MODELING AND EVALUATION OF PLATFORM-LEVEL INTEROPERABILITY FOR MOBILE MONEY TRANSFER SYSTEMS

Elyjoy Muthoni Micheni

A thesis submitted in partial fulfillment for the requirements of the degree of Doctor of Philosophy in Information Technology of Masinde Muliro University of Science and Technology

2014
ABSTRACT

Techniques to expedite money transfer have been perfected over time. The use of Mobile phone to transfer money as an alternative to existing traditional payment systems is one of the evolutions of mobile telephony. Mobile money services offer the most convenient means of transferring money and are constantly evolving and are predicted to become the number one choice for cashless transactions in emerging markets. However, despite these prospects, there are various challenges to the expansion of this technology, cross network money transfer being one of them. For example, it is not possible to directly transact money between the different mobile money service providers in Kenya seamlessly. Although the money will be finally transacted, one has to pass through several agents before being able to transact. The research study was aimed at developing a platform level interoperability model for mobile money transfer systems using the Real Time Gross Settlement (RTGS) money transfer system as a reference model. The study used both qualitative and quantitative data from the four main mobile money providers in Kenya, M-Pesa, Airtel Money, Orange Money and Yu Cash to provide empirical evidence for the study. The study is grounded on two theories of interoperability. The first is Institutional Theory of interoperability which stipulates that organizations respond to pressures arising from both their external and internal business environments and adopt structures and practices that are accepted as appropriate organizational choices. The second one is the Interoperability Theory, which indicates that there is no single form or optimal amount of interoperability that will suit every circumstance and therefore, it should be allowed to evolve naturally. Data was collected using mainly a structured Questionnaire and face to face interview. The study used an interpretative exploratory research approach, simple random sampling to distribute the questionnaires and purposive sampling technique for the interview schedules. Qualitative and quantitative data collected was analyzed using both descriptive (frequencies, mean and standard deviation) and inferential statistics (Spearman’s rho and factor analysis). Expert opinion survey was used to develop the proposed interoperability model. The model was validated by Structural Equation Modeling (SEM) using Analysis of Moment Structures (AMOS). The interoperability metric was developed based on ISO/IEC 15504-2 standard; the metric was applied to the four main mobile service providers. The model was successfully accepted by experts. The findings of this study are essential to the government in regulating mobile money and also form a basis for future development of interoperability of mobile money transfer systems.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>2</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>9</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>10</td>
</tr>
<tr>
<td>ACRONYMS AND ABBREVIATIONS</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>DEFINITION OF OPERATIONAL TERMS</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>CHAPTER ONE: INTRODUCTION</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.1 Background to the study</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.2 Statement of the Problem</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.3 General Objective</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.4 Specific Objectives</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.5 Research Questions</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.6 Significance of the study</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.7 Scope of the Study</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.8 Limitations of the study</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.9 Contributions of the Study</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>1.10 Organization of the Thesis</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>CHAPTER TWO: LITERATURE REVIEW</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>2.2 Mobile Money</td>
<td>Error! Bookmark not defined.</td>
</tr>
</tbody>
</table>
2.2.1 Definitions

