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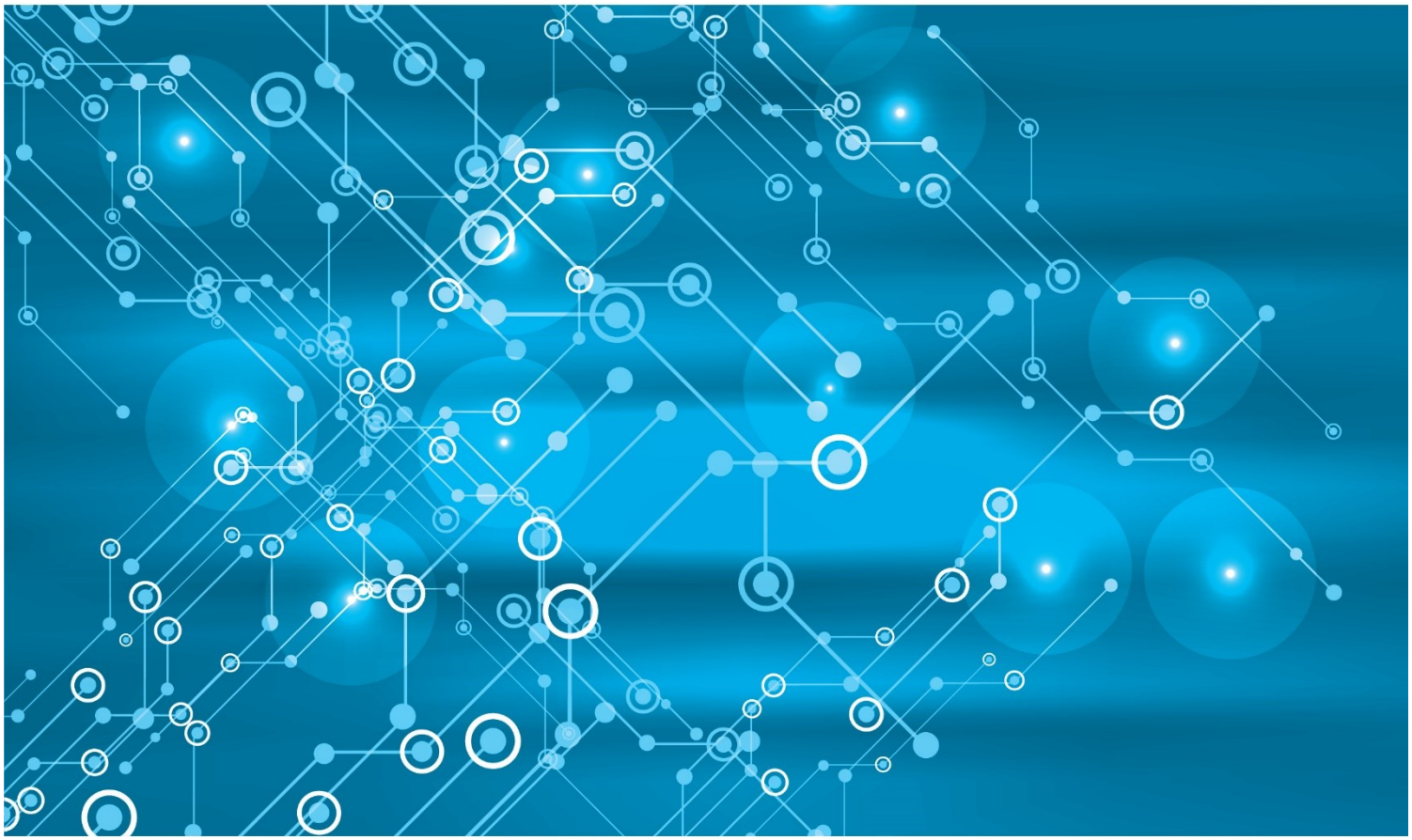

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APPLICATIONS, CHALLENGES AND FUTURE OF LIFI

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***Abstract*— This paper aims to show that Li-Fi now reached at a state, where it can be considered as a reliable wireless communication solution for the future technologies. Currently the Internet can be accessed using Wi-Fi, but it has its limitations too. It is sufficient for current Internet services, but insufficient with IoT and cloud-based services. In the upcoming decade, hard drives will be obsolete and everything will be on cloud. Modern Web applications i.e., 4K & 8K videos, games and high-resolution photos etc. require fast bandwidth. Li-Fi opens a reliable door for the end users to access the future technology-based services at high speed.**

