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Ambient E-Services: Framework and Applications

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ABSTRACT

Most of existing mobile services were designed based on the client/server architecture. Those mobile services neither paid much attention to mobile users' interactions with their environments nor considered the cooperation efforts between the mobile users in a dynamic peer group. In this paper, the notion of ambient e-services is defined to identify a new scope of mobile e-services. The notable features of ambient e-services are the exhilarated linkage based on social context and significantly rapid growth of connections. We also present an ambient e-service framework that characterizes ambient e-services with three dimensions (value stack, environment stack and technology stack). We exemplify several ambient e-service applications, which rest on the mobile peer-to-peer technology and ambient context aware sensors environments. Ambient e-services make a mobile user not only connect to dynamic ambient environments but also build channels that connect with other mobile users in the nearby surrounding environment, capitalizing dynamic environmental values as well as dynamic social values. Lastly, we identify for ambient e-services certain important issues worthy of future intensive research.

***Keywords*:** Ambient e-Services, Mobile commerce, Context awareness, Social context, Mobile Peer-to-Peer

1. INTRODUCTION

Mobile commerce promises to deliver the real potential of Internet for commercial purposes to a significantly expanded market of existing and new users. A four-level integrated mobile commerce framework was proposed in [1], which discussed how to successfully define, architect, and implement the necessary hardware/software infrastructures in support of mobile commerce. However, the applications mentioned in [1] were grounded in the client/server architecture where the only interactions involved are between a services provider and a mobile user. Mobile users were standalone due to the lack of technology functions and communication channels that enabled mobile users to interact with each other; interactions or cooperation between mobile users were not considered as an important issue in mobile service scenarios. Consequently, the collected value attained from the mobile users of a peer group (or multiple peer groups) cannot be produced.

Fortunately, the latest Peer-to-Peer (P2P) technology (e.g., JXTA) makes it possible for individual mobile peers communicate with each other and wirelessly exchange their own information under sensors-enabled environments. One may notice that P2P computing has increasingly emerged at the forefront of Internet computing. The cooperative computing and resource sharing has been around for quite a while [2]. The collaborative interactions between mobile users bring mobile commerce into a new paradigm. Accordingly, a new framework of mobile applications should be investigated, considering dynamic environments and collected efforts of mobile users.

The ambient intelligence refers to the vision that technologies become invisible, embedded in our natural surroundings, present whenever we need them, enabled by simple and effortless interactions attuned to all our senses, adaptive to users and context and autonomous acting [8]. In other words, ambient intelligence is to embed information representation in everyday objects and the physical environment becomes an interface to digital information. In this paper, we embrace this vision into mobile e-services built with the Mobile-P2P technology, unfolding the notion of ambient e-services.

Moreover, Location-based services (LBS) employ knowledge of the user's location to enable the provision of new or enhanced services to a user via a wireless handheld device (e.g. mobile phones, PDAs). Wireless e-services can be potentially very personal, timely and relevant, or even integrated with other services in a near-seamless way [4]. Within ambient environments, wireless handheld devices are very personal to a user and carried by the person; the context of the user (e.g., time and place) can be measured and interpreted; services can be provided at the point of need; and applications can be highly interactive, portable and engaging.

However, some people may wonder if current sensor networks can replace ambient e-services. Wireless Integrated Network Sensors (WINS) provide distributed network and Internet access to sensors, controls, and processors that are deeply embedded in equipment, facilities, and the environment. However, in sensor network environment, peers within the range may not know who others peers are (i.e., social context is confidential and presumed to be retained privately). But ambient e-services are capable of leveraging peers' private social context or past interactive experience, diversifying the potential opportunities of the dynamic collected efforts. There exists something about ambient environments that the sensors network cannot accomplish. The social connections based on the context aware environment provide a trustworthy linkage on the strength of the social networks and keep sensitive data from others. The social contexts accordingly must be retained in the personal devices. Otherwise, sensitive data kept in a central server will makes user loath to participant in such services. Compare with the client/server architecture, the P2P design makes the connection numbers in a significantly rapid progression growth especially in an open space. Those are two distinguished characteristics that make the P2P design more appropriate than client/service architecture in ambient e-services.

This paper does not intend to offer fixed answers about how ambient e-service application systems should be designed in the future. Instead, it aims to motivate a new direction of research, which addresses challenges and research questions that arise when we take a system-oriented but high-level view of ambient e-services. We are interested in examining those novel applications and technologies that constitute the frontier of the ambient e-services.

