Characterization and Semantic Modeling of Services in Multiservice Networks

Carlos Rodrigues, Solange Rito Lima, Luis M. Álvarez-Sabucedo*, Paulo Carvalho

University of Minho, Dept. of Informatics, Braga, Portugal
*Universidade de Vigo, Dept. of Telematics, Vigo, Spain

***Abstract*— The use of the Internet as a global communication infrastructure to support a wide range of multiconstrained applications and services poses new challenges to ISPs regarding network services management and auditing. In this context, the semantic characterization and modeling of services provided to users assumes an essential role in fostering service management automation. Moreover, the semantic and formal description of services allows enhancing the negotiation and interoperability between clients and service providers. This paper reports the first steps toward the definition of an ontology for multiservice networks that eases and systemizes decision support of QoS deployment in ISP infrastructures, according to service levels established in SLAs. Other management tasks such as dynamic service negotiation and configuration, service monitoring and auditing may also benefit from the present ontology proposal.**

I. Introduction

The evolution of IP networks to a service class paradigm poses new challenges and needs to network management, which has to be more focused on managing services instead of network devices. This approach requires the capability of viewing the network as a large distributed system, offering an encompassing set of services to users. The ever growing number of home and business customers and their increasingly high service demands compel Internet Service Providers (ISPs) to differentiate services and apply appropriate Quality of Service (QoS) policies. The type of service, its QoS requirements and other administrative issues are settled between customers and ISPs through the establishment of Service Level Agreements (SLA). The technological component of this agreement is defined through Service Level Specifications (SLS). SLSs provide a valuable guidance to service deployment on network infrastructures and to assist contract compliance auditing. Attending to the diversity of customers, contracted services and network heterogeneity, the implementation and management of network services are very demanding tasks for ISPs. Besides the inherent complexity, this process may lead to inefficient policy implementation and poor resource management.

In order to fulfill these tasks, the support of semantics has been used in the past with different level of success (check Section II). The main contribution of this paper is the provision of a holistic semantic support for the fully characterization of the domain of multiservice networks (check Section III). This model can be used to derived added-value services. Section IV highlights these applications and lays the main conclusions.

II. Related work

Several research studies on QoS ontologies are found within the research community. While part of the ontologies focuses on Web Services (WS) QoS requirements, other concentrates on SLA/SLSs support.

The QoSOnt [1] is an OWL ontology that centers on comparative QoS metrics and requirements definition. Although this ontology supplies the correct semantics for matchmaking, this was never demonstrated due to datatype limitations in OWL. To overcome this problem, a pure XML based solution was used, losing all of the virtues of OWL [2].

The DAML-QoS [3] is a QoS metrics ontology for WS developed in DAML+O. The ontology is divided in three layers: QoSProfile Layer, QoS Property Definition Layer and QoS Metrics Layer. In [4] a new Service Level Objective (SLO) concept, metrics' monitoring and statistical calculation semantics are presented.

MOQ [5] is another proposal of a QoS semantics model for WS, but it is not exactly an ontology. It only specifies axioms and does not present a taxonomy structure or a dictionary of concepts.

MonONTO [6] ontology aims at creating a knowledge base to support a client recommendation system. The ontology serves as a support to a decision recommendation tool by providing high level information to the user about the compliance of the network facing the service level demands.

In [7], an ontology which aims for the automation of network services management and mapping of services requirements into the network is proposed. The ontology is viewed in three perspectives: (i) the network service classification; (ii) the service level specification; and (iii) the deployment of network services.

A group of generic ontologies to provide a framework for building SLAs is presented in [8]. In this context, the Unit Ontology contains all the comparable elements of an SLA, with the intention of supporting the creation of any type of measurable unit. It also allows the definition of unit supported comparators and the creation of comparison operations. The other examples of available ontologies are: the Temporal Ontology for temporal occurrences such as events and intervals; The Network Units Ontology for units related to telecommunications networks; and the SLA Ontology for basic SLA specification. Therefore, rather than a QoS ontology, a set of reusable ontologies is proposed for providing support for other QoS semantic model implementations.

The OWL-based ontology NetQoSOnt [9] intends to be the support of a reasoning tool for service requirements matchmaking. It promotes the definition of SLSs containing quality parameters belonging to the following levels: the Quality of Experience, the Quality in the Application Level, the Quality in the Network Level and the Quality in the Link Level.

In the above mentioned proposals, the lack of an unified and encompassing approach for semantic modeling of services in a multiservice environment is clear. In the present work, a holistic model for modelling multiservice networks is provided paying special attention to the characterization of QoS. This ontology also focuses on service contracts to assist network services' implementation by specifying how the contract definition elements are deployed in the network infrastructure, a feature not considered on the reviewed works. Although the proposed model is still evolving, its modular structure and the usage of Semantic Web technologies leaves room to model expansion and integration with other proposals.

III. Multiservice Network Ontology

The proposed model is divided in two modules: the service management module and the network module. These modules are organized as a layered structure where the upper layer has a dependency relation with the lower layer. This structure, where the management module is above and depends on the network module, mimics real life where this management component is, indeed, above the physical network. This formal representation of a network is expressed in formal terms using the support of OWL and following the principles from METHONTOLOGY [10].

The network module, as stated above, acts as the base layer. It includes concepts of network node, network interfaces and network equipment configuration elements related to the implementation of contracted services in the network. The management module covers the domain network service management related to service contracts, and service and network monitoring. This module uses several elements of the network module. Services are categorized by relating them to a type of SLS. According to the recommendations on [11]–[13], among others, the following services are defined: virtual leased line services, real-time services, multimedia services, data services, and default traffic service.

