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SERVICE LEVEL AGREEMENTS IN NEXT GENERATION NETWORKS

Mirjana Stojanović, Slavica Boštjančič Rakas
Mihajlo Pupin Institute, Belgrade

Abstract: *In this paper, we address the problem of end-to-end quality of service (QoS) specification in next generation networks. We discuss possible solutions for the structure and formats of the service level agreement (SLA). We further propose a framework for SLA specification and negotiation in all IP environments of next generation networks. The framework relies on a general structure of the service level specification form, which allows administrators to describe service classes in their own domains independently of the network technology and the applied QoS model. We also present the prototype implementation that demonstrates operating of the proposed framework.*

Key words: *Next Generation Netwoks, Quality of Service, Service Level Agreement, Service Level Specification, Signaling.*

1. Uvod

Next Generation Network (NGN) refers to an architectural concept of future telecommunication core and access networks, which assumes transport of all information and services over a common network, typically built around the Internet Protocol (IP). Providing different levels of end-to-end Quality of Service (QoS) guarantees is one of the key requirements for deployment of NGN.

New environment encompasses a set of independently administered domains, each providing different QoS model, such as Differentiated Services (DiffServ) for a core network, Integrated Services (IntServ) for a wired access network, services defined for the Universal Mobile Telecommunication System (UMTS), etc. QoS negotiation results in a Service Level Agreement (SLA), i.e., a contract between the provider and the user which defines all technical, financial and legal aspects related with a particular service. In this work, we use the term “user” in a broader sense, assuming either an end-user or another service provider. Service providers can use electronic SLAs to offer their services, while users can express their service level requirements through SLAs [1].

One of the most obvious issues in delivering inter-provider QoS is the lack of common service class definitions across providers [2]. This introduces the complexity of class mapping between different providers.

Technical issues in the delivery of interprovider QoS have been addressed in [2]. They encompass the need for common service class definition across providers, service specification forms, set of performance metrics and performance monitoring. Besides, three basic approaches regarding interconnection have been outlined, namely the bilateral, cooperative and third-party (3P) models. The bilateral model assumes that two providers interconnect at one or more points, and implement customized business processes and mapping between their service classes. This model is the most widely deployed at the moment. The cooperative model represents a generalization of the bilateral model, in which several providers should agree on certain basic mechanisms required to achieve the interprovider QoS. In the 3P model, the third party connects to the providers at various points, and is responsible for mapping of service classes, business processes, and performance monitoring.

This paper addresses the problem of SLA specification and negotiation in the NGN environment. Since the SLA structure and format have not been standardized, possible solutions are discussed. We propose a framework for SLA specification that allows administrators to describe services in their own domains independently of the network technology and the applied QoS model. The framework also encompasses a functional model of SLA negotiation. Finally, we briefly describe the prototype implementation of the proposed framework.

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2. QoS Management Issues

Requirements for end-to-end QoS, reliability and network survivability cause new approaches to design and development of a network management system with respect to definition of new management architectures, developing of new methods and software tools for management automation and developing of hardware and software platforms that allow for efficient implementation of fault, configuration, accounting, performance and security (FCAPS) functionality.

Service management aims to achieve common understanding between the user and provider through managing service level expectations and delivering and supporting desired results. IT-based services, or business services based on IT, may be delivered directly to the user or to the general public on behalf of the user (e-government). Service providers may be internal or external to the user organization. In general, the same principles apply, except that for internal provision the contractual arrangements will not have legal force.

In a NGN service supply chain, the service user, the service provider, and the network operator interwork with each other for service provisioning, service assurance, and service billing [3]. Service management information may be exchanged across different interfaces (end user – service provider, service provider – service provider, etc.).

ITU-T recommendation M.3341 defines functions and interfaces required to manage end-to-end QoS for the complete service life cycle, consisting of at least five phases [4]:

- Planning and development – considers a number of QoS and SLA aspects. It defines generic parameters and technology-specific parameters;
- Negotiation and sales – a service provider must negotiate and agree with the user technical details of a service, where QoS parameters may be customized or the same as those offered in the standard template;

- Implementation – in this phase a service is configured, activated and operations begins;
- Operation and maintenance – include normal in-service monitoring and operation, real-time QoS reporting and service quality validation and real-time SLA violation handling;
- Periodic assessment of the QoS of a service and whether it meets the SLA – scheduled during a single user SLA contract period where the assessment is related to the delivered QoS against the SLA parameter values and limits, and the levels of user satisfaction with the service product.

