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Selecting the Optimal Web Service Composition Based on QoS

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Thesis submitted in partial fulfillment of requirements of the degree "Master of Science in Informatics"

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DEDICATION

To my mother and father, who always supported me and encouraged me to get my Master Degree.

To my brothers and sisters for their support.

To my all real friends for their help and support.

ACKNOWLEDGMENT

I would like to express my sincerest appreciation and love to my parents and my family, for all their help and support during these past few years.

I would like to extend my sincerest thanks to my supervisor, Dr. Mahmoud AL-Saheb, for providing me with this opportunity. I would like to thank him for all his excellent guidance, precious advice, and endless support over the years during my graduate study and research at Palestine Polytechnic University (PPU).

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الملخص

في الآونة الأخيرة أدى الانتشار السريع لخدمات الانترنت في أعمالنا التجارية و كذلك في حياتنا اليومية إلى جعل جودة الخدمة جانباً هاماً لكل من مزود الخدمة و مستخدم الخدمة (الزبون) و الزبائن يفضلون التعامل مع أفضل خدمة ويب متوافرة على شبكة الإنترنت. و المشكلة الرئيسية هي كيف يمكن للمستهلك الحصول على خدمة ويب مركبة ذات جودة عالية ضمن عدد كبير من الخدمات المتاحة على شبكة الانترنت فلذلك ليس من السهل العثور على المسار الأمثل لخدمة ويب مركبة. و إن اختيار المسار الأمثل يعتمد على جودة الخدمة لكل خدمة مفردة داخل الخدمة المركبة. و في أغلب الأحيان تكون قيم خواص جودة الخدمة التي يقوم بنشرها مقدمو الخدمة غير موثوقة أو غير دقيقة و أن بعض المبرمجين يقيسون جودة الخدمة بالاعتماد على زمن الاستجابة و الإنتاجية و التوافرية. مساهمتنا في هذه الدراسة هو اقتراحنا أخذ عامل السمعة عند حساب جودة الخدمة من خلال خوارزمية النحل الاصطناعية و التي تقوم بدورها باختيار خدمة ويب مركبة مثلى. قمنا بتحليل تأثير عامل السمعة على عملية اختيار الخدمة المركبة من حيث جودة الخدمة و دقة الحل و كذلك دراسة تأثير عامل السمعة في حال غياب أحد العوامل الأربعة من خلال ثلاث تجارب قمنا بها و مجموعة من المقارنات و كانت النتيجة أن عامل السمعة يمكن أن يغطي بعض العوامل مثل عامل التوافرية و عامل الدعم الفني و زمن الاستجابة. قمنا بتحليل علاقة الارتباط بين عامل السمعة مع العوامل الأربعة الأخرى باستخدام فحص أنوفا والنتائج تبين أن هناك ارتباطا كبيراً بين عامل السمعة والعوامل الأخرى ما عدا عامل الموثوقية. استخدمنا الانحدار الخطي المتعدد و الانحدار متعدد الحدود بهدف التنبؤ بعامل السمعة من خلال العوامل الأربعة الأخرى و أوضحت النتائج أن هناك ثقة أعلى عند استخدام الانحدار متعدد الحدود لأن مجموع الفرق كان أقل من الانحدار الخطي المتعدد.

Abstract

In recent days, the fast spread of web services in our businesses and day-to-day lives has made QoS a very important aspect for both the service provider and the consumers. The consumers prefer to deal with the best web service available on the internet. The main problem is how the consumer obtains a high comprehensive quality composite service when there are a large number of web services available, so it is not easy to use an optimal execution path of web services; the choice of the optimal path depends on the QoS for every atomic service. The values of QoS attributes which are published by service providers may be not trusted or inaccurate; some of the developers typically measure a QoS in terms of response time, throughput, and availability. Our contribution is to study the influence of the reputation factor in the process of selecting the optimal path in the absence of one of four factors (Availability, Reliability, Response Time, and Price) and the possibility of covering for them. We have used the reputation factor when calculating the QoS by using artificial bee colony algorithm for selecting the optimal web service composition. Then we analyzed the impact of reputation on the process of selecting web service composition in terms of the QoS and accuracy of the solution. Also, we studied the impact of the reputation factor in the case of the absence of one of the four factors through three experiments and a set of comparisons. The result was that the reputation factor could cover for factors such as availability, Response Time, and technical support. We used multiple linear regression and polynomial regression to show the prediction of the reputation factor using the four other factors. The result has a higher confidence when we used multiple polynomial regression where the Residual Sum of Squares (RSS) was less than the multiple linear regression. In addition, we analyzed the association between reputation and the four other factors using ANOVA test; the result indicates that there is a significant association between reputation and (availability, response time, and price), but it is not significant association with the reliability.

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Abbreviations

ANOVA	**Analysis Of Variance**
Ava	**Availability**
CF	**Collaborative Filtering**
HTTP	**Hyper Text Transfer Protocol**
MLR	**Multiple linear Regression**
MMKP	**Multi-Dimension Multi-choice Knapsack Problem**
MPR	**Multiple Polynomial Regression**
P	**Price**
QoS	**Quality of Service**
Rel	**Reliability**
REST	**Representational State Transfer**
Rep	**Reputation**
RSS	**Residual Sum of Squares**
RT	**Response Time**
SC	**Service Composition**
SMEs	**Small and Medium sized Enterprise**
SOAP	**Simple Object Access Protocol**
TS	**Technical Support**
UDDI	**Universal Description, Discovery, and Integration**
WS	**Web Service**
WSDL	**Web Service Description Language**
XML	**Extensible Markup Language**

Chapter 1

Introduction

Web services have been gaining popularity since the introduction of Service-oriented architecture (SOA) which is one of the latest software architectures and cloud computing. SOA has been created primarily to meet business requirements and to removed the gap between software and businesses [4]. Web service uses standard-based way to realize SOA. Web services are internet-based modular application that uses the Simple Object Access Protocol (SOAP) for communication and transfers data in XML through the internet [5]. Web Service composition aims at selecting and interconnecting web services provided by different partners according to a business process [6].

In composite web service, every atomic service has a large number of web service providers that provide similar functionalities service with different non-functional property values. The Quality of Service (QoS) can be used as a criterion for service selection. QoS is considered a measure to differentiate between the services and their providers. From the consumers perspective, knowing the QoS provided by the service provider plays a crucial role in choosing a particular web service over its alternatives. Through the test of QoS, we can rank the web services from the best to the worst in the service registry. The description of each service includes its functional and non-functional properties. Functional properties present the objectives of the service while the quality of service is a set of non-functional attributes such as response time, throughput, reliability and availability [7].

Cloud service is becoming popular, and several leading IT enterprises including Google, IBM, Microsoft, and Amazon have started to offer cloud services to their customers [8]. Cloud service selection currently constitutes a major challenge attracting the research community to work on and investigate [9]. According to the customer type, the cloud services are divided into two categories: the enterprise cloud services for small and medium sized enterprises (SMEs) and the cloud application for individual customers [10].

1.1 Motivation

The consumer faces a challenge when selecting the best web service available within a large number of web service providers providing similar functionality services, but with different non-functional properties. So it is not easy to find an execution path of web services composition. The main problem in selecting composite service is how to select the optimal path among an enormous number of other available paths depending on the QoS for every atomic service in the composite service. QoS is considered a measure to differentiate the services and their providers. Some of the developers typically measure QoS in terms of response time, availability, reliability, and cost. QoS information published by the service providers may not always be accurate and up-to-date. In other words, the values of QoS attributes which are provided by service providers may be not trusted since service providers may sometimes advertise higher QoS data than the actual level of the service in order to attract more users to use their services and so gain better benefits. In this work, we took the reputation factor into account when calculating QoS to find an optimal path of web services composition.

1.2 Thesis Hypothesis

It hypothesized that the reputation factor covers for each of the QoS factors in the case of the absence of any one of them.

1.3 Contributions

Through studying the previous researches dealing with the same issue of selecting the optimal web service composition and using the bee algorithm to solve the problem, we have found that those researches depended on four main factors to measure the QoS which are response time, availability, cost, and reliability. In this study, we suggested studying the impact of reputation factor on selecting the optimal path and the possibility of reputation covering for the other four factors. We used the reputation factor when calculating the QoS through using artificial bee colony algorithm for selecting the optimal web service composition. Reputation factor is an aggregation of ratings for a service from consumers for a specific period of time. The main contribution of this study is to cover for the absence of one of the QoS factors by the reputation factor.

1.4 Thesis Organization

The theoretical background information behind this work is presented in Chapter 2, while Chapter 3 contains the literature review. The methodologies used for the our experiments are in Chapter 4. Chapter 5 explains the results of our experiments, while the conclusions and potential future are in Chapter 6.

Chapter 2

Background

This chapter covers the background which is needed to understand the rest of this thesis. The first Section 2.1 of this chapter defines the Service-Oriented Architecture (SOA) and its components. The second Section 2.2 introduces web services, definitions of web service and web services life cycle; it also lists several characteristics of web services. Section 2.3 describes web services composition and explains the meaning of composite service through the example of travel composite service, also we presented the structure of web services composition. And finally, this chapter covers the Quality of service (QoS) in section 2.4.

2.1 Service-Oriented Architecture (SOA)

SOA is considered one of the newest software architectures available. SOA have different characteristics and specifications when compared with other software architectures, but the aim of SOA is to remove the gap between software and businesses and to achieve loose coupling among interacting software components through the use of simple well-defined interfaces [4].

2.1.1 Definitions of SOA

Service-oriented architecture has many proposed definitions for the term "SOA", the followings are some of these definitions:

- "SOA is a technology as well as a paradigm of designing a software system to provide services to either end-user applications or to other services distributed in a network" [4].

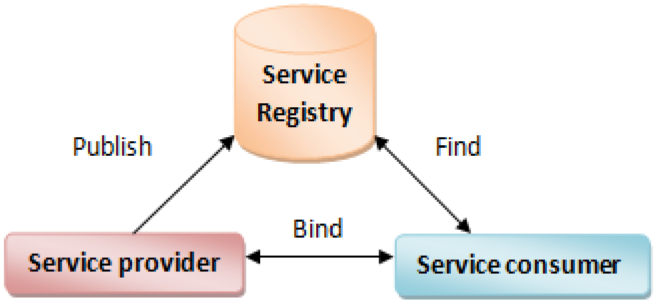

FIGURE 2.1: The web service model and the components of SOA

- "SOA is the architectural style that supports loosely coupled services to enable business flexibility in an interoperable, technology agnostic manner and it consists of a composite set of business-aligned services that support a flexible and dynamically re-configurable end-to-end business processes realization using interface-based service descriptions" [11].
- " SOA is a design pattern which is composed of loosely coupled, discoverable, reusable, inter-operable platform agnostic services in which each of these services follow a well defined standard" [12].

2.1.2 Summary of SOA

Through the previous definitions of SOA is considered a new architecture for business, and SOA consists of a composite set of business-aligned services that support a flexible and dynamically. SOA is characterized by a loosely coupled, discoverable, reusable, and interoperable platform agnostic services.

2.1.3 Components of SOA

SOA mainly includes three interactive entities; service provider, service consumer and service registry [13]. Figure (2.1) represents the web service model and the components of SOA.

- **Service Provider:** the service provider builds and creates a web service and makes it available on the internet for consumers. The service provider needs a standard format to describe the web service such as Extensive Mark-up Language (XML). The service providers publish the web service to a central service registry [13].

- **Service Consumer:** also called "service requestor" the consumer requests the specific web service existing on the network through sending an XML-SOAP request. In other word, service consumer retrieves the information about web service from the registry such as URL or called service description (Web Service Description Language (WSDL) file). Then the consumer uses the service description obtained to bind and invoke the web service that exists at the service provider [13].

- **Service Registry:** it is used as a central store, where the providers or developers can deploy new web services or find the existing services. Also, it is called information repository because it has additional information about the service provider such as address, contact with the providing company, and the technical details about the service. So, the service registry is considered an important component because the service providers publish their services here and the service requestors find services here and get binding information between providers and consumers here [13].

2.2 Web Services

The concept of web services has gained great importance and it has become incredibly an active area of research. Web Services are modular, self-described and self-contained applications [14]. Web Services as technology based on open XML standards like SOAP, WSDL, and Universal Description, Discovery, and Integration (UDDI) are widely used for integration purposes within enterprises, they possess the ability to invoke other web services and create more diverse systems and the open standards form an architectural style known as Service Oriented Architecture (SOA) [15]. Web services have the main feature which is interoperability; it is the ability of how to deal with multiprogramming language, multi-operating system, multi-version of XML message and multi-devices whether it is a computer, smartphone or tablet.

2.2.1 Definitions of Web Service

Web services have many proposed definitions for the term "web service". The followings are some of these definitions:

- " Web Service is a software system designed to support interoperable machine-to-machine interaction over a network and it has an interface described in a machine-processable format (specifically WSDL)" [16].

- " Web Service is any piece of software that makes it available over the internet and uses a standardized XML messaging system and XML is used to encode all communications to a web service" [17].
- " Web service is a collection of open protocols and standards used for exchanging data between applications or system,and software applications written in various programming languages and running on various platforms can use web services to exchange data over computer networks like the Internet in a manner similar to inter-process communication on a single computer" [18].

2.2.1.1 Summary of web service

- Any web service that is available on the internet.
- Used a unified messaging system XML.
- Any web service that is not associated with any specific operating system or programming language.
- Any web service that enables communication through using open standards such as HTML, XML, Web Service Description Language (WSDL), and Simple Object Access Protocol (SOAP).

2.2.2 Summary of the web services life cycle

In Figure (2.2) illustrates and describes the life cycle of web service. The description of life cycle passes through several steps as the following:

Step 1: The service provider publishes it's own services and makes it available on the internet, through attaching a description of service and QoS which are in the format of WSDL file and this file is stored in the web services registry.

Step 2: The service consumer tries to search his desired services in the registry and which suits his own requirements in term of QoS. The consumer sends his request as input data which in turn is translated into a message in XML language. Then the consumer waits for the response massage. The response occurs immediately after the search process, through receiving a massage of URL WSDL file about target service.

Step 3: After obtaining the URL of the web service from the registry, the consumer makes a binding with the provider through SOAP massage. At this point a consumer can use this service efficiently.

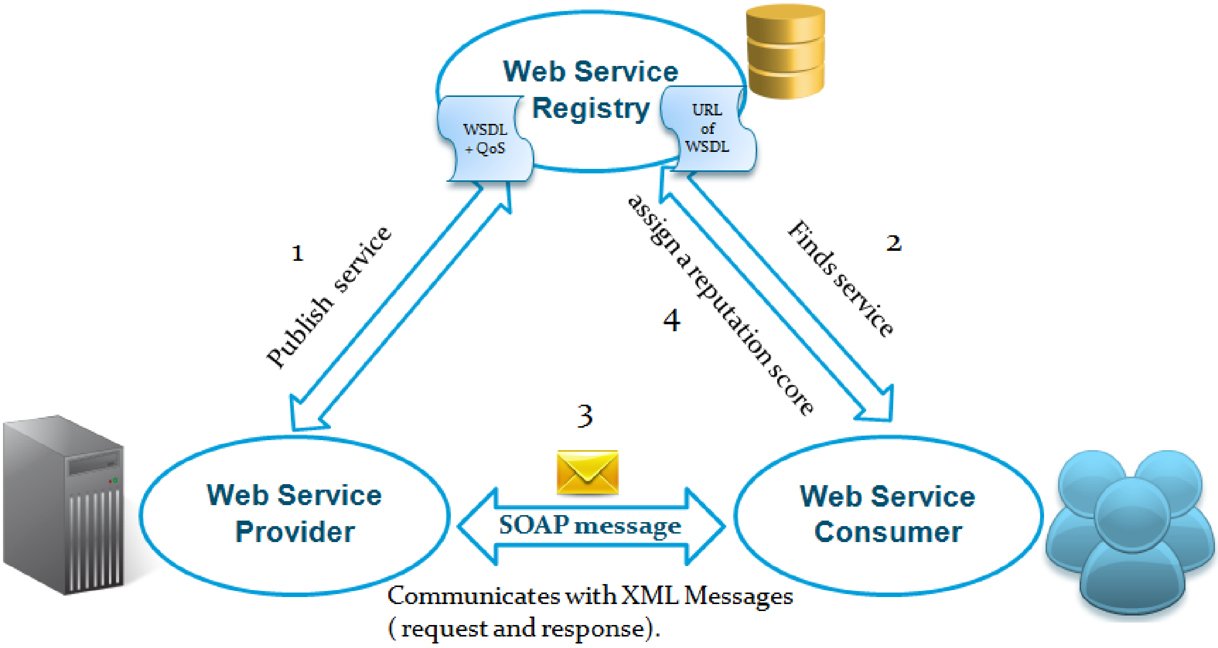

FIGURE 2.2: Web service lifecycle

Step 4: Eventually and after using this service, the role of the consumer comes so that he can evaluate this service through putting a value of rating.
All these operations are working under a family of protocols using SOAP protocols based on service oriented architecture (SOA).

2.2.3 Characteristics of Web Services

Michael Papazoglou in 2008 discussed the web services characteristics as the following [19]:

- **XML-based:** web services are dependent on XML for representation and transportation data, XML is independent in terms of operating system ,network, or platform binding [19].
- **Loose coupling:** There is no direct tie between a web service and its user (consumer). Alterations of the web service interface do not deteriorate the users capability of interacting with the service [19].
- **Interoperability:** Web services enable the share of data and the communication between different applications, for example VB or .NET application can interact with Java web services and vice versa this to achieve the application platform and technology independent [19].

TABLE 2.1: The difference between SOAP-based Web services and RESTful Web services [2]

#	SOAP	REST
1	A XML-based message protocol	An architectural style protocol
2	Uses WSDL for communication between consumer and provider	Uses XML or JSON to send and receive data
3	Invokes services by calling RPC method	Simply calls services via URL path
4	Does not return human readable result	Result is readable which is just plain XML or JSON
5	Transfer is over HTTP. Also uses other protocols such as SMTP, FTP, etc	Transfer is over HTTP only
6	JavaScript can call SOAP, but it is difficult to implement	Easy to call from JavaScript
7	Performance is not great compared to REST	Performance is much better compared to SOAP-less CPU intensive, leaner code etc.

- **Standardized Protocol:** Web services use industry standard protocol for the communication. This standardization of protocol gives the business many advantages like wide range of choices, reduction in the cost due to competition and increase in the quality [19].

2.2.4 Development of Web Services

There are two main ways for developing Web services: the traditional SOAP-based Web services and RESTful Web services. SOAP commonly uses HTTP, and the other protocols such as Simple Mail Transfer Protocol (SMTP) [20].

- **SOAP-based Web services**
  SOAP-based Web services depend on three important standardization initiatives, WSDL, SOAP, and the Universal Description, Discovery, and Integration (UDDI). SOAP can be used to exchange complete documents or to call a remote procedure [21].

- **RESTful Web services**
  REST (Representational state transfer) ”is an architectural style consisting of a coordinated set of architectural constraints applied to components, connectors, and data elements, within a distributed hypermedia system” [21].

Table (2.1) represents the main difference between SOAP-based web services and RESTful web services [2].

2.2.5 Atomic vs Composite Web services

- **Atomic Web Services**
  An atomic service also called (elementary service) “ is an access point to an application that does not rely on another Web service to fulfill user requests” [22]. Each atomic service provides a programmatic interface based on SOAP and WSDL [22].

FIGURE 2.3: Travel composite service

- **Composite Web Services**
  A composite service "is an umbrella structure that brings together other composite and atomic services that collaborate to implement a set of operations" [23]. The services brought together by a composite service are referred to as its component services [23].

2.3 Web Service Composition

Web service composition is considered a hot and active research area in SOA. In a lot of business to business applications, a single service is not enough to respond to the user's request, so services should be combined through services composition to achieve a specific user's request. Web services make it possible to achieve interoperability Business-to-Business (B2B) from interconnection services offered by multiple business partners based on business processes. This interconnection of web services to meet a certain business process is called Web Service composition [24].

2.3.1 Example of composition

The composition of service contains a set of atomic services which are combined together on the basis of the rules of composition. The aim of this combination is to satisfy a specific demand of the user and that demand cannot be achieved by a single service. For example if a user wants to travel to a foreign country (Turkey) so it is not enough for him to book the trip tickets, but there are many things that must be taken into account, he might reserve a hotel, rent a car etc. Figure (2.3) explains the meaning of composite service through an example on travel composite service.

2.3.2 Structure of Web Services Composition

In the previous example, in Figure (2.3), we assumed the composite service contains 3 tasks, and each task has 25 candidate services. Then there will be 25^3 possible web

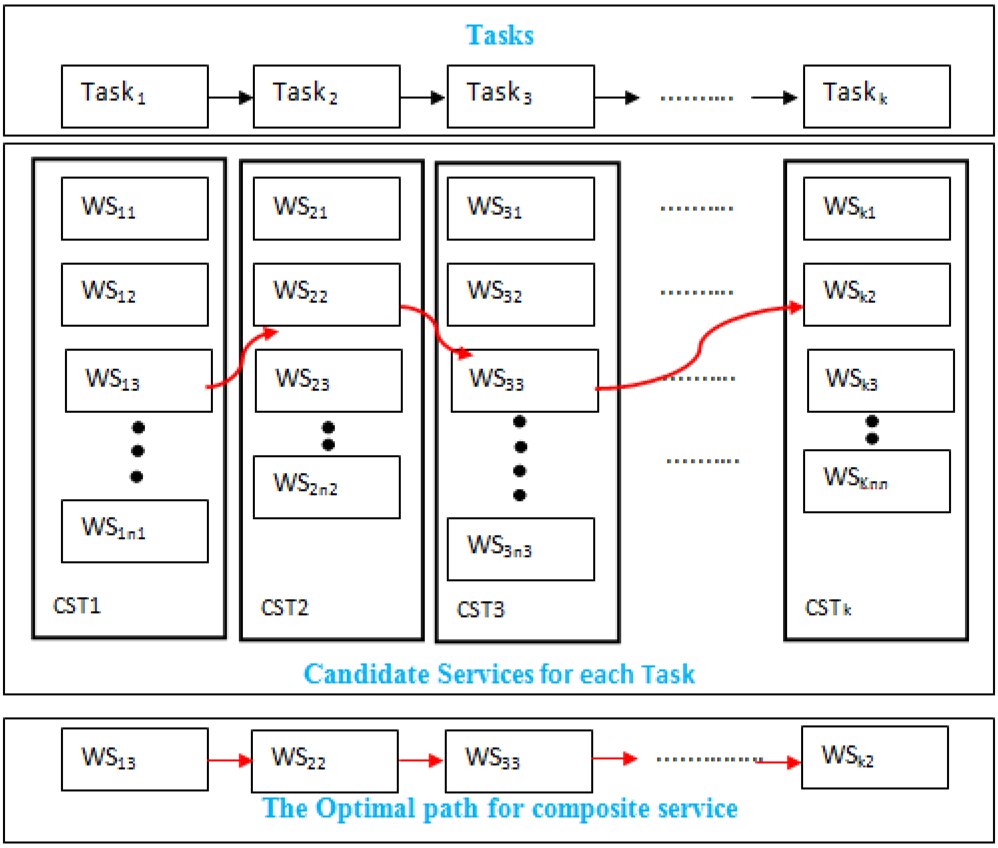

FIGURE 2.4: Structure of Web Services Composition

service selection solutions. Making the optimal web service selection decision from such a large number of possible solutions is computationally intractable. In general Figure (2.4) describes the nature of the structure of web services composition. As it is shown in Figure (2.4) there are a number of tasks (k). In each task there are a set of providers providing a similarity service $(p_1, p_2, p_3, \cdots\cdots, p_n)$ and the providers are called candidate service $(cs_1, cs_2, cs_3, \cdots\cdots, cs_n)$. The number of probability of the choosing the optimal path is huge. The number of the probability of paths can be represented in the equation (2.1), where C_1 represents the number of candidate services in the Task 1 while C_2 represents the number of candidate services in the Task 1 and so on. k is the number of tasks while the C_k represents the number of candidate services in Task k.

$$\#ofpaths = C_1 * C_2 * C_3 \cdots\cdots\cdots * C_k \tag{2.1}$$

The general term of quality of service (QoS) is "the totality of characteristics of service that bear on its ability to satisfy stated and implied needs of the user of the service" [25]. Calculating the QoS for each atomic service in the composition dependents on five factors response time, cost, availability, reliability and reputation.

2.3.3 Mathematical representation of composition service:

The composition service has a set of services $S_i, \forall i \epsilon \left[1 \cdots\cdots n\right]$. n is the number of candidate services and have a set of tasks $T_j, \forall j \epsilon \left[1 \cdots\cdots k\right]$. k is number of tasks.
An undetermined number of tasks, k, can be used to compose a service and an unlimited number of services, n, for each task Tj can be found, as it is shown in equation (2.2).

$$X_{i,j} = \begin{pmatrix} x_{11} & x_{21} & . & . & . & x_{k1} \\ x_{12} & x_{22} & . & . & . & x_{k2} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ x_{1n} & x_{2n} & . & . & . & x_{kn} \end{pmatrix} \tag{2.2}$$

If the service Si is allocated to task Tj set 1 in the matrix, as it is shown in equation (2.3)

$$x_{i,j} = \begin{cases} 1, & if\ service\ i\ is\ allocated\ to\ task\ j \\ 0, & otherwise \end{cases} \forall i \epsilon \left[1 \cdots n\right], \forall j \epsilon \left[1 \cdots k\right]. \tag{2.3}$$

We can consider that a composition is a set of atomic web services, and the sum of rows and that of columns in matrix X should be 1. In our example Travel composite service we suppose the composite service contains 3 tasks, and each task has 10 candidate services n =10, k=3. The possible web service selection solution $10^3 = 1000$. In the matrix Y represents one of the possible combinations in which service:

- service S5 will execute task T1
- service S3 will execute task T2
- service S7 will execute task T3
- Task T3 will be executed by service S2.

$$Y_{i,j} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

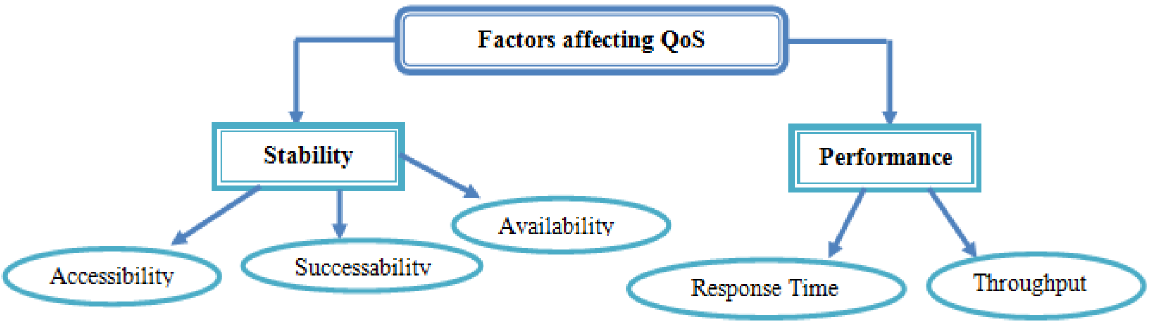

FIGURE 2.5: The service level measurement quality consists of five sub-quality factors

In matrix Y, the solution of web service composition is (T1-S5, T2-S3, and T3-S7).

