Design Science in NFC Research

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Abstract

Near Field Communication (NFC), as one of the promising technological developments, provides means to short range contactless communication for mobile phones and other devices alike. NFC has become an attractive design science research area for many academicians due to its exploding growth. A better understanding of the current status of NFC research is necessary to identify the gap between theory and practice. In this paper, we evaluate NFC literature from a design science point of view and seven important guidelines of the design science research are employed for evaluating some of the NFC related studies which propose innovative artifacts. Design science perspective of NFC literature gives beneficial guidelines for future studies. This rigorous and holistic literature review with the objective of bringing to the state-of-art in NFC design science research provides advancement of knowledge in NFC research and further research directions.

1. Introduction

Today the rapid development and adoption of information technologies is changing the way of doing business significantly. The growing interest on electronic commerce to perform business transactions brought vital improvements, especially in contactless technologies. Near Field Communication (NFC) has become one of the promising technological developments in IT industry. NFC technology is a short-range, high frequency, low bandwidth and wireless communication technology based on Radio Frequency Identification (RFID) technology. It allows us to transfer data within few centimeters. One of the advantages of NFC over other wireless technologies is simplicity [14]: transactions are initialized automatically after touching a reader, another NFC device or an NFC compliant transponder. Due to its simplicity, it has become a new and exciting area for practitioners, many NFC enabled applications and services are developed which are operating in three different modes; reader/writer, peer-to-peer and card emulation [81]. The integration of NFC technology into mobile devices offers many reliable applications; specifically payment, ticketing, loyalty services, identification, access control, content distribution, peer-to-peer data/money transfers, and set-up services.

NFC has become an attractive research area for many academicians due to its exploding growth and its promising applications and related services. Due to its nature, large proportion of the NFC research can be represented as design science research by Hevner et al. [1], which aims to propose an innovative design artifact and has a problem relevance and rigorous nature. For the last few years, there has been a considerable amount of increase in the number of research papers and activities concerning NFC. However, a better understanding of the current status of NFC research area is necessary to maintain the advancement of knowledge in NFC research and to identify the gap between theory and practice. Thus, an academic review of literature is necessary to fulfill the needs [6].

The purpose of this paper is to conduct a holistic review by analyzing the NFC literature from a design science research point of view, and complements our earlier work [6] which proposes an NFC research framework and classifies the NFC literature. This paper is organized as follows: first the related studies and resources for our literature review are examined; second the research methodology of this study is described clearly; third seven important guidelines of the design science research are employed for evaluating NFC literature; fourth the NFC research framework is described briefly; fifth the findings are evaluated; finally, promising questions and directions are suggested for future research.

2. Literature Review

Reviewing academic literature in a research area is a necessary work for providing contributions,

taxonomy, research frameworks and signifying open research areas, as well as future research directions. Such a work about NFC research area has not performed so far in a discipline and rigorous way. To provide a literature review on NFC research, primarily related review studies - information systems, electronic commerce, mobile commerce and RFID - are examined in detail.

Hevner et al. [1] propose the difference of behavioral science and design science research. Design science is inherently a problem solving process that creates and evaluates Information Technology (IT) artifacts intended to solve identified organizational problems. They mainly focus on the importance of design science in information systems research areas and creates a research framework which maintains relevance and rigorous of the research. They provide seven critical guidelines for researchers to achieve effective design-science research in Information Systems (IS). Thus, achieving a complete, effective NFC design science is a crucial and necessary issue for the advancement of NFC research. Today most of the NFC academic literature can also considered as a design science rather than a behavioral science. These guidelines help us to analyze NFC academic literature from a design science research point of view.

Another related and a broader research area is electronic commerce (e-commerce) because of its novelty and increasing growth. One can find several review studies on electronic commerce in different times and from different perspectives. In accordance with some e-commerce literature reviews such as Ngai et al. [4] and Wang et al. [5], researchers generally express e-commerce research taxonomy in four dimensions (applications, technology, support and implementation, other issues) and comparative analyses have a great impact for determination of problems and future research areas. The most considerable suggestion has been made on the development of "rigorous research methods of articles and further empirical studies" which is also a guideline for design science research [1].

