Secure Consumer-Oriented Integrated Services Using Activity-Based Attestation for Converging Online and In-Store Shopping Experience

Lee Fueng Yap, Masahiro Bessho, Tomonori Usaka, Takeshi Yashiro, M. Fahim Ferdous Khan, Noboru Koshizuka, and Ken Sakamura

***Abstract*—There has been an increasing number of consumers who engage in both online and in-store shopping in the recent years. However, little research has been done in providing integrated services to this group of consumers. We present the design of secure Consumer-Oriented Integrated Services (COIS) framework using activity-based attestation to converge customer services of both shopping modes. It offers consumers ease of use and privacy protection in managing receipts, products' warranty cards, coupons and vouchers. The activity-based attestation works by verifying a consumer's action i.e., proves that the consumer has purchased a product from a retailer. COIS also enhances the trust of user generated content for product review site by implementing access control mechanism via coupon system derived from the activity-based attestation. A prototype was built for evaluating the proposed framework. The evaluation results and analysis indicate that the proposed framework is capable of providing integrated services to the consumers, protecting their privacy and enhancing the trust of product review site's content.**

***Index Terms*—Activity-based attestation, consumer privacy, information trust, rights protection.**

I. Introduction

With the widespread use of the Internet and personal computing devices in these recent years, consumers have been given the liberty to shop via the Internet without having to visit the physical store. Goods selections and purchases are all carried out via the data networks. This new shopping mode known by various names e.g., online shopping and ecommerce has proliferated in recent years [1].

Even though online shopping has become ubiquitous and widely accepted, in-store shopping could not be easily displaced by the former [2]. This is because in-store shopping encompasses more than goods acquisition, it provides a channel for social interaction and entertainment [3]. Hence, in-store shopping and online shopping will coexist in the coming years; catering for the needs of individuals at different time [2]. Unfortunately, there is little research looking at providing integrated customer services to consumers who engage in both online and in-store shopping [4]. Most of the existing literatures treat online shopping and in-store shopping as separate entities that grow on their own.

Enhancements are made only to either one but not to both simultaneously such as work presented in [5], [6]. Furthermore, the rights and privacy requirements for this group of consumers have not been widely discussed in the literatures. Hence, an integrated, secure and consumer-oriented services framework that merges both the shopping modes will be needed as the number of such consumers increases in the coming future.

This paper looks at providing a secure Consumer-Oriented Integrated Services (COIS) using activity-based attestation for consumer who buys from both online and physical stores managed by the same company. The activity-based attestation function is provided by the digital receipt application built based on the Secure User-Centric Attestation Service architecture (SUCAS) [7] that uses the eTRON tamper-resistant solution [8] for digital receipts generation and storage. The activity-based attestation works by verifying a consumer's action i.e., proves that the consumer has purchased a product from a retailer. The digital receipts generated by the SUCAS protocol are non-forgeable but adhere to consumer's needs for privacy. COIS uses these digital receipts to issue digital copies of products' warranty cards, coupons and vouchers based on consumer's request.

To support services convergence, we have introduced a new type of coupon system in COIS. It only grants product review writing permission to consumer who has purchased the product from either the online store or physical store. This access control enhances the trust of the reviews submitted to the review site, making it harder for attackers and marketers from manipulating with the review site e.g., intentionally defaming a product or vice versa [9]. To further protect the consumer's rights, we have included a mechanism in COIS that notifies the consumer when his review is removed from the review site.

II. Related Work

The existing works on customer services can be broadly categorized into three categories namely the pre-sales, sales and post-sales services. Since COIS falls into post-sales customer services, we discuss the related works in this category.

1) Electronic receipts management [10]
2) Electronic voucher system [11], [12]
3) Product review [13], [14]

In [10], a web-based electronic receipt system that helps

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consumer to consolidate receipts from several merchants has been built for replacing paper-based receipt system. The consumer's purchase history is stored at the central server. This information could be data-mined by multiple parties for the generation of customized discount offers; jeopardizing the consumer's privacy. In COIS, consumer's digital receipts are stored and managed by personal tamper-resistant device that is protected by 8-byte user password. Also, the central databases uses for storing consumer data such as the coupons information are only accessible to the retailer. Retailer holds the sole liability in ensuring the security of consumer's information; simplifying the information control and protection.