2.4 Service level measurement quality of service (QoS)

Service level measurement quality is a set of quantitative attributes which describe the run time service responsiveness in a view of consumers. This quality factor represents how quickly and soundly web services can respond which can be measured numerically on system. Figure (2.5) illustrate the Service Level Measurement Quality consists of five sub-quality factors: response time, maximum throughput, availability, accessibility, and successability [26].

1. ***Performance:*** refers how fast the service is served and is measured in terms of response time and maximum throughout.

   (a) **Response time:** This refers to the time since the users send their requests to service server until it was responded [26].
   Figure (2.6) shows four kinds of latency which effect on the response time. When a consumer sends his request to the provider, latency may happen from the consumer, and his latency depends on the speed of the consumers computer and this latency is called consumer latency. The second latency which effects on the response time is called registry latency, this kind of latency refers to the delay time happen when to retrieve the URL of WSDL service. The third latency comes as a result of the nature of the network and it called network latency, which represents the period time from the moment when a consumer sends a massage request to the time of receiving the massage response. The fourth latency occurs from the provider during the preparation and processing service.
   Representation of the latency effecting on response time:

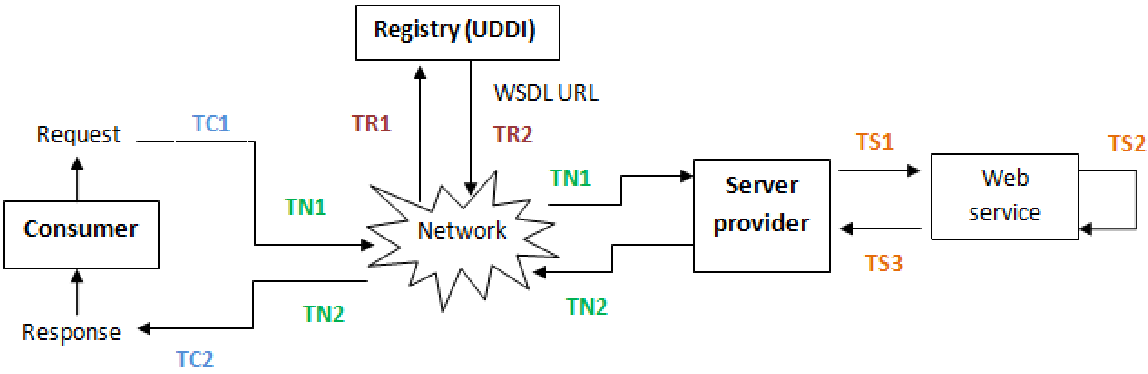

FIGURE 2.6: The model of analyzing response time of web services

- *Consumer latency* refers to the delay of time caused by the speed of consumer's computer in the whole processing time for a service request. It is the summation of Time Consumer when request service (TC1) and Time Consumer when response service (TC2). Equation (2.4) represents the Consumer latency.

$$ConsumerLatency = TC1 + TC2 \tag{2.4}$$

Where TC1 represents the time Consumer when request service, TC2 represents the time Consumer when response service.

- *Registry latency* refers to the delay of time caused when to retrieve the URL of WSDL service. It is the summation of Time request WSDL file from the registry (TR1) and Time response to retrieving URL of WSDL service (TR2). Equation (2.5) represents the Registry latency.

$$RegistryLatency = TR1 + TR2 \tag{2.5}$$

Where TR1 represents the time request WSDL file from the registry, TR2 represents the time response to retrieving URL of WSDL service

- *Network latency* refers to the time taken on a network for transmitting request message and response message. It is the summation of the time taken between consumers send a request and the time of server provider receives the request (TN1). And it is the summation of time taken between the service provider sends a response and the time of consumer receives the response (TN2). Equation (2.6) represents the Network latency.

$$NetworkLatency = TN1 + TN2 \tag{2.6}$$

Where TN1 represents the time taken between consumers send a request and the time of server provider receives the request, TN2 represents the time taken between the service provider sends a response and the time of consumer receives the response.

- *Server latency* refers to the delay time caused by a server system in the whole processing time for service. Equation (2.7) represents the Server latency.

$$ServerLatency = TS1 + TS2 + TS3 \tag{2.7}$$

Where TS1 represents the time of server latency when the user request the service, TS2 represents the time of server latency when processing service, TS3 when represents the time of server latency when retrieve service.

Response time is represent the summation for four equations above

$$RT = ConsumerLatency + Registrylatency + NetworkLatency + Serverlatency \tag{2.8}$$

(b) **Throughput:** Throughput can be defined as the number of requests per seconds and maximum throughput refers to the maximum amount of services that the service provider can process in a given time period. It is the maximum number of responses which can be processed in a unit time, and equation (2.9) represents the Throughput [26].

$$MaxThroughput = Max(\frac{\#RequestsProcessedbyServiceProvider}{MeasuredTime}) \tag{2.9}$$

2. ***Stability:*** refers how stably and continuously web services can provide their services. Stability is measured in terms of availability, accessibility, and successability.

(a) **Availability:** Availability is a measurement which represents the degree of which web services are available in operational status. This refers to a ratio of time in which the web services server is up and running, and equation (2.10) represents the Availability [26].

- *Down Time:* represents the time when a web services server is not available to use.
- *Up Time:* represents the time when the server is available

$$Availability = 1 - (\frac{DownTime}{Measuredtime}) \tag{2.10}$$

(b) **Accessibility:** Accessibility represents the probability of which web services platform is accessible while the system is available. This is a ratio of receiving Acknowledgment message from the platform when requesting services. That is, it is expressed as the ratio of the number of returned Acknowledgment message to the number of request messages in a given time, and equation (2.11) represents the Accessibility [26].

$$Accessibility = 1 - (\frac{\#of AckMessage}{\#of RequestedMessage}) \tag{2.11}$$

(c) **Successability:** It refers to a ratio of the number of response messages to the number of request messages after successfully processing services in a given time. Successful means the case that a response message defined in WSDL is returned, and equation (2.12) represents the Successability [26].

$$Successability = \frac{\#of ResponseMessage}{\#of RequestedMessage} \tag{2.12}$$

Chapter 3

Literature Review

This chapter contains a summary of some important contributions related to our work. In section 3.1 we summarize related studies of the challenges of selection web service composition. In section 3.2 we summarize approaches of web service quality composition modelling. also, in section 3.3 we summarize approaches of web services reputation system. In section 3.4 we summarize approaches of QoS prediction via reputation.

3.1 Challenges of Selection web service composition

In this section, we discuss the main challenges involved in the service selection problem. These challenges are:

- **NP-Hardness and Scalability:** Composite service selection can be modelled as a multi-dimension multi-choice knapsack problem (MMKP), which is known to be an NP-hard problem in the strong sense [27]. This indicates the problem is large too, so it is not easy to find an execution path of web services composition, hence, there is a need for heuristic approaches when the problem size is too large to be solved by optimization procedures [27].
  Approach to solve NP-Hardness and Scalability problem:
  Heuristic approaches: A number of heuristic algorithms for the service selection problem has been proposed in the literature such as [28],[29] and [30].
  Genetic Algorithm approach: In [31] have proposed a Genetic Algorithm approach to solve the scalability problem.
  Alternative proposal: Used to reduce the computational time of the service selection search algorithm is to shrink the search space. Alrifai et al has proposed

pruning the service candidates that are not likely to be part of the optimal solution, by computing the service skyline for each service class [32]. Guofeng Chang has proposed a QoS-aware web service selection approach for solving web service composition problem with a great number of web services. The approach adopts genetic algorithm to find the most suitable web service for service users. The results indicated the proposed approach significantly improve the web service selection process in web service composition problem [33]. Seog-Chan et al. Present a novel solution, named as BFStar, that adopts the competitive A* as a search algorithm. To solve the selection composition service problem [6]. He, Jun, et al. describe these challenges as three key points in web services composition optimizing problem: point one modeling of web service QoS properties; point two modeling of QoS properties aggregation; point three composition optimization algorithm [34].

- **Aggregation Functions:** Aggregation functions consider a critical challenge in selection optimal web service composition because the aggregated value of a QoS attribute should take into account the QoS attribute value of the individual services participating in the composite service [31].

3.2 Approaches for WS Quality Composition Modelling

In this section, we presented several of the proposals for web service quality composition modelling.

In [35] [36] the authors depend on the Web Service Description Language (WSDL) to define the functional properties and non-functional properties of the service; also this approach has some problems such as the issue of run-time support is not addressed.

In [37], the authors define QoS for web service by using XML schemas that both service consumers and providers apply to define the agreed QoS parameters, also this approach allows for the dynamic selection of web service depending on various QoS requirements. In [3] the authors proposed a predictive QoS model for workflows involving QoS properties. Many works describe QoS-aware service composition as a multidimensional, multiobjective, multi-choice knapsack problem (MMMKP); which takes many QoS criteria into consideration to obtain an optimal composite service that has high QoS value [38]. Some approaches focus on reducing the complexity of the composition using standard optimization algorithms [39] [40]. Some researchers propose QoS constraints such as minimum availability and reliability to restrict the composite services [41] [42].

3.3 Approaches of Web Services Reputation System

There are many approaches that are presented for the web services discovery process, and the main idea of these approaches is to ensure the correctness of the value that assigned by the consumer regarding the reputation of the service; also, some of these works are based on the functional properties and the others are based on both the functional and nonfunctional properties (QoS).

Al-Shargabi et al. 2014. Present a web service composition technique based on the user preferences such as price and availability; furthermore, they use a web service selection agent forced by users preferences, but the effect on the reputation in the selection approach did not be included [43]. Zhang et al. 2014. They have presented a tool or WS-QoS measurement, and this tool calculates the reputation based on the similarity values between the value offered by the service and the measured quality data value, but this algorithm is not updated for the trust and reputations, making trustworthiness information reflect the latest changes in service [44].

Nianhua et al. 2012. They have presented a reputation evaluation algorithm based in the similarity theory for the newly added web service; in addition, they use trust and similarities as weights for computing reputations from different recommenders [45]. Wang et al. 2011. Propose an approach for measuring reputation precisely, and they give a solution for the malicious rating of service users, and their approach, including two phases. In the first phase, they detect malicious feedback ratings using Cumulative Sum Method And the second phase, they use the Pearson Correlation Coefficient to detect and reduce the effect of different user feedback [46]. Nepal et al. 2010. Present a fuzzy trust evaluation approach for web services, and they present a trust-based reputation management framework for web service selection [47].

Sathya et al. 2010. They are evaluated the various techniques that are used in the quality of service based service discovery approach; also, they defined a set of criteria for QoS discovery approach; in addition, they organized the approaches into three main categories, including functional based service discovery approach, non-functional based service discovery approach, and user-based service discovery approach [48]. Josang et al. 2008. Used Bayesian reputation systems as a trust model to evaluating the quality of service in a single framework [49].

TABLE 3.1: Approaches of QoS prediction

Approaches	Main idea	Advantage	Disadvantage
neighborhood-based	Also named collaborative filtering (CF) approaches,which utilize the historical invocation information of similar neighbors to make a prediction.	Easy to understand and implement.	1-Bad prediction accuracy when the data density is very low. 2-Not suitable to be used on very large datasets.
Model-based	Matrix factorization (MF) is one of the most well-known model-based, which is to exploit the latent factors that can determine QoS both from the user and the service aspects.	Accurate and scalable in many applications.	Building efficient models.

3.4 Approaches of QoS prediction via Reputation

Most of the researchers assume that the QoS values are obtained from service providers but, may be unreliable, or the QoS values we need may be unknown. Therefore, many researchers have suggestions of how to predict the unknown QoS values [50][51][52].

There are two main types of approaches to predict QoS values for web services the first approach is one is neighborhood-based and the second approach called model-based approaches. Table (3.1) represents the summary of the main idea, advantage and disadvantage of the two approaches.

Qiu et al. 2013 have proposed a reputation-aware QoS value prediction approach based on CF and in the first step, the authors calculate the reputation of each user based on their contributed values and then takes advantage of reputation-based ranking to exclude the values contributed by unreliable users [53]. Tang et al. 2014 have proposed a hybrid trust-aware service recommendation method for a service-oriented environment with social networks via combining global trust and local trust evaluation [54]. Jianlong et al. 2016 present an effective QoS prediction approach, namely RMF, for predicting unknown web service QoS values [55].

In this work, we adopted on five QoS properties (Ava, Rel, RT, P, Rep) when calculating the aggregation function and we used bee algorithm to solve the selection the optimal composite web service problem. Due to the lack of sufficient information such as information of similar neighbours services about reputation so we added some missing information in the dataset that was obtained from websites that test the quality of service.

Chapter 4

Methodology

This chapter describes the methodology that has been used in this thesis. In section 4.1 we discuss our proposed system model used to measure the impact of reputation factor on the selection process of composite web service. Section 4.2 describes the structure of web service. Section 4.3 describes reputation module and update reputation algorithm. Section 4.4 describes the mechanism of calculating the QoS for composite service. Final section describes the bee algorithm.

4.1 The proposed model to measure the impact of a reputation factor

In this section, we discuss our proposed model used to measure the impact of reputation factor on the selection process of composite web service. We divide our proposed model into five steps, which must be consecutive as Figure (4.1) .

4.2 Structure of Web Service

This step expresses a structure of web service in SOA that we mentioned in chapter 2. Initially, the service provider publishes its own services and makes them available on the internet, through attaching a description of service and QoS which is in the format of WSDL file and this file is stored in the web services registry. Then the service consumer tries to search his own desired service in the registry that suit his own requirements in term of QoS. The consumer sends his request as input data which in turn is translated into a message in XML language. Then the consumer waits for the response message. The response occurs immediately after the search process, through receiving a massage

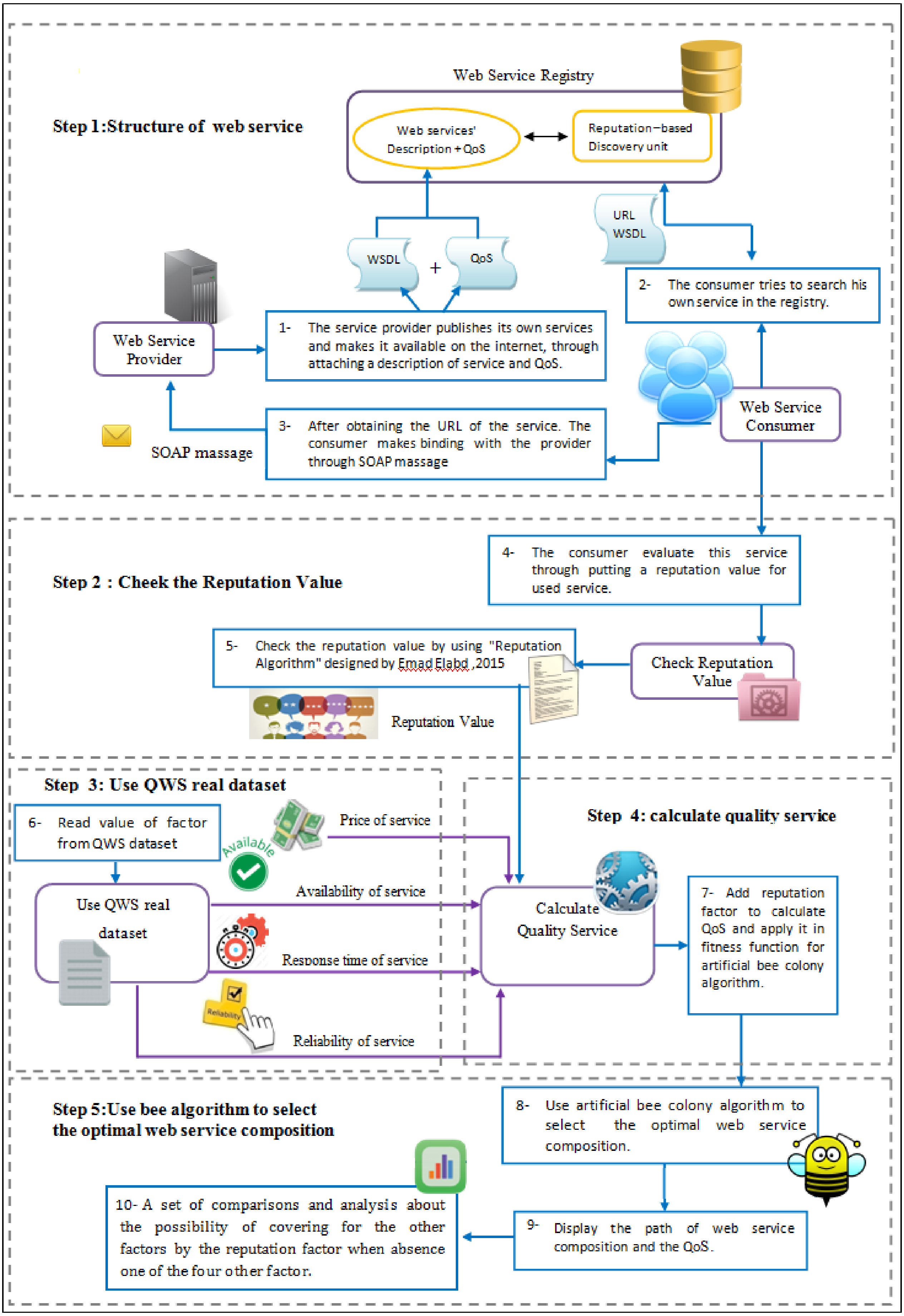

Figure 4.1: The proposed model of measuring the impact of reputation factor on the selected web service composition process

of URL WSDL file about target service. After obtaining the URL of the web service from the registry, the consumer makes a binding with the provider through SOAP message. At this stage, a consumer can use this service efficiently.

4.3 Reputation Value

Web service selection is one of the challenges in SOA; actually, selecting the best web service available on the internet is equivalent to selecting the most trusted web service with the highest ranking level, so we need to focus on adopting trust and reputation technology as a solution for web service selection problem. Reputation is originally a subjective conception for it expects for future behavior of an entity depends on past behaviors.

In SOA, the reputation quality considers a measure of trustworthiness for web service. The reputation of the services is an important parameter in QoS properties, for it is based on feedback from the consumers and user's experience using the service. In addition, when determining robust and precise reputation values for the web service, it reflects positively in the output from the web services discovery process by returning the most relevant services for the consumer; furthermore, reputation it essential in composition web services when selecting the best atomic services with high reputation, it helps in creating robust, high-performance, and cost-effective composite services.

Service reputation can be changed after the use of the service based on the different consumers opinions on the quality of web services. The dishonest consumers can assign incorrect values for the service reputation which affects on the discovery process, by returning an incorrectly ranked list of the relevant web service for the consumer [56], so the users rating is considered a very important factor for consumers to share their knowledge of direct experiences in interacting with the web services.

QoS approaches assume that the QoS data coming from service providers and the consumers are effective and trustworthy, but may be the QoS information published by the service providers not always be accurate and up-to-date; in other words, the values of QoS attributes which are provided by service providers may be unbelievable, the service providers sometimes may advertise higher QoS data than the actual level of the service in order to attract more users to use their services and so gain better benefits [57]. We need for both service providers and service consumers to define and determine the QoS. It is necessary to combine both subjective dimension (users feedback) and objective dimension (QoS performance monitoring) to assess the trust and reputation of web services.

4.3.1 Reputation Module

The service Reputation Module is responsible for collecting data from the service consumer, processing data, updating the Reputation Scores for a related service provider to ensure the integrity and objectivity of a web service reputation evaluation. We used the Reputation algorithm proposed by the El-Kafrawy et al for updating reputation of the web services based on the trust factors of the consumers and reputation threshold (RT) [58]. Algorithm (1) illustrates the process of update reputation value.

4.4 Calculate Quality of Service

This section explains the mechanism of calculating the QoS; in addition illustrates the main formulation that we need to understand the basic information about web service and composite web service, and which is explained as follows:

Formula 1 [web service(s)]: web service is a four-tuple. S= ID, Source, Function, QoS where:

- ID is the unique identification of web service.
- The source is the fundamental information including service name and publisher.
- The function is a function describing web services.
- QoS is the quality of web service.

$s \epsilon S$, where S represent web service set, which has identical functions but different non-functional attributes (QoS) [59].

Formula 2 [Quality of service (QoS) Properties]: QoS can be expressed as a five-tuple $QoS =< Availability, Reliability, ResponseTime, Price, Reputation >$.

The concentration of this work is mainly focused on five QoS attributes. The response time comes under the performance dimension, but the reliability and the availability come under dependability. In addition; the price represents the cost of service, but the reputation comes from the dimension of customer satisfaction. In this subsection, we provided definition and rules for five QoS attribute to computing its value.

Algorithm 1 Update Service Reputation Algorithm Pseudo Code [58]

Input

- Current reputation value of the service (it is null in the beginning).
- The trust factor threshold (TFT)and reputation threshold (RT).
- Consumer assigned reputation value (a).
- Consumer trust factor (can be null, in case that the consumer does not access any services from this registry before).

Output

- Updated reputation value for the service.
- Updated trust factor value for the consumer.

four different cases for calculating the reputation value for a service:

Case 1: The service is used for the first time. It has no reputation value assigned before and the consumer has no trust factor. The calculation of reputation is:

$$Ru(S_i) = \mathbf{a}.$$

where $Ru(S_i)$ the new updated Reputation Score for service S_i, i is the number of service and (**a**) represents the reputation value assign by the consumer.

Case 2: The service already has a Reputation Score; the consumer has no trust factor. In this case, the Reputation Module calculates the trust factor of consumer after updating the Reputation Score of service as follow:

if $|a - R_{ci}(S_i)| < RT$ **then**
    $Ru(S_i) = \left|\frac{a+R_{ci}(S_i)}{2}\right|$
else
    $Ru(Si) = Rci(Si)$
End If
$T(Ci) = 1 - \frac{\left|\frac{a-Rci(Si)}{100}\right|}{2}$

where $Rci(S_i)$ is the current Reputation Score of the service S_i and $T(C_i)$is the new trust factor for consumer i,$0 < T(Ci) < 1$.

Case 3: The service already has a Reputation Score and the consumer has trust factor.

$T(C_i) = \frac{(1 - \frac{\left|\frac{a-RC_i(S_i)}{100}\right|}{2}) + T(C_i)}{2}$
if $T(C_i) > TFT$ **then**
    if $a > Rc_i(S_i)$ **then**
        $Ru(S_i) = (\left|\frac{a-Rc_i(S_i)}{2}\right| * T(C_i)) + Rc_i(S_i)$
    else
        $Ru(S_i) = (\left|\frac{a-Rc_i(S_i)}{2}\right| * T(C_i)) + a$
    End If
Else
    $Ru(S_i) = Rc_i(S_i)$
End If

where $Tc(C_i)$ is the current trust factor of consumer i.

Case 4: The service already has no Reputation Score and the consumer has a trust factor.

if $Tc(C_i) > TFT$ **then**
    $Ru(S_i) = a * Tc(C_i)$
EndIf
$T(C_i) = Tc(C_i)$

4.4.1 QoS Properties

- **Response Time (RT)**

  Response time is the main factor for evaluating web service. In order to evaluate the service response time to a request, it includes the measurement of both the execution time and the waiting time. Equation (4.1) represents the response time.

$$ResponseTime(s) = ExecutionTime(s) + WaitingTime(s) \tag{4.1}$$

  – *Execution Time:* is the time required to perform service functionality.

  – *Waiting Time:* is the seconds elapsed for other activities. The small example for this response time is the message exchange between the service provider and the service consumer [60].

- **Availability (Ava)**

  Availability is the degree to which a service is operational and accessible when it is required for use. Availability is defined by the proportion of the services uptime to the downtime. Availability is represented by the Mean Time Between Failure (MTBF) and Mean Time To Recovery (MTTR) [60]. Equation (4.2) represents the availability.

$$Availability = \frac{UpTime(s)}{UpTime(s) + DownTime(s)} \tag{4.2}$$

- **Reliability (Rel)**

  Reliability is the service providers ability in order to successfully deliver the requested service functionality. This ability can be quantified by the probability of success in a service execution, but it is usually evaluated through the service failure rate. The service failure rate is calculated as the ratio of execution time and the mean time between failures (MTBF) [60]. Equation (4.3) represents the Reliability.

$$Reliability = 1 - FailureRate(s) \tag{4.3}$$

- **Price (P)**

  Price means the total fee from a user submitting service request to service execution being complete and returning results. Equation (4.4) represents the Price of service.

$$Price = ExecutionFeeCost(S) \tag{4.4}$$

- **Reputation (Rep)**

  It refers to consumers opinions on the quality of web services. The reputation quality is the measure of its trustworthiness. In another word reputation measures the degree of reliability of web service, mainly it depends on the user's experience using the service. Different end users can have different opinions about the same service. Authors as (Zeng et.2003 al and Liu et al.2004), defined the reputation as the average ranking given to the service by end users. Equation (4.5) represents the Reputation.

$$Reputation = \frac{\sum_{b=1}^{N} K_b}{N} \tag{4.5}$$

where k_b is the b^{th} ranking given to the service and N is the number of times the service has been ranked [61].

4.4.2 Combined Measure

The combined measure is the combination of all the five QoS factors such as response time, availability, reliability, price and reputation. The combined measure is given by equation (4.6)

$$QoS(s) =< Q_{Ava(s)}, Q_{Rel(s)}, Q_{RT(s)}, Q_{P(s)}, Q_{Rep(s)} > \tag{4.6}$$

4.4.3 Aggregation Formulas for QoS Computation of Composite Service

The aggregation rules are different for different QoS properties and based on the composition's control flow. In general, there are four main control patterns : Sequential, Parallel, loop and Selection. Each of them defines a separate aggregation rule. We have listed the aggregation rules for response time, price, availability, reliability and reputation in Table (4.1) [3]. Figure (4.2) represents the patterns for Service Composition, and this is illustrated in detail as follows:

Any execution path of web service composition is composed of four fundamental patterns [1]:

1. Sequential Figure (4.2.a): The computation formula for QoS is listed in Table (4.1.a).

2. Parallel Figure (4.2.b): Each Si is executed in parallel and the computation formula for QoS is listed in Table (4.1.b).

3. Loop Figure (4.2.c): Supposing that circulation model is executed k times. The computation formula for QoS is listed in Table (4.1.c).

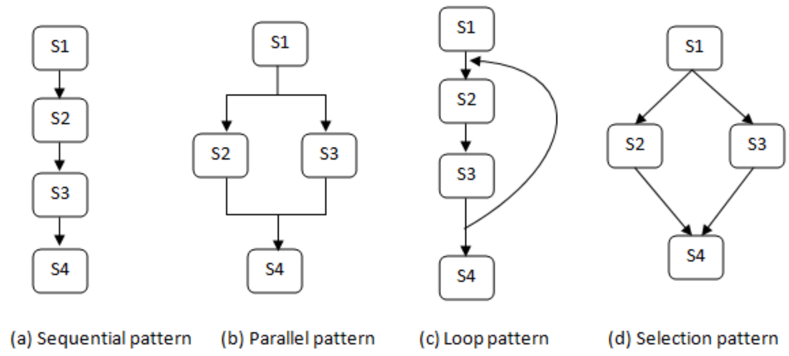

FIGURE 4.2: Four fundamental patterns for Service Composition [1]

4. Selection Figure (4.2.d): Supposing that the probability of each service Si being selected P_i. $\sum_{i=1}^{n} P_i = 1$ The computation formula for QoS is listed in Table (4.1.d).

