

A Model for Context Aware Mobile Payment

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Abstract

With the advent of mobile networks and mobile devices, mobile payment has been attractive to many ecommerce users. Mobile environment features a wide range and an increasing number of access devices and network technologies. Context-aware content/service adaptation is deemed necessary to ensure best user experience. We developed an Adaptation Management Framework (AMF) Mobile Payment Service which manages the complexity of dynamic and autonomous mobile payment service. In this Framework, a personal assistant agent is presented for automatic and intelligent payment and a model is implemented for inference and making appropriate decisions. To evaluate the suggested framework, context data were collected from content providers and a mobile network operator. The obtained results confirm the efficiency of the method.

Keywords: Mobile payment, Personal assistant agent, Context aware system, Ontology, Context management

1 Introduction

Nowadays, using mobile services like mobile banking, mobile education, and mobile amusement are getting popular among users. As these services progress, they become more complex and hard to manage. It has been shown that users are unwilling to use complicated devices and only 16% of new inventions have been welcomed to the market [5].

Mobile Virtual Center of Excellence (MVCE) in a program named *Removing the Barriers to Ubiquitous Services* done in cooperation with seven universities from Britain and other twenty industrial supporters to perform researches toward hiding the complexity of ubiquitous services from the users' views [5]. In this program, existing barriers have been studied from three perspectives: user perspective, network perspective and service/content perspective. From the user view, the number of devices with different capabilities and a variety of technologies and services lead to complex applications [5]. A solution to solve the problem of the complexity is to use the personal assistant agent. The main purpose of personal assistant agent is to hide the complexity of mobile features which make the user's environment complex [6], [13], [14], [18], [22]-[26], [29]. The dominant approach to develop a personal assistant agent is based on context-aware techniques [1]-[4]. The context is any information through which the status of entities can be explained. In this explanation, an entity is an individual, a location or any object related to the interactions between the user and the application. In ubiquitous environments, context can be explained as a collection of personal information and user's needs his present activities plus information by considering environmental and physical conditions [15].

Electronic payment is one of the most prominent and demanding application of mobile services. It is complex due to the variety in methods of payment, cryptographic needs, amount of transaction, latency of transactions, minimal and maximal amount for the cost of the transaction, and diverse involvement of financial institutions. Previous researches have suggested a model for mobile services and contents by using context information but so far no research has been done for adaptation of mobile payment service by using context information [8]-[10].

In this paper, a personal assistant agent framework has been proposed to hide all the complexities of mobile payment services from users and automatically looks after the activities related to the personal's mobile payment. In continuation, section 2 deals with context aware mobile payment and related works, section 3 discusses Adaptation Management Framework for mobile payment services, section 4 discusses the evaluation of the proposed framework, and finally there is a conclusion of the research.

2 Background

The money a person pays while using mobile devices include the following:

1. Call costs (domestic or roaming)
2. Digital content purchase cost: such as music, video, news, mobile ring tones, online game subscription, wallpapers, etc.
3. Costs for using services such as using the internet through mobile devices
4. Costs of buying hard goods like books, magazines, cinema tickets, etc.
5. Costs for transportation affairs like bus or subway fare or car park fees.

To fulfill any of the above payments automatically, the personal assistant agent needs to be aware of the context information effective in mobile payment. The influential context information in call cost consists of following: day of week (weekdays or weekends), time of day (peak or off –peak), special events like discount in call cost because of new years, location like discount if contact is from special place or discount in roaming fee in some countries, membership in group, kind of SIM card (pre- paid or post-paid), recharge option of SIM card or bill, the sort of mobile operator in case of roaming.

Influential context information in digital content purchase or using services consist of following: special event like discount in call cost because of new year's event, weather conditions, location, time of calling ,membership in group, digital content being advertised and so on, for example a news content provider may have variety of price tariffs for access to news in different places on the basis of weather conditions and different week days and whether or not the user is shown ads together with the news. By considering the cost of using services, for example, if the service provider is a shop owner, offering internet service within the shop to customers, three price tariffs are considered for the users. If the person is near the shop and visiting the shop portal, the internet is free of charge. If the person is near the shop and visiting other Web pages, a part of the fee is paid by the service provider and in case the person is outside the shop, the entire fee is to be paid by the person.

