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Research Article

Towards Enhancing the Capability of IoT Applications by Utilizing Cloud Computing Concept

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The emergence of smart and innovative applications in diverse domains has inspired our lives by presenting many state-of-the art applications ranging from offline to smart online systems, smart communication system to tracking systems, and many others. The availability of smart internet enabled systems has made the world as a global village where people can collaborate, communicate, and share information in secure and timely manner. Innovation in information technology focuses on investigating characteristics that make it easier for the people to accept and distribute innovative IT-based processes or products. To provide elastic services and resource the Internet service provider developed cloud computing to support maximal number of users. Cloud computing is a subscription paradigm in which users do not buy various resources permanently, but they purchase it with block chain-driven payment schemes (credit cards). A flexible, on-demand, and dynamically scalable computer infrastructure is offered by cloud providers to its clients on charging some amount of subscription. This research article provides an introduction of cloud computing and the integration of IoT concept, its impacts on crowd and organizations, provision of various services, and analyzing and selecting the appropriate features using probability distribution function for enhancing cloud-based IoT capabilities. In ambiguous and complex situations, decision makers use quantitative techniques combined with traditional approaches to select the appropriate one among a group of features. Probability distribution function is used to evaluate the appropriate features that will enhance the capabilities of cloud-based IoT application.

1. Introduction

Information technology has innovated our lives by presenting many state-of-the art applications ranging from healthcare to navigation systems, eHealth to m-Health systems, and many others [1]. These applications not only facilitated us by presenting routine services at doorstep but also reduced our efforts on performing different tasks. Technological fusion facilitates significant changes and encourages new IT products, processes, and services to be developed [2]. The emergence of internet of things- (IoT-) based devices has chosen new paths for the organizations to perform their normal operations with different perspectives and with more outcomes. Informational technology advancements enabled the organizations to respond technological developments in current operations by developing new capabilities that precede new opportunities. In the perspective of transformative trends in the development of information technology, cloud computing provides an environment where shared processors, laptops, computers, sensors, and various form of communication technologies are integrated to provide easy access to virtual resources [3].

The word "cloud" has originated from the telecommunication industry when providers began to use VPN networks to exchange data [4]. Clouds are some virtual computer resources, generally include server clusters, storage server, broadband resources calculations server, etc. [5]. Information technology made transferring data and computation

possible from desktops and personal computer systems to massive virtual data centers. It involves provisioning of hardware and software application supplied as Internet services in virtual data centers [6]. According to NIST *"Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability"* [7].

Virtualized resources are dynamically delivered to consumers via the Internet as services by means of devices such as laptops, computers, cell phones, and PDAs that are connected to cloud for accessing, developing, and storing program [8]. The IT efficiency and the computation power is efficiently used by scaling of hardware and software among users and business agility where IT works as a tool for deployment, processing, business analytics, and interaction by means of cell phone works in timely manner to achieve the requirements of users [9]. Resources are physically distributed and shared but are logically presented in single and complete forms. When necessary, users access the resources and pay for the quantity, but they do not manage them. To achieve the computation power, the tasks in cloud computing are distributed on the resource pool "Cloud" that consists of a huge group of computers, the storage memory, and applications in accordance to task requirements [5, 9]. Cloud computing has multiple implementation paradigms, each of which gives different offsets to organizations that migrate their processes to a cloud environment.

Resources are supplied in a firewall and retained in private clouds by the user entity. User entity manages the cloud resources with their own physical infrastructure and software's. In general, these services and resources are not shared publicly [10]. The major advantage here is that maintenance, upgradation, and security are more easily handled, and that deployment and operation are also effectively controlled [11]. When a large number of organizations build polices, share their needs, and cloud infrastructure together, then this is termed as community cloud model [10, 11]. Community cloud computing is a promising and evolving computing model for a particular community with similar issues, such as security, licensing, and governance. It uses networked alternative resources to provide the capabilities for communities to obtain cloud services. Effective collaboration between community clouds provides a strong computational capability for complicated jobs involving tasks that requires sharing of data [12].

In public clouds, provision of resources is made available to users as a service, mainly via internet, on a subscription charge (money). Users can utilize them on request without buying hardware permanently from organizations. Providers in public cloud control and manage their overall infrastructure and share resources to their users' accordingly with their demands [10]. Public cloud provides consumers with access to the cloud via various websites. Users of the cloud are only charged according to their usage and service's duration. This contributes to the reduction of the IT operating costs for individuals and organizations. Security of public cloud is less as compared with other cloud models therefore their software and applications are susceptible to various threats and therefore internal standard must be aligned with providers and users, security architectures must be updated, software maintained, and upgradation is necessary after some time. A specific strategy might be implemented to ensure security by validating the vendor and the customer from both sides. Commitment of both parties within their confines must also be well established [11]. The integration of public, private, and communal clouds forms hybrid clouds [10]. Companies of all capacities are utilizing it for cost optimizations [13]. The hybrid cloud model is the ideal solution to both the private and public world, combining public cloud model economies and efficiency with private cloud model for enhancing the security and control [14].

