Instrumenting the NYC MTA to Reduce Train Delays

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1 Introduction

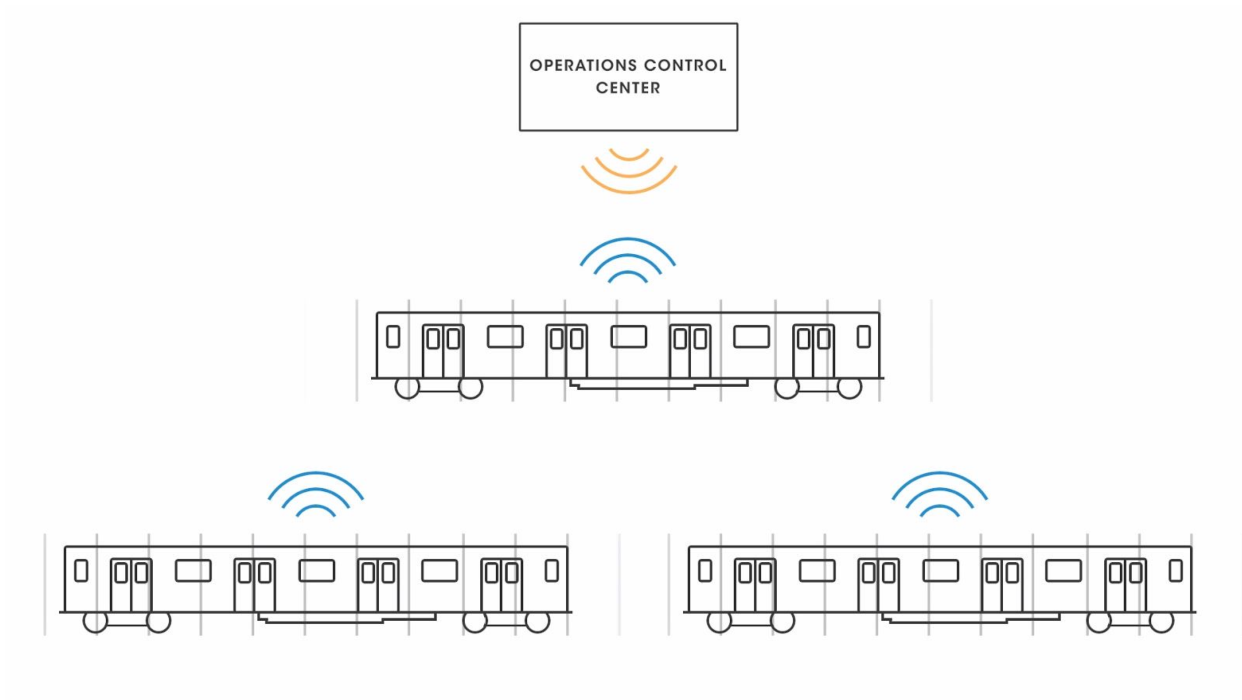
New York City is home to over 8 million residents, which comes with many challenges. The local government is entrusted with the complex and difficult task of managing its large population and providing them with essential services. As well as ensuring that these services are efficient, they must also be delivered to the right people in a convenient manner. Like any other metropolis, New York City struggles with meeting these expectations and faces a multitude of issues.

A fundamental service delivered by New York City is the Metropolitan Transportation Authority subway. The MTA subway offers 24-hours-a-day service throughout the five boroughs, acting as the primary mode of transport for many New Yorkers whether commuting to work, going to visit friends, or exploring the abundance of activities and attractions the city has to offer. It's clearly an essential part of the city, having an annual ridership of over one and a half billion riders. However, the subway system is built on outdated infrastructure and faces many problems.

One pressing issue with the subway system is frequent train delays which cause irritating, long wait times. In 2018, on average 57,774 trains were delayed every month and only 67.1% of weekday trains arrived on time (the MTA refers to this K.P.I. as their terminal on-time performance). Half a year later, it seems that scarce improvements are being achieved. For June 2019, the MTA reported that 84.3% of subway trips were completed within five minutes of their scheduled arrival (the MTA refers to this K.P.I. as their customer journey time performance).

Train delays are a product of various factors, including subway traffic, poor track maintenance, sick passengers, and track fires created by littered garbage. In June 2018, planned maintenance work was responsible for 26% of weekday train delays. That same month, 7% of weekday delays were caused by signal failures. This is expected as the MTA's signal system has not changed since the opening of the original subway system in 1904. Additionally, 2% of delays were attributed to people on the tracks.

