# Implementing and Evaluating a Smart-M3 Platform-based Multi-vendor Micropayment System Pilot in the Context of Small Business

Anna Rohunen[1], Matti Eteläperä[2], Kari Liukkunen[1], Tero Tulppo[1], Kai Wen Chan[1]
[1]Department of Information Processing Science
University of Oulu, P.O. Box 3000
90014 University of Oulu
Finland
[2]VTT Technical Research Centre of Finland
P.O. Box 1100
90571 Oulu, Finland
{Anna.Rohunen, Kari.Liukkunen, Tero.Tulppo}@oulu.fi, usochan@gmail.com
matti.etelapera@vtt.fi

*Journal of Digital Information Management*

***ABSTRACT:*** Today, micropayment systems usage is highly topical. For example, applications of mobile micropayment systems are widely used and are well known by the public.The objective of this study was to implement a micropayment system pilot based on an interoperability enabling platform (in this case, Smart-M3) for small businesses with restricted resources, scarce labor force, and a growing number of products and vendors.In these small and medium-sized enterprise (SME) contexts, piloting systems of this kind is usually problematic because of its immediate impact on the core business and monetary transactions that are essential for SMEs. An account-based system was considered an appropriate starting point for the micropayment system pilot. The applicability of the Smart-M3 platform was then validated by the implementation of the system. Lastly, a summative evaluation was carried out by interviewing direct stakeholders, to enrich the observations from the validation. The results of the study show that the implemented system provides small businesses with opportunities to reduce costs and more efficiently use resources, adding new devices and systems, new ways to produce services, andreal-time tracking of the sales process, as well as utilization of the data collected from the system. From the customers' point of view, the efficient use of resources may lead to more competitive prices of the products and services. Micropayment system usage can also be seen as a starting point for improved user experience, includingsafety, efficiency, and ease of use.

**Categories and Subject Descriptors:**
**J.1 [Administrative Data Processing]:** Business**; K.4.4 [Electronic Commerce]:** Payment Schemes

**General Terms:** Smart Platform, Micro-payment system, E-commerce

**Keywords:** Electronic Payment System, Micropayment, Multi-Vendor, Smart-M3 platform

**Received:** 10 August 2013, Revised 25 September 2013, Accepted 30 September 2013

## 1. Introduction

A micropayment system is an electronic payment system aimed at providing low-value and high-volume transactions. To be economically feasible, micropayment systems are expected to be efficient, with low transaction and computing costs. In addition, their security protection should be light to reduce the costs of the transactions.

While micropayment systems have significant potential for bringing benefits to both consumers and merchants, few of the existing systems have been successful (See-To et al. 2007). Tan and Tan (2009) discovered critical factors contributing to the success of an e-micropayment system in the context of a contactless smart-card ticketing system (Easy Card). Their findings show clearly that an e-micropayment system is a networked good with positive network effects. This creates a bandwagon effect as the network becomes more valuable and more users join in, leading to a positive feedback loop. In this case, users were also expecting the operator to increase the number of value-added locations, methods of value-added, and discounts. In addition, users were of the opinion that the operator needed to attract more transport-related, retail, and large corporations to accept Easy Card. These factors re-enforce one another, resulting in a chicken-and-egg situation, and the operator has to adopt a multipronged approach to achieve the ultimate objectives: a broad user base and extensive usage. Further, See-To et al. (2007) emphasize that micropayment markets can be conceptualized as a two-sided market involving consumers and merchants subject to positive network effects on both sides: the value of the system to consumers depends on the number of merchants adopting the system and vice versa. Based on an analytical model developed by See-To et al. (2007), it was found that a "*survival mass*" of merchants and consumers is required for a micropayment system to exist. Similarly, a "*critical mass*" for the acceptance levels is needed for the system to take off and remain stable.

