ezBUSINESS – A NOVEL MOBILE BUSINESS APPLICATION ARCHITECTURE

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ABSTRACT
The upcoming mobile and ubiquitous computing world will need new forms of information sharing and services collaboration between mobile devices and wireless reachable application services to support mobile commerce. In this paper we present ezBusiness application architecture for mobile e-business in hybrid network environment. Six major components of the ezBusiness architecture are identified and the responsibility of each of them is addressed. A mobile commerce application called ezShop is built to demonstrate the validation of proposed ezBusiness architecture.

KEY WORDS
MANET, Ad Hoc Networks, and Mobile Commerce

1. Introduction
In recent years, E-commerce has tremendous growth under fixed-wire network architecture. Lately, equipped with powerful handheld devices and wireless communication technologies, new business-style applications under mobile environments have emerged beyond the horizontal line; we call this new business environment as mobile commerce or the m-Commerce. In the past few years, built upon wireless telecommunication network infrastructure, the m-Commerce has been in action and served consumers through their advanced cellular phones with larger network bandwidth. Basic internet surfing function and particular application services such as weather report and game download are provided by telecom companies and their corresponding content providing partners. However, emerged WLAN and MANET infrastructures augment the ways of doing mobile business online. Recently the trend of providing intercommunication capability between 3G (WCDMA)/GSM/GPRS and WLAN is getting a lot of attention than ever before. Consequently, mobile applications based on ad hoc network become an important development area [1]. Upon the newly visualized m-Commerce infrastructure, new business methodologies and process integration are required to provide more reliable, fast, convenient, and available services in terms of new mechanisms and designs for service discovery and delivery, service advertisement and promotion, service payment, service security, and user privacy.

Due to the radio transmission range constraint of ad hoc communication, services may not be directly acquired by mobile consumers in one radio hop distance; multi-hop peer-to-peer communication pattern is used to advertise and exchange service information between a service provider and a service consumer. To clarify what basic functionalities should be provided under a mobile business environment, we identify a number of necessary components to support m-Commerce applications
development in MANET and 3G wireless network. We call this architecture as ezBusiness.

Recently there is several research works contributed in this area. Konark [2] is a platform-independent framework. It provides an infrastructure to facilitate mobile application development. The Konark development framework is composed of two protocols: service discovery protocol (SDP) and service delivery protocol. Once a mobile device installs a SDP manager, this agent will act as a broker to discover application-required services. After discovering interested services, application can use service delivery protocol to learn how to submit correct parameters and invoke corresponding services. In [3] a development platform called Proem is reported. Proem has one low-level transport protocol and three high-level protocols. The two major components of the Proem application environment are the Proem Runtime System and the Peerlet Development Kit. The Proem runtime system is a virtual machine which has implemented four Proem proposed protocols in order to support and execute Peerlet-based applications that are developed with Java APIs defined in Peerlet development kit. The iClouds project is part of the Mundo (Mobile and Ubiquitous Networking via Distributed Overlays) [4] research activity. The main notion of iClouds is information sharing and information exchange on which peers dynamically form an ad hoc network. iClouds proposed two information exchange lists: iHave-List and iWish-List. Based on these two lists, four possible actions are defined between two ad hoc connected peers; they are standard search, advertise, active service inquiry and active search. In summary, Konark and Proem systems tried to develop new protocols and construct application development platform on top of them. Instead, iClouds project concentrates on possible information exchange forms and policies under mobile ad hoc network environment.

This paper is organized as follows. We first illustrate the architecture – ezBusiness in Section 2. In Section 3, ezShop, an application implementation based on ezBusiness architecture, is studied. Finally, conclusion is given in Section 4.

2. ezBusiness Application Architecture

ezBusiness architecture diagram is shown in Fig. 1. There are six components including service management, marketing policy management, transaction management, security management, communication management, and profile management. Each component contains several modules to support mobile application functionalities.

- **Service Management** manages services provided by mobile applications and services consumed by mobile device users. Based on the ad hoc network characteristics three modules, service access point manager, service control manager, and service content manager, are proposed here to help the potential need and future requirement of m-Commerce applications. Service access point manager allows mobile device users to manage all encountered service access points that can communicate with wireless mobile devices and provide all kinds of different services for potential mobilized customers. This function is similar to the URL bookmark management function of browser application. Besides managing wireless (and wired) service access points, service control manager provides schemes to limit resources a service can acquire to perform its task on a mobile device such as continuous execution time and memory usage. Service content manager controls or filters incoming service content or reply on a mobile device to prevent user been bothered by unwanted or non-useful information result.