Keywords*— *Li-Fi; Areas of applications; Challenges of Li-Fi; Li-Fi Hybrid Network

I. INTRODUCTION

According to the Cisco Annual Internet Report (2018-2023) number of devices connected with the IP network will be more then thrice the population of human beings by the year 2023. To put the facts in perspective, there will be 29.3 billion devices connected with the Internet by the year 2023 [1]. By the year 2022, mobile data traffic accounts for an estimated total of 71% IP traffic and 80% of projected mobile IP traffic will happens indoors [2]. This increase in demand for more better short range wireless communication combined with the surge in use of smartphones, tablets, and IoT [3] [4] [5] collectively with the5G network requires improved networking infrastructure in order to meet the growing future communication needs [2] [6]. The latest Wi-Fi standard of IEEE 802.11ay offers 300 Gbps transfer rate at 60 GHz band [7]. In this current decade the avalanche of data traffic will make it progressively challenging for Radio Frequency (RF) to cater the communicational needs as per Harald Haas in [8]. Professor Herald Haas is credited for coining the term and the first public demonstration of Li-Fi in action during his talk at TEDGlobal in July 2011 [8] [9] [10]. Li-Fi simply uses visible light spectrum instead of RF to send 0s and 1s from sender to recover [11]. Li-Fi technology has already grabbed $70 million in 2019 and is estimated to reach $105 million in current decade as reported by Global Market Insights [12]. The key reasons for humans to reduce their reliance on Radio Waves (RW) are Capacity, Availability, Efference and Security [8] [10]. In the Electromagnetic Spectrum the ratio of RW to Visible Light Spectrum is 1:10,000 as shown in Figure 1 [13]. In simple words we have ten thousand times more room in Li-Fi then Wi-Fi and unlike RF, light spectrum is free of interference, which make is environment friendly and power efficient [8] [14]. This process is not visible to the human eye because of its speed.

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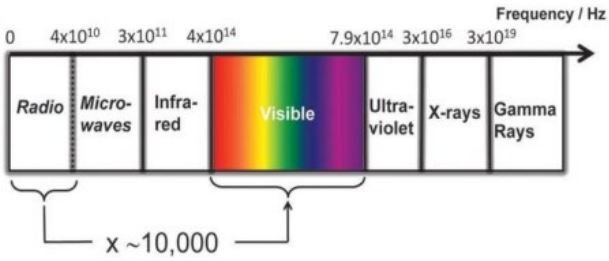

Figure 1. Ratio of RF to visible light spectrum

A. What is Li-Fi?

Professor Herald Haas introduced the term Li-Fi during TED Global in July 2011 [8] [9] [10]. Li-Fi is a form of optical wireless communication, in which light waves are used to deliver data along with lamination. It uses the visible light portion of the electromagnetic spectrum instead of radio technology [15]. It transmits data through LED without using any cable. Binary numbers 1 and/or 0 are used to switch on and off respectively and the LED controller will handle the data encoding. At the user end photo diodes will encrypt the data, which is in the form of 0's and 1's [11] [13] [15]. According to [16] Li-Fi can offer a whopping speed of 224 gigabytes per second and that with a common LED that we commonly use in homes and offices and it makes Li-Fi hundred time faster than Wi-Fi.

B. How does Li-Fi work?

The IEEE 802.15.7 standard for short-range Optical Wireless Communication (OWC) is paving way for standardization of Li-FI [17]. Li-Fi system has two components: Light source with a signal-processing unit and on the other end a photo detector. LED is used to stream data to the photo detector by its beam. A receiver dongle then converts the tiny changes in amplitude into an electric signal, which is then converted back into a data stream and transmitted to a computer device. This process is not visible to the human eye [17] [18].

This paper consists of five sections: Section 2, will talk about areas of applications of Li-Fi; section 3 will discussed the challenges of Li-Fi; section 4 will proposed Solution and finally paper will conclude with Conclusion in section 5.

