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Pervasive Computing Issues, Vision an Exclusive Relationship of Pervasive and Cloud Computing

Muhammad Shoaib Farooq, Taha Mubashar Rubbani, Atif Alvi, Muhammad Athar Naem

Department of Department of Computer Science, University of Management and Technology, Lahore, Punjab, Pakistan
*Corresponding author: Shoaib.farooq@umt.edu.pk

ABSTRACT
Pervasive computing also known by the name of ubiquitous computing is a computer paradigm which focuses the integration of self-communicating and intelligent devices into user's environment and daily life. Its major principle is to infuse computing into real world environment in such way that user cannot even realize it is existing. One of the best available source is mobile devices which can help with everything happening in real life. Mobile devices are not the only sources but they can be use to perform all the operations like downloading, uploading, computing the data, processing any type of data including audio video formats. The major issue could be the storage of such devices and the load taking to perform complex tasks. To tackle such issues, there is a need of cloud computing. Virtual Cloud computing could be the helpful as it provides the environment in which the larger data can be access pervasively. In this paper we will discuss how pervasive computing and cloud computing are associated with each other and how they can be beneficial to each other.

KEYWORDS
Pervasive computing, cloud computing, mobile devices, virtual cloud computing

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INTRODUCTION

The concept of Pervasive computing was invented by Mark Wieser in 1991, he sensed the desertion of computing systems from real world [2]. At that times it was like a dream, but from the progress made in hardware and software fields have proven that his finding was worth enough. Human Computer Interaction (HCI) has rapidly captures the daily life because of distributed systems and mobile computing [3]. Mobile computing and distributed systems are mainly foundations of pervasive computing. Personal computers are connected over the LAN due to distributed systems and by mobile computing [3]-[10]. The mobility been developed over distributed systems. Pervasive computing came into existence with the invention of mobile devices [7]. These devices becomes the need of everyone in today's world, everything has been done using them and that is actually what pervasive computing is all about. Everyone is using but no one realizes that they are using pervasive computing, From time zones to news or any kind of process we can do over the mobile devices.

In pervasive Environment, devices may need internet connectivity for some tasks, which are being provided in pervasive way. Despite the old times, user now do not need to make or established the LAN connection using wires. Telecommunication companies provides virtual network facilities which are mainly a pervasive way of getting network [7]. The main issue people faces in terms of pervasiveness was of storage space, low speed networks, update it needs time [8]. In 2007, the term cloud computing has been introduced, which could provide different services in invisible manner. These services assures reliability, quality and timely execution of tasks performed over data etc [24].

The connection between pervasive computing and cloud computing is mainly because of the cloud servers which means a user can have their data stored on cloud and can able to access whenever is needed at anytime and anywhere in a pervasive way. In this paper we will discuss the issues of pervasive computing, its vision and the relation between pervasive computing and cloud computing [25].

This paper is been divided in different sections. In section 1, pervasive computing is been discussed in depth. In section 2, cloud computing has been define. In section 3, we will be discussing the relation/association of pervasive and cloud computing. In section 4, Virtual cloud and pervasive environment been discussed. In section 5, we concluded the study.

Pervasive computing is a connection between distributed systems and mobile computing. The theoretical constraints of distributed system once combined with the wireless constraints create the mobile computing and the outcome is further combined with some other parameters which results into pervasive computing. Further it can be understood by as explained in reference [1]. It demonstrates the conceptual relationship and conception of pervasive computing.

Defining Pervasive Computing:

Pervasive/ubiquitous computing is a computer paradigm which involves integration of many intelligent and self-communicating devices in to the daily user environment. Some of the challenges of this computer paradigm include minimum user attention, natural implicit and embedded user interaction, development of context aware systems and natural multi-model interfaces etc [2].

Pervasive computing has many applications but implementing it is challenging due to the complexities faced in developing such interaction interfaces and cooperating such modes of interaction into them which promote invisibility, stability, remote access, distributed and mobile computing, smartness, high availability and many other problems in interaction and interaction environments. What characteristics have to be addressed to achieve this level of interaction and what issues have to be faced and how can they be solved to make pervasive computing possible are discussed here.