Currently, micropayment systems usage is highly topical, especially in the context of mobile payments. Micropayments are widely used and are well known by the public (such as the App Store and Nokia Store). However, the existing systems are often operated by big companies. In this study, the opportunity of SMEs to benefit from micropayment systems was investigated.The objective of this study was to implement a micropayment system pilot for small businesses, and to carry out a summative evaluation of the implemented system. This pilot was based on the needs of a project partner operating in the field of health exercise services with its own billing system for its customers. In this study, the context of small business was characterized by restricted resources, scarce labor force, and a growing number of products and vendors. In addition, flexible business relationships with partners and lower start-up costs were perceived as issues when implementing the pilot system. After studying the existing electronic micropayment systems, it was concluded that an account-based micropayment system could be an appropriate starting point for the pilot implementation. Further, the Smart-M3 platform was considered a solution to the implementation because of the portability and scalability of the technology, and its applicability for the implementation and its context was validated. After the implementation, a summative evaluation was carried out by interviewing project partnersto enrich the observations made by the authors and to gain information for future research and for a subsequent user-centric evaluation of the system.

This article is organized as follows. Section 2 includes a few examples of both token-based and account-based existing micropayment systems identified in the literature. Section 3 presents the objectives of the study and describes its context. In Section 4, the Smart-M3 platform and its implementation and validation for the micropayment system pilot are described. Section 5 includes an evaluation of the micropayment system pilot implementation and its results.Section 6 concludes the study.

## 2. Examples of Existing Micropayment Systems

During the past few decades, a variety of micropayment systems has been developed. In this study, micropayment systems are classified into the following categories according to how a transaction is processed: (1) token-based, (2) account-based, and (3) debit card or credit card based. Several token-based micropayment systems are introduced, and the reasons for their failure are described. Account-based micropayment systems are then discussed. Debit card or credit card based systems are not discussed in this article due to the fact that most of the processes of card based systems are managed by card issuers, such as banks.

### 2.1.Token-based Micropayment Systems

In a token-based micropayment system, the tokens are just like coins in the real world; they are used for the exchange of goods in the digital realm (Párhonyi et al. 2006). The generation of tokens is highly secured, and hence fraud and double-spending are prevented. However, there are high costs associated with the identification of tokens and the central administration of issuing the tokens. Most micropayment systems have also focused on providing high security and untraceable transactions, which requires the generation of cryptographic key of tokens.Due to their vendor specificity, token specificity, and rather poor interoperability, the token-based micropayment systems did not spread and deploy on a large scale (Párhonyi et al. 2006).

PayWord (Rivest and Shamir 1996), MicroMint (Rivest and Shamir 1996), Payfair (Yen 2001), Millicent (Manasse 1995), and NetPay (Dai and Grundy 2007) are all token-based micropayment systems. A few of thesesystems are briefly described as follows:

• **PayWord** (Rivest and Shamir 1996) is characterized as a credit-based micropayment system. However, it can also be classified as a token-based system because the generation and use of a payword chain is essential within the system. The payword chain is a collection of paywords (tokens). It is generated and signed based on a credit-based certificate and vendor identification. Thus, payword chains are vendor specific. In practice, the vendor does not verify paywords one after another, but only the last payword.

• **MicroMint** (Rivest and Shamir 1996) is optimized for unrelated low-value payments. The generation of tokens is rather cheap if the total number of tokens to be generated is high enough. The tokens can be spent separately in different transactions. However, they are vendor specific, and cannot be used across vendors. This drawback hinders the scalability of the system.

• **Payfair** (Yen 2001) enhances the implementation of PayWord and comprises a token-based micropayment system that is not vendor specific. In the system, tokens are created for general purposes. Once users spend tokens, the vendor verifies the tokens within the transaction by connecting them with the token issuers. In other words, tokens are not self-proven as valid.

There are also a few other examples of micropayment systems that apply specific tokens. For example, Millicent (Manasse 1995) applies vendor script issued with authority to help users and vendors claim validation of token spending. NetPay(Dai and Grundy 2007) is based on PayWord and improves the scalability of the payword chain, allowing the payword tokens to be spent on different vendors.

