Biometric Access System for MTA Services

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Abstract

The history and expansion of public transport has been directly linked to the evolution of technological innovation. To retain old users and welcome new ones in the face of increasing private transportation alternatives, the progress achieved in providing easy access to the MTA is as important as maintaining efficient and timely service. The implementation of biometrics is a critical step towards making public transport accessible and safer for the general public. Nevertheless, it is not without its caveats. The sheer challenge of running a distributed system in one of the busiest cities in the world presents difficulties in terms of execution. This includes system architecture, hardware, networks and privacy issues. In this report, we attempt to address these issues to propose a system that lays the foundation to resurrect a transportation system towards a truly smarter New York.

Introduction

You have just arrived at the train station to board your next train; you walk through a scanner that registers your finger impression, positively identifying you have bought a ticket/pass, sends back the boarding information on your mobile devices and your family, and the whole process takes few seconds. Welcome to the amazing world of biometrics, which can change the face of ticketing. Few will complain about that, and for good and varied reasons.

In order to look at one particular public transit system in the US, we need to have a brief understanding of the industry it caters to. The public transportation industry in the US includes all services provided to passengers over regular routes that span a state or two on a fixed timetable. The industry looks at a plethora of such transportation activities, but this report will focus on the heavy rail system like the subway and complimenting bus services.

For an industry that brings in $74.9 billion in revenue, it is rather strange that it collects only $4.3 billion in profit. That's just under 6% for a sector that caters to an urban population of 270 million and growing people. Although the industry has seen a 2.5% annual growth rate from 2013 to 2018, a stronger economy and affordable alternatives in the private sector will see that growth rate halve to 1.2% till 2023 (Hadad, 2018).

Due to the nature of how a public transport system is funded, it is unfair to point to industry revenue as a performance indicator. Although government funding is set to reduce over the years, it is still high and will continue to be. This benefits the industry in terms of subsidies and the general public in terms of employment. Ridership and demographic migration are more appropriate metrics to gauge industry performance. As the unemployment rate has lowered, more people are using public transit, but the same factor reflects onto a strong economy which has led to more people using private modes of transport as well. As a higher population is expected to move into urban areas, the public transit system is expected to carry the burden of providing efficient and cost-effective service on a daily basis.

With 86% of the total transit system being comprised of heavy rail and buses (Hadad, 2018), it seems necessary to understand the elements what will keep this system relevant in the eyes of the public. New York's Metropolitan Transportation Authority (MTA) is no exception. Good customer relations are critical to the success story of a transit authority. When an authority receives nearly two-thirds of its operation expenses from the government and the public sector, it must ensure that it provides safe, comfortable and prompt services to its patrons. Doing so will result in hitting two birds with one stone: having a better reputation and increasing their ridership rates by not only obtaining new customers but retaining old ones as well. Easy access to these services plays an equally important role. Not only is the location of stops and stations important to involve local residents but reducing wait times and implementing improved technology to make accessibility easier in the eyes of the customer is an important step in customer retainership.

MTA has the largest breadth in terms of services, among all other transportation systems in the world. It has 472 subway stations in New York and it has diverse service offerings like subway to commuter rail and buses, running both express and local. MTA serves over 15 million people living in five different boroughs, Long Island area, and southeastern New York state. The number of riders count is increasing day by day; therefore, continuous investment is necessary to

build capacity enhancement projects. MTA should focus on the sustainable innovations to provide the latest 21st century services to customers and enhancing customer comfort level (MTA, 2017).