Likewise, mobile commerce (m-commerce) literature reviews are also good sources those can be used when creating a suitable NFC taxonomy. Ngai et al. [3] identified the gaps between theory and practice and future research directions for m-commerce papers clearly through a well structured classification framework and analyses. In fact, RFID research area's further investigation was also proposed as well. When we narrow the research areas close to NFC literature, Radio Frequency Identification (RFID) research area -as a related technology to NFC - is also a part of e-commerce and m-commerce world. Ngai et al. [2] reviewed RFID academic literature and organized studies as "technological issues, applications areas, policy and security issues, and other issues". As stated by Ngai et al. [2], such a study is considered to be a reference study for those researchers interested in this area. Similar to literature review studies for other relevant research domains, a rigorous and holistic review with the objective of bringing to the state-of-art in NFC design science research will initiate further research on the growth of NFC technologies.

3. Research Methodology

The aim of this study is to understand NFC research as a design science research area by examining the current literature in order to provide insights for NFC practitioners and researchers. Since NFC is a rather emerging technology, research papers on NFC are relatively recent, so that the first NFC related papers are published starting from 2005. Thus the scope of this survey is limited to the time frame of 2006-2010; this 4 year period can be representative of the NFC literature.

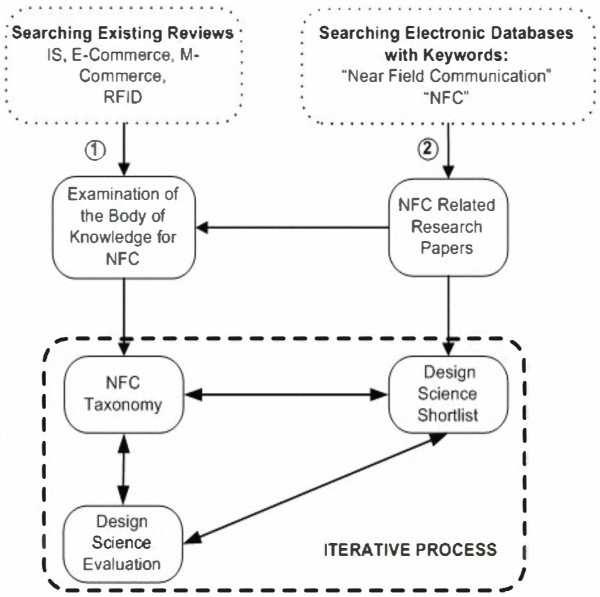

Figure 1. Search Strategy

This survey is based on articles in journals and mostly conference proceeding papers. We exclude master's theses, doctoral dissertations, textbooks, unpublished working papers, and white papers. Researchers and practitioners often use journal papers to acquire information and to disseminate new research findings [5], thus most of the existing literature reviews exclude conference proceeding papers, too. However, we did not exclude conference papers in our literature review as the proceeding papers provide also "progress of research, both in

width and breadth [5]" after journals. At the same time, we exclude some writings those are published as editorials, news reports or book reviews.

After performing the search for the papers as defined above, we have found 74 articles (see Figure 1, Step 2). The literature search was based on two descriptors; "NFC" and "Near Field Communication". It was conducted using the following electronic databases: IEEE/IEE Electronic Library, Association for Computing Machinery, ISI Web of Knowledge, Academic Search Complete, Computer and Applied Science Complete, Science Direct, Emerald Full Text.

By using the academic sources above, we listed all studies related to NFC along with their relevance. Two researchers started to work on the taxonomy of NFC research and categorization of each study, as seen in our earlier work [6]. Meanwhile, a shortlist from these studies is created for a design science evaluation; 25 studies were selected by two researchers.

Two strategies were followed during the selection of studies for a design science evaluation; elimination of similar papers in terms of topic coverage, varieties and selection of the papers which cover the subjects in- depth. This shortlist also gives information about title, author, source, domain and key research issues of the papers. 25 NFC related papers were reviewed from the design science point of view.

For an illustration purpose and contextualizing design science guidelines, consider the following two NFC studies which are examined from the design science perspective (see Table 1).

