Evolution of E-payments in Public Transport—Singapore's Experience

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Abstract

Public transport ticketing in Singapore has evolved over the past 20 years from manual cash collection to an advanced e-payment system using smart cards. This paper traces its development from the automatic fare collection system introduced in 1987 for the first metro system in Singapore, to the current contactless smart card system used for travel across the entire public transport network. The recent introduction of Symphony for e-Payment—an enhanced ticketing system based on open standards and which allows multiple card managers—marked another milestone in the evolution of e-payments in public transport. The use of a national e-purse standard CEPAS (Common E-Purse Application Specification) further enabled the development of a single transport card which can be used on both public transport and private transport i.e. road pricing and parking. This paper also shares the challenges and lessons learnt in facilitating the development of e-payment in transit and beyond.

Integrated Ticketing System — The Early Days

Till the late 1980s, public transport in Singapore primarily consisted of buses. Commuters paid cash fares to the bus driver on boarding a bus. 1987 saw the prelude to e-payments in public transport: when the rail system commenced operation with a fully automated fare collection system handling about 200,000 passengers daily.

In 1990, an integrated ticketing system (ITS) was introduced to provide a common fare payment system on both rail and bus services with a total daily ridership of 2.6 million. It used a magnetic ticket, termed the "farecard" (*Figure 1*), which became the first major stored value facility to be introduced in Singapore. The public transport operators jointly set up a service company, TransitLink Pte Ltd, to develop and manage this system.

Figure 1: A variety of magnetic farecards

For buses, the payment system under ITS remained largely manual. The commuter would insert his farecard into a bus validator (*Figure 2*) and choose the appropriate fare, after which his farecard would be returned together with a ticket for his ride.

Figure 2: A bus validator

Initially, the farecards could only be topped-up using cash at TransitLink offices in rail stations. This top-up service was later extended to bus interchanges. Self-service machines were subsequently introduced to allow top-up through EFTPOS (Electronic Fund Transfer at Point of Sale).

The convenience of the farecard, compared to the hassle of carrying sufficient cash, drove a progressive conversion to farecards. By the late 1990s, farecards were used for 85% of public transport trips. The reduction in cash management translated to a significant saving of about 7% in operating costs for the public transport operators.

Introducing Contactless Smart Cards

Contactless smart cards made their appearance in public transport in Europe and Japan in the early 1990s. Due to the need to enhance Singapore's ticketing system, the Land Transport Autority (LTA) undertook several years of studies and field trials and decided to use the contactless smart card as the new ticket medium even though the underlying technology, including the card itself, was largely proprietary.

In 2002, after three years of development, LTA rolled out the Enhanced Integrated Fare System (EIFS). The new system used contactless smart cards, known as ez-link cards, to replace the magnetic farecards. *Figure 3* shows a commuter tapping the contactless ez-link card against the reader at a fare gate.

Figure 3: An ez-link card being used at a rail station

Enhancements under EIFS

EIFS offered several enhancements over the ITS:

(i) 1¢ increments instead of 5¢ increments, to provide greater flexibility for fare setting and adjustments;

(ii) An extended fare structure compared to the magnetic card. This enhancement was necessary for the ticketing system to cater to an expanded rail network;

(iii) The extended fare structure allowed commuters to transfer between different transit networks (separate operators) without having to exit and re-enter. Fares were apportioned between the operators in the backend system on a daily basis based on an agreed formula. This capability made transfers easier for commuters and prevented unnecessary hardware costs as there was no need for additional fare gates between transit networks.

(iv) The transfer fare rebate[1] could be apportioned in absolute or percentage terms to allow a fairer revenue apportionment among the operators;

(v) More detailed and accurate analysis of data could be done in one-minute intervals instead of 15 minutes; and

(vi) Up to 15 public transport operators could be accommodated by the system.

In addition, EIFS undertook a major process and system re-engineering by having entry/exit processing on buses.

Bus commuters have to present their ez-link cards at the entry and exit processors (*Figure 4*) which will capture information for fare calculation, e.g., bus service number, direction, entry and exit fare stages. At the entry processor, the maximum fare for the remaining trip on the bus will be deducted from the card. At the exit processor, the actual fare will be calculated and unused fare refunded.

Figure 4: A bus entry processor and a commuter tapping her card upon boarding a bus

With this automatic calculation of fares, bus commuters were spared the hassle of enquiring and calculating the fares payable and bus drivers could focus on driving. The entry/exit processing also resulted in a significant reduction in fare leakage for bus operators, estimated to be in the region of $35m annually.

Ensuring smooth transition from ITS to EIFS

The EIFS replaced the magnetic farecard system within 9 months, helped by a comprehensive communications strategy that achieved buy-in from various stakeholders and ensured a smooth and successful implementation of the new ticketing system. Some measures included:

(i) The government showed strong commitment by providing significant funding for the upfront cost of developing the system. This in turn helped to secure support from the public transport operators;

(ii) As students formed 18% of the commuting public, LTA worked with TransitLink and the Ministry of Education to provide personalised concession travel passes, which also served as student identity cards. This arrangement reduced the abuse of concession privileges;

(iii) Prior to full roll-out of the system, a group of regular commuters was invited to use the cards. This served the dual objectives of: 1) educating this group so they would in turn be ambassadors to other commuters after full system roll out; and 2) generating a critical mass of 1 million transactions to stress test the system; and

(iv) Extensive publicity and public education programmes ran on various channels, such as TV, print media, roadshows, posters and communication sessions with grassroots leaders to educate the public on using the new system. Among the materials developed was a public education video entitled "Tap & Go." The phrase soon caught on with the public and became a "tagline" in various public education efforts.

