A Comparative Analysis of Electronic Transfer Systems

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Abstract

This paper carries out an in depth survey of five electronic transfer systems (ETSs), explains the transfers mechanisms for each case, establishes the merits and demerits of each type of electronic transfer system and finally performs a comparative analysis and ranking of the five common electronic transfer systems using named criteria. Electronic transfer systems being systems that transfer digital data or digital information from one computer or device to another over communication networks. The result obtained showed that GSM (Mobile phone) had the highest ranking. ATM was ranked second and E-mail, Interbank Transfer and E-commerce were ranked third, fourth and fifth respectively. The paper provided justification for the ranking.

Keywords: Electronic transfer systems, communication networks, inter-bank transfer and e-commerce.

1. Introduction

Electronic transfer systems involve the transfer of data (digital data) from one computer or device to another computer or device over communication networks. Communication networks are increasingly computer and communication networks that constitute the key infrastructure that characterize the world as an information society. Specifically the key infrastructure is the Internet. This interconnection has transformed the world into a global villages square resulting in an unprecedented economic and social value to mankind. It has also brought new forms of crimes and insecurities. Electronic transfer systems have contributed immensely to human-social relations by transferring global, content-rich communication generated by users in the form of cellular/smart phone conversations (speech), text messages, E-mails and voice over Internet (VOIP). They have also made possible many critical services available depending on the type of data transferred; for example in health care where patient data is transferred for processing, diagnosis and treatment. In finance where financial data is transferred to financial institutions and their customers to authorize credit or debit account, and provide fund transfer services in seconds to merchants and citizens that improve the economy and minimize the high dependence on cash transactions and risks of armed robbery associated with it [1], [2] [8]. Such transfers are effected using Electronic Funds Transfer (EFT) systems made possible by electronic banking and Information Communication Technology (ICT). EFT has the advantage of reducing fraud caused by the use of cheques, cash and other paper financial transactions.

Electronic transfer systems have made possible safe, secure and high speed transportation systems as against using space shuttles, aeroplanes, ships, trains and cars thereby reducing in the process dangerous emissions to the atmosphere and promoting "green" or environmentally friendly highways [13]. The applications and advantages of electronic transfer systems are many and varied. This paper therefore carries out a comparative analysis of the various electronic transfer systems in our globalized world.

2. Existing Electronic Transfer Systems

In this section, we review the basic building blocks for constructing Electronic Transfer Systems used by businesses, governments, universities and industries to acquire, store, process and communicate the results of processing to humans and machines. This paper restricts the use of electronic transfer systems to the banking industry. The central component of an electronic transfer systems is a computer which may be visible or embedded. Computers are used to acquire, store and process data. The data processed by computers and hence electronic transfer systems may be numbers, text, voice, video, graphics, fax and multimedia.

The information may be transferred either by telecommunication facilities or by computer networks [10]. Computer communication networks arose from the convergence of computer and communication technologies.

Thus computer, telecommunication and networks form the essential technology infrastructure for electronic transfer systems. These essential technology infrastructure are collectively called