Pervasive devices allow user to focus on task instead of the technology through the combination of interaction between task and affective information processing. To make this type of computing possible the development of devices which have a high level of task orientation is necessary [15].

Challenges in pervasive Computing:

Some challenges of pervasive/ubiquitous computing include the following:

- Interaction transparency challenges
- Device related challenges
- Radio frequency identification (RIFD) challenges
- Capacity, Integration and access.
- User mobility challenges.
- Human Movements
- Mobility and distribution
- Context aware interaction.
- Developing a continuously present interface.
- Presenting information at different levels of human consciousness.
- Connecting events of reality with the virtual world.
- Modifying traditional HCI to make natural interfaces and behavioral, informal and opportunistic interaction possible [16].

Few of the challenges are discussed below as follow:

Interaction Transparency Challenges:

Transparency is the amount of user attention and effort required for the operation and proper working of the system. It can also be called as invisibility [20], peripheral awareness, anticipation of user's intent [19] and embodiment of the system in to environment. A transparent interface disappears in such a way that it allows user to focus more on task than on working of the system. Mainly two forms of interaction transparency are considered i.e.

- Syntactic Transparency: It relieves the user form performing syntactic tasks like scrolling a window, saving a file, retrieving an email etc. A user logically does no actual work while performing these tasks. Such a system makes the user aware of its output in a non-intrusive way [17].

- Semantic Transparency: It is a phenomenon in which the system anticipates the user's intent [19] and performs the required task for him. Such system communicates with the real world acquiring information in a non-intrusive way. A common example of semantic transparency is a sliding door or a light coupled motion sensor [17].

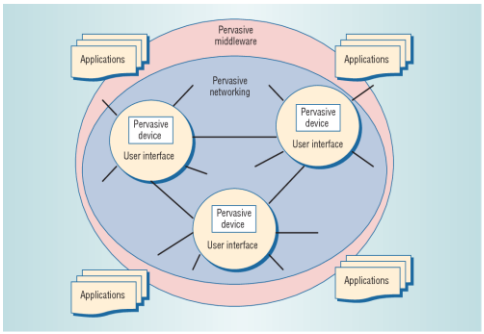

Figure 2. Pervasive computing framework. Middleware mediates interactions with the networking kernel on the user's behalf and keeps users immersed in the pervasive computing space.

Figure 1. Pervasive Computing Framework

Device related Challenges: Two device related challenges must be addressed by pervasive/ubiquitous computing i.e, Device mobility and device heterogeneity.

Device Heterogeneity: In computer systems heterogeneity will not going to end in the future, but they will sure increase because the range of computing devices expands. In a pervasive environment, devices will include sensors and actuators which will bridge the physical and virtual environments, devices being embedded in objects like watches, shoes, appliances of daily use, mobile devices such as handheld organizers, notebooks and conventional desktop devices. Heterogeneous devices will be required to interact seamlessly, regardless of wide differences in hardware and software capabilities. This will require an infrastructure that maintains knowledge of device characteristics and manages the integration of devices into a coherent framework that enables arbitrary device interaction (for example: between a mobile phone and a desktop workstation) [21], [26].

Device Mobility: Issues like maintenance of connections, as devices moves between different areas of different network access and management of network disconnections has been

introduced by mobility. Some of the issues of mobility have been handle by wireless networking protocols but few network level issues need knowledge of application semantics to be resolve. Co-operating with applications in order to perform device mobility related tasks such as management of replicated data in cases of disconnections, should be the responsibility of computing infrastructure [21].

User Mobility: User mobility dimensions define the freedom of movement the user has while using the system for example a desktop system has minimum user mobility as compared to a system on a portable device. There as mainly two forms of mobility i.e.

- Full mobility: Such systems do not contain any geographical constrains for interaction. Interaction with such systems is independent of the location of the user.
- Constrained mobility: It allows movement within specific constraints which may include that the user can interact with the system only within a specific area or at a particular location etc., [17].

Human Movements: To quantify human movement and factors that affect it like ageing and health, Fitt's law is used. According to law: "The time required to rapidly move to a target area is a function of the ratio between the distance to the target and the width of the target."

