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Service Negotiation Models in NGN environment

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Abstract

In the paper we address the issue of provisioning E2E QoS in NGN. We describe two of the main service negotiation models and propose a functional model of the QoS negotiation interprovider via a third party (3P) agent that manages the negotiation process in a group of domains. We also present an algorithm for mapping service classes between the provider's domains. To analyze the performance and evaluate our model and the algorithm, we develop an object-oriented application for QoS management.

1 Introduction

End to end quality of service (E2E QoS) is one of the main characteristics of next generation networks (NGN), which assumes fulfillment of performance objectives through a set of independently administered domains. Different domains may implement different QoS models, with different sets of service classes and mechanisms for QoS provisioning. Examples of different service classification can be found in [1], [2].

One of the main issues of inter-provider QoS provisioning is a lack of a common service class definition between providers [3], [4]. While some solutions rely on defining a set of classes known to all domains, thus avoiding problem of class mapping [4], [5], others introduce a generic service specification and implementation of automated class mapping algorithm at domain boundaries [6].

Requirements for E2E QoS stipulate for new approaches to service and network management. The basic requirements regard definition of new management architectures, development of new models for automated management as well as hardware and software platforms that provide efficient implementation of management functions [7].

2 Service negotiation models

Two basic approaches to interdomain QoS negotiation are bilateral and third party, but different hybrid models can be derived from these two basic models as well.

The most widely deployed negotiation model is bilateral model, where two providers agree on mapping process between their service classes to provide requested QoS (Figure 1). Description of service classes can be new, one of the existing sets or the ones that are common for all participating domains. E2E QoS provisioning assumes existing of a chain of bilateral SLAs (service level agreement) in advance. The main drawback of the bilateral model is a risk of unfairness, i.e. in the process of QoS negotiation some domains may consume more resources, thus forcing other domains to select better classes in order to achieve the required E2E objectives [8]. In this model, practical experience points out low reusability of the existing set of service classes and performance metrics for negotiation of another service.

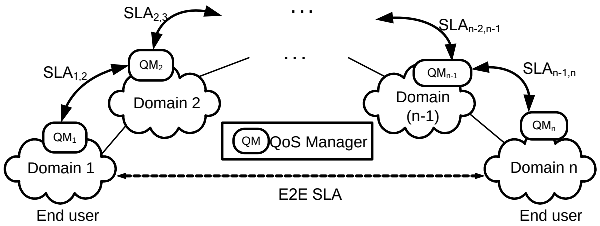


Figure 1. Bilateral service negotiation model

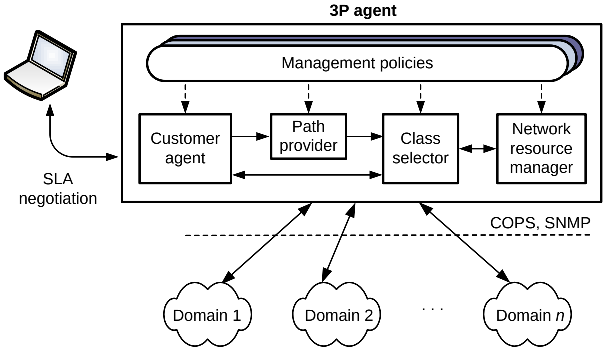


Figure 2. Service negotiation model via 3P agent

In third party (3P) approach service is negotiated via central entity that coordinates negotiation of a service in a group of domains. This central entity is responsible for mapping of service classes, translation of business processes and selection of performance metrics, as well as for the definition of E2E service. It has to keep information about offered service, network topology, link capacities between domains etc. for the purpose of service negotiation. The main advantage of this approach in highly dynamic NGN environment is that no cooperation among providers or reengineering of their networks is needed. The 3P approach allows a hierarchical organization of multiple 3P agents, in which central entity aggregates service requests at its own level and forwards them to a higher-level entity.

We have proposed a centralized approach to QoS negotiation, via 3P agent, which is responsible for negotiation process in a group of domains (Figure 2). The 3P agent maintains information about the topology, service classes in each domain, and resource utilization. It encompasses the following basic entities: Customer agent that represents a point of interaction between the customer and the central entity. Path provider maintains the information about optimal path, consisting of the chain of domains. Class selector is responsible for selection of the most appropriate class in each domain, thus avoiding complex class mapping at the domain boundaries. Network resource manager simulates the admission control procedure, i.e. it decides whether QoS request should be accepted or not. Rules concerning SLA forms, class selection algorithm, routing, admission control, bandwidth allocation, pricing, security, etc. are defined through different management policies. Detailed description of proposed model can be found in [9].

