Evolving Fare Technologies

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Introduction

The scope of fare technologies available in today's market is much broader than just a few years ago. In addition, the pace of deployment of new technologies has accelerated considerably. As a result, transit agencies are faced with many confusing choices when contemplating a new fare system. The wrong choice could leave the agency with equipment that becomes obsolete in only a few years or that is costly to maintain and operate. The focus of this paper is to examine evolving fare technologies and to begin the thought process that will lead to strategies for implementation of new fare equipment.

System Definitions

Fare collection systems for public transportation take on many faces depending on the mode of operation, size of system, and fare policy in place. They all reflect the same basic objectives, however:

- Collect fares in the most economic manner,
- Provide a user friendly environment,
- Provide an audit trail for verification of fares collected versus patrons carried, and
- Encourage fare payment and discourage evasion.

Attempting to meet these objectives results in various system configurations which are usually driven by the mode of transportation. For example rapid transit systems in the U.S. are most often gated and recent light rail systems usually use proof of purchase techniques. Bus systems typically utilize fareboxes with payment upon entry and the older commuter rail systems use conductors to validate tickets on-board. For the purposes of this paper, four basic systems are defined in Table 1.

There are many combinations and permutations of these basic systems. Any system can be integrated into one common system with one fare media and a central computer. The common piece of equipment for each system is the central computer. More often than not the central computer is only adaptable to the one mode through limitations on hardware or software. Most of the remaining equipment is unique to the specific mode of operation.

Equipment Definitions

To meet the needs of the various system configurations, manufacturers have responded over the years with the development of a complete range of fare equipment. Each piece of equipment is specifically designed to efficiently serve the fare policy in place.

The types of equipment given in Table 1 are described next.

Ticket Vending Machines

Ticket Vending Machines (TVMs) offer self-service ticket sales for flat-fare and distance based transit systems. Simple TVMs accept either coins or tokens, and issue a single ticket for a predetermined fare category. Full-feature TVMs dispense a variety of tickets, accept banknotes, coins, credit cards, debit cards, and make change; in addition, some provide automated fare and route information through various user displays. Full-feature TVMs also offer data processing and communication capabilities which provide a data link to a central computer network for automated data collection, maintenance, and equipment support.

Fare Gates

Fare gates provide the entrance and exit control required for the implementation of a closed fare collection system. Fare gate equipment includes the barrier device, coin and token acceptors, and/or magnetic ticket readers. Future gates will undoubtedly include smart card readers by proximity or by insertion.

Validators

Paper ticket validators are used primarily to validate pre-purchased tickets. As passengers enter the system, the validator prints the time of day, date, route, and zone information on the ticket. The validated ticket is then used as proof of payment for fare inspectors.

For bus applications, validation equipment is often of the magnetic type. These validators accept tickets and transfers and read and write magnetic information as required. Reciprocating readers and magnetic

TABLE 1 Basic Fare Systems

System Name	Most Common Fare Media	Modes Served in North America	Equipment Required	Other Possible Equipment
Proof of Purchase	Paper Ticket	Light Rail Comuter Rail Rapid Transit	Ticket Vendor	Ticket Office Machine Validator Central Computer
Payment on Entry (farebox)	Bills and Coins Tokens	Bus Light Rail	Farebox	Central Computer Transfer Issuer Validator
Conductor Validated	Paper Tickets	Commuter Rail	Ticket Office Machine	Ticket Vendor Central Computer Hand-Held Devices
Barrier	Magnetic Ticket	Rapid Transit Light Rail	Ticket Vendor Gates	Addfare Machine Central Computer

swipe-through readers are two types of magnetic ticket readers commonly used. Many of these validators also offer printing on the tickets. Smart card bus validators are also available. These validators perform the same functions as the magnetic type but printing on the fare media is not accomplished.

Fareboxes

Fareboxes provide a means for depositing fares on buses and sometimes light rail. Electronic fareboxes can be equipped with both coin and bill acceptors, visual displays that show the amount paid, and other data collection features.

For electronic registering fareboxes, ridership and accounting data is usually polled from a farebox at the time of vault exchange. The ridership information can then be transferred via modem to a central computer where statistical reports are tabulated.

Hand-Held Devices

Hand-held and portable fare collection devices are now being used by transit properties for ticket sales and validation. Hand-held validators are used by roving fare inspectors to time stamp single and multi-ride tickets. These battery powered devices are compact, lightweight, and weather protected.