2.2.2 Mobile money transfer service

2.2.3 Technologies supporting mobile payment transfers

2.2.4 Mobile Money Service Providers in Kenya

2.3 Interoperability

2.3.1 Key definitions of interoperability

2.3.2 Need for Interoperability

2.3.3 Evolution of Interoperability

2.3.4 Levels of Interoperability in relation to Mobile Money

2.3.5 Types of Interoperability

2.3.6 Theories of Interoperability

2.3.6.1 Interoperability Theory

2.3.6.2 Institutional Theory

2.4 Impact of Technology, Cost, Policy and Security on Interoperability

2.4.1 Technology

2.4.3 Cost

2.4.4 Security

2.5 Existing Interoperability Frameworks

2.5.1 Mobile Agents System Interoperability Facilities (MASIF) Framework

2.5.2 Open Mobile Access Abstract Framework (OMAF)

2.5.3 Foundations of Intelligent Physical Agents (FIPA) Framework
2.5.4 Grid Mobile Agent System (GMAS) Framework

2.5.5 Interoperability in Card Payment System

2.5.6 Tangaza Pesa

2.5.7 Real Time Gross Settlement (RTGS) System

2.6 Interoperability Assessment Techniques

2.6.1 Levels of Information Systems Interoperability (LISI)

2.6.2 Organizational Interoperability Maturity Model (OIMM)

2.6.3 Enterprise Interoperability Maturity Model (EIMM)

2.6.4 Government Interoperability Model Matrix (GIMM)

2.6.5 Information Systems Interoperability Maturity Model (ISIMM)

2.7 Conceptual Framework

2.8 Chapter Summary

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

3.2 Research Design

3.3 Research Strategy

3.4 Target Population

3.5 Sampling Design and Sample Size

3.6 Research Instruments

3.7 Pilot study

3.8 Validity of the Research Instruments

3.9 Reliability of the Research Instruments
3.10 Data analysis...............................................Error! Bookmark not defined.
3.10.1 Mean Interpretation .................................Error! Bookmark not defined.
3.10.2 Standard Deviation Interpretation ..............Error! Bookmark not defined.
3.10.3 Correlation interpretation ..........................Error! Bookmark not defined.
3.10.4 Regression Interpretation ........................ Error! Bookmark not defined.
3.10.5 Factor Analysis Interpretation ..................Error! Bookmark not defined.
3.11 Ethical Consideration .................................Error! Bookmark not defined.
3.12 Chapter Summary.......................................Error! Bookmark not defined.

CHAPTER FOUR: MOBILE MONEY TRANSFER PROCESS MODEL Error! Bookmark not defined.

4.1 Introduction ..............................................Error! Bookmark not defined.
4.2 Response Rate ...........................................Error! Bookmark not defined.
4.2.1 Response Rate for Mobile Money Transfer SubscribersError! Bookmark not defined.
4.2.2 Response Rate for Technical Staff ..............Error! Bookmark not defined.
4.3 Respondents Demographics ..........................Error! Bookmark not defined.
4.3.1 Gender of respondents ..............................Error! Bookmark not defined.
4.3.2 Age of Respondents .................................Error! Bookmark not defined.
4.3.3 Occupation of Respondents .......................Error! Bookmark not defined.
4.3.4 Level of Education of Respondents .............Error! Bookmark not defined.
4.4 Modeling the mobile money transfer process Error! Bookmark not defined.
4.5 The Proposed Process Model .......................Error! Bookmark not defined.
4.5.1 Architecture of the Model ........................Error! Bookmark not defined.
4.5.2 Algorithm for the model ..........................Error! Bookmark not defined.
4.6 Results and Discussions ..............................Error! Bookmark not defined.
4.6.1 Market Share of Mobile Service Providers...

4.6.2 Profile of mobile money transfer users based on gender of users...

4.6.3 Profile of Mobile Phone Money user and Length of time of using Mobile Money Transfer Platform...

4.6.4 Profile of Mobile Phone Money user and age bracket of the users...

4.6.5 Profile of Mobile Phone Money users and occupation of the users...

4.6.6 Profile of mobile money transfer with the geographical area of users...

4.6.7 Profile of mobile money transfer and frequency of use among the Subscribers...

4.6.8 Factors in the implementation of MNO Interoperability...

4.6.9 Factors inhibiting successful implementation of interoperability of MNOs in Kenya...

4.6.10 Model Significance with ANOVA...

4.6.11 Coefficients of the model to interpret relative ranking of the factors...

4.6.12 Key challenges that affect the implementation of mobile money network Interoperability...

4.6.13 Commonality Extraction...

4.6.14 Eigenvalues Component Extractions...
CHAPTER FIVE: A MODEL FOR EVALUATING THE INTEROPERABILITY OF MOBILE MONEY TRANSFER SYSTEMS

