Fare Collection and Fare Policy

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Automated fare technology can bring substantial benefits to transit operators, including the potential for virtually limitless fare structures. Transit agencies have a wide variety of technologies to consider: smart cards are becoming mainstream, international technology standards are progressing, and near field communication (NFC) – the cutting edge of fare payment technology – is increasingly being enabled in mobile devices. Newer technologies have significantly lower life cycle costs than older ticketing systems.

As a result of these innovations, fare policy is now limited only by institutions and ideas. This paper reviews the range of transit ticketing systems and fare policies in operation, or soon to be implemented, in the cities represented at the 2013 Transit Leadership Summit: Hong Kong, Montreal, New York, Seoul, Singapore, Vienna and Washington. Representatives from these cities' transit agencies provided information which informs this report.[1] By discussing the benefits of new capabilities in the context of these major transit agencies, this report aims to highlight how transit agencies might learn from one another as they consider future fare policies and structures. Table 1 briefly describes the fare payment technology used by, and planned by, Summit participants.

Table 1

City, Transit Agency	Primary Fare Technology	Fare Structure (*)	Recent Developments or Future Plans
Hong Kong, MTR	Smart card	Distance-based	Considering open payment (NFC)
Montreal, AMT	Smart card	Distance-based	Considering Open Payment/NFC
New York, MTA	Magnetic stripe card	Flat fare	Has piloted Open Payment/NFC
Seoul, SMG	Smart card & Open Payment/ NFC	Distance-, Time- and Mode-based	Mid-2000s reorganization integrated fare systems
Singapore, LTA	Smart card	Distance-based	Plans to reduce redundancies among multiple operators via cloud computing
Vienna, W.L.	Photo-card yearly pass; honor system	Zone-based	Considering multi-function smart card
Washington, WMATA	Smart card	Distance-based	Implementing Open System/NFC

(*) Fare structure: Note that all transit agencies have more complex fare structures than shown in this table. The table reflects the *primary basis* for fare prices. Transit operators may also provide concessions by passenger class, free or reduced transfers, discounts for bulk purchases, period passes, benefits for retail-related loyalty, different fares depending on payment media, and other variations.

Technologies and Potentialities

Table 2 shows the variety of potentialities – fare products, data observations and passenger conveniences – that are available with different types of automated fare collection. Magnetic stripe cards, which require a physical swipe, have been common in transit systems for more than 30 years. Smart cards, first introduced in the late 1990s, are microprocessor-embedded devices issued by the transit agency that communicate with readers at a very short range so that they do not have to touch the readers, i.e. they are contactless. Smart cards may be configured for use only in a transit system (such as in Montreal and Washington) or they may be accepted for small purchases such as for retail and parking (in Hong

The Transit Leadership Summit brings together public-transportation chief executives for three gatherings in 2012, 2013 and 2014 to discuss common challenges and share solutions in an intimate, closed-door setting. With no more than 30 participants representing a six to 12 major cities at each summit, executives can engage in a candid, off-the-record dialogue.

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Three white papers were commissioned to help inform discussions at the 2013 Transit Leadership Summit in Singapore: Fare Collection and Fare Policy; Capital Priority-Setting for Transit in Large Metro Areas; and Improving Customer Experience. They are available at www.rpa.org/transit-leadership

1 This report is informed by questionnaires completed by representatives from MTR Corporation (MTR, Hong Kong), Agence Métropolitaine de Transport (AMT, Montreal), Metropolitan Transportation Authority (MTA, New York), Seoul Metropolitan Government (SMG, Seoul), Land Transport Authority (LTA, Singapore), Wiener Linien (Vienna), and Washington Metropolitan Area Transit Authority (WMATA, Washington).

Table 2

Potential Applications	Magnetic Stripe	Smart Card	Open Payment System / NFC
Discounts by passenger class (senior, student)	x	x	x
Daily, monthly passes	x	x	x
Seamless intermodal transfer (a)	x	x	x
Distance-based fares	x(b)	x(b)	x(b)
Time-of-day-based fares	x(c)	x	x
Real-time origin and destination data		x(b)	x(b)
'Best Fare' policy(d)		x	x
Use fare card as debit/credit card		x	
Use fare media for retail purchases, parking, tolls, bike share		x	x
Use credit card for transit system entry			x
Use mobile phone for transit system entry			x
Fare cards are insurable	x (e)	x	n/a
Passengers top up cards, check past transactions online		x	x
Use employment/student identification cards for transit system entry			x
Personalized marketing (f)	x(g)	x	x

(a) Seamless Intermodal Transfer: Passengers can transfer between buses and trains without acquiring a ticket or other proof of payment.

(b) Distance-based fares and real-time origin and destination data collection require the passenger to swipe or tap (also called "tag") at egress (when exiting the station or bus). Among Transit Leadership Summit participants, Singapore and Seoul require tapping when exiting all modes; Hong Kong and Washington require it for rail only; Montreal and New York City do not require interaction with readers when exiting any mode.

(c) Time-of-day-based fares could be accomplished with a magnetic stripe system, but it would preclude other functions such as daily passes simultaneously. This is because the magnetic stripe system cannot access more than one 'purse'; while the cards can potentially hold both a monthly pass and cash, for example, one of those 'purses' must be expended before the other can be accessed.

(d) "Best Fare" policy refers to restricting the total amount a passenger can pay in a given duration. In London, for example, passengers using multiple single-journey fares find the total they've paid at the end of a day capped at the price of the daily pass.

(e) Each magnetic stripe card has a unique serial number that could allow for insurability.

(f) Personalized marketing based on data from fare collection may be restricted by regulations intended to preserve privacy. Some data (i.e. gender, residential location and consumer behavior) may be collected by transit operators when passengers register their smart cards, or by third parties when passengers use their credit cards. These data may not be linked, however, depending on regulations of both the credit card/payment industry and transit agency jurisdiction.

