GOVERNMENT OF INDIA

MINISTRY OF URBAN DEVELOPMENT






REPORT OF THE SUB-COMMITTEE

ON

AUTOMATIC FARE COLLECTION SYSTEM

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MESSAGE

The growth story of India is to be written on the canvass of planned urbannisation and the success of planned urbanisation depends upon sustainable urban transport and transit oriented development (TOD). Efficiently designed, operationally sustainable and user friendly urban transport systems are instrumental in urban mobility.

India's urbanization process has now gained pace and as per the latest census, the growth of population in the urban areas has already exceeded that in the rural areas. As urbanization accelerates, we would need to tackle the issues of redevelopment of existing areas, creation of newly urbanised areas as well as provision of mass transit systems, modernisation and up gradation of existing urban transport systems in a manner that meets the aspirations of all classes of society. The concept would have to strategic densificastion of the urban areas, so as to optimise the land use through TOD approaches. That would invariably lead to comprehensive mobility planning for the urban areas, including the potentially urbanisable areas.

Metro railways are undoubtedly the preferred mode for mass transport on high demand corridors in big and medium cities and lead to making growing cities more liveable and sustainable. As a matter of policy, the Ministry of Urban Development (MOUD) envisages cities with 2 million plus population to plan for metro rail networks in next few years. As can be seen in Delhi, mass transport facilities such as the Metro, have been a game changer for urban transport and urban development. And that would hold good for any other large city too in the country.

With the creation of new metro facilities in several cities (tier 1 and 2), and in view of capital intensive nature of the metro rail projects, there is a need for cost optimization strategies, such as standardization and indigenization, of metro rail systems. The setting up of a committee for "Standardization and Indigenization" of metro railway systems by the MOUD an endeavour in that direction. The Committee produced a "Base Paper" wherein consensus items were indicated and also suggestions were incorporated for constitution of a number of sub-committees for in-depth study. To make rthe task more manageable, the following thematic sub-committees were constituted:

- Traction and power supply systems

- Rolling stock
- Metro railway Operation and Maintenance
- Signalling systems
- Fare collection systems
- Track structures

The initiative of MoUD to draw upon the expertise of professionals across various disciplines and also from industry has resulted in finalization of the reports of the various sub-committees. The Base Paper as well as the sub-committee reports have suggested multiple strategies for standardization and indigenization. Such evolving long term strategies for cost reduction are expected to yield significant results – in terms of both, cost optimization and high end knowledge accumulation in the country.

I encourage all cities, states, metro railway organizations and other organizations associated with metro rail systems to make full use of these reports for planning and implementation of metro rail systems in their cities as well as contribute to their further evolution in future.

I congratulate all the members of the Base Paper Committee and Sub-committees for successfully bringing out their respective reports.

(Sudhir Krishna)

New Delhi
19th November, 2013

Preface

1. The Public transport in India had been relying for a long period on manual paper based ticketing systems. The introduction of Metro Rail in Kolkata witnessed a change from manual to Automatic Fare Collection system. Unlike the present system of contactless technology it was based on paper based magnetic tickets. Delhi Metro ushered in the country the first contactless ticketing system using smart cards and tokens. The Automatic Fare collection (AFC) system has improved the efficiency of fare box collection and made the journey convenient for the commuters.

2. While the AFC system has made a difference in the way commuters travel in Metro Rail or RFID based e-purse used for ticketing in national Railway, the disconnect is still being felt when it comes for travel in other modes of public transport. The general expectation from commuters is to have an integrated ticketing system which enables seamless travel and transfer from one public transport to another. This kind of multi-modal ticketing is already popular in many cities like London, Singapore, Hong Kong etc.

3. The value proposition for the use of contactless smart cards in the mass transit marketplace is established and working successfully for more than 15 years. Recent developments in the mass transit and financial payments industries have created opportunities for convergence and collaboration of two sectors.

4. The Sub-Committee on Automatic Fare Collection System for Metros was constituted vide MoUD's Order No. F.No.K-14011/26/2012-MRTS/Coord. dated 25th July 2012 and comprises of following Members:

   (i) Shri Raj Kumar Singh, Director(UT-I), MoUD
   (ii) Shri Brajendra Kumar, Bangalore Metro Rail Corporation Ltd.
   (iii) Shri Prashant Rao, Delhi Metro Rail Corporation.
   (iv) Shri T.M. Shridhar, Chennai Metro Rail Ltd.
   (v) Shri Kaustav Mandal, CRIS Kolkata
   (vi) Shri UC Pudia, Ahmedabad Municipal Corporation
   (vii) Shri Deepak Kumar, UTIITSL, N. Delhi
   (viii) Shri Ashok Chandra Chander, Kolkata Metro Rail Corporation
   (ix) Dr. A.K. Garg, D/o Electronics and IT
   (x) Shri Rajesh Narang, D/o Electronics and IT
   (xi) Shri A.K. Das, Centre for Development of Telematics
   (xii) Shri D.S. Pathania, M/o Road Transport and Highways
   (xiii) Shri Deepak Saxena, National Highway Authority of India

(xiv) Shri Aashish Kar, National Payment Corporation of India

5. The Terms of Reference of the Sub-Committee on Automatic Fare Collection System included the following:

(i) Study of technology / architecture involved for multi-modal ticketing
(ii) Study of efforts made by DMRC, BMRCL, DIMMTS, MoUD etc so far in this regard
(iii) Study of Hong Kong & UK (or others) multimodal ticketing system
(iv) Study of role of bank and mobile service operator for implementing the multimodal ticketing system
(v) Study of the issues (such as revenue sharing mechanism) which have become stumbling block so far in the implementation of such system
(vi) Study of vendors who can provide AFC system with compatibility with money transfer through mobile phone, common card and tokens
(vii) Identifying constraints in process of indigenous development and evolving strategy for placing development orders for assemblies / systems / subsystems
(viii) Report of study addressing above issues, analysis, recommendations and way forward for faster local capability / capacity building

6. The Committee had a series of meetings in September 2012 followed by interactions over e-mail. Several consultants and experts in the related field Mr. Alok Jain, Mr. Rahul Jain, Mr. Vivek, Mr. Mahesh Chandra, & Mr. Soichiro Tamura were also consulted and their opinion has also been taken into consideration. The Base Paper has been prepared based on inputs from all such stakeholders.

7. The opinion of a committee formulated to address the issues raised by one of the industry dealing in smart card, regarding security aspects has also been incorporated.

8. The Sub-Committee has since completed the assigned task and the effort has culminated in the production of this report. The report covers the following:

(i) The ISO 24014-1:2007 'Public Transport – Interoperable Fare Management system – Part 1: published standards on Multi-modal ticketing
(ii) Study of AFC system of Delhi Metro, Bangalore Metro and Chennai Metro and the efforts made towards multi-modal ticketing.
(iii) Study of the multimodal ticketing system of Hong Kong and London Metro
(iv) Different technologies being adopted worldwide in AFC systems
(v) Role of Banks and Mobile service providers
(vi) Role of vendors and potential of indigenous development
(vii) Security aspects in AFC systems
(viii) Way forward

The report is an outcome of dedicated efforts put in by the Sub-Committee members.

9. The Sub-Committee would like to thank Dr. Sudhir Krishna (Secretary/MOUD), Shri. SK Lohia (OSD/MOUD) and officials of Ministry of Urban Development for their constant inspiration and undertaking this seminal work.

CONTENTS

Base Paper on Automatic Fare Collection System

Report on AFC Systems by sub-committee members based on the Terms of Reference circulated vide MoUD letter no. K-14011/26/2012-MRTS/Coord dated 25-7-2011.

1. Study of technology / architecture involved for multi-modal ticketing.

1.1. The Multi-modal Ticketing systems adopt architecture as per provisions in ISO 24014-1:2007 'Public Transport – Interoperable Fare Management system – Part 1: published standards.

1.2. These standards broadly cover –

1.2.1. Different functional entities involved in relation to overall fare management system

1.2.2. A generic model which describes the logical and functional relationship between these entities.

1.2.3. Functionality where a customer is able to travel with all participating operators (seamless journey) using a single (TRAVEL) Medium.