For utilizing all the services of cloud computing there is a need for integrating IoT with cloud technologies. Researchers are working to unite these technologies for making life easier and safer. IoT is a dynamic technology that combines various things through a communication medium for enhancing various processes of organizations. IoT is becoming a key technology for organization where massive amount of data is gathered, processed, and stored. The integration of IoT with cloud technologies will assists user in gaining virtual resources like storage system, delivery of resources, and distribution of resources. An energy-aware system is required in integrating IoT, and cloud systems as heterogeneous technologies are linked together and they produce massive amount of data that may require huge storage space and processing time. Novel IoT applications are nowadays a necessity to be developed to utilize all cloud computing services [15].

The papers will contribute to achieve the following Aims:

(i) To analyse the impact of cloud computing on organizations and society

(ii) To examine various services of cloud computing

(iii) To investigate multifeatures of cloud for motivating organization in migrating towards cloud

(iv) To evaluate cloud features using probability distribution function for enhancing the capabilities of IoT applications

2. Literature Review

Nowadays, the hybrid technologies developed for the user of global society utilize advanced computing power, low-cost embedded sensors, and analytics power to carry out their main operations. The level of connectivity between these heterogeneous devices promotes the so-called industrial revolution, which promises increased speed and efficiency. The data is transferred with the help of embedded sensor from production area to connected cloud. The data from manufacturing site is collected by means of various IoT devices, and they are analysed properly to improve the processes, to provide more services, and to enhance the efficiency of the organizations [16]. IoT provides the solution to various

problems, but their solutions are domain specific in nature as various data models and communication protocols are required to remove complexities in their processes. Researchers and scientists are working closely to implement alternative methods for application development and to provide a common interface for interaction of these hybrid devices. Moreover, such efforts culminated in many software application development tools with semiservice management processes. IoT services are frequently delivered in physically confined business units with tightly coupled software, hardware, and middleware application semantics to meet domain specific development specifications [17].

Cloud computing has been used by large organization to assist them by managing and storing IoT data received from heterogeneous devices such as cameras, computers, and sensors. There is a necessity for implementing IoT frameworks that will supply services (resource provisioning) with short response clock time and low latency in order to operate latency sensitive real-time systems such as disaster and risk management systems in smart homes. The IoT process and devices are mostly not good in achieving self-adaptability and self-configuration to work properly in environmental changes, and the performance is not decreased throughout their operation and activity [18]. Managing economic and environmental performance was a critical challenge for many enterprises. Furthermore, it is increasingly challenging for expanding globalized firms to retain acceptable provider relations in order to balance economic and environmental performance goals. Modern information technology, such as cloud computing, based on transaction cost economics, can allow companies to maintain their performance by thoroughly economizing, evaluating, and monitoring their supply chain overall wealth such as money and other assets [19]. The searching time of a data owner for accessing data from server (cloud) is high. Thus, people are using and paying additional cloud services. Another problem in the cloud environment is high overhead system. To overcome all these difficulties, "Fast" a new approach for access control was presented. A table that temporary holds information depending on the data type and status of the data owner is maintained by the cloud service provider for increasing the process of accessing and data retrieval. The cloud service provider can locate the actual owner of data quickly via the table where the information is stored. Accessing time of data is significantly decreased with the table [20].

The scheduling of tasks in cloud computing setup is playing a vital role as it enhances cloud performance. From the flourishing digital information age to the growing need for quality of service in the business setups, the task scheduling algorithms and resource scheduling challenges have motivated researchers of information technology. A revolutionary technique called the Deep Q-Lerning (DQTS) task schedule that combines the Q-Learning and deep-neural network advantages was proposed. This novel solution is designed to solve the challenge of the management of a direct acyclic graph task in cloud computing settings. The key notion of this approach is the popular Deep Q-Learning strategy in task planning, which is mainly inspired by DQL. Based on improvements in WorkflowSim, tests are carried out that take into consideration the difference in the performance and load balance in task planning. The result demonstrates that DQTS offers advantages in terms of learning ability, restraint, and scalability compared to numerous conventional algorithms preceded in WorkflowSim [21].

A new elite-based differential evolution hybrid antlion optimization algorithm was presented for the solution of multiobjective task issue planning for cloud computing environments. The MALO suggested, the multiobjective aspect of the problem, stems from the necessity to minimize making-up while at the same time maximizing the use of resources [22]. In order to increase their capacity for exploitation and avoid becoming stuck in local optimums, the antilion optimization method was strengthened by elite-based differential evolution in local research techniques. On both synthetic and actual data sets, the CloudSim Tool Kit was used to undertake two experimental series. The results show that MALO exceeded other well-known algorithms for maximization. MALO was convergent for big search spaces quicker than other algorithms, which would suit major planning difficulties. Finally, the data were examined using t-tests that demonstrated that the results were significantly surpassed by MALO [22]. Decision framework is presented to aid managers in choosing appropriate cloud solution that meets customers' needs and assessing the many economic assertions of a cloud's effectiveness. This decision framework and investigation aid managers in allocating investments and evaluating cloud options that now interact with in data centers that cached, accessed, and processed data previously, as well as cloud service capabilities from another enterprise [23].

