

# Negotiating SLAs with Dynamic Pricing Policies

Peer Hasselmeyer  
IT Research Division, NEC Europe,  
Ltd.  
Rathausallee 10  
53757 Sankt Augustin, Germany  
+49-2241-92520  
peer@ccrl-nece.de

Bastian Koller  
HLRS  
High Performance Computing Center  
Stuttgart, University of Stuttgart  
Nobelstrasse 19  
70550 Stuttgart  
+49 -711-68565891  
koller@hlrs.de

Ioannis Kotsiopoulos,  
Dean Kuo, Michael Parkin  
University of Manchester  
Manchester M13 9PL UK  
+44-161-275-0678  
ioannis@cs.man.ac.uk  
dkuo@cs.man.ac.uk  
mparkin@cs.man.ac.uk

## ABSTRACT

This position paper argues for research in the development of focused solutions for dynamic pricing, service-level agreements and negotiation for eServices in a digital economy. Thereby the authors have a main focus on the development of an independent negotiation protocol, which satisfies the needs and preferences of customers and service providers, also with a certain focus on legal aspects of such a protocol. Another point of interest is hereby to examine what properties dynamic pricing components in a service oriented architecture should have and which benefits can be reached by following such approaches. We see that the provisioning of dynamic pricing components will surely affect the negotiation behavior of service providers and customers in a way that eBusiness will get stronger in Europe.

## Categories and Subject Descriptors

C.2.4 Distributed Systems, Distributed applications

## General Terms

Management, Design, Economics, Standardization, Legal Aspects.

## Keywords

Service Level Agreements, Negotiation, Dynamic Pricing, eCommerce.

## 1. INTRODUCTION

Service-oriented architecture (SOA) [4] is an architectural style (design principles) used in engineering robust and interoperable distributed applications. Services belonging to potentially different administrative domains are composed into distributed applications thereby promotes the reuse of existing software as services. The obvious extension to this is to establish a sustainable marketplace for eServices in line with the i2010 vision [5].

A service-level agreement (SLA) between a customer and a provider defines legal relationship between the two and forms part of a legally binding contract. Contracts are fundamental in the establishment of a marketplace as they provide the necessary protection for both customers and providers in the trading of goods and services. Disputes arising from trades can, as a last resort, be resolved in a court of law.

Included in a SLA is quality of service (QoS) that guarantees, what resources (hardware and software) will be provided, the cost of providing the service and liability to compensation if SLAs are not met.

A typical use case scenario is that the customer would first negotiate with the service provider to establish a legally binding contract (SLA) followed by the usage of the eService. During negotiation, a key component for both service providers and customers is price.

Service providers with the ability to quickly adjust their price based on current supply and demand data and with innovative pricing strategies will automatically increase their profitability.

This position paper argues for the need to develop, specify and implement pricing software for eServices, and their integration with a standardised and interoperable negotiation protocol, as they are essential in establishing an eServices marketplace. Service providers will then have the capabilities to automate the frequent adjustment of their price in response to the changing supply and demands and historical data of the marketplace which we refer to as “dynamic pricing” of eServices.

Pricing and what is negotiated in a contract is independent of the protocol used to establish a contract. This separation of concerns comes from contract law [6]. In contract law, the protocol for negotiating a contract is completely independent of what is being negotiated and the value of the contract – it may be a surprise to some readers that the law for negotiating a multi-million Euro contract for the construction of an office building is the same as the purchase of an apple from the grocery store.

Contracts in eServices today are typically still negotiated manually (face-to-face meetings and the signing of paper documents). In a open and competitive marketplace, automating aspects of negotiation and the adjustment of price would reduce the costs for service providers which would then be passed onto the customers.

Current European projects including NextGRID [1] and BREIN [2] did not have a focus on dynamic pricing and with that were and are developing infrastructures, which assume that pricing rarely changes. However, these projects enable us to have a good basis on what is needed. Thus the focus of this paper is to discuss and raise awareness of what are the key challenges and infrastructure necessary to establish a highly competitive and sustainable marketplace of eServices where services can dynamically price their services.

The remainder of this paper is organized as follows. Section 2 discusses the lifecycle of a legally binding relationship between a customer and a service provider. The objective of Section 0 is to initiate discussion at the workshop on novel dynamic pricing strategies and Section 0 provides a high level architecture for SLA management. Future research is presented in Section 5 followed by a conclusion.