Movement times for various movements have been calculated correctly which can be used in many interaction paradigms used in pervasive environments. Some of them include finger manipulation, head nodding, head, arm, torso movements etc. Forms of non-verbal communication including facial expressions, voice, eye movement, gestures, patterns of touch, cultural differences etc. are also important for proper interaction paradigms in pervasive environments [23].

Mobility and distribution: As users can be mobile and able to simultaneously exploit the capabilities of several devices, strong mechanism will be required to enable software mobility and distribution [35]-[40]. These mechanisms should be largely transparent to component developers, who should not be concerned with program and data migration or synchronization and coordination of distributed components. The mobility support will need to go beyond the current support for code migration provided by platforms such as the Java Virtual Machine(JVM), as run-time migration in heterogeneous execution environments will be required. Similarly distribution support will need to surpass that provided by platforms for example: COBRA which only offer transparency of distributed communication and usually do not address mobility, synchronization or coordination [21].

Figure 2. Pervasive computing interaction

Distributed System

It can be distinctive as a gathering of independent computers which uses it as a distinct system. It can be a system where mechanism is statically works with a wire connected model. Distributed computing consists of different software which are distributed to many hardware but can also able to work on a single system. It is just like different components can work together in a single component. Distributed computing follows LAN and WLAN. The concerns of distributed computing starts in 2001 when the problem of **black hole search** and **intruder capture** gets rise [3]. The computational model is generally known as distributed if it is a process model, in which all the activities are representing in a sequential process. The most obvious distributed process models are usually those in which processes communicates in queue. A process sends a message to receiver in a queue and the receiver takes the messages by removing it from a queue [4]. Most common real life examples of distributed systems are atm, internet etc. The system is mainly dependent on the server, server is responsible to take all the available data and distributes it towards the clients according to the availability. And as the system is mainly wired base it has security concerns also. **Figure 1** attached below explicates the connection of all the components creating and merging the distributed system. The theoretical parameter as explained in reference [5] are as follow:-

1**) Fault Tolerance**: If anyone component failed then it don't effects the other component's communications. The whole system takes negative effect due to the failure of any component. Solution of this problem is hardware redundancy and Software recovery.

2**) Heterogeneity**: All mechanisms must have interact among each other even if they have differences in terms of Hardware architectures, operating system, , programming

languages, protocol communications, models of security, interfaces etc.

3) **Scalability**: Even if the number of users load is increased along with any resource addition, the performance of the system should be enhanced instead of any failure or breakdown.

4**) Concurrency**: The system should not collapse if there is any simultaneous access by the programs to any resource is carried out.

5**) Openness and Extensibility**: All the interfaces of different programs should be clearly visible publicly to the users as a separate entity. The interfaces should be available for any extensions to both; the existing and any new components.

6) **Transparency**: It means that system should not show the users any inter-component complexity and the all the deployed components should behave like a single unit.

7) **Migration and Load Balancing**: The system should permit the tasks to move around without any hindrance and moreover the running applications and login users should also not be affected. Once such provision of task movement is present then there is a requirement of load distribution among the available resources for performance improvement [6].

8) **Security**: This is very important aspect as wires and components can be secured from any attacks but it is quite difficult to secure data which is in the air. Therefore all the resources should be secured in advance so that only authorized users and applications can access for any tasks.

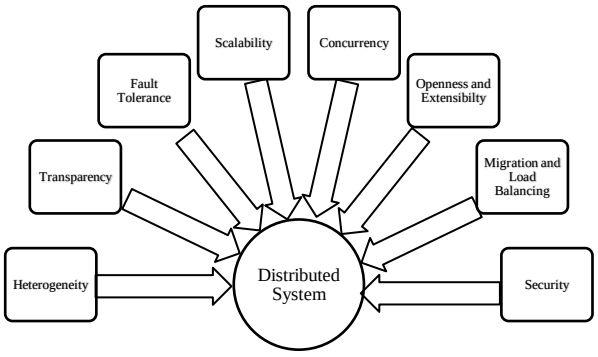

Figure 3: Main representation of Distributed system

Mobile Computing: Mobile computing is a technology which allows user to transmit or transfer data from one system to another without any kind of physical interactions between systems. The data could be of any type and can be shared wirelessly among the systems. Mobile computing becomes the fastest and reliable source for data transmitting in field of computing. There are also some limitations of mobile computing input models, system storage, battery power, latency and size of screens etc.

