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An Intelligent Location-Based Virtual Indoor Positioning and Navigation Using GPS and Smartphone Sensors

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Abstract: ***Various solutions have been suggested for indoor navigation systems in which most methods require the support of external physical hardware infrastructure which increases the complexity and cost of set-up of supporting hardware requirements, which will always be an issue with such systems. In this paper, we present the design of a smartphone based indoor navigation system. The proposed method is supported by a web based architecture, for easily creating indoor maps and providing an indoor location's information for navigation and positioning. The system has been implemented and the results indicate that the approach is useful for navigation in indoor environments.***
Terms: Indoor Positioning, Map Generation, Indoor Navigation.

I. INTRODUCTION

Position determination is done from many ages. In the early days people used to ask around local people while traveling, having fewer paths to cover. But the scenario has changed with rising technologies, having more routes to cover with busy schedule determining position has become a major problem. To overcome such problems many softwares are developed using advanced technologies making it easier for navigation. In simple words navigation is determining the correct exact path or a well defined path from the point of start to the exact location where the user has to reach.

Advanced technologies have caused a surge in personal locating techniques. When it comes to mapping, people are most familiar with Google or Apple maps. Talking about these technologies Google maps uses GPS(Global Positioning System) in their maps which is the most common type of navigation device technology. It uses a technology in which satellites pinpoint the location geographically such that the user can see its location on the map and all possible routes towards its destination.

The effectiveness and precision of Global Positioning System (GPS) has seen to grow in popularity in a wide range of position and navigation applications and systems. But Google maps works in-efficiently when a user moves from outdoor root to indoor navigation. GPS falls short to determine routes for indoor positioning. Google maps provide accurate information about basic floor plan and outdoor navigation but its positioning ermahmeds@gmail.com feature and wayfinding solutions for indoor spaces are limited which is why even after the numerous success of GPS outdoors the challenge was shifted to services for indoor navigation.

II. LITERATURE SURVEY

The research of Indoor Positioning Systems / Indoor Navigation is exhaustive and varied. It has been a subject that has been studied over the years using a variety of techniques. Thus the purpose of the following research is to identify the various methods that can be used to determine indoor navigation. The keywords that are used to obtain the research on indoor navigation were Trilateration, Min Max, Kalam Filter, BLE, RSSI filtering and so on. The time spent on mobile phones is increasing massively every year by people of every age group thus decreasing the useage of other media. Smartphone ownerships and fast Internet connections such as home broadband connections, 3G, 4G and 5G are increasing immensely.Many static conducted by various research center indicated that 92% of 18 to 29 years old, 74% of 50 to 64 years old and 42% of 65 and older are Smartphone users.This has resulted in the usage of mobile application. According to an analysis a user spends 5 hours on smartphones in which 90% of their time is spent on various applications. Different types of application related to entertainment, studies, communication, shopping and for anything a user requires is present on play store. The purpose of this report is to identify the need for indoor navigation and various technologies and devices that can be used to achieve the goal. Apart from that a user survey was conducted to enlighten the usage pattern of the positioning system by the user in everyday life. The collection of data raised many issues about how it can be integrated and also identified the need for authentication of the app content. The research focuses on how the app or features needed can be developed and the features in which the user would be more interested.

The following survey mainly focuses on indoor navigation and the application created for it. Different technologies such as GPS, AR ie Augmented Reality are needed to be replaced to create indoor navigation with other solutions. More detailed dimensions such as infrared, ultrasonic, radio signals etc are studied to evaluate various positioning technologies. Since traditional locating techniques such as GPS fall short when the user moves from outdoor location to indoor location. This is due to signal degradation that occurs when GPS signals encounter obstacles such as walls of buildings. To overcome this problem different techniques having different ideologies for positioning are stated in this paper.