Ticket Office Machines

Ticket office machines provide a fully automated ticket dispensing system. Office ticketing is performed by designated ticket agents, who use the office equipment to encode either paper or magnetic fare tickets with the appropriate information for a passenger's destination. Office ticketing machines offer data collection and communications capabilities, providing complete accountability for all transactions. Printed reports are available in addition to digitized data, which can be communicated to a central computer.

Central Computer

A central computer is defined here as a computer that collects data from more than one piece of fare equipment and provides informational reports as required. The collection of data can be accomplished through the use of dial-up or dedicated telephone lines and hard wire or radio transmission. A central computer can act as host computer for credit/debit card transactions by directing a request to the appropriate clearing institution for credit authority. Central computers are also used to capture transactional data for multi-agency fare integration. This data is used to apportion funds to each agency based on actual usage of multi-agency stored value fare media.

Addfare Machines

Addfare machines are generally used only in barrier systems with distance based fares. These machines allow a patron to add value to a ticket in order to make it good for exit. Some systems provide for a last ride bonus which eliminates the need for addfare machines.

Fare Media Definitions

In general terms, fare media is any instrument that is rendered or held as proof of purchase for a ride on a transit system. Fare media can be pre-purchased or cash can be used as fare media. The most common forms of fare media are next.

Cash

Coin and paper currency are the simplest of fare media. Most TVMs and fareboxes are equipped to accept all types of coins and the lower denomination bills.

Tokens

Tokens are pre-purchased and are unique to each transit system. They are usually used in systems with flat fares, but tokens can also be used in a zone system as the base fare.

Paper Tickets

Paper tickets are pre-purchased at TVMs or ticket offices and provide the passenger with the right of passage. Many transit properties offer books or blocks of single ride paper tickets, at discount prices.

Multiple ride paper tickets are also available at many transit properties and provide passage on the system for a number of trips. These tickets are validated by various means for each usage.

Magnetic Tickets

Magnetic tickets are a form of fare media which includes magnetically encoded information. This information can be read and rewritten allowing this fare media to store value for a specific number of trips. Monthly passes are often magnetically encoded tickets.

Smart Cards

Smart cards include an electrical circuit embedded into a card which is usually the size of a credit card. These circuits vary from strictly memory type to full microprocessor type with all inherent capabilities. Unlike magnetic cards, their memory is not limited and security is enhanced by the abilities of the microprocessor. In past applications the card was brought into electrical contact to be read and rewritten. For newer applications the smart card is brought into close proximity to the reader and data is transferred without electrical contact.

Debit Cards

Although not normally thought of as fare media, bank debit cards could someday become the common fare media that can be used on any system. Debit cards of the future will likely contain an electronic chip (smart card) with the capability of becoming an electronic purse for cashless payment in many places including transit.

Historical Perspective

In order to speak fully to the technological developments in the area of transit fare collection, it is useful to examine the history of fare collection over the past century.

The implementation of public transit began in the 1830s with the introduction of horse drawn wagons. The passengers entered the wagon from the rear and a leather trough was placed in the center of the wagon into which the passengers were to insert their coins for the ride. The trough enabled the collection of fares without the driver having to leave his seat. Oftentimes the number of coins inserted did not match the number of riders on the wagon. As a result, the wagons were redesigned to require the passengers to enter the wagon from the front and give the driver the coins directly.

In the 1880s several events occurred which changed the face of fare collection from its simple beginnings. Up until that time if more than one vehicle was required to travel to a destination, the passenger paid a separate fare for each vehicle. The first big change involved enterprising investors who bought up not only north-south routes but also east west routes and connected them with the "transfer." The use of public transportation increased overnight as it became more economical to ride.

The invention of the cable car and the electric traction motor did away with the horse and provided increased speed, hill climbing ability, and the new cars were able to haul many more passengers than a simple wagon. This in turn required the owners of these cars to hire people to operate the cars and to collect the fares. This gave rise to the invention of the fare box and the fare register.

Early fare collection was of two basic types. In both cases the operators made change for the passengers. First was the registering farebox, where the coin fares were inserted into a "meter" which counted the coins and gave them back to the driver to use to make change. At the end of the day, the operator removed the meter from the car and settled with the company by paying the amounts required by the meter.

