

Full Length Research Paper

Design of a secure unified e-payment system in Nigeria: A case study

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The automatic teller machine (ATM) is the most widely used e-Payment instrument in Nigeria. It is responsible for about 89% (in volume) of all e-Payment instruments since 2006 to 2008. Some customers have at least two ATM cards depending on the number of accounts operated by them and they represent the active users of the ATM cards. Furthermore, identity theft has been identified as one of the most prominent problems hindering the wider adoption of e-Business, particularly e-Banking, hence the need for a more secure platform of operation. Therefore, in this paper we propose a unified (single) smart card-based ATM card with biometric-based cash dispenser for all banking transactions. This is to reduce the number of ATM cards carried by an individual and the biometric facility is to introduce another level of security in addition to the PIN which is currently being used. A set of questionnaire was designed to evaluate the acceptability of this concept among users and the architecture of the proposed system is presented.

Key words: Automatic teller machine, e-Payment, smart card, biometrics, fingerprint, e-Identity, e-Banking.

INTRODUCTION

E-payment systems refer to the automated processes of exchanging monetary value among parties in business transactions and transmitting this value over the information and communication technology (ICT) networks. The common e-Payment channels include the payment cards (debit or credit), online web portals, point of sales (POS) terminals, automated teller machines (ATM), mobile phones, automated clearing house (ACH), direct debit/deposit and real time gross settlement (RTGS) system (Nnaka, 2009).

The wider patronage of e-Commerce is dependent on the availability of a secured and trusted e-Payment System (Baddeley, 2004). The various categories of e-Commerce include Business-to-Business (B2B): business transactions between organizations that involve companies buying and selling to each other; Business-to-Consumer (B2C): business transactions between organizations and consumers where goods and services

are sold directly to the consumer; Consumer-to-Business (C2B): business transactions between consumers and organizations, where consumers can fix prices for both goods and services offered and Consumer-to-Consumer (C2C): business transaction between consumers among others (Ayo, 2009). Therefore, appropriate considerations must be given to these categories so that the most suitable e-Payment system can be adopted. Nigeria has remained the fastest growing mobile phone country in Africa and the third in the world where over 60% of the populace are connected (Akwaja, 2010). Thus, Nigeria has great potential for mobile commerce implementation besides the electronic commerce that is gradually gaining momentum. The major distinction between the electronic and mobile business transaction prefixed as “e” and “m” is that the electronic medium offers “anytime access”, while mobile medium offers “anytime and anywhere access” to business processes respectively (Tiwari et al., 2006). However, the success of e-Payment will impact greatly on m-Payment if security and usability issues are well considered.

According to Anderson (cited in Sumanjeet, 2009),

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e-Payment system was classified into:

1. Online credit card payment system
2. Electronic cheque system
3. Electronic cash system, and
4. Smart card-based electronic payment system.

Regardless of the adopted system, the problems militating against e-Payment as listed by Sumanjeet (2009) generally revolve around:

- a) Integrity: to ascertain that transmitted financial information is unchanged in transit.
- b) Non-repudiation: to ascertain that all parties have non-deniable proof of receipt.
- c) Confidentiality: to ascertain that transactions are protected from possible eavesdroppers.
- d) Reliability: to ascertain that there is reduced possibility of failure.
- e) Authentication: to ascertain that there are reliable proofs of identities of all parties involved.
- f) Authorization: to ascertain that individuals are recognized and granted the desired rights and privileges.

Therefore, any reliable e-Payment system should guarantee privacy, integrity, compatibility, efficiency, acceptability, convenience, mobility, anonymity and low financial risk. The smart card-based e-Payment system is essentially a credit card sized plastic card with memory chips and probably an embedded microprocessor that offers greater storage capacity than the ordinary credit card. While the credit card stores a single charge account number in the magnetic stripe, the smart card can hold hundreds of such data, and can serve multiple identification purposes such as personal identification, bank account identification and transactions, health insurance identification among others (Sumanjeet, 2009). Therefore, the objectives of this paper is to design a unified (single) smart card-based e-Payment system that can be used for banking transactions in all the banks in Nigeria as well as serving other forms of identification.

