call states, and those entities are notified when those states change.

The reservation of network resources frequently requires learning the IP address, port, and session parameters from the caller. The solution proposed in RFC3212 introduces the concept of a precondition as a set of constraints about the session which are introduced in the offer. The recipient of the request generates a response, but does not alert the user or otherwise proceed with session establishment. That only occurs when the preconditions are met. This can be known through a local event, or through a new offer sent by the caller. In order to ensure that session establishment does not take place until certain preconditions are met, two different state variables that affect a particular media stream are distinguished: current status and desired status. The desired status consists of a threshold for the current status. Session establishment stops until the current status reaches or surpasses this threshold. Once this threshold is reached or surpassed, session establishment resumes. These two state variables define a certain piece of state of a media stream the same way the direction attribute or the codecs in use define other pieces of state. These two new variables in the same way as other Session Description Protocol (SDP) media attributes are treated in the request/response model used by SIP: they are exchanged between SCF and PD-FE using requests and responses in order to have a shared view of the status of the session.

In order to implement the interface in the reference point Rs, the SIP signaling has to maintain the corresponding information components exchanged across Rs. The information components for resource control request processing are transmitted within headers of the INVITE message and as parts of SDP media description. The QoS resource information sub-components for media session describe a set of information sub-components for a media session, which may be composed of data flows and control flows (e.g., RTP and RTCP flows for a VoIP call). The information sub-components of the media flow description is a set of sub-components of individual media flows or a group of media flows within a media session. Both media session and media flows descriptions are parts of SDP session description.

The information component used for binding purposes is the Authorization token. The token is requested by the SCF and provided in a response by PD-FE. A new P-Media-Authorization general header field is defined in RFC 3313. The P- Media-Authorization header field contains one or more media authorization tokens which are to be included in subsequent resource reservations for the media flows associated with the session, that is, passed to an independent resource reservation mechanism.

The charging correlation information component is optional and describes charging ID of the SCF and the network, and resource usage information. SIP is not used for transferring charging information.

A variety of indicators are used to request a specific resource control action per network event/condition. The SIP extensions defined in RFC 3312 allow indication of resource reservation mode and indication of the result for a resource request. The SIP event framework defines the methods SUBSCRIBE and NOTIFY, and introduces the notion of a package. A package is a concrete application of the event framework to particular class of events. Still no event package for transport events is defined. To use SIP for query and notification of a transport events it is needed to define event package for transport loss events, transport recovery events, and transport release events.

IV. OSA CONNECTIVITY MANAGER API

NGN network architecture accommodates requesting resources through a SCF and through a services platform.

Advanced third party applications may be developed by the use of standardized application programming interfaces (APIs). The APIs provide for external applications access to network functionality while hiding specifics of underlying network and protocol complexity.

The Open Service Access (OSA) defines an architecture that enables service application developers to make use of network functionality through open standardized interface, i.e. the OSA APIs and Parlay X Web Services.

The OSA Connectivity Manager API defines tools for the customers (for example administrator of the enterprise network) to set up a provisioned QoS service in the provider network [1]. The enterprise traffic is carried out through so called virtual provisioned pipes (VPrP) established in the provider's network. Each VPrP is defined with pre-specified QoS. The enterprise operator can retrieve available VPrP templates, complete the template selecting a value for delay, loss, jitter and excess traffic treatment action and submit it to the network provider. The operator creates a new VPrP with pending status that holds the selection. The network provider responds after validating request with approval or denial. If the provider approves the service, the operator may send packets with already negotiated QoS characteristics. It is not possible to request QoS reporting, monitoring and evaluation of delivered QoS. QoS data statistic outputs are the important proof to evaluate and improve service levels negotiated between client and network provider.

V. PARLAY X APPLICATION-DRIVEN QOS

Another technology that provides open access to QoS management is Parlay X Web Services. Parlay X Web Services interface for Application-driven QoS is defined in [2]. The Application-driven quality of service allows applications to govern the QoS available to the end user by requesting that pre-defined QoS feature profiles are applied on the end user's connection. It is the responsibility of the service provider to define these QoS features and share them beforehand with application providers, along with a clear indication as to which of these can be used as temporary QoS features and which can be used to set the default QoS on an end user connection. Specific QoS in NGN may be requested by external application. Parlay X Web Services interface for application-driven quality of service enables applications to govern quality of service (e.g. bandwidth) available on end user network connections.

