Exploring adoption of NetPay micro-payment: A simulation approach

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***Abstract*—with advances in technology sellers offer traditional goods and services on the internet. The payment systems developed for this reason was based on the credit cards or debit cards. Card providers charge sellers some amount based on the transactions. Therefore for some products or services with the low price, the charged amount is very high and not profitable for the sellers. For this reason, new payment systems are developed for transaction with low amount of money known as micropayments. These new systems are compared with traditional payment systems like credit cards and debit cards. One of the advantages of these new systems than credit cards is they are suitable for micro amount payment, E.g., reading online newspapers. These new systems cost lower than credit cards for vendors. Although many merchants still use traditional payments for micro payments but most of vendors recommend micropayment systems to customers. NetPay is one of the micro-payment systems. In this paper we evaluate the adoption of netpay micro-payment system through diffusion of innovation theory with simulation and mathematical approach.**

Keywords-micropayment, netpay, the diffusion of innovation theory, simulation

I. INTRODUCTION

Credit cards have become one of the most popular payments in online environments. This popularity of credit cards and wide usage of them is because of many benefits of credit cards like availability, convenience of usage and payment after buying. These macro payment systems such as credit cards are not suitable for high–volume, low-cost transactions, such as reading newspapers. These macro-payment technologies suffer from heavy-weight encryption and reliance on always online and slow response authorization servers [1]. Although existing macro-payment systems are suitable for most purchases but their transaction costs are too high to be profitable in micropayment transactions [2].

Mobile payments and other payment systems such as NetPay, CyberCash, DigiCash, First Virtual, Millicent, MPay, NetBill, and PayWord have been suggested as a solution to facilitate micropayments in electronic payments. Specially, NetPay offers payments with transaction costs as low as 1 cent to 1% of transaction amount [1]. Instead, in percentage terms, credit card companies charge about 2 to 6% of transaction amount from the seller [3].

While sellers benefit more in micropayment systems, they recommend their customers using these payment systems instead of macro-payment systems such as credit cards. But most of customers use the macro-payment systems for paying micropayments. Therefore we need to assess the adoption of these new payment systems.

In this paper we evaluate the adoption of micropayment systems especially NetPay using diffusion of innovation. The diffusion of innovation theory determines five innovation characteristics that affect adoption: relative advantage, complexity, compatibility, trialability, and observability [4]. Many researches in adoption of mobile payments and micropayment systems evaluate user adoption regarding to diffusion of innovation but most of them used surveys upon it. In this paper we use mathematical approach to evaluate adoption of NetPay micropayment systems. In this way we evaluate two factors of diffusion of innovation theory. First, relative advantage of NetPay micropayment based on the performance of the system, effectiveness and time saving in comparison with macro-payment systems such as credit cards, second, cost evaluation regarding to benefit of the seller in NetPay micropayments and credit card macro-payments.

The rest of this paper is organized as follows, section 2 reviews the literature about adoption models in information technology especially diffusion of innovation and NetPay. Section 3 represents mathematical models for two factors of relative advantage and cost. Section 4 concludes with some implications and direction for future research.

II. LITERATURE REVIEW

A. Adoption models

A number of research models have been introduced to explain e-payment adoption and users' behavior. TAM is one of the first research models to explain users' IT adoption behavior [5]. The TAM has been recognized as a useful model of technology acceptance behaviors in a variety of IT contexts. The fundamental rationale of the TAM is that IT users act rationally when they decide to use an IT [6]. The TAM evaluates two critical factors in adoption, first, perceived usefulness, second, perceived ease of use of the system. These two factors have direct impact on the adoption of new technologies by users. TAM is one of the most influential extensions of Ajzen and Fishbein's theory of reasoned action (TRA) in the literature. It was developed by Fred Davis and Richard Bagozzi [5, 7].