2.1 Algorithm for service class selection

For the purpose of automated implementation of class selection, we have proposed the algorithm for class selection as well. The algorithm performs automatic selection of the appropriate service class based on QoS parameters and specification of all service classes in each domain. QoS parameters should be satisfied during class selection with some degree of correspondence. After defining QoS requests, algorithm establishes the most appropriate degree of correspondence (DC) between the requirements for a particular service and a class from the available set of service classes for each domain in the path.

Algorithm extracts a set of required parameters from particular SLS and then retrieves the set of available service classes to select candidate classes, i.e. classes that satisfy the set of required values with some degree of correspondence. If any of DC values is lower then predefined threshold value, this class is eliminated from the further consideration and algorithm continues to analyze next candidate class. The purpose of the threshold is to restrict the set of candidate classes to classes with satisfying values of all required parameters. The selected class has the degree of correspondence closest or equal to 1. If two or more classes have equal best degrees of correspondence the algorithm selects the one with worse QoS characteristics. A detailed explanation of the algorithm can be found in [9].

3 Performance evaluation

Performance evaluation of the proposed 3P model has been performed with the application for QoS negotiation and management. Due to implementation of specific policies regarding QoS negotiation we designed this application using object-oriented design in C++ programming language for PC Windows environment. A more detailed description of the application can be found in [9].

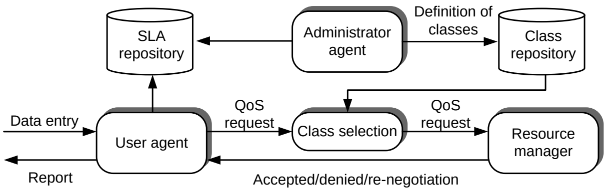


Figure 3. Functional model of the application for QoS negotiation and management

Functional model of an application’s structure is presented in Figure 3. User agent allows for registered users negotiation of new services. After accessing the application, service negotiation request is forwarded to Class selection entity, which implements algorithm for class selection described in previous section. It selects the most appropriate class by calculating the degree of correspondence for each class in every domain in the path of a traffic flow for which service is negotiated. Information about the selected class is then sent to Resource manager which simulates functionality of the admission control procedures, which returns a reply whether proposed agreement is accepted, denied or renegotiation is proposed.

Different experiments have been carried out in order to examine functionality of the proposed model. First we have investigated the influence of threshold to selection of the most appropriate class, in the sense of E2E QoS offered to the user. Threshold represents the measure of acceptability of the offered requested parameter value compared with the requested one. Three parameters have been specified, the throughput, delay and packet loss rate (PLR). The requested throughput is 2Mb/s and it can be satisfied by all classes in each domain. The delay request is 1500 ms and the requested PLR takes the value from the set $\{10^{-3}, 5*10^{-3}, 10^{-2}, 5*10^{-2}\}$. The number of domains N varies from 1 to 10.

Histograms of the DC values are presented in Figure 4, supposing service class specification for domains 2 and 3 (from Table 1).

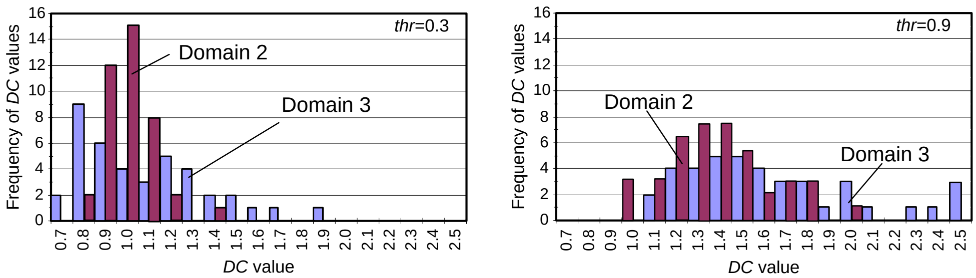
In the domain with finer QoS granularity (domain 2), DC values are concentrated around the value 1.0 for lower thresholds (*thr*=0.3). This indicates that the CMS selects the most appropriate class in terms of the overall degree of correspondence, in spite of the low threshold for individual metrics. With higher thresholds (*thr*=0.9) that indicate stronger guarantee for each metric, DC values are dispersed above the value 1.0, which points out to selection of a stronger class (equal or significantly better than requested).

