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Electronic payment systems

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Introduction

Consumers and businesses alike have been long accustomed to making payments in exchange for goods, services and information. Over countless centuries these payments have been made by the exchange of goods/services for other goods/services deemed to be of equal value (also known as bartering). In more recent centuries we have seen tokens (e.g., coins and notes) being used to represent value and being exchanged for goods/services. Today Tyree (1998) explains that these coins and notes are considered to be *legal tender*, so that providers are obliged to accept them as payment.

Tyree (1998) points out that non-cash payments have also existed for some time in the form of:

- banks reducing their financial liability to a customer (because a bank account is a debt which the bank owes to a customer) by transferring funds from the account of the payer to the payee's account; and

- a third party, such as a credit card issuer, making the payment to a supplier of the good or service on behalf of the individual – after which the individual must pay the third party, typically with interest!

With the advent of telecommunications and, more specifically and recently, the Internet, there has been a growing need for and development of electronic payment systems (EPSs). EPSs are computerised systems which enable payments between parties to occur online or electronically rather than using more traditional payments such as cash and cheques (Turban et al 2002). Lawrence et al (2002) similarly describe an EPS as "… a process that describes how value (usually **money**) is exchanged [electronically] for goods, services or information" (p. 213).

Some of these EPSs are online or more advanced versions of traditional payment models and techniques, such as:

- Internet banking, versus over-the-counter banking;

- EFTPoS (or Electronic Funds Transfer at Point of Sale) as an alternative to withdrawing cash using a debit card and paying by cash for goods/services; and

- smart cards, which could become the next generation of the more traditional credit card.

There has also been considerable research into and development of purely Internet-based electronic payment systems (IPSs), which include electronic cash, Internet credit cards and much more.

The majority of EPSs require the transfer of funds between banks, because it is not guaranteed that the payer and the payee will have bank accounts with the same financial institution. This is further exacerbated when it comes to payments across national boundaries, because the payer and payee's banks might reside in different countries. An important component of all EPSs, therefore, are interbank clearing systems which coordinate the exchange of funds between financial institutions, and ultimately the payer and payee.

This paper will provide an overview of various electronic payment systems: interbank clearing systems, electronic funds transfers, financial EDI, retail payments (ATMs, EFTPoS, card payments, smart cards), home banking and Internet payment systems.

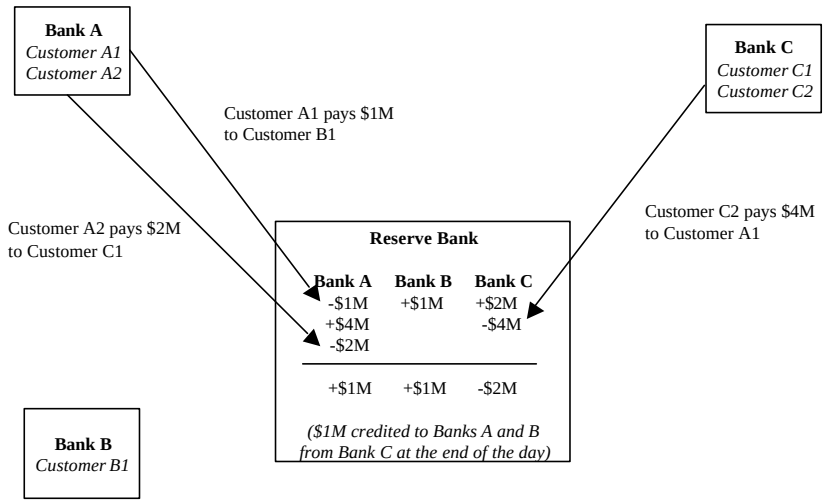
Interbank clearing systems

The global nature of eCommerce necessitates mechanisms by which payments can be made between organisations and individuals across (as well as within) national boundaries. For this reason, interbank transfers of funds and other transactions need to be facilitated, both within and between countries. Interbank clearing systems enable this transfer, clearing and settlement of funds between banks.