In a multisourcing context, a mathematical decision model is designed to assist with cloud service decision. The goal was to find out which cloud computing services from various suppliers are the most suited. Cost and risks are essential to be taken into consideration for decision-making process. The three security goals of availability, integrity, and confidentiality are used to model risks. The model's operational implications are found in the model's long-term decision support and holistic decision-making strategy. Three actual scenarios are studies, and a thorough analysis was carried out using software as a tool to test and verify the proposed model [24].

Cloud service providers now provide a diverse range of services for transferring virtual applications, software, and other services, such as storage and memory, in the cloud setup. However, the availability of a diverse range of these services has made hosting of applications and services a challenging one as they require authenticable and trustable platforms to enhance efficiency of organizations and minimize cost. A utility-based decision support approach for evaluating and ranking design time prospective application deployments spanning diverse cloud services was presented. The utility model is examined utilizing MediaWiki (Wikipedia) tool, and it reveals increased efficiency for choosing cloud services when compared to alternative decision-making methodologies [25].

Decision makers rely on statistics to validate their judgments, and the prevailing prepositions is that the data are

reliable and that the decision systems will deliver the appropriate solution. It is preferable to have a situation in which the DSS gives deterministic guidance in support of a choice opportunity while evaluating the probabilistic model. Furthermore, when the data resource is unavailable, the choice should be based on a selection from potential data alternatives [26].

3. Impact of Cloud Computing on Organizations and Society

By reforming the current IT strategy for organizational growth and competing against its current counterparts, organizations modified their business model which saves their cost and operational time. Employers are moving for the rapid and dynamic working culture of the company through scalable, dynamic, and flexible IT infrastructure. Cloud computing provides important benefits for scalable, dynamic, and low-cost IT solution and high availability of services, pay-per-use, and ease of use that are beneficial for effectiveness of businesses. Because of high resources availability, larger business has high cloud adoption, whereas small and medium-sized enterprises, on the other hand, have a relatively low cloud adoption [27]. The rise of cloud computing and its money saving potential find it essential for organizations [10]. For operating complex computational tasks, cloud computing has become the leading-edge solution. It is now employed for carrying out tasks in every business process. Many organizations utilize cloud computing capabilities to provide multicontinent coverage capabilities for the provision of services such as computation, storage, hosting of application, and service level agreements [28]. Services are delivered by huge low-cost computer units connected via IP networks [29].

The adoption of one or another technology should begin by assessing the organization financial processes. IT is an integrated component of a company, or ought to be. In order to sustain or promote business processes, we require technology. The organization should investigate its operations and assess the challenges and rewards delivered to its business before it leaps into the cloud. As midsized and small organizations have fewer sophisticated operations, they should be the first sector of corporations to utilize cloud computing services [9]. Organizations adopts cloud computing when they are interested in building capacity or adding additional capabilities without spending much money, training new employees, or purchasing new software. With this technology enhancement, you can purchase any subscription or pay-per-use service virtually without having it permanently which expands IT's existing capabilities in real time over the Internet [30]. Users of cloud computing are empowered to access various cloud infrastructures on subscription basis [31].

With cloud computing, the big capital expenses in hardware are no longer required to install or manage your business for developers who have unique ideas about the new Internet services. You do not need to worry about oversubsidizing a service whose popularity does not fulfill your expectations, therefore wasting expensive resources or supplying one that becomes very popular with prospective consumers and sales [32]. The cloud systems have enabled individuals to access their information from anywhere. It has vanished the concept of physical presence of individuals near to storage system. Cloud providers can provide you the resources required to run your business or home applications virtually. This is particularly advantageous for companies that do not have the same hardware and storage capacity as a larger organization. Small businesses can save their data on the cloud to remove purchasing and storing memory equipment costs. As only the quantity of storage needed is purchased, a business can buy additional space or lower its subscription accordingly with its requirements [33].

3.1. Services Provided by Cloud Providers. The consumers utilize IT infrastructure, cloud computing, or Internet-enabled platforms to execute various applications. With the intervention of cloud, the internet-enabled platforms are integrated and made transparent to provide various services such as software, hardware, data, platforms, and network. Different type of services is provided by cloud computing including hardware as a service (Haas), software as a service (SaaS), platform as a service (PaaS), data as a service (DaaS), infrastructure as a service (IaaS), and network as a service (NaaS).

3.2. Analyzing Multifeatures for Motivating Organization in Migrating towards Cloud. Software industries, such as Microsoft, Google, and Amazon, support cloud service development. Several companies, including companies that are not technologically orientated, wish to explore the effectiveness and advantages of cloud computing. However, various research works are devoid of analyzing the necessary multifeatures for enhancing cloud-based systems. There are many aspects of cloud computing that make it hard for identifying the significant features for enhancing the capability of cloud computing. These features were analysed from various literature studies for pinpointing the reasons of organizational migration towards cloud. The details of these features are described in the subsections.

