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Evaluation of QoS in Distributed Systems: A Review

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Abstract:
Quality of Service (QoS) is a significant concept in distributed systems. Therefore, several studies within QoS for distributed systems have been researched over the past years. It is very difficult to deliver an appropriate QoS level for frameworks running in different open resource environments, including the Internet. A distributed system's QoS characteristics are affected by the QoS of the specific hosts involved, and the QoS of the networking subsystem linking these hosts. This paper reviews the state-of-the-art of distributed systems evolution in QoS architecture. In the context of distributed systems, the method adopted is to address QoS terms and a generalized QoS system for identifying and explaining QoS.

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1. Introduction

Distributed systems are becoming more widespread with the ever-growing technological growth of the world (Haji et al., 2020; Shukur et al., 2020; Zeebaree et al., 2020). They are a comprehensive and dynamic field of computer science research (Divakar et al., 2016; Shukur et al., 2020; Zebari et al., 2018). Dynamic frameworks are characterized distributed systems, divided into many component subsystems by a sparsity of their inter-component connections (Alzakholi et al., 2020; Misik et al., 2016b; Zeebaree et al., 2020). There are many descriptions and interpretations of distributed systems: a distributed system is a system in which networked computing hardware or software components interact and organize their activities only by exchanging messages (Tatara et al., 2007; Zebari et al., 2019; Zeebaree et al., 2019). There are several nodes in a distributed system which use the network to be physically autonomous, but are interconnected. All the nodes are linked and control tandem processes in this system. Each of these nodes contains a small section of the distributed operating system software (Jader et al., 2019; Nadiminti et al., 2006; Zeebaree et al., 2020). A group of separate computers that act as a single device to the system's (Tatara et al., 2007; Zeebaree et al., 2020; Zeebaree et al., 2020). Here are many advantages of distributed systems and implementations, making it interesting to pursue. All nodes are connected in a distributed system. So, nodes can exchange data with other nodes easily. The distributed system can easily connect more nodes to it. Rather than being restricted to only one, devices such as printers can be shared with many nodes. One node's fall would not lead to the whole distributed system's failure, and all nodes could still connect (Dino et al., 2020; Haji et al., 2019; Nadiminti et al., 2006). Also, it is critical that all end-to-end components of distributed systems design work together to accomplish the desired behavior of the application layer (Abdullah et al., 2020; Aurrecoechea et al., 1998; Dino et al., 2020).

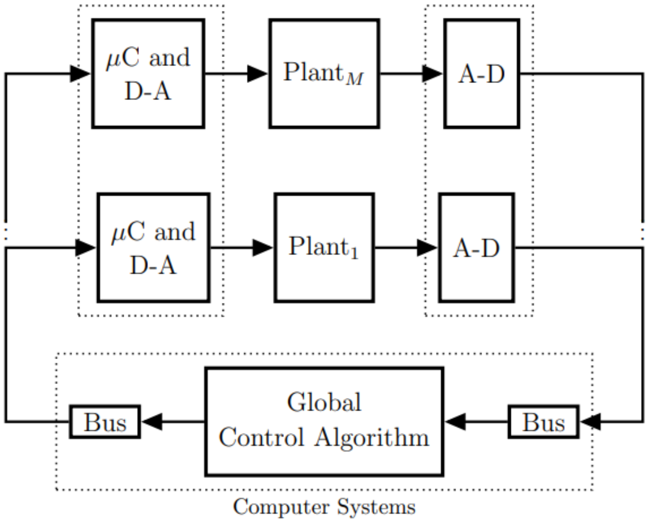

Fig 1. Distributed computer control (Misik et al., 2016a).

Different forms of applications and distributed systems and have been enhanced globally and are being utilized widely. Clusters, Distributed file systems, P2P (Peer-to-Peer) networks, Grids, and Distributed shared memory are common types of distributed systems (Campbell et al., 1994; Mahmood et al., n.d.; Sallow et al., n.d.). The idiom QoS architecture is utilized to specify middleware that provides QoS design and enforcement methods for applications. These architectures coordinate the services offered by the framework in order to satisfy the QoS specifications offered by the application (Dino et al., 2020.; Shukur et al., 2020; Siqueira & Cahill, 1999). QoS refers to any technology that processes data traffic on a network to reduce the loss of packets, delay, and jitter. QoS manages and controls network infrastructure by setting priorities for particular network data types (Ahmad, 2012; Saeed et al., 2021.; Salih et

al., 2020). The concepts of separation, integration, asynchronous, transparency, performance, and resource management are five principles that guide the development of QoS architecture (Campbell et al., 1994; Haji et al., 2020; Sallow et al., 2020).
The remainder of this paper is structured as follows: Section two explains the Quality of Services, their principles, and their mechanisms. Section three reviews the previous literature on Quality of services in distributed systems. Section four discusses and compares the results and the techniques used in each related works. Finally, section five concludes the paper.