Clearing is an accounting process by which banks determine the total amount of funds which they owe other banks or which other banks owe them (based on interbank payments) and then pay each other the difference to 'balance the books' (Tyree 1998). Settlement, by contrast, refers to the actual payment of the difference and/or the one of two ways in which the payment is done (General Government Division 1997; Tyree 1998):

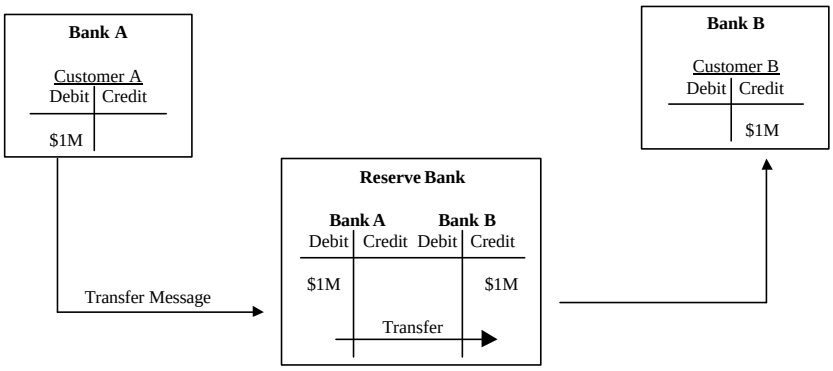
- deferred net settlement, where settlement (or payment) occurs between the banks once a day (see Figure 1); or
- real time gross settlement, where settlement occurs immediately when the payment is made between the customers of the two banks concerned (see Figure 2).

Figure 1: Deferred net settlement



Source: Adapted from General Government Division (1997), pp. 33.

Figure 2: Real time gross settlement



Source: Adapted from General Government Division (1997), pp. 20.

In the following sections we will look at some technologies, networks and clearing systems which facilitate interbank funds transfers.

SWIFT

At the international level, interbank transfers can be facilitated by the Society for Worldwide Interbank Financial Telecommunications (SWIFT). 239 banks from 15 countries founded SWIFT in 1973 (SWIFT 2001a). It provides the communications network and associated services for global (as well as domestic) funds transfers. SWIFT now supports over 7,000 financial institutions in 192 countries, which includes banks, brokers, clearing organisations and stock exchanges. In 2001 the SWIFT network handled over 1.5 billion messages, while the average daily value of payment messages is estimated at 6 trillion USD (SWIFT 2002).

SWIFT also specialises in specifying the standards by which the transactions and the information contained within should be presented so that the data are completely machine readable and can be integrated with the internal systems of financial institutions (SWIFT 2001b).

Fedwire and CHIPS

The US Fedwire and Clearing House Interbank Payments System (CHIPS) are examples of systems which handle large-dollar payments, clearance and settlement (General Government Division 1997).

Fedwire handles primarily domestic transactions within the United States (General Government Division 1997).

CHIPS, operated by the New York Clearing House, was founded in 1970 as an electronic funds transfer system and as an alternative to paper cheque clearance (NYCH 2000a) using the deferred net settlement approach (General Government Division 1997). CHIPS, in contrast to Fedwire, handles primarily international transactions worth approximately 1.3 trillion USD per day for over 1,000 financial institutions in the United States and

internationally (NYCH 2000b). According to CHIPS (2001) this constitutes 95% of all dollar payments exchanged between countries worldwide.

Australian payment clearing systems

In Australia there are four clearing systems coordinated by the Australian Payments Clearing Association (APCA) which have been established to handle the interbank clearing of payments between payment providers such as banks (APCA 1998a):

- the Australian Paper Clearing System, which is used primarily for cheque clearance in Australia;
- the Bulk Electronic Clearing System for low value recurring electronic payments, such as credit card payments, much like the paper-based clearing system;
- the Consumer Electronic Clearing System for ATM and EFTPOS transactions, and includes standards for ATM and EFTPOS network operation; and
- the High Value Clearing System for high value payments, which need to be highly secure and efficient and uses SWIFT.

Automated clearing houses

The National Automated Clearing Houses of American (NACHA) is an association in the United States which develops operating rules and practices for the Automated Clearing House (ACH) Network (NACHA 2000a). It also supports the adoption of a wide range of electronic payment systems, including financial EDI, electronic cheques and electronic benefits transfer (EBT).

The ACH Network links United States deposit financial institutions to the nationwide payment/collection infrastructure (NACHA 2000b). An ACH network is an electronic batch processing system, rather than transactions being settled on a per-transaction basis (General Government Division 1997). According to the US Federal Reserve, the automated clearinghouse electronic payment delivery system it employs is primarily used for pre-authorised recurring payments such as payroll, payments to suppliers, social security, insurance and utilities (US Federal Reserve 2001a).

Electronic funds transfer

Electronic Funds Transfer (EFT) is the transfer of funds from one bank account to another bank account automatically, where different banks often operate the bank accounts. EFTs are carried out based on payment instructions (which include the account from which payment should be made and the account details of the payee) provided by the payer to their financial institution. The clearing systems described in the previous section ensure that payments between the payer and the payee institutions can be settled successfully.

