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# Software Engineering Challenges in Mobile Application Development

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***Abstract:*** ***Software development of mobile applications involves a dynamic environment with frequently changing technologies, user needs and constraints which requires advanced approaches and methodologies in software engineering. Mobile applications are developed for various purposes in different categories. This paper discusses about the challenges faced in software engineering for mobile applications, specifically for a science educational and outreach aim as regards technologies and methodologies that could be used to explore the full potential of mobility. In particular, this paper analyses the main challenges that impact development in this field, such as dealing with networking protocols, enhanced connectivity and the fragmented ecosystem of mobile platforms.***
***Keywords:*** ***Software engineering, mobile application development, connectivity protocols, network protocols, mobile platform***

## I. INTRODUCTION

In recent years, there has been a rapid growth in the use and development of mobile applications, presenting new challenges to software engineering in this domain[1]. The concept of "bring your own device (BYOD)", enabling IT consumerisation, has shifted the computing paradigm from a desktop or even laptops to entire mobile based computing, in which data transfer takes place through the cloud platforms and users have access to computing wherever and whenever they need it. [2].

Software development for mobile devices takes place in a dynamic environment where technologies, approaches and methodologies have to be continuously improved to keep up with the enhanced capabilities and new applications of mobile devices meet the ever changing needs of the user. These challenges and constraints apply to various category of apps, whether outreach or

educational in different sectors (e.g., health, communication, scientific culture) or otherwise.

Mobile platforms are rapidly changing, with the addition of features through both internal and external hardware modules (Fig. 1) [3] and enhancement of processing capabilities. Most of the mobile devices are now equipped with a Global Positioning System (GPS) module that identifies the location of the device and different kind of internal sensors such as proximity or gyro sensors, the accelerometer and gesture sensor. Sensors can be improved with integration of humidity and temperature sensors, and motion sensors with external sensors interacting with the mobile devices, such as 3D sensors or the skin stickers [4]. With the growth of mobile sensor technology, mobile devices have transformed into self-aware devices with continuous data logging.

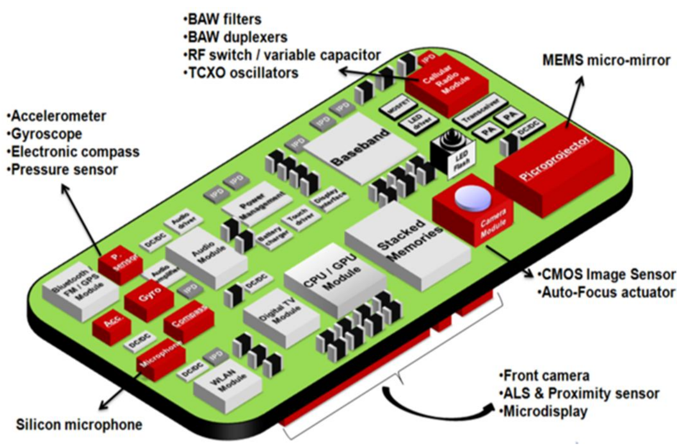


Fig 1. Type of sensors related to mobile devices

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Adding more sensors like medical sensors or 3D/stereo cameras can enable the device to understand emotions as well. The other major aspect of wireless network communication technologies, is that a mobile device includes short, medium and large range technologies, since their respective applications are different (e.g., data transfer with other devices like the smart applications related to activity logger, as well as broadband access to the Internet and micro-payments).

Modern applications running on mobile platforms need to scale on demand according to the hardware ability. Other challenges affecting development of mobile applications include the fragmentation of the hardware and software architectures and thus interoperability issues, the security implications and the authorization process for dataflow in a network environment, together with design features of customized user interface that are mainly based on touch interaction.

Mobile phones and devices are also becoming more powerful in terms of network connection and in the use of web infrastructure as the preferred platform with the availability of different cloud services. Such services enable saving and viewing documents or use online applications without any local installation and synchronization of features in any device. As consumer expectations evolve and developers are faced many challenges, both technical and business, that affect systematic design, build and deployment of new applications and systems. Design applications involve the improvement of methodologies to follow the development lifecycle of mobile applications that manifest differences with desktop- based applications

This paper thus discusses about the challenges faced software engineering in mobile applications, which even if independent by the target context, are considered for science dissemination or educational purposes.