Problem Statement

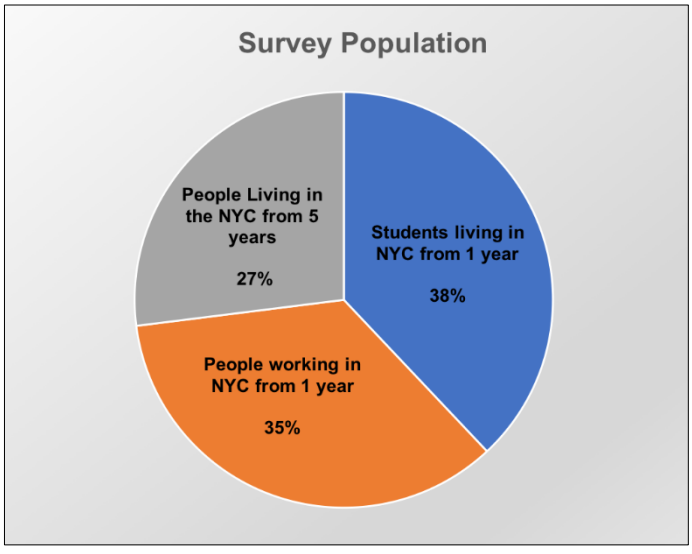
The current card system, albeit effective, is less secure. People have also managed to take advantage of "free-swipes" from someone else's unlimited ride subscription. Each bypass means the MTA is incapable of collecting revenue for that person on that ride. Using a card is increasingly becoming a hassle because of its reliability on the magnetic strip. Any damage to the card can have unfavorable side effects to the customers experience with the MTA.

The subway riders expect fast commute and the best service when it comes to paying a premium of $2.75 per ride. New York City MTA service is not the most expensive in the world, however it easily tops the charts in the USA. The Los Angeles subway service charges somewhat similar prices to what the MTA in New York City charges its commuters.

The MTA riders face several issues in their daily commute. Swiping the plastic cards at the turnstile is the only way to enter the station. Other issues involve but are not limited to loss of access card, damage to magnetic strip due to folding and bending and carrying the access card, no matter how secure and convenient, at all times. The cost of producing and keeping MetroCards in circulation cannot be overlooked from a financial as well as environmental standpoint. The proposed biometric system aims to address these issues and provide a suitable and more secure alternative.

To understand the human behavior and their approach to our proposal we conducted a survey with more than 26 millennials. Our target audience included:

- People living in the New York City from last 5 years
- People working in the New York City from last 1 year
- Students living in the New York City from last 1 year

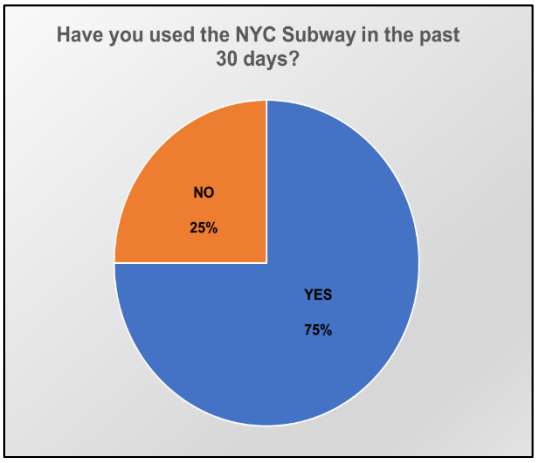


The following questions were asked to understand whether our recommendation is fitting well within the current environment -

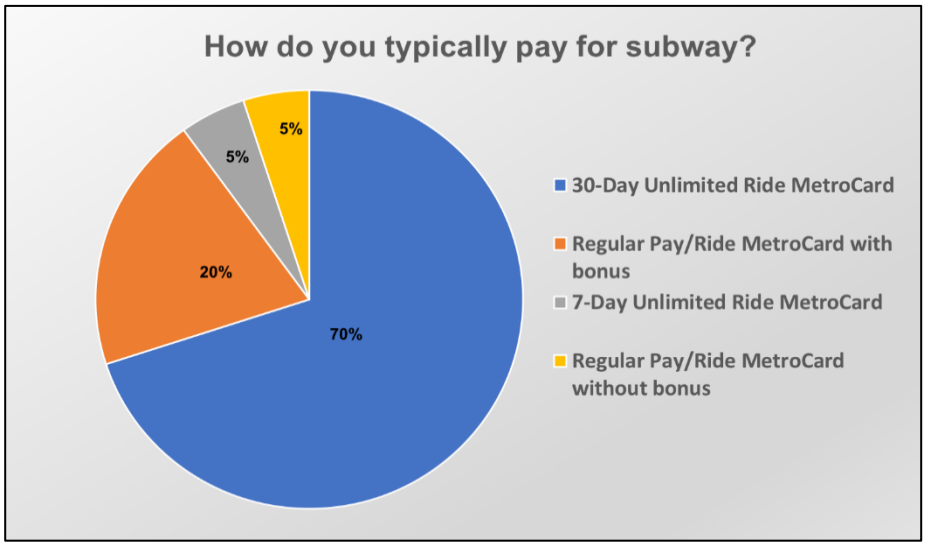
1. Have you used the New York City subway in the past 30 days?

