**PUBLIC TRANSPORTATION &OPTIMIZATION**

**PHASE-2**

**Abstract:**

The idea of a smart city is one that utilises Internet-of-Things technologies and data analytics to optimise the efficiency of city operations and services, so as to provide a high quality of life for its citizens. Due to reduced public funding, many public transport systems are already facing challenges to maintain their services. For a smart city, the goal of public transport is not simply the movement of people, but the provision and enhancement of mobility for living. This will be particularly challenging due to changes in habitation trends and work patterns. For example, the growth of mega-cities has led to extreme traffic congestion in city centres and urban sprawl on their outskirts.

In order to provide sufficient coverage and frequency of service, an integrated co-ordinated multi-modal public transport system is needed, leading to substantial increase in operational complexity. Environmental concerns and the recent pandemic may also change work and commuting patterns in the future, with more people working from home and companies adopting flexible work shifts. For smart cities, public transport must offer ubiquitous access, real-time response to demand, convenience and quality service, and energy-efficient operations. This paper will discuss the challenges in network design, operations planning, scheduling and management of smart public transport systems.

**Introduction:**

This paper discusses the challenges of designing and operating public transport systems today. On the one hand, the trend of urbanisation and increased consumer expectations have increased the scale and scope of the services expected. On the other hand, the budget for these systems are often insufficient to support the improvements needed to operate the increasingly complex public transport systems.

Recently, many cities have launched “Smart City” initiatives to explore and exploit advanced computer and communications technologies and big data analytics to improve the efficiency of its operations and services, in order to provide a high quality of life for its citizens. In this paper, we summarise the performance goals for public transport for smart cities, and mention some recent innovations. We also provide a brief survey of recent research. Finally, we discuss how changes in habitation and work trends might impact public transport systems in the future.

**Performance Goals for Smart Public Transport:**

Focussing on public transport, We posit that there are five essential performance goals, summarised by the acronym S-M-A-R-T.

**Service:**

The goal of “Service” for a public transport system is the provision of affordable means of travel in support of the activities for all the people. With government spending on public transport exceeding 2% of GDP in many countries, the cost-effectiveness of the provision of public transport is a major concern.

Construction of public transport infrastructure involves huge capital investments. However, as noted by Borndӧrfer, et al. (2010),

**Mobility:**

By mobility, we mean that the public transport system must support passengers’ desire to travel from their origins to their destinations in a direct way at the time that they want. Passengers do not want to spend a lot of time on circuitous routes to get to where they want to go.

This means that the public transport system must provide passengers with convenient departure times, short journey durations with minimal interchanges. To support this, the network design and scheduling of the system

**Accessibility:**

By accessibility, we mean the ease of access to public transport and a smooth and comfortable ride. Of course, passengers desire a door-to-door service on-demand at their convenient time. What is required of the system design is co-ordination between feeder network and backbone network in capacity and in service frequency, and wide coverage of access locations. When we have unlimited resources with no regard to cost, of course, it is easy to provide that.

**Responsiveness:**

Disruptions happen, demand shifts and are not deterministic. What we want for a smart public transport system is responsiveness and flexibility, where despatch and schedules can be adjusted dynamically in real time, ensuring that transport is available for people when they want and where they want, and they can get to their destinations on time.

With the wide availability of locational sensors and other data collection devices, and the increase in computational power, real-time disruption

**Technology:**

One area where the increased availability of data has had a major impact is passenger demand estimation and travel behaviour modelling. Decades ago, origin-destination trip data can only be obtained via household surveys. Because of the huge costs of surveys, there emerged a line of research since the 1970’s in estimating the O-D matrix using indirect data such as traffic count on links or ticket counts at origin or destinations. These estimation methods include linear regression,

**Post-pandemic Public Transport:**

As we have all experienced during the Covid-19 pandemic, when cities went into lockdown, the ridership of the public transport system dropped sharply. In many other aspects, our lives have changed drastically in this past year. Shops are opening with reduced hours, work and schooling are done at home, with meetings held online. International travel has been reduced by over ninety percent in many countries. Hopefully, the pandemic will pass, but maybe our lives will be changed and we will not go.

