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Review

A systematic literature review on QoS-aware service composition and selection in cloud environment

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ABSTRACT

Generally, cloud computing consists of providing virtualized and scalable resources as services through the Internet dynamically. According to the costumers' requests, various types of services which have the same functionality with different non-functionality features, are delivered in the cloud environment that often should be combined to satisfy the customer's complex requests. Recently, the composition of unique and loosely-coupled services into a preferred system is a prevalent industrial method and a commonly tracked research topic in academia. Service composition deals with generating new value-added services by merging some single existing services to provide an optimal composite service which includes formerly existing single and simple services aims to improve Quality of service (QoS). To the best of our knowledge, in spite of this issue's significance in cloud computing, there is not any comprehensive and systematic single research about this issue with a particular focus on QoS, which takes all metrics inspected in this paper into consideration. The most notable and impact of this paper is that it does not eliminate any paper in this scope, also it investigates more criteria than the current surveys. Hence, the purpose of this paper is to investigate the former mechanisms and techniques in terms of numerous factors. So, it adopts a systematic literature review, vital questions which can be enhanced by the research accomplished to address the stated problem have been extracted and raised. Afterwards, by classifying the researches into two primary groups (centralized and distributed) based on the environment of the problem and identifying the inspected QoS parameters, predefined goals, and developing environments, appropriate outcomes and statistics are attained that can contribute to upcoming works. In other words, this paper focuses to systematically categorize and evaluate the current research approaches and strategies on QoS-aware cloud service composition (published up to August 2017).

1. Introduction

Cloud computing is a network-based system in which information technology and computing resources such as hardware, operating systems, storages, networks, databases, and even entire applications are delivered to users as on-demand facilities (Buyya et al., 2008) only via the Internet. Cloud computing offers several benefits, such as dynamic environment, on-demand services, scalability, but also has number of challenges that should be overcome by experts such as privacy and security (Alsmirat et al., 2017; Gupta et al., 2016; Ibtihal et al., 2017; Jouini and Rabai, 2016; Memos et al., 2018; Zkik et al., 2017), virtualization (Lombardi and Di Pietro, 2011; Saleem and Rajouri n.d.), scheduling (Hu et al., 2010; Mezmaz et al., 2011; Selvarani and Sadhasivam, 2010), resource discovery (Calheiros et al., 2011; Goscinski and Brock, 2010), reducing the attacks (Bhushan and Gupta, 2017; Jeyanthi et al., 2013), service discovery (Han and Sim, 2010), data replication (Milani and Navimipour, 2016; Navimipour and Milani, 2016), service recommendation (Aznoli and Navimipour, 2017; H. Wang et al., 2018), service composition and selection, and etc. In this research, authors have inspected the service composition/selection challenges. With regards to the type of provided services, a cloud might have the form of software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS). Applications are supplied via SaaS (Fox et al., 2009) form or mashups of value-added applications. There are remarkable amounts of web services available in the cloud environments, nevertheless, a single abstract service has restricted utilization and can't fulfill the users' complicated request. Hence, the necessity of integrating the single services and providing a composite service is obvious. web services can be joint together to generate a composite service which fulfills the user's requirements (Jatoth et al., 2017). But, service composition/selection

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process has three challenges: (i) specs of necessities for integrated services, (ii) collection of candidate single cloud services with different non-functional features such as quality of service (QoS) factors, that are supplied by various suppliers, and (iii) implementation of composite cloud services (Anane et al., 2005; El Hadad et al., 2010). Handling these challenges occasionally appears as a multi-objective optimization problem (Canfora et al., 2004). Choosing the optimum required single services with various QoS parameters which are supplied by different service suppliers, and proposing an optimal combination method to make a complicated service. Addressing this problem as an optimization challenge is an NP-hard problem since it exhibits a tremendously large number of similar single services to different service suppliers in the cloud. Service composition is one of the better approaches that is proposed by researchers and applied by cloud providers. Picking up suitable services among available services, dealing with service composition/selection constraints, determining the vital QoS attributes, understanding the dynamic specifications of the problem, and having fast alterations in the features of the services and network are some significant matters that must be considered in this method to guarantee the service users' satisfaction.

In the early 2000s and in the years before applications in cloud computing, service composition/selection was presented and inspected for web services (Kosuga et al., 2002; Milanovic and Malek, 2004; Schmid et al., 2002; Singh, 2001). Service composition/selection methods were first applied in cloud computing systems in 2009 (Kofler et al., 2010; C. Zeng et al., 2009). Then, a considerable effort was made in this field. The number of ongoing researches in cloud computing service composition/selection is quickly increasing because of the increasing tendency of researchers within numerous fields of expertise to handle the problem.

To the extent of our knowledge, in spite of significance of QoS-aware cloud service composition/selection problem, there is no systematic literature review with comprehensive statistical information and survey about this problem which realizes the necessity of researchers to concentrate on QoS-aware cloud service composition/selection. Considering above mentioned issues, this paper aims to systematically study and review the former QoS-aware service composition/selection techniques in the cloud environment comprehensively, systematically and statistically. Also, the paper provides statistical information about datasets, simulation tools, QoS attributes, and etc. which were adopted in the former researches, to give an extensive guideline for upcoming researches. As far as we can tell, this research signifies the first systematical effort to observe service composition/selection in cloud environment which particularly focuses on QoS-awareness. Moreover, this paper does not omit any of the researches in this scope. With regards to our analytical observation, there is no any particular research to cover all issues investigated in this study. For instance, some surveys have addressed statistical information about simulation tools, datasets, etc., but other statistical information such as the most cited research, proposed method, etc. are not taken into account by them. Moreover, some researches have considered QoS-awareness in web environment while some others ignored QoS-awareness and just addressed cloud environment.

In term of above motivation, a systematic literature review is provided which will give a good roadmap for future research directions in the field of QoS-aware service composition/selection in the cloud environment. In contrast to the former surveys, we have taken more metrics into account to compare and analyze the current studies.

Considering the aforementioned discussion, the contributions of this paper are as follow:

- Preparing an outline of current issues about QoS-aware service composition/selection in the cloud environments.
- Providing a systematical and statistical review of the former approaches for QoS-aware cloud service composition/selection.
- Exploring the datasets, simulation tools and QoS attributes which are mostly used in recent works.
- Outlining crucial fields for improving the QoS-aware cloud service composition approaches in upcoming researches.

The rest of the paper is structured as follows. After this section, brief information and definition about the quality of service will be explained in section 2. Section 3 discusses some related work. The research methodology is provided in Section 4. Section 5 discusses QoS-aware service composition/selection strategies in the cloud environment and classifies them, as well as demonstrates an outline, merits, and demerits of the selected papers. Section 6 describes some threats to validity. Section 7 maps out analysis of SLR results and comparison of the selected papers in some tables. Section 8 discusses open issues and future works. Finally, the conclusion of this paper is shown in section 9.

2. Preliminaries

Technology of cloud services makes the chance of creating complex services by aggregating available single or combined cloud services from various corporations and subsequently presenting them as high-quality and strong services or techniques which are able to fulfill user's complicated requests (Yang and Papazoglou, 2004). QoS evaluation becomes a significantly interesting challenge and vital since complicated and objective critical applications are designed for services with various QoS attributes. For each cloud service, the QoS attributes are defined in service level agreement (SLA) between customers and the service suppliers. Actually, QoS has attracted remarkable attention in cloud computing scope (J. Liu et al., 2015a; Q. Zhang et al., 2014; A. Zhou et al., 2016). In the following the QoS modeling, monitoring and aggregating techniques for cloud services will be briefly summarized.

QoS modeling: There are three following classes of former researches in service QoS demonstration: single values demonstration, multiple values demonstration, and standard statistical distributions. Most of the researches denote QoS metrics as constant values (Casati et al., 2000; L. Z. Zeng et al., 2004). Time passing changes the QoS of a cloud service and environment configuration; however, this alternation will not be reflected by single value-modeled QoS. Aiming to model QoS for handling the problems, researchers employ standard statistical distributions (Cardoso et al., 2004; Rosario et al., 2008). Authors in (Cardoso et al., 2004) have indicated that a QoS factor can be defined as a distribution function, such as normal, exponential, uniform, and Weibull. Authors in (Rosario et al., 2008) have presented the QoS probability distributions in the form of the agreements between cloud service suppliers and service consumers.

QoS monitoring: QoS monitoring can provide the QoS of a cloud service. According to where the evaluation takes place, there are three tactics for QoS monitoring:**(a) Client-side monitoring**: the evaluation of QoS is operated on the client side (Mani and Nagarajan 2002; Rosenberg et al., 2006). QoS metric that is determined by customer experience, like lateness, is assessable on the client side. **(b) Server-side monitoring**: the server-side evaluation of QoS (Artaiam and Senivongse, 2008). Although this tactic needs to access the real cloud service conduction, it is not possible all the time in experiments. **(c) The third party based monitoring:** the evaluation of QoS is operated by a third party (Zheng et al., 2010). Cloud services will regularly be investigated by third parties in different network conditions from various geo-distributed locations and produce the QoS.

Composite QoS Aggregation: an aggregation method is provided by (Cardoso et al., 2004; Jaeger et al., 2004) for single valued QoS attributes which aims to compute the merged QoS. Various composition patterns are merged to make a composition. In order to compute QoS for the composition patterns, some formulae are specified. However, only single values can adopt these formulae. For both single values and multiple values demonstrated QoS (Hwang et al., 2007), the same computation technique is used. But each QoS value in composite service is considered as the probability value. For standard distribution demonstrated QoS (Cardoso et al., 2004; Rosario et al., 2008), simulation methods are adopted to evaluate the merged QoS. Before reaching to a QoS model for the composite service, a simulation should be performed for a lot of times.

Composition patterns: A composite service can be developed according to four basic composition patterns: sequential pattern, conditional pattern, loop pattern, and parallel pattern. However, in the majority of studies, only the sequential model is investigated, other composition models could be changed into the sequential model by some perfect strategies (Alrifai and Risse, 2009; Qi et al., 2010). In the sequential composition model, the aggregation types of different QoS metrics often differ. The widely accepted aggregation types which are used in the majority of the studies are shown in Table 1, where CS signifies a solution for composition problem and ws_i refers to a selected service for task T_i ($i = 1, \ldots, n$).

In addition, all the cloud services have some QoS metrics for service assessment. These metrics will be examined in all feasible combinations of cloud services. Some vital metrics which were mostly used by former researches are introduced as follows:

- **Price**: The amount of money that the service provider gets from a customer as service using cost.
- **Availability**: The probability that a service is accessible, in the other words it demonstrates the probability of successful invocation.
- **Response Time**: The time duration in which user should be waited after sending a request until receiving a response is response time.
- **Reliability**: The rate of error messages to total messages.
- **Throughput**: The total invocations of the service within a specified period of time, it is evaluated by invokes/second.
- **Reputation**: The reputation of a service is a vital metric for trusted service evaluation. Values of the most service qualities are available in SLA (Ludwig et al., 2003). However, the reputation value results from the customers' feedback; thus, it is subjective and appropriate to several extents. Typically, improving services is due to enhancing the quality of services by their providers. This improvement commonly is performed based on the feedback to catch the attention of more customers.
- **Time**: The execution duration between arriving a request and obtaining the result.
- **Successability**: Number of response/number of request messages

3. Related work

A glance of reliable published researches demonstrates researchers who are interested in this promising area meet a remarkable number of new ideas, techniques, mechanisms, frameworks, algorithms and methods, and additional expanding the range of problems. Moreover, some existing datasets, effective QoS parameters and implementation environments with various features and effects should be identified. Thus, and due to the insufficient related research, a systematic literature review of QoS-aware service composition/selection in the cloud environment is necessary and can help simplify upcoming studies. A systematic review in which the most crucial aspects of the published studies must be inspected, and valuable information and statistics must be selected. Several survey papers that argued the service composition/selection will be denoted in this section along with the description of their important merits and demerits.

Table 1
Widely accepted aggregation types.

Aggregation Type	QoS criterion samples	Aggregation function
Summation	Price, Response time, Lateness, …	$SC{\cdot}c_j = \sum_{i=1}^{n} ws_i{\cdot}c_j$
Average	Reputation, Throughput, …	$CS{\cdot}c_j = \frac{1}{n}\sum_{i=1}^{n} ws_i{\cdot}c_j$
Multiplication	Availability, Reliability, …	$CS{\cdot}c_j = \prod_{i=1}^{n} ws_i{\cdot}c_j$
Min	Reputation, Throughput, …	$CS{\cdot}c_j = \min_{1 \le x \le n} ws_i{\cdot}c_j$
Max	Reputation, Throughput, …	$CS{\cdot}c_j = \max_{1 \le x \le n} ws_i{\cdot}c_j$

Authors in (Soni and Koushal, 2017) have surveyed on the web services of dynamic discovery and composition in the cloud environment. Since the main problem with the current service selection is the lack of a strategy that considers QoS attributes for the service selection, this study has provided several approaches to web services discovery and composition. However, this research did not represent a SLR.

Moreover, researchers in (Manqele et al., 2017) have proposed various phases that need to be addressed when choosing a method of service selection. The phases were adopted in a state to choose the effective technique and later the technique was assessed based on recall, response time and precision metrics. Nevertheless, this study did not deliver a SLR.