2. How do you typically pay your subway?
3. What new technology do you want in near future to be implemented?
4. If biometrics were to be installed at MTA subway stations, would you be concerned about privacy issues?
5. If biometrics were to be implemented, which feature are you comfortable with?

In response to the first question, 75% of the commuters surveyed confirmed that they have used the NYC subway in the past 30 days. With the above results, we could verify that that our survey will attract a majority of commuters who have used the MTA service recently.

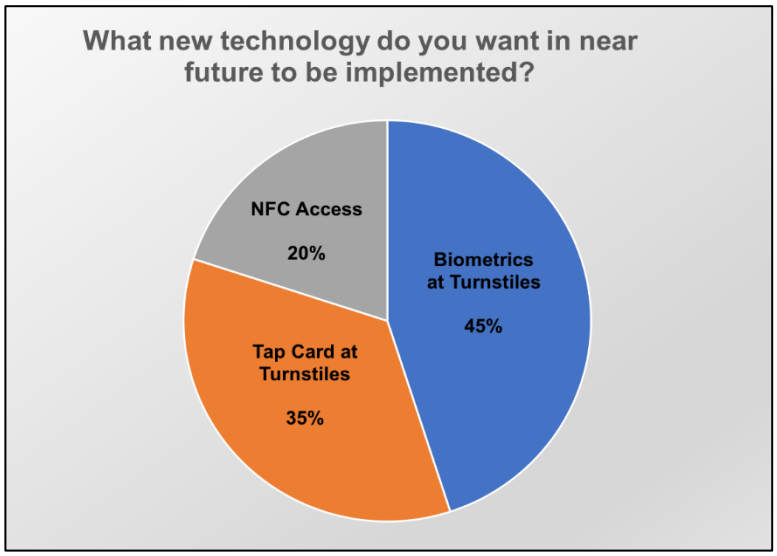


In response to the second question, maximum number of the (70%) commuters surveyed confirmed that they pay for their subway rides using a 30-day unlimited MetroCard. Commuters usually opt for a 30-day unlimited card when they are sure that they would utilize the service and gain more value as compared to a per-ride payment basis. This result proves the high frequency of travel our survey respondents make using MTA subway.



In physical — or even digital — form, tickets are inconvenient. They involve either collection or printing or saving to your mobile device. Using a mobile device for ticketing is convenient, however it does require you to keep your battery charged and keep it functional when you need it.

In response to the third question, the tap-card feature, which was voted second, is going to be implemented by the MTA in 2019. Commuters here are opting for a solution which is already implemented at other transit services like the PATH. The Port Authority Trans Hudson service gives commuters the facility of tapping their 'Smart Cards' as well as using the MTA Subway cards.

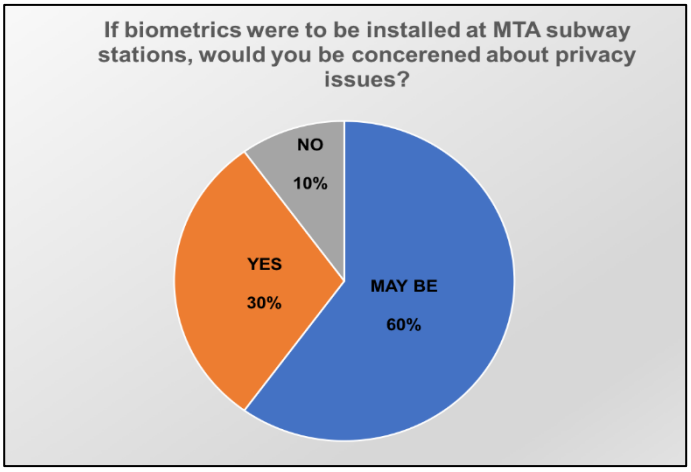


Very soon commuters using MTA subway will have an option of tapping their phone, a smart card, or even a bank card. However, considering the technological advancements, these offerings will soon become obsolete. Our idea is to offer something more robust and sustainable to the commuters.