There is some electronic voucher distribution and redemption research in the literatures such as [11], [12]. The previous work focuses on providing an electronic version of conventional coupon/voucher that enables consumer to purchase a merchandize with discounts or receiving a free gift. None of the work looks at providing the consumer with non-monetary or non-merchandize based coupon such as the privilege of writing a review for a purchased product. By using the activity-based attestation, the trust of the review can be enhanced. It ensures the users that the product review is contributed by the owner of the product.

There are many popular product review sites available nowadays, operated by the seller e.g., Amazon.com [13] and independent organization e.g., Epinions.com [14]. Common mechanisms used by these systems for enhancing the quality of the reviews submitted by the users are through user log-in, user's reputation and product rating systems. Our work tries to tackle the same problem from another angle. We add in an access control scheme to the existing system by limiting the rights for writing a review to only user who has purchased the product from either the online store or physical store. The proposed access control scheme works based on user's action i.e., buying a product from a retailer. Although Ebay.com [15] implements mechanism that automatically sends consumer an e-mail, asking for feedback after purchasing a product. Their implementation is more intrusive than COIS. The automatically sent email could be regarded as spam by some consumers. Also, their deployment is more applicable to online shopping environment.

III. Consumer Integrated Services

COIS purports the design of integrated, secure and consumer-oriented costumer services that map consumer's online and offline shopping activities. The fundamental element of COIS is the digital receipts generated by SUCAS [7] using the eTRON tamper-resistant device. The digital receipts represent the proof of purchase consumer obtained from the retailer through either online or in-store shopping. The generated digital receipts are non-forgeable. The security and integrity of SUCAS architecture has been verified with Japanese Subway Transportation System's delay certificate application [7]. Warranty cards, review coupons and vouchers known as the derivative documents are generated based on the content of the digital receipts. Table I depicts the format of the digital receipt stored in the eTRON tamper-resistant device. Each product, receipt and eTRON tamper-resistant device has a unique 128-bit code.

TABLE I: Fields Description of Digital Receipt

	Description
Product ID	An array for storing 128-bit product's ID, each ID corresponding to a unique product.
Price of product	An array for storing product's price. This field matches with the corresponding Product ID field.
Time stamp	Time information when the digital receipt is generated.
Receipt ID	A unique 128-bit code that identifies the receipt.
Owner ID	A unique 128-bit eTRON ID identifies the owner.

The derivative documents in digital format are distributed to the consumer via email pre-registered with the retailer. The eTRON tamper-resistant device's 128-bit ID known as the Owner ID is used as the key for finding the corresponding consumer's email address. The derived documents are managed by the consumer in personal electronic device such as the smart phone.

A. Integrated Services' Requirements

Ease of Use–The integrated services should support usability. Consumer's personal electronic device such as the smart phone could be leveraged for supporting seamless shopping experience.

Consumer Privacy–Consumer's privacy should be protected i.e., consumer should be given control on when to use his purchase history for the generation of derivative documents. This protects consumer from unsolicited advertising and spamming from the retailer. Consumer should also be protected from attacker who tries to steal private information and privilege designated to the consumer. Furthermore, consumer's private information stored at the retailer's database should be protected from unauthorized sharing with third parties.

Services Security and Integrity–The integrated services should prevent unreasonable consumer's rights withdrawal by the retailer, such as the deletion of consumer's review without any notifications and reasons. On the other hand, the services should also prevent malicious consumer from misusing the system such as generating fake derivative documents and reusing the designated one-time rights multiple times.

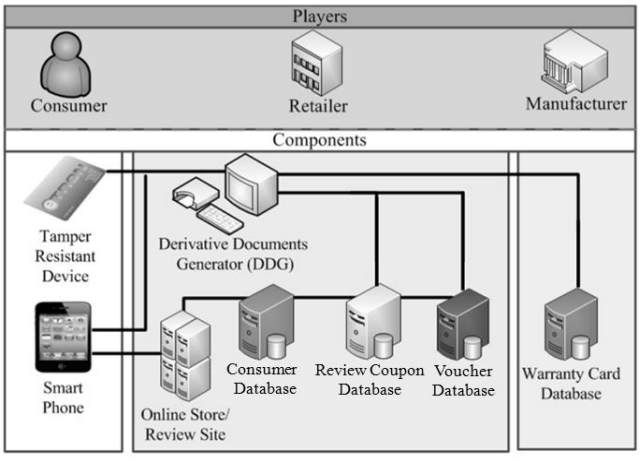

Fig. 1. Players and components of COIS

B. Players and Components of COIS

Fig. 1 shows the architecture of COIS. The players and the

functions of COIS's components are explained as below.

