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Mobility Computing Based on Cloud Computing: A Survey

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Abstract: A new era in computing has begun with mobility on cloud computing, where users of the cloud are drawn to a variety of services via the internet. Mobility on cloud computing has an innovative, adaptable, and economical platform for service delivery that makes advantages of the internet to offer services to users of mobile service cloud. Mobility on cloud computing, a process that eliminates obstacles to the performance of mobile devices, integrates in concept of cloud computing into a wireless networking device environment. This paper provides a comprehensive survey in the architecture of mobility on cloud-based computing, types and models of mobility on cloud computing and discuss some problems and their solutions. The research also examines the new trends and issues in mobile cloud computing and analyzes the relevant research on the mobility in cloud computing environment.

Keywords: Cloud Computing; Mobility; Multi-tenancy; Authentication; Authorization; Accounting; Security; Cloud Computing Models.

1. Introduction

Due to advancements in Internet computing and customer applications, several application models have seen fast growth over the past few years, including cloud computing, societal networks, and online shops. Since 2007, research on cloud computing, which has emerged as a highlighted application modeling in the age of Internet, has gained attention from the scientific and corporate worlds. A collection of operations made accessible through a Web cluster system is a typical definition of cloud computing. These low-cost cluster systems are made up of several workstations or Computers that arrange their resources as per to a predetermined managerial plan that facilitate customers with safe end, dependable, quick, easy, and transparent data storing, accessing, and computing capabilities [1]. The ability of users to access cloud resources from any location, at any time, and using any device is referred to as mobility in cloud computing. In today's fast-paced corporate climate, where employees must be able to work from remote places and engage with coworkers in real-time, this feature has grown in importance. Additionally, the widespread use of mobile devices like smartphones and tablets has ushered in a new era of cloud computing where users now anticipate having access to their data and applications [2]. Mobility computing enables mobile clients to access resources effectively, efficiently, and affordably, making services continually accessible over the internet [3] [4] [5]. By allowing data processing in the cloud to make up for the constrained computational capability of portable devices, it solves the inefficiencies of mobility computing and promotes ubiquitous computing, longer battery life, and greater storage capacity [6].

As mobile technology has developed and become more sophisticated, combining cloud and portable computing technologies may result in improvements of mobility for users. As demonstrated by Google's Gmail for mobile, the cloud expertise on mobility computing creates a friendlier experience in mobile advertising, mobile amusement, mapping, and credible data storage and accessed on the mobile network [7]. Additionally, by utilizing the internet connection provided by their telecommunications providers,

rural communities now have access to mobile services (such as m - learning, ecommerce, healthcare, and enjoyment) on their phones [8].

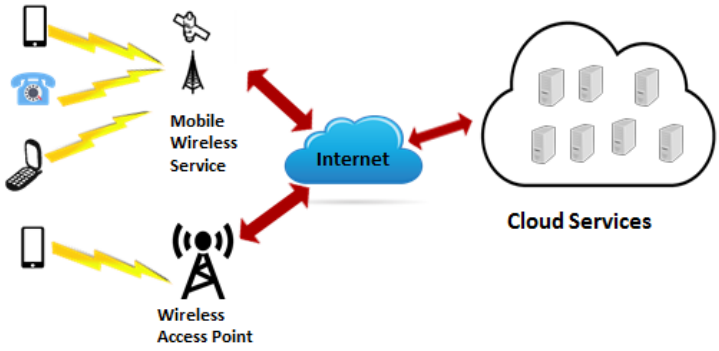

Figure 1. Mobility interact with Cloud Computing.

It is a sort of human-computer interface where a computer is planned to be carried during everyday use [9]. As seen in Fig. 1, the foundation of mobility computing is a combination of three core concepts: connection, application, and infrastructure may be thought of as transportable components of portable electronics like different types of computers. The software of mobile computing consists of various smartphone apps on gadgets, such as the mobile browser, antivirus software, and games. The infrastructure, protocols, and data delivery used by mobile networks are all part of the communication problem. They must be clear to customers [10]. Cloud computing, a game-changing technology that provides scalable and on-demand access to a sizable pool of computer resources over the internet, is at the core of mobility computing. Mobile devices can take advantage of the significant processing power and data storage capacity of cloud servers by shifting resource-intensive tasks and data storage to the cloud. Users can now take advantage of sophisticated applications and services that were previously out of their reach due to their constrained resources thanks to the symbiotic link between mobile devices and the cloud [11].