3.2.1. User Centric. When you relate to cloud, you can share and download messages, documents pictures, and applications as what is stored on the cloud becomes yours on subscription basis. Collaboration and communication with others are also provided in cloud setup. You can also utilize a device working in cloud environment on various payment schemes [34].

3.2.2. Task Centric. Task centric capability is provided by cloud to users as it focuses on what you need to achieve and how the cloud will provide you the required services [34].

3.2.3. Powerfulness. With the help of a single desktop pc, connecting hundreds or thousands of computers in the cloud generate a rich computer power. Because data is kept in the cloud, users may get additional information from various repositories immediately. As with a desktop computer, you are not restricted just to a single data source [34].

3.2.4. Intelligent. Enormous of data is stored on cloud. The cloud can use algorithm and artificial intelligence to analyze and predict things' situation in advance. They can also perform efficient decision on data [34].

3.2.5. Broad Network Access. These computer resources (hardware, software, and processor) are offered to the users of cloud on Internet, and they are used by different client apps located on a consumer site with heterogeneous devices (such mobile phones, computers, and personal digital assistant) [35].

3.2.6. Resource Pooling. Computing resources from a cloud service vendor will be 'supplied' to serve many users via the multitenancy model or the resources virtualization model that are dynamically assigned and reassigned according to consumer requirements using varied physical and virtual resources. Two key elements specialization and economies of scale have encouraged the development of such a pool-based computing paradigm. A pool-based approach results in the actual computing resources being 'invisible' to consumers who generally lack control or information about their locations, orientation, and originalities (e.g., the database, CPUs, etc.). For instance, customers are unaware about the data and its presence in the cloud [35].

3.2.7. Measured Service. Several users (i.e., multiple tenants) pool and share the computer resources, and the cloud architecture can employ adequate mechanisms and methods to measure and evaluate the use of those resources by means of measurement capability of each individual user [35].

3.2.8. Consistency. Consistency concerns how updates are distributed between duplicate copies. It is a matter of whether data elements are the same on various places. Moreover, how do individuals view things whether they see the same value or if they see different values [36]? Cloud service providers can pick a consistent level in accordance with the apps' access patterns. The most optimization efforts are therefore concentrated on providing appropriate compensation between consistency and performance [37].

3.2.9. Failure Handling. Failure handling [36] is the ability of a cloud system to react to hardware or software failures. It means that the system can operate even when faults or malfunctions occur.

3.2.10. Fault Tolerance. Fault tolerance is dynamic which results in unanticipated computing system behaviour's [34]. Cloud systems have high ratio of fault tolerance or self-healing ability [35–38]. Studies like [39] explained how to achieve fault-tolerance. Error management method is mainly important for distributed systems that are prone to failure. In case of any failure, the system must reexecute for ensuring efficiency and effectiveness. Cloud-based system must have a mechanism for identifying and tracking defects and correcting the defects without system crash.

3.2.11. Reliability. Reliability [38–40] is a key challenge in cloud computing as it is a key matric for accessing performance of a system. Reliability indicates the capacity of a cloud system or device to operate appropriately for a given time period under stated conditions.

3.2.12. Flexibility. Flexibility means that a system has the capacity to react promptly and cost effectively to potential internal or external changes that influence value supply. The rapid change in organizational setup poses various challenges for organization. Flexibility is a key factor for maintaining the overall structure of organization towards a change [41].

3.2.13. Virtualization. Virtualization utilizes software to establish a computer-based abstraction layer, which allows physical parts of a computer to be separated into several virtual machines—usually called virtual ones—into processors, storage, VMs, etc. [42]. Cloud computing helps to improve data storage and access via the Internet and the cloud. This is accomplished by virtualization. Virtualization produces a genuine hardware abstraction layer known as cloned hardware over a real hardware [43]. Due to virtualization property, cloud computing is gaining much importance [44]. Virtualization is crucial to improve efficiency and effectiveness of cloud computing [45]. Virtualization is utilized by organizations for testing and development, dynamic load balancing, and server consolidation [46].

3.2.14. Robustness. The robustness of cloud system can be increased with the increasing in fault tolerance capability of cloud. Robustness increases the availability and reliability of a system [47]. Cloud system has the ability to normally operate under unpredictable condition [48, 49].

3.2.15. Scalability. Cloud computing is a scalable and simple approach for client users to gain entree to a wide range of virtualized resources which can be automatically deployed to satisfy various requirements [50]. Scalability is the characteristics of cloud system to manage and control a vast number of resources. Scalability of hardware's [51], software's, and memory must be provided to increase the efficiency and effectiveness of various cloud processes. To deal with the competitive and unpredictable nature of shared cloud infrastructure, humans have built scaling, which is the most sophisticated, efficient, and intelligent artifact. To accommodate demand spikes and reduce downtime, apps and infrastructure must be scalable. A service can be scaled if the increasing traffic can be managed by increasing server capacity [52, 53].