It provides an overview of the main factors affecting mobile ecosystem, such as hardware and software features of devices architectures (i.e., plethora of devices, platforms, operators, languages and app stores) and the wireless network protocols that are fundamental to mobile data transfer. Challenges related to the increasing fragmentation of the mobile ecosystem involve important decisions on the choice of a framework or specific platform that affects development strategy. The paper also focuses on methodologies and approaches needed in effective mobile development. Techniques should consider the specialisation of applications in every phase of the development lifecycle (i.e., from planning and analysis, designing, building, testing, deploying, monitoring and reviewing) in order to understand if traditional software engineering methods are still feasible or new methods are required.

The diversity lies both in software and hardware features and in different approaches to development related to the deployment and distribution of an app, since basing the approach on the store's business model leads to lower revenues, shorter development cycle and more user interface (UI) complexity

## II. ADDRESSING CHALLENGES IN MOBILE DEVELOPMENT

To develop robust mobile applications [5], software engineering requires advanced practices, tools and methodologies, similar to the development of desktop-based software development.

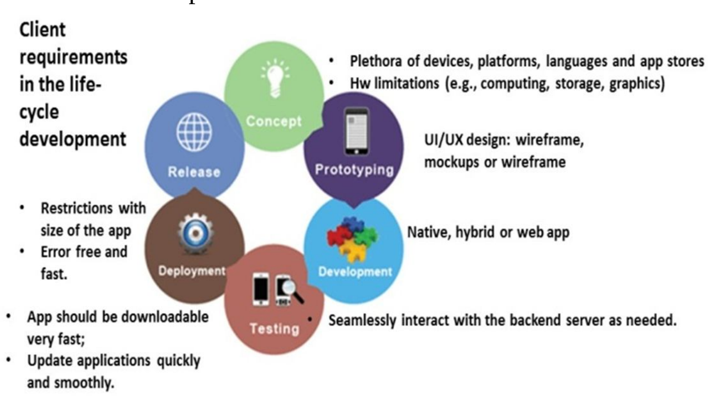


Fig 2. Challenges of mobile development in lifecycle development steps

Techniques to develop apps should take into consideration the platform complexity, fragmentation and constraints caused by working on multiple software and hardware platforms with different storage and computational limitations. This helps in selecting the best strategy to develop apps.An application designed for a desktop system, is not able to create a mobile user experience, since the reduced capacities of a mobile devices (like graphics and memory) might not handle various media as efficiently as the website itself. Approaches using responsive design [6], such as a methodology that enables websites to

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recognize the type of device on which the app operates so that it can change the layout and the image size accordingly, may not fit the scope due to the limitation on exploiting the full capabilities of the mobile device.

The decision to host mobile applications natively on the device itself, or include a mobile version of their website, or both, depends on the context and purpose. A mobile site usually aims to promote something (e.g., a company or an event) or to share information or content. Standalone applications are much more useful as connections between the data collected by the devices and a cloud service (e.g., apps in the healthcare market).

The limitations of UI design [7] can be factored to the complexities of interaction with the mobile device and its sensors. At the same time, the developer has to provide a great user experience despite reduced capabilities. Development phase constraints include power management, security and privacy models and policies, and dependence with external services. Many development tools which use multiple dynamic languages are available through various frameworks for providing native, web or hybrid applications [8]. Testing and verification techniques are necessary for validating the execution of an app on a multitude of different devices.

We focus on the key factors that affect mobile development in its ecosystem, based on the above assumptions, as recently highlighted by Gartner's research [9], namely multi-platform and multi-architecture implications and the wireless connectivity and networking perspective.

*A. Multi-Platform and Multi-Architecture Framework*

The design and development of apps involve different decisions, depending on their purpose and intended scope. The mobile ecosystem is highly fragmented and appears in a number of hardware and software platforms which require different programming languages, tools, and deployment methods.


| | iOS (Apple) | Android | Blackberry OS | Windows Phone |
|---|---|---|---|---|
| Languages | Obj-C, C, C++ | Java, (some C, C++) | Java | C#, VB NET, etc |
| Tools | Xcode | Android SDK | BB Java Eclipse Plugin | Wisual Studio, Windows Phone Dev Tools |
| Executable files | .app | .apk | .cod | .xap |
| Application stores | Apple Store | Google Play | Blackberry Store | Windows Phone Store |

Fig 3. Fragmentation of mobile operating systems, hardware, languages and tools

The market is based on three key platforms as well as three key applications architectures (i.e., native, web and hybrid). The combination of these platform and architecture requires the support of development tools to minimize software development costs.