EFT can be used for business-to-business payments, as well as by businesses to receive payments from many customers. The latter includes loan repayments, utility bill payments, tax payments, inter-account transfers, etc (Tyree 1998). We are also seeing the introduction by many banks (through Internet banking) of anyone-to-anyone payments, where an individual can pay other persons when given the bank account details of that person.

The statistics provided by the APCA (2001) show that direct debits have increased in Australia, with daily transaction volumes increasing from 0.3 million in 1994 to 1.3 million in 2001 and daily values from $1.3 billion in 1994 to $8.2 billion in 2001. There has been an even greater increase in direct credits of $1.9 billion per day in 1994 to $10.6 billion in 2001.

Financial EDI

Financial EDI is the electronic exchange of payments, payment-related information and financially-related documents in standard formats between trading/business partners (US Federal Reserve 2001b). More specifically, the payer can send its financial institution an EDI-based payment instruction or remittance advice, whereupon the financial institution will effect payment (via an automated clearing house operator) with the payee's financial institution. The payee's financial institution will then send the payee a remittance advice, which can also be EDI-based (US Federal Reserve 2001b).

Much like EDI adoption levels generally, financial EDI payments in Australia are still relatively small in number (Bank for International Settlements 1999).

In the United States, however, there has been an increase in financial EDI transactions. NACHA found that there were more than 96 million financial EDI transactions in 2000 compared with 79 million in 1999 (Anonymous 2001). According to Bill Nelson from NACHA (quoted in Anonymous 2001), this appears to be because of such factors as the increases in Internet-based B2B transactions and the ease by which financial EDI can be conducted over the Internet using third-party providers. The US Federal Reserve (2000b) predicted growth in financial EDI because of the US Federal Government mandated that all federal government payments would be made electronically back in 1999.

Murphy (2001) is less optimistic and points out that despite this increase in financial EDI transaction volume, it still represents a small percentage of the 900 million transactions via the ACH network (including payroll, tax and trade payments) as estimated by NACHA.

Retail payments

A range of electronic payment methods are now available for consumers for making purchases and for withdrawing cash. These approaches have progressed from Automatic Telling Machines (ATMs) through, more recently, to the current promise of smart cards. These retail payment methods will be examined in more detail in the following sections:

Automatic telling machines

According to the APCA (1998b) most ATM transactions in Australia result from withdrawals by consumers. The association points out that these withdrawals are technically part of the traditional cash system, until consumers use ATMs to withdraw cash from an ATM which is not operated by their financial institution. This is because cross-institutional clearing and settling is required to finalise withdrawals from another institutions ATM using the interbank clearing mechanisms described above.

There is currently an estimated 11,915 ATMs in Australia in 2001 from 4,073 in 1989 (APCA 2001). Monthly ATM transaction volumes have increased by about 8 million in 2000 since 1994 (from 40.7 million), with the value of these monthly transactions reaching $9.4 billion in 2001 compared to $4.4 billion in 1994 (APCA 2001). We will

see in the following sections that these increases are modest compared with the increases seen in EFTPoS and credit card transaction volumes and values.

The current use of ATMs could change in the future to offer additional services than just withdrawals, deposits, account transfers and bank balance checks. For example, Breitkopf (2001) outlines the deal between 7-Eleven and First Data Corp (in the US) which will see in future Web-enabled ATMs which can support bill payment, event ticketing, travel directions and road maps. In addition, Wells Fargo in the US anticipated installing 6,400 Web-enabled ATMs by the end of 2000 for consumers to access brokerage accounts, apply for loans, trade stock and complete other transactions (Merrick 2001). No further information appears to be available today about this work and its impact.

EFTPoS

Electronic Funds Transfer at Point of Sale (EFTPoS) allows consumers to purchase goods and services at the point of sale, where an EFT occurs between the consumer's and the merchant's bank account (APCA 1998b). Some merchants also allow consumers to include a "cash out" portion to the EFT, so that in effect they are also withdrawing cash as well as purchasing.

The popularity of EFTPoS in Australia is demonstrated best when looking at the growth of this form of electronic payment (APCA 2001):

- 11,452 EFTPoS outlets in 1989 to 362,848 in 2001;
- 20.6 million transactions per month in 1994 to 57.5 million in 2001;
- $1.1 billion in value per month in 1994 to $3.5 billion in 2001.

Mobile EFTPoS facilities are a more recent variation for handling remote consumer payments. For example, Coles Online uses this approach when groceries are home delivered, whereby the customer's credit or debit card is swiped through the mobile EFTPoS device and the transaction approved.