3.2.16. Autonomy. Autonomy in the cloud system is a major concern. Failed services are restarted through a recovery procedure, which allows the system to return automatically to its right execution without user intervention [54, 55]. Cloud computing is an autonomous system that distributes resources automatically and enable users to connect with the cloud to carry out various operations such as designing, deploying, and operating various application and processes without the participation of cloud provider's [56]. In order to deal with efficient management of resources, autonomy of cloud providers must be achieved [57].

3.2.17. Recovery. Recovery guarantees that services work properly. The cloud system is automatically recovered if functional error occurs [55]. Mandrake is a solution for autonomous recovery without human interference from simple cloud failures [58]. Automated, efficient control, introspection, and retrieval mechanisms should be used as much as feasible in cloud systems. Automated recovery, particularly, is necessary to maintain dependability and availability in the long run since human interference is not rapid and not each circumstance can be predicted. Automated recovery can be effective for monitoring and detailed identification of accurate causes in order to prevent future failure from occurring [59].

3.2.18. Accountability. In a cloud system, accountability must be assured because resources are shared among many cloud organizations [60]. Accountability is probably a fundamental notion both in the cloud and in new methods that contribute to increasing cloud computing trust. These strategies should be used appropriately [61].

3.2.19. Assurance of Services. Assurance of services are key factors to be considered in cloud for provision of various infrastructure services [62].

3.2.20. Performance. Cloud computing provides high performance by providing high computation, storage, and infrastructure [63] services. When compared to in-house computing infrastructures, cloud computing improves performance and lowers operational expenses [64]. The performance of cloud computing can be increased by utilizing various tools such as Map Reduce, MPI, Hadoop, CAP3, Dryad, and CGL [65].

3.2.21. Efficacy. Efficacy is an ability to complete the work at the required or satisfactory level. The efficacy of work can be boosted by using cloud resources [66]. Cloud resource may be scheduled by utilizing algorithm to improve efficacy [67].

3.2.22. Upgradation. The emergence cloud technology requires the upgradation of corresponding technology to manage large users and data [68, 69]. Cloud computing helps in the online upgradation of various software's and hardware's to meet the requirements of its users [70]. Online upgradation of the software may start when a user log in to cloud system [66]. The virtual upgradation of cloud infrastructure will save money and time of users and cloud organizations in carrying out various tasks.

3.2.23. Collaboration. Collaboration is a mutual process in which two or more entities participate to accomplish a specific goal. Cloud computing focuses on team collaboration for carrying out various tasks [71]. These tasks may be related to designing, development, and implementation of various tasks and methods. Collaboration among cloud providers and users is the key influences for organization to migrate towards cloud computing [72].

3.2.24. Throughput. Cloud computing provides high throughput to various processing tasks [73]. The increased throughput is due to the multiparticipating tenants that have enormous storage space, multiprocessing speed that allocates resources to various participating entities virtually and in a dynamic manner [74–76] that speed up the execution time and increases the throughput of a system.

3.2.25. Accessibility. The ability to access and utilize an entity or a system is termed as accessibility. The concept focuses on enabling access to people, to utilize various resources provided by provider's organizations. Cloud computing provides accessibility [77, 78] to data [62] and distribution of resources via computer networks [79].

3.2.26. Serviceability. Serviceability means providing various services to user such as installing application, configuring devices, and monitoring various systems and products for technical support personnel, identify hardware and software failures, debugging or identification of faults for root causes assessments, analysis, evaluations, and provision of hardware or software and their maintenance to resolve problems and restore the product into service [80]. In self-serviceability, users are provided with the resources like storage, memory, processor, according to their needs on a subscription basis. These resources are allocated to users by providers virtually in a dynamic manner [48, 81].

3.2.27. Real-Time. Cloud computing is a scalable and real-time service provision model. The computing resources supplied by cloud providers to various entities are real-time and can be rescheduled on demand [82], enabling real-time provisions of services, products, and software solutions over the communication link (Internet) [83, 84].

3.2.28. Connectivity. Cloud computing's emergence and booming is having an unprecedented impact both on the conventional enterprise connectivity market and on IT architecture and on the computing setup of enterprises [85]. The connectivity of IoT devices and cloud technologies will enhance processing power of various processes, and their integration may create novel methods for sharing resources in cloud computing ecosystem [86]. Cloud computing provides a virtualized connectivity for people and organizations [87] [88].

3.2.29. Concurrency. For improving efficiency, concurrent cloud processes are carried out [89]. With concurrent processes, the data may be accessed or retrieved for various databases in less time [90], and as multiple threads of a process are created [91], it will enhance the efficiency of overall processing of a system.

3.2.30. Rapid Elasticity. To meet the interests of end users, computer resources are not permanently allocated, but they are immediately allocated on demand, i.e., there is no direct commitment between users, and no signed contract with providing organization. Resources may properly be scaled to be used and they must be released as soon as their need is accomplished. In addition, the resource provision appears to be infinite as consumption can increase with the passage of time to satisfy the highest requirements of users at any specific time [35].

