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An Optimized Service Selection System Using Fuzzy Logic and Genetic Algorithm

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ABSTRACT

Various QoS non-functional characteristics are described as measureable quantities and expressed in terms of reputation, reliability and availability, cost and response time. **In [1] , we introduced a framework for** the Development of An Optimized Solution for Quality of Service Delivery Using Fuzzy Logic and Genetic Algorithm. We elucidated the fact that Quality of Service (QoS) plays a major role in selecting web services in terms of qualitative measure We proposed a future work that will delve into the implementation procedure for web service selection. In this paper, we reviewed existing selection systems and their designs and then presents a Fuzzy and genetic algorithms based system to provide optimality in web services selection.

Keywords: QoS, Web services, Fuzzy, Genetic Algorithms, Qualitative Measures

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1. INTRODUCTION

Web services are integrated web based applications that function over a protocol backbone. Web services selection is one of the most important steps in many of the web service applications such as Universal Description, Discovery and Integration (UDDI) registry and web services repositories. Each web services have its own functionalities which matches the service request. Quality of Service (QoS) plays a major role in selecting web services in terms of qualitative measure. Quality of Service refers to various non-functional characteristics. These specified characteristics should be measureable and constitute a description of what a web service can offer. The Quality of Service based selection and composition of web service will be expressed in terms of reputation, reliability and availability, cost and response time. QoS is essential when a set of quality metrics have to be achieved during service provision. The objective of the web service selection is to maximize the QoS values. Selected web service should have high reputation, reliability and availability whereas the cost and response time should be less.

The problem addressed in this work is to find an optimized solution for service selection bearing in mind the satisfaction of the user's Quality of Service needs. The integration and synthesis of fuzzy system with the search space and optimization power of genetic algorithm is proposed. The usage of the fuzzy system and genetic algorithm helps in finding an optimized solution for Quality of Service delivery.

2. A REVIEW OF THE EXISTING SYSTEMS

The number of parameters is one of the main concerns for fuzzy systems, especially when it is desired to increase the number of inputs and rules, since for the standard fuzzy system the number of parameters increases exponentially when the numbers of inputs or rules are increased, and computational complexity increases accordingly. A detailed and in depth analysis of existing systems are reviewed in order to determine the gap to be filled, we reviewed the following:-

i. The fuzzy approach build or model decisions based on the rules stored or contained in the knowledge base (KB) for service selection process. Therefore, decision is based on information or data. In most real-world settings, decision-relevant information is incomplete, uncertain and imprecise.

ii. The number of rules increases exponentially as the number of system variables, upon which the fuzzy rules are based, is increased.

2.1 Limitations in the Existing Systems

Fuzzy systems are rule based systems (knowledge based systems). The rule base of a fuzzy system is composed of fuzzy IF-THEN rules that are similar to the rules used by humans in their reasoning.

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The under listed are the drawback and limitation in the existing systems:

(i) it is hard to obtain optimal fuzzy set due due to the number of generated rules as the number of system variables are increased,

(ii) the fuzzy set doesn't have learning capability, it depends on a pre-defined set of rules which depends on the numbers of inputs that are to be processed, and

(iii) the problem of defining the rule base:

  a) redundant rules: whose actions are covered by other rules

  b) wrong rules: badly defined, thereby upsetting the system performance, and

  c) conflicting rules: worsens the system performance when co-existing with other rules in the RB (rule base).

These limitations make the system performance less efficient and effective due to fact that the service selection results always contain:

(i) Irrelevant and unjustified QoS values

(ii) Non-existing web services and

(iii) Wrong and inconsistent QoS values

Hence, the system performance is poor and unacceptable. These limitations is the central driving force behind the design of a more efficient and effective system where two techniques are combined in a manner that overcomes the limitations.