II. AREAS OF APPLICATIONS

The Light Emitting Diodes (LEDs) technology is not only commonly used homes and offices, but it is also energy efficient. With the help modulating circuits data can be transferred at the high rates, i.e., not visible to human eye, along with communication and the illumination aspect of LEDs that is called visible light communication (VLC) [19]. The applications of Li-Fi are virtually infinite, Li-Fi can be implemented at any place where LEDs are used. Previously hazardous places where Wi-Fi usage is not permitted due to RF interference can now enjoy wireless communication due to nature of light spectrum. To name a few, areas like manufacturing plants, hospitals, oil fields, nuclear power plants, airplanes, prisons, and fighter jets can now benefit from wireless communication due to Li-Fi [19] [20]. Following are the main areas of Li-Fi applications:

A. Smart Devices

According to the statista [21], the number of smartphone user is expected to increase from 7.26 billion in the year 2022 to 7.49 billion by the year 2025 as shown in Figure 2 [21] [22]. Almost every second person in the world is using at least one or two smart devices [23]. Li-Fi is ideal for smart devices because it offers high data rates and is more secure as compared to Wi-Fi. Short range Li-Fi system to share data between smart devices

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instead of using Bluetooth or Wi-Fi is feasible for home-based media centers or small offices. A practical demonstration was done by [24] using an android application Luximetro and camera of a smartphone to transfer and received light signals at a short range. Similarly, another work [25] uses flash light of a smartphone to send data and Arduino Uno to receive data. The scale of the work in [24] can be raise to form a multimedia system.

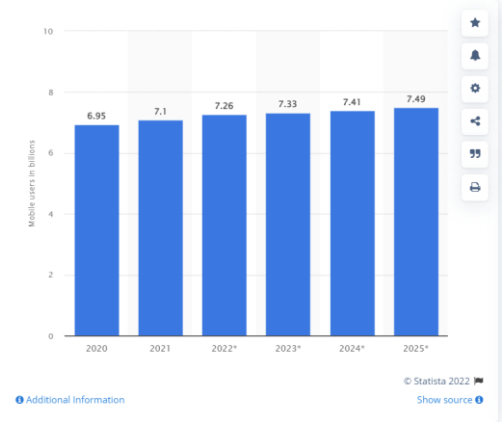

Figure 2. Smartphone users in billions

B. Charging Smart Devices & Vehicles

Using Li-Fi, we can also charge our smart devices, by embedding a thin crystal layer into the display that will act like a solar photovoltaic cell. The job of photovoltaic cell is to covert the light into electrical power [26]. Due to interference free nature of Li-Fi, it is suitable medium for transmission of Wireless Power Transfer (WPT) in vehicular ad hoc networks [27].

C. Industial Application

Li-Fi can be used in industrial environment to achieve low-latency wireless communication such as connecting head mounted cameras of an industrial robot to a cloud [28]. Researchers in their work [29] demonstrated an enhanced Li-Fi positioning system that offers enhanced accuracy, reliable, improved productivity and secure wireless communication medium to fulfill the future needs of Industry 4.0.

D. Healthcare

It is a common observation that people admitted in hospitals requires continuous monitoring of human vitals signs: body temperature, heart rate, blood pressure, and breathing rate. Suitability of li-Fi in hospital environment is due to its non-interference with RF based medical equipment such as MRI [30] [31]. In [30], researchers presented practical vitals monitoring system based on life that offers accepting only the required signals, filtering noise, and 100% accuracy of received signals along with the patient mobility. The proposed prototype uses a Fiber Bragg Grating (FBG) sensor carried by a patient and Li-Fi receiver may be installed in ceiling of room for wireless transfer of vital signs of patient to cloud [32] [33], central monitoring unit or anywhere hospital administration deems suitable. In work [34], the researchers examined the implementation of Li-Fi in a typical neurosurgery operation room of a hospital. Researcher examined various locations for transmitter and receiver for best wireless communication using Li-Fi as shown in Figure 3 [34].