Assuming that the other three non-sequential patterns can be converted to the sequential, so in this work, we depend on the sequential pattern as the basic to research the issue of web service composition optimization.

Formula 3 [QoS pretreatment]: Different types of indexes have different dimensions. It is necessary to eliminate the incommensurability stemming from different dimension and different dimension unit [62]. Therefore, all indexes need to be normalized to a dimensionless interval according to a certain utility function (usually it is normalized to [0,1]).

There are two phases in merging the multi-dimention resource constraints.

1. Scaling Phase: QoS properties were divided into negative and positive. Negative includes response time and price for service. The better service has less response time and less cost, so they are negative and normalized by equation (4.7).

$$V_{m,j} = \begin{cases} \frac{Q_j^{max} - Q_{m,j}}{Q_j^{max} - Q_j^{min}} & , Q_j^{max} - Q_j^{min} \neq 0 \\ 1 & , Q_j^{max} - Q_j^{min} = 0 \end{cases} \tag{4.7}$$

Positive includes availability, reliability and reputation.the better service has higher availability, reliability and reputation, so they are positive and normalized by Equation (4.8).

$$V_{m,j} = \begin{cases} \frac{Q_{m,j} - Q_j^{min}}{Q_j^{max} - Q_j^{min}} & , Q_j^{max} - Q_j^{min} \neq 0 \\ 1 & , Q_j^{max} - Q_j^{min} = 0 \end{cases} \tag{4.8}$$

Table 4.1: Aggregation formulas to compute the overall QoS of service compositions [3]

QoS property	(a) Sequential	(b) Parallel	(c) Loop	(d) Selection
Availability	$\prod_{i=1}^{m} A(S_i)$	$\prod_{i=1}^{p} A(S_i)$	$A(S)^k$	$\prod_{i=1}^{n} P_i * A(S_i)$
Reliability	$\prod_{i=1}^{m} R(S_i)$	$\prod_{i=1}^{P} R(S_i)$	$R(S)^k$	$\prod_{i=1}^{n} P_i * R(S_i)$
Response Time	$\sum_{i=1}^{m} T(S_i)$	$Max(T(S_i)_{i\epsilon\{1\cdots\cdots p\}})$	$K * T(S)$	$\sum_{i=1}^{n} P_i * T(S_i)$
Price	$\sum_{i=1}^{m} P(S_i)$	$\sum_{i=1}^{p} P(S_i)$	$K * P(S)$	$\sum_{i=1}^{n} P_i * P(S_i)$
Reputation	$f_S(F(S_i))$, $i\epsilon\{1\cdots\cdots m\}$	$f_P(F(S_i))$, $i\epsilon\{1\cdots\cdots p\}$	$f_L(F(S_i))$, $i\epsilon\{1\cdots\cdots k\}$	$f_C(F(S_i))$, $i\epsilon\{1\cdots\cdots n\}$

Where $m = (1, 2, 3, \cdots\cdots, N)$ represents number of services, $j = (1, 2, 3, 4, 5)$ represents number of properties,Q_j^{min}, Q_j^{max} represents the minimum and maximum thej^{th} property, and $Q_{m,j}$ represents the j^{th} property of service m.

2. Weighting Phase: After scaling phase, weight determines based on the nature and type of web service

$$Q = \begin{cases} \sum_{i=1}^{5} \omega_i V_i \\ \sum_{i=1}^{5} \omega_i = 1 \quad , 1 \geq \omega_i \geq 0 \end{cases} \tag{4.9}$$

where ω_i represents weight of the jth property,Q represents the Quality of web service.

Formula 4 [Service Composition(SC)]: Service Composition is a multi-tuple. Equation (4.10) represents the SC [59].

$$SC = s_i^j | s_i^j \in S_i \wedge i \in [1, n] \wedge j \in [1, m] \tag{4.10}$$

Where:

- S_i denotes the set of candidate services of the ith sub task
- S_i^j represent the jth web service of candidate service set in the ith sub-task
- n and m_i represent the number of sub-tasks and candidate services in the ith sub-task.

We can conclude that in Equation (4.11).

$$SC \in S_1 \times S_2 \times \cdots \times S_{n-1} \times S_n \tag{4.11}$$

We take the example of calculating QoS for travel composite service that illustrated in figure (2.3). In Table (4.2) we suppose to have three task and each task has candidates

TABLE 4.2: Example of travel composite service and their factors

Task 1	Task 2	Task 3
Atomic service 1 Task 1 RT: 505ms, P: 200$, A: 94%, R: 83%	Atomic service 1 Task 2 RT: 103ms, P: 135$, A: 97%, R: 73%	Atomic service 1 Task 3 RT: 270ms, P: 50$, A: 95%, R: 90%
Atomic service 2 Task 1 RT: 170ms, P: 50$, A: 92%, R: 73%	Atomic service 2 Task 2 RT: 427ms, P: 80$, A: 88%, R: 80%	
	Atomic service 3 Task 2 RT: 123ms, P: 155$, A: 87%, R: 95%	

TABLE 4.3: Data after normalization process

Task 1	Task 2	Task 3
Atomic service 1 Task 1 RT: 0, P: 0, A: 1, R: 1	Atomic service 1 Task 2 RT: 1, P: 0.2, A: 1, R: 0	Atomic service 1 Task 3 RT: 1, P: 1, A: 1, R: 1
Atomic service 2 Task 1 RT: 1, P: 1, A: 0, R: 0	Atomic service 2 Task 2 RT:0, P: 1, A: 0.1, R: 0.3	
	Atomic service 3 Task 2 RT: 0.9, P: 0, A: 0, R: 1	

TABLE 4.4: Calculation QoS for all paths

Path of Composite service	Calculation Process	QoS	Accuracy of the solution
service1Task1–> service1Task2–> service1Task3	RT= (0*0.25)+(1*0.25)+(1*0.25) = 0.5 C=(0*0.25)+(0.2*0.25)+(1*0.25) = 0.3 A=(1*0.25)*(1*0.25)*(1*0.25) = 0.0156 R=(1*0.25)*(0*0.25)*(1*0.25) = 0	QoS=0.5+0.3 +0.0156+0 =0.8156	0.10195
service1Task1–> service2Task2–> service1Task3	RT= 0. 25, C= 0. 50, A=0.0015625,R=0.0046875	QoS= 0.75	0.09375
service1Task1–> service3Task2–> service1Task3	RT= 0.475, C= 0.25, A= 0, R= 0.015	QoS= 0.74	0.0925
Service2Task1–> service1Task2–> service1Task3	RT= 0.75, C= 0.55, A= 0, R= 0	QoS= 0.55	0.06875
Service2Task1–> service2Task2–> service1Task3	RT= 0.50, C= 0.75, A= 0, R= 0	QoS=1.25	0.15625
Service2Task1–> service3Task2–> service1Task3	RT= 0.725, C= 0.50, A = 0, R= 0	QoS=1.22	0.1525

service. Task 1: Airplane Service has 2 candidates service. Task 2: Hotel Service has 3 candidates service. Task 3: Care Renter Service has 1 candidate service. Because of the heterogeneity of the data units, so the data will be subject to the process of normalization based on equations (4.8) and (4.9). The result data after normalization between (0 - 1). Table (4.3) represent the data after normalization process. Based on equation (2.1) the number of path = 2 * 3 * 1 = 6. Table (4.4) illustrates the calculating process of QoS for all paths based on equation (4.2) and based on sequence aggregation in table (4.2). The best path colored blue is Service2Task1−− > service2Task2−− > service1Task3. The QoS equals 1.25, and it has a higher accuracy from among all solutions is the closest to the optimal solution.

In the previous example we took the small number of candidate service, but in the real world the number of candidate service are increasing with the passage of time, and this increase called exponentially increase because the number of possible paths become huge as illustrated in Figure (4.3); therefore, we need algorithm to select the optimal path without passing on all paths available, so in this theses we proposed to use the

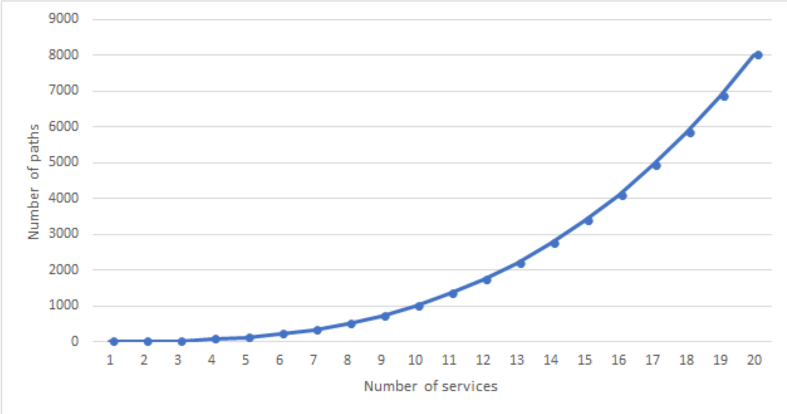

FIGURE 4.3: Exponential increased of the possible paths

bee algorithm to select the optimal path, and the following section displays the bee algorithm in the details.

4.5 Multi Objective Bees Algorithm

In the real world, there are many problems requiring the best solution to satisfy numerous objectives, so we need for methods such as Multi-Objective Optimization (MOO) to solve these problems. MOO (also called multi-criteria optimization, multi-performance or vector optimization) [63]. The Bees Algorithm is inspired by the honey bees natural foraging behavior it has been developed by Pham et al. It is based on natural foraging behavior of honey bees.

4.5.1 Bees in Nature

Scout bees move randomly looking for food sources. When they return to the hive, scout bees deposit the nectar that they have collected during the search process. Then they start to do a ritual called waggle dance to communicate with other bees and give them information about the food source [64]. The waggle dance is performed in a particular area of the hive called the dance floor, and communicates three basic pieces of information regarding the flower patch: the direction where it is located (angle between the sun and the patch), its distance from the hive (duration of the dance), and its quality rating (frequency of the dance) [65], [66]. After the waggle dance, the dancer bee goes back to the flower patch with its followers, called recruited bees. The number of recruited bees depends on the quality rating of the patch. Flower patches that contain rich and easily available nectar or pollen sources attract the largest number of followers

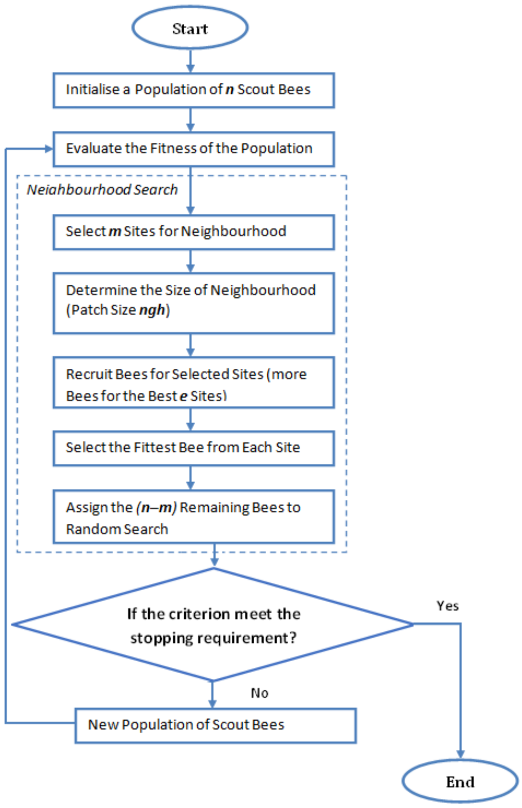

FIGURE 4.4: The flow chart of the basic Bees Algorithm

(foragers)[67], [68]. Once a recruited forager returns to the hive, it will in turn waggle dance to direct other idle bees towards the food source. Flower patches with plentiful amounts of nectar or pollen that can be collected with less effort should be visited by more bees, whereas patches with less nectar or pollen should receive fewer bees.

4.5.2 The Bees Algorithm

The Bees Algorithm is an optimization algorithm inspired from the natural foraging behavior of honey bees to find the optimal solution. Figure (4.4) shows the flowchart of the Basic Bees Algorithm [69]. The bees algorithm required a number of parameters to be set, namely: n, m, e, ngh, nep and nsp. Table (4.5) illustrates all parameters.

The pseudo code of bees algorithm is shown in Algorithm (2). The algorithm starts with n scout bees randomly distributed in the search algorithm. In step 2 we calculate the fitness of sit visited by scout bees and then we storing the value in array then the array will be reordered based on the evaluation from the higher to the lower value. In step 3 stop condition when ending the number of repetitions imax. In step 4 the m site will be selected randomly from n, then the best e site out of m that determent randomly.

TABLE 4.5: All parameters and the description

Parameters	Description
n	The number of scouts bees.
m	The number of sites selected out of n visited sites.
e	The Number of best sites out of m selected sites
ngh	Initial size of patches ngh which includes site and its neighbourhood and stopping criterion.
nep	The number of bees recruited for best e sites.
nsp	The number of bees recruited for the other (m-e) selected sites.
n-m	Remaining bees to random search.

In step 5 determine the Size of Neighbourhood (ngh). In step 6 the algorithm searches around the selected site. In step 7 The remaining bees in the population will be assigned randomly around the search space [69].

Algorithm 2 Pseudo code for the bees Algorithm [69]

1. Initialise population with random solutions.
2. Evaluate fitness of the population.
3. While (stopping criterion not met)
//Forming new population.
4. Select sites for neighbourhood search.
5. Recruit bees for selected sites (more bees for best e sites) and evaluate fitness.
6. Select the fittest bee from each patch.
7. Assign remaining bees to search randomly and evaluate their fitness.
8. End While.

Simple Example of Bees algorithm

This section illustrates a simple example that explains the use of bees algorithm to get the best value representing a mathematical function (fitness function). Figure (4.5) represents the initial population of scout bees (n = 10) in a random search and evaluates the fitness and this figure illustrates the first step in bees algorithm. Figure (4.6) illustrates the fourth step in bees algorithm which selects the best m site from n (m = 5) and then selects the best e site from m (e = 2);also, it selects sites by recruiting more (nep = 4) bees to the best e-sites and fewer (nsp = 2) bees to the non-elite best sites (m-e); therefore, it selects the best bee from every m site. Figure (4.7) represent initials new population. The remaining bees (n - m) in the population will be randomly assigned around the search space; also, the counter will be reducing until end number of the repetitions imax. Figure (4.8) represents the best solution.

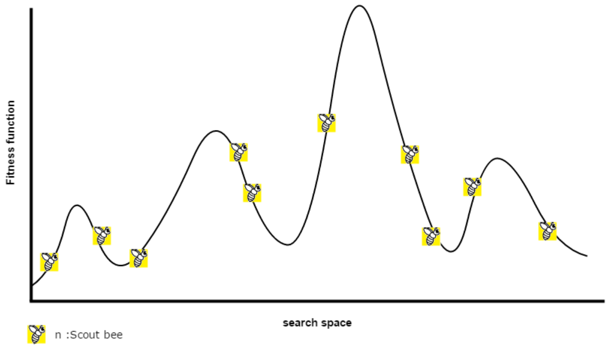

FIGURE 4.5: Initialise a Population of (n=10) Scout Bees with random Search and evaluate the fitness.

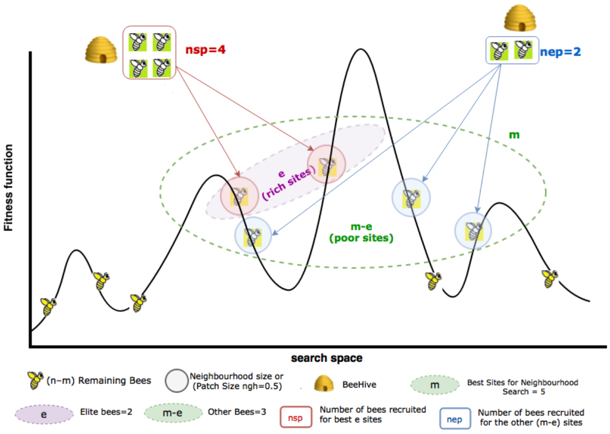

FIGURE 4.6: Select best m=5 and elite bees e=2. m-e=3 other selected bees, Recruit Bees for Selected Sites,determine the Size of Neighbourhood ngh=0.5

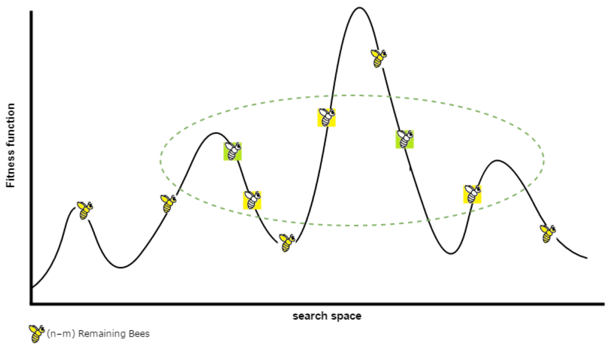

FIGURE 4.7: Assign the (n−m) Remaining Bees to Random Search

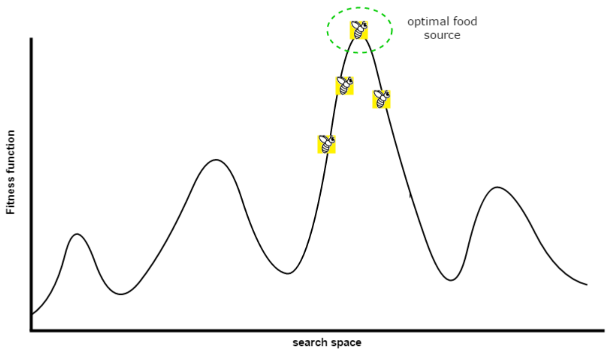

FIGURE 4.8: Find The Best bee

4.6 Regression Tools

Regression tools allow fitting a function to a set of data points by finding the parameters that best approximate it. In this study, we used two types of regression tools the first is multiple linear regression and the second is multiple polynomial regression. Two types used for the relation between several variables, but the linear function that best fits a given set of data points.

The result can have a small -usually insignificant- deviation from optimality, but usually it is very good and further improvement possibilities are very small [70].

4.6.1 Multiple linear Regression(MLR)

A multiple linear regression model is a linear model that describes how a y-variable relates to two or more x variables. A multiple linear regression model with N predictor variables $x_1, x_2, \cdots, x_N$ and a response y , can be written as the following equation (4.12)

$$y = \beta_0 + \beta_{1x_1} + \beta_{2x_2} + \cdots \beta_{Nx_N} + \epsilon. \quad (4.12)$$

where β are regression coefficients, ϵ is a scalar called the error term and N is the number of sample data [71].

4.6.2 Multiple Polynomial Regression(MPR)

In general, we can model the expected value of y as an n^th degree polynomial, can be written as the following equation (4.13)

$$y = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \cdots + \beta_m x_i^m + \epsilon_i, i = 1, 2, 3 \cdots n. \quad (4.13)$$

where β are regression coefficients, ϵ is a scalar called the error term, m is the degree of the polynomial and n is the number of sample data [72]. In this work, we used online multiple linear regression tools and online multiple polynomial regression tools [71][72].

4.7 Analysis Of Variance Test (ANOVA)

The definition of ANOVA test "is a statistical procedure used to test the degree to which two or more groups vary or differ in an experiment and in most experiments, a great deal of variance (or difference) usually indicates that there was a significant finding from the research" [73]. ANOVAs are used in three ways: one-way ANOVA, two-way ANOVA, and N-way Multivariate ANOVA [74].

- One-Way ANOVA :A one-way ANOVA refers to the number of independent variables and it has just one independent variable.
- Two-Way ANOVA :A two-way ANOVA refers to an ANOVA using 2 independent variables.
- N-Way ANOVA :n-way ANOVA refers to using many independent variables simultaneously.

In this work, we used the second type that called (Two way ANOVA) to show if there are any statistical differences between the reputation factor and the other four factors.

Chapter 5

Experiments and Results

In this chapter, the experiment settings and the results will be described through six sections. Section 5.1 describes the experiment environment, the resources and the programming language. Section 5.2 briefs the dataset and algorithms used for implementing the solution. Section 5.3 presents the value of reputation after applying the "update service reputation algorithm". Section 5.4 describes the results of all the experiments and covers the mechanism of a collection of the QoS for the composite service. This section also illustrates the optimal solution using bee algorithm for many cases, and it contains a set of analyses about the possibility of covering for the other factors by the reputation factor when absence one of the four other factor. Section 5.5 introduces the results of predicting the reputation factor based on the other four factors. Section 5.6 describes the results of the association of reputation with the other four factors using ANOVA test.

5.1 Experiment Settings

We conducted the experiments on a computer which has the following specification: Intel (R)-Core i5, 2520M CPU, 250 GHz, a 4GB RAM processor, Microsoft Windows 7 and an 8Mbps Wi-Fi internet connection. Also, Java language is used to build the code of our experiments, and NetBeans IDE 8.0.2 to apply the experiments practically.

5.2 The Algorithms and The Dataset

In this thesis, two algorithms are used. The first algorithm is "Update Service Reputation algorithm" and the second one is "Multi-Objective Bees Algorithm". Update

Service Reputation algorithm is used for updating the reputation value for the service based on the value that given by the consumer after using it. This algorithm was also used for updating the trust factor of the consumer. Multi-Objective Bees Algorithm was used to find the optimal composite web service based on QoS.

In our experiments, a dataset with real QoS from Cloud Armor is used. Cloud Armor is a research project at the University of Adelaide which aims at developing a scalable trust management system for cloud services [75]. In this project, the researchers gathered the consumers' feedback from a set of cloud computing providers such as Cloud Hosting Reviews, Best Cloud Computing Providers, and Cloud Storage Reviews and Ratings [75]. The dataset contains approximately 10,000 feedbacks by 7,000 consumers for 113 real-world cloud services and the feedbacks are based on Quality of Service (QoS) attributes [75]. In addition, we added some missing information in the dataset that was obtained from websites that test the quality of service [76][77].

After that, a simulation program using Java language is built to evaluate each web service based on "trust result" attribute in the dataset. This attribute depends on user's opinion of the evaluated service. It is also used to measure the impact of reputation factor on selecting composite web service. In addition, we used the program to create a set of comparisons to show the possibility of covering for the other factors by the reputation factor.

We suppose that the composite service contains three tasks as a simple composite service. We divided the dataset into four sets, each having three tasks and each task has about 9 candidate services. Each candidate service has four real QoS properties (Ava, Rel, RT, P). The tables from Table (A.1) to Table (A.4) in Appendix A contains the average for each of the real QoS properties for all services in the dataset.

5.3 Results of evaluating reputation for the web service

We used the Reputation algorithm proposed by the El-Kafrawy for updating reputation of the web services based on the trust factors of the consumers and reputation threshold (RT), and we described an example of how we obtained the updated reputation value for each atomic service in the composite service.

The example was on the first service named 1and1 located within the first set. The results of the example are illustrated that in Table (A.5) in Appendix A and it shows the reputation value and the value of trust factor in each assessment by consumers. We just documented the results for the service, because the results generated by the update reputation algorithm of the whole service were very large data, and we just illustrated

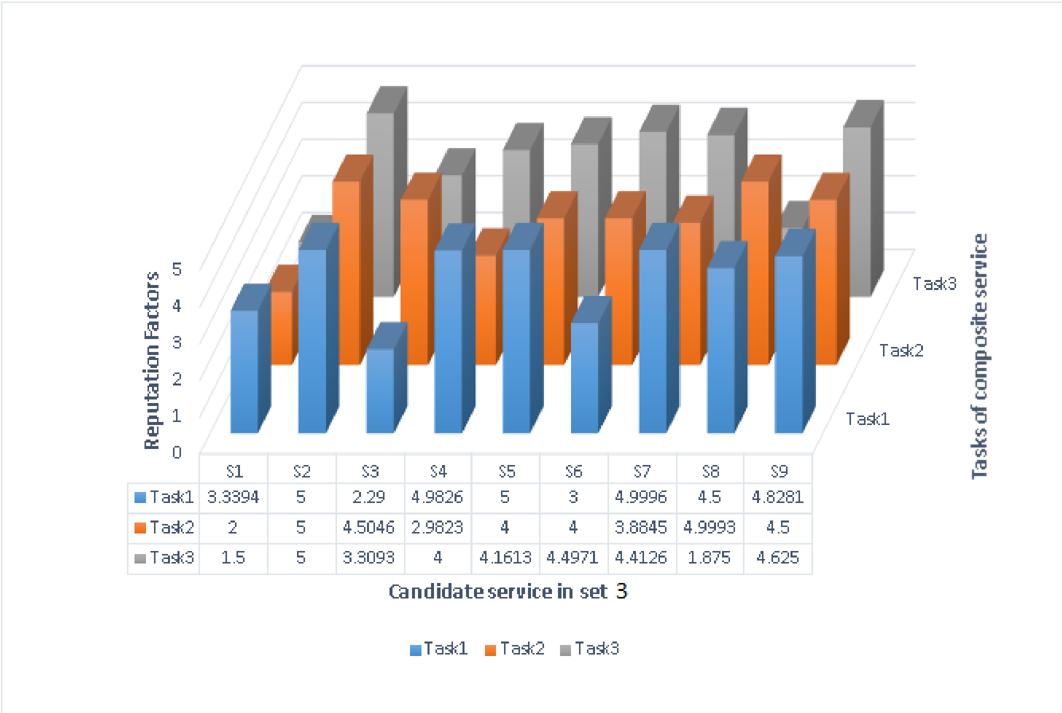

FIGURE 5.1: The Composite Web Service based on Reputation Factor

TABLE 5.1: The QoS information of the composite service in Set 3.

Set 3					
	Task 1				
Service in Task 1	Availability	Reliability	ResponseTime	Price	Reputation
IConvergentComputing	null	null	5	5	5
Service in Task 2	Task 2				
Janalent	null	null	5	4.6667	5
Service in Task 3	Task 3				
Meritide	null	null	5	4.625	5

the mechanism of the update process and how the reputation changed in after every evaluation by a user; and how the trust factor changed after the consumers used the services.

This mechanism has been applied for all services to obtain the value of the reputation factor. After we completed the evaluation of all services, we obtained a reputation value based on the user's assessments of services. The tables from Table (A.6) to Table (A.9) in Appendix A contain the value of reputation factor that was calculated by the update service reputation algorithm and the last value is the approved value. Figure (5.1) represents the composite web service based on reputation factor, and we used the reputation value for the services located in set 3. As shown in Figure (5.1), the second service in each task received the highest reputation value. Table (5.1) contains the QoS information of Set 3, and as shown in table the value of the reputation factor was closed to the QoS properties which indicates that this value is logical.

5.4 Results of the Experiments

We set up an experiment to study the effect of reputation factor on other QoS factors (Ava, Rel, RT, P). More specifically, our experiment aims to check whether the reputation factor will cover the absence of one or more QoS factor or not. To this end, we conduct our experiment three times. The first setting is conducted using the data of the four factors availability, reliability, response time and price. In the second setting, we replaced the reliability factor with the technical support factor due to the lack of sufficient information about the reliability factor in the dataset. The third setting is conducted on services that have full data information. In each experiment's setting, we suggested 7 cases for selecting the optimal composite path using bee algorithm. The following sub-sections will illustrate our experiments in details.

