SUSTAINABLE DEVELOPMENT BASED INNOVATION TECHNOLOGY IN FARE COLLECTION SYSTEMS

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ABSTRACT

Both travel tickets and cards are alternatives currently used to collect money in transportation systems. Using recycled paper for the development of transport tickets and biodegradable cards that complete their life cycle as used in the system, are ways to take up in order to protect the environment and, thereby, the planet.
Such alternatives in fare collection systems are much better than those currently used in much of the world, yet they need to be processed. Thus, an initiative that uses our fingerprints as identification for registry and transport use, could bring not only environmental benefits but also operational ones.

Keywords: Sustainable transport, biocards, recycled paper transport tickets, transportation fingerprint, sustainable alternatives, control of transport users

INTRODUCTION

Fare collection systems to fund transportation, involves collecting and forwarding card or ticket / paper ticket for using the service.

In European countries such as France, Spain and Italy the sale of travel tickets is done almost entirely by paper ticket machines, the tickets are issued with high frequency, wasting paper, because in the end, about 1hour 15minutes later the ticket becomes useless and turns into waste. This is not environmentally sustainable as the production and consumption of paper requires pulpwood, which leads to deforestation. In these countries there are also smart cards for passengers entitled to travel at lower prices, such as students, people with reduced mobility (PRM), frequent travellers, and tourists.

The current fare collection system in the capital of Colombia is done by a contactless smart card, which can be found in different types: rechargeable cards with a certain amount of money, business cards, and student cards.

Smart cards used worldwide have been well received by users, although their fabrication involves the use of PVC or similar material, which is non-recyclable and cause serious risks to both the environment and public health.

Then, from the environmental point of view, How can we contribute to develop a sustainable transportation system?

This article explains some steps to be followed in order to set up a fare collection system that is environmentally friendly, such as the use of tickets out of recycled paper as well as biocards, which are a type of Smart Cards. The article goes further exploring the use of fingerprint as own innovation proposal for access, collection and user control within the transport system.

The fingerprint is not only an environmentally friendly identifying method, but also a potential mechanism to develop a sustainable fare charging-&-monitoring method over time in a city like Bogota. In such a city it is not possible to make spatial zoning, given its inequitable conditions in terms of space distribution (the poorer a citizen is, the farer he/she lives from the job place, thus we would be charging the highest fares to them). It is also unfeasible to continue with the current unique-pricing ticket system because it is unaffordable to the city administration, in the long run. However, it is possible to set staggered prices combined with a personal identification system which could help to overcome the current shortcomings.

1. CURRENT FARE COLLECTION SYSTEM AND ITS ENVIRONMENTAL IMPACT

Nowadays the fare collection starts in the box office, where the sale of smart cards is made or in the vending machines for tickets/paper tickets (Figure 1).

Figure 1 – Cards and paper tickets / tickets (Source: Organized images from Internet)

Then, users go to the cash registers or access gates (Figure 2), which can be of different types, such as complete panels used in some European cities like Paris, and tripods or turnstiles as used in Bogotá.

Figure 2 – Access Controllers (Source: Gunnebo. For a safer world)

After going through these cash registers, the system transmits the fare collection and the counted number of passengers traveling in and out of the central control system, so the money collected is transmitted to a unique fund that transfers payments to transport operators.

The numbers of people passing through the access controllers are large: in Paris, around 4.05 million per day were travellers for a total of 1,479 billion per year according to figures from the Syndicat des transports d'Île-de-France STIF in 2009, the TMB in Barcelona recorded 5.1 million passengers in 2010, currently registered 1262 steps in the network[1].

In Colombia, according to the 2010 Transmilenio Report, overall 187.830 passengers were mobilized at rush hour in December for a total of 1, 656 million people per day, a lower figure than those recorded in Paris.