The ambient e-service is a new thinking. To ward off ambient e-services framework limited to those scenarios we provided, we deploy the presentation of the paper in a top down structure. In section 2, we propose the ambient e-service framework that represents the ambient applications in three dimensions. Section 3 illustrates several key ambient e-service scenarios and their basic interaction architectures. Then we discuss those issues arise in ambient e-services in section 4. Finally, in section 5 we describe some conclusion remarks and future research topics.

2. AMBIENT E-SERVICES FRAMEWORK

In this section, we present an ambient e-service framework (as shown as Figure 1), identifying some possible deliverables (values) of ambient e-services and addressing the technologies required to support the applications of ambient e-services. The framework is composed of three dimensions, the value stack, the environment stack and the technology stack. The descriptions of the stacks will be detailed in the following subsections.

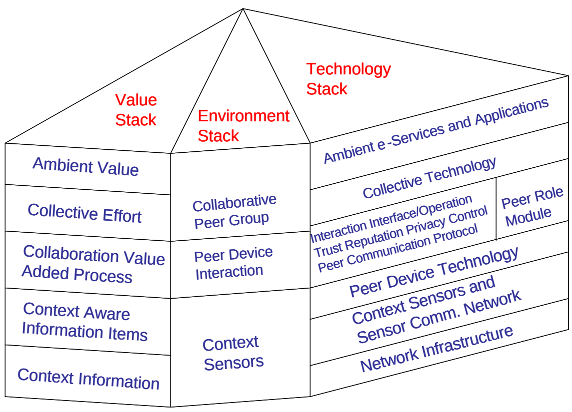


Figure 1. Ambient e-Service framework

2.1 Value Stack

The ambient value stack comprises five layers indicating the supporting value layers for ambient e-services (deliverables of higher levels requiring the provision of deliverables of lower levels). The basic layer is the "Context Information", which is attained from the ambient sensor environments. A mobile user can interact with the environments (e.g., entering a room) and the context sensors then communicate with the device the user carries (e.g., informing the user of his/her location). Comparing the user ' s profile, the second layer "Context aware Information Items" send to the user information items that matches his/her preferences.

The information items received from the environments may be useful to the user, but sometimes some of the information items may be irrelevant. With the communication ability, a mobile peer can collaborate with another mobile peer and exchange carried information items stored in their mobile devices. Through these collaboration interactions, it may be the case that there is someone whose information items are valuable to me and thus I can exchange or trade with them with a micro payment or a barter process. This is called "Collaboration Value Added Process".

Not only communicating with only one peer, a peer can also interact with a peer group of multiple peers. Aiming at the same goal or interests, a peer group can collect their abilities to accomplish the goal that is impossible for a single peer to reach. Therefore, "Collective Effort" represents the power of a peer group (or multiple peer groups). The ambient value subsequently refers to the collective efforts, which include the peers' interactions and peer groups' interactions.

2.2 Environment Stack

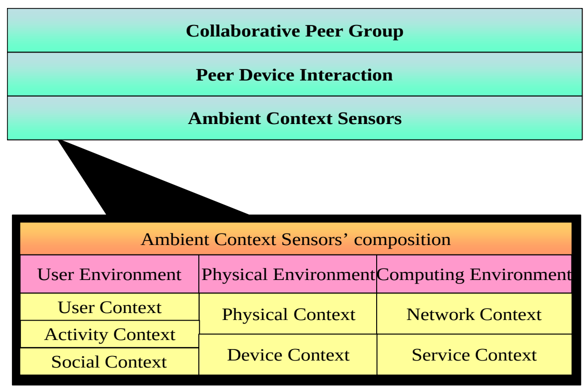


Figure 2. Ambient environment stack

The environment stack consists of three layers indicating the supporting environment layers for ambient e-services (environments of higher levels comprising those of the lower levels). The sketched stack diagram is shown in Figure 2.

The "Ambient Context Sensors" is the bottom layer, which include three categories of environments. Schilit, Adams & Want claim that the important aspects of context are: where the user is, who the user is with, and what resources are nearby. [12]

The user environment includes the user context, the activity context and the social context. The user environment represents the profile of a user, such as peer identification, where the user is, who the user is, the user's preference, their privacy concern, their social situation and relations with others, etc. The physical environment includes the physical context and the device context. The physical environment refers to things like temperature, noise and lighting level and device context. The computing environment includes the network context and the services context. The computing environment represents the network connectivity, available processors, cost of computing, bandwidth and available nearby services, etc.