5.4.1 Results of Experiment 1

As we mentioned, this experiment is conducted using the data of four factors (Ava, Rel, RT, P) that are available in the dataset. In the following, we will firstly calculate the QoS in composite service. Then, the optimal solution using bees algorithm and based on higher QoS is selected. Finally, we will discuss our finding and results of this experiment.

5.4.1.1 Calculating QoS in Composite Service

Before calculating the QoS for the path of each atomic service data must undergo normalization using the negative normalization equation (4.7) and positive normalization equation (4.8) which were mentioned previously. Table (5.2) represents an example that explains how to calculate normalization factors of the service 1and1. The normalization processed aimed at making the data easier to deal with because they have different units. Naturally, the smaller the value of response time and price the better, so these two factors underwent negative normalization equation (4.7). In contrast, it is desirable to have a greater value for the other three factors, so those factors were normalized using the positive normalization equation (4.8). Then we calculated the overall QoS by using sequential aggregation function in Table (4.2) which was mentioned previously. Table (B.1) to Table (B.4) in Appendix B contain the results of normalization data for all factors, and the third column in Table (B.5) in Appendix B lists the results of the overall QoS for all cases.

TABLE 5.2: The mechanism of calculation normalization of data

1And1				
Factors	Max value	Min value	Current value	normalization
Availability	5	1.8302	2.3284	$V_m^i = \frac{Q_{m,j}-Q_j^{min}}{Q_j^{max}-Q_j^{min}} = \frac{2.3284-1.8302}{5-1.8302} = 0.1572$
Reliability	5	2.32	2.32	$V_m^i = \frac{Q_{m,j}-Q_j^{min}}{Q_j^{max}-Q_j^{min}} = \frac{2.3-2.3}{5-2.3} = 0$
Response Time	5	2	2.94	$V_m^i = \frac{Q_j^{max}-Q_{m,j}}{Q_j^{max}-Q_j^{min}} = \frac{5-2.94}{5-2} = 0.6867$
Price	4.41	1	3.0018	$V_m^i = \frac{Q_j^{max}-Q_{m,j}}{Q_j^{max}-Q_j^{min}} = \frac{4.41-3.0018}{4.41-1} = 0.4129$
Reputation	4.5	1	4.487	$V_m^i = \frac{Q_{m,j}-Q_j^{min}}{Q_j^{max}-Q_j^{min}} = \frac{4.487-1}{4.5-1} = 0.9963$

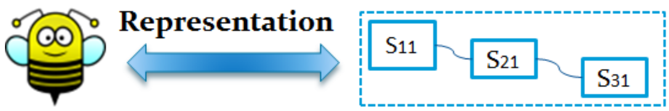

FIGURE 5.2: The representation of solution in bee algorithm

TABLE 5.3: Parameter setting of multi-objective bees algorithm

The Parameters
The number of scout bees n = 200
The number of sites selected m out of n visited sites; Randomly generated by the computer.
The Number of best sites e out of m selected sites; Randomly generated by the computer.
Initial size of patches ngh which includes site and its neighbourhood and stopping criterion 0.5 .
The number of bees recruited for best e sites nep = 40
The number of bees recruited for the other (m-e) selected sites which is nsp = 20
The number of algorithm steps repetitions imax= 1000
The fitness function represent the Quality of service.

5.4.1.2 Selecting the optimal solution using bees algorithm based on higher QoS

We ran the bee algorithm to select the optimal solution for composite service. The bee algorithm starts with n scout bees, and we supposed the initial population of scout bees n =200 solutions. scout bees, here represents the composite service path. Figure (5.2) illustrates the representation of solution in bee algorithm. Selecting a solution depends on the higher fitness function. The fitness function for each solution is calculated based on QoS as mentioned previously. The solutions are ranked based on QoS from highest to the lowest. Based on the bee algorithm, the second step is to randomly select the best m site from n, and then selecting e from m. Other bees are recruited to the m and e sites. Forty solutions are recruited to the e site while half of that number is recruited to the m site based on the size patches (ngh). This process is repeated until imax ends. Table (5.3) contains the parameter setting of multi-objective bees algorithm.

We applied bee algorithm into several cases to study the possibility of covering reputation factor during the absence of one of the other four factors. We made a comparison between the case in which the reputation factor is absent with a set of cases that have the reputation value but lack one of the other factors.

The following cases were suggested:
- Case 1: in this case, we took the following factors (Ava, Rel, RT, P) to get an optimal solution without considering the reputation factor in QoS.
- Case 2: in this case, we took the following factors (Rel, RT, P, Rep) to get an optimal solution without considering the availability factor in QoS.
- Case 3: in this case, we took the following factors (Ava, RT, P, Rep) to get an optimal solution without considering the reliability factor in QoS.
- Case 4: in this case, we took the following factors (Ava, Rel, P, Rep) to get an optimal solution without considering the response time factor in QoS.
- Case 5: in this case, we took the following factors (Ava, Rel, P, Rep) to get an optimal solution without considering the price factor in QoS.
- Case 6: in this case, we took the all five factors (Ava, Rel, RT, P, Rep) to get an optimal solution .
- Case 7: in this case, we only took the reputation factor to get an optimal solution.

We conducted the selection process 10 times to get an optimal path with the highest quality. In addition, this has been applied to all four sets and also for all suggested cases. Table (B.4) to Table (B.8) in Appendix B contain the results of the optimal path, the QoS and the accuracy of the path for all sets.

5.4.1.3 The Summary of results in experiment 1

In Table (5.4) we summarized all the results of the first experiment for all sets (Set1, Set2, Set3 and Set4). The column (QoS) in the table represents the quality of service value that was obtained by the selected path using bee algorithm while the (accuracy of the solution) represents the proximity of the optimal solution. Matching ration represents the result of comparing the path obtained from case 1 with the path obtained from each the other suggested case. As the dataset contained null values the percentage was calculated in the tasks in all the suggested case. The average of the null value for three tasks was calculated as the null value ration.

Figure (5.3) represents the differences of QoS for each set in all the cases. As shown in Figure (5.3), we note that the factor of availability is an important factor because in its absence the QoS was low and in contrast, the price is less important and as shown in the figure the absence of price factor has no significant impact on QoS. Figure (5.4) represents the accuracy of solution path for each set in all the cases in the absence of one of the four factors. As shown in Figure (5.4), the case of "4 Factors without availability" has received less accuracy of solution for all sets but the case of "4 Factors without price" has received higher accuracy of solution for set 1, set 2 and set 4.

Table 5.4: The table of analytical of first experimental results in the absence of one of QoS factors

Experiment 1: all Factors used are Availability, Reliability, Price, Response Time						
	Set 1					
	4 Factors without Reputation (Ava, Rel, RT, P)					
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas	Null value	Null value ration
4 Factors without Availability (Rel, RT, P, Rep)	3.0087	0.752175	33%	T1	T1=19.4%, T2=10%, T3=25%	18.10%
4 Factors without Reliability (Ava, RT, P, Rep)	2.9688	0.7422	66%	T1, T3	T1=16.6%, T2=12.5%, T3=16.6%	15.20%
4 Factors without Price (Ava, Rel, RT, Rep)	3.1823	0.795575	66%	T1, T3	T1=30.5%, T2=16%, T3=31.1%	23.40%
4 factors without Response Time (Ava, Rel, P, Rep)	3.1389	0.784725	0%	No match	T1=22.2%, T2=17.5%, T3=30.5%	25.80%
All five Factors (Ava, Rel, RT, P, Rep)	3.6379	0.72758	100%	T1, T2, T3	T1=24.4%, T2=16%, T3=31.1%	23.80%
1 Factor the Reputation (Rep)	1	1	33%	T3	T1=0%, T2=0%, T3=0%	0%
	Set 2					
	4 Factors without Reputation (Ava, Rel, RT, P)					
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas	Null value	Null value ration
4 Factors without Availability (Rel, RT, P, Rep)	3.0699	0.767475	100%	T1,T2,T3	T1=30.5%, T2=19.4%, T3=12.5%	20.80%
4 Factors without Reliability (Ava, RT, P, Rep)	3.0699	0.767475	100%	T1,T2,T3	T1=27.7%, T2=16.6%, T3=12.5%	18.90%
4 Factors without Price (Ava, Rel, RT, Rep)	3.4877	0.871925	66%	T1, T3	T1=50%, T2=30.5%, T3=21.8%	26.30%
4 factors without Response Time (Ava, Rel, P, Rep)	3.0818	0.77045	33%	T2	T1=41.6%, T2=25%, T3=21.8%	34.10%
All five Factors (Ava, Rel, RT, P, Rep)	3.9817	0.79634	100%	T1,T2,T3	T1=40%, T2=24.4%, T3=17.5%	27.30%
1 Factor the Reputation (Rep)	1	1	0%	No match	T1=0%, T2=0%, T3=0%	0%
	Set 3					
	4 Factors without Reputation (Ava,Rel,RT,P)					
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas	Null value	Null value ration
4 Factors without Availability (Rel, RT, P, Rep)	2.8362	0.70905	33%	T1	T1=30.5%, T2=16.6%, T3=19.4%	22.20%
4 Factors without Reliability (Ava,RT,P, Rep)	3.1213	0.780325	66%	T1,T2	T1=22.2%, T2=16.6%, T3=22.2%	20.30%
4 Factors without Price (Ava, Rel, RT, Rep)	2.9556	0.7389	100%	T1, T2, T3	T1=38.8%, T2=30.5%, T3=33.3%	34.20%
4 factors without Response Time (Ava, Rel, P, Rep)	3.0772	0.7693	0%	No match	T1=41.6%, T2=25%, T3=30%	32.40%
All five Factors (Ava, Rel, RT, P, Rep)	3.2041	0.64082	66%	T1, T3	T1=33.3%, T2=24.4%, T3=26.6%	28.10%
1 Factor the Reputation (Rep)	1	1	0%	No match	T1=0%, T2=0%, T3=0%	0%
	Set 4					
	4 Factors without Reputation (Ava, Rel, RT, P)					
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas	Null value	Null value ration
4 Factors without Availability (Rel, RT, P, Rep)	3.0247	0.756175	0%	No match	T1=25%, T2=18.7%, T3=29.5%	24.40%
4 Factors without Reliability (Ava, RT, P, Rep)	3.2041	0.801025	33%	T1	T1=27.7%, T2=14.5%, T3=25%	22.40%
4 Factors without Price (Ava, Rel, RT, Rep)	3.4179	0.854475	0%	No match	T1=45.4%, T2=25%, T3=38.6%	36.30%
4 factors without Response Time (Ava, Rel, P, Rep)	3.2291	0.807275	33%	T2	T1=27.2%, T2=18.7%, T3=27.2%	24.40%
All five Factors (Ava, Rel, RT, P, Rep)	3.6733	0.73466	33%	T2	T1=36.3%, T2=20%, T3=30%	29%
1 Factor the Reputation (Rep)	1	1	0%	No match	T1=0%, T2=0%, T3=0%	0%

We compared the path result of the first case with the results of the rest suggested cases which have mentioned in the previous section to analyze the match ratio in the solution of the path. For example, when taking the case when Availability factor was absent and comparing it to the case with no reputation the result showed that the proporation of matching was 33% and the similarity is in the service that achieved the task one (T1).

In addition, the result when comparing the case of "4 factors without reputation" with the case of "4 factors without reliability" indicates that the proportion of similarity was

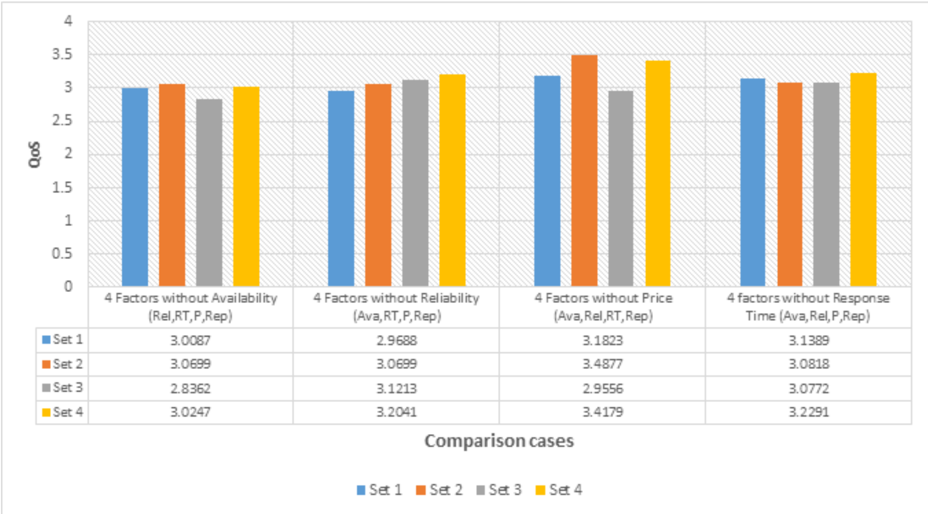

FIGURE 5.3: Experiment 1 The differences in QoS for each set in all cases in the absence one of the four factors.

66% and the similarity is in the service that achieved the task one (T1) and task three (T3). The same results apply for the case of "4 factors without price". In contrast, there is no similarity when comparing the case of "4 factors without reputation" with the cases of "4 factors without response time" and "1 factor: the reputation".

We explained the ratio of the similarity through a set of figures. It was found that the orange color area which represents the absence of the factor of reliability, appeared in all four sets. It constituted 66%, 100%, 66%, 33% in Figures 5.5, 5.6, 5.7 and 5.8 respectively. This indicates that in the case of absence of the reliability factor the reputation factor can cover for it because there is a matching ratio, but there is some doubt about reliability factor because the dataset contained null values especially the reliability, so the experiment was repeated by replacing the reliability with technical support because it contained sufficient data.

Because the similarity of the path is incomplete we analyzed the percentage of the null values in the dataset. It was found that the coverage area had the highest null ration. The null ration for figures 5.9, 5.10, 5.11, and 5.12 was 25.80%, 34.10%, 32.40% and 24.40%. By looking at the figures that represent the matching ration the area in the case of the absence of response time, it is seem that there is little or no matching which indicate that there is a relationship between the proportion of matching and the proportion of null values.

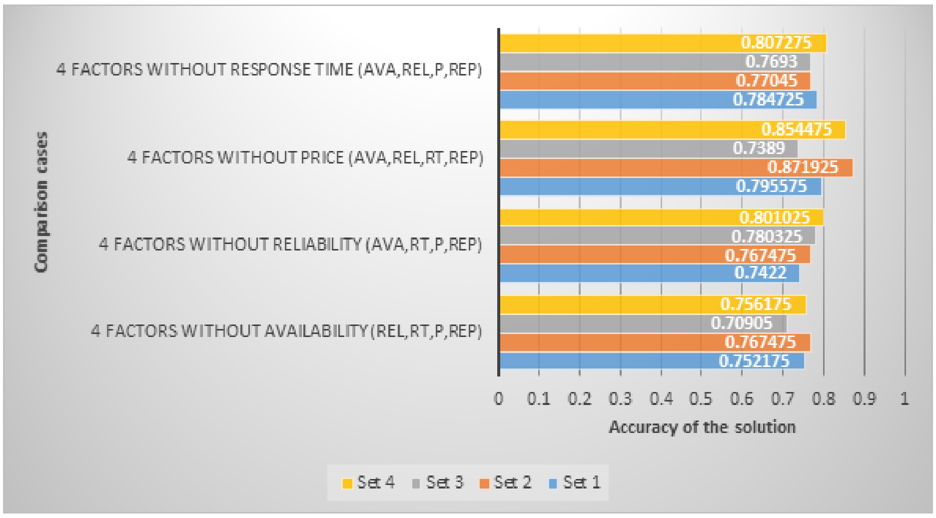

FIGURE 5.4: Experiment 1 The accuracy of solution path for each set in all cases in the absence one of the four factors.

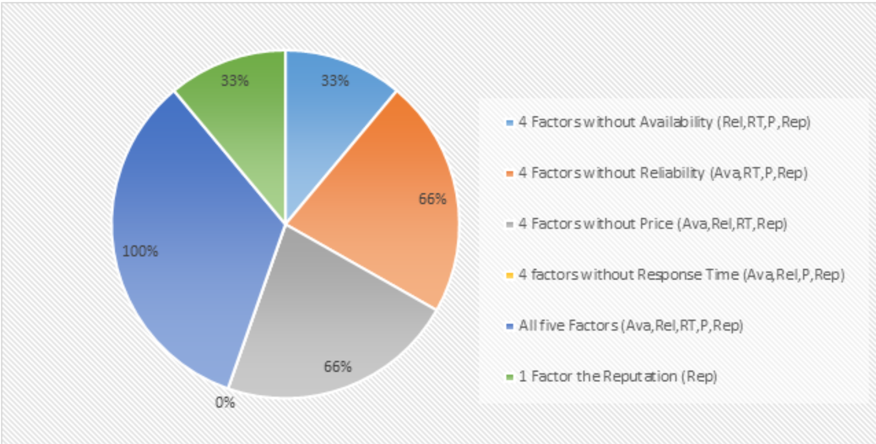

FIGURE 5.5: Experiment 1 (Set 1) The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, Rel, RT, P)".

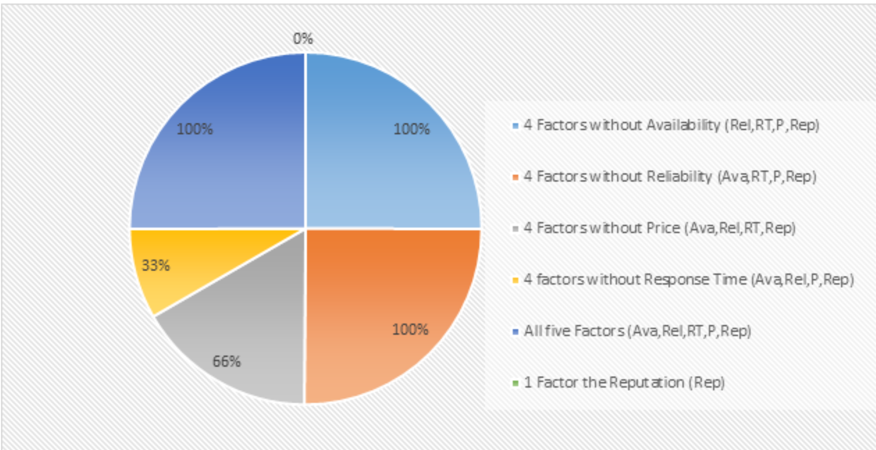

FIGURE 5.6: Experiment 1 (Set 2) The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, Rel, RT, P)".

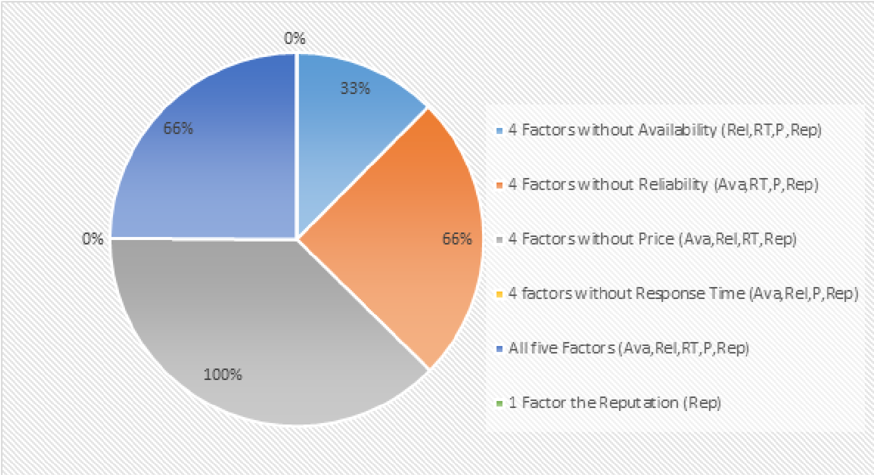

FIGURE 5.7: Experiment 1 (Set 3) The Matching ratio of the paths in all cases with the path in case 1 ”4 Factors without Reputation (Ava, Rel, RT, P)”.

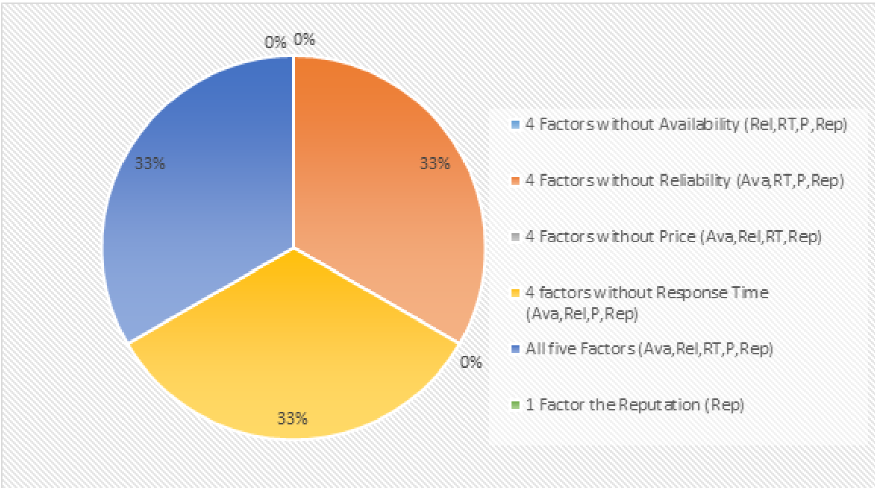

FIGURE 5.8: Experiment 1 (Set 4) The Matching ratio of the paths in all cases with the path in case 1 ”4 Factors without Reputation (Ava, Rel, RT, P)”.

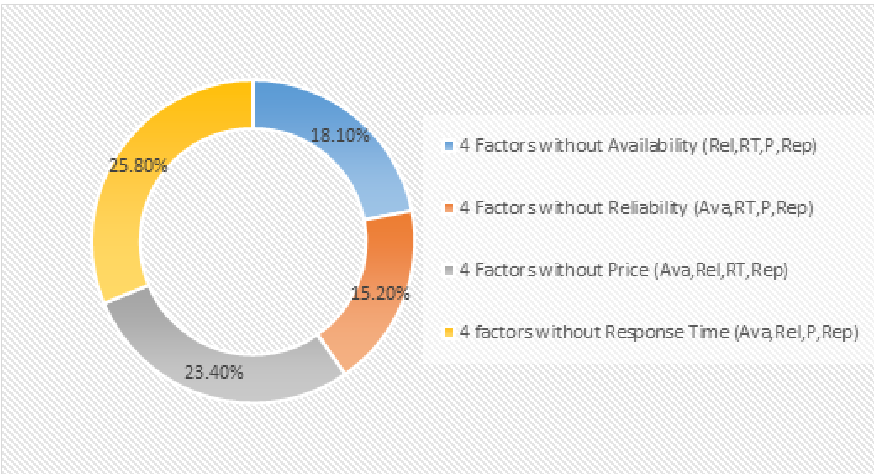

FIGURE 5.9: Experiment 1 (Set 1) The null ratio in all cases.

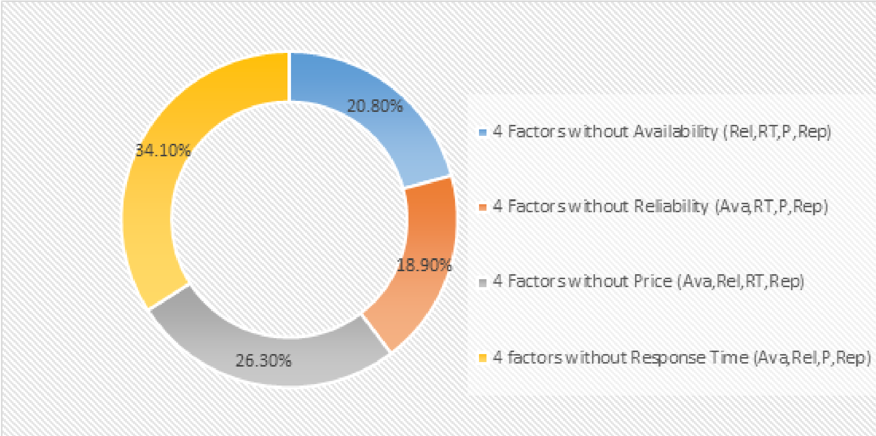

FIGURE 5.10: Experiment 1 (Set 2) The null ratio in all cases.

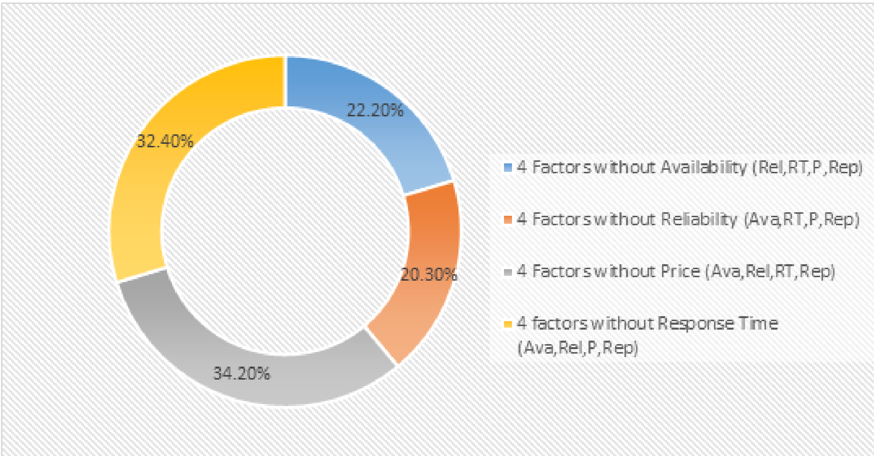

FIGURE 5.11: Experiment 1 (Set 3) The null ratio in all cases.

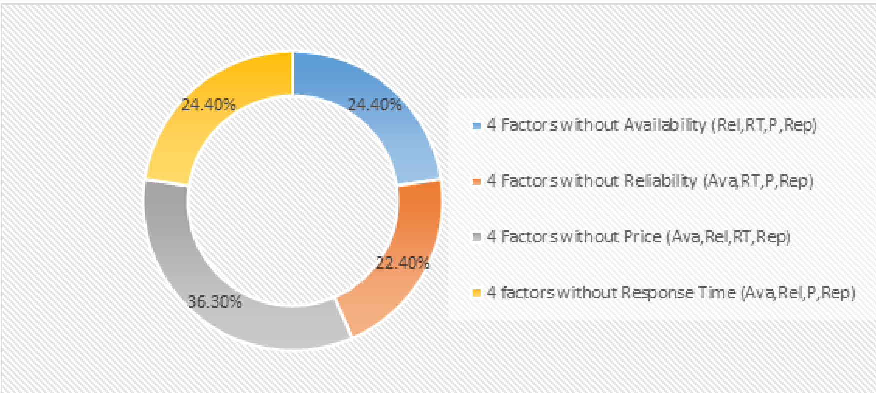

FIGURE 5.12: Experiment 1 (Set 4) The null ratio in all cases.

