Selecting Communication Services in a Service Oriented Network Architecture

Rahamatullah Khondoker, Bernd Reuther, Paul Müller
University of Kaiserslautern
{khondoker, reuther, pmueller}@cs.uni-kl.de

I. Introduction

Today networks offer few communication services provided by their associated protocols for communicating on the network. In the future, it is expected that networks will offer a large number of different communication services. With so many services available, determining which service to select and use will become much more difficult. Here we propose a description schema including an ontology for describing and selecting communication services. For service selection a human decision making process called Analytic Hierarchy Process (AHP) is utilized which is specially adapted and extended for automatic processing.

By using the Service-oriented Architecture (SOA) paradigm, a Service Oriented Network Architecture (SONATE) has been proposed. As with SOA paradigm, the main three components of SONATE are Service Provider, Service Consumer and Service Broker as shown in Fig 1.

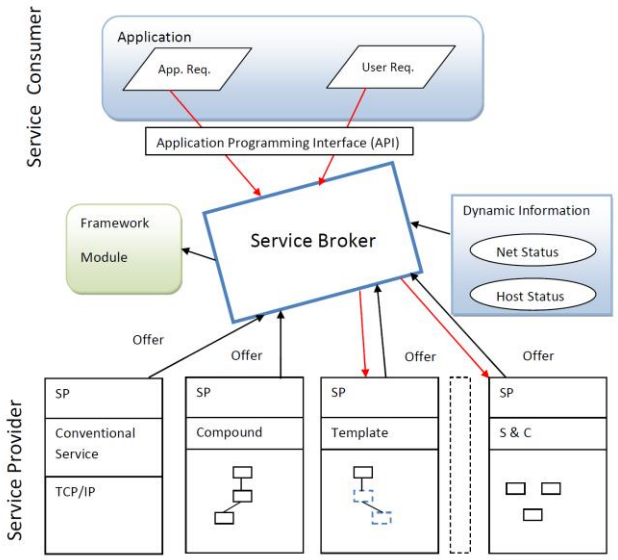

Figure 1. Components of a service-oriented network architecture

Communication services are offered by Service Providers. It is expected that in future there will be several different Service Providers. These different types of providers will offer communication services ranging from services provided by current protocols to fully dynamic composition services. One Service Provider might provide new services which are pre-defined, pre-compiled and pre-composed. Several methods have already been developed for doing the pre-composition. For example, the Netlets approach [1]. Another Service Provider might provide a template for constructing a service which is slightly more flexible compared to the pre-composed approach. Here, certain functionality can be added or deleted based on the needs of the user. A fully automatic selection and composition (S&C) can be provided by one of the Service Providers which take the requests from the user and compose a service on-the-fly based on the requirements specified by the user.

Taking the number of services and their composition time into account, different types of Service Providers are considered here. The number of services in the conventional Service Provider is limited and can be accessed very quickly whenever necessary. Compound Service Providers which store a lot of pre-composed services might consume time to search and select the appropriate one. The template Service Provider requires computation to compose the appropriate service after getting the requirements. A S&C Service Provider might take very long time to compose a service.

The Consumer needs a common Application Programming Interface (API) to make it transparent to him which Service Provider will be selected, and of course a large number of different APIs cannot be supported. It is notable that there may be different APIs for different classes of services, but the API supported by a service could be just one mandatory requirement. Definition of such an API is beyond the scope.

Residing in the middle of the Service Provider and the Service Consumer, the Service Broker accepts the user and application requirements from the Service Consumer, receives dynamic information from the host and the network, gets services from the Service Providers and then selects the appropriate service based on the application requirements and dynamic information.

In addition, the broker takes into account that

- There may be a large number of services,
- Some Service Providers need requirements to perform composition and
- Some of them may need a non-neglectable amount of time for composing a service (i.e., add delay to the decision making process)

The different types of Service Providers facilitate consumers (users/applications/nodes) by providing services considering their time and demand. This requires support of the API between Application and Broker which must provide limits for the selection time. Since the process of "rating" a service uses vector multiplication and can be done quickly, it is possible to promptly handle a large number of services.

