Case Study Cardomat/Migros An Open EFT/POS System

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Electronic Funds Transfer at Point of Sale (EFT/POS) is an application of information technology for which a very bright future had been predicted, but whose growth rate has been subdued. This paper provides a study of a particular approach to EFT/POS which has successfully addressed the factors which have held back progress. Although some aspects of the application may not be transportable due to particular cultural and institutional factors operating in Switzerland, both the technology and the principles are applicable in other countries.

Keywords and Phrases: EFT/POS, consumer, retailer, bank, financial institution, payment systems, credit card, debit card, smart card, chip-card, open systems.

CR categories: J.1, H.3.5, H.4.3, H.1.2, K.4, C.3.

1 ELECTRONIC FUNDS TRANSFER AT POINT OF SALE

EFT/POS refers to an arrangement whereby a customer, at the point in time and space at which he purchases goods or services, initiates the transfer of funds from his own account with a financial institution to that of his supplier, using some form of secure identification and a secure electronic link. The common form of secure identification in use at present is a plastic card with a magnetic stripe on the back containing machine-readable data, combined with a code or Personal Identification Number (PIN) which is intended to be known only to the card's owner. Descriptions and discussion of EFT/POS systems and their economics, politics and impacts may be found in Walters (1989) and Clarke and Walters (1989). Transition appears to have begun towards a plastic card with an embedded chip containing a microprocessor and associated storage (variously referred to as a 'smart card' or 'chip-card' — see Walters 1991).

The earliest EFT/POS systems were implemented in the United States in the mid-1970s, and many systems were initiated in the mid- to late-1980s. In some sectors in some countries, there has been enthusiastic acceptance, eg in service stations in the United States, Switzerland and Australia, and in France more generally. In other cases, there has been only a moderate level of interest, eg in Australian supermarkets during the late 1980s. There have been some instances of abject failure and withdrawal, eg in the New Zealand retail sector in the late 1980s. Depending on the measures used, it can be argued that France, Australia and/or regions of the United States have to date achieved the greatest penetration of the potential market for EFT/POS services.

Despite the high levels of consumer support which ATMs attracted in the late 1970s and early 1980s, EFT/POS penetration has been much slower and patchier. An EFT/POS system is of course a much more complex proposition, because it involves not just the financial institution and the consumer, but also a critical mass of merchants and usually one or more third-party network suppliers. In a number of countries, there have been institutional constraints (eg the limitation of US banks to State boundaries), infrastructural problems (such as inadequate national network services), and consumer education shortfalls (eg lack of understanding of the differences between credit, debit and charge-cards; and magnetic-stripe, memory, 'smart' and 'supersmart' cards). Until recently in Australia, the fragmentation resulting from incompatible, competing services also contributed to confusion among consumers, and to inadequate reliability, speed and consumer convenience.

This case study describes one particular EFT/POS application, and identifies key factors which appear to have led to its success. The confidence with which general

principles can be reliably inferred from a single case is of course very limited. The circumstances are, however, similar to those which hold in other countries, including Australia. It is therefore suggested that careful consideration of this report may be of benefit to parties throughout the world who are currently contemplating, planning, designing, constructing, implementing, operating, modifying or abandoning EFT/POS systems.

2 RELEVANT ASPECTS OF THE SWISS ENVIRONMENT

Switzerland occupies an area of 40,000 square kilometres (about two-thirds the size of Tasmania), and half of that is steep alpine country. In that small space, however, it has a population of 6.3 million, about the same as New South Wales. It is in at least one sense the wealthiest country in the world, with a per capita Gross National Product about double that of Australia.

There is considerable diversity and decentralisation inherent in the country's culture (four languages, with many dialects) and political system (23 cantonal administrations and a federal government with very limited powers). The deep-rooted scepticism about centralised power extends to the marketplace, where few industries are dominated by a single company. The marketplaces for financial services in general, and credit-card services in particular, are lively, competitive arenas, with a multiplicity of cards in use, issued by a multiplicity of banks and non-bank financial institutions.

There is considerable similarity between the retail sectors of Switzerland and of other advanced Western nations such as Australia. Supermarkets are similarly distinguishable from department stores and specialty stores, and the general design of, and procedure at, checkout counters is moderately consistent with those in many other countries. A considerable proportion of sales are in cash, a limited number are by cheque (more than in Australia, but far fewer than in the United Kingdom and France), and there has been a growing acceptance of credit card payment, initially using manual vouchers and 'flick-flacks'.

The nature of the Swiss banking sector is fairly familiar to an Australian observer, with a small number of very large and long-established banks controlling the payments system, and thereby resisting incursions from the many smaller and newer banks and non-bank financial institutions. In general, banking services are a little less advanced than they are in Australia. In particular, most ATMs are only now being connected on-line to account details in the host bank. On the other hand, the services are fairly well integrated, in that the 'ec-Card' (the 'ec' stands for 'Euro-Cheque') is issued by all of the major banks, and is accepted not only by all of their ATMs, but also by terminals at most petrol stations. A company owned jointly by the major banks, Telekurs AG, runs a single processing

centre, which holds details of valid cards and monthly balances. This contrasts with the situation in Australia, where, even after an amount of rationalisation has taken place, there are still three separate ATM networks accepting, respectively, the cards of two of the four major banks and some other institutions; those of the other two majors and some other institutions; and those of a large number of non-bank financial institutions. The various Australian EFT/POS systems are now fully inter-connected, however.

There is a significant difference between the payments system in Switzerland and that in Australia. In common with most European countries, the dominant method of payment by Swiss consumers has been and continues to be via the national PTT's 'giro' system. Cheques have only come into common use during the last decade, and appear unlikely to ever represent a significant percentage of transactions.

