Multipurpose Smart Cards in Transportation:
Benefits and Barriers to Use

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Never carrying change. Needing only one identification card. Downloading concert tickets. Providing access to buildings. Tracking frequent flyer programs.

Smart cards are the technology that allows each of these functions to occur. Although the technology evolved in the 1980s, it was only used for simple functions like pay phones. In the last decade, there has been a rapid increase in the use and scope of smart cards. Smart cards have been used to hold heath records, allow electronic signatures and act as electronic purses.

In transportation, smart cards could become the next fare payment media replacing or supplementing cash, tokens and passes. But we are at an interesting time. A few transport agencies have adopted smart cards; more are considering it. However it is not yet clear how such programs will be structured. What will multipurpose mean? Are smart cards to be used only for transportation, allowing regional fare integration and toll payment programs? Or will smart cards replace cash, making it a universal currency accepted by all vendors including transport agencies?

This paper seeks to understand the major issues implicit in these questions by looking at how smart cards have been used in many situations, particularly Hong Kong and Paris. These examples highlight the four main reasons for adopting smart cards: cost reduction, service improvement, fare policy flexibility and increased revenues. Analysis shows that the size of the benefit depends on existing conditions, implying that introducing smart cards will not necessarily improve profitability. Because of this it is

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critical that there be a clear business rationale for implementing smart cards. Smart cards should not be implemented because they are the 'new, new' thing.

When smart cards do make sense, there are a set of implementation questions, particularly institutional arrangements, technical systems, user requirements and system equity, to be evaluated. The next section deals with these issues concluding that there is no single implementation plan which will work universally. Instead local conditions, particularly usage and fare structure, should govern the implementation decisions.

Finally, I will consider the implications of this discussion on the proposed smart card project in the San Francisco Bay Area, TransLink. Intended to integrate regional transit fare payment, this project highlights the importance of having control over fare policies to ensure that the full benefits of smart cards emerge. Without this control, there will be cost reductions and service improvements, but it is unlikely that there will be dramatic impacts on transit ridership.

In general, analysis of the benefits and implementation barriers to smart cards shows that adopting smart cards as fare payment media will not necessarily guarantee any improvement in net revenues or customer service. Instead the cards should be used when the benefits of implementation, such as reducing maintenance costs, eliminating cash handling, or improving fare policy, justify the costs of the program. When smart cards are justified, they provide a tool to implement creative and flexible fare policies that can influence demand for transport services.

Technology Basics

While this paper will focus on the benefits of and barriers to smart cards, it is important to have an understanding of the different types of cards and how smart cards work. Smart cards vary in two important ways – the level of technology on-board the card and how the system reads the card. The on-board technology, i.e. what type of chip, can be memory or microprocessor (Smart card basics.com 2000). Memory cards are useful for storing data, but have no data processing capabilities. The best examples of these cards are prepaid telephone cards that allow users a certain amount of talk time. Microprocessor cards are the true 'smart cards' (although the title generically refers to all chip cards). These chips act as mini-computers allowing multiple applications to be resident on one card. The chip controls access to files and programs, ensuring that

information is secure and private (Smart card basics.com 2000). One example of a microprocessor card is the school ID developed at Florida State University. This card contains building access, four electronic purses for various campus merchants, and a loyalty scheme for one vendor (Davis 1999).

Communication between cards and the system occurs through a contact or contactless connection. Contact cards require physical contact between chips and a reader, similar to our current credit cards systems. Banks have favored these systems because they are seen as more secure and more compatible with existing infrastructure. As the name implies, contactless cards communicate with the reader through radio frequency coupling technologies that allow the card to be read short-range, 5 to 15 cm from the reader, or long-range, several feet (useful for toll collection) (Schweiger 1997; Chambers 1998; Fleishman 1998). Contactless cards tend to be preferred in transit, because patrons can be processed most quickly in this environment. See Figure 1 for more examples.

Figure 1: Card Technology Examples

Type of Reader		Memory	Microprocessor
	Contactless		Transit fare cards • SF Bay area • Washington, DC Electronic Toll Coll. • E-Zpass (Northeast) • FasTrak (CA) • SunPass (FL)
	Contact	Pre-paid phone cards	College IDs Debit & credit cards
		Memory	**Microprocessor**
		Type of Chip	

Source: Davis 1999; Smart Card Basics.com 2000

The different desires of banks and transport agencies for card communications will hamper interoperability efforts. However, there may be a technological solution. Combination contact-contactless cards have been developed which could work in either environment. These "combi" cards are currently priced at $10 each, roughly double the cost of single-interface cards. Although this cost differential is expected to narrow, experts still believe dual-interface cards will remain 20% more costly than single-interface contactless cards (Balaban 1999a).

Background on Smart Cards

As mentioned earlier, simple memory cards have been around since the 1980s. However the boom in smart cards in the 1990s has come from four areas – the use of cards in GSM mobile phones, the desire of banks to enter the low-value transactions market, the need for better identification cards for government programs and the need for alternative fare payment media in transportation (Davis 1999).

As smart cards have proliferated, more attention has been paid to interoperability between cards and the number of functions each card has. For example, credit cards currently have high interoperability. I can use my Visa card at almost any credit card accepting merchant, no matter who our respective banks are. Credit cards also have a large number of functions, because of their ubiquitous merchant acceptance. In contrast, smart card pay phones have one function and the cards are generally not compatible between phone systems.

Figure 2 shows a selection of projects arrayed against these two measures. As we shall see in the case studies and later discussion, the questions of interoperability and number of functions are at the heart of the decisions any transport agency must make when implementing smart cards. Each choice has advantages and disadvantages. It seems likely that smart cards will migrate to having a large number of uses and high interoperability. However, it is not clear when that will occur and is not likely in the next 5 to 10 years.