It is basically an advance version of distributed computing which allows user to communicate with anyone from anywhere and at any time. The dependencies over the huge systems has been catered by this approach. Few applications of mobile computing are as follow:

1. **Mobile networking**: it includes the mobile client address like IP and adhoc protocols etc. The mobile devices has different limitations like hardware, mobility, vendors, operating system etc., we need to have the understanding of mechanism of addressing in distributed environment. in wireless environment For the improvement of TCP some techniques are implemented [7].

2. **Support for adaptive applications**: In mobile computing if we see the mobility factor, an application has to be execute without any defect or fault and the speed of execution should be fast enough to adapt and acknowledge the application based agile techniques in mobile computing [8].

3. **Energy-saving techniques**: these techniques basically observes the issues or limitations of mobile devices in mobile computing. The main concern in mobile environment is energy or power. So the mechanisms adapt the applications and helps in saving the energy [9]. All the device which follows mobility have to be scheduling properly with time management mechanism for better efficiency. Thus, this is the need of 21st century because mobiles has to be schedule so processor can process the decisions by keeping the speed of processor in considerations [10]. Memory is another limitation of mobile computing, where the space management for mobile devices need to be address and this space management mechanism also needs to be efficient in terms of energy consumption [11].

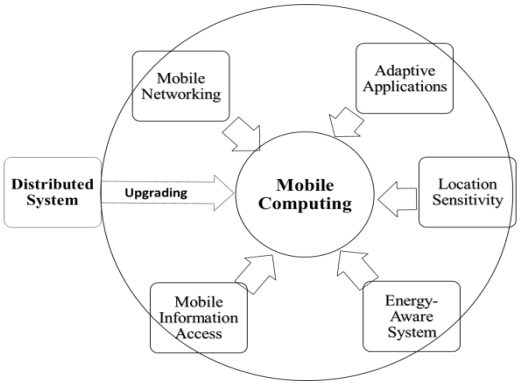

Figure 4. Main Features of Mobile Computing

4. **Location sensitivity**: Location is the most important context in terms of mobile computing. The sense of location of any mobile device is very important to process an application in mobile computing. There are applications which are basically location based and are known as LBSQs (location based spatial queries) [12]. It is important to

understand the behavior of any mobile device which depends on location. So it can be identified by the location [13, 14].

Vision of Pervasive Computing: The main concept or vision of pervasive computing is to reduce the dependency of devices and make everything easy and access able from anywhere.

Now a days the major part of pervasive computing is perform by the networked computing devices. Computing devices are very common and in use almost by everyone and everywhere in our live.

It is not wrong to say that in real life human cannot do anything without the help of computing devices. Pervasive computing helps the real world into merging with a virtual world.

In today's era, Covid disease makes a lot of things to virtual world. It can be the best example of pervasive computing. People are no more dependent upon the devices, Students can continue the study without the physical interaction over the virtual class rooms via mobile phones or laptops or computer systems. Shopping can be done without the interaction over the internet using any kind of device. Offices are running in the virtual environment. All these things are possible due to the pervasive behavior of computing. People plays games virtually connected with almost all over the world with each other. In the past decades, gaming bound people to be together and make a network for specific number of people but now pervasive computing helps people to connect and play together despite the locations pervasively without even getting dependent over any device.

Cloud Computing

The term "cloud Computing" introduced in late 2007, it can be explained as using services which are hosted on virtual servers over internet to manage, process or store data unless those, which is been hosted on personal computer or any local server. The services might include everything like infrastructure or any applications etc. Cloud computing includes both hardware and software services. Gmail, Hotmail and other mail providers can be best fit as examples where users only need to signup/login and all the storage and services are available to them by the cloud. Users can use the services portably through the internet from anywhere.

Virtualization is playing an important role in cloud computing, where an illusion has been created that user can have infinite services with high level of scalability.

Back in 2009, Google launches "Google apps" and "windows Azure" being launched by the Hotmail in 2011, which gives real boost to cloud computing within 2 years. Later on office13 and windows8 has been launched also using the cloud platform [24].