The layer "Peer Device Interaction" represents environments (featuring peer-to-peer interactions) in which mobile users may exchange their experience and trade attained information items with nearby peers. The "Peer Device Interaction" layer rests on the "Ambient Context Sensors" layer; that is, all peers' information items originally come from the interaction with the dynamic environments of the bottom layer.

The top layer of the environment stack represents environments featuring peer groups' interactions and collaboration. Peer group can collect all peers' power for certain objectives (e.g., collective buy, forming a task-oriented workforce group, etc.).

2.3 Technology Stack

Network infrastructure is the fundamental of all ambient technology stacks. The wired and wireless hybrid network infrastructure provides the basic communication infrastructure for context sensors and peer devices. Above the network infrastructure layer, context sensors and sensor communication can interact with the surrounding peers. Peer devices function on top of the sensor communication network and the mobile device's hardware, operation systems and software platforms.

The layer above the peer device technology layer has two folds: (1) For peers to interact with each other, a peer communication protocol is required (similar to that in web services). (2) In ambient environments peers may just know nearby peers for quite a short period of time. How can a peer trust the nearby peers? Is it possible to build a reputation system for the aforementioned situation so that it is feasible to trust unfamiliar peers? Similarly, privacy control should be addressed in ambient e-services. Resting on trust, reputation and privacy control as the communication basics, mobile users can engage ambient interactions to handle some operations between peers. These operations are the likes of "discovery", "request", "respond", "bargain", "transact" and "delivery".

Since a mobile user plays different roles in different interactions, the peer role module can be applied to the peer in response to the dynamic roles rendered. Mobile users, who have the information items required by other users, play the seller role by applying the seller module. The surrounding peers (who have attained various kinds of information) then can play as the broker role by applying the broker module. Mobile users, who need the information from others, apply the buyer module and play the buyer role (who can trade or barter with other mobile users).

Beyond the peer to peer interactions, peer group collective effort is the communal power of peers. Collaborative technologies that support peer and peer groups to work together underlie the key character of ambient power. Based on the collective technology, ambient e-services can be unfolded in various applications, which we will discuss in the next section.

3. AMBIENT E-SERVICE APPLICATIONS

It will be useful, to begin with, making a distinction between two kinds of ambient e-Services. One is for the distributed trading; another is for the distributed collaboration. Please note that the social context and the rapid growth of connections are the major incentives of applying the ambient e-service design. The two characteristics are not mutually exclusive; of course, one scenario may apply both of the ambient characteristics.

This section aims to identify several important ambient e-service application scenarios presuming ambient environments of mobile commerce are provided. Without loss of generosity, the physical context of location is referenced and considered in the ambient environments addressed in the following scenarios, naturally relating to the LBS research. As mentioned in Section 1, ambient e-services aim to identify a new scope of mobile e-services mainly addressing dynamic collected efforts between mobile users (enabled by M-P2P) and dynamic interactions with ambient environments (envisioned by LBS).

Since LBS was categorized into four major types (transaction services, information services, navigation and tracking services and safety services [3]), we accordingly exemplify some scenarios reflecting the LBS types as well as exhibiting dynamic collected efforts based on M-P2P.

We introduce an ambient shopping mall scenario to be a representative of ambient transaction services. The shopping mall scenario can easily be modified to act as ambient safety services. The information items distribution cooperation scenario then is considered as an exemplar of ambient information services. The cooperative peer group scenario then can be instantiated into ambient navigation and tracking services. As to the ambient location information acquisition scenario, it can be considered as an instance of ambient transaction services, ambient information services or ambient navigation and tracking services.

These applications differ from the past mobile e-services in addressing dynamic collected efforts between mobile users and dynamic interactions with ambient environments. The collective efforts of mobile users are not possible in the primal mobile services framework that deploys the services with the client/server architecture. Moreover, mobile devices in ambient e-services applications are very personal to the users, and thus the social contexts retained in the personal devices (e.g., the social relationships in the vicinity) can unfold the e-services of high complexity and security than that of no social contexts in sensor networks.

E-services with the social context environment render ambient e-services capable of providing the most appropriate collaborative power for mobile users anywhere whenever needed.

In the following subsections, each scenario will be detailed in terms of its motivation and promised value and the interaction structure.

