PUBLIC TRANSPORTATION OPTINIZATION

Abstract— With the ever growing global population, crowding in public transport is becoming an increasing menace. Public transport systems around the world have remained largely the same over the past several decades although the population they serve has burgeoned. This paper aims to demonstrate a low cost IoT based solution to the crowding problem by using smart seats that can detect and display the seat occupancy status in real time over an internet or mobile application. The feasibility of the project was assessed and simulated using the NETSIM simulation software. The results of the software simulation showed promise and hence a hardware prototype was built using the IEEE 802.15.4 standard on the Arduino - Raspberry Pi – nRF platform. The prototype results are positive and show a fully functional IoT system that can be implemented in buses and trains.

Keywords— IoT; Crowd management; Raspberry Pi; IEEE 802.15.4; Public Transport.

I. INTRODUCTION

The population explosion around the world over the past century has seen a tremendous increase in the demand for public transport services. This demand is rarely adequately met since the public transport services in countries like India and China have failed to catch up to the growing rates in population. In addition to this, newer technologies have scarcely been implemented to manage crowds in public transport. Beijing and Singapore have seen cases where individuals are crushed to death due to overcrowding in the subway systems. This begs the need to implement technological solutions to ease the problem and perhaps save lives. The concept of IoT first emerged when Kevin Ashton originally used the term IoT in 1999 under the context of supply chain management and it later evolved to include applications like healthcare, utilities, and bio-sensing [1]. Today with the development of RFID, IPv6 and cloud computing, IoT is becoming ubiquitous [2]. The various application scenarios include smart cities, environments, security, retail, logistics, agriculture and homes [3,4]. Urban IoT applications for smarter and more efficient cities focus on smart homes, public transport, street lighting systems and energy systems [5-8]. In the domain of public transportation, IoT has been explored only to cover the following aspects:

1. Navigation and Route Planning
2. Real-time Tracking
3. Accident Prevention and Safety
4. Information Alerts

Keeping in mind the increase in crowding seen in public transport and the lack of IoT based solutions for this problem, this paper presents an IoT crowd management system. It uses an individual sensor per seat to display the seat occupancy over a mobile application. The seat occupancy status being displayed in real time would allow passengers to know before hand the crowding situation in an arriving bus/train. This would inform them to look for an alternate route or mode of transport in advance to reach their destination on time. The accuracy of the system also allows for passengers to form evenly distributed queues to

distribute the crowd across multiple train coaches.
This system also offers the added benefit of data analytics. Large amounts of data regarding seat occupancy can be gathered by the transportation corporations to study and analyze travel patterns to better organize, distribute and plan public transport routes. This would avoid having empty buses/trains during off peak hours and overcrowded buses/trains during peak hours. This system is only applicable to transport systems where pre-booking of seats is not done for example metro trains, local buses and general compartments of non-local railway trains. Crowding is a nuisance in these systems and not in systems where pro-booking of individual seats is done.
The validity of the system was assessed using the NETSIM simulation software. Section 3 discusses the throughput, delay and feasibility. Section 4 demonstrates the prototype that was built and tested using the RaspberryPi – Arduino – nRF platform..

II. LITERATURE SURVEY

The use of IoT for public transport has largely been limited to routing, navigation, safety and tracking [9-11]. On the other hand, wireless sensor networks to determine seat occupancy have been used in auditoriums, cinema halls and concerts [12]. These systems use large multi-hop networks with a hybrid topology to determine seat occupancy for large systems. However, the use of such systems in public transport is nascent and not fully explored. There have been different approaches to estimate crowding in public transport [13,14]. Primarily, these systems use Digital Image Processing (DIP) with background subtraction to estimate the crowding in the bus based on pixel density of the subtracted image [13]. However, this approach has several limitations. Firstly, accuracy of such a system is limited since it can only determine whether the bus is fully occupied, moderately occupied or empty. Exact seat occupancy is not revealed. Also, such systems are highly susceptible to lighting conditions, weather and time of day. The computation power necessary for DIP processing is also a lot higher, reducing the longevity of the system. Due to these concerns, it is safe to assume that a more robust, long-lasting and accurate system is required. Since the use of IoT has not been thoroughly explored in managing crowds for public transport, this paper aims to provide a foundation for the same.

III. SYSTEM DESIGN AND WORKING PRINCIPLE

Fig 1. shows the structural outline with the abstraction layers of the IoT system proposed with an individual sensor on each seat to read the real-time seat occupancy status. The Boolean data of occupancy is calculated based on a threshold value of pressure. The Boolean output data is routed to a gateway node. The information is uploaded to a cloud platform and can be accessed by a remote mobile application. The transmission distance was found to be less than 15 meters since we are transmitting at 2.4GHz in an outdoor environment [15].

Fig. 1: Abstraction layers of the IoT system

The following design considerations were decided upon based on the real world application:

PUBLIC TRANSPORTATION OPTINIZATION

1. Cheap and robust sensor (Velostat)
2. Low power modules
3. Real-time data
4. High Accuracy

Velostat is a black, opaque, volume-conductive, carbon-impregnated polyolefin. The electrical characteristics are not affected by age or humidity. The sensor is used per seat to ensure the system is practically implementable in the real world. Low power modules that consume less than 20mA of power during transmission and remain on standby otherwise have been used to increase longevity. The system is designed to last 12-15 months before the batteries need to be replaced. The system sends real-time data with high accuracy since there is an individual sensor per seat. This is especially important since passengers need to be readily informed of the occupancy. When a bus or train is about to arrive at the destination, passengers stand up to get off and this real-time information of empty seats on an arriving bus/train is invaluable to those waiting at the platform.

The software simulation has been carried out in NETSIM for a 50 seat scenario as shown in Fig. 2. A group of 5 sensors on each row of seats transmits the occupancy status to an intermediate node. The 10 wireless nodes transmit the data to a receiver and the information is routed via the gateway to the cloud database.

On running the simulation, the average throughput for the network is found to be 89 bps and the delay in transmission is 0.516 seconds. Since the real world application falls well within the simulation results both in terms of throughput needed and delay generated, it has been concluded that the network design is realistic and implementable.