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Intelligent Agents' Based Fuzzy Liquidity Management Technique for Mobile Money Transfer

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Abstract: ***Mobile money transfer technologies are providing services to millions of people. People can safely transfer money through the mobile phones without necessarily relying on bulky cash. M-Pesa is an example of a mobile money transfer system prominent in Kenya. Mobile money liquidity management, having approximately the right amounts of both the physical cash and e-cash, remains a key challenge for many mobile money retail agents. In most cases, the mobile money customers are unable to transact. On the other hand, mobile money retail agents have to make one or more trips to the bank in order to rebalance the liquidity. The mobile money transfer systems operate in uncertain environment. A review of intelligent agents' and fuzzy logic based applications in uncertainty management shows that integrating the two one can have a more precise mobile money liquidity management technique. In this paper we present liquidity management technique that allows integration of intelligent agent and fuzzy logic. Intelligent agents will analyze both internal and external environment of the mobile money transfer system to collect all the data affecting liquidity management. Fuzzy logic manages the accumulated data to give a more precise output of a predicted e-cash and physical cash. Evaluation of the technique showed that it effectively managed liquidity with lower percentage error as compared to the existing liquidity management techniques and tools. The study recommends the possibility of linking the tool with EFTPOS or the banking systems that directly or indirectly affect the mobile money transactions of a specific group of people in order to provide more meaningful data trends / patterns on mobile money.***

Keywords: fuzzy logic, liquidity management, e-cash, physical cash and MPesa

1. Introduction

According to [1], the communication market in Kenya as well as the entire East Africa Region is still growing. The level of competitive rivalry among several company providers in the mobile and internet market has also grown over the time. According to [8], the mobile money technologies are currently providing services to millions of people in Kenya and the East Africa Region at large. With this innovation, many people can safely send money or pay bills without relying exclusively on bulky cash. M-Pesa is an example of a mobile money transfer system prominent in Kenya. After M-Pesa was invented, people shifted to it as the most preferred means of sending cash to friends and relatives. "LIPA NA M-PESA" is operational in almost every business premise including at vegetable kiosks [5]. This is a clear evidence of the positive social impact that mobile money transfer technology has had to the society.

Mobile money liquidity management, which is having approximately the right amount of physical cash as well as the e-cash, remains a key challenge for many mobile money retail agents in the day to day running of their businesses. In most cases, the mobile money customers are unable to transact due to lack of either enough physical cash or e-cash held with the mobile money retail agents [9]. For this reason, the mobile money customers have to put up with the inconvenience of having to return to the mobile money retail agents to access the service at a later time of the day or the week. At the same time, the mobile money retail agents have to make one or more trips to the bank in order to get more physical cash or be able to load more e-cash on their e-account. This creates a huge expense and inconvenience for both the mobile money retail agents and the customers. The situation is worse in the rural areas where the retail agents have to travel for relatively long distances before they are able to access the bank or bank agents. The mobile money retail agents in Kenya have not been an exemption to this challenge [9].

In the modern information age and knowledge based economy, the vast amount of information generated on the network can be mined and be made meaningful for strategic and competitive advantage. Intelligent agents and fuzzy logic have been used in various applications to aid in decision making in uncertain environment. The study recommends the use of intelligent agents which identify the trends, learn and determine the various factors that affect mobile money liquidity management. At the same time, the fuzzy logics can determine the degree to which each of these factors can affect liquidity, by managing sets of accumulated knowledge.

The rest of the paper is organised as follows; Section 2 presents related work. Section 3 describes the proposed technique. In section 4 the paper presents the experiments and results of the study and section 5 presents discussion of the results. Section 6 presents the conclusion and future work.

2. Related Work

Indeed so much literature exists of work that has applied intelligent agents and fuzzy logics in managerial decision making for handling uncertainties and imprecise information involved in the process. Mobile money transfer services operate under uncertain environment. A detailed review was done with different emphasis, on the models developed to solve the difficulties of decision making under uncertainty.