Credit, Debit, Private Label Credit and Charge Cards

A variety of plastic cards exist which satisfy a range of payment needs of consumers. These cards typically have magnetic stripes on their backs for holding customer information and other details. In addition to allowing customers to purchase goods and services, their link with an "owner" also provides the ability to track a purchaser's activities when the cards are used with merchants. The four main types of cards are:

- *Credit Cards* typically have an annual charge and provide customers with a pre-set credit limit beyond which they cannot spend. Interest starts to accrue on these cards immediately when cash withdrawals are made, and after a pre-set period in the case of goods and services. Customers generally only need to pay a minimum amount each month against the amount owing on the card. Commercial credit cards are also provided (eg, by Visa International) for the purchasing needs of businesses;
- *Debit Cards* are similar to credit cards (in terms of goods/services purchasing and withdrawals of cash) but operate against a customer's bank account, where sufficient credit is available for the transaction;
- *Specialist Credit Cards* or private label cards are primarily owned by retail outlets. They offer a similar service as bank credit cards but can only be used in the outlet of the issuer. They also typically charge higher interest rates than bank issued credit cards;

- *Charge Cards* usually have an annual fee, but rather than a pre-set spending limit they are issued based on the income level of customers. Charge cards require full payment of the amount owing each month, although some cards offer a loan service in association with the card. These cards often have the perception of being higher "status" by consumers when compared to bank credit cards.

We will see later that credit cards are one of the dominant forms of consumer Internet payments. One of the concerns by most consumers with credit card purchases over the Internet is the perceived risk that their credit card numbers will be obtained and used in a fraudulent manner.

Smart Cards

A smart card typically takes the shape and form of plastic credit cards, but differ in that they can hold a lot more information than credit cards (Turban et al 2002) because of their imbedded chips. Chips can also be used with such devices as bracelets and necklaces, but are often placed on plastic cards because of their familiarity to users.

The two main types of smart cards are memory cards and micro-processor cards (Turban et al 2002).

- Microprocessor cards are programmable and are capable of processing the data stored in its memory chip. They can provide security (such as PIN authentication) and can support multiple applications and hence purposes. All personal details (such as account number and financial information in the case of payment smart cards, medical records in the case of medical smart cards, etc) are highly protected/secured by PINs and encryption. This means that others cannot use the card if it is lost or stolen.

- Memory cards can be used to store from 1,000 to 4,000 characters of data, which make them suitable for stored-value applications (eg, in pay phones, vending machines and retail transactions). Magnetic stripe cards, by contrast, can typically store up to 220 characters. Memory cards are not secured by PINs, so that other people can use them if they are lost or stolen.

In addition, these cards can be either contact or contactless depending on whether they require physical contact with the card readers (Turban et al 2002).

Smart cards require 'readers' (e.g., swipe devices as used with credit cards, or contactless readers with contactless smart cards) to access, update and manipulate the data on the card (Turban et al 2002). For example, a store-value memory card reader will check the balance on the card and decrement the value on the card by the purchase amount. A microprocessor card also has the processing capabilities to access, update and manipulate its own data.

A smart card requires an operating system (either on the card in the case of microprocessor cards, or on the readers in the case of memory cards) on which the smart card applications run (Turban et al 2002), much like computer operating systems. There have been rapid technical developments in this area and hence problems – like personal computers in the early days, smart card manufacturers and application developers have interoperability issues because smart card applications have been developed for proprietary operating systems. Sun Microsystems with its Java Card Technology (see Byous 2000) and Microsoft with its Windows for Smart Cards (Microsoft 2000) are trying to address this issue by providing their own versions of non-proprietary platforms on which developers can produce applications for smart cards.

Home Banking

Consumers have been able to complete many banking functions at home with the introduction of such services as phone banking, Internet banking and BPay. Phone and Internet banking permits consumers to access their accounts (securely using PINs) to transfer funds, check their account balances, obtain transaction histories, order cheque books, pay bills and even pay other individuals direct to their bank accounts (even if those are with other financial institutions).

In the case of Internet banking, additional online services are being provided to retail and business customers, which include cash management services, integration with major accounting packages (so that bank statements, for instance, can be downloaded and input into internal systems) and online application services.

Bill payment to merchants and utility companies using phone and Internet banking has been enabled (and made easier) by BPay, which is a centralised electronic bill payment service provided by Australia's leading financial institutions (BPay 2002a). Businesses must register with the BPay via their financial institution to accept BPay payments (BPay 2002c).