III. INDOOR NAVIGATION APP ANALYSIS

Indoor navigation requires a map to locate user destion and the path towards its final location. When it comes to mapping, the majority of people are familiar with Google maps and Apple maps. But Google maps is unable to determine the location of an indoor user since the signal deteriorates as the GPS encounters obstacles such as walls. Talking about indoor maps the image that often comes to mind is the 2D maps located at the entrance of a building. Different technologies are used to create an indoor map in different dimensions such as 2D and 3D as well. Various software are present to-date to create indoor maps in different dimensions. Companies make use of such software to create maps for indoor navigation technologies which are efficient for mapping large buildings, such as shopping malls, a university, airports, and building complexes. The application provides the visitors with important information about the venue using an indoor map having detailed information about the layout where they are present. For places offered by the app, visitors can easily download the indoor navigation apps and access the map in real-time.

The app also uses a compass to determine the direction in the map. The layout of the place is indicated in the maps.As soon as the user starts using the app the application shows the position of th eiser in the location maps and shows the path the user needs to undertake to reach the destination. If the user goes in the wrong direction leaving the track indicated in the map the application notifies the user thus making sure the user reaches its location.

IV. SURVEY EXISTING SYSTEM

Before we started our project we did research on related work regarding applied indoor navigation and positioning techniques applied on mobile devices. Most of them rely on calculating Received Signal Strength Indicator (RSSI) triangulation and/or Bluetooth BLE Beacon techniques or WiFi Based Fingerprinting. They combine two methods in order to calculate a precise position. At first they use matching of prerecorded received signal strength from nearby access points. This method is called “fingerprint matching”. The data is combined with a distance-based trilateration approach with at least three known access point coordinates which are also detected on the device. By this combination of both methods they received a high accuracy of the user position in an indoor environment. Technology such as Bluetooth beacons are also used for indoor navigation. Beacons are basically small radio transmitters that send bluetooth signals to mobile devices in the area.The beacons only act as transmitters without storing any data. As it is one of the most popular uses of beacons, indoor navigation makes seamanship easier when the user is inside of a venue. Indoor positioning system companies has used this technology regardless of the venue size to create application for indoor navigation. Apart from tracking position of the user, beacons are useful for goods and products since they can be equipped on products and tracked throughout a warehouse. Beacons also makes it possible to send notifications in a navigation app and mapping apps. Indoor maps can integrate with other technology for marketing and advertising purposes.

Different indoor navigation presents different mapping system information.

1) The Gatwick Airport navigation app leverages Augmented Reality (AR) to highlight routes that guide people towards their destination.
2) When it comes to mapping software, people are most familiar with Google Maps and Apple Maps.
3) Google Maps technology provides accurate information about basic floor plans and outdoor navigation, its positioning feature and wayfinding solutions for indoor spaces are limited.

V. LIMITATIONS OF EXISTING SYSTEM/RESEARCH GAP

The build out of mobile devices and the growing demand for navigation systems that pin-points location based on current device location have led to an increase in research and product development in this field . However, most efforts have been focused on the functionality aspect of the problem. This has resulted in the research for development of innovative techniques that address the essential challenge of this problem i.e. the positioning technique itself. Indoor navigation is done with the combination of hardware devices and software applications. This makes the work costly as hardware components are also used.

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VI. PROBLEM STATEMENT

The need for tracking and locating objects in an environment where traditional locating systems, such as GPS, fall short are required. Indoor navigation systems for mobile applications need to be created by using different solutions as traditional locating techniques such as GPS works poorly in indoor locations. The signal degradation that occurs when GPS signals encounter obstacles such as walls of buildings is the reason behind the downfall in .

Therefore, in our app we are providing special features and functionalities that will overcome all the challenges and difficulties. Use cases for such a system are varied and many. Examples include indoor navigation for office buildings and hospitals, providing contextual information at a museum and so on.

VII. OBJECTIVE

The objective of our project is to develop computational logic in order to calculate the respective distance to provide accurate navigation. The utilization of GPS and digital compass to develop a portable qibla which can give an exact location of the user. The app has been developed in such a way that users can use it without any hesitation.