The first model reviewed in this study is Agent-based negotiation and decision making tool for dynamic supply chain formation. [11] proposed this model to solve the challenges facing modern businesses on effectively coordinating supply chains from upstream to downstream services. Each agent works as a broker for each service type, dedicated to selecting solutions for each service as well as interacting with other agents in refining the decision making to achieve compatibility among the solutions. The model only embraced team work characteristics of the intelligent agents whereby each agent performed its function and all combined they accomplished the function of decision making. In the model all service type was valued with equal weight on the influence of the decision making which is not the case.

The second model reviewed was an intelligent agent-based approach to sales operations at E-stores proposed by [10]. Intelligent agents are incorporated in an E-store to improve the performance of operations including sales, forecasting demand and supporting order fulfillment. Pre-existing information is extracted from available information to E-stores that include database systems and websites' server log-files. Master sales agent (MSA) that provides periodic system wide adjustments to sales tactics for example setting price modifications or seasonal sales based on the recent behaviour of all customers and a group of Personal sales agents (PSAs) that select sales tactics by comparing online actions of customers to suggestions provided by MSA. MSA creates and updates the set of adjusted tactics. PSAs use the adjusted sales tactics and the knowledge of customer behaviour produced by the MSA to assign a tactic to a customer based on his/her online actions.

Intelligent-agent-based fuzzy group decision making model for financial multicriteria decision support model that was reviewed. According to [7], credit scoring is one of the key analytical techniques in credit risk evaluation. They proposed a novel intelligent-agent-based fuzzy group decision making (GDM) model as an effective multicriteria decision analysis (MCDA) tool for credit risk evaluation. In this proposed model, intelligent agents are first used to analyze and evaluate the risk levels of credit applicants over a set of pre-defined criteria. Then these evaluation results, generated by different intelligent agents, are fuzzified into some fuzzy opinions on credit risk level of applicants. Finally, these fuzzification opinions are aggregated in to a group consensus and meantime the fuzzy aggregated consensus is defuzzified into a crisp aggregated value to support final decision for decision-makers of credit-granting institutions. The model does not incorporate real time dynamic data.

According to [2], decision making process in stock trading is a complex one. With the huge availability of stock information, made possible by the internet, the task of the investor has been made more difficult, as he will have to collect, analyse, filter and make correct decision from several information. To successfully trade in the financial markets, it is important to develop models where one can identify different states of the market so as to modify one's actions [6]. They proposed a predictive stock market technical analysis using fuzzy logic. The proposed technique deploys fuzzy inference to stock market, with four indicators used in technical analysis to aid in the decision making process in order to deal with probability. The fuzzy rules are a combination of the trading rules for each of the indicators used as the input variables of the fuzzy system and for all the four technical indicators used, the membership functions are defined. The result is a recommendation to buy, sell or hold. The technique did not fully filter all the stock information through application of intelligent agents.

[4] proposed a probabilistic fuzzy logic based stock price prediction technique. Stock market prediction is the act of determining the future stock value of a company on a stock exchange. The proposed technique presents an innovative probabilistic approach for stock price prediction that minimizes the investors risk while investing money in the stock market. The main feature of the stock market is uncertainty because the movement of the stock market is highly non-linear and dynamic. In order to predict the future stock value, current and previous conditions of the market are analysed based on economic data.This approach triggers an appropriate output event to notify the opportunities to buy and to sell share in real-time based on event patterns of price movements. Analysis of real time data should be considered to allow for a more effective decision.

In the applications discussed above, fuzzy logic and intelligent agents have been used in an uncertain environment to allow for most accurate actions to be taken. The applications do not allow for analysis of the environment they operate in. The suggested technique for liquidity management allows for integration of fuzzy logic and intelligent agents. The intelligent agents analyses the environment in order to determine all the factors affecting liquidity in mobile money transfer. Fuzzy logic will incorporate all the identified factors by weighting each of them depending on the influence it has on liquidity. Each of the factors will be fuzzy input variables and fuzzy rules will then be applied. A decision of how much e-cash and physical cash to have will be the output.

3. Fuzzy Liquidity Management Technique.

3.1 Fuzzy Liquidity Management Technique

A detailed description of how the proposed technique was designed is presented. The technique is built based on the functional and non- functional requirements obtained during requirement gathering.

