How to Enhance Service Selection in Distributed Systems

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Abstract

The progressing complexity of distributed information systems causes an increasing use of object-oriented technologies. As a consequence today's standard architectures of distributed systems like CORBA include a basic trading service. The standard trader mediates service offers to clients' requests if their specified characteristics match exactly each other. This paper extends that concept towards enabling the trader to return offers even if they do not fit exactly to the user specification, but exhibit a certain service distance to be defined properly. Moreover, the decision theoretic concept of QoS- and QoSP-functions allows including user preferences into the trader's selection mechanism. The implementation shows that the extended trader is only slightly slower than its predecessor. The customer thus wins a very useful new functionality on relatively small costs.

Keywords: Distributed Systems, Trading, CORBA, QoS, Decision Analysis, Service Distance

1 Introduction

The progressing distribution of complexity in information systems yields more and more the use of object-oriented technologies. The use of middleware allows integrating heterogenous existing components into one network. Thus the users need not give up their well-known environment, but get access to a multitude of new services.

Since 1989 the Object Management Group (OMG) aims at developing object technologies. The concepts coming therefrom have been put together to form the Common Object Request Broker Architecture (CORBA). It divides services into Basic Services being application independent and specified in the CORBA standard, application-oriented Common Facilities and Application Services to be programmed as clients and servers and to be accessed directly by the user.

This article deals with one of the Basic Services in greater detail, i.e. the CORBA Trading Service. Its main task within a complex distributed system is to manage and trade object references. As in addition to the OMG the standardization group of the Open Distributed Processing (ODP) activity is concerned with this service since a long time, it may be viewed as a well established research field in the area of distributed systems.

The common trader concept we start from (see [SPM94]) allows a service to be offered to the user only if its characteristics meet exactly the user specification. On the other hand, if there is a couple of services fulfilling the user expectations but still being different in some features, the service to be finally offered is chosen in a very handwaving way. This article proposes concepts to overcome these disadvantages. The concept of service distances allows answering service demands even if there is no offer available matching exactly the expectations. In this case the service offer with minimal distance to the user's demand is chosen. A more refined approach uses ideas from decision analysis to integrate customer preferences into the service selection mechanisms. In this approach the user of the system is allowed to state preferences by assigning priorities to the different service properties and computing preference functions over the values taken by each distinct property. Hence the user may state quantitatively which property she wishes to be handled in which way. In response the service offer most suitable for her will be offered before she has to decide whether to accept this offer or not.

This article is structured as follows: The next section is to give a short overview of the CORBA trader. Section 3 deals with the concept of service distances, whereas section 4 introduces a decision theoretic approach to include user preferences and proposes a model for the trader's evaluation unit. Section 5 deals with the implementation and shows measurement results. The final section summarizes the paper and gives some directions of further research.

2 Trading concepts

The trading concept of the OMG has been adopted as OMG document in 1995 [OMG95]. Here is a brief sketch of the trading service within CORBA (cf. figure 1): Clients and servers belong to the class of Application Objects. The server objects export their object reference and describe each service by a service type and a couple of service properties. If a client object requests a service, i.e. is looking for an object reference at run time, then the trading service mediates the reference, and the suitably chosen service is bound dynamically. The Object Request Broker (ORB) allows the interoperability between the different objects.

This trading concept is based on the exact user specification of a requested service by describing the required features. For each service type there may be a couple of different service offers, i.e. descriptions of the functionalities offered by the respective objects within the CORBA system. They are characterized by properties or attributes, in the form of (name, value)-pairs. A service request can be answered positively if in the trader's service directory there is at least one service offer matching the required service type and the restrictions specified by the user.

There are two general mechanisms for service request formulation. The `search` function looks for all service offers matching the user restraints, whereas `select` returns only one offer by using superlative functions or random choice. In these two cases the user has no possibility to contribute her own preferences to the selection procedure.