The second type of fare collection involved the use of a conductor. In this arrangement, the passenger gave the conductor the fare and the conductor reached up to pull a cord. This cord rang a bell and recorded the fare on a mechanical meter: one fare, one ding. At the end of the day, the conductor would have to hand over money equaling the number of fares registered.

In the early part of the 20th century, the use of trolley cars was complemented by interurban railways. The interurbans and commuter trains relied mostly on tickets rather than onboard cash fares. Tickets were sold at stations and canceled by conductors on the train. This system accommodated distance based fares.

The early subway systems used tickets initially. Turnstiles were introduced fairly quickly, however, which were mostly mechanical and were able to accept and process only a single coin. Initially fares were a nickel. When the fares increased, the coin became a "token" and was sold for whatever the current fare was. Mechanical turnstiles were developed in the 1920s and are still in use today in such cities as New York and Boston.

The motorbus did not make its appearance until the early 1900s. With the depression of the 1930s, many trolley companies were bought up by companies controlled by General Motors, Esso Oil, and Firestone, with the intent of converting them to gasoline operated buses. The same fareboxes used on trolleys were fitted to motorbuses.

Introduction of New Technologies

Between the years of 1965 and 1970 several events occurred which again changed the course of fare collection. Crime, which until that time was not an issue on buses, began to be a problem relative to drivers having access to money to make change. This led to the almost universal conversion to "exact fare" and the emergence of the locked cashbox. The driver of the bus no longer had access to the money to make change and the passengers were required to have the correct change upon boarding.

Through the 1960s, the bus operator was required to determine if the correct fare had been paid. The driver had to visually inspect and mentally count the inserted fares to do this. In the early 1970s, Duncan Industries introduced the first electronic registering farebox. It was different in two respects; it counted the coins before the coins landed on the inspection plate and it had a dollar bill transport to permit paper money to be inserted and registered. These first electronic fareboxes had mechanical meters which had to be recorded manually.

In 1965 the success of early experiments using magnetically encoded information led the planners of the Bay Area Rapid Transit (BART) to decide to incorporate magnetically encoded tickets in their system to permit graduated fares instead of the conventional coin turnstile. Thus, BART developed all of the required elements for a modern fare collection system, including the tickets, the vending machines, the gates, and the exclusive use of tickets instead of cash.

BART opened in 1972. It was followed by the Washington Metro, which used a similar system, in 1975. Both systems use the same type of magnetic tickets and "bi-parting" faregates.

The next advancement was due to the advent of the microprocessor in the 1970s. This gave the equipment not only processing power, but also the electronic memory, which made mechanical registers obsolete and permitted data transmission to a centralized location by use of dedicated wires or phone lines.

Problems Encountered

The application of new technologies over the years has not been without its own set of problems. Some of these problems are described next.

Fraud

Internal fraud has been and remains the number one problem. In the early days, drivers used a number of ingenious methods for preventing the meter wheels from turning to register the fares. With the use of "locked boxes," openings were used to introduce wires and rods to "fish" out the inserted money.

The marriage of the mechanical registering meters to the locked box was not successful at deterring theft due to the large volume of coins inserted. The meters often became jammed due to the coin overflow resulting from the low coin capacity of the cash box.

As fares increased, the number of coins on the inspection plate also increased. With the "locked box" the driver was no longer responsible for the proceeds, so they stopped trying to count the inserted coins. With one coin on top of another it was difficult to determine if the correct fare had been paid, especially when passengers purposely inserted small denomination coins to pay the fare.

Paper Money

When the fares approached 85 cents, the flood of dollar bills also jammed the fareboxes. The meters could not count bills and the locked boxes required the bills to be folded so small that in many instances only one half a bill was inserted. The increased use of dollar bills also was the beginning of the end for the vacuum extraction system. In its height, it was used in Boston, New York, Kansas City, Sacramento, Long Beach, Atlanta, Orange County, Santa Monica, San Francisco, and many other cities. Today only Boston and New York retain the vacuum system—and they do not accept paper money even though their fares are over one dollar.

Increased fares also posed a problem for the mechanical turnstiles. While the sale of tokens continued, transit properties wanted electronic validation of coins and tokens instead of simple mechanical sensing. Counterfeits were eating into revenues in major subway systems and there were few real methods of determining genuine from bogus tokens without electronic detection. In the 1970s and 1980s, Chicago, Atlanta, Miami, and the MUNI system in San Francisco all introduced electronic coin acceptors into their turnstiles to accept coins as well as tokens.