Payers typically provide the payment amount and a reference number (such as a biller's account or invoice number), which the payer's financial institution turns into a payment instruction handled through a clearing system (Tyree 1998). Payers, via Internet banking, are also able to control the date on which they pay bills and receive a receipt number confirming the payment.

According to BPay (2002b) there are currently more than 3,000 companies in Australia offering BPay payment options for its customers, and benefits to businesses (or billers) include (BPay 2002c):

- no dishonoured cheques;
- easy transaction data reporting; and
- straightforward reconciliation of payments.

Internet payment systems

The Web has provided much of the impetus for the growth of IPS services, to the extent that financial institutions can no longer ignore this trend. More specifically, we will be looking at how card-based payments are conducted via the Internet, third-party Internet-based payment systems and Internet-based micropayment systems.

Card-based Internet payment systems

We have seen above in this paper that credit, debit, private label and charge cards are examples of traditional payment systems which are evolving to provide online payment mechanisms. One such evolution is the emergence of smart card technology. All of these cards have the potential to be used via the Internet, including smart cards if smart card readers are attached to a PC.

In the context of credit card payments via the Internet we also saw above that one of the concerns was the ability to authenticate whether the user of the card is actually the owner, so that fraudulent use of credit cards might be reduced. The following are examples of

approaches which have been introduced to address the problem of authentication and/or fraud:

- American Express has introduced a new form of online payment called Private Payments, where cardholders can obtain from American Express a unique number which is linked to their card account but which is only valid for a period of 30-67 days (American Express 2000a). The unique number can be used instead of the user's card number with any merchant which accepts American Express cards. If the number is stolen it cannot be used to make any purchases, because the number expires and is only used for a single purchase transaction. In addition, the unique number is only generated on request by the cardholder and when the cardholder's username and password is provided to an American Express web server (American Express 2000b);

- Cybacom (<http://www.cybercom.com>) allows consumers to provide their credit card details once, after which they are assigned an electronic version of a MasterCard called CybaCard. Consumers can pay with this virtual card instead where MasterCard is accepted (Cybacom 2000a). The merchant never learns of the consumer's real credit card details and, in addition, customers are permitted to identify themselves as 'Cybacom Member' rather than using their real name (Cybacom 2000b). The virtual card can also be turned off, an email can be sent by Cybacom to the customer for all account activity (for checking) and the available balance set to reduce the prospect of fraud when compared to conventional credit cards (Cybacom 2000c);

- InternetCash (<http://www.internetcash.com>) is a variation on CybaCard in which customers purchase a virtual InternetCash card of a certain value. Consumers can then provide the virtual credit card number for online payments at sites which accept InternetCash (InternetCash 2001); and

- International credit card companies have developed a protocol known as SET (Secure Electronic Transactions) using public key cryptography. The SET scheme is a system of digital signatures which are verified and authenticated by private certification authorities. Credit card information is encrypted by the user's software and digitally signed by the user. This scheme permits the credit card to be used on the Internet in a way that is entirely analogous to its normal use. The transmitted credit card information cannot be intercepted (because it is encrypted) and even if it could, it would be useless to the interceptor because of the need to provide a digital signature when a new purchase is contemplated.

Third-party based Internet payment systems

Financial institutions and other third parties also provide solutions which enable organisations to authenticate credit card payments automatically. For example, St George Bank's Online Credit Authorisation (OCA) server can be used by a merchant over a dial-up or leased network connection to access the Australian EFTPoS Network to have credit card transactions authorised and authenticated. The OCA server can connect with the merchant's web server, internal network of computers and normal EFTPoS devices. (See <http://www.stgeorge.com.au/code/ecommerce/credit/default.asp> for more information.)

Other examples include CyberCash's CashRegister product which provides real-time credit card, debit card and charge card authentication and processing (<http://www.cybercash.com/cashregister>). The CashRegister software is installed by the merchant and connects with CyberCash's payment processing servers to receive payment authorisation (CyberCash 2001). Telstra also offers a bill payment service for organisations which can be linked into the company's web site to receive customer credit card payments (Telstra 2001).

Third-party Internet-based payment systems can also include online clearing houses where consumers and merchants can register to send and receive payments without credit card details being sent to the merchant. The third-party instead coordinates the clearing of funds between and on the behalf of consumers and merchants.