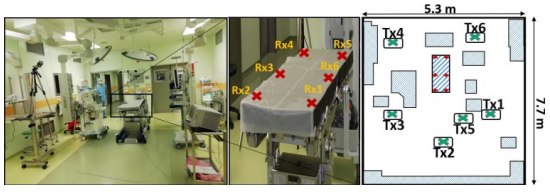

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Figure 3. Li-Fi based prototype for a neurosurgery room

E. Aviation

The use of LEDs technology can be witness in every walk of life and aviation industry is not an exception. On average there are 2 to 3 hundred LEDs in an airplane. With small tweak of economical circuitry these LEDs can be used as a network switch. Lodge of an airplane usually have a large set of LEDs and that can offer many times faster wireless connectivity to the passengers then Wi-Fi and that without worrying about Electromagnetic Interference (EMI). With the proposed system in [35], people in flight can enjoy browsing, calls, and in-flight theater as shown in the Figure 4 [35]. EMI can occur with the use Wi-Fi technology during flights. However, Li-Fi technology can be used for in-flight communication to avoid EMI with aircraft equipment such as radar [36] and solely this feature makes Li-Fi suitable for use in military aviation as well.

Figure 4. Li-Fi based in-flight gaming setup

F. Green Environments

One of the key reasons for the popularity of LED technology is its energy efficacy. LED in contrast with fluorescent tube consume very less power. LED consume about 10% of energy as compared with fluorescent tube and offers more lifespan. The on state of an LED is simply considered as sending 1 and off state of a led is communicating 0 in a binary number system. The more data is transferred the less LED is in on state which results in further decreases in power consumption [37]. Researchers in [38], argues that Li-Fi not only consume less power in comparison with Wi-Fi, but also offers improved security, better range, and minimal effects on environment. As Li-Fi uses light spectrum and common household and office equipment for communication, it is suitable for future smart cities and green cities. In larger perspective Li-Fi can contribute in decreasing the use of fossil fuels as it is about 24 times betters in performance and energy consumption ratio [38].

G. Underwater Applications

Typical underwater robots communicate with operator on surface through wired fiber-optic or shielded ethernet cables and both of them are inclined to faults [39]. Radio waves do not travel well in water due to signal attenuation. Li-Fi technology is appropriate solution to enhance underwater communication. Underwater communication using RF is not completely impossible, but the used technology relay on Very Low Frequency (VLF) radio waves that falls in the range of 3-30KHz. In simple words VLF renders broadcast over long distance but meager bandwidth [40]. Researcher in [40], proposed an Unmanned Underwater Vehicle (UUV), with LightByte modems, using point-point communication that is able to communicate at the speed of 5.8 KB per second which is stuffiest to control UUV with a wireless joystick. Secure Connectivity. Figure 5 shows the waterproof LightByte (Li-Fi) modems [39].

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Figure 5. Waterproof LightByte (Li-Fi) modems

III. CHALLENGES OF LI-FI

Besides several useful applications of Li-Fi in all walks of life, there are still limitations to this emerging technology. Following are the currently main challenges of Li-Fi [10] [11]:

A. Limited Coverage

Despite its benefits, we cannot enjoy this technology easily everywhere because it cannot travel through walls, which is one of the major drawbacks. If you move from one place to another, you need the LED bulb in that place too.

B. Light Dependency

Li-Fi is dependent on the light. We cannot access the Internet in case of light failure.

C. Additional Hardware

A Li-Fi supported lighting system and Li-Fi enabled devices are required for the Li-Fi.

D. Atmospheric Instability

If a Li-Fi lighting system is installed outdoors, it needs to be compatible with extreme weather conditions.

E. Light Pollution

Light intensity needs to be enhanced for longer distance communication, which may create an impact on human health. How can these challenges be overcome? The next section will propose solutions towards these challenges.

IV. PROSPOSED SOLUTION

Wi-Fi is a reliable way to access indoor Internet, but in buildings with different kinds of walls can reduce the signal strength. Weak signals will create an impact on the speed. If multiple users are sharing the 1 connection than it will also cause the slow connectivity. By Li-Fi/Wi-Fi hybrid network solution one can provide reliable speed and connectivity.

Li-Fi offers 10,000 times better bandwidth than Wi-Fi and Wi-Fi range is better than Li-Fi [41]. Users can choose Li-Fi for good bandwidth and speed. As a user will be in limited coverage, the device can automatically select Wi-Fi. If people are using Li-Fi then load on Wi-Fi will be reduced and the people who are on Wi-Fi can also experience a better service. It will significantly improve the user Internet experience [6].

As shown in Figure 6, tablet and mobile users are provided data access via Li-Fi, while laptop and desktop computer data are provided data by Wi-F while another mobile user using Wi-Fi for uplink and downlink for Li-Fi. This heterogeneous approach can free RF resources to serve users being more mobile or outside the Li-Fi

coverage area [6]. More highly mobile users will be able to fall back on the broader coverage of the Wi-Fi network. Such network is solution for security cordon environments, where authorized personals can access the Internet by Li-Fi. It will also give more parental control; parents can easily manage the time their children spend online.