Table 1: Evaluating feature relevancy.

Features	[34]	[35]	[36]	[111]	[38]	[41]	[42]	[47]	[51]	[56]	[55]	[60]	[62]	[63]	[66]	[69]	[72]	[73]	[78]	[80]	[82]	[86]	[89]	[95]
User centric	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓
Task centric	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✓	✗	✓	✓	✗	✓	✗
Powerfulness	✓	✗	✗	✗	✓	✓	✗	✗	✗	✓	✗	✓	✗	✗	✓	✗	✓	✗	✗	✓	✗	✗	✗	✓
Intelligent	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Broad network	✗	✓	✓	✗	✓	✗	✓	✗	✗	✓	✗	✗	✓	✗	✗	✓	✗	✓	✓	✓	✗	✗	✗	✗
Resources	✓	✓	✓	✗	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓
Measurement	✗	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗
Consistency	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗
Failure control	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
Fault tolerance	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Reliability	✓	✓	✓	✗	✓	✓	✗	✓	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗
Flexibility	✓	✓	✓	✓	✗	✓	✗	✗	✓	✗	✗	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✗	✗
Virtualization	✓	✓	✗	✗	✓	✗	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓	✗	✗
Robustness	✗	✗	✓	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✗	✗
Scalability	✗	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗
Autonomy	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Recovery	✗	✗	✓	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗
Accountability	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗
Assurance	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✗	✗	✗
Performance	✓	✓	✓	✗	✓	✓	✓	✗	✓	✗	✗	✓	✗	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✗
Efficacy	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
Upgradation	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✓	✗	✗	✗	✗
Collaboration	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗
Throughput	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	✗	✗
Accessibility	✗	✓	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗
Serviceability	✗	✓	✗	✗	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✗	✗
Real-time	✓	✓	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗
Connectivity	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓	✓	✓	✓	✗
Concurrency	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗
Elasticity	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✗	✓	✓	✗	✗
Resource management	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓
Cost reduction	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓

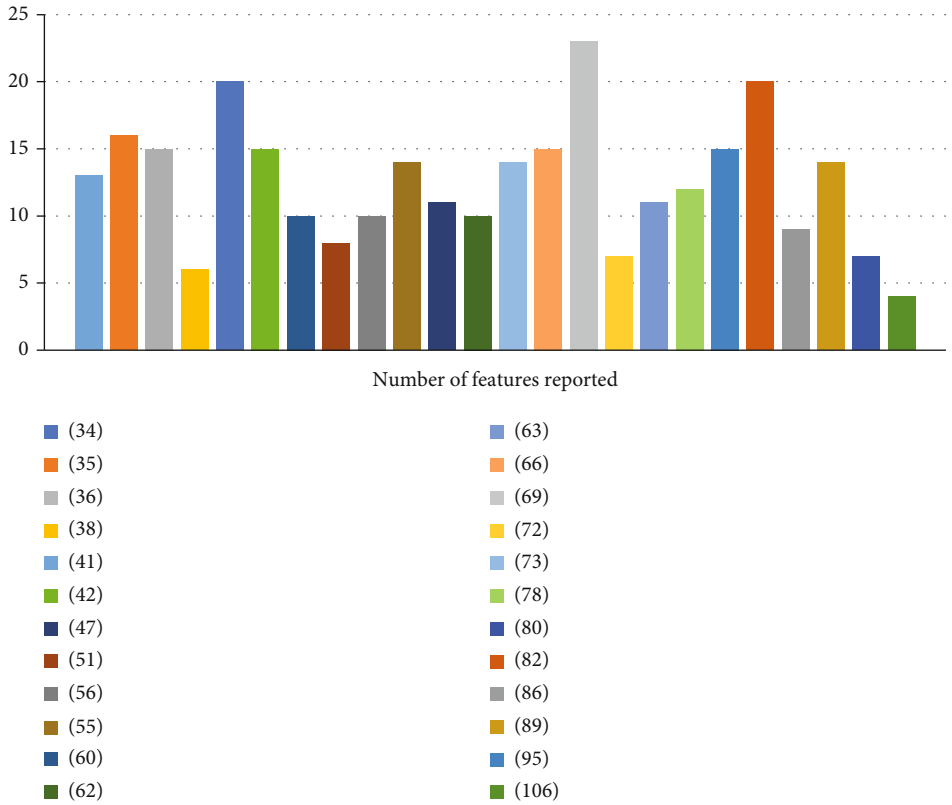

Figure 1: Evaluation of features based on selected article.

3.2.31. Resource Management. Cloud computing offers various services to users from a resources pool. These resources include various cloud infrastructure, software, and applications [92]. Users can be released from burden of data storage and maintenance by utilizing virtual resources [93]. Cloud computing facilitates the decentralization of the data in many configurable resources [94]. Multitudes of resources are available on cloud that can be utilized accordingly with the requirement [95]. Resources are pooled and dynamically assigned to users according to their demands [96–98]. Maximization of profit is achieved by the optimum resource usage [99], and it can also increase the performance of organization [100].