Implementing cloud-based services in a mobile environment presents several challenges. Due to the inherent limitations of wireless devices, complex applications may not function properly. Additionally, the need for offline functionality must be addressed, as mobile devices cannot always maintain an internet connection. The development of Mobility on Cloud Computing is further complicated by the absence of standards, security and privacy concerns, and the need for adaptable mobile applications. Understanding these challenges is essential for identifying research opportunities and advancing the field [12].

1.1. Features of Mobility on Cloud Computing

- Flexibility

The simplicity with which a gadget can be moved between multiple environments or within a learning environment.

- Cost Friendly and Flexible

Mobile cloud applications are easy to develop and update thanks to cloud services. Additionally, Mobile cloud computing supports a wide range of tools and development techniques. Mobile cloud computing can be utilized regardless of the cloud platform you choose.

- Interconnection: The capacity to connect remotely to communicate data in any situation.
- Variety of network circumstances

Objects typically use a range of networks, including wired ones with fast broadband, wireless WWANs with low capacity, and even unconnected ones. [1].

- Shared Resources and Storage

Mobile clouds require fewer, easier-to-manage resources to operate. Because they are cloud-based, mobile apps that run in the cloud need less device resources. For instance, procedures that require huge data might be performed in cloud computing. Therefore, mobile apps are not limited by the amount of storage or processing power on a smartphone. Because most of the processing is done be the cloud, battery usage is reduced [13].

- Multi-tenancy

Multi-tenancy is the process of sharing resources to accommodate a range of apps and many users.

- Dynamic provisioning: The resources can be added on demand dynamically instead of advance reservation.
- Ease of Integration

When there is a need, the Internet and cloud can mix numerous services from various sources and deliver them to users. Distributed and integrated computer capabilities are provided by the cloud architecture. The solution makes it simple to combine cross-domain capabilities for reliable, on demand, energy-efficient, and flexible access to the infrastructure of developing virtualization technology [14].

- Anytime, Anywhere Access

With mobility, users can access cloud resources from anywhere, at any time, using any device, if they have an internet connection. This feature provides flexibility and enables employees to work remotely, improving productivity and efficiency [15].

- Device Independence

Without the need for specialized hardware or software, mobile cloud computing enables users to access their data and applications from any device, including smartphones, tablets, laptops, and desktops. Table 1 shows the key distinctions between mobile cloud computing and cloud computing in different networks [16].

Table 1. Difference between Cloud Computing and Mobile Cloud Computing

Cloud Computing (CC)	Mobile Cloud Computing (MCC)
It refers to the delivery of computing services over the internet, including storage, processing, and networking.	It refers to the delivery of cloud computing services to mobile devices, such as smartphones and tablets.
Can be accessed from any internet-connected device, including a desktop or laptop.	Can be accessed from mobile devices, such as “smartphones and tablets”, as well as from desktop computers and laptops.
Typically provides higher computing power, storage, and network capabilities than mobile devices.	Must consider the constrained capabilities and processing power of mobile devices.
Can support more complex applications and workloads, such as big data analytics and machine learning.	Due to the constrained resources of mobile devices, must offer lightweight applications and data processing.
Typically involves centralized data storage and processing in data centers.	Must be able to handle distributed data storage and processing across mobile devices and cloud resources.

1.2. Benefits of Mobility in Cloud Computing

Several benefits of Mobility in Cloud Computing are as follows:

- Enhanced flexibility

Users can access cloud services and data via a range of mobile devices at any time and from any location thanks to cloud computing mobility. Now that employees can work from home or while travelling, productivity can increase, and expenses associated with traditional office settings can decrease [17].

