Innovative Solutions for EV Charging and Passenger Handling in Public Transport

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Abstract: The rapid emergence and evolution of electric vehicles have created a need for new technologies that can help improve the passenger handling and efficiency of public transport systems. An emphasis will be on the development of new integrated solutions that involve advanced charging infrastructure and the optimization of passenger handling procedures. The goal is to foster energy-efficient, time-efficient, and easier-to-use systems that improve the overall experience for the end-user. Additionally, these steps include the implementation of modern public transport network technologies that incorporate smart grid systems, automated passenger handling systems, and wireless charging. This will make public transportation much more efficient and better for the environment.

1 INTRODUCTION

Transport, the economy, and the individual itself are key elements of modern life. Every day, it is not only important, but also necessary for the physical movement of people and property in profitable ways. With the population and the number of urban residents increasing rapidly, the impact of human mobility behaviour and environmental impacts with a variety of major challenges. The fatigue of finite resources of fossil fuels, the global heating crisis due to increased concentrations of greenhouse gases, and the rise in air pollution in particularly large cities, are serious issues that need to be addressed. As a result, pressure on the sector will be transformed into sustainable alternatives, increasing to reduce negative environmental impacts and promote long-term sustainability.

Perhaps the most attractive approach that has attracted a huge amount of attention in recent years is the use of battery types. Driven electric vehicles (EVs). Vehicles with electric motors powered by rechargeable batteries have proven to be a potential replacement for traditional internal combustion engines (ICVs). Compared to electronics/trolley cars, electricity, for example B. electric vehicles and vehicles, backup electrical networks, etc. are external (and do not rely on excessive line wires). This freedom offers a wide range of options in terms of different applications of different modes of transportation, different applications of vehicles belonging to individual users (such as cars) or multi-users (such as buses and vans). The greatest advantage of EVS lies in the submission of local contamination solutions. EVs cannot release emissions from tail tubes, as electric vehicles do not emit fossil fuels. Therefore, EVs can generally significantly improve the air quality of urban cities where pollution is worsened. This improvement in air can then be used to significantly reduce the burden of respiratory disease, improve public health, and ensure a safe environment. Furthermore, the energy efficiency of the EVS is much greater than that of TEC vehicles. The EV shows the energy of the Rad well. This indicates the total energy fertility that begins from generating electricity to moving the vehicle. EVs are ICVS competitors, and their efficiency comparisons show that they have better fountains than cycling metrics. This example is particularly reflected in cars as EVs have internal engines compared to IEVs. This allows for easier mobility, cleaner air and increased energy efficiency.

EVs offer amazing benefits, but not without environmental impact. The main drawback is your life cycle, and in the case of the recycling reduction stage, it is also known as a "cradle to grave" or a critical cradle. This refers to such a life cycle, including any level of the lifespan of a product that begins or is recycled from extraction of raw materials

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(cradles) to discard or recycled (graves). The production stage, particularly lithium-ion battery production level, is a major EVS environmental issue. Raw material extraction (such as lithium, cobalt, nickel) has devastating environmental films in these batteries. Recovery through use could lead to the destruction of habitat, water diseases and human rights violations in mining areas, mainly through an increase in international violations. Furthermore, battery production with electricity is hungry and creates a large amount of carbon emissions. In other words, the environmental benefits of electric motors (EVs) have been partially neutralised. Additional concerns regarding toxicity and environmental damage during the period of disposal or recycling strategies have priorities related to the use of heavy metals in EV batteries. These demanding situations need to be resolved with technology in a larger state, primarily in terms of layout and battery shredding.

More efficient recycling technology will regain valuable substances from used batteries, reduce the desire to extract raw materials, and increase the ability to minimize adverse environmental impacts to dispose of waste batteries. In the same style, improving battery consumption performance reduces energy loss and can decorate the total environmental balance of your EV. One of the most important drivers for moving to an electric motor is the ability to limit greenhouse gas emissions. EVs driven by energy from renewable energy sources such as Sun, Wind, and Hydropower have a near-zero CO2 footprint. This makes for a perfectly ideal preference for reducing climate change. Nevertheless, the environmental benefits of EVS are immediately related to the power generation resources provided. If energy is taken from fossil fuel strength, especially flowers from coal, the correct carbon emissions of electric vehicles may be near traditional ICVs. This makes it easier to take over EVs as it underscores the need to migrate global energy networks to renewable energy and transport electrification perfectly well for Arena's decarbonisation target. And encourage your use to promote your recordings. Such incentives include subsidies, tax credits, gifts, and many different systems that make EVs particularly expensive for individuals and institutions. By using EVs that can easily collect it, the government wants to improve records and reduce reliance on fossil fuel engines.