A sophisticated example of this approach is Achex (<http://www.achex.com>) in which both merchants and consumers register with the online service to send and receive payments (Achex 2000a). Achex is designed especially for consumers who do not have a credit card (or prefer not to use one), but have a bank account from which funds can be drawn (Achex 2000b). Merchants use Achex software tools to provide an Achex (in addition to Visa, Mastercard, etc) payment option on their web site and to send/receive payments from Achex (Achex 2000c). Consumers register with Achex (which includes credit rating checks) and all payments are then authorised by the consumer using a username and password with Achex rather than with the merchant (Achex 2000c). This means that no financial data is provided to the merchant, and these data are only transmitted once to Achex at the time of registration (Achex 2000d). NETeller (<http://www.neteller.com>) is a similar example.

Other types of third-party payments take the form of electronic versions of physical cheques, and are especially popular in the United States with its strong cheque culture for payments. For example, eBay established BillPoint for users of its Internet auction site, so that sellers can invoice bidders, and bidders can provide their cheque account (or other payment) details. The payment is then settled by Wells Fargo and paid directly into the seller's bank account. Email notifications are sent to both parties when payment is cleared (eBay 2001).

A more generic online cheque payment system is provided by CheckSpace (<http://www.checkspace.com>), which allows individuals and small businesses in the United States to register with the service and provide their cheque or credit card details (CheckSpace 2001a). Payments can be sent to individuals or organisations – even those who are not CheckSpace members – electronically, whereby payee's are notified by email that a payment has been received. Non-members need to sign-up for CheckSpace in order to receive the payment (CheckSpace 2001b). CheckSpace also offers complementary services such as sending a paper cheque (using the payer's financial details) on behalf of the payer to a payee, allowing small businesses to send invoices to members and non-members, and integrating CheckSpace with internal accounting systems and web sites (CheckSpace 2001c). A similar generic online service is provided by Bank One's eMoneyMail service (<http://www.bankone.com>) and TeleCheck (<http://www.telecheck.com>).

CheckFree (http://www.checkfree.com>) is a long established and more sophisticated online cheque payment mechanism again. For the consumer it includes a complete suite of payment management systems, including payment scheduling and forms displaying all the consumer's payees to simplify multiple payments (CheckFree 2000). It services approximately 4.4 million consumers, 1,000 businesses and 400 financial institutions in the United States (CheckFree 2001).

Billers can also use the service to distribute bills (which can be formatted just like their paper-based bills) to CheckFree users, and integrate this bill distribution with their internal accounting systems (CheckFree 2000). This form of electronic payment service is currently known as 'electronic bill presentment and payment' and is growing in popularity in the USA in particular. Advantages can come from this approach if customers are able to obtain all their bills online through the one service.

Electronic token-based Internet payment systems

We have seen previously that credit card payments via the Internet have been used successfully for many online purchases. The exception is for low-value transactions (for

instance, cents rather than tens of dollars), because of the high transaction costs associated with credit cards (Turban et al 2002). It therefore stands to reason that these low-value payments need to be supported on the Internet.

For these types of payments, new payment forms are being introduced. They are generically known as 'computer money', 'digital cash' or 'e-cash'. They generally take the form of token-based payments where an electronic token represents value, although we will see in the next section that notational micropayment systems have also been developed. Because digital cash is seen primarily as a low-value payment mechanism, it is common to refer to a payment unit as a 'digital coin'.

Turban et al (2002) outlines some of the key advantages of digital cash:

- Digital cash works much like physical cash in that it is completely anonymous. In other words, banks, digital cash issuers and merchants cannot track the spending of consumers, because the digital coins do not store information about individuals with the digital coin.

- Digital coins cannot be spent more than once, because the digital cash issuer has a database of digital coins which have been redeemed for cash by merchants. This therefore prevents double-spending of the same digital coin.

- Digital cash solutions are secure because they use the latest encryption and digital signature technology, however, a discussion of these technologies is beyond the scope of this paper.

The use of digital cash requires a number of steps once the consumer has a digital cash account with a coin issuer (Tyree 1998):

- the purchaser requests digital coins from a coin issuer;

- the issuer sends the purchaser the coins (e.g., to the purchaser's 'wallet' on their PC) and debits the account of the purchaser;

- the purchaser sends the appropriate digital coins to a merchant;

- the merchant checks with the issuer that the digital coins have not been spent previously before accepting the coins for payment;

- the issuer adds the spent digital coins to its database of spent digital coins.

Turban et al (2002) notes, however, that non-credit-card based digital cash solutions have so far all failed, including DigiCash (which went bankrupt, was then bought by eCash Technologies, and has since been acquired by Infospace in 2002) and CyberCoins (operated by CyberCash). We will see in the next section that the more successful micropayment alternatives tend to involve credit cards.

Micropayment-based Internet payment systems

Electronic cash is an example of an Internet-based micropayment mechanism for purchasing (electronic) goods from as little as a few cents to a few hundred dollars. We will now look at the major types of micropayment systems which have emerged or are evolving, which include digital cash approaches described in the previous section.