(g) Magnetic stripe or simple cardboard cards can be linked to a specific passenger who pays by automated debit. For example, in Vienna, passengers use cardboard cards with their photos affixed and the transit operator markets directly to these passengers using data provided when setting up automatic payments for yearly passes.

Kong and Singapore). Open payment/NFC refers to transit operators using readers that accept payment from third party smart cards (such as Master Card PayPass or VISA Wave) and near field communication-enabled mobile phones (referred to in the industry as NFC).

Of the Transit Leadership Summit participants, most use smart cards (Montreal, Hong Kong, Washington, Singapore and Seoul). New York City uses a magnetic stripe system; Vienna uses a time-stamp paper ticket and cardboard yearly pass with a photograph and the honor system. Seoul has incorporated open payment/NFC with its smart card system, and Washington is planning to transition to open payment/NFC systems in the future. Vienna is considering a smart card system. None of these operators use all of the potential applications listed in Table 2 (page 5), either due to explicit policy, proprietary agreements restricting the use of technology, or political considerations.

Benefits of Advanced Fare Technology

Advanced fare technology offers a wide range of benefits to transit operators and passengers. These include convenience for the passenger, managing demand and/or addressing equity concerns through differentiated fares, cost savings and revenue-raising for the operator, and improved data collection.

Passenger Convenience & Throughput

Conventional level of service indicators for transit agencies are speed, reliability, frequency and coverage. Advanced fare technology can provide improvements to speed of ingress. In Singapore, for example, commuter throughput at train stations doubled when the system switched from magnetic stripe to contactless smart cards. Bus dwell times are reduced as well. In Seoul, the T-money card permitted more complex transfer allowances, distance-based fares and pricing, resulting in faster buses (by 8.3%) and more bus riders (by 1.6%). An equally important improvement that results from advanced fare technology is increased passenger *convenience*.[2] Passengers using smart cards pay less frequently and have more choice in how they pay; they can refill cards automatically from their bank accounts and can attach transit cards to credit cards. NFC-enabled phone users can purchase fares directly from any NFC-enabled poster or sign, including from maps. Passengers handle their cards less often; entry and egress can be made without removing the card from a wallet or handbag. Smart cards can come in many forms such as fobs, bracelets, mobile phone cases and other devices which are easier to access than cards. Open payment systems further expand convenience by decreasing the number of separate payment media a passenger must carry, and increasing the

2 Vienna's system, while not an 'advanced' fare technology, is able to offer many of the same conveniences listed here because of its gate-free honor system and use of ancillary internet-based payment applications.

information directly available to passengers regarding routes and arrival times. These improvements may seem peripheral to transit system operations, but there is evidence that they attract and retain passengers. Passenger experience may be a greater determinant of travel behavior than conventional metrics; passenger attitude is largely shaped by features such as convenient payment systems, and passenger attitude helps explain mode choice.[3]

Differentiated Fares

Advanced fare technologies vastly increase the potential fare structures available to transit agencies. Single-journey tickets or tokens are restricted to a single price. Magnetic stripe cards can provide period passes (such as monthly passes) or bulk discounts (i.e., 10% bonus for purchase of $20 or more) and may be enabled for zonal charges. Smart cards and open payment/NFC systems enable the transit agency to charge different amounts depending on the time of day, mode, route, number of transfers, and (where passengers tap their cards at egress) by fine gradations of distance. These differentiated fares, when informed by rich data sets provided through advanced fare technology (discussed below), can be used to manage demand, increase revenue, and address equity considerations.

There is a wealth of literature around the use of price to manage demand. The full body of evidence and theory will not be explored here; much of it reinforces the general principle that fare price can shift ridership patterns enough to moderately reduce crowding and increase operational efficiency in the long term.[4] Along with simple peak period pricing, transit operators can use differentiated fares to exploit different sensitivities to fare price by payment method, income class, and fare structure. Taylor and Jones (2012) and Hensher (1998) review multiple elasticities for multiple fare products.[5]

New fare technologies expand the potential for addressing equity concerns and raising revenue by differentiating fares by passenger class. Most agencies offer concessionary fares to students, seniors and disabled passengers using specialized cards. In some cases the transit operator internalizes the cost of the concession, while in others the concession is paid by a government agency that administers programs for students, seniors or the disabled. While concessionary fares are possible with conventional fare technology, advanced technologies can make them more convenient and flexible. Instead of requiring a station agent to visually confirm a concessionary pass, advanced fare payment systems read the pass and process the appropriate fare. Open payment systems can be interoperable with smart cards provided by social service agencies. For example, in Germany, France and other countries citizens are issued a smart card for use of the healthcare system; in the U.S., 'food stamp' cards are embedded with microprocessors; these could potentially be used for free or reduced transit access for certain passengers, perhaps according to a reimbursement arrangement with the social service agency. Colleges and universities regularly issue smart cards as student identification as well as to ration printing, gain access to facilities, and receive discounts from retailers; these could be accepted on transit as well. Washington has a complex fare structure to address differing abilities to pay which could be rationalized by using smart cards. Currently, low income jurisdictions sell lower priced fares locally and reimburse the transit agency (WMATA) for the difference. By directly subsidizing the passenger, rather than all travelers originating in the low-income jurisdiction, WMATA could create a more equitable, simplified and expanded system. Passengers in need could be directly subsidized through a social service office, employer or institution which in turn purchases full-fare passes from WMATA. Because smart cards can be remotely programmed, it is possible to personalize the level of fare discount benefits. For example, when an unemployed passenger finds a job, his smart card could be updated from charging discounted 'job search'-level fares to charging the full fare, or perhaps a discounted fare for a low wage job.