3.2.32. Cost Reduction. Cost reduction is as a major cloud feature [101]. The cost of tasks is minimized as users have not to buy things permanently but for time being whenever required.

4. Experimental Setup and Results

To tackle global competitiveness challenges, companies are continuously struggling to select relevant features. The decisions become more complex as the decision-makers in the cloud environment setup have to analyse a broad variety of appropriate features based on competing criteria. Various multidecision making approaches are now available in order to support these selection procedures. Probability-based distribution function was utilized for selecting features based on their occurrence in relevant research articles. Multiattribute is optimized based on specific constraints [102]. Probability distribution is a function that represents the possibility occurrence of a specific value in an experiment [103].

4.1. Feature Selection. Selection of appropriate features is commonly employed in machine learning to tackle complex problems. Inserting several attributes into the feature model increases the calculation and raises the dilemma of severe dimensionality. By selecting the most relevant feature, a massive and complex data set is minimized [104]. While dealing with a gigantic amount of data, it is more difficult for decision maker to make an optimum decision. The capability of decision making can be improved by using decision support system [105] and features selection techniques. The precision of existing feature set is not affected [106]. When handling a manipulated set of features, specification of procedures that select appropriate features is necessary. FS is compulsory is extensively demanded when dealing with contemporary situations like inadequate or chaotic features. Selection of features is regressively used in diverse areas such as image processing [107], identification patterns [108], text classification [109, 110], and data mining [104]. Features are mostly selected to reduce simulation time, boost prediction, performance and extract enriched information that are hidden in available set of data. Resultantly, the accurate feature may promise for achieving high identification and recognition results.

Based on the data replicated in Table 1, the statistical analysis is performed to extract the most suitable feature that can be used for the performance evaluation of cloud computing.

Table 2: Statistical analysis of features using different mathematical evaluation techniques.

Features	Frequency	Probability $P(x)$	Features occurred in a paper (x)	Mean $= x * P(x)$	$(x-m)^2 * p(x)$
User centric	13	0.040625	13	0.528125	0.070316559
Task centric	7	0.021875	16	0.35	0.407413544
Powerfulness	9	0.028125	15	0.421875	0.309188507
Intelligent	1	0.003125	6	0.01875	0.100975372
Broad network access	10	0.03125	20	0.625	2.160925598
Resource pooling	18	0.05625	15	0.84375	0.618377014
Measured service	10	0.03125	10	0.3125	0.088659973
Consistency	3	0.009375	8	0.075	0.127262054
Failure handling	5	0.015625	10	0.15625	0.044329987
Fault tolerance	6	0.01875	14	0.2625	0.100539734
Reliability	14	0.04375	11	0.48125	0.02049115
Flexibility	14	0.04375	10	0.4375	0.124123962
Virtualization	13	0.040625	14	0.56875	0.21783609
Robustness	6	0.01875	15	0.28125	0.206125671
Scalability	2	0.00625	7	0.04375	0.137146057
Autonomy	6	0.01875	11	0.20625	0.008781921
Automated recovery	3	0.009375	12	0.1125	0.000933929
Accountability	11	0.034375	15	0.515625	0.377897064
Assurance of services	14	0.04375	20	0.875	3.025295837
Performance	1	0.003125	9	0.028125	0.022518341
Efficacy	3	0.009375	14	0.13125	0.050269867
Upgradation	9	0.028125	7	0.196875	0.617157257
Collaboration	4	0.0125	4	0.05	0.738120239
Throughput	9	0.028125	12	0.3375	0.002801788
Accessibility	16	0.05	15	0.75	0.549668457
Serviceability	10	0.03125	20	0.625	2.160925598
Real-time	8	0.025	9	0.225	0.180146729
Connectivity	4	0.0125	14	0.175	0.067026489
Concurrency	15	0.046875	7	0.328125	1.028595428
Rapid elasticity	20	0.0625	4	0.25	3.690601196
Resource management	19	0.059375	2	0.11875	5.568610199
Cost reduction	19	0.059375	1	0.059375	6.77800473

These features are analysed from various research articles, and a statistical method is applied to check their probability in these articles.

The various features are analysed during the studies from relevant research articles. These articles are evaluated using probability and distribution functions based on their occurrence in certain selected article occurrences, the higher bar value in a chart represents the most suitable articles based on analysed features. Figure 1 represents the evaluation of features in different studies.

4.2. To Evaluate Cloud Features Using Probability Distribution Function for Enhancing the Capabilities of IoT Applications. Probability distribution function is followed for assigning weighting criteria to every individual feature based on the occurrence and its applicability and importance in certain research articles. Following are the selected weighting criteria. The prime objective of this probability distribution function in this research work is to tag the most frequently used feature in the domain of cloud development. In our case elasticity, cost reduction, resource management, resource pooling, accessibility, reliability, and flexibility are the most frequently used performance metrics (features) for the validation and applicability testing purposes. After evaluating the relevant research articles, the statistical approach comprised of means, probability, and standard deviation is used, as depicted in equations (1), (3), and (5).