- **Security Management** provides security supervision for m-Commerce applications. From m-Commerce application point of view two modules
are very important: data security policy manager and network transmission manager. Data security policy manager prevents important data in mobile device from being stolen by device intruder. Customized security policies can be specified via the manager to meet different security level requirements. Regarding to data security during (wireless or wired) network transmission period, network transmission manager is responsible to provide mechanism options and guarantee the data transmission security.

- **Transaction Management** controls the validation and success of a transaction task. Since data transaction among services or mobile devices will be one of the most important tasks and functions in m-Commerce applications, we propose two main modules, persistent session manger and atomic transaction manager, to perform related work. In order to maintain the current session between two transaction-executing parties, the existence of persistent session manager is necessary. Atomic transaction manager provisions transaction validation function and supervises the process of atomic transaction task.

- **Profile Management** is in charge of important user-related data. Personal information manager and potential interest manager are proposed modules in profile management component. Personal or private information of a mobile device user/owner is managed by personal information manager module. Critical personal data can even get encrypted first, before submitting it to be managed by this module. Personal information manager can also maintain other application-related personal information such as access or execution rights. Potential interest manager is responsible to manage mobile device user’s interested services or information. Mobile device users should provide their potential interests in advance and the information can be probed and utilized by services providers.

- **Marketing Policy Management** offers modules to deal with special marketing situation occurred in ad hoc network environment. Three modules cover different aspects are revealed here. They are discount bonus manager, policy manager, and advertisement manager, respectively. To encourage mobile device users providing his mobile device as a router or message relay station for other unnecessary and irrelative messages to broadcast through, some kind of benefit must be offered from service providers to mobile device users. Discount bonus manager provides the management capability of possible benefit such as discount coupons or bonus points for users. On the other hand, if service application running on a mobile device wants to promote its service to surrounding mobile device users, advertisement manager will become its must-have function module. Advertisement manager delivers advertisement messages with different formats and patterns based on device power consumption, network bandwidth condition, message forwarding algorithms and other dynamic factors such as the current number of reachable neighbors. Policy manager constructs both advertisement distribution policy and advertisement acceptance policy. Therefore, both service providers and service consumers need to equip policy manager module. Policies maintained in policy manager can be used to restrict advertisement functionality and recode current state of disseminated data, specify caching preferences like refresh rate and replacement strategy, and also describe advertisement preferences such as frequency, time-to-live, etc.

- **Communication Management** manages communication-related issues of an m-Commerce application in ad hoc network. We discuss two
modules in the communication management component: cost accounting manager and time usage manager. Upon the emerging m-Commerce infrastructure how to charge reasonable service fee is a very serious and interesting topic. Cost accounting manager and time usage manager can help this matter by calculating service cost via communication expense and the consuming time of a service execution.

3. Case Study – ezShop Implementation

The target consumer devices in ezBusiness architecture are handheld devices with mobile communication support in at least 100 meter radio transmission range. Based on the ezBusiness architecture we express the ezShop application which provides mobile consumers online shopping services via ad hoc wireless communication. In this case study, we assume two service providers, a bookstore and a music store, both of which have offered an online shopping website with wireless access capability implemented. Inside each application web server a promotion dissemination agent is executed to publish promotion messages such as services locations and discount coupons to pass by mobile consumers. The ezShop application is assumed to be installed in consumers’ mobile handheld devices. In ezShop application an advertisement controller is implemented based on our ezBusiness architecture. This controller gives the capability for each mobile device to exchange online advertisements when they encounter each other (two devices can listen to one another’s radio signal). To reflect current mobile device communication capability, we exclude multi-hop communication type in this case. All communication between two peers (a peer may either be a mobile device or a wired server embedded with wireless access point) is occurred directly with one hop radio transmission range. Laptop computers with 802.11b wireless network cards running in ad hoc mode are used as the mobile handheld devices in this application scenario. ezShop application is developed with J2SE toolkit.

