UbiPay: Conducting Everyday Payments with Minimum User Involvement

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Abstract
As services embedded into public spaces become increasingly transparent, one peripheral aspect of use continues to demand explicit user attention: payment. UbiPay is a system that carries out small everyday payments in a way that minimises user involvement by choosing an interaction method based on context information. The aim is to make paying like breathing: something we are only peripherally aware of unless we exert our resources beyond the usual. This idea has powerful implications for business and design.

Keywords
Electronic payment, mobile devices, transaction costs

ACM Classification Keywords
K.4.4 [Computers and Society]: Electronic Commerce ---Payment Schemes, Cybercash, digital cash;
H.5.2 [Information Interfaces and Presentation]: User Interfaces---Input devices and strategies

Introduction
Automatically dispensed goods and services in public spaces are increasingly paid for using electronic payment systems. Mass transit fares and car parking spaces in Tokyo are paid with stored value cards, while in Helsinki the same services can be paid by sending a premium SMS message from a mobile phone. SMS messages have also been applied as a payment method

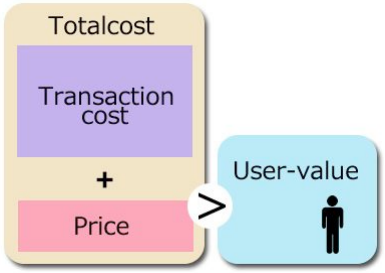

Figure 1. In small purchases, transaction costs can easily turn an attractive deal unfeasible to the buyer.

for digital music, drinks in bars, and beverages in vending machines. As a consequence, the usability of payment systems is an increasingly important topic.

By considering the usability of a payment system as a transaction cost that contributes to the total cost of a service, we see that the payment system limits the range of services that can feasibly be offered for sale. Services with a very small single purchase value, such as various ubiquitous services envisioned for public spaces, cannot feasibly be charged for on a per-use basis, since the act of payment would incur more effort than the service itself is worth.

As a solution, we present a system called UbiPay, which compares context information with user preferences to determine the level of user involvement appropriate for each transaction: small, familiar transactions can be carried out automatically, while more conspicuous transactions require silent assent or even explicit approval from the user. By making a single transaction very "cheap", we enable individualised charging for services that so far have always been bundled with other services, e.g. air conditioning in a subway carriage.

In this paper, we focus on the background and implications of the UbiPay concept, and describe the design of a first prototype system. As a next step, we plan to conduct preliminary user studies. The main contribution of this research is in everyday consumer payment transactions, but it also contributes towards more general understanding of how computer systems can dynamically choose user interaction methods based on use context.

Background

Usability as a transaction cost

In economics, the term "transaction cost" is used to refer to any cost, either in the form of money, time, effort or other disutility, which is incurred in the process of making an economic exchange [1]. Typical transaction costs include time, effort and attention dedicated to locating and paying for a good or service.

The total cost of a good or service to the consumer is its price plus the transaction costs incurred. A rational consumer is willing to make the purchase only if the perceived benefits exceed the total cost. For large purchases, payment related transaction costs do not usually represent more than a negligible share of the total cost. But for smaller purchases, they may represent a significant share (Figure 1). For example, a commuter in a mass transport system may forgo purchasing a ticket not because the ticket would be expensive, but because the payment process is too troublesome compared to the perceived benefit (avoiding a fine if caught by a ticket inspector). In effect, the usability of the payment system establishes a lower boundary on the value of goods and services that can feasibly be sold using it.

There are several ways in which vendors attempt to circumvent this problem. Services with a very small single purchase value can be bundled together to form larger units, e.g. individual articles are bundled to form newspapers and individual issues are bundled into subscriptions [3]. Another approach is the stored value or "micropayment" model: user deposits value in lumps and uses it to pay for services flexibly. The act of micropayment itself may involve some transaction costs, however.

Bundling, subscriptions and micropayments represent essentially the same approach to mitigating transaction costs: increasing purchase size while decreasing purchase frequency [3]. The problem with this approach is that it limits the choice available to consumers: buying small goods and services individually is not an option. First-time users, casual users and users considering switching to a competing service may also not be willing to commit to more than a single use at a time. The approach may also create barriers to entering the market, since small vendors may have to find suitable micropayment or bundling partners.

Wallet phone

An alternative to the approaches that seek to circumvent transaction costs by increasing purchase size and decreasing purchase frequency is to attack the problem head-on: to reduce the time and effort required to carry out a purchase. This is achieved by improving the usability of the payment system.

Osaifu-Keitai[1], meaning "wallet phone", is a mobile payment system developed by NTT DoCoMo that enjoys de-facto standard status in Japan. Unlike a single purpose smartcard, Osaifu-Keitai can contain several payment applications. An electronic money system called Edy comes pre-installed, and other stored value systems and credit cards can be installed later. Payment is initiated by holding the phone next to a reader/writer installed at the point of sale. Small payments are completed immediately, while larger payments may require the user to confirm the transaction. For example, using the DoCoMo-issued DCMX credit card application, payments of up to ¥10,000 (approximately €70) are completed immediately, while larger sums must be confirmed by entering a four-digit PIN code to the phone.