Technical Obsolescence

One of the major problems being faced by transit agencies today is obsolescence. There are three major aspects to obsolescence. First are those items of equipment which are more than 10 years old and for which there are few, if any, spare parts. It is not economically feasible for the manufacturer to keep inventories of such parts, as model changes lead to newer and better products. As a result, prices for parts have become higher and the order time has increased for those parts that are available. The result of this trend is poorer maintenance and a rapid decline in equipment operation.

A second problem is technical obsolescence. This is where the benefits of the new equipment are such that there is significant financial return in buying the new equipment, even though the older equipment is perfectly functional. An example of this is when fareboxes are changed out for new ones with data capabilities and/or ticket processing abilities.

The third problem area involves equipment sophistication. Software, as well as hardware, is difficult to maintain due to unique designs. While the equipment of today is better in terms of quality than in past years, the unique mandated designs and modifications in terms of hardware and software, coupled with normally low production quantities of a given model for a given customer, often results in each customer getting "custom" equipment. This is to be contrasted with the "standard" equipment which was developed and sold over the years. Given the interrelationship of electronic equipment, when it works its works well and when it doesn't, the entire system is subject to failure.

Trends

Through the years various trends have taken place that have had a great impact on the current state of fare technology. The most significant of these is examined next. These are discussed to help gain insight into today's trends and potential future changes.

Proof of Payment

In the early 1970s, a bold experiment took place in Europe. This experiment involved requiring the passenger to pay the fare on or off the vehicle and obtain a printed receipt rather than having the driver of the bus or tram collect the fare. The receipt would then be shown to an inspector when requested. This was the development of the "honor system" or, more accurately, the "proof of payment" system. In Europe, where there is a strong transit infrastructure and a strong respect for authority, this concept took hold and has been extensively developed. It has been slow to come to the United States, however.

In the late 1970s and 1980s, several light rail systems were planned and implemented in the United States and Canada. Taking from the successful results in Europe, these new systems utilized the "proof of payment" system.

This was done for several reasons. First, the use of multi-car trains made on-board fare collection in the conventional manner difficult. Second, the systems did not want to have conductors collecting tickets and fares. Finally, these systems did not have "stations" in the conventional sense, so the use of controls such as turnstiles was out.

Due to the success on the initial light rail systems, the City of Portland decided to experiment with "proof of payment" on their bus system. After a trial period, this experiment was deemed to be unsuccessful. Some of the reasons attributed to this failure were a complex fare policy, free fares in the central business district, and the lack of equipment specifically suited for the job.

Ticket Vending

In order to facilitate the "proof of purchase" systems, stations were equipped with paper ticket vending and validating machines. Most of the technology, if not the machines themselves, came from Europe. The evolution of these machines has been from simple mechanical dispensing machines with mechanical validation, to full service machines, employing electronic displays, coin and bill acceptance, along with credit and bank card acceptance, for the purchase of tickets.

From a trend perspective, the machines are becoming more sophisticated in terms of their ability to interface with the passenger. In addition to simply accepting money and vending tickets, these machines now employ color interactive touch screens along with spoken instructions—often in various selectable languages.

Less Cash to Cashless

With the increasing cost of collecting and counting money, transit agencies are promoting the use of tickets. Aside from removing the cash from the buses, this also provides the cash "up front" before the service is rendered. The advantage to the passenger is the elimination of the need to pay each time the system is used. In fact, many transit passes and multi-ride tickets can be "charged" to a bank or credit card, making the transaction even more transparent.

Accepting fare media on-board means that the bus fare collection equipment must process tickets, passes, and other media, in addition to cash. Over the past few years, many of the new fareboxes bought and installed included magnetic card readers to enable this type of fare media to be machine read.

Information

Until recently, bus fare collection equipment was intended to collect and secure collected fares and provide a very little, if any, data relating to the process. With the introduction of electronics, the aspect of data collection and reporting took off. The need and dependence on information has greatly increased recently. Whole MIS departments can now be found to collect, process, disseminate, and store information.

The employment of cheaper, faster, and more powerful computers along with associated memory devices has enabled fare collection data systems to start to evolve into transactional databases. This means information on a given transaction is saved as a separate packet of information as opposed to being merged with other data as is conventional. This also means that the rides of each passenger or card holder can be individually tracked through the system. The problems and benefits of such a system have yet to be determined. But numerous potentials exist related to marketing incentives and variable fare determinations.