This is the starting point of the work presented in this paper. The standardized trading function will be extended in two directions: the definition of a distance between two services is a first approach towards trading service offers which do not meet exactly the user specification. A second approach allows the user to specify her preferences w.r.t. to the single service properties in greater detail, thus having a very useful additional trader functionality. To this end the quality of a service is expressed by a Quality-of-*Service* (QoS-) function combined from a couple of Quality-of-*Service-Property* (QoSP-) functions that characterize the quality of each single service property. Finally note that in both approaches, by using "k.o. criteria" the user has still the possibility to specify requirements that must be met under all circumstances.

The idea of service distances was first proposed in [TP96] and will be used here in a modified and simplified version. Further applications of decision analysis, especially with respect to uncertainty in the offered service properties, are to be found in [MLB94].

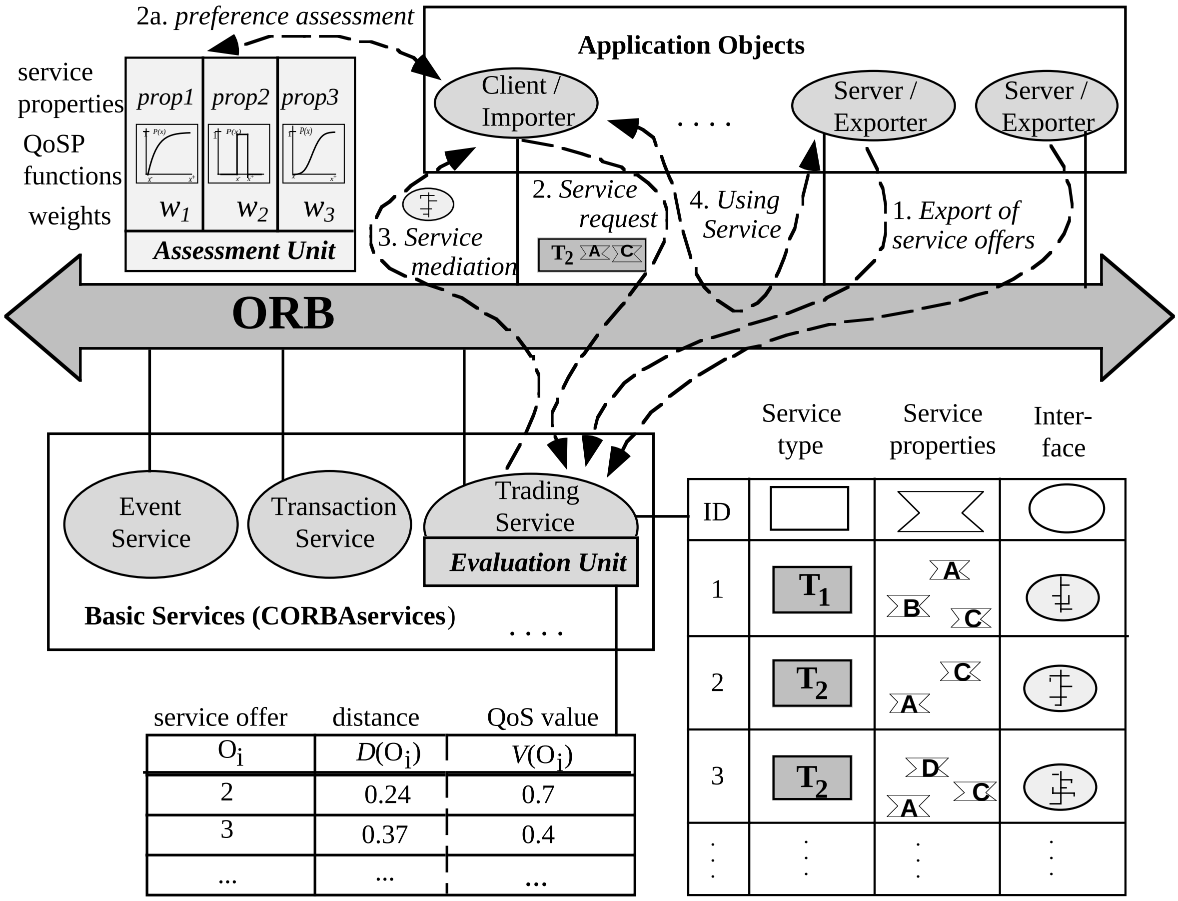

Fig.1: The concept of the extended trader under CORBA

3 Service distances

The service distance function to be defined in this section simply maps a service request and a service offer onto a real number (or infinity). It is assumed that the exporter describes her offers by specifying each service property either by a target value or by an interval of values the exporter can guarantee. Similarly the importer either requires a target value or states an interval of acceptable values. Clearly both parties have to specify the respective service type as well.

Obviously the case of a target is the special case of an interval with identical upper and lower bounds, hence we can put both cases together. Note that the service distance D is set to infinity if the requested service type does not match the offered one. Otherwise in a first step the distance between a request property r_p and an offer property o_p is defined as follows:

- if the request property does not correspond to an offer property, the distance is infinity
- if the request property is specified as "k.o. criterion" and is not matched by the offer adequately, the distance is set to infinity
- if the request interval intersects the offer interval, the service distance is set to zero
- otherwise the service distance equals the smallest difference between a value in the request interval and one in the offer interval.

Note that if a property cannot be expressed numerically, a qualitative assessment must have taken place beforehand, marking "good" and "bad" values by high and low numbers, resp.

In a second step the calculated distance has to be normalized by the average distance of the respective property, because otherwise one property could easily outweigh all the others. Then the resulting number d_p is multiplied by a weight w_p specified by the user to express her priorities. Finally, all the distances are viewed as components of a distance vector $d(o,r)$. In [TP96] it is shown that in a comparable case the use of several metrics (e.g. maximum, Manhattan or Euclidean) for computing the difference between two such vectors does not yield qualitative differences in the results. Thus, for simplicity reasons, in this paper the 1-metric (Manhattan metric) is used, hence the difference D between request R and offer O_i turns out to be

