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Efficient Parking & Toll Management: A RFID-Enabled Approach with Vega Aries Development Board

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Abstract:- The project described in the text seeks to use of indigenous Vega Aries v3.0 Development Board to create an Internet of Things (IoT) based system for effective parking and toll management. With regard to traditional parking and toll management systems, the project seeks to address the problems of inefficient use of parking spaces, insufficient real-time information, manual toll collection, and insufficient security measures. The toll collection process will be automated by the system and real-time parking availability information will be provided via Radio-Frequency Identification (RFID) technology. The Vega Aries Development Board will also be utilised in this project to minimise needless fuel use, enhance security, and maximise parking space utilisation.This paper also addresses the shortcomings of conventional toll and parking management systems and the demand for effective, automated, and safe substitutes. The text's related work section examines a number of earlier research projects on automated parking and toll collection systems built with the use of diverse technologies, including WSNs, Bluetooth, Wi-Fi, image processing, and Arduino Uno. The suggested system, the text says in its conclusion, is based on Indian Development Boards, which are more affordable, quicker, safer, and more scalable for future growth.

Keywords:-*Internet of Things, RFID, Parking Management, Toll Management, Vega Aries Development Board, ESP8266, THEAJS32.*

I. INTRODUCTION

➢ *Background:*

In the current era where Artificial Intelligence is spreading its wings wide, The Internet of Things also known as IoT has revolutionized how we used to interact with the physical things around us. Due to the transformative technology and widespread use of IoT in many different domains, including transportation, security, healthcare and redesigning urban infrastructure. In the relevance of smart cities, IoT plays an essential role in enhancing quality of life, sustainability, and operational efficiency in smart city settings.

One of the major pressing issues faced by urban cities is the increasing quantity of vehicles and limited number of parking spaces.[1]The huge proliferation in the number of vehicles in the cities has led to several problems regarding gridlock in the roads, increased fuel burn, air pollution as well as noise pollution and most importantly driver's frustration and time waste.It has been found that an individual wastes almost 15 minutes to search for a suitable parking spot daily.[1]

➢ *Problem Statement:*

The numerous obstacles associated with traditional parking and toll management impede the efficiency and productivity of the systems in place. The following are the main limitations:

- *Ineffectual Utilisation of Parking Spaces:*
  Manual parking allocation techniques frequently leave spaces unoccupied, causing drivers to waste time looking for open spots.

- *Inadequate Real-Time Information:*
  Whenever drivers cannot find parking, they navigate in circles, which contributes to traffic congestion and increases fuel consumption.

- *Manual Toll Collection:*
  The methods that comprise manual toll collection are tedious, prone to blunders, and highly susceptible to toll evasion.

- *Inadequate Security Measures:*
  A lack of adequate security leaves cars and revenue at risk of theft. Conventional parking and toll systems frequently lack inadequate security measures.

Efficient, automated, and secure solutions that may enhance security, boost parking space utilisation, and provide real-time parking information are crucial to address these issues.

➢ *Objective:*

This project's objective is to develop an Internet of Things (IoT)-based smart parking and toll collection system that uses a combination of existing Radio-Frequency Identification (RFID) and C-Dac developed fully indigenously Vega ARIES v3.0 Development Board. The following goals are the system's primary goals:

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- *Real-Time Parking Facilities:*
  Direct drivers to open spots with real-time parking availability information provided by RFID sensors and Internet of Things technology.

- *Automatic Toll Collection Feature:*
  Real-time parking availability: Direct drivers to open spots with real-time parking availability information provided by RFID sensors and Internet of Things technology.

- *Improved Security:*
  Use RFID technology to guard parking lots, stop illegal access, and discourage car theft.

- *Improved Parking Efficiency:*
  Reduce traffic and unnecessary fuel consumption by optimising parking space usage by giving drivers and parking operators access to real-time data.