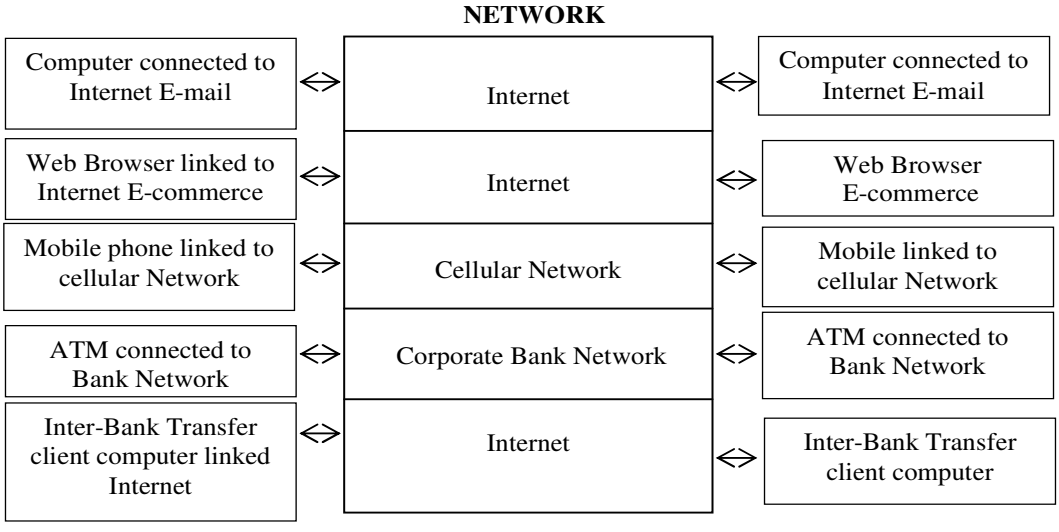

Figure 1: Block Diagram Representation of a General Overview of Five Electronic Transfer Systems (E-mail, E-commerce, GSM, ATM and Inter-bank Transfer).

Information Technology (IT) or Information Communication Technology (ICT) [4][9]. These technologies constitute the backbone of Electronic Transfer Systems.

The five ETSs reviewed in this paper are E-mail, E-commerce, Global System for Mobile Communication (GSM), Automated Teller Machines (ATM) and Inter-bank transfers using Internet banking (e-banking) or mobile banking (m-banking). Figure 1 shows a block diagram representation of a general overview of an electronic transfer system.

2.1 E-mail

The network in figure 1 represents a composite network. For E-mail operation, the network used is the Internet. To send an E-mail, a user logs in using his or her user name and password on a computer connected to the Internet. The user composes the mail on a text box, revises it and sends it to the person he wants to communicate with by pressing the send button. The mail is then transferred from the Internet to the inbox of the receiver's computer where it can be accessed and read.

A typical email-architecture contains four elements:

1. **P**ost offices - where outgoing messages are temporally buffered before transmission and where incoming messages are stored. The post office runs the server software capable of routing messages (a message transfer agent) and maintaining the post office database.
2. **M**essage transfer agents - for forwarding messages between post offices and to the destination clients. The software can either reside on the local post office or on a physically separate server.
3. **G**ateways - which provide parts of the message transfer agent functionality. They translate between different e-mail systems, different e-mail addressing schemes and messaging protocols.
4. **E**-mail clients - normally the computer which connects to the post office. It contains three parts:

. E-mail Application Program Interface (API), such as MAPI, VIM, MHS and CMC.

. Messaging protocol. The main messaging protocols are SMTP or X.400. STMP is defined in RFC 822 and RFC 821, whereas x.400 is an OSI-defined e-mail message delivery standard.

. Network transport protocol, such as Ethernet, FDDI, and so on.

2.2 E-commerce

The network used for E-commerce in figure 1 is also the Internet. To carryout E-commerce, the customer performs a sequence of steps as follows [3] [11]:

i. Visit the e-commerce website using a web client (a computer equipped with a browser) to browse a catalogue on the web server describing each good on sale, and its availability.

ii) Select the good to be purchased and place an order for the good. System holds the order made on an order database.

iii) System prompts customer for his or her credit card details or any on-line payment mechanism.

iv) Customer supplies requested details. System places details of the good ordered on a goods database and details of the customer on a customer database.

v) Customer uses tracking facility provided by the E-commerce system to track the progress of the purchase using his or her web browser.

2.2.1 E-Commerce Structure

The following steps are involved in E- commerce transaction:

Step 1. The consumer enters an order along with their credit card information and sends it to the merchant.

Step 2. The merchant sends the consumer an invoice, their certificate and their bank's certificate.

Step 3. The consumer acknowledges and approves this information and returns it to the merchant.

Step 4. The merchant then generates an authorization request for your credit card and sends it to their bank.

Step 5. The merchant's bank then sends the credit authorization request to the Acquirer.

Step 6. The Acquirer sends an acknowledgement back to the merchant's bank after receiving an acknowledgement from the consumer's bank.

Step 7 Once the consumer's bank authorizes payment, the merchant's bank sends an acknowledgement back to the customer with the authorization number. This arrangement is shown in figure 2 as E Commerce architecture.

2.3 GSM

A GSM (Global System for Mobile communications) uses a cellular network provided by mobile phone operators as shown in figure 1. In operation, a call originating from a mobile phone (radio signal) is transmitted from a nearby base station through the cellular network of base stations to the base station in the vicinity of the mobile phone called. The called mobile phone converts the received radio signal into voice for the two-way conversation between the caller and callee to take place. GSM is an open, digital cellular technology used for transmitting mobile voice and data services [7] [12].