Benefits of EIFS

Faster commuter throughput for buses and trains

The automatic fare calculation under EIFS enabled commuters to board buses more quickly, which shortened the dwell time of buses at bus stops. Commuter throughput at the train stations also doubled, significantly reducing congestion in the busier stations during peak periods. These improve the overall efficiency of public transport services.

Enhanced data mining capability for strategic planning

LTA established an EIFS Data Warehouse to capture the large volume of transactions and enable automatic extraction of data from the backend system. This replaced manual surveys of bus commuters. The data warehouse has since become a valuable resource for LTA in its strategic planning, route planning for rail and bus services, and setting key performance indicators for public transport services. For example, through data collected from EIFS, LTA can monitor the travel time commuters spend on public transport and develop initiatives for improvement.

Lower maintenance costs

Finally, contactless smart cards are more reliable and durable than magnetic farecards, with a failure rate of 1 in 25,000 transactions compared to 1 in 5,000 transactions for magnetic farecards. This means commuters spend less time replacing faulty cards. The operators also benefit from a substantial reduction in equipment maintenance and operating costs, from 9% to 5% of capital cost, which is low by industry standards.

Developing a New Generation of Ticketing System

EIFS, like ITS, was built around the single issuer-single acquirer model. This restricted the choice of cards for both the commuters and service providers.

Besides the ez-link card, the other stored value card widely used in Singapore is the Cashcard. This is a contact card issued by NETS[2]. It is used for the payment of road pricing charges and parking at many car parks.

The lack of interoperability between the two systems precludes the sharing of infrastructure. For instance, the ticketing system has to bear the high cost of installing and supporting an add-value system instead of leveraging on what has been deployed by the banking sector for the Cashcard.

In line with Singapore's vision for a cashless society and to bring greater convenience to the general public, there was a need to move away from proprietary systems and cards towards an environment where there are multiple card managers whose cards can be used anywhere anytime. To achieve this, it was necessary to develop standards to allow cards which are interoperable across various systems.

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The confluence of business needs and availability of suitable technology provided the impetus for LTA to develop a new ticketing system inhouse based on open standards.

Contactless e-Purse Application Specification (CEPAS)

By 2004, the security and performance of cards and readers had improved significantly. This in turn facilitated a more flexible business model for e-payment. The Government set up a taskforce comprising representatives from several government agencies and the smart card industry to develop a national e-purse standard. The objectives were to:

(i) Bring together multiple payment applications onto a single smart card;

(ii) Enable greater synergy between applications and consequently less duplication of development resources and infrastructure; and

(iii) Permit multiple entities participating in a common e-payment scheme to create their own keys on a card that would be used to protect their own liabilities without affecting the liabilities of other parties. This is analogous to each tenant of a building having secure and independent access to their specific units without being seen by others, including the landlord.

The Contactless e-Purse Application Specification (CEPAS) was released in 2nd quarter 2006 as the National e-Purse Standard SS518. It incorporated the requirements of a banking e-purse as well as that for transit ticketing and road pricing, among other applications. (See box on *Features of CEPAS*).

CEPAS in Transit Ticketing—Symphony for e-Payment (SeP)

Symphony for e-Payment (SeP) is the backend processing, security and clearing system developed by LTA for transit and non-transit payments to support CEPAS. It was developed entirely inhouse using open standards. This gives LTA greater flexibility to modify and enhance the system in future to meet evolving ticketing needs without the constraints from use of proprietary software. As SeP is built on open standards, card managers will have a wider choice of card suppliers while the public will benefit from a wider choice of cards. SeP also significantly reduces the technical entry barrier to new card managers for transit ticketing as new business rules and operational procedures for handling cards from different managers have been established.

Given that SeP can support multiple card managers, it is important to give the stakeholders a greater assurance on the accuracy of financial reports generated by the system. Hence a well established accounting firm was engaged to design the financial reports to meet best accounting practices.

Features of CEPAS

Several unique features were incorporated in CEPAS to provide the reliability and performance required for deployment in a myriad of applications. These included:

(i) Atomicity, i.e. no corrupted or partial updates to the card in contactless usage to ensure that information, when written on to a card, is always complete;
(ii) AutoLoad to increase purse balance by a specified amount when the debit amount is greater than purse balance, provided the card is linked to a bank account or credit card. This eliminates the need to go to a specific top-up terminal;
(iii) Partial Refund to allow refund up to full reversal of the previous transaction. This is useful for transactions in retail and for bus fares; and
(iv) Cumulative Debit to minimise transaction processing overhead by accumulating several debit operations for one card into a single transaction at any point of sale.