UTAUT [8] proposes four key constructs – performance expectancy, effort expectancy, social influence, and facilitating conditions as direct determinants of usage adoption and behavior. The TAM's perceived usefulness and performance expectancy in UTAUT are the same. Performance expectancy is defined as "the degree to which an individual believes that using the system will help him/her to achieve gains in job performance." The TAM's perceived ease of use is as same as UTAUT's effort expectancy which means "the degree of ease associated with the use of the system." Unlike TAM, UTAUT introduces moderating constructs such as gender, age, experience, and voluntariness of use which are posited to moderate the impact of the four key constructs on usage intention and behavior.

The diffusion of innovation theory evaluates 5 factors consist of relative advantage, complexity, compatibility, trialability, and observability. The diffusion of innovation theory has been widely used to evaluate the adoption of information systems and mobile payments. The reason of using this theory for evaluating the adoption of NetPay micropayment systems is the difference between this theory and TAM model. TAM was developed to predict user acceptance of information systems within organizations, but in the diffusion of innovation theory subjects are consumers, not organizational users [9].

B. NetPay

NetPay is one of the micropayment systems that used electronic coins (e-coins) encoded as a payword chain of elements encrypted by fast one-way hash functions. The NetPay protocol shifts the communication traffic bottleneck from a broker and distributes it among the vendors by using transferable e-coin Touchstones and Indexes [1]. Customers are prevented from double spending as the index of the payword chain indicates the balance of customer's e-wallet, and the touchstone can be used to verify the payword chain has not been tampered with [10].

Macro-payment systems are not suitable for every transaction on the internet. Assume a situation that a customer wants to view a small portion of information or service on the internet, or wants to download a song or clip-art and only pay a small amount of money e.g., 1c, 2c, 10c or 20c. Macro-payment systems such as credit cards have slow authentication servers and also they charge the vendor some percent of the transaction amount but the transaction amount here is very low therefore, it is not profitable for the vendor to use such systems. Regarding to these limitations of the macro-payment systems there was a need for systems that have these elements as listed below [11, 12, 13, 14]:

- Ease of use for customers
- Security of electronic coins (e-coins) from fraud
- Ideally anonymous like traditional cash- the vendor has no idea who the customer is.
- Vendor-transferable e-coins allowing customers to buy coins from a broker and spend at many different e-commerce sites.
- Offline processing of payments, i.e., no online bank authorization server needed by vendor.

III. ADOPTION OF NETPAY MICROPAYMENT

In this section we will evaluate adoption of NetPay by diffusion of innovation theory. This theory consists of five factors- relative advantage, compatibility, complexity, costs, network externalities and critical mass, security and trust, and use situation [8]. In this paper we just evaluate the relative advantage with simulation model and costs with mathematical approach.

A. Relative advantage of NetPay micropayment system

In past researches about information system adoption, where adoption were studied in the organizational context, the relative advantage factor has consisted of performance measures such as performance increase, effectiveness, and time savings [5, 15]. To evaluate the effectiveness of the NetPay system we must compare it with other payment system e.g., credit card that is a macro-payment system. For this reason we need some evaluation criteria as listed below:

- Response time- measures how long it takes for a page to be returned from the vendor site.
- Server CPU time- measures the time spent in the vendor's server debiting NetPay e-coins.

Dai et al. evaluates response time and server CPU usage with prototypes of newspaper websites for three systems: client-side NetPay, server-side NetPay and credit card system. The outputs of this prototype are shown in the table 1. Although, the response time is dependent on a number of factors, some of which cannot be controlled such as number of users accessing the internet, but primarily depends on the bandwidth of the ISP's connection to the internet and the performance of the web server hardware and software. It also depends on the page weight of the site's pages which depends on the number and complexity of images and animations [16].

TABLE I. PROTOTYPE PERFORMANCE

System	Response Delay Time	Server NetPay CPU Time Usage
Credit card	16ms	-
Server-side NetPay	80ms	64ms
Client-side NetPay	950ms	-

First we must understand the NetPay model and how it works and then simulate and evaluate it. For this reason we imagine two NetPay models (client-side and server-side) and then simulate the performance.