$$D_R(O_i) := \sum w_p \cdot d_p(o_p, r_p)$$

This simple approach allows the user at least to contribute her priorities concerning the different properties, whereas assessing the importance of the distance between request and offer still is with the trader. The following section shows how to shift this aspect to the user as well.

4 QoS- and QoSP-functions

User preferences concerning service properties may be divided into two types: Firstly, to every property as a whole the user may assign a priority relative to the others (e.g. by assigning a weight to it as in the previous section), secondly the user may have preferences for certain values of each single service property. These preferences w.r.t. a single service property may be expressed by a Quality-of-*Service-Property*- (QoSP-) function P_d which assigns a number between 0 and 1 as preference to each value of service property d . Using the weights these single QoSP functions then may be combined towards a Quality-of-*Service*- (QoS-) function V as

$$V(O_i) := \sum w_d \cdot P_d(O_i)$$

for each alternative service offer O_i. This approach requires the service properties to be mutually preferentially independent [KR76]. Note that in this model it is assumed that both client and servers characterize services just by specifying a target value for each service attribute, and that furthermore the service offer can guarantee this target in case the offer should be accepted (i.e. the consequences of the user choice are certain).

The determination of the QoSP-functions is based on subjective assessments of the user and takes place interactively between the user and a special assessment unit (see figure 1) before the client may request a service. The service request then must include these informations (weights and QoSP-functions at least in the form of some points to be interpolated by the trader) besides the usual parameters. After receiving a request the evaluation unit in the trader evaluates each offer of the correct type by means of the user specific QoS function and returns the service offer with the highest evaluation as the most suitable for the user. Note that there is still the possibility for the user to specify "k.o. criteria" which must be met by a service offer in every case.

How can one gain the information required for the QoS and QoSP functions? Decision analysis [KR76, EW93] provides a lot of ideas like Direct Rating or the Midvalue Splitting Technique for obtaining QoSP functions and the Tradeoff method or the Swing method for obtaining suitable weights. Most of these approaches are based on the user trying to determine tradeoffs (e.g. in terms of costs) between different alternatives. Each of them has its own merits, thus unfortunately there is no generic method for solving this problem. The only way is to choose a suitable method from case to case.