The transition from cash-registers to more complex point-of-sale terminals has been under way in Switzerland for some years. To date, the primary developments have been for large corporations to integrate their point-of-sale terminals more effectively into their own inventory and purchasing systems. In some cases, proprietary EFT/POS functionality has been incorporated in point-of-sale terminals, enabling the retailer's own card to be used as an alternative to cash. Until the implementation of the system reported on in this case study, there had been no installation of an open system capable of accepting a variety of cards.

The Swiss PTT (roughly equivalent to Telecom Australia after its absorption of the Overseas Telecommunications Commission, OTC) provides sophisticated telecommunications services. It has been far in advance of the PTT of its large neighbour, Germany, about the equivalent of the (very differently structured) United States system, and not markedly inferior to the world leader, Telecom France. The Swiss PTT is well-advanced with its introduction of chip cards, with pilots completed, and some half-million now issued. To date their principal purpose has been to carry a complete audit trail of transactions and the current balance on the card-holder's account, capable of being displayed on a device which is not attached to the network. A multi-function chip card is being piloted (PTT 1988, 1990).

This report reviews a particular EFT/POS application, which is being progressively installed throughout a large chain of Swiss supermarkets, using products developed by a Swiss company. The interests of the retailer, its customers, and the primary supplier are considered. The report concerns itself with the period between 1986 and 1991, and is based on interviews conducted in January and June 1991 with senior executives of the two main companies involved, a demonstration of the equipment and procedures, observation and use of the system in supermarkets,

publicly-available brochures and some internal papers.

Because the system was launched by a retailer rather than a bank, it is of far more than merely local or European interest. Although the details of implementation are specific to the Swiss environment, it is possible to infer some general principles. In addition, the equipment and software are directly applicable in other countries which have adopted international telecommunications standards.

3 MOTIVATIONS
3.1 The Retailer's Perspective
Migros is a large Swiss conglomerate, comprising a dozen regional cooperatives operating a number of services, including supermarkets, retail stores, service stations, travel agencies and a bank. A joint Head Office operates out of Zurich. The chain of over 500 supermarkets is the largest in the country, with 1990 turnover of about 10,000 million Swiss Francs (about the same in Australian dollars). Migros' own Bank is small in comparison to the four giant institutions, but is nonetheless significant in terms of the value of turnover and deposits, and the number of customers and cards on issue.

Migros has a very strong commitment to community service, a philosophy which is expressed in its Constitution, and embedded in its managerial and operational culture. The Migros cooperative movement has had a long and strong aversion to credit, and to credit cards, and its EFT/POS services have therefore been based on debit-cards, which access the card-holder's own funds, rather than borrowing against a line of revolving credit.

In the mid-1980s, the Finance Director of the Migros Group of Cooperatives, Hr J. Kaufmann, was concerned that EFT/POS systems would be implemented by the banks, under conditions and charging structures suitable to themselves rather than the retailers and consumers. This has been the case in many countries, particularly in the country's neighbour, France. The Group therefore decided in 1986 to develop its own EFT/POS system which would be 'open' in the sense that it would accept, and process on-line, cards issued by many different organisations. Migros and other retailers formed an association in 1988, which has successfully precluded the banks from controlling EFT/POS in Switzerland, and ensured that the openness concept is intrinsic to the Swiss EFT/POS system.

Participants whose interests needed to be taken into account were retail merchants, banks, the PTT, and manufacturers and suppliers of hardware and software. Most critical, however, were the customers (and, in Migros' case, members). Exhibit 1 shows Migros' interpretation of their most critical requirements (translated from Pfister 1988).

Exhibit 2 summarises Migros' view of the most important cost and benefit factors (translated from Pfister 1988).

For both banks and retailers, cash transactions are relatively expensive (because of the high cost of labour-

Exhibit 1. Customer Requirements Relating to Payment Options at Point of Sale
— the 'modern' customer
— wants simple, quick and secure payment at the point of sale.
— is prepared to take part in the payment process by moving the card through the reader and keying the PIN (self-service principle)
— wants to be able to make purchases up to the limit of his account
— the 'careful' customer
— wants to be able to access at any time the current balance on his account
— wants to receive a comprehensive and understandable receipt for every purchase
— wants to have his cashless purchases expressed clearly on his statement
— the 'emancipated' customer
— wants to choose his own payment means (Migros Card, ec-Card, PTT-Card, Migros-cheque, cash, etc)
— wants to be able on occasions to withdraw cash in shops
— the 'parsimonious' customer
— knows that cashless transactions keep his money in his account longer and thereby earn more interest
— wants to gain from cashless shopping without paying extra charges

Exhibit 2: EFT/POS Costs and Benefits

CUSTOMERS
Costs
— account costs (no additional costs for existing account holders)
— statement charges (free statements twice per annum)

Benefits
— payment convenience (no forms, quicker service)
— ability to purchase independently of cash-holding and bank opening time
— no cash loss and theft risks
— more interest as a result of keeping money in account

RETAIL MERCHANTS
Costs
— hardware and software investment
— running costs of the system
— education costs for shop staff
— higher control and reconciliation costs
— advertising costs

Benefits
— reduced cash-handling (counting, sorting, packing, transport)
— decreased risk of theft and robbery due to decreased cash holdings
— decreased credit card commission costs
— speedier point of sale process
— speedier transfer of funds into the company's account
— cost recovery from card issuers

CARD-ISSUERS (BANKS, PTT)
Costs
— hardware and software investment
— running costs of the system
— communications costs
— advertising costs

Benefits
— simplification and automation of payments (cf cash and cheques)
— decrease in the issue and receipt of coins and banknotes.

intensive cash receipt and dispensing), and so too are cheque transactions, which require physical handling and capture, and whose full costs are of the order of 2-3 Francs

per cheque. Since the cost of EFT/POS transactions (assuming moderately high volumes) is of the order of 20-80 cents each, the costs of banking could be reduced by replacing cash and cheque transactions with electronic ones. The extent to which these savings would accrue to the bank or the retailer would depend on negotiations. In addition to reductions in cash-handling costs, the lower opportunity costs of cash-holdings would be significant.

