

Implementation of an Enhanced Integrated Fare System for Singapore

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ABSTRACT: In the light of need for a more flexible and expandable fare structure, and higher transaction processing requirements, the Land Transport Authority of Singapore launched its new S\$300 million contactless smart card based fare collection system in early 2002. This system replaced the magnetic ticket based system that was in use since 1989. This paper will focus on the lessons learnt in the implementation of the Enhanced Integrated Fare System (EIFS).

1 BACKGROUND

The work started in 1994 when it was decided that the existing magnetic ticket based system had to be replaced by year 2002. LTA began the search for the right ticket media and ways to improve the system. By 1998, after a few laboratory tests and a field trial, the second-generation automatic fare system for Singapore was conceptualized and ready for construction.

The Enhanced Integrated Fare System (EIFS) is the name given to the new contactless smart card (CSC) based ticketing system. The modifications in the rail system were mainly to support the new contactless smart card media. The fare collection equipment were either retrofitted or upgraded to support the smart card system that provides a better interface to commuters. For buses, the changes were more extensive and radical. Buses now use entry and exit processing to provide a closed loop fare deduction mechanism so that passengers no longer need to select the fare to be paid. Although the concept of stored value on ticket and transfer rebates remains, the fare due is automatically calculated and deducted from the ticket.

EIFS also introduces a new wireless data transfer system used to transfer usage data from buses to the depot computer at each depot automatically. This will help to ensure successful upload of transaction data and download of operation parameters. The interchanges are also fitted with the same system as the depots to upload and download data.

2 LESSONS LEARNT

2.1 Effectiveness of Publicity and Public education

Preparation for the launch began in August 2000 with the formation of the EIFS Public Relations (PR) Steering Committee. The committee put together a PR plan to determine the schedule and range of activities. The committee's key considerations were the radical change in the method of fare payment,

higher deposit for the ez-link card, increased complexity of the new ticketing machine, potential wrong fare deductions and passengers who forget to exit-process from buses.

The PR activities included press releases several months before the launch. Stories of the upcoming new ticket media and how the public transport operators were preparing for the change were featured in the newspapers to generate interest.

To gather feedback from the public, a selective preview was conducted. The committee issued a press statement, sent invitation letters to trial participants, distributed EIFS instructional leaflet and frequently asked questions (FAQs) and set up an EIFS hotline and website.

To prepare for the launch, user guides were distributed and briefings were conducted for the community leaders and the media. We bought television time, press advertisement and put up publicity posters in the residential estates. Road shows were held at train stations and bus interchanges where there is high volume of commuter traffic.

Public education was a main concern for the PR steering committee. As the entry and exit-processing feature on buses could be a difficult concept for the general public to understand, the committee simplified it to – “Maximum fare deduction on entry and credit of unused fare on Exit”.

Generally, the public was well informed by the time the system was officially launched. People were aware about the new methods of fare payment on buses although many were initially unsure about how to use the bus processors. This resulted in cases of passengers not performing exit processing on buses. This figure decreased with time as the public became familiar with the usage of the bus processors.

The fare gates in the rail system had fewer problems with patron flow, as it was basically similar to the current the magnetic system. except that instead inserting the card into the reader, it is just “tap and go”. The new General Ticketing Machine (GTM) has more complex functions than its magnetic predecessor. However, the operation of the GTM is simpler and more intuitive as the screens are carefully planned and designed. This has helped the public to easily learn its functions and perform their transactions quickly.

2.2 Magnetic System and CSC in parallel

EIFS was launched on 13 April 2002. Ticket offices throughout Singapore started selling the contactless smart card, branded the “ez-link card”.

The launch of the ez-link card also kicked off the parallel run, during which the magnetic ticket and the contactless smart card could be used simultaneously. The aim of the parallel run was to allow the public time to buy their new ticket and switchover to the new system progressively. The switchover was achieved in 1 December 2002 after EIFS has been in parallel run for more than six months.

The take up rate of the ez-link card was overwhelming. There were long queues at the ticket sales offices during the first few days after the launch. Many commuters wanted to try out the new card. Sales quantity was high initially and reduced gradually as more people had bought their cards.

On 31 March 2004, the ride according to payment methods were as follows:

Table 1: Average Daily Ez-link and Cash Usage Comparison

Ez-link Card	Cash
1,192,991	180,872

The number of cards sold or personalised are as follows:

Table 2: Card Sale Details as at 31 March 2004

Sold	Personalised
5,697,698	1,338,582

The parallel run allowed the public sufficient time to switch over and familiarise themselves with the new system. and identified areas to fine-tune the reliability and performance of the system.

