Negotiating SLAs with Dynamic Pricing Policies

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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.

Categories and Subject Descriptors
D.4.7 [**Organization and Design**]: Distributed systems;
C.2.4 [**Distributed Systems**]: Distributed applications

General Terms
Management, Design, Economics, Standardization, Legal Aspects.

Keywords
Service Level Agreements, Negotiation, Dynamic Pricing.

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 promoting 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 a 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 an SLA is information on the resources (hardware and software) to be provided, the quality of service (QoS) level to be maintained, the cost of providing the service, and the 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 an 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 on to 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 serve as a valuable experience foundation and pointed us towards what is needed. Thus the focus of this paper is to raise awareness of the key challenges and to discuss the infrastructure necessary to establish a highly competitive and sustainable marketplace of eServices where service providers 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 3 is to initiate discussion at the workshop on novel dynamic pricing strategies and Section 4 provides a high level architecture for SLA management. Future research is presented in Section 5 followed by a conclusion.

2. SLA LIFECYCLE

EServices are services that provide their functionality electronically and the interaction between the customer and provider is through a communication network. There is no constraint as to what these services provide – they could provide simple weather forecasts and stock quotes or resource intensive simulations of complex systems.

Before a customer gets access to a provider's service, they need to establish a contract that regulates that access. SLAs are one expression of such a contract. A typical scenario between a customer and a service provider is that they first negotiate an SLA that includes price, service type and quality of service attributes. 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.

A key parameter in determining a base price for a service is the cost for the provider to provide the service. The cost includes the purchase and maintenance of hardware and software, network access, and risks. 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.

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 SLA 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 SLA 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.

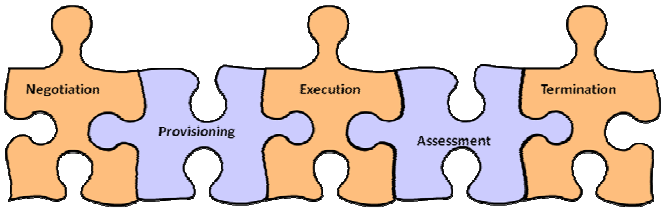

Figure 1: SLA life cycle

The creation of SLA templates for an eService identifies and defines the non-functional quality of service attributes and the price, which impacts all the later stages of the SLA lifecycle including negotiation, monitoring and service provisioning.

Introducing dynamic pricing into SLA negotiation affects the service and SLA template development stage. In addition to developing the service and its associated SLA templates, additional effort needs to be invested in developing and realizing pricing policies that match the service function and quality attributes.

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

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 surprisingly simple and well-defined. Essentially, the customer uses the SLA 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, an SLA has been established while in the latter the provider may provide reasons (similar to a quote) as to why the offer was rejected to aid the customer 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 an SLA. Essentially, the service provider needs to calculate a price in real time based on 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 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 negotiate SLAs as the price can change significantly during negotiation. However, it is important to note that once an 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. The establishment of an SLA and the setting of a certain price affect that particular provider-consumer interaction only. The price for the same service provided to another customer might be different.

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 ones 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 SLAs 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 providers to predict future supply and demand. This is outweighed, however, by providers securing future revenue. In general, providers will encourage customers, 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 rates 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 time 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 the liability.

Anticipating and adjusting to changes in supply and demand of eServices is challenging as these 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.

Another key parameters that affects price is the base cost 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.