Figure 2: Current Projects


Bold indicates smart cards
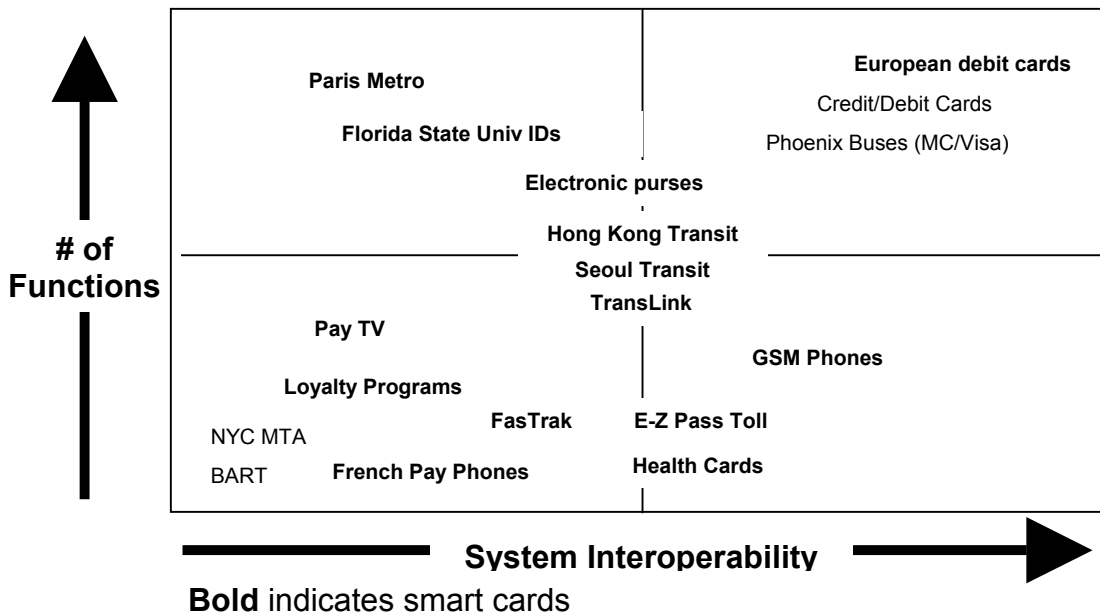
Case Studies

        To better understand the role that smart cards can play in transportation, it is instructive to look at two case studies. Hong Kong provides an example of a regionally integrated transit smart card. Smart card use in Paris shows how banks and transit can jointly develop a program.

Hong Kong

        When looking for examples of multipurpose smart cards, it is hard to avoid Hong Kong's experience. Launched on September 1 1997, the Octopus system integrates fare payment for five transit operators with one contactless smart card. The card can be used on buses, subways and ferries and currently accounts for approximately 40% of daily transport trips (4.5 million transactions) (Clark 2000). That number looks even more impressive when one looks at the penetration of some of the major transit systems in Hong Kong. For example 86% of Mass Transit Railway (MTR, Hong Kong's subway) trips are paid for with the Octopus card. The equivalent numbers for bus systems accepting Octopus are 60 to 70% (Davis 1999). The lesson is that in the systems where Octopus has been introduced, it has been quite successful. Figure 3 shows the rapid growth of smart card ownership and usage in the three years following the Octopus system launch.

Figure 3: Smart Card Growth in Hong Kong
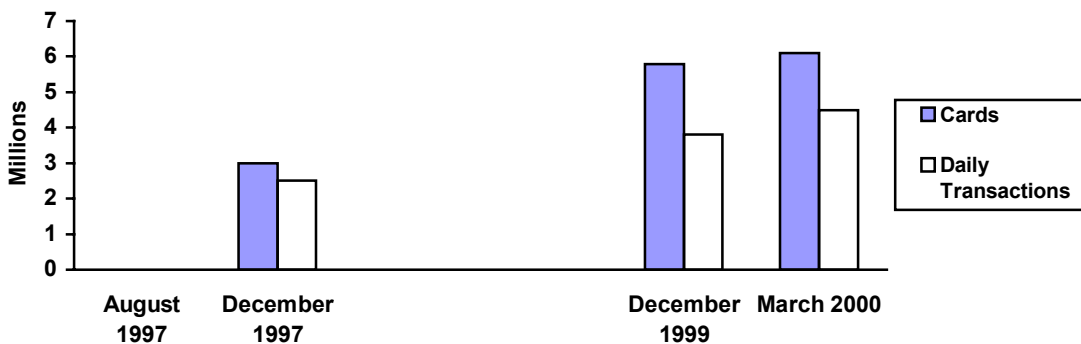
Source: Chambers 1998; Davis 1999; Clark 2000

        Why have the adoption rates been so high? Understanding this question could provide critical insights into the implementation of smart cards in the United States. From the user's perspective, the smart cards were the second generation of stored-value

fare media. The first generation was a stored-value card for use on the MTR; these cards were quite well received with over 50% of Hong Kong adults (3 million people) having a card (Chambers 1998). When the Octopus cards were launched, the MTR offered a 10% fare discount to those who adopted to smart cards (Davis 1999). Although no fare bonuses were offered on the other systems, the MTR discount provided a substantial switching incentives for stored-value cardholders. This lesson shows the importance of using fare policy to induce conversion to smart cards and of having substantial smart card transaction volume.