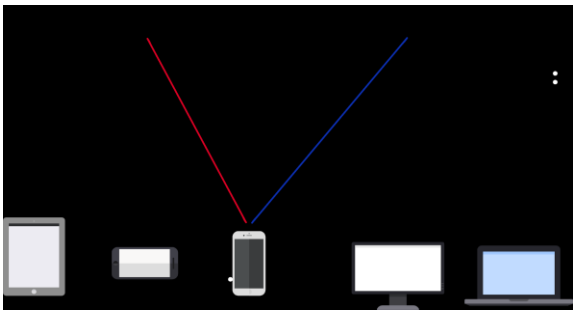

Figure 6. The proposed Li-Wi Fi Heterogeneous Network

V. CONCLUTION

This paper is based on the analysis of emerging technology Li-Fi. Wi-Fi limitation motivates the use of Li-Fi. This ecofriendly solution is more efficient and cost effective as compare to Wi-Fi. It can be used to charge smart devices, road communication, deployed in hospital without causing EMI, offers wireless connectivity to previously hazardous places, such as nuclear power plants as well as to provide secure Internet access to authorize people. Limited coverage's, light dependency, additional hardware, light pollution and atmospheric instability are the current challenges of Li-Fi. These challenges can be resolved by a Li-Fi/Wi-Fi hybrid network, which will improve the user Internet experience and source utilization and create new horizon in the Internet connectivity and parallelly promote the green environment.

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STUDYING THE METAVERSE EFFECT ON ITS USERS

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***Abstract* - This research is set to answer the question how Metaverse can be a dangerous space for its users. Metaverse is a collection of Meta applications such as Facebook, Instagram, WhatsApp and Oculus that is integrated into virtual reality (VR) and augmented reality (AR). To answer the question, different issues that were undertaken in the history of Meta and its CEO, Mark Zuckerberg, was taken into account to see the potential negative effects it will have on end-users.**

The potential issues Metaverse can have includes issues with uneven power distribution, issues with cyber security and privacy threats, and negative impact on the user's mental health. An interview was conducted and the results supported the prior claims, with an emphasis on the dangers of lack of security and privacy leaks and breaches, followed by mental health concerns, then lack of regulations, followed by spread of misinformation and abuse of power. The solutions to these issues consisted of adding and adopting better regulations, integrating a monitoring system, and including a function for tracking and limiting end-user's screen time. Alas, technology and the internet are ever-changing and needs constant evaluation and regulations, especially if it is from a big tech-company such as Meta. A company is useless without its customers, so keeping them safe should always be a top priority.

Keywords* - *Metaverse, VR, Dangers.

I. INTRODUCTION

In the 28th of October 2021, the CEO of Facebook, Mark Zuckerberg, announced during a virtual event that the company is set to rebrand itself as "**Meta**," thus every application and software that run under Facebook such as Facebook itself, Instagram and WhatsApp will be integrated into the "Metaverse" operating system of Web 3.0. According to Salvador Rodriguez [1], the concept of "Metaverse" is referred as an extension of the real world turned virtual [1,2,3,4].

The idea of living out a virtual life sounds intriguing at first, but the more you think about, the more you start to doubt the direction the team at Meta is heading. One of the main problems with the initiation of the Metaverse is trust, security and privacy. Mark Zuckerberg, and Facebook, are no strangers to user information and data leaks, spreading misinformation, uneven power distribution/biasness in users and privacy breaches [5].

It is important to take account and consider every aspect of Metaverse – the good and the bad – and try to determine if Metaverse is actually dangerous and harmful to end-users. It is natural to be cautious with anything that is related to Zuckerberg and his affiliation due to their track records, but the questions are *how cautious should one be?* and *how can Metaverse be a dangerous space for users?* The approach used to answer the prior questions is through conducting qualitative research with a grounded and narrative research approaches, along with methods of observation, interviews and secondary research from existing data related to the scandals Facebook (Meta) and Zuckerberg have previously faced.

