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Towards a web payment framework: State-of-the-art and challenges

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ABSTRACT

In the Internet era, through the web, and access to content, products and services has evolved in a spectacular way. At the same time, different business models have been developed for access and consumption. Many of these business models are based on making a payment via the web. The use of electronic payments in the web is a complex issue since it involves the support of multiple payment instruments, the secure exchange of payment information, receipts, and so on. A proposed solution approach to web payments is the development of a *web payment framework* based on a layered approach. This article analyzes the functionality this framework should provide, what solutions may be used, and what issues still need to be addressed so that a web payment framework can make e-payments more widespread.

1. Introduction

In the last ten years, electronic commerce activities have been associated with important changes and innovations, from a technological perspective and for the business models that have been introduced. Recent advances in electronic payments also reflect this. The use of e-payments based on credit and debit cards has been growing on the Internet over the years, and systems such as PayPal have seen as its volume of payments have increased year by year. More recently, the birth of Bitcoin (Nakamoto 2008, Barber et al. 2012) has been a watershed event in the adoption of electronic cash to make payments on the Internet (Peck 2012, Hileman 2014). Until recently, the adoption of e-cash had mostly been a series of failed initiatives. At the same time, new payment systems such as Apple Pay have appeared. With several payment instruments available today, many of them mobile payment systems, the challenge has been to make it easier for the different to perform the different steps that take place for a purchase transaction so that security and interoperability are guaranteed. This includes a variety of stakeholders, such as consumers, merchants, banks, mobile operators and payment services providers.

B2C transactions on the web typically take several steps in which payment information and payment systems are used, in order to complete them (Ruiz-Martínez et al. 2012). First, the consumer locates the product or service (shortened to just "product" hereafter) to be purchased or consumed through her web browser installed on her PC or her smartphone. Then she will obtain the description of the product with the payment conditions required by the merchant. Depending on the kind of transaction, the price and payment options available may be negotiated and chosen. Thereafter, the consumer will proceed with the checkout and the payment will be made. If the payment succeeds, the transaction will finish and the consumer will be able to acquire the product, for example, via a ticket that is issued to confirm purchase. Associated with the purchase, the merchant will provide a receipt of the transaction to the consumer. The consumer may receive some loyalty information (ticket, points, coupons) that can be used in subsequent transactions to obtain better prices or other advantageous conditions (Turban et al. 2014).

Related to product access, if a problem occurs or the product does not satisfy the conditions agreed to, the consumer will be able to request a refund. If the request is accepted, the merchant will refund the payment by issuing a ticket or some kind of a coupon that will be considered as an alternative currency (de Lange et al. 2012), or by making a payment to the consumer. In this scenario when a web payment is made, there are different exchanges of information. In these exchanges, different kinds of payment information and different payment instruments can be used. Currently, the web and the different standards that define it do not offer a comprehensive and standard solution that supports all of the steps mentioned though. The solution proposed to overcome this challenge has been the definition of a *web payment framework* (Ruiz-Martínez et al. 2012, Jaffe and Boyera 2015, W3C 2015b). It aims to facilitate, along the purchase process, the exchange of payment information and the use of different payment instruments in an easy way at the same time it guarantees interoperability, trust and security.

The development and adoption of this kind of framework is a challenge though. It requires the definition of a set of components

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that perform different kinds of tasks. With this in mind, I will analyze two issues. First, I will examine the tasks a web payment framework should accomplish in each step of the purchase process, and what solutions have been defined for these tasks so far. Second, based on the current state-of-the-art, I will asses the different issues that are still to be overcome in order to have a comprehensive and standard solution that performs the tasks previously mentioned.

2. Web payment frameworks: layers, goals, and current solutions

The development of a web payment framework has been addressed in several previous academic and industry research works. They include: the Joint Electronic Payment Initiative (JEPI) (Chung and Dardailler 1997); the Secure Electronic Marketplace for Europe (SEMPER) (Lacoste et al. 2000b); and the W3C Common mark-up for micropayment per-fee-links (Michel 1999). The latter contains some ideas proposed in this specification that were followed in another article, by the present author (Ruiz-Martínez et al. 2009). Other initiatives include the Internet Open Trading Protocol (IOTP) (Burdett 2000, Hiroya and Kawatsura 2004, Dulai et al. 2013), and the Payment Frameworks (PayFrameworks) related to the purchase of electronic products (Ruiz-Martínez et al. 2012).

These solutions were not adopted due to two main reasons. First, the use of e-payment systems was not widely diffused, and some of the core technologies were not mature enough to support payments effectively (e.g., the web, security, and semantics). Second, not all of the stakeholders were taken into account in their development. The participation of all stakeholders is especially relevant for the success of any mobile payment initiative (Gannamaneni et al. 2015).

