



# An analysis of trusted service manager development modes by mobile operating system designers in Taiwan



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## ABSTRACT

A trusted service manager (TSM) mediates between service providers, mobile network operators (MNOs), and the secure element (SE) issuer. As a facilitator to accelerate the development of the Near Field Communication (NFC) application ecosystem, such as mobile payments, e-tickets, etc., the TSM and its issues have received increased attention in recent years. In this study, the TSM development modes are analyzed under the challenges of mobile operating system designers (OSD) by an analytical network process. The research framework for developing a TSM is constructed by four main criteria and twelve sub-criteria through a literature review. Based on the authors' previous work, five possible developing modes of TSMs are set as alternatives. An analytic network process (ANP) framework is proposed, and expert questionnaires are designed. Eighteen experts in NFC-related domains, including MNO, bank, smart card, and TSM stakeholders, were interviewed, and a proper developing mode for TSM in Taiwan was obtained. All these experts are in businesses related with TSM or are familiar with the TSM ecosystem.

The analytical results not only include the ranks of four main criteria and twelve sub-criteria but also reveal that experts expect "Cooperation mode" to be the best alternative for developing a TSM in Taiwan. The explanations for the ranks are discussed with the current NFC ecosystem in Taiwan. The research framework for developing a TSM in this study is also expected to be applied to different countries, as developing modes of a TSM are generally multiple-criteria decision-making issues. Developing modes of a TSM for other countries could be implemented by changing the criteria, sub-criteria and alternatives of this research structure according to a country's own political, NFC-related business environment or development stage of the NFC industry. In conclusion, this study provides academic and managerial implications of the results showing why "Cooperation mode" could be the best alternative to develop a TSM in Taiwan. This study's contributions are as follows. First, an ANP network of TSM development is constructed, and it can be applied to other countries with similar developing mode analysis processes. Second, a proper developing mode of a TSM in Taiwan based on the views of different experts is uncovered.

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## 1. Introduction

Near field communication (NFC) technology has received increased attention in recent years; the emergence of smartphones has combined NFC technology enhancements with the potentiality of mobile commerce and smart mobile applications, such mobile wallets, e-Tickets, etc. This growing enthusiasm can be explained by the imminent launch of mobile phones equipped with NFC chipsets (Ondrus and Pigneur 2009). NFC is a short-range, wireless technology; operating at 13.56 MHz; it allows electrical equipment to exchange data or have contactless communication within 20 cm,

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and its standards are based on existing radio-frequency identification (RFID) standards, including ISO/IEC 14443 and FeliCa<sup>®</sup>. New features made possible via NFC handsets could create easier device-to-device communication or proximity transactions. However, over the last decades, despite the maturity of NFC technology, no unitary standard business model has been established due to the variety of stakeholders in the NFC ecosystem.

Stakeholders in the NFC ecosystem include the trusted service manager (TSM), mobile network operators (MNOs), service providers (SP), financial institutions, mobile handset manufacturers, and mobile operating system designers (OSD). Some of these stakeholders may play the role of the secure element (SE) issuer and may have the chance to dominate the service provided by the SE. Among these stakeholders, different MNOs, SPs, and financial institutions need to reach agreements and contracts to cooperate for the provisioning of NFC services, and the TSM plays the mediator among these stakeholders. The processes of reaching agreements are time-consuming since these stakeholders need to coordinate with one another in a many-to-many way. Cox (2009) stated that the role of the TSM could be a facilitator to accelerate the development of the NFC ecosystem. The TSM aims to be a common window among all stakeholders to raise the efficiency of the NFC ecosystem. The concept of a TSM was proposed by Global System for Mobile Communications Association (GSMA) (GSMA 2007), and the TSM is set to become a united communication window among different stakeholders and further enhance the efficiency of the NFC ecosystem by reducing the communication cost among different stakeholders (Cox 2009). That the NFC ecosystem requires a TSM for successful development is widely mentioned in previous reports from Moby Forum (2011) and GSMA (2007, 2013).