### 2.2 Account-based Micropayment Systems

Account-based micropayment systems rely on user identification along with account management. Each user is usually connected to an account profile that communicates the user's details to the system, such as bank account information and preferred payment methods.Typically, there is no simultaneous charging with a transaction. Instead, users are invoiced on a monthly basis. Recently, account-based systems have experienced increased popularity in the micropayment world. They are widely accepted on the Internet, such as NTT DoCoMo's i-mode with 47.5 million subscribers in 2011 (NTT DoCoMO) and PayPal with over 100 million active registered accounts in 2011 and with 25 currencies (PayPal).

## 3. Objectives of the Micropayment System Pilot Implementationand Evaluation

After analyzing the problems of token-based micropayment and the advantages of account-based micropayment, it was concluded that an account-based system could be an appropriate starting point for the multi-vendor micropayment system pilot that was developed in this study. A platform for a micropayment system should enable specific capabilities for each of the three basic roles of the account-based micropayment systems: users or buyers (authorizing their identities and claiming validation of their account), host or broker (who owns the account information and deals with banks after the purchase is completed) and merchants (who providegoods information and deliver goods). The contextual issues that the micropayment system pilot was intended to solve were as follows:

• Small businesses with restricted resources, especially scarce labor force

• No (direct) cash flow in the use case

• High-volume and low-cost transactions

• Growing number of products and vendors

• Flexible business relationships with partners

• Lower start-up costs

• Management of customer service configuration

In addition, technology- and user-related dimensions of electronic payment systems suggested by Abrazhevich (2001), Lee et al. (2001), and Párhonyi et al. (2006) were used as guidelines in the micropayment system pilot planning stage. The technology-related dimensions of "*scalability*" and "*interoperability*" were found to be especially relevant to the system to be implemented. Correspondingly, user-related dimensions such as "*ease of use*" and "*reliability*" were also of importance.

An open-source semantic interoperability architecture, the Smart-M3 platform, was considered to be the solution for implementation because of the portability and scalability of the technology. Therefore, one of the objectives of the study was to validate the applicability of this platform in the presence of thepreviously mentioned contextual issues. Further, a summative evaluation of the implemented pilot system was carried out by interviewing direct stakeholders (project partners) to enrich the observations made by the authors and to gain information for future research and the subsequent user-centric evaluation of the system.

## 4. Description and Implementation of the Smart-M3 platform

In this section, the Smart-M3 technology and the micropayment system pilot implementation are described in more detail.

### 4.1 Smart-M3 platform

Smart-M3 is an implementation of the M3 semantic interoperability architecture. M3 stands for multi-vendor, multi-device, and multi-platform, and it highlights the portability and modularity of the technology (Lappeteläinen et al. 2008). Manufacturers of devices and services usingSmart-M3 may choose to publish information relatedto their products to whiteboard-like information brokers. This information may be used by other third-party services and devices to ultimately form smart mash-up applications combining information from both physical and digital world objects.

On a logical level, Smart-M3 consists of three main components: (1) The semantic information broker (SIB) is a database capable of semantic reasoning and is the shared memory of a smart space, (2) knowledge processors (KPs) are agents that interact with the SIBs, and (3) KPs can use seven smart space access protocol (SSAP) functions for communication with an SIB. These functions include:

• Join (), for joining a smart space

• Leave (), for leaving a smart space

• Insert (), for inserting triples into the smart space

• Query (), for querying information from the smart space

    o Query language support depends on support in the SIB

- Currently SPARQL or WilburQL (Lassila 2007)

• Subscribe (), for subscribing to changes in triples

○ KP is automatically notified when the information it subscribes is changed by another KP

• Unsubscribe ()

• Remove (), for removing triples from the smart space

The relations between the three M3 components are shown in Figure 1. KPs do not directly communicate with each other, nor do SIBs. Communication between KPs is loosely coupled; e.g., SIBs are used as shared memories for information exchange between KPs. A single KP can also be connected to multiple SIBs. M3 does not define discovery mechanisms for locating SIBs, but the brokers can advertise themselves via network-specific discovery