2. Background Theory

2.1 Quality of Service (QoS)

QoS is the most critical factor for enforcement. IP voice or video conferencing calls are uncertain, incompatible, and unsatisfactory if the network QoS is not in service. So, in a distributed system, a QoS process has a significant role (Campbell et al., 1993) In general, QoS includes end-to-end scenarios. See Figure 2.

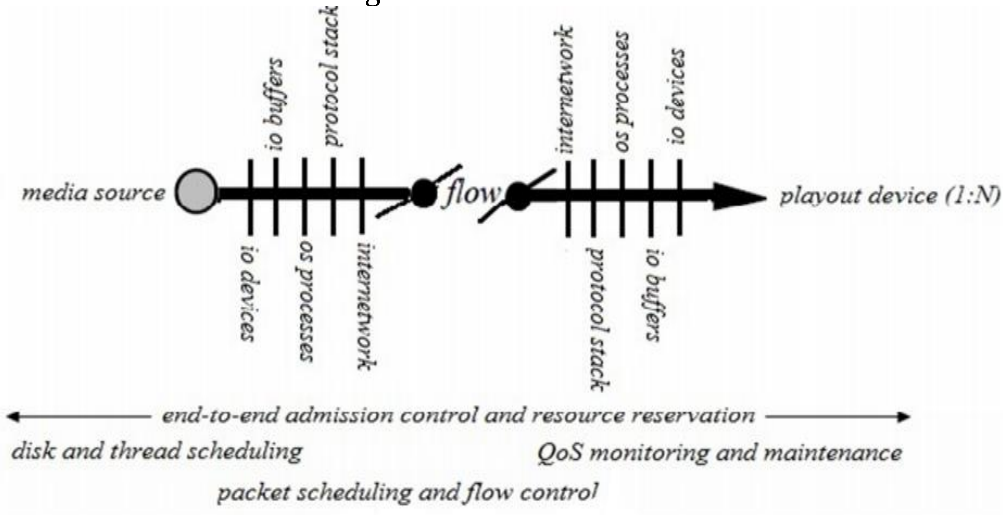

Fig 2. End-to-End QoS Scenario

However, progress has been made in the provisioning of QoS when keeping individual architectural layers in mind, but an overall structure is required to guarantee QoS in the end-to-end scenario (Ageed et al., 2020; Campbell et al., 1994; Dino & Abdulrazzaq, 2019).

2.2 Cloud Computing Service models

There are five QoS principles that govern the construction of QoS structure. Each of them is explained in details below:

2.2.1 Integration principles

To achieve end-to-end service quality, the integration principle specifies that service quality should be maintainable, configurable, and predictable overall architectural layers. Flows traverse QoS utility modules from source devices at each layer, down through the source protocol stack, through the network, back to the devices through the receiver protocol stack. Each QoS module passed through must have QoS configuration, resource guarantees, and on-going flow maintenance (Campbell et al., 1994; Dino & Abdulrazzaq, 2020).

2.2.2 Separation Principle

The separation theory notes that architectural practices that are functionally separated are media transition, control, and administration. The separation concept shows that it is important to separate all processes into architectural structures. One portion of the difference between signaling and media-transfer is the disparity. Isochronous flows commonly involve a wide range with high capacity, low latency, unsecured playout services on the playout devices with some type of jitter correction. On the other side, signaling requires low latency, guaranteed networks without jitter constraints, and Full-duplex and more asynchronous (Campbell et al., 1994; Lazar, 1992; Rashid et al., 2018).

2.2.3 Transparency Principle

The principle of transparency explains that the sophistication of underlying QoS control mechanisms and requirements such as QoS monitoring and maintenance should be shielded from applications. An important aspect of transparency is the QoS-based API for which needed service quality levels are shown. The advantage of transparency is three-fold. This decreases the need to integrate quality of service features in software. This includes the details of the fundamental service specification of the application and transfers the complexity of managing QoS management tasks to the fundamental QoS framework (Campbell et al., 1994; Jacksi et al., 2015; Subhi RM & Karwan, 2015).