3.1 Ambient Shopping Mall Scenario

In Figure 3, a picturesque view of the ambient shopping mall scenario is presented. In a shopping mall (fully equipped with wireless network infrastructures), information items (e.g., advertisement or sales promotion information) can be broadcast to passing-by peers with Info_BC_Station. This means the attained information items of a peer vary based on the peer's interactions with the shopping mall ambient environments.

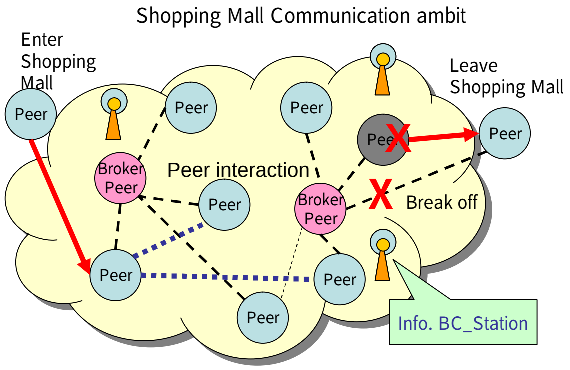


Figure 3. Ambient shopping mail scenario

The ambient e-service addressed in this scenario will be delineated for the case of new customers of high buyer perishability (entering the shopping mall and being in a rush to buy certain items without the knowledge of where to buy and how to buy cheap given relevant sales promotion). Those new customer peers carrying mobile devices can communicate with nearby peers when they just enter the shopping mall.

In such scenario, the goal of ambient shopping mall e-service is to provide a new channel for customers to get needed information. The assumption of this scenario is that the contents of information items kept in peers are different from one another based on their membership status. Mobile users will receive the information items based on their user context such as their preferences or membership data. Those members with higher loyalty points will get a higher discount e-coupon. This would encourage customers to join the membership program.

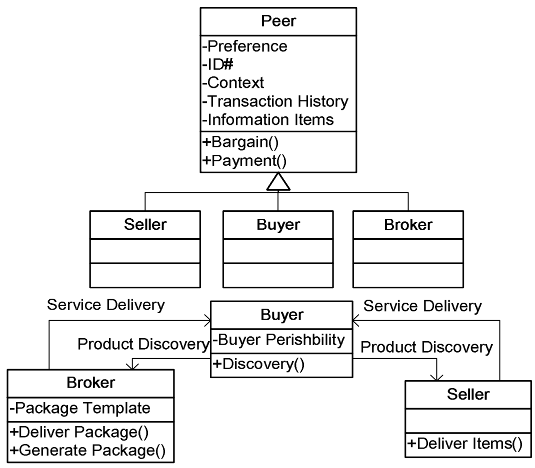
All mobile peers have their temporary peer ID number, preference, context data, transaction history and the information attained information items. Peers can do basic operations such as bargain and payment. Mobile peers can apply different role modules to do specific operations. There are the buyer module, the seller module and the broker module for mobile peers.

When a peer applies the seller module, it can respond a buyer's product discovery operation. If a seller peer has the information items that the buyer required, the seller then responds the buyer's request and starts a bargain operation with the buyer peer. After the payment process, the seller delivers the information items to the buyer. The operations performed by the buyer module are complementary to those performed by the seller module. But the buyer module has been designed not only to handle the transactions with seller module, but also to request the package service from the broker module.

The broker module is applied to those peers who will stay in the mall for a long time and own much complete information items. The broker module is designed for peers serving as service providers. The broker module has the 'generate' package, which can generate services of producing information items of the buyer's interests and preference. Package templates are used for the broker module to produce a service package in an easy way. Also, the broker module has the same ability as the seller module that can deliver the products.

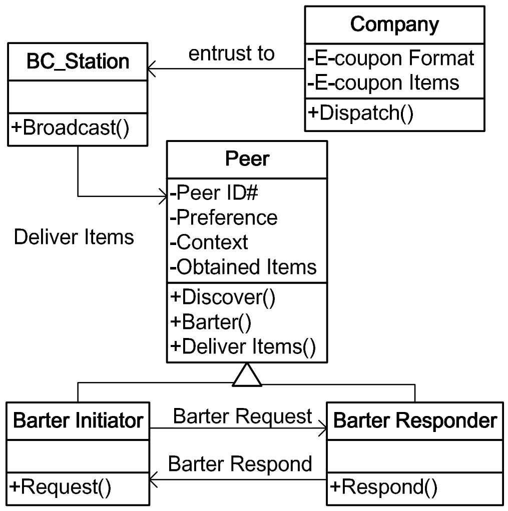
Although the effective reach is one of the shopping mall's goals. If the contents of information items are the same for everyone, both client/server and P2P designs can pass the items to the public but in different ways. However, mass broadcast like spam mails will annoy customers and thus be reluctant to join this shopping program, attaining the contrary results. When considering user differentiation, content differentiation will be in relation to user profiles and to ambient context sensors in the environment stack (that subsequently will involve social context and correlate to the privacy concerns of the customers). Those concerns make the P2P design is more applicable than the client/server architecture.

