iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4567

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Internet of Vehicle (IoV) for School Bus Safety

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Abstract: ***The Internet of Things (IoT) is the concept of describing the idea of smart objects which are connected to the internet and be able to identify themselves to other devices. This idea of connecting such smart objects over the internet can also be restricted to vehicles and is called as the Internet of Vehicles (IoV). Thus, IoV is the merging of mobile internet and IoT. With the continuously increasing population, vehicle ownership is also increasing at an exponential rate. Due to the increase in the number of vehicles, traffic management, and accident fatalities has become a great problem in our day-to-day life. This paper provides a brief research on IoV and also gives a solution for Intelligent Transport System.***
Index Terms: ***Internet of Vehicles, Big Data, Intelligent Transport Systems, Internet of Things, VANET.***

I. INTRODUCTION

With the increase in the urban population and with the increase in rapidly expanding cities, the ownership of the vehicle is also growing rapidly at a great rate. As the number of increasing vehicles are all connected to the Internet of Things (IoT), the ordinary Vehicle Ad-hoc Networks (VANETs) are now transforming into the Internet of Vehicle (IoV).

As noted, every vehicle which participates in VANET [1] is turned into a mobile node or a wireless router, which further enables the vehicles to connect to each other to create a wide range of a network. The vehicles in the network can opt out of the network or can fall out of the signal and other vehicles who want to join can join in. In this way, the vehicles are connected to each other to create a mobile internet. VANET can only cover very small mobile network which leads to mobility constraints. The use is also made difficult because of tall buildings, traffic jams, complex road networks, etc. For VANET, the objects involved are temporary, random and unstable, and the range of usage is local and discrete. Therefore, VANET cannot provide global and feasible applications for customers. Over the past several years, there has not been any popular implementation of VANET.

In contrast to VANET, IoV is envisioned to serve as an essential data sensing and processing platform for intelligent transportation systems [2]. A vehicle is a sensor platform, which absorbs information from the environment or from other vehicles or drivers and uses it for traffic management and safe navigation. The Internet of Vehicles (IoV) consists of vehicles that communicate with each other as well as with handheld devices carried by pedestrians, roadside units (RSUs), and the public networks using V2V (vehicle-to-vehicle), V2R (vehicle-to-road), V2H (vehicle-to-human) and V2S (vehicle-to-sensor) interconnectivity thereby creating a social network where the participants are intelligent objects rather than the human beings. This leads to exposure of Social Internet of Vehicles (SIoV). SIoV is essentially a vehicular instance of the social IoT (SIoT). It extends VANET's scale, structure, and applications [3]. In this way, Internet of Vehicles (IoV) focuses on the combination of humans, environment, and vehicles and is a large network which provides services for large cities or for a whole country.

II. ARCHITECTURE OF IOV

A. A standard IoV architecture is composed of three layers as shown in Figure 1 [4,5]

Perception layer: This layer contains all the sensors within the vehicle that gather environmental data and detect specific events of interest such as driving patterns, environmental conditions, etc. It also has radio frequency identification (RFID), roads environment perception, vehicle position perception, etc.

Network layer: This is the communication layer that ensures connectivity to communications networks such as GSM, WiMax, WLAN, Wi-Fi, and Bluetooth. It supports different wireless communication modes such as Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P) and Vehicle-to-Sensor (V2S).

Application layer: This layer includes statistics tools, support for storage, and processing infrastructure. It is responsible for storage, analysis, processing, and decision making about different risk situations such as traffic congestion, bad weather, etc. It represents smart applications, traffic safety, and efficiency.