1) **Consumer**–User who purchases a product or service from the retailer.

Tamper-Resistant Device–Smartcard for storing digital receipts. The eTRON architecture ensures the confidentiality and the integrity of the stored digital receipts.

Smart Phone–Device used by the consumer for storing derivative documents generated by the retailer. Assumption is made such that this device is connected to the Internet.

2) **Retailer**–Seller of product or service.

Derivative Documents Generator (DDG)–DDG is the core of COIS that is responsible for generating product warranty card based on the product's Product ID found in digital receipts. It is also responsible for generating product related review coupon that enables consumer to write a review for a purchased product at the review site. Finally, the DDG also issues cash voucher that can be used at the online and physical store.

Online Store/Review Site–Website that provides online store/review site and online warranty claim services.

Consumer Database – Database that stores consumer's email address, Owner ID, online store account's information and other related information provided by the consumer.

Review Coupon Database–A database for storing review coupons issued by the DDG and the corresponding product's Product ID. This database is linked to the Consumer Database.

Voucher Database–A database for storing vouchers issued by the DDG. This database is also linked to the Consumer Database.

3) **Manufacturer**–The producer of product who holds responsibility to the product's quality.

Warranty Card Database–A database for storing a copy of consumer's warranty card and the corresponding product's Product ID. DDG communicates with this database through secure HTTPS channel.

C. Format of Derivative Documents

A unique 128-bit code known as the ucode [16] defined by the Ubiquitous ID (UID) architecture is used for representing each of the derivative documents. The meaning of the ucode is defined by the issuer of the ucode; the retailer or the manufacturer of the product defines the meaning of each ucode embedded in the derivative document.

The ucode used for the derivative documents is represented in QR Code and text-based 128-bit string. We choose to use QR Code format on top of text-based ucode for ease of use purpose. Thus the consumer can use the derivative documents in both online and physical store without having to key in the 128-bit code manually. The QR Code used in this implementation adheres to the QR Code specification defined by the UID architecture [17] such that the QR Code is signed by the ucode issuer.

D. Phases of COIS

COIS works in 2 phases, the derivative documents generation phase and the consumption phase.

1) Generation Phase

The phase starts when the consumer connects his eTRON device to the retailer's DDG via either ISO/IEC 14443 connection or ISO/IEC 7816 connection. In order for the DDG to generate derivative documents for the consumer, consumer must authenticate himself by submitting an 8-byte password. This authentication process also grants authorization to the DDG in reading the consumer's digital receipts. A secure communication channel between the eTRON device and DDG is created upon completing the authentication process. The communication is encrypted by Triple DES algorithm using pre-shared keys. A list of choices is provided to the consumer based on the content of the digital receipts. Consumer can be given 3 choices. The flow for each choice is explained as follows.

Warranty Cards Generation–Warranty card can only be generated for certain products such as electronic appliances, jewelries, watches and other luxury goods. DDG acts as a trusted proxy by forwarding the corresponding Product ID and time stamp information found in the digital receipt to the manufacturer through secure HTTPS channel. Manufacturer checks the Product ID in order to make sure no previous warranty card has been generated for the particular Product ID. After completing the checking, the manufacturer issues an ucode to represent the product's warranty card. The manufacturer then updates its Warranty Card Database by linking the warranty card's ucode with the Product ID and time stamp information. Next, manufacturer forwards the warranty card's ucode to the DDG. DDG sends the warranty card to consumer's smart phone via pre-registered email.

Review Coupons Generation–Review coupon can be generated for all products found in the digital receipts. However, the generation of review coupon is limited to one time for each product. An ucode is used for representing the review coupon. The DDG updates the Review Coupon Database that stores the mapping between Product ID, review coupon's ucode and Owner ID. Finally, DDG distributes the review coupon to the consumer.