A lot of awful focus on EVS is on its use in private transport, but there is a great ability for EVs to trade public transport for good. Public transport is an important part of urban mobility, offering important offers to hundreds of thousands of people every day. These include buses, trains and taxis that limit traffic congestion, even if urban mobility is much more achieved. However, at its greatest, public transport has excellent environmental benefits, especially in urban environments. Buses and taxis release large-scale environmental pollution emissions and CO2 footprints into the ecosystem via fossil fuels. The involvement of electric engines in public transport structures risks affecting the load on emission discounts and operational performance. Electric buses can offer a clean, quiet, energy efficient alternative to conventional diesel engine buses. Other benefits over time include lower operational costs, along with much better air quality. Similarly, electrified taxis may further lower urban mobility's carbon footprint by giving cleaner and more sustainable alternatives for short distances.

Yet integrating electric vehicles with public transport is not without its challenges: the need to provide widespread charging infrastructure to supplement mass-scale electric bus and taxi use. It is also essential to ensure that charging points are placed where they are needed and can provide sufficient electricity whenever there is a shortage of supply to meet the high level of demand. The problem of battery capacity is significant because public transport vehicles must cover long distances and run for long hours during the day. Batteries need to be developed which have increased capacities with fast charge time, so that, electric vehicles can meet the demands of public transport.

The shift to battery electric vehicles is viewed as a significant step forward in addressing environmental issues related to the transportation sector. Although EVs offer substantial advantages in reducing local emissions and enhancing energy efficiency, we must not ignore their environmental impact during production and disposal. With ongoing development in battery technology, recycling technologies, and the penetration of renewable energy into the grid, EVs can become a key part of creating a more sustainable and environmentally friendly transport future. Further, increasing the application of EVs in public transport systems also presents a chance to achieve maximum environmental gains of electric mobility, lower emissions at a larger scale, and provide more environmentally friendly urban environments.

The integrated systems are oriented toward bettering the greatest advancement, upgrading public transport through introducing technologies like Wireless Sensor Network ticket readers and Wireless Power Transfer. Passenger flow is enhanced, congestion is reduced, and energy efficiency is boosted. This system allows for real-time updates on passenger counts and bus locations that enable seamless travel. Future upgrades involve machine learning for route optimization, cloud platforms centralizing data management, and IoT-supported safety features to ensure reliability and protection. The system tackles existing utility limitations while creating further grounds for smarter and sustainable future public transit networks.

2 LITERATURE SURVEY

Integrating such wireless charging systems into public transportation represents an innovative approach in charging technologies for electric vehicles (EVs). Central to this development is dynamic wireless charging (DWC), which permits the vehicle to charge while on the move, intervening to correct some major issues such as range anxiety and long periods of charging downtime by the user. The demand-side management for EV charging, using mobility-aware algorithms, is key to optimizing utilization of such infrastructure, enabling balanced load on grid and preventing overloads. It also has optimization through online, spatial EV allocation strategies, when applied to an Internet of Electric Vehicles (IOEVs) network, as evidenced by case studies for cities like Dubai and Sharjah, UAE, which indicated noticeable load balancing and energy efficiency improvements.

Moreover, Location-Based Social Network Services (LBSNs) like Foursquare have been explored to analyse urban mobility patterns and to ameliorate destination choices, ultimately for transportation planning purposes. The vast volumes of data created through user check-ins allow for a more precise prediction of travel behaviours, especially for leisure and business trips, which is opposed to traditional, manual data collection methods. This methodology informs improved modelling of long-distance travel and transportation systems when more informational inputs such as destination attractiveness are taken into consideration based on user activity intensity. (R. SA, M. A. Karim et al 2015).

With the incorporation of the IoT-based sensing technology into public transport systems, crowd management and passenger control have improved multi-fold. The facilities allow on the spot survey and forecasts into crowd congestion so that realization may be afforded in the form of adaptive route planning, real-time alerts, and indicative notifications to passengers. The deployment of such technologies does not only enhance the efficiency of the urban transport system but also advances the comfort and safety of passengers during heavy traffic situations or emergencies, such as in COVID19. In addition, mobile communication data, particularly anonymized call detail records (CDRs), have been employed for mapping urban dynamics and for shedding insights on labour and recreational movements and citywide activity patterns. With these insights in hand, urban planners might make rational decisions on how to optimize city layouts and transportation infrastructure. (G. Sagl et al. 2014), (R. A. Becker et al.,2011).