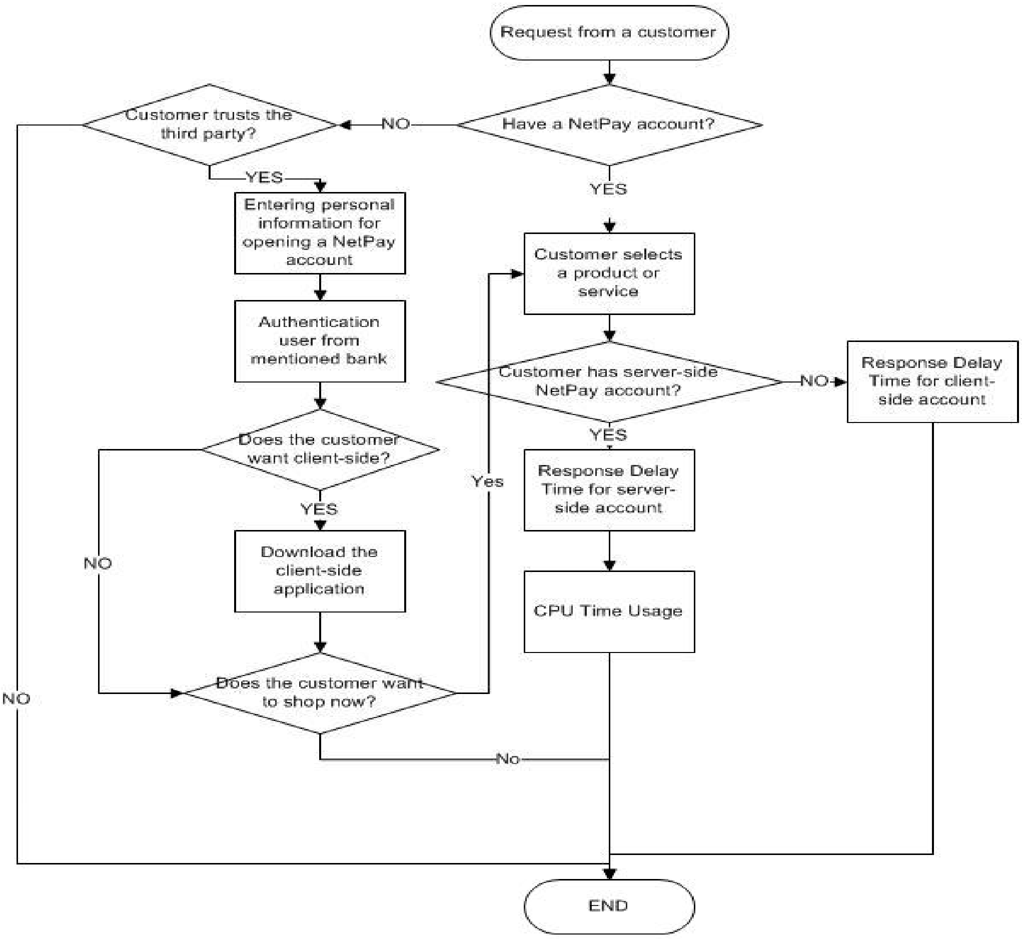

Figure 1. NetPay logic model

We used Arena simulation software. Figure 1 shows the NetPay logic in the simulation. Each process in the logic model will consume time. We evaluate these times by generating random numbers based on the real world actions. We generate some random numbers and fit them with statistical algorithms. The results of the estimated times for each process is represented in table 2. In figure 1, requests are arrived in the system randomly in every 1 minute. Then the requests are processed whether they have NetPay account or not. We assume that half of the requests have the NetPay account. If they have a NetPay account then the customer should select the product or service he wants to pay for it. This selection takes time and also the resource of the system, e.g. database of the website. The resource of this process will be released after a request lefts the process. We evaluate the process time BETA(0.988, 1.1) as mentioned in the table 2. Then the system checks whether the customer has server-side NetPay account or the Client-side. Again we assume that half of the requests have server-side account. If the request is server-side we evaluate two processes of response time and CPU usage time based on the table 1. If the requests are client-side we evaluate only the response time process based on the table1. Based on these two situations requests are done and will leave the system.