By following the Design Science Research Guidelines [1], two researchers conducted separate evaluations of these papers to see any discrepancy with their evaluations. The papers selected were examined and evaluated again to ensure more objective, systematic and rigor assessments. The research strategy followed for this study was an iterative process with a backward strategy (see Figure 1) while working on the classification of the NFC literature. We tried to find and add new studies about NFC to our review and design science shortlist. In doing so, we are able to provide academicians and practitioners with a comprehensive base for better understanding of NFC research.

4. Design Science Research Guidelines

As mentioned before, design science is inherently a problem solving process. Knowledge and understanding of design science research guidelines is the critical part of our research study. In fact, these guidelines are not mutually exclusive. In accordance with [1], the first requirement is that design science research has to provide an innovative, purposeful design artifact in the form of a construct, a model, a method, or an instantiation. The design artifact has to solve a specific problem or to develop technology based solutions which refers to problem relevance as the second requirement.

Table 1. Example from Design Science Guideline Evaluations

Guidelines	Keywords	Paper 77	Paper 78
Guideline 1: Design as an Artifact	Constructs, Models, Practices, Representations, Methods, Instantiations, Prototypes	Platform to securely manage smartcard applications in NFC devices	Prototype of a snowboarder community platform
Guideline 2: Problem Relevance	Problem Solving, Optimization, Profit Maximization	Clearly mentioned; need for secure management	Mentioned; for social interaction and provides product information
Guideline 3: Design Evaluation	Observational (Case Studies), Analytical, Experimental, Funtional or Structural Testing, Descriptive (Scenarios)	Not evaluated, only implications of the platform	Not evaluated; implications of use cases are mentioned
Guideline 4: Research Contributions	New Metrics, System Development Methodologies, Design Tools, Prototypes or Improvement of Existing Foundations	Contributes due to its nature	Mentioned but not satisfactory
Guideline 5: Research Rigor	Applicability, Generalizability, Appropriateness, Feasibility of the Design Artifact, Well Design Evaluations	Not highly rigorous; not satisfactory design evalautions	Not explicitly seen
Guideline 6: Design as a Search Process	Iterative Process, Searching for The Best, Optimal Design, Future Studies	Facilitates search process	Facilitates search process
Guideline 7: Communication of Research	Managerial and Technology Oriented Audiences	Communicates all audiences	Communicates all audiences

Indeed, these two guidelines generally mentioned in a typical design science paper due to their nature. Design evaluation as the third requirement maintains the evaluation of utility, quality, and efficiency of the proposed design artifact through observational, analytical, experimental, testing or descriptive methods [1]. In our assessments, we mainly focused on which techniques for design evaluation were used in detail, and the quality of the design evaluations. As well, a design science research has to provide clear and verifiable research contributions.

In essence, the design artifact itself must be rigorously defined, formally represented. Applicability and generalizability of the artifact has to be mentioned explicitly which is the sign of research rigor. Such a rigorous research work with clear contributions and efficient design evaluations has to facilitate a search process (i.e. the search for the best or optimal design artifact). Furthermore, the proposed design artifact must be presented both to technology-oriented as well as management-oriented audiences [1]; each side needs sufficient detail about the design artifact. Such communication of design science research provides repeatability of the proposed artifact and further research works for technology oriented audiences. At the same time, management oriented audiences appreciate such an artifact's nature; make assessments within their specific organizational context. This paper identified 25 academic research papers on NFC technology to provide reasonable amount of insight into the current status of NFC literature through design science guidelines.

5. NFC Research Framework

In our earlier work, an NFC research framework of the NFC literature is presented and a total of 74 studies were classified with respect to the proposed framework [6]. NFC academic literature is classified in four major categories (see Figure 2) and signified the bidirectional relationships between categories: NFC Theory and Development, NFC Infrastructure, NFC Applications and Services and NFC Ecosystem.

According to the presented framework, NFC Theory and Development is the fundamental level of the given NFC research framework. It includes the studies related with the development of NFC technology and applications, and these papers generally focus on more behavioral issues and behavioral sciences which seek to develop and justify theories, rather than developing a design artifact.