Payment systems, and micropayment systems in particular, can be categorised in a number of different ways. For example, Camp et al (1995) state that payment systems can be token-based (with markers or tokens representing value, such as electronic cash) and

notational-based systems (with value stored as notations, such as stored value smart cards and credit cards).

We have also seen from the previous sections that payment systems can be centralised or distributed. Centralised payment systems require all parties to belong to the same provider such as a financial institution. Distributed payment systems, by contrast, do not have this restriction, which we saw with credit card systems allowing people and businesses using different financial institutions to exchange payments.

When we combine these two dimensions (token versus notational and centralised versus distributed) a total of four categories of micropayment systems are possible. It is not surprising, perhaps, that efforts in the areas of distributed micropayment systems will be especially important in the near future because of the global nature of eCommerce. We will look at each of these four categories in more detail in the following subsections.

Centralised notational micropayment systems

NetBill (<http://www.netbill.com>) is an example of a centralised notational micropayment system in which a NetBill server operates accounts which store value for participating merchants and customers (linked to accounts of their respective financial institutions). Customers can add funds to their NetBill account and then purchase digital products (including information, software, CPU cycles, music, journal articles, services, etc), while merchants can redeem cash from their NetBill account to an account with their financial institution (NetBill 1997a). A credit-based model can also be used (at greater risk of non-payment by customers) whereby customers accumulate purchases and then make payments later (NetBill 1995).

NetBill is a research project at Carnegie Mellon's Information Networking Institution which started in 1995 and, as yet, appears to have very few merchants (NetBill 1997b). This could be explained by the fact that it is a student research project system (NetBill 1995), rather than a commercially backed or supported system. NetBill is currently a centralised system, but could be distributed if customers could purchase products and services from merchants which are registered with any (rather than a particular) NetBill server or payment broker.

Qpass (<http://www.qpass.com>) is an example of a credit-based, centralised notational micropayment system in which merchants and customers register with the Qpass system. Purchases are accumulated and the customers' credit cards are then billed monthly (Qpass 2001a). This enables merchants to offer products and services for small values, while also minimising transaction costs due to the aggregation of all these small purchases over a month. In addition, purchases can be made in foreign currencies, because Qpass converts between the seller's currency and the chosen billing currency (Qpass 2001b). A similar micropayment system is provided by InterCoin (http://www.intercoin.com>).

MilliCent (<http://www.millicent.com>) is quite a different form of centralised token micropayment system in that it operates using scrip. According to Manasse (1997), scrip is very much like a vendor-specific prepaid phone card (with a PIN or Personal Identification Number), where the value (in this case of the scrip) can only be 'spent' with that vendor or merchant. Scrip is essentially vendor-specific currency which can be created by the vendors.

According to Schneider and Perry (2000), MilliCent brokers or financial agents then purchase vendor-specific scrip for a discounted price from the merchant, which therefore associates 'real' money with the scrip. Consumers register with one broker and buy generic, broker scrip in bulk using their credit cards or some other payment mechanism. When the consumers find a small value product on a merchant's web site, the consumer using their electronic wallet to convert broker (or generic) scrip into vendor-specific scrip which is needed to purchase the product. This vendor-specific scrip is then exchanged with the merchant for the product.

MilliCent was trialled in Japan, but development work was subsequently suspended to investigate possible launching in North America (MilliCent 2002).

Distributed notational micropayment systems

Mondex smart cards are an example of a distributed notational micropayment system, because it can store value which can be spent at merchants with smart card readers, including products/services of small values (Schneider and Perry 2000). Schneider and Perry (2000) outline the sequence of steps involved in making a payment using the Mondex smart card, which includes checking digital signatures to authenticate the two parties involved. We can also see that smart card payments such as Mondex are different to the others mentioned in that value is transferred directly from the customer to the merchant without the involvement of a third-party – at least until the merchant redeems the electronic cash for real cash!

The Mondex smart card system is currently being trialed in communities, so that it is currently uncertain as to whether it will be successful and whether it will be adopted on a wide scale (that is, worldwide). Mondex, for example, has been trialed in the Sherbrooke region of Quebec, Canada since 26 August 1999 (Mondex 2000). In the 12 months which followed, $2 million in e-cash downloads have occurred from ATMs, which was available for spending at 600 merchants and 750 vending machines. Cash can also be loaded from telephones and the Internet (using special devices) and card-to-card e-cash exchange devices (Mondex 2000). In Australia Mondex cards are primarily being used by staff in banks such as ANZ, National Australia Bank and Westpac (Mondex 2001a).