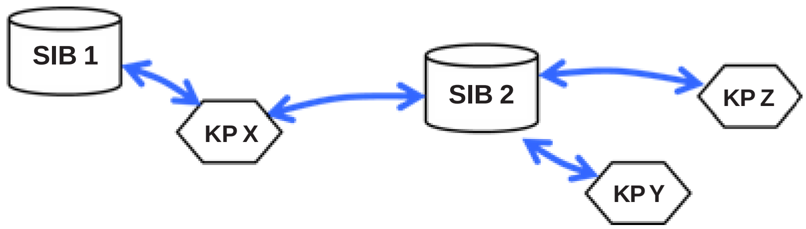


Figure 1. Example of Smart-M3 logical architecture; agent-like KPs can communicate with a number of databases, such as SIBs via the SSAP protocol (blue arrows)

protocols such as multicast DNS (mDNS). Current M3 implementations such as Smart-M3 use TCP/IP as their network protocol, and SIBs are thus able to be located using mDNS.

Functionality in the system is implemented via KPs, which can be categorized as producers, consumers, or aggregators (a combination of the consumer and producer) of the information in SIBs. An M3 compatible temperature sensor is a producer KP, which converts real-world information to a semantic format. Likewise, a script reading information from the Internet and publishing it in an SIB is a producer KP. A typical consumer KP might be, for example, an M3-compatible embedded device actuating a light switch. Aggregator KPs use existing information stored in SIBs to produce new, refined data.

The Smart-M3 information model is similar to the Semantic Web, as it uses the Resource Description Framework (RDF) triples and graphs as a way to express relations between information. A single triple is formed by a subject, a predicate, and an object. An example of such a triple would be "*livingRoom*," "*hasTemperature*," "+22." This representation is, possibly, the most generic information model imaginable, as new triples can be made to link existing pieces of information to new meanings. For example, an extension to the information presented in the previous triple could be "*livingRoom*," "*hasHumidity*," "35%." To make the triple representation scalable and manageable, RDF defines resources, properties, and classes with keywords, and it uses a URI prefix with each element of a triple (with the exception of literal values). In addition, Web Ontology Language (OWL) extends the RDF further by aiming at developing ontologies compatible with the World Wide Web. Ontologies are definitions and classifications of concepts, entities, and the relations between them. These information models allow systems to express and reason first-order logic and deduce facts from existing information. What Smart-M3 does is bringing these key Semantic Web technologies to local smart environments.

**4.2 Micropayment System Pilot Based on the Smart-M3 platform**

The micropayment system pilot was implemented with Smart-M3 components. Custom micropayment ontology was created as the information model of the system. The system is composed of five KPs, which are connected to both external entities and a common shared memory, the SIB. The KPs are subscribed to RDF triples in the SIB, so the system is event-based, and all functionalities in the KPsare triggered by updating information to the SIB. The KPs exchange information with each other via subscribing to and updating information in the SIB.

The system presented in Figure 2 works in the following manner:

1. The KP RFID is triggered by touching the RFID reader with a tag; it thenupdates personal information to the SIB.

2. The KP Buyer is triggered and it assigns goods information to the SIB.

3. The KP micropayment (MP) broker secures personal information, and triggers (via the update-subscribe mechanism) the KP MP vendor to check goods information, which prevents the KP MP Buyer from providing incorrect goods information.

4. The KP MP vendor confirms the goods information based on the vendor's customized goods database.

5. The KP MP broker completes the charging and billing process, which prevents cheating on charging, and then informs the KP vendor to deliver the goods.