In the domain with very coarse QoS granularity (domain 3), concentration of DC values can be observed only for the lowest threshold (*thr*=0.3). For the highest threshold (*thr*=0.9), DC values are dispersed in the interval [1.1, 2.5], which indicates frequent selection of the premium service (class 1).

We further explain the relationship of the obtained values to E2E QoS offered to the user. Figure 5 presents the ratio of maximum offered to requested E2E delay for different thresholds. The requested E2E delay is 1500ms, while the requested PLR is 10^{-3}. The DC value is indicated above each column. For higher thresholds (*thr*=0.9), the offered service is better than the requested one in most cases, which is verified by DC≥1.2. For lower thresholds, in some situations the offered service is worse than the requested one; but, it is still typically better than the predefined threshold for each individual metric. In such cases, DC values are in the interval [0.7, 0.9]. For all thresholds, when the offered service nearly (or perfectly) conforms to the requested one, the degree of correspondence equals to 1.0 or 1.1.

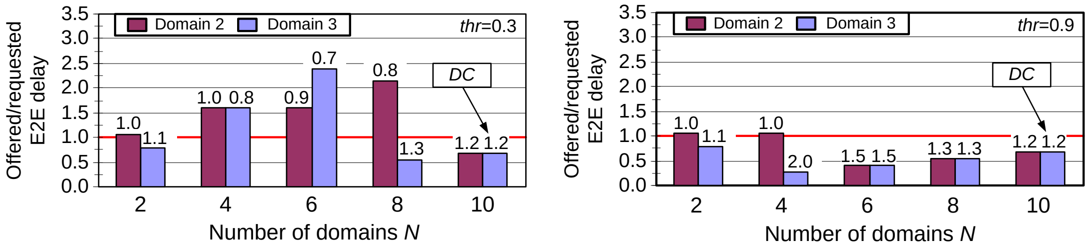
Table 1. An example of class specification

Dom.	Service class	Delay (ms)	Jitter (ms)	Packet loss rate
1	$C_{1,1}$	≤100	≤20	$\le 10^{-3}$
	$C_{1,2}$	≤300	≤40	$\le 10^{-3}$
	$C_{1,3}$	≤400	≤80	$\le 10^{-2}$
	$C_{1,4}$	–	–	$\le 10^{-2}$
2	$C_{2,1}$	≤100	≤20	$\le 10^{-4}$
	$C_{2,2}$	≤400	≤40	$\le 10^{-4}$
	$C_{2,3}$	≤600	≤100	$\le 10^{-3}$
	$C_{2,4}$	≤800	–	$\le 10^{-3}$
	$C_{2,5}$	≤1000	–	$\le 10^{-2}$
	$C_{2,6}$	–	–	–
3	$C_{3,1}$	≤100	≤20	$\le 10^{-4}$
	$C_{3,2}$	≤600	≤50	$\le 10^{-3}$
	$C_{3,3}$	–	–	–



(a) (b)

Figure 4. Histograms of the DC values from the 40 trials: (a) thr=0.3; (b) thr=0.9.



(a) (b)

Figure 5. The ratio of offered to requested E2E delay, maximum requested PLR=10^{-3}: (a) thr=0.3; (b) thr=0.9.

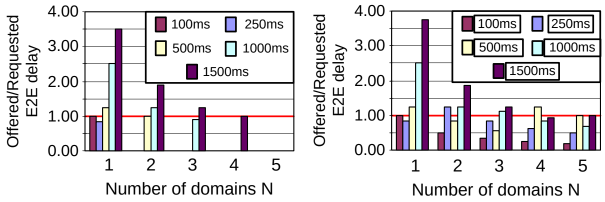
The above results indicate that the selection of the appropriate threshold should be a matter of the specific management policy. Strong guarantees for each individual QoS parameter typically cause the selection of better but more expensive class. The policy should be related with the domain attributes (e.g., granularity). For domains with finer QoS granularity, higher thresholds may be useful in selection of the service class with parameters that tightly correspond to requested ones.