The development of wireless inductive power transfer systems for charging while in motion has also been a crucial area of research, especially regarding power transfer efficiency and driving range enhancement. Addressing the issues related to the power pad designs and the magnetic resonance coupling, researchers have identified that there are several parameters to ensure the optimized performance of dynamic wireless power transfer systems. These proposed methods give great promise in solving the issues associated with in-motion EV charging.

Likewise, cloud-based frameworks, such as Cloud Track, enhance the functioning of data-driven intelligent transportation systems by monitoring real-time logistical operations and supply chain management. These frameworks make a mark by utilizing cloud computing features to improve vehicle routing and fleet management thus opening greater avenues for transportation care operations optimization on a larger format. (Bahga and V. Madisetti,2013).

To enable developing and planning into the future of EV charging infrastructure, analysis of the charging profiles and waveforms, as recorded in the EV-CPW dataset, would be paramount. Hazardous events such as distortion in voltage, harmonic content, and load behaviour significantly throw light on power quality issues which can further assist investigations in preparing for the burgeoning expectation for EV charging that will ensure a stable and robust power grid as more vehicles get integrated into the system.

Finally, the study of commuting flexibility shows, by means of GPS data, that commuting patterns are much more variable than it has been traditionally assumed. This flexibility allows further planning of transportation services, such as dynamic route changing to optimize travel time management, improving the efficiency of and alleviating the strain of daily commuting. (Y. Shen et al. 2013).

3 PROPOSED SYSTEM

The proposed system comprises of two sections namely Bus section and Station section. In bus section, ticket reader acts as a fundamental input. The reader reads each passenger's travelling ticket to monitor entry and exit details of every passenger. Micro controller which is implemented in bus calculates passenger's entry and exit details through output of ticket reader. If a bus departs from a particular bus stop, count of passengers is sent to next bus stop through wireless sensor network (WSN). This process will notify the number of passengers in bus to the people waiting for that bus in second bus stop. In station section, bus id reader is installed to read each bus id number to verify which bus is arrived to that bus stop. This information is also sent to next bus stop via WSN and it is displayed for public monitoring.

Wireless power transfer setup is installed in every bus stop to supply electric charge to bus as it is considered as an electric vehicle. Charging unit in bus is covered by glass to protect passengers from any shock effects. LCD is incorporated in both bus and station sections to notify various live statuses. The system data can be further integrated to web application for better user convenience.

4 METHODOLOGY

The steps in the development and implementation of the proposed system involve key fundamentals. Crux to these steps is a detailed study of how to design and install the wireless power transfer (WPT) infrastructure in support of electric vehicle charging. This involves choosing wireless power transfer technology and light integration of this technology with bus stops and depots, enabling the charging process to be well-integrated into operating schedules (figure 1).

At the same time, the real-time bus tracking will be done employing RFID technology; RFID tags are fixed on each bus and RFID readers are placed along the route to get real-time tracking data. The passenger management component will involve the RFID based ticketing system on the bus's onboard system to facilitate smooth and quick ticket processing and through the number of tickets it will calculate the passenger count. After the successful pilot testing, the system will be unveiled throughout the public transport network, where it will undergo inspection and maintenance to assure its reliability and encourage more continuous improvements. The integrated approach is toward improving the efficiency of public transport while reducing operational costs and ensuring comfort and seamless experience for passengers without being a burden (figure 2).

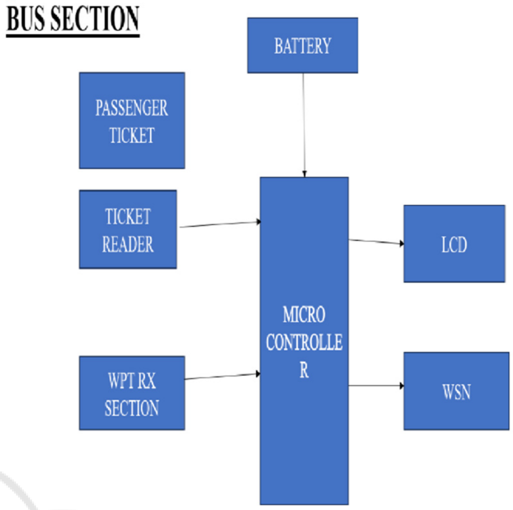

Figure 1: Block Diagram of Bus Section.