3. Service Level Specification

Regardless of the applied QoS model, SLA should consist of the two main parts: the business part and the technical part. The business part covers financial and legal aspects: information about pricing, charging, billing and payment; penalties for both the user and the provider in the case of contract violation. The technical part encompasses a set of descriptors and associated attributes that describe the particular service class and the traffic profile.

The technical part of the SLA is often called service level specification (SLS) [5], [6], [7]. A lot of previous work regarding SLS formats addressed the DiffServ environment, where similar SLS contents have been recognized, including both the QoS specification and the traffic profile [8, 9, 10]. The proposed SLS parameters mainly encompass: communication type, service class code, traffic conditioning rules, treatment of the out-of-profile traffic, performance metrics and, optionally, service availability and reliability.

The ITU-T has provided guidelines for the definition of SLA representation templates, regardless of the applied QoS model [11]. Technical part of the SLA is divided into the service, technology and QoS report parts. Service part describes the detailed information about the service provided to the customer. It includes the negotiated service contents and the agreed service level. Technology part gives the detailed information about QoS parameters, metrics set, and some technical supporting infrastructure, such as supporting equipments and system design information, etc. QoS report includes the information provided to the customer in order to evaluate service level negotiated in the SLA.

QoS specification framework proposed in [12] focuses on providing a specification language and an associated software tool to define QoS requirements, offers and contracts in mobile and wireless environments. The SLA template, proposed in [13] for provider-to-provider SLA in wireless networks, contains every necessary parameter to support the services offered by both providers, and every offered class of service.

Considering the ITU-T recommendation M.3342 [11] and propositions from [14], [15], we will further assume a general structure of the SLS, as illustrated in Figure 1. SLS is composed by three main parts, namely the traffic flow specification, traffic profile specification and QoS specification. Each of those parts contains a set of descriptors and their associated parameters that describe the required service class according to technical agreements between the 3P agent and each involved domain. This general structure is independent of the network technology (e.g. wired, wireless) and the applied QoS model.

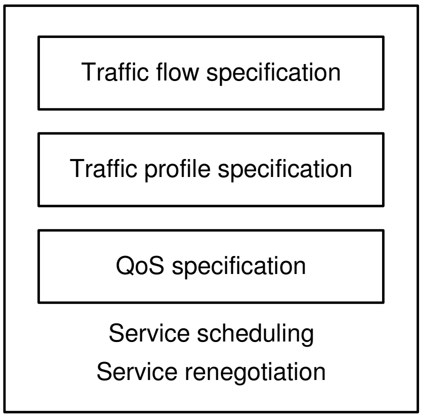

Figure 1. *General structure of the SLS.*

Traffic flow specification describes the individual traffic flow in terms of the type of communication (one to one, one to many, many to many) and the 5-tupple in the IP packet header (source and destination addresses, port numbers and transport protocol type).

Traffic profile specification represents the set of traffic flow properties. It may include parameters like packet size, peak and/or average bit rate, peak and/or average burst size, time-to-live (TTL), resilience, treatment of the excess traffic etc.

QoS specification may encompass a variety of performance metrics. According to [6] QoS in packet networks is expressed by at least four parameters including throughput, delay, jitter, and packet loss rate. The IETF IPPM (IP Performance Metrics) working group has developed a set of standard metrics that can be applied to the quality, performance, and reliability of Internet data delivery services [16]. Those metrics encompass: connectivity, one-way delay and loss, round-trip delay, delay variation, loss patterns, packet reordering, bulk transport capacity, link bandwidth capacity, packet duplication, etc. Similarly, the ITU-T recommendation Y.1540 [17] defines parameters that may be used in specifying and assessing the performance of speed, accuracy, dependability and availability of IP based packet transfer.

In addition to the three previously described parts, SLS typically contains requests for service schedule and service renegotiation. Service scheduling specifies time interval in which the service is available (e.g. 24 hours/7 days). Service renegotiation explicitly defines whether administrator is allowed to offer another service if the network can not meet the requested one.