6. KP MP Vendor is asked and confirmed to deliver the goods.

7. Goods are delivered via the KP door, by opening an

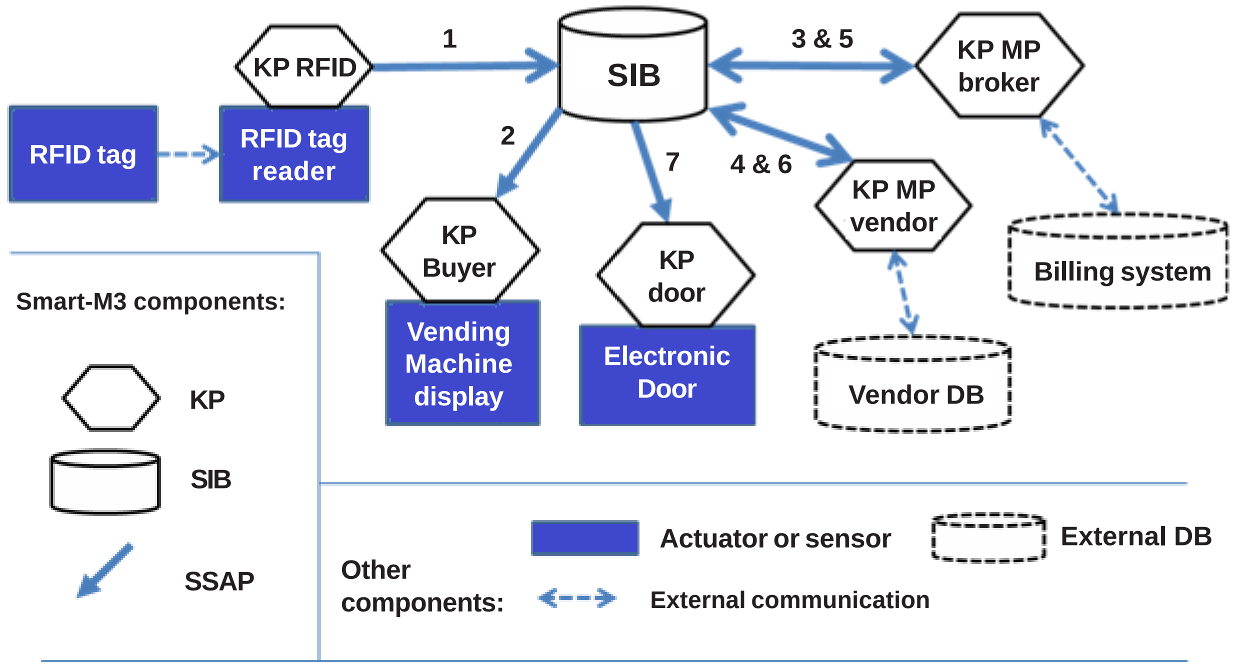


Figure 2. Smart-M3 view components of the micropayment system

electronic door in the smart space.

All knowledge processors in the system were implemented on an Ubuntu Linux laptop using the open source Smart-M3 platform for SIB (Sourceforge Smart-M3). Connections to the KP RFID (Idesco ICU unit [Idescoproducts]) and KP Door (iBoot-G2 [iBootproducts]) devices were accomplished through a local TCP/IP network. All code was written in C. Figure 2 shows how the transactions are performed in the system. A detailed evaluation of the micropayment system pilot is presented in Section 5.

The components in the system were implemented by two developers working in different organizations. The amount of information needed by the developers to build new KPs on the existing systems was small: they needed a description of the custom micropayment ontology model and a description of the functionalities of the existing KP in the system.Because the system worked as specified, and it was modularly upgraded during the course of the work, we can state that the Smart-M3 platform supports seamless extensions of new functionalities to existing smart space applications.

The system has been demonstrated in project consortium meetings and field-related events. According to the feedback collected from these demos, the system can provide small businesses with the following advantages:

• Opportunities to establish additional services and products

• Opportunities to further enhance the micropayment application by adding new features through KPs

• Savings due to decreased wage costs related to the sales of supplementary products

• Ease of building KPs that enable new vendors to join the system

• Opportunities to generate new services based on the data from the system

It is also worth noting that developers without prior experience of Smart-M3 were able to create KPs in a modular way on top of the existing systems.