The next question is what motivated the transit operators to launch the smart card and what have the benefits been. The Octopus system was established as a joint venture company, Creative Star Ltd., in 1994 by the MTR, Kowloon Canton Railway, Kowloon Motor Bus, Citybus and Hongkong & Yaumati Ferry (Chambers 1998; Davis 1999). Each of the operators had varying reasons for entering the partnership. For the MTR, the most sophisticated company in the partnership, the goals were to reduce maintenance costs and the faulty reads associated with the existing stored-value system (Chambers 1998). The remaining operators, all of whom had cash-based fare collection systems, wanted to reduce the costs of cash handling and increase the complexity of their fare structures (Chambers 1998).

It is somewhat difficult to estimate how successful the operators have been in achieving these goals; specific reports on operation performance were not easily available. However, I believe that the usage numbers shown earlier present a successful system. It is also interesting to note that other operators, outside the consortium, are beginning to accept Octopus for payment. This includes two public light bus companies and non-transport applications.

System Operations

When the consortium formed in 1994, it awarded a contract to ERG (the same company doing the Bay Area TransLink project) to design, supply and install a system of 3 million smart cards (Chambers 1998). The $65 million dollar system, which took three years to develop, is contactless with compatible machinery operating at all participating operators (Davis 1999). The most interesting aspect of the organization structure is that a central clearinghouse, run by the joint venture company, processes all transactions. It is

this entity that is responsible for determining how revenues should be shared between participating operators (Chambers 1998). Having an outside entity to process and reconcile transactions seems a critical part of any successful smart card program. It is difficult enough for transit agencies to determine how to share the revenues; it might require too much trust to rely on one agency for fare reconciliation.

System Extensions

The management of the joint venture company wants to continue the transaction growth of the past three years. However, it is difficult to conceive of this growth coming from increasing penetration of the transit sector. Many of the remaining transport operators are very small scale and servicing their needs might be too expensive. For example making the 18,000 taxis operating in Hong Kong able to accept Octopus compliant would require new technology to interface with taxi meters and lengthy negotiations with the many individual owners (Clark 2000). Because of this, Creative Star is trying to add applications outside of transport. For example, the card can currently be used at public phones and photo booths in MTR stations (Clark 2000). There are also trials underway to use the cards at Coke vending machines and car parks (Clark 2000).

There may be legal challenges to the company's bid to grow outside of transport. Currently the Hong Kong Monetary Authority restricts the issuance of multiplication cards to banks. Because of this, Creative Star is limited to processing transport transactions. Under the current arrangement, 15% of transactions can be non-transport as long as they have transport synergy, i.e. parking, phones in stations. The company would clearly like to aim at the low value transactions market and have therefore applied to become a deposit taking company which will allow them to have up to 50% of transactions in non-transport businesses (Clark 2000). Not surprisingly, the Hong Kong banks are strongly opposing this move. A final decision has yet to be reached.

The Hong Kong example highlights the potential turf battle between transit agencies and banks over low value transactions. I believe, however, that the United States regulations in this area will become much clearer by the time any U.S. provider reaches the scale of the aptly named Octopus.

Lessons Learned

The experience in Hong Kong provides a good lesson in how transit operators can successfully launch a smart card program. While there are clear differences between the U.S. environment and Hong Kong (use of transit being a major one), this case study has highlighted several important issues, particularly:

- Define the benefits to be derived from smart card fare integration for each participant
- Use fare policy to induce conversion to smart cards
- Create a central clearinghouse that is independent from any of the participating operators
- Stay aware of the influence that the financial sector may have on transit operated smart card systems

Paris

Looking for examples of true multiapplication programs, where cards can be used at multiple vendors, is difficult work. These programs are just beginning with pilots or planned programs in Paris; London; Manchester, England and Trondheim, Norway (Meland 1998; Adams 1999). One of the most interesting programs is in Paris where a consortium of two transit agencies, the Paris Metro and the French state railway, and four banks, Caisses d'Epargne, the Banques Populaires, Societe Generale and La Poste, have launched a smart card containing an e-purse and a transit application ("Three Becomes One" 1999).

Banks in France have been quick to roll out smart cards because fraudulent card usage is nearly twice that of the United States (Davis 1999; "A New Day…" 2000). This means that many merchants have or will soon have the infrastructure to support contact cards. This situation has created incentives for banks and transit agencies to work together. Banks want to take advantage of this infrastructure to capture a share of the low-value transactions market. Electronic purses are the application designed to replace cash. But consumers have been slow to adopt e-purses making it difficult for banks to make money with this product. For the business model to work, banks need a high volume of transactions (Balaban 1999a). Transportation provides the needed volume.

For transit agencies there have been other motivating factors behind the smart card project. The Paris Metro's 10% fraud rate has encouraged managers to investigate smart cards ("Paris Project…" 1998). Partnership with banks is also attractive because it will allow the agency to reduce implementation risk and system costs. These conditions

make cooperation between transport and banks much more likely than in the United States.

The smart card program has been implemented slowly with several pilot phases. These started in 1993 with Paris Metro employees using smart cards for travel and office access. In March 1997, the first passenger trials began with 1,000 users in part of the system ("Paris Project…" 1998). Evaluations of the pilot program were positive and the consortium has decided to fully implement the system. The goal was to have 400,000 cards in use by the end of 2000 and 5 million cards by 2002 ("Paris Transit…" 1999). This goal may be somewhat ambitious, because the contract for card provision was only awarded in March 2000 (Jackson 2000).

The other issue that the consortium faces is card interoperability. There are currently two other e-purse programs being launched in France by other bank consortiums and it is not clear which will dominate ("France Pilots…" 1999). Currently, there is no interoperability between the systems. This could cause difficulty in the future as each gains market share and users want to use their e-purses to pay for transport services.

Lessons Learned

While the Paris project is still in the early stages, I think it highlights several points that are important for successful implementation. These are:

- Implement the program in phases to ensure that it works and anticipate problems
- Consider the ramifications of linking transport with one e-purse application.
    - What will happen if that application does not become the standard?
    - Is there any interoperability between the applications?

