A QoS and Cognitive Parameters based Uncertainty Model for Selection of Semantic Web Services

Aditya Khamparia^{1*} and Babita Pandey²

¹Department of Computer Science and Engineering, Lovely Professional University, Phagwara – 144411, Punjab, India; aditya.khamparia88@gmail.com ²Department of Computer Applications, Lovely Professional University, Phagwara – 144411, Punjab, India; shukla_babita@yahoo.co.in

Abstract

Objectives: The major goal of this research paper is to present a QoS and cognitive parameter based model for selection of semantic web services. The presented model provides a completely novel and formalized measurement of different cognitive parameters. Methods/Statistical analysis: Rule based model is used for describing hierarchical relationships among QoS and cognitive parameters. The short life factor is used for dealing with known certainties lies in these parameters. The certainty factor is computed by using a measure of belief and measure of disbelief. Finally, the computed result is based on the satisfaction level of consumer agent. Findings: The rule base model generated from the hierarchal structure is used for computing CCF of each qualitative and quantitative parameter. As the rule base is generated from the hierarchical tree therefore as tree changes the rule base also changes. It is observed from the result that the overall computational overhead is very less in this cognitive based uncertainty model; it leads to fast, efficient and smart retrieval or selection of services for consumer agent. The proposed approach overcomes limitations of different models by combining several cognitive parameters, focusing on user's preferences on QoS attributes in an efficient way. Application/Improvements: The predicted applications of proposed model in E-learning, E-governance based systems and identification of web services. The generated rule base is large so by adapting neuro symbolic rules the rule base could be reduced to provide efficient and fast delivery of services.

Keywords: Certainty Factor, Cognitive Parameters, QoS, Rule Based, Short Life

1. Introduction

The architecture which governs with Quality of Service effectively and efficiently provides interoperability among heterogeneous systems and integrates inter-organization and applications. Web services describe a standardized way of integrating web based application with other web applications for the purpose of exchanging data. They are self-contained, modular, distributed, dynamic applications that can be described, published, located or invoked over the network¹. The increasing popularity and adoption and availability of numerous types of web services causes problems in effectively and efficiently discovering and selecting appropriate services to meet specific user

needs. On the other hand the semantic web plays a role to convert current web in machine processable meta-data and give formal and explicit meaning to the information. Due to this information is easily processable by human as well as software agents.

Service selection is identified as the important primitive of Semantic Web Service composition process². Most of the component of Semantic Web Service (SWS) composition process such as discovery, selection, composition, orchestration and choreography and matchmaking are tightly related to the qualitative (Quality of Service (QoS)) and cognitive parameters of SWS³. QoS is a part of service description whereas cognitive parameters serve as deciding factor in SWS⁴. These parameters serve as important parameter to select and invoke suitable SWS from the available services discovered. For SWS process, to invoke or select desired service various types of cognitive parameters such as capability, desire, intention, commitment, trust, reputation etc. and a number of QoS parameters such as cost, response time, reliability, accuracy, security feature, execution time, exception handling feature, penalty on breaking service contract etc. are taken into consideration.

As per knowledge, issue related to uncertainty lies among the QoS and cognitive parameter is not addressed by any researcher till now. In addition, no generic method of service selection (applicable to all types of SWS) based on QoS and cognitive parameter is also not proposed by any researcher. This is because of two reasons: 1. Complexity of QoS metrics and 2. Lack of formal measurement of cognitive parameters. The proposed Hybrid Selection Model (HSM) provides the formalized and normalized procedure for QoS and cognitive parameters and provides a dynamic feedback system affecting the reputation of selected service provider based on the quality of its present service⁴.

In present work, we have developed a rule based model for SWS selection from expert consultation. This model selects the SWS based on qualitative and quantitative parameters. Quality of Services (QoS) parameters such as: Integrity (I), Benevolence (B), Experience (E), Adaptability (A), Expertness (Ex), Credibility (Cr) are quantitative parameters whereas cognitive parameters such as Capability (C), Desire (D), Commitment (Co), Trust (T), Persuasion (P), Emotions (Em) and Reputation (R) are qualitative parameters. The rule base model generated from the hierarchal structure is used for computing CCF of each qualitative and quantitative parameter. The models also deals with the uncertainty lies in the both qualitative and quantitative parameters⁵. This is a generic model independent on types of SWS and deals with uncertainty lies among the QoS and cognitive parameters.

In this section some of similar work reported in literature has been discussed. However no work was found dealing with the selection of Semantic Web Services based on both non-functional parameters like QoS and various cognitive parameters study with short life formula in combined form.