There were potential benefits for Migros' customers/members also. One source was lower prices resulting from the lowered cost-structures of Migros and the financial institutions. More directly, there was a possibility of time-savings at checkout-counters. For example, a study in Zurich showed that about half of the time spent at checkout-counters was involved with payment rather than the handling of goods, and that time and money might be saved. Where the customer pays by cheque (which is common in countries with cheque guarantee cards, such as the United Kingdom and France), payment requires some two minutes after the cost of the goods has been totalled. A reduction to, say, 30 seconds, would therefore result in measurable benefits such as fewer checkout positions, staff salary savings and/or more satisfied customers, and more space for product display (Hinnen et al 1987). These studies are not conclusive, however. Payment in cash is a relatively quick procedure typically involving about only 15 seconds after the cost of the goods has been totalled. Hence, where electronic means means replace cash payments, EFT/POS offers less significant time-based financial savings or other improvements. Other advantages to consumers are the convenience of cashless shopping, the decreased risk of loss of cash, and the possibility of withdrawing cash at the checkout till.

Other important changes are under way in point of sales operations, including the scanning of machine-readable product-numbers and the auto-weighing and charging of bulk and fresh goods, both of which relieve the checkout assistant of keying some or all of the prices or goods identification codes, and may in due course lead to self-service checkout, with resulting labour-savings. Migros chose to deal with those technologies in a separate (though related) project, and this case study accordingly leaves those developments to one side.

3.2 From the Primary Supplier's Perspective
Ascom Autelca AG manufactures a variety of equipment, including coin-operated telephone and ticket vending machines, ATMs and EFT/POS terminals. The company operates out of Bern, the Swiss capital. With its experience in ATM networks for the banks and the PTT, and petrol station EFT-terminals, the company anticipated that card-issuers would not be able to agree common technical requirements for EFT-terminals. It concluded that competitive advantage would accrue to a supplier which could

implement, using a single family of terminals, applications which satisfied each card-issuer's specifications, read cards which used different technologies (in particular, magnetic stripes and chip-cards), and provided a range of alternative security levels.

Ascom Autelca's motivations were therefore to develop a new line of business leveraging on their existing strengths, and thereby to enter a new market which provided significant growth prospects. The company had a strong preference to develop a family of products which would satisfy a real consumer need, rather than adopting a technology-driven approach. In this way, the company reasoned that it would maintain long-term market-share and volume, gain repeat business, and thereby have a longer period in which it could recover its substantial initial investment. During the company's early discussions with Migros, in the mid-1980s, it was apparent that this desire for a genuine, long-term solution to the needs of the various parties, was common ground.

4 STRATEGIC DECISIONS
4.1 Retailer Strategy
Migros sought a solution which would be convenient and attractive to its customers, and which would involve paralleling of the tasks of calculating the total owed, and preparing for payment. In effect, customers' free time while waiting for the goods to be totalled would be put to good use as gratis labour, as they swiped the card and keyed the PIN. This dictated the need for an additional piece of equipment, located in front of the customer.

The responsibilities of the primary participants were conceived as follows (translated from Pfister 1988):
The retailer:
— drives the payment process;
— enters, or ensures the entry of, the payment details;
— journalises the payment details;
— provides a receipt to the customer; and

The bank:
— issues the customer with the card and PIN;
— verifies the identity of the terminal;
— verifies the PIN;
— checks the capacity of the account to support the transaction (eg that the account is not suspended and that there are adequate funds);
— debits the customer;
— credits the merchant; and
— provides a periodical account statement to the customer.

Migros had a long-standing policy of using multiple equipment suppliers, and wished to retain that policy. It was concerned to provide its constituent regional cooperative with choice, not only as to their supplier but also in relation to the type of cash register used. In addition, it wished to allow for a long transition phase, because (in the

normal cycle of re-fitting) some shops had only recently installed relatively modern, but non-programmable, cash registers.

Because of the large number of locations which were to be served by EFT/POS, and the need to provide connections to several different banks, the PTT's X.25-based service, Telepac, was selected as the communications network. It was decided to support conventional magnetic-stripe cards in the first instance. The chip-card was perceived to have several potential advantages over magnetic-stripe cards, including:
— PIN validation with or without access to the host;
— storage of the audit trail on the card;
— non-copyability; and
— the capability of supporting a range of services with a single card.
It was therefore decided that the system should be conceived in such a manner that chip-cards could be supported as and when that facility came to be needed.

To ensure the customer's information privacy, Migros decided that the merchant's terminal was not to display any personal details other than those essential to completing the transaction, and the system was not to store any personal details other than those essential in ensuring an effective audit trail. This meant that Migros intentionally excluded the option of collecting data concerning customer buying behaviour, whether for its own use or for sale to and use by third parties. This contrasts with developments in the United States, where some merchants are trafficking in customer profile data, in some cases purchasing from consumers the right to do so, in others without the customer being aware of the activity.

As a further element of the strategy of attracting customers to EFT/POS as a way of life, Migros decided to provide standalone units in the entrance areas of their stores, to enable customers to check their account balances before and after payment.