Zulu (2006) identified the challenges of e-Payment in Africa as inadequate telecommunication infrastructure which include: connectivity failure in telephone lines; low Internet bandwidth; high Internet cost, unavailability of dedicated data service networks and close financial networks as well as frequent power interruption. Similarly, he identified lack of proper legal and regulatory framework and low level of credit access as the other challenges. The threats notwithstanding, there are standard security features already developed to handle them. Some of the available solutions include public-key cryptography, digital signature and certificate, secure socket layer (SSL) and secure electronic transaction (SET) as well as the introduction of biometrics authentication among others (Pesonen, 1998; Zulu, 2006;

Table 1. Distribution of the amount of currency in circulation.

| Year | Amount (₦ billion) |
|------|--------------------|
| 2004 | 545.7 |
| 2005 | 642.4 |
| 2006 | 770.1 |
| 2007 | 960.5 |
| 2008 | 1,155.1 |

Source: CBN annual reports: 2006, 2007 and 2008.

Ayo, 2009).

One of the greatest threats to e-Banking is the increasing trends of identity theft, which is a major challenge to the Internet age (Helmbrecht, 2008). Therefore, there is need for a technology that is safe, convenient and not too demanding on the part of the user because of the level of literacy in the developing nations of the world, particularly Nigeria.

THE STATE OF E-PAYMENT IN NIGERIA

Nigeria is predominantly a cash-based economy with a lot of cash in circulation. Analysts opined that the cash-based nature of payments in the country is responsible for the abysmally low level of participation in e-Commerce where the acceptable medium of settling transactions is e-Payment (Ojo, 2004; Ayo, 2007; Ovia, 2002). The Governor of the Central Bank of Nigeria embarked on bank recapitalization exercise as a strategic move to save the Nigerian banking sector from incessant failure and collapse (Nwachuku, 2005; Gbolahan, 2005). The result of the exercise brought about a reduction of the 89 banks to 25 solid and strong banks through mergers, acquisition and recapitalization of asset base. As reported by Ayo et al. (2007), virtually all the 25 banks in Nigeria that survived the recapitalization exercise engaged the use of ICT for efficient service delivery. All the banks have one form of e-Payment system or the other. Alao (2009) reported the colossal amount of money lost in Nigeria to ATM fraud through ATM card cloning, PIN theft among others and government had resorted to removing ATM from public places as well as installing security cameras at the ATM locations to track the activities of fraudsters. However, the level of ICT usage notwithstanding, the level of adoption of e-Banking by the citizen is still very low. Table 1 shows the distribution of the amount of currency in circulation from 2004 to 2008 in Nigeria.

The table raised a lot of issues about the influence of ICT on e-Banking and the banking habit of Nigerians, particularly the volume of cash in circulation. The amount of currency in circulation has continued to increase in view of the various efforts of government. Tables 3 and 4

Table 3. Demographic profile of respondents.

| Gender of respondents | Frequency | Percent |
|---|------------------|----------------|
| Male | 140 | 58.6 |
| Female | 99 | 41.4 |
| Total | 239 | 100 |
| Age of respondents | Frequency | Percent |
| < 20 | 25 | 10.4 |
| 21 - 30 | 77 | 32.2 |
| 31 - 40 | 95 | 39.7 |
| 41 - 50 | 28 | 11.7 |
| 51+ | 14 | 5.9 |
| Total | 239 | 100 |
| Educational level of respondents | Frequency | Percent |
| Valid none | 26 | 10.9 |
| Primary school | 4 | 1.7 |
| High school | 11 | 4.6 |
| OND/NCE | 24 | 10 |
| B.Sc/HND degree | 58 | 24.3 |
| Post graduate | 102 | 42.7 |
| Others | 14 | 5.9 |
| Total | 239 | 100 |
| Sector where respondents work | Frequency | Percent |
| Valid others | 36 | 15.1 |
| Finance | 47 | 19.7 |
| Manufacturing | 33 | 13.8 |
| Oil and gas | 13 | 5.4 |
| Aviation | 4 | 1.7 |
| Education | 21 | 8.8 |
| IT and telecom | 85 | 35.6 |
| Total | 239 | 100 |

will help to shed more light on the inhibiting factors which probably revolve around lack of safety, trust and security. It is evident from Table 2 that the most prominent form of e-Payment system in Nigeria is the ATM card. It remained dominant over the years both in volume and value.

The other media such as the Internet payment, POS and Mobile payments are still at their infancies. The level of involvement of these instruments of payment presents a clearer picture of the low level of involvement of Nigerians in e-Commerce, knowing fully well that ATM cards are not suitable for international settlement of transactions.