## 5. Evaluation of the Micropayment System Pilot Implementation

The micropayment system pilot presented in this study has not been put into use in the real world or been widely introduced to actual users.At this stage of the research, we decided to carry out a summative evaluation of the system to enrich the observations made by the authors, to be able to gain insight into the system's potential use and future opportunities forthis kind of system, and to analyzethe issues that should be taken into account when implementing corresponding systems. As Beynon-Davies et al. (2004) state, a summative evaluation is also likely to suggest a number of ways in which the system may be modified or extended, thereby contributing to systems maintenance work. In addition, we wanted to determine evaluation areas to be included in the futureuser-centric evaluation of the system andto discover possible new evaluation metrics essential to the study but not included in the existing evaluation frameworks.

Evaluation was carried out by interviewing representatives of project partner companies. Themes of the semi-structured interviews were planned based on the framework of ubiquitous computing evaluation areas by Scholtz and Consolvo (2004) and U-business value measures presented by Kim et al. (2009). From the framework by

Scholtz and Consolvo, selected measures included in the evaluation areas of adoption, interaction, and impact and side effects were considered valid for this study and discussed in the interviews. For the U-business value, a set of measures were selected that were applicable to the study. In addition to the existing studies, the interview themes were based on feedback from demos given in project consortium meetings and field-related events.

For the evaluation, two companies were contacted and asked to provide participants forthe semi-structured interviews. Three interviewees presented the perspective of direct stakeholders (Friedman and Kahn 2003). Two of them were from a large-scale enterprise that provides services and devices for smart exercise environments. These two interviewees represented a technical expertise point of view. The third interviewee was a representative of an SME operating in the field of health exercise services, therefore bringing a business aspect to the evaluation.The interviews were conducted in June 2012. The large-scale enterpriserepresentatives were interviewed in pairs via phone, and the SME representative was interviewed face-to-face. The interviews lasted around 30 minutes and were recorded by the interviewers. The results were synthesized, andthe main findings related to benefits, opportunities, and challenges of micropayment utilization areas follows:

• The Smart-M3 platform provides the following benefits: adding new devices and systems is easy, maintenance procedures are improved due to vendor-specific interfaces, and there areopportunities to save resources because the tailoring of vendor-specific interfaces is not needed.The Smart-M3 platform especially suitsclosed environments where identifiers are used for customers.

• Small, frequent purchases are an important part of gym or health exercise services businesses, and their management has to be automated; this can be done if a micropayment system is implemented.Costs due to a separate transaction have to be low enough.

• In the long run, cost savings may occur after considering whether it is more profitable to charge customers for certain products instead of keeping them available for free.

• Due to decrease in labor costs related to micropayment utilization, the prices of the products and services may become more competitive.

• Micropayment can be offered to customers as an opportunity for upgraded membership.

• Compared with cash or debit/credit card payments,the micropayment system can provide an improved user experience, composed of safety, efficiency, and ease and pleasantness of use.

• Micropayment system usage provides an opportunity for a real-time tracking of the sales process.

• Opportunities to establish additional services and products, add new vendors to the system, and to further enhance the micropayment application by adding new features are essential to micropayment systems utilization.

• Based on the data from the system, there are future opportunities related to the generation of new services, improvement of the selection of goods,and marketing communication.

• There are, however, challenges related to micropayment systems: how to appropriately respond to users' demands for reliability and safety of the system, how to protect the products to avoid pilfering, and how to optimally manage the design, monitoring, and maintenance of the infrastructure.

From the business users' point of view, one of the most important benefits from a Smart-M3 platform-based micropayment system seem to be the cost savings and more efficient use of resources. In addition, this kind of a micropayment system provides the business users with opportunities to easily add new devices and systems, real-time tracking of the sales process, and utilization of data collected from the system. From the customer's point of view, efficient use of resources, enabled by the use of themicropayment system, may lead to more competitive prices of the products and services. Micropayment system usage can also be seen as a starting point for improved user experience, including safety, efficiency, and ease of use. On the whole, when developing and implementing a micropayment system, it is essential that alternative or existing designs are improved or made more effective from the viewpoint of both the businesses and customers.