The recommendation to implement biometrics at MTA turnstiles is voted the highest. Biometric verification introduces a considerable level of convenience and security. Given that there is no need to remember passwords, or carry anything additional, biometric verification has become more popular in corporate and consumer markets.

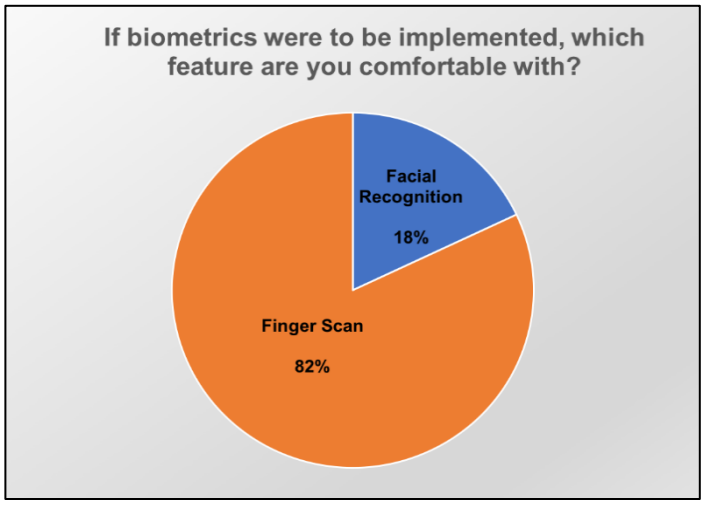
Our proposal is to reduce the interaction cost for the commuters while making the onboarding process seamless. Currently, MTA commuters have to carry plastic cards to get through the turnstiles, which at times obstructs the passageway because people search for the cards at the turnstile, swipe too fast or slow and try swiping multiple times before realizing the need to recharge.

Biometric identifiers rely on unique personally identifiable biological characteristics, such as fingerprints, retina and iris patterns, voice waves, signatures, hand geometry etc. These identifiers have been widely implemented by premier brands such as Apple's Touch ID for the iPhone.



In response to the fourth question, it is easy to understand the reaction of the commuters. People

usually are not comfortable in sharing their biometrics with the world. Facial recognition is an option that will make the ticketing process seamless, however given the monetary and more importantly security constraints, a considerable population will never opt for it in the near future.



The devices used in Biometrics, also in fact introduce vulnerabilities from a security standpoint. For example, biometric knowledge such as signatures, fingerprints can be obtained by fraud and used to trick the biometric systems.

The greatest disadvantage of biometric systems is the inability to change basic biometric information (for e.g. fingerprints) when a breach occurs. Whereas nonbiometric factors like passwords can be easily changed when compromised.

The advantage to a biometric is that it doesn't change. It goes where you go, so it's difficult to lose. It's also very difficult to forge or fake. In some cases, it is next to impossible. It provides a very strong access control security solution satisfying authentication, confidentiality, integrity, and non-repudiation requirements.

Previous Attempts

As trivial as it may seem, ticketing systems have always been an important part of a customer's transit experience. As the first point of contact in their journey, transit authorities have time and again refined their ticketing systems around the world to be cost effective while simplifying the process of access for customers. The MTA is no stranger to this evolving process.

The MTA first started out charging customers by issuing a ticket per ride. As the number of routes and customers increased over time, transfers became difficult and having personnel generate tickets became a massive hindrance to commuters in terms of time. The ticket was phased out by 1920 and customers could pay with currency directly. While this seemed like a logical step, fare prices rose which required engineers to program turnstiles to detect different sized coins. As this was not possible at the time, a standardized token method was introduced.