Osaifu-Keitai reduces payment related transaction costs in several ways. Instead of having to carry around a number of plastic cards, the user can access the same services using a phone. The actual payment event is very fast and does not involve counting change or writing a signature. For small payments, the only actions required from the user are taking out the phone and placing it next to a reader. On the other hand, the phone becomes even more crucial than before and losing it becomes an even more worrisome proposition. To some, the phone may also be a private object that they would rather not expose at every possible payment situation.

The UbiPay concept

According to the transaction cost theory, the faster and easier we can make the purchase event, the smaller goods and services we can viably buy and sell. The wallet phone goes some way towards improving the usability of payments: for small sums, the only actions required from the user are taking out the phone, locating a reader and placing the phone next to the reader. We attempt to take this simplification approach even further. The objective is to develop a means of effectuating payments that causes the minimum possible transaction costs to the user.

The easiest conceivable payment method is a one that is completely automatic: any payment request is honoured immediately and automatically without any distraction to the user. While such a system would

[1] おサイフケータイ in Japanese

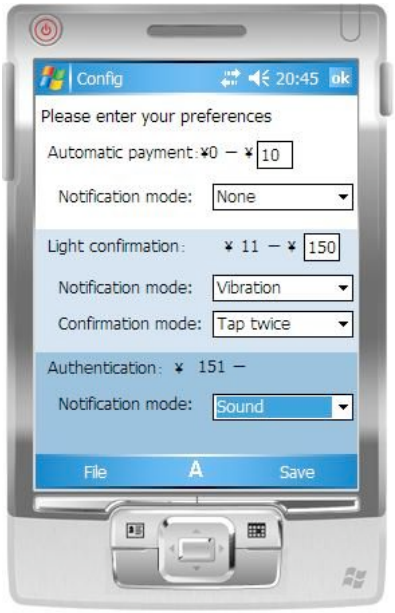

Figure 2. First prototype configuration interface. Users can specify three price ranges and choose which notification and confirmation methods are applied to transactions falling in them.

definitely minimise the time and effort involved in conducting a payment, it would also open up the door to incorrect payments. Incorrect payments are here defined as payments that the user would not approve of if presented with the details (time, sum, recipient, good/service) and asked for confirmation. The potential for incorrect payments arises due to e.g. a vendor making a mistake, the user mistunderstanding a pricing system or someone attempting to commit fraud.

Design

Osaifu-Keitai seeks to avoid incorrect payments by requiring two types of confirmation from the user. For bigger sums, a stronger and more disruptive confirmation is required (entering a PIN code). This reflects the fact that the potential of a large incorrect payment is a graver problem than recurring distraction caused by confirmation. For smaller sums, only a simple confirmation is required (placing the phone next to a reader), since the possibility of a small incorrect payment is considered such small cost that it is not worth seriously distracting the user over.

More generally, we can hypothesise that the level of security and confirmation the user expects (and in other words, the level of distraction and effort the user is willing to endure) for a specific payment transaction depends on the situation. It can range from completely automatic payments with no user awareness, through ambient notification, to all the way to the explicit, disruptive confirmation that is the norm in most systems today. To minimise transaction costs, we should aim *towards minimum sufficient user involvement* in each transaction. This is the main principle of the UbiPay concept.

The correct level can be guessed at by referring to information about the payment and the context: amount, recipient, time, date, location, previous payment history and user preferences. When the risk of incorrect payment is small, or when the consequences of an incorrect payment would be negligible, less attention is required from the user. For example, the following are examples of good candidates for completely automatic payment execution:

- A request for a sum of less than ¥500 or €3.50 from the mass transit company in the morning when entering a subway station
- A request for a sum of less than ¥300 or €2 from a vending machine located at the same station
- Any request for a sum of less than ¥15 or €0.10 from a known vendor

To test this hypothesis, we require a payment system that has the following features:

- Collects payment context information in real time
- Analyses the information according to preferences expressed by the user
- Has a variety of more and less disruptive user interaction methods, the method chosen depending on the result of the analysis
- Records the decisions taken to allow the user to assess their correctness afterwards

For developing the preferences according to which the context data is evaluated, there are two approaches that could be used. Firstly, users can simply be asked to input their preferences (using a rule template for

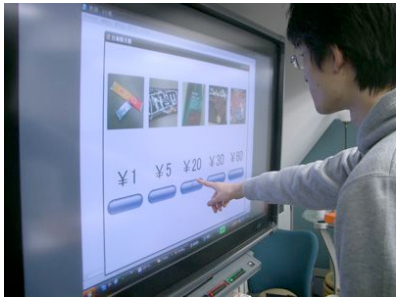

Figure 3. Vending machine mock-up with a touch screen interface

Figure 4. iPAQ rx5965, two Cookies and a ¥10 coin

ease of use). Secondly, rules can be derived from users' past behaviour using suitable algorithms.