Basic Components of GSM

The following are the basic components of GSM communication:

2.3.1 Mobile Station

The mobile station (MS) consists of the mobile equipment (the terminal) and a smart card called the Subscriber Identity Module (SIM). The SIM provides personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal. By inserting the SIM card into another GSM terminal, the user is able to receive calls at that terminal, make calls from that terminal, and receive other subscribed services. The mobile equipment is uniquely identified by the International Mobile Equipment Identity (IMEI). The SIM card contains the International Mobile Subscriber Identity (IMSI) used to identify the subscriber to the system, a secret key for authentication,

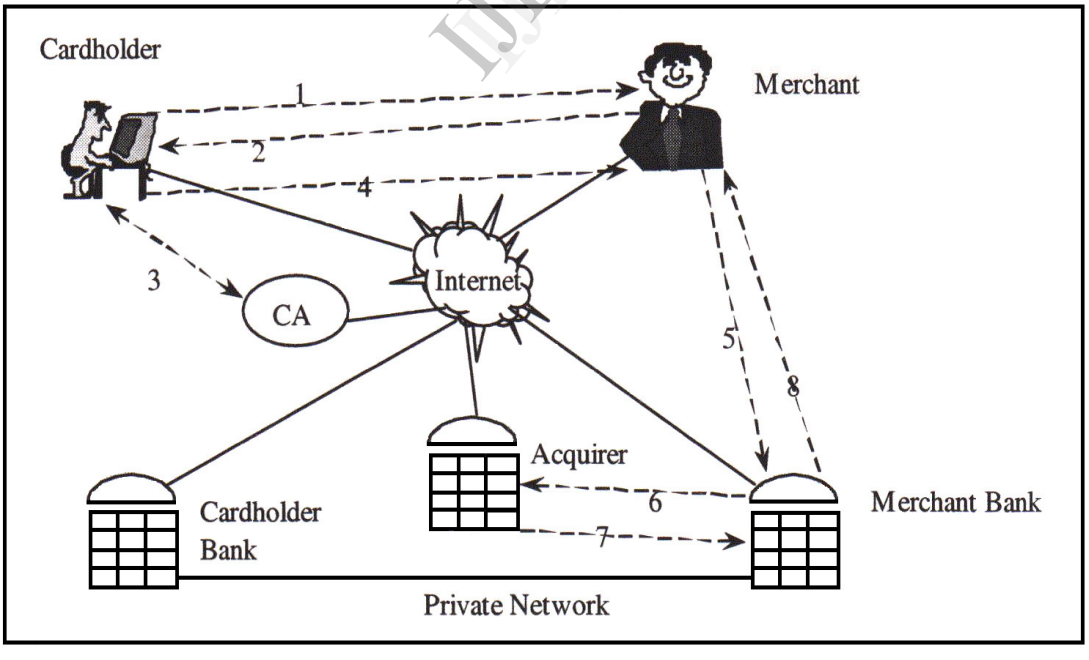

Figure 2: Architecture of E-Commerce

and other information. The IMEI and the IMSI are independent, thereby allowing personal mobility. The SIM card may be protected against unauthorized use by a password or personal identity number.

2.3.2 **Mobile Switching Centre**

The central component of the Network Subsystem is the Mobile services Switching Centre (MSC). It acts like a normal switching node of the PSTN or ISDN, and additionally provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. These services are provided in conjunction with several functional entities, which together form the Network Subsystem. The MSC provides the connection to the fixed networks (such as the PSTN or ISDN). Signalling between functional entities in the Network Subsystem uses Signalling System Number 7 (SS7), used for trunk signalling in ISDN and widely used in current public networks. The Home Location Register (HLR) and Visitor Location Register (VLR), together with the MSC, provide the call-routing and roaming capabilities of GSM. The HLR contains all the administrative information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile. The location of the mobile is typically in the form of the signalling address of the VLR associated with the mobile station. There is logically one HLR per GSM network, although it may be implemented as a distributed database. The Visitor Location Register (VLR) contains selected administrative information from the HLR, necessary for call control and provision of the subscribed services, for each mobile currently located in the geographical area controlled by the VLR. Although each functional entity can be implemented as an independent unit, all manufacturers of switching equipment to date implement the VLR together with the MSC, so that the geographical area controlled by the MSC corresponds to that controlled by the VLR, thus simplifying the signalling required.