Smart cards and open payment systems can also enable a 'Best Fare' policy wherein a single passenger does not exceed a given expenditure limit on transit fares in a set duration. The Best Fare policy, which is in place in London, corrects the problem of passengers purchasing incorrect fares and spending more than necessary for a trip. Overpayment can become a problem as fare structures become more complex.[6]

Both "social fare" policies discussed herein – a 'best fare' policy that guarantees the price regardless of ability to pay for all trips in advance, and a set of discounts available to lower income and marginalized groups – would free transit agencies from the affordability and equity considerations that have historically depressed base fare prices. Transit systems that were built prior to magnetic stripe technology – including in New York and Vienna – historically used a single flat fare for all journeys. The base fare was kept low to maximize overall affordability, with extra concessions for seniors, students and the disabled. New technology enables transit operators to consider higher fares as socially just when implemented alongside expanded concessions.

However, the adoption of these social policies must be weighed against the effect on revenue and diversion from transit agencies' core mission. It would require a shift away from historical precedence to an explicit statement of institutional goals for affordability, not often considered by transit agencies, along with demand management and cost recovery. Among the agencies surveyed for this report, all provide concessions for seniors, students and the disabled,

3 See, for example, these three articles: Van Acker, V., B. Van Wee, and F. Witlox. "When Transport Geography Meets Social Psychology: Toward a Conceptual Model of Travel Behaviour." *Transport Reviews* 30 2 (2010): 219-40; Kitamura, R., P.L. Mokhtarian, and L. Laidet. "A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area." *Transportation* 24 2 (1997): 125-58; Shankelman, Jessica. "Public Transport Gets Smart." *The Guardian* January 8, 2013.

4 For a review of fare elasticities, see Button, K. Transport Economics. Northampton, MA: Edward Elgar Publishing, 2010, and Balcombe, R., et al. The Demand for Public Transport: A Practical Guide. London: TRL Limited (2004).

5 Taylor, Kendra C., and Erick C. Jones. "Fair Fare Policies: Pricing Policies That Benefit Transit-Dependent Riders." Ed. Johnson, Michael P. Vol. 167. *International Series in Operations Research & Management Science*: Springer New York, 2012. 251-72; Hensher, D.A. "Establishing a Fare Elasticity Regime for Urban Passenger Transport." Journal of transport economics and policy (1998): 221-46.

6 Lathia, N., and L. Capra. "Mining Mobility Data to Minimise Travellers' Spending on Public Transport." ACM KDD, San Diego, California (2011).

but none includes affordability in its fare-setting formula.[7] Only one (Singapore) explicitly addresses affordability in its fare policy. There, the Public Transport Council estimates the burden of the fare on a representative household in the second-income quintile to determine whether the fare is becoming less affordable.[8] As income inequality grows in urban areas, fare affordability is becoming a more relevant and more complex metric.[9]

Transit operators may be institutionally disinclined to address affordability and interagency concessions, however. Transit agencies often tout their ability to operate 'like a business', unlike typical government agencies. 'Social fares' emphasize that transport is a public service which in some cases is delivered based on need rather than ability to pay. This may be ideologically uncomfortable for transit agencies. The prospect of 'social fares' also raises the issue of transit agencies entering agreements with non-transit government agencies, specifically inter-agency reimbursement relationships. Inter-agency relationships require scarce management resources and political acumen, and may not be viewed as central to the transit operator's goals.[10]

Operational Cost Savings

Smart card and open payment/NFC systems generally cost less to operate than conventional ticketing technology. There is no comprehensive analysis of costs available; transit agency organizational structure varies widely, and each agency accounts for fare collection costs differently.[11] Anecdotal evidence and a review of the literature suggests a few generalizations: the capital cost of smart cards is higher than magnetic stripe or paper tickets[12], but life-cycle costs are dramatically lower; likewise, the initial capital expenses of installing new readers is more than compensated by declining costs of collection. While a comparative cost-per-transaction is not known, and there are fees related to each transaction, in general costs have declined with new fare technology. In Singapore, agency expenses related to fares and ticketing (life-cycle costs) declined by 6% after implementation of smart cards. In Hong Kong, the cost of operating magnetic stripe technology is at least double the cost of the smart card system. Part of these savings are due to lower cost for ticket recycling, equipment maintenance, cash handling and the cards themselves. Hong Kong will start phasing out magnetic ticket later this year (2013). In Washington, for example, the average cost per dollar for collecting cash fares is more than twice the cost of collecting credit/debit fares ($0.10 USD versus $0.04 USD). Accepting cash slows the transaction process time, and requires a very labor-intensive back-office cash handling process. Credit card fees are low by comparison.

Other cost savings are derived from lower maintenance expenditures. Smart cards are much more durable than magnetic tickets; in Hong Kong, smart cards need to be replaced after 30,000 cycles (or trips with use at entry and exit) while magnetic tickets only last about 60 cycles; in Singapore, the failure rate for smart cards is one in 25,000 transactions compared to one in 5,000 for magnetic stripe cards.[13]

Finally, the cost of the fare media is rapidly declining. In Singapore, for example, a new smart card that cost $4.00 SGD in 2009 is now $1.80 SGD.[14] Open payment systems reduce costs further by minimizing in-station ticketing infrastructure and the number of cards a transit operator issues. It also off-loads back office revenue allocation as the transit agency becomes one of many merchants in an established payment system architecture. Washington, for example, anticipates substantial cost savings when it implements its planned open payment system. The savings will come from shedding a proprietary technology, reduced reliance on agency-issued fare media and increased availability of self-service functionality.