RESEARCH DESIGN

The research design is two - fold. On one hand, a set of

questionnaire was designed and administered randomly to 300 respondents out of which 239 were returned representing about 80%. Cronbach's reliability value of 0.782 was obtained, which attests to the reliability of the instrument. Pertinent questions about the demographic profile of respondents as well as the state and operations of ATM card were asked and the data collected was analyzed based on descriptive statistics using the SPSS and the results were presented in Tables 3, 4 and 5. On the other hand, a design of the proposed unified Smart card-based ATM was presented as well as its activity diagram.

RESULT AND DISCUSSION

Out of the 239 respondents, about 59% of them are male while about 41% of them are female. From the age distribution, over 90% of the respondents are at least 20 years old. Keeping in mind that persons below the age of 18 years are not permitted to operate a bank accounts in

Table 4. Distribution of the respondents and banking transactions.

| Have bank accounts | Frequency | Percent |
|---------------------------|------------------|----------------|
| Valid none | 2 | 8 |
| No | 3 | 1.3 |
| Yes | 234 | 97.9 |
| Total | 239 | 100 |

| Number of ATM cards possessed | Frequency | Percent |
|--------------------------------------|------------------|----------------|
| Valid none | 4 | 1.7 |
| One | 24 | 10 |
| Two or more | 211 | 88.3 |
| Total | 239 | 100 |

Table 2. Level of adoption of e-Payment system.

| Payment instruments | Volume (%) | | | Value (%) | | |
|----------------------------|-------------------|-------------|-------------|------------------|-------------|-------------|
| | 2006 | 2007 | 2008 | 2006 | 2007 | 2008 |
| ATM | 93.16 | 88.7 | 91.0 | 73.35 | 88.5 | 90.5 |
| Web (Internet) | 1.71 | 5.1 | 2.4 | 3.51 | 7.1 | 5.7 |
| POS | 4.83 | 2.4 | 1.8 | 23.04 | 4.3 | 3.7 |
| Mobile | 0.31 | 3.8 | 4.8 | 0.11 | 0.1 | 0.2 |

Source: CBN annual reports: 2006, 2007 and 2008.

Nigeria because that is seen as the age of apprenticeship. Furthermore, about 90% of the respondents have at least the first school leaving certificate (primary school), while only 10% of them (26 out of 239) did not indicate to have had any formal education at any level. Majority of the respondents (35.6%) work in the IT and Telecoms sector, followed by the finance sector (19.7%), the manufacturing sector (13.8%), the education sector (8.8%) and those outside the finance, manufacturing, oil and gas, aviation, education and IT and Telecoms account for 15.1% of the respondents. It is interesting to note that majority (about 98%) of the respondents operate a bank account. Also, about 88% of the respondents have two ATM cards or more. This gives validity to the proposed unified e-Payment system. Most of the respondents attested to the convenience of the ATM services (59%) as well as its simplicity (69%). However, its reliability (25%), safety (16.3%) and privacy (31.8%) are in doubt. Therefore, a greater percentage of the respondents disagreed with its reliability, safety and privacy features. However, most of the respondents favour the desirability of having a unified (single) ATM card for all banking transactions (36.8%) as well as the inclusion of a fingerprint reader on the teller machine (66.9%).

SYSTEM DESIGN

A typical ATM has a keypad that is composed of:

1. Numeric keys (0-9)
2. Character keys (A – Z)
3. Operational buttons (Accept, correction, cancel)

The screen has eight (8) buttons arranged at the two sides (4 at each side). The features of the ATM are presented in Table 6 and a typical picture shown in Figure 1. Table 6 shows the features of the ATM of four banks (UBA, Oceanic, Intercontinental and CMFB) in Nigeria. It is obvious that no special design is required. A common choice for the design is one that has numeric keys (0-9), character keys (A-Z, *, #, -, +), and operation buttons (OK, Change, Cancel), while the blank button can be replaced with the biometric fingerprint reader.

The structure in Figure 2 represents the unified Smart card-based ATM card that has the possibility of being used for multiple identifications. Four (4) different ATM cards for the four banks were considered and their features incorporated to arrive at this design.