Evolving Technologies

The historical perspective provided a view of how far fare technologies have come in a relatively short period of time. Through this evolutionary process, today's technologies now offer a wide array of options for all types of transit modes and allow complete system integration through computer networking when necessary. Manufacturers continue to improve their products and add new features, usually at a rate faster than the natural implementation process of most transit properties. In many cases new products have been developed in anticipation of a future need. These products are tested in the manufacturers' laboratories first and then sometimes offered free of charge to an agency for limited live testing. Each manufacturer has its own unique approach to research and development. Quite often companies are purchased in order to capture an advanced product that would lend itself to future applications in the transit world.

Provided below is a review of the product lines of the manufacturers with equipment in the North American market or those who are poised to enter the market in the near future. Table 2 lists these manufacturers and provides a quick overview of their capabilities and where their equipment has been purchased. The list is intended to provide examples of the different types of companies and products available. The list is not intended to provide any type of endorsement.

AES

Headquartered in Perth, Australia, this company is best known for its pioneering work in smart card technology and associated applications to bus validation systems. Beginning in 1986, AES has installed several systems in Australia. Their local offices are in Mississanga, Ontario where they serve their current customer GO-Transit and market their products to the rest of Canada and the U.S. For GO-Transit, AES is supplying ticket vending machines and electronic transfer machines.

The initial smart card applications developed by AES were of the contact type. However, their recent programs, including the one in Manchester, England, are of the contactless type. The Manchester program is described later in the Case-Study section.

AES has indicated an interest in entering the U.S. market but has been held back by "Buy American" regulations and the widespread use of flat fares. The principle behind their bus products is its adaptability to zone or distance based fares. As distance based fares become more popular in the United States to maximize revenue, this market may entice AES to begin proposing on new jobs.

Ascom

From their headquarters in Gumligan, Switzerland, Ascom specializes in manufacturing ticket vending machines and markets this product worldwide. They have several standard models ranging from the simplest coin only machine to a full service machine that accepts credit and

TABLE 2 Examples of Fare Equipment Suppliers

Manufacturer	North American Location	Headquarters Location	Product Line[a]	Applications[b]
AES	Mississauga, Ontario	Australia	TVMs Gates Fareboxes MVAL SCBVAL TOMs	Go Transit (Comm) Australia (Bus) Manchester (Bus) New Zealand (Bus) Norway (Bus)
Ascom	Philadelphia, Pennsylvania	Switzerland	TVMS Gates MBVAL	San Diego (LRT) NJ Transit (Comm) Los Angeles (Comm) Portland (LRT) San Jose (LRT) Philadelphia (Comm) Vancouver (LRT) Calgary (LRT) Europe (all modes) Hong Kong (LRT)
CGA	White Plains, New York	France	TVMs Gates MBVAL	Baltimore (HRT) Boston (HRT) Buffalo (LRT) Oakland (MBVAL) France (all modes) Hong Kong (HRT) Taipei (HRT)
Cubic	San Diego, California	San Diego, California	TVMs Gates Fareboxes MBVAL	BART (HRT) New York (HRT) Washington, D.C. (HRT) Chicago (Metra) Philadelphia (PATCO) London (HRT) Singapore (HRT) Hong Kong (HRT) Sydney (Comm)
Dassault	New York City	France	TVMs Gates	Los Angeles (LRT&HRT) PATH (HRT) France (all modes)
GFI-Genfare	Chicago, Illinois	Chicago, Illinois	TVMs Gates Fareboxes MBVAL	Los Angeles (LRT&HRT) PATH (HRT) Philadelphia (HRT)

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TABLE 2 *(continued)*

Manufacturer	North American Location	Headquarters Location	Product Line[a]	Applications[b]
Sodeco	New York	Switzerland	BV	BART (HRT) PCS (Comm) LIRR (Comm) MNCR (Comm) Baltimore (LRT&HRT) Los Angeles (Comm) Switzerland (all modes) Germany (all modes)
Scheidt & Bachmann	Dallas, Texas	Germany	TVMs	LIRR (Comm) MNCR (Comm) PCS (Comm) Baltimore (LRT&HRT) St. Louis (LRT) BART (HRT) Germany (all modes)
Schlumberger	Virginia	France	TVMs	Buffalo (LRT) VRE (Comm) Memphis (LRT) Tallahassee (Bus) France (all modes)
Thorn Transit Systems	Toronto	England	TVMs TOMS Gates	Stockholm (HRT) Hong Kong (HRT) Seoul (HRT) England (all modes) Ankara (HRT)