Data Collection

Automated fare collection creates data on station entry which can help transit operators diagnose crowding as well as route and station under-utilization. Smart cards are capable of storing considerably more data than magnetic stripe cards: with magnetic or other stored value 'memory' cards, the data stored is limited to the number of memory cells. Magnetic stripe cards can typically carry about 140 bytes of data while smart cards carry anywhere from 1KB to 5MB. Smart cards include microprocessors which are capable of performing multiple functions. Smart card and open payment/NFC systems also enable agencies to adopt account-based models where data are stored on the host system and not on the card.[15] Smart card data can thereby show individual passenger flows, allowing a more robust investigation of travel behavior and greater ability to estimate and manage demand.[16] When coupled with egress tapping (signaling a reader at the exit gate), automated fare collection is further expanded to allow operators to observe the origin and destination of journeys in

7 Hong Kong, Singapore, Montreal and Washington use a fare setting formula which accounts for costs and wages. The fares are adjusted according to the formula with some regularity, although the timing and frequency of adjustments may not conform to an established schedule.

8 In the U.S., transit operators comply with federal regulations (Title VI) by examining whether changes to fare structure disproportionately burden racial/ethnic minorities. They must also ensure that discounts are available to all regardless of ability to pay. While these in effect produce lower and therefore more affordable fares, the policies do not require examining affordability per se. Fares are therefore maintained at universally low levels for universal affordability.

9 Vasconcellos, E.A. Urban Transport, Environment and Equity: The Case for Developing Countries. London: Earthscan Publications, 2001.

10 Despite the ideological challenge, some transit agencies are leveraging advanced fare technology for social fares. In the San Francisco region, the Metropolitan Transportation Commission is currently studying whether and how to implement needs-based fare discounts. Reisman, Will. "Muni and Other Agencies Consider Basing Fares on Income." *The Examiner* November 30, 2012.

11 In the U.S., the Smart Card Alliance has attempted to consolidate information on costs. See "Planning for New Fare Payment and Collection Systems: Cost Considerations and Procurement Guidelines": Smart Card Alliance, March 2010.

12 A full-featured contactless smart card costs between 90 cents and $1.00 to produce, which is 25 times more expensive than a magnetic stripe card that costs four cents on average. Quibria, N. "Emerging Payments Industry Briefing: The Contactless Wave: A Case Study in Transit Payments." Boston, MA: Federal Reserve Bank of Boston 9 (2008).

13 Prakasam, S. "The Evolution of E-Payments in Public Transport's Experience." *Japan Railway & Transport Review* 50 (2008): 36-39.

14 $4.00 SGD equals approximately $3.26 USD or €2.45. $1.80 SGD equals $0.81 USD or €1.10

15 Account-based models are also possible in low-tech, honor systems such as in Vienna.

16 Elliott, Mark. "High Performance Meets Intelligence: The Importance of Advanced Fare Management." *Mass Transit* February 11, 2011.

real time.[17] These data are regularly used by transit agencies, including those represented at the Transit Leadership Summit, for daily operations, strategic planning, and transport demand modeling. Finally, open systems can match travel patterns with consumer behavior, creating data sets of great value to marketers.

Despite improved potential data collection, transit agencies with even the most advanced fare systems may not realize the full benefits of that potential. Transit operator use of the data often depends on institutional, rather than technical, arrangements. For example, a back office 'data warehouse' may be operated under a proprietary agreement that precludes easy access to data for transit agency managers. The use of data to inform routing, scheduling or fares may also be impeded by institutions empowered with those decisions that are reluctant or lack the capacity to utilize the data (this is the case in Singapore). In open systems, credit card privacy regulations prevent linking personal data with trip patterns: in the case of Hong Kong, the benefit of the data collected accrues mainly to the private, retail-oriented corporations that accept Octopus cards. Thus despite a wealth of new data, institutional arrangements – largely established prior to implementation of advanced fare technology – restrict realization of the benefits of these data. Some transit agencies – including in Washington and Hong Kong – are using voluntary passenger registration to collect more data: passengers can opt-in to a registration system wherein they agree to make some passenger-level data available for the operator's use. Transit agencies have used incentives, including card discounts, to encourage registration. However, these methods involve self-selection and therefore may not be valid for all purposes.

Common Experiences and Lessons Learned

Each transit agency approaches the issue of fare technology and fare structure in its unique historical, institutional and political context. The existing physical infrastructure and regulatory climate will shape the options that transit agencies can realistically pursue. The agencies at the Transit Leadership Summit represent a wide variety of contexts, each presenting its own challenges to implementation of new technology or innovative fare structures. There are several commonalities, however, which may be informative for agencies regardless of context.

Beware of proprietary arrangements

For transit operators, off-the-shelf technology can be very attractive. Developing technology in-house can be expensive, redundant to efforts already underway in the payment industry, and can distract from the transit operator's core mission. Buying technology, however, often requires entering a proprietary arrangement which can inhibit flexibility. Singapore's experience with Sony FeliCa smart cards is informative. The off-the-shelf technology was successful for seven years (2002-2009) but ultimately proprietary restrictions limited the scope of applications. Only after developing a set of national standards could Singapore begin charging distance-based fares by the kilometer, for example. Seoul and Washington had similar experiences: in Seoul, the proprietary MiFare card limited intermodal transfers and fare structure complexity; in Washington, the Cubic GoCard chip technology became obsolete and was no longer manufactured, requiring an expensive hardware and software retrofit to read and process a new contactless chip. Washington and New York exemplify how proprietary arrangements can limit back office data management. Restricted to a single vendor and outdated hardware, the transit agency is unable to access real-time data or even updated origin and destination flows without a tedious process. Any change to the fare structure is expensive for the transit agency in both cost and time.

