“Smart Electronic Ticket Machine (ETM) with GPS-based Occupancy Tracking for Public Transport

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Abstract— **The Smart Electronic Ticket Machine (ETM) combines ticketing and GPS passenger tracking with cloud-live monitoring. It has been developed to allow for greater transparency and operational efficiency in public transportation. For this purpose we used the Raspberry Pi Pico W and interfaced it with a keypad, TFT display, GPS, and WI-FI. Data related to ticketing and passenger boarding and destination stop is stored locally, and passenger count is updated through a self-generating drop list. The system is also able to detect and map the vehicle's position using GPS. The system captures and transmits the vehicle's real-time location and updated occupancy status through a common IP platform for remote monitoring. Validation of the system was done using a moving vehicle with simulated passenger data to test the dynamic accuracy of the system, its promptness, and the responsiveness and reliability of cloud updates. The prototype revealed a cost-effective and scalable intelligence system that bridges the transportation systems gaps to support improved commuter experience and smarter mobility.**

With the use of most common means of transport, buses, and some form of public transport in almost every city, they form the basic unit of mobility in urban centres. Despite their utility, they are, in most cases, understaffed and overcrowded. Passengers are faced with the problem of not knowing whether there will be space on the one. This results in delays and inefficient spread of crowd. Transport operators also face challenges due to the unavailability of demand data. This Makes optimizing timetable slots and bus assignments, along with service planning very difficult. Electronic Ticket Machines, or ETMs, are one of the devices used in most bus networks for ticketing. ETMs' functions include issuing of tickets, passenger trip recording, and data for the purpose of revenue collection. However, their use and limitations is that they cannot connect to any real time systems. Consequently, whilst they can prove to be extremely useful in recording passenger trips, they are not able to provide real time passenger data, while the vehicle is still in operation and the vehicle is in motion, they are also not able to provide a data points that indicate how full a vehicle is and passengers. Consequently, the data provided is not able to be used for the investigation of the most optimal way to transport passengers ETM documentation and has also been used to create a new model of transport using Smart ETMs. These are the leading devices of a type of new etm that has been developed to link the Smart ETMs with transport services and a geo position of the transport service. ETMs will still provide ticketing, however they will also provide feedback on the number of passengers that are in the transport service (loaded and unloaded).

Integrating ETM data with GPS-based tracking systems allows Smart Electronic Ticket Machines (ETM) at Dept of ECE, BMSCE to stream real-time information regarding passenger load, bus location, and ETA. This information is made available to commuters via integrated applications, such as Namma BMTC, allowing passengers to make informed decisions regarding their travel. Simultaneously, operational fleet management, route optimization, and demand forecasting are improved through real-time data.

I. LITERATURE SURVEY

[1] F. Araujo, M. Curado, P. Furtado and R. Barbosa, "Taking an electronic ticketing system to the cloud: Design and discussion," 2014 IEEE International Conference on Big Data (Big Data), Washington, DC, USA, 2014, pp. 1-10, doi: 10.1109/BigData.2014.7004438.

According to Araujo et al. (2014), moving electronic ticketing systems to cloud computing is beneficial due to the availability of cloud services that support system scalability and cloud-based real-time monitoring. Araujo et al. (2014) show that operational ticketing data and analytical data are processed separately, allowing for the operational data to be processed an an uninterrupted period. This aligns with the vision of our project, which is to support the cloud connectivity of ETM devices. This means that occupancy and routing data will be collected and provided to both system operators and commuters. Araujo is the source of our Smart ETM system design, which facilitates the integration of low-cost, reliable real-time data delivery systems focused upon real-time data relating to the usage of public transport systems.

[2] A. Cyril, V. George and R. H. Mulangi, "Electronic ticket machine data analytics for public bus transport planning," 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Chennai, India, 2017, pp. 3917-3922, doi: 10.1109/ICECDS.2017.8390198.

Cyril et al. (2017) present a comprehensive study on the various ways ETM data can be converted into usable planning tools, including but not limited to, origin-destination matrices, demand profiles, load factors, and short-term demand forecasts via ARIMA time-series models. They emphasize ETM devices as more than just ticketing machines, but also as planning tools with extensive data opportunities. They do, however, note the lack of de-boarding data as well as fare-stage Dept of ECE, BMSCE 2 Smart Electronic Ticket Machine (ETM) Granularity. Our project directly addresses this by augmenting ETM's with GPS-based passenger management that can update boarding and de-boarding counts dynamically. Thus, our system delivers greater insights for demand analytics, as advocated by Cyril, and also addresses the issues noted in their research.

[3] P. Manikandan, G. Ramesh, V. Muneeswaran, S. S. Kumar, P. V. Siddartha and A. K. Koushik, \A Smart Paperless Electronic Ticketing System using RFID and Bluetooth Technologies", 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2022.

Manikandan et al. (2022) present a smart paperless ticketing system using RFID and Bluetooth technologies, showing in real time the possible seamless, cashless, and ticketing system. Their work highlights the emphasis on convenience to the user by removing the cash counter, using a mobile app, and quick boarding. This work, along with ours, shows the modernization of public transport ticketing systems using technologies driven by the Internet of Things (IoT).

