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A Study on the Impact of Building Information Modeling (BIM) in AEC (Architecture, Engineer, Construction) Industry

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Abstract: ***The field of Architecture, Engineering, and Construction (AEC) plays a vital role in driving global progress. Yet, the need for innovative ideas has presented the AEC sector with its fair share of hurdles. Introducing Building Information Modeling (BIM), a rapidly expanding tool on the global stage, aimed at boosting AEC efficiency and resolving key challenges. Recent times have witnessed both public and private sectors making BIM integration a requirement in new construction projects. However, the utilization of BIM by governments, particularly in less developed nations, remains limited. This research brings together industry stakeholders to discuss the merits of BIM, identify obstacles, and suggest practical solutions, thus encouraging wider adoption and reaping the benefits of BIM.***
Keywords: BIM, BIM benefits, barriers, perceived benefits, AEC

I. INTRODUCTION

Architecture, Engineering, and Construction (AEC) have been increasingly embracing Building Information Modeling (BIM). In the industry, it has become a big deal like a high-tech tool. BIM has a bunch of roles in AEC, like making 3D models look real, catching issues, checking if things work, calculating amounts needed, and guessing costs. Plus, it's all about 4D schedules, green analysis, making drawings, and managing buildings. With BIM being used throughout a project, it's like a superhero team – making things less risky, stopping mistakes, helping everyone cooperate, and sharing knowledge between designers, engineers, and builders, making sure everything's accurate and reliable.

The AEC business is like the heart of development for lots of countries (Elhendawi et al., 2019), having a big say in how a country grows (Giang & Pheng, 2011). But there's been a bunch of issues in this sector over time, from clients not getting what they want to projects taking too long, costing too much, and not being top-notch (Ahmed et al., 2018). Inside AEC, Azhar et al. (2015) show that there's not enough work getting done, efficiency's down, performance is meh, keeping things eco-friendly is a struggle, the environment isn't protected well, working conditions aren't great, and safety isn't well-managed. With technology getting more complicated, data managing getting trickier, supply chain stuff changing a lot, and how deals are made switching up (Ahmed et al., 2018), people want smart and green buildings. BIM has come to the rescue as a way to improve communication and teamwork in AEC (Gerges, M. et al., 2017; Matarneh & Hamed, 2017). BIM actually started back in the '70s, but it really hit the AEC scene in the 2000s. Since then, lots of different industries and governments have seen how useful BIM is and started using it (Eastman et al., 2011).

II. BENEFITS OF BUILDING INFORMATION MODELLING (BIM)

Just like tech is helping out everywhere, BIM is like the tech sidekick for AEC. BIM can do lots of cool stuff, depending on whether you're new to this or already a pro (McGraw-Hill, 2009). Here's what we've learned from lots of reading – check out Table 1 to see the big benefits of using BIM.

Table 1: Benefits of Building Information Modeling (BIM)

Sl. No	Authors	Benefits of BIM	Participants					
			C*	A/E*	C/SC*	D*	OP*	FM*
1	(Sabol, 2008; Omar, 2015)	Management of the building (during planning and construction)	Yes	Yes	Yes	Yes	Yes	Yes
2	(Karna, et al.,2009)	Increase client and consumer happiness.	Yes	Yes	Yes	Yes	Yes	Yes
3	(McCartney, 2010)	Designers are learning more about construction processes.	Yes	Yes	Yes	Yes	Yes	Yes