The basic results of this research suggests that there is an unarticulated and inferred doubt people have with Metaverse along with concern for their safety and privacy. Thus, this paper will provide suitable suggestions for the team over at Meta that could be integrated to reduce worry and increase user-interference such as adding regulations, improving monitoring systems, and tracking and limiting end-user screen time.

II. PROBLEM DEFINITION

Precisely define the problem you are addressing (i.e. formally specify the inputs and outputs). Elaborate on why this is an interesting and important problem.

To define a problem, one must first determine and specify the outputs, followed by the inputs of the topic at hand. In the case of this research paper, the problem output of the topic is through the end-users; Whether will

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take off or not will both heavily impact the lives of the end-users, so acknowledging the possible problems they would face is important. The possible problems that this paper predicts in terms of issues and concerns for end-users include biasness, chances of getting their privacy violated through security breaches and data leaks, and an increase of mental health cases such as addiction and personality disorders like inferiority complexes, and depression due to lack of human interaction and the rise of cyberbullying and doxing. Whereas in terms of the company itself, there are issues regarding power of monopolization, control and moderation, along with the safety of their customers.

The inputs include an identification of the source data, so the usage of secondary data from articles, news reports and web pages surrounding the concept of Metaverse along with the issues Meta have faces will be accounted for, in addition to conducting an interview with 5 recipients who are end-users of any Meta applications.

To recap, the problem being addressed in this report surrounds the dangers of integrating Metaverse on end-users. The problem is rather interesting due to its nature being completely virtual and deals with technological issues and ethical dilemmas on Meta's end of the bargain. It is important to nitpick the concept as it deals with human lives. It has been proven time and time again that social media and the Internet has negative affects on humans from un-solicitations to breach of privacy and data leakage, especially when it involves Zuckerberg and Meta.

III. PROPOSED SOLUTIONS

The technique used to address the problems at hand was to take each one of the issues with common solutions and group them up. A lot of brainstorming and fact checking was taken accounted for, especially when most of the solutions are theoretical yet logical if one takes a step back to see the full picture. The following image will illustrate the different problems and connect them to a simple solution that fits its purpose as a framework:

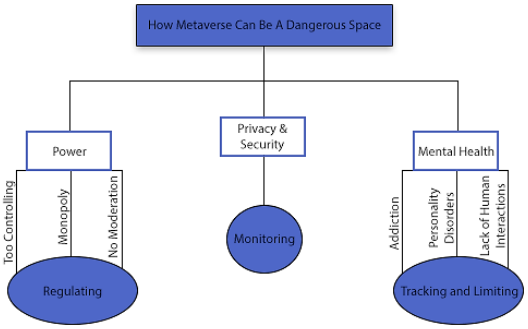
A. Regulating

A better regulation is required due to the imbalance of **power** the company has against its end-users. In a sense, the end-users are vulnerable against corporations like Meta who have full power over the user's data and information. Social media platforms have control over third parties that are integrated to user's data from personalized ads to selling information to other companies. Metaverse is a monopoly, in which the goal is to combine all of the Meta applications into one shared system, which would be worrisome since it implies if one account got hacked then every other account that are linked are vulnerable to getting hacked as well. In addition, moderating is quite difficult for one platform so having to overlook multiple ones at once would be near impossible.

Thus, the solution to the lack of moderation, monopoly and too much control over end-user's information would be to have constant and consistent **regulations**. Most people are concerned that Metaverse is a way for Zuckerberg to attain complete control and power over modern-day technologies, thus it is most logical to redistribute the power amongst democratic officials that have been elected by the board of directors or form a parliament. That way, Zuckerberg will not have sole control over user information and monopoly. In addition, to add more moderation, there should be regular regulations online to make sure some users are not breaking any laws or are committing hate crimes either through verbal or non-verbal acts, and sexual assault [51,52,53].

B. Monitoring

Implementing a **monitoring system** that detects leak and breach patterns is essential in any technological corporations, especially when dealing with the Cloud. Because Metaverse is heavily reliant on virtual reality, it would be even more dangerous for users if any of their information got leaked with the possibility of them getting doxed online, especially since the usage of VR would suggest recordings of the user's physical appearance, their



movements, speech patterns and voice, and even recording what room they are in and tracking their locations. The only issue is Meta's track record [54,55,56,57,58]. The company has been included in various cases and scandals regarding security and privacy being leaked, that it has people questioning whether the company will ever learn

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from their huge and life-threatening mistakes. Would rebranding really help? Or is it too late to patch up the wound they created for themselves?