2.2 Analysis of a Typical Existing System

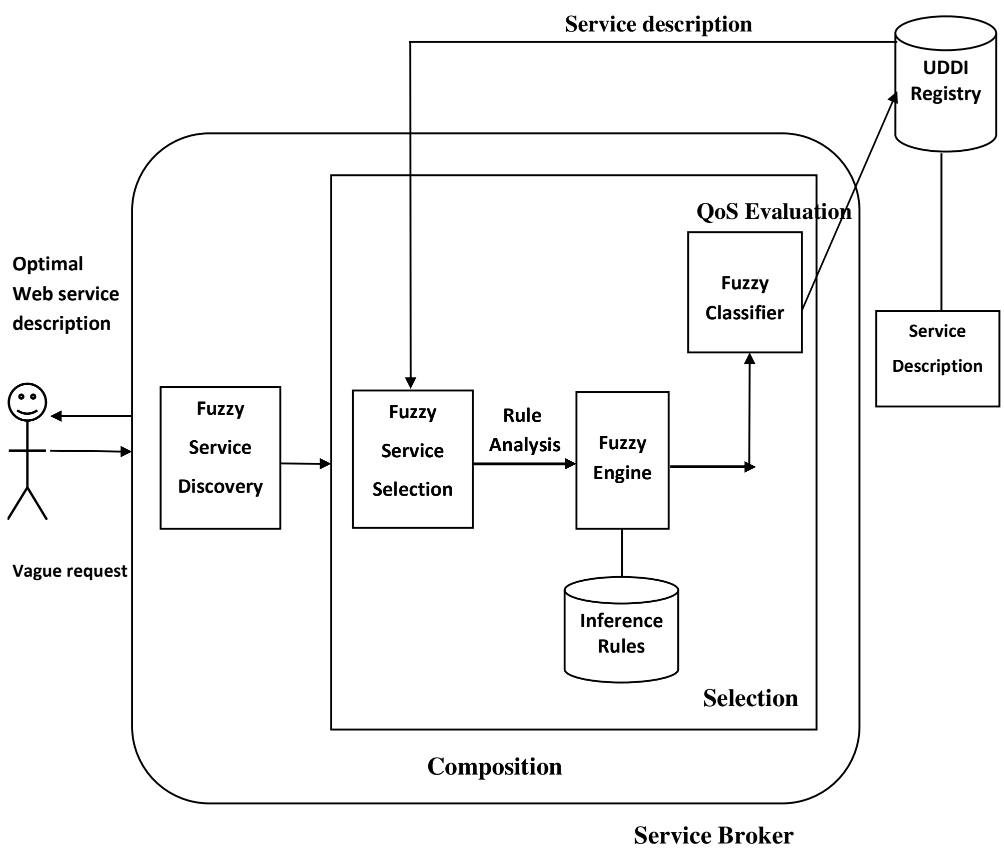

Fig. 1: Existing Architecture of the web service selection by Priya *et al.* (2014)

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Procedure of Usage

i. The user input vague request to the Fuzzy Service Discovery module to find the list of services that are available in the registry.
ii. The registry will return the collection of service description to fuzzy service selection.
iii. The returned service may be available or not available to the user (which depends on the service provider).
iv. If the services are not available, because of the user preference matching the service and on seeing the service down, the user gets dissatisfied.
v. The user move to next preference matching the services.
vi. This process is time consuming and results in more cost and poor response time.