1) The device must be able to accurately and efficiently determine its location in a building.
2) The device must guide a user along an optimal path to their destination.
3) The device must have an intuitive user interface
4) To be able to identify efficient directions.
5) To represent simple maps easy to read.

VIII. PRODUCT SCOPE DESCRIPTION

The purpose of this navigation application is to ease people from the tedious task of finding directions by locating it manually in the new area. This indoor navigation application will be the solution to all the problems that people face now-a-days.

IX. PROPOSED SYSTEM

Advance technologies that have led to the growth and propagation of smartphones has created new opportunities for finding location with the help of apps. Solutions developed by developers that will provide utilities and an easy accessibility to specific area information are stated. Our app contains the following important features and functionalities:

A. Geo Location

With the help of GPS sensors that are already present in the phones we can get geo location in coordinates of latitude and longitude. By the help of this location feature we can find the actual address of the smartphone user and then we provide our best facilities to the user. Our app gives all indoor maps that are not provided by another software. Let, take example if user enter into the some hospital then help of application user can see hospital inside map in their smartphone and with the help of our application user can find out any department or area inside hospital.

B. Location Tracker

With the help of user location inside the hospital or any place administration can track the user. Administration guides the user if the user wants. Administration can also track the user if necessary. There are many applications of location tracking.

C. Authentication

Our application provides user authentication means no anonymous user can use it without getting registered. With the help of this administration, make sure that no unauthenticate person can enter inside. Apart from that if any crime happens then the administration can take selected information from their Id. As the user registers itself all the necessary information gets saved in the data along with a timestamp which makes it possible to see the previous logs and activities of the user.

D. Analysis Daily user

Administration can analyze how many people are using their application, which one is the most visited place inside, how much a person is spending time in a particular place and so on. User logs also get saved along with timestamps and activities. Top search shows which place is mostly visited and where navigation is greatly used.

X. DETAILS OF HARDWARE AND SOFTWARE

A. *Android Smartphone*

A powerful, high-tech smartphone that runs on the Android operating system (OS) developed by Google and is used by a variety of mobile phone manufacturers. Pick an Android mobile phone and you can choose from hundreds of great applications and multitask with ease. You'll also get regular software updates that add great new features to your smartphone.In the proposed application smartphones are used to geolocate the users coordinated which gives the location of the user.

B. *VS Code*

Visual Studio Code is a lightweight but powerful source code editor which runs on your desktop and is available for Windows, macOS and Linux. It comes with built-in support for JavaScript, TypeScript and Node.js and has a rich ecosystem of extensions for other languages (such as C++, C#, Java, Python, PHP, Go) and runtimes (such as .NET and Unity). Visual Studio Code combines the simplicity of a code editor with what developers need for their core edit-build-debug cycle. It provides comprehensive code editing, navigation, and understanding support along with lightweight debugging, a rich extensibility model, and lightweight integration with existing tools.

XI. TECHNOLOGY USED

A. *Flutter (frontend)*

Flutter is Google's UI toolkit for building beautiful, natively compiled applications for mobile, web, desktop, and embedded devices from a single codebase. Flutter is Google's SDK for crafting beautiful, fast user experiences for mobile, web, and desktop from a single codebase. Flutter works with existing code, is used by developers and organizations around the world, and is free and open source. Flutter is fast. It's powered by the same hardware-accelerated 2D graphics library that underpins Chrome and Android: Skia. We architected Flutter to support glitch-free, jank-free graphics at the native speed of your device. Flutter code is powered by the world-class Dart platform, which enables compilation to 32-bit and 64-bit ARM machine code for iOS and Android, as well as JavaScript for the web and Intel x64 for desktop devices.