Vouchers Generation–Voucher is issued to the consumer based on the policy of the retailer. For example, the consumer's total spending can be used as a measurement for voucher generation. Once the receipt has been used for voucher generation, it could not be reused for the same purpose. Each voucher is represented with an ucode. The DDG keeps the issued voucher's ucode, receipt's ucode and Owner ID in the Voucher Database. Finally, DDG sends the voucher to the consumer via email.

2) Consumption Phase

The consumption phase takes place when the consumer uses the derivative documents for receiving the designated privilege. The consumption phase for warranty card and voucher can take place in either virtual world or real world.

Warranty Cards Consumption–Consumer presents the received warranty card together with the product and the Product ID in order to claim for warranty. The retailer checks the validity of the warranty card by contacting the respective manufacturer. The Warranty Card Database plays a crucial role in verifying the submitted warranty card.

Review Coupons Consumption–Review coupon is used when consumer writes a review for the purchased product at the review site. The review site must confirm the linkage of review coupon, the product being reviewed, and the identity of the owner before accepting the review. This is done to

prevent attackers from using stolen review coupon. Besides that, the review site needs to make sure that a review coupon is only valid for one review. Reuse of the same coupon must be prevented. With this system, the consumer can choose to hide his identity from the readers of the review site but assuring the readers that he has purchased the product. This feature offers some level of privacy control to the consumer. Also, the review site's administrator needs to inform the reviewer through email when his entry is deleted from the review site with reasons of deletion.

Vouchers Redemption–The voucher can be used in both online and physical stores. Consumer needs to provide the voucher's ucode together with his user login when using it online. The voucher's QR Code and eTRON device are needed when using it in-store. To prevent multiple redemptions with the same voucher, retailer carries out validity check before granting the privilege to the consumer.

IV. Implementation and Experiments

A prototype was developed to justify the COIS framework. The prototype modeled a use case where a consumer uses his digital receipts obtained from online and physical shopping to request for derivative documents from the retailer. The consumer will later use these derivative documents for warranty claim, review writing and online purchase. A Intel® Core™ 2 DUO CPU with 2 gigabyte memory machine installed with eTRON development environment was used to represent the DDG. Another server installed with Apache Server 2.2, PHP 5.2.14 and MySQL 5.1 database systems was used for setting up the online store/review site. The same server was also used for hosting the manufacturer's database. This server communicated with the DDG via TCP/IP networks. A 16-bit eTRON device and an iPhone 4 were used for representing consumer's devices. The eTRON device communicated with the DDG via ISO/IEC 7816 connection.

Tests were carried out to verify the generation and consumption process for warranty card, review coupon and voucher. The screen-shots of review coupon generation and consumption are shown in Fig. 2. The output results for warranty card and voucher generation are similar to part 1 and part 2 of Fig. 2. The consumption process for warranty card and voucher can take place in both real and virtual worlds. For real work consumption, the QR Code generated in the generation phase is needed whereas for virtual world consumption, consumer needs to visit the online store/review site by clicking at the link embedded in the derivative documents' email. The average size of the email is about 10KByets.The size is relatively small compare to today's smart phone's memory capacity, thus enabling consumer to use his smart phone for managing the derivative documents. The average time taken to complete the generation process is about 40 seconds while the average time for consumption phase varies according to the type of usage. The results suggest that COIS seems to be effective in providing integrated customer services to the consumer.

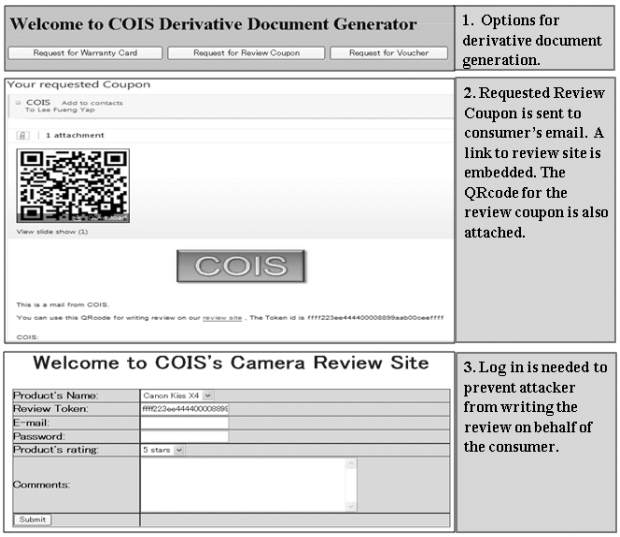

Fig. 2. Review coupon generation and consumption

V. Analysis

Besides system performance, the COIS framework is analyzed from consumer's privacy protection and services' security and integrity assurance perspectives.