- Scalability

Cloud computing's mobility enables organizations to scale their infrastructure up or down as necessary without having to buy new hardware or software. Increased agility and large cost reductions are possible outcomes of this.

- Improved collaboration

Regardless of their location or device, employees can collaborate in real-time thanks to mobility in cloud computing. This can promote innovation and team productivity.

- Real-time data accessibility

Cloud computing's mobility enables users to gain access to real-time data and analytics from any location at any time. Organizations may be able to make better decisions and react to shifting market conditions as a result [18].

- Reduced IT expenditure

Cloud computing's support for mobility can assist reduce IT costs by avoiding the need for costly hardware and software upgrades as well as internal IT workers.

- Improved customer service

Client service is improved due to mobility in cloud computing, which gives staff members access to client information and real-time responses to queries regardless of their location or device.

The paper is structured as follows. Section 2 provides an overview of cloud computing and its significance in facilitating mobile computing. Section 3 delves into the architecture of mobility within cloud computing. Section 4 reviews existing research on mobile cloud computing. Section 5 examines the security and privacy issues associated with mobility in cloud computing. Section 6 addresses the implications and suggests potential solutions for mobility in cloud computing. Section 7 summarizing the main findings and suggesting future research and development directions in this domain.

2. Background Study

It is possible to think of Mobility on Cloud Computing as an infrastructure that opens new possibilities for applications allowing data storage and retrieval to occur away from a smart phone, like location-aware mobile social networks. Because of this, a larger subscriber base may access different mobile cloud applications, which are accessible on several less sophisticated mobile devices in addition to powerful smartphones [19].

Mobility on Cloud Computing is divided into two main subcategories: Cloud-based-Computing and Mobile-based-Computing. Mobile devices include things like desktops, Tablet pcs, smartphones, and other portable electronics that connect to an access point over a wireless link [20]. Even though the client has migrated from personnel computer or other stands for equipment to mobile devices, cloud computing is still the core concept. Smartphone users can use a search engine or desktop application to send requests to the cloud. The QoS is ensured up until the connection is complete using Mobility on Cloud Computing monitoring and computation features. Resources are then distributed to the request to create connection by the cloud's management component. The NIST definition of the cloud model calls for availability and comprises three Models, four Types [20].

2.1. Types of Cloud Models

- Software as a Service (SAAS)

Utilizing apps from the provider that are stored on a cloud infrastructure is an option for the customer. A variety of client devices can access the apps using a client interface, which is like a web browser [21].

- Platform as a Service (PAAS)

The customer can upload software they have created themselves or bought to the cloud infrastructure using the development resources and tools given by the provider. The parameters of the application hosting environment and perhaps the installed programs are controllable by the user, but the network, servers, operating systems, and storage that make up the cloud infrastructure are not [22].

- Infrastructure as a Service (IAAS)

Users have the option to configure processing, storage, connectivity, and other critical computing infrastructure to support the deployment and operation of various software, including operating systems and applications. While they cannot manage or control the underlying cloud infrastructure, they do have limited control over certain network components, operating systems, storage devices, and installed applications [23].

2.2. Cloud Deployment Models

- Private Cloud

The organization is the single user of the cloud infrastructure. It might be located on- or off-site and operated by the organization or related parties [24].

- Public Cloud

This type is owned by a business that provides cloud services and is accessible to the masses or a sizable industry association [25].

- Community Cloud

This kind of cloud architecture supports a specific community with connected challenges and is shared by many organizations. It may be controlled by the companies or related parties and may be present on or off-site [26].

- Hybrid Cloud

To allow for the mobility of data and applications, the cloud resources are comprised of two or even more clouds (personal, communal, or public), each of which is separate but connected by industry-standard or proprietary technologies [27].

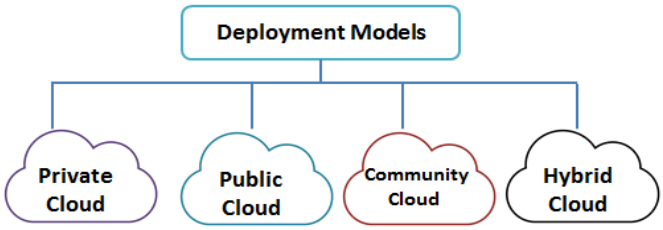

Figure 2. Deployment models of mobility on cloud computing.

