International Journal of Information Science and Management
Vol. 20, No. 4, 2022, 193-218
https://dorl.net/dor/20.1001.1.20088302.2022.20.4.12.1

Original Research

Identifying Influential Trends in the Cloud Computing Pricing Research Using Computational Literature Review and Social Network Analysis Centrality Measures

Azade Abasirad
Ph.D. Candidate, Department of Business Management, Faculty of Management, University of Tehran, Tehran, Iran.
a.abasirad@ut.ac.ir ORCID iD: https://orcid.org/0000-0002-1057-832X

Mohsen Nazari
Associate Prof., Department of Business Management, Faculty of Management, University of Tehran, Tehran, Iran.
Corresponding Author: Mohsen.nazari@ut.ac.ir
ORCID iD: https://orcid.org/0000-0003-2861-2052

Soheil Sibdari
Professor, Department of Decision and Information Science, Charlton College of Business, University of Massachusetts, Dartmouth, USA.
ssibdari@umassd.edu ORCID iD: https://orcid.org/0000-0001-7231-8999

Received: 27 November 2021
Accepted: 19 January 2022

Abstract

Cloud computing has become one of the newest and most popular topics in the field of the Internet. Pricing is one of the main factors that can affect the successful implementation of cloud computing. Due to the large volume of research conducted in this field, the purpose of this study is to review the cloud computing pricing literature using a Computational Literature Review (CLR) and identify influential trends in this field. For this purpose, the publication and citation trends are first identified. The most influential authors, journals, and articles are then determined using citation analysis. Next, the structure of the co-occurrence network of keywords is analyzed using three centrality measures degree, betweenness, and closeness. Finally, the thematic trends are identified using a positional analysis based on centrality measures. According to the obtained results, research in this field has grown significantly. Keywords such as edge, computer architecture, and distributed computing have recently come to the fore. Also, words such as model, energy, allocation, strategy, auction, design, and reliability have been among the most influential in this field. The positional analysis indicates that the researchers are trying to overcome resource scarcity through three lines of work: resource provision, resource allocation, and resource distribution. Trends show that the cloud industry is highly attractive and will also have high growth. In the future, we will also see an increase in the use of value-based pricing methods in cloud computing and research in this area.

Keywords: Computational Literature Review, Cloud Computing, Pricing, Social Network Analysis, Positional Analysis, Research Trends.

Introduction

Since 2008, cloud computing has become one of the most popular topics in the field of the Internet (Banijamali, Pakanen, Kuvaja, & Oivo, 2020). Information technology (IT) companies, ordinary users, government agencies, and research institutes showed great interest in cloud computing. In general, it can be said that cloud computing is about to change the Internet industry paradigm (H. Sun et al., 2013).

In the business environment, 95% of organizations now trust cloud computing services for their business (RightScale, 2016). The software and cloud computing industries are expected to experience explosive growth due to their management benefits, such as reduced operational costs, high flexibility, the economy of scale, fast deployment, remote access, and green mobility and computing. According to a survey by Oxford Economics and SAP, more companies will become medium to heavy users of cloud services in the next few years (Oxford Economics and SAP, 2014). The global cloud computing market is projected to reach $ 1251.09 billion by 2028. This growth is affected by various factors, such as digital transformation in different industries, Internet penetration, and the use of big data in other sectors (Grand View Research Inc., 2021).

Cloud computing is servitizing the IT industry (K.-C. Huang & Shen, 2015). Servitization is known as a process that can transform the physical environment of traditional IT and software products into services provided to customers via the Internet (Ojala, 2016). This feature enables end-users to process, manage, and store data at a very high speed and a reasonable price (Al-Roomi, Al-Ebrahim, Buqrais, & Ahmad, 2013). Traditionally, the serivitization of manufactured products and how manufacturing companies can add value by adding services to their products is studied in the literature. However, in the case of cloud computing, servitization is seen as a new model by which the hardware and software products can be turned into services (Sultan, 2014b).

Cloud computing can be divided into three service layers: (1) Infrastructure as a Service (IaaS), which provides computing infrastructure and storage space, (2) Platform as a Service (PaaS), which provides software development tools and an application execution environment, and (3) Software as a Service (SaaS), which provides software on top of the IaaS and PaaS (Mrozek, 2020).

The growing trend toward service delivery through cloud computing is changing the industry's competitive environment (Sultan, 2014a) and challenging existing business strategies (Bustinza, Bigdeli, Baines, & Elliot, 2015). Web-based services are influencing more traditional service delivery systems, raising the question of how these emerging online service delivery mechanisms make profitable and sustainable businesses and how the availability of web-based services can coexist with traditional service delivery models (Lyons, Playford, Messinger, Niu, & Stroulia, 2009). Cloud computing provider delivers on-demand services to the customer through the Internet. Therefore, these services are provided to users with pricing schemes.

Pricing plays various roles in cloud computing firms (Saltan & Smolander, 2021), including being a symbol of implied product quality, supporting a brand or undermining it, supporting the firm's strategy, positioning the firm in the market or industry, and influencing the customer. In addition, pricing affects the firms' cash flow (Haahtela, 2011). Pricing directly determines the level of turnover and long-term returns. In case of wrong decisions, the company's reputation and relationship with the customer will be at risk. Therefore, deploying a proper pricing model helps companies to achieve more revenue (Al-Roomi et al., 2013).

Pricing schemes are essential for the cloud computing provider to offer products or services. Price is one of the most important criteria that a service provider can control to encourage the use of its services (Al-Roomi et al., 2013). Pricing makes it possible to regulate the supply and demand of computing services and, along with changes in service models, affects providers' profit and social welfare (Hussain & Abdulsalam, 2014). While the main goal of cloud computing providers is to achieve maximum revenue through pricing schemes, users seek services with the highest quality at a reasonable price (Singhal & Singhal, 2021). Therefore, the satisfaction of both parties requires an optimal pricing scheme (Dutta, Zbaracki, & Bergen, 2003). Cloud computing provider deploys a variety of pricing schemes to set prices. Therefore, numerous studies have addressed the pricing of cloud computing services (Mazrekaj, Shabani, & Sejdiu, 2016).

According to previous studies by Wuni, Shen, and Osei-Kyei (2019), while increasing research in a field accelerates its development, the large number of published studies is a challenge for those who use the output of the research. Also, the large volume of articles published in a field confuses new researchers and makes it difficult to accurately assess the nature of general knowledge, its impact, and contribution, and in particular, identify key issues that have not been addressed or ignored so far (Hosseini et al., 2018). Therefore, it is necessary to examine the historical research trend in cloud computing pricing to classify existing research and identify existing gaps.

In this regard, Sun, Zhuo & Wang (2020) provided a comparative review of the most appropriate traffic engineering pricing in cloud computing. Chauhan, Pilli, Joshi, Singh and Govil (2019) conducted a comprehensive review of cloud brokerage in interconnected cloud environments. It also presented and analyzed a classification of cloud brokerage techniques based on their strengths, weaknesses, and limitations. Kumar, Baranwal, Raza, & Vidyarthi (2018) comprehensively reviewed spot pricing in the cloud ecosystem. Mazrekaj et al. (2016) provide an overview of cloud computing pricing schemes. It also compared several pricing models and schemes from different providers. Tian, Qin and Liu (2018) examine recent advances in the analysis and design of computational pricing models for Internet-related industries, such as online advertising and cloud computing.

Although qualitative literature reviews enhance our understanding of cloud computing pricing research, they have common limitations. For instance, these reviews lack extensive coverage (Wuni et al., 2019), are highly dependent on the researcher's subjective judgments and prejudices (Hammersley, 2001), are time-consuming (Markoulli, Lee, Byington, & Felps, 2017), and cannot analyze the network of researchers, geographical areas, institutions, and keywords (Olawumi & Chan, 2018). However, quantitatively structured methods can overcome these limitations and provide a comprehensive and objective picture of the research situation (Hosseini et al., 2018). Among these methods is the Computational Literature Review (CLR) (Mortenson & Vidgen, 2016), which can be used to examine the structure and history, information flow, research process, relationships between authors, the impact of journals, etc., in a research area.

This study aims to review the research conducted on cloud computing pricing and identify influential trends and topics using the CLR method. For this purpose, 674 articles indexed in the web of science database and published between 2009 and 2020 are analyzed. First, this study evaluates the publication and citation trend and the impact of authors, articles, and journals. Then, the structure of the co-occurrence network of keywords is analyzed to identify popular and new areas in cloud computing pricing. To better analyze the co-occurrence network of keywords and identify influential trends, the centrality indices (degree, closeness, and betweenness) are deployed in social network analysis. The results obtained in this study can help researchers and scholars to understand the perspective of the cloud computing pricing research field. The results also help to identify new areas and topics and influential trends in this field.

The rest of this paper is structured as follows. In Section 2, the research methodology used in this research is described. The results of this study are presented in Section 3. Finally, this research is concluded in section 4.

Materials and Methods

Computational literature review

Computational literature review (CLR) is the answer to the problem of selecting, screening, and analyzing large volumes of research articles. This method complements the human researcher in the systematic literature review process and is useful for further general analysis of journals, scientists, and research teams. CLR analysis is a research set consisting of the following dimensions (Mortenson & Vidgen, 2016):

Impact analysis

Impact analysis examines the publication trend and the impact of authors, journals, and articles using citation analysis. Examining the number of citations is often used to indicate the importance and acceptance of research work (Zurián, Cañigral, Cogollos, & Aleixandre-Benavent, 2021). Citation analysis evaluates national scientific policies, research groups and laboratories, books and journals, and scientists (Bornmann & Daniel, 2008). The number of citations is used to evaluate the impact of scientists' work in the scientific community because high-quality work by a scientist generates more responses (citations) from colleagues than low-quality work (Van Raan, Visser, Van Leeuwen, & Van Wijk, 2003).