The token ticketing system is still one of the most prevalent methods to charge fare in public transit. While some systems have done away with them now, services like New Delhi Metro still use drop-in tokens to give customers access. Bengaluru Metro uses tokens than can be scanned for entry and dropped-in for exit thus keeping them in circulation within the system. But these systems are used primarily for point-to-point transport and transfers are not handled by the same authority. The MTA however delivers on a unique case where all buses and trains allow transferability since they are all governed by one body. It also provided a solution to finding

exact change, as customers could just buy one or more tokens beforehand and take their trip. Still, this presented a challenge in itself, as now customers would not only need to carry tokens with them but when a price hike would be announced, travelers would hoard older tokens, so they could save on the price hike. While newer tokens were implemented for each new price hike, it became a cumbersome problem. Production costs worked against the concept of the token and having to keep their volume in circulation steady and improving was a losing battle. After going through 5 dominant token designs spanning nearly 40 years, technology would soon provide a cost-effective solution in the form of the MetroCard.

The MetroCard was introduced in 1994 and with it came a slew of opportunities to provide better services to travelers. Passengers could now swipe their cards at turnstiles for access and recharge them with money on-the-go. The MetroCard Vending Machines allowed the MTA to automate and quicken the passenger checkout process, with each card able to be programmed to hold a certain amount of digital currency or time validity for rides. Transfers became a breeze for passengers and the MTA cut down on production costs since the plastic cards are much easier to produce. But now, after 24 years of the MetroCard era, its faults are out in the open. Like any other magnetic-strip card, wear and tear can lead to turnstiles unable to read card information. It is one more item everyone needs to carry in a world where access to services resides on your wearable or smartphone. While the customer pays $1 to generate a new MetroCard, the cost of making new one's hits MTA revenue. Environmental activists point out that these plastic based cards are harmful to the environment and their proper disposal is not being handled well by the authorities.

Proposal

Every person has a unique biometric attribute which can be used to distinctively identify individuals. This includes a fingerprint, iris, and face recognition. Although biometric technology is in its infancy, it can play an important role in the future of secure access systems. The adoption of biometric technology as a MTA ticketing system will be the step towards a secure and reliable card-less system.

There are a plethora of methods which can deem the system as a secure implementation for passenger access. The biometric system has two major categories of implementation - First is unimodal biometric system which uses a single biometric trait as an identification parameter and second is multimodal biometric system which uses multiple biometric traits as identification parameters (Kumar, 2008).

But one critical aspect to remember is that with each additional layer of security added to the system, we are ignoring our two biggest reasons to change the ticketing system: revenue and customer satisfaction. Burning through cash is not an option for the MTA as implementing even a single layer of security involves government funding and the usage of their already minimal profits. A project of this magnitude must be launched as a pilot and gradually allowed to spread across the service area. Also, customers are less likely to adopt dual or triple identity verification, which is very likely to slow down the access rather than speed it up.

Although a multimodal biometric system improves security features, it does so at the cost of time. A unimodal biometric system that uses only a single method of access, be it a fingerprint, facial or retina recognition, is a lot more effective in this regard. Facial and retina scanning is still a young and unreliable technology (Nakanishi, 2007). The fact that this is still

the case on personalized devices like the smartphone is indication enough that it is not ready for execution on such a large scale. Fingerprint sensors have evolved over time, becoming an easy and reliable source of authentication and cheaper to manufacture and implement in more and more systems. Sentiment analysis tells us that people are a lot more likely to embrace biometric authentication as long as it is not recording their face (Kumar, 2008). It is therefore a sensible option to execute this project using the unimodal method.

This single verification process is not without its faults. Each biometric trait that can be used has its unique drawback. Senior citizens and children have faded and underdeveloped fingerprint ridges. This presents a problem to read these demographics in. A substandard facial recognition software will introduce the problem of scanning printouts of people's faces, a common problem with smartphones today as well. Development of a superior face recognition software will require more time and money as well as increase installation costs. All these issues are valid even for iris scanners with the addition of having difficulty giving access to people with pathological eye conditions (Khan, 2006).