3. Architecture of Mobility on Cloud Computing

Base stations that establish and maintain connections and cause operational disruption between mobility computing link mobile or wireless phones. The centralized microprocessor linked to the servers delivering mobile network services receives requests and information from mobile users. The queries from the subscribers are subsequently sent to a cloud by using the Internet. Controllers of a cloud manage user requests and connect users to the appropriate cloud providers. Several technologies were developed utilizing the principles of hypervisor, computation, and provider structure [28]. Cloud computing varies in complexity according to the situation. A more general description of universal architecture can be seen in Fig 3.

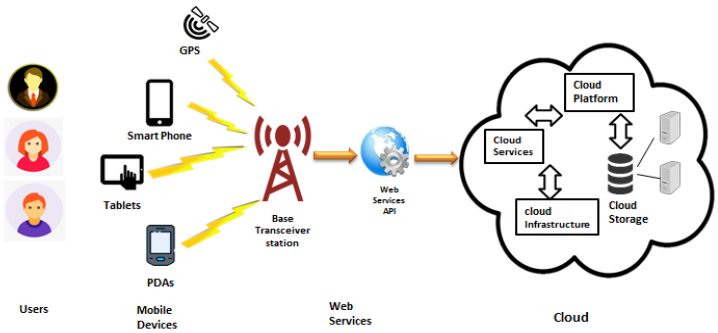

Figure 3. Architecture of Mobility on Cloud Computing Source: Adopted from [29]

In this study, it defines it as a cutting-edge computing architecture that merges digital and mobile computing based on the cloud to provide users with cloud-based services across online and mobile platforms. Mobility on the cloud has the potential to expand both cloud hosting and smartphone use [28]. The development, management, deployment, and utilization of mobile apps have all experienced significant changes because of the shift from smart phone intensive computation, storage systems, and mass processing information to the "cloud." As a result, there is less of a need for mobile devices to have more resources and computational capacity. The benefits and primary goal of cloud technology are demonstrated by the fact that the terminals used to browse and purchase web services are suited for devices such as smartphones, Blackberries, Tablets, and iPhones and are not restricted to predetermined objectives. Mobility on cloud computing is a development of decentralized, matrix, and hierarchical techniques with a wide variety of possible applications [30].

Mapping of both computing is illustrated in Figure 4. Computers, PDAs, telephones, and other gadgets that can connect to a hotspot or base station network resources are considered mobile devices. Due

to the relocation of computing and essential computational tasks to the "cloud," even reduced portable media players and non-smartphones can achieve mobility through virtualization [31].

Even though PCs are now the clients in cloud computing and mobility, Cloud computing is still the main concept. The Quality of service is subsequently maintained using the mobility-based cloud computing features up until the connection is complete. The management part of the cloud allocates resources for the connection request. Web browsers or desktop programs are used by mobile users to submit service requests to the cloud.

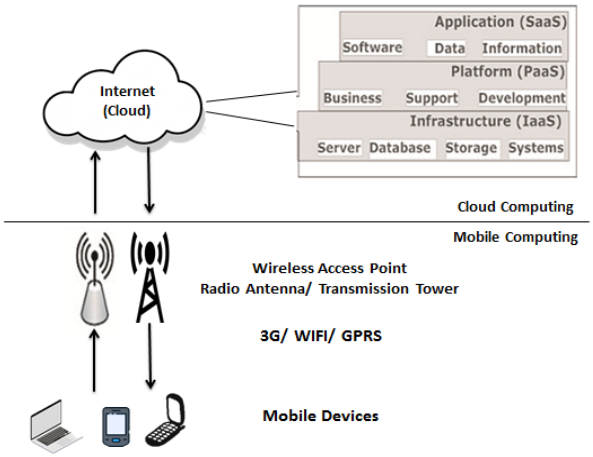

Figure 4. Mapping of Mobility and Cloud Computing: Source: [32]

4. Related Work

Industrial and scientific groups have up to this point conducted a variety of studies to address the difficulties. The following is a collection of common research situations and projects: According to the paper [33], CC has emerged as a progeny of several other technology-related fields, including service-oriented architecture, grid and distributed computing, and virtualization. It has also inherited its developments and restrictions, as well as some of each of these technologies' benefits and drawbacks [34]. In that it offered a greater advantage over the currently underutilized resources at computing facilities and data centers, they pitched Cloud Computing as a new paradigm.