Context information effective in physical goods consists of two parts: context information effective in goods price and context information effective in selection of payment method. Context information effective in goods price and seller's selection includes the following cases: free transportation fares or offering discount by the seller, packing cost, tax and customs duties, seller's credit, delivery duration, offering discounts for shipping multiple items in one order, etc.

Influential context information which is crucial in selecting method of payment includes: order amount, user's preferences e.g. payer anonymity, the period of transaction (micro-payment should be fast), involvement of financial institutions and the amount of money they get as commission, seller's preferences for example offering discount if payment is done in special manner, the status of credit card, the capabilities that mobile network operator offers, security requirements, device specifications, payment time (pre-paid, pay-now system, post payment), the characteristics of issuer bank and acquirer bank and so on.

Influential context information which is crucial in selecting transportation fares payment method consists of the following parts: location, time, device specifications, issuer bank specifications, and the capabilities that mobile network operator offers and so on. After the determination of context information, it should be modeled and then reasoning should be made.

According to Linehan and Tsang, a context aware system should do the following processes: Gathering, Administration, and Adaptation [20].

(1) Gathering: in this stage, information is collected from the environment and consists of the following parts: Discovery and Registration, Communication, Acquisition, Data Formatting.

(2) Administration: context aware application systems get different kinds of information from different sources. After receiving, the information should be interpreted, manipulated and stored. A collection of these processes is called context administration. Context administration consists of the following parts:

Aggregation: this process includes managing uncertainty in the context information. The following sub processes should be done for aggregation: filtering, reasoning, augmentation. Reasoning the context data is carried out by using several logic-based methods such as first order logic, temporal logic, description logic, higher order logic, fuzzy logic, and learning techniques like Bayesian networks, neural networks.

Modeling: Context modeling shows the way of saving context information, formatting the exchange of data. Context modeling is done in various ways. Seven of which are supported by current context-aware infra-structures. These methods are as follows: graphical, logic-based, ontological, object-oriented, tuple-based, hierarchical and geometric. Among them, ontology is the most appropriate.

(3) Adaptation: Many of the context aware infrastructures only provide functions for Gathering and Administration with Adaptation functionality delegated to the application itself. Infrastructures that do provide adaptation functionality usually do so either by providing support for Rules or for Machine Learning algorithms [20].

2.1 Related Work

Borman and Flake have shown a context aware service discovery system for advice of charge service, for example when you go on a trip to abroad, you can see different mobile network operators which are different in their fees. By using context aware advice of charge service the rating and charging engine introduces the best and most useful mobile network operator to the user. The user can easily send his/her preferences which can be the most inexpensive mobile network operator or a service with a higher band width to the rating and charging engine. Then on the basis of the user's preferences and other context information like time, location and so on. The system sends the user the best mobile network operator [7].

Mobile networks consist of three kinds of business roles: the mobile network operator, service provider and content provider. The mobile network operators have the network equipment and infrastructures. In Local Mobile Services (LOMS) project a pricing model is offered to service or content providers on the basis of which the providers take the cost of using the service or content on the basis of different contexts like location, weather and user preferences into consideration [8]-[10].

Lukkari and Korhonen have established a smart restaurant with the capability of mobile payment in a context aware environment. The Web service of this smart restaurant is installed on a host and then users are connected to this Web service through their mobile devices and they can determine the time of their food delivery. In this restaurant, payment relies on the time and location [19].

Automating the payment process in the supply chain leads to the optimization and promotion of efficiency of the entire supply chain. Zamani and Bayat have offered software architecture for context aware payment for supply chain [31].