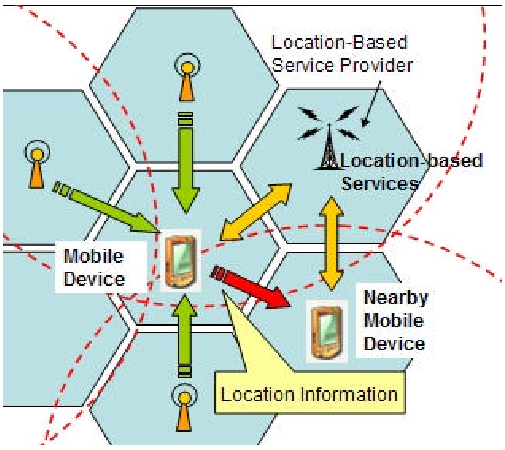
A UML class diagram is depicted (as shown in Figure 4) represents the relationships between the different modules as well as the peer module basic functions.

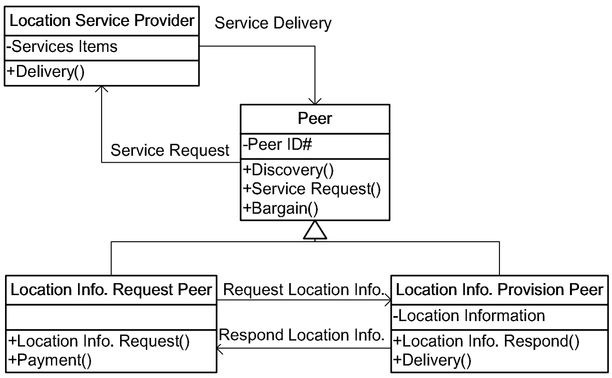


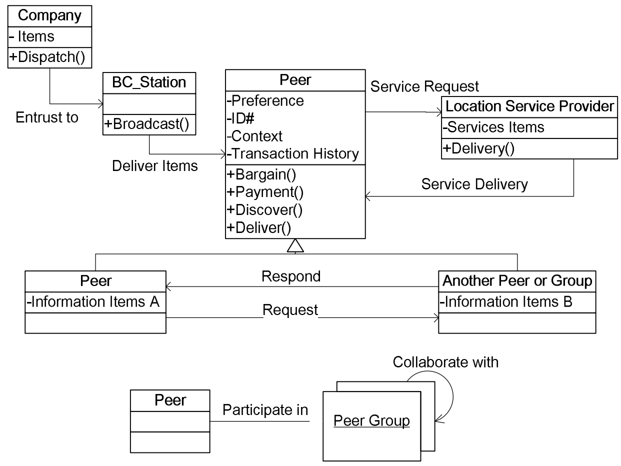
ambient e-service based on a mobile advertising infrastructure. Distributor companies can broadcast shops[1] advertisement items (e.g., e-coupons) through an ambient advertising infrastructure, which dispatches advertisement items relevance to their preferences to proximate users. In this scenario, e-coupons are considered as valuable information items. When a mobile user passes through a shop and wants to buy certain products but is short of the relevant e-coupons, the mobile peer can probe the surrounding environment to see if there are some nearby peers that own the desired e-coupons.

The P2P design combined with social awareness will make the connections not only in a rapid growth but also with persuasiveness, being more powerful than the client/server design. Moreover, as mentioned in Section 3.1 e-coupons become a valuable information item if the contents of information items are different. In this business model, mobile users can exchange their e-coupons, get some financial benefit, and be attracted to join the program so as to create a large scale of the participants. That is a win-win situation is created for both customers and the shops.