2.2.4 Asynchronous Resource Management Principle

Functionality distinction between architectural components which extends to access and control modeling systems. A direct reflection requires essential time constraints in distributed communications environments in parallel between operations. Due to these numerous time scales, the state of the distributed communication system is organized. Optimized algorithms that regularly operate and share control data are used to achieve the controller parameters of contact activities (Aurrecoechea et al., 1998; Zeebaree, et al., 2019; Zeebaree et al., 2019).

2.2.5 Performance Principle

Finally, a set of generally agreed standards for the design and implementation of QoS-guided communications subsumes the concept of performance. These rules lead the practical division into high-performance structuring of routing protocols, multiplexing avoidance, guidance for constructing data exchange such as framing of application layers and automated processing of layers, with the use of equipment helps to manage protocols (Dabbous & Diot, 1996; Jacksi et al., 2020; Zebari, 2011).

2.3 Mechanisms for QoS

According to user-supplied QoS specification, availability of resources, and strategic planning policies, quality of service structures are selected. QoS processes are defined in resource management as either static or dynamic in design. Static resource allocation is concerned with the creation of flows and end-to-end QoS renegotiation stages, defined as the providing of QoS consisting of three components: QoS mapping, admission checking, and resource reservation, The media transmission method described as QoS control, including stream forming, flow planning, flow management, data processing and flow synchronization, and QoS management mechanisms are handled by dynamic resource management, including QoS tracking, QoS maintenance, QoS depletion, QoS communication, and QoS usability. The disparity between the former and the latter is dependent on various time ranges in which they function which is a direct product of the asynchronous resource management concept. The QoS control separates itself from control by working on a shorter, more responsive time frame (Aurrecoechea et al., 1998; Misik et al., 2016a; Qaqos et al., 2018).

3. Literature Review

Guo and Wang (2016) suggested a view of skyline utility selection based on the forecast of QoS. Their method involves four steps: they first regarded the QoS context documents as periodicity and estimated the QoS values to provide more detailed QoS attribute values using the Autoregressive Integrated Moving Average model. Afterwards, by introducing an increased coefficient of variance, they determined the volatility of the estimate. They used Skyline computing for replanting unnecessary solutions to enhance the quest space and then rendered Skyline service discovery using Mixed Integer Programming to pick the suitable Skyline services with higher performance and smaller cost of time. Their approach can significantly improve Skyline service selection's real-time performance with a reliability guarantee compared to the previous approaches. Gabor (2016) recommended a Thompson sampling version of QoS-aware for multi-armed robbers. It is important in circumstances where the fulfillment of an arm must be efficiently ensured with high conviction, rather than seeking the optimum arm when reducing disappointment. Further study in the field of QoS-aware decision making was promised and motivated by their preliminary experimental findings. Souza et al. (2016) showed that it is possible to design complicated formulations, deal with the assessments, and anticipate and prevent the misbehavior of the framework before achieving unpredicted states with the architectural model of reliability, availability, and serviceability. Their existing methods were focused on vertically and horizontally DDB device scalabilities, and to eliminate these unpredictable states, this could be directly implemented in a DBMS. These concepts were not a new concept but sufficient for this lack of conceptualization of architecture over the database area to be filled. For further improving this analysis into a new implementation, Some techniques were faced with a simple algorithm recognizing the standard actions expected. Di and Ma (2016) suggested an open small QoS traffic technique and QoS-ensure technique relating to the latest definition of SDN that distinguishes the control and data layers, which improved QoS-controlled flexibility reliability achieve adequate utilization of the network and great flow management. The experimental findings confirmed their method's quality and effectivity via the implementation and simulation execution of the Mininet network simulation framework. Their trial results confirmed their effectiveness.