4. A Framework for SLA Negotiation

The proposed functional model of SLA negotiation is illustrated in Figure 2. The SLS template should be disseminated to users for purpose of service negotiation. At the user's side, the model assumes coexistence of both QoS-aware and legacy applications at the customer premises. QoS-aware applications access the QoS signaling protocol entity through QoS application programming interface (API) to forward their requirements to the provider. For legacy applications, QoS access interface should be manually configured. User requirements are typically specified in an informal manner (e.g., qualitatively rather than quantitatively). The translator entity within QoS access interface is responsible for mapping informal user requirements to a formal request and vice versa.

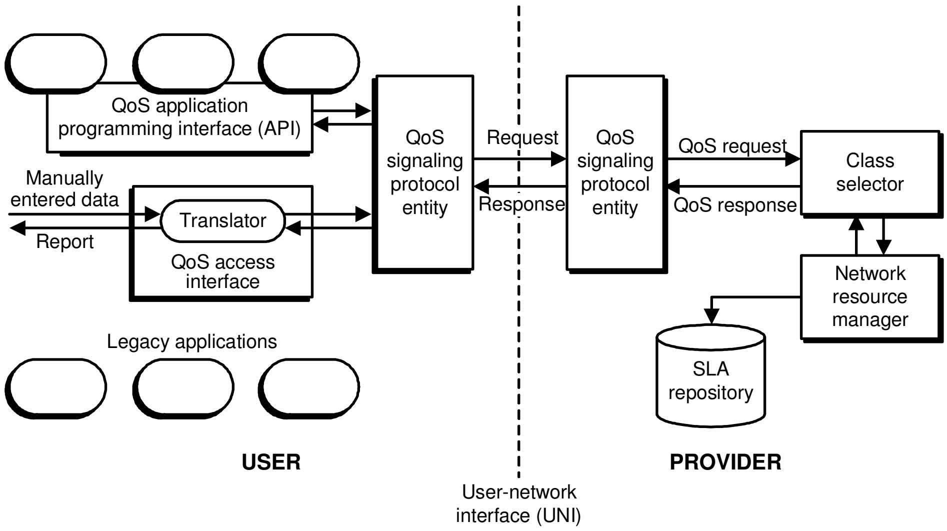

Figure 2. *A functional model of SLA negotiation.*

It should be emphasized that this functional model does not assume any particular signaling protocol (e.g., Resource Reservation Protocol, Next Steps In Signaling, or some proprietary protocol). Instead, we make use of the fact that all QoS signaling protocols rely on "Request/Response" paradigm and suppose a generic protocol with two basic types of messages: Request and Response. Request message carries user requirements for a particular service in terms of service level specification, with the associated parameters and descriptors. Response message carries either the answer from the provider: positive, negative or request for service re-negotiation.

At the provider's side, QoS signaling protocol entity accepts Request message, extracts relevant traffic and QoS parameters and forwards them to the Class selector, through the internal primitive QoS request. Class selector is responsible for evaluating user requirements with the set of service classes offered by the provider and finding the most suitable class for ingress traffic flow that will provide required QoS level. Network resource manager decides about the admission of new traffic flow and allocates resources (bandwidth, buffer space, etc.), according to QoS requirements and the state of network resources. Based on that decision, Class selector generates the appropriate internal primitive QoS response, which is further mapped to Response message in QoS signaling protocol entity. All negotiated SLAs are stored in the SLA repository.

6. The Prototype Implementation

The prototype of proposed framework has been developed for PC Windows environment, using object oriented design and C++ programming language. Modular design provides a high level of portability and also enables efficient upgrade and customization. The application, named SLAM (Service Level Agreement Manager), consists of the set of windows that appear alternatively after selection of appropriate commands (menu items, program buttons or shortcuts from the keyboard).

At the moment, the prototype supports manual configuration of QoS parameters through access interface that is called User agent (Figure 3). It allows creating of password protected user entry, specification and negotiation of a new SLA, service re-negotiation through modification of the existing SLA, inspection of the negotiated SLAs and cancellation of the SLA. It allows authorized users to specify the level of required service. Then it forwards the QoS request to the Network Resource Manager, which decides about the admission of new traffic flows and resource allocation, according to QoS requirements and the state of network resources [18]. This entity returns a reply whether request is accepted, denied or renegotiation for a service of worse performance is suggested. Based on the reply, User Agent creates a report for the user. If SLA request is accepted or is in status of renegotiation, User Agent creates the SLA and stores it in the appropriate repository. User Agent also allows user to inspect, change or cancel his own agreements.