Figure 1 shows a level 0 data flow diagram of the major processes that comprise the liquidity management technique for a mobile money transfer system. The major processes comprise of internal exploration agent which gathers mobile money data from the mobile money transfer system. The external exploration agent , gathers data related to mobile money from the external sources. The data from the external exploration agent and the internal exploration agent is stored in a central database. The data from the central database acts as the input for the fuzzy engine. Fuzzification process takes place by weighting each of the input data depending on its

influence to liquidity management. Membership function is identified and fuzzy rules are formulated. An output is produced which is a decision of the values of the e-cash and the physical cash requirements for a mobile money retail agent.

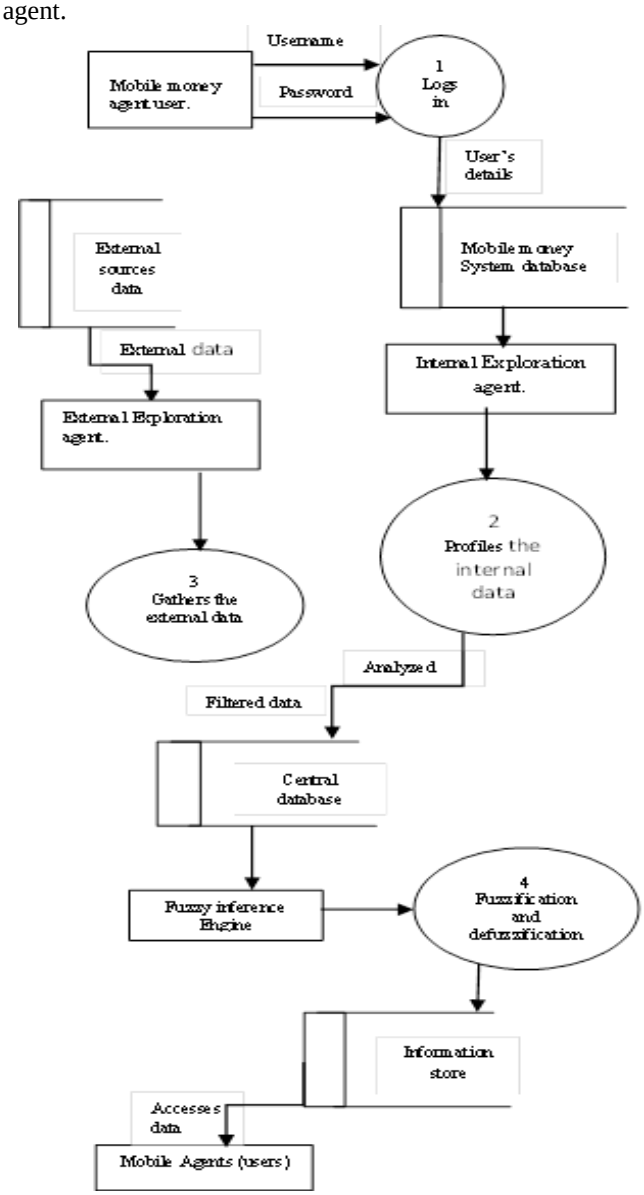


Figure 1: Level 0 DFD for the intelligent agents' based fuzzy liquidity management technique for a mobile money transfer system

3.2Intelligent Agents

The origin of intelligent agents can be attributed to the field of artificial intelligence (AI) where the goal of developing artifacts capable of behaving in a seemingly intelligent manner inspired attempts by early researchers to simulate human capabilities so that machines could behave reactively and proactively in an autonomous fashion [12].Intelligent agents have the ability to decide their course of actions dynamically. This characteristic and the others exhibited by an agent has led the researcher to apply intelligent agents in this study to learn the environment that mobile mobile transfer system operate in. The details of the two intelligent agents used in the study are discussed in section 3.2.1 and 3.2.2.

3.2.1 Internal Exploration Agent data modeling.

The mobile money transfer system's data is collected by the internal exploration agent. Data is then loaded into the accounts' profiling analyzer agent. The data is then grouped into different transactions category. The transaction patterns are then analysed and the output (data patterns) generated is sent to the central database.