4.2 Supplier Strategy
Ascom Autelca is not a cash-register manufacturer, and did not intend entering into competition with such companies. The company wished to address, at least in the first instance, the large retailers, who have a significant number of cash registers in each retail location. Another important consideration was to be able to support not only those points of sale which had modern programmable electronic cash registers, but also those which were fitted with older, but quite serviceable, models. These factors all suggested a solution based on a retail-site concentrator, rather than a cash-register with its own direct network link.

The company also wished to confront the spectre of a backlash by the public against telecommunications-based services at some time in the future. In Switzerland, neither the public nor the private sector is subject to any form of

data protection legislation, but the public has recently become more highly sensitised to privacy issues, particularly as a result of the Kopp affair. During a 1989 investigation into a case of 'pillow talk' by the then Attorney-General to her financier husband, it accidentally became public that the Federal Police had for nearly 40 years maintained secret surveillance of some 140,000 Swiss citizens and 580,000 aliens. This has resulted in the traditional Swiss scepticism about large organisations (public or private) being exacerbated.

Finally, Ascom Autelca did not perceive EFT/POS in major retail stores as a phenomenon independent of other areas of development. EDI is growing quickly, and public access to a variety of services (such as directories, public transport timetables and reservations, home banking and tele-marketing/tele-shopping) is emerging. The Swiss PTT is running a number of community-based pilot projects, including an 'electronic cash' or 'value-card' system, in the city of Biel (PTT 1988, 1990). Ascom aimed for a conception which would enable it to capitalise on its investment in EFT/POS technology by using equipment from the same family to support such other innovative applications as appeared likely to gain in popularity.

5 THE CARDOMAT EFT/POS SYSTEM
The planning phases of the Cardomat/Migros project took place in the period 1985-86. Migros gave the go-ahead for implementation in May 1986, and the first site 'went live' in April 1987, initially supporting only Migros' own card. In June 1987 the PTT agreed that its cards could be used on the system, and this service went live in February 1988. Agreement was reached with the banks in June 1989 for the ec-Card also to be accepted in open EFT-terminals. The specifications for this were published in December 1989, and implemented in June 1990. The remainder of this paper concentrates on the scheme as it has been piloted in several of the regional cooperatives, and is in the course of implementation in the remainder, throughout Switzerland, during 1991-92.

5.1 Overview
The hardware, software and procedures were developed by Ascom Autelca AG, in close association with Migros. The generic product is called EFTOMAT, and the initial version implemented with and for Migros is called CARDOMAT. To avoid the amount of information becoming unmanageable, this case study has been restricted to the Migros implementation. Exhibit 3 provides a simplified overview of the system as a whole, comprising point-of-sale equipment, concentrators, network and host machines.

Ascom Autelca has delivered its software in a form compatible with cash registers from a number of different suppliers. Together the models cover more than half of the current market in Switzerland, and a significant propor-

Exhibit 3: Cardomat/Migros Overview (based on Migros Diagram of December 1990)
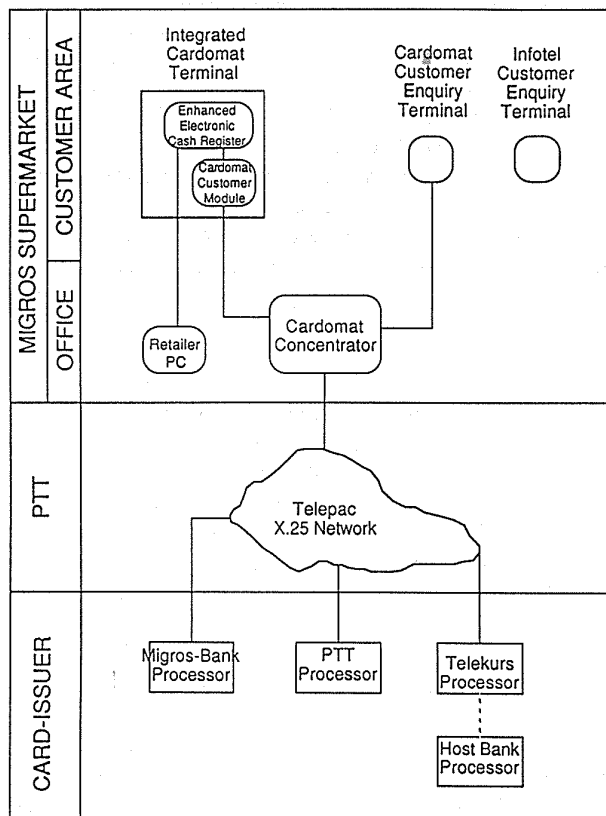
tion of the European market as a whole. The national X.25 network, Telepac, operated by the Swiss PTT, is the main message-carrier, although the public switched network can also be used, depending on the type of terminal.

The following sections present the point-of-sale equipment and concentrator design, the cards supported and services provided, and the operating procedures from both the customer's viewpoint and the technical perspective. A final sub-section discusses security, integrity and reliability aspects.

5.2 Point-of-Sale Equipment and Concentrator Design

There are two alternative terminal designs, one mainstream, the other tansitional. The transitional arrangement is for sites which have recently installed new cash registers which are not programmable, or which are not able to support an additional interface. Because this component raises no substantial issues, it is not further reported on here.

The **Integrated Cardomat Terminal** comprises two physically separate elements:
— an electronic cash register, supplied by a cash register

supplier, but incorporating software and interfacing defined by Ascom Autelca; and
— a customer module supplied by Ascom Autelca.