In^{1.3.6–9}, have proposed an algorithm which works on ranking between trust and reputation management but they have not considered the various different cognitive parameters and their ranking similarities. In proposed a fast QoS aware web service selection approach using PSO algorithm with respect to user requirements. Lee address service selection by representing services QoS value as discrete random variable with probability mass functions^Z. The work proposed by¹ based on an architecture that makes automatic selection of service provider based on context and QoS ontology but they also not considered QoS with cognitive parameters dependency. Kumar proposed Hybrid Selection Model (HSM) which provides the formalized and normalized procedure for QoS and cognitive parameters and provides a system which affects the reputation of service provider based on the service quality offered^{4,10}. The proposed QoS aware web service selection lexicographic approach for QoS preference specification. Similarly, from Yijiao focused on feedback mechanism of QoS management to improve selection accuracy and speed of service¹⁰. They considered the user rating tendency but no input on cognitive science. In¹¹ have proposed cognitive parameter based rating of semantic web services but they have not considered QoS based rating in their selection model. In³ brings into limelight the role played by cognitive parameters in context of web service selection using multi agents system³. In^{11,12} have proposed service selection approaches but they have not considered the cognitive parameters in their service selection approaches^{11,12}. The quality index generated by their model is very discrete in nature. The proposed hybrid service selection based approach in SAWSDL13 based on logic based matching as well as text matching strategies.

2. Limitation of Existing Model

All existing model does not deal with the uncertainty lies in the cognitive parameters. There are some uncertainty sources which lead to uncertainty in cognitive parameters¹⁴ like machine which refers to some predicted system, environment in which predicted machine system works, man is the cognition subject of machine environment system. Every source relies on data collection, data preprocessing and assessment of failure criteria which leads to uncertainty in cognitive parameters¹⁵. The existing models either deal with only few qualities of services parameters such as trust, credibility, integrity, benevolence or cognitive parameters such as emotions, adaptability¹⁶ but no model deals with both types of parameters and uncertainty lies among them. Therefore we need to develop a model which selects the web services based on both quality of services and cognitive parameters and also deals with uncertainty¹⁷ lies among them.

3. Cognitive Parameters and Hierarchical Relationship among them

As discussed above all the cognitive parameters such as trust, reputation, integrity, commitment, capability, benevolence, desire, emotions, credibility, capability, persuasion, adaptability, expertness and experience play important role in the Semantic Web Service selection. These cognitive parameters are dependent on each other and having a hierarchal relationship among them. In this section, a hierarchical model of cognitive parameters is developed.

The cognitive parameters trust is described by Lewicki and his colleagues as an individual belief in and willingness to act on the basis of word, actions and decisions of others. Reputation is a socially transmitted meta belief concerns properties of agents, namely their attitudes towards some socially desirable behavior, reciprocity or non-compliance. Commitment is a parameter which enhances the strength of dedication, desire, trust, ability¹⁸. Benevolence is a kind of trait which is important for establishment of interpersonal trust. It is helpful in assessing trustworthiness of system in service of decisions about appropriate reliance and delegation¹⁸. Capability is used in context of service provider to provide capability of service provider. Credibility is considered as combination of source expertness of knowledge, perception of knowledge expertise, openness and honesty, concern, care and trust worthiness of source. Persuasion is an extent to which attitude, belief, reputation and intention can be changed. Emotion is state of mental readiness which provides an evaluation of objects and events arises from cognitive appraisals of thoughts and events. Desire is a motivational state directed at either goal or an act or sense of lodging for a person or object hoping for outcome. Experience determines the number of times service requested and used by user. More experience of service leads to best selection⁴. Integrity determines the accuracy of service provider to provide best service.

Figure 1 shows the hierarchical relationship among different cognitive parameters like Trust (T), Integrity (I), Benevolence (B), Reputation (R), Commitment (Co), Capability (C), Experience (E), Credibility (CR), Desire (D), Expertness (Ex), Persuasion (P), Adaptability (A) and Emotions (Em) on their sub parameters. As shown in left most part of Figure 1, trust dependent on important factors like integrity, ability, benevolence, satisfaction in which certainty factor between integrity and ability will be calculated first then resultant will merge with certainty factor of benevolence this leads to new certainty factor, similarly merges with satisfaction and finally we achieved computed measure of belief or degree of satisfaction. Reputation depends on uniqueness, attributes and admireness, commitment and advocacy, cooperation. Credibility depends on trust, expertness of service, perception of openness and honesty and perception of concern and care. Persuasion depends on belief, attitude, intentions and behavioral motivations as shown in top middle part of Figure 1, integrity dependent on consistency of past action, credibility of communication, commitment to standards of belief and congruence of other words and deeds. Commitment depends on dedication, desire, ability, motivation, will power. Expertness depends on reliability, technical skills and experience. Adaptability depends on cost, capability delivered and demanded and time delivery. As shown in top right most part of Figure 1, benevolence depends on honest and open communication, delegating decisions and sharing control to others. Capability¹⁹⁻²¹ depends on perception processing, planning, anticipation, capacity. Desire depends on pleasure, will power, dependency, capability, emotions. Experience depends on adaptability, reputation and commitment and finally emotions dependent on greed, lust, anger, desire, willingness, regret, curiosity²².