Benefits of Smart Cards in Transport

As exciting as smart card technology seems, there need to quantifiable business reasons to implement such a system. I believe there are four broad categories of benefits from smart cards – cost reduction, service improvements, fare policy flexibility and increased revenues (Dinning and Collura 1996; Fleishman 1998).

Cost Reduction

Smart cards reduce costs in three ways. First, they make fraud, estimated to account for up to 10% of revenue[1], more difficult by allowing agencies to cancel cards immediately when fraud is suspected (Waters 1995; Dean 1998). Second, contactless smart card readers are expected to be more reliable, leading to reduced maintenance and failure rates (Scrase 1997). This factor was very important to Hong Kong's decision to implement the Octopus system (Dean 1998). Third, and most significantly, smart cards can reduce fare collection expenses by eliminating or decreasing the need for cash or token handling. Dealing with cash is quite expensive; it requires retrieval of cash from fare boxes, safe transit and counting (by hand at times) (Dean 1998). Smart cards can reduce this cost by eliminating or reducing the need to deal with cash by encouraging higher-value transactions and automated card reloading (Collura and Plotnikov 2000).

Table 1 shows the distribution of fare collection costs by system type. What becomes immediately obvious is that these costs, on average, are substantial, but that there is considerable variation between systems. Therefore cost reduction will be proportional to the current inefficiencies in fare collection. Systems that currently handle cash and have no automated vending, e.g. AC Transit, will see much more cost reduction than an agency using stored-value cards that does not have agents sell tickets, e.g. BART. Accordingly, we would expect that the on-going costs of fare collection with smart cards would be similar to that of agencies such as BART and Washington Metro that currently use stored-value cards approximately, 3 to 4%. Figure 4 shows the fare collection costs of individual agencies. From this we might expect SEPTA and NYCTA to experience substantial cost savings from introducing smart cards (assuming they reduce staffing levels) (Collura and Plotnikov 2000).

Table 1: Fare Collection Costs as a Percent of Revenue

| Mode or Size of System | Cost (as Percent of Total Fare Revenue) | | | | | |
| | Production and Distribution of Media | | Collection and Processing | | Total | |
	Range	Average	Range	Average	Range	Average
Heavy Rail	0.5-10	2.8	1.5-7	4.2	2-17	7.1
Commuter Rail	0.2-7	2.7	1.6-15	9.2	1.8-22	11.9

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[1] It is difficult to get a consistent estimate of fraud; the range is from 1 to 10% depending on the source

Light Rail	0.4-2	1.3	1-7	3.4	1.4-9	4.7
Large Bus	0.2-5	1.9	0.3-3.5	2.1	0.5-8.5	4.0
Small-Medium Bus	0.1-2	1.1	0.4-6	2.3	0.5-8	3.4
Overall	0.1-10	1.9	0.3-15	4.3	0.5-22	6.2

Source: Fleishman, et al 1998

Figure 4: Agency Fare Collection Costs as a Percent of Revenues
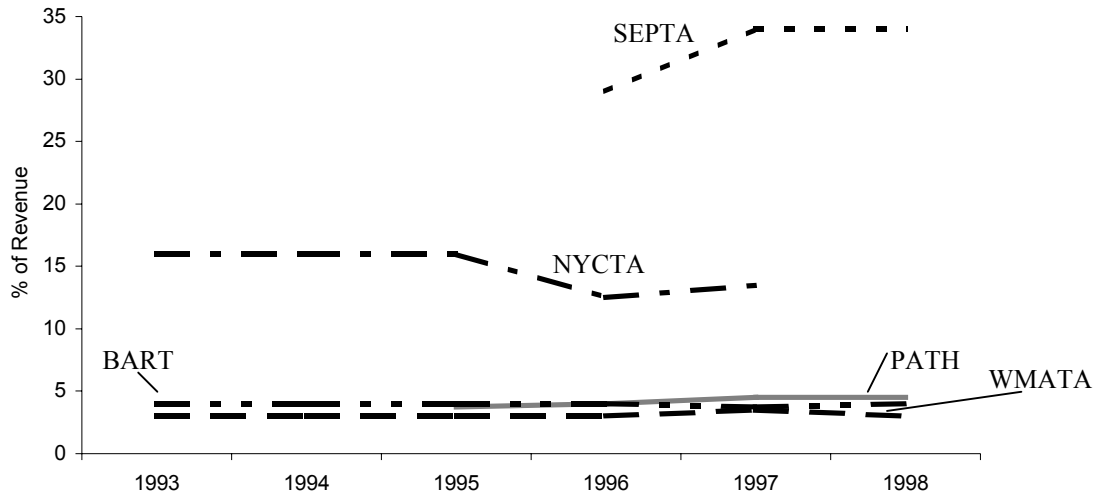
Source: Collura and Plotnikov 2000

Service Improvements

Smart cards can improve transportation service by making it easier to use the system. At the most basic level, smart cards eliminate the need for cash or change. Because most transit agencies require exact change, this can often be a headache, particularly for infrequent users. An extension of this first benefit is the fact that smart cards can act as an integrated fare card for regional transport agencies making it easier for users to transfer to other systems (Dinning and Collura 1996). In the United States transit fare integration programs are just beginning, but integrated highway toll collection is much more advanced, particularly in the northeast.

The E-Z Pass program provides the best example of how regionally integrating fare collection can provide service benefits to patrons. E-Z Pass began with New York metropolitan area bridges. It has since been adopted by the New Jersey Turnpike, Garden State Parkway, NYS Thruway, Massachusetts Turnpike, West Virginia Turnpike, the Delaware portion of I-95 and other regional roads (E-Z Pass NY 2000). Currently, two-thirds of New York metro area tolls are paid with E-Z Pass (~700,000 trips/day) (Samuel 1999).

