Chapter 59
Anonymous Pico-Payments for Internet of Things

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ABSTRACT

In this Chapter a new way of payments for Internet of Things services is proposed, based on a stream of anonymous pico-payments realized by means of pico-coins. System architecture and information flow are presented, showing fully automated way of contextual payments which protect customers' privacy. With the proposed stream of pico-payments, two basic problems of efficient and widely acceptable payment method for the Internet of Things are solved: privacy protection, and toleration of frequent unexpected disconnections.

INTRODUCTION

Recently we observe continuously expanding expectations concerning Internet of Things (IoT) (Atzori, Iera, & Morabito, 2010). People are looking for Marc Weiser's predictions come true: computers are smaller and smarter, freeing people from some tedious tasks and acting as "good servants" – unseen, however useful (Weiser 1991). In other words, people expect better integration of real and digital worlds which together constitute smart environments. Smart environments are particularly important in cities where human population is dense. Smart environments are able to automatically personalize services, both real and digital, to improve human life at a lower energy expenditure and lower pollution. However, a question arises how far we are from mass application of IoT devices and which are major obstacles to mass deployment of IoT services?

Up to date, research on Internet of Things (Haller, Karnouskos, & Schroth, 2009) and Services (Towards the Internet of Services, 2015) has been strongly focused on technological issues, such as standardization, identification, communication, knowledge representation and information exchange, as well as human-to-machine interfacing. There are many different solutions to those problems which may

DOI: 10.4018/978-1-5225-9866-4.ch059

be successfully deployed. Problems which remain to be solved are ones of economic nature, limiting mass deployment of IoT. As any technical solution, also IoT needs a proper business model. IoT must generate income and profit necessary to cover costs of investment, maintenance and operation. So far, this part of discussion on IoT was bypassed mostly because economic issues of IoT cannot be solved without a development of new technologies going beyond current solutions.

The fundamental problem of IoT economy concerns payment methods appropriate for IoT operation. In the Internet of People (and in the real world as well) payment instruments, such as cash, checks, credit cards and money transfers are always initiated and controlled by human payers (Karnouskos 2004). For several reasons, it is not possible to apply this mode of operation to IoT devices and services. As each IoT device works according to Marc Weiser's "good servant" rule, it is not possible to: (1) foreseen the moment and place of a "meeting" of a human with an IoT device deployed in a smart environment, which is providing a service to this human; (2) estimate in advance the duration of such meeting; and (3) control IoT device operation by a human being served. As a result, classical payment methods based on the prior knowledge of the goal, place, and time of the payment, become useless. For example, it is not possible to pay with a credit card to each IoT device a human is passing by in a smart environment, which moreover usually is hidden, to enter a coin, confirm a bank transfer, etc. Moreover, a payment method for IoT should preserve anonymity of payers to protect their privacy, because fear of mass surveillance of IoT users is one of the major obstacles to IoT deployment.

In this Chapter we propose a new payment method basing on a stream of digital pico-coins sent from an anonymous IoT service recipient to an IoT service provider as long as the duration of an IoT service provided. The general concept of this payment method is the following. If an anonymous person appears for a while within a range of an IoT device deployed in a smart environment, her personal electronic device starts to pay for service by sending digital pico-coins with constant frequency as long as that person remains within the range of that device. Detailed description of this method is presented in the third section of the Chapter. Before, in the second section, we describe current methods of payments and we analyze their usefulness for Internet of Things. In the fourth section we present overall system architecture based on streams of pico-payments, followed by the most important technical details related with information flow among key system elements: the city, pico-coin issuer, service providers, and customers. We also analyze possible privacy threats, and finally we conclude the Chapter, showing possible directions for future research.

Analysis of Current Methods of Payment from the IoT Viewpoint

There are a number of reasons why current payment methods developed for people not devices are inappropriate to IoT.

Most of payment methods being in use are based on some material goods. In case of coins, banknotes or checks, pieces of metal or paper are exchanged between payer and a payee. In case of credit cards, though money is immaterial (digital), cards and card readers are material. In case of a bank transfer, again money is immaterial, but a terminal (a computer or a smartphone) is material. In all those methods, a payment is always initiated and controlled by a human payer who explicitly decides when, to whom and how much money is paid.

In case of IoT, where according to Weiser's rule devices should be unseen servants, a payment transaction should arise between devices without direct intervention of a human. Otherwise, an IoT device