2.3 System Performance Indicator

Table 3: System Performance Indicators

	Contactless Card Performance	Magnetic Card Performance
Corruption	1 in 200,000	1 in 6000
Entry/Exit Mismatch	0.19%	<0.05%
Processing Time	200ms	400ms
Average throughput at fare gates (pax/min)	50	40
Average throughput at bus entry (pax/min)	50	35

From the above figures, it is clear that the smart card corruption rate is very low compared with magnetic tickets and the processing time is approximately halved. This translates into higher reliability and lower cost for replacement in a CSC environment. Throughput of passengers boarding buses and patron flow at fare gates has also substantially increased as a result of the decrease in processing time.

The initial rejection rate was slightly higher due to the unfamiliarity of patrons with the new system but improved with usage.

2.4 Data Transfer Through Wireless LAN

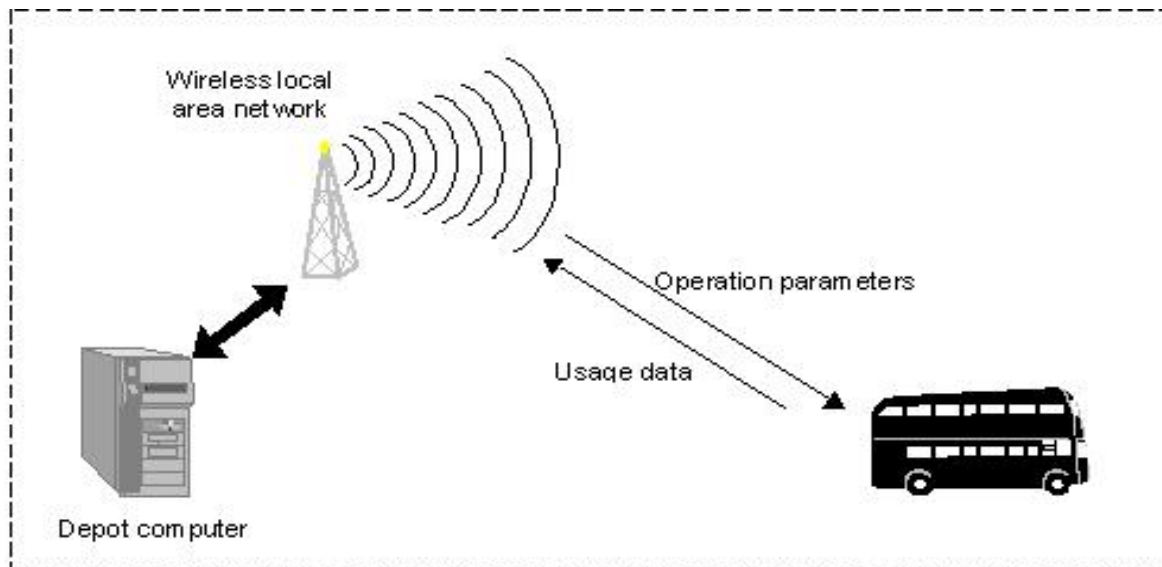


Figure 1. Wireless Data Transfer System in a Bus Depot

The magnetic system relied on bus drivers to manually upload the data cartridge from the bus to the DCS. This resulted in delays claiming the revenue from the clearing house by the bus operators. At the same time, new parameters take time to propagate throughout the system. The bus operators have to go to every bus to input the new parameters. EIFS harnesses the technology of the Wireless LAN for the transfer of data between the buses and the Depot Computer System (DCS).

Each bus depot has been installed with wireless LAN access points and the Integrated Driver's Fare Console (IDFC) on the bus is equipped with wireless LAN capability. Configuration data (CD) is downloaded from DCS to the IDFCs via the wireless LAN at the start of each business day. When the bus returns to the bus depot, the Usage Data (UD) generated during the day is then uploaded to the DCS via the wireless LAN.

Despite the extensive surveys conducted at all the depots to determine the best positions for the wireless LAN antennae, it is still not possible to achieve 100% coverage at some depots. In addition, like all wireless communications, the performance of the wireless LAN is also affected by environmental factors. On rainy days, the wireless LAN signal is attenuated and the coverage of the wireless LAN is reduced.