II. RELATED WORKS

In the past several parking systems have been built using various technologies like WSNs, Bluetooth, Wifi and image processing. Various models show functions like automatic check-in, checkout, remote sensing, reservation for parking and theft control. Networks like ad-hoc help in enabling real-time navigation. Bluetooth can be used for low-power wireless tech.[1] In reference[4], We have looked through numerous studies on automated parking and toll collection systems written by numerous researchers. Even so, we are aware that toll collection and manual parking are unreliable and can cause delays and significant losses for a variety of reasons.[5]

We learn about work done with a GSM module, which replaces tiny near-range communication sensors with a high-range sensitivity detection device. Various parking and toll management models have been built using Arduino Uno[14] but ours is based on Indian Development Boards which are safer, cheaper, faster and more affordable for future developments.A magnetic sensor is used by parking to count the number of cars.[14]

In the paper[17], we see that Vehicles with RFID tags installed can automatically deduct the toll from the driver's account when the vehicle passes through a toll booth as the tag is read. This can help to lessen traffic congestion, save time and money for travellers, and greatly reduce the need for manual toll collection.

The system created for the project[16] tracks the availability of open parking spaces and directs the car to the closest one. To save the user time, the system shows the total number of parking spaces that are available along with the occupied and unoccupied slots on the display board. This allows the user to check the available slots before entering the parking area and to park his or her car in the desired slot right away. The data on the display board is updated continuously, and the parking spaces are constantly being observed.

Harvesting Real-Time Vehicular Parking Information Mobile Sensor System uses ultrasonic sensors for detecting empty slots.

Another technology known as Internet-Scale Sensing Services[14] uses iris tech to find parking space.

In Reference[10], We observe work being done on an automated system that permanently affixes an RFID to a car. In which cars can also detect surrounding vehicles which are also equipped with RFID tags.In reference[10], a method is also proposed for a hindrance-free vision for the driver.

➢ *About Work[12].*
With reference [13], The article outlines a coordinated parking system framework for the Internet of Things that makes use of an Arduino Uno board and an ultrasonic range detection sensor to track and indicate the availability of single parking spaces. The authors suggest a time-driven grouping technique to maximise parking spot utilisation and lessen traffic jams brought on by cars looking for parking. The system's goal is to make parking spaces more accessible to cars and cut down on search time. The system's architecture and its potential to lower fuel consumption and CO2 emissions are also briefly discussed by the authors.

In reference to the paper [16], which addresses the issue of parking in large cities, the authors present a smart parking system built on RFID technology. The parking slot availability is tracked by the system, which directs cars to the closest available slot. A feature for pre-reserving parking spaces is also included. The system's goals are to expedite parking procedures, lessen traffic jams brought on by parking searches, and save time. The system counts the number of cars in the parking lot and detects when one enters or exits using Arduino and RFID technology. Shopping centres, hospitals, airports, and other urban areas with parking issues can use the fully automated system.

III. SYSTEM ARCHITECTURE

➢ *Overview:*
In this paper, we have proposed an efficient system architecture that constitutes the combination of hardware and software solutions to provide an effective way of contactless car parking and toll system to manage vehicular traffic[17] and maintain a database of incoming and outgoing traffic, type of vehicle, weight of vehicle etc. The system is also easy to implement with all kinds of infrastructure.

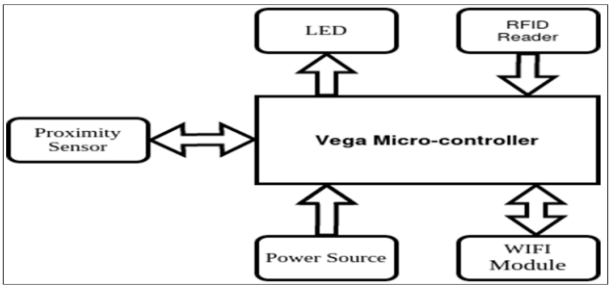

Fig 1 Block Diagram

➢ *Components:*

The model can easily be implemented with already established infrastructure with ease as it consists of minimal complexity and the system has minimal cost.

- *RFID(Reader)*:

The Radio Frequency Identification (RFID) tag is a device that uses radio waves to transfer information from the tag to the reader. An RFID reader is a device that collects data from RFID tags, which are used to have individual, unique objects[5].