Also, researchers in (Kowsalya et al., 2017) have provided a basic survey on semantic web service composition, furthermore (Libin and Immanuel, 2017) proposed a survey paper about the constantly evolving web services, their composition approaches and the different issues and challenges that they met. The survey aims to deliver an outline of various web service technologies like UDDI, WSDL, soap and etc. However, neither (Kowsalya et al., 2017) nor (Libin and Immanuel, 2017) did not provide a SLR.

In (Sheng et al., 2014), authors have provided a survey of web service composition to review the service composition methods in two groups: automated and semi-automated service composition. But, they take into account only web service composition approaches and the QoS attributes and search methods were ignored particularly in cloud computing.

Jula et al. have provided one of the significant researches about the cloud service composition (Jula et al., 2014). In this study authors have discussed different QoS attributes such as reliability, latency, availability, trust, and cost. Moreover, their paper consists of a comprehensive taxonomy on the basis of various factors which are obtained from former methods' investigation. Additionally, in this research, papers published up to 2013 are categorized according to their mechanisms into four groups: machine-based approaches, classic and graph-based approaches, frameworks approaches and combinatorial approaches. Nevertheless, article selection method, open problems and recently published articles are not taken into account.

Moreover, authors in (Lemos et al., 2016) have examined the service composition problem in cloud computing consists of knowledge re-use, tool support, execution system, and target customers. Although they have investigated the problem and analyzed several papers, QoS attributes observation, service composition/selection mechanism, article selection method, and open problems have been missed.

Finally, surveying the service composition methods in the framework-based, heuristic-based and agent-based have been done by (Vakili and Navimipour, 2017). But, in this study, a limited number of papers have been inspected; thus, some of the good researches have been ignored. Also, this paper did not cover the papers published in 2017. Moreover, datasets and simulation tools, which were used in the investigated researches have been neglected.

With respect to the above-mentioned gaps, the former survey articles have some deficiency as follows:

1. Newly published articles, particularly in 2017, have been missed.
2. The structure of some papers is not systematical since the paper selection mechanism is not obvious.
3. The QoS attributes are not taken into account by some researches in the surveying process.
4. The service composition mechanism is not revealed in some papers.
5. Lots of articles do not classify the papers in a reasonable way.
6. Most of the articles do not illustrate an obvious statistical information of datasets and simulation tools.

The stated reasons stimulated us to propose a systematic literature review paper which addresses all of the aforementioned weaknesses.

4. Systematic literature review

This section provides a Systematic Literature Review (SLR) of QoS-aware service composition/selection in cloud computing with a particular concentration on QoS-awareness, to give an obvious illustration of this field.

4.1. Research questions

Identifying, categorizing, and synthesizing a reasonable outline of state of the art researches is called a systematic literature review that transfers information in the research community (Brereton et al., 2007; Keele, 2007). Till now, to the extent of our knowledge, there isn't any systematic literature review about QoS-aware cloud service selection or composition which has not filtered any article, investigated all the researches in the scope and also explored the datasets and simulation tools employed in the researches. Thus, we have conducted a SLR about QoS-aware cloud service selection or composition to identify, classify, and systematically evaluate the former research techniques and approaches. The important purpose of this SLR is to answer the below Research Questions (RQ).

→ RQ1: What is the concept of cloud service composition? The answer to this question was given in section 1.
→ RQ2: What is the concept of QoS? The answer to this question was given in section 2.
→ RQ3: Which QoS attributes are mostly employed in QoS-aware service composition? The answer to this question was given in section 2 and more details will be given in section 7.
→ RQ4: What are the current researches which tackle with QoS-aware service composition/selection in the cloud environment? The answer to this question will be given in section 5 and section 7.
→ RQ5: Which important motives stimulate the researchers to study in the field of QoS-aware service composition/selection in cloud computing? The answer to this question was given in section 3.
→ RQ6: What simulation tools, datasets or benchmarks are used and what case studies are considered? The answer to this question will be given in section 7.

4.2. Search query

Aim to specify search strings for databases and inclusion and exclusion criteria, some keywords have been defined. We have specified search strings by considering the synonyms and different spellings of the question items and connect them using "and" and "or". Hence, we have chosen the most appropriate and relevant keywords that support our research field. Thus, four search strings have been chosen: "service composition", "cloud", "service selection", "QoS-aware". In an attempt to inspect the inclusion of our results, we have employed the results of our primary examination as a pilot and passed various stages, then we have specified the query. Due to the researches which were not retrieved by the initial query in our experiment, we have refined the query string and added some more keywords for instance "service composition" or "service selection" and "cloud", "QoS-aware". Aiming to develop the range as extreme as possible, we have employed the search string to abstract, titles and body of the papers. We have carried out the search in August 2017, without any specified time range.

4.3. Selection of sources

Most important journal papers and conference articles have been chosen for the search query. In order to extract appropriate results, these publishers were subsequently classified and analyzed. We have used Google Scholar, web of science, and Scopus as the data sources. Therefore, the search procedure included the papers accessible in some of the most credible databases which are precisely and methodically peer-reviewed: IEEE, ACM, ScienceDirect, SpringerLink and Elsevier among others.

4.4. Article selection process

In an attempt to choose the articles for a systematic literature review, a process with three main phases is conducted:

Phase 1: Automated search with regards to the keywords
Phase 2: Selection according to the title of the articles and articles language
Phase 3: omitting all the papers which are not included three of keywords simultaneously including: "cloud", "QoS" and "service composition" or "service selection".

In phase 1, keywords (service composition, service selection, cloud computing, QoS-aware, service composition in the cloud environment, service selection in the cloud environment) have been searched to find appropriate papers. 10560 articles from conference papers, journals, notes, books, chapters and any articles, was recorded as a result of the search in which a part of mentioned keywords was stated.

Phase 2 was conducted by considering some criteria. Hence we concentrated on the papers selected from journal publications and IEEE conferences published by IEEE, Springer, Elsevier, ACM, and Doaj. In this respect, the worthless conference papers, working papers, technical reports, commentaries, editorial notes, erratum, and review papers were excluded. The papers were selected due to their titles related to QoS-aware cloud service composition and related concepts.

In phase 3, full texts and abstracts of the chosen papers were analyzed by authors to ensure that only publications were included in the study that have inspected all the stated search strings simultaneously and verifying the relevance of these papers. Due to these relevancies to the subject matter and other specification, each paper was either included or excluded. Finally, 50 papers were selected.

4.5. Selection criteria

In this SLR, we have provided a Quality Assessment Checklist (QAC) on the basis of (Kitchenham et al., 2009), to select and evaluate only the qualified researches which have included all the stated search strings simultaneously without any limitation for publication time. The checklist covers the following questions (Kitchenham et al., 2009): (a) Is the study in cloud computing field? (b) Does the research methodology consider the QoS? (c) Is the investigation of research accurately performed?

In the process of article selecting, each research meets evaluation

Table 2
The inclusion-exclusion criteria for the proposed systematic protocol.

Criterion	Rational
Inclusion1: A research which is conducted in cloud environment	Cloud computing is one of the main criteria for this research
Inclusion2: English language papers	Only the papers written in English are chosen to provide more feasibility
Inclusion3: A research which is conducted by academics	Only academic solutions that are related to this research
Exclusion1: A research that includes journal papers, conference papers, and book chapters	Only the researches published in journal papers, conference papers, and book chapters were selected and the other formats such as masters and doctoral dissertations, editorial notes, textbooks, and unpublished working articles were omitted.
Exclusion2: A research that does not take QoS into consideration	This paper only concentrates on researches that present QoS on service composition/selection problem

criteria is selected. Table 2 summarizes the inclusion-exclusion specifications for the systematic protocol in this paper. Moreover, due to the significant role of the cloud computing for service composition/selection optimization, we excluded the researches which are performed in the web environment. Also, we have omitted the researches that did not consider QoS-awareness.

4.6. Quality assessment and data extraction

For additional examination, the data are summarized from the chosen researches in data extraction stage. All of 10560 researches are identified. Firstly, we read search keywords, abstracts, and concepts which indicate the contribution of the article. Then, the researches with unfavorable abstracts were omitted. Therefore, the whole body of the remaining articles was studied and some of which were not relevant to the stated issue were also omitted. With regards to the QAC and inclusion/exclusion criteria, the researches were refined and finally, 50 papers were selected as an initial research for the systematic survey. Fig. 1 demonstrates an outline of the paper selection methodology in this research.

4.7. Article classification

In this section, the classification of the papers based on their relevance to the QoS-aware cloud service composition and selection is described. Among the two categories of cloud service composition, 31 articles out of 50 (62%) were related to distributed, multi-cloud (Table 3); 19 articles out of 50 (38%) referred to centralized, single-cloud (Table 4). Moreover, the classification of the papers based on the year of publication that elected up to 2017 is shown in Fig. 2, also Fig. 3 demonstrates the distribution of articles by year of publication in each category (single-cloud and multi-cloud). In 2016, the number of published articles was maximum, as Fig. 4 illustrates 34% of investigated papers were published in 2016. Also, Fig. 5 shows the classification of the papers over time in each category including Elsevier, Springer, IEEE, Doaj, ACM, ProQuest, Sersc, Inass, Scientific, Kpubs, and Ijorset. Fig. 6 illustrates the classification of the papers among 13 publishers, where 36% of the total articles are related to IEEE, 28% of the articles are related to the springer, 12% of the articles belong to Elsevier. And also each of ACM, Sersc, ProQuest are included 4% of articles, and each of the remaining databases includes 2% of the articles. The number of published papers in each publisher is depicted in Fig. 7. Furthermore, Fig. 8 demonstrates the number of each publication's papers in each category (single and multi-cloud).

5. Cloud service composition classification

This section proposes two classifications of existing methods in QoS-aware service selection or composition in the cloud environment. The purpose of this section is to present an understandable trend of QoS-aware cloud service composition/selection by examining all 50 selected articles. In addition, their methods, differences of them will be mentioned as well. Papers are classified on the basis of two different perspectives. In section 5.1 we have categorized the papers based on the number of clouds and the environment of the composition process. Furthermore, in section 5.2 papers have been categorized on the basis of single-objective and multi-objective optimization.

5.1. Classification based on the number of clouds

We have analyzed the current papers in the context of their deployment models and the resultant method by which cloud candidate services should select and compose. In the light of these considerations, the papers have been categorized into two classes including multi-cloud (distributed) and single-cloud (centralized). Their methods, algorithms, metrics, merits, and demerits will be discussed in the following. The centralized model is managed by a single cloud provider at a time. Several cloud users may be handled by one cloud provider. There is a simple client-provider interaction between each of cloud users and the provider. In other words, all candidate services for composition process are in the same cloud. Moreover, In the distributed model, candidate abstract services may be distributed across two or more cloud bases simultaneously. These abstract services should be composed to encounter the users' requests and requirements. Since these candidate abstract services are distributed in different clouds, sometimes issues such as communication latency are raised. Fig. 9 depicts the classification of papers' approaches.

5.1.1. Distributed (multi-cloud)

The class of distributed methods refers to the methods in which multi-cloud environments are considered and also some of the communication attributes such as transfer rate, communication latency, cost and etc., are addressed. Moreover, we deposit some other environments as a multi-cloud environment in distributed class, including cloud manufacturing and mobile cloud. Generally, the cloud service composition problem is described as a single-objective problem with local/global QoS optimization or a multi-objective problem with global QoS optimization. Authors in (Dandan Wang et al., 2014) have proposed a global composition model using genetic algorithm with regarding service providers for a geographically distributed cloud environment. The proposed model has taken both QoS of services and QoS of network into account, also it has mitigated the execution time. However, this research has the problem of incompatibility during the execution process. In order to aid customers making a flexible decision in cloud manufacturing environment, researchers in (F. Chen et al., 2016a) have proposed a new QoS-aware web service composition (QWSC) technique by multi-objective global optimization with regarding evolutionary algorithm. Although this study has improved scalability, flexibility, and efficiency, it suffers from high time

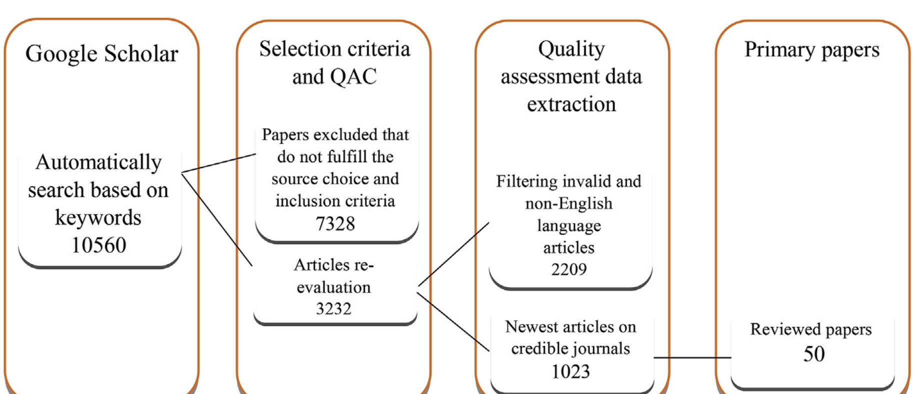

Fig. 1. Outline of the paper selection process.

Table 3
Distribution of QoS-aware service composition in multi-cloud environment, articles by journal and conference names.