3 Adaptation Management Framework for Mobile Payment Service

Adaptation Management Framework (AMF) is a server and it is located as an interface between user's environment, service and content providers, bank and mobile network operator. The purpose of AMF is hiding the complexities of user's environment in mobile payment service. Figure 1 shows the AMF which consist of two parts: Payment Manager and Adaptation Manager. The functions of these two parts will be explained later. Different mobile payment methods supported within the Adaptation Management consist of the following cases:

1. Payment via Visa card or Master card using SMS
2. Payment via Americans Express, Diner Club or Discover credit cards through SMS
3. Payment via Visa card or Master card through WAP technology
4. Payment via American Express, Diner Club or Discover credit cards through WAP technology
5. Payment via debit card through WAP technology
6. Payment via debit card through SMS technology
7. Payment via billing through mobile phone
8. Payment via electronic cash stored in mobile application (limiting online electronic cash and having an intermediate company)

In this framework different payment methods are suggested, for example the difference between credit cards and debit cards is that in credit cards people can go to the expense of what they want more than their cash or money they really have and they can pay the rest of their debts in installment to the end of the month. The situation depends on people's status, you may have no money in your bank account but you want to use your credit. The difference between Visa card and Master card with American Express, Dinner Club or Discover credit card is that in these cards people have to pay their entire debts by the end of the month but in Visa card or Master card people can pay their debts in several installments. It depends on people's financial status.

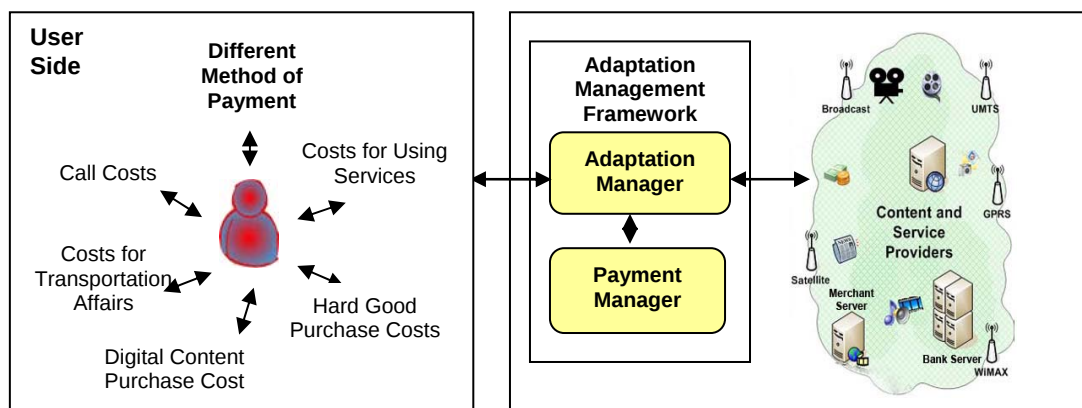


Figure 1: General Architecture of Adaptation Management Framework

3.1 Adaptation Manager

The function of Adaptation Manager is modeling and reasoning context information to choose the best method of payment. When PAA send information such as user's preferences, location and so on through wireless communications to Adaptation Manager, first of all the Adaptation Manager model the context information and then reasoning them. For the system components to have a mutual understanding of the context elements and be able to cooperate, ontology has been used in context modeling. Context modeling and reasoning both have a leading role in context aware system. Web Ontology Language (OWL) has been used for context modeling and Semantic Web Rule Language (SWRL) has been used for reasoning context information and representing first order logic-bases rules. SWRL rules are integrated with Web ontology language. Figure 2 shows the internal structure of Adaptation Manager.

According to figure 2, the work method of Adaptation Manager is as follows: first the Context Acquisition gets the context information from the personal assistant agent, database and mobile network (for user location). SWRL Jess Bridge is used to change Web Ontology Language (OWL) to JESS. Then JESS inference engine starts to infer the context information (Site 1). The best method of payment is selected by JESS inference engine and it is sent to the Payment Manager in an OWL file. The Payment Manager has been implemented in Java and Jade agent platform. In Java for communicating with OWL ontology we must use Jena library (Site 2). Protégé has been used to implement context modeling and for inference (Site 3).