Kalchenko (2016) presented a Quality of Services (QoS) control method in Next Generation Networks (NGN) that effectively monitors and maintains user satisfaction with the quality of services at the level required. Their method was based on the use of fuzzy logic methods and neural networks. Afterward, the possibility of applying the distributed control system approach to networks has been demonstrated. Li et al. (2019) suggested an innovative method to service selection that also accounted for user requirements for QoS correlations. Their method was the first approach to service selection that considered customer requirements in QoS correlations. Besides, their method was decentralized, and the single point of failure was able to be eliminated. Their experimental findings showed the effectiveness of the method proposed. The suggested solution will achieve a higher performance rate and much lower consumer price and obtain much more value for consumers compared to the previous approaches. Shitara et al. (2016) used the Kernel density estimator to eliminate sensing errors and low accuracy. To achieve a continuous density function from specific dispersed sample data like the QoS data collected, they expect to predict certain densities only from the device utilization records and their relative positions. Extracting high-density fields from the application used to evaluate QoS degradation from the QoS perspective was necessary. The boundary between the high-density field as well as the other field was calculated after evaluating the Kernel density estimation method by using a value that might be obtained from the existing data. In simulated tests, the feasibility of the proposed approach has been presented. Yosra et al. (2016) used the QoS method to maximize the usability of the conventional protocol and introduced the OLSR protocol. Their strategy consists of metrics to use the tools available to identify the most accurate path based on parameters of delay, bandwidth, and dropped results. Multiple packets are exchanged while the OLSR protocol is introduced, and results indicate fragmentation between nodes and some lost packets. So, they adopted a new CO-QOLSR protocol to remove these issues and improve OLSR spectrum utilization. The suggested metric is to effectively endorse modern protocol with distinct parameters of QoS. Simulations results indicated that the COQOLSR variants introduced work better than the OLSR protocol. Ghahramani et al. (2017) examined technical details relevant to the cloud and categorized it into different groups, providing a chance to gain insight into the different facets of QoS structures. They also derived a list of capabilities from their description of QoS metrics that are considered relevant to facilitate effective cloud resources management. Besides, the issue of resource allocation in the cloud environment and its different strategies have been considered. Since clouds consist of heterogeneous services that can be handled separately in other areas with unique functions, they have examined QoS monitoring tools' main role from users and providers' perspectives. They also defined a categorization of various cloud resources that provide in depth analysis into QoS issues to achieve a coherent structure. Finally, the researchers and clinicians discussed the issues and challenges facing them. Niu et al. (2017) solved the problem of modeled web service design with QoS instability with the consideration of unknown service QoS, which was translated by an unspecified interval number into a multi-objective optimal solution, which can be addressed using a non-deterministic multi-objective modeling technique by their proposed solution. First, the approach models a UQ-WSC issue with an unknown period number into a multi-objective optimization issue. To address the period number multi-objective issue and get the optimal solutions set, a ndmoea/d algorithm is then suggested. On their simulated datasets, large-scale empirical experiments have been performed. Their experimental finding showed that their suggested method would find an ideal composite service solution set with satisfactory convergence effectively and efficiently.

Wang et al. (2017) proposed a new approach for service selection based on related criteria of QoS, called SCORE-QoS. With QoS correlation functions, the correlations between different QoS requirement dimensions have been formalized and integrated into the COP that models service selection. Two types of QoS specifications have been considered: even without user management goals. Their experimental results showed that, relative to other representative methods, SCORE-QoS could determine the best approaches for service selection with high efficacy, high system accuracy, and reasonable numerical workload. Subbulakshmi et al. (2018) Implemented a method designed to impute missing values by clustering, similarity testing, and optimization techniques in QoS datasets. And the Genetic Algorithm (GA) has improved the solution. The optimization of QoS values has helped to produce a more detailed dataset. Finally, the QoS prediction of WS was determined by utilizing imputed datasets. It helped determine the consistency and rating of various WS. Their experimental results showed that the proposed solution predicts the values of web service QoS more accurately and that optimal web service is predicted/suggested to the user using these datasets. Wang et al. (2018) developed an SDN (S5) application-sensitive QoS assurance framework that provided the QoS guarantee on the core networks between user networks and idcs. S5 proposed a novel calculation solution for QoS and theoretically proved its rationality. A variety of QoS guarantees mechanisms have also been established by their system to ensure the QoS indications for the required use, including intelligent call admission monitoring, optimized queue management, and QoS-motivated redirection. The prototype was introduced, and the results were inspired by comprehensive evaluations. Zuhra et al. (2019) introduced the intra-WBSN LLTP-QoS routing protocol, which addressed the issues faced by wbsns' existing priority-aware routing protocols. The LLTP-QoS was proposed to enhance the transfer of essential data and avoid node and link-level congestion. In comparison, the LLTP-QoS consisted of two primary systems, such as prioritizing traffic and discovering routes. Using a specific queue allocation method, the LLTP structure efficiently preferred the data packets and avoided node-level aggregation. To satisfy an integrated set of criteria, the configured route is chosen, resulting in increased network efficiency in capacity, average end-to-end latency, PDR, normalized routing load, and lifetime of the network. Compared to the existing routing protocols, the simulation findings confirmed the improved performance of the LLTP-QoS protocol. Venkatesh et al. (2019) introduced new solution called ANFIS-AODV, which can be extended to cellular ad hoc networks used for time-sensitive data exchanges. It also recommended an improved method that supported service efficiency. A high quality transmitted video was produced as ANFIS-AODV and SVC were merged, which can be used to avoid congestion. A path was estimated between the supply and the destination node using the proposed method based on ANFISAODV. In the first step, local bandwidth is calculated at any node. In the second step, the bandwidth consumed between the packets is defined. Finally, under ANFIS-AODV, A curing process was suggested, which is used to form a connection when a loss happens.