The **Electronic Cash-Register** (ECR) comprises:
— a device for capturing price or goods identity data (ie keyboard or scanner);
— a display screen for the checkout assistant;
— a display screen for the customer;
— a cash drawer;
— a printer, for customer receipts;
— an audit trail mechanism (eg a separate printer and/or cassette or diskette);
— a programmable processor;
— a program-loading facility (typically one or more slots for ROM-cards).

The ECR must be fitted with software and an interface which implements Ascom Autelca's specifications. The functions performed are:
— acquisition of the amount of the transaction from the ECR's internal storage;
— communication with the host (via the Customer Module and Concentrator);
— receipt of a return code; and
— passing of the authorisation back to the ECR.

Naturally the implementation involves close cooperation between Ascom Autelca and the cash register supplier. In accordance with Migros' long-standing policy, several suppliers are approved, including NCR (a long-standing supplier of point of sale equipment to Migros), ICL (which has not previously been a supplier, but has long experience in the retail industry), Sweda and IBM. Under Migros' Constitution, each regional cooperative is free to make its own decision as to which supplier and model it selects.

The **Cardomat Customer Module** is a separately housed device, manufactured and supplied by Ascom Autelca (see Exhibit 4). It comprises:
— a card-swipe, for ISO 2/3 cards and chip-cards;
— a numeric keyboard;
— six special keys; and
— a small display screen.

The keyboard and display are recessed. The keyboard is set at 20° above the horizontal. The 20-character display is set above the keyboard and at a higher angle. The numeric keys have the conventional alphabetic equivalents printed on them. The six special keys are colour-coded. The device may be table-top, stand- or wall-mounted, with the card-reader either vertical or horizontal.

Each ECR is connected to its Customer Module, and each Customer Module to a purpose-designed **Cardomat Concentrator** which connects up to 93 devices to Telepac, and hence to the card-issuers' machines. The concentrator comprises a processor, modules handling communications with both the terminal modules and Telepac, storage (a

Exhibit 4: Cardomat Customer Module.

hard disk), and a printer. In addition to its primary, real-time functions, the concentrator maintains an audit trail (which includes the card-id and transaction amount, but under no circumstances the customer account-balance). The journal and traffic statistics can be printed and/or uploaded to the merchant's own processor, to enable centralised network management and problem-investigation.

The **Cardomat Customer Enquiry Terminal** comprises a stand-alone Cardomat Customer Module, with software which provides a display of the account balance, or the amount remaining available for use during the current day or month (which of these applies, depends on which card the customer uses). This class of terminal is installed in the entrance area to supermarkets, to allow customers to check their balances, particularly before and after making purchases.

The **Infotel Customer Enquiry Terminal** provides a service exclusively for holders of PTT Postomat-Plus cards. Each such chip-card contains an audit trail of transactions undertaken using it, and this terminal is a stand-alone unit which reads the chip and displays the transaction data it contains. Infotel terminals are owned by the Swiss PTT, but are relevant to this case study partly because they are manufactured by Ascom Autelca, but particularly because they are installed at Migros supermarkets at the same time as Cardomat, as a service to customers, and a means of piloting chip-card services for the public.

5.3 Cards and Services Supported

Three cards are currently operational under the Cardomat/Migros system:

— **Migros' own M-Card**, a conventional magnetic-stripe card, issued gratis to account-holders by the Migros subsidiary Migros Bank;

— **the PTT's Postomat-Plus Card**, a chip-card issued gratis to account-holders by the postal service; and

— **the ec-card, issued by the major Swiss banks** to account-holders against an annual fee. It is a conventional magnetic-stripe card.

The terminals are on-line to the Migros Bank's system, enabling on-line verification. The PTT database, on the other hand, is only updated periodically, and the ec-Card service is on-line only to the Banks' front-end processor run by Telekurs AG, not to the Banks themselves, and the Telekurs database is only updated nightly. The services available therefore vary:

— **purchases** up to the level of account-balance (M-Card), Fr.3000 per month (Postomat-Plus Card), or Fr.2000 per day (ec-Card);

— **cash withdrawals** up to Fr.1000 per transaction (M-Card), or Fr.300 per transaction (Postomat-Plus Card). At present the Banks do not permit cash withdrawal against an ec-Card; and

— **display** of the current account balance (M-Card), the purchase-balance remaining for the month (Postomat-Plus Card), or the card-limit remaining for the day (ec-Card).

The M-Card service has been available since the first trials of Cardomat in 1987. Postomat-Plus cards have been supported since 1988, and are important to Migros because of the very large number of people who are used to using PTT services, and the very large card-base. Because it is a chip-card, and contains a complete audit trail, it is also possible to display the transactions which have been undertaken using the card; this service is only available on Infotel Customer Enquiry Terminals, however.

The ec-Card service was added in 1990, and involves delicate 'feeling-out' of the bounds of collaboration within a competitive environment. This card can also be used for a number of off-line services, including as a cheque-guarantee card, at 2,500 Bancomat ATMs owned by the banks, and at off-line terminals at about 2,000 petrol stations.

It has been an important aspect of Ascom Autelca's strategy to ensure that, in principle, any card and a wide range of services, can be supported within the existing architecture, merely by implementing an appropriate version of the software in the Customer Module and/or Concentrator.

5.4 Cardomat Operating Procedure — Customer Viewpoint

To pay for goods using Cardomat, the customer swipes the

card and keys the PIN. A series of instructions and messages is shown on the small display. Except for the final step, the customer may undertake these actions independently of the checkout assistant's registration of the customer's goods. The response is displayed within a few seconds. A purchase may be paid for wholly by card, wholly in cash, or partly in cash and partly by card, and the customer can tell the checkout assistant which option he or she wishes to use at any time until the registration of the goods has been completed. Depending on which card-type the customer uses there are minor differences in the procedure, such as when the card can be removed from the cradle, and whether it is necessary to strike the 'OK' key to complete an action.