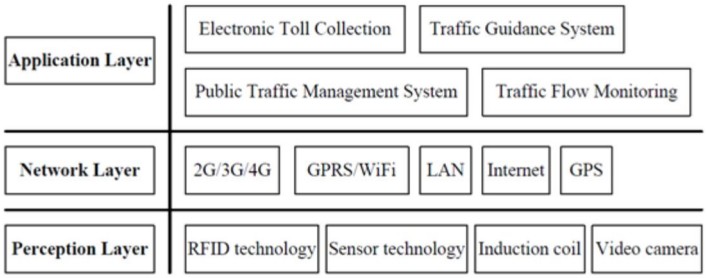


Figure 1 – Architecture of IoV [4]

For the online presence of vehicles, each vehicle should have a uniquely identifiable number on the Internet. A Vehicular Global ID (VGID) is at the base of the IoV. The GID addresses problems with RFID that include its one-way nature, limited range and coverage, lack of speed, and unintelligent operation. More importantly, GID provides vehicles with "cyber license plates" or "cyber IDs [6].

III. IOV FOR SCHOOL BUS SAFETY

School bus fleet management companies, as well as the school transportation departments, are both under continuous pressure to provide safe and reliable service to students and their parents and also keeping in mind to cut the costs. IoV can be used smartly in the implementation of school bus safety. Safety of the students travelling via school bus is a major concern to their parents. Parents live in a constant fear about the whereabouts of their wards till the time they return they return. While schools are safe havens, the daily commute to and from the school is a cause of anxiety for most parents. Roads are not safe. A 2011 National Transportation Safety Board study says, “Buses and other commercial motor vehicles have a higher likelihood of fatal accident involvement per registered vehicle”. In the case of an accident, the driver is responsible 77% of the time. Over speeding/overtaking, alcohol/ drugs influence, and driving distractions remain top reasons for which a driver can be held responsible for. Just imagine that parents will be able to view their child’s bus route, get notified about the driver’s behavior and receive alerts via SMS about their child reaching school. The school administrator can view the bus route in real-time and can notify the parents about the arrival delays. The bus fleet company can manage their drivers and prevent accidents. This is only a small fraction of what is possible with an Internet of Vehicles (IoV) solution.

IV. HOW PROPOSED SYSTEM IS BETTER THAN CURRENT SYSTEM

Even the most technologically sophisticated school bus tracking systems are not more than an inconsistent GPS tracking device over a loose internet connection. Such GPS device may not provide enough functionality when the network is bad or there is no internet access a such. Tracking systems via GPS have been around for a while now. While they, when installed on school buses, with the help of GPS or GSM can report the real-time location to the user, the system is not sophisticated enough to alert a distractive driver, debunk a drunk driver, etc. Also, the safety of the school buses is not limited to the road accidents, but also the safety of the child is of utmost importance. The number of children abducted on their way to school and to home is increasing rapidly. Majority of the kidnapped children were found dead or had been missing. This is a dangerous situation. You cannot always have your children by your side. So finding a reliable solution to this is a necessity. Also cases such as harassment of a child by the bus staff, ill-treatment being done with the child, etc. are also on the rise. In such cases, the safety of the child travelling through the school bus is important. Due to such crimes, parents are in constant fear. Also, the current system does not consist of sensors or motion detectors due to the fact that it will lead to increase in cost without giving a second thought to safety. Attendance monitoring, CCTV footages, report creation, etc are some of the features which are not present in the current system.

V. IMPLEMENTATION OF IOV FOR SCHOOL BUS SAFETY

We will see how IoV can be implemented in different ways in school bus safety and how it is better than the current system:

1) *On-Road Safety:* The On-Board Diagnostic (OBD) device attached to the vehicle’s dashboard gathers important details about a school bus in a group in addition to reporting the live location. The device has necessary sensors to detect a driver who is driving harshly, overspeeds, takes sudden turns and constantly overtakes other vehicles, etc. If a driver goes overboard and the admin believes his action might harm little children, he can disable the engine remotely and can send a cop in his direction.
2) *Enabling of mobility solutions:* Using a real-time tracking system, the school bus can be tracked and can also be accessed from a mobile or a desktop browser or the dashboard software. The GPS chip inside the OBD device attached to each school bus

pushes the data to a public cloud through 4G using MQTT. MQTT (MQ Telemetry Transport/Message Queuing Telemetry Transport) is defined as an ISO standard published-subscribed-based messaging protocol which works on top of the TCP/IP protocol [7]. It is described as a lightweight messaging protocol. MQTT is used for small sensors as well as mobile devices and is optimized for unreliable networks [8]. Any device ranging from Android to iOS, be it the dashboard placed at the school or the PC of the gatekeeper or school admin, can track the school bus location in real-time. The option of live tracking views the bus travel live on the map, giving more insight into safety.