The figures above leads to think of the amount of cards issued, for example in Bogotá, and the percentage of tickets / paper tickets for the Paris and Barcelona. Either cards or tickets must be used on a daily bases just to be got rid of, right after being used. This indicates that, despite of Smart cards can be better in environmental terms, these are plastic and even with its resistance and usefulness eventually the cards get scratched, damaged and at the end must be disposed having a problem of waste management.

1.1. Tickets Or Paper Tickets

Tickets / paper tickets are made with paper of a certain thickness to ensure durability. Previously it had been named the number of passengers/day for some cities for almost the total use of these paper tickets. Numbers ranging from 1.5 million passengers in Barcelona

[1] Article: billete metro Barcelona. Source: http://www.lavanguardia.com
[2] Tout ce qu'il faut savoir sur le ticket de métro. Source: http://www.leparisien.fr/yvelines-78/tout-ce-qu-il-faut-

to 4.05 million for Paris, in which roughly 15,000 tickets are sold every minute thus yielding to more than 600 million per year[2]. In Spain every machine sells an average of 164 transport tickets a day and 16 in rush hour; each operation requires about 42 seconds on average and they have 722 machines, then the total number of tickets issued are 118,408 titles daily and 1,152 on rush hour.

Considering the amount of paper generated to support this passengers' demand in these cities (which are just two of many cities in the world), brings to mind large numbers of paper used.

The SNCF is the Société Nationale des Chemins de Fer Français who is responsible for the operation of rail transport in France, makes transport tickets even bigger as shown in the top of Figure 1. Transport tickets of the SNCF and generally in Europe have a size of almost nine times a normal ticket in the underground (Figure 3). The SNCF reported in 2009 a figure of 1.2 million of tickets only sold for TGV Prem's as says some information of the SNCF. In addition for tourists are generated 15,000 train tickets per year.

Figure 3 – Dimensions of travel de Tickets (Source: Own)

Reports from the H line, for example, in Transilien of Paris operated by SNCF recorded 200,000 passengers daily[3]; taking into account that there are 9 more lines in this place, this yields 1'800.000 of travelers, which is the 44% of all travelers in the Paris region.

All these numbers gives a simple picture: huge paper consumption. Now, n order to produce so much paper, it is required a large amount of cellulose, which is a vegetable-based input,

[2] Tout ce qu'il faut savoir sur le ticket de métro. Source: http://www.leparisien.fr/yvelines-78/tout-ce-qu-il-faut-savoir-sur-le-ticket-de-metro-04-11-2010-1134876.php
[3] Transilien de SNCF. Source: http://www.transilien.com/web/site/accueil/plus_sur_transilien/les-lignes-transilien

consisting of fibers or fiber bundles obtained from herbal substances. The basic raw material to obtain it, is pulp wood.

According to the World Watch Institute, 40% of the wood harvested for industrial purposes is used to make paper. Out of this, 25% are direct cuts for the paper industry, while the other 15% comes from products from other sectors, including transport. The sources of these fibers, discriminated according to the different types of forests that they come from, are: 17% comes from primary forests (virgin forest), especially in northern regions, 54% of secondary forests, and, finally, the 29% of forest plantations.

Those figures tell us that something must be done in order to reduce deforestation. The International Air Transport Association (IATA) made by 240 airlines around the world suggested that from June 2008 air tickets would be issued as electronic tickets exclusively, thus contributing with the environment and putting an end to the issuance of paper tickets. This arrangement allowed companies to save not only paper but more than 3.000 million dollars per year, as the electronic ticket costs 0.50 US cents whereas the traditional paper ticket costs 10 cents. The contribution from this arrangement for the environment is important because it is estimated that for air tickets issuance 50,000 trees per year were used (5 km ²)[4].

1.2. Smart Cards

A smart card is a pocket-sized card that contains integrated circuits that allow running some calculations, storing data, and running programmes through complex security protocols. The range of applications that smart cards have is wide: virtual money, secure storage of information associated with the holder[5], control cards and payment cards for public transport, credit cards and SIM cards for mobile phones.