From an operational perspective, smart cards may offer a way to decrease payment queues. The argument has been made that smart cards and contactless readers can process transactions faster than many current systems. However, research suggests that the mode of travel and existing payment system greatly affect the degree of benefit. On highways, electronic toll collection allows users to pass through fare booths without fully stopping and, in the future, may allow passage without speed reduction (Samuels 1999). If enough drivers adopt the system, queues at tollbooths could be reduced.

On buses, boarding and payment usually occur simultaneously. If the average time customers spend paying can be reduced, it should be possible to decrease the bus dwell times at stops. A field test of smart cards in southern California showed that smart cards reduced average boarding time from approximately six seconds with cash to three seconds with the cards. However, when bus dwell times were studied there was no corresponding decrease. This occurred because only 20% of riders were using the smart card and the longer boarding times of cash riders dominated the dwell times (Chira-Chavala and Coifman 1996). This shows that smart cards can help decrease bus dwell times, but only if significant numbers of the riders adopt the cards.

On rail systems, there is reason to believe that smart cards can decrease queues, but only if the smart card system has a lower error rate than the current system. For example, when New York City introduced their magnetic stored-value MetroCard, passenger throughput at entry gates decreased. This occurred because the cards regularly required passengers to swipe cards multiple times to get a "read" (Baugher, et al 1996; Weinstein, et al forthcoming). The lesson here is that systems with very simple fare payment methods may not experience large improvements in passenger throughput with smart cards.

Fare Policy

Smart cards provide the infrastructure necessary to implement creative and flexible pricing policies. Currently most transit agencies rely on flat fares or distance based fares. Due to the difficulty of implementation (and political concerns), most agencies have not attempted to use price to control demand and more efficiently manage the system. With smart cards, it would be relatively simple to offer peak and off-peak

fare differentials to encourage utilization of the network during non-peak times and to more accurately reflect the true costs of providing service.

Experience in New York City highlights how pricing changes can greatly affect ridership, even in mature systems. When NYMTA introduced the MetroCard in 1997, they offered free transfers between subway and bus and 10% fare bonuses[2] (Newman 1998). This had the effect of increasing bus ridership 30% and subway ridership 17% in the year following the policy changes (Lueck 1998). These are fairly impressive gains in a city that already has the highest transit usage in the United States.

Operators of the Washington Metro implemented a smart card program in 1999. The first year of the program has been very quiet. Although users receive a 10% fare bonus[3] when using the card, only 23% of riders have signed up for the cards (Layton 2000). Because of this, card operators have been forced to offer additional programs to increase adoption rates. Operators will now track travel patterns and recalculate fares so that the lowest fare is charged (Layton 2000). For example, you no longer have to buy passes in advance. If your card usage is high enough so that a monthly or daily pass would be beneficial, you will be charged the pass rate rather than a higher per trip rate. This program would not be possible without smart cards.

A few electronic toll collection programs have been setting the standard in using smart card technology to allow flexible pricing. High occupancy toll (HOT) lanes on I-15 in southern California use smart cards to allow congestion pricing (SANDAG 2000). Upstream of the toll lanes, signs advise drivers of the current toll and single occupant vehicles have the option of paying the toll to use the lanes. On the New Jersey Turnpike, system operators have used pricing to encourage smart card adoption and off-peak travel. There are four possible prices for the same trip – cash, off-peak, peak and weekend ("New Jersey Turnpike…" 2000). Currently the cash price is highest and the charge for off-peak and weekend are the same. In the future, smart card technology would allow system managers to implement congestion pricing.

Smart cards are also very useful for loyalty programs; it is possible to imagine scenarios where peak riders are offered discounts for weekend trips. In the United

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[2] when more than $15 was loaded onto cards
[3] on values over $20

Kingdom, Boots drug stores have introduced a smart card that gives shoppers bonus points equal to 4% of purchases. The company has since found that smart card holders spend an average of 10% more than other customers (Davis 1999).

Of course having the technology only makes it possible to have flexible pricing; implementation requires political and management support which may be more difficult to get.

Increased Revenues

Proponents of smart cards point to increased revenues as a major benefit. These revenues come from three sources – increased ridership, interest on card balances and fee revenues generated by leasing the system to vendors. Increases in ridership may come through the two factors discussed previously, service improvements and fare policy. I tend to believe that the impact of fare policy will dwarf the effect of service improvements. For example, would the mere fact of a smart card system existing encourage someone to ride transit? I doubt it. However, if I received a free ride transfer, I might consider making the entire trip on transit. But, increasing ridership does not necessarily equate with increasing revenues. The impressive gains in New York City's ridership figures have been accompanied by a $86 million decrease in revenues from 1997 to 1998 (Lueck 1998). This is a very important issue and operators must think about how much they are willing to "pay" to convince riders to adopt smart cards.

The next two categories for increased revenues would only apply to closed systems or a public private partnership where the transport companies share in the revenues. When transport users pre-pay for services, the system managers generate interest or float on the deposited funds. For systems that have never had a stored-value or token system, this will be a new source of revenue. For the remainder, float revenues will increase as long as riders place higher balances on their cards than previously. It is expected that this will be the case due to the higher security of smart card systems (Fleishman 1998).

Transport smart card systems also have the opportunity to earn fee revenue from vendors that choose to accept their smart card. The obvious tie-in would be merchants in transit stations, phones, etc (Fleishman 1998). This is beginning to be done in Hong

Kong and seems to have potential (Clark 2000). If desired, transport operators can make this a contractual requirement of vendors operating within transit stations.