1.2.4. Implementation of additional add-on services like loyalty programs, car sharing, park and ride etc.

1.2.5. Identify the customer while protecting their privacy as appropriate.

1.2.6. A model which is neutral to different technologies which may be deployed (e.g. contact or contactless medium (short range, wide range), independent of access technologies.

1.2.7. Multimodal tickets (MMTs) enable passengers to make journeys using more than one mode of transport. These may coincidentally be multi operator &/or multi trip journeys, as well as comprising area wide travel. MMTs may have various periods of availability. The Multi modal ticketing includes (Ticket media: it can be paper, token, card or anything else) useable in all or some of the following situations:

- on journeys comprising more than one leg (or trip)
- on a succession of independent journeys
- on more than one vehicle
- provided by more than one operator
- by more than one mode
- avail concessions which different operators offer and allow each operator to follow his tariff like monthly pass etc.

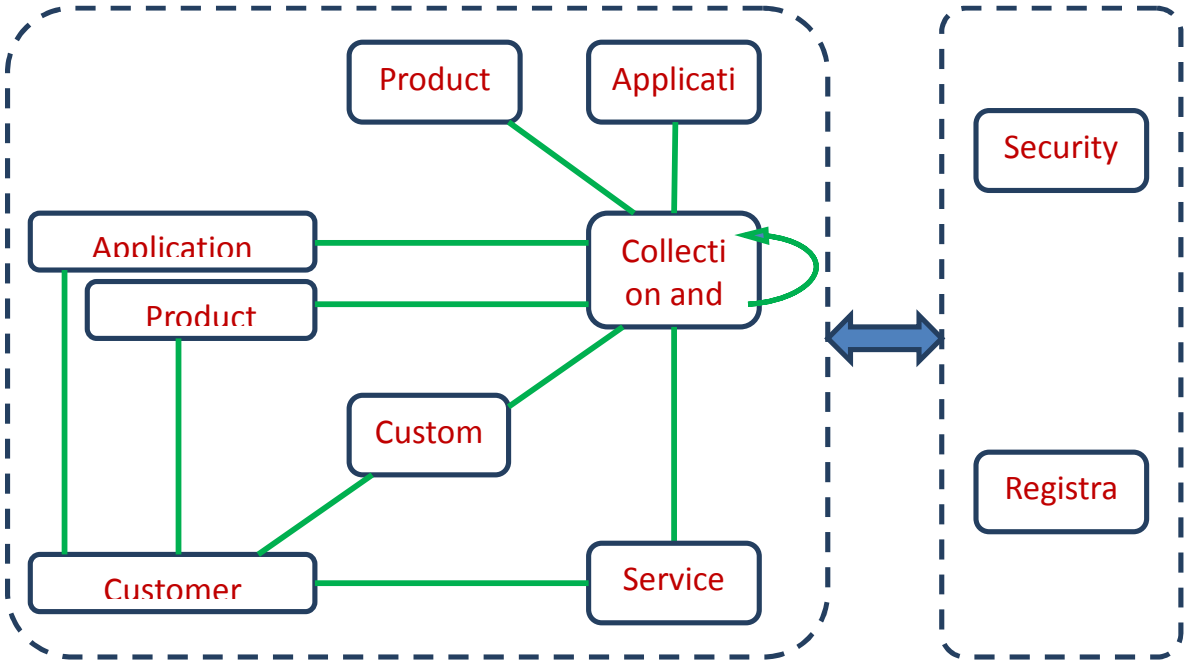
1.3. The different entities involved are-

1.3.1. A Central Body owned by third party or jointly by all the stakeholders which will manage and operate-

- Central Clearing house for transaction settlement
- Card Logistics and Issuing
- Acquirers who will sign-up the Service Providers
- Security Manager checks the component against the Set of Rules.
- Registrar to issues unique registration codes by generating unique identifiers.

1.3.2. The apportionment of the charges to the Service Providers (Transit and non-transit) whose services are used by card holders. The money is apportioned to Service Providers through Central Clearing House.

1.3.3. Banks who hold the float for the Central Body and settles the money to Service Providers on agreed basis with Central Body.



ISO 24014-1:2007 Architecture (Operational and Management Entities)

2. Study of efforts made by DMRC, BMRCL, BMTC, CMRL, CRIS etc. so far in this regard

DMRC has implemented Automatic Fare Collection System in the year 2002. The System is based on the concept of Contactless Smart Card for Multiple Journey Store Value Ticket, Contactless Token for Single Journey Ticket.

DMRC has also set up a Central Clearing House System for connecting to other Operators in the City of Delhi. The detailed in-house testing of the same is in progress. The Central Clearing House shall link the various Central Systems of Operators like:

- **DMRC**
- **Rapid Metro Gurgaon**
- **Airport Line (DAMEPL)**
- Indian Railways (CRIS), etc.

Technical discussions and interfacing with Rapid Metro & Airport Line DAMEPL are already underway and an Interoperable Ticket is planned to be launched with the Start of Operation of Rapid Metro. The Interoperable Ticket shall be same as the existing Smart Card of DMRC and it shall allow the user to use it on both the systems.

Additionally, DMRC has also launched a Delhi More Card for interoperable use on the Delhi Metro Rail and Delhi Metro Feeder Bus System. The system is in trial on 10 Feeder Buses on a particular route. The System allows the DMRC Smart Card to be used for payment on both the Metro Rail & Bus systems. After the completion of the trials, based on the feedback, further action will be taken to extend the system on other DMRC Feeder Buses.

2.1. BMRCL introduced Integrated Metro-Bus ticketing system during the launch of its services in October 2011. Due to the technology constraints of local Bus operator, BMTC, the integration is between the machine-readable fare system of BMRCL and human readable fare system of BMTC. The commuter needs to possess a smart card to avail this service. A printed day-pass called MBT is issued to the commuter which is valid for unlimited travel during a day on both BMTC buses and Metro. The paper day pass acts as a voucher for validation of smart Card at Metro Ticket counter. Once the smart card is validated, it can be used for unlimited day travel in Metro and paper day pass for travel in buses.

2.2. BMTC is planning to introduce the Intelligent Transport System (ITS) which will include use of Electronic Ticket Machines (ETM) in buses. The specifications of ETM have been taken care to accept Metro smart cards as well. Once the ITS is introduced in BMTC, both systems will have machine readable systems so integration of ticketing system through usage of smart cards will be done.

2.4. Study of Efforts made in CHENNAI:

For integrating the interoperable fare media a committee: - CUMTA is formed.

CUMTA- Chennai Unified Metropolitan Transport Authority

- CUMTA Act was Passed in 2010
- Hon. Minister (Transport of Tamil Nadu)- is the Chairman and Chief Secretary of Tamil Nadu is Vice Chairman
- Operators (MTC, Metro, Suburban Rail, CMDA) are members
- CUMTA Sets Framework for Operator Coordination and Cooperation
- Regular meetings are held with different operators to resolve issues for implementation of interoperability and use of common ticketing.
- Chennai Metropolitan Development Authority are also part of the committee. They plan for the space required for the smooth change over form one system to other.
- Presently the CMRL is in construction phase and the work of interoperability is in initial stage.
- CMRL is going to introduce the automatic ticket vending machines during the course of execution. There are issues like frequent changes in the design including material and size of coins and currency notes, which have to be addressed. The automatic vending machines are supposed to decipher the value of the coins and currency based on the structure and the problem compounds when the currencies both new and old exist for transaction.
- Also, the State Home department requires that the automatic machines have to be installed in such a way that it can be monitored by CCTV and also there is no gap in between and in the rear of the machines which can be made use of by mischief mongers. This can be an issue for the operators like city transport who opt to install automatic ticket machines.

Other Operators (Current Status)

- Manual Ticket
- No Paid Area
- Possibility of ticket less travel
- Difficulty in reconciliation of cash
- Parallel Operations
- Requirement of Feeder Services which does not merge with existing main transport system.
- Not fully scientific management.

Standards for Interoperability

The standards to be followed are as listed below. CMRL AFC will design the system in compliance with these standards and they will provide the interface requirements for achieving the interoperability.