The card is manufactured using polyvinyl chloride or a similar material that produces a sheet with proper thickness, which is printed and then trimmed. Polyvinyl chloride or PVC is a thermoplastic polymer, exposure causes health damage as it is a toxic substances. PVC is a non-recyclable material thus causing serious risks to the environment and public health throughout their life cycle. These are associated with the generation and emission of dioxins during the manufacturing process of vinyl chloride and incineration of PVC products, and the migration of additives, such as plasticisers, which necessarily contain these soft plastic products. Therefore, the PVC may be called "environmental poison."

In Bogota, the collection system handles these plastic cards calls Contactless Smart Card (TISC) -provided by the company SAR that designs it-, produces and integrates technology and collection management for transportation systems. This system allows Transmilenio users to get into the Rapid Bus-based Transit System, by approaching the card to the censor board located in the control barrier. Cards must be recharged in specialized booths.

[4] Billetes electronicos. Source: http://www.paraconocer.com/billetes-electronicos/
[5] Targeta Inteligene. Source: http://es.wikipedia.org.

According to the report of Transmilenio 2011, in 2010 256.138 cards were delivered, reaching a total of 516.630 cards in circulation and, in December 2012, 27% were sold. From this amount of cards in use, it can be concluded that the annual increase of cards is roughly 50%.

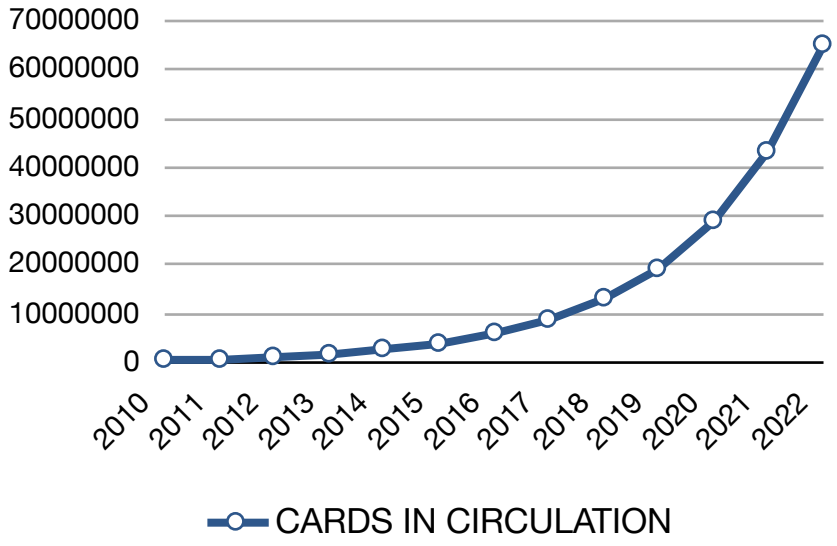

Figure 4 – Estimation of cards in circulation in 2012 (Source: Own creation)

If we keep at this pace, this year 2012 around 65 million of cards will circulate. This is a lush figure, without taking into account the cards that will be required to run the so called SITP system, which includes even more cards because SITP´s fare collection system is not fully integrated with Transmilenio. In the same way, such increased cards consumption, will have a bigger environmental impact.

2. MECHANISMS FOR SUSTAINABLE DEVELOPMENT

After explaining two current collection system methods used in public transportation, we will proceed by suggesting two alternatives to be implemented, in order to turn such systems into environmentally sustainable ones. Following this line of thought, fingerprint is proposed as a mechanism to collect money and to control users.

2.1. Recycled Paper And Environmentally Friendly Paper

To reduce the impact caused by the production of paper tickets, we can implement the use of recycled paper or environmentally friendly paper used worldwide. This is part of a popular complete methodology so called the 3 R's: Reduce Reuse and Recycle.