Structure analysis

The structure of the Keywords Co-occurrence Network (KCN) is examined in structure analysis. KCN is created by considering keywords as nodes and the co-occurrence of keywords as links between nodes. The number of co-occurrences of a keyword pair is regarded as the weight of the link between the two. The network created in this way represents an undirected weighted network. It is necessary to use social network analysis indicators to extract additional information from a network. This research uses social network analysis centrality measures to identify and predict emerging areas based on the framework (Dotsika & Watkins, 2017). In this framework, the positional influence of keywords is identified using degree, betweenness, and closeness measures.

According to the framework (Dotsika & Watkins, 2017), keywords with a high score in all three measures are known as influential trends. Also, keywords whose degree, betweenness, and closeness are not positively correlated provide different insights into network structure (Dotsika & Watkins, 2017). Therefore, these centrality measures are combined to identify other trends in the literature. The various combinations of centrality measures and their corresponding trends are presented in Table 1.

Table 1
Combination of centrality measures and corresponding trends

Centrality measures combination	Trend
High degree, betweenness, and closeness	Influential
High degree / low closeness	Popular, mature
High degree / low betweenness	Popular, niche
High betweenness / low degree	Bridging, infrequent
High betweenness / low closeness	Bridging, niche; rare
High closeness / low betweenness	Central, mature
High closeness / low degree	Central, rare

The method of theme analysis with an inductive approach, presented by Braun and Clarke (2006), is used to analyze the obtained trends. This method includes 6 phases, which are briefly described below.

1. **Familiarizing with data:** This phase generally includes looking through the data to get a thorough overview of all the data.
2. **Generating initial codes:** After familiarizing the data, the interesting features are coded systematically, and all data relevant to each code is collected.
3. **Searching for themes:** The codes are collated into themes, and all data relevant to each potential theme is gathered.
4. **Reviewing themes:** Checking if the themes work with the coded extracts and the entire data set.
5. **Defining and naming themes:** The codes are collated into themes, all data relevant to each potential theme is gathered, and clear definitions and names for each theme are generated.
6. **Producing the report:** At this phase, a scientific-analytic report is generated.

Database selection

The most popular databases used in CLR are Scopus and Web of Science (WOS), each with its characteristics and limitations. WOS provides a common research language and interactive environment for researchers to explore a wide range of information and examine indicators influencing resource and content analysis. Therefore, in this research, the WOS database is used as the source of information.

Search strategy

In this study, to review articles in the field of cloud computing pricing in the WOS database, the term (TS = ("cloud computing") and TS = (pricing)) is searched in the title, abstract, author keywords, and keyword plus fields. 692 documents were retrieved from 2009 to March 1, 2020. Then, to improve the results' quality, the document type was limited to journal articles and proceeding papers. The language of published articles was also limited to English. Due to the restrictions imposed, 674 articles were extracted and analyzed.

Software selection

This article uses VOSViewer software (van Eck & Waltman, 2010) to analyze the results. Due to its graphical features, this software can provide more understanding for the researcher in constructing and visualizing bibliometric data. The Gephi software (Bastian, Heymann, & Jacomy, 2009) also calculates the centrality measures for the keywords in the co-occurrence network.

Research findings

This section presents the results of this research in two subsections: impact analysis and structure analysis. The impact analysis subsection shows the publication trend, influential authors, top journals, and influential articles. The thematic trends are analyzed in the structure analysis subsection. in the structure analysis subsection

Impact analysis

Publication trend

Figure 1 shows the publication trend from 2009 to 2020. As can be seen, the publication trend in ng pricing did not grow much in 2009 and 2010, but since 2012, the publication has increased. Also, the publication has a strictly upward trend; the highest number of articles were published in 2020 (109 articles, 16.17% of the total). During the last three years, from 2018 to 2020, 318 articles were published, equaling This trend indicates that paid more attention to this area of research in recent years. In recent years It can be expected that this growing trend will continue in the future.

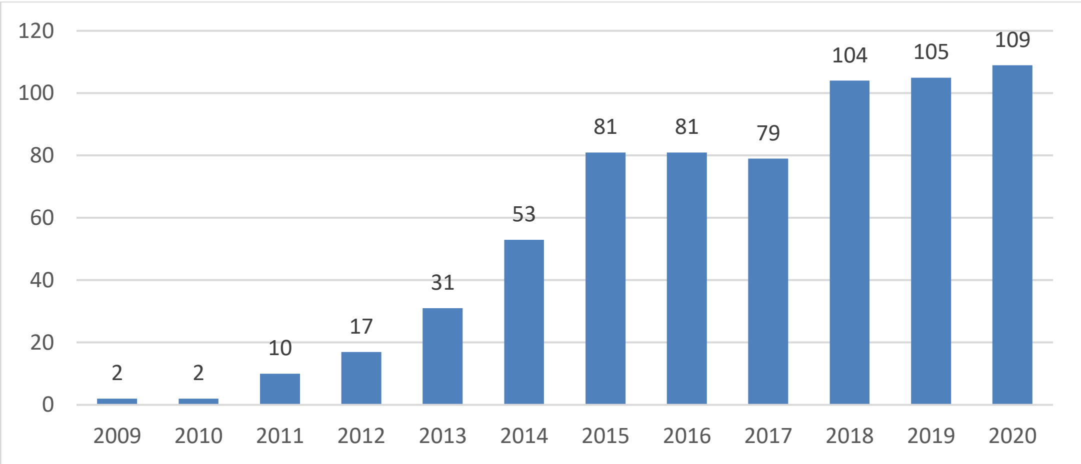


Figure 1: publication trend

Figure 2 illustrates the citation trend over years. Accordingly, the total number of citations is 9299, and the average citation per article is 13.79. As can be seen, article citations have grown exponentially in recent years, with 2019 having the most citations with 2121.

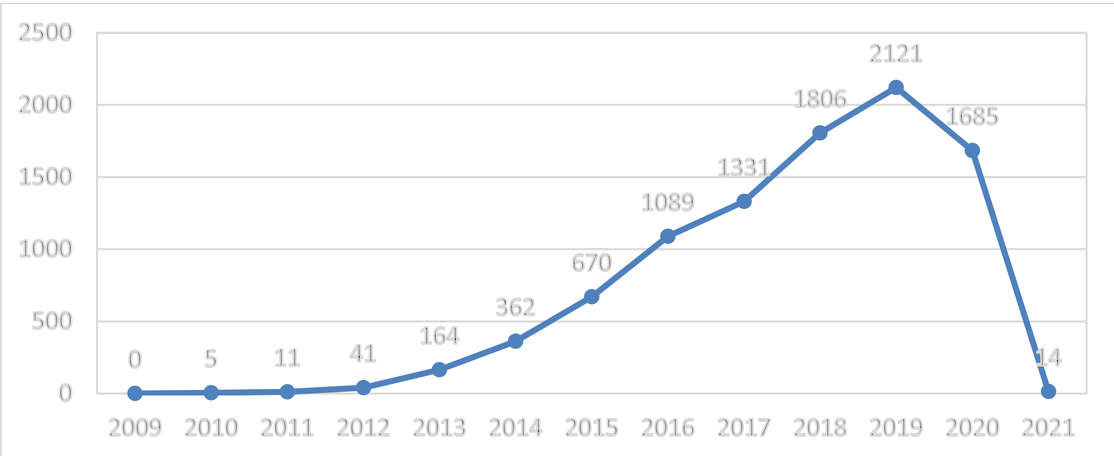


Figure 2: citation trend

Influential authors

In this section, the top authors are examined regarding the number of publications and citations. Table 2 represents ten productive authors (left column) by the number of publications and ten well-known authors by the number of citations (right column). In cases where the authors have the same number of articles (citations), they are sorted by the number of citations (articles).

Table 2

Top Authors in Cloud Computing Pricing

No.	Author	Publications	Author	Citations
1	Buyya, Rajkumar	21	Buyya, Rajkumar	388
2	Niyato, Dusit	9	Niyato, Dusit	364
3	Liu, Jiangchuan	8	Lee, Bu-Sung	316
4	Vidyarthi, Deo Prakash	8	Llorente, Ignacio M.	291
5	Zomaya, Albert Y.	8	Montero, Ruben S.	291
6	Li, Zongpeng	7	Moreno-Vozmediano, Rafael	291
7	Liu, Xue	7	Liu, Xue	272
8	Wu, Chuan	7	Zomaya, Albert Y.	239
9	Li, Keqin	6	Rao, Lei	233
10	Ardagna, Danilo	21	Li, Keqin	228

Among the authors, Buyya and Niyato, with 21 and 9 articles, respectively, and Liu, Vidyarthi, and Zomaya, with eight articles, are the most productive authors. Also, the most well-known authors are Buyya, Niyato, and Lee, with 388, 364, and 316 citations. Among the authors, Buyya, Niyato, Zomaya, Liu (Liu, Xue), and Li (Li, Keqin) have been among the most productive and well-known authors, which indicates the importance and outstanding contribution of these authors in the field of cloud computing pricing.