To reduce the number of delays MTA customers face, we propose a big data solution. Our solution is to install a wireless network that allows each train to share real-time diagnostic data collected from low-cost sensors to prevent malfunctions that affect riders. By instrumenting subway cars with low-cost sensors and bringing that data together to a central operation control center, where operators will be able to keep an eye on all of the MTA's assets. This will allow the MTA to quickly deploy the right maintenance to the affected system and improve maintenance efforts. We believe that this will be able to cut the number of delays in half and drastically increase the MTA's terminal on-time performance and customer journey time performance. In the long run, this system will also decrease the MTA's operational costs.



Through a wireless communications network, MTA trains and tracks will share individual sensor data with the operations control center.

2 Scope

Systems and Processes Impacted

This solution would modernize the MTA subway's maintenance process. Instrumenting the MTA subway system would change how its assets are monitored. Real-time monitoring will allow MTA operators to rapidly respond to train or track failures by sending the appropriate repair team and hence improve the efficiency at which maintenance is conducted.

The communication network would also be able to track an individual train's location from the control center. This would be a major improvement in the way that trains are operated with the current block signal system, allowing trains to travel more closely together while maintaining safety. This will also provide accurate train arrival times.

Involved Stakeholders

This new system will aid the job of MTA operators in the control center. It will also allow the MTA to deliver to its customers better subway performance by reducing train delays while reducing operational expenses. MTA passengers will also be able to receive status alerts on their favorite lines and more accurate train arrival times.

3.1 Overview: Enabling Technology

Wireless Connected Network

Commonly, cellular networks have served as the dominating infrastructure for building Internet of Thing solutions. However, since the subway system runs underground, there is a lack of a cellular network. Expanding the cellular network underground would be an expensive and time-consuming task. Therefore there is a need for a new, cheap and easy-to-install wireless network that is equally reliable and can handle the multitude of data sources.

A viable network to meet these demands could be created using ultra-wideband technology. Ultra-wideband is a radio technology that can transmit a lot of data (having a high bandwidth) over short distances while using little power. Ultra-wideband transmitters and receivers are also extremely small, making it easy to deploy the network quickly and simply. In addition, this technology has become extremely ubiquitous and cheap to manufacture.

To build this network, ultra-wideband receivers would be installed in the tunnel's wayside lighting system at equidistant intervals. Transmitters would be placed on the train and would share their sensor data with the receivers. Transmitters can also share the train's location with high precision. The receivers would then send the collected data to the already existing system that communicates signal data with the operational control center.

Low-Cost Sensors

To monitor the subway system, we propose that the MTA outfits its assets with low-cost sensors. Sensors are devices that record physical properties, bringing the physical world into the digital world. As technology has rapidly grown in the past decade, manufacturers have been able to produce sensors that are both smaller and cheaper. This makes them perfect for this project as their small size factors would not disrupt the existing asset's performance and their affordability also makes it feasible to deploy sensors across all of the large subway network.

For instance, by outfitting temperature sensors into subway cars, the control center would be able to detect if a car's temperature is abnormal and could then dispatch someone to investigate into the car's temperature regulation unit in minutes. This would reduce the chances that a passenger gets sick from heat exhaustion and therefore reduce the number of delays.

Additionally, cameras paired with computer vision could detect objects in the tracks. If trash was detected, it could be flagged for pickup by the sanitation crew and help decrease the chances of track fires caused by littered trash. Cameras could similarly identify if a person is in the tracks and automatically trigger the train's emergency stop. Communicating with the rest of the network, the power in the tracks could also be removed.

Furthermore, using ultrasonic sensors could monitor the wear and tear on tracks. Ultrasonic sensors measure distance using ultrasonic waves. By placing ultrasonic sensors under the train, uneven tracks and other track abnormalities could be spotted. Ultrasonic sensors could also measure the distance between the tracks, formally known as the track gauge. If the recorded metric does not match with the 4 ft. 8.5 in. wide track gauge, then a maintenance team could be sent to examine the track. Problems in the tracks can cause train failures and derailments that can trigger substantial delays.