Their RFID approach for cashless transactions differs from our design which incorporates similar IoT concepts but also integrates GPS-based passenger tracking for operational and commuter transparency. In combination with our three works, we provide a robust foundation—cloud integration (Araujo), data analytics for planning (Cyril), and IoT-based smart ticketing (Manikandan)— that collectively substantiate and clinically endorse our proposed Smart ETM with GPS-based passenger management system.

II. PROBLEM ANALYSIS & SOLUTION

A. Problem Definition

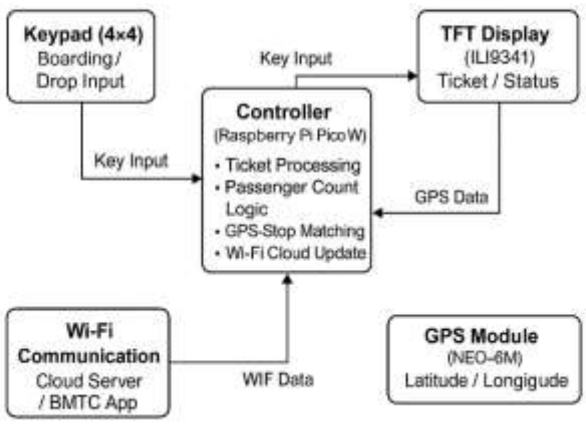
- The project's focus is the lack of a cohesive intelligent system that merges ticketing, passenger load management, and bus location tracking. ETMs have extended uses, but these end of the line devices are limited to ticketing and boarding record transactions. They do boarding record transactions, do not account for real-time passenger load updates, and are not connected to a GPS for geospatial bus location tracking. Consequently, commuters do not know how full a bus is or where the bus is, and managers are blind to how and when to make adjustments to real-time passenger demand. This problem exacerbates the over crowding of certain bus routes, the gross neglect of under-utilized bus routes, and bus route inefficiencies. The new generation of Smart ETMs with GPS is the proposed solution for these problems.

B. Recommended Solution

The Smart ETM system focuses on integrating ticketing, passenger management, and GPS-based real-time passenger stop detection. When a passenger sells a ticket, the ticketing ETM does a boarding and alighting record transaction, saving the boarding and alighting stops to the ETM database. At the same time, the ETM's GPS module is used to track the real-time position of the bus. When the bus reaches a stop that corresponds to a passenger's recorded alighting stop, the system will automatically decrement the onboard passenger count. The system will then be able to process the updated passenger count record, and push the updated record to the database over Wi-Fi. Consequently, the updated passenger count and bus position data are available in real time to BMTC passengers.

Transport authorities can also use the same data for the purpose of monitoring and making operational decisions. This workflow - Passenger, Ticketing, ETM Database, GPS Stop Detection, Logic, Wi-Fi and Cloud Integration - allows the system to promote effective passenger management, ensure clear information to commuters, and facilitate the optimization of data for public transport operations.

III. METHODOLOGY & IMPLEMENTATION



A. Structure

The central controller in the block diagram is the Raspberry Pi Pico W which connects with the keypad, GPS module, TFT display, and Wi-Fi. Input is provided by the keypad about the ticket, the locations are provided by the GPS, and the status is shown by the display. The controller processes the information, updates the count of passengers, and relays information in real-time to the cloud.

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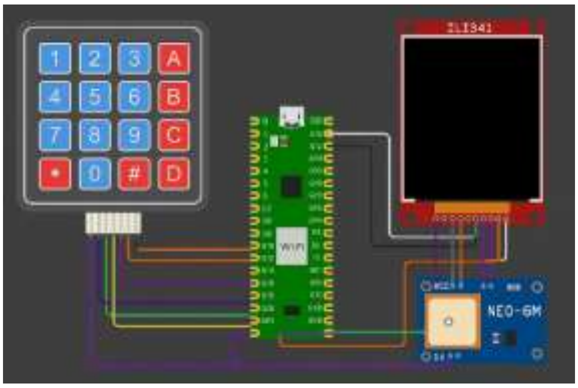
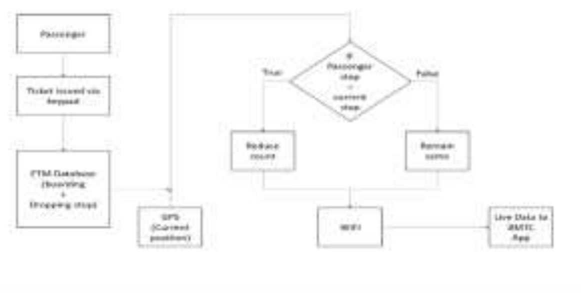
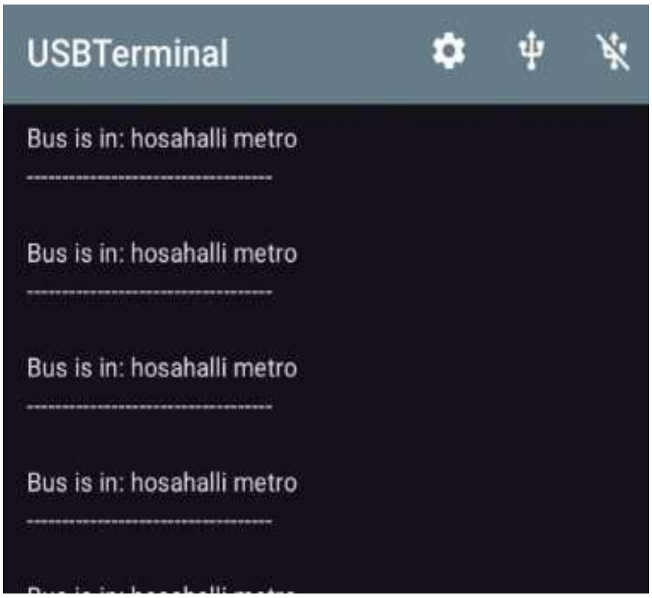