5 Implementation and Results

The implementation of both concepts for an extended trader as described in the previous sections is based on an Orbix trader developed at our department [MZP96] and offering the standard trader functionalities.

Measurements have shown (see figure 2) that compared to the classic trader CT of [MZP96] the extended traders' time requirements are of roughly the same size. The QoS function approach (QoSF) needs slightly longer than the service distance approach (SD), but it can be shown that a more buffer consuming implementation leads to QoSF results being indistinguishable from the SD curve.

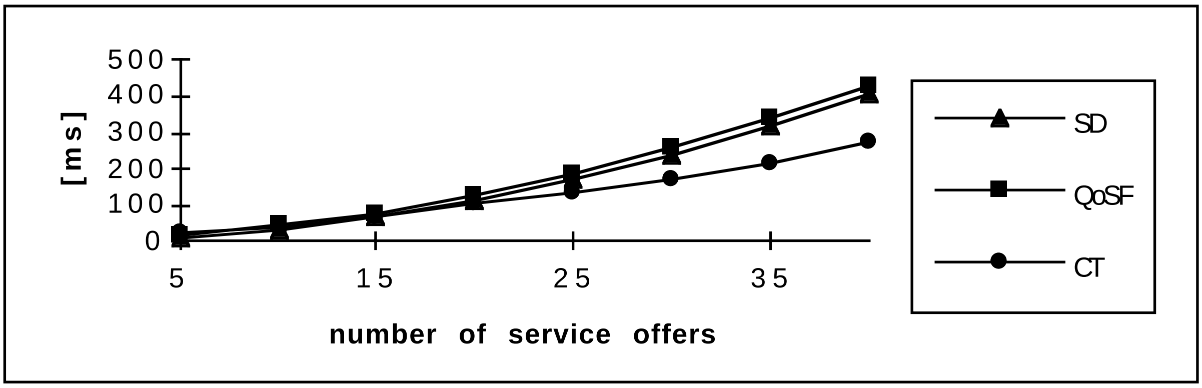

Fig. 2: Time requirements of the classical trader vs. the extended traders

6 Summary

This paper deals with concepts for enhancing service selection in a trader. Two concepts are explained which allow the trader to mediate service offers to the requesting client even if they do not match exactly the user's specification. These approaches allow the user to include preferences and priorities within his service request. Measurements show that by spending a small amount of additional time the user may win a very useful new functionality. Future work in this area will concentrate on further refining the preference models, especially by including uncertainty aspects like Dempster-Shafer theory or utility theory.

7 References

[EW93] F. Eisenführ, M. Weber: Rational Decisions. Springer 1993. (in German)

[KR76] R. Keeney, H. Raiffa: Decisions with Multiple Objectives. Wiley 1976.

[MLB93] Z. Milosevic, A. Lister, M. Bearman: New economic-driven aspects of the ODP Enterprise specification and related QoS issues. In: J. de Meer, B. Mahr, S. Storp (eds.): Open Distributed Processing II. Berlin, September 1993 (Chapman&Hall).

[MZP96] B. Meyer, S. Zlatintsis, C. Popien: Enabling Interworking between Heterogeneous Distributed Platforms. Proceedings of ICDP'96. Dresden, February 1996 (Chapman & Hall).

[OMG95] [ISO/IEC JTC1/SC21 WG7 (ODP] ODP Trader Document, OMG Document Number 95-07-06.

[SPM94] O. Spaniol, C. Popien, B. Meyer: Services and Service Trading in Client-/Server Systems. Thomson International Publishing 1994 (in German).

[TP96] D. Thißen, C. Popien: Finding Optimal Services within a CORBA Trader. Accepted for publication in: Proceedings of TreDS'96. Aachen, Oct 1996 (Springer).