Components of Cloud Computing

A. Client Computers: All the devices which communicates with cloud platforms are client computers. There are two types of clients, thin client and thick client. Thin clients are basically online applications which can be access through internet from any location and have different multiple platforms. Thick clients are offline applications, they have enough resources stored to be operate/processed without internet connectivity [25].

B. Distributed Servers: The servers have been deployed all over the world in different regions or different places but act together same as they are placed in same location. The distributed behavior even didn't affect their performance or speed.

C. Data Centers: A place where all the servers are placed which keeps applications, accessible by the users over internet. They are kept accordingly to the needs of requests and software, hardware works simultaneously and maintained regularly. Data centers are mainly of three types small, medium and large. They have been managed by the need of their size. For example, Google and Microsoft needs a larger data centers where huge number of machines are placed and worked together to provide smooth and reliable services to the users [26].

Central Server: it plays the most important role in cloud computing by looking after the traffic and demands of the clients. It uses different middleware and protocols to ensure the stable communications among the networked computers. Cloud computing stores the details in two different servers so in case any one of the server breaks down, the data stays safe and system got no effect over it. Central server is mainly retrieving all the data in case of any server's breakdown. [27]

Service Models: User can able to use different services related to software and hardware both to run their applications using cloud computing explained briefly in [28]. The Figure attached below explains the service models.

There are few services:

1. **Software as a service (SaaS):** It is basically a distribution of a software over internet using the third party. Instead of installing and maintaining the software you just pay for the services and can fulfill all of your desired requirements over internet. It mainly helps a user to not get involved in to complex hardware and software managements. It provides Operating system and network.
2. **Platform as a service (PaaS):** In this type, it provides a platform where a software or application can be built,

test and deploy. It is also provides operating system and network.

3. **Infrastructure as a service (IaaS):** it gives access to user to use software, hardware, platform, servers and all components of networking. User just has to pay and can access all the facilities of their need without any hustle.

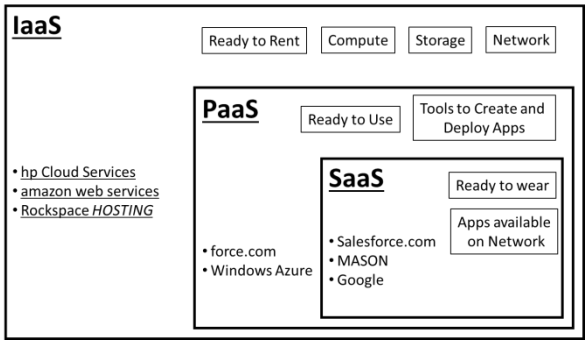

Figure 5: Cloud Computing Architecture.

Cloud Service Deployment Types: there are different types of cloud services for different levels. They have been discussed below and attached Figure 5 explains its structure below.

Public Cloud: it can be owned by anyone any organization, institute etc. it gives the services which are publically available for everyone to use.

Private Cloud: Unlike the public cloud. It doesn't give access to anyone publically. It can be owned by any single organization and is authorized by them, only the users they allow can access the services available.

Community Cloud: it is more or less similar to the private cloud, but here the services or authorization/ownership can be shared by exchanging the security information like passwords etc.

Hybrid Cloud: It is the mixture of all three types discussed above. They services can be share with some rules or restrictions defined by the authorized owner.

As the discussion above, Pervasive computing develops an environment where the users can communicate through the wireless computing devices. While the pervasive computing gives the characteristic of wireless sensing, distributed computing, mobile computing and invisibility of the backend communication, it faces some limitations as well. Limited availability, disconnections, power battery shortage, low storage etc., are major of them. These limitation can be catered by cloud computing which provides the better solution for the most of the above mentioned limitations.

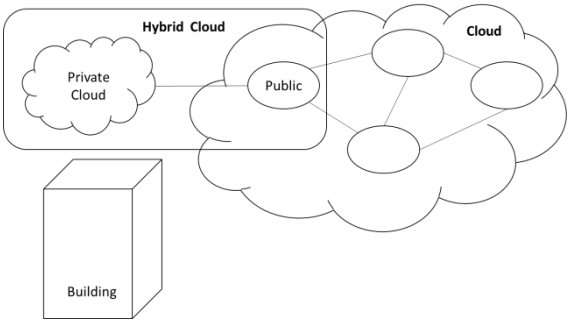

Figure 6: Cloud Services type Deployment

Pervasive and cloud Computing Relationship

Moreover, concept of data offloading and computation in cloud computing reduces the major lacks of pervasive computing. Figure attached below is the pictorial form of association between cloud and pervasive computing.