[a]Abbreviations:
BV = Bill Validators
TVMs = Ticket Vending Machines
RFBVAL = Radio Frequency Bus Validators
TOMs = Ticket Office Machines
MBVAL = Magnetic Bus Validators
SCBVAL = Smart Card Bus Validators
LRT = Light Rail Transit
Comm = Commuter Rail
HRT = Heavy Rail Transit
PCS = Peninsula Commuter Service (San Francisco)
LIRR = Long Island Railroad
MNCR = Metro North Commuter Railroad
VRE = Virginia Railway Express

[b]Bus applications not listed for U.S. unless combined with rail integration or special demonstration program

debit cards. Through their sister company, Monetel of France, they also offer gates and a line of bus equipment. Their local subsidiary company, Ascom Automation Inc., is located in Philadelphia and markets Ascom's product throughout North America. The vast majority of their TVMs issue paper tickets. However, they have the capability to vend magnetic tickets also. For example, their vendors for British Rail issue magnetic tickets which are good for use on the London Underground.

In Biel, Switzerland, Ascom is providing equipment for a smart card demonstration program. In this project, contact type smart cards are used for purchases at retail stores, the post office, and for purchase of rides on public transportation.

Among Ascom's new products are TVMs with information centers. These TVMs are connected to computers with vast amounts of data on restaurants, shopping, sightseeing, and public transportation. Patrons would use this menu driven feature to plan a trip. After the trip is planned the necessary tickets could be purchased by credit or debit card at the same machine. This new TVM also includes voice response.Ascom has also completed research and development on a contactless smart card system for gates and bus validators. These new products are being introduced through their marketing program.

CGA

CGA, located in France, specializes in providing equipment for gated systems using magnetic tickets. Besides providing gates for the Paris Metro and TVMs for French National Railways, CGA has major installations in Taipei, Baltimore, the Lille and Lyon Metros, and the Orly-VAL line. They are represented in North America by Alta Technologies, in White Plains, New York.

CGA also has a full line of bus equipment and has participated in a smart card demonstration program in Blois, France. They are now engaged in research and development for contactless type smart card and attempting to narrow down the type of technology to be used for transfer of data.

Cubic

Cubic, which is located in San Diego, specializes in equipment for systems using magnetic tickets. Cubic also has a product line for buses including electronic registering fareboxes and magnetic validators and ticket issuers. The bus equipment is primarily marketed in North America, whereas their magnetic ticket barrier systems are sold worldwide. Recent contracts include New York City and Sydney, Australia.

As an added feature to their gated systems and for use on buses, Cubic has developed a contactless farecard known as "Go-Card." The card allows entry to a barrier system by simply touching it to a target on the gate. It can also be used for transfer to bus by touching a target on-board. Each time the card touches a target, a value is subtracted depending on the nature and distance of the trip. This system has been demonstrated on the London Underground and is about to be demonstrated at WMATA.

Dassault

From its headquarters in St. Cloud, France, this company manufacturers TVMs and gates for systems in France and has also participated with GFI on programs in Los Angeles and PATH. From their local office in New York City they market airline ticketing equipment as well as transit fare equipment.

GFI-Genfare

Located near Chicago, this company began as a farebox and coin accepting gate manufacturer and has steadily expanded its product line to include TVMs, magnetic gates, and magnetic bus validators. Their predecessor company, Duncan, developed the first electronic registering farebox sold in the United States in early 1970s. Since that time they have continually updated this product line. Today, they offer a magnetic bus validator known as the "TRIM" unit. This unit issues thermally printed paper or plastic tickets and validates tickets for transfer or full fare journeys. This system has been sold to several bus properties including Los Angeles (MTA) where it is part of an interagency demonstration program.

GFI-Genfare, through an agreement with Dassault, has sold TVMs to Los Angeles and PATH. GFI produced the cabinet and the bill unit and performed final assembly. Dassault supplied the ticket and coin systems and much of the electronics.