This is in contrast to the traditional approach of engaging an accounting firm to audit the system after its completion.

On 1 October 2009, SeP replaced EIFS for transit ticketing.

CEPAS in Electronic Road Pricing and Parking

To enable the Electronic Road Pricing (ERP) system to support the use of CEPAS, LTA developed a new in-vehicle unit (IU) for electronic road pricing. The new IU (*Figure 5*), launched in July 2009, offers the following improvements:

i) It accepts Type B CEPAS compliant contactless cards as well as contact cards for compatibility with the existing contact card system;
ii) The IU software is programmable, embedded in very secured hardware and upgradeable to allow future software changes if necessary;
iii) The contact card interface can be progressively eliminated, yielding a cheaper and simpler IU design in future;
iv) It allows auto top-up (by linking the card to a bank account or credit card) so that the motorist need not be concerned with having sufficient value on the card; and
v) The new IU in taxis can potentially accept payment from passengers with the appropriate card. This could eliminate the need for additional payment terminals in taxis in future.

Today, many car parks in Singapore have implemented the Electronic Parking System based on ERP technology. The IUs are used in conjunction with the car park barrier system

Figure 5: A new ERP in-vehicle unit which supports CEPAS

for payment of parking charges. With the new IU in place, the electronic parking system will be upgraded to accept CEPAS cards from various card managers.

A Single Transport Card

With the development of SeP and the new IU to support CEPAS, a single contactless smart card can now be used for ERP, parking and public transport. The journey towards a single transport card has been a major challenge for LTA. The "One Transport Card" has to serve not only transit but also the high performance requirements of processing ERP transactions at less than 140 milliseconds at the ERP gantries. In addition, it has to be compatible with the existing transit readers and new in-vehicle units.

Work to develop a new card started in 2005 while the CEPAS specifications were still in draft stage. LTA worked very closely with the various card vendors to ensure that the card operating system was implemented according to CEPAS specifications as well as the stringent requirements of both ERP and the transit environment. Testing was comprehensive. More than 2000 test scenarios were conducted at both the vendor and LTA test laboratories. Extensive load/stress tests were conducted to ensure that there were no blind spots within the detection field of the transit reader (typically less than 8 cm). Temperature chamber burn-in tests were conducted to ensure the cards remain functioning even at temperatures of up to 85°C[3].

To rigorously evaluate the performance and reliability of the system using the new card, half a million transactions were carried out in the transit environment (rail/bus) and 1.3 million transactions simulated in the ERP environment (vehicles). The whole development effort took two years.

E-payment in Transport and Beyond

The ticketing system for Singapore's public transport has evolved from a single modal transit ticketing system to a multi-modal ticketing system (ITS), then a multi-purpose single issuer card system (EIFS), and finally a multi-purpose, multi-issuer system (SeP). At each stage, there were significant savings for transit: reduced cost of cash handling in ITS and reduced fare leakage in EIFS. The savings that SeP will provide for transit has yet to be quantified but adoption of CEPAS is expected to be the enabler.

Beyond transit, the acceptance of stored value cards has been relatively slow. A business case for e-payment based solely on it being a substitute for cash is often futile as cash management is generally considered sunk cost and the benefits are quite nebulous. It must also be recognised that cash is entrenched in many people's pockets and arguably as efficient in many retail environments.

The key missing element for a pervasive e-payment system is extensive terminalisation and more importantly, a common terminal network across all card managers.

Nonetheless, Singapore has many prerequisites in place to support the successful proliferation of e-payment. Today, about S$20 billion of transactions a year are still done using cash. More can be done to take advantage of the 15 million cards in circulation (both ez-link cards and Cashcards). The availability of more than 1.1 million personalised concession cards also provides good opportunities for loyalty programs. The key missing element for a pervasive e-payment system is extensive terminalisation and more importantly, a common terminal network across all card managers.

The experience of implementing e-payments in transit provides some useful lessons:

i) Business process re-engineering has to be considered and exploited for a sound business case;
ii) There is a transition cost (including a long payback period) which should be factored in and managed so that it does not become a deterrent; and
iii) Convenience to users is a strong consideration, even though its benefits cannot be easily quantified.

The success of the Electronic Parking System proves that it is not difficult to change the mindset of the public and service providers as long as there are obvious benefits and a sound business case.

Conclusion

Transit has shown the way in using e-payments to improve processes, reduce cost and bring a higher level of service to customers.

Service providers and card managers have to be nimble to adopt new technology and design suitable business models. As there are about S$20 billion cash transactions per year, the potential opportunities for the first movers are significant.

Notes

1. The public transport system in Singapore does not have a through fare system, except for travel within its mass rapid transit (MRT) network. For commuters who make bus-bus or bus-MRT transfers, they are given a transfer rebate to partially offset the second boarding charge. This rebate is borne by the operator of the second leg of the journey.
2. NETS is a company formed by 3 major local banks to drive the adoption of electronic payments in Singapore.
3. Temperature chamber burn-in tests were necessary to ensure that cards remain functioning even after being left in vehicles parked in open car parks and exposed to the sun for long hours.

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