Technical Description	STANDARD USED
Contactless Smart Card Used	ISO/IEC 14443 (Type A) and Felica (Type C)
Compliant and certified Standards	ISO 14443, ISO 7816 or ISO 18092, ISO 10373-6 and EN 1545
Shape and Physical Dimensions of Contactless Smart Card	As per ISO 7810
Base material of Contact less Smart Card	PVC or PETG
Card lifetime	5 years
General characteristics of Card	
Hardware and software security of contact- less Smart card	EAL4+
Electrical and mechanical parameters certification	ARSENAL/equivalent
Baud Rate of contact less Smart card	424 Kbps
Memory Size of contact less Smart card	4Kbyte or more
Crypto functions Supported	DES, 2Key Triple DES, 3Key Triple DES and AES
Read / Write endurance	1,00,000 cycles
Data Retention	10 years
Payment Industry Standards	PCI PED

EMV Standards	EMV
Identification Card Systems. Surface Transport Applications. Interoperable Public Transport Applications. Framework	EN 15320
Identification Card Systems. Surface Transport Applications.	EN 1545
Identification Cards -- Test Methods -- Part 6: Proximity Cards	ISO 10373-6
Identification Cards -- Contact less Integrated Circuit Cards -- Proximity Cards	ISO 14443
Information Technology -- Security Techniques -- Evaluation Criteria for IT Security	ISO 15408
Identification Cards -- Contact less Integrated Circuit Cards	ISO 15693
Information Technology -- Security Techniques -- Code of Practice for Information Security Management	ISO 17799
Information Technology -- Telecommunications and Information Exchange Between Systems -- Near Field Communication -- Interface and Protocol (NFCIP-1)	ISO 18092
Information Technology -- Telecommunications and Information Exchange Between Systems -- Near Field Communication Interface and Protocol -2 (NFCIP-2)	ISO 21481
Public Transport -- Interoperable Fare Management System -- Part 1:	ISO 24014-1

Architecture	
Information Processing Systems -- Open Systems Interconnection -- Basic Reference Model	ISO 7498
Criteria for Cards Containing Integrated Circuits	ISO 7810
Identification Cards -- Integrated Circuit(s) Cards (All Relevant Parts)	ISO 7816
Standard for Financial Transaction Card Originated Messages, Interchange Message Specifications.	ISO 8583
Card readers	ISO/IEC 14443 (Types A & B) and Felica (Type C)
SAM Slots	Minimum 4

2.5. Study of CRIS :

For Indian Railways, CRIS has already developed RFID based e-purse for availing journey in unreserved trains for the zonal Railways since 2005. Extending this purse for reserved trains and many other railway facilities is already under progress.

CRIS has replaced the old AFC system of Metro Railway, Kolkata with contactless card and tokens based AFC system in July 2011. The migration has been done seamlessly with zero downtime in business operation of Kolkata Metro. Majority of the AFC equipments are running with CRIS developed software.

As a value added service **CRIS has developed automatic ticket vending machine for Indian Railways and automatic recharge machine for Metro Railway Kolkata** to enhance customer satisfaction without any precedence.

Govt. of India announced implementation of pan India basis travel card named "**go-India Card**" in the Railway Budget 2011-2012 and development for the same is in progress. CRIS is already having its own revenue settlement mechanism in place for apportionment of revenues across 17 Zonal Railways. A separate clearing house in Kolkata is in the pipeline to cater interoperability among different mode of transports including Metro Railway, Kolkata, KMRCL, Indian Railways etc.

3. Study of multimodal ticketing system

3.1. **Hong Kong's Octopus Card:**

On the 1st of September 1997, following 3 years of development and testing, one of the world's largest contactless smartcard projects, the "Octopus" system, began full public operation. The system has been implemented and is operated by the Creative Star consortium. In less than 18 months of service over 5 million cards have been sold, over 1.2 billion transactions taken place and over $2.25 billion ($8 billion HK) of electronic cash used in the process.

Usable on urban rail (Mass Transit Railway (MTR) and Kowloon Canton Railway (KCR), light rail (KCR)), bus (Kowloon Motor Bus, City bus, New World First Bus. And KCR feeders) and ferry (Hongkong and Yaumati Ferry), the system enables individual operators to implement their own fare collection methodologies such as distance-related, flat and monthly pass schemes in both barrier-based and barrier free ticketing environments.

Each station and ferry terminal has its own local area network which connects all barriers, validator's, add-value machines, and ticket office processors to a local station computer, which is then linked to the transport operator's central computer where detailed management reports of usage, revenue and performance are produced. In the case of mobile processors, located on buses, transaction data is collected at the fuelling bays using a wireless LAN connected to the Bus Depot computer.

All transaction data are transmitted to the Central Transaction Clearing House (TSH) for reconciliation and settlement of revenue between the service providers within 24 hours. In addition, the TSH also monitors card usage history and is capable of detecting any anomalies and establishing files of invalid cards for downloading to the processing devices. Security of the system is a combination of the inherent smart card encryption and authentications between devices overlaid with fully centralised transaction monitoring and audit trail capability.

In the first few days of operations some unfamiliarity with contactless operation of the card meant that an occasional retry was necessary, but after a very short period cardholders quickly adapted and gate throughput increased by 15%-20% above the previous magnetic system. It became apparent that the feature of not needing to take the card out of the cardholder's wallet or handbag was perceived as a major convenience.

Over the first 18 months of operations, there was a higher card failure than anticipated. The failure rate is correlated to way cards are used and stored by the cardholders. The cards were manufactured and tested to current ISO standards. It is believed that a more rigorous standard is required regarding accommodating expected in-service stress applied across the plane of the chip. Such stress can occur for example if the card is kept by the cardholder in a back pocket, where bending or flexing can occur when the cardholder

sits or bends down or when the card is stored in a wallet or purse alongside a zipper or stud. A new generation of cards incorporating a strengthened fabrication technique has been introduced with substantially improved results.

While the standard ISO smartcard is accepted and preferred by the public, its small thickness of 0.76 mm imposes almost impossible constraints on the smartcard manufacturer to achieve target in-service failure rates of 0.1% per year. Embedding the chip in a watch or inserting the card in the protective envelope of a mobile telephone achieves both added value in terms of use and also provides the physical protection the chip requires.

The Octopus can be used in over 500 public telephones on MTR and KCR stations and also for the automatic photo booths also located with MTR. Expansion to other services, such as generic vending machines, is dependent upon development of a low cost reader/writer. With the huge market penetration of the Octopus card, there is much interest in expanding the applications outside of transport. Creative Starís policy is to particularly focus on those applications, which have some synergy with the core transport application. Dialog with other electronic-purse-scheme issuers is taking place although real opportunities are only likely to occur once a common contact/contactless smartcard standard is available.

In an overall sense with over 6200 pieces of equipment, 250 distributed computers, and over 4.2 million lines of unique software in the system there were occasional teething problems, but overall the system has performed well with only a few deep and intermittent problems still under investigation. One should not, however, underestimate the challenges in bringing such applications from concept to reality.

3.2. **LONDON'S OYSTER CARD:**

Launched in 2003, the Oyster Card is a contactless prepaid card for London's Tube, buses, DLR transport systems. It is issued by London's transport authority, Transport for London, and managed by TranSys, a consortium of technology providers including EDS, CTS, Fujitsu, using open-source architecture.

The Oyster Card provides passengers with a convenient single-journey prepaid wallet or season passes. It can also be issued as a dual interface card in conjunction with Barclay's contactless One Pulse program, which links the Oyster transport card with a Barclay's Visa credit card on a single card. This allows users to use their Oyster Card for purchases at any retail outlet.

The Oyster card uses the Philips MIFARE 1k ISO 14443 (RFID) Type A 13.56 MHz contactless smart card standard. The system is a proprietary closed system, run by TranSys. TfL uses anonymous information from the Oyster data to understand journey patterns, and has been investigating the possibility of using Oyster journey data to measure system reliability and crowding

levels. TfL has also begun to analyse full journey patterns, e.g., how people make end-to-end trips from Tube to bus, using Oyster data. TfL encourages customer to register their Oyster card to protect it if lost or stolen (a registered card can be cancelled with a replacement product issued). TfL mandates registration for high-value ticket products (monthly or longer period season tickets). An Oyster card can hold up to three "products" at the same time. These may be Travel cards or bus passes, and PAYG. Four main factors affect the price of the ticket when paying with the Oyster card:

- In how many zones the ticket is valid
- When (time of day and weekday) does the journey take place
- Which transport mode is used
- Season ticket validity

TfL manages the accounting and revenue allocation between modes within TfL (e.g., bus, Tube, DLR, etc.) and between TfL and the TOCs on TfL products. The allocation is done based on both actual travel (as measured by Pay-as-you-go journeys) and surveys of Travel card users to capture journey behaviours of customers.