Table 5.5: The table of analytical of second experimental results in the absence of one of QoS factors

Experiment 2: all Factors used are Availability, TechnicalSupport, Price, Response Time				
	Set 1			
	4 Factors without Reputation (Ava, TS, RT, P)			
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas
4 Factors without Availability (TS, RT, P, Rep)	2.8861	0.721525	33%	T3
4 Factors without TechnicalSupport (Ava, RT, P, Rep)	2.8146	0.70365	100%	T1, T2, T3
4 Factors without Price (Ava, TS, RT, Rep)	3.4175	0.854375	33%	T3
4 factors without Response Time (Ava, TS, P, Rep)	3.0735	0.768375	33%	T3
All five Factors (Ava, TS, RT, P, Rep)	3.4412	0.68824	33%	T3
1 Factor the Reputation (Rep)	1	1	33%	T3
	Set 2			
	4 Factors without Reputation (Ava, TS, RT, P)			
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas
4 Factors without Availability (TS, RT, P, Rep)	2.6429	0.660725	66%	T1, T2
4 Factors without TechnicalSupport (Ava, RT, P, Rep)	3.0699	0.767475	100%	T1, T2, T3
4 Factors without Price (Ava, TS, RT, Rep)	3.2174	0.80435	0%	No match
4 factors without Response Time (Ava, TS, P, Rep)	3.0035	0.750875	0%	No match
All five Factors (Ava, TS, RT, P, Rep)	3.429	0.6858	100%	T1, T2, T3
1 Factor the Reputation (Rep)	1	1	0%	No match
	Set 3			
	4 Factors without Reputation (Ava, TS, RT, P)			
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas
4 Factors without Availability (TS, RT, P, Rep)	2.7017	0.675425	66%	T2, T3
4 Factors without TechnicalSupport (Ava, RT, P, Rep)	3.1213	0.780325	33%	T1
4 Factors without Price (Ava, TS, RT, Rep)	3.3869	0.846725	66%	T2, T3
4 factors without Response Time (Ava, TS, P, Rep)	2.9847	0.746175	0%	No match
All five Factors (Ava, TS, RT, P, Rep)	3.585	0.717	100%	T1, T2, T3
1 Factor the Reputation (Rep)	1	1	0%	No match
	Set 4			
	4 Factors without Reputation (Ava, TS, RT, P)			
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas
4 Factors without Availability (TS, RT, P, Rep)	3.0251	0.756275	66%	T2, T3
4 Factors without TechnicalSupport (Ava, RT, P, Rep)	3.2041	0.801025	100%	T1, T2, T3
4 Factors without Price (Ava, TS, RT, Rep)	3.8291	0.957275	100%	T1, T2, T3
4 factors without Response Time (Ava, TS, P, Rep)	3.1688	0.7922	33%	T2
All five Factors (Ava, TS, RT, P, Rep)	4.0069	0.80138	100%	T1, T2, T3
1 Factor the Reputation (Rep)	1	1	0%	No match

5.4.2 Results of Experiment 2

Due to the lack of adequate information and especially the reliability data that was collected in the first experiment from the websites that test the quality of service, we have replaced reliability factor with another factor, which is technical support due to the availability of its information in the original dataset. The aim of this experiment is to study the possibility of covering for the reputation factor in the absence of technical support factor, so we repeated the experiment using the four factors (Ava, TS, RT, P). Table (5.5) represents a summary of all the results of the second experiment for all sets (Set1, Set2, Set3 and Set4).

Table (B.9) to Table (B.12) in appendix B contain results of selecting an optimal path in all suggested cases for this experiment. Figure (5.13) represent the differences of QoS in experiment 2 for each set in all cases. Figure (5.14) represent the accuracy of solution path in experiment 2 for each set in all cases in the absence of one of the four factors.

As shown in the figures, the proportion of similarity was generally high, and especially in the case of absence of the technical support factor as it was 100% in Figure (5.15),Figure (5.16), and Figure (5.18) and 33% in Figure (5.17). This indicates that the reputation factor can cover for the technical support factor.

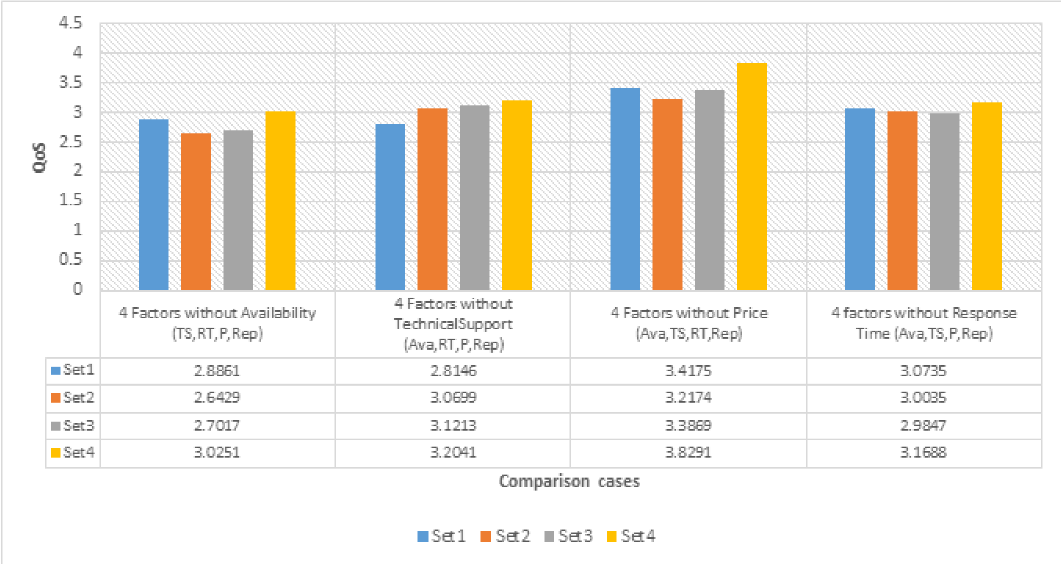

FIGURE 5.13: Experiment 2 The differences in QoS for each set in all cases in the absence one of the four factors.

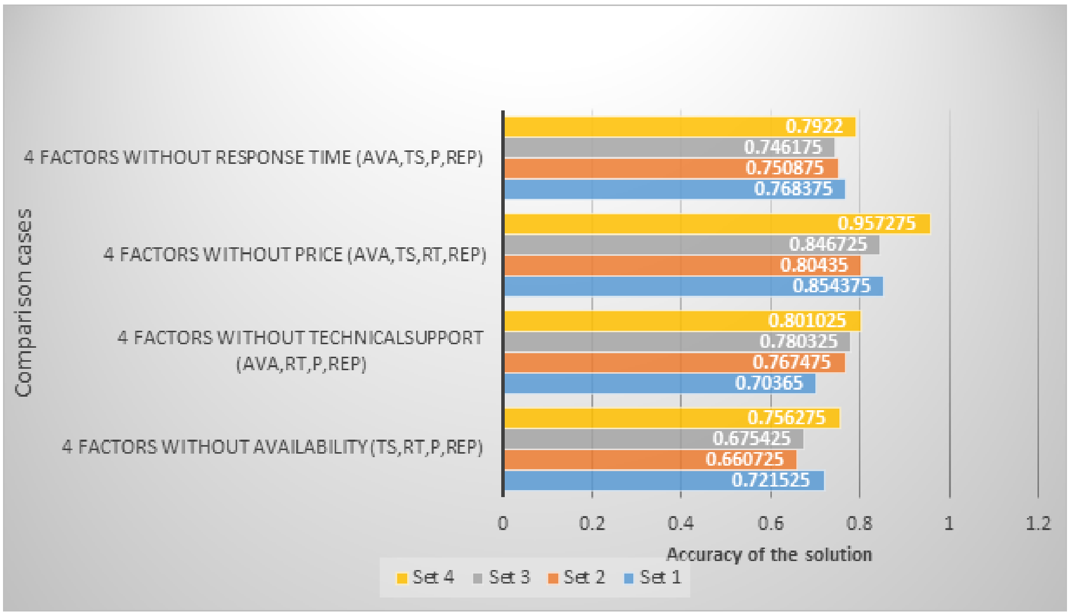

FIGURE 5.14: Experiment 2 The accuracy of solution path for each set in all cases in the absence one of the four factors.

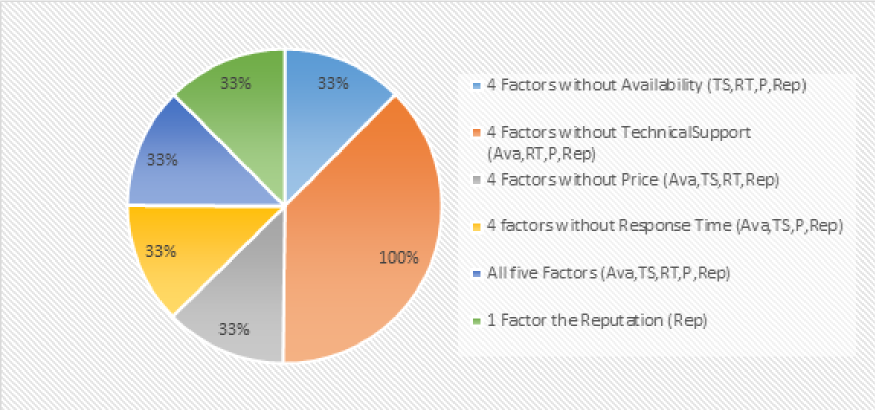

FIGURE 5.15: Experiment 2 (Set 1) The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, TS, RT, P)".

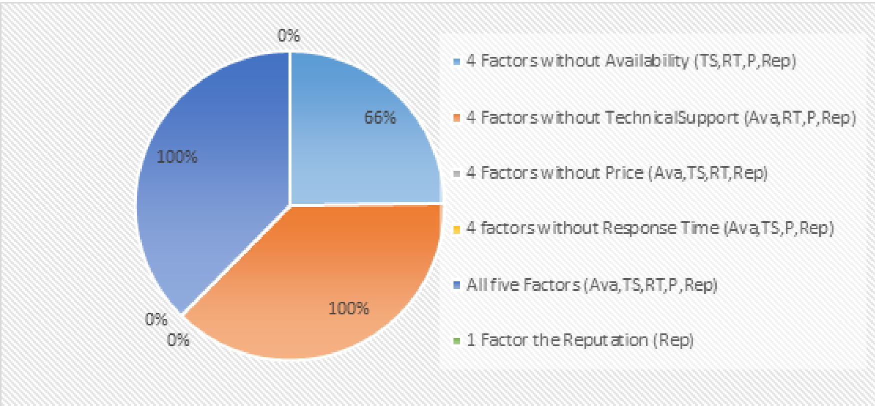

FIGURE 5.16: Experiment 2 (Set 2) The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, TS, RT, P)".

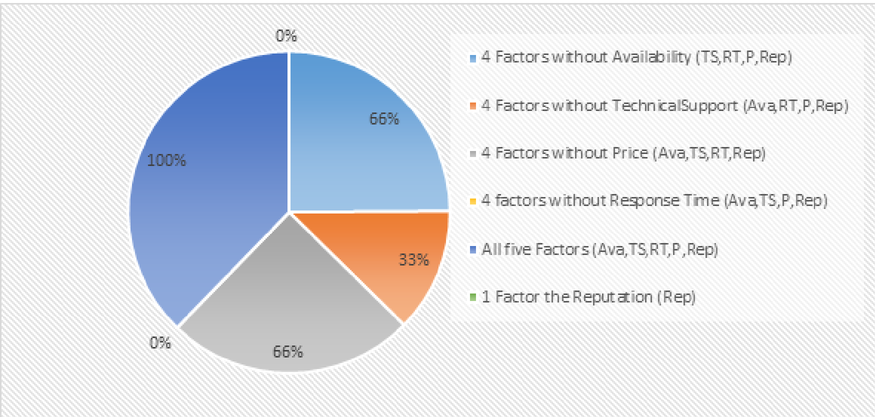

FIGURE 5.17: Experiment 2 (Set 3) The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, TS, RT, P)".

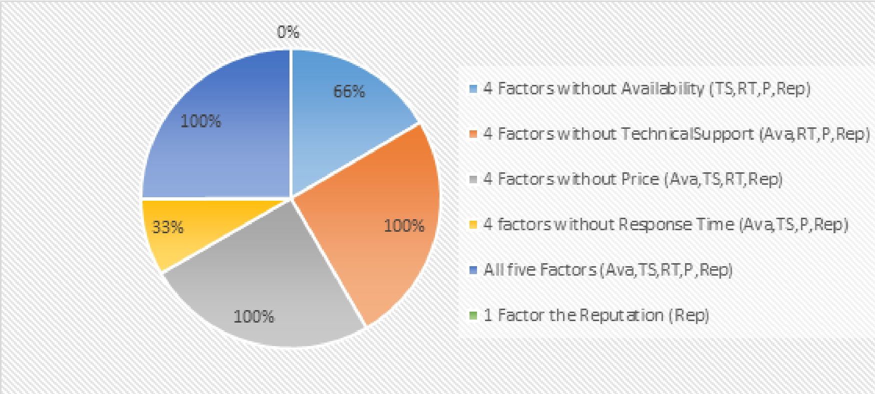

FIGURE 5.18: Experiment 2 (Set 4) The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, TS, RT, P)".

TABLE 5.6: The table of analytical of Third experimental results in the absence of one of QoS factors

Experiment 3: all Factors used are Availability, Reliability, Price, Response Time				
	4 Factors without Reputation (Ava, Rel, RT, P)			
Comparison	QoS	Accuracy of the solution	Match ratio of the path	Match areas
4 Factors without Availability (Rel, RT, P, Rep)	2.4399	0.609975	66%	T1, T3
4 Factors without reliability (Ava, RT, P, Rep)	2.4399	0.609975	0%	No match
4 Factors without Price (Ava, Rel, RT, Rep)	2.8295	0.707375	0%	No match
4 factors without Response Time (Ava, Rel, P, Rep)	2.9046	0.72615	33%	T2
All five Factors (Ava, Rel, RT, P, Rep)	2.9429	0.58858	33%	T2
1 Factor the Reputation (Rep)	1	1	0%	No match

5.4.3 Results of Experiment 3

Due to the factor that technical support is not considered one of the four main factors of QoS, we repeated the experiment by using 43 services that had full data about Availability, reliability, response time and price. We distributed the full services on the three tasks where each task had 14 candidate service. Table (B.13) in appendix B contains results of selecting an optimal path in all suggested cases for this experiment.

Table (5.6) represents the results of the third experiment in terms of similarity ratio with the path resulting from the case of the absence of reputation. Figure (5.19) represents the differences of QoS and shows that the availability and reliability factors have less QoS and this indicates their importance. Figure (5.20) illustrates the higher matching ratio in the absence of availability factor.

5.4.4 Discussion the experiments results

We summarized the results of the three experiments in Table (5.7) that presents the possibility of the reputation factor covering for the absence of one of the other factors. The coverage ration in Table (5.7) is the percentage of times that there were a possibility

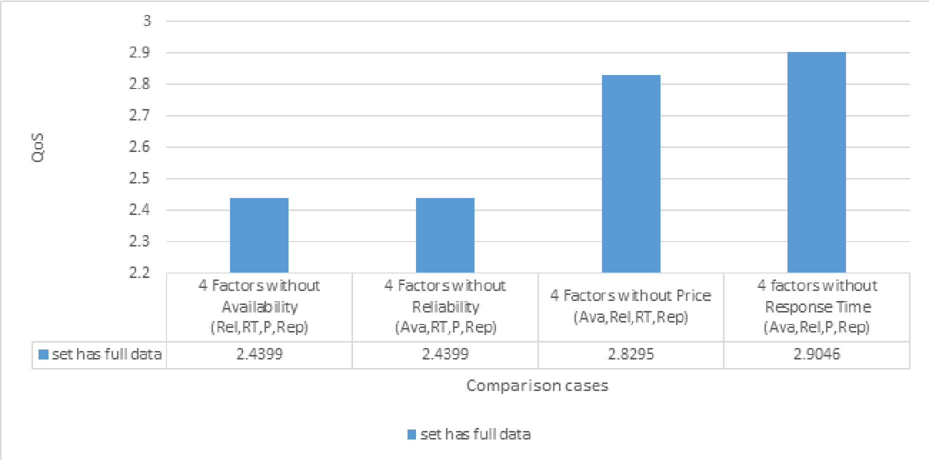

FIGURE 5.19: Experiment 3 The differences in QoS for each set in all cases in the absence one of the four factors.

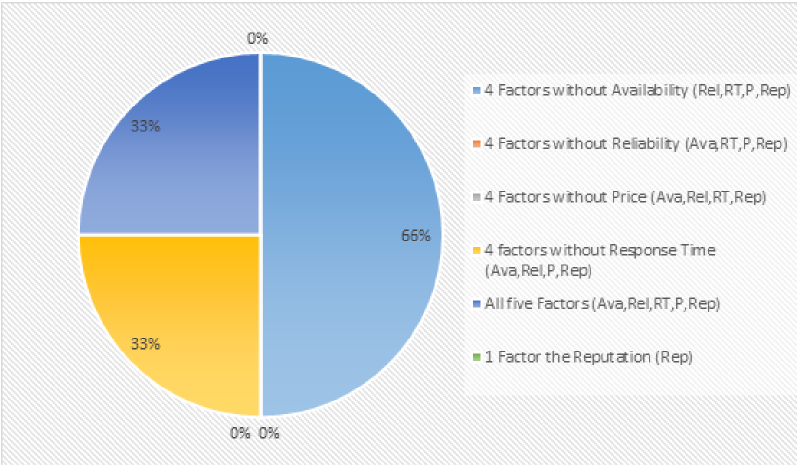

FIGURE 5.20: Experiment 3: The Matching ratio of the paths in all cases with the path in case 1 "4 Factors without Reputation (Ava, Rel, RT, P)".

TABLE 5.7: Covering reputation factor for the other factors

Experiments	Ex 1				Ex 2				Ex 3	Summary
factors / sets	Set1	Set2	Set3	Set4	Set1	Set2	Set3	Set4	full Set	Coverage ratio
Availability	yes	yes	yes	no	yes	yes	yes	yes	yes	92%
Reliability	yes	yes	yes	yes	-	-	-	-	no	50%
Response Time	no	yes	no	yes	yes	no	no	yes	yes	66%
Price	yes	yes	yes	no	yes	no	yes	yes	no	50%
TechnicalSupport	-	-	-	-	yes	yes	yes	yes	-	100%

that the reputation factor will cover for other factors, For example it was 92% for availability because it could cover for 3 out of 4 cases in Ex1 and all cases in Ex2 and Ex3. Based on the results in our experiments, it was suggested that the value of the coverage ration is accepted if it was higher the 50%. We conclude that the reputation factor can replace some factors such as availability, response time and technical support as shown in Figure (5.22).

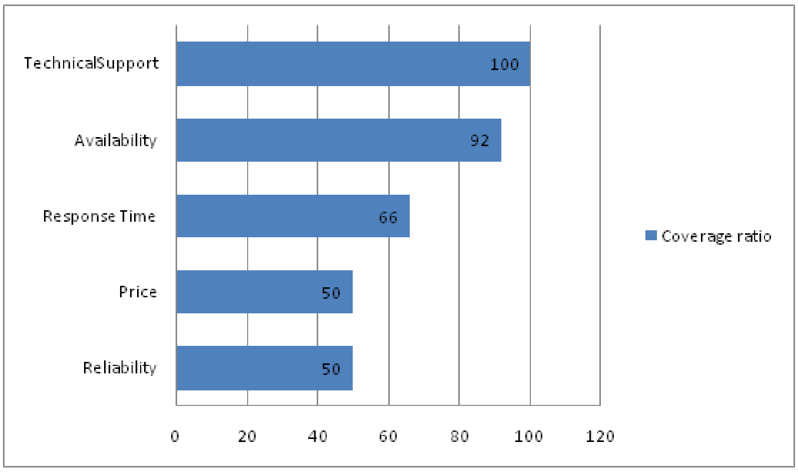

FIGURE 5.21: The ratio covering reputation factor for the other factors

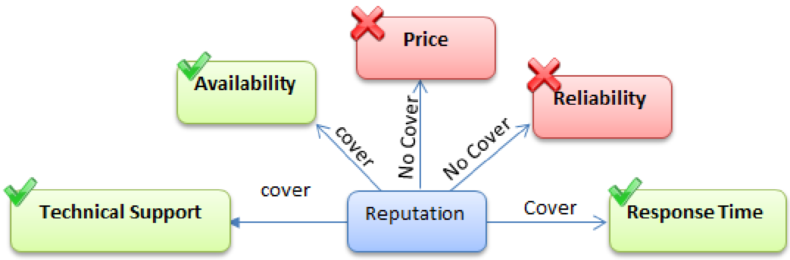

FIGURE 5.22: The Covering reputation factor for the other factors

5.5 Prediction of reputation factor based on the other factors

In this experiment, we used the services that have full data for all factors to predict the reputation depending on the other factors; so we divided the full data into two groups, the first group contained 32 rows of services. It was used as training data to obtain an equation using interpolation, but in the second group we used it as testing data for the 10 rows that were not used in the training data. In addition, we applied this data on the equation given by interpolation to predict reputation factors. Then we made a comparison between the actual value and the expected value for the reputation and we calculated the difference between them. Figure (5.23) represents the proposed model of prediction of reputation factor based on the other factors. In table (5.8), the yellow rows represent the training data that was used to create the equation of predict the reputation factor and the blue rows represent the testing data that was used to apply the equation. We used two types of interpolation to predict the reputation. The first is multiple linear regression and the second is multiple polynomial regression, the following section illustrates the results for the two types.

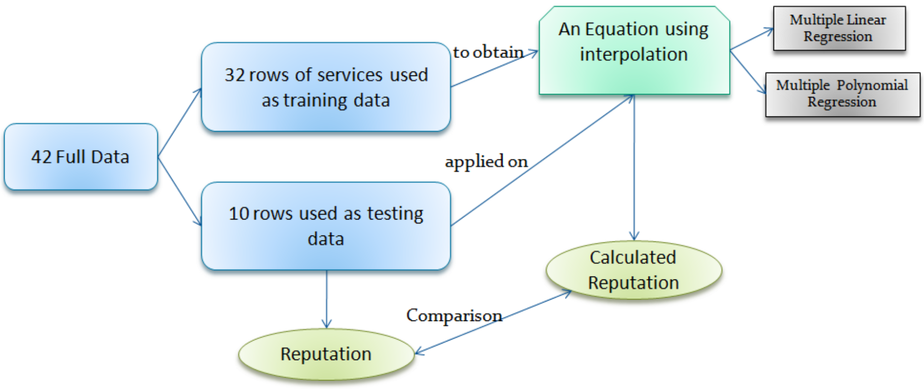

FIGURE 5.23: The proposed model of prediction of reputation factor based on the other factors

TABLE 5.8: The training data and testing data to predict the reputation factor

Name	Availability	Reliability	Response Time	price	reputation
1and1	2.3284	2.32	2.94	3.0018	4.486993236
Adrive	5	3	5	1	3
BlueHost	2.7611	3.3249	5	3.562	4.942989342
backupgenie	5	5	5	5	5
Backblaze	4	5	4	3.7692	3.883278564
awardspace	4.54	4.195	4.01	4.1167	4.485646609
Arvixe	4.9065	1.305	1.8	4.8785	4.999969078
Carbonite	2.3833	5	2.7	2.6494	3.691441943
DreamHost	3.3075	3.43	3.555	4.1339	4.679869088
Go Daddy	3.1401	3.495	4.6667	3.5603	4.726879345
FatCow	4.0395	4.0072	4	4.1855	4.016902852
Globat	2.0791	2.11	2.365	2.9887	3.965892984
elephantdrive	4.5	5	4	4	4.5
Dropbox	2.9091	5	3	2.9024	2.944600949
HostGator	4.3894	3.4516	4.785	4.4156	4.189902297
GreenGeeks	3.6548	4.0226	1.625	3.9641	4.073006159
HostMonster	2.752	3.3745	3.09	3.5021	4.646045624
iBackup	3.3077	4	3.7692	3.5714	4.733466845
icdsoft	4.8319	4.47	4.93	4.7699	4.612972107
InMotion	4.6156	4.4939	4.1	4.6155	4.982604943
iDrive	4.3333	5	4.6667	1.7273	2.290039063
iPage	3.7977	4.1637	2.395	3.8785	4.828120676
livedrive	4.3333	5	4	3.3333	3.884467051
Lunarpages	4.8554	3.395	3.24	4.8795	4.999264281
justcloud	4.3662	5	4.4789	4.6512	4.50462649
JustHost	3.5916	3.6938	4	4.0232	2.982307939
midPhase	2.0238	2.655	2.96	3.0238	3.309336427
Mozy	3.3714	5	3.5429	3.5094	4.161266753
MyPCBackup	4.55	5	4.75	4.7347	4.497148208
RealWebhost	4.7412	5	5	4.8118	4.999418991
Rackspace	2.7143	2.75	3.115	3	2.624513312
Powweb	2.2449	3.535	2.79	3.5102	4.870804964
10 for Testing					Actual value
SugarSync	3.8529	5	3.8824	3.4694	3.333496
sos-online-backup	3.9091	4	4.1818	3.6667	4.433403
Site5	2.8723	3.1	3.13	3.9574	2.776882
SiteGround	3.35	3.74	3.38	3.9324	4.935847
Servage	3.582	3.04	3.3	4.2869	4.960897
Surpass	3.6218	3.715	4.015	4.395	4.925798
u2web	4.8008	5	5	4.8459	4.99609
WebHostingHub	4.7302	4.925	4.89	4.5185	4.944645
WebHostingPad	4.1305	4.204	4.2776	4.5511	4.848659
Zip Cloud	4.6296	5	4.5926	4.6232	4.011588

TABLE 5.9: The results of multiple linear regression using training data

Experiments	Factors	Result	RSS	R^2
Ex1: multiple linear regression using all factors	X1=Ava, X2=Rel, X3=RT, X4=P, y=Rep	$Rep = -8.857560574 * 10^{-2}x_1$ $-1.016724442 * 10^{-1}x_2$ $+5.721720885 * 10^{-2}x_3$ $+6.402648477 * 10^{-1}x_4$ $+2.327258041$	8.5907	$5.266868602 * 10^{-1}$
Ex2: multiple linear regression without reliability factor	X1=Ava, X3=RT, X4=P, Rep	$Rep = -1.057107003 * 10^{-1}x1$ $+1.995351246 * 10^{-2}x3$ $+6.353639218 * 10^{-1}x4$ $+2.147311612$	8.8469	$5.125741727 * 10^{-1}$

5.5.1 Results of predicting reputation using multiple linear regression equation

This section illustrates the results of predicting reputation using multiple linear regression. We used the data of 32 services to predict reputation equation by multiple linear regression, then we conducted the experiment two times to test which equation is more convenient for data. In the first time we adopted all factors in predicting process and the result is equation (5.1), but the second time, we did not consider the reliability factor in the prediction process and the result was equation (5.2).

$$Rep = -8.857560574*10^{-2}x_1 - 1.016724442*10^{-1}x_2 + 5.721720885*10^{-2}x_3 + 6.402648477*10^{-1}x_4 + 2.327258041 \tag{5.1}$$

$$Rep = -1.057107003 * 10^{-1}x_1 + 1.995351246 * 10^{-2}x_3 + 6.353639218 * 10^{-1}x_4 + 2.147311612 \tag{5.2}$$

Where x_1 represents the availability, x_2 is the reliability, x_3 is the response time and x_4 is the price. Table (5.9) represents the results of the multiple linear regression, and as shown in the table (5.9) the Residual Sum of Squares (RSS) for Ex1 is more accurate than Ex2 and the reason is that the rss in the first experiment is lower and this means it is more fit based on the used data.