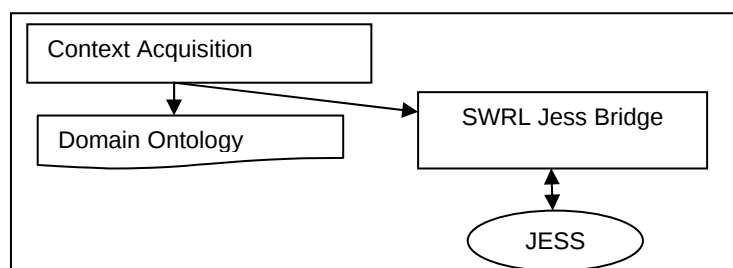


Figure 2: The Internal Structure of Adaptation Manager

3.2 Payment Manager

Purchase has got six stages: 1- need identification, 2- product brokering 3- merchant brokering, 4- negotiation, 5-purchase (payment) & delivery, 6- product service and evaluation [16]. Web search methods for goods and negotiation to get the best price have been considered in many research activities [12], [21], [27], [28], [30]. These research agent technologies have often been used, since in automating a process, intelligence is needed. Without automating of payment, the whole process will not become automatic. By considering different method of payment which is available for buyers, there is a need for intelligence so that the best payment method is selected. Payment Manager has been created from the integration of multi agent systems and mobile agent's technology and uses these agents to carry out payment process. Information agent, strategy agent and negotiation agent perform pre-payment activities. These mobile agents wait for the Payment Manager to send the tasks. After the negotiation stage, the Payment Manager loads the financial agent to perform the payment related operations. In figure 3 you can see the multi agent structure of Payment Manager. PAA is available on mobile devices and send the user information such as user preferences and user location through wireless communication to Adaptation Manager.

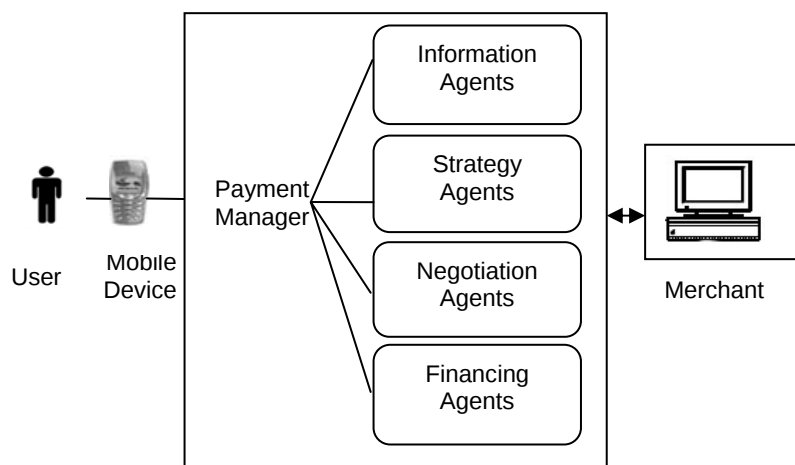


Figure 3: Multi Agent structure of Payment Manager

After the negotiation agent announces the termination of its operations, the Payment Manager announces the start of the payment operation to the financial agent. Payment method includes payment agents through credit card, payment through electronic cash and payment through billing. Figure 4 shows the structure of financial agent. As we explained above the best method of payment is selected by Adaptation Manager and then it is sent to Payment Manager, then the agent of payment method is selected and the process of payment is done automatically.