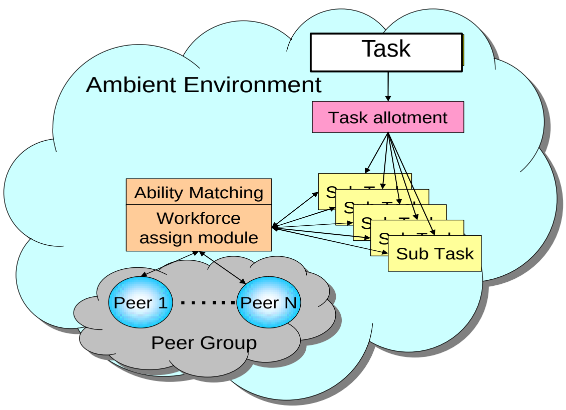
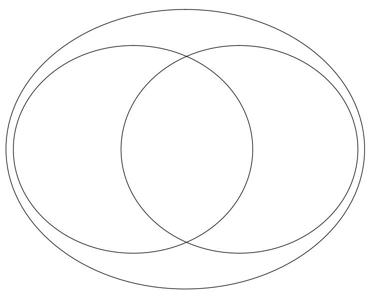


Figure 8. Cooperative peer group scenario



3.5 Ambient e-services Infrastructure

4.1 Trust, Reputation and Privacy Issues

Ambient e-services rest the focus on the interactions and collective efforts of the surrounding environments and nearby participating peers. However, in the ambient environments of ad-hoc networks, peers are not familiar with others. Not like the fixed Internet environment, there are no permanent databases of historical data that can be analyzed in the ambient environments. Accordingly, there exist no mechanisms for peers to trust each other in the ad-hoc network domain. However, before cooperating with other peers, peers need to guard themselves and seek who can be trusted based on the peers' reputations.

Privacy may have different meanings and significance to different mobile users. Privacy must be considered together with all other requirements-functionality, usability, performance, costs, security, and so on [6]. The privacy issue is not only important in the fixed Internet environment, but is even more important in the ambient environments.

The privacy concern is the barriers for mobile users join ambient e-services. When users are not feel safety for their sensitive data, they may not participant in such e-services. However, the more participants, the power of ambient e-services will provide. The social effort appears only when the number of the connections reaches above a certain threshold. This is the central problem for developing ambient e-services. Therefore, it is interesting to identify the privacy requirements for ambient e-services. Having decided the privacy issue for ambient e-services application, the interaction between reputation data and trust mechanism become meaningful. The semantic interactions of privacy, reputation and trust are depicted in Figure 11.

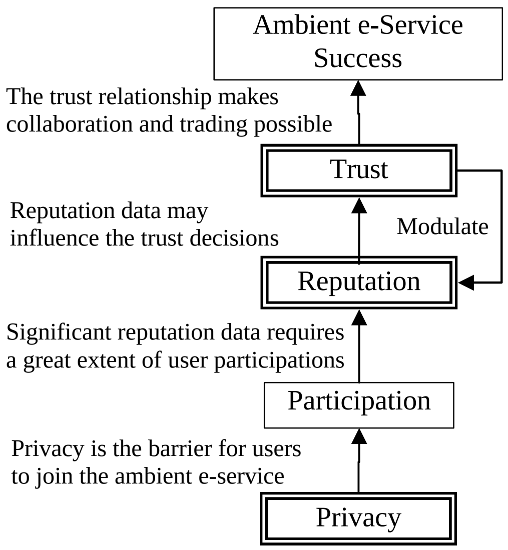


Figure 11. Semantic interactions of Privacy, Reputation and Trust

Many distributed trust management systems have been studied [5, 7, 9]. In a distributed trust system, reputation information is scattered among parties in the system. For instance, a distributed trust and reputation management framework for e-services was proposed to solve the trust issues in a distributed environment, a distributed broker-based architecture which gather enough information to make a confident judgment of the trustworthiness [5]. Nevertheless, this solution is so designed with the client/server architecture that the brokers and the users live with the fixed Internet. Although this system like the ambient framework, use the collective efforts of the broker peers to build up the trust and reputation management system. However, this may work in the fixed Internet; but it is not suitable for the ambient e-services environments. The rationale is two-fold.