Furthermore, considering the spate of identity fraud, the

Table 5. Distribution of the respondents experience with ATM cards.

| | Agree (%) | Disagree (%) | Neutral (%) | Do not know (%) | Total (%) |
|-------------------------------------|------------|--------------|-------------|-----------------|-------------|
| Reliability of ATM services | 60 (25.1) | 97 (40.6) | 64 (26.8) | 18 (7.5) | 239 (100.0) |
| Convenience of ATM services | 141 (59.0) | 56 (23.4) | 27 (11.3) | 15 (6.3) | 239 (100.0) |
| Simplicity of ATM services | 165 (69.0) | 26 (10.9) | 31 (13.0) | 17 (7.1) | 239 (100.0) |
| Safety of ATM services | 39 (16.3) | 123 (51.5) | 59 (24.7) | 18 (7.5) | 239 (100.0) |
| Privacy of ATM services | 76 (31.8) | 90 (37.7) | 50 (20.9) | 23 (9.6) | 239 (100.0) |
| Desirability of one ATM card | 88 (36.8) | 76 (31.8) | 36 (15.1) | 39 (16.3) | 239 (100.0) |
| Include fingerprint on ATM machines | 160 (66.9) | 19 (7.9) | 23 (9.6) | 37 (15.5) | 239 (100.0) |

Table 6. Features of ATM cards.

| Bank | Features | | |
|------------------|--------------------|----------------------------------|---|
| | Numeric keys (0-9) | Character keys (A-Z, *, #, -, +) | Operation buttons OK/Enter/Accept, Cancel Correction/Change/Clear/Blank |
| UBA | Yes | Yes | OK, change, cancel and blank |
| Oceanic | Yes | Yes | Accept, correction, cancel and blank |
| Intercontinental | Yes | Yes | Accept, correction, cancel and blank |
| CMFB | Yes | No | Enter, clear, cancel and blank |

**Figure 1.** A typical ATM.

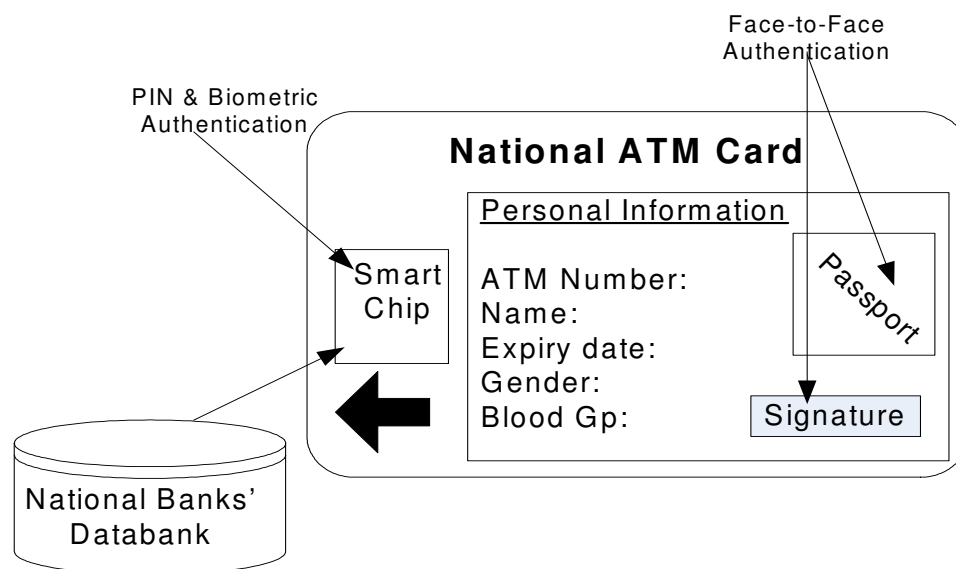


Figure 2. Smart Card-based ATM card.

law enforcement agencies should be able to check at random the various ATM locations to verify the identity of the carrier, though less frequently, hence the inclusion of the holder's passport, gender and signature. Similarly, in case of accident the blood group is included. All other details are contained on the National Bank's Databank which is a repository of the identities of all banks' customers in Nigeria.

The activity diagram is shown in Figure 3. It shows an additional layer of information, which is the selection of bank to transact business with a single card is being used for several banks, after which the usual (old) display follows: User identification PIN but now with fingerprint capture; Selection of Operation (Enquiry, Withdrawal etc); Selection of amount of money; Request for receipts and Exit.