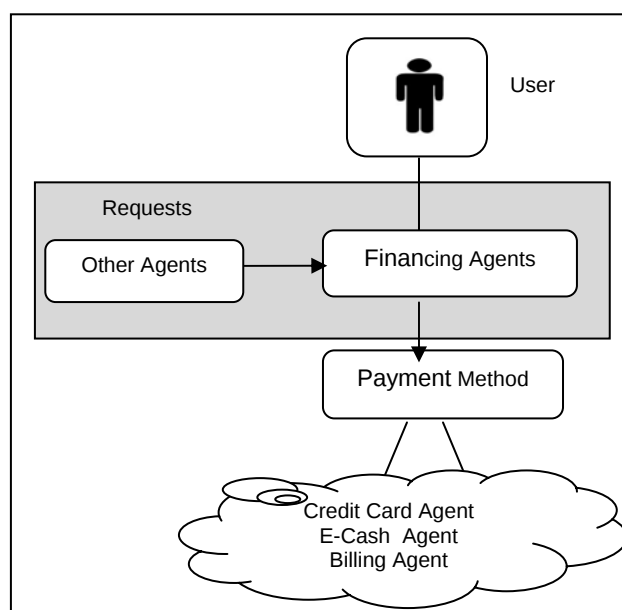


Figure 4: The Structure of Financial Agent

3.3 Context Aware Application

In the context aware application which is installed on the mobile device, you can find a possibility of planning for call costs in addition to purchase of items and digital content. Planning for call cost is performed through modeling user profile and other context information influence the call cost and then reasons the context information when the user chooses a certain option, the personal assistant agent sends the user's option to the Adaptation Manager by using wireless communication. In figure 5 you can see the relationship between the different parts of suggested model.

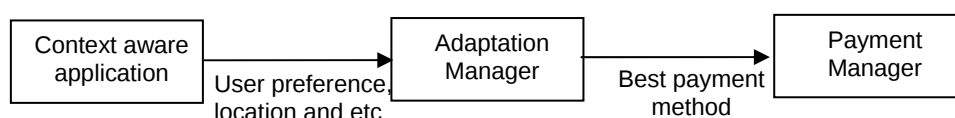


Figure 5: Relationship between the Different Parts of Suggested Model



Figure 6: Context aware application

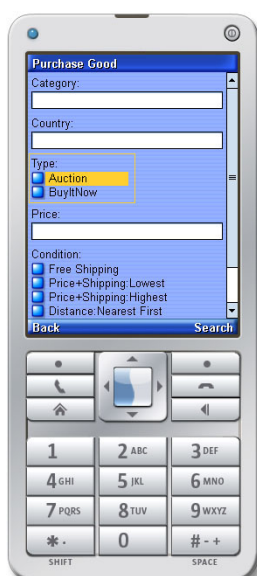


Figure 7: Purchase Good

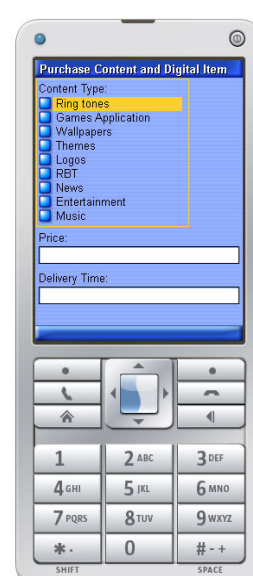


Figure 8: Purchase Content and Digital Item

Context aware application is made up of the following parts: purchase good, purchase content and digital item, transportation fare, parking fee, planned phone call. Figures 6 to 8 are demos of this program. Figure 6 shows the main menu of application. Figure 7 shows the context information which is influential in buying items, such as free transportation fares or offering discount by the seller, packing cost, tax and customs duties, seller's credit, delivery duration, offering discount for shipping multiple items in one order. User can choose his/her favorite options. Figure 8 shows the type of content which the user is willing to buy along with influential context information in buying content. After choosing the option by user, this information will be sent by PAA to Adaptation Manager.

3.4 General Architecture of the System

When deploying agents on mobile devices, a number of constraints must be taken into account. These constraints are related to the limitations of the devices. The limited properties supported by the Java Virtual Machines on these devices. It is possible to run JADE agents on MIDP-enabled mobile devices with the LEAP add-on component. JADE-LEAP exists in three different ways corresponding to the three main types of Java environments found on the devices considered:

- J2SE: to execute JADE-LEAP on PCs and servers in the fixed network running JDK
- PJava: to execute JADE-LEAP on hand-held devices supporting J2ME CDC
- MIDP: to execute JADE-LEAP on hand-held devices supporting MIDP [11]

In figure 9 you can clearly see the general architecture of the system. This model has got several parts. The first one is the application which is installed on mobile device. The JADE-LEAP (J2SE) has been installed on the central server. The main container, the Adaptation Manager and the Payment Manager are on this server. Other containers are in the bank server, seller server and etc. AMF includes two main parts: Payment Manager and Adaptation Manager. These two parts are installed on central server. The application which is installed on user's mobile device communicates with central server through wireless communications [11].