Expect passenger acceptance

In all cases studied for this report, passenger acceptance of new fare technology quickly exceeded expectations: pilot projects with small groups of commuters proved successful, and passengers using the first stations with available readers adopted the new technology quickly. Fare incentives can spur usage, but *agencies report passenger convenience as the most important factor*. Specifically, both Hong Kong and Washington found that the ability to maintain higher stored values on smart cards was the convenience that led many passengers to switch to the new technology; in Washington, the further improvement in card durability (from paper magnetic stripe cards to smart cards) led to passenger acceptance. This is the case even though advanced fare technology often provides less information at the reader – the point of use – than conventional fare payment. Contactless smart card readers can provide remaining balance information when the passenger taps the card at the gate, but not all do; open payment systems generally do not provide this information at the gate; and the cost of the trip is generally only available through station-based kiosks and online/mobile applications, rather than at the turnstile. Also, distance-based fare structures do not allow passengers to easily know the cost of the journey before embarking. Discovering the cost requires using a trip planning tool or reading a complex matrix. There is evidence that this switch from information provided at the turnstile to information-on-demand has had little effect on passengers (except to speed ingress). In Washington, a survey of smart card users found that passengers were ignorant of the amount left on their cards at any given time, but did not consider vit a substantial problem.

The cash fare can be accommodated

To comply with universal service obligations, transit agencies must provide a way for passengers to pay cash for their fare. The potential for differentiated fares raises the additional problem of equitable fare prices for those passengers who will

17 Entry-only systems can use on algorithms to link passenger station origins with likely destinations. This is true of both magnetic stripe systems such as New York City and smart card systems such as Montreal.

continue to pay for a single journey with single-use fare media: unbanked passengers, infrequent travelers, and the unplanned trip. Transit agencies must consider the extent to which they can justly offer discounts to non-cash users. (For example, only about half of urban residents in the U.S. have smart phones.[18] A discount for NFC-enabled devices, therefore, may not be politically acceptable or socially just, even though fare collection through NFC costs the agency much less than conventional fare collection.) Single-trip tickets represent a small and shrinking share of fare transactions. In Singapore, only 2.5% of passengers purchase single-journey tickets in the station; in Washington it is less than 10%. In Hong Kong, 94% of passengers use smart cards, and in Montreal around 90%. Advanced fare technology decreases the share of passengers using cash by attracting them with greater convenience and boarding speed. In addition, for most of the cities participating in the Transit Leadership Summit, the unbanked population is a relatively small group.[19] Urban populations are more likely to have bank accounts and smart phones than rural populations.[20] Nevertheless, this group must be accommodated by providing an alternative to using bank cards, credit cards and mobile phones for payment. Retailers can sell *low balance cash cards* compatible with both magnetic stripe and smart card readers. Consumers are already familiar with these cards as gift cards, welfare cards and campus cards. These general-purpose prepaid cards do not require a bank or credit card company relationship. They can be topped up with cash at retail outlets and with the issuing institution.[21] To cover the cost of the card, transit agencies may (as many do now) charge $1 or $2 for the initial purchase of the card and may choose to reimburse the passenger for that amount, along with any remaining balance, when it is turned in. This last step (infrequently pursued by passengers) could be accomplished by retailers, or by mail and with checks or wire transfers, eliminating the necessity for station agents to handle cash.

Multiple technologies can co-exist

New technologies can be implemented incrementally. Not all passengers must change their behavior at one time, and not all technology must be replaced en masse. Introducing a new fare technology system to passengers usually occurs in stages. There is often a pilot phase which tests the technology with a group of commuters, university students or government employees.[22] This is followed by a public awareness campaign to widely introduce the technology to passengers.[23] Finally the new readers, enquiry kiosks and other infrastructure are installed in stations, and the new fare media is sold. While integrating legacy systems comes at a cost, systems can operate with older methods of fare payment in tandem with the new method over a fairly long transition period. *Smart card and NFC readers have been successfully integrated with magnetic stripe technology* in Hong Kong, Montreal, Seoul and Washington. In Montreal, for example, some of the transit operators in the AMT region added smart card readers to their existing magnetic stripe readers, while others replaced their readers with new ones that had both magnetic stripe and smart card capability. NFC readers are now available that use the same infrastructure as smart card readers.

Institutional intransigence limits the benefits of new technology

From the passenger's perspective, the convenience of new fare technology is realized as soon as readers and fare media are available system-wide. From the agency's perspective, however, the benefits (other than cost savings) may require institutional shifts to fully realize. Institutional arrangements can limit the extent to which the technology is used for innovative fare structures, or to which data are mined for improved operations or for marketing. Advanced fare technology lends itself to experimentation: there are myriad different fare structures available and data can be gathered at a very fine level. Experiments with innovative fare structures are difficult to accomplish, however. Some transit agencies must undergo a political process to change fare prices, while others are tied to a formula; changing fare structure is complex and politically charged in all cases. Issues of fraud and cost can present political hurdles even when there are feasible solutions. The use of data is likewise constrained by the parties using it. As discussed above, contractual arrangements and regulations intended to promote security can create barriers to an agency's access to fully disaggregated travel behavior data.

Conclusion

As the payment industry advances, passenger expectations are likely to change. Passengers are already learning to expect transit systems to provide real-time arrival information, interactive maps, and seamless intermodal and inter-agency transfers. The payment industry is further raising consumer expectations for fast, contactless, cashless payments; rewards for frequent purchases; easy transaction tracking;

18 The share of urban residents with smart phones grows each year, as does the income diversification of this population: Pew finds that lower- and middle-income urban residents are discontinuing land lines and cable television in favor of smart phones. Horrigan, J. "Home Broadband Adoption 2009." *Pew Internet & American Life Project* (2009).