By October 2007 more than sixteen million Oyster cards had been distributed In September 2007, Oyster card journeys represented around 73% of bus and Tube journeys Increase of passenger flows at gates (up to 25 passenger per gate per minute vs. 20 with magnetic tickets) Reduction of fraud in London Underground

3.3. Other cities where such systems are working are-

- ***Clipper* in San Francisco**
- ***Ez-link* in Singapore**
- ***T-Money* in Seoul**
- **Paris ticket t+ in Paris**
- ***Touch 'n Go* in Kuala Lumpur**
- **SUICA and PASMO in Tokyo**

3.4. POST-PAYMENT & OPEN PAYMENT SYSTEMS

For some systems, the trend is also seen towards the use of *Account Based Systems* and *Open Payment Systems*. Within the European Commission the proposals currently being drafted will be based around centralised account based systems in order to achieve the maximum intermodality in transport agencies of the different nation states.

3.4.1. Account Based Systems

In Account Based Systems the value loaded by the traveller is deposited not in the card itself but in the Back-office systems. This gives us a number of important advantages in the system:

- Improved Fare Policies – The use of an account based system allows for more attractive fare products such as Fare Capping, not only on a daily basis, but per week, month or even per year
- Intermodal & Interagency operation – Complex clearing rules for the division of revenue can be implemented in the back-office and are carried out off-line.
- Faster Validation Times – As the fare calculation is made in the back-office this reduces the processing needed at the local validation device.
- Simpler Validation Devices – As less processing is needed at validation the validation devices in the field do not need to have such a powerful CPU.
- Lower card costs – As the card is used only as a token to identify the traveller large data capacity and processing power are not needed.

All travellers using this system need to operate using a card registered in the system. This card can be personalised, especially in the case of Reduced Fares (OAPs, Students, etc.), or anonymous.

Each card is linked to an account in the back-office system which contains either the value pre-loaded to the card, or the credit available to the customer.

The card itself can either by a transport agency issued card or could be a third party card such as a Student ID card managed by a University or an Employee Security ID badge for large companies which negotiate a reduced travel rate or have pre-tax travel benefits.

NFC phones and other ISO14443 compatible devices could be used and would be linked to a centralised account in the same way as any other card. Additional over-the-air functionality could be designed for these devices allowing balance checks and reloads of the account.

Some Account Based systems use only the serial number of the contactless card as the identification of the passenger. A slightly better system would be to have a very light application installed on the card which will add an extra level of security and if well designed will not unduly penalise transaction times.

Specifications for the system should not limit the choice of the card or chip used but should define a framework allowing the choice of different form factors and devices which will allow the system to work correctly and securely.

Value is loaded to the account by multiple means: at a TVM or Ticket Office, through the internet web page, from a mobile device or automatically by an

auto load feature triggered periodically or when the balance falls below a specific level. Most agencies are promoting the use of auto loads and reloads using internet/mobile devices in order to eliminate cash handling costs. In some cases they do not allow reloads to be made in TVMs or Ticket Offices.

Online reloads can be made by direct debit to the bank or credit card account and new up and coming payment means can be considered such as intermediaries and aggregators like PayPal, Amazon Flexible Payment Systems or OboPay, and virtual currencies like Facebook credit. With the growth of Internet commerce new payment means are being continuously developed and improved, by using a centralised system implementation and evolution of these new means as they become available is simplified as these only need to be included in the back-office.

On using the card the validator only has to check the validity of the card and that it has not been included in a black-list but no fare calculation is made at this time. All transactions for either tap-in or tap-in/tap-out systems are transmitted to the central back-office for post-processing.

Once all transactions have been uploaded the system will first carry out journey reconstruction to understand the full extent of the travel made. A journey can be made up of a number of different trips with transfers between them either within a single transit agency or as a multi-mode / multi-agency journey. Depending on the fare policy required these transfers can be free or at a reduced rate. Once the full journey has been reconstructed the cost of the journey can be calculated and the division of the revenue between the different agencies involved.

Traditionally fare products allowed for single tickets, return tickets, multi-trip tickets or period passes. The more trips involved potentially allowing for a lower individual trip cost so helping to promote the use of public transport. However the decision of which fare product to be used had to be made before travel was taken and led to a socially unfair system where the poorest members of the travelling public could not benefit from the best prices even if they travelled every day as many cannot afford the outlay for a period pass as they may only have the money to pay for the current day's travel.

The use of the Account Based System changes the paradigm of the fare policy and while it can be used to build a fare policy mirroring the current system it will tend towards a simpler, more effective, system where the fare is calculated in post-processing. In this case the account will be loaded only with monetary value instead of trips and passes and after carrying out journey reconstruction will analyse the journeys made by a user over different periods of time in order to apply the most appropriate fare. As an example, if a traveller makes a single trip then he will be charged the base fare for this trip; if within the same day he makes the return trip then this can be calculated at a reduced price; if he travels on multiple trips over a period of time then each of

these will be progressively charge less to give the pricing equivalent to a multi-trip ticket; and finally if he travels every day to and from work on public transport he will initially be charged as per the multi-trip ticket until he reaches the cost of a monthly pass at which point a *Fare Cap* will be made and he will be able to travel for the rest of the period at no additional charge. In this case as long as a there are funds in the account (which could be loaded on a daily basis if necessary) then the most needy users will have access to the best fares if they are frequent travellers.

The fact that you do not have to decide before hand is a great motivator for the travelling public and the post-processing allows for a fairer use of the system; both of which can help increase customer satisfaction and usage of the public transport systems.

When journey reconstruction and fare calculations are made at the higher levels this allows the use of complex interagency rules creating an integrated fare policy coming from bilateral; regional; or national agreements between agencies. When using traditional card-based, rather than account-based, systems these calculations cannot be made locally at validation without penalising the transaction time, either creating queues in the stations or increasing the dwell time on boarding the bus.

The system is intrinsically more flexible and more “coherent”. As the fare calculations are made at a higher level all of the available data will be taken into account in order to apply the best fare. As these rules are defined at the higher level they do not need to be distributed to the thousands of different devices that will be used for validations in the field. In this way it is faster and easier to modify fare products, introduce new rules or products for special events. The system will have inputs from all the different transport modes as well as others such as parking so that a Park-and-Ride fare can be implemented which gives reduced parking rates only if the passenger has actually travelled after parking the car.

The trend towards “Account Based Systems” which allow post-payment is now beginning to be deployed in few cities around the world. London will soon be rolling out a system, WMATA in Washington is tendering for one, and St Louis, Missouri (USA) is now deploying an account based system capable of intermodal operation.

The Account based Systems have a good future. However, they have a difficulty when it comes to Single Journey Tickets. Hence purely an Account Based System has its limitations in practical deployment.

3.4.2. Open Payment Systems

The other major advance being seen over the last few years is the use of *Open Payment Systems* where the transport system takes advantage of the

banking industry's role-out of contactless debit cards. These devices are designed for micro-payments as a contactless card and the transport industry is one field where they expect them to be used. All the major card brands now have a contactless debit card such as Visa's Pay Wave, MasterCard's Pay Pass and American Express' Express Pay.

These cards are especially interesting for occasional users as in a well-designed system they need no pre-registration nor do they need the passenger to purchase any fare product but simply tap-in (and tap-out if necessary) at the gate or validator and they are automatically charged the value of a single ticket.

In order for these systems to be a success the banks need to promote them heavily so that they become the payment means of-choice for small payments.

The use of these cards creates a cost saving in the required infrastructure as the TVMs are not required for their use so reducing the capital cost investment and the operating costs of the equipment. The access gates and validation devices may be slightly more expensive to purchase due to the need for bank certified readers. The cost of the operation itself will include the fee from the banking industry for processing each operation (which varies from country to country and will depend on the individual deal negotiated between the transport agency and the bank), while this will be compensated by a reduction in the handling costs of cash.