The Clone Cloud was first introduced by B. Chun [35] in 2011. To fully or partially automate the extension or modification of the mobile phone execution to a distributed environment, the main strategy entails offloading portions of a program's execution from mobile devices to Clone Cloud by virtual machine migration techniques. Clone Cloud enhances mobile applications by moving some of the server workload from mobile devices to clone's devices. It is designed to serve as a platform for mobile device services. This service worked well for mobile processing on common devices. In a Clone Cloud system, a smartphone acting as a virtual machine's mirror image is the "Clone" (see Figure. 5). The system uses the cloud, the best network connection available, application-calculated patterns, and mobile devices to transform a single execution from a mobile device into distributed execution.

By modeling applications as a consumption graph and selecting the appropriate modules, AlfredO [36] is a platform provider that dynamically distributes numerous application tiers in smartphones and the cloud, respectively. The test's outcomes demonstrate how well this platform works to increase the performance of cloud computing applications. The AlfredO system is made up of three bundles: AlfredO Client, Rendering Engine, and AlfredO Core on the client and server, respectively (shown in Figure. 6).

Before transmitting the application description and services list to the client, Alfredo core models the requested application and chooses the appropriate implementation. The Energy-optimal application execution on the cloud-assisted mobile platform has been proposed by Y. Wan et al. in [37].

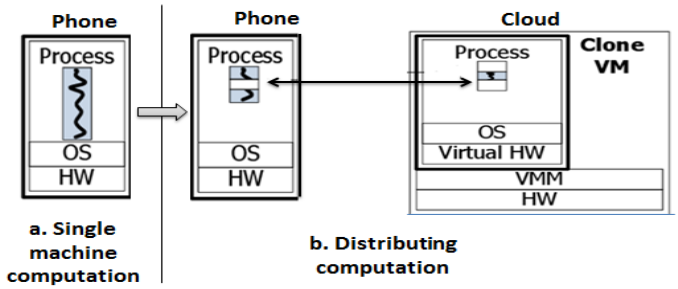

Figure 5. Cloud Clone System Architecture. Source: Adopted from [35]

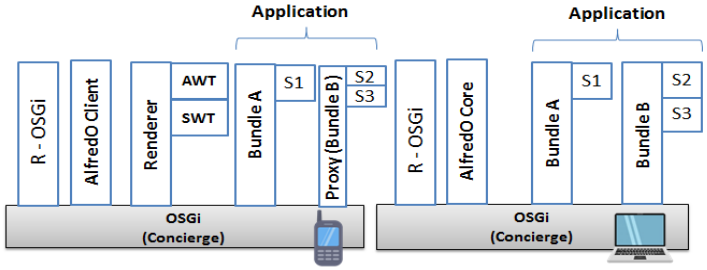

Figure 6. AlfredO System Architecture.

The goal was to reduce the mobile device's overall energy usage. By carefully configuring the device's sample rate, the amount of processing resources needed to run the programs on the mobile device may be reduced to a minimum. By carefully configuring the transmission data rate while using a stochastic wireless channel, the transmission energy when the applications are operating in the cloud clone may be reduced.