- *RFID(Writer):*

A radio frequency device that is used to transfer data mainly to track and identify if the given object is registered to the same system and performs the task of receiving the proper feedback. It sends data to the microcontroller for further processing and working of the system.[5]

Table 1 Technical Specification of UFH

Parameter	Description
Operating Frequency	860-960 MHz
EEPROM Size	512 bit user memory
Unique Serial Number (UID)	8 byte (64 bit)
RF Interface	ISO 18000-6C
Read/Write Range	5" / 12.7 cm
Data Retention (years)	10
Write Endurance (cycles)	100,000
Memory Organization	64 bit TID 96 bit EPC 512 user

➢ *Wi-Fi Module(ESP8266):*

It serves as a wireless entry and exit system that is controllable from any location and by any internet-connected device that has access to the module. A self-contained SOC with an integrated TCP/IP protocol stack, the ESP8266 Module[19] allows any microcontroller to connect to a WiFi network. Either an application can be hosted on the ESP8266, or it can delegate all WiFi networking tasks to another application processor. Pre-programmed with an AT command set firmware, each ESP8266 module enables the user to combine it with microprocessors such as Arduino, Vega, and others to create a wide range of inventive projects. Many individuals and communities are using the ESP8266 module, which is a very affordable board, to work on and develop projects.

Table 2 Technical Specification of Esp8266

Parameter	Description
Operating Frequency	2.4 GHz
Communication Protocol	802.11 b/g/n
Operating Temperature	-20deg Celsius to 60 deg Celsius
Power Supply Voltage	2.7V to 5.5V
Power Consumption	Varies by module, not specified in the provided sources
Data Transfer Rate	Up to 10 Mbps
Interface	UART, USB serial Communication
Antenna Type	Diversity antenna switch outputs

➢ *Vega Development Board:*

It is an open-source platform based on friendly hardware and software developed in India. It is developed for a wide range of multi-purpose projects and is an efficient way of designing interactive and innovative projects. It provides a wide range of processors and the most commonly used processor and the preferred processor for this system is the Vega Aries processor. The ARIES v3.0 is an entirely native device and “Made in India" product to introduce embedded systems and basic microprocessor programming. The VEGA Processor, which powers this board, is RISC-V ISA compliant and features user-friendly hardware and software. Table 3 contains the development board's specifications.

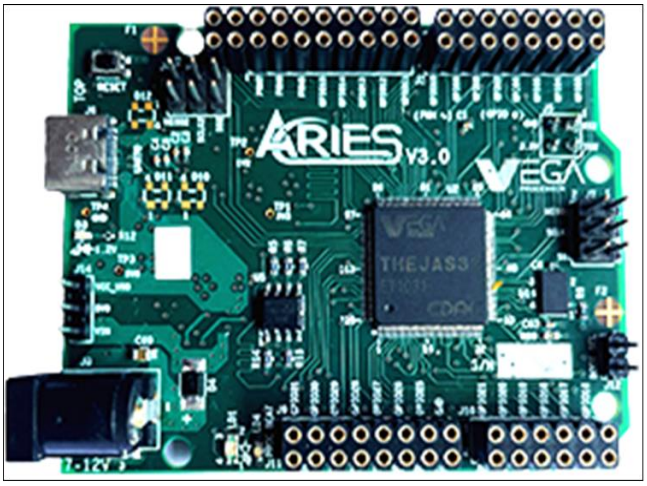

Fig 2 VEGA Aries 3.0
Source: vegaprocessors.in

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Table 3 Technical Specification of Vega Aries V3.0

Parameter	Description
Controller	860-960 MHz
SRAM	512 bit
Flash	8 byte (64 bit)
Input Voltage	ISO 18000-6C
PWM Pins	5" / 12.7 cm
Pins for Analog Input	10
SPI	3.00 nos
UART	3.00 nos
12C	2.00 nos
GPIOs	32
DC Current (I/O Pin)	12.0 mA
IO Voltage	3.3 V
Clock Speed	100 MHz
Length	78.00 mm
Width	66.00 mm

Table 4 Technical Specification of Thejas32 Soc

Parameter	Descriptions
Processor	VEGA ET1031
RAM	5256KB
PWMs	8 nos
SPI	4 nos
TIMER	3 nos
GPIO	32 nos
UART	3 nos
12C	3 nos
Frequency	100 MHz
IO Voltage	3.3 V
Core Voltage	1.2 V
Package	LQFP 128

- *Servo-Motor:*

It constitutes a closed-loop servomechanism that regulates motion and end position via position feedback. It will offer a way for the parking and toll systems to function so that cars can pass after getting the appropriate feedback.