## 6. Conclusions

In this study, a Smart-M3 based account-based micropayment system pilot for small businesseswith restricted resources was implemented, and the applicability of the platform for the implementation in the SME context was validated. In addition to scarce resources, the context of this study was characterized by a growing number of products and vendors, and theaim to achieve lower start-up costs and flexible business relationships with partners. Afterthe implementation, a summative evaluation of the micropayment system pilot was carried out by interviewing project partners to enrich the observations made by the authors and to gain information for future research and subsequent user-centric evaluation of the system.

According to the results of this study, a micropayment system based on the Smart-M3 platform is suitable for SMEs that have their own billing systems for their customers. These companies include, for example, gyms and golf courses. Since the customers are invoiced regularly, micropayments can be easily added to the bills, and any third parties (such as banks) are not needed to facilitate the transactions or invoicing. Overall, micropaym-ent systems based on interoperability platforms, such as Smart-M3, seem to be suitable solutions to micropayment in a multi-vendor environment with a growing number of products and vendors. Business users are expecting a micropayment system of this kind to provide them with the cost savings and more efficient use of resources, as well as opportunities to easily add new devices and systems, real-time tracking of the sales process, and utilization of data from the system. From the customer'spoint of view, micropayment system usage can also offer improved user experience.

In this study, the evaluation of the micropayment system pilot was based on interviewing a limited stakeholder group. For further user-centric evaluation, based on an appropriate evaluation framework, such as the framework by Scholtz and Consolvo (2004), the direct and indirect stakeholders need to be identified. In other words, all user groupswho will be affected by the application should be discussed(Scholtz and Consolvo 2004).Based on the results of this study, which evaluation areas should be included in the user-centric evaluation and whether there are evaluation metrics essential to the study but not included in the existing evaluation frameworks need to be evaluated. For example, Scholtz and Consolvo (2004) state in their study that the "*walk-up-and-use*" systems should score well in the evaluation areas of interaction and conceptual models and that the personal information processing should score high in trust.Furthermore, after revealing several important evaluation metrics that were not originally tested for (such as comfort, privacy, and predictability), Carter and Mankoff (2004) found that the appropriateness of each metric varied across the studies that focused on various applications.

## 7. Acknowledgements

This article is based on research conducted in the Devices and Interoperability Ecosystem (DIEM) research program, financially supported by the Finnish Funding Agency for Technology and Innovation (Tekes), and Internet Connected Objects for Reconfigurable Ecosystems (iCore) project, funded by the EU FP7 program.

## References

[1] Abrazhevich, D. (2001). Classification and Characteristics of Electronic Payment Systems. *In:* Proc. of the 2nd International Conference on Electronic Commerce and Web Technologies, p. 81–90. Springer, London.

[2] Beynon-Davies, P., Owens, I., Williams, M. D. (2004). Information systems evaluation and the information systems development process.*Journal of Enterprise Information Management*, 17 (4) 276–282.

[3] Carter, S., Mankoff, J. (2004).Challenges for Ubicomp Evaluation.*Technical Report UCB-CSD-04-1331*, Computer Science Division, University of California, Berkeley.

[4] Dai, X., Grundy, J. (2007).NetPay: an off-line, decentralized micro-payment system for thin-client applications. *Electronic Commerce Research and Applications*, 6(1) 91–101.

[5] Friedman, B., Kahn, P. H., Jr. (2003). Human Values, Ethics, and Design.*In:* Jacko, J., Sears, A. (eds.),*The Human-Computer Interaction Handbook*, pages 1177–1201. Lawrence Erlbaum Associates, Mahwah NJ.

[6] iBoot products, http://dataprobe.com/iboot-g2.php

[7] Idesco products, http://www.idesco.com/

[8] Kim, C., Oh, E., Shin, N.,Chae, M. (2009). An empirical investigation of factors affecting ubiquitous computing use and U-business value.*International Journal of Information Management*, 29 (6) 436–448.

[9] Lappeteläinen, A., Tuupola, J.-M., Palin, A., Eriksson, T. (2008). Networked Systems, Services and Information - The Ultimate Digital Convergence.In: Proc. of the 1st International Conference on Network on Terminal Architecture (NoTA 2008), p. 1–7.