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4	(Liu, et al.,2010)	Increased accuracy	Yes	Yes	Yes	Yes	Yes	Yes
5	(Liu, et al., 2010 : construction, M.H, 2012)	Claims and legal cases have been reduced.	Yes	Yes	Yes	Yes	Yes	Yes
6	(Azhar, et al., 2011 : Abbasnejad & Moud, 2013)	Reduced requests for information (RFIs) (improves project comprehension and eliminates uncertainty)	Yes	Yes	Yes	Yes	Yes	Yes
7	(Azhar, 2011; Chan, 2014)	Innovative and creative solutions	Yes	Yes	Yes	Yes	Yes	Yes
8	(Eastman, et al., 2011)	Overcoming geographical distances and bridging capacity gaps with international AEC professionals	Yes	Yes	Yes	Yes	Yes	Yes
9	(Eastman, et al., 2011; Samuelson & Bjork, 2013)	Increase the capacity of designers and the competition	Yes	Yes	Yes	Yes	Yes	Yes
10	(Eastman, et al., 2011: Sebastian, 2011)	adherence to specifications, norms, and codes	Yes	Yes	Yes	Yes	Yes	Yes
11	(Elbeltagi & Dawood, 2011: Bryde, et al., 2013)	Encourage prefabrication for higher quality	Yes	Yes	Yes	Yes	Yes	Yes
12	(Construction, M.H, 2012)	Maintain repeat customers, Market new products and services (such as reality capture) and increase profitability.	Yes	Yes	Yes	Yes	Yes	Yes
13	(Construction, M.H, 2012; Chan, 2014)	Human Resources should be distributed more evenly.	Yes	Yes	Yes	Yes	Yes	Yes
14	(Latiffi, et al., 2013 : Chan, 2014 : Gerges, et al., 2016; Matarneh & Hamed, 2017)	Assistance with construction and project management (strategic planning, site planning, risk management, communication, executive, change plans, added value, greater safety, and improved facility management)	Yes	Yes	Yes	Yes	Yes	Yes
15	(Moreno, et al.,2013)	Promote safety plans to reduce accidents.	Yes	No	Yes	No	Yes	No
16	(Eadie, et al., 2013 : Doumbouya, et al., 2016)	Increase the accuracy of building sustainability analyses.	Yes	Yes	Yes	Yes	Yes	Yes
17	(Wang, et al., 2014; Omar, 2015)	Interactive architectural visualization using augmented reality	Yes	Yes	Yes	Yes	Yes	Yes
18	(Love, et al., 2014 : Volk, et al., 2014)	As-built plans (for existing properties, laser scanning)	Yes	Yes	Yes	No	Yes	Yes
19	(Jernigan, 2014)	Integrating new team members quickly and easily	Yes	Yes	Yes	Yes	Yes	Yes
20	(Chan, 2014; Gerges, et al., 2016)	Procurement on time (decrease inventory length and order materials just in time)	Yes	Yes	Yes	Yes	Yes	Yes
21	(National Building Specification, 2014; Azhar, et al., 2015)	Improve competitiveness (advance the firm's competitive advantages)	Yes	Yes	Yes	Yes	Yes	Yes

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22	(Elmualim & Glider, 2014)	Value for money should be promoted.	Yes	Yes	Yes	Yes	Yes	Yes
23	(Jernigan, 2014)	Maintain participant satisfaction by keeping them informed. Reduce your hazards.	Yes	Yes	Yes	Yes	Yes	Yes
24	(Jernigan, 2014; Omar, 2015)	Client interaction begins early.	Yes	Yes	Yes	Yes	Yes	Yes
25	(Harrison & Thurnell, 2014; Love, et al., 2014)	Based on verified data, make quick and correct decisions.	Yes	Yes	Yes	Yes	Yes	Yes
26	(Chan, 2014; Doumbouya, et al., 2016; Matarneh & Hamed, 2017)	Time saving (reduces the time spent on project documentation, communication, and analysing several possibilities in a short period of time)	Yes	Yes	Yes	Yes	Yes	Yes
27	(Sales, 2015)	Improve site logistics plans	Yes	No	Yes	Yes	Yes	Yes
28	(Azhar, et al., 2015)	Assembly that is automated	Yes	No	Yes	Yes	Yes	Yes
29	(Omar & Dulaimi, 2015)	Reduce waste (waste removal and value creation)	Yes	Yes	Yes	Yes	Yes	Yes
30	(Baik et al., 2015)	GIS with BIM integration	Yes	Yes	Yes	No	Yes	No
31	(Doumbouya, et al., 2016; Matarneh & Hamed, 2017)	Improve efficiency (quicker and more efficient processes and approaches)	Yes	Yes	Yes	Yes	Yes	Yes
32	(Almutiri, 2016)	Design that is free of flaws.	Yes	Yes	Yes	Yes	Yes	Yes
33	(Doumbouya, et al., 2016; Matarneh & Hamed, 2017)	Cost savings (lower overall project costs, design and construction expenses, and communication costs)	Yes	Yes	Yes	No	Yes	No
34	(Gerges, M, et al., 2017)	Improving quality (less rework and better design), ensuring data availability throughout the project life cycle	Yes	Yes	Yes	Yes	Yes	Yes
35	(Matarneh & Hamed, 2017; Gerges, M, et al., 2017)	Clash detection (checking for design nonconformities at the pre-building stage, resolving conflicts between disciplines prior to construction)	Yes	Yes	Yes	Yes	Yes	Yes
36	(Gerges, M, et al., 2017: Shaban & Elhendawi, 2018)	Improve visualization (simulation, building representation in an integrated data environment, elimination of design misinterpretation risk)	Yes	Yes	Yes	Yes	Yes	Yes
37	(Matarneh & Hamed, 2017: Ahmed, et al., 2018)	Improve collaboration and communication among all parties	Yes	Yes	Yes	Yes	Yes	Yes
38	(Matarneh & Hamed, 2017)	Maintaining control throughout the project's life cycle and increasing productivity	Yes	Yes	Yes	Yes	Yes	Yes
39	(Matarneh & Hamed, 2017)	Change orders should be reduced greatly	Yes	Yes	Yes	Yes	Yes	No
40	(Zewein, 2017; Khalil, 2017)	Improve the value engineering and lean construction principles.	Yes	Yes	Yes	Yes	Yes	Yes
41	(Elhendawi, et al., 2019)	Budget and expense estimation have been improved.	Yes	Yes	Yes	No	Yes	No