Top journals

In this section, the most influential journals in the field of cloud computing pricing are examined. Table 3 represents the most productive (left column) and well-known (right column) journals.

Table 3

Top journals in cloud computing pricing

No.	Author	Publications	Author	Citations
1	Future Generation Computer Systems	54	Future Generation Computer Systems	1406
2	IEEE Transactions on Cloud Computing	33	IEEE Transactions on Services Computing	862
3	IEEE Transactions on Parallel and Distributed Systems	29	IEEE Transactions on Parallel and Distributed Systems	842
4	IEEE Transactions on Services Computing	28	IEEE Transactions on Cloud Computing	351
5	Journal of Supercomputing	22	IEEE Transactions on Computers	328
6	IEEE Access	17	Journal of Network and Systems Management	294

No.	Author	Publications	Author	Citations
7	Concurrency Computation Practice and Experience	15	International Journal of Information Management	254
8	Cluster Computing: the Journal of Networks, Software Tools and Applications	13	IEEE Internet of Things Journal	207
9	International Journal of Advanced Computer Science and Applications	10	Journal of Parallel and Distributed Computing	173
10	Journal of Cloud Computing: Advances, Systems and Applications	21	Cluster Computing: the Journal of Networks, Software Tools and Applications	158

According to the results, *Future Generation Computer Systems, IEEE Transactions on Cloud Computing*, and *IEEE Transactions on Parallel and Distributed Systems* were the most productive journals in this field, with 54, 33, and 29 articles, respectively. Based on the number of citations, *Future Generation Computer Systems*, *IEEE Transactions on Services Computing*, and IE*EE Transactions on Parallel and Distributed Systems* were the most well-known journals, with 1406, 862, and 842, respectively. As can be seen, the *Future Generation Computer Systems* journal is ranked first in terms of both the number of publications and citations, representing this journal's leadership in this research field.

Influential articles

In this section, the most influential articles are examined. The top ten most influential articles in terms of the number of citations are presented in Table 4.

Table 4
Top ten influential articles

No.	Paper	Title	Citations	Publication year
1	(Abrishami, Naghibzadeh, & Epema, 2013)	Deadline-constrained workflow scheduling algorithms for Infrastructure as a Service Clouds	305	2013
2	(Chaisiri, Lee, & Niyato, 2011)	Optimization of Resource Provisioning Cost in Cloud Computing	292	2012
3	(Jennings & Stadler, 2015)	Resource Management in Clouds: Survey and Research Challenges	255	2015
4	(Tordsson, Montero, Moreno-Vozmediano, & Llorente, 2012)	Cloud brokering mechanisms for optimized placement of virtual machines across multiple providers	193	2012
5	(Bera, Misra, & Rodrigues, 2014)	Cloud Computing Applications for Smart Grid: A Survey	157	2015
6	(Chesbrough, 2011)	Bringing Open Innovation to Services	157	2011
7	(Hsu, Ray, & Li-Hsieh, 2014)	Examining cloud computing adoption intention, pricing mechanism, and deployment model	140	2014

No.	Paper	Title	Citations	Publication year
8	(Wei, 2019)	Empirical Study on the Benefit Distribution Model of Port Supply Chain under Cloud Environment	135	2018
9	(Guerrero-Ibanez, Zeadally, & Contreras-Castillo, 2015)	Integration challenges of intelligent transportation systems with connected vehicle, cloud computing, and internet of things technologies	130	2015
10	(Zhu, Zhang, Li, & Liu, 2015)	Evolutionary Multi-Objective Workflow Scheduling in Cloud	115	2016

As can be seen, the article (Abrishami et al., 2013) with 305 citations is the most cited in this field. In this study, the authors designed and analyzed a two-phase scheduling algorithm for utility grids, called Partial Critical Paths (PCPs), which aims to minimize the cost of workflow execution while meeting a user-defined deadline. In this paper, the PCP algorithm is adapted for the cloud environment, and two workflow scheduling algorithms are proposed. Another well-cited paper is (Chaisiri et al., 2011), with 292 citations in which an optimal cloud resource provisioning (OcRP) algorithm is proposed by developing a stochastic programming model to address the issue of uncertainty about future consumer demand and providers' resource prices to achieve the best-advanced reservation of resources. Also, (Jennings & Stadler, 2015), with 255 citations reviewed the literature in the field of resource management in the cloud environment, examined more than 250 published studies in this field, and identified the existing challenges. It also provides a conceptual framework for managing cloud resources and uses it to structure the literature review.

Structure analysis

The co-occurrence network of keywords

Keywords represent the main content of published research and cover a wide range of research topics in a field (Hosseini et al., 2018). A network of related keywords provides an overview of the production of scientific knowledge in the form of patterns, relationships, and intellectual structure of the topics (Su & Lee, 2010). Figure 3 represents the co-occurrence network of 157 keywords out of 2136 keywords. For creating this network, the minimum number of occurrences of keywords is set to 5.

Each node's size indicates the corresponding keyword's total number of occurrences. For instance, the keywords management, algorithm, and model have distinctly larger nodes than other keywords, indicating a higher number of occurrences in the literature. The higher number of occurrences indicates the popularity of the keyword and the related area (Radhakrishnan, Erbis, Isaacs, & Kamarthi, 2017). The edges between keywords represent the co-occurrence of keywords. Also, in Figure 3, keywords with high co-occurrences are grouped into eight distinct clusters and shown in different colors. For instance, the keywords optimization, technology, storage, computing, and challenges are in a cluster marked in red.

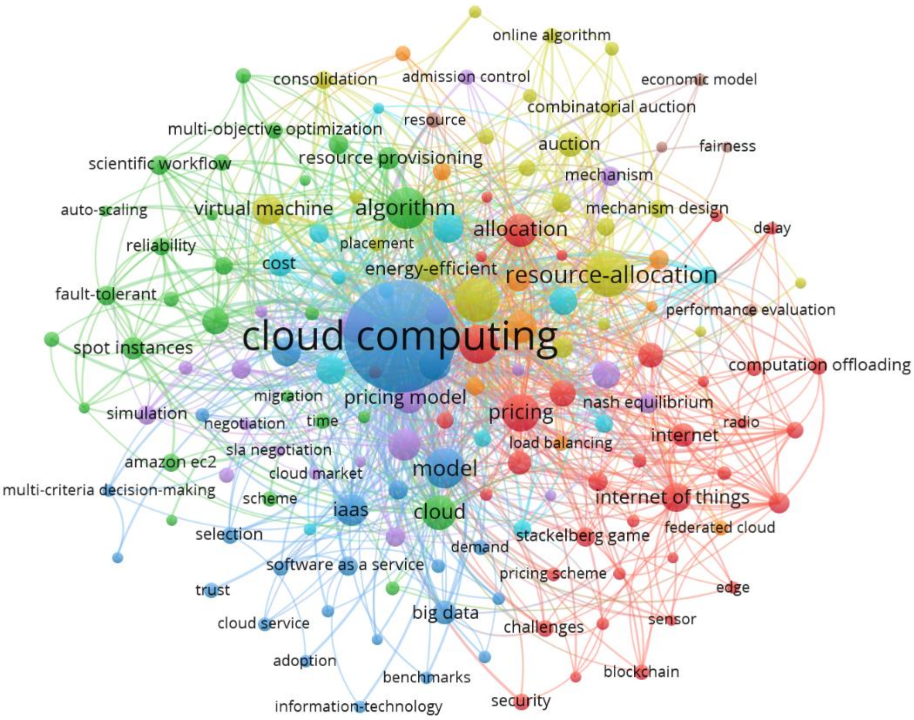


Figure 3: The co-occurrence network of keywords

The co-occurrence network of keywords, taking into account the average publication of keywords, is represented in Figure 4. In this figure, as in Figure 3, the size of each node indicates the number of occurrences of the corresponding keyword. In this figure, the color of each node indicates its average publication year. Accordingly, the bluer the color of a node, the more years the keyword has been used in the literature. In contrast, the yellow color of a node indicates that the corresponding keyword has attracted more attention in recent years.

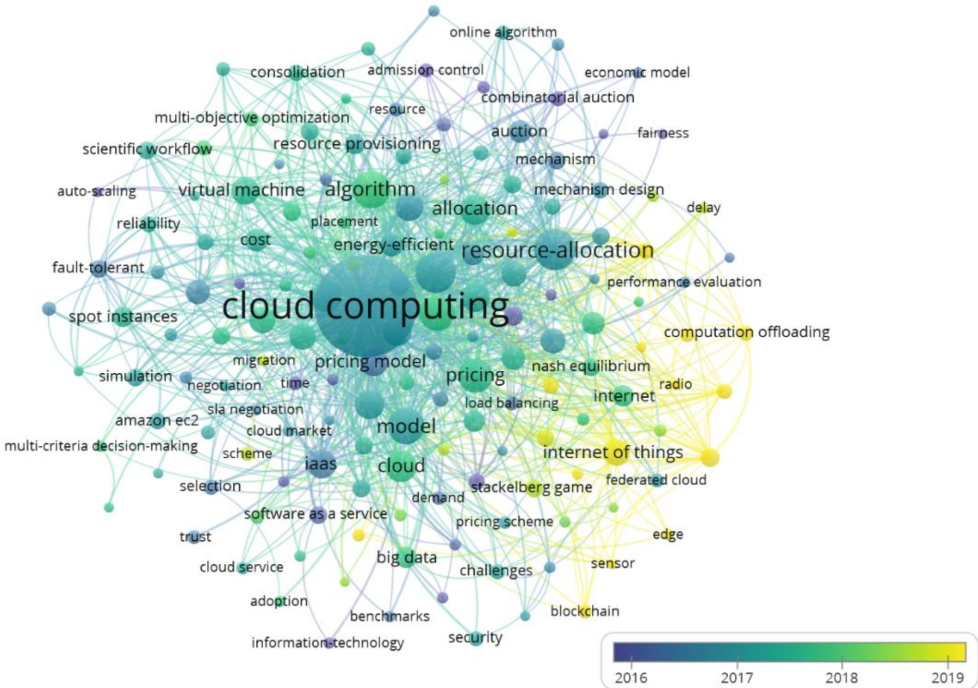


Figure 4: The co-occurrence network of keywords considering the average publication year

Table 5 provides additional information on the co-occurrence network of keywords. The keywords in the left and right columns are sorted by average publication year and occurrence, respectively. The average publication year indicates the average year of publication of the articles that include the corresponding keyword. Therefore, the average publication year can be considered an indicator of keyword novelty in the literature. Keywords with a high average publication year have recently entered the literature and attracted researchers' attention. Accordingly, keywords such as edge, computer architecture, processor scheduling, energy-cost, and feedback control could indicate potential new topics for future research.