B. *Firebase (backend)*

Firebase is a Backend-as-a-Service (Baas). It provides developers with a variety of tools and services to help them develop quality apps, grow their user base, and earn profit. It is built on Google's infrastructure. Firebase is categorized as a NoSQL database program, which stores data in JSON-like documents. In Firebase, a document is a set of key-value pairs defined by a schema. A group of documents makes up a collection. It is the backend software of our application. Firebase is a Google-backed application development software that enables developers to develop iOS, Android and Web apps. Firebase provides tools for tracking analytics, reporting and fixing app crashes, creating marketing and product experiments.

XII. DESIGN DETAILS

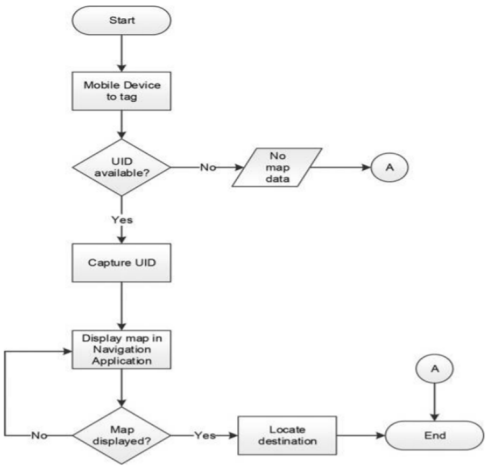

Fig. 2. Flowchart

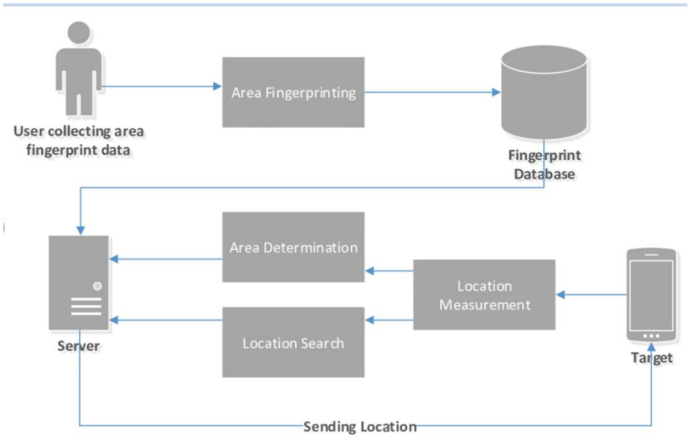

Fig. 3. Data Flow Diagram

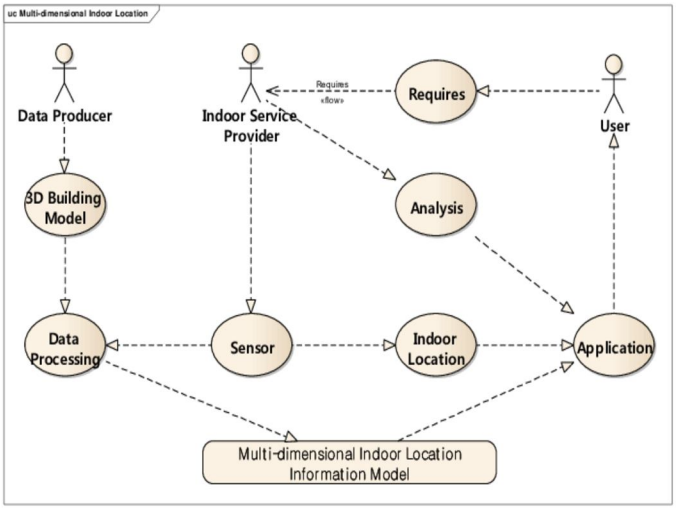

Fig. 4. Use Case Diagram

XIII. METHODOLOGY

A. *Agile Scrum Methodology:*

Agile scrum methodology is a team-based project management system whose goals are to deliver the highest value to stakeholders and be more efficient .

1) Scrum is a framework that allows for more effective and communication collaborations among teams working on complex and important projects.

2) Agile and scrum are two similar project management with a few features that are different.