Furthermore, all other changes are software based. The ATM monitor has 8 operational buttons distributed at both sides of the screen. There are 25 banks in Nigeria, modeled banks A to Y, therefore 7 banks can be listed per screen while the 8th key reads "More" for the next screen of 7 banks and the "More" Key, more and more until all the banks are displayed. This design took into consideration the issue of audit trail as proposed by OCED (2009) as well as security, cost, acceptability, usability and interoperability amongst others (Poenar, 2008).

COST IMPLICATION OF THE DESIGN

The cost implication of this design is very minimal on the part of the operators (banks). All the Keypads have a

blank button which can be replaced with fingerprint reader through the USB Connection to the Central Processing Unit (CPU). Similarly, the cost of card redesign is not considered a major challenge since each card has expiry date. Therefore, the cost of a new card is borne by the card holder. Similarly, all other changes are software based: the selection of banks and fingerprint authentication which can be taken for regular software update and the cost borne by the operator. However, the major task is the integration of the various banks accounts into the National Banks' Databank. This design approach will most likely be a cheaper alternative than installing security cameras at each location in addition to the cost of relocating the machines to more secure premises.

Conclusion

The level of adoption of ICT in the banking sector in Nigeria is on the increase, yet the amount of cash in circulation is equally increasing, a situation which is attributable to lack of safety, security, privacy and reliability in the e-Payment instruments. Therefore, the introduction of a Smart card-based ATM with biometric authentication will ameliorate these challenges. More than that, the design of a unified Smart card-based ATM with biometric authentication is cost-effective and secured. No special design is required as the current system can accommodate the proposed features at minimal cost. The fingerprint scanner can be accommodated on the keypad while a slight software redesign is required to accommodate a layer of service that will

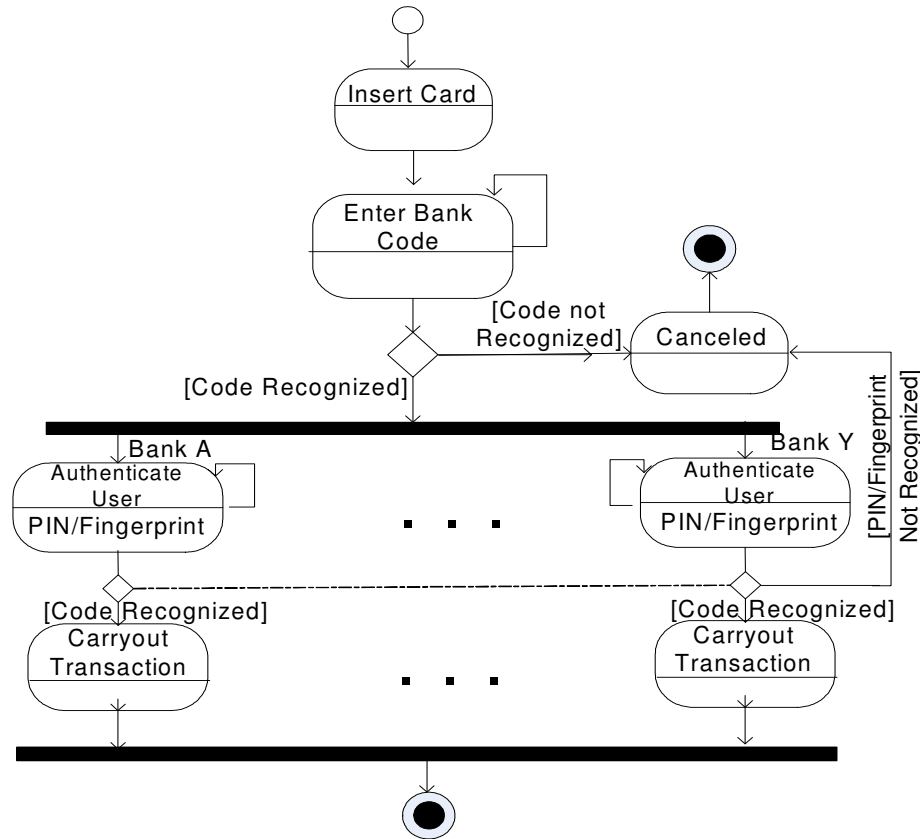


Figure 3. Activity diagram of the proposed system.

enable the user select a bank of choice. Most importantly, the number of ATM required is drastically reduced, which reduces the cost of production and renewal, and there is enhanced safety, security, and privacy. Furthermore, the fingerprint authentication will be a cheaper alternative than to relocate all ATMs in Nigeria (several thousands of them), to safer premises and the inclusion of security camera at each location.

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