Figure 2 shows a complete hierarchal relationship among all the cognitive parameters. In the figure, root shows the Satisfaction level (S) of user and lies in the closed interval of 0 and 1. If the overall certainty factor for cognitive parameters at root is 1 then it is satisfactory and if it is 0 then unsatisfactory. The equation 1 defines the satisfaction level as:

 $S [0, 1] = \{x: x \in [0, 1]\} - - - - Equation 1.$ x = 0 then unsatisfactory.

0<x<1 degree of satisfaction.

x = 1 then satisfactory.

The value between 1 and 0 tells the degree of satisfaction. If the calculated overall certainty is less than 0.8 i.e. threshold value can be (changeable depending upon the expert knowledge) then result obtained is unsatisfactory otherwise it leads to satisfaction.

3.1 Rule based Model

The formulation of rule based model from hierarchical model as shown in Figure 2 which was developed from





Figure 1. Hierarchical relationship among functional attribute and various cognitive parameters.



Figure 2. Hierarchical models of cognitive parameters for web service.

expert consultation and literature. It shows modular representation of facts and information. The leaf nodes in hierarchical tree shown in Figure 2 are represented using symbol R_{xyz} such as: R₁₁₁: integrity, R₁₁₂: ability, R₁₁₃: benevolence, R_{114} : satisfaction, R_{141} : consistency of past action, R₁₄₂: credibility of communication, R₁₄₃: commitment to standard of favors, R₁₄₄: congruence of other words and deeds, R₁₂₁: uniqueness, R₁₂₂: attributes and admireness, R₁₂₃: commitment and advocacy,R₁₂₄: cooperation, R_{131} : dedication, R_{132} : desire, R_{133} : ability, R_{151} : pleasure, R_{152} : dependency, R_{153} : willpower, R_{154} : capability, R_{155} : emotions, R₁₆₁: belief, R₁₆₂: attitude, R₁₆₃: intention, R₁₆₄: population, R₁₆₅: behavior motivation, R₁₇₁: honest and open communication, R_{172} : delegating decision, R_{173} : sharing control, R₁₈₁: perception processing, R₁₈₂ attention allocation, R₁₈₃: planning, R₁₈₄: anticipation, R₁₈₅: capacity, R₁₉₁: greed, R₁₉₂: desire, R₁₉₃: lust, R₁₉₄: anger, R₂₀₁: cost, R₂₀₂: capability, R_{203} : time, R_{211} : reliability, R_{212} : technical skills, R₂₁₃: experience, R₂₂₁: perception of knowledge and expertise, R₂₂₂: trust, R₂₂₃: expertness of service, R₂₂₄: openness and honesty, R₂₂₅: perception of concern and care. The rules of composition are shown in Figure 3.

Modules are connected to each other from lower level to higher level, after travel of certain levels we reach to highest level i.e. root level where net certainty factor or degree of satisfaction level is calculated. Rule based formulation for cognitive parameters are described in next section. $\mathbf{R}_{111} \oplus \ \mathbf{R}_{112} \oplus \ \mathbf{R}_{113} \oplus \ \mathbf{R}_{114} \rightarrow \mathbf{R}_{11}$

 $\mathbf{R}_{121} \oplus \quad \mathbf{R}_{122} \oplus \quad \mathbf{R}_{123} \oplus \quad \mathbf{R}_{124} \to \mathbf{R}_{12}$

 $\mathbf{R}_{131} \oplus \quad \mathbf{R}_{132} \oplus \quad \mathbf{R}_{133} \to \mathbf{R}_{13}$

 $R_{141} \oplus R_{142} \oplus R_{143} \oplus R_{144} \rightarrow R_{14}$

- $\mathbf{R}_{151} \oplus \ \mathbf{R}_{152} \oplus \ \mathbf{R}_{153} \oplus \ \mathbf{R}_{154} \oplus \ \mathbf{R}_{155} \rightarrow \mathbf{R}_{15}$
- $R_{161} \oplus R_{162} \oplus R_{163} \oplus R_{164} \oplus R_{165} \rightarrow R_{16}$