The proposed biometric system will require each passenger to create an account using their smartphone and kiosk at the station for initial stages. People will register using their basic information like full name, date of birth, gender and place of residence along with a fingerprint scan and secure password created by them. First time users of this system registering by their smartphone will need to download the MTA application and enter their basic information only. This will generate a unique and secure code for each users account. Due to security reasons, fingerprints will not be registered using a user's smartphone. The secure code is used by the user to register their fingerprint for the first time at a kiosk when they travel using this system. If a user does not hold a smartphone device, they can complete the preliminary registration steps at any subway station kiosk across the city.

Using the MTA mobile application, a user can recharge their accounts with time or value as they do currently with cards, modify their basic information and look into the logs of their travel history. This system will save time of standing in long lines to recharge their cards. The new system will be used with subways as well as with the bus transportation MTA facilities. The wired and wireless infrastructure of buses and subways will remain the same with the change at the user-end of card swipe device to fingerprint scanner. The network base for security and faster authentication of the system will require an upgrade to high speed optic fibers as compared to traditional network base. Thus, improving the authentication speed at the front end.

The backend will have a secure Distributed Database Management system (DDBMS) containing an entity-relationship schema of the person's information gathered during the registration process linked to the timestamp of the individual's travel history, the unique code generated by the scanner for each fingerprint, current balance, and balance recharging history. This unique code in the database will be identified as the primary key of the data. Each scanner has a mathematical algorithm which reads the fingerprint and creates it equivalent unique code.

At each travel instance, when the user scans his/her fingerprint, the scanner generates the code of the print and matches with the primary key of the user database followed by verifying the balance of the user. Thus, giving the user access to cross the turnstile. This process will not take more than 5 secs for the user to cross the turnstile at initial stages. Further, with the implementation of machine learning algorithms, duration to cross the turnstile will reduce. To execute this system MTA needs to take some of the following steps:

1. Gradual installation of fingerprint biometric scanning machine co-existing with the card-swipe machines for 90 days. This would help the customers adapt to the change.
2. Installation of biometric scanners on the kiosk with the easy step guidance of its usage.
3. Sanitizing wipes can be strategically placed around the fingerprint scanners to address hygiene issues
4. Setting up a database management system and software, followed by creating and implementing the pattern recognition algorithm and upgrading a network base to distribute the data of the new system. This will help in easy access of data for authentication purposes.
5. Creation of a registration system for each commuter to create and manager accounts, which can be access by them using their smartphones, kiosk and information desk at the subway station
6. Lastly, special cases where if a person is suffering from a disability that hinders the biometric scanning the system can let them access through a special ticket of travel which they can generate from the Kiosk. (or enter a unique identification code assigned to them on a per case basis. Generating tickets is not time efficient.

Feasibility

MTA evolved and explored completely new dimensions once they introduced tokens back in 1953. But the point is, was this necessary? What were the pros and cons involved? What were the predictions? The tokens were not only accepted but were used in abundance and they simplified the processes. It was the introduction of tokens which had streamlined the management and usage of metro services without causing any confusion, misunderstanding and failure. The ease of use helped in creating a process which was less dependent on manpower thereby increasing efficiency.

Similarly, by 1993, MTA worked on the ticketing system and introduced the $1 MetroCard, an efficient and lighter form factor for providing services which were more secure, and technology driven. This was tried and tested multiple times and the analysis was done on all the important aspects before introducing it to the market. As a result, people readily adopted the same and by 2003, a decade later, only 8% of the people choose to stay with old token system, rest 92% of them successfully shifted from tokens to MetroCard. This also provided users with more options such as creating a wallet in the card which could be recharged and used at multiple locations which helped in reducing the dependency on human manpower and making the ticketing system more efficient and technology driven.

At the time of launching swipe-card technology, the MTA was unsure whether this change will be accepted or not. Yet, the question is, if we do not try to upgrade, how will we know? We are in a very similar situation here, where we are looking for another change in form of biometrics for the ticketing system. This technology will not come without its own challenges, be it functional, technological, operational or the cost involved. Since biometrics is trending in today's world and people are adapting to it at various places such as offices, societies, airports or even their homes, what's important is what impact it is going to provide on day to day activities. Not only is its feasibility being questioned here but its implications as well! These implications will lead to fast and easy access at the turnstile, saving time and money which leads to increased efficiency. It will cut down on the carbon footprint per passenger by eventually eliminating the manufacturing of plastic MetroCard. Most importantly, keeping track of non-paying riders in relevance to the highest-riders system with the primary motive to get rid of fare evasion activities is a positive side-effect (Hinds, 2012). The system will also be able to intervene during anti-social or dangerous activities that places the public in danger and use its capabilities to reject access to such elements and report it to law enforcement.