Publisher	Year	Author	Journal/Conference name
IEEE	2013	(Karim et al., 2013)	IEEE Ninth World Congress on Services
	2013	(Li et al., 2013)	22nd International Conference on Computer Communication and Networks IEEE
	2014	(Grati et al., 2014)	e-Business (ICE-B), 2014 11th International Conference on
	2014	(J. Huang et al., 2014b)	2014 IEEE International Conference on Services Computing
	2015	(Ridhawi and Ridhawi, 2015)	IEEE 7th International Conference on Cloud Computing Technology and Science
	2015	(Comi et al., 2015)	IEEE 24th International Conference on Enabling Technologies: Infrastructures for Collaborative Enterprises
	2015	(J. Huang et al., 2015)	IEEE Transactions on Cloud Computing
	2015	(M. Zhang et al., 2015)	Conference on Collaboration and Internet Computing
	2016	(Z Ye et al., 2016)	IEEE Transactions on Services Computing
	2016	(Y. Huang et al., 2016)	13th International Conference on Service Systems and Service Management
	2016	(S Wang et al., 2016b)	IEEE Transactions on Cloud Computing
Springer	2012	(Zhen Ye et al., 2012)	Chapter- Service-Oriented Computing
	2014	(Xiang et al., 2014)	Central European Journal of Operations Research
	2015	(Jin et al., 2015)	Journal of Intelligent Manufacturing
	2016	(Faruk et al., 2016)	Advances in Signal Processing and Intelligent Recognition Systems
	2016	(J. Zhou and Yao, 2016)	The International Journal of Advanced Manufacturing Technology
	2016	(B. Liu and Zhang, 2016)	The International Journal of Advanced Manufacturing Technology
	2017	(Helali and Brahmi, 2017)	Information Systems Architecture and Technology
Elsevier	2012	(Qi et al., 2012)	Journal of Computer and System Sciences
	2014	(Dandan Wang et al., 2015)	Computers and Electrical Engineering
	2016	(F. Chen et al., 2016a)	Computers & Industrial Engineering
	2016	(Spezzano, 2016)	The 7th International Conference on Ambient Systems, Networks and Technologies
ACM	2012	(Klein et al., 2012)	21st international conference on World Wide Web
	2014	(B. Huang et al., 2014a)	Enterprise Information Systems
Doaj	2016	(Shehu et al., 2016)	International Journal of Advanced Computer Science and Applications
Sersc	2014	(Lu et al., 2014)	International Journal of Grid and Distributed Computing
	2014	(Peng and Changsong, 2014)	International Journal of Future Generation Communication and Networking
Inass	2016	(Bharath Bhushan and Pradeep Reddy, 2016)	International Journal of Intelligent Engineering and Systems
scientific.net	2014	(L. Liu et al., 2014)	Applied Mechanics and Materials
Taylor	2017	(J. Zhou and Yao, 2017)	International Journal of Production Research
kpubs.org	2015	(Dandan Wang et al., 2015b)	KSII TRANSACTIONS ON INTERNET AND INFORMATION SYSTEMS

complexity. Moreover, for global optimization of QoS-aware service composition problem, in (M. Zhang et la., 2015) a genetic algorithm (GA) with improved crossover and mutation operator have been investigated which considers the geo-distributed multi-cloud environment. The attained outcomes have revealed that this technique has high scalability, whereas high time complexity cloud reduces its performance. Also, in (J. Zhou and Yao, 2017) a multi-objective hybrid artificial bee colony (MOHABC) algorithm for global optimization of service composition and optimal selection (SCOS) in cloud manufacturing has been proposed which both the quality of service and the energy consumption are taken into account. This method improves the convergence speed and has high performance on small scales; however, it sometimes gets stuck in local optima in large-scale problems. Also, in (Z Ye et al., 2016) the authors have proposed a framework for cloud service composition which chooses the optimal composition with regards to users' long-term QoS requests, but it has low accuracy in small scales. Besides, in (Ridhawi and Ridhawi, 2015) in order to find some functions for processing mobile media a cloudlet-supported and semantic-based service composition solution is discussed. Hence, mobile media can be seamlessly integrated into media delivery sessions. This method has high accuracy, stability, and flexibility though it slightly decreases the success rate. Furthermore, in (Li et al., 2013) a shortest-path according to voting algorithm have been proposed that placements persistent services for the wide-range consumers over the long-run which decrease response time, but this approach only considers small-scale in term of instance service number. Also, researchers in (S Wang et al., 2016b) have adopted a network-aware method by using mixed integer programming (MIP) that links services and networks. Also, it takes network resource consumption into consideration in the service composition process. The proposed method is inappropriate for multiple data centers; nevertheless, it has high QoS optimality, efficiency and low computation time. As another research, in (Y. Huang et al., 2016), to solve the QoS-aware cloud service composition problem, two threshold-based query tactics have been presented in dynamic service networks which suffer from high overhead. Moreover, in (Shehu et al., 2016), authors have employed fruit fly optimization algorithm to implement network-aware service composition in the cloud environment. The proposed approach has good accuracy and low cost; though, it suffers from high computation time in large-scale problems.

Also, in (Comi et al., 2015) a reputation-based strategy have been designed to support the service composition with regards to QoS factors prepared by the evaluating systems, and reputation factors prepared by the users as customers feedback. Despite that, this study is not evaluated experimentally. Furthermore, researchers in (J. Huang et al., 2014b) have proposed an approach which answers the challenge of converging network-cloud lied in QoS-aware network and cloud service composition. This approach provides low running time though it has high execution time in large-scales. Also, authors in (Qi et al., 2012) aiming to support cross-platform service invocation in cloud environment, have investigated a QoS-aware composition approach. Although the proposed approach has high scalability, flexibility, and feasibility, it suffers from high failure rate in small-scales and high time complexity. As another research, in (Spezzano, 2016), a new framework for supporting the collection of services have been proposed which considers runtime modifications in the QoS of services. This approach suffers from high computational time in large-scale problems, nevertheless it has high scalability. In (Grati et al., 2014) researchers have proposed a method in which both meeting QoS constraints prioritized by the cloud user and regarding the resource constraints of the cloud supplier are taken into account. The attained results have proved that this method has good feasibility and scalability, whereas it suffers from high computation time in small-scales. Furthermore, in (J. Huang et al., 2015) a QoS-aware service composition technique have been employed which answers the challenge which guarantees to perform the convergence network-cloud service provisioning as well as possible in the process of composing network and cloud services with end-to-end efficiency. The proposed method has good feasibility and low response time though it has high

Table 4
Distribution of QoS-aware service composition in single cloud environment, articles by journal and conference names.

Publisher	Year	Author	Journal/Conference name
IEEE	2011	(Shangguang Wang et al., 2011a)	IEEE Conference on Computer Communications Workshops
	2012	(Bao and Dou, 2012)	26th International Parallel and Distributed Processing Symposium Workshops & Ph.D. Forum
	2015	(D Wang et al., 2015a)	International Conference on Cloud Computing and Big Data
	2015	(S. Liu et al., 2015b)	Evolutionary Computation (CEC), 2015 IEEE Congress on
	2015	(Feng and Kong, 2015)	11th International Conference on Semantics, Knowledge, and Grids
	2016	(Hongzhen et al., 2016)	Online Analysis and Computing Science
	2016	(Y. Chen et al., 2016b)	IEEE Transactions on Cloud Computing
Springer	2011	(Zhen Ye et al., 2011)	Chapter-Database Systems for Advanced Applications
	2013	(Shangguang Wang et al. 2013)	Mobile Networks and Applications
	2015	(Huo et al., 2015)	Applied Intelligence
	2016	(Seghir and Khababa, 2016)	Journal of Intelligent Manufacturing
	2016	(Seghir et al., 2016)	Chapter- Intelligent Systems Technologies and Applications
	2016	(Karimi et al., 2016)	The Journal of Supercomputing
Elsevier	2015	(Jula et al. 2015)	Expert Systems with Applications
	2016	(Z.-Z. Liu et al., 2016)	Information Sciences
Proquest	2013	(C. Zhang et al., 2013b)	International Conference on Parallel and Distributed Processing Techniques and Applications
	2013	(C. Zhang et al., 2013a)	International Conference on Grid Computing and Applications
Other Publications	2014	(Younes et al., 2014)	International Journal of Computer Applications
itiis	2016	(Dandan Wang et al., 2016a)	KSII Transactions on Internet and Information Systems

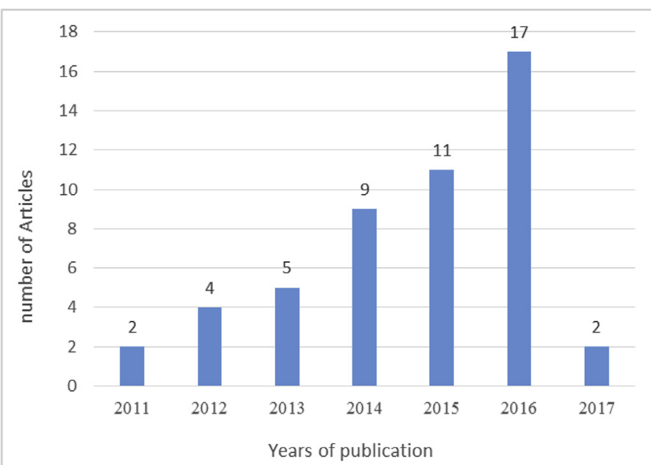

Fig. 2. Distribution of articles by year of publication.

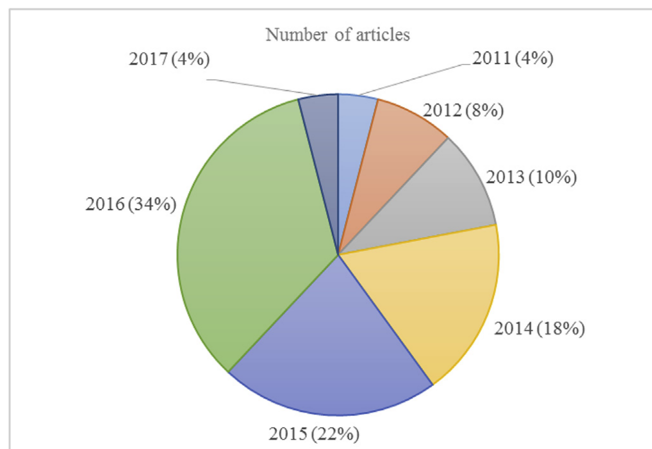

Fig. 4. A pie chart of the percentage of the QoS-aware cloud service composition papers based on their publication year.

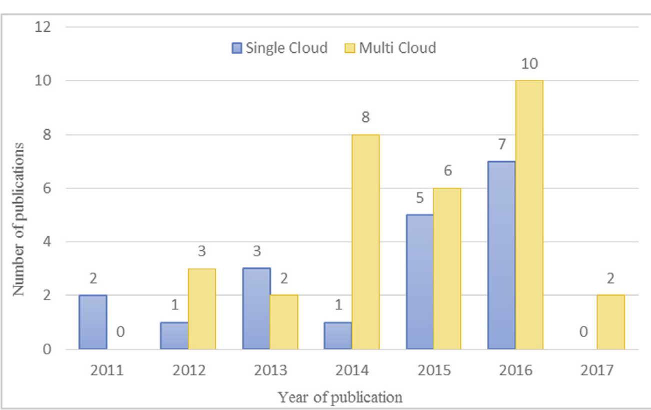

Fig. 3. Distribution of articles by year of publication in each category.

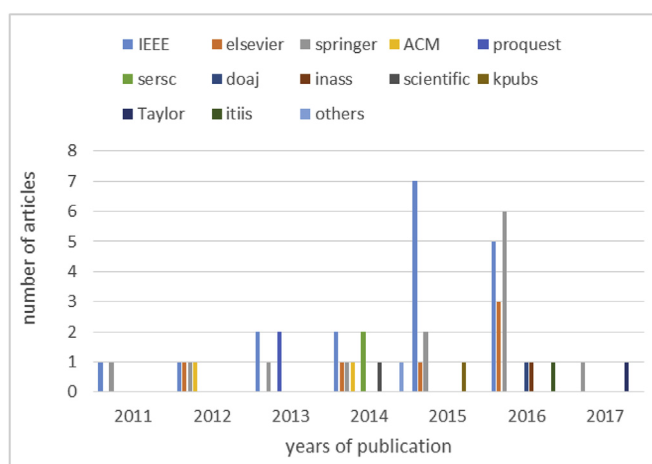

Fig. 5. Distribution of the articles over time in each investigated categories.

execution time. Moreover, in (J. Zhou and Yao, 2016) authors have presented a novel method by adopting hybrid artificial bee colony (HABC) algorithm aims to solve composite cloud manufacturing service optimal selection (CCSOS) problems. The simulation results have illustrated that this method has high stability, while it suffers from high time complexity in large-scales. In (Jin et al., 2015) the quality correlations among manufacturing cloud services have been considered, also for optimal services selection problems, an effective method by using genetic algorithm, named PGA, have been proposed though it's insufficient in

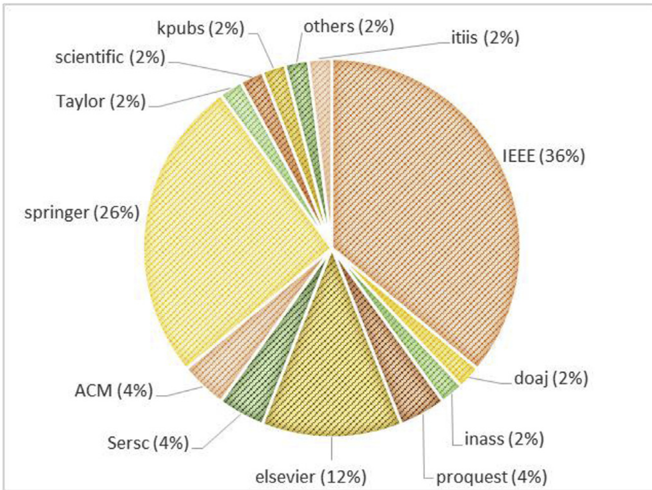

Fig. 6. A pie chart of the percentage of the QoS-aware cloud service composition articles based on different publishers.