Cloud Technology

Instrumenting the large MTA system and collecting realtime data from thousands of sensors would generate terabytes of data annually. The MTA's current data center cannot store such a vast amount of data. Rather the collected data would be stored on a third-party cloud server. Cloud storage is the concept of on-demand data servers that are billed on a per-use basis.

Systems of Insight

To make use of this data, it will be displayed to the operations control center on a maintenance dashboard. The maintenance dashboard's home page will show each line's status and operational status. The operational status will display the number of alerts and pending maintenance jobs alongside a map of the subway where an operator can monitor each train. Any assets that are in an abnormal condition will be highlighted for the operator to investigate and be able to request the appropriate maintenance. The operator also has the option to filter by subway line. The dashboard will also include an alerts view, where the operator will be able to see a list of system-wide alerts. Alerts will contain the affected asset name, the time the alert was created, the affected location, and the alert priority. When clicking on an alert, the operator will be able to see a more detailed view of the affected system, including all current and past sensor readings. The historic data will also be able to used to generate future insights about individual asset's performance. Analytical models will be able to create predictions about asset failures and which assets will likely need repairs.

3.2 Overview: Stakeholder Engagement Plan

As the MTA tries to become more transparent with its customers, it could share the collected data on its mobile app. The app would display exact arrival times. Passengers could then see in real-time the true cause of their train delay and how the issue is being addressed. The mobile app would also include any other alerts that would affect the customer and send them push notifications, personalized to the lines they frequently ride. Customers could also see if the air control unit in a train car is not working and could avoid riding in that car.

Furthermore, the app could include a crowdsourcing feature that would leverage the power of citizen sensing. For example, users could report if a car's A.C. unit is defective. Furthermore, maintenance times could be decreased as customers could report incidents.

3.3 Overview: Success Factors

For this solution to be successful, it is critical that both the hardware and software are properly installed and built out. If the network or sensors are incorrectly deployed such that the system is not delivered in real-time or inaccuracies exist, the full potential of the system is not achievable. The software must also be designed to be intuitive and have all the features necessary that MTA train operators will need to monitor their assets and easily maintain the subway system.

3.4 Overview: Partnership Model

The MTA is always looking for new smart solutions to improve its system as part of the Fast Forward plan, whose goal is to modernize the subway system, and have formed partnerships with multiple companies to deploy innovative solutions. To bring our vision to life, we hope to partner with the MTA and provide them with the necessary hardware and software. The MTA will be tasked with installing the network infrastructure in its tunnels and low-cost sensors on its trains while we will set up the network and build and sustain the custom maintenance dashboard.

4 Success Story: London Underground

We are confident that this solution will greatly benefit the MTA subway system, especially since a similar project was deployed in London's Underground system with great success. Like the MTA subway system, the Underground is one of the world's oldest and most used public transportation systems. The partnership between Transport for London, Telent, CGI, and Microsoft allows the control center to monitor sensor data from across the tube system. As well as reducing the number of train breakdowns and improving maintenance, Microsoft expects the system to decrease operational costs by 30%.

5 Objections

Logistical Challenges

Although the ultra-wideband network and low-cost sensors are simple to install, the MTA subway network is so large that installing a communication network from nothing will take time. Another challenge will arise with fitting the trains with sensors as the MTA runs 24/7 and therefore the train could only be instrumented when it is not in service.

Technological Challenges

Like any technological system, this solution is vulnerable to cyber-attacks and hackers. To prevent such attacks, which could disrupt the operation of the whole subway system, high levels of cybersecurity are imperative. Sensor malfunctions could also misguide subway operators.

6 Conclusion

By outfitting the MTA subway system with low-cost sensors and sharing this data through a cheap and quick-to-install ultra-wideband wireless communications network, the MTA can take a step towards a more modern subway system. This solution will help operators in the control center monitor its trains and tracks and be able to dispatch the appropriate maintenance team if the sensors indicate the asset is malfunctioning. This will improve maintenance and decrease system failures, which will decrease the number of train delays. Decreasing train delays will make customers happy and increase their use of the subway system as service reliability will increase — generating more revenue for the MTA. This solution will also decrease operational costs for the MTA as maintenance will become more targetted and effective. Additionally, the MTA will be able to deploy more trains on its tracks by being able to track its trains' exact location and replace the current out of date signal blocking system. Finally, data collected will also be shared with passengers, increasing transparency as customers will know the true causes for delays immediately.

7 References

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