## 2. SLA LIFECYCLE

A typical scenario between a customer and a service provider is that they first negotiate a SLA that includes price, service type and quality of service attributes.

EServices are services that provide its functionality electronically and the interaction between the customer and provider is through the Internet. There is no constraint as to what these services provide – it could provide simple weather forecasts and stock quotes or highly services providing simulation of complex systems.

Key parameter in determining a base price for a service is the cost, for the provider, to provide the service and they include the purchase and maintenance costs of hardware and software, network access and risks. SLAs specifying non-functional properties in an agreement are another important parameter in negotiating a price for the service – an SLA with tight time constraints will be of greater risk to the provider and thus will incur a greater price. We envisage that SLAs provide the foundations to the successful establishment of a sustainable eServices marketplace. Service usage will be governed by SLAs under a well-established legal framework.

The complete lifecycle of an SLA is described by the TeleManagement Forum [3] and is split into six distinct phases as listed below:

- Development of Service and Service Templates
- Discovery and Negotiation of an SLA
- Service Provisioning and deployment
- Execution of the Service
- Assessment and corrective actions during execution (parallel phase to execution of the service)
- Termination and Decommission of the Service

There is still ongoing discussion as to whether the creation of a service and service template should be part of the lifecycle or whether is it a predecessor of the lifecycle. We see it as a predecessor and not as part of the lifecycle as depicted in Figure 1.

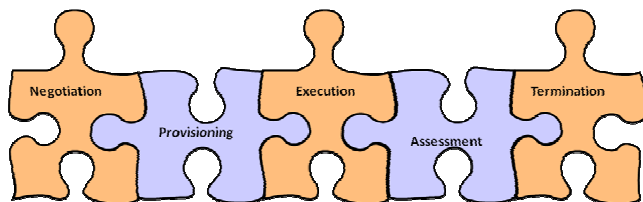


Figure 1: SLA life cycle

The creation of service templates for an eService identifies and defines the non-functional and quality of service attributes, and

price, which impacts on all the later stages of the SLA lifecycle including negotiation, monitoring and service provisioning.

After the negotiation of an SLA the service provider has to configure his system accordingly to provide the system to the customer. With that it is prepared for the execution of the service whose quality will be assessed (e.g. for accounting and billing purposes) until the SLA life is terminated. Within this paper we concentrate on the first phase of the SLA lifecycle – the negotiation.

Dynamic pricing necessitates the introduction of additional terminology into SLA templates for customers and providers to express price in terms of both functional and non-functional properties.

Negotiation between customer and provider is achieved through a negotiation protocol. Our position is that the eServices community should adopt the protocol that has been abstractly defined by contract law [6] and it is surprising simple and well-defined. Essentially, the customer uses the service template to make the service provider an offer, the provider acknowledges the receipt of the offer and then either accepts or rejects the offer. In the former case, a SLA has been established while in the later the provider may provide reasons (similar to a quote) as to why the offer was rejected to aid the customer to make a new offer that is more likely to be accepted.

The reason why service providers do not make offers is to prevent denial-of-service attacks as explained in Parkin et al. [7]. In contract law, quotes are not legally binding meaning that a service provider has no legal obligations to accept an offer based on a past quote – however, rejecting offers based on quotes may damage a provider's reputation and reduce its profitability.

With dynamic pricing, the price may change while the customer and service provider are negotiating a SLA. Essentially, the service provider needs to calculate a price in real time based on what is the current state of the marketplace (supply and demand), historical data to predict future supply and demand, the provider's business objectives and risks. The price can in practice, for the same SLA, change every minute in a highly dynamic marketplace similar to stock markets.

It is important to note that once a SLA has been established then the price is fixed between the service provider and customer.

## 3. DYNAMIC PRICING

Dynamic pricing refers to the continuous changing of the price for goods and services. The fluctuation results from the constant change in the supply and demand of the marketplace – in general, prices go up when supply is low or demand is high while prices go down when supply is high or demand is low. Dynamic pricing affects how customers and providers would negotiation SLAs as the price can change significantly during negotiation. However, it is important to note that once a SLA has been agreed to – that is, a contract has been established – then the price is fixed for the remainder of the lifetime of the SLA.