NFC Infrastructure and NFC Applications and Services layers are the intermediate levels. NFC Infrastructure is examined in terms of three major aspects; Network and Communication issues hardware issues dealing with Tags, Antennae, Reader and NFC Chip, Security and Privacy issues that focus on developing design artifact rather than behavioral issue. In case of NFC Applications and Services, NFC technology covers a wide range of applications and these applications provides real implementations or prototypes with rigor design artifact evaluations such as experimental, testing or field studies etc. NFC applications are investigated from the standpoint of NFC operating modes: Reader/Writer Mode Applications, Card Emulation Mode Applications and Peer-To-Peer Mode Applications.

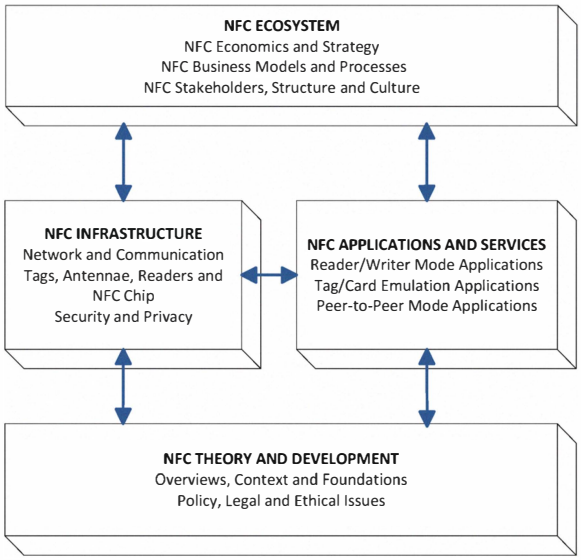

Figure 2. Classification Framework for NFC Research [6]

NFC Ecosystem as the highest level of the NFC Research Framework can be also referred as a part of the problem space or environment of NFC research. NFC ecosystem is examined in three major categories in this framework. NFC Economics and Strategy and NFC Business Models and Processes are dealing with more business requirements, analysis and managerial sides of the NFC technology. Third aspect is the NFC Stakeholders, Structure and Culture which is dealing with more social sides of NFC technology such as roles, characteristics and capabilities of stakeholder (e.g. user acceptance, usability, adoption, reliability, manageability) of stakeholders (e.g. MNO, service providers, end users), culture of NFC enabled services.

6. Discussion

NFC as a new emerging research area has attracted the attention of both practitioners and

academicians. According to the findings, academic research activities on NFC area have increased significantly after the year 2006. With this study, we want to shed light on the current status of NFC research. This paper as a complementary of our earlier work [6], evaluates 25 design science research papers which are selected from these 74 papers through design science guidelines. These two particular analyses will provide us promising guidelines for pursing rigorous and business relevant research on NFC and its applications, services. Although today, literature review on NFC does not provide so many articles published in journals, this study will provide useful insights into the NFC literature, future research directions and will identify the gap between theory and practice. The results from NFC classification scheme and from design science guideline evaluations have several important implications.