**Other Emerging Trends and Technologies:**

Three emerging technologies have generated a lot of recent research. Here we briefly disucss their impact on public transport systems.

Electric vehicles – The current challenge is the limited range and the location of the charging stations, which add a lot of complexity to the design and planning of public transit systems. See, for example, Olsen, Kliewer and Wolbeck (2020), Yıldırım and Yıldız, (2021). With technology improving, some aspects of the problem might go away. If the delivery items

**Challenges for the Future:**

With the increase in computational power and data availability, the models and methods for the design, operation and management of public transport systems have been greatly advanced, from simplified partial models solved by heuristics, to integrated models solved by exact methods, to more comprehensive realistic models with robust solutions that accounts for uncertainty. For a smart city, richer and more precise information will be available to enable planners to devise and operate.

**A Tale of Two Smart Cities: One with Smart Public Transport, One Without:**

Smart public transport may be the most important element of smart city planning because it affects everyone. All citizens and visitors need to get from one place to another, quickly and safely, and in today’s densely populated cities that means public transport.

In cities with smart public transport, people waiting at a bus stop know their bus will be on time because they get alerts about estimated arrival times. They may or may not know that their city’s department of transportation automatically deploys more buses when necessary, staggers arrival times to avoid “bus bunching,” and keeps buses on the go by continuously analyzing sensor data and proactively fixing things before they take a bus out of service.

Contrast this with a city not using data to make public transport more efficient — people will wait for a bus, worrying that it won’t arrive on time to get them to work, a doctor’s appointment, or a job interview. Data from the sensors on the buses would be stored in databases and analyzed in batches after-the-fact, preventing the DoT from dynamically re-routing buses or proactively fixing buses before they fail.

In some cities, budget is the issue. In others, bureaucracy or lack of voter conviction stand in the way.The good news, however, is that technology like ours is reducing the cost and difficulty of implementing smart public transport, making it easier to overcome financial and political barriers. The opportunity is available for cities willing to move forward with smart city public transport initiatives — even with the remaining challenges to face.

**Making Your Smart City Public Transport Efficient with Event-Driven Architecture – A Summary:**

Your public transport system is already producing millions of data points for you, and one of the greatest opportunities your city has today is to harness this data for smarter transportation infrastructure.

In a smart city, the amount of data generated per second can be staggering. You’ll need a system that can handle the magnitude of information coming in from the millions of events happening all over the city per day, while providing processes for citizen privacy. This is especially true for public transport.

In a world where city populations are growing, a smart transportation initiative based on event-driven architecture and powered by an event mesh is the best way to manage your public transport system.Our event-driven solution is already helping leaders of smart public transport initiatives build the necessary event-driven architecture to carry them into a brighter future.

**Sensor technology:**

Over the last decade, sensor technology has become ubiquitous and has attracted a lot of attention. Sensors have been deployed in many areas such as healthcare , agriculture , and forest , vehicle and marine monitoring. In transportation, sensor technology supports the design and development of a wide range of applications for traffic control, safety, and entertainment. In recent years, sensors, and actuators such as tire pressure sensor and rear-view visibility systems have become mandatory in the manufacturing of vehicles and the implementation of intelligent transportation systems, aimed at providing services to increase drivers’ and passengers’ satisfaction, improve road safety and reduce traffic congestion.

Other sensors are optionally installed by manufacturers to monitor the performance and status of the vehicle, provide higher efficiency and assistance for drivers. Currently, the average number of sensors in a vehicle is around 60–100, but as vehicles become “smarter”, the number of sensors might reach as many as 200 sensors per vehicle .