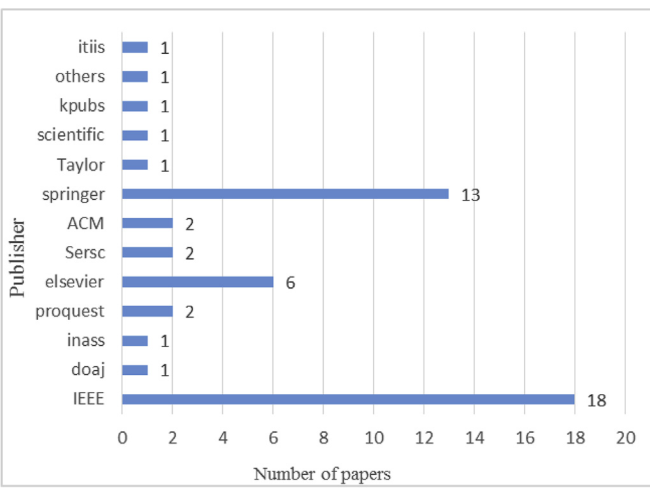

Fig. 7. Number of each publication's papers which are investigated in this research.

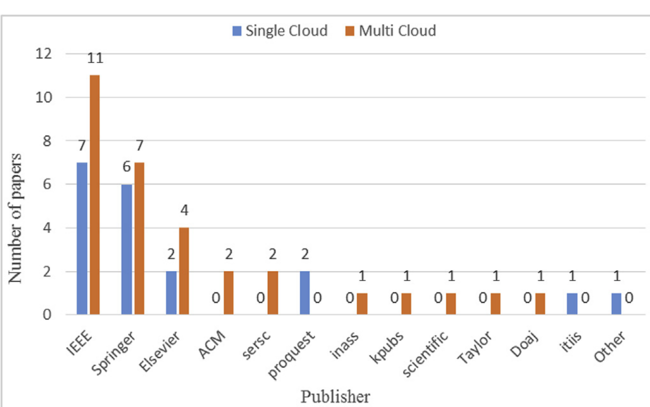

Fig. 8. Number of each publication's papers in each category (single and multi-cloud).

large-scale problems. Moreover, researchers in (Xiang et al., 2014) for addressing the problem of service composition and optimal selection (SCOS), have proposed a novel multi-objective optimization algorithm (GLA-Pareto) according to the merging Pareto solution idea and a new globe optimization algorithm, called group leader algorithm (GLA) which is on the basis of QoS and energy utilization. It has high quality; however, it is inefficient in large-scale problems. As another research in (B. Liu and Zhang, 2016) authors have adopted genetic algorithm to a global optimization by investigating a method of service composition on the basis of grouping synergistic elementary services. This method has good quality and success rate, whereas it has a high time cost. Furthermore, based on multi-agents system in (Helali and Brahmi, 2017) an effective cloud service composition method have been proposed that inspects both QoS of services and network QoS. The experimental results have demonstrated that this method is scalable, while it suffers from high execution time. Also, for composing best QoS-aware services with the minimum number of cloud combinations, in (Bharath Bhushan and Pradeep Reddy, 2016) an algorithm has been introduced. This approach has low communication cost; nevertheless, it has low quality. Also, in (Dandan Wang et al., 2015b) first a graph model have been demonstrated which observes both QoS of web services and QoS of network. Afterward, a new method aiming at selecting the optimal composition path that meets the user's end-to-end QoS requirements have been proposed. This method reduces response time, while suffers from high runtime in large-scales. Moreover, in (Lu et al., 2014) according to objective QoS haphazardness and subjective trust assessment in cloud computing a global dynamic service composition have been proposed, also this research has adopted hypothesis test which eliminates inaccessible items and corrects the QoS values. Although the proposed method has good quality, stability, and accuracy, it suffers from high time. Also, a new service composition framework has been presented by authors of (Peng and Changsong, 2014) which employs evolution mechanism aiming to tackle with the multiple QoS constrained service composition problem and takes advantage of flexibility delivered by cloud systems. Experimental results have shown that this method has good optimality, scalability, and stability, while it suffers from high overhead. Furthermore, for the cloud service composition problem in (L. Liu et al., 2014) a particle swarm optimization algorithm by focusing on multi-QoS has been presented. This method has the ability to escape local optima, whereas it suffers from low convergence speed. Moreover, authors in (B. Huang et al., 2014a) have adopted the chaos control operator algorithm (CCOA) to investigate the problem of cloud service composition optimal-selection (CSCOS) in cloud manufacturing (CMfg). The proposed method has high quality; nevertheless, it suffers from high time in small-scale problems. As another research, in (Zhen Ye et al., 2012), discrete Bayesian network has been adopted to signify the economic model of customers which considers cloud service composition from a user-based side. The simulation results have shown that this method provides low time whereas it suffers from high time. In addition, researchers in (Klein et al., 2012) have employed genetic algorithm for proposing a network-aware method which manages the QoS of services and the network QoS separately. Despite the good scalability and low latency, the proposed method suffers from high overhead. Also, a unique heuristic technique has been deliberated by researchers of (Faruk et al., 2016) to deal with the QoS-aware cloud service selection which is provided by an improved genetic-particle swarm optimization (GPSO). Although the proposed method has good optimality and stability, it suffers from prematurity convergence. Furthermore, in (Karim et al., 2013) authors have introduced a set of mapping rules and present a novel way of calculating the end-to-end QoS values in the cloud environment regardless of this, the suggested method has not been simulated. More metrics about the current classification are presented in Tables 7 and 10.

5.1.2. Centralized (single cloud)

The class of centralized methods refers to the methods in which single-cloud environments are considered, these methods are simple to implement because there is no need to combine the clouds and calculate some extra attributes like transfer rate and communication properties including cost, latency and etc. For QoS-aware cloud service composition,

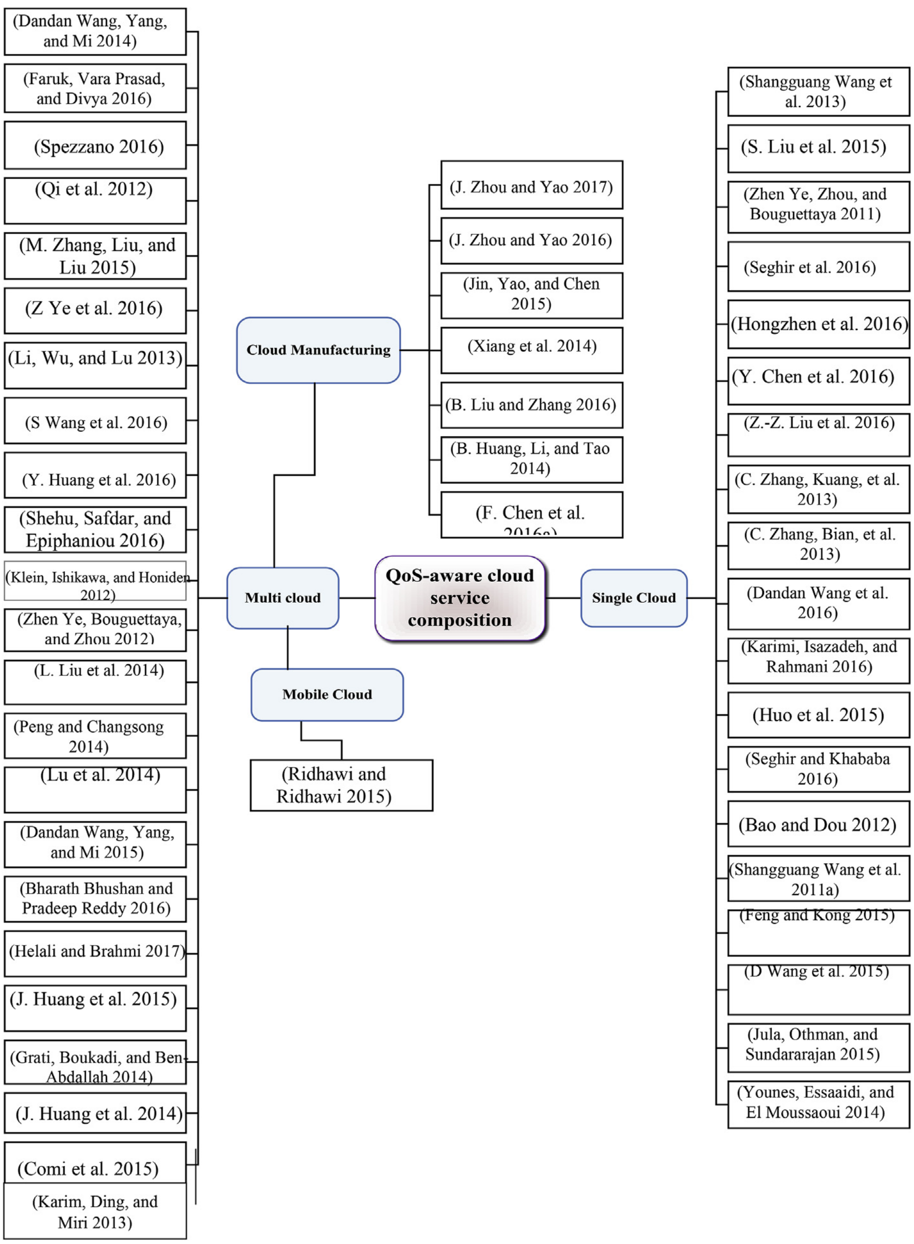

Fig. 9. Classification of investigated papers' approaches.

Table 5
Multi-objective researches and their parameters.

Authors	QoS-aware	Other parameters
(S Wang et al., 2016b)	✓	Network-aware
(Xiang et al., 2014)	✓	Energy-aware
(J. Zhou and Yao, 2017)	✓	Energy-aware
(F. Chen et al., 2016a)	✓	–
(Spezzano, 2016)	✓	–
(Feng and Kong, 2015)	✓	–
(Hongzhen et al., 2016)	✓	Security-aware
(Y. Chen et al., 2016b)	✓	QoS-Dependency

a novel approach on the basis of shuffled frog leaping algorithm (SFLA) has been proposed by (Younes et al., 2014) that provides a general model with end-to-end QoS. The experimental results have revealed that the proposed tactic has low computational time; however, it suffers from incompatibility. Also, in (Shangguang Wang et al., 2013) researchers have adopted PSO to provide a fast cloud-based web services (CWS) composition method which employs Skyline operator to trim unnecessary CWS candidates. The proposed method has low computational time; nevertheless, instability of cloud composition system has caused the approach to be weak. Moreover, in (Jula et al. 2015) the Proclus classifier and classified search space imperialist competitive algorithm (CSSICA) have been employed to address service time optimization in cloud computing service composition. Although the proposed method has high scalability, it considers only one QoS parameter. Also, in (Zhen Ye et al., 2011) a cloud service composition approach based on genetic-algorithm has been proposed which takes scheduling into account; however, it provides poor performance in large-scale problems. Furthermore, a new specific swarm intelligence algorithm model called the specific social learning optimization (S-SLO) algorithm has been introduced by (Z.-Z. Liu et al., 2016) to deal with QoS-aware cloud service composition problem. This approach has high convergence speed and search capability, whereas it suffers from high time complexity. Additionally, authors in (D Wang et al., 2015a) have proposed a feasibility-enhanced method for QoS-aware web service composition in the cloud environment which contains a service assessment technique

Table 6
Datasets, simulation tools and QoS parameters which are adopted by each research in single-cloud class.