Administrator agent implements a search engine by defined criteria like user name, service class, etc. It allows network administrator to access all user entries and SLA repository and inspect all of data related with users and their associated SLAs, as well as to cancel user entries and/or their associated SLAs.

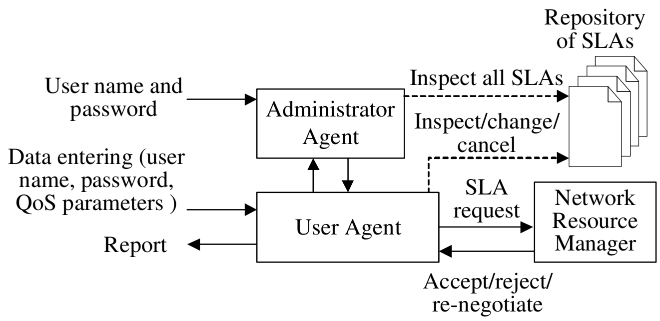

Figure 3. *Functional block scheme of the application SLAM.*

The use of application SLAM is illustrated in Figure 4. All possibilities offered to user are shown in the main menu of the main window that consists of the following items: **User**, **Negotiation**, **Help** and **About**. The item **User** provides two choices: log out and password change. The item **Negotiation** allows user to choose from one of options like negotiation, renegotiation, inspection of negotiated SLAs and canceling an agreement. With the item **Help**, user can find explanations on how to use the application. The item **About** provides detailed information about SLAM (version, date, author, etc.)

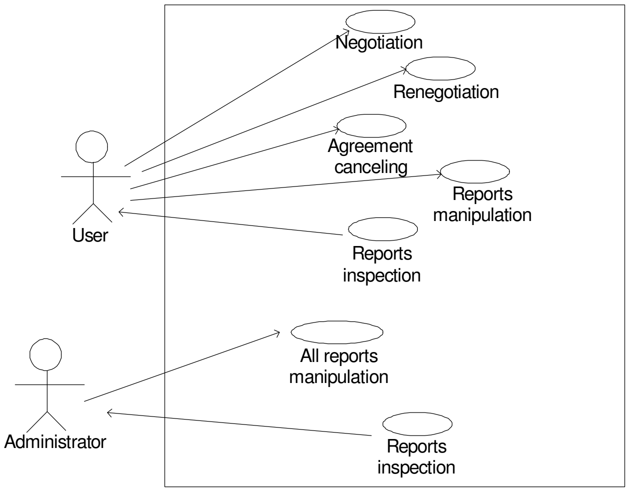

Figure 4. *The use of application SLAM.*

There are several shortcuts in SLAM for easier and quicker use of application, including buttons for SLA negotiation and renegotiation, user log out, password change, canceling an agreement, etc. These shortcuts are shown in the main window under the main menu.

Figures 5 and 6 show examples of user interface for service negotiation and premium service agreement report, respectively.