A. Privacy Protection

Consumer's Privacy Protection from the Attacker–Consumer's privacy is protected by eTRON 8-byte user password. Only the owner of the eTRON device can request for derivative documents from the retailer upon completing authentication process. Furthermore, no personal information is encoded in the ucode of derivative document; to use the derivative document authentication is needed. Also, encrypted channels are used for all COIS transactions except during the distribution of derivative documents via email; this prevents the leakage of consumer's information.

Consumer's Identity Hiding from the Manufacturer –Consumer's personal information is never revealed to the manufacturer during the warranty card generation. Retailer who manages a copy of the consumer's personal data acts as a trusted proxy by forwarding the generated warranty card to the consumer on behalf of the manufacturer.

Consumer's Identity Protection in Review Site–Since only consumer who has purchased the product could be granted permission to write a review. Consumer can choose to present only the review coupon certification instead of showing his identity when reviewing the product.

Stolen Derivative Documents Usage Prevention–Since authentication is needed when using the derivative documents, attacker is prevented from using any stolen derivative documents. Also, the correct Product ID is needed when using the product warranty claim services.

B. Security and Integrity Assurance

Consumer's Rights Protection–The administrator of the review site is responsible to inform the consumer with reasonable reasons when the consumer's review is removed from the review site.

Fake Derivative Documents Prevention-Derivative documents can only be generated from digital receipts issued by SUCAS, hence the faking of these documents can be technically challenging. Also, the derivative document

represented with unique ucode is linked to the consumer's Owner ID; attacker is prevented from submitting an arbitrary 128-bit code for stealing legitimate consumer's privilege. Finally, the QR Code representing the derivative document is signed by the issuer with hash function.

One-time Generation of Derivative Document–Each type of derivative document can only be generated once for each product, e.g., a product can only have a warranty card and review coupon. Similarly, each digital receipt can only be used once for the generation of voucher. This prevents any malicious consumer from misusing the system in order to gain extra benefits from the retailer.

One-time Usage of Derivative Document–Similar to the concept of one-time derivative document generation, the generated derivative document can only be used once.

VI. Conclusion and Future Work

In this paper, we present the design and development of a secure consumer-oriented integrated services based on digital receipt application that provides activity-based attestation functionality. The services merge the consumer's online and in-store shopping purchase history for the derivation of warranty cards, review coupons and vouchers upon receiving authorization from the consumer. Also, an access control scheme based on the user's action is implemented in COIS for product review site. With this new scheme, consumer can choose to hide his identity when writing the review; enhancing the trust of the review without jeopardizing the privacy of consumer. A prototype was developed to test the feasibility of COIS. System performance and security analysis had also been carried out. The results indicate that COIS can provide designated services to consumer who engages in both real and virtual worlds shopping. Besides providing privacy protection, the security and integrity of the proposed services have also been assured. Moving forward, we plan to enhance the current COIS framework with the following features:

Integration with public review site – the current implementation assumes that the review coupon and review site are managed by same entity i.e., the retailer. With the extended model, consumer will be able to use the review coupon issued by the retailer at any public review site such as the Epinions.com [14].

Derivative documents transfer – transfer of warranty card will be needed when the original owner resells the product to other. This feature can be used for supporting seamless online auction transactions.

Detailed and careful analysis and studies are needed before implementing each of the feature into the COIS framework. These steps are crucial in preserving the consumer's privacy protection and maintaining the security and integrity offer by the existing COIS framework.

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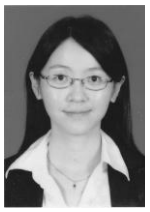

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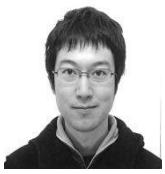

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