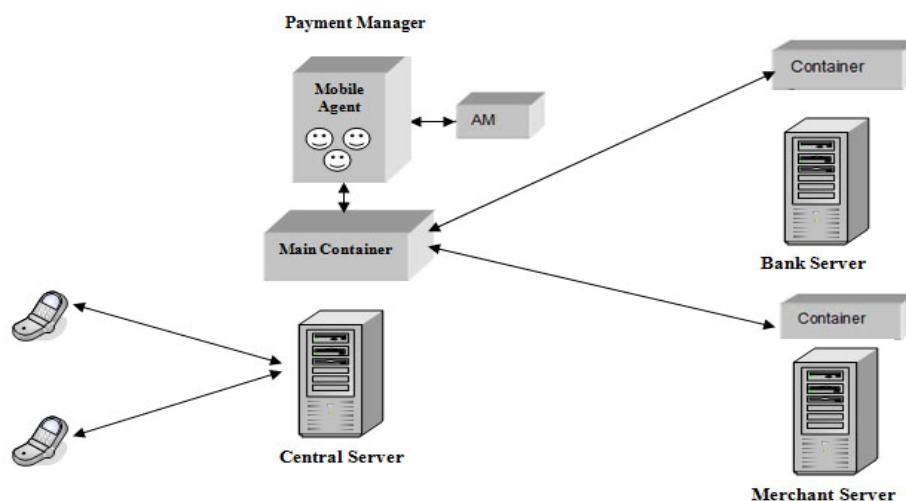


Figure 9: The General Architecture of the System [11]

3.5 Security

Security needs of a payment system are divided into five groups: payment authentication, payment authorization, payment integrity, payment confidentiality and nonrepudiation of payment transaction. Security services are the most essential needs of any payment system so security is so vital that without it the system cannot provide its services appropriately [17].

To implement security, we can use asymmetric and symmetric encoding algorithms. Symmetric encoding algorithms cannot support nonrepudiation of payment transaction and it has got some problems so in this model asymmetric encoding algorithms have been used [17]. The Java™ Cryptography Extension (JCE) offers a framework and implementations for encryption, key generation and key agreement, and Message Authentication Code (MAC) algorithms. Support for encryption includes symmetric, asymmetric, block, and stream ciphers. By using APIs which are provided by JCE data is encoded and sent on wireless network (Site 4).

4 Evaluation

To test and evaluate the suggested framework different kind of data should be given to system. The data consists of:

- 1-data related to different goods with their price, seller's characteristics and sale's conditions.
- 2-data related to content and service providers with their different conditions.
- 3-data related to the call cost of mobile network operator.

Group		
ID	Group Name	Member
1	Football Fan club	Esteghlal Tehran
2	Football Fan club	Foolad
3	Football Fan club	Malavan
4	Football Fan club	Naft Tehran
5	Football Fan club	PAS
6	Football Fan club	Paykan
7	Football Fan club	Persepolis
8	University Community	Amir Kabir University
9	University Community	K.N Toosi University
10	University Community	IAU Central Tehran Branch
11	University Community	Shahid Beheshti University
12	University Community	Tarbiat Modares University
13	University Community	University of Science and Technology
14	University Community	University of tehran

Figure 10: Group Table

Time		
ID	Type	Description
1	Day of week	weekdays
2	Day of week	weekends
3	Time of day	Peak
4	Time of day	Off Peak
5	Event	Promotion-Autumn Festival
6	Event	Promotion-Spring Festival
7	Event	Promotion-Summer Festival
8	Event	Promotion-Winter Festival
9	Event	Religious-Compassion from Irancell to People with Disabilities
10	Event	Religious-Haj
11	Event	Religious-Shaban