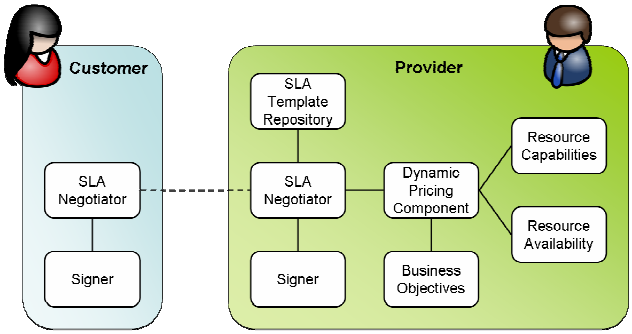

Figure 2 - SLA Negotiation Architecture

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

- **SLA Template Repository:** The template repository contains non-binding SLA proposals. These are transferred to the customer on request and are a method of advertising the provider's service offering.
- **Resource Capabilities:** This component provides data related to the capabilities of the resources deployed in the service.
- **Resource Availability:** This component provides up-to date information on the status of the system including current load, future reservations necessary to meet agreed SLAs and predicted demand.
- **Business Objectives:** Logical representation of the service providers' business preferences, behavior, etc. For example, a service provider might prefer a particular customer and would agree on a discounted price to increase business with him.
- **Dynamic Pricing Component:** The component computes a price taking into account the offer received, the service provider's business objectives, the "resource capabilities", and "resource availability".
- **SLA Negotiator:** This is the main component that enables customer and provider to negotiate an SLA. The negotiation protocol defines the messages the negotiators can send to each other during the negotiation phase and they include messages that contain requests for quotes, the actual quotes, offers, and acceptance and rejection notifications.
- **Signer:** Parties agreeing to an offer show their agreement by digitally signing that offer. This component performs the signing process.

The architecture looks at one particular interaction between a customer and a provider only. In a real system, multiple negotiations are progressing simultaneously. Each individual negotiation can be seen as independent of all other negotiations. Although parallel negotiations can influence each other indirectly (e.g. the establishment of an SLA affects resource availability and can therefore change the price), this is not visible in the high-level architecture and is abstracted with the various components.

Another property of service oriented systems is abstracted in our architecture – the chaining of services. A particular service might

need another service to operate properly. Establishing a new SLA with a service can therefore influence the relationship of that service with ones it depends on. Such a scenario does not influence our architecture as the management of the resources a service needs to work properly is abstracted by the resource capabilities and availability components. Whether a service is based on other underlying services or not is not visible to its customers. The architecture is generic enough to deal with such scenarios.

5. FUTURE RESEARCH

We are currently devising a protocol for SLA negotiation which mirrors contract law. 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 more sophisticated pricing strategies. This approach will also provide us with an opportunity to evaluate objectively the different classes of dynamic pricing functions.

Dynamic pricing affects the strategies used by both customer and provider when negotiating an SLA. In scenarios where prices are fixed, negotiation is trivial – the customer sends an offer based on the advertised price and the service provider accepts the offer if it has sufficient resources to meet the terms specified in the offer. Dynamic pricing introduces potentially large numbers of parameters that affect 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 find useful yet viable sets of price-determining factors.

We believe that dynamic pricing can provide a competitive advantage over static policies. Providers using dynamic pricing can increase their revenue in times of high resource demand and can attract additional business in times of low demand by appropriately adjusting their prices. Although it seems obvious that dynamic pricing is superior to static prices, it needs to be researched how the market behaves and which strategies are most promising in case many or all providers employ a dynamic pricing model.

Pricing service usage dynamically does not come for free. Various parameters that influence the price need to be determined. Some are easy to measure, e.g. the current resource load, but some require more effort, e.g. the estimation of future work load. It therefore needs to be research how much cost and effort different pricing schemes incur and what benefit can be gained from them. It also needs to be evaluated how much manual input is needed for a pricing scheme to produce adequate prices and how much this whole process can be automated.

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 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 taking into account just a single variable, e.g. the current load. We will then progressively increase complexity by incorporating other parameters and by combining them to form interesting dynamic pricing policies. The research then aims to evaluate and compare different strategies with the purpose of making recommendations to customers and service providers and to provide input to government roadmap(s) to realise a viable digital economy in Europe

6. CONCLUSION

In this paper, we have described the lifecycle of an SLA and its relationship with dynamic pricing and negotiation. Dynamic pricing is a fundamental concept that needs further research as the eServices world moves towards a sustainable digital economy. Service providers will achieve greater profitability if they can adopt and automate dynamic pricing of services based on current load, risks and projected supply and demand.

This position paper advocates focused research and development of models for dynamic pricing in service-oriented computing. As a starting point, it has identified key challenges that need to be addressed. We introduced a high-level architecture for negotiating SLAs with dynamic pricing. We identified the factors that might have an influence on the price, including risk, supply and demand, existing SLAs, and business models. This position paper clearly shows that future research is necessary to realise the digital economy envisaged by i2010.

7. ACKNOWLEDGMENTS

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