Table 5 Technical Specification of Sg90

Parameter	Description
Operating Voltage	Typically +5V
Torque	2.5 Kg/cm
Operating Speed	0.1s/60 deg
Gear Type	Plastic
Rotation	0 deg - 180 deg
Weight	9g
Wire Configuration	Brown: Ground Red: +5V Orange: PWM signal
Equivalent Models	VTS-08A Analog Servo, MG995 High Torque Metal Gear, MG90S Metal Gear
Power Supply Voltage	4.8V to 6.5V, commonly operated at +5V

IV. METHODOLOGY

➢ *System Design:*

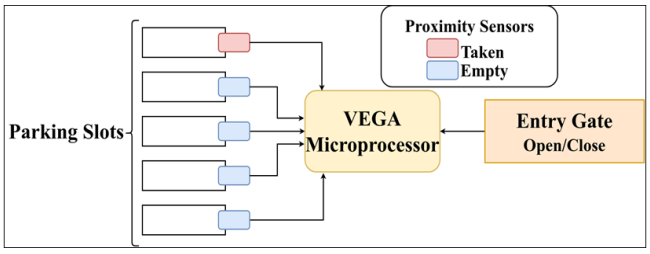

Fig. 3 Network Flow Diagram

➢ *Software Requirements:*

Operating System: Ubuntu 20.04 LTS

IDE :Arduino IDE

Language :C/C++

Libraries :Adafruit,MFRC522

Database :Firebase

➢ *Implementation:*

- In this system we have used the Vega Aries Micro-controller for the processing of the data and input received by the sensors which in turn handles the working of the actuators.
- The RFID tag has been integrated with this Aries Microcontroller to validate the vehicle.
- On receiving proper feedback from the tag, the signal is sent to the Aries microcontroller which then sends a signal to the actuator and the barrier of the toll and parking system is then lifted.
- A Wi-fi (ESP8266) module is also integrated with this system which allows it to be more flexible and less dependent on only one hardware. This helps the system to perform even if any problem occurs with the RFID system allowing its user more ease.
- The Wi-Fi module is connected to the Aries module and the user is provided with the functionality to control the system via the internet, on receiving proper input the Wi-fi module sends the signal to the Aries board and the barrier is then lifted.
- The brain of the complete system is the Vega Aries processor and controls the whole system centrally on receiving proper input and feedback.