Implementation Barriers

While smart cards have the potential to improve transit service and agency profitability, they are not a silver bullet to be applied without significant consideration. Even when a clear business case can be made for smart cards, there are institutional, technical, user and equity issues that must be addressed. The following describes some the major challenges in each of these areas.

Institutional

Transport operators must choose from a number of institutional arrangements when implementing smart card systems. The most basic choice is whether the system should be an open or closed payment system. An example of an open system is the current credit card model, e.g. Visa and MasterCard. There are multiple card issuers and multiple merchants who accept the card. Historically, transit agencies have operated closed systems where the transit property issued its own cards or tokens and the media were valid only on that system, e.g. BART, NYMTA.

A second institutional choice is who will administer or act as a transaction clearinghouse for the system. In the open model of credit cards, Visa and MasterCard currently play this role. In an open system involving transit, it is likely that an independent financial company would play this role. However, in a closed system there are more choices. An agency, a consortium of agencies or an independent company (Fleishman 1998) could run the system. The choice between these will depend on the scope of the smart card system. As transport agencies look to a future where fare media can be used on more than one system and potentially for non-transport services, they must assess the benefits and costs of each model to determine their strategy. Figure 5 shows some of the institutional options.

Figure 5: Institutional Arrangements

	Multiple		• Joint Venture • Contracting with 3rd party processor

# of Card Functions	Transport Only	• Contracting with 3rd party processor • Agency Consortium • Agency	
		Closed	**Open**
		Payment System	

Closed Payment Systems

Under a closed system, the issuing agency bears all costs, including procuring and maintaining the cards, terminals and load devices, system operation and customer support. In return for this, the agency gains all revenues, including user fees, interest income on card balances and remainder balances on tickets (Thaw 1999). Under this system, the agency has more autonomy in determining how the system should operate. If the system is successful and gains substantial market share, the issuing agency may have an opportunity to collect transaction fees from other vendors that opt to use the system, e.g. newsstands, pay phones in stations (Fleishman 1998). It should be noted that there might be legal problems with non-banks extending the reach of their cards to non-transport applications (Thaw 1999).

As mentioned above, the issuing agency in a closed system could be an individual operator, a consortium of operators or an independent company. If the goal of the project is regional fare integration between transit services and perhaps transport-related services, e.g. parking, it is likely that a consortium of operators will opt to jointly control the system. For example, in Hong Kong five operators created an independent company to run the Octopus program (Chambers 1998). In San Francisco, the TransLink program is proposing to contract with Motorola and ERG Ltd. to perform clearinghouse functions (Balaban 1999a). Even New York City, which has one operator controlling multiple modes, has opted to launch the MTA Card Company as an independent entity to distribute MetroCards and look for additional business opportunities (Fleishman 1998). Two reasons for this behavior is that operators want to distribute the risk of the smart card implementation and a lack of trust between operators to rely on one agency to do the processing and revenue distribution, nor is it a core competency of transport companies.

Open Payment Systems

As discussed above an open payment system has multiple card issuers and merchants with one entity setting up the rules and infrastructure needed to operate the system. In the credit card model, Visa and MasterCard serve this rule-making function. This business model provides benefits to consumers because they have a choice of competitive providers and because they can access more merchants with one form of payment (Thaw 1999). For merchants, an open system eliminates the need to individually implement a revenue collection system. Instead, they pay for the card readers and a transaction fee that is typically 2% of the transaction value (Fleishman 1998; Thaw 1999). The essential difference between this and a closed system is the allocation of risk. In a closed system, an agency or consortium takes on all the risk and cost associated with developing the system; in an open system, transport companies would be just another merchant without risk in the system development.

But there are important complexities associated with transport being "just another merchant". Most important is the effect of an open system on the fare or tariff complexity. For example, if transport riders use an open system to pay tariffs with a general electronic purse this will curtail an agency's ability to offer discounts, e.g. a 10% fare bonus, because the money could be used at any other location accepting e-purse payments. Similarly, complex fare structures, e.g. free transfers between BART and Muni during off-peak hours, might require a separate transport application that has the correct logic to determine fares (Fleishman 1998).

One solution to this problem is having a separate transport application that users could load onto multipurpose smart cards. This program would create a separate transit electronic purse that allowed complex fares and bonus or loyalty programs which could operate under an open payment system. While this would solve the problem, it would require transport agencies to create and continuously manage this program, thereby losing some of the system development savings available under an open payment structure.

This example highlights some of the issues that will arise under open payment systems between transport agencies and financial institutions. To enter into an open payment scheme, agencies will need to negotiate transaction fees with the financial institutions overseeing the system, create and load a transport application onto the card

and finally, ensure that contactless cards are available. Negotiating the fees with the financial institution will not be simple. The current credit card model is that merchants pay a percent of the transaction value to the processor. To effectively negotiate this rate, agencies must understand the value they bring to the table – high volume and a large user base.   They must also accurately estimate what they will lose by going to an open payment system, i.e. float on pre-paid balances, and the costs they will save.

The second two issues – adding transit applications and ensuring the use of contactless cards – have obvious technical answers, but will require substantial coordination between financial institutions and transport agencies. Without this coordination, transit agencies may not be able to piggyback on the efforts of banks to convert the American public to smart cards.

Technical
Technical difficulties in smart card implementation come from a lack of standards. Two types of technical standards are particularly important, physical and program interoperability. By physical, I mean standards for the design of cards, software and communications. Interoperability standards refer for the ability of programs to work with one another. For example, a Proton electronic purse can not be used outside of Belgium currently ("A New Day Dawns…" 2000).