Wherever possible, the system will aggregate open payment fare transactions generated using the same payment instrument to reduce processing fees. On first use, the system will perform a pre-authorization against the payment instrument and begin transaction aggregation. Transactions will be aggregated

over a specified time period and up to a specified value. These aggregation rules can vary by determining the card type through the Primary Account Number (PAN).

Open Payment schemes are being slowly rolled-out by regions in the US and in Europe where, for example, in London they are widely distributed and can start to be used in London Transport and in Barcelona where they are being launched and the Metro and other means are adapting the systems to allow them to be accepted.

An Open Payment system can co-exist with an Account Based system, theoretically the Open Payment device could be used as a registered card for the user. However the most forward thinking systems have them working in parallel so that occasional users, or those from out of town, can turn up and go travelling with their contactless debit card without the need to buy any specific fare product, while the frequent users

will use a specific transport card in order to access the discounted rates for frequent travellers.

4. Study of role of bank and mobile service operator for implementing the multimodal ticketing system

The Bank becomes a necessity, when features such as Top up through Bank Account, Payment through Internet Gateway, Auto top-up etc. are added to the AFC System.

Hence, it is desirable to have a Bank linked to the System for the following added features:-

- Issue of Combo card having transit card as well as bank card
- Sale of Transit card issued by Card issuer
- Add value on card using following channel
    - Net Banking
    - Credit Card
    - Debit card
    - Pre-Paid Card

Care must be taken when considering the use of financial cards as the AFC support. These cards require equipment to have additional certification and homologations which may notable increase the overall cost of the system. These convergence projects need to be handled very carefully in order to assure that the public transport needs are protected

4.1. **DMRC had interaction with Banks for the following:**

4.1.1. DMRC issued a Co-Branded Card with Citi Bank in 2008. The same card could be used as a Magnetic Strip Citi Bank Credit Card and also as a DMRC Smart Card. There was no electronic linkage between the two. However, the response to the Card has not been very encouraging over the years.

4.1.2. DMRC has finalised the Bank (ICICI) and has also introduced Top up through Internet. Soon DMRC shall introduce facility of Auto Top up through AFC Gates. Additionally, DMRC has made its Central Clearing House Functional and interacting with the Transport Department of Delhi for the possi9bility of Inter-Operable Ticket for Metro and Buses.

4.2. **Existing BMRC arrangement with Banks and Mobile Operator:**

4.2.1. BMRC has tied up with State Bank of India, Federal Bank and ICICI Bank for integrating its AFC system. (Layout in annexure-1)

4.2.2. The scope of banks is to provide the following services-

- Providing of EDC POS terminals at ticket counters and Automatic Ticket Vending machines
- Topping-up of smart cards at ATMs
- Topping-up of smart cards through Net banking and Mobile banking
- Topping-up of smart cards through Payment gateway at BMRCL website
- Topping-up of smart cards through Auto-top up using Standing Instructions from Bank customers / commuter.

4.2.3. Bank will also issue combo-cards (Multi-interface) to its customers. These combo-cards combine the above Contactless Smart Card application with that of the debit /credit card application issued by bank in one single card. These cards have both - the CSC features required for the AFC application as well as the Magnetic strip/ EMV functionality that is necessary for banking related applications. This provides convenience to the commuters and relief from carrying of two different types of cards.

SBI Debit-cum-transit card (Combo card)

4.2.4. BMRCL has tied up with Airtel for allowing Metro commuters to top-up their smart cards through any Airtel retailer in the city. The commuter need not be Airtel customer. Further Airtel customers who are holding

Airtel Money account can directly transfer money from their Airtel Money account to Metro smart card. Airtel retailers capture the smart card number on their mobile handset and take the cash from customer for the value to be loaded on the card. This information is sent by retailer to Airtel who in turn sends it to BMRCL.

4.2.5. CMRL is about to finalize Acquirer Bank. The Bank is to issue the Combo Card as well. CMRL is also deliberating the issue of media including topping up through Franchisee as in case of Mobile operators. BMRCL experiment with Airtel Money is worth studying.

4.3. **Role of Banks:**

4.3.1. Recent developments in the mass transit and financial payments industries have created opportunities for convergence and collaboration. For example, the financial payments industry is focusing on expanding its share of the micropayments market and making the necessary changes in business rules and practices to foster that expansion. Some transit agencies, who are seeking further improvements in customer service and operating efficiencies, are looking beyond their successful fare collection systems toward reducing, though not eliminating entirely, their role as a payment media issuer and transaction acquirer and becoming more like a retail merchant in an open payment system. This notion overlaps a broader transit industry goal to facilitate regional travel through open, interoperable fare payment in a way that is both convenient for customers and efficient for transit agencies.

4.3.2. The Banks are thus too keen to enter into the transit market. In the present dispensation the banks are only acting as a partner to distribute the combo cards. The ownership of card lies with bank, but the transit product on the card is owned by transit operator. Probably we can think of giving preferential treatment to passengers having links with Acquirer Bank e.g. separate queue so that we reduce the rush at the counters. Banks will see this as value addition and probably will pay higher royalty.

4.3.3. Implementation considerations for this approach to transit fare payment center more on business and operations rather than on issues arising from technology definition, standards, and technical infrastructure. In the context of accepting traditional, unaltered financial payments solutions, the three key issues that emerge for transit agencies are-

- transaction time
- online authorization
- Risk management**.**

4.3.4. In the case of credit/debit cards the authentication of every transaction is done online which requires minimum 2 seconds. In the case of transit operations, this is too long a time and will result in lower throughput of commuters. Any fault in online verification will bring down the system. Hence most AFC systems are designed for off-line working where authentication is between media and media reader. (Card-Gate in Metro, or Card-ETM in buses).

4.3.5. In Seoul, the T-Money cards are normal credit cards which contain contactless interface. The commuters flashing their cards in Metros and buses are allowed to travel on credit based on some bare-minimum off-line authentication between card and reader. The settlement is done at the end of the day. The credit rating of commuters is already done by card issuing companies and they take the risk of customer default. Such business model cannot be applied in India at this stage as financial inclusion in terms of basic banking is still inadequate, while credit card holding is at the end of the value chain.

4.3.6. The banks can issue multi-interface cards where the money resides in a common e-purse which is owned by a common Central body. The float of this e-purse is the biggest bone of contention. However a special purpose vehicle with joint ownership of all stake holders can be a way forward to address this issue.

4.3.7. Simultaneous with these developments in transit sector, the financial industry is introducing new payment media and is beginning to address the low value transaction (micropayments) market:

- The financial industry is now issuing contactless credit, debit and prepaid cards and other form factors such as fobs, targeting markets in which consumers typically use cash and where speed and convenience are critical.
- American Express, MasterCard, and Visa have implemented new programs and rules for certain merchant categories which perform low value transactions; these programs and rules may also apply to contactless credit and debit transactions. The new programs make financial payment products more attractive to consumers and merchants in markets that traditionally have used cash.
- New services and payment models, including aggregation of transactions and establishment of prepaid accounts, are being offered that may provide more cost effective processing for low value transactions.

4.3.8. The banks can thus also be a part of this process where they take care of aggregation of financial transactions, which is their strength, and apportion the amount among all the stakeholders.

4.4. Role of Mobile Operators:

Mobile Operators can also be used as a channel for payment for the AFC Ticket. However, as Near Field Communication Enabled Phones are yet not affordable, no Mobile Operator is in a position to adapt to the AFC Ticket Media. For NFC phones to work on already operational systems, like Kolkata Metro, DMRC & BMRCL, it will require changes in the Metro Systems and linkage with the Mobile Operators at the CCHS level. There issues of revenue sharing with the Mobile Operators and also the transaction times in use of Mobiles on Metro Devices. Only after the Mobile Operators move in a big way to NFC and the NFC Phone sets become affordable, can a Mobile system be used for Inter-Operable media. System in CMRL and BMRCL is compliant to NFC.