2.3 Other Systems

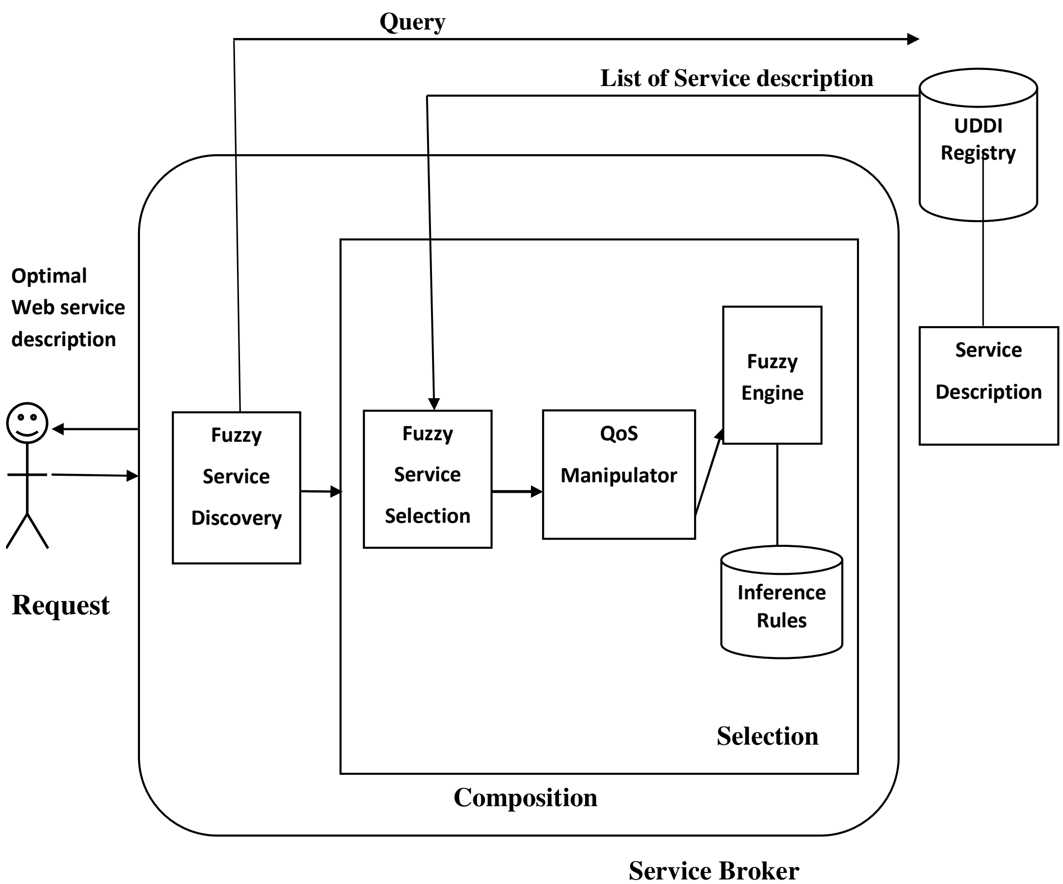

Fig. 2: Improved Architecture of the fuzzy logic system for web service selection by Priya and Chandramathi [4]

Procedure of Usage

i. To overcome the constraints the use of non-functional parameters was put into account for the fuzzy service selection.
ii. These parameters are manipulated in QoS manipulator and the resultant value is passed to the fuzzy inference engine control for decision-making process using MAX-MIN inference rules base approach.
iii. The MAX-MIN inference rules base approach is used in solving the control (IF-THEN rules) problem mathematically rather than attempting to model the system without obtaining an optimal set of rules.

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2.4 Existing Fuzzy Flow Diagram

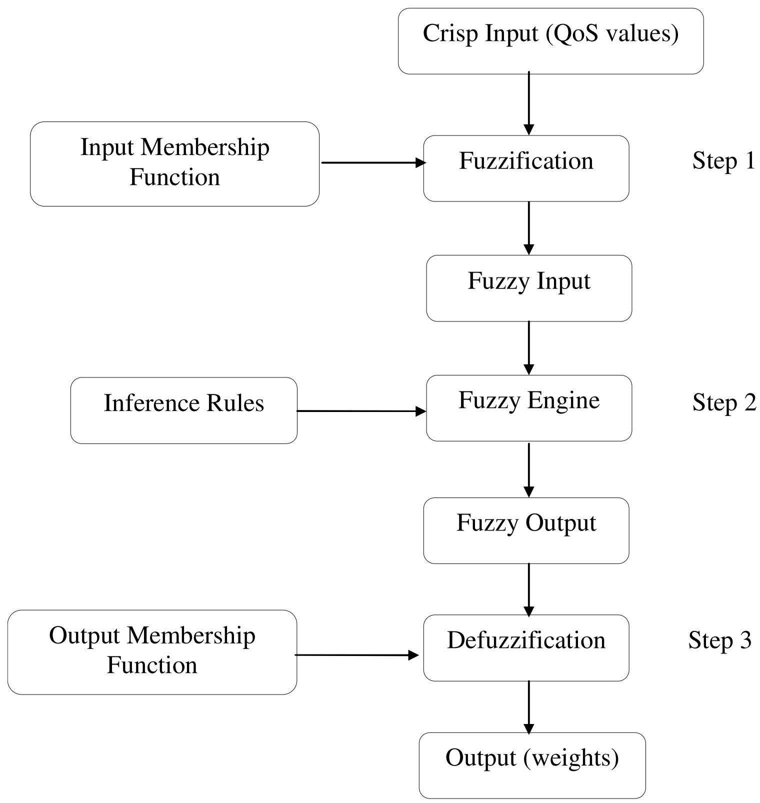

Fig. 3: Fuzzy flow diagram by Priya *et al.* [3]

3. DESIGN CONCEPTUALIZATION

3.1 Problem Formulation

We consider attend conference plan domain given in figure 3.1. A user needs to attend a conference and looks for a travel service that offers best services at less cost and good response time. The services which the agent offers are:

i. Advert Checking,
ii. Conference Registration,
iii. Flight Booking,
iv. Hotel Booking and
v. Car Rental

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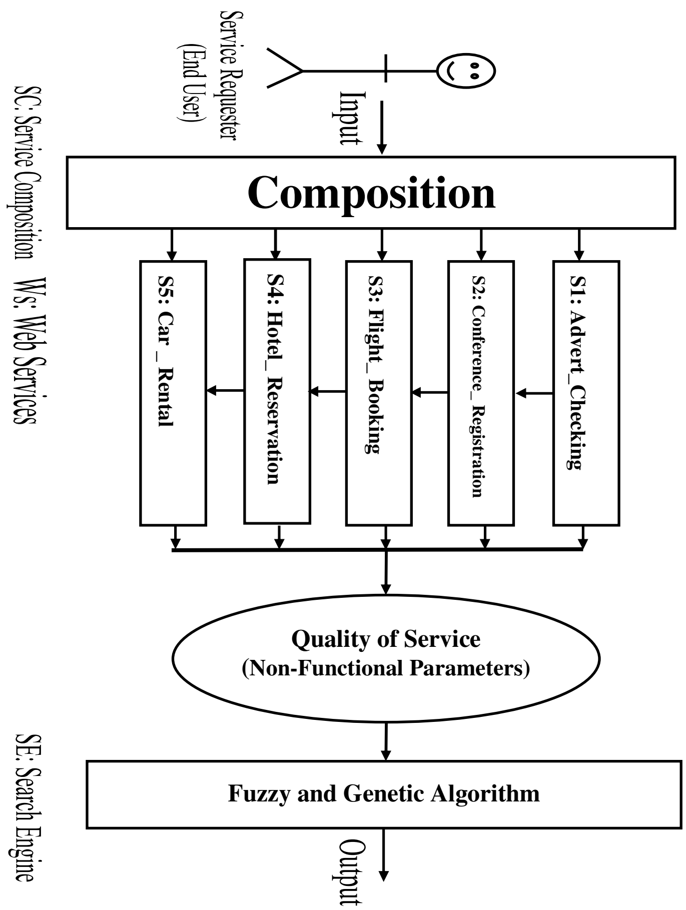