Another consideration is also to minimize the disruption to the bus operations. This translates to situating the access points in locations, which do not require digging up of roads in bus depots. This eliminated certain potentially advantageous Line of Sight (LOS) locations for the Access Point (AP) antennae, for example at the top of the lighting mast and lampposts in the bus parks. There are still blinds spots in some of the larger depots like Woodlands, where it is two-storeys with supporting pillars and low ceiling areas, which contribute to screening and LOS problem.

Subsequent surveys were conducted to identify the blind spots and areas of weak signals. A plan was formulated to increase the coverage of the wireless LAN in the bus depots which involved deploying additional APs and relocating the existing APs to improve the wireless LAN coverage. To date, the wireless LAN has achieved a 97.0% success rate for Usage Data upload, after the coverage of the wireless LAN has been improved and also the bus captains has overcome the initial learning curve of the new IDFC.

2.5 High Volume Backend Processing

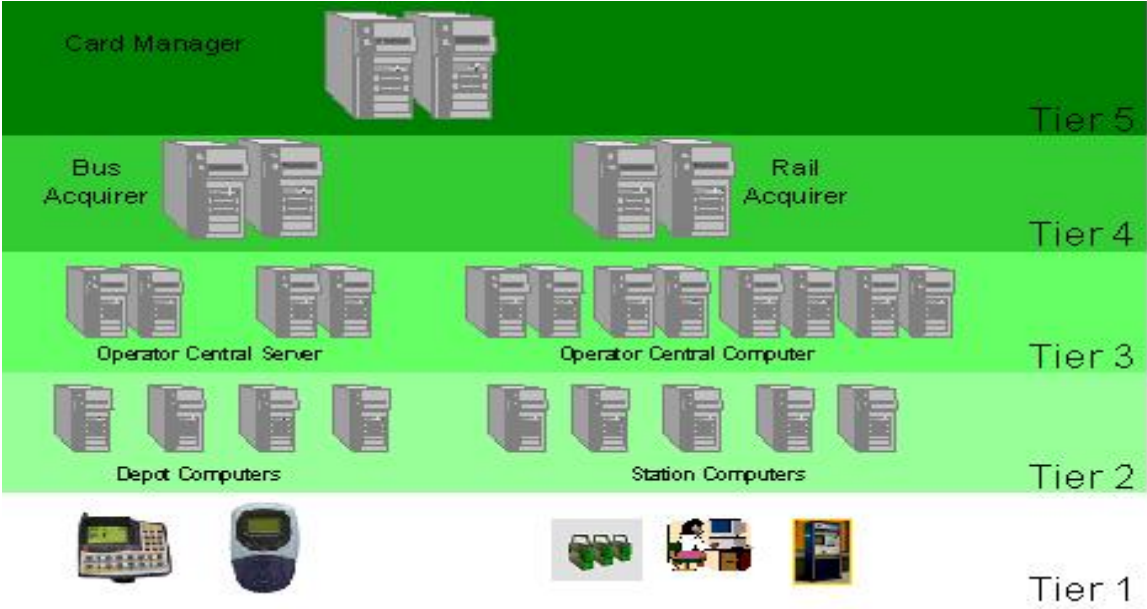


Figure 2. EIFS System Architecture

Figure 2 shows the EIFS system architecture, which consists of 5 tiers. At the top tier is the Card Manager, which is the central database that keeps an audit record of all the transaction for each individual Card. The Card Manager Backend Processes can be divided into four main categories, namely Card, Purse, Patron and Financial processes.

The Card Process represents a group of system services that aid the distribution and use of cards bought in the system. It includes all the necessary information needed to generate, maintain and distribute the blacklist table of the system. The Purse management process maintains the funds stored in the contactless smart card. It provides the necessary information for financial reconciliation with financial institutions. The Financial process provides the financial services for the participants in the system. It also handles the clearing and reconciliation of transactions between the participants.

The backend system is also able to keep track of the personal information for those cards that have been personalised. These cards store personal information of the owner such as name and identification number in the smart card chip as well as having the owner's photograph and personal particulars printed on the card. Such cards can be used as a means of identification, as they are in Singapore schools where students use these cards as student identification passes.

Currently, there are approximately 1.2 million tickets being used in the system daily. There are a total of 4 million transactions in the rail and bus system and approximately 180,000 add-value transactions each day. As EIFS is a potential platform for launching other applications (e.g. mobile top up, retail payment etc), the amount of backend processing is expected to increase as the system expands.