3) Agile is more flexible and promotes leadership teams,

Agile scrum methodology is a project management pathway that relies on exponential development. Each iteration consists of two- to four-week sprints, where each sprint's goal is to build the most important features and functions first and come out with a potentially deliverable product within time. More features are built into the product in subsequent sprints and are made based on stakeholder and customer feedback responses between sprints and peoples.

Whereas other project management methods build an entire product in one iteration from start to finish, agile scrum method focuses on delivering several iterations of a product to provide stakeholders and sprint team with the highest business value in the least amount of time and costs.

The Agile scrum method has several benefits. First, it encourages products to be built faster with less error, since each set of goals must be completed within each sprint's time frame with best performance. It also requires frequent planning and goal setting, which helps the scrum team focus on the current sprint's objectives and increase productivity.

B. Scrum

Scrum refers to a framework that makes for effective collaborations among team members that are working on complex products and with complex tasks. Although it is most often used by software development and rebuild companies, scrum can essentially be beneficial to any team that is working toward a common goal in the same path. In particular, scrum is a collection of meetings, roles and tools that work together to help teams to better structure and manage their workload and divide tasks to do well.

While scrum can benefit a wide variety of businesses and projects, these are the most likely beneficiaries:

1) Scrum method is ideal for projects that require teams to complete a backlog and perform well among teams.
2) Scrum is also beneficial to companies that value results over the documented progress of the process and every document is verified and decides the next plan for individuals .
3) Scrum can help companies that develop products in accordance with customer preferences and specifications and demand.

C. Agile

Agile is a process that allows a team to more efficiently manage a project by breaking it down into several stages, each of which allows for consistent collaboration with stakeholders to promote steady improvements at every stage.

Here are the principles of agile:

1) Customer satisfaction and cost effective
2) Early and continuous delivery
3) Clasp change to improve
4) Frequent delivery for getting feedback
5) Collaboration of businesses and developers furtherance
6) It motivates individuals personale to do well
7) Technical excellence
8) Simplicity
9) Self-organized teams and prepare
10) Modulation, reflection and adjustment to make product well

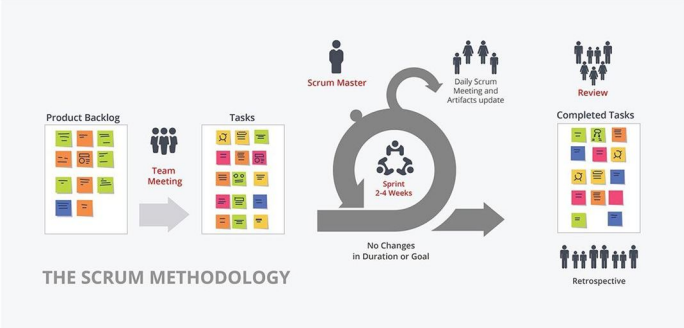

Fig. 5. Agile Scrum Methodology

XIV. CONCLUSION

There was a time when people used to have a hard time finding a location. It was easier in the past because finding a location wasn't too hectic. There were few directions and fewer distractions. But now people have 10-hour workdays, side gigs, cafes to go to after work, movies to watch, and whatnot! Naturally, it has become harder to accommodate all of those plus remember every location into a 24-hour day. The challenge is harder, particularly for senior citizens. Waking up at dawn and locating an address,finding a proper room and so on. Plus, the fact that many of these practices have to be done at particular times makes it all the more difficult for professionals leading a busy life.

The purpose of this was to provide an accurate, indoor navigation. But indoor navigation involves a lot of aspects having hardware and software uses as well. To overcome the challenge of determining an optimal path to the user's destination, the rooms and hallways of the building were represented as graphical nodes and branches.Many common routing algorithms were considered for use in determining the best path to the user's destination in the defined graph.

Therefore, in our app we are providing special features and functionalities that will overcome all the challenges and difficulties that people are facing today to offer the obligatory based on their current location.