2.3.3 **Base Station Subsystem (BSS)**

The Base Station Subsystem is composed of two parts, the Base Transceiver Station (BTS) and the Base Station Controller (BSC). These communicate across the standardized Abis interface, allowing (as in the rest of the system) operation between components made by different manufacturers. The Base Transceiver Station houses the radio transceivers that define a cell and handles the radio-link protocols with the Mobile Station. In a large urban area, there will potentially be a large number of BTSs deployed, thus the requirements for a BTS are ruggedness, reliability, portability, and minimum cost. The Base Station Controller manages the radio resources for one or more BTSs. It handles radio-channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile station and the Mobile service Switching Centre (MSC). GSM architecture is shown in figure 3.

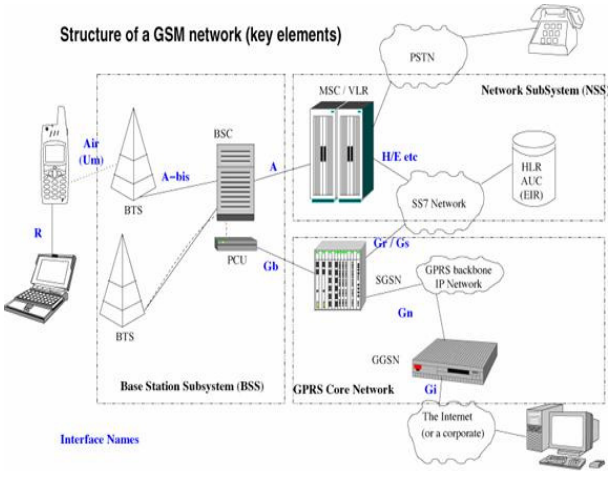

Figure 3: GSM architecture

2.4 **ATM**

The network used for an ATM in figure 1 is a corporate bank network or an interbank network. To carry out a banking transaction, a customer gains access to an ATM network using his or her ATM card and a secret PIN. The customer then follows a sequence of request response interaction with the ATM which authenticates the customer, verifies his account status by accessing the customer account database and concludes the transaction successfully for example withdraw cash if all the checks are true. The ATM machine withdraws the requested cash, gives it to the customer and debits the customer account. The architecture of an ATM system is shown in figure 4.

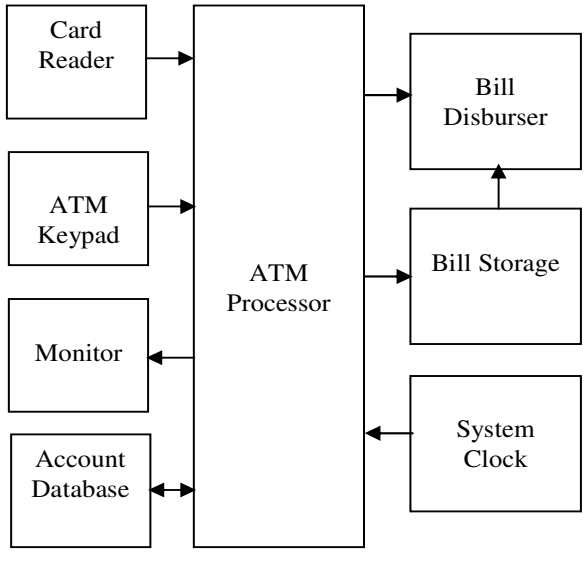

Figure 4: Architecture of an ATM System

2.5 Interbank Transfer

Interbank transfer also known as electronic fund transfer uses the Internet shown in figure 1 as a network. If a bank customer A wishes to transfer funds to a customer of another bank say B, using electronic funds transfer, he or she follows these sequence of steps:

i. A authorizes his bank (called the issuer) to transfer funds electronically to B by filling the transfer fund form giving A's bank details, the amount to be transferred, the bank details of the beneficiary B (the acquirer bank) and signs the form.

ii. The issuer bank confirms that A has sufficient funds for transfer and using its client sends a request to a web server to provide a funds transfer application service.

iii. The webserver queries the database server for the customer account and if satisfied the database responds by instructing the server to transfer the funds to the acquirer bank on behalf of the beneficiary B.

iv. The acquirer bank receives the funds almost immediately, credits the account of B with the funds transferred and alerts B that his account has been updated by the transferred amount using a GSM to send a credit alert to B.

v. Either A may use a mobile phone to communicate to B that he has transferred money to him or B may text A to acknowledge that he has received the money. Note that the money transfer is not direct (from A to B) but indirect from the issuer bank to the acquirer bank.