Running the system has not been without its problems due to the volume of data and complex nature of transaction validation and settlement. Software issues usually surface as discrepancies in reports and investigations have to be carried out to find the cause and rectification of the problem follows.

Besides using the backend information for fault tracing, the usage and traffic pattern of the EIFS system can also be generated. This information can then be used for system fine-tuning and analysis where the data is used for route planning purposes.

2.6 Financial Security

EIFS was designed with improved security features, compared to the existing magnetic farecard system. These security features play an important role in ensuring the system integrity and financial security of the EIFS.

The smart card uses a smart card chip, which provides a more secure storage of the information as compared to the conventional magnetic technology. The communication session between the reader and the smart cards are encrypted using Triple DES. This ensures data being communicated between the Card and Reader is secured and not vulnerable to being 'eavesdropped' by using data scopes. In addition, MACing is used for the transfer of data within the system. This is used to verify the authenticity of the devices sending the data through the system. The system uses a Key Management Facility (KMF), which is used to generate cryptographic keys to be used for secure communication in EIFS. The KMF can only be operated when 2 different sets of keys are presented.

EIFS has a comprehensive business validation process at the front-end devices, which checks for the validity of the cards, and also powerful backend servers to keep an audit trail of the transactions and events occurring in the system. Some of these financial checks include checking the purse value of the smart card against the maximum purse limit, blacklisting of smart card due to bad debts, excessive purse value, invalid bank accounts or cards which are not yet issued. The blacklist tables are maintained by every device and are updated on a daily basis.

The business model for GIRO top up services is designed to allow a specific amount for each top up and also the interval between 2 successive GIRO top ups is at least 3 days. This is to allow sufficient time to process the bank payment before allowing the next GIRO top up.

The backend processors also maintain comprehensive audit trails of all the transactions related to the cards. These audit trails are used in the monitoring of any fraudulent activities. Some examples of exceptions are duplicates or inconsistencies in the transaction sequence number (also known as Purse Sequence Number).

However, there are costs associated with these enhanced security features. These costs are translated into additional equipment and manpower required to administer the security operations. This includes additional equipment like Firewall servers, to prevent malicious penetration attacks, and network servers to achieve the distributed/delegated network management and defence-in-depth network protection policy. Having a larger backend database also translates into higher cost of database maintenance, with more reports being generated and managed.

3 THE FUTURE

Over the next few years, new features will be introduced to enhance the system which is expected to have a life cycle of 10 years.

One enhancement currently under design is the fixed location processor. The purpose is to supplement the GTMs with low cost add value devices as the majority of transactions performed at the GTMs are add value. The initial fixed location processor will support a new add value feature called Mobile Top-up where commuters can use their mobile phones to call the mobile top-up provider and secure a top-up using his credit card, then proceed to any fixed location processor to have their ez-link card topped-up.

A concept termed vicinity stop processing will be introduced in due course. Commuters normally present their ez-link cards at the bus entry processor upon boarding. The entry stage and ride maximum fare is ear-marked on the ez-link card. Upon presentation of the ez-link card at the exit processor, the actual fare is calculated based on the entry stage. The fare is deducted from the card and the ear-mark is cleared. In the event passengers forget to exit-process from a bus, the next device (for example the fare gates at the train stations) where the passengers present their card will calculate and deduct the appropriate bus fare based on a set of vicinity stop tables that contain information of bus fares for buses that ply within the area.

The update of fare stages on buses is currently performed by the bus drivers. This can lead to incorrect fare deduction if the driver fails to update fare stages properly. As an enhancement, a Vehicle Location System(VLS) will be introduced on buses which uses the Global Positioning System(GPS) and the bus odometer to determine the location of the bus and automatically update fare stages. This will ensure consistent and accurate fare stages.

4 AUTOMATED FARE COLLECTION IN SINGAPORE'S PUBLIC TRANSPORT

The fare collection system is operated by the two main public transport operators in Singapore. They are the Singapore Bus Service(SBS) and Singapore Mass Rapid Transit (SMRT). SBS is the major bus operator in Singapore whilst SMRT operates fewer buses. SMRT operates the North/South and East/West rail lines, whilst SBS Transit operates the North East rail line.

The fare structure on buses and trains in Singapore is distance related. Buses accept ez-link stored value cards or cash as payment, whilst the rail system accepts only stored value ez-link cards or single/return trip cards. Ez-link cards can be purchased from the station control or ticketing offices located most train stations. Single/return trip cards can be purchased from automated ticketing machines at all train stations.

