Chapter 2
An Ontological Perspective of Web Services

Web service mining requires Web services, the subject of mining, to be clearly defined so that mining techniques can be used to unambiguously target them. A Web service ontology provides an effective means for describing various Web service related concepts and their relationships. We represent the Web service ontology using a Unified Modeling Language (UML) diagram in Figure 2.1. In the following, we define key concepts depicted in the diagram.

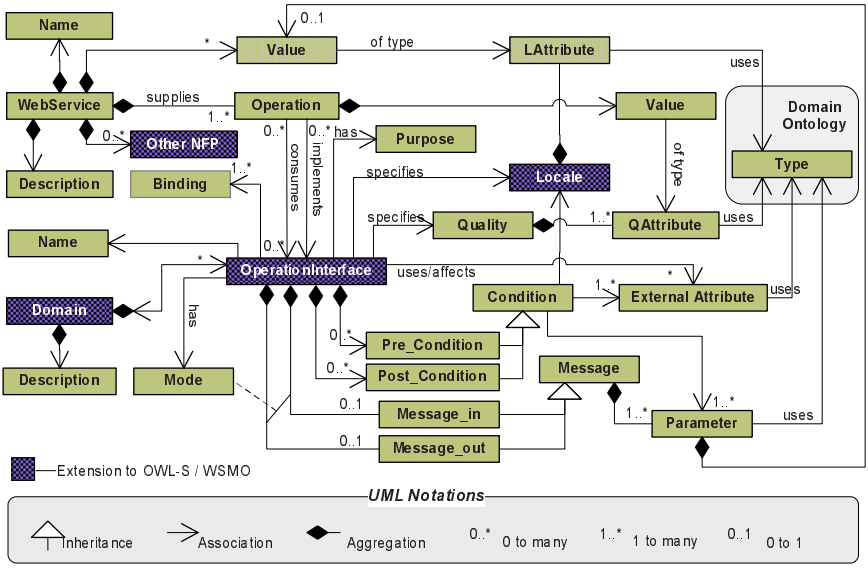

Fig. 2.1 Web Service Ontology

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Message. Web services communicate with each other through the exchange of XML messages. A message consists of one or more parameters. A parameter has a value of a certain data type. There are two types of messages: $Message_{in}$ and $Message_{out}$. $Message_{in}$ is used to send parameters to a service operation, $Message_{out}$ is used to return results from a service operation. $\diamondsuit$

Condition. A condition can be either a pre-condition or a post-condition. A pre-condition specifies the necessary condition for an operation to be activated. This may be expected values in $Message_{in}$ or relationships between these values. A post-condition describes the state of the information space after the execution of a service operation. This may be related to parameters in $Message_{out}$. $\diamondsuit$

An example of a pre-condition would be that the quantity or kinetic energy of an input parameter (or substance) to a biological process has to exceed a certain threshold. An example of a post-condition may be the dissipation condition that must be associated with an output parameter (or substance) generated by a biological process.

Domain. Web service operations are categorized by domains of interest. A domain contains a description that describes the purpose of the domain and summarizes its functionalities. $\diamondsuit$

Examples of domains include *travel*, *home entertainment*, *attorney services*, *credit check*, *healthcare*, *drug design*, etc.

Locale of Interest. Locale of interest $L = \{l\}$, where each l represents a semantic restriction containing attributes that describe the applicability of an operation interface. L can be used to limit the scope of mining. $\diamondsuit$

An example of semantic restriction would be a regional or geographical boundary. Web service operations are sometimes applicable only to certain regions. For example, a *reserveCar()* operation of a car rental service may require the car to be used in the continental US. L is used to specify such restrictions. In the context of drug and pathway discovery, an l may specify the locality of a certain receptor.

Quality of Web Service (QoWS). QoWS $Q = \{q\}$ is used to evaluate an operation provided by a Web service, where q is a quality attribute of concern. $\diamondsuit$

There are many quality attributes important to Web service operations. Table 2 organizes them into three categories: *runtime*, *business*, and *security* [70].

Operation Interface. Operation interface *OperationInterface* specifies a particular Web service capability through its name, purpose, domain of interest, locale of interest, quality attributes of concern, condition, signature and binding. Web services that implement the capability need to comply with what the interface has specified. The signature includes zero or one $Message_{in}$ and zero or one $Message_{out}$. $\diamondsuit$

The permutation of $Message_{in}$ and $Message_{out}$ determines the *mode* of the operation interface. There are four operation modes:

1. *one-way* - operation interface contains only $Message_{in}$
2. *notification* - operation interface contains only $Message_{out}$
3. *request-response* - operation receives $Message_{in}$ and then generates $Message_{out}$
4. *solicit-response* - operation generates $Message_{out}$ and then receives $Message_{in}$

Table 2.1 QoWS Attributes

Attribute Group	Attribute	Definition
Run-time	Response Time	Time between an invocation request is sent and processing results are returned
	Reliability	$N_{success}(op)/N_{invoked}(op)$ where $N_{success}$ is the number of times that *op* has been successfully executed and $N_{invoked}$ is the total number of invocations
	Availability	UpTime(*op*)/TotalTime where UpTime is the time *op* was accessible during the total measurement time TotalTime
Business	Cost	Dollar amount to execute the operation
	Reputation	$\sum_{u=1}^{n} Ranking_u(op)/n$, $1 \leq$ Reputation ≤ 10 where $Ranking_u$ is the ranking by user *u* and n is the number of times *op* has been ranked
	Regulatory	Compliance with government regulations, $1 \leq$ Regulatory ≤ 10
Security	Encryption	A boolean equal to *true* iff messages are encrypted
	Authentication	A boolean equal to *true* iff consumers are authenticated
	Non-repudiation	A boolean equal to *true* iff participants cannot deny requesting or delivering the service
	Confidentiality	List of parameters that are not divulged to external parties

Operation. An operation embodies a specific implementation of an *OperationInterface* by a Web service. An operation can also make known of its need to invoke operations that implement an *OperationInterface*. In addition, an operation exhibits values for the quality attributes specified by the *OperationInterface*. ♢

The separation of operation from *OperationInterface* allows the same *OperationInterface* representing a shared capability to be implemented by multiple Web service operations.

Web Service. A Web service is defined by a tuple *(Name, Description, Operations, NFPs)*, where:

- *Name* is the name of the Web service;
- *Description* is a text summary about the service capabilities;
- *Operations* are a set of capabilities provided by the Web service; and
- *NFPs* stands for any non functional properties that help describe the Web service.

In addition, the Web service specifies values for relevant locale of interest attributes. ♢

In a Web service modeling a biological process, examples of non functional property include the declaration of the type of an entity that can provide the corresponding service and the description of the source information that the Web service model originates from.

The majority of constructs captured in Figure 2.1 are also included in OWL-S and WSMO. A major difference between ours and these standards is our proposed use

of *OperationInterface*, which allows Web services to plug into one another declaratively at the operation level. Since *domain* is a grouping of functionalities, it is essentially a collection of corresponding *OperationInterfaces*.

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