5.1 Introduction

5.2 Response Rate

5.2.1 Respondent Demographics

5.2.1.1 Gender of Respondents

5.2.1.2 Age of Respondents

5.2.1.3 Occupation

5.2.1.4 ICT Qualification

5.3 The Proposed Model

5.4 Model Development

5.4.1 Architecture of the Model

5.4.1.1 Model Analysis

5.4.1.2 Model Measures of Fit

5.4.2 Applicability of the Model

5.4.2.1 Validation of the Model

5.4.2.2 Verification of the Model

5.4.2.3 Validation Tools for the Final Model

5.4.2.4 Quantitative Results of Model Validation

5.5 Metrics for Evaluating Interoperability

5.5.1 Base Metrics
5.5.2. Derived Metrics: The Interoperability Index.

5.5.3 Case Study

5.5.3.1 Case Study I: M-pesa

5.5.3.2 Case Study II: Air Tell Money

5.5.3.3 Case Study II: Yu Cash

5.6 Chapter Summary

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

6.2 Recommendations

6.3 Future Work

REFERENCES

APPENDICES
LIST OF FIGURES

Figure 2.1: Structure of the Mobile Finance Market.
Figure 2.2: Players in Mobile Money Ecosystem.
Figure 2.3: Cash in MNO Model.
Figure 2.4: Person to Person transfer MNO model.
Figure 2.5: Safaricom Operational Framework.
Figure 2.6: Card Payment System Model.
Figure 2.7: The RTGS Model.
Figure 2.8: Conceptual framework.
Figure 4.1: Transaction Process Interoperability Model for Mobile Money Transfer System.
Figure 4.2: Architecture of the Model.
Figure 4.3: Client-Server Architecture.
Figure 4.4: A flowchart for mobile transaction database query.
Figure 4.5: Flowchart for the Model.
Figure 4.6: Market Share of Mobile Service Providers.
Figure 5.1: Model Regression Weights.
Figure 5.2 MNOs Respondents Proportions.
Figure 5.3 MNOs Interoperability Preparedness.
LIST OF TABLES

Table 2.1: Key players in mobile money ecosystem

Table 3.1: Expert Opinion Survey Guide

Table 3.2: Reliability Coefficients

Table 3.3: Mean Interpretation

Table 3.4: Summary of Data Analysis Techniques

Table 4.1: Response Rate for Mobile Money Transfer Subscribers

Table 4.2: Response Rate for Technical Staff

Table 4.3: Gender of Respondents

Table 4.4: Age of Respondents

Table 4.5: Occupation of Respondents

Table 4.6: Level of Education of Respondents

Table 4.7: Profile of mobile money transfer based on gender of users

Table 4.8: Mobile Money User versus Length of Time of Using Mobile Money Transfer Platform

Table 4.9: Profile of Mobile Phone Money user and age bracket of the users

Table 4.10: Profile of Mobile Phone Money user and occupation of the users

Table 4.11: Profile of mobile money transfer with the geographical area of Users

Table 4.12: Frequency of use of mobile money transfer services among the subscribers

Table 4.13: Validity of Various factors influencing your choice of service Provider
Table 4.14: Key Challenges that Prevent mobile network Interoperability.

Table 4.15: Enhancing Mobile money transfer interoperability.

Table 4.16: Staffs information on the benefits of interoperability.

Table 4.17: Drawbacks of interoperability.

Table 4.18: Model Summary.

Table 4.19: Model Significance with ANOVA.

Table 4.20: Coefficients of the model to interpret relative ranking of the factors.

Table 4.21: Kaiser-Meyer-Olkin and Bartlett's Test.

Table 4.22: Commonality Extraction.

Table 4.23: Eigenvalues Component Extractions.

Table 4.24: Component Extractions.

Table 4.25: Factor category 1: Cost.

Table 4.26: Loading of Factor 2: Technology.

Table 4.27: Loading of Factor 3: Policy/regulation.

Table 4.28: Loading of Factor 4: Security.

Table 4.29: Spearman Correlation results for interoperability indicators.

Table 4.30: Moderating factors of interoperability.

Table 5.1: Response Rate.

Table 5.2: Gender of Respondents.

Table 5.3: Age of Respondents.

Table 5.4: Occupation of Respondents.

Table 5.5: ICT qualification.

Table 5.6: Interoperability Maturity Levels.
Table 5.7: Questionnaire Items ..........................Error! Bookmark not defined.
Table 5.8: Model Fit Measures ..........................Error! Bookmark not defined.
Table 5.9: Comparison of Model with related Maturity Assessment Models Error! Bookmark not defined.
Table 5.10: Quantitative Results of Model Validation Error! Bookmark not defined.
Table 5.11  Interoperability Maturity Levels ..............Error! Bookmark not defined.
Table 5.12  Metrics Index .................................Error! Bookmark not defined.
Table 5.13: Base Regression Weights Index ...............Error! Bookmark not defined.
Table 5.14: Moderating variables Index ....................Error! Bookmark not defined.
Table 5.15: Interoperability Index assigned scores.....Error! Bookmark not defined.
Table 5.16: M-Pesa Metrics Index ..........................Error! Bookmark not defined.
Table 5.17 Airtel Metrics Index .............................Error! Bookmark not defined.
Table 5.18 Yu Cash Metrics Index ..........................Error! Bookmark not defined.