International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 6 | ISSN : 2456-3307

Pervasive Computing Architecture, Applications, Issues and Challenges

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ABSTRACT

This paper describes the recent topic pervasive computing which focuses on introduction, its architecture, applications, issues and challenges of pervasive computing. The pervasive computing is the latest computing technology. Pervasive computing is an advanced computing paradigm which makes computing available everywhere and anywhere .The pervasive architecture rates how the end-user interacts with the pervasive network using the middle were support. Applications in such technology bring together devices connected through a heterogeneous network, services and resources are also brought together to enable information integration that is context-aware. Finally it explains about the future possibilities of pervasive computing through real time applications. The work presented in this paper deals with such problems from a design perspective and derives a new research for pervasive mobile assistance in the above-mentioned scenarios.
Keywords : Pervasive Computing, Computing Technology

I. INTRODUCTION

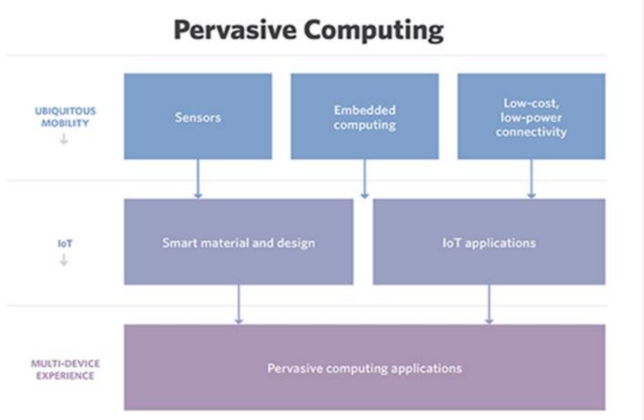
Pervasive computing has now reached to the top of the list of the most active area on which research is being done and has been done in the last two decades since the time it was introduced by Weiser in the early 1990s.

This combines currently active network technologies with wireless computing, voice recognition, Internet capability and artificial intelligence. The aim of this advanced electronics is to build an environment where we have embedded connectivity of devices.

Pervasive computing, also called ubiquitous computing, implies "existing everywhere" or "around us". It is a trend of embedding computational capability that is growing into everyday objects to make them effective to communicate and perform the required tasks in such a way that it minimizes the client's requirement to interact with computers. Such computing devices are connected to the network and available constantly.

In Pervasive environment any device from anywhere can be accessed by the user because it spreads the intelligence and connectivity to more or less everything. The major technologies and special purpose computing devices such as sensors, microprocessors, internet, operating system, mobile protocols, embedded controllers, smart phones, Wi-Fi, WI MAX have been coming from pervasive computing.

Pervasive computing includes three things which are: 1. it is concerned with the way people have a perspective about mobile computing devices and the way these devices are used by the people to perform tasks within their environments. 2. It takes into consideration the way in which applications are created and deployed in such a way as to make these tasks possible to be performed. 3. It also takes into account the environment and how it is developed by the emergence of newly developed information and functionality.



II. Pervasive Computing in Classroom Environment

Certain problems are associated with learning in modern classroom environments. Such problems include: inability of students to understand and assimilate all that is being taught in the classroom, difficulty experienced by students in learning new topics in classrooms, inability of students to retain what has been learnt in the classrooms, and the dynamic nature of the present day education syllabus, among others.

III. Current trends of pervasive computing in classroom environments

Mark wiser proposed three basic forms of pervasive computing systems namely: tabs (wearable devices), pads (hand-held devices) and boards (display devices). He also proposed much more useful ranges of pervasive devices such as dusts, skin and clay. Examples of the current trends of pervasive computing technologies were highlighted:

A. **Flipped Classrooms:-** Flipped classroom is a current trend of the application of pervasive computing to learning environments.it helps to improve the traditional teaching methods for the purpose of delivering online instructions in smart classrooms. Some researchers consider flipped classroom a new teaching model, which provides innovative ways of imparting knowledge to students in the classroom. Some researchers have conducted and are still conducting studies on flipped classrooms. Bergmann and Sam's presented flipped classrooms as a means of reaching out to every student by increasing the availability of online videos, flipped classroom models and increased easy access by the student.

B. **Learning Analytics**: - Learning analytics is also a current trend that employs advanced tools to improve educational experience and the performance measurement of students.it improves the learning experience of the student that can be learnt from the previous data and existing models of the classrooms system. It has also helped to refine classroom learning goals and strategies. Learning analytics has also been applied in the area of visualization and recommendation. Learning analytics has been applied to increase students' success rate.