Cash withdrawal (available in the cases of M-Card and Postomat-Plus card, but not in the case of the ec-Card), is not included as part of a purchase, but is handled as a separate transaction. The amount of cash which may be withdrawn is limited, but the frequency with which withdrawals may be undertaken is not.

The Cardomat Customer Module is designed to deal appropriately with all conceivable errors and idiosyncrasies in the customer's actions. For example, one circumstance which was inadequately handled by early versions of the software was repeated swiping of the card (eg due to slow response on the display panel). The messages appear in the language appropriate to the language-code on the card (German, French, Italian or English). A part-completed transaction can be annulled by the customer at any time until the message is sent to the host.

The printed voucher contains full details of the transaction, including date, time, shop and location, the nature of the transaction (purchase or cash withdrawal), the prices of the individual items (but until such time as bar-code scanning is introduced, not the item description), the total, the amount paid in cash and by EFT/POS, the card number and a voucher number (EFT-number). Transactions are printed, including varying degrees of detail, on the periodic account statement provided by the card-issuer to the card-holder.

5.5 Cardomat Operating Procedure — Technical Perspective

The manner in which a Cardomat transaction is processed is a function of a number of factors, particularly the cost-structure set by the PTT for Telepac packets, the design of the card-issuer's processing system, and the presence or absence of a processor on the card itself.

The **verification functions** which need to be performed are:
— **card verification:** that the card is available for the transaction (in particular it must exist, be date-valid, must not be barred, and must be empowered to conduct the particular transaction);

— **PIN verification:** that the PIN is correct for that card;
— **account verification:** that the account with which the card is associated is available for the transaction (in particular it must exist, must not be barred, and must be empowered to conduct the particular class of transaction). Note that the relationship between cards and accounts is not 1-to-1 but many-to-1, ie more than one card may be associated with a single account, typically one for each spouse; and
— **amount verification:** that the amount of the transaction is within the approved limit.

The **processing functions** which need to be performed are:
— debit to the card-holder's account with the card-issuer;
— credit to the merchant's account with the card-issuer or to the card-issuer's financial institution, as appropriate to the circumstances;
— provision of a receipt to the customer; and
— provision of a voucher to the merchant.

In addition, a set of **audit trails** must be maintained, which is sufficient to resolve ambiguities and disputes and provide evidence to the courts, but is not unduly expensive given the low frequency and financial significance of such ambiguities and disputes.

The manner in which these functions are performed is different in each case, because of the different configurations of the cards, accounts and services involved. In the case of **Migros' own M-Card**, the procedure is as follows:
— when the customer has swiped the card, keyed the PIN and quitted with the 'OK' key, and the checkout assistant has approved the transaction amount, a transaction is passed via concentrator and Telepac to Migros Bank's processor;
— all verification functions are performed in the Migros Bank processor. Because the Migros Bank has its account balances on-line, the transaction amount is tested against the funds in the account (Migros does not provide consumer credit, and hence the test is against the actual balance in the account); and
— if all verification tests are successful, the processing functions are performed, and an affirmative return code is sent via Telepac and the concentrator to the Cardomat terminal, causing a receipt to be printed. If, on the other hand, the transaction is rejected, the return code is negative, and a delicately phrased message is displayed to the checkout assistant.

In the case of **the PTT Postomat-Plus card**, the procedure is similar. The most significant difference is that the PIN verification function is performed in the chip on the card itself, by comparing the PIN keyed against that stored in the chip. Another difference is that the PTT authorises a maximum amount in any calendar month, and the amount verification is therefore against an approved maximum amount rather than against an account balance. Because

Postomat is a 'smart card', further possibilities exist. However the card does not at present contain data such as account balance or card and account barring. Such data could be down-line updated from the host, but with a delay factor of one business day, because the host database is currently updated overnight in batch mode. Until the host is updated on-line and accessed from Cardomat terminals on-line, increased sophistication in Postomat-Plus card processing seems unlikely.

The processing of **the ec-Card** differs in the following significant respects from the other two card-types:
— as soon as the card is swiped, the card-number is transmitted from the Cardomat Customer Module via the concentrator across Telepac to the Telekurs processor;
— the card and account verification functions are performed on the Telekurs host. If appropriate, a rejection is sent to the Cardomat Customer Module. If, however, the transaction is conditionally approved, a 'PIN offset' and the maximum authorised amount (based not on account balance, but rather a daily limit) are transmitted to the terminal;
— the Cardomat Customer Module performs the amount verification process;
— PIN verification is performed in another way entirely. The PIN off-set is received in the Cardomat Customer Module from the Telekurs host via Telepac and the concentrator. The PIN-pad contains a security-module, supplied by a Belgian company (and whose internal specifications are unknown to Ascom Autelca), which verifies the PIN keyed against that expected on the basis of the PIN offset; and
— if all verifications are successful, a second transaction (comprising essentially card number and amount) is transmitted from terminal to host, and a receipt printed at the terminal. When acknowledgement is received from the host by the Cardomat Customer Module, the transaction is completed.

The ec-Card solution, although in some respects more complex and therefore more expensive to implement and more error-prone, enables a shorter delay from approval of the transaction at the point-of-sale until the receipt commences printing (reported by Ascom Autelca to be about two seconds compared with about six seconds).

From the perspective of this case study, and EFT/POS transaction processing in general, the diversity of solutions appears to be excessive. The reasons are partly historical (modifying the various host systems to optimise Cardomat/Migros' simplicity would have been slow, error-prone, expensive and politically difficult), partly based on political and competitive factors, partly based on philosophy (Migros Bank was not prepared to transmit account balance to a terminal on the premises of another organisation), partly based on differing assessments of the future directions of the PTT's charging structure, and partly based on differing assessments of future host response times (eg processor and storage capacities, and software and database management system characteristics).