The ApplicationQoS interface provides methods for:

- Applying a new QoS feature to an end user connection. It is done either rapidly provisioning a re-grade, which results in a permanent change in the class of service provided over the end user connection, or dynamically controlling temporary QoS features in the network which will be active for a specified period of time.
- Modifying an active temporary QoS Feature on an end user connection.
- Self-care like operations.

The methods provided by the ApplicationQoS interface allow third party applications to send resource initiation request and receive resource initiation response, to request resource modification and receive confirmations that resource modification request has been received and indicate result, as requested in [2].

The ApplicationQoSNotificationManager interface is used by the Applications to manage their registration for notifications. The ApplicationQoSNotification interface provides the methods for notifying the Application about the impact of certain events on QoS features that were active on the end user connection when these events occurred. Using the methods defined, third party Web Services compliant applications can receive notifications for transport resource events, to request a specific resource control action (e.g., retrieving the resource information) for an established session, and to confirm that the request for the specific action has been received and to provide the requested service information.

A possible deployment scenario for Parlay X Web Services is shown in Fig.2. The application using Parlay X Application-driven QoS utilize Web Services to discover and interact with the network, and will not have visibility to the implementation behind the Parlay X Web Services Gateway. The Parlay X Web Services Gateway attaches to the Network Element through an interface defined by the Network Element. In the IP-based multimedia subsystem of NGN, this network element is Serving-Call Session Control Function (S-CSCF) and it 'talks' SIP. The S-CSCF plays a role of SCF. The PD-FE is built in Proxy-CSCF (P-CSCF) which also 'talks' SIP. Fig.3 and Fig.4 illustrate the way Web Services compliant applications using Application-driven QoS interface can be deployed in SIP-based network.

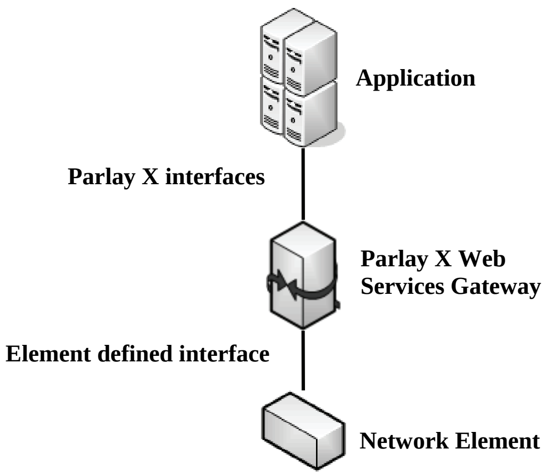

Fig.2 Deployment scenario for Parlay X Web Services

Fig.3 shows the interaction where the third party application requests applying specific QoS feature and receives responses, requests temporary modifications of QoS feature and receives acknowledgments.

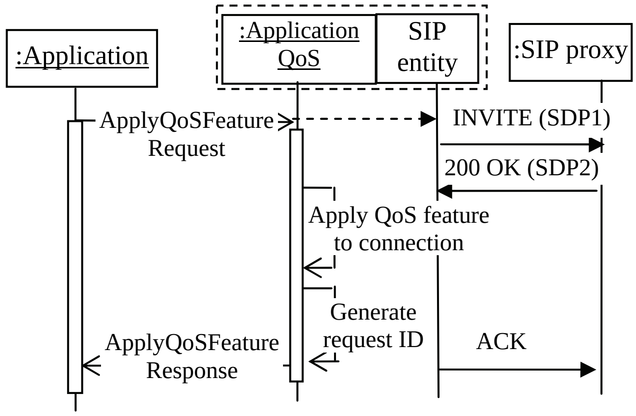

Fig.3 Applying a new QoS feature to the service

Fig.4 illustrates receiving notifications from the service. Notifications are unsolicited. The Application will indicate their interest in receiving notifications by registering for events. When an event occurs in the network that merits a notification to be raised, interested Applications will receive a notification and its implications on the temporary QoS features active on the end user connection.