A biometric access system has many advantages, but we must evaluate its technical feasibility and cost effectiveness. How it will affect the privacy? Can it be misused? Can this biometric data be stolen? Several questions here validate concern, but it is not necessary to implement the change immediately, rather it can run parallel with existing systems by allowing

users to opt for the new system over time. Biometric data will be saved in confidential servers where the data is secured and cannot be transferred.

Undoubtedly, several testing and controlling mechanisms will be required to implement such a project, and this process might involve a large amount of investment, but innovation at this scale rarely comes at a low cost. Allowing passengers an easier and more satisfactory travel experience and eliminating the cost of producing MetroCard will jointly give the adoption of a biometric system the upper hand against existing system.

Subway Ridership at a Glance

Year	Average Weekday	Average Saturday	Average Sunday	Average Weekend	Annual Total
2012	5,380,184	3,172,627	2,490,736	5,663,363	1,654,582,265
2013	5,465,034	3,243,495	2,563,022	5,806,517	1,707,555,714
2014	5,597,551	3,323,110	2,662,795	5,985,905	1,751,287,621
2015	5,650,610	3,309,731	2,663,418	5,943,149	1,762,565,419
2016	5,655,755	3,202,388	2,555,814	5,758,201	1,756,814,800
2017	5,580,845	3,156,673	2,525,481	5,682,154	1,727,366,607

Table 1 (MTA, 2017)

MTA New York City Transit Bus Ridership at a Glance

Year	Average Weekday	Average Saturday	Average Sunday	Average Weekend	Annual Total
2012	2,169,311	1,309,666	998,863	2,308,529	667,910,621
2013	2,166,376	1,314,515	1,007,340	2,321,854	677,569,432
2014	2,123,092	1,305,437	1,024,279	2,329,716	667,051,170
2015	2,070,386	1,278,031	995,788	2,273,819	650,681,784
2016	2,038,119	1,221,299	957,427	2,178,725	638,413,113
2017	1,923,993	1,168,978	923,694	2,092,672	602,620,356

Table 2 (MTA, 2017)

Subsequently, research says there are a total of 472 subway stations and approximately 5700 buses. Following the annual losses by the non-paying riders and consistent fare evasions from the chart below, MTA can make its capital for the installation of the biometric machines

and server in approximately 5 years. By these numbers, the installation for the new biometric system has a fixed investment cost which can be covered in a short span of time.

Everyday Riders	Fare evasion losses (annually) including trains and buses	Average Installation charges of finger print machines (per station)	Average Installation charges of finger print machines (per bus)	Total number of subway station	Total number of buses	Total installation cost
Approx. 5 million	$55 million	$81000	$2700	472	5700	Approx. $65 million

The transit budget department Director Aaron Stern highlighted that MTA was not only a boon in terms of cost cutting by millions, but also tried to minimize the fare evasion activity. During its initial 4 months, MTA saved $10 million and is further expected to make a revenue of $25 million (Barron, 2017). Generation Z is much more tech savvy than any other and more than 5 million such people are getting on the subway each day. By implementing this technology, MTA can provide value to passengers by providing easy access while improving security features of the system and implementing them at a lower cost and effort.

Implementing and installing scanning machines and servers for biometrics is just a fixed cost. MTA took a bold and radical step to phase out the token system in favor of the cheaper and customer-friendly MetroCard, seeing that it was becoming cumbersome to cater to a larger audience while maintaining their then infrastructure. Biometrics is the evolution after the MetroCard, a step towards a faster, better and safer, truly contactless interface in a city that is constantly in need to serve a larger global audience. Technology never moves backward, if it did then people would prefer using fax over emails. The same holds for the mobility backbone of one of the largest cities in the world. By moving ahead with an upgraded transport access system, we believe the delivery of a faster, more productive and secure process would be looked upon favorably by the general public.

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