In addition, we applied the equation (5.1) on the 10 testing data and the results are presented in a table (5.10) where column "y" represents the value of the actual reputation and column "calculated y" represents the value of the predicted reputation based on the equation (5.1). As shown in the table, the percentage of error in predicting the reputation factor is low and it can be concluded that there is a correlation between the reputation factor and the other four factors. Figure (5.24) represents the difference between the actual reputation value and the predicted value of reputation using multiple linear regression. As shown in figure (5.24) the error rate in most services is low, but in the site5 service the ratio of error was high; almost 60%.

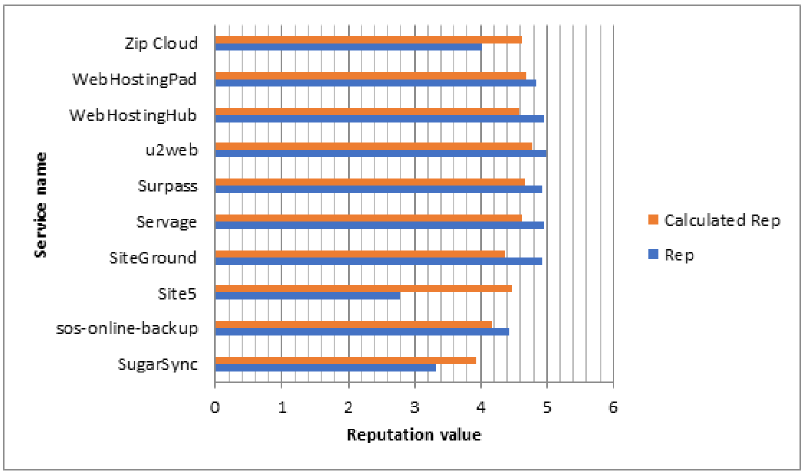

FIGURE 5.24: The difference between the actual reputation and the predicted value of reputation using multiple linear regression

TABLE 5.10: Data testing using multiple linear regression equation

Name	x1	x2	x3	x4	y	Calculated y	Error
SugarSync	3.8529	5	3.8824	3.4694	3.333496168	3.921098	0.176272
sos-online-backup	3.9091	4	4.1818	3.6667	4.433403363	4.161247	0.061388
Site5	2.8723	3.1	3.13	3.9574	2.77688167	4.470532	0.609911
SiteGround	3.35	3.74	3.38	3.9324	4.935847406	4.361446	0.116373
Servage	3.582	3.04	3.3	4.2869	4.96089671	4.634464	0.065801
Surpass	3.6218	3.715	4.015	4.395	4.925798021	4.672433	0.051436
u2web	4.8008	5	5	4.8459	4.996090243	4.782408	0.04277
WebHostingHub	4.7302	4.925	4.89	4.5185	4.944644763	4.58037	0.073671
WebHostingPad	4.1305	4.204	4.2776	4.5511	4.848659238	4.692627	0.03218
Zip Cloud	4.6296	5	4.5926	4.6232	4.011587743	4.631674	0.154574

5.5.2 Results of predicting reputation using multiple polynomial regression equation

In this experiment also we also used the data of 32 services to predict of reputation by multiple polynomial regression. We also conducted the experiment twice. The first time we adopted all the factors and the result of this was equation (5.3), but in the second time, we ignored the reliability factor and the result was equation (5.4).

$$Rep = 5.613808849 * 10^{-1}x_1^2 - 6.225172731 * 10^{-2}x_1x_2 - 7.40709063 * 10^{-2}x_1x_3 - 1.628093372 * 10^{-1}x_1x_4 + 9.3892666 * 10^{-3}x_2^2 - 5.835160577 * 10^{-2}x_2x_3 + 1.563231025 * 10^{-1}x_2x_4 + 9.162062868 * 10^{-2}x_3^2 - 0.41956877x_3x_4 - 0.227524679x_4^2 - 3.283535905x_1 + 1.516604158 * 10^{-2}x_2 + 1.527622797x_3 + 4.145155768x_4 - 2.490171441 \tag{5.3}$$

$$Rep = 0.684198347x_1^2 - 4.474802049 * 10^{-1}x_1x_3 - 7.548422255 * 10^{-1}x_1x_4 + 5.641417989 * 10^{-2}x_3^2 + 4.324633658 * 10^{-1}x_2x_4 - 4.624788122 * 10^{-2}x_4^2 - 0.62544914x_1 - 4.202647049 * 10^{-1}x_3 + 2.353277729x_4 + 1.883757923 * 10^{-1} \tag{5.4}$$

Where x_1 represents the availability, x_2 is the reliability, x_3 is the response time and x_4 is the price. Table (5.11) represents the results of the multiple polynomial regression for the two experiments; the first with reliability factor and the second without reliability. As shown in Table (5.11) the results were more accurate when taking reliability factor into account.

TABLE 5.11: The results of multiple polynomial regression using training data

Experimens	Factors	Result	RSS	R^2
Ex1: multiple polynomial regression using all factors	X1=Ava, X2= Rel, X3=RT, X4=P, y=Rep	$Rep = 5.613808849 * 10^{-1}x_1^2 - 6.225172731 * 10^{-2}x_1x_2$ $-7.40709063 * 10^{-2}x_1x_3 - 1.628093372 * 10^{-1}x_1x_4$ $+9.3892666 * 10^{-3}x_2^2 - 5.835160577 * 10^{-2}x_2x_3$ $+1.563231025 * 10^{-1}x_2x_4 + 9.162062868 * 10^{-2}x_3^2$ $-0.41956877x_3x_4 - 0.227524679x_4^2$ $-3.283535905x_1 + 1.516604158 * 10^{-2}x_2$ $+1.527622797x_3 + 4.145155768x_4 - 2.490171441$	6.0027	$6.693 * 10^{-1}$
Ex2: multiple polynomial regression without reliability factor	X1=Ava, X3=RT, X4=P, y=Rep	$Rep = 0.684198347x_1^2 - 4.474802049 * 10^{-1}x_1x_3$ $-7.548422255 * 10^{-1}x_1x_4 + 5.641417989 * 10^{-2}x_3^2$ $+4.324633658 * 10^{-1}x_2x_4 - 4.624788122 * 10^{-2}x_4^2$ $-0.62544914x_1 - 4.202647049 * 10^{-1}x_3$ $+2.353277729x_4 + 1.883757923 * 10^{-1}$	6.5364	$6.398 * 10^{-1}$

TABLE 5.12: Data testing using multiple polynomial regression equation

Name	x1	x2	x3	x4	y	Calculated y	Error
SugarSync	3.8529	5	3.8824	3.4694	3.333496168	3.901297	0.170332
sos-online-backup	3.9091	4	4.1818	3.6667	4.433403363	3.959435	0.106908
Site5	2.8723	3.1	3.13	3.9574	2.77688167	4.450732	0.60278
SiteGround	3.35	3.74	3.38	3.9324	4.935847406	4.211533	0.146746
Servage	3.582	3.04	3.3	4.2869	4.96089671	4.174255	0.158568
Surpass	3.6218	3.715	4.015	4.395	4.925798021	4.372808	0.112264
u2web	4.8008	5	5	4.8459	4.996090243	4.771036	0.045046
WebHostingHub	4.7302	4.925	4.89	4.5185	4.944644763	4.74629	0.040115
WebHostingPad	4.1305	4.204	4.2776	4.5511	4.848659238	4.44129	0.084017
Zip Cloud	4.6296	5	4.5926	4.6232	4.011587743	4.764664	0.187725

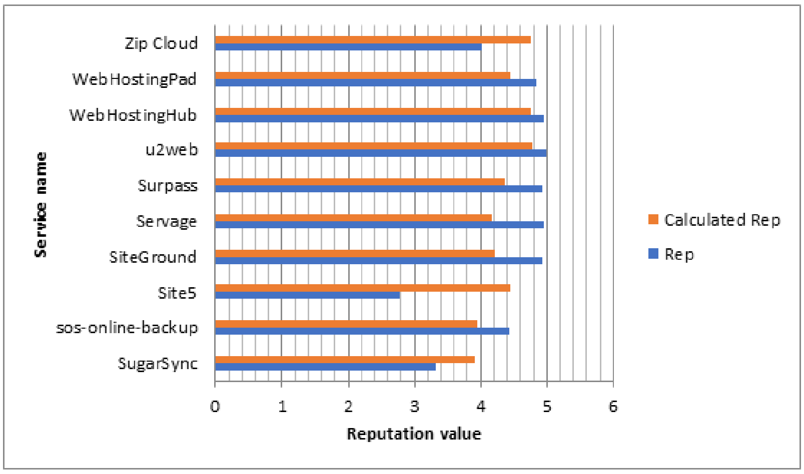

FIGURE 5.25: The difference between the actual reputation and predict reputation using multiple polynomial regression

When we applied equation (5.4) on the 10 testing data to predict reputation and the results in Table (5.12) were more accurate than the result of multiple linear regression because the RSS was less in multiple polynomial regression. Figure (5.25) represents the difference between the actual reputation value and the predicted value of reputation using multiple polynomial regression.

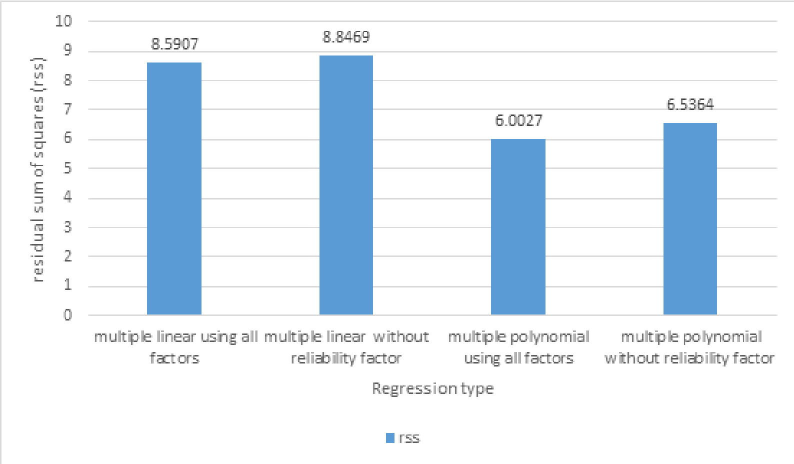

FIGURE 5.26: The residual sum of squares (ss) for multiple linear regression and multiple polynomial regression

TABLE 5.13: The description of parameters

Parameters	The description
	alpha is a significance level of 0.05 works well.
P-Value	P-value : The differences between some of the means are statistically significant. P-value >: The differences between the means are not statistically significant.
SS	Sum of Squares
df	Degrees of Freedom
F	F-Statistics
MS	Mean Sum of Squares

5.5.3 Discussion of the results of prediction reputation

Figure (5.26) represents a comparison between the experiments that used multiple linear regression and the experiments that used multiple polynomial regression. The result shows a higher confidence when we used multiple polynomial regression, where the residual Sum of Squares was less than the multiple linear regression. So the multiple polynomial regression using all factors is the most accurate because it has the least of the residual sum of squares that equals 6.0027.

5.6 Results of association with reputation using ANOVA test

We conducted ANOVA test to show if there are any statistical differences between the reputation factor and the other four factors and Table (5.13) presents the the parameters (P-Value, SS, df, F) and the description of them.

We conducted ANOVA test to show if there are any statistical differences between the reputation factor and the availability factor. We found that P-value equals 0.033127

TABLE 5.14: The results of association between reputation and availability

Summary of Data (Availability ->Reputation)			
	Treatments		
	1	2	Total
N	32	32	64
$\sum X$	119.3691	134.5138	253.8829
Mean	3.7303	4.2036	3.9669
$\sum X^2$	473.9195	583.5864	1057.5059
Std.Dev	0.9612	0.7652	0.8942
Result Details			
Source	SS	df	MS
Between-treatments	3.5838	1	3.5838
Within-treatments	46.7891	62	0.7547
Total	50.3728	63	
F = 4.74884			
The f-ratio value is 4.74884. The p-value is .033127. The result is significant at p <0.05			

TABLE 5.15: The results of association between reputation and reliability

Summary of Data (Reliability ->Reputation)			
	Treatments		
	1	2	Total
N	32	32	64
$\sum X$	126.1922	134.5138	260.706
Mean	3.9435	4.2036	4.0735
$\sum X^2$	529.5006	583.5864	1113.0869
Std.Dev	1.0138	0.7652	0.9006
Result Details			
Source	SS	df	MS
Between-treatments	1.082	1	1.082
Within-treatments	50.0111	62	0.8066
Total	51.0931	63	
F = 1.3414			
The f-ratio value is 1.3414. The p-value is 0.25123. The result is not significant at p <0.05.			

(less than 0.05) and this means there is an association between reputation factor and availability factor, as shown in Table (5.14).

We conducted ANOVA test to show if there are any statistical differences between the reputation factor and the reliability factor. We found that P-value equals 0.25123 (greater than 0.05) and this means there is no association between reputation factor and reliability factor, as shown in Table (5.15).

We conducted ANOVA test to show if there are any statistical differences between the reputation factor and the response time factor. We found that P-value equals 0.033674 (less than 0.05) and this means there is an association between reputation factor and response time factor, as shown in Table (5.16).

We conducted ANOVA test to show if there are any statistical differences between the reputation factor and the price factor. We found that P-value equals 0.033127 (less than 0.05) and this means there is an association between reputation factor and price factor, as shown in Table (5.17).

Table 5.16: The results of association between reputation and response time

Summary of Data (Response Time ->Reputation)			
	Treatments		
	1	2	Total
N	32	32	64
$\sum X$	119.2744	134.5138	253.7882
Mean	3.7273	4.2036	3.9654
$\sum X^2$	474.1056	583.5864	1057.6919
Std.Dev	0.976	0.7652	0.9025
Result Details			
Source	SS	df	MS
Between-treatments	3.6287	1	3.6287
Within-treatments	47.6814	62	0.7691
Total	51.3101	63	
F = 4.71843			
The f-ratio value is 4.71843. The p-value is .033674. The result is significant at p <0.05.			

Table 5.17: The results of association between reputation and price

Summary of Data (Price->Reputation)			
	Treatments		
	1	2	Total
N	32	32	64
$\sum X$	119.3691	134.5138	253.8829
Mean	3.7303	4.2036	3.9669
$\sum X^2$	473.9195	583.5864	1057.5059
Std.Dev	0.9612	0.7652	0.8942
Result Details			
Source	SS	df	MS
Between-treatments	3.5838	1	3.5838
Within-treatments	46.7891	62	0.7547
Total	50.3728	63	
F = 4.74884			
The f-ratio value is 4.74884. The p-value is .033127. The result is significant at p <0.05			

5.6.1 Discussion of the results of association factors with reputation

The association between reputation and the four other factors is presented in Table (5.18) and in Figure (5.27). We can conclude that there is a significant association between reputation and (Ava, RT, and P), but it is not significant for reliability. It is also noted in Figure (5.28) that the f-ration of the reliability factor is the least compared with the other factors. Figure (5.29) represents the P-value for each factor and as shown in the figure the P-value for reliability is 0.25123 which is higher than 0.05 and this means there is no an association between reputation factor and reliability factor, which may be explained by the fact that the data of reliability is not real because we obtained some of the reliability data from the website to solve the null problem in the used dataset (Cloud Armo).

Table 5.18: The summary of results

Factors	f-ratio	p-value	significant at p <0.05
Availability	4.74884	0.033127	significant
Reliability	1.3414	0.25123	not significant
Response Time	4.71843	0.033674	significant
Price	4.74884	0.033127	significant

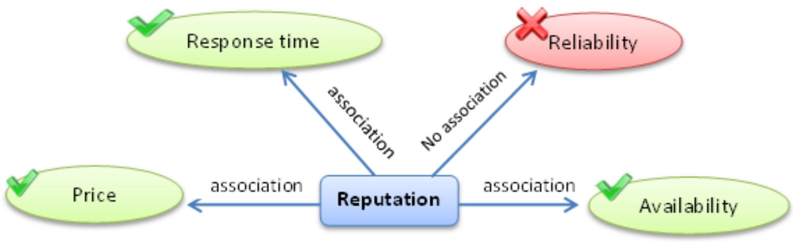

Figure 5.27: The association factors with reputation

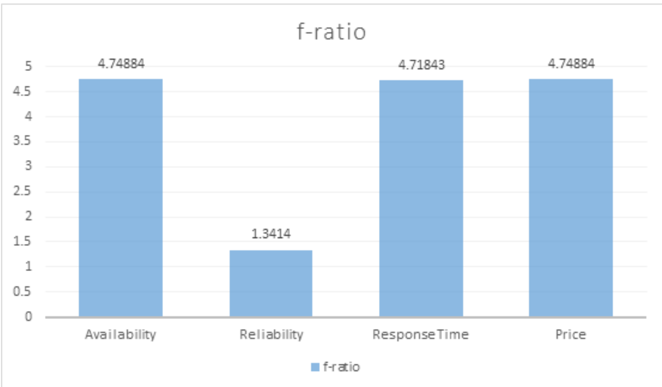

Figure 5.28: The value of f-ration for each factor

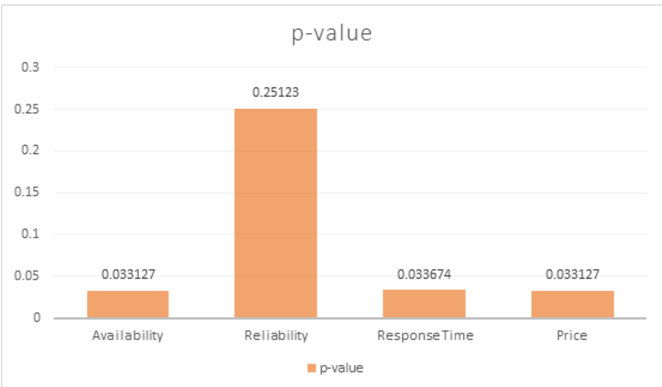

Figure 5.29: The P-value for each factor

Chapter 6

Conclusion and Future Work

6.1 Conclusion

Web services have received great attention because they support enterprises and business-to-business application, but when there is a large number of web services available on the repository service, it is not easy to find an execution path for composite service. In this study, we suggested study the possibility of using reputation factor to cover for the other factors in the absence one or more of the QoS factors. The reputation factor was also taken into consideration when calculating QoS to study its impact into selecting optimal path using bee algorithm.

We used the Cloud Armor dataset that has a real QoS. The dataset contains approximately 10,000 feedbacks by 7,000 consumers for 113 real-world cloud service and the feedbacks are based on QoS attributes. We supposed that the composite service contains three tasks, and we divided the dataset into four sets and each set has three tasks and each task has about 9 candidate services that have four real OoS properties (Ava, Rel, RT, P).

We built a simulation program in Java language to evaluate reputation for the web services based on trust result in the dataset and we used the reputation algorithm proposed by the El-Kafrawy for updating reputation of the web services based on the trust factors of the consumers and reputation threshold. Then we obtained a reputation value for all web services located in the dataset. Also, we used Java program to conduct the experiment three times to study the effect of reputation factor in case of absence of one of the other factors and the possibility of covering for them. The first experiment was conducted using the data four factors (Ava, Rel, RT, P) based on the dataset, but in the second experiment, we replaced the reliability factor with the technical support factor due to the lack of sufficient information on the reliability factor in the dataset. The third experiment was conducted on the services that have full data information. In each experiment we suggested 7 cases for selecting the optimal composite path using bee algorithm and we made a set of comparisons to show the possibility of covering reputation factor the other factors. The results proved that the reputation factor can cover some factors such as availability, response time and technical support.

In addition, we represented a prediction of reputation factor based on the other factors using the multiple linear regression and polynomial regression and the result has a higher confidence when we used multiple polynomial regression, where the RSS was less than the multiple linear regression. We used ANOVA test to study the association of reputation with the other factors and the results show a significant association between reputation and (Availability, Response Time, and Price), but it is not significant for reliability.

6.2 Future Work

- Developing the selection process of the composite service based on a number of factors, not just four factors and studying the influence of the reputation factor on them.
- Applying the selection process of an optimal path of composite service immediately when requested by the customer online.
- The results of the prediction experiment can be used to predict the missing factors in the dataset and then used for research purposes.

Appendix A

The Data of experiments

In this appendix, we put the data extracted from the experiments in the tables as shown below.

Table A.1: The average values of 4 QoS attributes for each atomic service in set 1.

SET 1					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
1and1	2.3284	2.32	2.94	3.0018	1.5602
4Shared	null	2.32	2.94	2	2.0
ABCComputers	null	null	4.8333	3.5	4.3333
Ace-host	1.8302	null	null	2.7925	2.2264
ADrive	5.0	3.0	5.0	1	1.5
AgileIT	null	null	4.57	4.41	4.555
AirVM	3.6667	null	null	4.3333	4.6667
Amazon online backup	null	5.0	2.0	1	0.5
AmazonEC	3.3333	null	null	3.6667	2.3333
Task 2					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Arvixe	4.9065	1.305	1.8	4.8785	4.8505
awardspace	4.54	4.195	4.01	4.1167	4.3733
B2BTechnologies	null	null	4.75	4.375	5.0
Backblaze	4	5	4	3.7692	3.1538
Backup And Share	null	3	2	2.5	2.5
Backup Genie	null	5	5	4	4.0
backupgenie	5	5	5	5	4.5
Banana	4.7857	null	null	4.9429	4.8857
BEI	null	null	4.3333	4.0833	4.3333
Bluehost	2.7611	3.3239	5	3.562	2.9855
Task 3					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Blurstorm	4.8415	null	null	4.8659	4.8293
C-D-H.	null	null	4.8667	4.5	4.9667
Carbonite	2.3833	5	2.7	2.6494	2.4675
Carbonitepro	null	4	5	2.625	3.75
Cari	4.5455	null	null	4	4.6364
CatapultSystems	null	null	5	4.5	5.0
Centare	null	null	4.8	4.6	4.8
ChampionSolutionsGroup	null	null	5	4.75	5.0
Cloudbg	4.4286	null	null	4	4.0

TABLE A.2: The average values of 4 QoS attributes for each atomic service in set 2

SET 2					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
ComputerSolutionsEast	null	null	5	4.3333	5.0
Concurrency	null	null	4.8333	4.5	4.8333
CorpInfoServices	null	null	4.6111	4.6111	4.7778
CPISolutions	null	null	3.9167	4.0833	4.8333
Crash Plan	null	null	null	2.5	2.5
Dataprise	null	null	4.5	4.05	4.75
Diino	null	null	null	0.5	1.0
dot5Hosting	1.3333	null	null	2.6111	1.2917
DreamHost	3.3075	3.43	3.555	4.1339	3.6368
Task 2					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Dropbox	2.9091	5	3	2.9024	2.6829
EastridgeTechnology	null	null	4.5	4.75	5.0
ECGridOS	null	null	null	4	4.0
Elephant Drive	null	null	null	2.7	2.6
elephantdrive	4.5	5	4	4	4.5
EPMSolutions	null	null	4.9167	4.75	5.0
FatCow	4.0395	4.0072	4	4.1855	3.9315
Globat	2.0791	2.11	2.365	2.9887	1.8475
Go Daddy	3.1401	3.495	4.6667	3.5603	2.5174
Task 3					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
GoGrid	4	null	null	4.2	4.4
Google online backup	null	null	null	0.75	1.5
GreenGeeks	3.6548	4.0226	1.625	3.9641	3.8125
HostGator	4.3894	3.4516	4.785	4.4156	4.2273
HostLogical	2.6429	null	null	3.5089	2.0714
HostMonster	2.752	3.3745	3.09	3.4	2.7052
iBackup	3.3077	4	3.7692	3.5714	3.3429
icdsoft	4.8319	4.47	4.93	4.7699	4.9204

TABLE A.3: The average values of 4 QoS attributes for each atomic service in set 3

SET 3					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
iCloud	5	null	null	2.1538	3.3846
IConvergentComputing	null	null	5	5	5.0
iDrive	4.3333	null	4.6667	1.7273	2.4545
InMotion	4.6156	4.4939	4.1	4.6155	4.6371
InnovativeComputerSystems	null	null	5	4.8333	5.0
Instant Computer Backup	null	null	null	null	3.5
Integra-Net	4.814	null	null	4.8953	4.8488
IOTAP	null	null	4	4.6667	4.8333
iPage	3.7977	4.1637	2.395	3.8785	3.9978
Task 2					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
IX	null	2	2	2.5	null
Janalent	null	null	5	4.6667	5.0
justcloud	4.3662	5	4.4789	4.6512	4.3488
JustHost	3.5916	3.6938	4	4.0232	3.3498
keepit	3.6667	null	4	3.6667	4.3333
KineticD	null	null	null	4	4
livedrive	4.3333	null	4	3.3333	2.8788
Lunarpages	4.8554	3.395	3.24	4.8795	4.8313
Mailjet Cloud Emailing Platform	null	null	null	4.5	4.5
Task 3					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Mediafire	null	null	null	1.5	1
Meritide	null	null	5	4.625	4.875
midPhase	2.0238	2.655	2.96	3.0238	2.2857
MiMedia	null	3	3	3.8	2.8
Mozy	3.3714	5	3.5429	3.5094	3.3774
MyPCBackup	4.55	5	4.75	4.7347	4.5306
NewSignature	null	null	4.8	4.5667	4.7333
Open Drive	null	null	null	1.5	1.25
ParivedaSolutions	null	null	4.1667	4.3333	4.6667

TABLE A.4: The average values of 4 QoS attributes for each atomic service in set 4

SET 4					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Penny Backup	null	null	null	5	1.5
Podio - Collaborative Work Platform	null	null	null	4.8	4.8
PolurNET	4.8582	null	null	4.8806	4.8582
PowerObjects	null	null	4.9375	4.4375	4.9375
Powweb	2.2449	null	null	3.5102	2.0
Rackspace	2.7143	2.75	3.115	3	3.1429
Racpspaze	5	null	5	5	5.0
RealWebhost	4.7412	5	5	4.8118	4.8941
RegisterFly	2.505	null	null	3.275	1.98
RyanTech	null	null	5	4.7	5.0
Safe Copy Backup	null	null	null	3.6667	2.6667
Task 2					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Servage	3.582	3.04	3.3	4.2869	3.5984
ShareFile	null	null	null	1.5	1.5
SharePoint	null	null	4.6667	3.8333	4.1667
SingleHop	4	null	null	3.5	4.5
Site5	2.8723	3.1	3.13	3.9574	2.9362
SiteGround	3.9324	3.74	3.38	4.1486	3.6622
sos-online-backup	3.9091	4	4.1818	3.6667	4.0
Storage Guardian	null	null	null	3	3
SugarSync	3.8529	5	3.8824	3.4694	3.449
Surpass	3.6218	3.715	4.015	4.395	3.4958
SymetriQ Cloud	4.875	null	null	4.125	4.25
u2web	4.8008	5	5	4.8459	4.7669
Task 3					
Name	Availability	Reliability	ResponseTime	Price	TechnicalSupport
Vizaweb	1.3966	null	null	2.931	1.1724
Vorsite	null	null	4.1	4.3	4.4
Webfortis	null	null	5	3.875	5.0
WebHost4Life	1.6869	null	null	3.0101	1.6869
WebHostingHub	4.7302	4.925	4.89	4.5185	4.5034
WebHostingPad	4.1305	4.204	null	4.5511	4.2377
Webserve	2.8265	null	null	3.6531	2.7551
yousendit-online-backup	4.5	null	5	4	4.5
ZAGTechnicalServices	null	null	4.9545	4.681	4.9545
Zip Cloud	4.6296	5	4.5926	4.6232	4.4638
Zoho Creator platform	null	null	null	4.5	4.75