Sodeco

Headquartered in Geneva, Switzerland, this company specializes in manufacturing banknote acceptors. Their product includes an escrow feature for up to 15 bills and a bill vault with capacity from 1,000 to 2,000 bills. Recent models can accept bills in any orientation. Their product has become the recent standard in the European and North American market.

Scheidt & Bachmann

The headquarters and manufacturing facilities for Scheidt & Bachmann are located in Moenchengladbach, Germany. The company specializes in TVMs, but also has a line of bus equipment for the German market. They have manufactured more than 4,000 TVMs for the German market alone. Recently, Scheidt & Bachmann have won several jobs in the U.S. including projects on the Long Island Railroad, Metro North, Baltimore, St. Louis, BART, and the San Francisco Peninsula Commute Service. For the programs in the U.S., Scheidt & Bachmann is represented by Agent Systems of Dallas, Texas. In addition to providing a marketing and program management arm, Agent Systems develops software for the central computer networks provided for their U.S. contracts.

Schlumberger

Headquartered in Montrouge, France, Schlumberger has recently set up offices and manufacturing facilities in Chesapeake, Virginia. Their product line includes TVMs, magnetic and smart card bus validators, and portable inspection devices. They have equipment in Italy, Spain, France, and the U.S.

Recent contracts in the U.S. include TVMs for the Virginia Railway Express, Buffalo light rail, Tallahassee and the Memphis vintage street car line. They also demonstrated their smart card systems in Pittsburgh and Los Angeles.

Thorn Transit Systems

Located in Wells, England, Thorn Transit Systems has a full range of fare equipment, including magnetic barrier systems, TVMs, and bus validation and ticket issuing equipment. Recent contracts include systems in Stockholm, Hong Kong, Seoul, and Ankara. Although not presently active in North America, they have hired a representative to investigate the potential for this market.

Case Studies

In order to meet the objectives described in the beginning of this paper, most transit agencies wish to move in the direction of more advanced fare equipment. Although there are often several obstacles to this advancement, two major ones come to mind:

- Funding, and
- Fear of equipment not proven elsewhere first.

Funding is always an obstacle, but it can be overcome if a real need can be demonstrated. However, policy boards are not about to invest in full scale programs with technologies that are not proven. BART took a bold leap of faith when they implemented a magnetic card distance-based fare system. Many of BART's other systems also involved great leaps of faith and they paid the price initially with several serious problems. Although today BART is thought to be one of the finest systems in the world, these early problems led other agencies to be cautious when implementing new technologies.

The preferred method today is to begin a program with a small demonstration test phase before the entire system is implemented. This enables the agency to make a small initial investment and to determine if the new technology has technical or human factor faults before commitment to full scale replacement is made. Several demonstration programs, varying in size and complexity, are currently in progress. A review of those most pertinent to transit is presented next.

Los Angeles Bus Integration

The Los Angeles County Metropolitan Transportation Authority (MTA) has embarked upon a program to integrate fare collection for the separate bus and rail systems operating in Los Angeles County. The first step in this program is to equip approximately 300 buses with ticket validators to allow patrons to transfer from one system to the next using one fare media. GFI-Genfare won the contract and will be utilizing a version of their TRIM unit. If initial testing is successful, additional buses will be equipped.

San Francisco Bay Area

The Metropolitan Transportation Commission (MTC) has spearheaded a program in the San Francisco Bay Area to institute one common fare media that will be accepted by all transit operators. Because BART serves nearly all the Bay Area Communities, the media was naturally chosen to be a magnetic ticket. Before widespread implementation, MTC chose to outfit the buses of Central Contra Costa Transit Authority (CCCTA) with magnetic card validators as a first step. These validators were designed by CGA of France and built in the U.S. After initial trials on one bus route went well, full implementation on all CCCTA buses is now in progress. Tickets are available to the general public from outlets, and ticket vendors will soon be installed in BART stations to augment the outlets. Remaining value is printed on the ticket for both bus and BART riders.

WMATA

The Washington Metropolitan Area Transit Authority (WMATA) has selected Cubic to supply their "Go-Card" system for a three phase demonstration program. The first phase includes installation of one target in each of 14 mezzanines on the Metro system. This installation would also include a target (reader) on one TVM in each mezzanine. For the second phase, 21 feeder buses will be equipped with targets to allow transfers and to test the equipment in the bus environment. The final phase will include the installation of targets in parking lots adjacent to the stations which are part of the demonstration programs. This equipment will feed information into the existing central computer which will allow WMATA to examine the data and make intelligent decisions regarding a more widespread use of a touch-and-go type system.