Based on ezBusiness application architecture, ezShop has implemented the following core modules: service management, marketing policy management, profile management, and transaction management. We address modules with particular designs as follows.

- **Data communication and services description**
  To provide a generalized data format, we choose to use XML document, which is independent of any language, self-describing, extensible, and strongly typed, to describe services and advertisement messages. Furthermore, XML data will be packaged into a SOAP [5] message before transmitting between two connected peers. Based on WSDL [6], we define a service description language to express services characteristics. Considering resource-limited mobile devices, our service description language is much simplified in comparison with WSDL.

- **Push and catch services**
  In an m-Commerce environment mobile consumers/users may carry advertisement messages that they got from services providers or store vendors. After mobile device
users connected through ezShop application, a user can use push function in ezShop application to promote advertisement messages she carries to neighbor mobile peers. On the other hand, a user can send a catch request from her ezShop program to actively acquire interested promotion messages from her connected mobile peers. Usually in order to encourage consumers to exchange promotion information, advertisement providers will offer bonus credits or other forms of reward to consumers who spread or accept their advertisement messages. Fig. 2 shows a snapshot of ezShop peer-view window with push and catch function buttons.

![Fig. 2 A snapshot of push and catch buttons in ezShop peer-view window.](image)

- **Service content manager**
  Service content manager processes service advertisements and service request messages. Based on policies defined in the policy manager of marketing policy management component it decides whether to drop, or to propagate incoming messages, how to record current state of disseminated data, and what mechanism should be used to forward messages if necessary.

- **Profile management**
  A hierarchical advertisement management structure is adopted in the profile management module of ezShop application. Advertisement items are first divided into different categories (e.g., food, living, etc.). In each category items are further assigned into three predefined lists: iWish list, iHave list and iAdv list. Note that advertisement entries may appear in iHave list and iAdv list at the same time. An iWish list stores the description of user interested items. Advanced search service can utilize this information to automatically search through the iAdv lists of connected peers for a match. Instead, an iHave list holds advertisement messages either received from other peers or gotten from services/goods providers. An iAdv list gets the same message information as an iHave list adds one. However, messages in iAdv list are set to be distributed to other mobile peers whenever there is an ad hoc connection established. Advertisement message is preserved in an iAdv list until its predefined broadcast times are reached. Once a message in an iAdv list reaches its broadcast quota, the message is discarded from corresponding iAdv list.

- **Marketing policy management**
  The advertisement manager stores service advertisement data received from neighboring mobile devices into cache and performs management task. These advertisements describe services that are running on the neighboring nodes or promotion information from stores. The advertisement manager governs various management policies such as advertisement expiration, cache replacement strategy, and consumed cache size, been properly executed. Due to the dynamic nature of the ad hoc network topology, it is not feasible to guarantee that services found in the cache are currently reachable. Whenever there is a hit in the cache for a service that is not currently available, the cache entry will be immediately deleted.

  The policy manager is responsible for enforcing policies to control advertisement behavior between peers. Policies are specified by advertisement schemes. The manager ensures that all peers are in compliance with specified policies. In ezShop policies are used to restrict advertisement functionality, specify caching preferences such as refresh
rate and replacement strategy, describe advertisement preferences such as acceptance frequency and time-to-live duration, and define permitted dissemination algorithms for incoming advertisement and outgoing request messages.

The discount bonus manager maintains and stores earned credits from different vendors for the ezShop user. Once a store’s credits have reached the threshold for services or goods exchange, user can directly connect to corresponding stores to exchange services through the hybrid network environment. At the same time used credits will be deducted from user’s discount bonus manager.

4. Conclusion
In this paper we present ezBusiness architecture to support mobile business application development in hybrid network environment with ad-hoc wireless network (MANET), wireless network (with base stations) and fixed network. Six major building blocks of the ezBusiness architecture are identified and the responsibility of each of them is addressed. These identified modules could be implemented and deployed with a new m-Commerce service. In order to demonstrate the validation of proposed ezBusiness architecture, we build a mobile commerce services application called ezShop. ezShop contains several building blocks of ezBusiness to perform a particular advertisement promotion service for store vendors among wireless device holders located in an reasonable moving range area with mutual one-hop radio reachable distance.

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