The TSM plays a role similar to that of smartphone application markets, such as Google Play<sup>®</sup> managed by Google Inc. or App Store<sup>®</sup> managed by Apple Inc. Instead of mobile applications managed by mobile markets, NFC applications, such as e-Wallets, mobile credit cards or other smart card applications, are managed by a TSM because extra secure element application software (applets) and personalized services are needed for NFC applications. The TSM is responsible for the following: first, NFC service registration and life cycle management for NFC SPs; second, life cycle management of secure elements; and third, NFC service over-the-air (OTA) provisioning and personalization. The third factor is also why TSM exists because the NFC ecosystem needs an actor to provide secure OTA provisioning service (Madlmayr et al. 2008). In summary, the TSM infrastructure can be regarded as a “general purpose over-the-air (OTA) personalization system” for secure element applets and also a “generic life-cycle manager” of the provisioned applets (GSMA 2013). The research institution Frost & Sullivan predicts that NFC Trusted Service Managers (TSMs) will be generating annual revenues of €330 million by 2015 and that the market will see a compound annual growth rate of 74% between 2010 and 2015 (Forst and Sullivan 2011).

The secure element (SE) is the key element; it plays an important role in NFC services and can be used to store sensitive and secure personal information, such as certificates, wallets, or private keys, so that consumers can have their own personalized services. Because the issuer (owner) of the SE can select SPs for the customers if multiple similar services are available, the issuer of the SE would be the dominator in the NFC ecosystem. However, MNOs, independent 3rd parties, SPs and OSDs could also act as the issuer (owner of the SE) individually. Different dominators would lead to different business models, which could have dramatic influence on the stakeholders in the ecosystem. For instance, if SPs or OSDs took the role of the SE issuer, MNOs would become only internet service providers and thus lose the dominant position in the NFC application ecosystem. To simplify the complexity of stakeholders' relationships, in this study, TSM is assumed to be operated by the SE

issuer, i.e., the TSM operator is the owner of the SE. As TSM is expected to be a facilitator to a mature NFC ecosystem, research for how it could be developed is needed.

Cox (2009) stated that the TSM can accelerate the development of the NFC ecosystem. This study aims to uncover a proper developing mode for the TSM by the analytic network process (ANP) methodology. To achieve this objective, this work operates from both an academic and practical view. An ANP framework constructed by a literature review is proposed, and expert questionnaires are designed. Experts in the related fields of TSM stakeholders, including MNO, SP, TSM, banks, and government, were interviewed, and a proper developing mode for TSM in Taiwan was obtained. This study's contributions are as follows. First, an ANP network of TSM development is constructed, and it can be applied to not only Taiwan but also other countries. Second, a proper developing mode of the TSM in Taiwan based on the views of different experts is uncovered.

The remainder of this paper begins with related works regarding TSM developing modes and the motivation for why the ANP methodology is selected in this study. Different developing mode analyses of TSM based on our previous work are discussed in Section 3. In Section 4, an ANP network for analyzing developing modes of TSM is presented, and the constructed ANP network is evaluated in the case of Taiwan in Section 5, followed by a discussion based on the analyzed results. Finally concluding remarks and further research are provided in Section 6.

## 2. Related works

### 2.1. TSM developing modes

The literature regarding TSM has mainly focused on mobile payment integration with NFC technology, and few studies have debated the development of TSM. Potential explanations include the following: first, in the past few years, standards for how the SE should be equipped with mobile phones could not be verified, and different standards could lead to varied development of TSM; and second, the TSM operator is a new stakeholder that never existed in the NFC ecosystem.

Wu (2008) discussed the development of TSM in Taiwan based on the comparative differentiation of the environment of the NFC industry with Hong Kong and Japan. SPs, such as transportation and financial institutions who possess a larger foundation of customers, would prefer to manage the platform by themselves. However, because SPs might need the space in the SIM-based SE, which is dominated by MNOs, SPs stand in an inferior position to dominate the TSM platform. To summarize, this study did not propose any development framework for TSM nor explore the impact of different stakeholders taking the role of TSM on other stakeholders in the NFC ecosystem.

GSMA extended the “Pay-Buy-Mobile ecosystem,” which is actually the TSM ecosystem proposed in 2007 (GSMA 2007) from the MNO and bank cooperated centric mode to three potential TSM business models, including “The MNO takes on the entire TSM role,” “The SP TSM acts as a technical aggregator,” and “The SP TSM acts as a technical and business aggregator” in 2013 (GSMA 2013). However, OSDs, such as Google and Apple, which act as intruders in the NFC ecosystem, were not included in the discussion. The discussion of the role of OSDs is important, especially new solutions introduced and applied by them, such as the host card emulation (HCE) technology introduced by Google Inc. in 2013 and the Tokenization standard announced by EMVCo (EMVCo) and applied by Apply Pay<sup>®</sup> in 2014.

Three frameworks proposed by Jovanovic and Muñoz-Organero (2011) mainly focused on mobile commerce under NFC technology. The first framework combines the credit card function with mobile phones, as shown in Fig. 1; however, only one NFC ser-

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