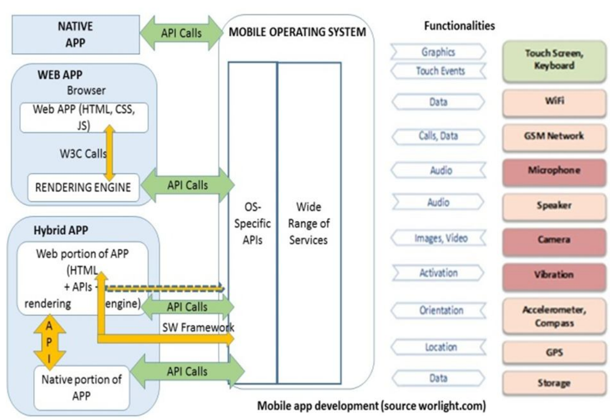


Fig 4. The three approaches and vision in mobile app development

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Tool selection deals with many technical and non-technical issues, that need a variety of tools to deliver for the required architectures and platforms.

It is also necessary to focus on the app's portability on different mobile platforms. The use of a standard language such as HTML5 [10] could guarantee a multi-platform portability, avoiding an increase in development time and cost and thus, reducing duplication. The pros and cons of the two strategies (web or native apps) need to be balanced and the developers who are making the decision should know that according to statistics [11], mobile users spend 80% of their time using apps and only 20% of their time on mobile browsing. Mobile sites are typically less expensive to develop (e.g., its realization implies the application of HTML5 tags), and might be automatically included in the website developed services. Using native applications instead, provides a smoother experience usually needs a team to make separate adjustments for changes in alignment with website version, which can lead to significant higher cost of maintenance. Unfortunately, native apps can go undiscovered unless promoted properly as they are related to the distribution channel. Web solutions have less costs and are easy to use; however, native applications have their own benefits and are more suited to the users' needs through easy-to-use programs for niche businesses and organizations. They enable customer engagement (by offering deals or specific information), ensure safer data transfers, and provide a more overall personalized experience. Hybrid apps, i.e., a mix of web and native approaches, are a trade-off solution, since they are based on frameworks working with HTML5-based standards that are able to convert a web page into a native app. Unfortunately, HTML5, is still fragmented and immature having many implementation and security risks. However, when its development tools are sufficiently stable, the popularity of the web and hybrid applications will increase, because, despite many challenges, HTML5 is able to deliver applications across multiple platforms through Application Programming Interfaces (APIs) for each feature (e.g., graphics and video).

To improve user experience designers should consider a variety of techniques (e.g., motivational design, use cases, storytelling) to design apps that are easy to use, equipped with enhanced features and graphical allure and are able to take advantage of mobile hardware add-ons (e.g., camera and sensors), to give an augmented reality experience to users [12].

The high standards for UI design be met with skills and hard work because of specific mobile usage. An app's execution cannot follow a linear cycle. It has to be capable of handling various tasks simultaneously. An app could be interrupted and put it in background, while the user is taking a call. User interaction with an app could be only partial, since unlike with a desktop PC, the user could be in any situation while using the app on his mobile device, such as walking, running, or sitting on a bus or a train. These factors that affect the design of apps and should be included in the analysis. Modern mobile devices contain faster chipsets and better graphics processors that greatly boost rendering, but engineers should be wary not to compromise an application's functionality for the sake of excessive processor-heavy animations which drain battery and could cause the mobile device to heat up and lose energy.

### *B. Wireless Network Protocols: Connectivity vs Networking*

Mobile apps needs wireless connections for data transfer, but there are several other wireless protocols. They can be divided into two distinct groups: those providing long- range connectivity (e.g. networking through the IEEE 802.11 standard better known as Wi-Fi [13] ), and those providing short-range connectivity (e.g., Bluetooth [14], Near Field Communication (NFC) [15] or infrared). Most apps, mainly interacting with other devices, sensors or objects, make a great use of short-range protocols (e.g., NFC for mobile payments [16] or Bluetooth in the interaction with on-body healthcare systems).