The mobile companies want to enter this market either through their mobile wallets or through Near Field communication (NFC). Airtel has already launched its m-wallet called Airtel Money. Other companies are also planning to follow the suit. If Mobile Operators enter as m-wallet provider, then they either act as repository of money or they substitute existing card. In the former case both m-wallet and card co-exist. In the latter case the role of card is taken over by m-wallet. Every transaction done through handset (preferably NFC) needs to be reconciled and settled through a common Central Clearing House. The NFC is in pilot scale in many monetary and non-monetary applications in many cities around the world. The issues related to NFC are –

- Chip to be part of mobile handset, or
- Chip to be part of SIM, or
- Chip to be independent of both, and may reside separately as memory card or sticker

4.4.1. Depending upon the chip-residency the control is in hands of handset manufacturer or Telecom service provider or independent of both.

4.4.2. NFC service provider can also be integrated to CCHS and the issuance function of NFC can be centrally controlled by CCHS. The add value function can be enabled through a mobile application.

4.4.3. The ubiquitous nature of mobile handset gives it a very promising future in terms of NFC, yet the issues are yet to be fully resolved. However NFC also requires a common Central Clearing House where all the transactions of mobile application usage need to hit and get reconciled.

5. Study of the issues (such as revenue sharing mechanism) which have become stumbling block so far in the implementation of such system

5.1. Any business model of multi modal transport needs to be implemented through multilateral body to address the issues of all stakeholders. ISO 24014-1:2007 has already detailed the various stakeholders and their broad roles and responsibilities.

5.2. The float money which resides in e-purse of every cardholder till it is actually consumed can be held in the account of Common Central body (SPV). The sharing of interest earned on this amount can be based on the volume of transactions generated by each service provider.

5.3. The other point of contention arises when a passenger pays a single fare for both bus and Metro. Generally the fare structures are so designed that fare per km reduces for longer distances of travel. The fare to be apportioned to each bus and Metro service provider in this scenario needs to be done as per best practices followed elsewhere.

5.4. There is a large mass of Smart Cards already in circulation in DMRC System (around 7.5 million). These cards are to Sony Felica & ISO 14443A Standard and the system is designed to read these cards. In case, any other card is introduced, then there is change required in the system for software/hardware. The new Card (e.g NCMC) can only be usable , once the change is done at all the Device level and a major change is done to the Central System to link to proposed TSH of UTIITSL for transactions, parameters, key management, etc.

5.5. Addition of one more card will surely impact the performance of the throughput of the system. The exact details can only be known once UTIITSL completes its trials with the actual implementation in Bangalore Metro. This is further linked to establishment of a CTSH or the city level clearing house to start with.

5.6. As the addition of one more card shall require a major change in the DMRC System, it can only be done in the night so as not to disrupt passenger traffic. There are around 6000 devices in the field. Hence the time and money required will be handsome.

5.7. Nevertheless , even to start with the trials for Integration in Lab environment , the following is required to start with:

- Finalization of the TSH
- Publication of the TSH to Other System Interface specifications.
- Design & Development by other operators to match the TSH Interface.
- Testing & Implementation.
- Finalization of the Vendor for Key Management System
- Publication of the KMS & SAM specifications. Handover of SAM's
- Design & Development by other operators to use the SAM.
- Testing & Implementation.
- Card layout Finalization & handover of Sample cards
- Issues which need immediate attention:
- Who will keep the Money?
- How to share the profit/loss generated from Money (Float)?

- Who will bear the cost of Media i.e. Cards
- Who will share the cost of the SAM's.
- Will all Operators be able to read all areas ? The process to issue Products of each other and refund products of each other.
- Time required to credit money from bank to Card issuer account
- Settlement time between card issuer and Transport Operator
- Transaction fee, to be charged by Card issuer from Transport Operator
- How to issue security keys : Operator wise or equipment wise
- How to change the Security Keys
- Revenue settlement in degraded mode i.e. When network connectivity is down.
- Settlement of missing transactions
- How to update revenue report after missing transactions are settled
- Service charges/Transaction fee charged by Banks/telecom operator
- RBI clearance, if any.

6. Study of vendors who can provide AFC system with compatibility with money transfer through mobile phone, common card and tokens

- AFC System Companies like Thales, Samsung, Indra, Singapore Technologies, ACS, VIX, Telvent, Siemens, ATOS, CUBIC, NIPPON SIGNALS etc. are well experienced in this field.
- There are many vendors in traditional AFC market. Some of these who participated in tenders of various Metro Rail companies either in the form of technology supplier or local implementation support are listed below :-

1. Telvent Trafico y Transporte, Spain
2. HCL Infosystems Ltd. India
3. Indra Sistemas S.A., Spain
4. Thales Transportation systems S.A., France Thales International India Pvt Ltd, India
5. IBM India Pvt. Ltd, India LG CNS co Ltd, Korea MSI Global Pvt Ltd, Singapore
6. M-tech Innovations Ltd, India Hyundai Information Technology Co. Ltd. Korea
7. Singapore Technologies Electronics Ltd. Singapore
8. AP Trans, Belgium Prodata Systems, Belgium

9. ACS Solutions Switzerland Ltd. Kerala State Electronics Development Corporation Ltd, India
10. Samsung SDS Co. Ltd. Korea Kalindee Rail Nirman (Engineers) Ltd. India
11. Nippon Signal Co. Ltd. Japan Mitsubishi Corporation, Japan
12. Tata Consultancy Services Ltd. India ERG Transit Systems Ltd.(now VIX) Australia
13. Cubic Transportation Systems, Inc. San Diego, California, USA
14. Ingenico International India Pvt Scheidt & Bachmann GmbH**,** Mönchengladbach, Germany

6.1 The extent of participation shows the level of competitiveness in the market. The Indian companies which were consortium members did not have any prior experience of AFC systems (except for Kalindee Rail Nirman Ltd.,Keltron) and hence they joined with other foreign companies having experience in this field. Centre For Railway Information Systems, an organization of Ministry of Railways, is also working with these technologies like AFC, Mobile Ticketing, Automatic Ticketing Machines etc .

6.2 The AFC systems consist of both hardware and software parts, of which the crucial hardware part is Automatic Gate. The gates need to provide throughput of passengers as high as 50 per minute. The downtime is least acceptable to any transit operator as it directly affects the flow of traffic.

The integration of AFC system with mobile phone companies, common card or a media of some other company basically requires having an open interface between the two entities. The security and privacy are other considerations which need to be looked into while integrating these systems, as any organization joining into this framework would be wary of these aspects because of its own policy and contractual obligations at home.

7. Identifying constraints in process of indigenous development and evolving strategy for placing development orders for assemblies / systems / subsystems

7.1 Transit AFC systems handle a number of functions, including issuing the payment instrument, applying agency-specific rules for determining the fare to be charged when the payment instrument is used, and processing the payment. Transit AFC systems have a number of critical requirements, including:

- Fast transaction speeds

- Transit fare policy support and pricing flexibility
- Data integrity and customer service
- Reduction in cash handling
- Data security and user privacy

7.2 The software part is usually linked to the business rules which are applied in AFC systems. Building up an application based on these rules is not something extra-ordinary and many Indian software companies can do it. What is required is exposure to such systems before a full-scale deployment can be considered. Being a revenue related matter, no operator would risk going with a new entrant in this field. The work could be taken up by the companies in access control and related security applications to scale up to a low-level AFC system. Over a period of time the expertise can be built through exposure and experience.

In 2007 CRIS started developing an AFC system which can meet the requirement of Metros. The solution was developed in Kolkata Metro in a phased manner. A significant progress has been made in this direction as Kolkata Metro AFC system is using majority of the software (Including KMS) developed by CRIS.

7.3 The Automatic Tickets Vending Machines are facing the problems of continuous changes in size and weight of Indian coins. The coin validators deployed in such machines cannot distinguish between old 50 paisa coin and new ‘ 1 coin. Similarly old ‘ 1 and new ‘ 2 are similar. It is difficult for vendors including Indian vendors to upgrade their systems to adapt to such frequent changes.

