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# The Impact of Service Pricing Models on Service Selection

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## Abstract

*Pricing of services, especially in a SOA and Grid environment with contractual relationships gain importance in recent years. For the resource planning, i.e. the allocation and orchestration of existing services, service pricing has a major influence. An orchestrator of services may face various pricing models from different service providers with e.g. long-term or short-term contracts, fixed or variable expenses for service invocation. Price as an important non-functional property of services lacks of a systematic investigation in this context, although it directly affects a service orchestrator's business targets. An appropriate categorization of pricing models is essential for this purpose.*

*This paper proposes a classification of pricing models for services in a SOA environment from a resource planning perspective, i.e. for service selection. Moreover, the impact of different pricing models on service allocation, respectively selection, and further implications for an intermediary, acting as a service orchestrator, are presented.*

## 1. Introduction

In recent years the Service-oriented Architecture (SOA) paradigm has become a major issue [1]. Also agile and flexible service-oriented workflows gain more and more importance concerning competitive markets. In this context, a certain level of Quality of Service (QoS) as well as an effective resource planning approach has to be implemented in order to meet customer requirements [2] [3].

Considering a large service market with various services having equal functional parameters, non-functional parameters such as price come to the fore. The question arises how different pricing models can be categorized and which impact they have on a service orchestrator that has to invoke services from several providers with different pricing models. For the resource planning, i.e. the decision which services have to be invoked in parallel at which step in a service-oriented workflow, service pricing has a major influence, because the orchestrator may be faced with e.g. long-term or short-term contracts or fixed or variable expenses for service invocation.

Therefore the paper presents a classification for service pricing models as well as the description of the impact of several pricing models on the service selection for an intermediary that acts as a workflow orchestrator.

The remainder of this paper is structured as follows. After an introduction of Web services as information products in section 2 the considered scenario is described in section 3. Further, a classification of pricing models of services is presented in section 4 and the impact on service resource planning is depicted in section 5. The paper closes with a summary and an outlook on future work.

## 2. Web Services as Information Products

The analysis of the impact of Web service pricing on resource allocation and service invocation in general requires, among others, an extensive examination of pricing models. Beyond the complexity of pricing immaterial services in general, the problem of pricing Web services must cope with the complexity of pricing information products, having a special cost structure. In general, an information product can be described as an immaterial resource for satisfaction of needs, which is developed and distributed with the help of information technology (e.g. Web services, telecommunication services). The characteristic of information products is that they cause significant first copy costs (fixed costs) for investments and research and development (R&D), but low marginal costs of reproduction [4]. Web services are digital goods and are reproduced and distributed fully digital without any physical storage medium or any other material containments, wherefore the variable distribution expenses become nearly zero. This means that the relation of fix costs to variable costs becomes very high, resulting in vast economies of scale, because the higher the relation of fix costs to variable costs is, the more significant total average costs per unit decline with additional units produced (and sold). This implies that the competitors with higher distribution enjoy less unit costs compared to competitors with less distribution. Lower production costs result in more profit or the ability of sooner price reduction. In case of the latter, the market share will increase when everything else remains unchanged. This will again intensify the decreasing of unit costs with the respective results on earnings.

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Arthur denote this effect as "increasing returns" [5]. A high ratio of fixed to variable costs can lead to the effect that dominating suppliers become more dominating in the market, which is generally well-known in business studies. Due to the mentioned cost structure, this characteristic is of high importance for competition in Web service markets. Suppliers of information products must recover their high fixed costs while avoiding competition to lead prices towards marginal costs of reproduction (zero). In a competitive market, commodity products are priced close to marginal costs of production in the long run, i.e. Web services would be priced close to zero and thus, without contribution margin. Therefore sellers of information products cannot apply cost-based pricing as it would not allow recovering of investments for the development. Also pricing according to competitors is extremely risky, as it forces ruinous price competition that only highly capitalized participants survive. Hence, Shapiro et al. argue that value-based accounting is the only reasonable option for sellers of information products [6]. In this context, the term "versioning" was introduced, which points at the offering of information in different versions as a means for customers to reveal their value they attach the information and the price they are willing to pay for it. Supposed differentiation criteria are e.g. delay, speed, convenience, comprehensiveness, community, support, annoyance and so on.