II. SERVICE SELECTION

When more than one Service Provider offers an appropriate service but with different quality attributes (loss ratio, delay), the Broker must decide which provider to select for service provisioning. This is done based on clear descriptions.

Comparing the semantics of requests and offerings is performed only by matching strings which reference terms of a common ontology. We defined an ontology for a list of communication services. Provided that each service in the ontology has a specific clear meaning, all of the services can be described by the Service Provider and can, in turn, be consumed by the Service Consumer.

A service can be described by a set of visual effects. Using the ontology, we described the name of visual effects for describing communication services. A visual effect can be of two types: mandatory properties, and optional properties. Each of those types of properties can contain qualitative property and/or quantitative property which can be defined by using an ontology and generic attributes.

Having different types of properties makes the service complex in structure which should be described in a generic way so that it can be handled easily.

The description must not be limited to a fixed ontology; it must be extendable so that new features can also be described in the future without changing the Service Broker.

A service is a set of visual effects. So, a service, S, is

$$S = \{VE_1, VE_2, \dots \dots \dots \dots VE_n\} \dots\dots \quad \text{eq(1)}$$

Services can be either requested or offered. The service that is requested by an application is called requested service, can be denoted by S_R and the service that is offered by the Service Provider is called offered service and can be denoted by S_O.

For getting the optimal service, it is required to compare S_R and S_O. According to eq (1), comparing of services can be done by comparing visual effects (VEi, where i = 1 to n). The requirements of the Service Consumer can be fulfilled when the following equation is satisfied

$$S_O = \{VE_i\} \supseteq \{VE_j\} = S_R$$

Every individual visual effect VEi can either be a mandatory property, or an optional property. A mandatory property is a property that should be compared at first and must be fulfilled. As the name indicates, an optional property is not required to match exactly. This property is optional and can be omitted as well when matching the property takes an unacceptable amount of time. Both mandatory and optional properties can have qualitative and quantitative values. These properties can be used for the following purposes

- find a service that is appropriate (has all mandatory properties)
- find the best service by optimization of optional properties

When more than one Service Provider offers the same service fulfilling mandatory properties but with different optional property, it is required to calculate or measure the weight of these properties (measured values) to choose the optimal service. The service description helps in the process of service selection by describing those properties in a generic way.

A client can ask for a service from a set of alternatives specifying the criteria for selection. Analytic Hierarchy Process (AHP) [2] is a mathematical model used to choose one alternative from a given set of alternatives, usually when multiple decision criteria are involved. AHP, originally proposed by Saaty [2], is a process designed for human decision making. Basically, AHP is used for determining priorities of different alternatives. The process is extended for selecting the best service.

The procedures for selecting the best service are

1. Define the effects for selecting a service
2. Assign pairwise priority to the effects
3. Calculate a priority vector of the effects not violating consistency
4. Pass the priority vector of the effects to the broker along with the requirements specified by the user/application.
5. Calculate pairwise priority among the offered services based on the requirements specified by the application and effects provided by the services. This requires a mapping mechanism which cannot be done by AHP. That is why, we propose a mapping mechanism (based on interpolation/extrapolation).
6. Calculate priority vector of the offered services preserving consistency
7. Calculate the overall priority vector of the offered services by multiplying the priority vector coming from the application and the priority vector calculated in the offers.
8. Select the service with the highest priority.

[1] L. Voelker, D. Martin, I. E. Khayat, C. Werle & M. Zitterbart, An Architecture for Concurrent Future Networks, 2nd GI/ITG KuVS Workshop on The Future Internet, GI/ITG Kommunikation und Verteilte Systeme, Karlsruhe, Germany, Nov 2008.

[2] T. L. Saaty. Relative Measurement and its Generalization in Decision Making: The Analytic Hierarchy/Network Process, RACSAM (Review of the Royal Spanish Academy of Sciences, Series A, Mathematics), (2008-06), 102 (2): 251–318.