Fig. 4: Attend a Conference Planner

Web service systems aim to satisfy a set of functional and non-functional requirements (NFRs). In general, functionality is the key for selecting the appropriate candidates for service composition. However, in the case where existing services have the same functionality but different non-functional properties (NFPs), the latter should be considered in order to best satisfy the overall NFRs. Figure 3.1 shows a travel plan scenario, where the following services needs to be composed.

s1:Advert_Checking,
s2:Conference_Registration,
s3:Flight_Booking,
s4:Hotel_Reservation and
s3: Car_Rental

The user has requirements on a number of NFPs such as reputation, reliability and availability, cost and response time. In our scenario, the user wants to ask some questions related to functional data (what was the reason for booking a particular flight or hotel?) but also to non-functional data (why does it take so long to receive a response? were all the hotel services available during the hotel reservation? what was the performance of the workflow?).The service providers (Adverts, Registration, Hotels, Flights and Cars) provide web services and offerings to perform reservations. To guarantee payments made by the customer's credit card companies also offer services.

Since the nature of the web service is loosely coupled the agent may not have any prior agreement with the service providers thereby allowing independent access to more web services and offer more options to users and to receive sophisticated services from credit card companies making the user happy and the service providers can offer services broadly and therefore generating business for themselves. The problem addressed here is simple and the agent must be able to get the exact services what the user is looking from the service provider. The user looks for quality in the service offered by the agents. The agent must choose the service with quality at lowest price. Hence, quality plays a major role. The web service architecture must be remodeled to meet the user needs. Given,

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(i) A composite web service consisting of number of web services and it is denoted as $Ws = \{Ws_1, Ws_2, Ws_3 \ldots Ws_n\}$ where n is the number of services available in web service registry.
(ii) QoS values for the reputation, reliability and availability, cost and response time are Q_{ij}^{Rel}, Q_{ij}^{Ava}, Q_{ij}^{Rep}, and Q_{ij}^{Cost}, Q_{ij}^{Time}
(iii) Weights assigned for the QoS parameters are W_{Time}, W_{Cost}, W_{Ava}, W_{Rel}, W_{Rep}

In general the QoS criteria must be Q_{ij}^{Rel}, Q_{ij}^{Ava}, Q_{ij}^{Rep}, $> Q_{ij}^{Cost}$, Q_{ij}^{Time}

3.2 Problem Description

Soft computing provides a model for cognitive behavior of human mind. Soft computing aims to exploit imprecision tolerance, uncertainty, robustness and low solution. The constituents of soft computing are fuzzy logic, genetic algorithm and Neuro computing. These are intelligent technologies that have drawn an increasing attention in web services. Web services are becoming technology that is used to share data in different domains. Web Service acts as an interface that describes a set of operations that are accessed through network using standardized Extensible Markup Language (XML) language. This description using XML notion is termed as service description. It contains all the necessary details to communicate with the services such as messages, protocols and destination. Ranking of services, during the process of selecting services has become challenging. There are various selection techniques, like using user preference based service selection and service qualities aware selection which plays an important role in all service related tasks, since the property values get updated dynamically based on the service provider network.

It is simple to imagine a scenario in which multiple services which provides the same functionality for fulfilling a user request. In this case the ability of the user to differentiate between the services depends upon their non-functional qualities. [1][3] The problems that occur in the quality driven service selection are volatile nature of the quality factors, quality statistics is not taken care while selection, multiple QoS factors has to be considered for selection and subject of the search process is not used. To improve the quality driven selection, there is a need for other approaches like, Genetic approach, fuzzy techniques. The genetic algorithm is a powerful tool for structure optimization of the fuzzy system, therefore, in this study, integration and synthesis of fuzzy system and genetic algorithm is proposed [2]][7. The genetic algorithms resulting from this integration is defined as fuzzy and genetic algorithm.