Price is determined by a function that can be dependent on a number of parameters – simple pricing functions typically will only take into consideration a few parameters while complex one will use more. Most of the parameters are measures of a service provider's internal state – e.g. its current and projected loads derived from established SLA with customers and historical data.

Some parameters can also reflect the state of the marketplace (external state) but these are typically difficult to assess. Other important factors in determining price are how the provider's competitors price their services and the provider's business model.

A key parameter in pricing functions relates to utilisation of the service. SLAs requiring the availability of resources in the future are problematic as it is difficult for service provider to predict future supply and demand. This is outweighed, however, by providers securing future revenue stream. In general, providers will encourage customer, through discounted prices, to reserve their services in advance which is consistent with reservations for airline seats and hotel rooms – customers typically can get the best rests when they book early.

Service providers will also price their services based on projected demand that can be based on historical data. Prices will not be discounted as much for advance reservations for a given when it is known that there will be high demand for that period. Airlines also employ such pricing policies as there are fewer discounted fares for school holiday periods.

Another key parameter in determining price is risk. If the SLA has tight deadlines or high liability then the price should include an insurance premium to cover its liability.

Anticipating and adjusting to changes in supply and demand of eServices will be challenges as it is more difficult to predict and changes in demand and supply can change frequently and significantly over a short period of time. This provides further reason for the need for software components that can automate dynamic pricing for service providers.

Other key parameters that affects price is the base costs for providing the service including the cost of purchasing and maintaining the hardware and software. Providers may, as an introductory offer, sell their services below costs but the business models, in the long term, need to be profitable.

This position paper argues for focused research and development in software for dynamic pricing. The range of possible pricing functions is almost limitless, we advocate to first engineer a simple solution with simple pricing policies with corresponding terminology for expressing quality of service before attempting to support more complex solutions that include the state of the supply and demand in the marketplace, historical data and other parameters.

The research calls on investigating and reusing, where appropriate, research results from operational research of resources in transportation and other fields. We anticipate that the eServices community can adopt many well-developed strategies from operational research.

#### 4. ARCHITECTURE

This section provides a high level description of an architecture as an example framework which would support negotiating SLAs with dynamic pricing and the above mentioned protocol. The architecture is based on the requirements and experiences gained from the BREIN [2] and NextGRID [1] projects for SLA negotiation and pricing.

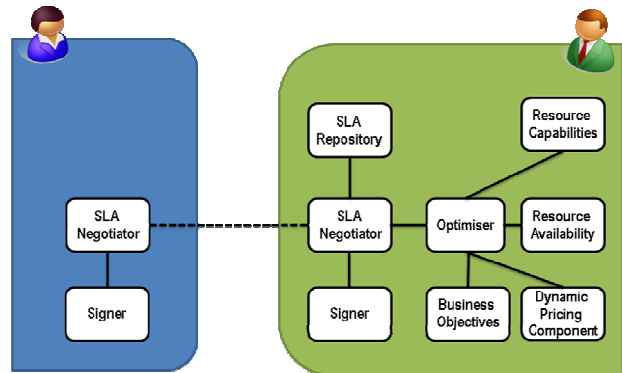


Figure 2 - SLA Negotiation Architecture

We identified seven areas of functionalities, which are represented shown in Figure 2:

- **SLA Negotiator:** This is the main component that enables the customer and provider to negotiate a SLA. The negotiation protocol defines the messages the negotiators can send to each other during the negotiation phase and they include messages to request for quotes, quotes, offers, the acceptance and rejection of offers.
- **Optimiser:** The component optimizes the offer received from the customer based on the provider's knowledge about the capabilities and availabilities of its resources. The output is the input to the dynamic pricing component.
- **Resource Capabilities:** This component provides data related to the capabilities of the resources deployed in the service.
- **Resource Availabilities:** This component is intended to provide up-to date information on the status of the system including current load, future reservations necessary to meet agreed SLAs and predicted demand.
- **Dynamic Pricing Component:** The components that computes a price, which takes into account the service provider's business model information from the "resource capabilities", "resource availability" and "optimizer" components.
- **Signer:** Offers accepted by the service provider/Customers are signed by this component for non-repudiation purposes.
- **Business Objectives:** Logical representation of the service providers' business preferences, behavior. E.g. it could be that a service provider prefers a customer X and would agree on making him a cheaper price to get him in business.