The occurrence indicates the number of times the keyword has been used in the literature. The higher the keyword occurrence, the greater its popularity in the literature. It can also be concluded that more research has been done in this area. Accordingly, keywords such as resource allocation, management, optimization, and quality of service (QOS) have the highest occurrence in the literature and have been considered by many researchers.

Table 5
Additional information on co-occurrence network of keywords considering average publication year

	Sorted based on Avg pub. year				Sorted based on the occurrence			
No.	keyword	Avg. pub. year	occurrence	Avg. citation	keyword	Avg. pub. year	occurrence	Avg. citation
1	edge	2020	6	6.17	cloud computing	2016.87	422	14.85
2	computer architecture	2020	4	1.50	resource-allocation	2016.93	69	19.29
3	decision	2020	3	1.00	management	2017.00	67	14.94
4	processor scheduling	2020	3	2.67	algorithm	2017.84	57	14.70
5	biological system modeling	2020	2	0.00	model	2017.04	54	17.52
6	distributed computing	2020	2	0.00	optimization	2017.74	52	16.87
7	energy-cost	2020	2	13.00	pricing	2017.57	47	6.64
8	feedback control	2020	2	0.50	cloud	2017.74	42	11.00
9	fuzzy-logic	2020	2	0.50	allocation	2017.47	39	17.54
10	interference	2020	2	0.00	quality of service (QOS)	2017.21	39	11.67

Thematic trends

The Positional analysis in networks is done using centrality measures. Centrality measures indicate which nodes have significant positions in the network (Wasserman & Faust, 1994). Degree, betweenness, and closeness measures are calculated for nodes (keywords) in the network. The centrality measures here express the popularity of keywords/themes and show the impact that their position has on the process of bridging and controlling thematic flows.

Influential trends

Significant results identifying the central thematic trends of the keyword network are presented in Figure 6. This figure represents a word cloud consisting of keywords with a high degree of betweenness and closeness. The size of each word is proportional to the number of its occurrences in the literature. The keywords used in the search strategy are removed from the corpus to improve the results.

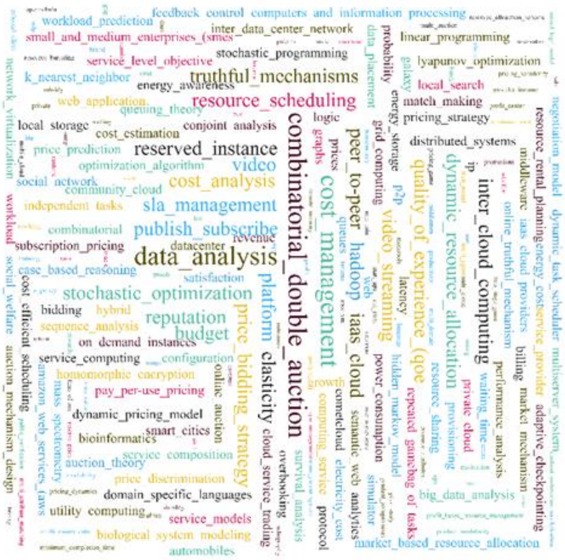
Figure 5: Influential keywords with a high degree of betweenness and closeness

As can be seen, keywords such as allocation, model, energy, Internet, design, auction, consolidation, strategy, and reliability have been among the keywords that significantly impact the network. The following is a description of resource allocation and auction areas.

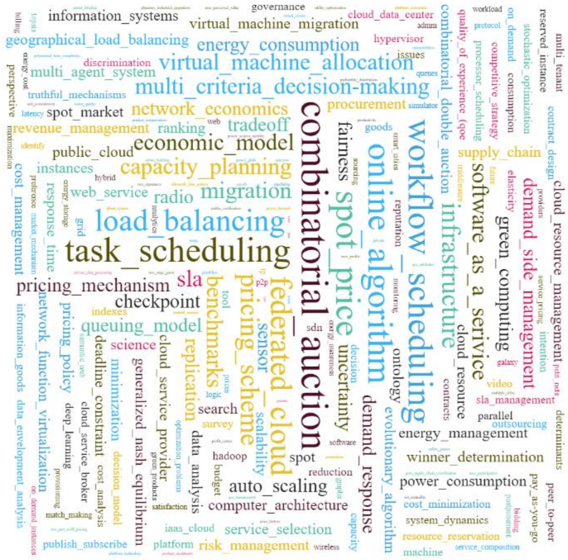
- **Resource allocation:** Resource allocation strategy is one of the key features in a cloud computing environment because scarce resources must be used optimally. In cloud computing, resource allocation is a process in which resources are allocated to the user according to their demands and applications. The resource allocation strategy should be based on criteria such as operational requirements, service level agreements (SLAs), oversupply, and underutilization of resources (Anuradha & Sumathi, 2014). Therefore, different models with different assumptions are proposed in the literature to optimize resource allocation.
- **Auctions:** Auction is another hot and attractive topic in cloud computing. In an auction, the price is determined by the supply and demand of resources. Auctioning is easy, decentralized, and suitable for distributed systems such as cloud and grid computing. This method is also one of the best ways to implement dynamic pricing.

Other trends

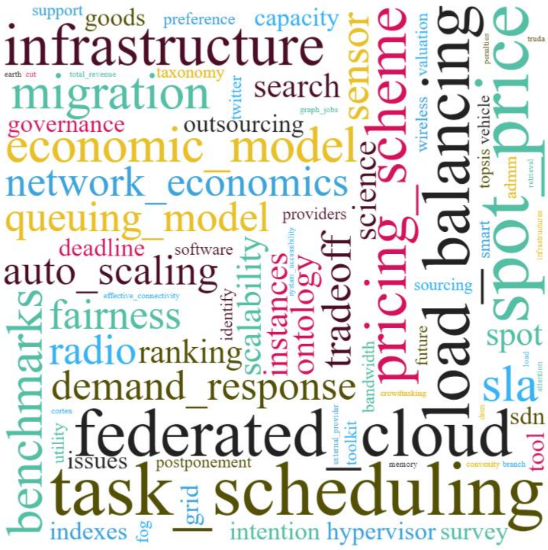
Keywords whose degree, betweenness, and closeness measures are not positively correlated provide different insights into network structure (Dotsika & Watkins, 2017). Figure 7 shows six different combinations of centrality measures and corresponding trends.



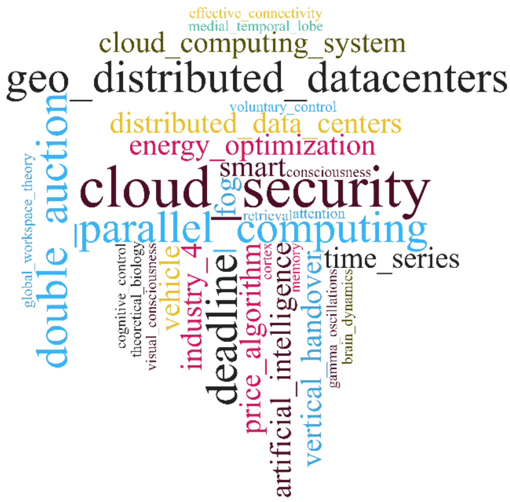
a) keywords with high closeness and low degree



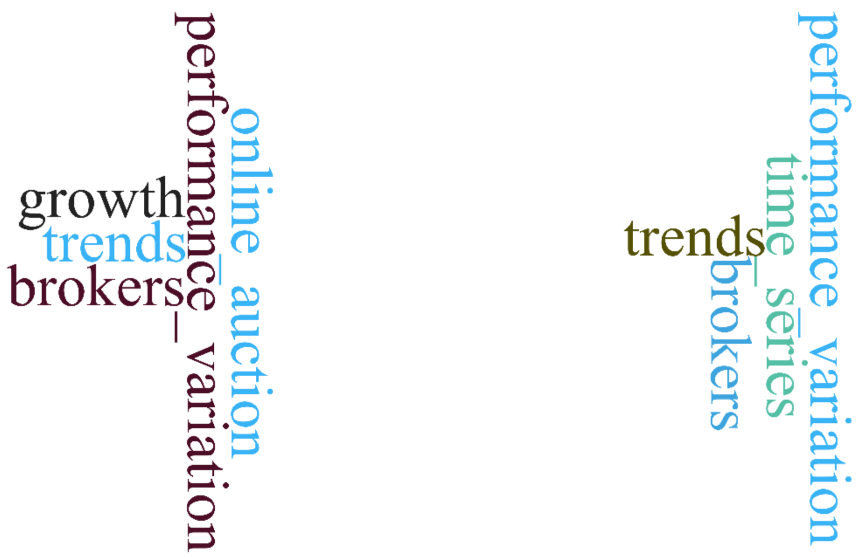
b) keywords with high closeness and low betweenness



c) keywords with high degree and low betweenness



d) keywords with high degree and low closeness



e) keywords with high betweenness and low degree

f) keywords with high betweenness and low closeness

Figure 6: different combinations of centrality measures

I. Central and rare trends

Keywords with high closeness and low degree represent the central and rare trends (Figure 7-a). Notable trends are data science, reserved instances, cost management, inter-cloud computing, SLA management, truthful mechanisms, resource scheduling, and quality of experience, price estimation, distributed systems, energy storage, auction mechanism design, probabilistic programming, pricing strategy, and negotiation model. A brief description of data science and service level agreement areas is presented in the following.