Table A.5: Data of Update Reputation Algorithm for Service (1and1) in the Task 1 and in the Set 1

Data Update reputation Algorithm						
				Result		
#	Consumer	Task/Set	Service	Value	Reputation	Trust factor
1	2d70d7269c514da29ff3f43356c05d8a19e8f47a272192324d729f4a7f15fbec	Task1_1	1and1	1	null	null
2	9345a35a6fdf174dff7219282a3ae4879790dbb785c70f6fff91e32fafd66eab	Task1_1	1and1	5	3	0.99
3	030796207219c5aec3961025a2ea1566f6722dd9cdcf13cc4b2b08da63f71a0a	Task1_1	1and1	5	4	0.995
4	40abbd508552107748bc7a16526b5e54fb73f20fb772efdb4be685867cce42cf	Task1_1	1and1	1	2.5	0.9925
5	f178a7f17448b74a2e835e105211d18ce906473cb7e7305ba45125e7d6e17846	Task1_1	1and1	1	1.75	0.99625
6	f92d32a333e5062f14837c42338457b0052ae3b354130060cf3c147377d82f66	Task1_1	1and1	5	3.375	0.991875
7	834196a414b6122b7ac523cb351e0bd0ca892bb303077357289329d7ef496cc8	Task1_1	1and1	2.5	2.9375	0.9978125
8	4b20d56a313282c545ad2dcde5bbc6c0d459f98701144e705948e577fae5e1e7	Task1_1	1and1	3	2.96875	0.99984375
9	bad3aa692701757a7b268319467047f254e8a9e3c2b635b4b4a43a938c01059c	Task1_1	1and1	1	1.984375	0.995078125
10	f1bc73325baeb17c60b595e35c07497de1ca5c26fac9ebacfa3caa858e832506	Task1_1	1and1	3.5	2.7421875	0.996210938
11	0fc18a0d301222018aaa20f72f1b4bad47da850bdc63b0931c845d3da432be3a	Task1_1	1and1	4.5	3.62109375	0.995605469
12	7e8c729e4e4ecc320cb411c4d1419bf5fbad733212d4e9491b7630aaef0b8b1c	Task1_1	1and1	2.5	3.060546875	0.997197266
13	4e29bfca943fd98b0290362de58189f399275350b33330a28ab95657f0af24fe	Task1_1	1and1	1.5	2.280273438	0.996098633
14	196812685e9a39680783950487f2c46c2449f22ccfe73c338c72151741431426	Task1_1	1and1	1	1.640136719	0.996799316
15	9345a35a6fdf174dff7219282a3ae4879790dbb785c70f6fff91e32fafd66eab	Task1_1	1and1	3.5	1.640136719	0.990350342
16	5ea26535f4efa0622af22120117be2479e1b32c98f43cdf85de5bdfae0022a44	Task1_1	1and1	2	1.820068359	0.999100342
17	0c9ab8c55d678ea513149008ce0ca19990aabc50f6bde84189031dad16079780	Task1_1	1and1	2.5	2.16003418	0.998300171
18	866b3a5cb1cb3d1e83d0ec67609ab8cc88f8d41765b3dc30cc67e3793a7e66a6	Task1_1	1and1	1	1.58001709	0.997099915
19	3d28271ec52e3d07fe14f5f16d01f2c09cbcac1949f9904b305136d0edbee12d	Task1_1	1and1	2.5	2.040008545	0.997700043
20	19c3fd6de646493a61a411846b1d649a75d7076784e0845fb30f32a2f8f27980	Task1_1	1and1	2	2.020004272	0.999899979
21	1deb0a3b86750d0e4a4c21dc9601736954ae5ccac654c57f3d45563a1f595998	Task1_1	1and1	2.5	2.260002136	0.998800011
22	300648cea31d54fdec1ce29f8771bcae5107e97e6a9d3b98567a28cf85306b64	Task1_1	1and1	2	2.130001068	0.999349995
23	db74c940d447e877d119df613edd2700c4a84cd1cf08beb7cbc319bcfaeab97a	Task1_1	1and1	3.5	2.815000534	0.996575003
24	5c03a68b8b8ea420de69343d1da973990187bdae7a30b3e630d4647c6c832c4f	Task1_1	1and1	4	3.407500267	0.997037501
25	96bd923157c731249a40c36426fc326062ad3b2904ed6792b3f404f223d35651	Task1_1	1and1	3	3.203750134	0.998981249
26	849babdbeeb879e1e8c58c23f338feb5dba6d4c7fa585e0d40b0c4d36db8d46e	Task1_1	1and1	5	4.101875067	0.995509375
27	c10873196eb1124ed74461c20a67094e395f2310f6305607b9694ee6b1ee8b43	Task1_1	1and1	1.5	2.800937533	0.993495312
28	d7cda0ca2c8586e512c425368fcb2bba62e81475bfceb4284f4906de8ec242bc	Task1_1	1and1	1.5	2.150468767	0.996747656
29	42e546fddcccc9c2251fea5bd7763e678932c385acadbdff1ec5f28da06c5538	Task1_1	1and1	2	2.075234383	0.999623828
30	49faaade493be8b6b6164ee67f7e4d101812a5dda970d6ca693dda8b8cf82e4b	Task1_1	1and1	4	3.037617192	0.995188086
31	365618a6fd5a831179bc17db8f67aa2ffa259cde8b65f29aa57ae004298ebe17	Task1_1	1and1	3.5	3.268808596	0.998844043
32	4ecde249d747d51d869ae689c44cc1e6191b581b8315edac97990fdc4dce40d7	Task1_1	1and1	3	3.134404298	0.999327979
33	cfd1476422c64d6ccaf3e33805dac3afd0c34ec185c97642a9f5c5595f14ccaf	Task1_1	1and1	1	2.067202149	0.994663989
34	18d6d5406c957fa34cf4d6e2dc5f188ebe5a35dd7415f77ac027b6766781dd51	Task1_1	1and1	4	3.033601074	0.995168005
35	55f21269c7d1d2af8739a689e2ca885b86a59cbf14372c71db368595e4049821	Task1_1	1and1	4.5	3.766800537	0.996334003
36	13d68aacb809f8fa881e2a408fc670257f05d2e568d9aceecbd6e1fd2cab2ab0	Task1_1	1and1	3	3.383400269	0.998082999
37	9db0da90670c42a3e9c6ac101a7d4d21404100b958ee6293c06a7821c1635309	Task1_1	1and1	3	3.191700134	0.999041499
38	5e60146bfc2a25151735e8c33ba4e9f2838ff5616c8db5e42d36d8b8f5b3c2cc	Task1_1	1and1	4	3.595850067	0.99797925
39	80f2aed3c618c423ddf05a2891229fba44942d907173152442cf6591441ed6dc	Task1_1	1and1	1	2.297925034	0.993510375
40	1eb1cf7c147ea9f46d43a3ea8b35431e05b3d02aa84592e2d65ff346ad61876d	Task1_1	1and1	1	1.648962517	0.996755187
41	6af59dc0322b802d34d0b7f0ecb9588fea8e86f9199a02a781a3fdf8a90b354e	Task1_1	1and1	3	2.324481258	0.996622406
42	a8cfcd74832004951b4408cdb0a5dbcd8c7e52d43f7fe244bf720582e05241da	Task1_1	1and1	1	1.662240629	0.996688797
43	3f27483f97c94ecf0c8f11148fbbd048dffcdecbe5c62fa23076297ae804f6c6	Task1_1	1and1	2.5	2.081120315	0.997905602
44	ab3a903f4bc80a359f6b12c910b75f94eb134b4cad6c805ef7fac014ccd1a2bf	Task1_1	1and1	1	1.540560157	0.997297199
45	3544ab6988c1aea6018361ca4510c629edea2c83a0421e9d9766f9e00b454703	Task1_1	1and1	4.5	3.020280079	0.9926014
46	e44a429c9b0437e050365149f519b16e156dd3f601f39c007106982232202873	Task1_1	1and1	4.5	3.760140039	0.9963007
47	04f8996da763b7a969b1028ee3007569eaf3a635486ddab211d512c85b9df8fb	Task1_1	1and1	2.5	3.13007002	0.99684965
48	8360721f93d2e7e21a8f4201f3515ec089bb2a95148d8a1aca453442c98484ca	Task1_1	1and1	3	3.06503501	0.999674825
49	d20d093a7ef2709f608f9080441e59d1f984f58bd2b807db332adb9748832e82	Task1_1	1and1	2.5	2.782517505	0.998587412
50	f6dce2c608ef3fd522dcd3a4ab897f855945309f2d04e64f86e507730137596a	Task1_1	1and1	1	1.891258752	0.995543706
51	4985842a779748cfa0f2b32c6f9420960984295fef685d06378639a3ea2008ce	Task1_1	1and1	1.5	1.695629376	0.999021853
52	40309695f0b0d960b154c704c21901cde4d94e7e9e4852ca08aa453105ed6f5c	Task1_1	1and1	4.5	3.097814688	0.992989073
53	4ecde249d747d51d869ae689c44cc1e6191b581b8315edac97990fdc4dce40d7	Task1_1	1and1	1	3.097814688	0.994419453
54	5d7fd74645571c4d9ab5bfb75ee4c1672e57df212b824f8486bb68d4e9047ae4	Task1_1	1and1	2.5	2.798907344	0.998505463
55	f66025c51e65b02ffdaf55ea9460656a0b79598cb7db1514dc7a23a81b4cf1aa	Task1_1	1and1	3	2.899453672	0.999497268
56	07b2c0146e1fec40ebbc8b2bc7827f55d49b6e802b3f2ce6435dfa8a4e8150b7	Task1_1	1and1	1	1.949726836	0.995251366
57	2f888d7a8050c5fbf6f41ef62e6696784638c71e28481c338271c012e1892d64	Task1_1	1and1	1.5	1.724863418	0.998875683
58	f089eaef57aba315bc0e1455985c0c8e40c247f073ce1f4c5a1f8ffde8773176	Task1_1	1and1	4.5	3.112431709	0.993062159
59	84a4b19e19aa4e2a562ae0286b1e188ef4f4f9a98a92b8730d20a1e0f2882523	Task1_1	1and1	1	2.056215855	0.994718921
60	31f7a65e315586ac198bd798b6629ce4903d0899476d5741a9f32e2e521b6a66	Task1_1	1and1	3	2.528107927	0.99764054
61	e7a4477ec945697c1003e467ec7b8fc2c485d90453882a203c08956d377d8cbd	Task1_1	1and1	1	1.764053964	0.99617973
62	f8ce85591c31f9f949a210e89e1337ba902745da3835682d114f55ba720995c9	Task1_1	1and1	2	1.882026982	0.999410135
63	6a6705b61e5c6148f7b7828e5186465f65c6c2c466f3f383902cc694a2cfa354	Task1_1	1and1	3	2.441013491	0.997205067
64	80f2aed3c618c423ddf05a2891229fba44942d907173152442cf6591441ed6dc	Task1_1	1and1	2.5	2.441013491	0.996607721
65	0099a09fb38d515d1c60db48d6c5baff5eacc200c5158c7a2b36140fe8739c1c	Task1_1	1and1	1	1.735203348	0.996323983
66	77ada22b06b65aceb5d2b4fc9b298a6816642808f754c2a9d63d7c81ce13959f	Task1_1	1and1	3.5	2.617601674	0.995588008
67	2d8b63befe2d8417b3f6977be11eeebfd2b119f2d862df2805eb97f9653d6bd7	Task1_1	1and1	1	1.808800837	0.995955996
68	90a5d5a8573d7f52021a85d65d98f44c58a2006b9532204039206705a4d31f80	Task1_1	1and1	4.5	3.154400419	0.993272002
69	cc90e81847433c9734a4d93d18d27018501cc7bf2285fac6499183ed63a8cce1	Task1_1	1and1	3.5	3.327200209	0.999136001
70	88e27fb4b1703bb2671edab87148ee492d8294d99a32895d39ec79fb27967480	Task1_1	1and1	5	4.163600105	0.995818001
71	274b035b3a7951105c53b842fb39f717b250af1704a143e794d4581a13627d87	Task1_1	1and1	2.5	3.331800052	0.995841
72	6cd4c9c389b460a1f60357bebdec27a788c4abbf1aa3dead4d3c0cfd0cebea2a	Task1_1	1and1	3	3.165900026	0.9991705
73	3482a260fcbb67e29fda560a7f81e9bd1dac7bf2a1d87be5c8c0e711dc413595	Task1_1	1and1	5	4.082950013	0.99541475
74	aac09a648fc382b6f78897595486e691d00de9dfc742f3ba1930464b56eecda6	Task1_1	1and1	5	4.541475007	0.997707375
75	971bb441fc0576c493a8fe014877c3be53397139254dd76e7fe4528d7c95e0d3	Task1_1	1and1	1	2.770737503	0.991146312
76	c14e1ee5aa291ccf904090891322ed66a96ea1b4d14bb4cfb965a11b6b3a97aa	Task1_1	1and1	2	2.385368752	0.998073156
77	4ecde249d747d51d869ae689c44cc1e6191b581b8315edac97990fdc4dce40d7	Task1_1	1and1	2	2.385368752	0.996246304
78	4c26d9074c27d89ede59270c0ac14b71e071b15239519f75474b2f3ba63481f5	Task1_1	1and1	2.5	2.345980549	0.999229903
79	281aca1a80b52620bd717e8b14a0386b8ada92ae859ac2c8a2ac222efa02edbb	Task1_1	1and1	3	2.672990274	0.998364951
80	e89fe62ec86347c2b50f4a874bf6cc5e67b1cd579a9989a8bf7cb956045d40d7	Task1_1	1and1	3	2.836495137	0.999182476
.	.	.	1and1	.	.	.
.	.	.	1and1	.	.	.
.	.	.	1and1	.	.	.
.	.	.	1and1	.	.	.
560	96bd923157c731249a40c36426fc326062ad3b2904ed6792b3f404f223d35651	Task1_1	1and1	1.9	2.268808172	0.996634891
561	bb507c2c2782fb0b0737df77aa759ba96820407b8f1eb7af46de11930cfbec91	Task1_1	1and1	4.1	3.091891773	0.994959459
562	97eb2ad3ac5c6b6cab04de95aa88909b8a4a89596a66066d81040618f2c8232d	Task1_1	1and1	0.7	1.895945887	0.994020271
563	04fbbd9ace9d892d29e1b315d7ea143308e4becc068215e74acdf9c20685bf8f	Task1_1	1and1	4.6	3.247972943	0.993239865
564	50e4aec37d62ff8459d51cd5e22de5f4faefb0b8394017e488701bd216811c13	Task1_1	1and1	4.7	3.973986472	0.996369932
565	ffad05c0bffb25fa682a14011757bdafa14b9b727434360002718f8a4f71e349	Task1_1	1and1	5	4.486993236	0.997434966
566	84a4b19e19aa4e2a562ae0286b1e188ef4f4f9a98a92b8730d20a1e0f2882523	Task1_1	1and1	3.9	4.486993236	0.994215744

Table A.6: The Reputation factor of set 1

SET 1	
Task 1	
Name	Reputation
1and1	4.487
4Shared	2
ABCComputers	4.5
Ace-host	2.2038
ADrive	3
AgileIT	3.2617
AirVM	3.5
Amazon online backup	1
AmazonEC	3.5
Task 2	
Name	Reputation
Arvixe	5
awardspace	4.4856
B2BTechnologies	4.6875
Backblaze	3.8833
Backup And Share	3
Backup Genie	4
backupgenie	5
Banana	5
BEI	4.4688
Bluehost	4.943
Task 3	
Name	Reputation
Blurstorm	5.0019
C-D-H.	4.9843
Carbonite	3.6914
Carbonitepro	4.3737
Cari	3.9843
CatapultSystems	4.75
Centare	4.6875
ChampionSolutionsGroup	5
Cloudbg	4.5

Table A.7: The Reputation factor of set 2

SET 2	
Task 1	
Name	Reputation
ComputerSolutionsEast	4.875
Concurrency	4.75
CorpInfoServices	4.8613
CPISolutions	4.7188
Crash Plan	3.5
Dataprise	4.7822
Diino	1
dot5Hosting	1.7834
DreamHost	4.6799
Task 2	
Name	Reputation
Dropbox	2.9446
EastridgeTechnology	4.75
ECGridOS	4
Elephant Drive	3.2402
elephantdrive	4.5
EPMSolutions	5
FatCow	4.0169
Globat	3.9659
Go Daddy	4.7269
Task 3	
Name	Reputation
GoGrid	4
Google online backup	2.6249
GreenGeeks	4.073
HostGator	4.1899
HostLogical	4.6391
HostMonster	4.646
iBackup	4.7335
icdsoft	4.613

TABLE A.8: The Reputation factor of set 3

SET 3	
Task 1	
Name	Reputation
iCloud	3.3394
IConvergentComputing	5
iDrive	2.29
InMotion	4.9826
InnovativeComputerSystems	5
Instant Computer Backup	3
Integra-Net	4.9996
IOTAP	4.5
iPage	4.8281
Task 2	
Name	Reputation
IX	2
Janalent	5
justcloud	4.5046
JustHost	2.9823
keepit	4
KineticD	4
livedrive	3.8845
Lunarpages	4.9993
Mailjet Cloud Emailing Platform	4.5
Task 3	
Name	Reputation
Mediafire	1.5
Meritide	5
midPhase	3.3093
MiMedia	4
Mozy	4.1613
MyPCBackup	4.4971
NewSignature	4.4126
Open Drive	1.875
ParivedaSolutions	4.625

TABLE A.9: The Reputation factor of set 4

SET 4	
Task 1	
Name	Reputation
Penny Backup	3
Podio - Collaborative Work Platform	4.8125
PolurNET	4.998
PowerObjects	4.6719
Powweb	4.8708
Rackspace	2.6245
Racpspaze	5
RealWebhost	4.9994
RegisterFly	4.979
RyanTech	4.9375
Safe Copy Backup	3.5
Task 2	
Name	Reputation
Servage	4.9609
ShareFile	3.9889
SharePoint	4.25
SingleHop	3.5
Site5	2.7769
SiteGround	4.9358
sos-online-backup	4.4334
Storage Guardian	2.9949
SugarSync	3.3335
Surpass	4.9258
SymetriQ Cloud	4.9843
u2web	4.9961
Task 3	
Name	Reputation
Vizaweb	2.4243
Vorsite	4.7813
Webfortis	4.5625
WebHost4Life	2.0439
WebHostingHub	4.9446
WebHostingPad	4.8487
Webserve	2.5868
yousendit-online-backup	4.5
ZAGTechnicalServices	4.9219
Zip Cloud	4.0116
Zoho Creator platform	3.9983

Appendix B

The results of normalized data and the results of bee algorithm

Table B.1: Experiment 1 The normalization factors of set 1

Experiment 1: Set1					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	Reputation
Ace-host	0	null	null	0.4743	0.3439
ABCComputers	null	null	0.0556	0.2669	1
4Shared	null	0	0.6867	0.7067	0.2857
1and1	0.1572	0	0.6867	0.4129	0.9963
Amazon online backup	null	1	1	1	0
AirVM	0.5794	null	null	0.0225	0.7143
AgileIT	null	null	0.1433	0	0.6462
ADrive	1	0.2537	0	1	0.5714
AmazonEC	0.4742	null	null	0.2180	0.7142
Task 2					
Name	Availability	Reliability	ResponseTime	Price	Reputation
BEI	null	null	0.208344	0.3667	0.7344
BlueHost	0	0.546658	0	0.5752	0.9715
backupgenie	1	1	0	0	1
Banana	0.904283	null	null	0.0228	0.9999
Backup And Share	null	0.458728	0.9375	1	0
Backup Genie	null	1	0	0.4	0.5
B2BTechnologies	null	null	0.0781	0.25	0.8438
Backblaze	0.553352	1	0.3125	0.4923	0.4417
awardspace	0.794542	0.782138	0.3094	0.3533	0.7428
Arvixe	0.958238	0	1	0.0486	0.9999
Task 3					
Name	Availability	Reliability	ResponseTime	Price	Reputation
Blurstorm	1	null	null	0	1
Carbonite	0	1	1	0.9891	0
C-D-H.	null		0.0579	0.1633	0.9866
Carbonitepro	null	0	0	1	0.5206
Cari	0.8796	null	null	0.3865	0.2235
CatapultSystems	null	null	0	0.1633	0.8078
Centare	null	null	0.0870	0.1187	0.7601
ChampionSolutionsGroup	null	0	0.05172	0.9985	null
Cloudbg	0.8320	null	null	0.3864	0.6170

Table B.2: Experiment 1 The normalization factors of set 2

Experiment 1: Set2					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	Reputation
CPISolutions	null	null	0.7497	0.1284	0.9597
CorpInfoServices	null	null	0.2691	0	0.9965
Concurrency	null	null	0.1154	0.0270	0.9677
ComputerSolutionsEast	null	0	0.0676	1	0.9963
dot5Hosting	0	null	null	0.4865	0.2022
Diino	null	null	null	1	0
Dataprise	null	null	0.3460	0.1365	0.9761
Crash Plan	null	null	null	0.5135	0.6452
DreamHost	1	1	1	0.1161	0.9496
Task 2					
Name	Availability	Reliability	ResponseTime	Price	Reputation
Go Daddy	0.4383	0.4792	0.0979	0.5803	0.8671
FatCow	0.8098	0.6565	0.3593	0.2754	0.5217
Globat	0	0	1	0.8592	0.4968
elephantdrive	1	null	0.3593	0.3659	0.7567
EPMSolutions	null	null	0	0	1
ECGridOS	null	null	null	0.3659	0.5135
Elephant Drive	null	null	null	1	0.1438
EastridgeTechnology	null	null	0.1633	0	0.8784
Dropbox	0.3428	1	0.7511	0.9013	0
Arvixe	0.9582	0	1	0.0486	0.9999
Task 3					
Name	Availability	Reliability	ResponseTime	Price	Reputation
Google online backup	null	null	null	1	0
GoGrid	0.6199	null	null	0.1418	0.6522
HostGator	0.7979	0.0704	0.0439	0.0881	0.7422
GreenGeeks	0.4622	0.5916	1	0.2005	0.6868
HostLogical	0	null	null	0.3137	0.9553
HostMonster	0.0498	0	0.5567	0.3154	0.9585
iBackup	0.3037	0.5709	0.3512	0.2981	1
icdsoft	1	1	0	0	0.9429
Cloudbg	0.8320	null	null	0.3864	0.617

Table B.3: Experiment 1 The normalization factors of set 3

Experiment 1: Set2					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	Reputation
InMotion	0.6803	1	0.3455	0.1175	0.9936
iDrive	0.4455	null	0.1279	1	0
IConvergentComputing	null	null	0	0	1
iCloud	1	null	null	0.8697	0.3872
IOTAP	null	null	0.3839	0.1018	0.8155
Integra-Net	0.8453	null	null	0.032	0.9999
Instant Computer Backup	null	null	null	null	0.262
InnovativeComputerSystems	null	null	0	0.0509	1
iPage	0	0	1	0.3427	0.9366
Task 2					
Name	Availability	Reliability	ResponseTime	Price	Reputation
Mailjet Cloud Emailing Platform	null	null	null	0.1595	0.8
livedrive	0.5869	null	0.3333	0.6498	0.5538
Lunarpages	1	0.465	0.5867	0	0.9997
keepit	0.0594	null	0.3333	0.5097	0.6
KineticD	null	null	null	0.3696	0.6
justcloud	0.6129	1	0.1737	0.0959	0.8019
JustHost	0	0.5646	0.3333	0.3599	0.1929
Janalent	null	null	0	0.0894	1
IX	null	0	1	1	0
Task 3					
Name	Availability	Reliability	ResponseTime	Price	Reputation
Meritide	null	null	0	0.0339	1
Mediafire	null	null	null	1	0
MiMedia	null	0.1471	0.9804	0.289	0.7143
midPhase	0	0	1	0.5289	0.517
Mozy	0.5334	1	0.7143	0.3788	0.7604
MyPCBackup	1	1	0.1225	0	0.8563
NewSignature	null	null	0.098	0.0519	0.8322
Open Drive	null	null	null	1	0.1071
ParivedaSolutions	null	null	0.4085	0.1241	0.8929

Table B.4: Experiment 1 The normalization factors of set 4

Experiment 1: Set4					
Task 1					
Name	Availability	Reliability	ResponseTime	Price	Reputation
PowerObjects	null	null	0.0332	0.2813	0.8619
PolurNET	0.9485	null	null	0.0597	0.9992
Safe Copy Backup	null	null	null	0.6667	0.3686
Podio - Collaborative Work Platform	null	null	null	0.1	0.9211
Penny Backup	null	null	null	0	0.1581
RealWebhost	0.9061	1	0	0.0941	0.9998
Racpspaze	1	null	0	0	1
Rackspace	0.1704	0	1	1	0
Powweb	0	null	null	0.7449	0.9456
RyanTech	null	null	0	0.15	0.9737
RegisterFly	0.0944	null	null	0.8625	0.9912
Task2					
RegisterFly	Availability	Reliability	ResponseTime	Price	Reputation
SugarSync	0.4896	1	0.5976	0.4114	0.2508
sos-online-backup	0.5177	0.4898	0.4375	0.3524	0.7464
Storage Guardian	null	null	null	0.5517	0.0982
Site5	0	0.0306	1	0.2655	0
SiteGround	0.5293	0.3571	0.8663	0.2084	0.9729
SharePoint	null	null	0.1782	0.3026	0.6638
SingleHop	0.5631	null	null	0.4023	0.3258
Servage	0.3544	0	0.9091	0.1671	0.9841
ShareFile	0	null	null	1	0.5462
SymetriQ Cloud	1	null	null	0.2155	0.9947
Surpass	0.3742	0.3444	0.5267	0.1348	0.9683
u2web	0.963	1	0	0	1
Task 3					
Surpass	Availability	Reliability	ResponseTime	Price	Reputation
Zoho Creator platform	null	null	null	0.1038	0.6737
Vizaweb	0	null	null	1	0.1311
Vorsite	null	null	1	0.2181	0.9437
Webfortis	null	null	0	0.4608	0.8683
WebHost4Life	0.0871	null	null	0.9548	0
WebHostingHub	1	0.9058	0.1222	0.0933	1
WebHostingPad	0.8201	0	null	0.0747	0.9669
Webserve	0.4289	null	null	0.5876	0.1871
yousendit-online-backup	0.9309	null	0	0.3894	0.8467
Zip Cloud	0.9698	1	0.4527	0.0335	0.6783
ZAGTechnicalServices	null	null	0.0506	0	0.9922

TABLE B.5: Experiment 1 The results of bee algorithm for selecting optimal path in set 1