Author	Dataset	Simulation tools	QoS parameters	Number of citations
(Younes et al., 2014)	RG[a]	Java	• Response Time • Cost • Availability • Reliability	1
(Shangguang Wang et al. 2013)	• QWS • SG[b]	Matlab 7.6	• Response time • Lateness • Availability • Reliability • Throughput • Successability	49
(Jula et al. 2015)	WSDream-QoS dataset2	C#.Net 2012	• Response time • Throughput • Service time	16
(Zhen Ye et al., 2011)	RG	Not-mentioned	• Time • Price • Availability • Reputation	104
(Z.-Z. Liu et al., 2016)	RG	C++	• Cost • Response Time • Reliability • Availability Successability	10
(D Wang et al., 2015a)	RG	Java SE7	• Response Time • Availability • Price • Reputation	0
(Feng and Kong, 2015)	RG	Not-mentioned	• Price • Time Delay • Availability • Reliability • Reputation	1
(Shangguang Wang et al. 2011a)	• WS-Dream • RG	Matlab 7.6	• Response Time • Response data size • Failure probability	105
(Bao and Dou, 2012)	• generated by computer communication	Not-mentioned	Cost Time	27
(S. Liu et al., 2015b)	• RG	Not-mentioned	• Response time • Cost • Availability • Reliability	5
(Hongzhen et al., 2016)	• N/A	N/A	• Time • Availability • Credit • Reliability • CPU occupancy rate • Safety • Security	0
(Y. Chen et al., 2016b)	• WS-Dream • QWS	Not-mentioned	• Response Time • Throughput • Availability • Reliability • Successability • Lateness	1
(Seghir et al., 2016)	• QWS • RG	Matlab 2013a	• Response Time • Availability • Reliability • Throughput Price	0
(Seghir and Khababa, 2016)	• RG	Matlab 2013a	• Response Time • Price • Availability • Reliability	11
(Huo et al., 2015)	• QWS • RG	Matlab R2010b	• Response Time • Lateness • Reliability • Availability • Successability • Throughput	21

(continued on next page)

Table 6 (*continued*)

Author	Dataset	Simulation tools	QoS parameters	Number of citations
(Karimi et al., 2016)	• QWS • RG	VC# 2013	• Price • Reputation • Response Time • Lateness • Reliability • Availability • Successability	7
(Dandan Wang et al. 2016a)	• RG	Sun Java 7 VM	• Throughput • Response Time • Price • Reputation • Availability	1
(C. Zhang et al., 2013b)	• RG	Not-mentioned	• Availability • Reliability	1
(C. Zhang et al., 2013a)	• RG	Not-mentioned	• Availability • Reliability	0

[a] Randomly generated data set.
[b] Synthetically generated data set.

and a service selection/composition algorithm by employing genetic algorithm and simulated annealing. The simulation results have proved that the proposed method is able to escape from local optima; however, it sometimes fails in solution searching. Furthermore, in (Feng and Kong, 2015) for generating optimal composition instance set, the fuzzy multi-objective genetic algorithm (FMOGA) have been offered also to describe the uncertain information this research has adopted triangular fuzzy number. The proposed method has good accuracy; nevertheless, it provides inappropriate results in large-scale problems. Moreover, in (Shangguang Wang et al., 2011a) researchers have used mixed integer programming to propose an effective and efficient QoS-aware cloud service selection method. This method has low computational time and high success rate while it suffers from high overhead. Also, authors in (Bao and Dou, 2012) have adopted an enhanced tree-pruning-based algorithm and finite state machine (FSM), also they have employed a simple additive weighting (SAW) method for selecting an optimal composite service. This method has improved scalability, efficiency, and feasibility, while it has provided high time cost in large-scale problems. Additionally, to describe the long-term based cloud service composition problem (LCSCP) as an optimization problem, authors of (S. Liu et al., 2015b) have offered a new formulation long-term cloud service composition method which suffers from lack of feasibility in low population size over large-scales. Moreover, in (Hongzhen et al., 2016) researchers have employed hybrid PSO algorithm to solve the service composition problem based on QoS in cloud environment. Though this research claims it has obtained high efficiency, it consists of no simulation results. Furthermore, researchers in (Y. Chen et al., 2016b) have discussed a model for QoS dependency-aware service composition in which multiple QoS attributes are taken into consideration. The proposed method increases efficiency and reduces execution time; however, there is no guarantee to obtain all the exactly Pareto optimal solutions. In (Seghir et al., 2016) to tackle the QoS-aware cloud service composition issue, an efficient discrete imperialist competitive algorithm (DICA) has been proposed. The simulation results have shown that the presented method improves feasibility and scalability while it requires high computation time. Also, authors in (Seghir and Khababa, 2016) to answer the QoS-aware service composition problem have offered a hybrid genetic algorithm (HGA) which combines the genetic algorithm and fruit fly optimization algorithm. This method has good feasibility, optimality and low execution time; however, it sometimes fails to obtain optimal fitness value. In (Huo et al., 2015) the discrete Gbest-guided artificial bee colony (DGABC) algorithm has been adopted to tackle cloud service composition problem. The proposed approach acquires high efficiency; however, it suffers from high time cost. Also, in (Karimi et al., 2016) genetic algorithm has been employed to obtain global optimization which takes service level agreement into consideration. Additionally, service clustering has been adopted to mitigate the search space of the problem. This approach has good results in case of computation time, convergence speed, scalability, and feasibility, whereas it suffers from low quality and high overhead. Moreover, for QoS-based web service composition in the cloud environment in (Dandan Wang et al. 2016a), a feasibility-enhanced method containing a service selection algorithm, a parallel running technique, and a service evaluation strategy has been investigated. Though this method is capable to escape local optima, it has high running time in large-scales. Furthermore, in (C. Zhang et al., 2013b) based on a hybrid genetic algorithm and simplex method, a combination cloud services selection algorithm has been introduced. This method provides good convergence speed, while it suffers from high running time in large-scales. Moreover, in (C. Zhang et al., 2013a) based on the hybrid GA, a combination services selection algorithm has been presented which improves reliability though it has high overhead. More metrics about the current classification are presented in Tables 6 and 11.

5.2. Classification on the basis of single-objective and multi-objective

In this section, with respect to the objective functions, papers are classified into two categories including single-objective and multi-objective optimization mode. More details are described in section 7.7. As stated in section 7.7 it can be seen that only 8 papers through 50 have supported multi-objective optimization mode which are brought in Table 5.

Since merits, demerits, and summaries of the studied papers have been investigated in the previous section, we have only addressed the papers regarding multi-objective optimization in Table 5. Moreover, the papers' objective metrics have been mentioned in the table. According to Table 5, it can be observed that in addition to QoS-awareness, few number of researches have also considered other parameters such as energy-awareness, network-awareness, security, and QoS-dependency. Authors in (S Wang et al., 2016b) have proved the proposed network-aware approach can be adopted to effectively mitigate network resource consumption and provide QoS optimality while fulfilling the QoS constraints for the candidate composite services in the cloud environment. Moreover, two researches (Xiang et al., 2014; J. Zhou and Yao, 2017) have provided approaches which result in high quality composite services with low energy consumption. In (Y. Chen et al., 2016b) researchers have studied QoS dependency-aware service composition considering multiple QoS attributes. Finally, in (Hongzhen et al., 2016) authors have presented evaluation criteria and quantification formula of QoS in the cloud environment aiming at the increasing of security.

Table 7
Datasets, simulation tools and QoS parameters which are adopted by each research in multi-cloud class.

Author	Dataset	Simulation tools	QoS parameters	Number of citations
(Dandan Wang et al., 2015)	RG	Java SE7	• Response Time • Availability • Cost • Reputation • Service Time	29
(F. Chen et al., 2016a), (F. Chen et al., 2016b)	SG	Matlab 7.1	• Cost • Execution Time • Latency Time • Reliability • Availability	11
(J. Zhou and Yao, 2017)	SG	Matlab 2013b	• Price • Time • Availability • Reputation	0
(M. Zhang et al., 2015)	• QWS • RG	Not-mentioned	• Response Time • Reliability • Cost • Network delay	1
(Z Ye et al., 2016)	• Real cloud service data (Jiang et al., 2012) • RG	Not-mentioned	• Response Time • Throughput • Cost	13
(Ridhawi and Ridhawi, 2015)	• Media services	OverSim for OMNET++	• Delay • Jitter • Cost	1
(Li et al., 2013)	• Not-mentioned	Not-mentioned	• Response Time • Service execution time • Communication Latency	18
(S Wang et al., 2016b)	Collection of real datasets (Al-Masri and Mahmoud, 2007, 2009; Zheng et al., 2010)	WebCloudSim (Shangguang Wang et al. 2011b; L. Zeng et al., 2003)	• Delay • Throughput • Reliability	9
(Y. Huang et al., 2016)	WSC'09 (Chinese et al., 2009)	Not-mentioned	• Response time Cost time	0
(Shehu et al., 2016)	• Meridian RTT dataset (Wong et al., 2005) • RG	Matlab 2014	Cost	2
(Comi et al., 2015)	• WS-DREAM	Not-exist	• Response time • Throughput • Cost	5
(J. Huang et al., 2014b)	• RG	Not-mentioned	• Execution Time • Response Time • Unmentioned	18
(Qi et al., 2012)	• RG	Java 1.5	• Reputation • Price • Time Complexity • Response Time • Availability • Success Rate	48
(Spezzano, 2016)	• QWS	NetLogo	• Response Time • Lateness • Availability • Reliability • Successability • Throughput	28
(Grati et al., 2014)	• RG	Java	• Response Time • Cost • Reliability • Throughput	2
(J. Huang et al., 2015)	• RG	A Simulator which is available online at (J. Huang, 2013)	• Response Time • Execution time • Process latency • Capacity • Cost • Delay • Bandwidth	4
(J. Zhou and Yao, 2016)	• RG	Matlab 2013b	• Time	10

(continued on next page)

Table 7 (*continued*)

Author	Dataset	Simulation tools	QoS parameters	Number of citations
(Jin et al., 2015)	• RG	Matlab R2011a	• Cost • Availability • Reliability • Execution time • Cost • Reliability • Availability	13
(Xiang et al., 2014)	• RG	Not-mentioned	• Service processing time	35
(B. Liu and Zhang, 2016)	• RG	Matlab R2011b	• Cost • Reliability • Time • Cost • Reliability	7
(Helali and Brahmi, 2017)	• RG	JADE	• Cost of service	0
(Bharath Bhushan and Pradeep Reddy, 2016)	• OWLS-Xplan	Not-mentioned	• Data transfer Cost • Execution time • Network latency • Response Time • Price • Availability • Throughput	1
(Dandan Wang et al., 2015b)	• RG	Not-mentioned	• Successability • Network delay • Network availability	2
(Lu et al., 2014)	• QWS • Simulated	• Matlab 7.0 • Java 1.7	• Availability • Response Time • Price • Reputation • Execution time • Reliability • Availability • Throughput	7
(Peng and Changsong, 2014)	• developed	•Java 2	• Comprehensive • evaluation • Availability • Cost • Execution time	3
(L. Liu et al., 2014)	• RG	•CloudSim	• Reputation • Execution Time • Cost	2
(B. Huang et al., 2014a)	Not-mentioned	Not-mentioned	• Availability • Reputation • Cost • Time • Energy	51
(Zhen Ye et al., 2012)	• SG	• Java • Elvira • Tenure scenario application	• Reliability • Response time • Cost	28
(Klein et al., 2012)	• RG	Not-mentioned	• Throughput • Network latency • Transfer rate	103
(Faruk et al., 2016)	Not-mentioned	Not-mentioned	• Execution time • Service price • Availability • Response time • Reputation	3
(Karim et al., 2013)	arbitrary	Not Exist	• Response time • Availability • Data control • Reliability • Usability • Reputation • Security • Cost	49

6. Threats to validity

Although this systematic literature review is organized as carefully as possible, it could have still suffered from various threats to validity. Thus, researchers to understand or openly using the analyzed or results of this systematic review in upcoming works, ought to remember the following limitations:

- **Research Scope:** Several resources such as technical reports, academic publications, web pages, editorial notes, and etc. address the use of service composition/selection in cloud environments. However, we have only selected academic publications including journal papers, conference papers and etc. Moreover, papers that intended to a specific QoS-aware cloud service composition/selection subject areas which are more likely to have tackled other topics rather than QoS-aware cloud service composition/selection problem, are excluded. Therefore, in term of qualifying this systematic, it must be taken into account that this SLR have considered published researches from the major international cloud computing conferences and journals.
- **Research questions:** The described questions might possibly not have included the entire QoS-aware cloud service composition area, which indicates the likelihood of establishing further relevant questions.
- **Study and Publication bias:** Considering earlier systematic experiences, we have chosen some of the most credible digital databases. Indeed, the statistics show that the mentioned digital databases need to provide most appropriate and reliable researches. However, choice of all relevant primary studies cannot be guaranteed. In the range of search string to the data extraction, there may be several reasons that can lead to missing some relevant studies in utilizing the techniques stated in section 4. We try to prevent missing relevant studies by fulfilling the referrals in primary researches as precise as possible.
- **Completeness**: The assessment and construction of the search string is the key factor in the design stage of SLR. In order to concentrate on inspecting a minor group of relevant findings, researchers had better use the search string or they will have to spend too much time filtering unrelated researches (Keele, 2007). In an attempt to improve the search process, the merged general search string and final selection string were utilized. In the search methodology of this paper, we have used the constructed search string to extract related researches from some databases. Then we have applied the inclusion and exclusion criteria mentioned in section 4.5, to refine the obtained researches. The search strings were provided to add the largest quantity of related papers, nevertheless, several articles might have been overlooked because of language limitations and the barriers of mentioned inclusion and exclusion criteria.
- **Data extraction:** The data related to the field of QoS-aware service composition/selection in cloud computing were extracted in our SRL. 10560 relevant researches were obtained since we employed general query. We applied supplementary search, as a result, 50 most applicable researches were selected to address our research questions.

7. Analysis of SLR results

In this section, the result of this study will be analyzed by addressing research questions RQ3, RQ4 and RQ6 which are mentioned in section 4.1. Datasets, simulation tools and QoS parameters which are adopted by each research in single-cloud class, are illustrated in Table 6, also Table 7 presents same metrics for multi-cloud class. Moreover, Tables 10 and 11 are prepared to demonstrate more metrics of the researches.