The numerical results demonstrate that the primary drivers of the optimum policy are the mobile communication mode and application profile, notably the volume of input data and the deadline. Ma et al. [38] published a survey-based paper on applications of location sensing technologies that take mobility on cloud computing environment's energy efficiency into consideration. Kosta et al. [39] have published a survey on the use of mobility on cloud computing across a range of industries, including social media, education, business, and healthcare. Then, open research questions that address the characteristic aspect of mobility on cloud computing are addressed. The application and security challenges, however, are not considered when designing the architecture. Mobility on cloud computing survey has been recommended based on offloading choices. Mobile cloud architecture is shown, which consists of cloud computing entities, network connection devices, and user mobile devices. Offloading-decision-affecting-mobility on cloud computing -modules are also emphasized. Application models are also examined depending on their parameter settings. The direction of future research is also mentioned.

The Cui et al [40] proposed a perspective on research projects that considers the general paradigm for estimating energy usage for mobility on cloud computing devices. Future research directions are also highlighted. However, mobility on cloud computing problems is not only energy-related; other problems like heterogeneity and application QoS have not been considered. It offloading mobility on cloud computing task research that took energy efficiency into account has been discussed in [41]. Handheld Big Data Stream Processing is suggested. Analysis is done on the BDSMC's energy efficiency. Then, future ways for research are presented.

The author provided work [42] of a thorough overview of mobility on cloud computing research, identifying problems and providing literature-based remedies. Additionally, [43] conducted research on mobility on cloud computing, outlining its design, applications, techniques, problems, and difficulties. This study differs from the others mentioned above in that it is a comprehensive survey and the articles used in the research were chosen using a rational, controlled, logical, and unbiased procedure. Additionally, it was created to address research goals and questions, in contrast to earlier evaluations.

A thorough overview of the security needs for cloud computing is provided by the research of [44]. The major focus of this work is the development of the nine prerequisites, remote access, non-repudiation, security assessment, assault or harm discovery, restoration and punishment, physical defense, and

confidentiality earlier works. This article focuses on the security concerns for cloud computing rather than the mobility of cloud computing. The S. Jeong [45] offered a revolutionary elastic application approach that enables the extension and resolution of mobile device limitations through the seamless and transparent utilization of the cloud. This paradigm allows for the division of a single application into several Weblet components, which are then dynamically deployed during execution at cloud and mobile terminals in accordance with a configuration strategy.

5. Security and Privacy to Mobility in Cloud Computing

According to the above study, it is seen that Mobility in cloud computing raises important security and privacy issues. When cloud resources are accessible online, they may be vulnerable to security risks such virus assaults, data breaches, and hacking. Furthermore, mobility in cloud computing frequently entails the use of individual mobile devices, which are not always secure and could be attacked. To prevent unwanted access and theft of their cloud resources and data, enterprises must employ strong security procedures [46]. Some of the security techniques that can assist protect cloud resources from security risks include firewalls, encryption, and multi-factor authentication [47]. Since personal data is frequently kept on cloud servers, privacy issues are also very important in addition to security issues. When gathering, processing, and storing personal data in the cloud, it is crucial to make sure that privacy laws and regulations are followed. For organizations to use cloud computing in an informed manner, both the benefits and drawbacks of mobility must be properly considered. The ability to access cloud resources from any location and on a variety of devices gives customers greater flexibility and scalability to adapt to changing business needs. This is one of the key benefits of mobility in cloud computing. By removing the need for pricey gear and software, it also aids in cutting IT expenditures [48].

Users may collaborate more readily thanks to mobility in cloud computing, which boosts output and effectiveness. However, there are some drawbacks to mobility in cloud computing, including security issues that necessitate strong security measures, connectivity problems that can cause service interruptions, and a reliance on internet connectivity that can result in downtime and service disruptions.

Table 2. Shows some Benefits and drawbacks of Mobility in Cloud Computing [49]

Cloud Computing (CC)	Mobile Cloud Computing (MCC)
Flexibility and Scalability	Connectivity Issues
Cost-Effective	Security Concerns
Increased Collaboration	Data Loss or Corruption
Improved Productivity and Efficiency	Dependency on Internet Connectivity
Greater Accessibility	Limited Control Over Cloud Resources
Real-Time Data Access and Analytics	Dependence on Cloud Service Providers
Reduced IT Overhead Costs	Compatibility Issues with Legacy Systems

6. Implications and Possible proposed Solutions in Mobility on Cloud Computing

a. Limited battery capacity and increase in consumer demand

As processors get faster, displays get sharper, and devices get more sensors, a device's ability to use energy significantly exceeds that of the battery. As a result, the battery life of mobile devices continues to place major limitations on the design of mobile applications. The demand from users for resource-intensive apps is rising every day. Examples include video games, streaming video and mobile devices with sensors that continuously provide streams of data about the user's surroundings [50].