Relevant for the theory of resource planning of service-oriented workflows is, that according to the theory of information products, service providers are likely to offer services in classes with different QoS properties. This is a form of second-degree price discrimination based on product quality. This is especially useful for Web services, as degrading QoS properties imply the introduction of services with the same functionality but with several QoS-levels, which is not expensive in the realization.

## 3. Scenario

This section describes the considered setting and the required assumptions in order to be able to describe the impact of service pricing on resource allocation. The main topic in this context is the resource planning of an intermediary that acts as a service orchestrator and that provides a workflow to his customers as shown in Figure 1. This intermediary may be a commercial service provider, utilizing limited resources such as processing performance, network bandwidth and in particular commercially sourced Web services from external providers in order to compose them to a workflow and provide this to its customers. This implies that depending on the point of view, a service provider may act as an orchestrator, utilizing existing services, e.g. from other service providers. He may compose these to a workflow for his own usage or he may act as a service provider himself by providing the composed workflow to other service consumers. In both cases, these services, charged by the respective providers (i.e. inducing costs), have to be allocated such that the benefits of the service orchestrator or both the service orchestrator and the service requester are optimized in compliance with QoS requirements of service requests. The intermediary invokes Web services from external providers, composing them to workflows that he may provide to his customers afterwards. On the one hand, this composition must comply with the amount of customer requests and their QoS requirements. On the other hand, the composition is liable to the orchestrator's own business objectives, such as the profitability. Whilst customer requests and QoS-demands are given variables, the profitability of the workflow is a result of the expenses that were made to suppliers and the fees that were charged from the customers. The service orchestrator must pay for invoked Web services, as well as he will charge for the entire workflow, i.e. each supplier-requester relationship in this scenario will be attributed with a pricing model. As achieving profit is a general motive and measure for the success of any commercial activity, we define the benefit of the service orchestrator as the difference between the fee charged to his customers and the costs for Web service invocations. This implies that when disregarding the fee charged to its customers, cost reduction refers to profit maximization.

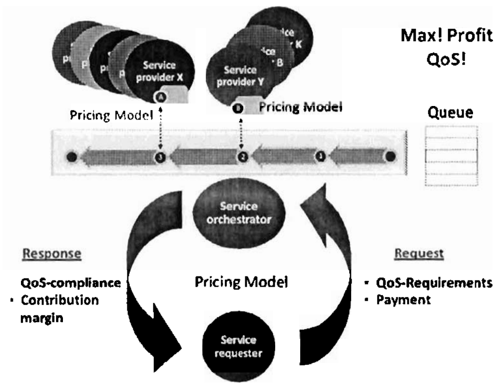


Figure 1. Research scenario

Regarding the integration of external services, there is a broad continuum of relationship intensities between ad hoc usage of a market for single transactions and static contribution to a long termed contract. While traditional IT outsourcing is usually based on a long-term contract between an organization and a single outsourcing provider, "utility computing" stands for advanced forms of outsourcing with more dynamic relationships between service consumers and providers, which is also an aspect of the SOA paradigm. Ideally, short-term contracts for service delivery are negotiated "on-the-fly" in order to reduce the risk of being dependent on decided providers. Such custom connections are subject to commitments and investments that lapse when switching to another provider (sunk costs). Sunk costs can delimit the service requester's freedom of choice to that effect that they could cause switching the provider to be uneconomic. In a utility computing scenario, the service requester should be in a more flexible situation, being able to select the most convenient service at any time. Contrary, traditional IT outsourcing provides respective certainty by long termed agreements. A detailed comparison of IT outsourcing and utility computing is depicted in Table 1.