C. **Tablet Computing**:-Tablet computing is an aspect of computing that applies mobile computers to solve daily real-life problems. Tablet computing is an aspect of computing that applies to mobile computers to solve daily real-life problems.

D. **D. Massive Open Online Courses (MOOCs)**:- Massive Open Online Courses (MOOCs) represent courses that are open and taken by different participants distributed in different locations across the web; course materials are also distributed. MOOCs represent a means to extend technological skills and knowledge to a large percentage of the world. It also acts as a motivation for promoting online education.

IV. Future trends of pervasive computing in classroom environments:-

Future trends of pervasive computing technology that will be applied within classroom environments in the next two (2) to three (3) years include: 3D printing technologies, games and gamification, virtual assistants and quantified self.

A. **3D Printing:-** 3D printing uses modelling software to design physical objects in the three-dimensional shape. Some of the concerns and research issues of 3D Printing include: (i) Cost (ii) Inability to easily print multiple materials on the same machine (iii) Availability (iv) Printing to the finest resolution (v) the printing process is slow
(vi) Legal issues.

B. **Games and gamification:** -Gamification is the application of the elements and concepts of game design and game thinking in a non-gaming context. It can serve as a means to provoke creative and critical thinking, develop problem-solving skills and promote collaborative work.

C. **Quantified self Quantified**:- self applied technologies that monitor data to help people keep track of their daily activities. Privacy concerns, high prices of gadgets and unavailability of equipment are some of the challenges currently facing quantified self.

D. **Virtual Assistants**:-Virtual assistants apply the knowledge of artificial intelligence to support people in their numerous daily activities. It enhances productivity by providing useful applications to the academia and industry. Language barrier, time difference, trust issues, payment and exchange rates are some of the concerns associated with virtual assistants.

V. Pervasive Computing to Enterprise Information Enquiry Service

The pervasive computing technologies used to create enquiry platform include configuration of WAP web site for the server end, application of service Chang Wu ShanHua Carpet Group Co., Ltd. Weihai, Shandong Province, PR. China, 264209 provided by China Mobile for Nokia66 10, configuration of CMWAP service for the mobile phone end and Java development technology for communication device. Taking e-commerce of ShanHua Carpet Group Co, Ltd. as background, the users' queries to carpet images and telephone book on the platform is implemented.

A. **Environment Configuration:** The first way mentioned above is introduced in this section. In this way, it can support the mobile enquiry only if the WAP website which is on the server end is configured.

B. **Configuration on the Server End:** First, make sure that the server has a legal IP address in the range of the Internet and can provide WWW service as well. Second, install the files needed and configure the WAP web site to make it sure that service can be accepted and responded. The necessary operation system and components on the server end are:(1) Windows 2000 Server
(2) Internet Information Server 6.0 (IIS6.0)
(3) Active Server Page (ASP)

C. **C. Configuration on the Mobile Phone End:** Taking Nokia6610 and related service provided by China Mobile for example, the configuration is as follows:.

(1) Access "Service" interface of the mobile phone, select "Setting" option. Generally, the mobile phone has prepared services providers' settings which are commonly used.
(2) Access "Modify Service Setting" Option. Users can set group name and home page freely, but generally

the mobile phone has set the group's name as "Mobile Dreaming Network GPRS" and default home page is http://wap.monternet.com. It'll be just ok if you don't want to modify them. Connection type can be "persistence connection" or "temporary connection". Default value is "persistence connection". Connection type means the connection way of GPRS. Persistence connection is that it is keeping connected at anytime and temporary connection is that it would connect to the GPRS when there is the request sent by the phone. There is no affection to the queries. The differences are that persistence connection generates more data. If the signal is not weak, it can e set to "temporary connection" in order to reduce the data traffic flow.

(3) Choose GPRS (General Packet Radio Service, GPRS) as data transform method. China Mobile provides two kinds of services. One is CMWAP which is the mobile gateway mode. It explores the WAP web site only through HTTP protocol and it is cheap. Another service is CNNET. CNNET can access any service without limitation and it is more expensive. Here, the CMWAP can satisfy the request of information service.

(4) Input GPRS connection settings to CMWAP. IP Address is "10.0.0.172". Authorization type is "common". Login type is "automation". User name and password can be null. So it finishes the mobile phone configuration.