GU (2019) focused on the QoS-qoe and association's modeling of conversational video flows. The general demand relationship between qoe and some QoS network layer variables of the communicative video service is analyzed and related distribution features are introduced through quantitative tests of the network video flow data using the ITU-T P.1201.1 model. From the user experience perspective, the suggestion indexes of the QoS variable are provided in each Mean Opinion Score quality period, and a qoe related QoS model is developed. The feasibility of the suggested QoS indexes is proven by verification and alignment with research assignment, which will help network operators find a balance among increasing network power and fulfilling the user's quality level. Gharsellaoui and Khalgui (2019) proposed a novel adaptive DIS solution in which an adaptive rule-based framework for both controllers and intelligence reconfiguration was applied. As a major contribution to this research, a new connectivity protocol for synchronization in distributed and area reorganization, called CORDIS, has been suggested. Their approach was specific as it can be applied to any framework of predefined assumptions. This paper was original since the automated intelligence reconfiguration of reconfigurable distributed intelligent systems is not discussed in all relevant works and all our previous works. The simulation and experimentation found that the system's response time increased and the memory use decreased by reducing the number of rules in the rule base. In this article, the consistency of the system in the coordination process and intelligence QoS was assured by proposing equations to verify the behavior of the system. Yang et al. (2019) proposed a predicting Web service QoS method by exploiting location and reliable data. First, the QoS data and user's geographic information are divided by the K-means clustering algorithm to obtain candidate untrustworthy users, QoS similar users, and geographically identical users. Then, the unknown service QoS values were predicted by using only trustworthy users' QoS data from matching users. Comprehensive experiments were conducted on the QoS dataset of a real-world web service. The experimental findings demonstrate that their approach outperforms the other methods of prediction of QoS. Ganesan (2020) researched under the primary interruption model for wireless networks, the flow admission management issue. In which each node has knowledge only about its d-hop area, a distanced distributed algorithm was given. A specification which is both appropriate and necessary to be possible for collecting flow rates was issued. It was shown that distributed algorithms with global parameter information could achieve the same output as a centralized algorithm streamlined. The literature has studied more general models of combinatorial interference than conflict diagrams, such as typographical interference models.

4. Discussion

In this paper, various papers are reviewed and summarized. Table 1. Illustrates the summarization of the reviewed related works. According to the illustrated table, it is investigated that the results of related works are varied in effectiveness and robustness. In (Li et al., 2019; Misik et al., 2016a), researchers achieved a higher performance rate and much lower user cost using the Candidate Service Pruning algorithm, Service Negotiation algorithm, and distributed algorithms. In (Divakar et al., 2016), the authors achieved high performance using improved Skyline service selection's real-time with reliability guarantee based on Autoregressive Integrated Moving Average (ARIMA) model. Reference (Nadiminti et al., 2006) validated their effectiveness by deploying the Mininet network simulation platform and simulation implementation using optimization theory. Also, (Aurrecoechea et al., 1998) found exactly those quality indicators, which allowed reaching the maximum effect within acceptable costs. The fuzzy logic method effectively monitors and maintains user satisfaction with the quality of services at the level required. (Campbell et al., 1994) used Kernel density estimation algorithm that affected the reduction of sensing errors and low accuracy that caused by the crowd sourcing data. Results in (Divakar et al., 2016) were not much advantageable since they facilitated efficient cloud resource management and achieved a unified system using load balancing algorithms. However, results in (Misik et al., 2016b; Tatara et al., 2007) were not satisfied since they could develop it by allowing more efficient QoS-aware decision-making.. Also, results in (Siqueira & Cahill, 1999) were not quite advantageable because It proposed a CO-QOLSR protocol that is much less efficient than the OLSR protocol that needs to be changed.