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C-Customer
A/E-Architect/Engineer
C/SC-Contractor/Subcontractor
S-Supplier
D-Dealer
Op-Other participants

Salla (2014) listed the top fifteen benefits of employing BIM in the following order: (1) reduce mistakes and omissions in the design process, (2) improve collaboration with owner/design firms throughout the building phase, (3) improve organizational image, and (4) improve organizational performance. (4) Minimize rework. (5) Reduce construction costs, (6) Improve cost control and predictability, (7) Shorten project length, (8) Market new business, (9) Provide new services, (10) Increase profits (11) Maintain business viability. (12) Shorten workflow cycle times. (13) Shorter client approval periods; (14) Increased safety; and (15) Shorter regulatory approval cycles.

III. BARRIERS OF USING BIM (BUILDING INFORMATION MODELING)

As outlined by Azhar et al., (2015), organizations in developing countries are facing lots of challenges when it comes to adopting BIM, even though it has obvious benefits. Adopting BIM is like solving a hard puzzle. Eadie et al. (2014) point out that BIM challenges vary according to whether you already use them. According to Panuwatwanich et al., some of the main problems with BIM are:

Big Challenges Highlighted by (2013) and Omar (2015): According to (2013) and Omar (2015), there are two major roadblocks that stand out: first, there's not enough dedication from management to actually put BIM to use, and second, there's a serious lack of know-how when it comes to switching to BIM and dealing with the problems that come with it.

Now, let's look at what McGraw-Hill (2012) discovered – the top difficulties in using BIM are things like making different software work together, getting the hang of how things should work (people sometimes get it wrong), getting everyone on the same page about what BIM should give us, clients being unsure about bringing in BIM, not having enough BIM skills, and really needing a tool that makes 3D building stuff.

Table 2: BIM Barriers for AEC industry

Sl. No	Type of Barrier	Authors	The Barriers
1	Personal Barrier	(Bryde, et al., 2013 : Alhumayn, et al., 2017)	Inadequate knowledge of what BIM is
		(Saleh,2015)	Inadequate BIM understanding of current and developing technologies
		(Almutiri, 2016 : Gerges,M,et al., 2017)	Cultural concerns that cause resistance to change
		(Banawi, 2017; Matarneh & Hamed,2017)	Inadequate education and training
2	Technical Barrier	(Liu, et al., 2010)	BIM file sizes are very huge. It is difficult to transport, manipulate, store, or share very big files.
		(Succar, et al., 2013)	BIM is still used as a tool, for example, object-based modeling or model-based collaboration, whereas BIM users should strive for network-based integration.
		(Chan, 2014)	Interoperability is inefficient.
		(Chan, 2014; Volk, et al., 2014)	Information upgrading, difficult information update in BIM (time-consuming)
		(Chan, 2014; Biu et al., 2016)	Inadequate infrastructure-based technology
		(Volk, et al., 2014; Matarneh & Hamed, 2017)	There are no customized standards or explicit rules.
		(Saleh, 2015 : Gerges, M, et al., 2017)	Current technology is sufficient