7.1. QoS parameters observation

QoS parameters which are adopted in each research are listed in Tables 6 and 7. Considering RQ3, most researchers concentrate on these QoS attributes: price or cost 18%, availability 16%, response time 15%, reliability 13%, throughput 8% and both time and reputation 6%. More details and explanation of the attributes are given in section 2. The total number of every parameter in each category is shown in Fig. 10. Percentage of QoS parameters are illustrated in Fig. 11, Fig. 12 and Fig. 13 for total, single-cloud class, and multi-cloud class respectively.

7.2. Datasets observation

In an attempt to evaluate proposed approaches and to compare the experiments' results, different datasets are processed, each of which can support various QoS parameters. Unfortunately, the number of datasets that are available in the research domain is very low and is limited to three datasets, QWS (Al-Masri and Mahmoud, 2007), WS-DREAM (Zheng and Lyu, 2008) and OWLS-Xplan (Klusch et al., 2005), and randomly generated dataset (RG). In several cases, researchers have also employed a synthetic generator. Significant lack of datasets for cloud environments is observed since those mentioned are more suitable for web environments. The datasets used in each study are listed in Tables 6 and 7. In addition, their statistics are summarized in Fig. 14. According to Fig. 14, it can be observed that 50 percent of researchers have preferred to use randomly generated data (RG). Meanwhile, the highest usage percentage of the listed datasets is allocated to QWS with 13%.

7.3. Simulation tools observation

Different simulation tools have been used in the studied researches. However, some of them didn't mention their tools and some didn't have any simulation. Considering RQ6, Fig. 15 demonstrates the percentage of used simulation tools. According to Fig. 15, 36% of studies have not mentioned their tools and the highest percentage of usage can be seen in Matlab (23%).

7.4. Proposed method and fitness function observation

This section intends to investigate proposed method and fitness function for all the researches to compare them from several aspects.

Method Type: To address RQ4, all of the proposed or applied approaches are divided into two main distinct categories, heuristic-based and non-heuristic. Moreover, to clarify the results thus enabling easy access for other researchers, the used heuristic algorithms are listed by name. These categories and their statistics are summarized in Tables 10 and 11 also Figs. 16–18, for the investigated researches in single-cloud, multi-cloud environments and total respectively. It can be inferred from Fig. 18 that 35% of researchers chose non-heuristic approaches and the rest preferred heuristic ones in which the highest percentage of usage can be seen in genetic algorithm (31%).

Proposed method explanation: In addition to categorizing approaches into heuristic-based and non-heuristic, proposed methods are investigated in terms of explicit explanation of them; hence, two categories are taken into consideration, clear and not clear. Fig. 19 demonstrates the total number of each category in both single-cloud and multi-cloud approaches separately. According to Fig. 19, it is observed that 34 papers among 50 papers have clearly explained their proposed method. In the other words, it can be said that 68% of approaches are clearly explained.

Fitness Function: About fitness functions of each research, the same evaluation is conducted as shown above and the results are demonstrated in Fig. 20. According to this figure, it is detected that 37 of 50 papers have clearly explained their fitness functions. In the other words, it can be said that 74% of papers have obviously explained their fitness functions.

7.5. Observation of comparisons

This section inspects the comparison of proposed methods in all the investigated researches, which divides them into two groups, the ones

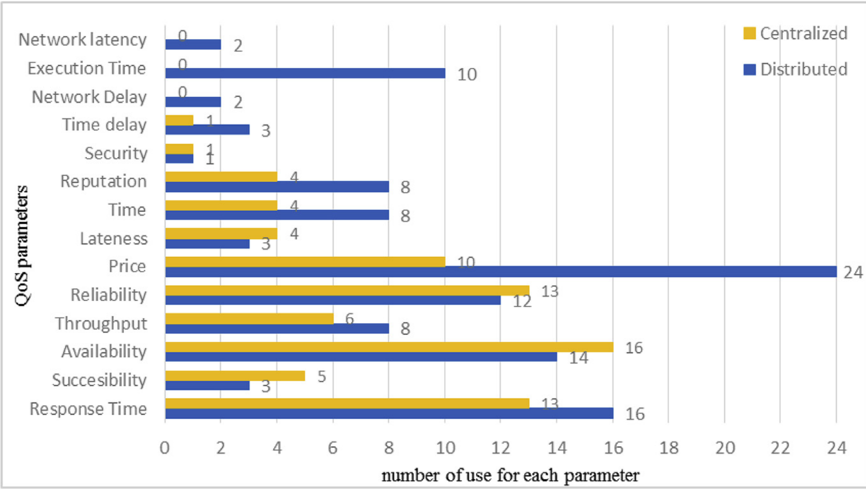

Fig. 10. The total number of each parameter in each category.

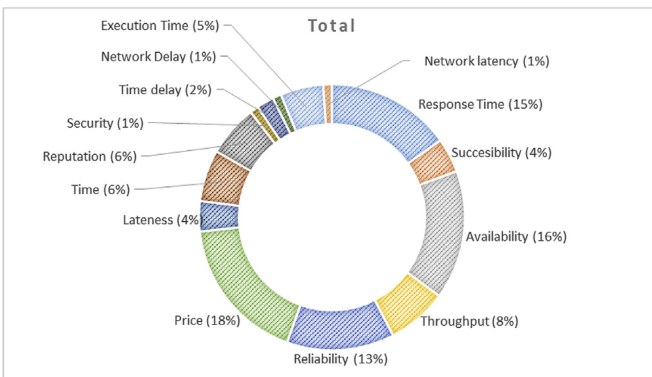

Fig. 11. Percentage of QoS parameters for all investigated papers.

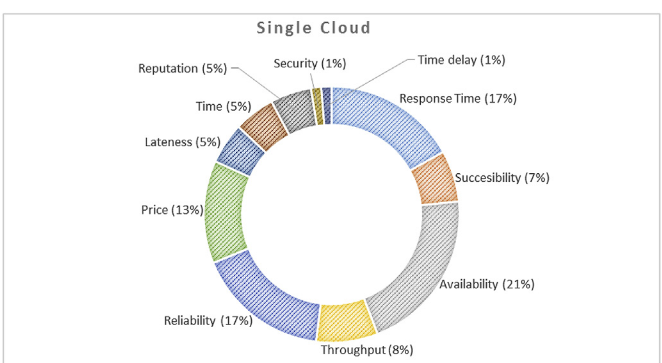

Fig. 12. Percentage of QoS parameters for investigated papers in centralized class.

are compared to the state of the art researches and the rest. Researches which compared their method to the unrelated state of the art researches are placed in the second group. Hence, these researches have not been compared to the state of the art studies. Fig. 21 shows the total number of each group in both single-cloud and multi-cloud approaches separately. As reported by Fig. 21, it can be seen that 28 of 50 investigated papers (56% of approaches) are not compared to the state of the art researches.

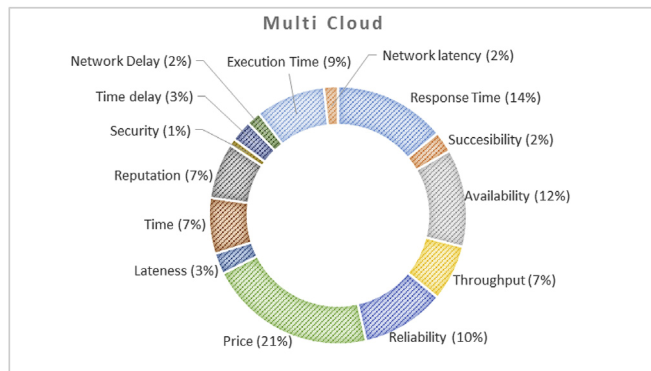

Fig. 13. Percentage of QoS parameters for investigated papers in distributed class.

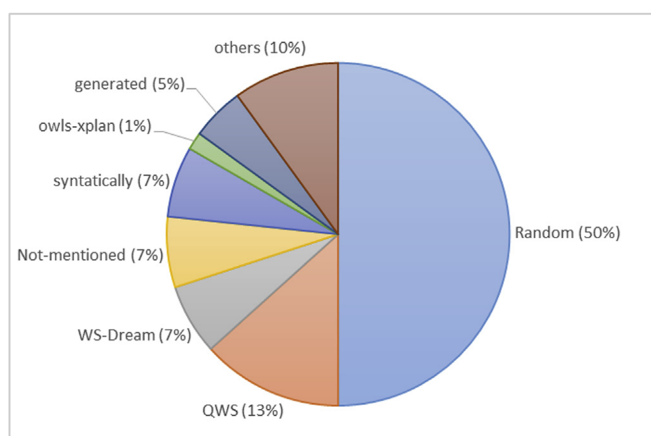

Fig. 14. Statistic of used datasets.

7.6. Observation of optimization mode

In service composition process to create a new composite service, the more appropriate existing service components are extracted and composed using the aggregation function. Generally, three following strategies are used: 1) local selection strategy, 2) global optimization strategy, 3) hybrid strategy (local and global). Fig. 22 illustrates the total number of each method type in both single-cloud and multi-cloud

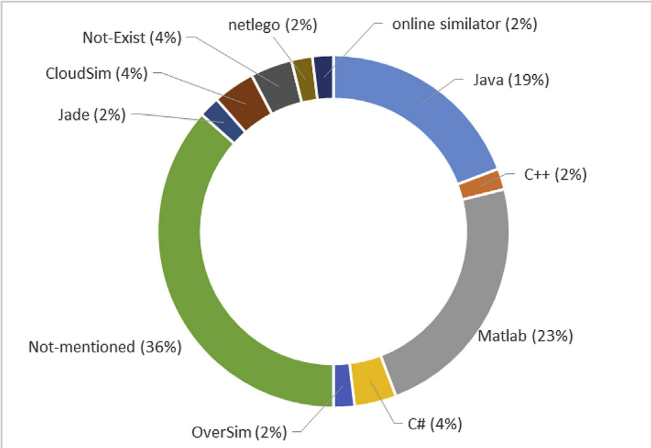

Fig. 15. Percentage of used simulation tools.

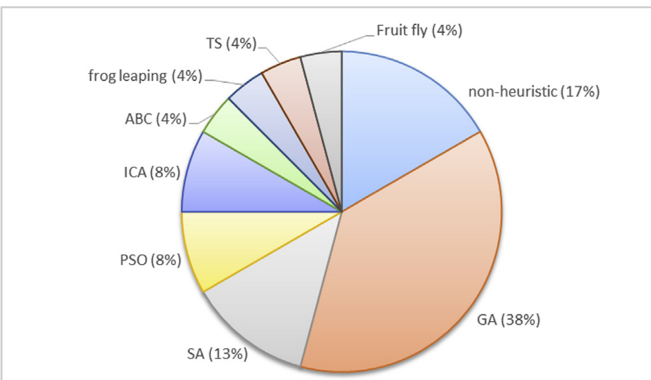

Fig. 16. Percentage of adopted methods in centralized (single-cloud) class.

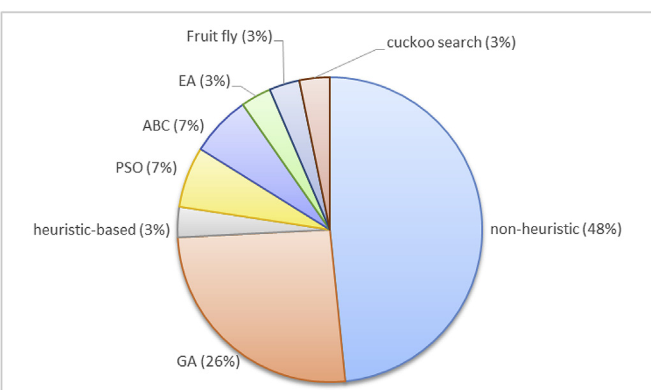

Fig. 17. Percentage of adopted methods in distributed (multi-cloud) class.

approaches separately and according to Fig. 23, it can be seen that 76% of studies focus on global optimization mode.

7.7. Observation of multi-objective, multi attributes optimization

This section investigates the studied researches in terms of multi-objective optimization and multi attributes optimization.

Multi-Objective: The process of solving the mathematical optimization problems with several objective functions that should be optimized simultaneously is a part of multiple-criteria decision making which is called multi-objective optimization. It is also referred to multi-objective

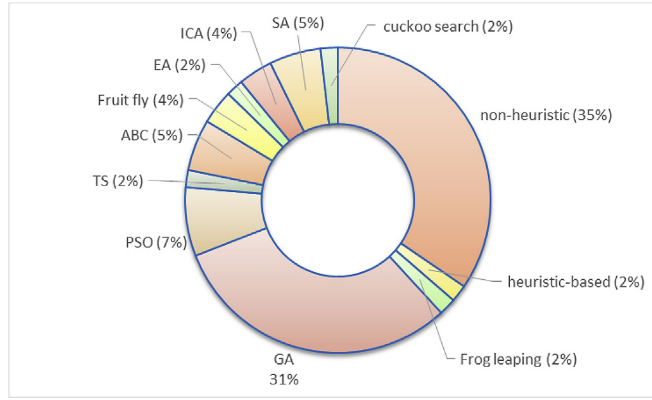

Fig. 18. Percentage of adopted methods in total investigated papers.