Table 1: Summarization of the Reviewed Studies

Author(s)	Algorithm	Objective(s)	Results summery
Guo and Wang (2016)	(ARIMA) model	Finding the right Skyline services with better reliability and reduced cost of time	Improve Skyline service selection's real-time performance with reliability guarantee
Belzner and Gabor (2016)	Thompson sampling	Identify a configuration that satisfies the criteria of QoS and increase confidence in this configuration.	More research in the field of QoS-aware decision making is encouraged
Souza et al. (2016)	Architectural Recovering Model	To explain the use of the assessment equations of a Quality of Experience (qoe) theoretical application form by Quality of Service (QoS)	QATS is applicable in settings where QoS satisfaction of an arm has to be ensured with high confidence efficiently.
Di and Ma (2016)	Optimization theory	To achieve optimal network resource consumption and fine-grained flow management.	Validated its effectiveness. Through the deployment in Mininet network simulation platform and simulation implementation
Kalchenko (2016)	Fuzzy logic method	To effectively monitor and maintain user satisfaction with the quality of services at the level required	Found exactly those quality indicators, which improvement allows to reach maximum effect within acceptable costs.
Li et al. (2019)	Candidate Service Pruning algorithm, Service Negotiation algorithm	To select services to satisfy user QoS requirements.	Achieved a higher performance rate, achieve a much lower consumer price, and obtain much more value for consumers
Shitara et al. (2016)	Kernel density estimation algorithm	To reduce the sensing errors and low accuracy caused by the crowd sourcing data	The feasibility of the proposed approach has been presented.

Yosra et al. (2016)	Dijikestra algorithm.	To improve OLSR protocol performance	A new approach implemented, CO-QOLSR protocol that is performed better than the OLSR protocol.
Ghahramani et al. (2017)	Load balancing algorithms	Analysis of Cloud Systems and Cloud Services	Facilitated efficient cloud resource management and achieved a unified system.
Niu et al. (2017)	Ndmoea/d algorithm	Modeling the issue of Web service composition with QoS uncertainty that is translated into a multi-objective optimization problem	Solved the UQ-WSC problem effectively and efficiently, which has satisfactory convergence.
Wang et al. (2017)	Greedy methods, Lagrange multiplier methods.	Service selection based on correlated QoS requirements, called SCORE-QoS	SCORE-QoS can find the optimal solutions for service selection with high success rates, high system optimality, and acceptable computational overhead.
Subbulakshmi et al. (2018)	Genetic Algorithm (GA)	Imputing the missing values in QoS datasets	Web service QoS values are estimated more correctly and an optimal web service is suggested to the consumer using these datasets.
Wang et al. (2018)	Heuristic algorithm	An Application Sensitive QoS Assurance System via SDN	Provides the QoS guarantee in the core networks between user networks and idcs
Ganesan (2020)	Distributed algorithms	Distributed Algorithms for QoS in Wireless Ad Hoc Networks Under the Primary Interference Model	Distributed algorithms are proposed for the admission control problems, and performance guarantees of distributed algorithms are given.
Zuhra et al. (2019)	LLTP scheme	Low Latency Traffic Prioritization and QoS-aware routing in Wireless Body Sensor Networks	The reliability of critical data transmission is Enhanced.
Venkatesh et al. (2019)	ANFIS model	ANFIS based QoS-aware Routing Protocol for Video Streaming in MANETS	Establish the connection when there is a failure occurs.
GU (2019)	ITU-T P.1201.1 model	Data Driven qoe-QoS Association Modeling of Conversational Video	Help network operators strike a balance between saving network capacity and satisfying the user's standard of service.
Gharsellaoui and Khalgui (2019)	Q-FCRA algorithm	Intelligence Dynamic Reconfiguration for High Independent Adaptability of Actions Distributed schemes	By decreasing the number of rules in the rule base, the response time of the system becomes better and the memory consumption decreases
Yang et al. (2019)	K-means clustering algorithm	Web service QoS prediction via exploiting location and trustworthy information	The influence of unreliable data and user context on QoS prediction are reduced, the accuracy of prediction is improved.

5. Conclusion

Distributed systems are becoming more and more popular with the increasing technological growth of the world. It is a large and diverse area of computer science research. The distributed system is a collection of individual computers that act as a single computer to users of the system. Quality of service refers to any technology that processes data traffic on a network to reduce the loss of packets, delay, and jitter. This paper reviewed some generalized QoS models and addressed their challenge, guided by five design principles: transparency, integration, separation, multiple time scales, and compared their performance. We proposed that distributed system designers should follow an end-to-end approach to satisfy application-level QoS specifications. The variables affecting each environmental algorithm's consistency and efficiency are summarized by using many algorithms, as several researchers have tried and are still trying to find optimal solutions for the Quality of Services in distributed systems.

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