In , the author presents a classification of three categories of sensors based on the place of deployment in the vehicle: powertrain, chassis, and body. Another work classifies sensors in a vehicle based on the type of application the sensor is intended to support, and four categories of sensors are identified: sensors for safety, sensors for diagnostics, sensors for convenience and sensors for environment monitoring . We extend the classification proposed in to include two additional categories of sensors, namely sensors for driving monitoring and traffic monitoring.

All of the IoT data that your city produces from sensors, apps and GPS becomes infinitely more usable when treated as events. An event mesh enables you to manage the events across multiple industries and environments .

By enhancing the system using a publish-subscribe event streaming and management platform, you’re able to manage the event volume that your city generates and organize it in a way that can be used safely by the entire city – not just one department . It’s scalable, reliable, and with its clustering features, downtime is significantly reduced.

The multiple event brokers in an event mesh automatically stream the events to subscriber systems to do everything from re-routing buses to instantly updating bus displays to give .

In the near future, smart cities will become the go-to destination for modern citizens looking for best-in-class services and communities. Smart cities will benefit from the available data of their populace and, in turn, citizens will become active participants in improving their cities.

**In-vechile sensors:**

In ITS, identifying the type of sensors to develop applications that contribute to address problems such as:

(1) traffic congestion and parking difficulties

(2) longer commuting times

(3) higher levels of CO2 emissions

(4) increase in the number of road accidents, among others is of critical importance for improving a vehicle’s performance as well enhancing the driving.

**Applications for In-Vehicle Sensors**

Tire-pressure monitoring is an application that is required for the National Highway Traffic Administration of the U.S. to alert drivers using acoustic, light or vibration warning if the tire air pressure is low .

Proximity, ultrasonic and electromagnetic sensors are used in parking assistance and reverse warning applications. Proximity sensors can detect when a vehicle gets close to an object. Ultrasonic sensors use a type of sonar to identify how far the vehicle is from an object, alerting the driver when the vehicle gets closer than a set threshold.

Electromagnetic sensors alert the driver when an object enters an electromagnetic field created around the front and back bumpers. Proximity sensors have been used to develop a system based on a rectangular capacitive proximity-sensing array for occupant head position quantification to meet the guidelines of the Insurance Institute for Highway Safety . However, these types of sensors are frequently affected by temperature and humidity, reducing their accuracy.

RAdio Detection And Ranging and laser sensors constantly scan the road for frontal, side and rear collisions and allow safety applications to adjust throttle and activate brakes to prevent potential collisions or risk situations by using radio waves to determine the distance between obstacles and the sensor. The application notifies the driver if something close to the vehicle is detected and automatically activates the brakes to avoid a collision.

The gyroscope and accelerometer sensors are used in Inertial Navigation Systems to determine the vehicle’s parameters such as vehicle position, orientation, and velocity. INS are used in conjunction with Global Positioning Systems to improve accuracy.

Radar and speed sensors are used in applications that warn the driver of potential danger if changing lanes or wandering out of the lane is detected. The driver is usually warned through vibration in the seat or steering wheel or acoustically using an alarm.

Cameras are used to: monitor the driver’s body posture, head position and eye activity to detect abnormal conditions such as signs of fatigue or the vehicle behaving erratically and execute night vision assistance applications to help drivers see farther down the road and detect objects such as animals, people or trees in the path that can cause a potential risky situation or an accident.

**Conclusion**

Finally, studies have shown that public transportation reduces air pollution, which contributes to both short- and long-term health risks. Save your time! Public transportation is a great way to get around a city. It is a safe, inexpensive and eco-friendly way to commute.

Sensors will play a vital role for ITS in the future. Their usage enables the development of a wide variety of applications for traffic safety, traffic control entertainment and driver assistance. Sensors provide the mechanism to data acquisition related to the vehicular context that can be integrated with the current transportation systems to mitigate some of the problems that past and current transportation systems have been facing.

**SUBMITTED BY,**

G SANTHOSH KUMAR

311421106050