3.3 Analysis

Herrera and Lozano [2] states that Fuzzy System are very useful when the processes are too complex for analysis by conventional quantitative techniques. Moreover, a Fuzzy System is one of the most successful applications of the fuzzy set theory.

The performance of a fuzzy system depends largely on the control of the membership functions and rule bases. It is a suitable tool for handling imprecision and uncertainty. Several researchers have applied a fuzzy system approach for Quality of Service based selection and composition of web services but they did not use any optimization technique to find optimal solution to the problem.

Fuzzy Systems are based on three well-known stages:
(i) the fuzzification stage,
(ii) the knowledge base stage,
(iii) the defuzzification stage,

Fuzzy System has been implemented in many experimental cases and in industrial applications because these controllers have advantages such as:
(i) easy implementation,
(ii) suitability for complex dynamic systems
(iii) high flexibility
(iv) robust nature

4. OPTIMAL IMPROVEMENT IN THE EXISTING SYSTEMS

The design of the parameters of a fuzzy system can be analyzed as an optimization problem. To overcome the limitations, genetic algorithm (GA) offer a possibility to solve these problem. Therefore, to overcome the drawbacks and limitations, genetic algorithm (GA) is proposed for designing and optimizing the parameters of the fuzzy system to obtain an optimized solution.

The most important key area to be optimized is the Knowledge Base (KB). The Knowledge Base of a fuzzy system consists of the Rule Base and Data Base.

- Rule Base (RB) - a rule base containing a number of fuzzy IF–THEN rules,
- Data Base (DB) - a database which defines the membership functions of the fuzzy sets used in the fuzzy rules.

4.1 Analysis of the Proposed System

Several researchers have applied fuzzy approach for Quality of Service based web service selection and composition. But they did not use any optimization technique to find an optimized solution to the problem.
In this work, the key point is to employ genetic algorithm (GA) in modulating, improving and optimizing the fuzzy system to find an optimized solution.
Our Proposed System Exhibits two (2) important characteristics or uniqueness :-
(i) Fuzzy System:- Model user preference and the desired QoS parameters of the service with fuzzy approach (IF-THEN rules).
(ii) GA System:- Optimized the control structure or decisions-making and search for an optimized solution (best rules) to the given problem. Find an optimized solution-best service to the user's preference during the selection process.

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4.2 Proposed System Design

The proposed architecture for the web service selection must be remodeled to meet the user's request. The composition of QoS properties is done with the help of fuzzy rule and fitness function based service selection. Figure 3.5 shows the proposed system architecture of the optimized web service selection:

(i) End user gives vague request (query relevant services) to the Fuzzy service selection broker
(ii) Fuzzy service selector analyze the given request by passing it to fuzzy inference engine
(iii) Fuzzy Inference engine calls the knowledge base and evaluate the QoS criteria's for the listed service
(iv) Genetic Algorithms then optimizes the fuzzy system parameters.
(v) Finally, there is optimization of composition unit works based on Genetic Algorithms. Fuzzy rules, which are created based on user request together with user constraints, constitute one fitness function.
(vi) GA parameters are defined for the system. QoS criteria's related to different compositions are evaluated and an optimized solution is selected in accordance with user request and convenience.