3) *OBD motion detector:* Most of the accidents happen due to the distraction of the driver or the bus staff. To make sure that the driver is not distracted while driving, the driver's and the bus staff's mobile phone enters lockdown mode as soon as the OBD detects motion. In case of emergency, the driver can make voice calls to receive information from the school through hands-free communication using the app.
4) *Smart Video Surveillance:* Using the same application as the real-time tracking, parents and school admin can monitor the live CCTV footage of the bus in case of an emergency and take necessary action if needed. It is another feature being installed and used to improve passenger safety and monitor student or driver behavior in real-time. This technology further helps in faster and more accurate response and also helps in improving the process of bus transportation for students, parents and school administrator.
5) *Attendance Monitoring:* Attendance of each student on the bus will be updated on a custom cloud-based application using the data gathered from RFID reader or IRIS scanner. A chip installed inside each student's ID card can be used to track the attendance of the child on the bus. The attendance using the ID card can be marked using the RFID (Radio Frequency Identification) module which uses electromagnetic fields to automatically identify and track tags attached to objects. The data collected is then pushed to the cloud in the same way as done for the mobility solutions and is stored in a database and also further published to different users. The ID card of the student needs to be swapped to the machine inside the bus before he travels so that his attendance can be marked and the parents are made sure that their child has indeed taken the bus. Also, we will know prevention to be taken if a child is not present in the vehicle. Also, the ID card of the bus staff and the driver can also be scanned.