Recycled paper is entirely made of paper raw material, used by the consumer and recovered, such as newsprint, magazines, cardboard, paper documents, etc..

Environmentally friendly paper is not bleached with chemical products based on chlorine, -which is harmful to the environment-. Its natural white colour ensures a clean manufacturing process. Paper chlorine free quality is exceptional; it just has not been subjected to the bleaching process.

The advantages of using recycled paper and environmentally friendly are evident. First, logging decreasing trends would improve the forests, seconds, other sectors such as energy will experience some benefits through energy savings of 62%, and 86% of recovered water resources; third, reduction in the water pollution of 92%[6] and, of course, overall natural environment conservation.

2.1.1. Development

The following graph (Figure 5) shows the process of making recycled paper:

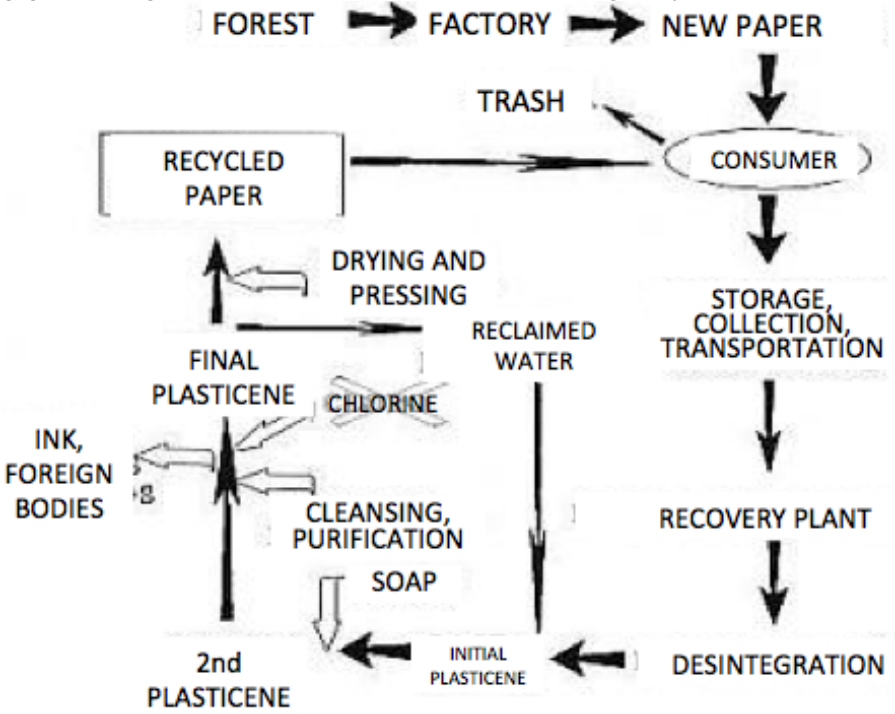

Figure 5 – Process of making recycled paper (Source: El papel http://www.manueljodar.com/pua/pua3.htm)

As indicated above environmentally friendly paper implies not using chlorine as shown in the previous figure.

[6] Corporación Educacional de la Construcción. Chile. 2011. Fuente: http://www.coreduc.cl/ver.asp?ver=noticias&idc=383

2.1.2. Implementation

Implementation comes from the 3'R and it is based on preventive approach, so called «front of pipe», (figure 6) It could be applied to the tickets production by implementing a recharging system, reusing waste papers to make new products, and Recycling for deposit on the machine.

Figure 6 – The 3 R's (Source: El papel http://www.gisits.com/img/Reciclar3Rs.jpg)

The implementation would be simple, by providing this type of paper to the machine and verifying its well-functioning.

2.2. Biocards

The Biocards are designed cards with a biodegradable material, and have the same functions as a normally designed card with PVC.

The following information provided in the title 2.2.1. to 2.2.3. corresponds to the source of Akrocard Biocard.