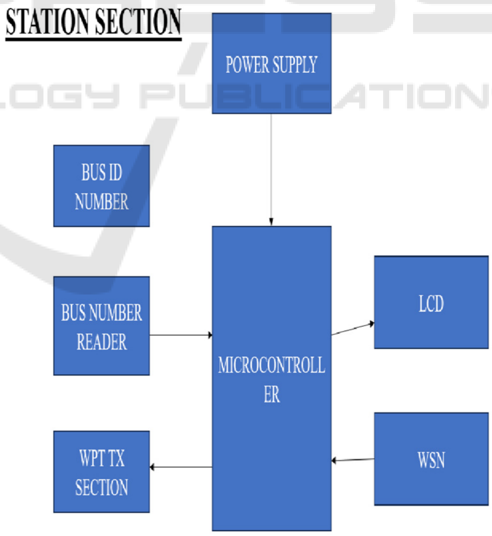

Figure 2: Station Section.

- HARDWARE REQIUREMENT (figure 3)
- MICROCONTROLLER
- RFID READER/TAG
- WPT MODULE
- WSN MODULE

- POWER SUPPLY
- BATTERY
- LCD
- VOLTAGE SENSOR

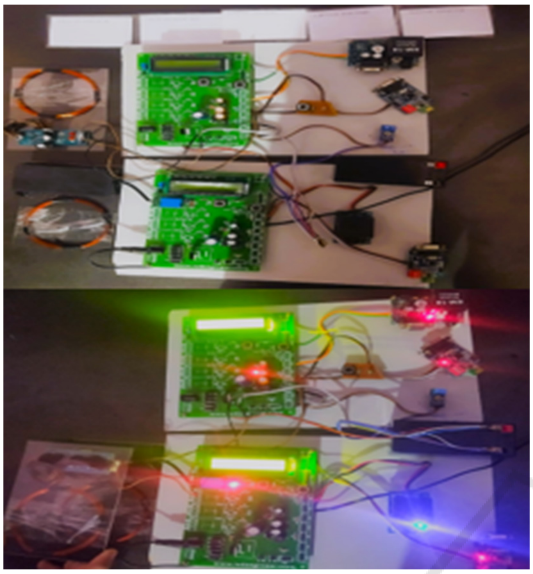

Figure 3: Hardware Connection.

- SOFTWARE REQIREMENT
- EMBEDDED C
- ARDUINO IDE

5 RESULTS AND DISCUSSION

The prototype shows the successful communication of two ESP32 devices based on the ESP-NOW protocol. The sender device, monitoring the number of passengers with the help of an RFID Reader, the voltage, and charging status, sends this information to the receiver in a precise format. The receiver displays this information on an LCD in real-time and controls the relay for charging based on the received status. The system is resilient enough and offers clear serial statistics for debugging the data transmission/reception to establish the system is functional. Although the implementation is functioning and fairly low-latency, aspects that can be improved are; the use of unused variables to carry more information, error handling in the event of a transmission failing, and energy conservation mode improvements. Overall, this goes toward showcasing a practical demonstration of real-time monitoring and control with a simple/expandable design. Also, the data of number of passenger, bus starting/next stop along with its number and date will be displayed in the web application (figure 4).

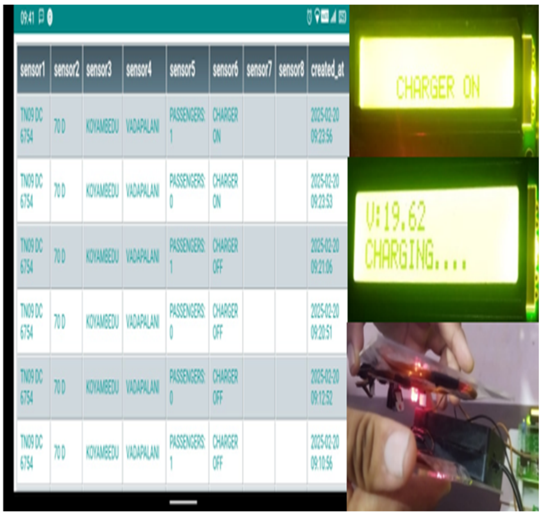

Figure 4: Software and Results Obtained.

6 CONCLUSIONS

Innovative solutions for EV charging processes and passenger handling in public transport "focusing on technology sectors to optimize energy efficiency, passenger flow and environmentally friendly alternatives in public transport Wireless Electricity transmission, feature tickets and real-time passenger tracking including RFID-based. For this project, the rationale behind working on smart, green public transport solutions was to decrease manual tasks, increase bus occupancy, and therefore be capable of conducting seamless charging for EBs to increase operational efficiency. The project additionally aims to advance wireless charging technology to enhance charging speed, improve passenger data collection, and allow for interoperability among other emerging smart transport systems in the future work to be undertaken. Focusing on pushing for innovation and sustainability, this project will be a springboard to an efficient, environmentally friendly, and customer-oriented system in public transport; a huge leap toward taking cognizance of global requests for greener urban mobility solutions.

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