 $\mathbf{R}_{171} \oplus \mathbf{R}_{172} \oplus \mathbf{R}_{173} \rightarrow \mathbf{R}_{17}$

 $\mathbf{R}_{181} \ \oplus \ \mathbf{R}_{182} \ \oplus \ \mathbf{R}_{183} \ \oplus \ \mathbf{R}_{184} \ \oplus \ \mathbf{R}_{185} \ \rightarrow \mathbf{R}_{18}$

 $R_{191} \oplus R_{192} \oplus R_{193} \oplus R_{194} \rightarrow R_{19}$

 $\mathbf{R}_{201} \ \oplus \ \mathbf{R}_{202} \oplus \ \mathbf{R}_{203} \rightarrow \mathbf{R}_{20}$

 $\mathbf{R}_{211} \oplus \mathbf{R}_{212} \oplus \mathbf{R}_{213} \rightarrow \mathbf{R}_{21}$

 $R_{221} \oplus R_{222} \oplus R_{223} \oplus R_{224} \oplus R_{225} \rightarrow R_{22}$

 $\begin{array}{cccc} R_{11} \oplus & R_{12} \oplus R_{13} \oplus & R_{14} \oplus R_{15} \oplus & R_{16} \oplus R_{17} \oplus R_{18} \oplus & R_{19} \oplus & R_{20} \oplus & R_{21} \oplus \\ R_{22} \rightarrow R_1 \end{array}$

Figure 3. Rule of composition.

 R_{11} : IF there is integrity (z1) and IF benevolence (z2) and IF ability (z3) and IF satisfaction (z4) THEN trust (z).

 R_{12} : IF there is uniqueness (z1) and IF attributes and admireness (z2) and IF commitment and advocacy (z3) and IF cooperation (z4) THEN reputation (z).

 R_{13} : IF there is dedication (z1) and desire (z2) and ability (z3) THEN commitment.

 R_{14} : IF there is consistency of past action (z1) and IF credibility of communication (z2) and IF commitment to standard of favors (z3) and IF congruence of other words and deeds (z4) THEN integrity (z).

 R_{15} : IF there is pleasure (z1) and IF dependency (z2) and IF willpower (z3) and IF capability (z4) and IF emotions (z5) THEN desire (z).

 R_{16} : IF there is belief (z1) and IF attitude (z2) and IF intention (z3) and IF population (z4) and IF behavior motivation (z5) THEN persuasion (z).

 R_{17} : IF there is honest and open communication (z1) and IF delegating decisions (z2) and IF sharing control (z3) THEN benevolence (z).

 R_{18} : IF there is perception processing (z1) and IF attention allocation (z3) and IF planning (z3) and IF anticipation (z4) and IF capacity (z5) THEN capability (z).

R₁₉: IF there is greed (z1) and IF desire (z2) and IF lust (z3) and IF anger (z4) THEN emotions (z).

 R_{20} : IF there is cost (z1) and IF capability (z2) and IF time (z3) THEN adaptability (z).

R_{21:} IF there is reliability (z1) and IF technical skills (z3) and IF experience (z3) THEN expertness (z).

R₂₂: IF there is trust (z1) and IF expertness of service (z2) and IF perception of knowledge and expertise (z3) and IF openness and honesty (z4) and IF perception of concern and care (z5) THEN credibility (z).

 R_1 : IF there is trust (z1) and IF integrity (z2) and IF reputation (z3) and IF commitment (z4) and IF benevolence (z5) and IF capability (z6) and IF desire (z7) and IF emotion (z8) and IF expertness (z9) and IF persuasion (z10) and IF adaptability (z11) and IF credibility (z12) THEN root satisfaction (z).

As the rule base is generated from the hierarchical tree therefore as tree changes the rule base also changes.

The method of selection is based upon short life formula which is followed for several web service selections. Short life formula (Short life and Buchanan, 1984) is described as follows:

If an evidence e1 takes place with hypothesis h then its certainty factor becomes CF (h, e1), similarly another event e2 takes place with hypothesis h then it becomes CF (h, e2). Measure of belief and disbelief with both events occurred at same time then it can be calculated as follows:

 $MB (h, e1e2) = CF (h, e1) + CF (h, e2) - CF (h, e1)^* CF (h, e2)$ (1)

Where MB is measure of belief.

 $MD (h, e1e2) = CF (h, e1) + CF (h, e2) - CF (h, e1)^* CF (h, e2)$ (2)

Where MD is measure of disbelief.