19 The percent of adults holding an account at a formal financial institution are: 88.7 in Hong Kong, 95.8 in Canada, 88.0 in the United States, 93.0 in South Korea, 98.2 in Singapore, and 97.1 in Austria. 9.7% of households or 700,000 in the New York-New Jersey metropolitan area are unbanked. Demirguc-Kunt, Asli and Leora Klapper, 2012. "Measuring Financial Inclusion: The Global Findex Database." *World Bank Policy Research Working Paper 6025*, World Bank, Washington; Burhouse, S. and Yazmin Osaki. "National Survey of Unbanked and Underbanked Households." *Federal Deposit Insurance Corporation*, September 2012.

20 Chaia, A., et al. "Half the World Is Unbanked." *Financial Access Initiative Framing Note*. Washington (2009); Horrigan, J. "Home Broadband Adoption 2009." Pew Internet & American Life Project (2009).

21 A Guide to Prepaid Cards for Transit Agencies: Smart Card Alliance, February 2011.

22 For example, last year, Philadelphia began rolling out a smart card system by first issuing renewable smart cards only to students and university employees and a small pilot group of commuters. It was later expanded to monthly pass buyers and then weekly pass buyers at certain venues. Vending machines will be the next stage. Schmitz, Jon. "Pa: Weekly Transit Passes Now Smart Cards." *Pittsburgh Post-Gazette* December 21, 2012.

23 Singapore focused on stakeholder buy-in when replacing the magnetic card system. It took 9 months. Student cards and a commuter pilot period were important, along with passenger education. Prakasam, S. "The Evolution of E-Payments in Public Transport's Experience." Japan Railway & Transport Review 50 (2008): 36-39.

and negative balance protection. Transit operators in Singapore, Hong Kong, Seoul and other major cities have found that incorporating these features into their transit ticketing technology has boosted passenger convenience and operational efficiencies. Transit operators planning to adopt new fare technology in the future, such as those in New York and Washington, hope to maximize the benefits of new technologies. There are challenges for all involved. Proprietary arrangements can, depending on the transit operator's position, undermine operational cost savings and the potential benefit of improved data collection. Institutional structures can limit innovative fare structures and experiments with routing, scheduling and fares enabled by both the payment technology and data collected with it. These structural impediments to change must be addressed alongside decisions regarding fare technology implementation.

Discussion Topics

Three topics are presented below as potential points of discussion for the Transit Leadership Summit.

Social Policy

It is generally agreed that a progressive city has equitable access to transportation. In the U.K., Australia and elsewhere, the issue of equitable access is discussed in terms of social inclusion and exclusion. Social exclusion refers to one's failure to participate, for reasons beyond one's control, in desired activities. There are many factors that contribute to social exclusion, such as physical disability, low income, and racial discrimination. Transportation is often cited as part of the solution: transport could help individuals overcome mobility-related barriers to inclusion, and expand access for marginalized populations. Transit operators generally accept this as a responsibility for certain populations and certain activities. Universal design standards for rolling stock and station infrastructure, along with fare concessions for the elderly, students, and the disabled, attest to an underlying societal agreement that transport is important enough to warrant, where practicable, special treatment for these populations. To do otherwise might be considered discrimination of these groups, which is why measures such as universal design and fare concessions are often mandated by the state.

Despite the great contribution transport could make to expanding social inclusion, many transit agencies may be limited by operational and legally mandated budget constraints to consider adopting social inclusion as an explicit goal for *fare policy*. This is because lowering fares threatens an important source of revenue. Perhaps transit agencies' reluctance, in part, because 'social' fare policy has not been among their primary objectives. Concessions for certain populations are by far the most common social fare policy, and these are typically handed down to transport operators by the state. Concessions may be further removed from internal transit agency fare policy development when they are compensated by another agency, or they may be grouped with other unfunded mandates. Aside from population-based concessions, there are few examples of social fare policy. Geography-based concessions are one. Transit agencies may adjust fares by presumed ability to pay in a given place, that is, fares could be lower for those originating in lower income geographic areas or taking journeys observed to be popular for lower income travelers (as in parts of Washington). Another example is conforming fares to a standard of affordability. While a specific affordability criteria is rarely made explicit, fares are generally kept low enough for all income levels to be affordable to the near-lowest income level.

Compounding transit agencies' institutional distance from social fare policy, agencies may be reluctant to adopt a 'social inclusion' goal because it could promote an unfavorable image of transit. A high-tech, well-operated transit system can be an effective city status symbol. Services for marginalized populations, on the other hand, are necessary to city life but do not promote the same powerful image. Social inclusion could, therefore, seem to contradict other goals that align better with the image of transit as status symbol. Transit agencies are often motivated to shift travelers from their cars into public transit; mode shift is an efficient form of growth because it does not necessarily require building new lines, and can serve to fill under-utilized trains and buses. To shift drivers, transit must offer a desirable alternative, not just in terms of routing and frequency but comfort, convenience and amenities such as in-transit Wi-Fi and easy fare payment. Transit thus attempts to shift drivers by shifting its own image to be higher-end and more desirable. While these policies may not contradict, and may often be consistent with, social inclusion policies, social inclusion may not be considered the 'right direction' for transit agencies attempting to lure drivers or otherwise attract elites to public transportation.

Advanced fare technology presents the possibility for considering transit agencies' adoption of social fare policies. Smart cards and open payment/NFC promote a higher-end image of transit while potentially providing amenities *and* facilitating more complex and equitable fare structures (as discussed in section 3.2). Given potential applications of advanced fare technology, should transit agencies explicitly adopt the goal of social inclusion for fare policy? What are the risks and rewards of a social fare policy? Is transport-related social inclusion policy development best left with external government agencies, as it has been in the past, or is it better developed internally by the transport operators themselves? Since the fare represents a substantial part of transit agency revenue, does 'social fare policy' imply an inherent conflict of interest?