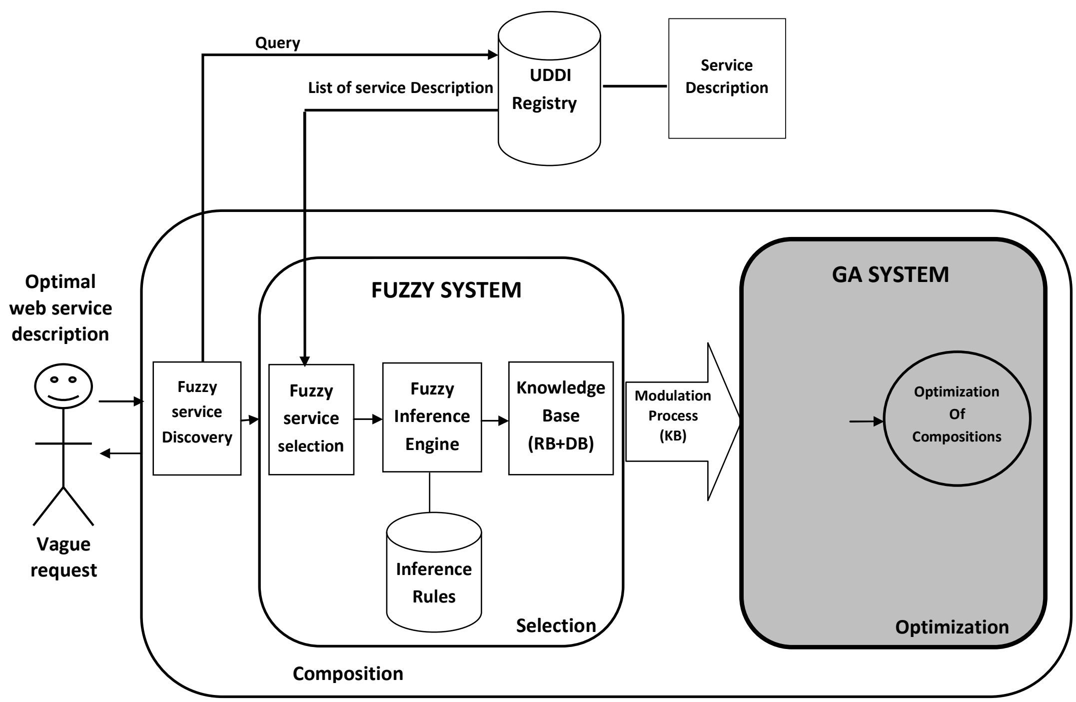

Fig. 5: Proposed Architecture of the optimized web service selection.

4.3 Layout of Proposed System Design

User Interface: - This is the system that allows a user to query (question) the fuzzy system, and to receive advice. The user interface is defined to be simple to use as possible. It comprises of:Fuzzy Service Discovery and Fuzzy Service Selection.Universal Description, Discovery and Integration (UDDI):-

(i) UDDI registries contain information about businesses and the services these businesses offer, examples are public and private registries
(ii) Directory service where businesses can register and search for Web services
(iii) Directory for storing information about web services
(iv) Directory of web service interfaces described by WSDL
(v) UDDI communicates via SOAP (Simple Object Access Protocol)
(vi) Provides a format for communicating between web services.

UDDI is Based On

(i) UDDI uses WSDL to describe interfaces to web services
(ii) WSDL provides the definition interface for web components to communicate.

Service Description: Communicates the service's capabilities, functionalities, interface, behavior, cost and quality-of-service (QoS).

Service Discovery: Locates appropriate services using requirements and selection criteria.

Fuzzy Inference Engine (FIE):- Referred to as the brain of the system. This is where decision-making process is performed using the rules contained or stored in the knowledge base (KB).

(i) The FIE acts like a search engine examining the KB for information that matches the user's query (question).
(ii) It uses the query to search the KB and then provides an answer or some advice to the user.
(iii) It also utilizes the contents of KB in conjunction with the data given by the user in order to achieve a conclusion.

Fuzzy Inference Rules (FIRs):- All the contributions and combinations of the rules are aggregated or summed using the Max-Min fuzzy inference rules techniques.

(i) This technique is used to calculate numerical results of the linguistic rules based on the system input values. The numerical results from this calculation are called fuzzy outputs.
(ii) This is where all generated rules are evaluated.

Max-Min fuzzy inference rule base approach is used in solving the control (IF-THEN rules) problem mathematically rather than attempting to model the system – without obtaining an optimal set of rules.

Knowledge Base (KB):- This is the most essential module of the fuzzy systems. It is referred to as the heart of the system. It contains and stores all data, information, rules and constraints used by fuzzy inference engine for solving difficult problems or tasks.

(i) The performance of a fuzzy system depends largely on the control (IF-THEN rules) structure and selection of the Knowledge Base.
(ii) Optimization of the Knowledge Base is critical to the performance of the fuzzy systems.
(iii) GA provides such a method to optimize the Fuzzy System parameters.

In the GA Optimization Process: the GA is used for improving and designing the fuzzy system such as optimizing the system variables for an optimized solution. Thereafter, an optimized solution is selected in accordance with the user's preferences. Optimization refers to finding the "best" solution to a problem. Here, "best" refers to an acceptable (or satisfactory) solution, which may be absolute best over a set of candidate solutions, or any of the candidate solutions.

4.4 Proposed System Analysis

To draw an accurate, reasonable and reliable conclusion in a fuzzy system, the knowledge base plays an important role and is the heart of the system, "heart – stores all data, information, rules and constraints used by fuzzy inference engine for solving difficult problems or tasks". Once a fuzzy system is built, we are faced with a large number of parameters which need to be optimized in order to improve the system performance in terms of the results (conclusions) obtained. The knowledge base of a Fuzzy System encapsulates expert knowledge and consists of the Data Base and Rule Base of the fuzzy system. Optimization of these knowledge base components is critical to the performance of the fuzzy system [1][9] [5].

The performance of a fuzzy system approach depends largely on the control structure and selection of the knowledge base. Hence, we find to improve the knowledge base. The solution is to employ genetic algorithm to design fuzzy system to improve and achieve optimal solution of the knowledge base, which can be considered as an optimization. The knowledge base is the most essential component of the fuzzy system. It is a collection of facts and rules and constraints used by an expert for solving difficult problems or tasks. And it's created from information provided by human experts.