- **Data science:** Data science is an interdisciplinary field that allows experts from different fields to cooperate. Big data analysis technologies make it possible to extract value from data that has five characteristics: volume, variety, velocity, and value (H. Chen, Chiang, & Storey, 2012). Infrastructure, platforms, and software must be adopted as a service approach to analyze data successfully. Data management in the cloud computing environment is one of the topics of interest in the literature (Abadi, 2009).

- **Service level agreement (SLA):** SLAs are terms and conditions provided by a service provider to satisfy service consumers. SLAs contain quality of service (QoS) parameters that a provider must maintain. Successful SLA management is a key factor that needs to be considered by both providers and consumers. SLA management is involved in SLA scaling and automation to adapt to dynamic environmental changes and heterogeneous resources (Sahal, Khafagy, & Omara, 2016).

II. Central and mature trends

Keywords with high closeness and low betweenness represent the central and mature trends (Figure 7-b). These include task scheduling, pricing mechanisms, online algorithms, spot pricing, and software as a service, pricing schemes, multi-criteria decision-making, virtual machine allocation, economic models, demand management, and computer design. The task scheduling and software as a service field are introduced briefly.

- **Task scheduling:** Some parallel programs reduce CPU usage when there is an increase in parallel workload. If tasks are not properly planned and scheduled, performance is reduced because of the large volume of data in the cloud environment. Therefore, scheduling mechanisms play a vital role in cloud computing (Arunarani, Manjula, & Sugumaran, 2019).
- **Software as a service (SaaS):** SaaS is one of the service delivery models which changes the way people produce, sell, buy, and use software. In this model, the software is provided as a service that the cloud user can access through the web browser (Tsai, Bai, & Huang, 2014). Various topics in the field of SaaS have attracted the attention of researchers, including SaaS acceptance, pricing, architecture, security, and quality.

III. Popular and mature trends

Keywords with high degree and low betweenness represent the popular and mature trends (Figure 7-c). These include federated cloud, load balancing, queuing models, spot pricing, benchmarks, infrastructure, fairness, scalability, migration, automated scaling, grid economics, ranking, etc. the following part describes the federated cloud and infrastructure as a service field.

- **Federated cloud:** the federated clouds are the future of cloud computing, mobile cloud computing, the internet of things (IoT), and big data applications. Using federated resources effectively increases service quality, reduces costs, and increases predicted reliability. Resource management in large federated clouds is a significant issue due to a lack of interdisciplinary knowledge, security, trust, and administrative policies (Liaqat et al., 2017).
- **Infrastructure as a service (IaaS):** IaaS is the delivery of hardware (server, storage, and network) and related software (operating system virtualization technology, file system) as a service through the internet. This breakthrough in traditional hosting infrastructure requires no long-term commitment and allows users to get the resources they need (Bhardwaj, Jain, & Jain, 2010).

IV. Popular and niche trends

Keywords with high degree and low closeness represent the popular and niche trends (Figure 7-d). These trends include cloud security, parallel computing, double auction, distributed data centers, energy optimization, artificial intelligence, cloud computing systems, and industry 4.0. The following are the fields of cloud security and industry 4.0.

- **Cloud security:** Usually, every organization chooses high-security infrastructure when moving its data to a location outside the organization. Due to NIST security, portability and information exchange interoperability are the most critical barriers to using cloud computing. The survey results show that 87% of organizations consider cloud security the top priority (Singh & Chatterjee, 2017). In the cloud, there are many risks to storing sensitive data. Therefore, many organizations are hesitant to transfer their sensitive data to storage clouds outside the organization (Fox et al., 2009).
- **Industry 4.0:** All emerging developments in technology and manufacturing reflect the transition of current industrial production to industry 4.0, characterized by intelligence and networks. The clever combination of cloud ideas and methods with production has created a disruptive paradigm called cloud production. Industry 4.0 and cloud production are the two main efforts to use information technology to further promote and develop the production

industry in the manufacturing community. Since the emergence of these concepts, they have attracted the great attention of experts from academia and industry (Liu & Xu, 2017).

V. Bridging and rare trends

Keywords with high betweenness and low degree indicate bridging and periodic trends (Figure 7-e). Among these trends are online auction, performance variation, trends, growth, and brokers. The fields of online auctions and cloud brokers are introduced in the following.

- **Online auctions:** Cloud resource transactions in the real world either occur when customer demands or cloud resources become available. Hence, it is modeled more realistically using online auctions considering the time factor. The customer's willingness to buy decreases dramatically over time, which must be considered for the practical auction mechanism. However, most existing cloud auctions focus on a single round auction and ignore such temporal relevance in decision making (Shi, Zhang, Wu, Li, & Lau, 2014).
- **Cloud broker:** In an evolving cloud ecosystem, it is difficult to determine from which provider (s) a particular cloud resource should be sourced. Currently, providers describe their offers according to the method defined by them. To automate resource acquisition decisions, a layer of brokerage services is considered between adjacent layers of three layers (e.g., IaaS, PaaS, and SaaS) (Mell & Grance, 2011) in cloud architecture. This broker gathers the required knowledge about providers' services and presents an integrated interface / API (Pawluk, Simmons, Smit, Litoiu, & Mankovski, 2012).

VI. Bridging and niche trends

Keywords representing the bridging and niche trends are characterized by high betweenness and low closeness (Figure 7-f). As can be seen, most keywords with high betweenness and low degree also have a low closeness. Hence, most of the keywords in Figure 7-e and Figure 7-f are common. However, the time series keyword has been added in Figure 7-f. The following introduces the field of time series in the cloud computing environment.

- **Time series:** A time series is a set of data points indexed in time order. Most commonly, a time series is a sequence taken at successive equally spaced points in time. Time series are mainly used in any field of science and applied engineering, including time measurements (J. Lin, Keogh, Lonardi, & Chiu, 2003). In the cloud environment, time series are used for anomaly detection for trustworthy services (C. Huang et al., 2017), identifying patterns in data (J. Chen et al., 2019), workflow forecasting (Khan, Yan, Tao, & Anerousis, 2012), price forecasting (Alkharif, Lee, & Kim, 2018), etc.

Discussion

The purpose of this study was to review the cloud computing pricing literature using CLR and identify influential trends in this field. Accordingly, the thematic trends were identified and classified into three themes: resource provision, resource allocation and resource distribution. The following discusses these trends and their place in the cloud pricing literature .

As mentioned, the basic premise of cloud computing pricing research is resource scarcity. In this regard, Kushida, Murray, and Zysman (2015) state that computing power has been a scarce and expensive resource throughout history, and cloud computing, in its simplest sense, is a model of computing resource management. Baranwal and Vidyarthi (2014) also state that although users of cloud resources think that cloud resources are unlimited, the increasing number of users and data indicates that this scarcity of resources will continue in the future. Therefore, Anuradha and Sumathi (2014) suggest that in addition to optimizing and managing existing resources, resource allocation for use and allocation of scarce resources within the cloud environment should be done in a way that meets the needs of cloud applications.

The first way to solve the problem of resource scarcity is resource provision. Peddi (2016) states that resource provision involves dynamic allocation with increasing resource scale, depending on current and future demand. Resource provision solves the scarcity problem by providing resource management for each request for a resource for service providers. The results of the present study showed that the trend of task scheduling, optimization, and resource utilization management are effective ways of resource provision. Shukri, Al-Sayyed, Hudaib and Mirjalili, (2021) point out that tasks must be efficiently scheduled to minimize execution time and cost while maximizing resource utilization.

Among the research that has addressed resource provision are studies focused on data centers. Buyya, Beloglazov, and Abawajy (2010) express that data centers hosting cloud applications consume a considerable amount of energy and contribute to high operating costs and environmental carbon footprint. Therefore, the focus should be placed on developing resource algorithms that consider the synergy between the various data center infrastructures (e.g., hardware, power units, cooling, and software) and generally increase the energy efficiency and performance of the data center. In addition, Peddi (2016) indicates that using predictive strategies to predict the system's future behavior based on the number of user requests or data packages to be processed is effective in resource provision. In addition, distributed parallel computing published on the cloud is one of the topics that has been addressed to improve and reduce processing time and thus improve resource utilization (Zeebaree, 2020)

In addition to resource provision, this study showed that the optimal allocation of available resources to maximize resource utilization is one of the solutions to the problem of resource scarcity. Asha and Rao (2013) state that resource allocation is an essential component of cloud computing, and its efficiency directly affects the performance of the entire cloud environment. Also, Lin, Lin, and Wei (2010) point out that the allocation method has a key role in large-scale management of computing capacity in cloud computing .