Figure 11: Time Table

Mobile Network Operator						
Il	Country	Mobile Network Operator	Local Calls :Peak	Local Calls:Off Peak	Call to Iran:Peak	Call to Iran:Off Peak
1	India	Bharti Cellular - Airtel	91.43	91.43	135.44	135.44
2	India	BPL Mobile Cellular	59.73	59.73	135.44	135.44
3	India	Hutch (Fascel)	59.73	59.73	135.44	135.44
4	Jordan	FastLink	0.71	0.71	1.51	1.21
5	Jordan	MobilCom	0.5	0.5	1.21	1.21
6	Netherlands	KPN	0.76	0.22	3.07	2.25
7	Netherlands	Orange	0.61	0.61	0.98	0.98
8	Netherlands	Telfort (O2)	0.55	0.55	2.32	2.32
9	Netherlands	T-Mobile	0.55	0.55	1.08	1.08
10	Netherlands	Vodafone	0.73	0.22	1.8	1.17

Figure 12: Mobile Network Operator Table

Goods									
Goods	Categor	SellerID	Seller Credit	Price	Free Ship	Packing Cost	Discount	Amount for multiple items	Discount for multipl
Polaroid	Cameras	7515	100%	84\$	☒	No	Visa	> 100 \$	5%
Polaroid	Cameras	1224	95%	80\$	☐	No	--		
Polaroid	Cameras	324	100%	90\$	☒	Yes	--	> 200 \$	8%
Polaroid	Cameras	1192	98%	110\$	☐	No	Amex		
Polaroid	Cameras	1245	97%	87\$	☒	Yes	Master		
Polaroid	Cameras	234	100%	82\$	☐	No	--		
Polaroid	Camera	678	97%	102\$	☒	No	--	> 300\$	3%

Figure 13: Hard Goods Table

The context information from IranCell mobile network operator (Figures 11 and 12), Tebyan and Beep content and service providers (Figure 10) and sellable goods on electronic auction sites (Figure 13) have been collected and stored in database then the database was given to the system as the context source.

PersonID ▾	Total Value ▾	Visa/ Master ▾	Amex/diner club/ discover ▾	Debit card ▾	Ecash ▾	Device tools ▾	Bank Facilities ▾
145	9000\$	6000\$	2000\$	400\$	600\$	SMS/WAP	SMS/WAP
146	5000\$	--	4000\$	1000\$	--	SMS/WAP	SMS/WAP
147	7000\$	5000\$	1000\$	1000\$	--	SMS/WAP	SMS/WAP

Figure 14: User Account Table

According to figure 14 several users' data is given to the system, for example a user with PersonID=145 wants to buy Polaroid digital camera. According to figure 13 we can see that 7 sellers sell this kind of camera with different conditions. The first seller with 100% credibility sells this camera for 84\$. Transportation and packing cost is free. If the payment is done through Visa card a discount will be offered. The first seller will also offer discount in the case of buying more than 100\$. The suggested model chooses sellerID=7515 as seller and the best method of payment for this user is Visa card. The seller with sellerID=1224 sells this product for 80\$ but transportation cost should be paid by user and seller credibility is about 95%.

5 Conclusion

In order to keep the existing customers and to attract new customers, mobile network operators offer new services and encouraging plans. However, to become aware of any new facilities, the users should visit the operator's Web site regularly so that they can make a plan for the method with the lowest price according to the context information. The context information effective in the mobile payment is enormous and is changing every day. Users are not interested in this volume of information. In this article, a framework has been offered for the management of complexities related to mobile payment so that the best solution is found with regard to all context information using personal assistant agent.

One of the services common in the mobile communication services is mobile commerce which includes mobile banking, mobile payment, mobile auction, mobile marketing, mobile content purchase, location-based services and information services. Mobile commerce services are very varied and have many complexities. The improvement of suggested framework and adding capability to it, for managing the complexity of mobile commerce services, improves the efficiency of offered model and increases its usage.

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<http://www.jessrules.com>

Site 2: HP Labs and Open Source Community: Jena Semantic Web Library, available online at:

<http://www.sf.net/>

Site 3: Stanford University: Protégé Ontology Editor, available online at:

<http://protege.stanford.edu/>

Site 4: Java™ Cryptography Extension (JCE) Reference Guide, available online at:

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