TABLE II. PROCESSES STATISTICAL ALGORITHMS FOR NETPAY MODEL

Entry	**Prompt**		
	Allocation	***Delay Time***	***Units***
Selecting product or service	Value added	BETA(0.988, 1.1)	Minutes
entering account information	Value added	BETA(0.893, 1.08)	Minutes
authentication user through bank	Value added	BETA(0.893, 1.08)	Minutes
download application	Value added	NORM(4.12, 1.16)	Minutes

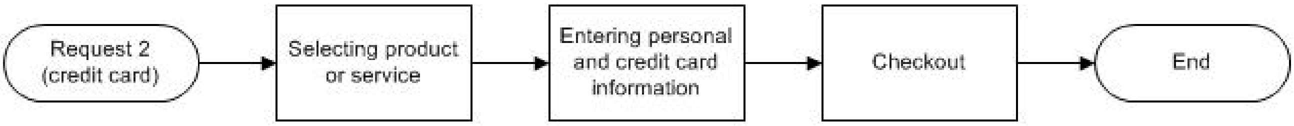

Figure 2. Credit card simulation model

Back to the condition of the whether the customer has a NetPay account, half of the requests will enter the next condition. Half of them will trust the NetPay provider and the rest will leave the system. The customers that have trusted the NetPay provider will open a new account by entering the personal information and also a credit/debit card information. This process takes about BETA(0.893, 1.08) minutes for each customer, and will consume the resources of the system until the customer fill the related forms. The entered information about the customers' credit/debit cards will be authenticated through the bank. This process will take about BETA(0.893, 1.08) seconds for each request. In the next condition, customers will decide whether they want client-side or server-side NetPay account. We assume that half of them will select the client-side account and will conduct to the next process of downloading the application for the client-side account. This process takes about NORM(4.12, 1.16) minutes. After this process customer will decide whether he wants to shop now or not, half of the requests are returned to the selecting the product or service process for shopping, and the rest will leave the system.

Figure 2 illustrates the credit card simulation model in comparison with the NetPay. In this model, payment requests are entered to the system randomly every minute. Then the customers select the product or service they want to pay for it that takes about BETA(0.988, 1.1) minutes for each requests and will consume the resources of the system until each request leaves the process. In the next process customers enter their personal information and also the credit card number that takes about BETA(0.893, 1.08) minutes for each customer. In the next process that is known as checkout, the vendor will check the account validity of the customer and payment transaction is made between vendor and bank. The checkout process will take about 0.016 seconds for each request based on the table 1. In this stage the payment transaction is done and the requests will leave the system.

In the simulation model we evaluate NetPay and credit card payment models for 5, 10, 15, 20 hours and then compare the output results. We compare 3 output parameters for NetPay and credit card payment that include waiting time, total time and total time for each request. Table 3 shows these results for the NetPay simulation model. The total average waiting time, average total time for each simulation period is mentioned. The total number of requests that had left the system is also represented in this table. We calculate the average total time for each request based on the effective requests that left the system for each period. The effective requests are the number of requests that had a NetPay account or wanted to shop after they opened a new account. In NetPay model the number of effective requests is smaller to the number of total requests that leave the system. But in the credit card model, these two numbers are the same.

TABLE III. SIMULATION OUTPUTS FOR NETPAY

Simulation time(hour)	Average Waiting time	Average total time	Number of requests	Number of effective requests	Average total time per effective requests
5	1.61E-03	0.01782	328	195	7.57436E-05
10	0.0014	0.01724	619	377	4.06631E-05
15	0.00148	0.01811	906	550	2.78727E-05
20	0.00143	0.01751	1188	744	2.10349E-05

The simulation output for the credit card system is illustrated in the table 4. The results are the same as table 3, but number of requests and the number of effective requests are different.