Biocard trademark of PVC cards are 100% biodegradable. These are made from chemically treated material so that its degradation accelerates as soon as they have contact with the environment.

Figure 7 – Biocard Logo (Source: www.biocard.es)

Biocard cards degrade in less than four years. This is a breakthrough, if you consider that degradation takes about 400 years, for a card made with standard PVC.

2.2.1. Some Concerning

Biocard ® Akrocard cards ® have the same characteristics as the standard PVC card used until now: Flexibility, consistency, durability and good print quality. Also they allow all applications and uses of other plastic cards: RFID, smartcards, card wallet, access control, public transportation, citizen card, identification, membership, etc.

2.2.2. Development And Use

Biocard ® cards are obtained by using manufacturing special PVC layers, so they are 100% biodegradable (100% biodegradable according to European Directive CE 94/62 (Method of testing :: ISO 14855).

The central layer is made of copolymers, whereas the overlay is 100% copolymer. This is a new formulation of PVC that arises to satisfy the demand for green products and fulfill the requirements of the REACH (Registration, Evaluation Authorisation and restriction of Chemicals).

These cards are manufactured in the same way than PVC cards: the design is printed on the front and back of the card; a transparent sheet covers printing from scratch and damage on both sides, the central layer contains the chip and antenna (for contactless cards); through a process of temperature lamination all sheets are join in one; An automatic cutting matrix join the sheets ensuring the measurements of the regulation for plastic cards ISO 7810/11.

2.2.3. Advantages

While the material which makes the Biocard ® degrades at 100% after 39 months of being in contact with the environment, without any negative impact on the ecosystem. PVC (ABS in some cases) used up to now to make plastic cards about 600 years to decompose on the natural environment.

Figure 8 – Biocard (Source: www.biocard.es)

- In a year are used a total of 17.000 millons of credit cards.

- Over 99% of all plastics are produced or derived from non-renewable energy sources.

The raw material used to manufacture Biocard ® has received certification of biodegradability by an independent laboratory under the agreement and supervision of the University of Milan.

The formulation of the used material for these Biocard ® cards also meets the requirements of the REACH (Registration, Evaluation and Authorisation of Chemicals) which ensures complete safety in its use.

More than 100,000 tons of wastes are generated annually by the plastic card industry in the world. The widespread use of cards made from biodegradable plastics contributes positively not only to increase this figure but reducing it significantly if it is imposed against PVC or ABS.

3. FINGERPRINT READING, AS A SUSTAINABLE MECHANISM OF FARE COLLECTION IN PUBLIC TRANSPORT

According to the UN, in 2015 more than 60 megacities will exist sheltering an estimate over 600 million people. This implies a growing demand for public transportation that threatens the current systems because it might not be satisfied. In 2015, according to the estimations given in Figure 3, there will be 3.8 millions of cards. This leads to think about the creation of a more efficient fare collection mechanism that can favour the environment.

This article proposes a system of collection control by using fingerprints. Nowadays there is a growing utilization of that system. For example, some Hewlett-Packard computers give the possibility to access them by scanning user's fingerprints as displayed in Figure 9.

Figure 9 – Fingerprint reader hp computers (Source: Internet Images)

In Colombia some banks and financial institutions, use a fingerprint reading devices to identify their users (Figure 10).

Figure 10 – Fingerprint Reader (Source: Internet Images)

The fingerprint identification takes less than two seconds, which fits perfectly the conditions to attend the growing passengers demand in public transport for big cities.

If we go beyond of what exists in the world for fare collection, we can see that this method would work perfectly, since humans have an integrated identification card: their own fingerprints which are virtually unique to each person. Thus, there is no need to implement tickets or identification cards for each.

3.1. How would It Work?

- A fingerprint reader would be established in the access spots to the station, that currently hosts the transmilenio reader card.