5.6 Security, Integrity and Reliability Aspects
Data security and integrity are important considerations (see, for example, Schmitz 1989, Weber 1989 and Clarke 1990). From the viewpoint of the banks and merchants, it was necessary to ensure that funds transfer was accurate, reliable and resistant to interception and unauthorised modification. This was in large measure achieved through the use of the Telepac network, PINs, and in the case of Migros' own card, on-line account balance checking.

A transaction may not be approved due to difficulties with the card. The major circumstances in which this arises are:
— multiple unsuccessful PIN entries;
— stopped cards, in particular those that have been reported missing, and those which have been cancelled by the card-issuer, eg due to insufficient funds;
— out-of-date cards, ie whose period of validity has expired; and
— early cards, ie whose period of validity has not yet commenced.

In all of these cases, the offer of payment by card is simply declined by the checkout assistant, and no further action is taken — Migros has refused to perform any security functions such as the capture of stopped cards.

From the viewpoint of the reliability of the service, the terminals include an emergency electricity supply which enables an appropriate completion or suspension of transactions which are in process at the time of a power failure. During periods in which the system is unavailable, a fall-back system involving paper vouchers is used. For Migros cards and PTT cards, this uses an 'emergency voucher'. This is accepted by the card-issuer at no risk to the retailer for an amount of no more than SF300. Although this is in principle a very insecure mechanism, it is relied upon sufficiently infrequently and unpredictably, and there has been a sufficiently low incidence of fraud, that it is retained as a means of customer convenience.

In the case of the ec-Card, the only fallback is the use of a Euro-Cheque (which is a payment instrument issued to bank customers in blocks of 10 looseleaf sheats, rather than in bound booklets of 30 or more sheets as is normal in the United Kingdom and Australia).

6 PRESENT AND FUTURE
6.1 Implementation Experience
From a marketing perspective, it was critical that the public quickly come to terms with the system and its advantages for them. Brochures and advertising placards concentrated on pictures rather than text, on the extra interest which could be earned by keeping cash in a bank account rather than in a wallet or purse, and on speedier service at the checkout counter.

Although deposit rates in Switzerland are extremely low (1.5-4% pa cf 7-11% pa in Australia), the volume of cash is very high, due to the absence of a widely-used chequing system, and a standard of living about double that of Australia. On the assumption that the amount of cash carried by Swiss people is of the order of 1-5000 Swiss Francs, conversions to cashless operation would offer an actual interest-income difference of 30-200 Swiss Francs pa. A further promotional measure was the offer, during the implementation phase, of a bonus of 0.50 Swiss Francs for each cashless purchase transaction.

The level of use during pilot implementation in 1986-87 was 50-100 transactions per day for purchases and cash withdrawals. The proportion of all purchases undertaken using Cardomat has been as high as 12% (in Winterthur, a medium-sized, German-speaking industrial city). The size of cashless transactions was on average higher than for cash transactions. There was a further 25-50 transactions per day for display of account balance alone (ie at Cardomat Customer Enquiry Terminals), which suggested firstly that many consumers were taking advantage of the ability to check the accuracy of transaction processing, and secondly that there may be a strong desire to avoid embarrassment at the checkout counter by having too little in the account to cover the purchase. To date, on the other hand, use of Infotel Customer Enquiry Terminals has been very low. On the basis of surveys conducted to date, the cash withdrawal facility was regarded as a significant service, and the majority of checkout assistants regarded the Cardomat system as simple to use.

The self-service principle in relation to card and PIN has proven satisfactory in practice, and an essential step in paralleling the activities of registration and payment, and hence reducing, or at least maintaining, the speed of service at the point of sale. The time spent at the checkout counter, however, has proven to be scarcely any different from that for cash-based transactions, which is in contrast to expectations, and to the advertising brochures.

From a cost/benefit perspective, the merchant is faced with additional equipment investment of several thousand Swiss Francs. After the initial staff training costs, some ongoing refresher training and training of new staff must also be taken into account. Reconciliation and dispute-resolution costs are currently higher, although this would appear likely to be a transitional factor. On the positive side, funds reach Migros' own bank accounts on the same day as the transaction instead of one day later, and bank charges for cash-handling of about one Swiss Franc for every 1000 in cash turnover are able to be saved. Other advantages which have been realised are:
— a system open to all cards in principle, and many cards in practice;
— retailer choice of cards which are to be accepted;
— no commission paid by the retailer on debit-card transactions;

— decreased commission paid by the retailer on credit-card transactions; and
— communication costs paid by the card-issuer.

6.2 Future Developments
Cardomat is being progressively installed in all large and medium-sized Migros supermarkets, subject to the decisions of the individual regional cooperatives. It is being considered for Migros specialist retail outlets, in insurance (Secura), bookshops (ex libris), travel agencies (Hotelplan) and service stations (Migrol).

Ascom Autelca is actively selling the generic product, EFTOMAT, to other merchants, particularly to the larger specialty shops, and to stores operated by Migros' major supermarket competitor, Coop. In its present form, the system is less applicable to small, single-site retailers.

In principle, EFTOMAT is capable of connection to a wide range of card-issuing organisations, including credit-card companies, although in Migros' case, the cooperative's philosophy and Constitution precludes the acceptance of credit-cards. Coordination with the parallel EFT/POS developments of other large retail groups is being investigated. The Swiss subsidiaries of credit-card operators (importantly American Express, Diners Club, EuroCard and Visa) have published a specification to accept their cards at on-line terminals. (In Australia, the majority of transactions entered into EFT/POS terminals to date have actually been such credit-card rather than debit-card transactions). Cardomat is designed in such a way that the difficulties of accommodating these and other cards is not great.