Market-oriented allocation rules, which apply the pricing mechanism to capacity control, are useful for designing a more efficient algorithm. The improper allocation may cause system inefficiencies (W.-Y. Lin et al., 2010). Therefore, research has focused on dynamic pricing methods. A clear example of dynamic pricing can be seen in the use of auctions in Amazon EC2 services (Kumar et al., 2018). Other auction methods, such as randomized auction (Zhang, Li, & Wu, 2014) and double auction (Kumar, Baranwal, Raza, & Vidyarthi, 2017), have also been considered by researchers. In addition, data science allows providers to allocate resources optimally by examining customer consumption patterns and estimating future demand. On the other hand, the sharing of computing resources in the form of federated clouds has created new issues in pricing (El Zant & Gagnaire, 2014) and resource allocation (Middya, Ray, & Roy, 2019) of federated clouds.

The third theme identified in this study is resource distribution. (Baranwal & Vidyarthi, 2014) in the field of cloud resource distribution states that when the service provider is aware of unused resources, it can use the concept of redistribution, which represents distributive justice to satisfy customers. The provider may take back the unused resources from the users and reallocate them to the requesting customer .

The use of information technology in providing cloud services has made it possible for cloud service providers to collect data related to customer consumption patterns and use new pricing strategies (Saltan & Smolander, 2021). The use of auction-based pricing for computing resources (Amazon EC2) (Kumar et al., 2018), bundling and discount pricing in the game industry (Choi & Chen, 2019). Premium and reference pricing in storage as a service (such as Dropbox and Microsoft OneDrive) (Harmon, Demirkan, Hefley, & Auseklis, 2009) demonstrates the high potential of value-based pricing methods in the cloud computing industry. Providers can also manage resource distribution by customizing service plans and pricing for each customer (Wang, 2021). However, Sirotnak and Ushakov (2022) state that different customer costs for the same service lead to the perception of distributive injustice for customers and create challenges for service providers. Therefore, fairness has been considered one of the crucial factors in evaluating cloud pricing models in the literature (Al-Roomi et al., 2013).

Conclusion

Due to the importance of pricing in the success of cloud computing, several studies have been conducted in this field. Therefore, this study used CLR and social network centrality measures to quantitatively review the literature and identify the influential trends in this field. Based on the CLR, this study analyzed the literature at two levels: impact analysis and structure analysis. The impact analysis level presents the publication trend, influential authors, top journals, and influential articles. The publication trend in this field has been strictly ascending in recent years, which is expected to continue. Buyya, Niyato, Liu, Vidyarthi, and Zomaya were the most prolific authors, respectively, and Buyya, Niyato, and Lee were the most well-known authors. Among the journals, Future Generation Computer Systems, IEEE Transactions on Cloud Computing, and IEEE Transactions on Parallel and Distributed Systems were the most productive journals, and Future Generation Computer Systems, IEEE Transactions on Computing Services, and IEEE Transactions on Parallel and Distributed Systems were the most well-known journals.

The co-occurrence network of keywords was analyzed to analyze the scientific structure of this field. Based on the results, resource allocation, management, algorithm, model, optimization, and quality of service (QOS) were among the most widely used keywords. Also, edge, computer architecture, processor scheduling, distributed computing, feedback control, and fuzzy-logic keywords have received more attention in recent years.

Three centrality measures of degree, betweenness, and closeness were used to identify the influential trends in this field. Using these measures, influential (e.g., resource allocation and auction), central and rare (e.g., data science and service level agreements), central and mature (e.g., task scheduling and software as a service), popular and mature (e.g., federated clouds and infrastructure as a service), popular and niche (e.g., cloud security and industry 4.0), bridging and rare (e.g., online auctions and cloud brokerage), and bridging and niche (e.g., time series) trends were identified.

According to research trends in this field, it can be seen that the basic premise of the research is the lack of resources needed to meet the growing demand of users and customers. Therefore, researchers are trying to overcome this limitation in three ways: (1) resource provision, (2) resource allocation, and (3) resource distribution. Research on resource provision focuses on increasing capacity while reducing space occupied, the cost of creating and utilizing new resources, and improving resource performance through optimization and management of computing in data centers. Given these trends, it can be expected that computing and storage resources with higher capacity will require less space and cost in the future. This cost reduction will increase profit margins and lead to the industry's growth. On the other hand, the reduction in the space required for resources and initial costs makes the industry attractive to new players. Therefore, we can expect new companies, especially small and medium-sized companies, to enter this industry and increase the size of the industry.

On the other hand, research on resource allocation seeks to use existing resources effectively and efficiently by optimizing and appropriately allocating resources. Therefore, we can see trends such as task scheduling, infrastructure as a service, load balancing, and queuing models. Also, some research has focused on aggregation and dynamic resource sharing due to the variability of demand, limitations in the supply of new resources, and the need to manage resources at the demand peak. Therefore, we are witnessing the popularity of trends such as federated clouds and cloud brokers. Sharing resources and relying on complementary resources will reduce the issue of providing primary resources for new companies, and as a result, the industry will become attractive to new players. Meanwhile, the need for continuous monitoring, quality assurance of services and protection of critical data, service level agreement and cloud security trends have been vital in the literature.

Research on resource distribution seeks to increase resource productivity through the proper and optimal distribution of allocated resources. Trends such as software as a service and industry 4.0 seek to provide customers with the services they need at the required time and location by transforming customer service delivery and providing global access to customers. Also, this transformation in service delivery has led to customers being able to pay based on their usage of services. Therefore, the pricing of services is changed from traditional cost-based to value-based methods. It can be expected that the trend of using value-based pricing methods in cloud services will continue. By using value-based pricing methods, customers feel more fairly and will increase their willingness to use cloud services.

On the other hand, service delivery transformation allows providers to collect rich data on consumption patterns and customer behaviors. They can use data science to estimate future customer consumption and thus distribute resources more efficiently. This makes users more desirable and, as a result, increases the use of services and leads to the industry's growth.

Given the current trends, it can be said that the cloud industry is highly attractive and will also have high growth. However, it will also face risks. The basic premise is that computing and data storage resources are costly and require considerable space. However, technology trends show that in the future, the cost to a capacity of resources will be reduced, reducing companies' desire to outsource IT services. Therefore, the active and new entrants in this field should also consider the risk of declining demand.

This study used social network analysis measures to identify influential trends. However, analyzing the content of articles and identifying different topics requires complementary and auxiliary methods. Therefore, it is suggested that in future research, text mining methods such as topic modeling should also be used in addition to the methods used in the current study. Also, considering that this framework in this research is not specific to the field of cloud computing pricing, it is suggested to use it to identify influential trends in other related areas.

References

Abadi, D. J. (2009). Data management in the cloud: Limitations and opportunities. *IEEE Data Eng. Bull.*, *32*(1), 3–12. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.717.4940&rep=rep1&type=pdf#page=5

Abrishami, S., Naghibzadeh, M. & Epema, D. H. J. (2013). Deadline-constrained workflow scheduling algorithms for infrastructure as a service clouds. *Future Generation Computer Systems*, 29(1), 158–169. https://doi.org/10.1016/j.future.2012.05.004

Al-Roomi, M., Al-Ebrahim, S., Buqrais, S. & Ahmad, I. (2013). Cloud computing pricing models: a survey. *International Journal of Grid and Distributed Computing*, 6(5), 93–106. http://dx.doi.org/10.14257/ijgdc.2013.6.5.09

Alkharif, S., Lee, K. & Kim, H. (2018). Time-series analysis for price prediction of opportunistic cloud computing resources. *Proceedings of the 7th International Conference on Emerging Databases*, 221-229. https://doi.org/10.1007/978-981-10-6520-0_23

Anuradha, V. P. & Sumathi, D. (2014). A survey on resource allocation strategies in cloud computing. *International Conference on Information Communication and Embedded Systems (ICICES2014)*, 1–7. https://doi.org/10.1109/ICICES.2014.7033931

Arunarani, A. R., Manjula, D. & Sugumaran, V. (2019). Task scheduling techniques in cloud computing: A literature survey. *Future Generation Computer Systems*, 91, 407–415. https://doi.org/10.1016/j.future.2018.09.014

Asha, N. & Rao, G. R. (2013). A Review on Various Resource Allocation Strategies in Cloud Computing. *International Journal of Emerging Technology and Advanced Engineering (IJETAE)*, 3(7). Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.413.3493&rep=rep1&type=pdf

Banijamali, A., Pakanen, O.-P., Kuvaja, P. & Oivo, M. (2020). Software architectures of the convergence of cloud computing and the Internet of Things: A systematic literature review. https://doi.org/10.1016/j.infsof.2020.106271

Baranwal, G., & Vidyarthi, D. P. (2014). An econometric based model for resource scarcity problem in Cloud computing. *2014 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT)*, 1–6. https://doi.org/10.1109/CONECCT.2014.6740276

Bastian, M., Heymann, S. & Jacomy, M. (2009). Gephi: an open source software for exploring and manipulating networks. *Proceedings of the International AAAI Conference on Web and Social Media*, 3(1), 361–362. Retrieved from https://www.aaai.org/ocs/index.php/ICWSM/09/paper/viewPaper/154

Bera, S., Misra, S. & Rodrigues, J. J. P. C. (2014). Cloud computing applications for smart grid: A survey. *IEEE Transactions on Parallel and Distributed Systems*, 26(5), 1477–1494. https://doi.org/10.1109/TPDS.2014.2321378

Bhardwaj, S., Jain, L. & Jain, S. (2010). Cloud computing: A study of infrastructure as a service (IAAS). *International Journal of Engineering and Information Technology*, 2(1), 60–63.