Currently, the situation in the e-payments area is different. The use of e-payments is thriving and there are different mobile payment solutions too. They include: Paypal, EMV, BulaPay, Google Wallet, Square Cash, Bitcoin, Apple Pay, MPesa, and APSWPP, among others (Javan and Bafghi 2014). The variety of e-payments solutions, mainly mobile payment systems, is causing problems with interoperability, usability, and security. To solve these problems and to enable competition and innovation in web payments, the W3C has launched the Web Payments Interest Group (WPIG) (Jaffe and Boyera 2015, W3C 2015b). There are also other initiatives of standardization considering issues regarding e-payments such as the Financial Business Ontology (2015).

Fig. 1 shows a *conceptual layered architecture* that reflect all of the elements a payment framework should define to support the core tasks, and that is based on the initiatives I have mentioned.

In this work, I will follow a top–down approach for the description of the different layers and solutions available so far. The Web Application layer shows information about the product that a consumer may be interested in purchasing through a web page, and also includes payment information. How this information is provided is fundamental to produce a good consumer experience and prevent the risk of shopping cart abandonment. This information should also be exchanged in a secure way. To this end, it is embedded in the web page using some language that allows its automatic processing, which also is intended to improve the consumer experience. For embedding this information in a web page (HTML5), such microformats as Turtle, RDFa and JSON for Linking Data (JSON-LD), which has been adopted by WPIG, can be used. These formats attempt to express meaning on the web in a simpler way than the XML vocabularies do.

With this data, a consumer should also have information about the identity of participating entities in the system that allows her

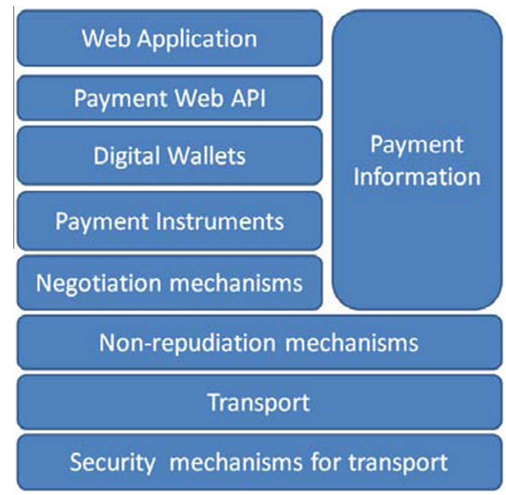

Fig. 1. Web payment framework layers.

to determine their trustworthiness. For identification and authentication, there are several mechanisms available. They include X.509 certificates, OpenID Foundation (2015, Recordon and Reed 2006), Mozilla Persona (Mozilla 2015), WebID (Story 2015, W3C 2015c), and Identity Credentials from WPIG (Sporny 2014b, W3C 2015a). The latter initiatives have arisen because certificates do not provide enough information about the kind of entity that is involved. For example, the WebID and Identity Credentials aim at identifying an entity through the web at the same time they allow working with her credentials. Currently, these initiatives are still in draft form and need to be developed further.

As for trust, there are two approaches to determine the extent of trust that exists for a web site. On the one hand, it is possible to use directories of certifying identities, such as TRUSTe. On the other hand, some mechanisms based on the concept of the "Web of Trust" are being developed, such as the Monkeysphere Project and WebID. The Identity Credentials specification (Sporny 2014b) aims at unifying the work done in identity projects such as WebID and Mozilla Persona. It provides expressive information on identity that allows associating third-party information with an entity and establishing whether it is trustworthy. It also aims to define integration mechanisms with other solutions, such as OpenID and OAuth.

When the consumer confirms the transaction, the payment process is executed by invoking the services provided by the Payment Web API. This process should be easy, quick and comfortable for the consumer.

The *Payment Information layer* represents the vocabularies and semantics used to describe information related to a purchase: products and their categories within various catalogs, payment instruments, loyalty information, and so on, as I noted earlier. The representation of this information in a semantic way facilitates the process, so that subsequently, the purchase processes can be delegated to intelligent agents (Rosaci and Sarn 2014) or recommender systems can be built (Wang et al. 2014). This information can also be shared in applications of social commerce, as an extension of e-commerce (Huang et al. 2014). The use of loyalty and coupon schemes is being introduced in mobile wallets as an additional feature (Gannamaneni et al. 2015).

Currently, the main efforts being made to define ontologies available for this purpose are progressing. They include: the GoodRelations ontology for details of products, which is widely supported by search engines (Ashraf et al. 2011); the schemas and ontology defined in the per-fee-link framework, mainly focused on payment information (Ruiz-Martínez et al. 2012); and