Solution**:** Numerous methods have been proposed to increase CPU utilization [51] and best utilize existing resources to cut back on power usage. Unfortunately, these options call for new technology or alterations to the way smart phones are made, which requires more engineering and elevates the cost relative to standard devices. Computation offloading techniques keep mobile devices from needing a lengthy execution time by shifting large calculations and complex processing from devices with limited resources

to devices with plenty of resources. Several trials have been conducted to evaluate the effectiveness of offloading tactics.

b. Security

Today's mobile devices are fully functional equivalents to desktop computers. This presents a security risk to mobile devices just like it does for traditional computers. To reduce these security concerns, threat detection techniques that operate on portable apps must use a lot of computation and power [52].

Solution: Moving these monitoring services to the cloud could be a solution. It minimizes the device's need for CPU and memory at the expense of extra bandwidth. The advantages of this approach are as follows:

- Improved harmful malware detection.
- Reduced use of device resources
- Simpler on-device software environment

c. Limitations of mobile devices

Smartphones have undoubtedly made advancements in several areas, including memory and CPU performance, memory, screen resolution and operating systems, but they still have significant flaws that make it challenging to implement sophisticated apps. These downsides include a lack of energy and computational resources [53]. These smartphones, including the iPhone 4S, Android, and Windows Mobile models, all have processing speeds that are three times slower, memory speeds that are eight times slower, storage speeds that are between five and ten times slower, and network speeds that are ten times slower than PCs and laptops in each scenario [57] [58].

Typically, a smartphone must be charged every day to use its dialing, messaging, internet browsing, community access, and other online apps. According to past development trends, the rapid advancement of screen technology and enhanced mobile computing capability will result in the deployment of increasingly complex apps in smartphones. One of the most important problems we currently face is how to efficiently conserve battery life in a smartphone if battery technology cannot be quickly improved. The processing power, storage, battery life, and communication capabilities of these smartphones will all continue to improve with the development of mobile computing. Mobility on Cloud Computing will still face a huge challenge because of these enormous variances.

Solution**:** Virtualization and Image, Task migration.

d. Data Storage Capacity and Processing Power

Storage remains a significant challenge for mobile devices. Mobile Cloud Computing (MCC) addresses this by providing mobile users with access to extensive cloud-based data storage. For example, Amazon Simple Storage Service (S3) [54] is widely used for this purpose. Cloud computing (CC) efficiently supports tasks such as data warehousing, management, and online document synchronization. By storing data in the cloud, mobile devices can overcome storage limitations, offering users virtually unlimited storage capacity.

Microsoft has begun developing new office software designed to integrate seamlessly with all types of mobile devices and leverage cloud computing. This software will enable users to store, publish, and share their work across desktop computers, mobile devices, and with other users [55] [56].

7. Conclusion

Fast developing technology, mobility in cloud computing has the potential to completely change how businesses function. It offers increased scalability and flexibility, allowing users to access cloud resources at any time and from any location using a variety of devices. It does, however, have significant drawbacks, such as security issues and reliance on internet connectivity. Before implementing cloud computing, businesses should carefully weigh the benefits and drawbacks of mobility. They should also take the necessary precautions to protect the security and privacy of their cloud resources and data. Looking ahead, it is obvious that cloud computing mobility will keep playing a crucial role in the digital transformation of enterprises. As more businesses adopt cloud computing and mobile device technology, mobile computing will become ever more essential for successful and efficient operation. With the emergence of new trends and issues like edge computing, 5G networks, and the Internet of Things (IoT), new solutions to security and privacy issues will be needed. Organizations must address these issues and adopt new trends to fully reap the rewards of cloud computing for mobility and to remain competitive.

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