GO Transit

GO-Transit has issued a request for proposal (RFP) and is now in the process of selecting a contractor for a demonstration of a proximity card type system for use on the commuter rail system and feeder buses from the Mississauga bus system.

Two commuter rail stations and 45 buses will be used during the program. If successful, GO-Transit hopes that a similar system can be implemented in the greater Toronto area.

Biel, Switzerland

Sponsored by the Post Office in Switzerland, a rechargeable contact type smart card program is being conducted in Biel. In addition to being used on transit, the smart card is also good for retailers, hotels, restaurants, gas stations, and the post office. Smart cards are issued free and can be charged with value at machines or at specific outlets. Presently they are investigating its use for public telephones.

Manchester, England

Manchester, England has begun a very ambitious program to outfit their buses with a proximity smart card system. Thirty-two separate bus operators will be included in this program with a total of 2,700 buses. The joint venture of Scanpoint and AES has been awarded the contract for the project. Beyond the application to transit, plans include the use of the smart card for retail, public registration, pay phones, and school meals.

Implementation Alternatives

From the foregoing we have become acquainted with the way fare equipment has evolved through history and we have learned what technologies are now considered state of the art and those which are still evolving. Example demonstration programs have also been examined. But the question still remains—what is the best approach for a transit agency to implement advanced technologies? It is clear from the examples that initial small scale demonstration programs are preferred to reduce the potential risk. Even this approach begs other questions such as

- Should the specifications be specific as to the technology?
- How large should the demonstration programs be in order to provide meaningful results?
- How does the agency arrive at the technological direction?
- How tight should the program schedule be?

The last question related to schedule captures one of the critical problems related to demonstration programs. In some cases the demonstration program schedule is stretched out to such an extent that the technology being tested becomes nearly obsolete. This is not to say that demonstration programs should be eliminated or unrealistically scheduled, but they should be given high priority with adequate resources. Too often demonstration programs are allowed to languish and precious time is wasted.

The other key question from the list above is the level of detail to be specified. Hardware specifications tend to limit competition and yet performance specifications leave the details to the manufacturer and can lead to misunderstandings as to the specific hardware features. Usually a demonstration program can be best served by performance specifications especially if a negotiated procurement is possible.

The size of the demonstration program is also a critical factor. A program that is too small may fall short of proving the technology is reliable and acceptable to the average patron. Large programs may eat into budgets and usually require more time to complete. Unfortunately there is no secret formula for the optimum program. Each agency must analyze their specific needs and create a program that most effectively meets those needs.

Finally, the technological direction may be the most difficult choice. Predicting the future in this rapidly changing environment is nearly impossible. Some of the factors that must be evaluated include

- Potential cost for full system,
- Long-term ability to integrate system with other technological changes,
- Schedule for full system implementation, and
- Maturity of technology in transit environment.

The final choice can be either very specific, which may limit competition, or an open concept allowing several technologies to compete. Either way the specifications must be clear at the time the RFP is issued.

Conclusion

In summary, fare technology appears to be at the brink of major developments that will shape the future of how fares are collected on all modes of public transportation. Transit agencies have a choice of waiting on the sidelines for an appropriate technology to develop for their application, or becoming active through studies, demonstration programs, and full scale implementation to help shape the future. If too many agencies choose the former, the technological advances will not be guided by transit specific needs.

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References

1. L. Levine. High-Tech Fare Collection Cuts Costs, Increases Ridership. *Metro Magazine*, May/June 1993, pp. 32-40.
2. J. Wolinsky. Toward the Cashless Bus: Automatic Fare Collection Brings High Technology to the Farebox. *Busworld*, Spring 1993, pp. 8-11.
3. R. C. Townend. Prepaid Cards: A Tour D'Horizon. Presented at CardTech '93, Crystal City, Va., April 18-21, 1993.
4. C. Bushell, ed. *Jane's Urban Transport Systems 1991*. The Jane's Information Group Limited, Coulsdon, Surrey, United Kingdom, 1991.
5. C. J. Standord. Contactless Cards an Overview. Presented at CartTech '93, Crystal City, Va., April 18-21, 1993.
6. Booz, Allen & Hamilton Inc. *New Technologies for California Passenger Rail Services*. Written for State of California Department of Transportation. Oct. 1991.