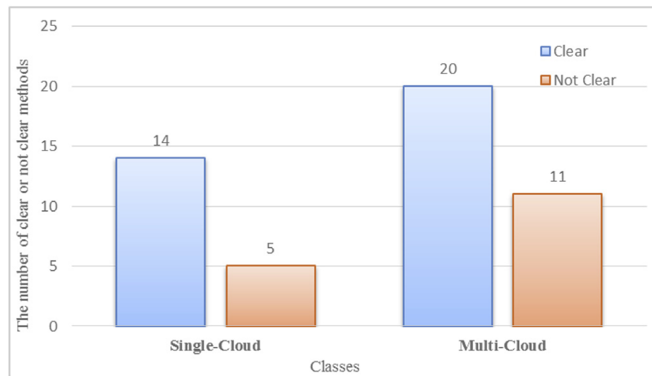

Fig. 19. Total number of clear and not clear methods in each category.

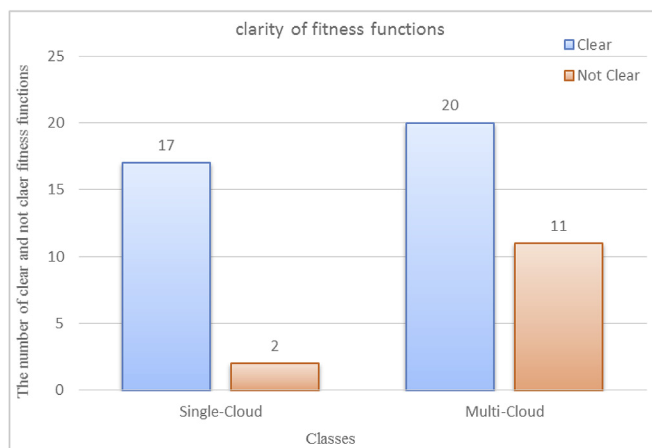

Fig. 20. Total number of clear and not clear fitness functions in each category.

programming, multi-criteria optimization, multi-attribute optimization, vector optimization or Pareto optimization in some resources. The problem of QoS-aware cloud service selection or composition is a multi-objective problem but the majority of the studies considered employing some techniques (e.g. SAW) to combine multi-objectives into a single function. Fig. 24 demonstrates the number of investigated studies which supports the multi-objective optimization in both single cloud and multi-cloud methods separately. With reference to Fig. 24, only 16% of analyzed approaches (8 of 50 papers) support the multi-objective optimization.

Multi-Attribute: There are three groups of existing QoS-aware

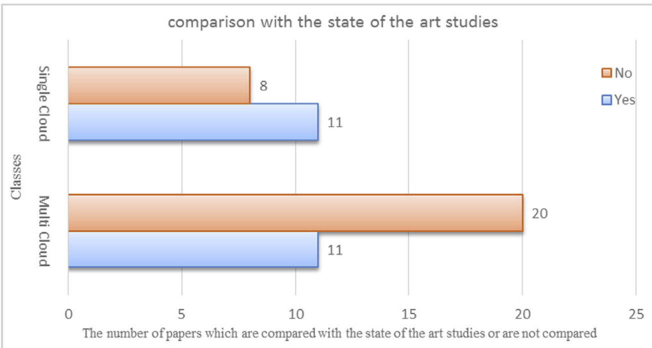

Fig. 21. Total number of papers in each category which are compared with the state of the art studies or are not compared.

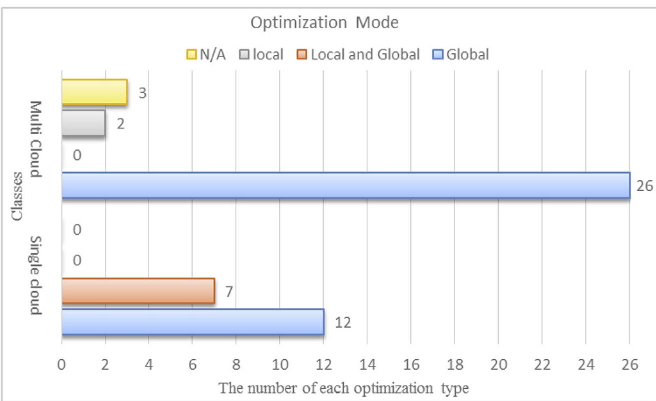

Fig. 22. Total number of each optimization type in both single-cloud and multi-cloud approaches.

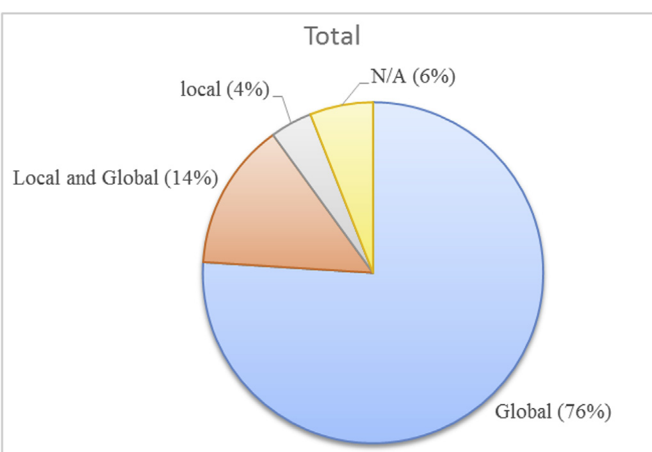

Fig. 23. Percentage of each optimization type.

service selection/composition methods:

- Scalarization-based approaches: Various QoS attributes aggregate into a single global value by using the global evaluation function. This aggregation process is also known as scalarization which usually uses simple additive weight (SAW) technique. Even though QoS-aware cloud service selection/composition is a multi-objective problem, most of the current methods adopt saw to reduce this issue into a single-objective one (Cremene et al., 2016).

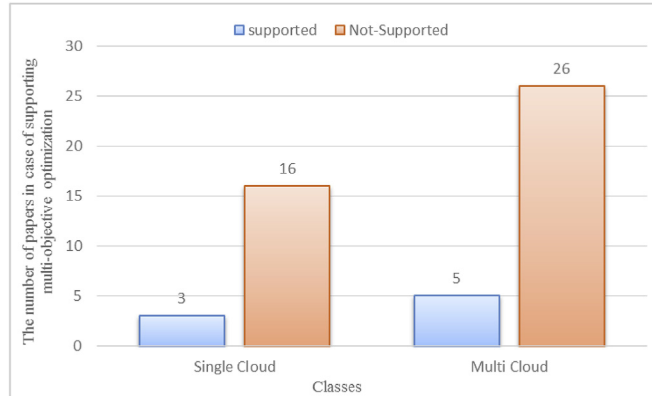

Fig. 24. The total number of papers in each category in case of supporting multi-objective optimization.

- Pareto-based approaches: In an attempt to recognize several solutions, researchers utilize multi-objective algorithms. By exploring the existing researches, it is observed that Pareto-based methods rarely are used for this particular issue in the literature. Pareto-based methods choose the solution relative to customer preferences with more accuracy (Cremene et al., 2016).
- Hybrid methods: There are some recent techniques that have merged both Pareto and scalarization-based methods. Due to being on the basis of scalarization, they illustrate the similar disadvantages already stated (Cremene et al., 2016).

As the last columns of Tables 10 and 11 show, in this subsection, papers are categorized based on above explanations into three classes. The statistical results are presented in Figs. 25 and 26 that show the results in our main categories according to section 7.7 (single-cloud and multi-cloud) and all the papers in one as a total, respectively. According to Fig. 26, %68 of researches adopted saw technique to reduce the problem to a single objective one.

7.8. Observation of author names and number of citation for each paper

In this section, we have investigated the current papers in terms of author names and the number of citation for each paper. It seems that results of this section will give an effective guideline for the future research trends in this field. Hence, we have prepared Tables 8 and 9. It should be mentioned that this observation is conducted on 14 December of 2017 and obviously, these results will change over time.

The number of citation for all the investigated papers is shown in Tables 6 and 7. Moreover, papers which are cited more than 20 times, are listed in Table 8. Future researchers can find the articles with the most referrals from other researches through this table. In other words, based on our research these are hot papers in the scope of QoS-aware service composition in the cloud environment. In this table the first column refers to the reference of the papers, the second column states the number of citation to each paper, and the last column denotes the papers' publishers.

In Table 9 we have listed authors names whose published papers in the field of QoS-aware cloud service composition are more than one paper. According to Table 9, it can be observed that three authors: Dandan Wang, Yang Yang, and Zhenqiang Mi have the most number of published papers by 4 papers in this field. In this table the first column represents authors names, the second column states the number of their published papers in the aforementioned field and the last column denotes the reference of those published papers.

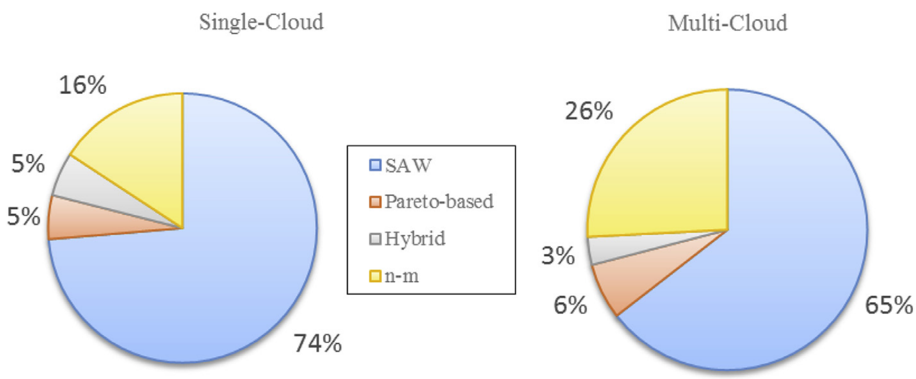

Fig. 25. Percentage of each multi-attribute strategy in single-cloud and multi-cloud researches.

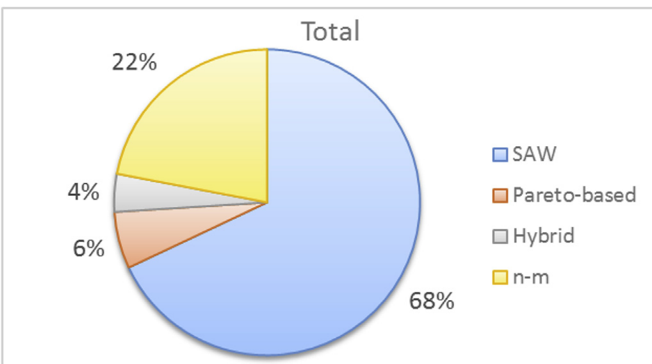

Fig. 26. Percentage of each multi-attribute strategy in all investigated researches.

Table 8
List of most cited papers.

Paper	Number of citation	Publisher
(Shangguang Wang et al. 2011a)	105	IEEE
(Zhen Ye et al., 2011)	104	Springer
(Klein et al., 2012)	103	ACM
(B. Huang et al., 2014a)	51	ACM
(Shangguang Wang et al. 2013)	49	Springer
(Karim et al., 2013)	49	IEEE
(Qi et al., 2012)	48	Elsevier
(Xiang et al., 2014)	35	Springer
(Dandan Wang et al., 2015)	29	Elsevier
(Spezzano, 2016)	28	Elsevier
(Zhen Ye et al., 2012)	28	ACM
(Bao and Dou, 2012)	27	IEEE
(Huo et al., 2015)	21	Springer

7.9. Observation of QoS specification constraints

The goal of QoS-aware service selection/composition algorithms is to select individual services that satisfy QoS constraints and deliver the best result for the composition problem. Some researches do not take QoS constraints into consideration. In this subsection the studied researches are investigated in term of supporting QoS constraints, the results are shown in Fig. 27. The number of papers in all three QoS constraints strategies for each category (single-cloud and multi-cloud) is demonstrated in Fig. 27 using a bar chart. Based on data shown in this fig, 84% of studies (42 of 50 papers) have considered QoS constraints, 8% (4 of 50 papers) have not supported QoS constraints and the rest 8% (4 of 50 papers) not mentioned if they have supported QoS constraints or not.

Table 9
List of authors with the highest number of published papers in the field of QoS-aware cloud service composition.