2.5.1 Inter-bank transfer process

Inter-bank EFT performs on-line transaction carried out on private networks to transfer funds; the bank plays the role of both payer and payee. Such transfers take place between a bank and its customers, or a bank and another bank. As opposed to check payment system, which involves several processing days and manual efforts like signature verification, check sorting, and information capture, EFTs are same-day, almost instantaneous payments. Figure 5 illustrates a method of funds transfer to conduct payment [2]. As shown in figure 5, customer X uses commercial bank A to remit a fixed amount of money to customer Y and his/her commercial bank B. After receiving the remittance amount plus any fees, commercial bank A sends an electronic credit transfer message to commercial bank B through a clearinghouse. According to the credit instruction, commercial bank B credits the remittance amount to customer Y's account. After a predefined accounting period, the computer system at the clearinghouse calculates the settlement positions for participating banks and sends them to the central bank via telecommunication channels. The system at the central bank will use the accounts held by commercial banks to perform debit/credit operations for clearing the difference of transfer amount among banks, thus completing the fund transfer process.

3. Comparison and Ranking of Electronic Transfer Systems

The first step in comparing electronic transfer systems is to identify and select usable criteria for carrying out the comparison. Among the criteria that could be used for comparison, the following eleven were deemed representative and so were selected:

1. Type of network used by the Electronic Transfer Systems (ETS).
2. ETS use – whether widespread or used by a specific sector.
3. User spectrum (individuals, organizations, businesses, government or all).
4. Services provided by ETS.
5. Demerits of ETS.
6. Knowledge required to use ETS.
7. Ownership cost and cost of use.
8. Impact of ETS on economy standard (style) of living and civilization.
9. Hazard or harm resulting from use.
10. Risk exposure.
11. Sources of income generated to banks by using ETS for EFT.

The comparison of the various ETSs is carried out using table 1.