#### 5. Future Research

The protocol for negotiation mirrors contract law, which we are currently engineering. It complements the research and development in dynamic pricing. The protocol is independent of what is being negotiated providing an opportunity for us to engineer and deploy a solution for pricing incrementally. We will integrate a simple dynamic pricing mechanism into the negotiation process and then incrementally deploy for sophisticated pricing strategies. This approach will also provide us with an opportunity to evaluate objectively the different classes of dynamic pricing functions.

We believe that dynamic pricing is will affect strategies used by both the customer and provider when negotiating a SLA. Negotiation when prices are fixed (static) is trivial, the customer sends in an offer based on the advertised price and the service provider will accept the offer if it has sufficient resources to meet the SLA specified in the offer. Dynamic pricing introduces potentially large number of parameters that affects which offers are accepted by the service provider – e.g. risk, projected supply and demand, existing agreed SLAs with customers, and business models. Further research is required to evaluate useful yet viable sets of price-determining factors.

Dynamic pricing provides new business opportunities in value-added eServices where they can negotiate with service providers and then value-add on sell new services to customers.

One of the critical issues with service orientation is interoperability across administrative domains where services are engineered and developed independently. There is a need for well-defined standards with interoperable and dependable implementations. At this time, the standardisation process such as the WS-\* stack of standards is NOT providing us with the necessary interoperability. The specifications are often ambiguous for there to be any realistic chance of implementations being interoperable.

The work MUST incorporate more rigorous techniques in defining standards and we are proposing the use of some formal methods techniques such as TLA/TLC [8] and Z [9] in specifying standards. Formal methods force software engineers to be more precise and rigorous in what they are specify which reduces ambiguity and provides greater dependability and interoperability between implementations.

The focus of the research however is to first develop simple pricing strategies and then take an incremental approach towards more complex and interesting dynamic pricing policy. The research then aims to evaluate and compare different strategies with the purpose of making recommendations to the customers, service providers and government roadmap(s) to realise a viable digital economy in Europe

## 6. CONCLUSION

Dynamic pricing is a fundamental concept that needs further research as the eServices moves towards a sustainable digital economy. Service providers will achieve greater profitability if it can adopt and automate dynamic pricing of services based on current load, risks and projected supply and demand.

This position paper advocates for focused research and development for dynamic pricing in service-oriented computing. It has identified key challenges that need to be addressed.

In this paper, we have described the lifecycle of a SLA and its relationship with dynamic pricing and negotiation, and key parameters to a pricing function. The paper also has described a high level architecture for negotiating SLAs with dynamic pricing and future research necessary to realise the digital economy envisaged by i2010.

## 7. ACKNOWLEDGMENTS

This work has been supported by the NextGRID project and has been partly funded by the European Commission's IST activity of the 6th Framework Programme. This paper expresses the opinions of the authors and not necessarily those of the European Commission. The European Commission is not liable for any use that may be made of the information contained in this paper

This work has been supported by the BREIN project (<http://www.gridsforbusiness.eu>) and has been partly funded by the European Commission's IST activity of the 6th Framework Programme under contract number 034556. This paper expresses the opinions of the authors and not necessarily those of the European Commission. The European Commission is not liable for any use that may be made of the information contained in this paper

## 8. REFERENCES

- [1] The NextGRID Project, Priority IST-2002-2.3.2.8. Website <http://www.nextgrid.org/>.
- [2] The BREIN Project, Activity IST-2005-2.5.4
- [3] SLA Management Handbook - vol. 2 - Concepts and Principles, TeleManagement Forum, 2005
- [4] P. Helland. *Data on the Outside vs Data on the Inside*. MSDN Library.
- [5] What is i2010? [http://ec.europa.eu/information\\_society/eeurope/i2010/what\\_is\\_i2010/index\\_en.htm](http://ec.europa.eu/information_society/eeurope/i2010/what_is_i2010/index_en.htm)
- [6] R. Stone. Principles of contract law. Cavendish principles of law series 2000.
- [7] M. Parkin, D. Kuo, J. Brooke and Angus Macculloch. Challenges in EU Grid Contracts.
- [8] L. Lamport. Specifying Systems: The TLA+ Language and Tools for Hardware and Software Engineers. Addison-Wesley Professional.
- [9] J. Spivey. The Z Notation: A Reference Manual. Prentice Hall International (UK) Ltd.