[10] Lassila, O. (2007). Programming Semantic Web Applications: A Synthesis of Knowledge Representation and Semi-Structured Data. Ph.D. dissertation, Helsinki University of Technology.

[11] Lee, Z. -Y., Yu, H. -C. Ku, P. -J. (2001). An Analysis and Comparison of Different Types of Electronic Payment Systems.*In:* Proc. of the Portland International Conference on Management of Engineering and Technology (vol. 2), p. 38–45. IEEE.

[12] Manasse, M. (1995).The Millicent Protocols for Electronic Commerce.*In:* Proc. of the 1st USENIX Workshop on Electronic Commerce (vol. 1), p. 9. USENIX Association, Berkeley.

[13] NTT DoCoMO, http://nttdocomo.com/about/operating/index.html

[14] Párhonyi, R., Nieuwenhuis, L.,Pras, A. (2006).The Fall and Rise of Micropayment Systems. *In:* Lammer, T. (ed.), Handbuch E-Money, E-Payment & M-Payment, p. 343–362. Springer, Heidelberg.

[15] PayPal, https://www.paypal-media.com/about

[16] Rivest, R., Shamir, A. (1996).PayWord and MicroMint: Two Simple Micropayment Schemes. *In:* Lomas, T.M.A. (ed.), Proc.of the International Workshop on Security Protocols, p. 69–87. Springer, London.

[17] Scholtz, J., Consolvo, S (2004). Toward a framework for evaluating ubiquitous computing applications.*IEEE Pervasive Computing*, 3 (2) 82–88.

[18] See-To, E. W. K., Jaisingh, J., Tam, K.Y (2007). Analysis of electronic micro-payment market. *Journal of Electronic Commerce Research,* 8 (1) 63–83.

[19] Sourceforge Smart-M3, http://sourceforge.net/projects/smart-m3/

[20] Tan, W. -K., Tan, Y. -J. (2009).Critical Factors Influencing the Successful Development of e-Micropayment Program. *In:* Proc. of the International Conference on Management and Service Science, p. 1–4. IEEE.

[21] Yen, S. -M. (2001). PayFair: a prepaid Internet ensuring customer fairness micropayment scheme. *Computers and Digital Techniques*, 148 (6) 207–213.

**8. Author Biographies**

**Anna Rohunen** works as a researcher at the University of Oulu, Finland. She received her M.Sc. degree in 2005 in process engineering, with automation and information technology as the area of specialization. Since then, she has worked for several research projects at the Oulu Southern Institute and in the Department of Information Processing Science at the University of Oulu. She is preparing her doctoral dissertation on data privacy protection, and her research interests are currently focused on the measurement of individuals' personal data privacy concerns.

**Matti Eteläperä** (M.Sc. EE) is a research scientist at the VTT Technical Research Centre of Finland. He joined VTT in 2004 and has since worked on research topics such as System-on-Chip performance simulation and analytic methods, application workload modelling, and video codec optimization. Currently, he works on the EU FP7 project iCoreas a work package leader and focuses his research on semantic smart environments and the Internet of Things.

**Kari Liukkunen** (Ph.D., M.Ed.) is a program manager at the University of Oulu, Finland. He previously worked at the University of Oulu as the head of the digital media production unit (2001–2007) and coordinated educational technology development projects (2004–2006). He has also led and managed a number of research projects in cooperation with industry. He has served as an organizing chair and committee member for many international conferences. His main research interest areas are distributed work, software engineering, and service production.

**Tero Tulppo** works as a researcher at the University of Oulu, Finland. He received his M.Sc. degree (2009) in information processing science, with mobile services as the area of specialization. Since then, he has been working in the Department of Information Processing Science at the University of Oulu. His research interests are currently focused on privacy issues around personal dataintensive ubiquitous systems.

**Kai Wen Chan** has been working as a research assistant at the University of Oulu in Finland (2010 to 2011). He received his M.Sc. degree in 2011 from the University of Oulu, with mobile services as the area of specialization. He has worked on the research projects of the Department of Information Processing Science at the University of Oulu, focusing on data quality and micropayment issues.