3	Organization Barrier	(Bui, et al., 2016 : Gerges, M, et al., 2017)	Scarcity of BIM experts
		(Arayici, et al., 2009 : construction, M.H, 2012)	Cost of hardware upgrades and software purchases
		(Chien, et al., 2014 : Azhar, et al., 2015)	Financial standing of the organization and difficulties in managing the BIM transition
		(Jernigan, 2014; Omar, 2015)	Change resistance/unwillingness to change
		(Memon, et al., 2014 : Volk, et al., 2014 : Gerges, M, et al., 2017)	BIM necessitates significant changes in the organizational chart and work flow.
		(Saleh, 2015; Omar, 2015	There are no other competing initiatives.
		(Bui, et al., 2016 : Matarneh & Hamed, 2017)	Lack of government assistance
		(Elhendawi, et al., 2019)	Inability to transition from non-BIM to BIM users due to a lack of BIM experience
4	Business Barrier	(Azhar, 2011; Saleh, 2015)	Return on Investment (ROI) Uncertainty
		(Construction, M.H, 2012; Omar, 2015)	Most construction players choose a wait-and-see strategy because they haven't had enough time to analyse.
		(Construction, M.H, 2012; Saleh, 2015)	Benefits are unclear.
		(Harrison & Thurnell, 2014; Banawi, 2017)	Inadequate contractual arrangements
		(Gerges, et al., 2016)	Training new users takes time and money.
		(Gerges, et al., 2016 : Gerges, M, et al., 2017 : Matarneh & Hamed, 2017)	Cost implications for purchasing software licenses, hardware upgrades, training costs, and time at the start of BIM implementation
		(Alhumayn, et al., 2017 : Gerges, M, et al., 2017)	The time-consuming and difficult modeling process
		(Elhendawi, et al., 2019)	There is no mandatory government policy mandating BIM.
5	Market Barrier	(Porwal & Hewage, 2013; Banawi, 2017)	According to the market, the incorrect understanding of BIM, as it tends to be introduced by software developers, is overdue in the beginning stage for switching to BIM.
		(Gerges, et al., 2016 : Gerges, M, et al., 2017)	Inadequate client/government demand
		(Gerges, et al., 2016 : Matarneh & Hamed, 2017)	Low adoption owing to a lack of BIM awareness
		(Banawi, 2017)	Clients who do not adequately support the benefits of BIM
6	BIM Process Barrier	(Linderoth, 2010; Elmualim & Glider, 2014)	BIM is not used by all participants.
		(Chien, et al., 2014 : Eadie et al., 2014 : Azhar, et al., 2015)	Legal and contractual issues (data ownership, traditional procurement methodology)
		(Saleh, 2015)	Work procedures are changing (due to a lack of good coordination among project participants).
		(Saleh, 2015; Banawi, 2017)	The risks and challenges of using a single model (BIM)
		(Banawi, 2017)	Collaboration, integration, and interoperability are all essential.

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IV. PERCEIVED BENEFITS OF BIM

When people talk about BIM, they usually say it makes things work better. This idea of "BIM boosts productivity" is something a lot of people agree on. The differences in opinions come from people who haven't tried BIM yet, but they have big hopes. They believe that if everything goes right, BIM can do great things.

A. From the Client's Side

For them, BIM saves time, keeps projects on track, solves coordination problems, lifts quality standards, makes it easy to compare projects, gets clients involved early on, and cuts costs. Some also say that starting with BIM from the beginning of a project is super important. They know that trying to add BIM later can mess things up.

B. From the Contractor's Point of View

Contractors see BIM as a big help in getting everyone working together. It's like a team captain. BIM can save money, show clear project pictures for smart planning, and help with budget control using its tools. There's software that can find design problems before building starts, making things less messy. Also, with 4D BIM, tracking inventory gets easy, managing buildings becomes smooth, and making stuff gets faster.

C. From the Designer's Perspective

Designers really like how BIM makes their creative process better. It's like a treasure chest of ideas in a short time. BIM lets them quickly see changes, unlike the old ways with CAD. Plus, BIM is all about teamwork, less arguing, and fewer design mistakes. It's a quick way to exchange info and get accurate measurements.

V. DEALING WITH CHALLENGES AND FUTURE HOPES

The big roadblock in using BIM is the resistance to change – like trying to get everyone to switch to a new way of doing things. To tackle this, local businesses can team up with big global construction companies that know how to use BIM. It's like getting experts to show us the ropes. And the bosses at the top need to step up, understand how BIM can boost the whole company, make us better than the rest, and bring in more money. So, they need to be convinced to make the switch to BIM. To make things go faster, both the team and the top dogs should work together. Team members can start the change, but they need strong support from the top.

When it comes to getting projects rolling, Integrated Project Delivery (IPD) is the best approach to match with BIM. Governments should guide schools to teach BIM to students. This way, we'll have lots of people who know BIM and can join the workforce. Schools and BIM software makers should work together to show everyone how awesome BIM is through free training events.

Industry Foundation Classes (IFC) are like magic keys that open BIM files for use with different software. They stop problems when different software tries to work together. Sorting out who owns what in the models is also important, and clear rules should be in the contracts. The New Zealand handbook (2014) says designers and owners need to agree on using the model, and owners need designers' permission to use it too.