8 **Security aspects**:

8.1 The security of the AFC system needs to be evaluated in the light of various ISO standards-

a) ISO 15408:1, 2 & 3 - “Common Criteria for Information Technology Security Evaluation (CC)”.

b) ISO 18045 - a companion document to ISO 15408

c) ISO 27001 – Information Security Management system

d) ISO 17799 - Information Technology -- Security Techniques -- Code of Practice for Information Security Management

8.2 ISO 15408 standard will be primarily used to define the following aspects of AFC system –

a) Security Objective

b) Security Target (ST)

c) Protection Profile (PP)

d) Threats and Countermeasures

8.3 Security Objective:

a) Security Objective will need to be defined for AFC system. It is a statement of intent to counter identified threats and/or satisfy identified organization security policies and/or assumptions.

b) It requires defining of Security Problem in the form of a statement, which in a formal manner, defines the nature and scope of the security that the object under security evaluation is intended to be addressed.

c) The object under security evaluation is called “Target of Evaluation” (TOE). It includes -

- A smart card integrated circuit e.g. the chip inside the smart card;
- An operating system (OS) e.g. card OS;
- The chip in combination with an OS;
- A software application e.g. Transit application on card;
- A software application in combination with an OS and a workstation;
- The cryptographic co-processor of a smart card integrated circuit.
- A Local Area Network including all terminals, servers, network equipment and software;

d) Examples of security objectives for the TOE are:

- The TOE shall keep confidential the content of all files transmitted between it and a Server;
- The TOE shall identify and authenticate all users before allowing them access to the Transmission Service provided by the TOE;
- The TOE shall restrict user access to data according to the Data Access policy to be formulated as per IT Security Policy.

8.4 Security Target:

a) The Security Target (ST) is the central document for the specification of the security capabilities of a product or system. It serves as a specification for the evaluation as it contains both security enforcing functions and evaluation requirements.

b) The evaluation requirements are stated by referring to one of the seven hierarchal evaluation assurance levels EAL 1 to EAL 7.

c) Usefulness of the results of an evaluation strongly depends on the ST, and the usefulness of the ST strongly depends on the quality of the security problem definition.

d) It is therefore often worthwhile to spend significant resources and use well-defined processes and analyses to derive a good security problem definition.

e) The security problem definition shows the threats that are to be countered by the TOE, its operational environment, or a combination of the two.

8.5 **Protection Profile**

a) A Protection Profile (PP) is typically a statement of common set of security needs. It gives users a means of referring to this set, and facilitates future evaluation against these needs.

b) Therefore only when a specific IT product meets the required PP, it can be considered for induction into the system.

c) ISO 15408 also allows Multiple Protection Profiles i.e. PPs to conform to other PPs, allowing chains of PPs to be constructed, each based on the previous one(s). For instance,

- PP for an Integrated Circuit (IC) and
- PP for a Smart Card OS,

can be used to construct a PP for Smart Card (IC and OS both). Thereafter a PP on Smart Cards for Public Transport can be written based on –

- PP for Smart Card and
- PP for Applet Loading

Finally, a developer can then construct a Security Target based on the Smart Cards for Public Transport PP.

8.6 Threats:

a) A threat consists of an adverse action performed by a threat agent on an asset.

b) Examples of threat agents are hackers, users, computer processes, and accidents. Threat agents may be further described by aspects such as expertise, resources, opportunity and motivation. In case of AFC system –

- Expertise with threat agents lies in the knowledge and experience of working with technology of smart cards.
- Resources at the disposal of threat agent are limited if the operational environment housing AFC system is isolated from outside network both physically and logically. However in case of smart cards, the resources at his disposal for attacking the card are unlimited as these cards are in his custody.

- The opportunities available are also similarly related to the operational environment of entities of AFC system. Any entity including cards and value adding machines kept out of secure environment provide more opportunities and time to attack them.
- The monetary aspect associated with the value on cards is biggest motivation.

c) Examples of threats include:

- a hacker (with substantial expertise, standard equipment, and with motivation to do so) remotely adding value to smart cards;
- Any other surreptitious card operation
- a worm seriously degrading the performance of a server or wide-area network;
- Denial of service
- a system administrator violating user privacy;
- Manipulating or sniffing on RF communication link between card and reader.
- sniffing on confidential electronic communication on internet or intranet.
- a business partner of multi-modal system raising inflated claims based on tampered records.

d) An IT product connected to an entrusted network exposes itself to threats from that network. A trusted channel ensures means by which one trusted IT product can communicate with necessary confidence to another.

e) An IT product may be incorrectly designed and implemented, and may therefore contain errors that lead to vulnerabilities. By exploiting these vulnerabilities, attackers may still damage and/or abuse the assets. These vulnerabilities may arise from accidental errors made during development, poor design, intentional addition of malicious code, poor testing etc.

8.7 Countering threats:

a) The attack potential of threat is a measure of the effort to be expended in attacking a TOE, expressed in terms of an attacker's expertise, resources and motivation. Accordingly countering a threat can be any of the following –

- Removing that threat
- Sufficiently diminishing that threat
- Sufficiently mitigating that threat.

b) Examples of removing a threat are:

- removing the ability to execute the adverse action from the threat agent;
- moving, changing or protecting the asset in such a way that the adverse action is no longer applicable to it;
- removing the threat agent (e.g. removing machines from a network that frequently crash that network).

c) Examples of diminishing a threat are:

- restricting the ability of a threat agent to perform adverse actions;
- restricting the opportunity to execute an adverse action of a threat agent;
- reducing the likelihood of an executed adverse action being successful;
- reducing the motivation to execute an adverse action of a threat agent by deterrence;
- requiring greater expertise or greater resources from the threat agent.

d) Examples of mitigating the effects of a threat are:

- making frequent back-ups of the asset;
- obtaining spare copies of an asset;
- insuring an asset;
- ensuring that successful adverse actions are always timely detected, so that appropriate action can be taken.

e) Countermeasures are imposed to reduce the risks to assets. These countermeasures may consist of

- IT countermeasures (such as firewalls and smart tokens) and
- non-IT countermeasures (such as safeguards and procedures).

f) The ISO 27001 and ISO 27002 standards provide general discussion on security countermeasures (controls) and how to implement and manage them.

8.8 **Sufficiency of the countermeasures:**

a) The sufficiency of countermeasures depend upon the security objectives for the TOE.

b) Significant security can often be achieved through or supported by administrative measures such as organizational, personnel, physical, and procedural controls.

c) **The organizational security policy through set of security rules, procedures, or guidelines for the environment in which the TOE is operated can determine the sufficiency of**

countermeasures. A policy may pertain to a specific operational environment only.

8.9 Certification Process:

a) The ISO 15408 standards providing a common set of requirements for the security functionality of IT products and for assurance measures applied to these IT products during a security evaluation. These IT products may be implemented in hardware, firmware or software. The committee is of the opinion that security certification of both hardware (Chip) and software (OS) is required but need not be composite security certified. OS may also be third party security certified.

b) The evaluation results may help consumers to determine whether these IT products fulfill their security needs and is useful as a guide for the development, evaluation and/or procurement of IT products with security functionality.

c) It is the duty of certification body to ensure the equivalence of all certification results. Therefore evaluations aimed at certification have to be performed by evaluation facilities licensed by the Certification Body and is specific to a particular set of criteria.

d) The certification process is the independent inspection of the results of the evaluation leading to the production of the final certificate or approval, which is normally publicly available.

e) While the evaluation process establishes a level of confidence that the security functionality of the IT products and the assurance measures applied to these IT products meet these requirements, the certification process is a means of gaining greater consistency in the application of IT security criteria.

9 Report of study addressing above issues, analysis, recommendations and way forward for faster local capability / capacity building

9.1 The report addressing the above issues and analysis is given in preceding paras.

9.2 A lot of Metros are planned for tier-II cities. Apart from that BRT projects using AFC system are also planned in smaller towns and cities. It is recommended to involve local companies for smaller AFC systems which are scalable when the network grows. Preference in procurement from Local Vendor.

9.3 Involvement of Technical Institutes for development of Local solution (Hardware and Software).

9.4 Discussion with NIC, if Card Operating System can be developed by them for both Transit and non-Transit Operators.The architecture of all AFC systems to be standardized so that integration to city level city Transaction Settlement House (CTSH) remain easy.

9.5 The Central System of Multimodal ticketing should cater to legacy systems which are already in operation. The up gradations in architecture of CTSH should be such that it should not affect the existing AFC systems.