Integrated Transport Planning

For many years, urban planners have envisioned integrated transportation systems that reduce congestion, improve access and benefit the environment through optimal mode shares and efficient traffic flows. In this vision, the traveler is guided to the trip option that best benefits the overall system, given his destination and preferences. This vision requires real-time information provided to the user: what is the time and cost difference between a taxi and the subway to the airport, given current traffic conditions? Considering the distance of the destination from the station, and the current weather, is it better to take the bus or the train? The traveler must be able to access the best option without barriers; fare payment, transfers, parking, and toll payment must be predictably and seamlessly available. The vision also requires development of interfaces that leverage knowledge of travel behavior: some passengers will always make the same trip regardless of conditions because the 'cost' (anxiety) of deviating from habit seems insurmountable. 'Selling' the most efficient option to travelers must therefore include providing complex information, customizing incentives, and addressing the inertia of habit.[24]

Transport operators have begun to leverage advanced payment technology to move closer to realization of this vision. In Singapore and Seoul, payment for parking, tolls, and transit fares are integrated. Combined with dynamic tolls that vary with VMT and traffic congestion, and fares that vary with distance, these technologies encourage travelers to minimize their contribution to traffic congestion, especially for short trips. These agencies, along with others pursuing open payment/NFC systems, are also making it easier to pay for travel-related expenses with multiple, multi-use devices. The next step will be to directly inform passengers of the best options for specific trips at specific times. Already, transit operators are making their data available to web-based application developers. Travelers can use apps that provide maps, prices and estimated journey times for multiple modes. Customized incentives to guide real-time decisions are not yet available, and most apps stop short of purchasing the ticket, reserving the parking space or renting the car.

As technology geared at informing travelers is further developed, transit agencies must consider the extent of their involvement in the process. Should transit agencies adopt goals for regional modal shares, or simply for growth of transit's share? How can advanced fare technology be used to encourage fewer cars and more public transport? Is it sufficient to provide passengers with minimal, conventional data on trip times and suggested routing, while competing private applications provide real-time information about multiple modes? Should transit agencies, having developed expertise in payment technology, lead the development of applications for passenger mode choice? Overall, is the technology available for an integrated transport plan such as the type discussed above? Are transit agencies positioned to lead such an effort?

Transit Agency Cooperation

This paper has discussed the problems that can arise when transit agencies are confined by proprietary technology and contracts. Some agencies have resolved these issues by developing fare-related technology internally; some look to open payment/NFC systems to maximize use of off-the-shelf payment media and readers. Given these challenges, cooperation among transit agencies would seem potentially beneficial. Multiple transit agencies could combine data to better understand the transactions costs of new fare technology, for example. Informed at this macro level, transit agencies could then perhaps exert more influence on the payment industry to create suitable products at lower prices. Transit agencies have, in the past, coordinated efforts with others in the payment industry to develop international payment standards, and there are peer-learning groups comprised of multiple transit agencies devoted to fare technology. Is there a potential benefit from extending this cooperation to fare technology development or purchasing?

Furthermore, should transit agencies coordinate fare technology or fare policy implementation? The diversity among transit agencies might present challenges to cross-agency coordination. Each transit agency has a unique organizational structure. Some are comprised of multiple private operators, and others are public agencies; some span across political jurisdictions and others operate within a single jurisdiction. Each has a different history and confronts today's fare technology and policy options with different physical and institutional resources. Nevertheless, could coordination among transit agencies potentially leverage resources or promote new fare policies? How could cooperation among transit agencies benefit the development of new fare technology or new fare policies?

24 Several studies have identified that habit along with attitude determines travel behavior. Therefore only major changes in fare, service or circumstances will result in a modal or temporal shift. For example, there are several articles in an edition of the journal *Transportation* devoted to this topic (*Transportation* 30 1 2003).

Appendix: Advanced Fare Technology Studies

Improving Fares and Funding Policies to Support Sustainable Metros

This paper argues that transit operators would benefit from a more principled approach to fare setting and regulation. Fares should be adjusted regularly and systematically; fares should better reflect the costs of inputs and affordability, support the imperative to renew assets and enhance service quality and, through differential pricing, more closely reflect the variable cost of travel.
Anderson, R. et al. *Improving Fares and Funding Policies to Support Sustainable Metros*. Transportation Research Board 91st Annual Meeting. 2012.

Pervasive Technology and Public Transport: Opportunities Beyond Telematics

This paper reviews the range of advanced traveler information systems that provide real-time information to passengers. The range includes static and dynamic versions of transit agency data as well as crowd-sourced data. The paper also discusses the benefit of in-transit services such as WiFi connectivity, as compared with conventional operational improvements.
Camacho, T., M. Foth, and A. Rakotonirainy. "Pervasive Technology and Public Transport: Opportunities Beyond Telematics." *Pervasive Computing, IEEE* 99 (2012): 1-8.

Avoiding the Crowds: Understanding Tube Station Congestion Patterns from Trip Data

Using one month of data from London's Oyster cards, the authors devise a simple tool to predict crowding on a per-station basis. In residential stations, there is a steep morning peak period where passengers enter the station with a less-steep evening peak when passengers exit; in business district stations, the pattern is reversed. In transport hub stations, the peaks are consistently steep at both morning and evening. Evening peaks are further characterized by three distinct sharp peaks at 30 minute intervals, suggesting both business and social adherence to hourly schedules. The authors consider how providing information to passengers on crowding might alter travel behavior, relieving crowding and better utilizing trains at the shoulders around peak periods.
Ceapa, I., C. Smith, and L. Capra. "Avoiding the Crowds: Understanding Tube Station Congestion Patterns from Trip Data." Proceedings of the ACM SIGKDD International Workshop on Urban Computing. (2012).