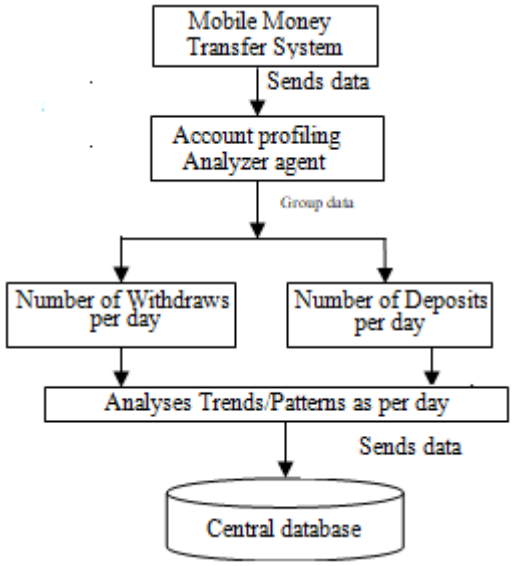


Figure 2: Internal Exploration Agent data modeling.

3.2.2 External Exploration Agent data modeling

The data and / or information from electronic network is collected by the external exploration agent. It is then loaded in to the data filtering analyzer agent. Data is then filtered to give out data only related to the mobile money. The filtered data is analysed to identity factors that influence transactions on the mobile money transfer system. The factors identified are then sent to the central database.

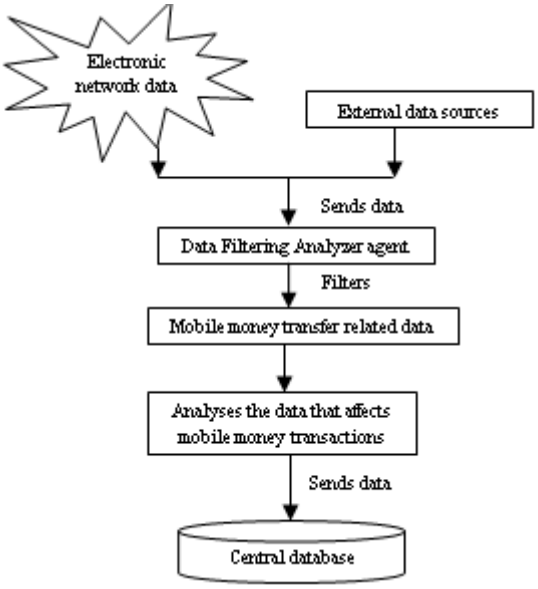
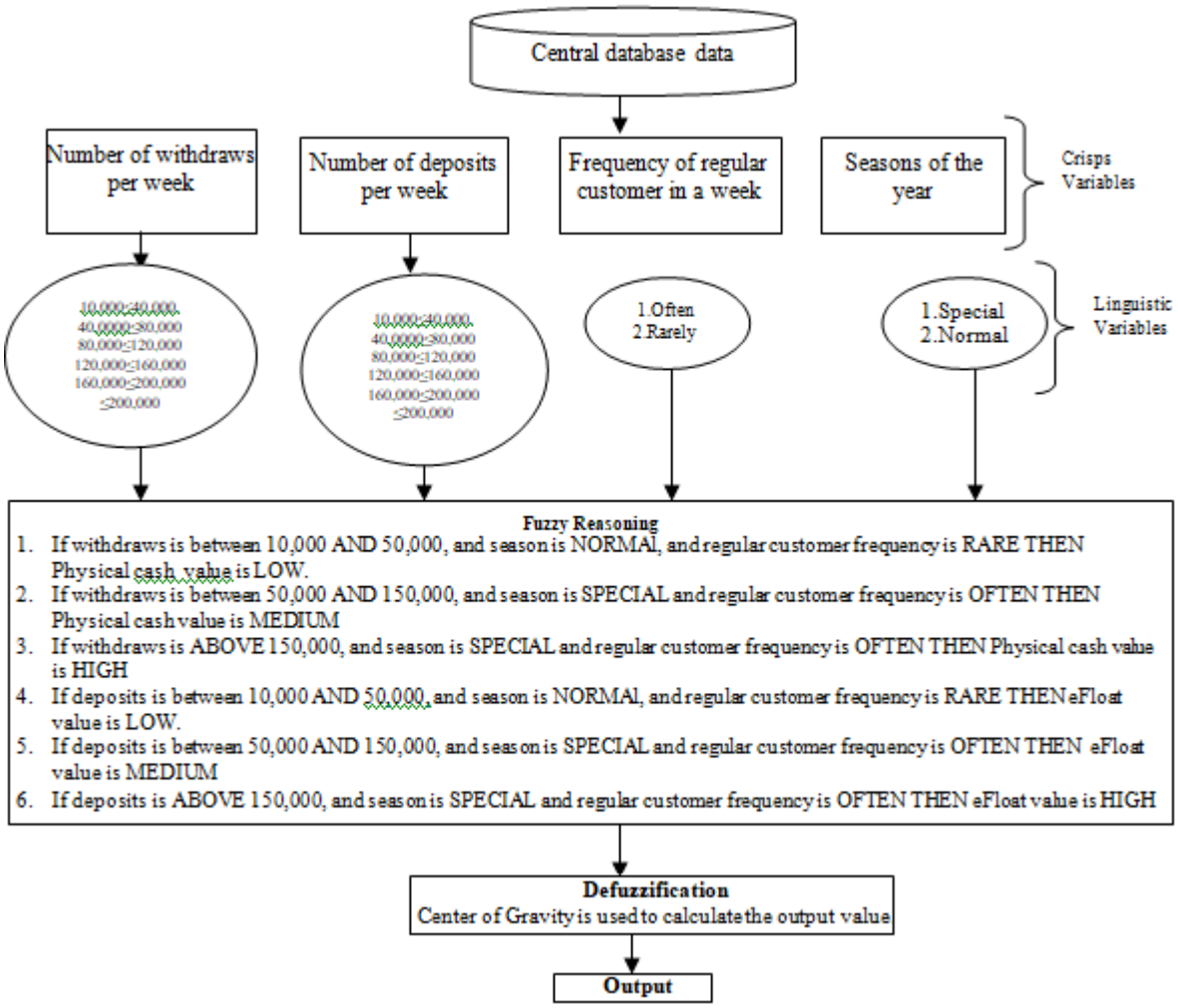