According to Kost [7,84,85,86,87], there are various ways large corporations like Meta could prevent possible

Figure 1: Flow chart

leaks and security breaches and it starts with evaluating the risk of third-parties, then monitoring all network access, identifying all sensitive data, securing all endpoints, encrypting all data, evaluating all permissions, and lastly, monitoring the security posture of all vendors.

C. Tracking and Limiting

To reduce the chances of end-users developing serious mental illnesses such as addiction, anti-social personality disorders, depression, and inferiority or superiority complexes, along with feeling out of touch with reality due to lack of physical human interactions, **tracking and limiting** the end-user screen time to make sure that users are spending a healthy amount of hours online and not over-doing it, along with limiting what contents should be visible to the general public and what should not. An example of something that should be limited and not be seen as a trend is the unhealthy and unrealistic beauty standards. In most cases, you would have a celebrity or an influencer that is A) very rich and can afford a personal trainer and health meals, B) got work done on their persons, and C) promoting false ideologies of what a perfect body should look like due to sponsorships that almost seem like pyramid scams and fads than scientific like the popularization of detox teas [59,60,61].

When it comes to the number of hours spent online, Meta could implement a system like the playtime feature that was adopted in recent FIFA gaming series to reduce chances of addiction that can lead to anti-social behaviors [13]. The playtime feature allows the end-user to track and set limitations to how much time they spend online [29,30,31,32,33].

IV. Related Work

Along with this research, there are various other works that have similar point of views as this paper. A New York Times article written by Sheera Frenkel and Kellen Browning [2] discussed and theorized how the Metaverse has a dark side when it comes to harassment and assault from personal experiences (a 29-year-old woman got sexually harassed in a virtual lobby). The NYT article relates to the research as it discusses the lack of moderation and monitoring in the Metaverse, which are some of the issues that this paper predicted [62,63].

Another article that discusses the negative effects of Metaverse on users comes from an article written by Jeon Joo-Eun [3]. The article's methodology includes taking a sample of Metaverse-platform users and integrated a multiple regression to test the impact of the respondents' commitment and relationship with each Metaverse platform [64,65,66,67]. This research will also take into account Metaverse users and their opinions and experiences while using Metaverse prior and after the rebranding. 13,14,15]

V. Research Methodology

The following sections will elaborate on the methodology used in supporting this research along with a discussion on the methodology's results [68,69,70]:

A. Methodology

To start off the methodology, one must first determine what criteria should be used to evaluate the methods being used. In this instance, since this research is heavily based on qualitative research methods and relies on interviews as its main source of data, then the criteria to evaluate the method would be [16,71,72,73,74]:

- What information is needed to emphasize on the topic and issue?
- How reliable and truthful will the information be?
- Will the information collected be of use or relevant to the topic?
- How flexible will the research be?
- Will there be any biasness? If so, will it affect the results?

The research question is "How can Metaverse be a dangerous space?" And because it is a qualitative research based on findings and not relying on testable data, then a hypothesis would not be included but rather a proposition would be more suitable. [19,20,21,75,76] The following are the research's claims based on the research question:

- The biggest issue, if not most dangerous, is the security and privacy issues.
- Metaverse will affect the end-user's mental health negatively.
- Regulation will be more difficult with Metaverse's integration.

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To prove the claims made above, an interview was conducted to see any correlations with the responder's answers to the claims made about Metaverse and how or if they were affected by any controversies that Meta was in based on either the regulation issues, mental health issues, or the security and privacy issues, or all of them combined [22,23,24,25].

Because the research is qualitative in nature, an exploratory design was used to fit the purpose of the claims made above. An in-depth interview was conducted to collect the respondent's feelings, thoughts and opinions of the matter at hand. The **interview questions** surrounded around the research question to examine if there are any correlations between the research question and the claims made. The interviewees consisted of a businessman, a student, a parent, a streamer, and an influencer. In addition to the in-depth interviews, a **Likert scale** analysis was used to determine which issue felt the most important to least in the eyes of the interviewees [26,27,28].