Table 1. Traditional IT-Outsourcing versus utility computing

| Traditional IT-Outsourcing | Utility Computing |
|---|---|
| long-term contracts | ad-hoc, short-term contracts |
| fixed expenses, periodical payments | variable expenses, pay-per-use |
| risk of lock-in high | risk of lock-in reduced |

Web services are characterized by reusability and exchangeability. A multitude of functionally equal Web services may be available on a commercial market. Here, supply and demand could meet in an ad hoc manner, resulting in competition and utilization of market efficiency. Such a scenario offers the potential for a service orchestrator to decide the procurement of Web services during runtime. Dynamical, runtime planning of resources according to actual QoS requirements, such as capacity, response time etc. can be enabled. With Web service technology, utility computing is a realistic opportunity. Instead of long-termed agreements, contractual relationships arise and perish dynamically. In this context, different pricing models, provided by the Web service providers, may have different effects on the trade-off between the QoS and the CoS (Cost of Service). The discussion of pricing models and their dynamics in connection with resource planning is the objective of the considerations depicted in the next section.

## 4. Classification of Pricing Models for Services

This section outlines different pricing models mentioned in literature and provides a classification of pricing models for services from the perspective of a resource planner.

When signing a contract about the invocation of a Web service, different types of contracts are possible and discussed in literature. Basically, fixed fee, variable fee and hybrid fee pricing models must be separated and analyzed. In the first case, the fixed fee pricing model, the service requester (consumer) is charged a fixed fee that grants a certain volume of requests to the Web service provider. The fee could also grant unlimited access to the Web service for a certain amount of time, but when regarding a maximum processing capacity per time unit, this can also be calculated into a certain maximum volume of requests within this time period $t$.

The second class of pricing models charges the user with a fee that depends on the actual usage of the Web service. This approach is referred to as variable fee pricing model (also known as pay-per-use), as the fee is assessed subject to the amount of requests to the provider, i.e. the quantity of requested Web service executions. In case of this pricing model, the service provider charges service usage according to the actual quantity supplied. The fee $y$ is defined as a function $y = f(x)$ of the supplied quantity $x$. Hereby, the function $f(x)$ can be of any continuous or discontinuous shape. Moreover, besides the quantity $x$ of supplied service, any other external variables (e.g. technical conditions, market prices etc.) can be determinants of the fee (i.e. $y = f(x, v_1, ..., v_n)$). In such a case, the relation between fee $y$ and quantity $x$ is subject to variances caused by other determinants $v_i$. According to this, we distinguish between variable fee pricing models with static scheme and dynamic scheme. In case of a static scheme, the fee per request is known in advance. This implies that according to the number of requests, the service user is able to determine the respective fee in advance, as the prices per any number of requests do not change over time. A static scheme indicates that the functional relation between fee $y$ and quantity $x$ is not subject to variances, i.e. a fee $y$ induced by any quantity $x$ can always be determined a priori. Contrary, a scheme where the fee $y$ induced by quantity $x$ can vary over time, according to any other defined variables $v_i$, is referred to as dynamic scheme. Basically, external determinants $v_i$ in the context of Web service pricing can be originated in technical conditions of the service provider's resources (e.g. bandwidth, capacity utilization etc.), the user's willingness-to-pay (e.g. bids in an auction system, price formation through supply and demand) or any market condition (e.g. prices of competitors). According to the nature of the underlying variable(s), we classify dynamic schemes of variable fee pricing models as resource-oriented, user-oriented or market-oriented.

Finally, there is the class of hybrid fee pricing models that combines a fixed fee with a variable fee, whereas the most common methods for pricing Web services nowadays are mainly fixed fee (flat-rate) models and minor static pay-per-use models, mostly following a quantity- and/or priority-based price discrimination [7], [8]. Offering quality or priority classes can serve as a means for the provider to let the customer reveal his price sensitivity and conversely increase flexibility in terms of varying customer preferences. This additional means can be applied to any pricing model. For example QoS research on economics-based network resource allocation discusses this concept as means for using market mechanisms to suppress low-value