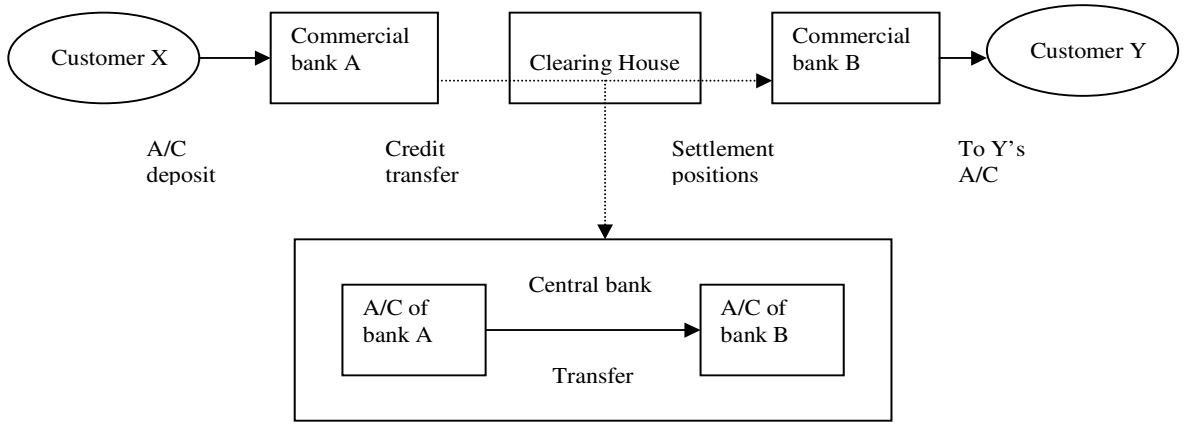

Figure 5: A Method of Funds Transfer to Conduct Payment

Table 1: A Comparison of the Five ETS using the Eleven Criteria

Criteria for comparison / ETS Type	Types of Network	ETS use-widespread or sectoral	User spectrum (individuals, business, organizations, government, all	Services provided
GSM (mobile phone)	Cellular network	Ubiquitous	ALL	SMS, e-mail, mobile banking, Internet access, GPS navigation, camera for photography, etc
E-mail	Internet	Ubiquitous	ALL	Cheapest, fastest, most convenient means of sending, receiving and accessing mails
Inter Bank Transfer	LAN, MAN, WAN, Internet	Sectoral. Used only by banks	Individuals, businesses, organization	Money transfers, standing orders, payment of bills
E-commerce	Internet	Sectoral. Used by commercial sector	Individuals, businesses	Purchase of goods and services; advertising, promotional vouchers, advertising; tracking purchase delivery
ATM	Interbank networks	Widespread in urban areas	Individuals	Cash withdrawal, cash deposits, account balance, payment for utility bills, cardless withdrawal.

Table 1 (Cont'd): Comparative Analysis of Five Electronic Transfer Systems Using 11 Criteria

Criteria for comparison / ETS Type	Demerits	Knowledge required for use	Ownership cost and cost of use	Impacts of ETS on economy, style of living and civilization
GSM (mobile phone)	Non-availability of network for a variety of reasons; identity theft.	Low	Low cost	Very high impact
E-mail	Inaccessibility of the Internet, Rapid spread of viruses, fraud; spam mail, identity theft.	High	Ownership cost is free; cost of use depends on cost of internet access which is generally high	High impact
Inter Bank Transfer	Financial Fraud	High	High cost	High impact
E-commerce	Inaccessibility of the Internet; Insecurity of funds if site is not well secured; problems of payment mechanism	High	High cost	High impact
ATM	Cloning of cards; exposing PIN to others; Timing out of network during withdrawal	Low	Low cost	High impact

Table 1 (Cont'd): Comparative Analysis of Five Electronic Transfer Systems Using 11 Criteria

Criteria for comparison / ETS Type	Hazard or Harm resulting from use	Risk exposure	Sources of generated to banks by using ETS for ETF
GSM (mobile phone)	Negligible	Low	Alerts from mobile banking: Inter Bank Funds Transfer is sometimes charged. Bill payment is charged
E-mail	Tolerable	High	-
Inter Bank Transfer	Serious	High	All transactions charged
E-commerce	Serious	High	Revenue accrues to participating banks from payment system.
ATM	Serious	High	Payment to bank for ATM card; use of other ATMs other than your bank's ATM is sometimes charged

4. Ranking of Electronic Transfer System

Using the proposed eleven criteria and table 1 to carryout a comparative analysis of the five ETS under review we arrive at the following ranking:

1. GSM (mobile phone)
2. ATM
3. E-mail
4. Interbank Transfer
5. E-Commerce

4.1 Justification of GSM as Having the Highest Ranking

1. Criteria 8 shows that GSM has a very high impact on the quality of life and civilization because man is a social being and communication is central to his or her existence. GSM enables the use of mobile technologies even in remote areas. E-health, for example, can be enabled using GSM whereby doctors in urban areas can consult with patients in remote areas via the GSM cellular network.
2. The relative cost of ownership and maintenance of GSM phone is low based on criteria 7.
3. The level of knowledge required for its use is also minimal. This means that even uneducated people can make use of it without much difficulty. This is based on criteria 6.
4. GSM provides a rich array of services such as voice calls, SMS etc. It is one of the three items that people carry on them at all times (the other two being their house keys and wallet containing money and/or identification cards). It is therefore readily available for use by individuals when the need arises to make financial transactions (m-banking) on the move or from the comfort and convenience of their homes. M-banking can be made using secure SMS or via the internet. GSM can be internet enabled. M-banking is simple, easy to use when making transactions with SMS. The service variety is highest for a GSM phone than for the other transfer technologies based on criteria 4.
5. GSM can generate money for banks from alerts and mobile banking. When mobile banking becomes widespread in future, GSM phones have the potential for huge revenue generation (see criteria 11).
6. GSM phones can be used at all levels, individual, organizations, businesses, universities etc. Due to its widespread use and its performance based on the other criteria discussed, GSM phones have the highest importance and best performance index compared with ATM, E-mail, Interbank transfer and E-commerce.

4.2 Automated Teller Machine (ATM)

Automated Teller Machine is second in ranking of the five ETS. It has become widely available in urban areas and increasingly in rural area where bank branches are located.