Experiment 1: Set 1			
4 Factors (Availability+Realibality+Price+Response Time)			
#Run	Path	QoS	The accuracy of the solution
1	Amazon online backup —>BEI —>Blurstorm	3.0597	0.764925
2	Amazon online backup —>BEI —>Cari	3.0681	0.767025
3	Amazon online backup —>BEI —>Cari	3.0681	0.767025
4	Amazon online backup —>BEI —>Cari	3.0681	0.767025
5	Amazon online backup —>BEI —>Cari	3.0681	0.767025
6	Amazon online backup —>BEI —>Cari	3.0681	0.767025
7	Amazon online backup —>BEI —>Cari	3.0681	0.767025
8	Amazon online backup —>BEI —>Cari	3.0681	0.767025
9	Amazon online backup —>BEI —>Cari	3.0681	0.767025
10	Amazon online backup —>BEI —>Cari	3.0681	0.767025
4 Factors (Reliability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
2	AmazonEC —>Banana —>Carbonite	2.9814	0.74535
3	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
4	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
5	AmazonEC —>Banana —>Carbonite	2.9814	0.74535
6	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
7	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
8	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
9	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
10	Amazon online backup —>Banana —>Cloudbg	3.0087	0.752175
4 Factors (Availability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
2	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
3	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
4	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
5	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
6	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
7	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
8	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
9	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
10	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
4 Factors (Availability+Reliability+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
2	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
3	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
4	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
5	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
6	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
7	Amazon online backup —>Banana —>C-D-H.	3.0955	0.773875
8	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
9	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
10	Amazon online backup —>BEI —>Blurstorm	3.1823	0.795575
4 Factors (Availability+Reliability+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
2	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
3	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
4	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
5	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
6	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
7	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
8	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
9	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
10	ABCComputers —>backupgenie —>C-D-H.	3.1389	0.784725
5 Factors (Availability+Reliability+ResponseTime+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
2	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
3	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
4	Amazon online backup —>B2BTechnologies —>Blurstorm	3.5703	0.71406
5	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
6	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
7	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
8	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
9	Amazon online backup —>BEI —>Blurstorm	3.6379	0.72758
10	Amazon online backup —>B2BTechnologies —>Blurstorm	3.5703	0.71406
1 Factor (Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	ABCComputers —>backupgenie —>Blurstorm	1	1
2	ABCComputers —>backupgenie —>Blurstorm	1	1
3	ABCComputers —>backupgenie —>Blurstorm	1	1
4	ABCComputers —>backupgenie —>ChampionSolutionsGroup	0.9995	0.9995
5	ABCComputers —>backupgenie —>Blurstorm	1	1
6	ABCComputers —>backupgenie —>Blurstorm	1	1
7	ABCComputers —>backupgenie —>Blurstorm	1	1
8	ABCComputers —>backupgenie —>Blurstorm	1	1
9	ABCComputers —>backupgenie —>Blurstorm	1	1
10	ABCComputers —>backupgenie —>Blurstorm	1	1

Table B.6: Experiment 1 The results of bee algorithm for selecting optimal path in set 2

Experiment 1: Set 2			
4 Factors (Availability+Realibality+Price+Response Time)			
#Run	Path	QoS	The accuracy of the solution
1	Diino—>Dropbox —>Google online backup	3.0611	0.765275
2	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
3	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
4	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
5	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
6	DreamHost —>ECGridOS —>Google online backup	3.494	0.8735
7	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
8	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
9	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
10	DreamHost —>Elephant Drive —>Google online backup	3.7054	0.92635
4 Factors (Reliability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	DreamHost—>Elephant Drive —>HostLogical	3.1595	0.789875
2	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
3	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
4	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
5	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
6	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
7	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
8	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
9	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
10	DreamHost —>Elephant Drive —>HostLogical	3.1595	0.789875
4 Factors (Availability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	DreamHost—>Elephant Drive —>Google online backup	3.0699	0.767475
2	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
3	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
4	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
5	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
6	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
7	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
8	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
9	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
10	DreamHost —>Elephant Drive —>Google online backup	3.0699	0.767475
4 Factors (Availability+Reliability+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
2	CPISolutions ——>icdsoft	3.2313	0.807825
3	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
4	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
5	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
6	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
7	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
8	DreamHost —>Elephant Drive —>Google online backup	3.3645	0.841125
9	DreamHost —>Elephant Drive —>Google online backup	3.3645	0.841125
10	DreamHost—>ECGridOS —>Google online backup	3.4877	0.871925
4 Factors (Availability+Reliability+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
2	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
3	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
4	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
5	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
6	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
7	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
8	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
9	Crash Plan —>Elephant Drive —>icdsoft	3.0818	0.77045
10	Dataprise —>Elephant Drive —>icdsoft	3.0664	0.7666
5 Factors (Availability+Reliability+ResponseTime+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	DreamHost—>ECGridOS —>Google online backup	3.9817	0.79634
2	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
3	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
4	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
5	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
6	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
7	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
8	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
9	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
10	DreamHost —>Elephant Drive —>Google online backup	4.0699	0.81398
1 Factor (Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
2	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
3	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
4	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
5	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
6	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
7	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
8	CorpInfoServices—>EPMSolutions —>iBackup	0.9988	0.9988
9	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1
10	ComputerSolutionsEast—>EPMSolutions —>iBackup	1	1

Table B.7: Experiment 1 The results of bee algorithm for selecting optimal path in set 3

Experiment 1: Set 3			
4 Factors (Availability+Realibality+Price+Response Time)			
#Run	Path	QoS	The accuracy of the solution
1	iCloud—>IX —>Mediafire	2.9566	0.73915
2	iCloud—>IX,—>Mediafire	2.9566	0.73915
3	iCloud —>IX —>Open Drive	2.9566	0.73915
4	iCloud—>IX,—>Mediafire	2.9566	0.73915
5	iCloud —>IX —>Open Drive	2.9566	0.73915
6	iCloud—>IX,—>Mediafire	2.9566	0.73915
7	iCloud—>IX,—>Mediafire	2.9566	0.73915
8	iCloud —>IX —>Open Drive	2.9566	0.73915
9	iCloud —>IX —>Open Drive	2.9566	0.73915
10	iCloud—>IX,—>Mediafire	2.9566	0.73915
4 Factors (Reliability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	iCloud—>KineticD —>Mozy	2.8362	0.70905
2	iCloud—>KineticD —>Mozy	2.8362	0.70905
3	iCloud—>KineticD —>Mozy	2.8362	0.70905
4	iCloud—>KineticD —>Mozy	2.8362	0.70905
5	iCloud—>KineticD —>Mozy	2.8362	0.70905
6	iCloud—>KineticD —>Mozy	2.8362	0.70905
7	iCloud—>KineticD —>Mozy	2.8362	0.70905
8	iCloud—>KineticD —>Mozy	2.8362	0.70905
9	iCloud—>KineticD —>Mozy	2.6924	0.6731
10	iCloud—>KineticD —>Mozy	2.8362	0.70905
4 Factors (Availability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	iCloud—>IX —>Open Drive	3.1213	0.780325
2	iCloud—>IX,—>Open Drive	3.1213	0.780325
3	iCloud—>IX,—>Open Drive	3.1213	0.780325
4	iCloud—>IX,—>Open Drive	3.1213	0.780325
5	iCloud—>IX,—>Open Drive	3.1213	0.780325
6	iCloud—>IX,—>Open Drive	3.1213	0.780325
7	iCloud—>IX,—>Open Drive	3.1213	0.780325
8	iCloud—>IX,—>Open Drive	3.1213	0.780325
9	iCloud—>IX,—>Open Drive	3.1213	0.780325
10	iCloud—>IX,—>Open Drive	3.1213	0.780325
4 Factors (Availability+Reliability+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	InnovativeComputerSystems—> Mailjet Cloud Emailing Platform —> MyPCBackup	2.9556	0.7389
2	IConvergentComputing—>Janalent —>MyPCBackup	2.9819	0.745475
3	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
4	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
5	IConvergentComputing—>Janalent —>MyPCBackup	2.9819	0.745475
6	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
7	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
8	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
9	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
10	InnovativeComputerSystems—>Janalent —>MyPCBackup	2.9989	0.749725
4 Factors (Availability+Reliability+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
2	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
3	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
4	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
5	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
6	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
7	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
8	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
9	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
10	IOTAP —>Mailjet,Cloud Emailing Platform—>MyPCBackup	3.0772	0.7693
5 Factors (Availability+Reliability+ResponseTime+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	iCloud—>KineticD —>MiMedia	3.2041	0.64082
2	iCloud—>KineticD —>MiMedia	3.2041	0.64082
3	iCloud—>KineticD —>MiMedia	3.2041	0.64082
4	iCloud—>KineticD —>MiMedia	3.2041	0.64082
5	iCloud—>KineticD —>MiMedia	3.2041	0.64082
6	iCloud—>KineticD —>MiMedia	3.1676	0.63352
7	iCloud—>KineticD —>MiMedia	3.2041	0.64082
8	iCloud—>KineticD —>MiMedia	3.2041	0.64082
9	iCloud—>KineticD —>MiMedia	3.2041	0.64082
10	iCloud—>KineticD —>MiMedia	3.2041	0.64082
1 Factor (Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Integra-Net—>Janalent —>Meritide	1	1
2	IConvergentComputing—>Janalent —>Meritide	1	1
3	InnovativeComputerSystems—>Janalent —>Meritide	1	1
4	IConvergentComputing—>Janalent —>Meritide	1	1
5	Integra-Net —>Janalent —>Meritide	1	1
6	InnovativeComputerSystems —>Janalent —>Meritide	1	1
7	IConvergentComputing —>Janalent —>Meritide	1	1
8	InnovativeComputerSystems —>Janalent —>Meritide	1	1
9	InnovativeComputerSystems —>Janalent —>Meritide	1	1
10	InnovativeComputerSystems —>Janalent —>Meritide	1	1

Table B.8: Experiment 1 The results of bee algorithm for selecting optimal path in set 4

Experiment 1: Set 4			
4 Factors (Availability+Realibality+Price+Response Time)			
#Run	Path	QoS	The accuracy of the solution
1	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
2	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
3	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
4	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
5	SafeCopy Backup —>ShareFile —>Zip Cloud	2.8398	0.70995
6	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
7	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
8	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
9	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
10	SafeCopy Backup —>ShareFile —>Zip Cloud	2.9892	0.7473
4 Factors (Reliability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
2	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
3	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
4	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
5	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
6	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
7	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
8	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
9	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
10	RegisterFly—>SugarSync —>Vorsite	3.0247	0.756175
4 Factors (Availability+Price+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
2	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
3	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
4	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
5	Podio - CollaborativeWork Platform —> SymetriQ Cloud —>Vorsite	3.131	0.78275
6	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
7	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
8	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
9	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
10	PolurNET—>ShareFile —>Vorsite	3.2041	0.801025
4 Factors (Availability+Reliability+ResponseTime+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
2	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
3	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
4	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
5	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
6	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
7	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
8	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
9	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
10	PodioCollaborative Work Platform —>u2web —>Vorsite	3.4179	0.854475
4 Factors (Availability+Reliability+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
2	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
3	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
4	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
5	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
6	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
7	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
8	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
9	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
10	RealWebhost—>ShareFile —>Webfortis	3.2291	0.807275
5 Factors (Availability+Reliability+ResponseTime+Price+Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	RealWebhost—>ShareFile —>Vorsite	3.6733	0.73466
2	RealWebhost—>ShareFile —>Vorsite	3.6733	0.73466
3	RealWebhost—>ShareFile —>Vorsite	3.6733	0.73466
4	RealWebhost—>ShareFile —>Vorsite	3.6733	0.73466
5	RealWebhost—>ShareFile —>Vorsite	3.6733	0.73466
6	Safe Copy Backup—>u2web —>Vorsite	3.5286	0.70572
7	RealWebhost—>ShareFile —>Vorsite	3.6733	0.73466
8	Podio Collaborative Work Platform —>u2web —>Vorsite	3.5239	0.70478
9	RealWebhost —>ShareFile —>Vorsite	3.6733	0.73466
10	RealWebhost —>ShareFile —>Vorsite	3.6733	0.73466
1 Factor (Reputation)			
#Run	Path	QoS	The accuracy of the solution
1	Racpspaze —>u2web —>WebHostingHub	1	1
2	Racpspaze —>u2web —>WebHostingHub	1	1
3	Racpspaze —>u2web —>WebHostingHub	1	1
4	Racpspaze,—>u2web —>WebHostingHub	1	1
5	Racpspaze—>u2web —>WebHostingHub	1	1
6	Racpspaze—>u2web —>WebHostingHub	1	1
7	Racpspaze—>u2web —>WebHostingHub	1	1
8	Racpspaze—>u2web —>WebHostingHub	1	1
9	Racpspaze—>u2web —>WebHostingHub	1	1
10	Racpspaze—>u2web —>WebHostingHub	1	1

Table B.9: Experiment 2 The results of bee algorithm for selecting optimal path in set 1

Experiment 2: Set 1			
4 Factors (Availability+TechnicalSupport+Price+ResponseTime)			
#	Path	QoS	The accuracy of the solution
1	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
2	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
3	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
4	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
5	Amazon online backup —>Backup And Share —>Cari	2.9293	0.732325
6	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
7	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
8	Amazon online backup —>Backup And Share —>Cari	2.9293	0.732325
9	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
10	Amazon online backup —>Backup And Share —>Blurstorm	2.9463	0.736575
4 Factors (TechnicalSupport+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
2	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
3	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
4	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
5	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
6	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
7	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
8	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
9	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
10	AirVM —>Arvixe —>Blurstorm —>	2.8861	0.721525
4 Factors (Availability+Price+ResponseTime+Reputation)			
Run	Path	QoS	The accuracy of the solution
1	Amazon online backup —>Arvixe —>Carbonitepro	2.8146	0.70365
2	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
3	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
4	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
5	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
6	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
7	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
8	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
9	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
10	Amazon online backup —>Backup And Share —>Blurstorm	2.9688	0.7422
4 Factors (Availability+TechnicalSupport+ResponseTime+Reputation)			
Run	Path	QoS	The accuracy of the solution
1	ABCComputers —>Arvixe —>ChampionSolutionsGroup	3.263	0.81575
2	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
3	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
4	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
5	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
6	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
7	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
8	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
9	AirVM —>Arvixe —>Blurstorm	3.4175	0.854375
10	AirVM —>Arvixe —>Blurstorm —>	3.4175	0.854375
4 Factors (Availability+TechnicalSupport+Price+Reputation)			
Run	Path	QoS	The accuracy of the solution
1	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
2	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
3	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
4	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
5	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
6	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
7	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
8	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
9	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
10	ABCComputers —>BEI —>Blurstorm	3.0735	0.768375
5 Factors (Availability+TechnicalSupport+ResponseTime+Price+Reputation)			
Run	Path	QoS	The accuracy of the solution
1	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
2	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
3	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
4	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
5	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
6	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
7	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
8	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
9	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
10	AirVM —>Arvixe —>Blurstorm	3.4412	0.68824
1 Factors (Reputation)			
Run	Path	QoS	The accuracy of the solution
1	ABCComputers —>backupgenie —>Blurstorm	1	1
2	ABCComputers —>backupgenie —>Blurstorm	1	1
3	ABCComputers —>backupgenie —>Blurstorm	1	1
4	ABCComputers —>backupgenie —>Blurstorm	1	1
5	ABCComputers —>backupgenie —>Blurstorm	1	1
6	ABCComputers —>backupgenie —>Blurstorm	1	1
7	ABCComputers —>backupgenie —>Blurstorm	1	1
8	ABCComputers —>backupgenie —>Blurstorm	1	1
9	ABCComputers —>backupgenie —>Blurstorm	1	1
10	ABCComputers —>backupgenie —>Blurstorm	1	1

Table B.10: Experiment 2 The results of bee algorithm for selecting optimal path in set 2

Experiment 2: Set 2			
4 Factors (Availability+TechnicalSupport+Price+ResponseTime)			
#	Path	QoS	The accuracy of the solution
1	DreamHost—>Elephant Drive —>Google online backup	3.0047	0.751175
2	DreamHost —Drive —>Google online backup	3.0047	0.751175
3	DreamHost —Drive —>Google online backup	3.0047	0.751175
4	DreamHost —Drive —>Google online backup	3.0047	0.751175
5	DreamHost —Drive —>Google online backup	3.0047	0.751175
6	DreamHost —Drive —>Google online backup	3.0047	0.751175
7	DreamHost —Drive —>Google online backup	3.0047	0.751175
8	DreamHost —Drive —>Google online backup	3.0047	0.751175
9	DreamHost —Drive —>Google online backup	3.0047	0.751175
10	DreamHost ——>Google online backup	2.9413	0.735325
4 Factors (TechnicalSupport+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	DreamHost ——>GreenGeeks	2.6168	0.6542
2	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
3	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
4	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
5	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
6	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
7	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
8	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
9	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
10	DreamHost —>ECGridOS —>GoGrid	2.6429	0.660725
4 Factors (Availability+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	DreamHost —Drive —>Google online backup	3.0699	0.767475
2	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
3	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
4	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
5	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
6	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
7	CPISolutions —>elephantdrive —>Googleonline backup	2.6247	0.656175
8	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
9	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
10	DreamHost —>Elephant Drive —>Google onlinebackup	3.0699	0.767475
4 Factors (Availability+TechnicalSupport+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	CPISolutions ——>icdsoft	3.2174	0.80435
2	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
3	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
4	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
5	DreamHost —>elephantdrive —>icdsoft	3.1697	0.792425
6	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
7	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
8	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
9	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
10	CPISolutions —>EastridgeTechnology —>icdsoft	3.2174	0.80435
4 Factors (Availability+TechnicalSupport+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	ComputerSolutionsEast—>EPMSolutions —>icdsoft	3.0035	0.750875
2	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
3	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
4	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
5	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
6	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
7	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
8	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
9	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
10	ComputerSolutionsEast —>EPMSolutions —>icdsoft	3.0035	0.750875
5 Factors (Availability+TechnicalSupport+ResponseTime+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	DreamHost ——>Google online backup	3.429	0.6858
2	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
3	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
4	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
5	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
6	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
7	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
8	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
9	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
10	DreamHost —>ECGridOS —>Google onlinebackup	3.429	0.6858
1 Factors (Reputation)			
#	Path	QoS	The accuracy of the solution
1	CorpInfoServices ——>iBackup	0.9988	0.9988
2	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
3	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
4	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
5	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
6	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
7	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
8	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
9	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1
10	ComputerSolutionsEast —>EPMSolutions —>iBackup	1	1

Table B.11: Experiment 2 The results of bee algorithm for selecting optimal path in set 3

Experiment 2: Set 3			
4 Factors (Availability+TechnicalSupport+Price+ResponseTime)			
#	Path	QoS	The accuracy of the solution
1	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
2	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
3	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
4	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
5	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
6	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
7	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
8	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
9	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
10	iCloud—>Mailjet Cloud Emailing Platform —>MiMedia	2.9512	0.7378
4 Factors (TechnicalSupport+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	Integra-Net—>Mailjet Cloud Emailing Platform —>MiMedia	2.7017	0.675425
2	Integra-Net —Cloud Emailing Platform —>MiMedia	2.7017	0.675425
3	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
4	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
5	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
6	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
7	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
8	Integra-Net —Cloud Emailing Platform —>MiMedia	2.6913	0.672825
9	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
10	Integra-Net —,Cloud Emailing Platform —>MiMedia	2.7017	0.675425
4 Factors (Availability+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	iCloud —>IX,—>Open Drive	3.1213	0.780325
2	iCloud —>IX —>Open Drive	3.1213	0.780325
3	iCloud —>IX,—>Open Drive	3.1213	0.780325
4	iCloud —>IX,—>Open Drive	3.1213	0.780325
5	iCloud —>IX,—>Open Drive	3.1213	0.780325
6	iCloud —>IX,—>Open Drive	3.1213	0.780325
7	iCloud —>IX,—>Open Drive	3.1213	0.780325
8	iCloud —>IX,—>Open Drive	3.1213	0.780325
9	iCloud —>IX,—>Open Drive	3.1213	0.780325
10	iCloud —>IX,—>Open Drive	3.1213	0.780325
4 Factors (Availability+TechnicalSupport+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
2	Integra-Net —Cloud Emailing Platform—>MiMedia	3.3869	0.846725
3	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
4	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
5	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
6	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
7	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
8	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
9	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
10	Integra-Net —,Cloud Emailing Platform—>MiMedia	3.3869	0.846725
4 Factors (Availability+TechnicalSupport+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	IConvergentComputing—>Lunarpages —>Meritide	2.9847	0.746175
2	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
3	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
4	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
5	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
6	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
7	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
8	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
9	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
10	InnovativeComputerSystems—>Lunarpages —>Meritide	3.0017	0.750425
5 Factors (Availability+TechnicalSupport+ResponseTime+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	iCloud—>Mailjet Cloud EmailingPlatform—>MiMedia	3.585	0.717
2	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
3	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
4	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
5	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
6	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
7	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
8	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
9	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
10	iCloud—>Mailjet,Cloud EmailingPlatform—>MiMedia	3.585	0.717
1 Factors (Reputation)			
#	Path	QoS	The accuracy of the solution
1	InnovativeComputerSystems—>Janalent —>Meritide	1	1
2	InnovativeComputerSystems—>Janalent —>Meritide	1	1
3	InnovativeComputerSystems—>Janalent —>Meritide	1	1
4	InnovativeComputerSystems—>Janalent —>Meritide	1	1
5	InnovativeComputerSystems—>Janalent —>Meritide	1	1
6	InnovativeComputerSystems—>Janalent —>Meritide	1	1
7	InnovativeComputerSystems—>Janalent —>Meritide	1	1
8	InnovativeComputerSystems—>Janalent —>Meritide	1	1
9	InnovativeComputerSystems—>Janalent —>Meritide	1	1
10	InnovativeComputerSystems—>Janalent —>Meritide	1	1

Table B.12: Experiment 2 The results of bee algorithm for selecting optimal path in set 4

Experiment 2: Set 4			
4 Factors (Availability+TechnicalSupport+Price+ResponseTime)			
#	Path	QoS	The accuracy of the solution
1	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
2	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
3	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
4	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
5	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
6	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
7	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
8	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
9	PodioCollaborativeWork Platform —>SymetriQ Cloud —>Vorsite	3.0538	0.76345
10	PolurNET —>ShareFile —>Vorsite	2.9754	0.74385
4 Factors (TechnicalSupport+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
2	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
3	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
4	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
5	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
6	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
7	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
8	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
9	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
10	PolurNET—>SymetriQ Cloud —>Vorsite	3.0251	0.756275
4 Factors (Availability+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
2	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
3	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
4	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
5	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
6	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
7	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
8	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
9	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
10	PolurNET —>ShareFile —>Vorsite	3.2041	0.801025
4 Factors (Availability+TechnicalSupport+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
2	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
3	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
4	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
5	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
6	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
7	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
8	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
9	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
10	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	3.8291	0.957275
4 Factors (Availability+TechnicalSupport+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
2	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
3	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
4	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
5	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
6	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
7	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
8	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
9	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
10	PowerObjects —>SymetriQ Cloud —>Webfortis	3.1688	0.7922
5 Factors (Availability+TechnicalSupport+ResponseTime+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
2	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
3	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
4	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
5	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
6	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
7	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
8	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
9	PodioCollaborative Work Platform —>SymetriQ Cloud —>Vorsite	4.0069	0.80138
10	Safe Copy Backup —>SymetriQ Cloud —>Vorsite	3.8085	0.7617
1 Factors (Reputation)			
#	Path	QoS	The accuracy of the solution
1	Racpspaze —>u2web —>WebHostingHub	1	1
2	Racpspaze—>u2web —>WebHostingHub	1	1
3	Racpspaze—>u2web —>WebHostingHub	1	1
4	Racpspaze—>u2web —>WebHostingHub	1	1
5	Racpspaze—>u2web —>WebHostingHub	1	1
6	Racpspaze—>u2web —>WebHostingHub	1	1
7	Racpspaze—>u2web —>WebHostingHub	1	1
8	Racpspaze—>u2web —>WebHostingHub	1	1
9	Racpspaze—>u2web —>WebHostingHub	1	1
10	Racpspaze—>u2web —>WebHostingHub	1	1

Table B.13: Experiment 3 The results of bee algorithm for selecting optimal path

Experiment 3: full Set			
4 Factors (Availability+Reliability++Price+ResponseTime)			
#	Path	QoS	The accuracy of the solution
1	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
2	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
3	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
4	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
5	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
6	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
7	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
8	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
9	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
10	Backblaze —>iDrive —>SugarSync	2.3212	0.5803
4 Factors (Reliability++Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
2	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
3	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
4	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
5	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
6	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
7	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
8	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
9	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
10	Carbonite —>Mozy —>SugarSync	2.5618	0.64045
4 Factors (Availability+Price+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
2	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
3	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
4	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
5	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
6	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
7	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
8	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
9	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
10	Arvixe —>Lunarpages —>WebHostingHub	2.5227	0.630675
4 Factors (Availability+Reliability+t+ResponseTime+Reputation)			
#	Path	QoS	The accuracy of the solution
1	backupgenie —>justcloud —>u2web	2.8027	0.700675
2	backupgenie —>justcloud —>u2web	2.8027	0.700675
3	backupgenie —>justcloud —>u2web	2.8027	0.700675
4	backupgenie —>justcloud —>u2web	2.8027	0.700675
5	backupgenie —>justcloud —>u2web	2.8027	0.700675
6	backupgenie —>justcloud —>u2web	2.8027	0.700675
7	backupgenie —>justcloud —>u2web	2.8027	0.700675
8	backupgenie —>justcloud —>u2web	2.8027	0.700675
9	backupgenie —>justcloud —>u2web	2.8027	0.700675
10	backupgenie —>justcloud —>u2web	2.8027	0.700675
4 Factors (Availability+Reliability+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	backupgenie —>livedrive —>u2web	2.8218	0.70545
2	backupgenie —>livedrive —>u2web	2.8218	0.70545
3	backupgenie —>livedrive —>u2web	2.8218	0.70545
4	backupgenie —>livedrive —>u2web	2.8218	0.70545
5	backupgenie —>livedrive —>u2web	2.8218	0.70545
6	backupgenie —>livedrive —>u2web	2.8218	0.70545
7	backupgenie —>livedrive —>u2web	2.8218	0.70545
8	backupgenie —>livedrive —>u2web	2.8218	0.70545
9	backupgenie —>livedrive —>u2web	2.8218	0.70545
10	backupgenie —>livedrive —>u2web	2.8218	0.70545
5 Factors (Availability+Reliability++ResponseTime+Price+Reputation)			
#	Path	QoS	The accuracy of the solution
1	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
2	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
3	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
4	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
5	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
6	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
7	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
8	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
9	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
10	backupgenie —>livedrive —>WebHostingHub	2.9278	0.58556
1 Factors (Reputation)			
#	Path	QoS	The accuracy of the solution
1	backupgenie —>Lunarpages —>RealWebhost	1	1
2	backupgenie —>Lunarpages —>RealWebhost	1	1
3	backupgenie —>Lunarpages —>RealWebhost	1	1
4	backupgenie —>Lunarpages —>RealWebhost	1	1
5	backupgenie —>Lunarpages —>RealWebhost	1	1
6	backupgenie —>Lunarpages —>RealWebhost	1	1
7	backupgenie —>Lunarpages —>RealWebhost	1	1
8	backupgenie —>Lunarpages —>RealWebhost	1	1
9	backupgenie —>Lunarpages —>RealWebhost	1	1
10	backupgenie —>Lunarpages —>RealWebhost	1	1

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