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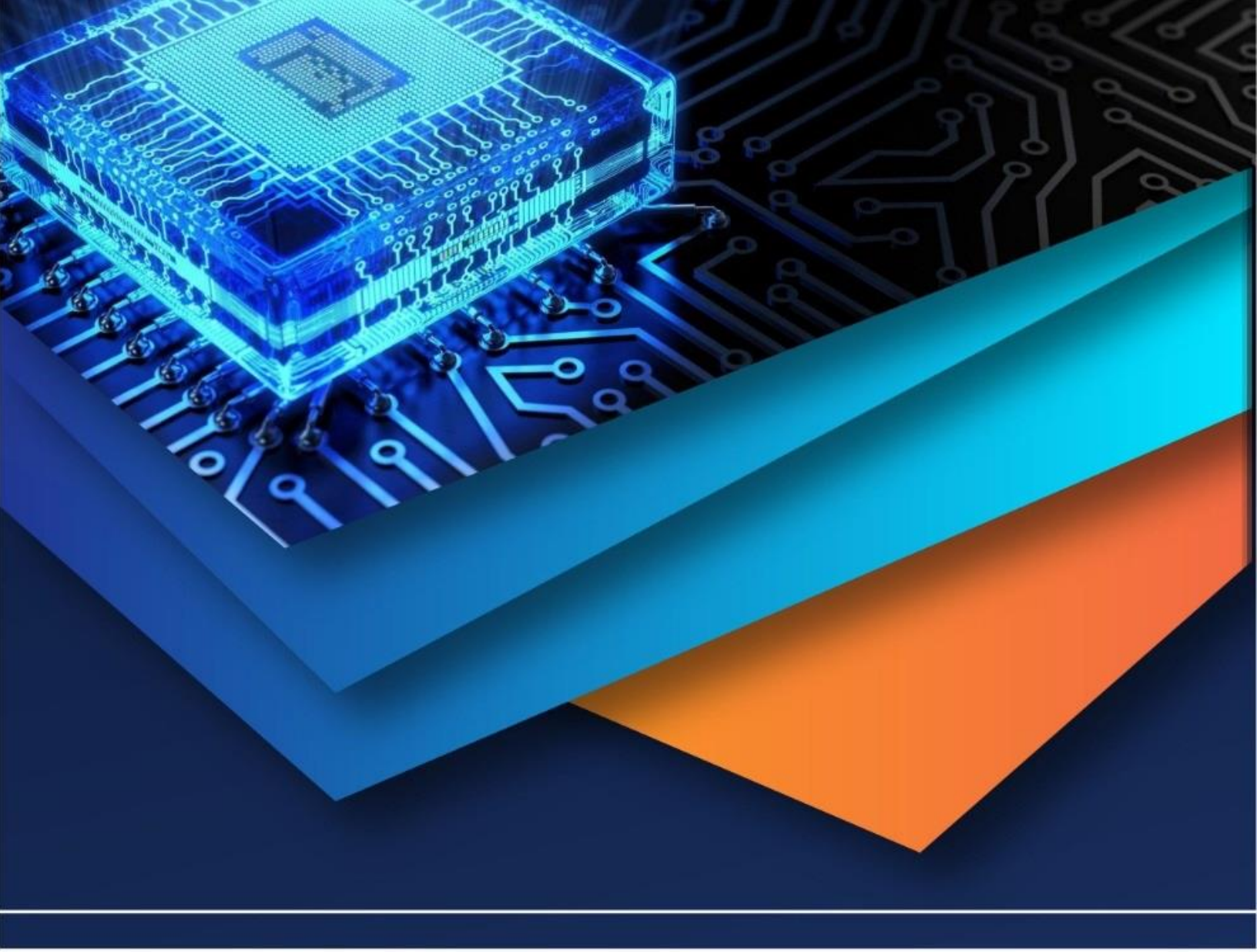

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