Bornmann, L. & Daniel, H. (2008). What do citation counts measure? A review of studies on citing behavior. *Journal of Documentation*, 64(1), 45–80. https://doi.org/10.1108/00220410810844150

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. http://dx.doi.org/10.1191/1478088706qp063oa

Bustinza, O. F., Bigdeli, A. Z., Baines, T. & Elliot, C. (2015). Servitization and competitive advantage: the importance of organizational structure and value chain position. *Research-Technology Management*, 58(5), 53–60. https://doi.org/10.5437/08956308X5805354

Buyya, R., Beloglazov, A. & Abawajy, J. (2010). Energy-efficient management of data center resources for cloud computing: A vision, architectural elements, and open challenges. https://doi.org/10.48550/arXiv.1006.0308

Chaisiri, S., Lee, B.-S. & Niyato, D. (2011). Optimization of resource provisioning cost in cloud computing. *IEEE Transactions on Services Computing*, 5(2), 164–177. https://doi.org/10.1109/TSC.2011.7

Chauhan, S. S., Pilli, E. S., Joshi, R. C., Singh, G. & Govil, M. C. (2019). Brokering in interconnected cloud computing environments: A survey. *Journal of Parallel and Distributed Computing*, 133, 193–209. https://doi.org/10.1016/j.jpdc.2018.08.001

Chen, H., Chiang, R. H. L. & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly*, 36(4), 1165–1188. https://doi.org/10.2307/41703503

Chen, J., Li, K., Rong, H., Bilal, K., Li, K. & Philip, S. Y. (2019). A periodicity-based parallel time series prediction algorithm in cloud computing environments. *Information Sciences*, 496, 506–537. https://doi.org/10.1016/j.ins.2018.06.045

Chesbrough, H. W. (2011). Bringing open innovation to services. *MIT Sloan Management Review*, 52(2), 85. Retrieved from https://sloanreview.mit.edu/article/bringing-open-innovation-to-services/

Choi, H. S. & Chen, C. (2019). The effects of discount pricing and bundling on the sales of game as a service: An empirical investigation. *Journal of Electronic Commerce Research*, 20(1), 21–34. Retrieved from http://www.jecr.org/node/574

Dotsika, F. & Watkins, A. (2017). Identifying potentially disruptive trends by means of keyword network analysis. *Technological Forecasting and Social Change*, 119, 114–127. https://doi.org/10.1016/j.techfore.2017.03.020

Dutta, S., Zbaracki, M. J. & Bergen, M. (2003). Pricing process as a capability: A resource-based perspective. *Strategic Management Journal*, 24(7), 615–630. https://doi.org/10.1002/smj.323

El Zant, B. & Gagnaire, M. (2014, March). New pricing policies for federated cloud. In *2014 6th International Conference on New Technologies, Mobility and Security (NTMS*) (pp. 1-6). IEEE.. https://doi.org/10.1109/NTMS.2014.6814036

Fox, A., Griffith, R., Joseph, A., Katz, R., Konwinski, A., Lee, G., … Stoica, I. (2009). Above the clouds: A berkeley view of cloud computing. *Electrical Engineering and Computer Sciences*. Retrieved from https://www2.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf

Grand View Research Inc. (2021). *Cloud computing market size, share & trends analysis report by service (SaaS, IaaS), by enterprise size (Large Enterprises, SMEs), by end use (BFSI, Manufacturing), by deployment, and segment forecasts, 2021-2028*. Retrieved from https://www.marketresearch.com/Grand-View-Research-v4060/Cloud-Computing-Size-Share-Trends-14883533/

Guerrero-Ibanez, J. A., Zeadally, S., & Contreras-Castillo, J. (2015). Integration challenges of intelligent transportation systems with connected vehicle, cloud computing, and internet of things technologies. *IEEE Wireless Communications*, *22*(6), 122–128. https://doi.org/10.1109/MWC.2015.7368833

Haahtela, T. J. (2011). Sensitivity analysis for cash flow simulation based real option valuation. http://dx.doi.org/10.2139/ssrn.1864909

Hammersley, M. (2001). On'systematic'reviews of research literatures: a'narrative'response to Evans & Benefield. *British Educational Research Journal*, *27*(5), 543–554. https://doi.org/https://dx.doi.org/10.4135/9781473957626.n9

Harmon, R., Demirkan, H., Hefley, B., & Auseklis, N. (2009). Pricing strategies for information technology services: A value-based approach. *2009 42nd Hawaii International Conference on System Sciences*, 1–10. https://doi.org/10.1109/HICSS.2009.350

Hosseini, M. R., Martek, I., Zavadskas, E. K., Aibinu, A. A., Arashpour, M., & Chileshe, N. (2018). Critical evaluation of off-site construction research: A Scientometric analysis. *Automation in Construction*, *87*, 235–247. https://doi.org/https://doi.org/10.1016/j.autcon.2017.12.002

Hsu, P.-F., Ray, S., & Li-Hsieh, Y.-Y. (2014). Time series anomaly detection for trustworthy services in cloud computing systems. *International Journal of Information Management*, *34*(4), 474–488. https://doi.org/10.1109/TBDATA.2017.2711039

Huang, C., Min, G., Wu, Y., Ying, Y., Pei, K., & Xiang, Z. (2017). Time series anomaly detection for trustworthy services in cloud computing systems. *IEEE Transactions on Big Data*, 1–1. https://doi.org/10.1109/TBDATA.2017.2711039

Huang, K.-C., & Shen, B.-J. (2015). Service deployment strategies for efficient execution of composite SaaS applications on cloud platform. *Journal of Systems and Software*, *107*, 127–141. https://doi.org/https://doi.org/10.1016/j.jss.2015.05.050

Hussain, M., & Abdulsalam, H. M. (2014). Software quality in the clouds: a cloud-based solution. *Cluster Computing*, *17*(2), 389–402. https://doi.org/10.1007/s10586-012-0233-8

Jennings, B., & Stadler, R. (2015). Resource management in clouds: Survey and research challenges. *Journal of Network and Systems Management*, *23*(3), 567–619. https://doi.org/https://doi.org/10.1007/s10922-014-9307-7

Khan, A., Yan, X., Tao, S., & Anerousis, N. (2012). Workload characterization and prediction in the cloud: A multiple time series approach. *2012 IEEE Network Operations and Management Symposium*, 1287–1294. https://doi.org/10.1109/NOMS.2012.6212065

Kumar, D., Baranwal, G., Raza, Z., & Vidyarthi, D. P. (2017). A systematic study of double auction mechanisms in cloud computing. *Journal of Systems and Software*, *125*, 234–255. https://doi.org/https://doi.org/10.1016/j.jss.2016.12.009

Kumar, D., Baranwal, G., Raza, Z., & Vidyarthi, D. P. (2018). A survey on spot pricing in cloud computing. *Journal of Network and Systems Management*, *26*(4), 809–856. https://doi.org/https://doi.org/10.1007/s10922-017-9444-x

Kushida, K. E., Murray, J., & Zysman, J. (2015). Cloud computing: From scarcity to abundance. *Journal of Industry, Competition and Trade*, *15*(1), 5–19. https://doi.org/10.1007/s10842-014-0188-y

Liaqat, M., Chang, V., Gani, A., Ab Hamid, S. H., Toseef, M., Shoaib, U., & Ali, R. L. (2017). Federated cloud resource management: Review and discussion. *Journal of Network and Computer Applications*, *77*, 87–105. https://doi.org/https://doi.org/10.1016/j.jnca.2016.10.008

Lin, J., Keogh, E., Lonardi, S., & Chiu, B. (2003). A symbolic representation of time series, with implications for streaming algorithms. *Proceedings of the 8th ACM SIGMOD Workshop on Research Issues in Data Mining and Knowledge Discovery*, 2–11. Retrieved from https://www.cs.ucr.edu/~eamonn/SAX.pdf

Lin, W.-Y., Lin, G.-Y., & Wei, H.-Y. (2010). Dynamic auction mechanism for cloud resource allocation. *2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing*, 591–592. https://doi.org/10.1109/CCGRID.2010.92

Liu, Y., & Xu, X. (2017). Industry 4.0 and cloud manufacturing: A comparative analysis. *Journal of Manufacturing Science and Engineering*, *139*(3). https://doi.org/https://doi.org/10.1115/1.4034667

Lyons, K., Playford, C., Messinger, P. R., Niu, R. H., & Stroulia, E. (2009). Business models in emerging online services. *SIGeBIZ Track of the Americas Conference on Information Systems*, 44–55. https://doi.org/https://doi.org/10.1007/978-3-642-03132-8_4

Markoulli, M. P., Lee, C. I. S. G., Byington, E., & Felps, W. A. (2017). Mapping Human Resource Management: Reviewing the field and charting future directions. *Human Resource Management Review*, *27*(3), 367–396. https://doi.org/https://doi.org/10.1016/j.hrmr.2016.10.001