Figure 3: Internal Exploration Agent data modeling.

3.2 Fuzzy Logic concept

In this study, fuzzy logic is very useful because human perceptions are required as inputs where ambiguity and vagueness exists. All the inputs from central database are evaluated using fuzzy reasoning. The following are the inputs

used in the fuzzification process; number of withdraws, number of deposits, frequency of regular customer and season of the year. The membership function is defined as per the number of the four variables. The results of the rules are combined and defuzzified. The output is a crisp number which is the predicted values of both the e-cash as well as the physical cash required by each of the mobile money agents in running their businesses for specific days. Figure 4 shows the fuzzification and defuzzification process.



Experiments and Results

4.1 Initial Investigations

Data was collected using questionnaires in Timau market in Meru county, with 10 mobile money agents purposively sampled. The initial investigation of the study shows 33% of the customers complained in a month that they unable to transact,61% of customers felt that the main source of complain was due to lack of enough physical cash and 28% of the cause of complain was due to lack of enough e-cash. The average monthly value of transactions (deposits and withdraws) and frequency of the regular clients was the main factors that the mobile money retail agents identified as the key drivers of the e-float and the physical cash requirements for the mobile money retail agents. Further in the study 74% of the mobile money retail agents felt that the methods of estimating the day's e-cash and physical cash is inefficient,10% of the mobile money agents felt that all the key drivers of e float and physical cash were not considered.

4.2 Technique output

The technique's output appears as shown in the screen shot in figure 5. It will be used by the mobile money agents to project the following day's required e-cash and physical cash.

The displayed projection is as a result of analysis of transactions pattern of a mobile money agent, season of the year, working capital and other factors like time of the year. The technique displays the day's transactions both withdrawals and deposits, the following day projection, projection's percentage variation. A graph of active users in a month is also displayed.