Establishing a Fare Elasticity Regime for Urban Passenger Transport

Using an extensive survey from metropolitan Sydney and advanced microeconomics techniques, the author estimates cross-elasticities for mode and fare classes (single- vs. multi-trip ticket). He finds that increasing the price of a multiple-trip transit ticket leads to higher revenue growth and smaller patronage declines than increasing the price of single-trip tickets. This is especially true for bus riders. He also finds that passengers are more likely to switch modes (train to bus and vice versa) than to switch fare classes. Finally, changes in public transport fares regardless of fare class do not necessarily lead to greater car use, whereas changing the cost of car use does affect the use of public transport.
Hensher, D.A. "Establishing a Fare Elasticity Regime for Urban Passenger Transport." *Journal of transport economics and policy* (1998): 221-46.

Consumer's Perception of Fare When Using Farecard in Urban Railway Route Choice

The authors tested hypotheses related to how passenger price perception varies according to payment method and fare media. The study is a statistical analysis of attitudinal data for passengers on non-work trips on Tokyo's rail system. Findings are mixed, but overall the study finds smart card users perceive the price of travel as lower than regular ticket users. This report also conducts a literature review on fare media and payment methods and finds very little research on the subjects, suggesting a need for further study.
Kato, H., et al. "Consumer's Perception of Fare When Using Farecard in Urban Railway Route Choice." National Research Council (US). Transportation Research Board. Meeting (82nd: 2003: Washington).

Modeling Transit Rider Preferences for Contactless Bankcards as Fare Media

Surveys from Transport for London (TfL) and Chicago Transit Authority (CTA) show that most riders prefer to use transit agency-issued fare media rather than bank-issued smart cards to pay their fare. In its 2009 survey, TfL showed that 55% of riders prefer the TfL (Oyster) card, 31% prefer contactless bank cards, and 14% prefer the paper tickets. In a 2008 CTA survey, passenger were asked how likely they would be to use contactless bank cards to pay the fare. 48% were very unlikely, 15% somewhat unlikely, 17% somewhat likely, and 20% very likely. In both places, those passengers more likely to prefer bank-issued smart cards included younger passengers and those who already have credit and debit cards.
Kocur, G. *Modeling Transit Rider Preferences for Contactless Bankcards as Fare Media: Transport for London and the Chicago Transit Authority*. Transportation Research Board 90th Annual Meeting. 2011.

Mining Mobility Data to Minimise Travellers' Spending on Public Transport

This study links ticket purchasing behavior and public transport usage datasets to examine the relation between mobility and purchase habits. It finds that travelers overspend by approximately £200 million per year by buying the incorrect fares. They find that passengers are relatively uniformed; there are few transparent links between passenger class and trip characteristics that reveal the best fare; and that travelers have trouble identifying the best way to pay. This study develops an algorithm for personalized ticket-purchase recommendations based on travel history data that can be accessed from fare technology.
Lathia, N., and L. Capra. "Mining Mobility Data to Minimise Travellers' Spending on Public Transport." ACM KDD (2011).

Smart Card Data Use in Public Transit: A Literature Review

This paper reviews smart card and NFC technology, privacy concerns and uses of data by transport operators. It anticipates linking socio-economic data to the totally disaggregate data produced by advanced fare technology to overcome the privacy regulations preventing exploitation of this data. It finds the most promising research avenues include comparison of planned and implemented schedules, systematic schedule adjustments, and the survival models applied to ridership.

Pelletier, M.P., M. Trépanier, and C. Morency. "Smart Card Data Use in Public Transit: A Literature Review." *Transportation Research Part C: Emerging Technologies* 19 4 (2011): 557-68.

Fair Fare Policies: Pricing Policies That Benefit Transit-Dependent Riders

This analysis of the Best Fare system finds that capping the aggregated cost of single passenger's trips at the cost of a multi-trip pass would create an equitable system for those passengers who cannot afford to pay for multi-trip passes in advance. Smart cards enable the Best Fare system. The authors' model a Best Fare system coupled with a base fare increase and finds it saves money for low income riders while raising revenue for the transit agency. The research is premised on the idea of multiple elasticities for multiple fare products, rather than broadly characterizing low income passengers as inelastic to fare prices.

Taylor, Kendra C., and Erick C. Jones. "Fair Fare Policies: Pricing Policies That Benefit Transit-Dependent Riders" Community-Based Operations Research. Ed. Johnson, Michael P. Vol. 167. International Series in Operations Research & Management Science: Springer New York, 2012. 251-72.

Controlled Public Transport Fares in the Developing World: Help or Hindrance to the Urban Poor?

This article uses data from a transport planning survey of 57,000 households in Cairo, Egypt, to consider public transportation pricing for the urban poor. Referring to several case cities in the developing world and Europe, the article recommends Cairo incorporate transport into various welfare programs, none of which currently directly addresses transport. Overall, the article emphasizes shifting subsidies from agencies to passengers.

Thompson, J.E., and K. Nagayama. "Controlled Public Transport Fares in the Developing World: Help or Hindrance to the Urban Poor?" ITE Journal (2005).

Does Transit Mean Business?

The authors surveyed U.S. transit agencies on the potential for differentiated fares given new fare technology. They find that political and institutional resistance is the greatest obstacle to marginal cost pricing or any type of variable pricing. Transit agencies are found to be reactive to budgetary pressures, reluctant to change fare structures when changing the price, and focused on avoiding risk and minimizing public scrutiny. Transit agencies hold competing goals and ambiguous missions, which leads to reactive rather than rational fare setting.

Yoh, A., B.D. Taylor, and J. Gahbauer. *Does Transit Mean Business? Reconciling Academic, Organizational, and Political Perspectives on Reforming Transit Fare Policies*: University of California Transportation Center, 2012.