Other apps providing precise location currently use technologies such as Wi-Fi or GPS for enabling location-based services. The two protocols are related for many apps. Short-range protocols are mainly used in interactions with other devices (single or acting in a sensor networks), while collected data is transmitted using long-range connection to be saved on Internet-based databases or cloud service.

Internet-based apps, used for multimedia streaming (e.g. also TV programs) exploit the full potential of broadband connectivity, such as the services offered by the new generation of cellular networks like Long term Evolution (LTE) networks [17].

### *C. Connectivity Protocols*

Mobile devices are a part of personal area network (PAN) connecting smartphones or tablets and other devices such as sensors. Such networks are standardized (Fig. 5) by IEEE 802.15 standard [18], with its various specifications and have a great role in the development of smart cities and homes [19]. Wireless networks are mainly used for connectivity rather than networking, for

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the diffusion of such technology on mobile devices. Apps are becoming the preferred method of data collection from various wearable devices (e.g., on-body healthcare sensors, smart watches, hand mounted devices (HMD) [20] display devices like Google Glass and sensors embedded in clothes and shoes). These devices communicate with mobile apps to collect and transmit this information over the Internet in order to provide some useful services. Some dedicated apps also provide a wide range of products and services, especially in areas such as fitness or healthcare. This is also central idea behind the Internet of Things [21] (IoT) wireless sensor technologies.

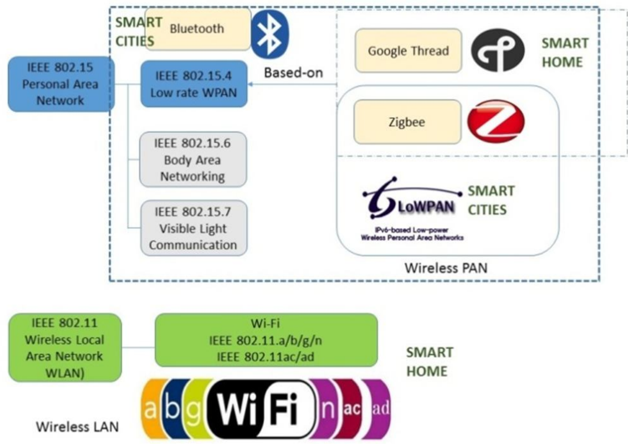


Fig 5. Personal Area Networks standards and Wireless Local Area Network standards

Smart objects, which are part of IoT communicate with mobile devices and it's apps perform many functions like acting as remote controls, displaying and analysing information, linking with social networks to monitor "things" that can be posted, paying for subscription services, ordering replacement consumables and updating object firmware. Since, the physical connectivity medium is wireless, there is a necessity of low-energy network standard at a short/medium range. This is due to battery management issues of each app.

Historically, Bluetooth and Wi-Fi have been widely used, but they use up a lot of power from battery. Current researches focus on low power versions of such protocols. Currently the reference protocols are the enhanced versions of Bluetooth protocol with different names (e.g., Bluetooth Smart or Bluetooth Low Energy or BLE, Bluetooth 4) [22]), and other protocols based on a sub-specification of the IEEE 802.15 standard that is the IEEE 802.15.4 [23] as implemented by different organizations. Bluetooth is a proprietary standard managed by the Bluetooth Special Interest Group (SIG); it was initially standardized by IEEE as IEEE 802.15.1, but it is no longer maintained. The IEEE 802.15.4 standard is a communication standard for wireless PANs optimized for low power devices and operation on, in, or around the human body, but not limited to humans. It defines data communication having low-data-rate, low-power and low- complexity short-range radio frequency (RF) transmissions. Another sub-specification of the same IEEE 802.15 standard is the IEEE 802.15.6 [24]. This specification is applied to the wireless body area networks (WBAN) also known as mobile body area (MBAN) networking [25]. It defines a short-range wireless communication near or inside a human body, using existing industrial scientific medical (ISM) bands or other approved bands. It supports quality of service (QoS), low power and data rate up to 10 Mbps, and also takes into account the effects of radiations on the human body.