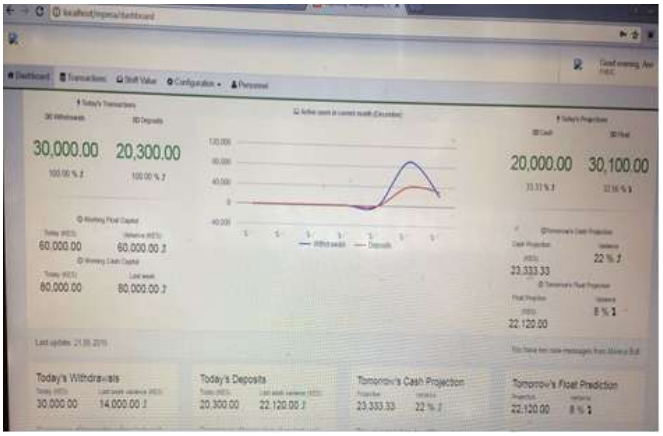


Figure 5: Technique's output.

4.3 The technique's Evaluation

The functional testing was done to determine whether the functions of the technique were working as expected. All the ten mobile money retail agents were involved in the testing. The following checklist was used for evaluation.

Table 1: Check list for the technique's functionality testing

Functionality to be tested	Description of the functionality test carried out	Expected outcome	Error	Inference
Mobile money agents log in	The money retail agent logs in to the system	Successful log in	None	Perfect
Accounts profiling	Identifies a specific data trends/patterns based on transactions over time	Data patterns successfully identified	None	Perfect
Data filtering	Extracts only the relevant data from the electronic network	Data relevant to mobile money agents successfully extracted		Perfect
Fuzzy Engine	Analyzes the data in the central database with an intention to make most approximate predictions	Data successfully analyzed but with an error of 9% for deposits and 9.5% for withdrawals	Average error of 30.921 %	69.079% success
Information store	Stores the information relevant to the mobile money retail agents	Only information relevant to retail agents was stored	None	Perfect

4.4 Technique's output percentage average error margin

Random tests were done on each of the ten mobile money retail agents in order determine the level of effectiveness of the technique. The deposit and the withdrawal transactions for the last six months was passed through the technique and the output compared to the actual deposits and withdrawal transactions realized by the specific mobile money retail agent for the specific day chosen at random. After this, the overall average percentage error rate for all the mobile money retail agents was 30.9%. This percentage average error rate was used to determine the level of effectiveness of the Intelligent Agent's based Fuzzy liquidity management technique for a mobile money transfer system. The technique's percentage error was 12% which was a lower value compared to the current tools and techniques.

5. Discussion

The study shows that liquidity management still remains to be one of the biggest issues facing the mobile money retail agents while conducting their businesses. It is evidenced that many customers report that the mobile money agents have had insufficient funds therefore they are unable to transact. The current liquidity management tools are time consuming, too manual and do not allow the mobile money retail agents to fully analyse both the internal environment as well as the external environment in which they operate in. Intelligent agents with their characteristic of ability to learn allows them to identify all factors in both the internal and external environment of the mobile money transfer. Fuzzy logic has proved to be an effective way of processing data by allowing partial set membership. A more thorough analysis of both the internal and external environment in which the mobile money retail agents operate in is key in helping to make the most approximate prediction of both the e-cash and physical cash requirements for the mobile money retail agents. In the proposed technique, intelligent agents are used to analyse and evaluate all the factors that affect liquidity. The factors are then fuzzified and the fuzzy rules are applied. An appropriate decision is made on the approximate e-cash and physical cash a mobile money retail agent should have. The output is defuzzified to a crisps value. This research therefore integrates the intelligent agents and fuzzy logics in ensuring that the mobile money retail agents have approximately required e-cash as well as the physical cash for the day to day running of the business. The evaluation results shows the technique effectively addressed the errors identified from the other models.

6. Conclusion

The aim of the study was met through achievement of the specific objectives. From the study there is need for liquidity management since it was clear that there were customer's complains being unable to transact due to lack of either e-cash or physical cash. The review of the current techniques and tools clearly showed that they are too manual and inefficient. The intelligent agents' and fuzzy logic technique for liquidity management in a mobile money transfer system provides the intelligent agents' developers with the potential to group several disparate intelligent agents together to work collaboratively towards achieving an overall goal.

7. Future Work

Further research could be done to study the possibility of linking the tool with other systems that directly or indirectly

affect the mobile money transactions of a specific group of people. A good example is linking the tool with EFTPOS or the banking systems in order to provide more meaningful data trends / patterns on mobile money.

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