Finally, we have compared the 3P service negotiation model to bilateral model in the sense of E2E QoS provisioning. Two types of domains have been investigated (Domains 1 and 3 from Table 1). Chains consists of up to five domains with the same attributes. Two different QoS requests were defined; requested delay takes the values from the set {100ms, 250ms, 500ms, 1000ms, 1500ms}, while requested PLR takes the values from {10^{-4}, $5*10^{-4}$, 10^{-3}, $5*10^{-3}$, 10^{-2}}.

The main difference between the two negotiation models can be observed in the case of additive performance metric (delay). With the stringent delay requirements (100ms and 250ms), in bilateral approach (Figure 6 (a)), service can not be negotiated even in the case of only 2 domains. For moderate requests (500ms) service can be negotiated in the case of maximum of 3 domains in the chain. For five domains in the chain, service can not be negotiated, even for the relaxed delay request (1500ms). High values of ratio of requested to offered E2E QoS (DC>>1) indicate selection of better class then required.

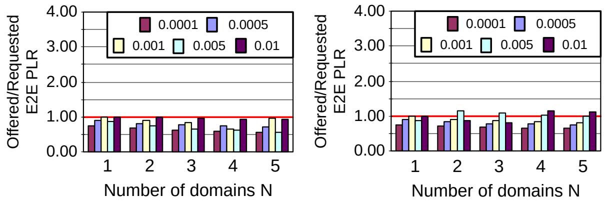
In 3P model (Figure 6 (b)) service can always be negotiated, but for stringent delay requirements (100 ms and 250 ms) ratio of requested to offered QoS is very low (DC<<1), indicating high under-provisioning. For indirectly multiplicative requirements (PLR) situation is similar for both approaches (Figure 7). Values of ratio of offered to requested E2E QoS are close to 1, indicating fulfillment of requested QoS.

Irrespective of the negotiation model in use, additive metrics are critical, but the rate of successful service negotiation is much higher in the case of 3P approach. Service negotiation is affected by specification of the classes in the domains, as well.



(a) (b)

Figure 6. Ratio of offered to requested E2E delay (Domain 1 from Table 1): a) bilateral model; b) 3P model.



(a) (b)

Figure 7. Ratio of offered to requested PLR (Domain 1 from Table 1): a) bilateral model; b) 3P model.

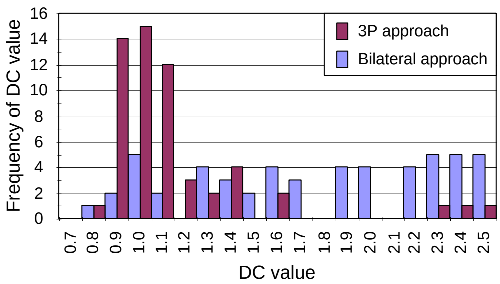


Figure 8. Distribution of DC values (service classes correspond to domain 1 from Table 1)

Figure 8 shows the frequency of DC values, indicating the resource utilization in the two negotiation models. Three QoS parameters are required, i.e. throughput, delay and PLR. The requested throughput is 2Mb/s and it can be satisfied by all classes in each domain, with perfect conformance (DC=1). The requested delay is 1600ms, while the requested packet loss rate takes the values from the next set $\{10^{-3}, 5*10^{-3}, 10^{-2}, 5*10^{-2}\}$. The number of domains N varies from 1 to 5 (domain 1 from Table 1).

In 3P service negotiation model concentration of DC values is around 1.0, which indicates that in most cases the most appropriate class was selected.

The bilateral model shows dispersion of DC values above the value 1.0, which means that a stronger class (equal or significantly better than requested) was selected thus indicating poor resource utilization.

4 Conclusions

In this paper we addressed the problem of E2E QoS provisioning in heterogeneous NGN environment. We have described the two basic negotiation models for the inter-provider QoS: the bilateral model and the third party model. We claim that the third party model is better suited for dynamic NGN environment, due to presence of a central entity responsible for negotiation of all E2E SLAs. We have performed performance evaluation using the object-oriented application for QoS management. Results of the simulation have pointed out that generally 3P model is better suited for the purpose of dynamic service negotiation, especially in a heterogeneous NGN environment.

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