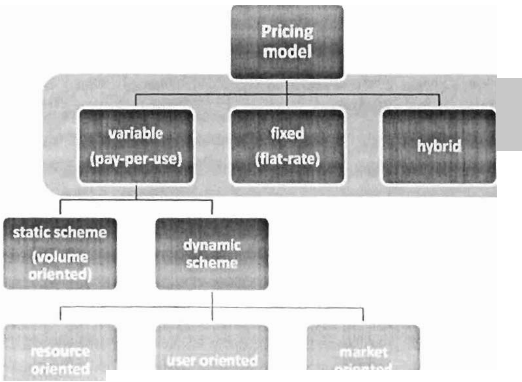


Figure 2. Pricing models

data traffic by differentiating prices according to priority-classes. In principle, these approaches [8] [9] [10] [11] can be transformed into usage-based Web service pricing where each customer pays according to the quantity and quality of provided service. The Web service provider can provide a list of trade-off alternatives between the Quality of Service (QoS) and the Cost of Service (CoS). The negotiation, in terms of both parties having to evaluate the list of QoS and CoS alternatives for allocating a convenient combination, is denoted as logrolling [7]. Besides increasing flexibility, multidimensional models also enable pricing of more sophisticated business models with unique, non-repetitive and expensive services. An example of a priority-class model is the "price-based resource allocation mechanism for priority services" proposed by Marbach [12]. The priority classes reveal different QoS-properties and respective prices, while prices are set a priori in a static scheme. The author argues that a dynamic scheme is too expensive to implement, showing that a static scheme can at least achieve network efficiency as it can be sufficient to manage congestion and sharing of network bandwidth analogue to the user's requirements. Altogether, in this kind of approaches service prices and respective priority classes are set by the provider. Yahav et al. charge these methods failing to support varying client priority conditions and, in a further contemplation, delimited potential to truly reflect customers' willingness-to-pay and propose an auctioning model [13]. Nevertheless, a given set of priority classes with provider-commissioned prices in combination with a reasonable scheduling policy can help sustain simple fairness conditions in processing of service requests. Obviously, a trade-off between economic efficiency and technological feasibility arises in this context. Research in this area, as well as practical appliance is not very far yet. Hence, the following section discusses the impact of different pricing models on the service invocation and the resource planning for service-oriented workflows.

## 5. Impact for Service Selection

This section focuses on the impact of the discussed service pricing models for the service selection by an intermediary in our considered scenario.

In case of a fixed fee pricing model, a service provider charges a fixed fee (flat-rate) that grants unlimited access to a Web service in a certain time span or request volume. Regarding the intermediary, acting as a service orchestrator that purchases a Web service with fixed fee, there is a heightened obligation to the provider within the flat period or flat volume. Switching the resources, i.e. the service providers, could turn the flat fee into sunk costs. The intermediary faces decreased flexibility and extended procurement risk by obligation to specific providers. Moreover, on supply side the service orchestrator runs the respective merchandising risks. Inversely to the disadvantages of inflexibility, a flat fee approach benefits both, the service orchestrator and the service provider, with low overhead for pricing and billing, i.e. reduced transaction costs [14]. Regarding the resource planning problem of the intermediary, the contribution margin per workflow execution increases with the number of executions, because the average unit cost per service invocation results from dividing the fixed fee by the amount of service executions (invocation). Accordingly, regarding a fixed revenue per workflow for the intermediary by selling the workflows at a third party, the contribution margin increases by skimming the available resource volume.

Considering variable fee pricing models with static scheme, the prototype of a variable fee pricing model with a static scheme is the one dimensional, linear usage-sensitive pricing model with a fee equal to $y = f(x) = a * x$ (volume-based pricing) [15]. From a technical perspective it suffers, like any static policy, from inflexibility as it does not allow any reaction to varying conditions. From an economic perspective, it will not transport economies of scale towards customers, which they expect. Accordingly, customer bonding is neglected. Especially large scale customers will be penalized in such a model. Moreover, this form of pay-per-use pricing does not provide any incentives to adapt usage behavior, as usage is always accounted with a uniform linear factor.