A. Management Module

The management module models the service contract or SLA. The first concept is the Client which identifies the client of the contract and stores all his information. A client is related to at least one SLA. As stated before, SLSs, another main concept in this module, are the technical component of an SLA and provide guidelines for service implementation and management. An SLA can have more than one SLS. The SLS structure follows the recommendations in [12], [13] and includes:

- SLS Identification. This field identifies the SLS for management purposes, being used by both provider and customer. It is composed by a unique SLS id parameter and a Service id parameter, allowing to identify various SLSs within the same service.
- Scope. The scope specifies the domain boundaries over which the service will be provided and managed, and where policies specified in a service contract are applied. Normally, SLSs are associated with unidirectional flows between at least one entry point and at least one exit point. To cover bidirectionality, more than one SLS is associated with a service. The interface identification must be unique and is not restricted to the IP address (the identification can be defined at other protocolar layer).
- Traffic Classifier. The traffic classifier specifies how the negotiated service flows are identified for differentiated service treatment. It supports multifield (MF) classification and behavior aggregate (BA) classification (see Section III-B). Usually, BA classification takes place on previously marked traffic, e.g. in network core nodes or in the case of SLSs between ISPs.
- Traffic Conditioner. This field specifies the policies and mechanisms applied to traffic flows in order to guarantee traffic conformance to the traffic profiles previously specified. The conditioning is applied after traffic classification, so there is a relation between the traffic classifier and the traffic conditioner specified within a SLS.
- Performance Guarantees. The Performance Guarantee fields specify the guarantees of service quality and performance provided by the ISP. Four quality metrics are considered: delay, jitter, bandwidth and packet loss. Whenever there is a performance guarantee specification, a traffic conditioning action must also be specified.
- Service Schedule. The Service Schedule defines the time period of service availability associated with an SLS. A start date is always specified. An end date is only specified in case of Reserved Service Schedule in which the client requests the service during a specific period of time. By default, the service is explicitly ended by the client so an end date is not set.
- Reliability. The Reliability is usually specified by the mean downtime (MDT) and by the maximum allowed time-to-repair (TTR). The no compliance of the negotiated parameters may result in a penalty for the ISP.
- Monitoring. Monitoring refers to QoS and performance parameters monitoring and reporting. For these parameters, a measurement period, a reporting activity and a threshold notification are specified. Other parameters such as the maximum outage time, maximum bandwidth, total number of outage reporting, document style and reporting destination may be specified.

B. Network Module

At present, an ISP is represented as a cloud network, where only edge (ingress and egress) nodes are visible. In this module there are three key elements:

- Interface. The element Interface represents ingress and egress points of the ISP domain. Specifically, it allows the mapping of external network interfaces or entry/exit points of ISP border nodes. Each interface has a total bandwidth capacity and a reserved bandwidth capacity specified dynamically for ingress traffic and egress traffic. For QoS purposes, it is possible to specify a set of QoS policies. In this case, a QoS policy is a relation between a traffic classifier instance and a set of traffic conditioner instances applied to traffic classified by the former.
- Traffic Classifier. In traffic classification, packets are identified to receive a differentiated treatment according to the service specification previously defined. The classification is conducted by a set of rules that are organized in two forms: Multi-field classification and Behavior Aggregate classification. In Multi-field classification, flows are classified based on a set of parameters. Traditionally it is used a five parameters tuple (source address, destination address, source port, destination port and protocol id). In this model, the setting of multi-field classification rules is more flexible. The rule parameters are combined with use of a logic operator AND or OR. Behavior Aggregate classification is based on packet marks, i.e., on previously marked packets. This type of classification is based on a single parameter and only specific protocol fields are used: IPv4 DSCP, IPv6 Traffic Class, MPLS Exp.
- Traffic Conditioner. The traffic conditioner is designed to measure traffic flows against a predetermined traffic profile and, depending on the type of conditioner, take a predefined action based on that measurement. Traffic conditioning is important to ensure that traffic flows enter the ISP network in conformance with the established service profile. It is also an important policy for the differentiation of packets according to their level of conformance within a certain traffic profile with the purpose of differentiated treatment by the network. In this model there are three types of traffic conditioners: policer, shaper and marker. With the policer, there is an immediate action to be taking on packets according to their compliance against predefined traffic profile.
  Different policer specifications can be accomplished depending on their measurement algorithm, measurement parameters and number of conformance levels. While the Single Rate Token Bucket has two conformance levels, a Single Rate Three-Color Marker has three levels of conformance, i.e., traffic flows are measured according to a committed information rate and a committed burst size for traffic bursts.

IV. Conclusions

The proposed multiservice ontology provides the main concepts and properties required to describe multiconstained QoS services in a network domain. Among other applications, it provides a uniform and formal support: (i) to foster client and service provider interoperability; (ii) to manage network service contracts, easing the dynamic negotiation between clients and ISPs; (iii) to access/query SLA/SLSs data on a individual or aggregated basis to assist service provisioning in the network; and (iv) to sustain service monitoring and auditing.

This paper has presented a first approach to the development of a semantic model in the domain of multiservice networks. This model covers concepts related to service and SLA/SLS definition, and multiservice network configuration elements. Although being conceptually aligned with the differentiated service model, it does not imply a specific QoS paradigm. Network elements are conceptualized on a per-domain behavior basis, focusing on the entry/exit points of the network domain, on traffic classification and conditioning processes. The usefulness of the present semantic service modeling has been pointed out for multiple applications in the context of multiservice management and auditing.

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