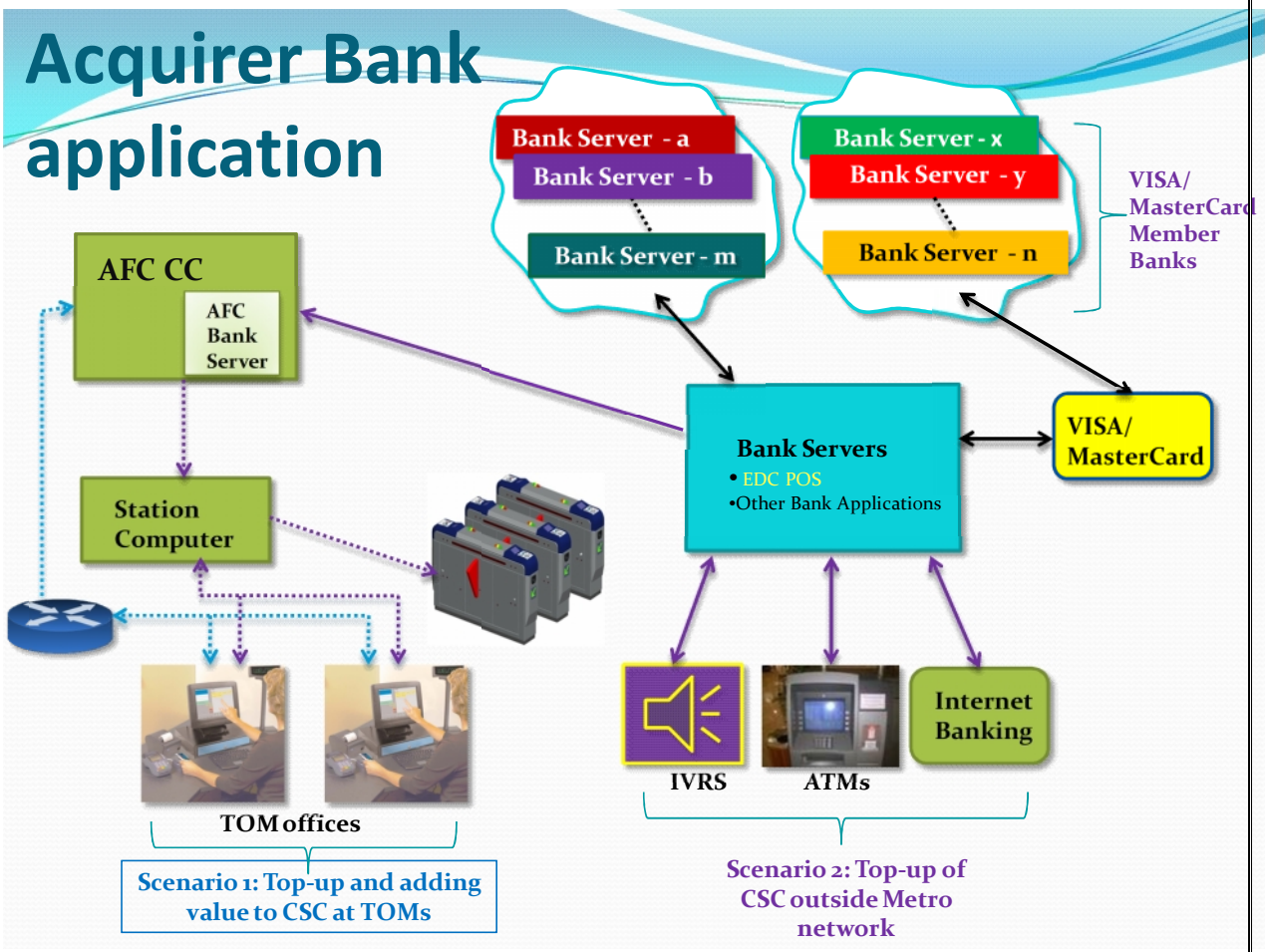
9.6 Once standards are tested involving local companies in upcoming smaller projects, these can be evolved so that these companies are able to take up the role in expansion of Metros and buses of larger cities.

9.7 The AFC system in a multi-modal transport environment envisages a number of stakeholders. The roles and responsibilities of each of them are defined to ensure proper co-ordination among all of them. However the stakeholders rely on the integrity and confidentiality of data generated and exchanged between various entities either owned individually or shared among them. Therefore security of the whole eco-system is linked to the level of security desired at different levels for different entities. The role of Security Manager as defined in ISO 24014:1 assumes significance to address the security aspects in a comprehensive manner. The list is exhaustive starting from chip of the smart card, the OS on the chip, applications running on Smart card, operating environment of AFC system consisting of servers, network, Automatic Gates, fixed or handheld validators etc. The IT security certification for each of these will depend on Security Target and Protection Profiles defined for these in consultation with all stakeholders.

9.8 Currently the existing Metros in India are using smart cards that have composite certification for both chip and operating system, since the supplier is same for both. However if a national standard is developed which provides for a separate operating system which caters to chips of any vendor, then the operating system needs to undergo the security evaluation and certification process to ensure that both chip and OS are trusted systems operating in a secure environment. While security certification of both hardware (Chip) and software (OS) is required but need not be composite security certified. Software may also be third party security certified.

9.9 The progress in the field of Account based systems and Open payments systems in transit industry will pave way for a model where the onus of handling micro-payments and ticketing system shifts to financial institutions or to Special Purpose Vehicles with multiple stakeholders. While most of the legacy AFC systems operate in a quasi-offline environment, the recent developments in the field of communications will overcome the challenges of online working. In a transit environment, no transit operator can afford to see its passengers lined up due to network breakdown, the open payments model will come out with solutions which address the twin challenge of availability of system and throughput of passengers.

Annexure-1


Acquirer Bank application
Bank Server - a
Bank Server - b
Bank Server - m
Bank Server - x
Bank Server - y
Bank Server - n
VISA/ MasterCard Member Banks
AFC CC
AFC Bank Server
Station Computer
Bank Servers
• EDC POS
•Other Bank Applications
VISA/ MasterCard
TOM offices
IVRS
ATMs
Internet Banking
Scenario 1: Top-up and adding value to CSC at TOMs
Scenario 2: Top-up of CSC outside Metro network

Bank connectivity diagram introduced in Bangalore Metro

Annexure-2

Abbreviations:

AFC	-	Automatic Fare Collection
ISO	-	International Standard Organization
MMT	-	Multi Modal Ticket
DMRC	-	Delhi Metro Rail Corporation
BMRCL	-	Bangalore Metro Rail Corporation Ltd.
DIMMTS	-	Delhi Integrated Multi Model Transport System
MoUD	-	Ministry of Urban Development
DAMEPL	-	Delhi Airport Metro Express Pvt. Ltd.
CRIS	-	Centre for Railway Information System
BMTC	-	Bangalore Metropolitan Transport Corporation
MBT	-	Metro Bus Transit
ITS	-	Intelligent Transport System
ETM	-	Electronic Ticketing Machine
CUMTA	-	Chennai Unified Metropolitan Transport Authority
MTC	-	Metropolitan Transport Corporation
CMDA	-	Chennai Metropolitan Development Authority
CMRL	-	Chennai Metro Rail Ltd.
CCTV	-	Close Circuit Television
EMV	-	Europay, Master Card and Visa
PCIPED	-	Payment Card Industry PIN Entry Device
PVC	-	Polyvinyl Chloride
PETG	-	Polyethylene Terephthalate
DES	-	Data Encryption Standard
EN	-	European Standard
IEC	-	International Electro Technical Commission
MTR	-	Mass Transit Railway
LAN	-	Local Area Network
TSH	-	Transaction Settlement House
PIN	-	Postal Index Number
Tfl	-	Transport for London
PAYG	-	Pay As You Go
EDC	-	Electronic Data Capture
POS	-	Point of Sale
ATM	-	Automatic Teller Machine
NFC	-	Near Field Communication
CCHS	-	Central Clearing House System
SPV	-	Special Purpose Vehicle
UTIITSL	-	UTI Infrastructure & Technology Services Ltd.
CTSH	-	Central Transaction Settlement House
SAM	-	Secure Access Module
CC	-	Common Criteria
TOE	-	Target of Evaluation
IC	-	Integrated Circuit
PP	-	Protection Profile
TOM	-	Ticket Office Machine
CC	-	Central Computer


Airport
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