Mazrekaj, A., Shabani, I., & Sejdiu, B. (2016). Pricing schemes in cloud computing: an overview. *International Journal of Advanced Computer Science and Applications*, *7*(2), 80–86. Retrieved from https://citeseerx.ist.psu.edu/messages/downloadsexceeded.html

Mell, P., & Grance, T. (2011). The NIST Definition of Cloud Computing-Recommendations of the National Institute of Standards and Technology. NIST. *NIST Special Publication*, 145–800. Retrieved from http://faculty.winthrop.edu/domanm/csci411/Handouts/NIST.pdf

Middya, A. I., Ray, B., & Roy, S. (2019). Auction based resource allocation mechanism in federated cloud environment: TARA. *IEEE Transactions on Services Computing*. https://doi.org/10.1109/TSC.2019.2952772

Mortenson, M. J., & Vidgen, R. (2016). A computational literature review of the technology acceptance model. *International Journal of Information Management*, *36*(6), 1248–1259. https://doi.org/https://doi.org/10.1016/j.ijinfomgt.2016.07.007

Mrozek, D. (2020). A review of Cloud computing technologies for comprehensive microRNA analyses. *Computational Biology and Chemistry*, 107365. https://doi.org/https://doi.org/10.1016/j.compbiolchem.2020.107365

Ojala, A. (2016). Adjusting software revenue and pricing strategies in the era of cloud computing. *Journal of Systems and Software*, *122*, 40–51. https://doi.org/https://doi.org/10.1016/j.jss.2016.08.070

Olawumi, T. O., & Chan, D. W. M. (2018). A scientometric review of global research on sustainability and sustainable development. *Journal of Cleaner Production*, *183*, 231–250. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.02.162

Oxford Economics and SAP. (2014). *The cloud grows up*. Retrieved from https://www.oxfordeconomics.com/recentreleases/%0Athe-cloud-grows-up

Pawluk, P., Simmons, B., Smit, M., Litoiu, M., & Mankovski, S. (2012). Introducing STRATOS: A cloud broker service. *2012 IEEE Fifth International Conference on Cloud Computing*, 891–898. https://doi.org/10.1109/CLOUD.2012.24

Peddi, P. (2016). Comparative study on cloud optimized resource and prediction using machine learning algorithm. *ISSN: 2455*, *6300*, 88–94. Retrieved from http://publications.anveshanaindia.com/wp-content/uploads/2018/08/COMPARATIVE-STUDY-ON-CLOUD-OPTIMIZED-RESOURCE-AND-PREDICTION-USING-MACHINE-LEARNING-ALGORITHM.pdf

Radhakrishnan, S., Erbis, S., Isaacs, J. A., & Kamarthi, S. (2017). Novel keyword co-occurrence network-based methods to foster systematic reviews of scientific literature. *PloS One*, *12*(3), e0172778. https://doi.org/https://doi.org/10.1371/journal.pone.0185771

RightScale. (2016). *Cloud Computing Trends: 2016 State of the Cloud Survey*. Retrieved from http://go2.digitalrealty.com/rs/087-YZJ-646/images/Report_RightScale_2016_State_of_the_Cloud.pdf

Sahal, R., Khafagy, M. H., & Omara, F. A. (2016). A survey on SLA management for cloud computing and cloud-hosted big data analytic applications. *International Journal of Database Theory and Application*, *9*(4), 107–118. https://doi.org/http://dx.doi.org/10.14257/ijdta.2016.9.4.10

Saltan, A., & Smolander, K. (2021). Bridging the state-of-the-art and the state-of-the-practice of SaaS pricing: A multivocal literature review. *Information and Software Technology*, 106510. https://doi.org/https://doi.org/10.1016/j.infsof.2021.106510

Shi, W., Zhang, L., Wu, C., Li, Z., & Lau, F. C. M. (2014). An online auction framework for dynamic resource provisioning in cloud computing. *ACM SIGMETRICS Performance Evaluation Review*, *42*(1), 71–83. https://doi.org/https://doi.org/10.1145/2637364.2591980

Singh, A., & Chatterjee, K. (2017). Cloud security issues and challenges: A survey. *Journal of Network and Computer Applications*, *79*, 88–115. https://doi.org/https://doi.org/10.1016/j.jnca.2016.11.027

Singhal, R., & Singhal, A. (2021). A feedback-based combinatorial fair economical double auction resource allocation model for cloud computing. *Future Generation Computer Systems*, *115*, 780–797. https://doi.org/https://doi.org/10.1016/j.future.2020.09.022

Sirotnak, J., Ushakov, D. (2022). The Dynamic Environment of Pricing in E-Commerce and the Impact on Customer's Behavior. In: Kryvinska, N., Poniszewska-Marańda, A. (eds) *Developments in Information & Knowledge Management for Business Applications. Studies in Systems, Decision and Control*, vol 377. Springer, Cham. https://doi.org/10.1007/978-3-030-77916-0_23

Shukri, S. E., Al-Sayyed, R., Hudaib, A. & Mirjalili, S. (2021). Enhanced multi-verse optimizer for task scheduling in cloud computing environments. *Expert Systems with Applications*, 168, 114230. https://doi.org/10.1016/j.eswa.2020.114230

Su, H.-N., & Lee, P.-C. (2010). Mapping knowledge structure by keyword co-occurrence: A first look at journal papers in Technology Foresight. *Scientometrics*, *85*(1), 65–79. https://doi.org/https://doi.org/10.1007/s11192-010-0259-8

Sultan, N. (2014a). Making use of cloud computing for healthcare provision: Opportunities and challenges. *International Journal of Information Management*, *34*(2), 177–184. https://doi.org/https://doi.org/10.1016/j.ijinfomgt.2013.12.011

Sultan, N. (2014b). Servitization of the IT industry: the cloud phenomenon. *Strategic Change*, *23*(5–6), 375–388. https://doi.org/https://doi.org/10.1002/jsc.1983

Sun, H., Tu, Q. W., Wang, X. W., Zhang, J. H., Wu, Q. Z., & Qin, S. W. (2013). The Pricing and Charging of Cloud Computing SaaS. *Advanced Materials Research*, *798*, 703–707. https://doi.org/https://doi.org/10.4028/www.scientific.net/AMR.798-799.703

Sun, X., Zhuo, X., & Wang, Z. (2020). A Survey of Pricing Aware Traffic Engineering in Cloud Computing. *Journal of Internet Technology*, *21*(2), 357–364. https://doi.org/10.3966/160792642020032102004

Tian, F., Qin, T., & Liu, T.-Y. (2018). Computational pricing in Internet era. *Frontiers of Computer Science*, 12(1), 40–54. https://doi.org/https://doi.org/10.1007/s11704-017-6005-0

Tordsson, J., Montero, R. S., Moreno-Vozmediano, R., & Llorente, I. M. (2012). Cloud brokering mechanisms for optimized placement of virtual machines across multiple providers. *Future Generation Computer Systems*, *28*(2), 358–367. https://doi.org/https://doi.org/10.1016/j.future.2011.07.003

Tsai, W., Bai, X. & Huang, Y. (2014). Software-as-a-service (SaaS): perspectives and challenges. *Science China Information Sciences*, *57*(5), 1–15. https://doi.org/10.1007/s11432-013-5050-z

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Van Raan, A. F. J., Visser, M. S., Van Leeuwen, T. N., & Van Wijk, E. (2003). Bibliometric analysis of psychotherapy research: Performance assessment and position in the journal landscape. *Psychotherapy Research*, *13*(4), 511–528. https://doi.org/https://doi.org/10.1093/ptr/kpg038

Wang, Z. (2021). *Optimal pricing strategies of multinational SaaS firms under dual distribution channels*.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications* (Vol. 8). Cambridge: Cambridge university press.

Wei, M. (2019). Empirical Study on the Benefit Distribution Model of Port Supply Chain under Cloud Environment. *Journal of Coastal Research*, *94*(SI), 793–797. https://doi.org/https://doi.org/10.2112/SI94-157.1

Wuni, I. Y., Shen, G. Q. P., & Osei-Kyei, R. (2019). Scientometric review of global research trends on green buildings in construction journals from 1992 to 2018. *Energy and Buildings*. https://doi.org/https://doi.org/10.1016/j.enbuild.2019.02.010

Zeebaree, S. R. M. (2020). Remote controlling distributed parallel computing system over the cloud (RCDPCSC). *2020 3rd International Conference on Engineering Technology and Its Applications (IICETA)*, 258. IEEE.

Zhang, L., Li, Z., & Wu, C. (2014). Dynamic resource provisioning in cloud computing: A randomized auction approach. *IEEE INFOCOM 2014-IEEE Conference on Computer Communications*, 433–441. IEEE.

Zhu, Z., Zhang, G., Li, M., & Liu, X. (2015). Evolutionary multi-objective workflow scheduling in cloud. *IEEE Transactions on Parallel and Distributed Systems*, *27*(5), 1344–1357. https://doi.org/10.1109/TPDS.2015.2446459

Zurián, J. C. V., Cañigral, F. J. B., Cogollos, L. C., & Aleixandre-Benavent, R. (2021). The most 100 cited papers in addiction research on cannabis, heroin, cocaine and psychostimulants. A bibliometric cross-sectional analysis. *Drug and Alcohol Dependence*, *221*, 108616. https://doi.org/https://doi.org/10.1016/j.drugalcdep.2021.108616