ISSN No:-2456-2165

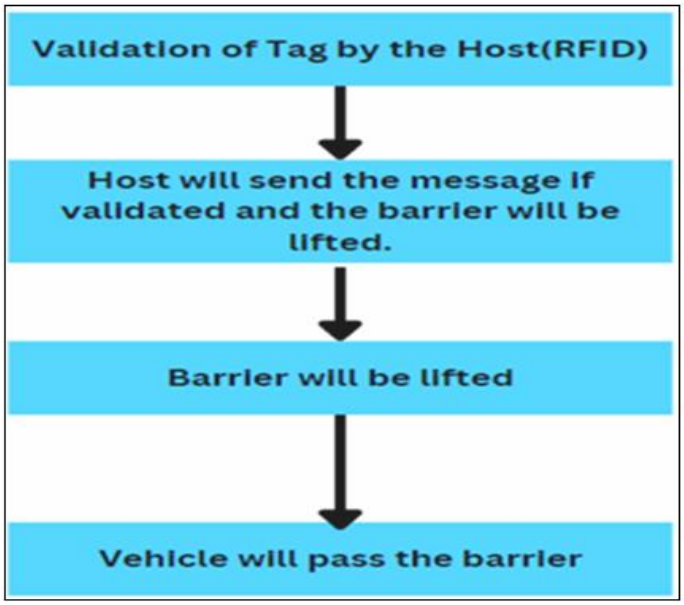

Fig 4 System Flow

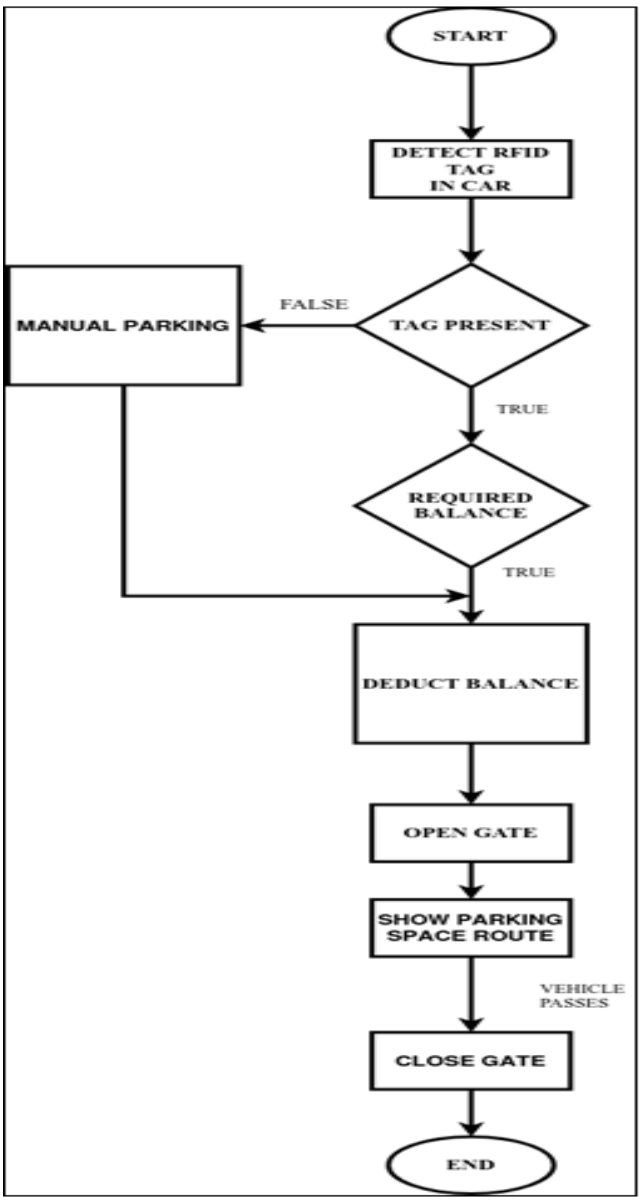

Fig 5 System Flow II

V. RESULTS & DISCUSSION

The Vega Aries microcontroller proposed system is more reliable, safer, faster, and more affordable than existing solutions. The system is easy to install and maintain, and it does not require any special infrastructure. The system is also scalable, and it can be easily deployed in large parking lots. This ushers in a new era of microcontroller innovation, offering users and developers a fresh perspective on hardware choices. Additionally, the Vega series of microprocessors, being indigenously produced, presents a cost-effective solution for IoT development, fostering a more inclusive and accessible ecosystem.

VI. CONCLUSION

In conclusion, the implementation of the Vega Aries microcontroller showcases new grounds with alternative hardware choices for end-users and inventors alike.The system's use of RFID technology and the Vega ARIES v3.0 Development Board makes it a viable solution for deployment in urban areas. The system's real-time parking availability information, automatic toll collection, improved security, improved parking efficiency, and reduced traffic and fuel consumption make it a compelling choice for municipalities and parking lot operators. Moreover, due to the indigenous nature of the Vega series of microprocessors, a more cost-effective path has been uncovered for Internet of Things development.

FUTURE WORK

This work considers only the implementation of a novel microcontroller, however, we can further incorporate it with efficient parking-related solutions such as [1]. Future work should focus on enhancing the user experience, integrating the system with other traffic management systems, conducting a large-scale pilot study, and exploring further advancements in RFID technology and cybersecurity. Additionally, expanding the system's functionality to include dynamic pricing, reservations, valet parking, and car-sharing services should be considered. A further attempt to improve this work can also be made by improving the precision and error correction of the proximity sensors.

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