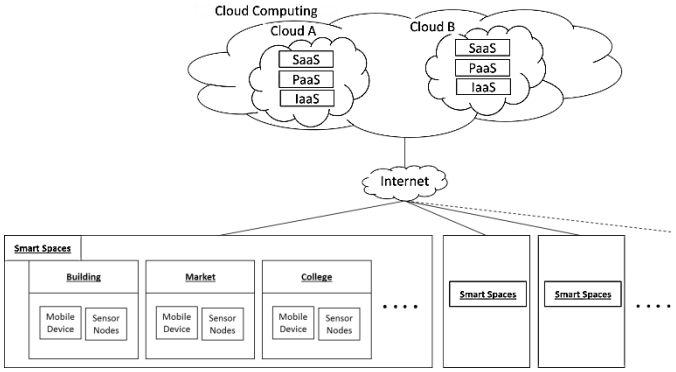

Figure 7: Pervasive Cloud Computing

However, the Cloud Computing rectify the issues of pervasive computing by following.

A. **Resource Pooling:** Cloud computing gives high storage and can tackle huge amount of data easily, so the limitation we faced of low resources and low energy consumption has been laid off.
B. **Availability:** Cloud computing ensures the availability anytime and anywhere so the limited availability and disconnection in pervasive computing is being laid off with it.
C. **Scalability:** The issue of pervasive computing has limited users could be served been laid off using cloud computing because it gives ease by little changes, a new server and client can be dealt.
D. **Cloud Computing Component (CCC):** The main characteristic of pervasive computing of invisibility and adaptive nature can be also found in cloud computing because it gives everything virtually. SAAS, IAAS and PAAS gives all the required environment of pervasive computing.

E. **Pervasive Computing Component (PCC):** For getting uninterrupted services, all the record has been saved in smart spaces and can be moving differently without the user knowing about it. And all the record kept safe and secure. So no data can be lost in a pervasive environment.

Virtual Cloud Computing: Pervasive cloud computing gives the users to access all the services anywhere and anytime but there are some barriers which needs to be in attention. The services are always dependant on the continuous connection availability and are bit expensive and hard to afford by everyone, but if virtual pervasive cloud computing is being treated it can resolve these issues. In Virtual pervasive mobile computing, mobile devices acts like a service providers as if someone is downloading some large file or data and faces a connection interruption, the virtual cloud server gives same services without interruption because of its data backups [29].

All devices in smart space can be providers because of their pervasive behaviours. Few components of virtual pervasive cloud computing are discussed below:

A. **Application Manager**: this manages the data load and offload times of an application. And helps in smooth execution once the application is in under process.

B. **Resource Manager**: This helps in managing the resources requires in the process of any application. It provides the missing and cuts off the extra memory consumptions by the application under process.

C. **Context Manager**: this helps to manage the UI/UX of an application. They helps synchronization of an application through the UI and made the processes available to nearby devices.

D. **Peer to Peer Component**: It informs the context manager about the strength of devices and always have a look on new incoming and outgoing connections among the devices.

E. **Offloading Manager**: It help sharing the request between devices, take the request from one and provides it to the other to complete the task in process. It also is responsible to detect and resolve the failure faced during the process.

Conclusion The research paper is been written to discuss the relationship between cloud computing and pervasive computing. At the start we discussed and have review of both the concepts (cloud computing and pervasive computing), and in the result of the review we found that pervasive computing has some gaps which are to be filled up. By reviewing cloud computing we figured out that the gaps found in pervasive computing can be fixed by using cloud computing and pervasive computing all together.

We figured that cloud computing can strengthen the pervasive computing. Through using and creating a virtual network connections, Devices in smart spaces can be operated with each other using the cloud pervasive computing environment where the virtual cloud can be helpful. But still there will be some gaps due to rapid increase in the technologies and there are still need of more research in this area like Bluetooth networking localization, enhancing of speed and integrations of mobile device online between each other in a larger area.

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