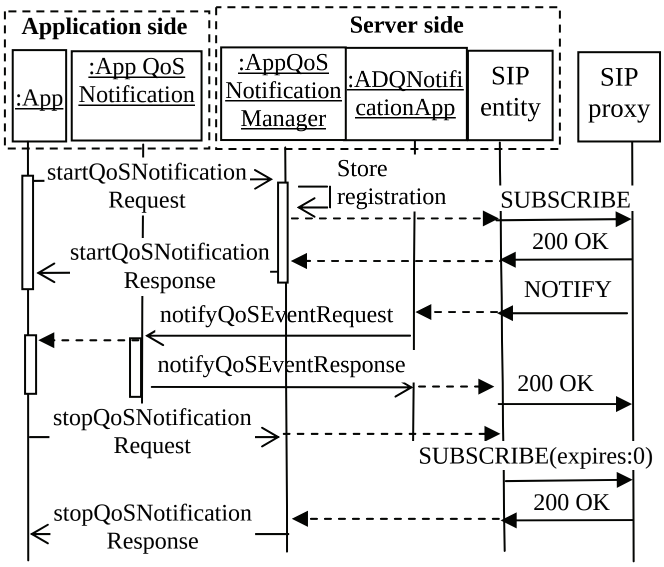

Fig.4 Receiving notifications from the service

The QoS events supported by Parlay X Application-driven QoS do not include transport recovery events and transport release events. The application can be informed that the end user connection is terminated abnormally because of a fault in the network causing all the temporary QoS features that were active on the connection to be released as well.

Parlay X Web Services might be seen as a higher layer of abstraction of Parlay/OSA. 3rd party applications that will derive added value from combining different network functions using Parlay/OSA API will not be able to access quality of service control functions in the same way. Further, Web services are currently a good solution to integrate existing heterogeneous applications and a new way to access to the Web, but they still have some open problems like: the lack of a common standard framework for security, absence of warranties about the adequacy of service repositories, and slow performances with current synchronous protocol invocations.

VI. CONCLUSIONS

The key function in NGN with the main responsibility for the session management and service provision is S-CSCF which in the role of SCF makes requests for transport resources and may receive notifications when resources are reserved and released. The P-CSCF is the first contact point for users within the IMS and it has four unique tasks assigned to the P-CSCF: SIP compression, IP security association, interaction with the PD-FE and emergency session detection. Both entities are able to release sessions on behalf of the user (e.g., when the S-CSCF detects a hanging session or the P-CSCF receives a notification that a media bearer is lost) and are able to check the content of SDP payload and to check whether it contains media types or codecs that are not allowed for a user. The protocol supported is SIP. The analysis shows that some additions to SIP might be required to cope with resource and admission control.

The common service framework for multimedia services in NGN defines open access to network functions through standardized interfaces. The OSA Connectivity Manager API provides functions for QoS management but it does not support access to all network functions concerning resource management. The Parlay X Web Services Application-driven quality of service allows third party applications to request application specific QoS and to monitor the delivered QoS. Web services are currently a good solution to integrate existing heterogeneous applications including QoS management and a way to access to the Web, but they are not mature yet for a widespread deployment because they still have some open problems.

However the development of API providing access to application specific QoS management would allow creation of advanced application capable to manage telecommunication resources in support of end-to-end quality of service.

ACKNOWLEDGEMENT

The research is partially funded by the project D170ni-7 “Optimal telecommunication resource allocation considering cross-layer interaction”.

REFERENCES

[1] ETSI ES 202 915-10, Open Service Access (OSA), Application Programming Interface (API); Part 10: Connectivity Manager SCF, v1.4.1, 2006

[2] 3GPP TS 29.199-17, Open Service Access (OSA), Parlay X Web Services; Part 17: Application-driven Quality of Service (QoS), v7.0.2, 2007

[3] G. Iliev, Z. Nikolova, V. Poulkov, G. Stoyanov, *Noise Cancellation in OFDM Systems Using Adaptive Complex Narrowband IIR Filtering*, Proc. 2006 IEEE ICC, June 2006, Istanbul, Turkey, pp. 451-455.