According to our model, the service orchestrator has no incentive to schedule or adapt the processing of requested workflows, respectively the concrete task item in any way when confronted with a linear pay-per-use pricing model. Regardless of any other task item in the workflow, he will process any workflow request immediately, as the Web service's contribution margin does not change in any way. Variable fee pricing models with static scheme can also reveal a non-linear relation between obtained quantity and payable fee that can be of any continuous or discontinuous shape. These schemes represent a form of price discrimination [16]. Here, price is differentiated according to the level of usage. For example a system of price discounts based on several thresholds (i.e. volume-based rate with volume-discounts) could serve for this purpose. The motivation for such a quantity-price relation is to fit to the customer's willingness to pay and/or to manage usage-behavior. Figure 3 shows an example form of a pay-per-use model with volume-discounts. In a pricing model with volume-based discounts, unit-costs per requested Web service decrease with increasing volume-interval. Hence, the service orchestrator will minimize the average expense per Web service, i.e. maximize the contribution margin, by processing in the system of volume-thresholds. For the intermediary, it will be reasonable to process the requests in "bursts" in order to minimize average unit-costs per request. However, regarding queuing it has to be considered that in runtime planning, information about future requests is delimited (online problem). A naive priority rule would be to queue requests in a FIFO approach as long as possible (regarding QoS) in order to accumulate enough quantity to aim a certain average volume-discount per accounted request.

A hybrid pricing model is such combining a fixed fee per request with an, in general volume-based, variable fee. This will decrease financial risks for the service provider while it will increase the risks of a lock-in for the intermediary. It can be stated that the key dynamics of a hybrid model, in terms of our contemplation, are determined by the variable-pricing scheme [16].

In contrast to the above mentioned pricing schemes, the characteristic of dynamic pricing schemes is that the price cannot be determined in relation to the execution quantity in advance. Concerning the introduced scenario in section 3, the intermediary faces a situation in which he accounts a uniform fee per workflow execution, whereas the regarded invoked services induce non-uniform expenses, dynamically determined during runtime. Accordingly, the contribution margin will vary and inhabit respective financial risks for the intermediary, as it is not guaranteed that it can turn negative. Therefore, procurement, i.e. invocation of Web services with dynamic pricing schemes, is only reasonable when charging dynamically for the workflow as well. The intermediary will aim to adapt his service utilization in a way that reduces his expenses and therefore increases the contribution margin of processed requests. The expenses accounted by the service provider are responding to the "environment", which is also influenced by the behavior of the service requester. This means that the intermediary is reacting to the prices which he in turn influences by his own behavior (e.g. in terms of utilization). As the intermediary has no prior knowledge about incoming requests and requests from other consumers he will have to heuristically optimize his profits.

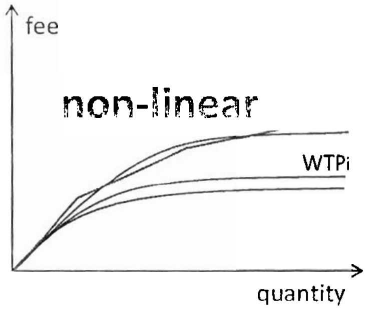


Figure 3. Non-linear pay-per-use pricing model

## 6. Conclusion

Currently, a set of pricing models can be assumed considering pricing of services (especially Web services). Pricing of services has a high impact on the service selection. Particularly in a SOA scenario considering an intermediary that acts as an orchestrator invoking services form several providers with several pricing models the service selection is affected. Depending on the specific pricing model, the intermediary is faced with different conditions that affect the decision which services have to be invoked at which step in the workflow. Therefore this paper proposes a classification for pricing models of services and describes their impact on the service selection in a SOA environment.

Our further research aims at extending our previous work in resource planning to other pricing models. Further the impact of different pricing models on the service selection, i.e. the resource planning problem, will be analyzed with extensive simulations.

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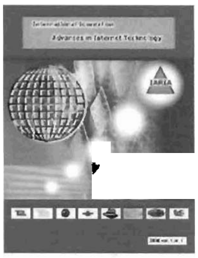


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