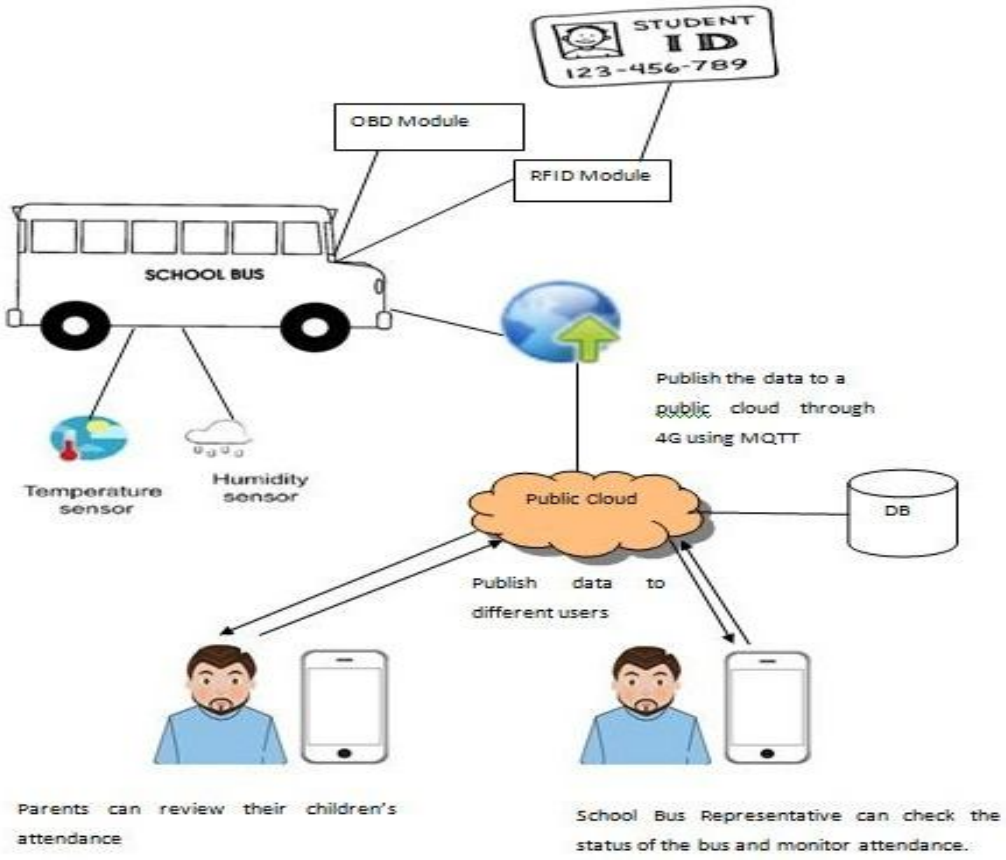
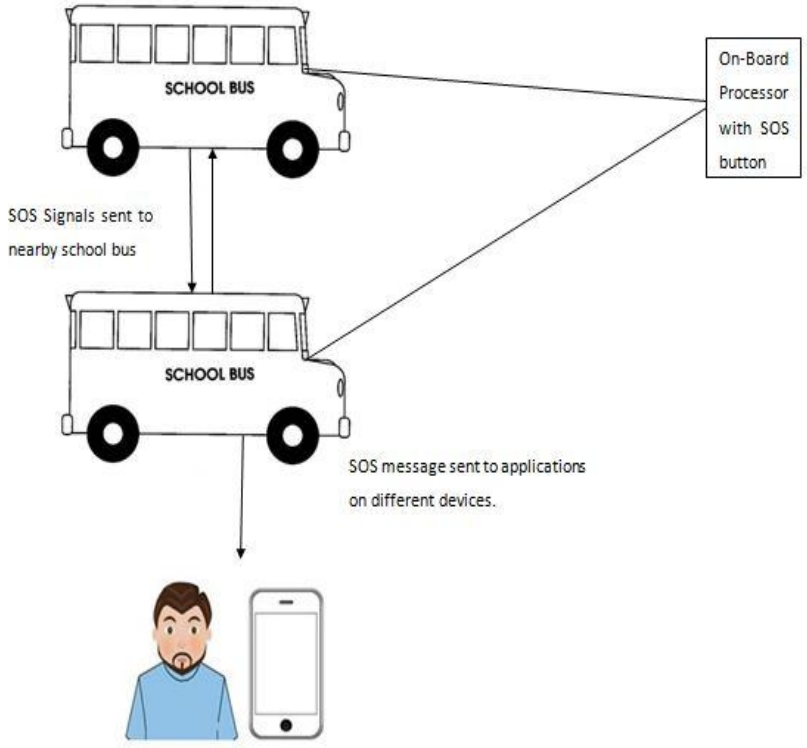


Figure 2 – Working of IoV In School Bus Safety

6) *Connected Buses:* The concept of the connected school bus is a flexible solution which combines safety, security and network access and also provides benefits to students, parents and school staff. Connected School Buses will allow parents to have greater visibility into bus routes telling them if buses will be on time or delayed via notifications. Connected school buses can be transformed into mobile classrooms which will result in positive results beyond learning.
7) *Communication between school buses:* The buses can communicate with each other by sharing data such as the nearby surroundings of the buses can be monitored using an onboard camera, the proximity between the buses, the speed of the vehicles communicating within a particular radius, etc. When the bus is not in use or is in use, its proximity to other vehicles in its immediate surrounding can be beneficial in avoiding accidents or damage to the vehicles. By knowing the speed of a school bus surrounding a particular vehicle can be useful to issue a warning to the nearby school bus on the road about a fast-approaching vehicle and the driver can be made alert.
8) *SOS Signals:* The OBD module can also have an SOS button, in case of an emergency. The driver or the school staff can press the SOS button which will send the signal to the school admin and also flash an SOS message on the application on different devices. Also, the message will be sent to the nearby school bus. This can be used in case there is a threat or in case of any accidents or injuries so that necessary actions can be taken effectively and on time. Also, each seat will be equipped with an SOS button underneath, so even the students can use it if they feel something is not right. Also, the app will get alerts when the driver goes off the route to save fuel, time and ensure safety.