The knowledge base is comprised of two components:

(i) Data Base (DB), containing the definitions of the scaling functions of the variables and the membership functions of the fuzzy sets associated with the linguistic labels, and
(ii) Rule Base (RB), constituted by the collection of fuzzy rules. A collection of rules used in the knowledge base of a fuzzy system. It has an IF-AND/OR-THEN structure.

The first step in designing the system is to decide which parts of the knowledge base are subject to optimization by the GA. The decision on which part of the knowledge base to optimize depends on two conflicting objectives: dimensionality and efficiency of the search. Knowledge base depends upon the dimensionality and efficiency of the search. A search space of a smaller dimension (for Fuzzy System having low numbers of input variables) results in a faster and simpler modulating process, but the obtainable solutions might be suboptimal i.e. "less quality" [7] [8].

A larger, complete search space (for greater number of inputs, more formal methods of KB optimization are required) that comprises the entire knowledge base and has a finer dimensionality is therefore more likely to contain optimal solutions i.e. "best quality". Genetic Algorithms provide such a method to optimize the Fuzzy System parameters. The knowledge base parameters compose the optimization space, which is transformed into a suitable genetic representation on which the process operates.

The genetic algorithms will also be used in optimization problems consisting of maximizing or minimizing a real function - QoS. The genetic algorithms fitness function is designed to maximize some QoS parameters or attributes and minimize some others, based on service requester's point of view. Once the fuzzy system has been constructed, the process of solution begins. The outputs are validated. When the outputs are not as desired, changes are made to the fuzzy set descriptions by genetic algorithm optimization process. An optimized solution is selected in accordance with user need and convenience.

5. FUZZY AND GENETIC ALGORITHM FLOW DIAGRAMS AND ALGORITHMS

5.1 Proposed Fuzzy and Genetic Algorithm

In the system architecture of the optimized web service selection (Fig 3-6) the fuzzy and genetic algorithm flow diagrams are designed to carry out the process of selecting an optimized solution (best service) stored\contained in the QoS database (KB). The system allows the user to specify their requirements not only based on functional attributes but also non-functional attributes [5] [6] The total QoS fitness score is computed for each service during the selection process. Finally, the top n (n <=5) service with the highest score is selected, advice the list of selected services to the user based on scores computed as the recommended optimized solution (best service). Two main QoS parameters viz: availability and reliability for service selection are employed in this work.

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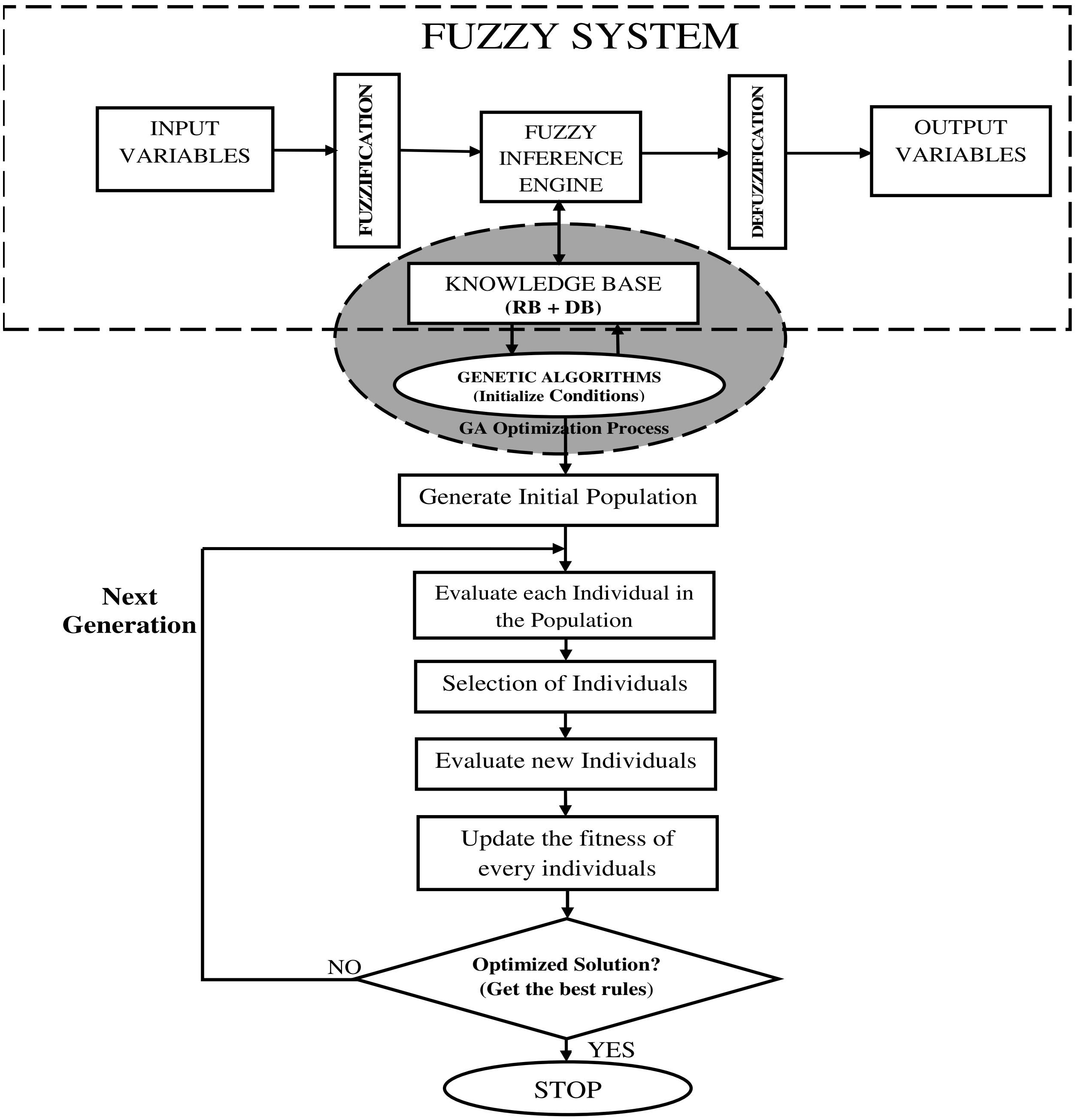