VI. CONCLUSION

Right now, the construction folks are all about cutting waste and making things more efficient to boost quality and profits. BIM is like a treasure chest of info that gets everyone working better together, lowers financial risks, ramps up how well projects go, and helps figure out costs and how much stuff is needed. It's like magic that makes more money and stops arguments.

But there are some problems stopping BIM from being amazing everywhere. Like not everyone knows about it in the AEC world, bosses aren't always on board, the government doesn't push it enough, people don't want to change how they work, there aren't many BIM experts, and changing to BIM takes time and money.

To beat these problems, tech companies can step in. They can teach people who already work and those who want to learn at universities. Teaming up with governments and schools can help everyone learn about BIM. This way, the industry can get better and faster, and the AEC world will be superefficient and great at what they do.

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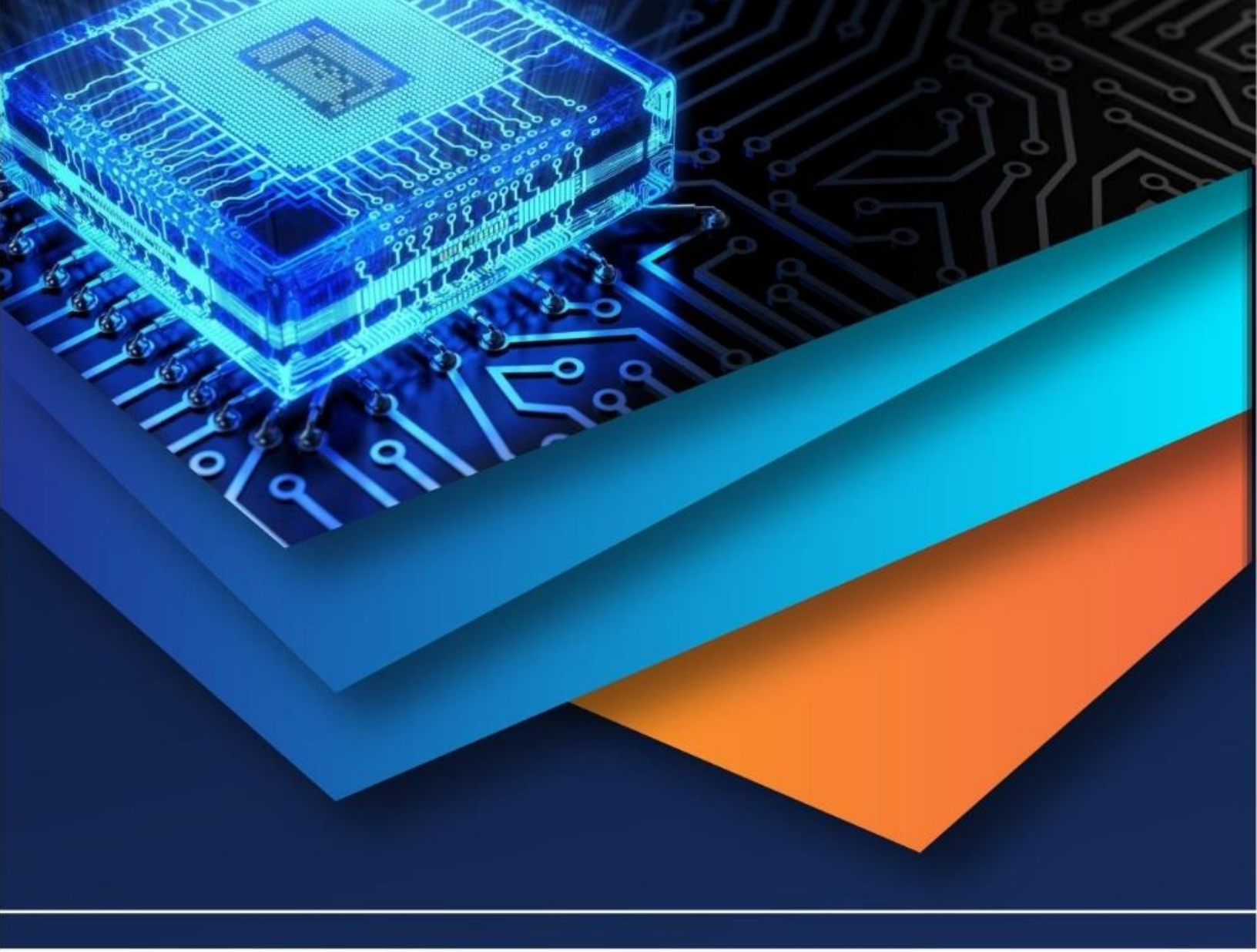
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