ATM is easy to use if one is able to read and follow the instructions on the screen. The phasing out of magnetic-stripe cards and their replacement with PIN – and – chip on cards reduces drastically the risk of cloning ATM cards.

ATM has high impact, low cost of use and brings revenue streams to banks.

However, a large percentage of the population do not have bank accounts which is a pre-requisite for obtaining an ATM card.

The risk of using an ATM is higher than that of GSM phone since transactions are done in public albeit in an enclosed space. This can lead to a PIN being seen by others particularly malicious criminals. Automated Teller Machines are ranked second of the five Electronic transfer technologies.

4.3 E-Mail, Interbank Transfer and E-commerce

E-mail, Interbank Transfer and E-commerce come third, fourth and last respectively in ranking of the five ETS technologies. These three ETS require the intensive use of the Internet. In order to access the Internet, an individual would need an Internet-enabled phone, tablet, notebook, laptop or desktop computer. The individual also requires an internet connection either at home, in the office or in cyber cafes. This is not readily available to the generality of the people.

In cases where one has access to the Internet, it is not affordable and requires knowledge and training to use. Internet service providers (ISPs) charge a high upfront fee that includes the cost of the modem.

Although E-mail, Interbank Transfer and E-commerce have high impact, E-mail is ubiquitous in use while Interbank Transfer and E-commerce are sectoral (see table 1).

Although the risk exposures of these three ETS are high, E-mail has tolerable hazard while the hazard from Interbank Transfer and E-commerce are serious.

5. Summary

We defined electronic transfer systems as systems that transfer data (digital data) or digital information from one computer or device to another over

communication networks. They have resulted in unprecedented economic growth, contributed immensely to human social relations and transformed the banking industry. Electronic transfer systems have made possible safe, secure and high speed transportation systems than using space shuttles, aeroplanes, ships, trains and cars thereby reducing in the process dangerous emissions to the atmosphere and risk associated with travels. Indeed the applications and advantages of electronic transfer systems are many and varied.

We also reviewed the building blocks for constructing electronic transfer systems and found that:

1. Electronic transfer systems are network intensive and use Internet, corporative bank network or cellular network depending on the type of electronic transfer system.
2. Because electronic transfer systems should be accessible anywhere and anytime their networks are distributed.
3. Because the data or information transferred are electronic, an attacker may attempt to gain access to the data or information (interception threat) or make part of the system unavailable (interruption threat/denial of service) or tamper with the data or information (modification threat) or insert false transaction information say in a banking system (fabrication threat). Hence there is need for security in electronic transfer systems. We also explained how each of the five electronic transfer systems under review operated and discussed in depth the merits and demerits of each of the five electronic transfer systems under review. We covered factors that result in network insecurity and available mechanisms and techniques used to mitigate network vulnerabilities. Finally we compared and ranked the five electronic transfer systems using eleven criteria. From our comparative analysis we arrived at the following ranking.

1. GSM (mobile phone)
2. ATM
3. E-mail
4. Interbank Transfer
5. E-commerce

We justified why GSM ranked first with six key reasons.

5.1 Conclusion

Electronic Transfer Systems are very important to society since they improve the quality of life of citizens, help the economy become sustainable and confer tremendous advantages to the banking sector. This study has shown that Electronic Transfer Systems are network intensive and have merits and demerits. The demerits arise primarily from information and data insecurity caused by compromising Confidentiality, Integrity and Availability (CIA) through network vulnerabilities which could be detected and exploited by hackers, criminals and disgruntled people.

However, the study has also shown that the merits of computer networks outweigh the demerits since the disadvantages could be mitigated using available technologies and techniques.

The study proposed eleven criteria for carrying out a comparative analysis of the Electronic Transfer Systems. Using these criteria, the five ETS under study were ranked from the highest to the lowest rank as follows:

1. GSM (phone)
2. ATM
3. E-mail
4. Interbank Transfer
5. E-commerce

Finally reasons were given to justify the ranking as the best ranking possible given the proposed criteria used.

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Authors' Briefs

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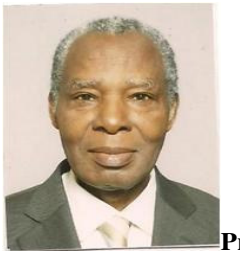

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