TABLE IV. SIMULATION OUTPUTS FOR CREDIT CARD

Simulation time(hour)	Average Waiting time	Average total time	Number of requests	Average total time per effective requests
5	0.00857	0.02528	314	7.55096E-05
10	0.00906	0.02519	623	3.82504E-05
15	0.00884	0.02485	918	2.5305E-05
20	0.00813	0.02397	1199	1.9166E-05

We compared the output results from two NetPay and credit card systems. Figure 3 illustrates the waiting time for 5, 10, 15, 20 hours of simulation period for NetPay and credit card systems. As it is shown in the figure 3, NetPay system is better than the Credit card system based on the average waiting time for all the requests, this figure does not take into account the effect of the number of effective requests for the NetPay.

Compared results for the total time for all requests are illustrated in the figure 4. As it is shown in the figure the total time based on the all observed requests of the NetPay account is effective than the credit card total time. Like figure 3, this diagram doesn't take into account the number of effective requests that left the NetPay system. It is only based on all the requests that entered and left the NetPay model. By these assumptions NetPay model is more time efficient that the credit card. But if we take into account the impact of requests that really had a payment transaction with the NetPay system, we will achieve different results. Figure 5, illustrates the total time for each effective requests. As it mentioned before the results of the effective requests and observed requests for the credit card system are the same. And the number of effective requests for each simulation period is mentioned in the table 3.

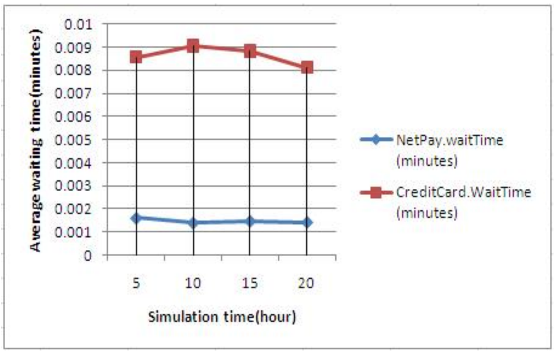

Figure 3. Waiting time comarison for NetPay and credit card

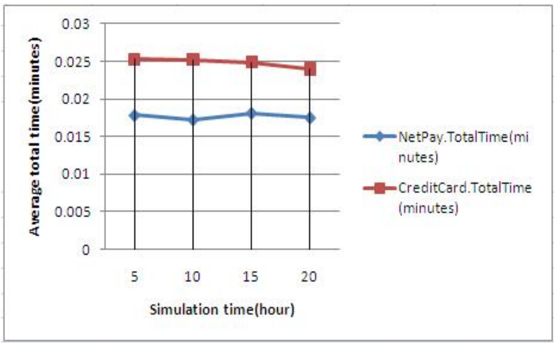

Figure 4. Total time for observed requests

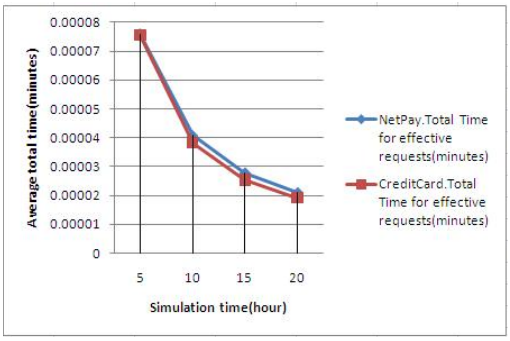

Figure 5. Total time per effective requests

As it is shown in the figure 5, we calculate the total time for each request, and also we take into account only the effective requests that have a NetPay account and have made a transaction with NetPay. In this case, it is obvious by the diagram that the performance of the credit card payment is better than the NetPay.

Therefore, NetPay is not time effective for customers but still sellers offer this type of payment for the micropayment transaction because of the high credit card fees for each micropayment transaction. In this situation sellers offer discounts and other direct marketing startegies. In the next section we will discuss the cost benefit of the NetPay compared to the credit card payments.