Author name	Number of papers	Papers
Dandan Wang	4	(D Wang et al., 2015a)
Yang Yang	4	(Dandan Wang et al., 2015)
Zhenqiang Mi	4	(Dandan Wang et al. 2016a)
		(Dandan Wang et al., 2015b)
Li Liu	3	(Dandan Wang et al. 2016a)
		(L. Liu et al., 2014)
		(M. Zhang et al., 2015)
Zhen Ye	3	(Z Ye et al., 2016)
Athman Bouguettaya	3	(Zhen Ye et al., 2012)
		(Zhen Ye et al., 2011)
Fangchun Yang	3	(S Wang et al., 2016b)
		(Shangguang Wang et al. 2011a)
		(Shangguang Wang et al. 2013)
Xiaofang Zhou	2	(Zhen Ye et al., 2012)
		(Zhen Ye et al., 2011)
Jun Huang	2	(J. Huang et al., 2014b)
Qiang Duan	2	(J. Huang et al., 2015)
Yuhong Yan	2	
Miao Zhang	2	(L. Liu et al., 2014)
Songtao Liu	2	(M. Zhang et al., 2015)
Shangguang Wang	2	(S Wang et al., 2016b)
		(Shangguang Wang et al. 2011a)
Qibo Sun	2	(Shangguang Wang et al. 2011a)
Hua Zou	2	(Shangguang Wang et al. 2013)
Wanchun Dou	2	(Bao and Dou, 2012)
		(Qi et al., 2012)
Hao Ding	2	(D Wang et al., 2015a)
Zenggang Xiong	2	(Dandan Wang et al. 2016a)
Chengwen Zhang	2	(C. Zhang et al., 2013a)
Bo Cheng	2	(C. Zhang et al., 2013b)
Lei Zhang	2	
Xifan Yao	2	(Jin et al., 2015)
		(J. Zhou and Yao, 2016)
Fateh Seghir	2	(Seghir and Khababa, 2016)
Abdellah Khababa	2	(Seghir et al., 2016)

8. Open issues and future trends

There are some important issues in the improvement of QoS-aware cloud service selection or composition that are not in the range of current research path. This section discusses and analysis these mentioned issues. It is undeniable that any strategy could include all issues associated with QoS-aware cloud service composition. For instance, some strategies consider QoS attributes or QoS specification constraints, although some ignore these issues. Furthermore, some researches have adopted the comparison with the state of the art researches, on the other hand, some did not utilize them for evaluation. In addition, almost all researchers employ tools that are on the basis of simulator for assessments, thus conducting the mentioned methods in the real-world experiments will be fascinating in the future. Afterward, such strategies

Table 10
Some metrics for investigated researches in Multi-cloud class.

Publisher	Author	Method	Proposed method explanation	Fitness function	Comparison with the state of the art methods	Optimization mode	Multi-objective optimization	QoS specification constraints	Multi-attribute optimization
IEEE	(Karim et al., 2013)	Theoretical	n-c	n-c	no	global	n-s	S	Saw
	(Li et al., 2013)	Voting algorithm	Approximately clear	n-c	no	N/A	n-s	n-m	n-m
	(Grati et al., 2014)	Genetic algorithm	Clear	clear	no	Global	n-s	S	Saw
	(J. Huang et al., 2014b)	Approximation algorithm	n-c	n-c	no	Global	n-s	S	Saw
	(Ridhawi and Ridhawi, 2015)	Semantic-based	n-c	n-c	no	Global	n-s	n-s	N/A
	(Comi et al., 2015)	Reputation-based	Theoretical	Clear	no	Global	n-s	S	Saw
	(J. Huang et al., 2015)	Approximation algorithm	n-c	n-c	no	Global	n-s	S	Saw
	(M. Zhang et al., 2015)	Genetic algorithm	Clear	Clear	No	Global	n-s	S	Saw
	(Z Ye et al., 2016)	Framework-based	Clear	Clear	Yes	Global	n-s	n-m	Saw
	(Y. Huang et al., 2016)	Dijkstra algorithm	Clear	n-c	No	Global	n-s	n-m	N/A
	(S Wang et al., 2016b)	Mixed integer programming (MIP)	Clear	Clear	Yes	global	S	S	Saw
ACM	(Zhen Ye et al., 2012)	Bayesian network	n-c	n-c	No	Global	n-s	S	Saw
		Dynamic programming							
	(Klein et al., 2012)	Genetic algorithm	Almost clear	n-c	No	n-m	n-s	S	n-m
	(B. Huang et al., 2014a)	Chaos control operator algorithm	Clear	Clear	No	Local	n-s	S	Saw
Springer	(Xiang et al., 2014)	Genetic algorithm	Clear	Clear	Yes	Global	S	S	Pareto-based
	(J. Zhou and Yao, 2017)	Hybrid modified ABC and Cuckoo search algorithm	Clear	Clear	Yes	Global	S	S	Pareto-based + Saw
	(Jin et al., 2015)	Genetic algorithm	Clear	Clear	Yes	Global	n-s	S	Saw
	(Faruk et al., 2016)	Genetic-Particle Swarm Optimization (GPSO)	Clear	Clear	Yes	Global	n-s	S	Saw
	(J. Zhou and Yao, 2016)	(HABC) hybrid artificial bee colony	Clear	Clear	Yes	Global	n-s	S	Saw
	(B. Liu and Zhang, 2016)	Genetic algorithm	Clear	Clear	No	Global	n-s	S	Saw
	(Helali and Brahmi, 2017)	Agent-based	Clear	Clear	No	Global	n-s	S	n-m
Elsevier	(Qi et al., 2012)	Mixed integer programming (MIP)	Clear	Clear	Yes	Local	n-s	S	Saw
	(Dandan Wang et al., 2015)	Genetic algorithm	Clear	Clear	No	Global	n-s	S	Saw
	(F. Chen et al., 2016a)	Evolutionary algorithm	Clear	Clear	No	Global	S	S	Pareto-based
	(Spezzano, 2016)	PSO	n-c	n-c	No	Global	S	S	n-m
Doaj	(Shehu et al., 2016)	fruit fly	Clear	Clear	Yes	Global	n-s	n-s	n-m
Sersc	(Lu et al., 2014)	Hypothesis test	Almost clear	Clear	No	Global	n-s	S	Saw
	(Peng and Changsong, 2014)	Evolution strategy	n-c	n-c	Yes	Global	n-s	n-s	n-m
inass	(Bharath Bhushan and Pradeep Reddy, 2016)	Heuristic-based on PROMETHEE	Clear	n-c	Yes	n-m	n-s	S	Saw
Scientific	(L. Liu et al., 2014)	PSO	Clear	Clear	No	Global	n-s	S	Saw
kpubs	(Dandan Wang et al., 2015b)	Graph theory	Clear	Clear	No	Global	n-s	S	Saw

Table 11
Some metrics for investigated researches in Single cloud class.

Publisher	Author	Method	Proposed method explanation	Fitness function	Comparison with the state of the art methods	Optimization mode	Multi-objective optimization	QoS specification constraints	Multi-attribute optimization
IEEE	(Shangguang Wang et al. 2011a)	Mixed integer programming	Clear	Clear	Yes	Global	n-s	S	Saw
	(Bao and Dou, 2012)	Tree-pruning-based algorithm	Clear	Clear	Yes	Global	n-s	S	Saw
	(D Wang et al., 2015a)	GA-SA	Clear	Clear	No	Global	n-s	S	Saw
	(S. Liu et al., 2015b)	GA, SA, TS	Clear	Clear	No	Global	n-s	S	saw
	(Feng and Kong, 2015)	Genetic algorithm	n-c	Clear	Yes	Global	S	S	Pareto-based + Saw
	(Hongzhen et al., 2016)	Hybrid PSO	Theoretical	Clear	No	Global	S	n-s	Saw
	(Y. Chen et al., 2016b)	Vector Ordinal Optimization	Clear	Clear	Yes	Local + Global	S	S	Pareto-based
Springer	(Zhen Ye et al., 2011), (Zhao et al., 2014)	Genetic Algorithm	Clear	Clear	No	Local + Global	n-s	S	Saw
	(Shangguang Wang et al. 2013)	PSO	n-c	Clear	Yes	Global	n-s	S	Saw
	(Huo et al., 2015)	Artificial Bee Colony Algorithm	Clear	Clear	No	Local + Global	n-s	S	Saw
	(Seghir and Khababa, 2016)	Hybrid GA And Fruit Fly Optimization Algorithm	Clear	Clear	Yes	Local + Global	n-s	S	Saw
	(Seghir et al., 2016)	Imperialist Competitive Algorithm	Clear	Clear	Yes	Global	n-s	S	Saw
	(Karimi et al., 2016)	Genetic Algorithm	Clear	Clear	Yes	Global	n-s	S	Saw
Elsevier	(Jula et al. 2015)	Imperialist Competitive Algorithm (ICA)	Clear	Clear	Yes	Global	n-s	n-m	n-m
	(Z.-Z. Liu et al., 2016)	Social learning optimization (SLO)	Clear	Clear	No	Global	n-s	S	Saw
Proquest	(C. Zhang et al., 2013b)	GA with simplex method	n-c	n-c	No	Local + Global	n-s	S	n-m
	(C. Zhang et al., 2013a)	GA with simplex method	n-c	n-c	No	Local + Global	n-s	S	n-m
–	(Younes et al., 2014)	Shuffled frog leaping algorithm	Clear	Clear	Yes	Local + Global	n-s	S	Saw
itiis	(Dandan Wang et al. 2016a)	GA-SA	Clear	Clear	Yes	Global	n-s	S	Saw

C: clear, n-c: not clear, T: theoretical, S: supported. n-s: not-supported, n-m: not-mentioned.

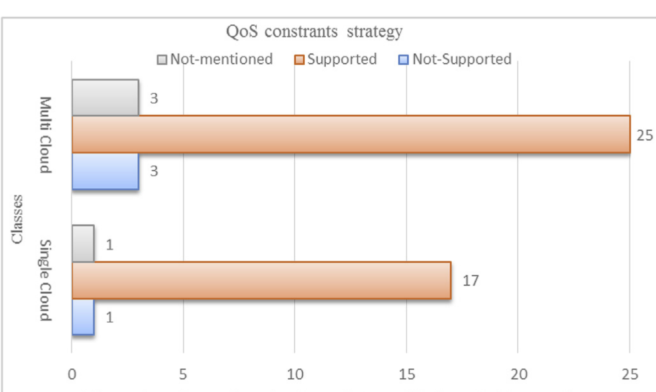

Fig. 27. The number of papers in each category in term of QoS constraint supporting.

should be examined in the same situations to provide realistic results.

It is observed that no single research addresses all QoS attributes for a cloud service composition/selection problem. For example, some researches focus on availability, time complexity, and optimality while other attributes such as scalability, efficiency, reliability, and etc. are ignored. Moreover, analyzing the process of adaptive decomposing the global QoS constraints and anticipate the QoS of cloud services are incredibly fascinating. In addition, preparing a QoS adaptive anticipation tactic that can organize numerous acceptable QoS anticipation strategy based on the real-time state is another path for upcoming researches.

With regards to the results of this research, obtaining certain goals is very important for the development of future work. Developing the same comparative environment for the comparison of the proposed approaches and methods is necessary to supply set of variously sized standard problems and a comprehensive QoS dataset. The dataset should include lots of unique services and service providers and cover price, availability, response time, reliability and throughput as significant QoS parameters. Another important research goal is to concentrate on designing comprehensive numerical models for calculating QoS values of composite services that cover all of the involved parameters and their importance percentage. Proposing real-time algorithms that can obtain a few optimal composite services for the given requests denotes remarkable achievements in this field. Additionally, the less considered goals should be taken into account, for example, **Qualitative to quantitative transformation of QoS parameters:** Researchers need to convert the qualitative QoS attributes into quantitative values employing credible methods, to be able to apply them in decision making. Proposing an **improvised QoS numerical model:** Computing a QoS value for composite services needs a numerical model in which total aspects, customer requirements, attributes, and trends are shown. To obtain this objective, some researchers have tried to demonstrate improved models that concentrate more on these aims, **Revenue maximization:** with regards to the capability to amass remarkable profits, stimulate service suppliers to introduce their high-quality services. Hence, revenue maximization can be mentioned as an essential fundamental purpose and also optimization of the service discovery process: if the services are not registered on the basis of aforementioned requirements by the policy of service composer, then it must detect required accessible abstract services in the network. Having the type of policy which adopts optimal discovery methods is critical.

In addition, since large-scale QoS-aware cloud service composition problems might take remarkable CPU time and energy to find valid near-optimal solutions, it is promising to use parallel computing together with evolutionary algorithms. On the other hand, existing methods are not powerful enough to deal with issues with more objectives, future work will focus on coming up with multi-objective evolutionary algorithms for tackling some more objective QoS-aware cloud service composition issues.

Service providers, providing QoS dynamically in nature. The QoS background and the short-term advert may neglect to picture this dynamic action. It's a good idea to consider the dynamic behavior criteria and efficient model of composition process into the design of the anticipate model in the future works.

9. Conclusion

This paper demonstrated a systematic literature review which systematically reviewed the former and the state of the art strategies in this issue. Moreover, this research introduced a classification of the investigated QoS-aware cloud service composition/selection mechanisms. In addition to that, it has a comprehensive insight into the problem of QoS-aware cloud service composition/selection and it's reflection on upcoming works challenges. This paper used the search query on some well-known databases; as a result, it extracted 1023 researches that were published up to 2017. Among these researches, 50 papers which focused on QoS-aware cloud service composition, were thoroughly investigated. This SLR has provided a comprehensive description and investigation of QoS-aware cloud service composition/selection by observing the investigated papers on various aspects. For instance, the observation on proposed method demonstrated that 34% of researchers chose non-heuristic approaches and the rest preferred heuristic ones in which the highest percentage of usage can be seen in genetic algorithm (31%). The authors have claimed that this research has indicated the first effort to systematically inspect service composition/selection with a particular focus on QoS-awareness and the cloud environment. The most significant and impact of this research is that it has not ignored any paper in this scope, also it has taken more criteria into consideration (in comparison with current surveys) to give more statistical information about the state of the art papers. Certainly, this will lead to providing a single research including as much as information to give an obvious roadmap for upcoming researches in this field. Finally, it should be mentioned that conducting a SLR takes a lot of time and effort; hence, this paper aims to save effort and time of future researchers by presenting a comprehensive survey of past strategies for QoS-aware service composition/selection in the cloud environment.

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