First, peers in ambient environment form a dynamic organization structure. Not like in the fixed Internet environment, peers do not have permanent ID in the ambient environments. A peer enters an ambient environment ambit and gets a temporary peer ID with the technology of mobile identity management [10]. Lack of permanent identification ID, the trust and reputation data cannot be tracked as the framework mentioned. Accordingly, unlike the fixed Internet environment the trust and reputation information cannot be retained. Second, an ambient environment's setting is different form the fixed Internet. In the fixed Internet environment, all brokers can communicate with each other. But in ambient environments, due to peer connections are in a limited range, peers may only connect to the surrounding peers. That makes the framework not applicable to the ambient e-services environments.

In short, there exist distributed trust and reputation systems to provide methods for collecting participators' reputation information for e-services. Unfortunately, it does to suit for the ambient e-services environments due to the difference in environment architectures and design ideas. These challenges are still awaiting future research to counteract.

4.2 Social Issues and Economic Issues

With the advent development of trust, reputation and privacy control for safety of ambient e-services, the relevant social issues and economic issues can be subsequently investigated.

The ambient e-services will develop certain revolutionary business models, which definitely needs to be paid attention in this new ambient era. User interface and the usability of the ambient e-services are quite different from the primal mobile commerce that should also be concerned as a vital social issue awaiting future studies. Not only technical problems being barriers to ambient e-services implementation, the legal issues are also troublesome. How to protect intellectual property in the ambient e-services [11]? How to treat the ambient e-service taxation?

Regarding the economics issues, one of the most important issues is the pricing utility issue. The ambient e-services require several kinds of supporting infrastructures, such as sensor networks, wired/wireless network infrastructures, broadcast stations and the e-service application providers.

The ambient value is delivered with the combined efforts of the supporting infrastructures. Accordingly, how to price ambient e-services and how to divide the revenue between the infrastructure providers will become an important issue.

In certain ambient e-service scenarios, the pricing issue is regarded as the major problem. For example, in the ambient shopping mall scenario, a buyer peer requests information packages from a broker peer. How the broker peer price the service package for different buyer peers is an important issue. Based on the buyer's anxiousness and preference, the broker can provide the buyer several packages of services in different prices. The buyer can also bargain with different brokers before concluding a transaction. In the information items distribution cooperation scenario, mobile users may exchange their information items using the barter mechanism. When bartering with other peers, how to evaluate the value of certain information items and how to make a fair-trade agreement are also belonging to the pricing utility issue. Even for the ambient location information acquisition scenario, the mobile users who own the location information can be treated as sellers holding information valuable to nearby mobile users (who want to engage location-based services but do not have the ability to know the location information). Mobile users with the location information can also price the information items based on buyer's preference and anxiousness.

Besides the pricing issue for the ambient interactions, the issue also occurs to the network infrastructure utility rates rendered for ambient e-services providers.

In cases that the infrastructures are built by governments, different networking enterprises and different service providers, different vertical or horizontal relationships result in different pricing and revenue sharing strategies. In short, how to price the e-services and how to divide the revenues of e-services will unfold as an important problem when the ambient e-services industry forms. Accordingly, the pricing utility issue of ambient e-services is a major economic issue worthy of future intense research.

5. CONCLUSIONS AND FURTHER RESEARCH

In this paper, the notion of ambient e-services is defined to identify a new scope of mobile e-services, addressing dynamic collected efforts between mobile users (enabled by M-P2P), dynamic interactions with ambient environments (envisioned by LBS), and the moment of value (empowered by wireless technologies).

Ambient e-Services applications can be divided into two types. One is for the distributed trading; another is for the distributed collaboration. However, social context and significant rapid growth of connections enable by P2P are the two major incentives for applying ambient e-service to such revolutionary business models.

The paper also presents an ambient e-services framework characterizing three supporting stacks. The ambient value stack describes the value process in ambient environments. The ambient technology stack identifies the technology process to ensure connectivity and security in ambient interactions and cooperation between peers and then realize powerful collective efforts. The environment stack then represents the ambient basics for the collaborations.

We also exemplify several ambient e-service applications. Those applications differ from existing mobile e-services (grounded on client/server design) in terms of the focus of the dynamic interactions between peers in dynamic ambient e-service environments.

Finally, we identify a few future important research issues as follows: (a) trust, reputation and privacy control in ambient e-services environments, (b) pricing utility issues such as how to price the e-services and how to divide the revenues between the ambient e-services infrastructure providers (c) new business model in ambient e-service environments, (d) the taxation problem for ambient e-services (e) the intellectual property rights issues. Many of the traditional issues (such as QoS, fault tolerance, etc.) are also need to be revisited now that suitable solutions for the ambient e-service environments are desired.

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