The applications of MBAN are ever increasing to match the development of wearable networking devices. A standard case is a wearable heart-rate monitor device enabled with wireless protocol that transmits a signal to a gateway device which can instantly relay that information over the Internet to an off- site cloud service. Connectivity protocols used in these contexts are Bluetooth's new version (i.e., Bluetooth 4.0, Bluetooth Smart, BLE) and other IEEE 802.15.4-based protocols such as Zigbee [26] and Google Tread [27]. Such protocols are defined as connectivity protocols for the sensors, while Wi-Fi manages the networking aspect. The smart home market also adopts such protocols, and thus the development of mobile apps interacting with them, could have a great scope. An integration [28] of these technologies in IoT is required rather than competition between them, since essential building blocks of the things (e.g., sensors, actuators, controllers), are based on PAN connectivity.

Zigbee is a global wireless protocol supported by the Zigbee Alliance, based on IEEE 802.15.4 specification, in order to provide a reliable, robust, low power, scalable, and secure connection. Currently its current 3.0 version is used for machine-to-machine

(M2M) communication [28], i.e., for small volume of data transfer over a short distance, but consuming little power. Zigbee-based chips are connected in a mesh network (rather than the star network of Wi-Fi) and uses ZigBee Pro networking to enable reliable communication.

Its applications are mainly in the smart homes, connected lighting and the utility industry. The Zigbee Alliance is working to create a standard for another special type of network which is the neighbourhood area network (NAN) [29]. Such networks allows connecting devices outside the home (e.g., smart meters or data aggregators). Currently, only few of such communications are standards based, but analysts [30] estimate that, by 2020, 85% of NAN connectivity will be standards-based. Transformation of connectivity into networking involves solving the challenges of system-level wide security, ease of installation, low latency, and standardization of the application languages for lighting, climate control, security, care, retail, etc.

The development of these wireless standards is connected to wearable devices, smart cities and smart home markets, especially in the healthcare sector, or the cultural and creative industries. A research of ABI on mobile health [31], forecasts that Wi-Fi, Bluetooth and other standardized wireless protocols are set to rule wireless protocols in the field of mobile medical devices by 2018, because of the need to integrate remote health-reporting systems with familiar electronics. The same research forecasts the use of standardized alternatives (projected to grow by 72% in the next five years), especially those based on IEEE 802.15.4 standard with respect to proprietary wireless solutions. The adoption of standardized wireless protocols in the medical industry represents another step towards the protocols' convergence. In this regard, devices are also equipped with IEEE 802.15.6 connectivity that are for MBAN, though with a slower market penetration. The recent IEEE 802.15.6 and IEEE 802.15.4 enabled devices that can operate in the dedicated wireless spectrum (2360-2400 MHz) allocated for MBAN, could improve a further development, especially in addition to with the other protocols (e.g., Bluetooth). Connection protocols can enable MBAN wireless sensor data and provide connectivity through gateway devices to cloud-based healthcare services, by using customized mobile apps using such protocols.

Regarding networking connectivity, emerging Wi- Fi standards such as 802.11ac (Waves 1 and 2), 11ad, 11aq and 11ah will increase Wi-Fi performance, and make Wi- Fi more relevant to apps in providing new services. Demands on Wi-Fi infrastructure will increase over the next three years as more Wi-Fi-enabled devices begin to appear in organizations, with specific apps using these protocols to provide services.

Long Term Evolution (LTE) and its successor LTE Advanced (LTE-A) are cellular technologies that improve spectral efficiency in order to reach peak downlink speeds of up to 1 Gbps, while reducing latency. Thus, cellular networks could have the same throughput as that of wired networks which are based on fibre optics. The use of such protocols both for connectivity and networking along with their enhanced performance and improved bandwidth, will enable network operators to offer new services for mobile apps.