FFigure 3 – SOS Signal

9) *Other applications*
a) *Emergency management:* In case of an emergency, select the bus route and the details of students such as blood group and contacts are sent to the hospital immediately.
b) *Preventive Maintenance:* Sensors and application prevent mechanical failures by sending alerts when an inspection is due or if a problem arises.
c) *Driver Survey:* The school administrators can get reports about the driver's behavior automatically and the driver will be rated accordingly based on the speed violation., punctuality and also driving habits. Also, the reports of the bus staff will also be generated and rated.
d) *Downloadable Reports:* Reports such as attendance, bus location, speed, and history can be accessed anytime.

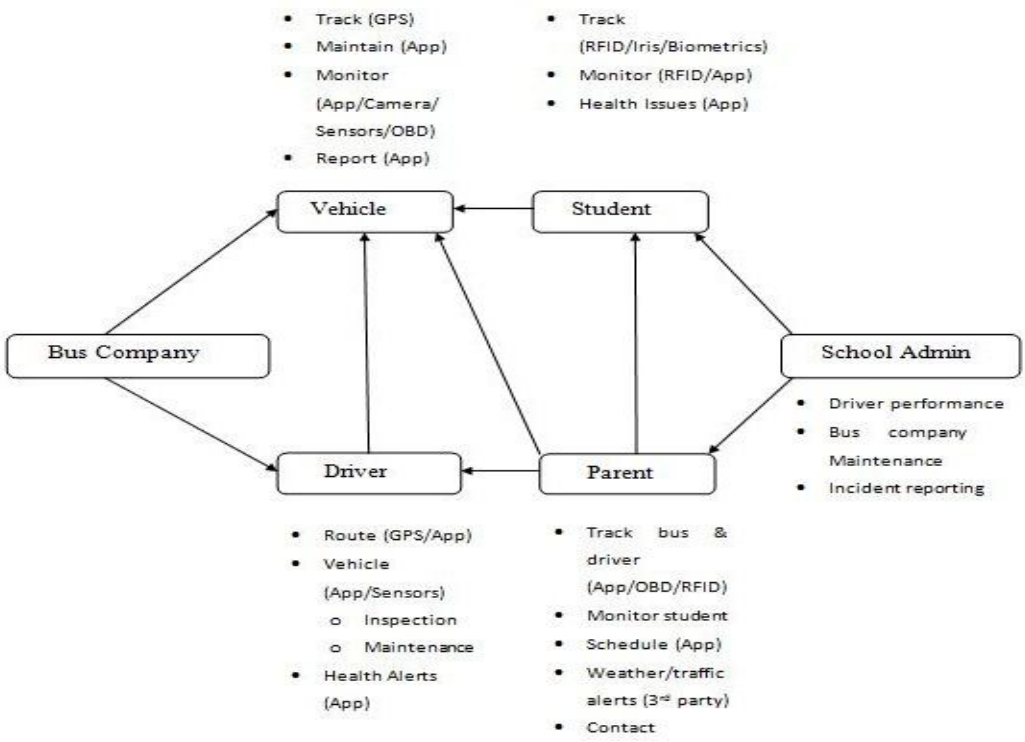


Figure 4 – IoV implementation in School Bus Safety

VI. ADVANTAGES OF IOV IN SCHOOL BUS SAFETY

IoV has the following advantages in school bus safety:

1) *Safe Driving:* One of the most important features of ITS is collision avoidance. Collision avoidance can serve two functions :
2) *Driver Assistance:* It controls the vehicle for steady state or for an emergency interference. It provides notifications to the driver to provide early warnings and prevent an accident from happening in the first place.
3) *Collision Warning:* The driver is warned if a collision seems to be happening. It includes notifications about a car accident, or road conditions such as slippery road, etc.
4) *Real-time information:* Undoubtedly, one of the most important features of the IoV based system is the real-time information that once receives about the location of the school bus. It helps one to know where the buses are, monitor pickup and drop off. Alerts will be sent if any bus goes a wrong route or if there is an unscheduled stop or delay.
5) *Student-Safety:* Get notified if a student gets into a wrong bus or steps out at a wrong location. Even if a student misses the location, the parent will be informed via alert messages. The exact location of the child can be identified with RFID tags attached to the devices.
6) *Theft Avoidance:* The sensors onboard which are installed can be helpful to identify breaking of windows, keyless entry in vehicles and forceful starting of the vehicle. The processor will immediately lock down the vehicle by preventing it from starting and notify the nearby police station.
7) *Predictive & Preventive Maintenance:* IoV sensors allow administrators to monitor the health of a fleet from any connected device. Predictive maintenance utilizes IoV so to access the conditions of the vehicles and predict the failures. Maintenance based on conditions can prevent failures and also extend vehicle life, etc. Also, vehicle speed, tyre pressure, fuel level are monitored and a warning is issued to the user in case any of the above attributes exceed or drop below a specific threshold value.
8) *Emergency Response:* If a vehicle is moving at a fast speed, the parent will be informed and the school authorities can be warned to prevent accidents. When a vehicle detects a collision to a nearby vehicle, emergency response vehicles like ambulance, fire-engines are immediately sent vehicle location or the location of the accident. This can save lives by accelerating an emergency response.

VII. ISSUES AND CHALLENGES

The implementation of IoV is met with the following issues and challenges. These issues should be addressed to make IoV very reliable and widely adopted.

1) *Big Data:* A major challenge in the implementation of IoV for school bus safety is the processing as well as the storage of big data created in IoV due to the huge number of connected vehicles as well as all the data gathered from students as well as the administrator. Cloud computing and mobile computing play important roles in dealing with big data.
2) *Security And Privacy:* Since the implementation of IoV involves the integration of many different technologies, data security is needed. IoV can be a target or cyber attacks or intrusion, which may lead to privacy leakages and physical damage to the system. With the huge number of vehicles on the road, there are a number of links to a number of nodes and all these are connected to a central server. A single fault anywhere in signals or the nodes can result in the crash of the entire system.
3) *Failure Of Networks:* Cars, sensors, and network hardware can malfunction. IoV requires every vehicle to be installed with processors and sensors. A drawback, in this case, is the load generated by a large number of vehicles. The servers and the processors should be able to handle the data efficiently, otherwise, this may lead to the failure of the entire network.

VIII. CONCLUSION

Internet of Vehicles (IoV) is a special application of the Internet of Things (IoT). IoT Solutions are a combination of sensors/communication devices (Data Collection), cloud storage (Cloud Applications), ERP integration and business intelligence technology (Oracle and SAP). IoV has potential advantages over the traditional IoT in school bus safety. IoV is a much efficient way in the application of school bus safety system and making travelling in school bus safely and secure for children. IoV is a complex integrated network system that interconnects people within and around vehicles and intelligent systems onboard vehicles in urban environments. This study can be used in setting up better architectures for school bus safety system and to make an impact on the effectiveness of monitoring and emergency response to traffic and accident incidents.

The implementation of IoV school bus safety system with RFID and OBD module will surely reduce the number of crimes and attacks against students. Even if a child is abducted, it makes it easy for the authority to find the missing child within minimum time. Enabling internet in each and every vehicle on the road can pave way for complete automation of vehicles and traffic [9]. The concept of the Internet of Vehicles (IoV) can be extended to every mode of transport making a huge difference in the way that communication occurs between different media of transport. IoV will make all the students travelling is school buses enjoy more convenient, comfortable and safe road service and make their parents free from the stress about the safety of their child.