Fig. 6: Proposed Fuzzy and Genetic Algorithm Flow Diagram.

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Table 1 show the definition and nature of the parameters employed for service selection in this work.

Table 1: Basic Qualities for Service Selection.

S/N	Parameter	Definition	Nature
1	Availability (%)	Availability is the probability that the system is up and ready for immediate consumption when invoked - the probability that a service is available.	High
2	Reliability (%)	The ability of a service to function correctly and consistently and provide the same service quality despite system or network failures in a particular time interval.	High

The two parameters are selected for maximizing because of their relative impact in helping users to make reasonable selection decision as they relate to dependability metrics which are fundamental qualities of web services that are necessary for the fulfillment of user's objectives. Dependability relates to building confidence about a web service. Reliability and availability come under dependability metrics. Reliability and availability are considered crucial parameters in service selection.

5.1 Algorithm for QoS delivery using fuzzy and genetic algorithm

Depicted below is the QoS selection delivery using fuzzy and genetic algorithm.

Input: ***Web Services and QoS Parameters***
Output: ***Optimized Solution***
Step1: User query the registries for services.
Step2: Retrieve the QoS parameters available for each service from the WSDL document.
Step3: Extract the QoS parameters of the listed service with respect to QoS values.
Step4: FIE facilitate to select the best service obtained in the QoS database (KB) for service selection.
Step5: Services are stored in QoS Database as their functional type and QoS parameters. To determine if the QoS is best, we use:.
Genetic Algorithm: QoS based service selection
Input: ***Availability and Reliability***
Output: ***Weights for each service***
Step5-1 [Start] Create a random population of individual variables. Which form the first generation**.**
Step5-2 [Fitness] Evaluate the fitness of each individual variables based on the fitness function defined in Equation 2.9. The equation is used in computing the total QoS fitness score for each service during the selection process.
Step5-3 [New Population] Create a new population by repeating the following steps until the new population is complete:

i. Selection of Individuals for next generation. The better fitness, the bigger chance to be selected.
ii. Evaluate new individuals
iii. Update the fitness of every individuals

Step5-4 [Replace] The new population is used over the existing population for a further run of algorithm until the best individual is good enough.
Step5-5 [Test] If the end condition is satisfactory, stop, and return the best solution in current population.
Step5-6 [Loop] Otherwise, Go to Step5-2 and repeat the procedure till required solution is obtained.
Step6: Advice the list of selected service to the user.
Step7: An optimized solution (best service) is selected in accordance with the user's preferences.

Table .2 Definition of key terms used in the proposed fuzzy and genetic algorithm flow diagram.

Nature	Computer
Gene	Encoded form of a parameter being optimized.
Parameter	A variable in the system of interest.
Individual	Any possible solution. (A solution)
Population	Group of all individuals.
Fitness	Quality of a solution – a value we are trying to maximize or minimize.
Search Space	All possible solution.
Search Operators	Crossover and Mutation.
Variable	The input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values.

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6. CONCLUSION

In this paper, we presented the design of a Fuzzy and Genetic Algorithm based service selection system for web services optimization. Our design for optimal solution for QoS delivery in web service selection modeled cognitive behavior of human mind - a model shift which reflects the human mind. This design is suited for real live problem and achieves desirable results in a reasonably less time.

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