VI. Provenance-aware Pervasive Computing in Clinical

The healthcare cost that is increasing at a constant rate and scarcity of clinical professionals have increased the use of pervasive computing technologies in the healthcare sector. While pervasive healthcare is still in its infancy, pervasive computing technologies offer a promising future in developing clinical applications, where patients' condition must be monitored continuously. More specifically, modern low cost and low power mobile devices, portable wireless sensors and advanced communication technologies open the opportunity to construct a pervasive healthcare environment that surrounds an individual patient and enables gathering rich clinical data about him (e.g., patients' behavior, physiological parameters, social dynamics, etc.). The information collected by the devices can be further transited to a centralized clinical information system and become a part of the patient's electronic healthcare record (EHR). However, one of the main challenges for such a system in healthcare is its ability to collect quality data traceable to individual devices' context and usage and ensuring its validity for use, based on which critical decisions may be taken. Recent work in provenance research and the recent adoption of the provenance standard W3C PROV provide a potential solution to address this challenge. The concept of provenance originates from the fine arts where it refers to the trusted, documented history of some work of art. In computer systems, provenance is concerned with tracing the history of individual pieces of data. In this paper, we discuss how to capitalize on the existing engineering solutions and previous research efforts in pervasive computing in order to support data collection, validation, and integration processes in clinical applications. We propose generic provenance-aware pervasive system architecture that allows recording not only clinical facts about patients at the point of care (the current state of the art), but also relevant provenance information.

VII. Advantages and challenges for pervasive computing in clinical applications

Over the last decade, the pervasive adaptation of ICT has dramatically changed the healthcare landscape. The wide deployment of information system technology in healthcare centers has greatly improved the availability and accessibility of patients' electronic records. The growing volume of healthcare information can help to improve the quality of healthcare service, allowing more extensive clinical research, and supporting rapid decision making in treatment of a disease and epidemic control [9]. Clinical research includes patient-oriented research studies on human subjects. Several ICT application projects have emerged recently to facilitate acquisition and integration of medical information into clinical research. These projects aim to develop infrastructures for integrating distributed, and often heterogeneous, healthcare data sources for supporting clinical research. For instance, the Electronic Health Records for Clinical Research (EHR4CR) project proposes an integrated platform that provides controlled and regulated access to hospital healthcare and research information systems, such as Electronic Health Records (EHRs) and Clinical Research Information Systems (CRISs). These may be distributed throughout numerous hospitals in many countries. A clinical researcher may then query the clinical research data for a multi-site study, for example to determine the number of patients who meet a set of criteria that would make them eligible subjects for a clinical trial. Such systems bring both financial (e.g. by reducing costs) and nonfinancial (e.g. by reducing selection times) benefits to those setting up and conducting clinical trials. Clinical research findings directly rely on complete and accurate data. Clinical research data capture is an extremely important part of a clinical research project. Traditionally, the process relies heavily on paper-based documentation which is time consuming and error prone. Over the last decades, paper case report forms (CRFs) at hospitals are increasingly replaced by computerized data capture, such as remote data capture (RDE) and electronic data capture (EDC) which are indeed early forms of pervasive computing applications. The adoption of these computerized data collection approaches were not initially motivated due to the lack of mobile hardware for data collection. With the advancement of mobile hardware and communication technologies however, pervasive computing becomes increasingly viable to replace the conventional data collection mechanisms in the healthcare domain . At the same time, such issues as data traceability and validation still remain among the challenges that discourage computerized data collection in clinical applications. Although paper-based data collection is time consuming and error prone, paper data source documents can be kept for further validation and investigation. It is however difficult during computerized data collection in systems that lack of provenance capacity. Even if clinical data is stored in centralized information systems, questions regarding where, how, by whom and in what circumstances it has been collected would still have to be answered in a validation and investigation event.

A. **Clinical trial scenario :** The review of the existing pervasive healthcare solutions suggests that most are lacking provenance capture functionality to specifically address the issues of data quality, integrity, and validation. The questions of how data has been collected, transformed and verified are crucial in the healthcare domain, especially when integrating multiple data sources (e.g. from several points of care) or taking same measurements in different settings (e.g. blood pressure of a standing or lying patient). For example, one clinical system can store patient's age, while another – his date of birth. Date format may also be different. Such variations could lead to fact distortion, which may be critical when selecting patients for participation in clinical trials; incorrect inclusion or exclusion of patients may seriously affect research findings. Below, we propose a provenance-aware pervasive computing system that is designed to address the named issues. To assist us in demonstrating our solution (presented in the following section), we provide a running example that describes the data collection process in a clinical trial. This example illustrates how advanced pervasive computing technologies can be used for optimizing collection of clinical data from study subjects and improving the quality of the data. In our scenario, a phase-I clinical trial is conducted for testing the safety of a new drug. The study is carried out in a smart hospital, in which a pervasive healthcare environment is implemented with methods similar to those we reviewed in the previous section. In the hospital, all patients wear Radio Frequency Identification (RFID) tags. The patient rooms are instrumented with portable vital sign monitors that can communicate to a central data server via wired or wireless networks. Site professionals are equipped with wireless PDAs that can download and upload data from and to centralized hospital information systems.