Prototype

We have implemented a simple prototype of the design described above. It consists of a mock-up vending machine and the user's UbiPay device. The vending machine is a PC with a touch screen interface displaying various goods for sale and their prices (Figure 3). The UbiPay device (Figure 4) consists of a HP iPAQ rx5965 handheld computer and a coin-sized accelerometer sensor from the Cookie series developed jointly with Nokia Research Center [2]. The prototype supports three configurable user interaction modes, corresponding to varying levels of user involvement:

- Automatic payment: payment is completed automatically, but the user may choose to be notified through sound or vibration.
- Light confirmation: the device notifies the user with sound or vibration and expects the user to confirm the payment by either patting or shaking the device.
- Authentication: the device notifies the user with sound or vibration and expects the user to confirm the payment explicitly by looking at the screen and entering a PIN code.

Osaifu-Keitai uses NFC communication between the phone and the vendors' systems, but since we wish to explore different levels of user involvement all the way down to fully automatic payments, UbiPay uses wireless communication, which can be initiated without any action on the user's part. When the user stands in front of the vending machine and selects an item by touching it, the vending machine establishes a WLAN connection to the user's UbiPay device and issues a payment request. The device analyses the request and initiates the appropriate user interaction mode. For now, the only piece of information considered in the analysis is the price. Price ranges that trigger different forms of notification and confirmation are specified by the user using a preferences pane (Figure 2).

The next step is to conduct user studies to measure how much the prototype actually reduces transaction costs, using measures such as time and number of distinct actions required to complete a payment. At the same time, we begin accumulating data on how users valuate the different levels of involvement in practice, that is, how much additional financial risk they are willing to accept for each increase in convenience.

Discussion

From a HCI point of view, the main challenges and contributions of this work are in the context-adaptive user interface. But the idea of reducing transaction costs for very small payments to near zero has powerful implications for business and design. As an illustration, Tokyo subway trains have two types of cars: with full air conditioning and with reduced air conditioning. The fully air conditioned cars are more comfortable, but they cost more to operate and have a larger environmental footprint. Currently there is no way to charge those who choose an air conditioned car, since the fee would be too small to be feasibly collected. The cost of air conditioning is thus bundled into the price of the ticket.

With UbiPay, the bundle can be broken as each commuter can be charged according to their choice. Similar bundles can be opened in transport, shopping

malls, retail stores and restaurants. Individual actions begin to be more directly reflected in one's cost of living, and expenses that today are born collecively can be replaced with personal responsibility for actions. We become aware of the cost of things that we have thus far considered free, and gain the option of not consuming something that was previously unavoidable.

Vendors could also begin to offer more individualised services to consumers. Different seats in a restaurant, different lanes on a road or different hours in a park could attract a different price. UbiPay gives the user unobtrusive feedback about the cost of their lifestyle, allowing them to adjust their behaviour where necessary, e.g. by exiting a space that "feels" too expensive. From the point of view of commercialising new ubiquitous services, a crucial feature is that the payment transaction need not be tied to any physical point of sale.

Challenges

As with many ubiquitous computing applications, some major challenges separate the laboratory prototype from a commercially deployable implementation. Probably the biggest issues are in security and privacy. It is easy to encrypt the payment request protocol to stop third parties from eavesdropping, but how to deal with fradulent requests and "spam" is a different matter. Most likely the rules will have to be very strict towards unknown vendors, using strong cryptographic authentication to ascertain the vendor's identity.

This still leaves the system vulnerable to erroneous requests from trusted vendors. If context data is not fine-grained enough, someone standing on a train platform might end up paying for an air conditioned carriage that passes by. According to the principle of minimum sufficient involvement, any incorrect payments should be so small as to be tolerable. But even when a confirmation is triggered and the user cancels the transaction, the resulting distraction is problematic if it occurs often.

From the vendor's point of view, a user could engage in fraud by riding in the air conditioned carriage yet refusing to pay. Many services today, such as public rail transport in Helsinki, operate on an honour basis. Some users fail to pay, but this is tolerable if the value of a single "service theft" is small. The ratio of payers is kept at a sustainable level by ticket inspectors who conduct spot checks. Social norms also affect people's propensity to pay.

In a world of very low transaction costs, paying could become like breathing: we know it happens all the time, volume depending on activity, but most of the time we don't need to be more than peripherally aware of it. Only when we exert our resources beyond the usual should we really begin notice it. From a societal point of view, there are some vexing implications in this line of thought. But in our opinion, they only make research in this direction more worthwhile.

References

[1] Jürg, N. Transaction Costs. *The New Palgrave: A Dictionary of Economics*, v. 4, pp. 677-80 (1987).

[2] Kimura, H., Tokunaga, E., Okuda, Y. and Nakajima, T. CookieFlavors: easy building blocks for wireless tangible input. *CHI '06 extended abstracts on Human factors in computing systems*, 2006.

[3] Shapiro, C. and Varian, H.R. *Information Rules*. Harvard Business School Press, Boston, Mass., USA, 1998.