B. Flow Chart





IV. RESULTS & DISCUSSION

A prototype of the Smart Electronic Ticket Machine (ETM) was developed and tested for core functionality such as: automatic ticket generating, passenger counting, (while the machine self-monitors drop board and GPS-based) location, and live data IP (Interface Platform) data sending. The system was able to recognize passenger board/drops at each station through an automated (self-monitors) drop-list (data) mechanism. The presence of a GPS module was able to provide updates of the real location of the vehicle (while the machine self-monitors) and track (provide updates) to the moving vehicle. The IST (Integrated Smart Tech) system was able to provide updates on the operational status of the vehicle through the IST-cloud-based monitoring interface (while the machine self-monitors) and was able to provide updates on the total number of passengers. The monitoring interface working through a cloud-based interface provided (while the machine self-monitors) operational updates. The monitoring interface working through a cloud-based interface provided (while the machine self-monitors) operational updates. The presence of IoT (Internet of Things) devices and Technology provided a reliable data stream during cloud and hardware self-monitors and the user interface. These results validated the operational reduction of Smart ETM, the reduction of manual errors, the enhancement of passenger information and increased accessibility to ETM. The entire system of Smart ETM was proven to be real-world, cost-effective, scalable and deployable with only a few modifications.

Fig 5.1

Figures shows tested outputs of buses at stops particularly at Prasanna theatre (fig 5.1),10th cross (fig 5.2), Hosahalli metro (fig 5.3)

V. FUTURE TRENDS AND CONCLUSION

A. Conclusion

- Due to the ongoing digitalization of public transport system ticketing, there are now once-in-a-lifetime opportunities available for planning and operational refinement through the use of data. Electronic Ticket Machine (ETM) and smart card data capture passenger boarding patterns, route usage, and revenue data on a continuous and large scale. Smart card data supports the analyses of transit patterns, demands and revenue, while cash transactions are now the users of the accessible transit revenue data (Cyril 2014, Araujo 2017) and the data, once processed, assists with the operational insight through. ETM data was Cynthia (2017) and Araujo (2014) data analyses showed the data while from ETM data Cynthia (2017) data) and Araujo (2014) data showed the benefits of ETM data, Cynthia (2017). Araujo (2014) showed that the benefits of ETM data derived from the use of large scale, cloud, scalable, and cloud based storage systems. From the work of the 2017 2014 Araujo Cynthia and the 2014 Araujo. It can be concluded that, to create the desired transport analytical systems, adequate analytical and designed systems, the required data storage, quality data designed systems in order to achieve transport analytical systems.

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Fig 5.2

B. Future Trends

ETA systems and smartcards will begin to converge, and as a result, new technologies and data sources will completely change how we analyze data for public transportation. Automated vehicle location (AVL), Automated Passenger Counting (APC) systems, video surveillance systems (CCTV), and mobile network data will converge. These systems will allow for better data and more precise estimations and predictive analytics. Many modeling techniques will be replaced with machine and deep learning techniques as more and more predictive modeling applications become commonplace; unstructured, multiphase event driven travel behaviors and patterns will no longer present a modeling problem. Edge computing and analytics in the cloud will move predictive modeling (in the cloud) for near real-time demands, pattern deviations, and adjustments to routes or travel frequencies as a function of real-time demand.

Fig 5.3

Federated learning and the blockchain will change not only how we monetize/broker data in transportation, but how we analyze and work with data in transportation. Flexible and responsive transport and transportation demand management (TDM) will be implemented and integrated in the future with public transport data integrated with the smart card and electronic transport management (ETM) data. There will be a focus on seamless public and integrated transport systems, enhanced ticketing systems, and personalized travel planning services. predictive and responsive public transport analytics (ETM, smart card, data) will be integrated with Artificial Intelligence to facilitate real-time data collection/streaming and safe data collection/streaming to help manage, improve, and increase the movement of people in urban environments.

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VI. REFERENCES

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