VIII. Pervasive Computing used for Recovery Mechanisms for Context-Aware

A. Introduction : Context-awareness is a central aspect of pervasive computing applications, characterizing their ability to adapt and perform tasks based on the ambient context conditions. Typical examples of context include a person's location, proximity of people, proximity of a person to a device or an object, devices being used by a person, the activity in which a person is engaged in, etc. The computing environments for supporting context-aware applications provide services for context information management, resource discovery, location-independent naming, and authorization and access control. We designed and implemented a role-based programming framework for building such context-aware applications in which multiple users may be involved in collaborative activities. The function of a role in this framework is to represent a set of privileges for users to execute application tasks. One of the important characteristics of context-aware applications is their ability to adapt under changing context conditions. Context-based adaptation requires dynamic reconfiguration of the application. Our initial focus while building the programming framework was on providing appropriate mechanisms for designing context-based adaptive features. However, our experiences with the deployed applications revealed various robustness issues that arise due to the dynamic nature of such applications and also due to the dynamic nature of the environments in which the applications are deployed. We realized that the absence of application-level programmed error recovery mechanisms within this framework led to fragile applications, which were unable to cope with various failure conditions. We experienced the following three broad classes of robustness issues:

The dynamic reconfiguration mechanisms integrated in an application for context-based adaptation can themselves become a cause of robustness problems, if not properly designed. In some situations an application may fail to function correctly due to failures in finding the required resources and services during a reconfiguration. Moreover, the order of binding various services to an application during reconfigurations and concurrent processing of context events can affect the correctness of the application.

Various kinds of failures can arise during the users' interactions with the services bound to the application. These include failures due to network disruptions, service crashes, and access revocations by services, which may lead to disruptions of any interactive user sessions. A reconfiguration action could also disrupt an ongoing interactive session, Symposium on Reliable Distributed Systems 1060-9857/08 $25.00 © 2008 IEEE DOI 10.1109/SRDS.2008.13 13 causing it to terminate prematurely.

An application that requires a task to be executed only while some specified ambient context conditions hold is prone to failures when such conditions are violated. We refer to this as the context invalidation problem.

B. Programming Framework Overview: A context-aware application is programmed using an abstraction called activity. An activity defines a namespace for roles, objects, and reactions. The object abstraction is provided in the activity for accessing various resources and services required by the application. An object may be bound to different services under different context conditions. Objects defined in an activity's namespace are shared by all the roles defined in the activity. Each role defines a namespace for objects and role operations. Objects defined within the scope of a role are private to that role; a separate instance of such an object is created for each role member. Such objects are required because within a multi-user application we may want different members of a role to access different instances of a service type based on their individual context. A role operation represents a task that is explicitly invoked by the role members. A role operation consists of two parts: a precondition and an action. A role operation precondition must be satisfied before the action can be executed. For coordination purpose, two types of events, start and finish, are defined for a role operation. An operation's precondition may be based on predicates involving counts of start/finish events of various role operations, role membership predicates, and predicates involving ambient conditions queried from context services. An operation's action starts an interactive session as part of which a set of methods may be invoked on a shared or a private object. For each user, an interface component called User Coordination Interface (UCI) is dynamically created and transported to that user's device. Through the UCI, a user communicates with a role manager for executing the role operations.

IX. Pervasive Computing support Collaborative Work and Simulation

The computer supported collaborative work (CSCW) domain is probably one of the most active research fields of recent years. Indeed, due to the facilitations brought by computers and smart devices it is almost impossible to find people working without them. In this paper, instead of retelling the history of CSCW we will face next challenges and propose an original architecture based on promising perspectives. Among the recent technologies and paradigms, one has a special interest for us: the pervasive computing. This concept describes the "simple" idea that devices of user's environment should be able to communicate and interact to adapt their behavior to user's needs. Given this aspect our work has rapidly focused on the way we could integrate the pervasive computing within CSCW. Such integration could bring various advantages: resource and time saving for companies, work simplification and task automation for workers. In a "green" consideration it could also help reducing work's energetic impact by accompanying users' in using lighter devices and services. On the long road toward this accomplishment we have already sowed some seeds. Hence as we will describe in the next sections we have proposed the PCSCW model (see below) which is designed to natively support pervasive computing for collaborative tasks.