Mondex is intended to be a truly global system (and therefore distributed) when it launched worldwide, so that customers can use their Mondex smart card when they are travelling (Mondex 2001b). The value on the smart cards can be redeemed for 'real' currency with the customers' and merchants' financial institutions, so that they are not restricted to a single institution.

Centralised token micropayment systems

The electronic cash solution provided by eCash Technologies is an example of a centralised token-based micropayment system. This is because all merchants and customers using eCash for payments must have bank accounts with the financial institution which issues the electronic cash. This means that customers wanting to use this version of eCash to purchase from a merchant overseas would need to open up bank accounts with that merchant's financial institution. It now appears that InfoSpace, which acquired eCash Technologies, will use this technology more for e-coupons and loyalty programs points rather than for electronic cash (InfoSpace 2002).

Another example is the eCoin (<http://www.ecoin.net>) micropayment token system in which all vendors and consumers must have an account in order to exchange eCoins for payments (eCoin 1999a). Consumers purchase eCoins using a credit card (Turban et al 2002). eCoins operate in a similar manner to eCash from eCash Technologies, except that it can be combined with the e-Gold coins (eCoin 1999b) – an entirely different form of centralised token payment system. While the identity of the customer is still hidden from the merchant with the eCoin solution (Turban et al 2002), it is not hidden from the eCoin issuer like it is with the eCash solution from eCash Technologies.

e-Gold (<http://www.e-gold.com>) allows individuals to trade in metals such as gold, silver, palladium and platinum (rather than multiple currencies) by spending specified weights to and from their e-Gold accounts. These trades are backed by real gold, silver, palladium and platinum (respectively) which are held in a treasury grade vault – only the ownership changes. e-Gold supports B2C as well as C2C payments (e-Gold 2001).

Distributed token micropayment systems

Just as distributed notational micropayment systems are still currently under development and awaiting worldwide launches, so too are the comparable distributed token-based mechanisms.

An example is NewGenPay (<http://www.newgenpay.com>) – a distributed token micropayment system which used to be known as IBM Micropayments Technology and, prior to this, was known as MiniPay. NewGenPay is intended to be a globally interoperable token-based payment technology (and therefore distributed), because buyers of one Payment Service Provider (PSP) can purchase from sellers with another PSP, without each PSP having to have a direct relationship with each other. It also supports multiple currencies (NewGenPay 2001).

Other Internet payment systems

We are starting to see new payment techniques emerging on the Internet. For example, CyberGold (<http://www.cybergold.com>) offers consumers cash for conducting such activities as using web sites, filling out surveys, downloading software, signing up for online services, buying products, etc (CyberGold 2001a). Consumers can redeem the cash they accumulate for products or even have this cash credited to a bank account or credit card (CyberGold 2001b).

Mobile phone based payments

With the advent of Wireless Application Protocol (WAP) it is also becoming extremely important that payments can be made using devices such as mobile phones – in addition to typing in a credit card number into a phone-based payment service or a Web form.

Many notational payment systems are now permitting payments to be made by going to a web site using a mobile phone. Examples include CheckSpace (explained previously in this paper) which permits customers to provide their CheckSpace ID and Access PIN at the CheckSpace web site, select the payee from a list, enter the amount and then send the payment. This is much like the normal web-based method in which CheckSpace users can make online payments, only it can also be done via a mobile phone (CheckSpace 2001d).

NewGenPay and IBM are currently collaborating on a wireless payment solution which uses NewGenPay's core product – Valuto (NewGenPay 2002).

Fundamo (<http://www.fundamo.com>) is a more specialised mobile phone payment solution which includes adapters for point-of-sale terminals, computers, mobile phones and other wireless devices so that payments by a mobile phone can be made. B2B, B2C and even C2C payments can therefore be supported using Fundamo hardware and software. Businesses and individuals need to have Fundamo accounts between which payments can be made. Financial agents operate the Fundamo gateway through which value is exchanged from one bank account to the other. Fundamo is a distributed system because it supports payments between gateways (Fundamo 2001).

Summary

In this paper we have looked at a range of "traditional" electronic payment systems (EPSs) and how they are evolving with changes in technology – especially EFTPoS, smart cards and home banking. By examining these EPSs we have seen that interbank clearing systems

are critical to the efficiency and operation of most EPSs. We have also looked at a range of Internet-based electronic payment systems which have been introduced, some of which appear to be failing, some which are still under development and others still which are thriving. It is still not yet clear what electronic payment systems will look like in the future.

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