B. Costs

In the traditional adoption research, the cost is evaluated as a relative advantage factor. Based on the Mallat [8], we discuss the cost as a separate factor that has a significant influence on the adoption of new technologies. It is mentioned above that the credit card companies charge about 2 to 6% of the transaction amount from the seller, which can be a significant amount for the seller for the micro payment transactions newspaper providers. NetPay charge the seller about 1 cent to 1% of the transaction amount, therefore the amount is not significant for the seller and he can offer discounts for the service or product. It is illustrated in the previous section that the NetPay transactions take more time than the credit cards. Therefore the customers prefer it in comparison with NetPay. We suggest that the sellers can offer discounts to encourage the customers adopt the NetPay payment system.

In this section we present an equation for the seller profit and will prove why it is profitable for the sellers to use NetPay and offer discounts to encourage the customers.

Profit of selling products or services are derived from revenue of the selling minus cost of that product or service for the seller.as it is shown in the equation as follow

$$\text{Profit} = \text{revenue} - \text{cost} \quad (1)$$

, and we can expalin revenue as

$$\text{Revenue} = \theta + \theta K \quad (2)$$

where θ is the amount of money that the customer can pay for that product or service, also we can call it customer ability to buy, and K is the convenience of the special payment system for the customer. Convenience and time effectiveness for the customer increases the price of the produst or service. We explain the cost as follow

$$\text{Cost} = (\theta + \theta K)*\alpha + c \quad (3)$$

where α is the transaction cost percent for the seller from the NetPay or the credit card provider, c is the general costs like tax or oder fees for the seller. Substitution of equations 2 and 3 in 1 is as follow

$$\text{Profit} = \theta + \theta K - [(\theta + \theta K)*\alpha) + c] \quad (4)$$

To compare the profit of the seller with NetPay and credit card we can dispense the effect of c on the profit, because it is as the same for both NetPay and credit card. With this assumption Profit = $K\theta - [\theta + K\theta]*\alpha$. consider the credit card charge the seller 6% for each transaction amount, therefore Profit = 0.94θK – 0.6θ, and also consider the NetPay charge the seller 1% for each transaction amount, therefore Profit = 0.99θK – 0.1θ. It is obvious that for the same θ, profit of the seller depends on the convenience of the payment type. Therefore, sellers can use direct marketing strategies and security options to encourage the customers and leverage the effect of convenience for the credit card payment type.

IV. CONCLUSION

The main objective of our study was to evaluate two factors of the diffusion of innovation for adoption of NetPay micropayment system. To achieve our objective, a research model was proposed that has different approach in comparison with other approaches for evaluating the adoption of e-commerce technologies. This study discussed diffusion of innovation for NetPay and used simulation and mathematical approches instead of questionaries that is a regular proving approach for the adoptions of new technologies. This study evaluated two factors of relative advantage of NetPay and costs in the seller view.

Relative advantage consists of performance measures such as performance increase, effectiveness, and time savings. We evaluated the time factor using simulation approach. For this reason NetPay simulation model is represented. Three factors of waiting time, total time and total time per request was calculated in comparison with the credit card payment model. The first results indicate the decrease of waiting time and total time for all of the requests, but with further analysis it is showd that NetPay is not time effective for customers.

We also evaluated the effect of cost in adoption of NetPay micropayment in comparison with credit cards. For this reason we represented an equation based on the traditional equation for profit. We find that the profit of the seller depends on the amount of money that the customer can pay for that product or service, the amount of money that the card or NetPay provider charge per transaction from the seller, and the convinience of the payment system for the customer. NetPay provider charge a lower amount per transaction, therefore to gain the profitability of NetPay adoption for the sellers, we only have to take into account the impact of convineince of the payment system that is percieved by the customers. To improve the the perceived convinience sellers can offer discounts and use other direct marketing strategies. Finally, it is more profitable for the sellers to use policies to encourage the customers to adopt the new systems like NetPay for micropayments.

The diffusion of innovation theory consist other factors that can be evaluated thorough approches other than questuionaries. This approach can be used for the future researchs. For example security is one of the significant deteminants for adoption of new technologies that can be considered through this approach.

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