4. Results and Implementation

A service selection model was developed using Java. The model was implemented in two phases. In the first phase, the user selects the cognitive and QoS parameters and provides their CF as shown in Figure 4. In the next phase, the computation of Cumulative Certainty Factor (CCF) for each cognitive and qualitative parameter was done.



Figure 4. Trust certainty factor calculations.

For example the computation of CCF for trust is done as shown in Figure 4 is as follows: The user select the cognitive and QoS parameter of trust such as: Integrity (e1:0.87), ability (e2:0.3), benevolence (e3:0.7) and satisfaction (e4:0.4). The value in the bracket is read as evidence: CF (evidence: CF). Where e1, e2, e3, e4 is evidence of integrity ability, benevolence and satisfaction respectively.

Input the certainty factor for integrity (i) & Input certainty factor for ability (j)
While the user has not yet entered the CF
Add certainty factor for integrity and ability to calculate measure of
belief or CCF1
$CCF_1 = CF(i) + CF(j)(1-CF(i))$
Input the next certainty factor for benevolence (k)
Add calculated CCF1 with benevolence (k) to calculate CCF2
$CCF_2 = CCF_1 + CF(k)(1-CCF_1)$
Increment user value and input next certainty factor for satisfaction (1)
Add calculated CCF2 with satisfaction (1) to calculate CCF3
$CCF_3 = CCF_2 + CF(1)(1-CCF_2)$
If the calculated CCF ₃ is less than 0.8
Print 'calculated certainty or belief is not acceptable' else
Print 'final combined certainty or belief CCF3 as acceptable'



For evidence e1 and e2 the certainty factor is computed using Equation 1 as follows:

MB = 0.87 + 0.3 (1 - 0.87) = 0.909.For (e3:0.7), MB = 0.909 + 0.7 (1 - 0.909) = 0.972. For (e4:0.4), MB = 0.97 + 0.4 (1 - 0.97) = 0.982. Here measure of disbelief (MD) = 0. So, CCF = MB + MD = 0.982 + 0 = 0.982.

This will give the CCF of trust i.e. at first level of the hierarchical tree.

Similarly, the CCF for integrity is computed as follows: For e1 and e2

MB = 0.5 + 0.2 (1-0.5) = 0.6.For e3. MB = 0.6+0.4 (1-0.4) = 0.84.

For e4.

MB = 0.84 + 0.3 (1 - 0.84) = 0.878.

Here measure of disbelief (MD) = 0.

So, CCF = MB + MD = 0.878 + 0 = 0.878.

Similarly, the CCF for other QoS and cognitive parameters are computed. The CCF computed for R, Co, D, P, B, C, E, A, EX, CR are 0.97, 0.97, 0.97, 0.87, 0.90, 0.93, 0.8, 0.9, 0.9, 0.9 respectively as shown in Figure 5.

Now, the CCF of second level i.e. for S was computed as follows:

For two evidence T and R MB = 0.98 + 0.97 (1-0.98) = 0.99 MD = 0 CCF = MB + MD = 0.99

Similarly, CCF is calculated for other evidences of S which is 0.8. The CCF of S was greater than 0.8 as shown in root of the tree in Figure 6, therefore it is acceptable. The pseudo code for computation of CCF is shown in Figure 7.







Figure 7. Graphical User Interface for inputting the values of cognitive and QoS parameters.

4.1 Comparison with Existing Bayesian Network Model

If we compare our model with method proposed by¹⁴, our model has less computational overhead then their model. In Bayesian model, conditional probabilities calculated at each node to construct overall Conditional Probability Table (CPT) for particular web service^{23,24} which leads to high complexity and overhead but cognitive parameter based uncertainty model requires less computational overhead to compute the certainty factor at each node of hierarchical tree which results less computational overhead in overall computation of satisfactory level. This method facilitates smart and easier selection of Semantic Web Service with less computational overhead.

5. Conclusion

In proposed work our approach relies on rule bases model to deal with uncertainty lies in cognitive and qualitative parameters which are used for SWS selection. The rule base model generated from the hierarchal structure is used for computing CCF of each qualitative and quantitative parameter. As the rule base is generated from the hierarchical tree therefore as tree changes the rule base also changes. It is observed from the result that the overall computational overhead is very less in this cognitive based uncertainty model; it leads to fast, efficient and smart retrieval or selection of services for consumer agent. The proposed approach overcomes limitations of different models by combining several cognitive parameters, focusing on user's preferences on QoS attributes in an efficient way. The chosen scenario based example demonstrates that the proposed uncertainty model can prove its worth by giving excellent results so that consumer has flexibility on choosing the best available web service according to his needs or requirement.

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