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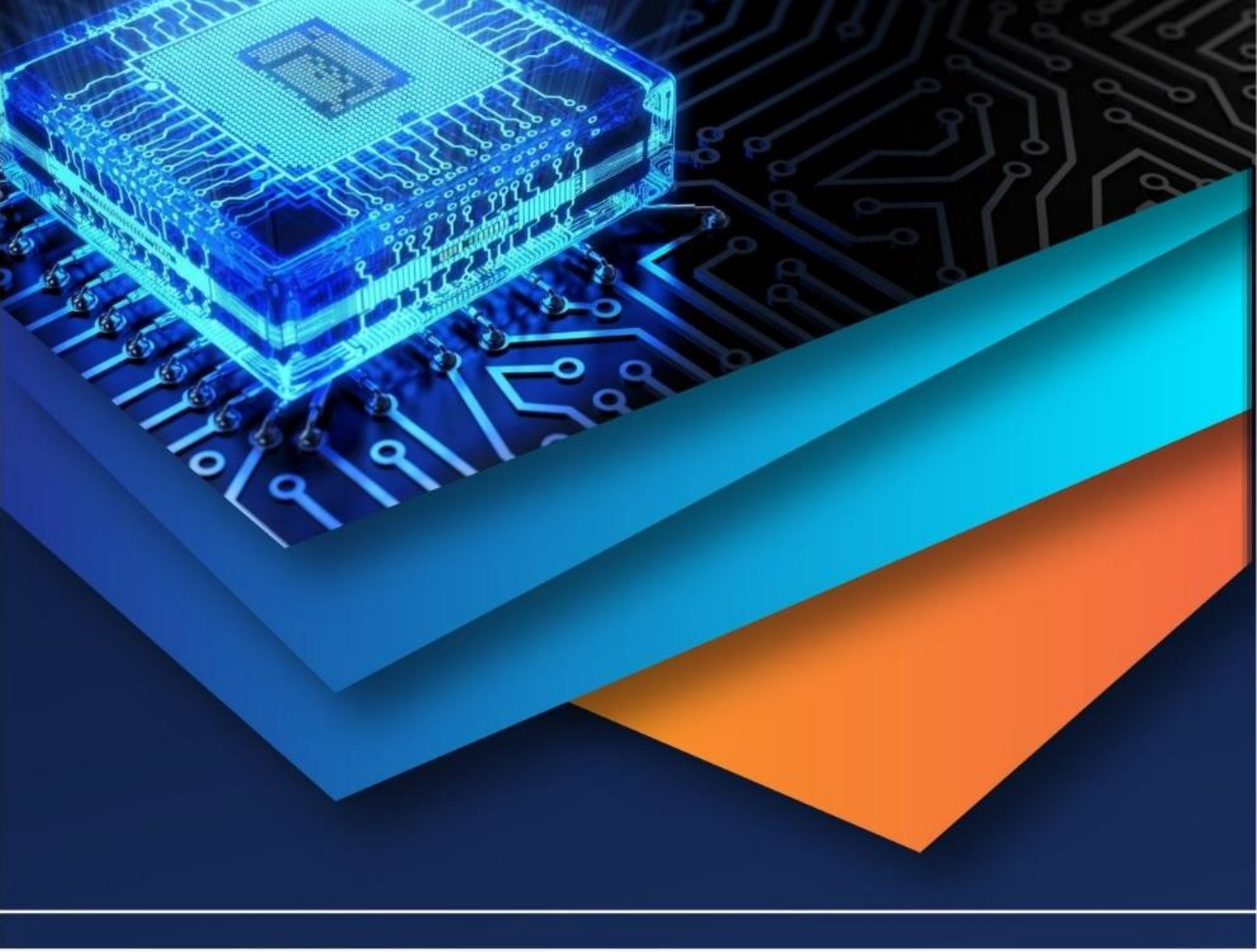

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