Physical
Standards are important in every aspect of smart cards, from card "hardware" and "software" to communications protocols to security levels. Most of the progress in standards has been made in card hardware due to international standards organizations, including ISO and the European Telecommunications Standards Institute (Smart card basics.com 2000). Software standardization has been slower, but is now coming about.

Microprocessor cards require computer code or software to retrieve data and access programs. Until recently, each card had its own proprietary operating system that was incompatible with programs developed for another type of card. However, there are now three operating systems on the market that will make it easier to migrate programs to different cards. These products are Java Card, Multos and Windows for Smart Cards. These programs will now make it possible for a programmer to create an application and

be able to run it on any manufacturer's cards, just the way word processing programs are able to run on most manufacturer's computer given the correct operating system (Wong 2000).

The communications protocols for contact cards have largely been agreed upon, but there is no standard for contactless cards. Because most transport applications require contactless cards, this is a major barrier to interoperability. There are three warring standards that differ in the type of radio signal the cards require from the card reader. Type "A" contactless technology requires pulsing radio waves; type "B" requires a constant radio wave which is reduced and diminished in intensity; type "C" uses the same radio signal as type B, but transmits data differently (Balaban 1999a).

Program Interoperability

If our current credit card system represents true interoperability between issuers and merchants, we are a long way from such a thing in smart cards. There are several reasons for this. First, various organizations are still competing for market share and rather than cooperating want their products to dominate the market. This is true in France where there are three different e-purses being launched in trials, all mutually incompatible ("France Pilots Three Electronic Purses" 1999). The reason for this is simple; the dominating applications will be able to generate license fees from other issuers. This revenue will help to cover the project development costs many of the companies have already incurred.

There is some reason to believe that interoperability will eventually come to e-purses. There has been agreement between MasterCard, Visa and Europay on standards for debit and credit chip cards (Balaban 1999b). A similar set of standards for e-purses have been introduced, the Common Electronic Purse Specifications (CEPS). However, not all chips are currently compliant and for operational reasons, which will be discussed below, it may be difficult to make all chips compliant ("A New Day Dawns…" 2000).

Second, there are differences in transaction security and time requirements among different industries. Transport operations require fast processing, generally a quarter of a second, but do not need the highest security levels. Banks face a different set of requirements. They generally want very secure applications, because they could otherwise create a situation where individuals could "print money" by fraudulently

adding value to electronic purse applications ("A New Day Dawns" 2000). These secure applications take much longer of a quarter of a second to complete a transaction. In fact, a demonstration of Common Electronic Purse Standards (CEPS) with the highest level of security took nine seconds to complete ("A New Day Dawns" 2000). Given this, it is currently impossible to have a transport application that uses the e-purse standards.

User

The best technical implementation of smart cards will be a failure if system users fail to adopt the card. Smart card projects only produce benefits when most riders use the cards. Because most transit smart card implementations have required users to pay for the card, it becomes critical that users perceive that card benefits outweigh out-of-pocket and switching costs. Knowing exactly what will make it "worth it" for riders is difficult. For some, the mere presence of the card will be enough to make them switch (the "early adopters"); for others, the ability to put high values on the card will make them switch (the "heavy users"); for others, the convenience of one fare media will make them switch (the "multi-moders"). As you can see there are a multitude of reasons and there is a need to do a reasonably detailed customer analysis to estimate what portion of each customer segment will convert. Based on this, the agency can see if the adoption rate is high enough or if incentive measures will be necessary.

Part of the customer segmentation process should be a consideration of rider demographics and usage patterns. For example, it does not make much sense to use expensive microprocessor cards to track usage when the majority of people do not use the system regularly or when the system is very small and there is little interest in developing new technologies. Instead, it might be more appropriate to take advantage of existing technology. Phoenix, Arizona provides an interesting example of this type of strategy. Since May 1995, Phoenix buses have been accepting MasterCard and Visa for fare payment. To reduce transaction costs and speed the boarding process, the operator submits charges weekly (Schweiger 1997).

If there is enough demand to validate introducing smart cards, it will probably be necessary to use inducements to encourage conversion. As we saw in the Hong Kong example, a 10% fare bonus was offered on the subway. In New York, MTA officials also offered a 10% fare bonus and free transfers to encourage adoption of the MetroCard.

Washington Metro offered a 10% bonus over $20 and has found that 23% of daily riders have adopted the smart card (Layton 2000). This is very low considering the system costs, and explains the introduction of a new set of benefits.

To understand why inducements are necessary, consider the example of a BART (or NY MTA or Washington Metro) commuter who does not need to change modes and never uses the system on the weekend. The introduction of a closed system smart card is meaningless to this person because, to them, it functions exactly like their current stored-value card. To induce this rider to convert to smart cards (and pay the cost of the card), it will be necessary to offer some additional benefits.

Focus groups of potential riders have shown that transit riders are also concerned about privacy when using the card (Dinning and Collura 1996). The most critical issue in this case is how agencies will use and who will have access to the transaction database. Precedents in other industries suggest that it will be fine for transit agencies to "mine" the database for their own use, particularly for determining what incentive offers to give users.