To calculate the chance of occurrence for a certain event is termed as probability. It can be represented by $P(X)$ where "X" represents the event, while "P" represents the chance of occurrence. It can be mathematically represented by

$$P(X) = \frac{Number\ \text{of}\ favourable\ outcome}{Total\ Number\ \text{of}\ favourable\ outcomes}, \quad (1)$$

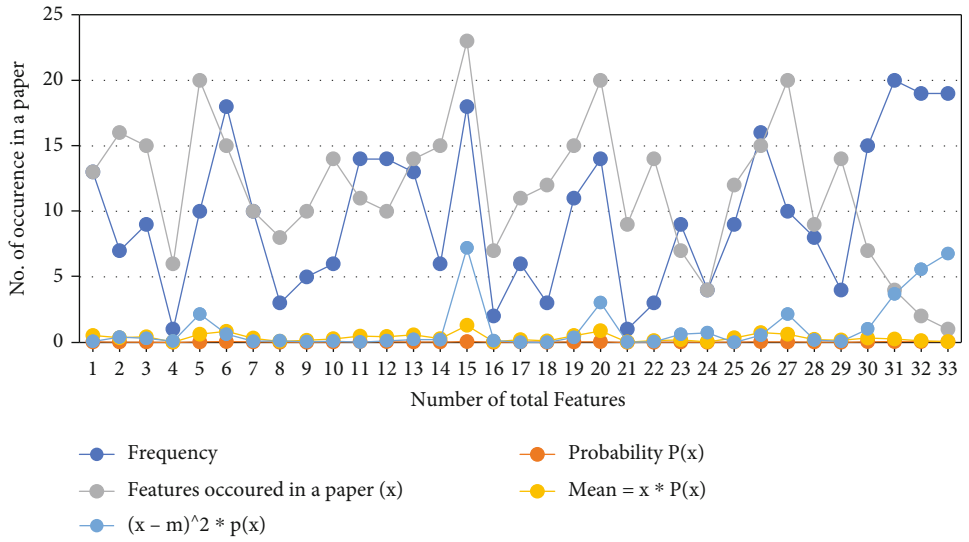

Figure 2: Performance evaluation of different cloud computing-based features using statistical analysis.

or

$$P(X) = \frac{n(X)}{n(S)}, \tag{2}$$

where $n(X)$ represents the number of favourable outcomes, and $n(S)$ represents the total number of events.

The mean can be defined as the average or central calculated value of a well-defined set of numbers and can be used for calculating the central propensity of data. Central propensity is the measure which distinguishes the complete set of data or distribution over a single value. It represents the precise description of entire data. Mean can be represented by

$$Means = \frac{Sum\ of\ All\ data\ Points}{Number\ of\ data\ Points}, \tag{3}$$

or

$$\mu = x \times P(x), \tag{4}$$

where μ represents the means for the number of occurrence, and x represents number of samples.

The degree of deviation of the data points with respect to its average points (mean) is known as the standard deviation. It can be represented as

$$\sigma = (x - \mu)^2 \times P(x), \tag{5}$$

where σ represents the standard deviation.

Based on this statistical analysis, the features are evaluated based on their occurrence in most relevant studies. The higher the probability of the feature, the higher is their significant to cloud providers. The underlined result is depicted in Table 2.

Figure 2 represents the probability of the features based on the number of occurrences in the most relevant research articles. The high probability depicts the list of the most relevant and suitable feature that can be selected for the evaluation in the proposed research domain.

5. Conclusions and Future Suggestions

Cloud computing is predicted to revolution IT services. Cloud computing converges the IT efficiency where computation power is efficiently used by scaling of hardware and software among users and business agility where IT works as a tool for deployment, processing, business analytics, and interaction by means of cell phone works in timely manner to achieve the requirements of users. With providing incredible opportunities for enhancing business processes, organizations wish to invest in cloud-related technologies [112]. Identifying and implementing a technical and complicated approaches such as cloud computing is not simple, and it requires analyzing its key aspects. With the abrupt technological changes, decision making is becoming crucial due to large contradicting features available in domain of cloud computing. In this research study, probability distribution function is utilized for assigning weighting criteria to feature based on their occurrence and applicability. The prime objective of the probability distribution function is to elicit the most frequently used feature in the domain of cloud development. Features are mostly selected to reduce simulation time, boost prediction, performance and extract enriched information that are hidden in available set of data. Resultantly, the accurate feature may promise for achieving high identification and recognition results. Organizations, such as Pinterest, Vivino, Kroger, game loft, eBay, PayPal, and Google, are using the services of cloud providers to provide their customer ease and comfort in their life activities.

Data Availability

Data is available and included in the paper.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Acknowledgments

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