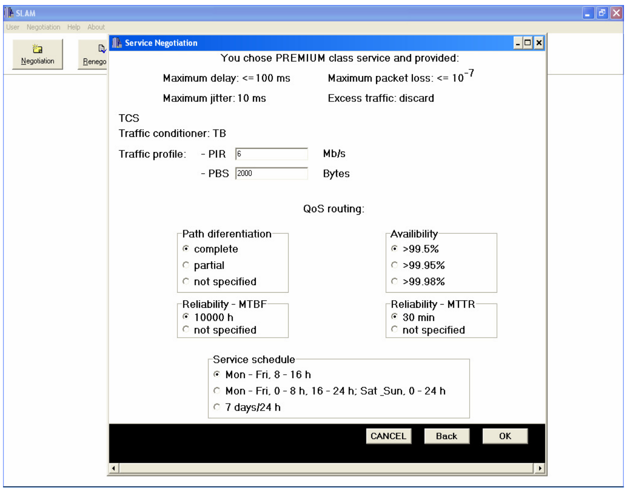

Figure 5. *User interface – service negotiation.*

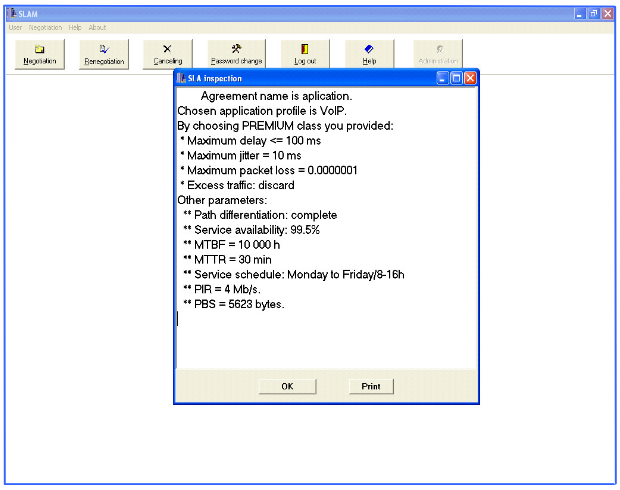

Figure 6. *User interface – SLA report.*

Figures 7 shows an example of administrator interface: default display of administrator's part of SLAM.

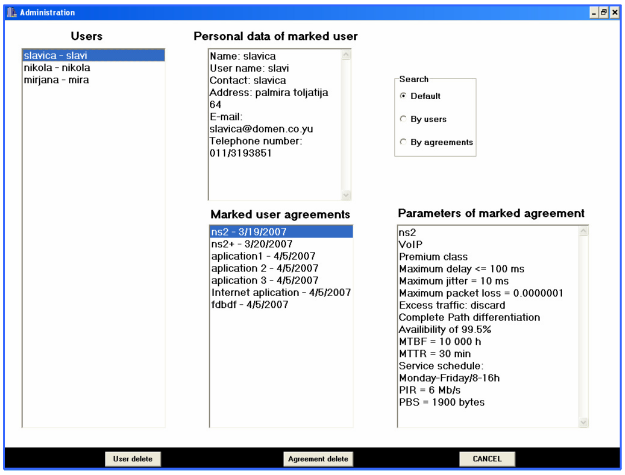

Figure 7. *Administrator's interface: default display of administrator's part of SLAM.*

7. Conclusion

One of the most obvious challenges in delivering inter-provider QoS is the lack of common service class definitions across providers. At the moment, standards for SLS formats (either generic or related with particular QoS models) are still missing, as well as a recommendation for a formal descriptive language that should be used for representation of SLS. Those issues are of key importance for developing QoS-aware applications and access interfaces, for achieving the inter-provider QoS and also for facilitating an automated service and network management.

This paper proposes a technical framework for SLA specification and negotiation in an all IP environment that is intrinsic for next generation networks. The framework relies on a formal definition of service level specification independently of particular network features (wireless/wired, fixed/mobile, QoS architecture, signaling protocols). Architectural design and implementation of a prototype management system based on the proposed framework has also been described.

The proposed prototype can easily be customized according to some specific needs of service providers. It can also be helpful in specification and development of new business models for service providers, suitable to stay competitive in the deregulated telecommunications market.

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Sadržaj: *U ovom radu razmatrana su otvorena pitanja specifikacije nivoa servisa u telekomunikacionim mrežama naredne generacije. Diskutovana su moguća rešenja strukture i formata sporazuma o nivou servisa (SLA). U nastavku rada je dat predlog funkcionalnog modela za specifikaciju i ugovaranje SLA u all-IP okruženju koje je karakteristično za mreže naredne generacije. Funkcionalni model se zasniva na generalnoj strukturi formata specifikacije nivoa servisa, koji omogućava administratorima da opišu klase servisa u sopstvenim domenima nezivisno od primenjene mrežne tehnologije i modela kvaliteta servisa. Na kraju je opisana i implementacija prototipa koja se bazira na predloženom funkcionalnom modelu.*

Keywords: *Kvalitet servisa, Mreže naredne generacije, Signalizacija kvaliteta servisa, Specifikacija nivoa servisa, Sporazum o nivou servisa .*

SPORAZUMI O NIVOU SERVISA U TELEKOMUNIKACIONIM MREŽAMA NAREDNE GENERACIJE

Mirjana Stojanović, Slavica Boštjančič Rakas