Fraud is also named as a concern by user focus groups (Fleishman 1998). Fraudulent use of smart cards is a legally ambiguous area. Current credit card laws limit user liability for fraudulent use at $50. However, there is no such equivalent law for smart cards. At the moment, it is not clear if the cards will be treated as a credit card or cash. I suspect that the policies will depend on the sophistication of the card. For example, with simple stored-value cards such as those used on BART and in New York City, the cards are like cash – you lose it, it's gone. However, if a card had multiple applications, particularly those with personal information, it will be necessary to have a means of canceling the cards and presumably to have some liability limits. In both Hong Kong and Washington, patrons have the option of getting an anonymous card or giving personal information and being able to cancel the card if lost (Clark 2000; Collura and Plotnikov 2000)

Equity

All systems that implement smart cards will need to consider the equity implications of the decision. Transit agencies must examine two aspects of their smart card fare programs related to low-income riders. First, what effect will the cost of the

card have on low-income access to transit and second, how will the unbanked access smart cards. If the cost of the card is enough to discourage some low-income riders from acquiring, it is important that there is another way of them accessing the system. This alternate access could be maintenance of a cash or token system that operates in parallel to the smart card system. The Washington Metro has chosen this approach; their smart card costs $5, but the existing stored-value cards are still accepted (WMATA 2000). One consequence of this approach would be that agencies would fail to achieve all the cost reductions associated with smart cards systems.

There are also consequences for the user in a dual media system. If fare bonuses are used as inducements in the smart card program, anyone that does not opt to purchase the card could potentially be paying a higher price than smart card riders. This could become an important equity issue if those that do not purchase the smart cards belong disproportionately to any one racial, ethnic, age or gender group. For example in New York City, studies have shown that women and Latinos are somewhat less likely to use the cards (income was not tested) (Chira-Chavala and Coifman 1996). Situations like this may mean that agencies need to monitor what part of the rider population is adopting the card. If certain groups are under-represented and the agency cares that they have equal access, the agency must ascertain why the group is not adopting the card. Is it because they do not know about it, because they can not afford it or because they do not want it? Each answer has a different remedy from improved marketing to subsidy.

The second equity concern – how the unbanked will access transit smart cards services – is an issue that transit systems are likely to face in the future under open system conditions. The obvious implication is that transit operators can never fully rely on other sectors to issue fare payment media. Agencies will always need to provide cards to those that may not qualify for other cards. I do not see this as a major stumbling block to smart card implementation, but as an issue that agencies must be aware as they continue to use smart cards.

Implications for the Bay Area

In light of these findings, it is interesting to consider the Bay Area's smart card program, TransLink. Managed by the Metropolitan Transportation Commission (MTC), this project seeks to integrate fare payment for 26 transit providers through a contactless

smart card. The card will be able to store value in three ways: 1) electronic purse, 2) pass for specific system, e.g. Muni monthly pass, and 3) stored rides, e.g. Caltrain 10-ride ticket ("TransLink Overview" 2000). Project developers have chosen a closed payment system with a third-party acting as clearinghouse. Although there are no plans to expand the system beyond fare payment, it has been mentioned that transport-related functions, e.g. parking, and even retail purchases could be possible in the future.

The reasons for launching this project are similar to the ones we have discussed, particularly making transit easier to use for patrons, reducing maintenance costs, increasing boarding rates and acquiring better customer data to be used in marketing and planning. But these prospective benefits do not come cheaply. The estimated capital costs for a full implementation are $37 million; annual operating costs are estimated between $8 and $14 million ("TransLink Overview" 2000). Currently there are plans for a $20 million demonstration project to run from summer to winter 2001. The trial will include six transit operators, BART, Muni, Golden Gate Transit, AC Transit, Caltrain and Santa Clara Valley Transportation Authority, and 5,000 patrons (Bowman 1999).

Given these not insignificant costs, it is important to try to understand the issues TransLink may encounter and its impact on regional transportation. I believe the primary difficulty that TransLink faces is the number of transit operators involved in the project. It has been very difficult for the agencies to agree on revenue sharing arrangements or to trust that the allocations would be fair. In many other American cities, there are not as many independent operators making it easier to develop a program, e.g. Chicago, New York. In cases where there are a number of operators, e.g. Hong Kong, it was important to form a separate company, with its own management, responsible for smart card development and implementation. In this case, MTC has assumed that role. This seems less than ideal, because each agency must deal with MTC in other contexts, primarily funding. It also means that participants are most interested in furthering the interests of their agency, rather than the success of smart cards in the region. This would be different if there were a separate company in charge of the project and operators shared ownership or simply contracted for service.

The large number of agencies also means that there will be little opportunity to use the smart card for fare policy innovations. As we saw in New York City, bus

ridership increased 30% when free transfers were offered between the bus and subway. Such policies are not likely to occur in the Bay Area because it would require two agencies to work out a revenue sharing arrangement – not very likely. So while TransLink will provide each agency with more information about ridership; it is unlikely that this information will be used to make fare policy changes across systems. Instead, there may be moves by the individual systems to change their own policies; but this is not likely to be a coordinated process.

So it seems that TransLink may bring localized benefits to operators and riders, largely through cost reductions and service improvements. But it is not likely to radically alter transit usage and patterns across the Bay Area because there will be no basis for coordinated fare policy changes.

Conclusions

The lesson from this analysis is clear; smart cards are not silver bullets that will guarantee improvements in transportation performance and ridership. Instead, the cards are a useful tool that may provide cost savings if current systems are inefficient or prone to failure; improve system throughput if smart cards are adopted by a high percentage of riders and are easier than existing systems; and increase ridership if creative fare policies are implemented.

When implementation is justified agencies should consider a range of institutional and technical options, choosing the system that allows them the most flexibility in fare collection at a reasonable cost. In the near-term this is likely to be a closed payment system, but joint ventures with banks should also be considered. Besides making good 'hardware' decisions, system operators must also consider the 'software' necessary for a successful implementation. Experience in. New York, Hong Kong, and Washington shows that fare policy is the 'software' critical to maximizing smart card benefits.

Fare policy affects card adoption rates and without high rates of adoption, there will be no benefits from the system. But fare policy can also affect overall demand for transit as we saw in New York City. To maximize these benefits, systems should encourage regional coordination of fares and allow complex fare structures.

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