Petrol cards are issued by the major oil-companies such as Shell, BP and Esso, and also by the Migros subsidiary, Migrol. For some years now, most service stations have been equipped with terminals providing first-generation, off-line EFT/POS capabilities (integrated with unattended, cash-payment, self-service functionality), and it may therefore be some years before the opportunity arises for EFTOMAT to address this market.

There are also a number of important 'house' charge-cards in use in Switzerland, such as those of the major department stores, Globus, Jelmoli and Loeb, and it is technically possible for these to be accommodated by EFTOMAT. Jelmoli is of particular interest, because its house-card was first issued (on metal) in the 1930s, and it has a large, active and affluent card-base, perhaps exceeding 250,000. As with service stations, however, any expansion of EFTOMAT into this sector would have to be timed to coincide with the renewal of point-of-sale equipment.

It is possible that the banks may approve cash withdrawal, and provide on-line connection to their accounts, and hence improved verification of transactions and removal of arbitrary limits on card use. They may also perceive it to be to their advantage to offer higher transaction-subsidies

to Migros, in order to encourage reductions in expensive cash, cheque and credit-card transactions.

7 CONCLUSIONS

This case study has described Ascom Autelca's EFTOMAT EFT/POS product, with particular reference to its first implementation, under the name CARDOMAT, in Migros' supermarkets. The system's technical features have been outlined, in the context of its economic, commercial and social purpose. The system resulted from synergy between Migros' vision of an open EFT/POS system, dominated by retailers rather than card-issuers, and the experience, orientation, strategy and capabilities of Ascom Autelca.

The gains from EFT/POS appear to be potentially large enough that each of the various parties (retailers, financial institutions, consumers and suppliers) can all win. The distribution of benefits among them, however, must be such that all parties have sufficient incentive to actively participate. Effective implementation is therefore contingent upon the critical success factors being identified and addressed at an early stage in the development of the system. Two clusters of important considerations arise from this case study. For further discussion of some of these points in the Australian context, see Clarke and Walters (1989) and Walters (1989) and (1991).

The first cluster of conclusions relates to **system architecture:**
— 'business openness' is vital — all EFT/POS terminals need to accept all cards;
— 'architectural openness' is vital.
  Either:
  — the infrastructure should be common; or
  — if several networks exist, then interoperability must be achieved; and
— 'technical openness' is needed, to underpin the first two requirements. By this is meant commitment to international telecommunications standards.

The other cluster of conclusions relates to **consumer acceptance:**
— successful EFT/POS system design demands a strong affinity with the retail point-of-sale environment, and more generally with consumers;
— consumer convenience is vital, in particular through:
  — support for a wide range of cards;
  — speed of service at the checkout counter;
  — availability of a cash withdrawal service; and
  — provision of a facility to check funds availability;
— the consumer must be active in the payments process, through direct interaction with a customer terminal which accepts the card, displays instructions and information, and enables keying of the PIN;
— privacy-sensitive design is important, including shielded keying of the PIN, display of account-balance

on the customer terminal only, and non-retention of personal data; and
— consumer education is vital (in particular, promotional material needs to stress the system's simplicity, convenience and economic benefits), and so is consumer encouragement (eg through a rebate on card-based transactions).

The extent to which these conclusions are applicable in contexts other than Migros is not addressed in this paper. It is apparent, however, that considerable similarities exist between the environment in Switzerland and that in many other advanced western nations. This case study may therefore contain important lessons for EFT/POS developers in other countries such as Australia.

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BIOGRAPHICAL NOTE
Roger Clarke spent 17 years in professional, managerial and consulting work in Sydney, London and Zurich, prior to taking up the post of Reader in Information Systems at the Australian National University in 1984. His interests are in application software technology and its management, and organisational, economic, legal and social aspects of information technology.

He was employed by a Zürich-based software house in 1979-82 and undertook a Visiting Professorship at the University of Bern in 1987-88. He has no commercial association with any of the companies involved in this case study.

International Conference on Theorem Provers in Circuit Design: Theory, Practice and Experience

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Focus and Objectives
Formal methods are increasingly seen as important in the design of digital systems. The use of these techniques in practice is often regarded as being strongly dependent on the support of appropriate mechanised theorem proving tools. The purpose of this conference is to provide a forum for discussing the role of theorem provers in the design of digital systems. The objective is to cover all relevant aspects of work in the field, including original research as well as case studies and other practical experiments with new or established tools.

The primary focus will be on the ways in which formal methods are supported by theorem proving tools, rather than on the theoretical foundations of formalisms and design methods. The topics of interest include the philosophy behind such tools, their design and development, their evolution, and their evaluation through use. Of equal importance is the migration path of a theorem proving tool and the associated technology into current digital engineering practice.

The intended audience includes workers in the field of hardware verification as well as practising digital designers.

Tutorials
A Tutorial Chair has been established to ensure that a wide range of systems are represented and to underline the importance that is placed on the matter. A digest of the tutorial presentations will be included in the proceedings.

Programme and Proceedings
The conference programme will start with a day of tutorials and demonstrations, followed by two days of presentations by contributing authors. The programme will also include invited lectures by three prominent researchers in the field of machine-assisted verification. The invited speakers are Mike Gordon, University of Cambridge; Warren Hunt, Computational Logic Inc.; Dave Musser, Rensselaer Polytechnic Inst.

The conference proceedings will be published by North-Holland before the conference.

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