- It is true that, NFC technology has become a promising, challenging research area in recent years. There is a clear need for more journal publications to provide business related and rigorous research papers on NFC technology.
- It is not surprising that most of the academic research papers were related to NFC Applications and Services, especially operating in reader/writer mode. The reason of such interact on this mode is that development and implementation of such services or applications are much easier than developing applications operating in other modes. Unfortunately we did not find many rigorous research papers on Peer-to-Peer Mode Applications.
- The second largest proportion of the papers is related with the NFC Infrastructure. Our review shows the importance of focusing on technical issues of a new technology again, rather than issues related to realizing economics, business values or strategies for NFC development, dissemination and marketing. As seen in Table 1 (Ozdenizci et. al. 2010), literature dealing with technical issues on NFC is useful for anyone who is studying on NFC Infrastructure. We expect more specific research to be conducted on business issues, economics of NFC technology.
- While developing new NFC enabled applications or services, ecosystem of NFC technology clearly needs to be considered. Such new applications or services can bring new business models, processes with new players. Especially the capabilities, characteristics and roles of stakeholders need to be evaluated and modified when necessary, in order to satisfy the requirements of new business models and processes.
- In terms of theory and development, most of the research papers published in journals were overviews and assessments on NFC technology rather than proposing a new design artifact. The articles in journals that we found are not sufficient for development of NFC literature. We expect more rigorous design science research on NFC to be published in journals.
- Policy, ethical and legal problems which can be referred as behavioral issues were another important and demanding research areas for development of a new, emerging technology. However, it is hard to find papers dealing with the public policy or legal problems (e.g. taxation problems, trust, fraud, privacy issues for internet privacy, financial privacy). Indeed, this should prompt academic researchers to investigate this area.
- Currently it seems that the most popular NFC related research subjects are on developing new NFC enabled applications and developing NFC infrastructure. Thus, NFC research can be mostly referred as design science research. The findings from our design science guideline evaluations shows that up to now most of the NFC design science papers proposes an innovative artifact which provides an utility for a specific, relevant business problem. These two requirements for a design science research is sufficiently considered and explained in the research papers. Needlessly to say that the explicitly emphasized business problems will be more beneficial and useful for the research's integrity and for other practitioners.
- As mentioned before utility and efficiency of the proposed artifact must be demonstrated in well-selected methods. Design Evaluation guideline needs to be highly considered while performing NFC academic research. Most of the papers (of 25 research papers) use more descriptive (e.g. scenarios, use cases to demonstrate its utility) or analytical (e.g. architecture analysis) methods while developing an applications or service, rather than performing experimental or testing methods. In some papers, inadequate design evaluations are performed, or implications of the proposed design artifacts are seen. Instead of evaluations through scenarios or use cases; field studies, controlled experiments or simulations will be more useful for representing the proposed artifact rigorously.
- As seen in our review, nearly all of the NFC research papers provide research contributions explicitly or implicitly, due to their nature. For instance, an NFC design science paper [15] provides varying contributions in terms of security, network and communication while proposing a new NFC enabled service. For sure the contributions have to be in a clear, explicit and verifiable way for future studies.
- When we look at in terms of research rigor perspective which depends on the construction and evaluation of design artifact, the design artifact's

applicability and generalizability have to be represented. There is a clear need for rigorous NFC research papers, which provide high level of research. On the other hand, most of the NFC related papers facilitates a search process, there is a desire to find optimal artifact. In terms of communication of research, nearly all of the NFC research papers presented to technology oriented and management oriented audiences. In some infrastructure papers, it is hard to consider this issue. They are mostly presented to technology oriented audiences. As well management oriented audiences need sufficient detail about the proposed artifact. Effective communication of the research is necessary for future works.

7. Future Work

The literature review presented in earlier work, Ozdenizci et. al. [6] and design science evaluations of NFC literature in this study aim to provide a holistic review and a comprehensive base for understanding of NFC research. According to the findings, 40.54% of the NFC literature concentrates on developing NFC applications and services in different operating modes. We expect more attention has to be paid to less developed research areas; in particular economics, strategy, business values, culture, policy and legal issues. In accordance with [2], also for NFC practitioners, more useful guidelines for the development of NFC enabled applications or NFC infrastructure is necessary within the context of NFC Theory and Development. In addition to our evaluations, we would like to propose some research questions for further research in Near Field Communication:

- Are there any public policies, regulations and legal standards for the development and adoption of NFC technology at the individual and corporate level?
- How to develop required NFC standards from policy, regulations and legal points of view?
- What are the potential NFC-enabled applications that are operating in peer to peer mode?
- What are the impacts on the adoption and acceptance of NFC applications on the user side?
- What are the possible implications of cultural differences on adoption of NFC technologies and new business opportunities?
- What are the impacts of NFC technologies on creation of business models and processes?
- How developments in NFC technology as an information technology tool can be evaluated in terms of economic performance and economic decision rules?

As a matter of fact, we believe that more sub-topics should be added and updated in the given classification framework (Figure 2) after five or six years; and with the development of NFC literature more rigorous and highest level of research as articles will be published in journals. At that moment, such a literature review [6] and design science analysis on NFC should be performed again to find new open research areas.

8. Acknowledgement

This study is supported by a grant from the ISIK University with the project number ISIKBAP 09A103.

9. References

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The comprehensive list of all reviewed 74 papers that corresponds to classification scheme can be found at http://it.isikun.edu.tr/icitst2010/references.htm