A. **Pcscw model & simulation:** As our research interest has focused on the integration of the pervasive computing aspect in the computer supported collaborative work, we have proposed in a previous work [1] an original model which aims at making smart devices cooperate seamlessly to improve and facilitate the collaboration of users. This model, named PCSCW for Pervasive Computing Supported

Collaborative Work, relies on some simple but essential "sub-models":

• A Task Model composed of mainly two concepts:

1. Task: represents a meaningful process to be performed by one or more users to achieve a specific goal, for instance "creating a webpage", can be composed of a set of subtasks or actions;
2. Action: describes an atomic step of a task, it has no discriminatory meaning as it can't be understood outside of a task. To illustrate it we can consider the action "opening a web browser" that doesn't convey any specific meaning but can be integrated in tasks such as "searching the web" or "checking mails".

• A Role Model built above the task model, it extends it by providing one more concept and some refinements about tasks.

X. A Service-Oriented Business Rule-Based Application Platform in Pervasive Computing Environments

The rapid development of pervasive computing [1] has created both new business occasions and new challenges for the modem enterprises. For dynamic associated undertaking cooperatively supplying business services to their customers, such as an association of urban public transport corporations or a so-called Virtual Transport Enterprise, the inherent requirements for the none headquarters administration mechanism has been a key issue for their applications integrating into the pervasive computing environment. Precisely because their business goals are not governed by a cooperative process, but some collaborative regulations or contracts to transparently as well as co-complementally provide uniform services of same or similar kinds to their customers. These requirements challenged the integrated application platform both in architecture design and application development. The combination of Service-Oriented Architecture (SOA) and Business Rules Management (BRM), as two software engineering techniques being enough maturity in both theory and practice for commercial organizations to align IT with the business goals, will be a powerful enabler to achieve this end.

A. The Motivation Scenario and requirements:

In the motivation scenario, the PTA mentioned above consists of several transport corporations, such as BUS Corporation, BRT (Bus Rapid Transit) Corporation and LRT (Light Rail Transport) Corporation, and so on. Each corporation in PTA can offer their transport services of same or similar kinds but in different traffic modes independently, including buying tickets, planning route, querying traffic information, etc. To achieve the goal of transparently providing the uniform services in pervasive computing environment, we firstly present the rational basic assumptions for the futuristic application as follows:

- There already exists a network for pervasive computing, and passengers can acquiren transport services of diversity via the network at anywhere and anytime.
- Smartcard is used for multiple purposes such as to identify a passenger, to pay for tickets, to record a bought e-ticket, and so on.
- E-ticket mode is adopted instead of traditional ticket to decrease cost and simplify the procedure of utilizing the transport facility, and an e-ticket recorded in smartcard can be read with the smartcard scanner installed on the buses or in stations.

✓ In the motivation scenario, the PTA demands an innovation application pattern to support their individual business services to be integrated into an application platform. The key challenges of requirements for the application platform are characterized as follows:

- Among the associated enterprises, there is none headquarters to govern the business to achieve the scalability, and all enterprises are autonomous and of equality. Each enterprise may dynamically accede to or secede from the association due to the agreed regulations.

- ✓ Within an individual enterprise, a centralized framework may be adopted to support pervasive services integrating and manage and control all the services of their own.
- ✓ Each centralized autonomous framework can be equally integrated together into a decentralized architecture of application platform to transparently supply the unified services for their consumers via the collaboration protocols and mechanism negotiated among the associated enterprises.
- ✓ Each service implementation must be business rule supported so as to agilely adapt to the rapidly changed markets, in the case of adjusting some fare concession rules to attract more passengers utilizing their vehicles, for example.
- ✓ A mechanism in the business rules management must exist for cooperative purposes, such as the case that BUS Corporation published a new ticket type named BusPlus Ticket that allows the passengers using this kind of ticket to journey in both Bus and Rail modes.

XI. CONCLUSION

Our research is still in an early stage. We intend to apply a prototype of the system and the provenance tools proposed in this paper to real-world applications such as the EHR4CR project . We also want to further investigate the challenges that exist in developing provenance-aware pervasive solutions. This paper introduces the methods to construct the pervasive computing platform using computer device and technology and modem communication means. The paper also implements an application on the platform by which clerks and customers of the company can request carpet images and telephone book services at anytime and anywhere. Along with more research on the pervasive computing, it will bring more business chances to the enterprise in future.

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