## III. CONCLUSION

Mobile apps are a new class of applications that are being increasingly developed nowadays to meet user expectations. However, they have multitude of constraints and challenges typical of the mobile context and related to hardware, software and networks implications. Users' requirement impose considerations from a usability point of view and business model underlining the delivery, that affect all the life-cycle of software development. The number of mobile device types further complicates mobile app development and operations efforts, because the range of device screen sizes, resolutions, hardware API access and performance is fragmented and changes rapidly in technology. There are no current approaches that can be considered universal for application development in mobile environment. On the other end, from a commercially point of view, app development is not very profitable, because distribution takes place through app stores especially in the case of non-specialized apps.

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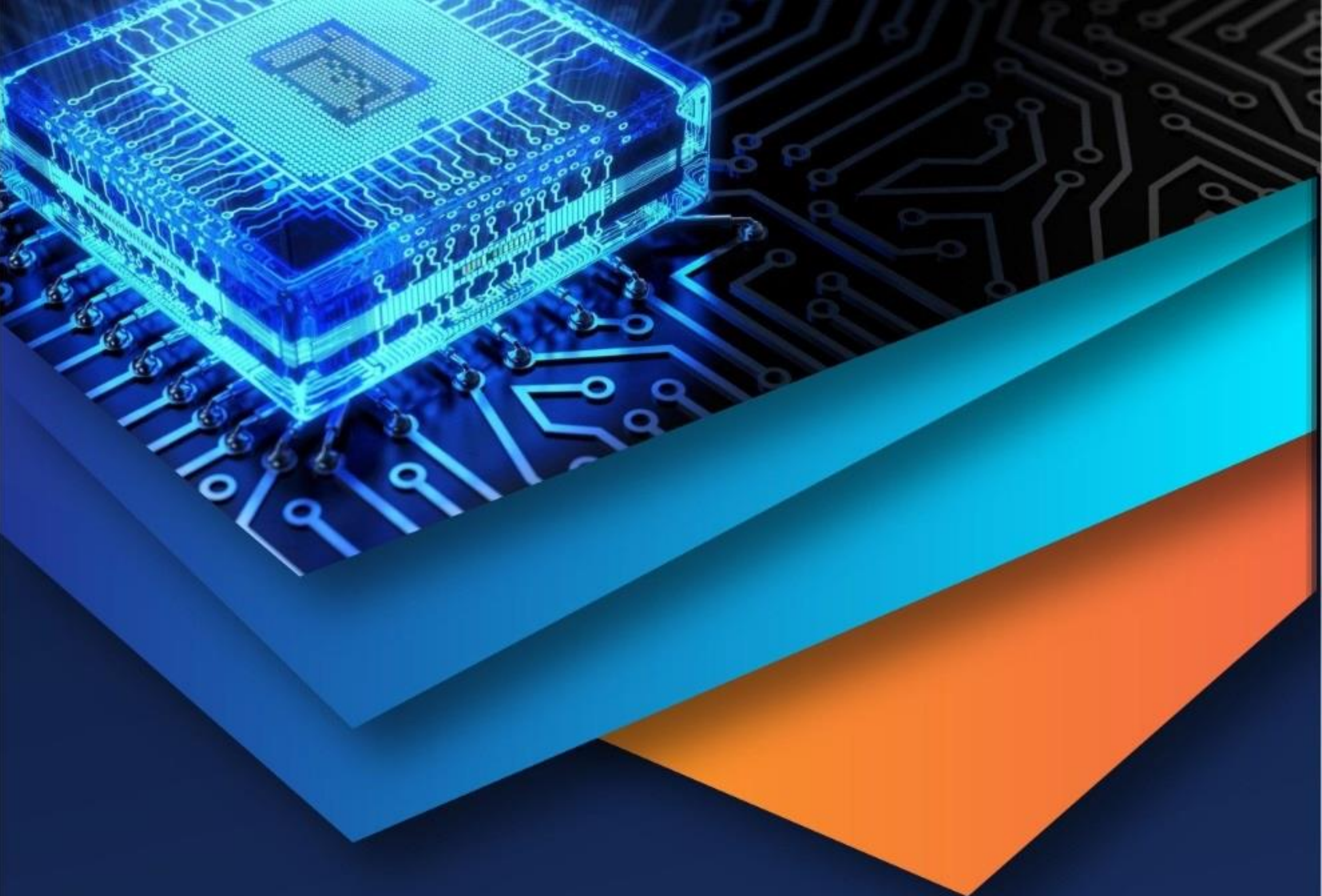

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