- In the ticket offices it would exist a card reader to recharge cash, or by using the ID number it will be possible recharge virtually

- The user would be able to access to the system by overlaying the fingerprint in the reader/fingerprint identifier. The index fingerprint would be the primary source of data; although in some cases there might exist the option to gain access by using a secondary fingerprint that corresponds to another finger. There would be a third option that would be the ID number or passport with which the user is registered.

- The identification system would allow having certain rates according to socio-economic strata. Either unregistered users or tourists will be charged with a higher fare. In such a way, the user would infer that the best way of being transported is being registered and these will be using biodegradable cards.

- There would exist controllers inside the transport system, which are people who are supposed to check that the user has passed their fingerprint to access the system, which will be required in such an open public transportation facilities.

- The PMR with disability in the arms will be able to use biocards for entry and shall enter by the preferential door that is currently use nowadays

Figure 11 – Reader incorporated in the system for the entry control (Source: Own – taken from Gimnasio BodyTech Bogota)

3.2. User Registration

Users must register their fingerprints thus providing the right information:

- Name: To Identify each person
- ID o passport, which will be use to make virtual recharges or as a third option of access.
- Age: since they might manage to handle certain benefits according to the age
- Socio-economic stratum: through this can be use a fare charging criteria according to socio-economic strata defined by the Records Office Bogotá.
- Home address.
- Phone: Personal and line phone.
- Occupation: In order to develop fare f benefits to the user.
- Other information.

The person must submit documents verifying certain socioeconomic information.

3.3. Advantages

In environmental terms, the fingerprint reader will reduce paper consumption and production of PVC, to elaborate tickets or transport cards reducing environment contamination, provides highly reliability at identifying the user, it avoids user's impersonation, which helps to control the usage of the way of transportation and a quicker verification.

In addition it could be implemented an affordable fare charging criteria which by the correct user identification the system of stratification. Besides this, as we have users information it is easier to develop fare benefits for students, companies, and others. Finally, there would be special prices for certain trips by range of age.

Despite such reductions, we must realize that when tickets are issued, vending machines are required; those machines consume lots of both energy and money. The TMB announced through its corporate magazine Rush Hour that during March and April 2012, a plan to "optimize automatic vending titles" was set up in order to reduce costs without affecting the service. Based on data provided by the 722 ticket vending machines that are on the underground and as estimated by TMB, disconnecting 66 of the 722 ticket vending machines will save about 250.000 per year for the company, especially on issues such as equipment breakdowns, power consumption, reel loading or transportation of the daily collection. This figure is impressive, representing approximately 0.5% of the total estimated for the expenditure rationalization plan approved, late last year by the company, which was quantified in 56 million Euros[7]. Therefore management fare collection systems can save not only energy but also paper and a lot of money, because by using new mechanics is reduced by the use of machines that allow recharge mechanism from the comfort of your home.

CONCLUSIONS

Sustainable transport must be developed in each of the parts that directly or indirectly involved this. The implementation of sustainable alternatives in the collection system is a measure that can bring many benefits primarily in environmental terms.

The use of recycled paper in vending machines in the transport tickets, bring environmental benefits ranging from no more use of trees for its production to the reduction of water contamination and the decrease in energy consumption.

Moving from traditional PVC cards, which degrade in about 400 years, to using a bio-card, which lasts 4 years to degrade itself, would be a way to contribute with the environment we live in.

[7] Apagan 10 de las maquinas de autovebta de billetes. Fuente: http://ecomovilidad.net/barcelona/es

Ruling out these physical alternatives for fare collection systems, thus embracing the use of our own fingerprint identification system to access to public transport, it is economically feasible in terms of eliminating the use of paper or plastic cards. Besides it gives a social benefit for the users and the operator for the control through the unification of the fare charging system

Little has been said about the paper waste and the cards manufacture. We should not expect others to take the initiative. Proposing a system of sustainable collection and in favour of the environment, is an initiative that was given after having observed the paper waste generated in the use of transport for different cities around the world, and consulted on the production of the plastic cards.

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