Starting off with the Likert scale data analysis, the table below illustrates the results of the scale based on what issues each interviewee felt was most important to cover [77,78,79,80]. Each issue is rated from 1 to 5, 5 being the most important and relevant [29,30,31,32,34,35]:

Table 1 shows that privacy and security issues tallied up the most points with 22 points out of 25. The runner-up is mental health issues with 21 points, followed by the lack of regulation with 17 points, while spread of misinformation comes in close with 15 points. Power abuse came in last with 10 points out of 25. In total, the majority feel like there are dangers and concerns that come with accepting Metaverse with 68% of the votes [36,37,38,39].

As for the interviews (To read full interview, see Appendix: Interview Questions), the following are some of the highlights of each interview and how they are provided as proof to the research's claims [41,41,42]:

- **Businessman:** "Metaverse is a great opportunity for small and big businesses alike, but only if security and privacy was a priority in Meta which is why I am giving it a 5. With lack of privacy and constant security issues, it could jeopardize the business." [43,44,45].
- **Student:** "From my personal experience with other Meta applications, the lack of regards to mental health of its users and lack of regulation truly and tremendously affects the users in the worst possible way." [46,47,48]
- **Parent:** "The concept of Metaverse scares me… Not for my sake, but my children's. I don't want them being exposed to a space that is known to put its users in harm's way from the lack of security to not stopping kids from being bullied and harassed online." [81,82,83]
- **Streamer:** "I am a big advocate for mental health awareness, but if we were to talk about my *professional* life and how Metaverse influences it, then I would say my biggest concern would be the privacy and security issues, along with the lack of moderation."
- **Influencer:** "Oh security and breach of privacy is definitely my major concern! I cannot afford the risk of having my information getting leaked, specially not when I use the platform as my sole source of income."

VI. Discussion

The results of the Likert scale and the interviews have supported the research's claims as they all indicate that there are major issues that comes with entrusting information and using Metaverse. The most common concern that the interviewees believed would be the most dangerous was the privacy and security issues in Meta, followed by the negative impact of the Metaverse can have on the user's mental health. Although, the other factors should still be taken into consideration such as the lack of regulation as it can related to mental health *and* security issues, along with the power control issue and spread of misinformation [49,50,77,78,79,80].

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Interviewees	Power Abuse	Spread of Misinformation	Mental Health Issues	Privacy and Security Issues	Lack of Regulation (i.e. cyberbullying)	Total
Businessman	4	4	2	5	1	16/25
Student	1	2	5	3	4	15/25
Parent	2	2	4	5	5	18/25
Streamer	1	3	5	4	4	17/25
Influencer	2	4	5	5	3	19/25
Total	10	15	21	22	17	85/125

Table 1 privacy and security issues.

The only downside, or weakness, of this method of collecting data is the number of interviewees and the chances of them having similar worries and concerns. It is important to note that every individual is different and not one person can have the same opinions as others. For example, just because the parent in this interview viewed the lack of security to be their main concern and the chances of their children getting cyberbullied does not mean every other parent will feel the same way. Some may find the spread of misinformation more harmful than the lack of moderation, and so on and so forth.

Regardless of the slight flaw in the interview's biasness and coincidence, the results still stand and it confirms the claims made earlier on: Metaverse *is* a dangerous space when it comes to the issues concerning security and privacy, mental health and lack of regulation. Whether it is a concern to the users or not, making sure the users are safe and protected is still the most ethical thing to do in Meta's part.

VII. Conclusion & Future Work

In conclusion, the results from the interviews and other studies and articles have confirmed the research's initial statement that the Metaverse does and will have negative impact on human society. With the track record of the company and constant allegations and scandals, it is evident that simply rebranding to Meta will not cut it. In order to attain the trust of their customers, Meta has to repolish and rebuild their internal systems and get their moral compasses in check when it comes to situations with ethical dilemmas. The results can help improve the

research by focusing on the common thread of issues (i.e., Meta's lack of care for customer safety and privacy) and do more intensive research on how tech-companies can improve with their security systems.

If we had more time, we would conduct more interviews and surveys amongst people from different countries and continents who are familiar with Meta applications, as well as reach out to victims of Facebook and Zuckerberg's scandals to further understand and learn their point of views and how the lack of security has affected them. The limitations faced during this report includes time constraint, page count constraint and subtle biasness when it comes to picking out the interviewees. The first two can be resolved by extending and expanding the requirements for the report from the University, or request an approval to continue the research as a solo project – which then would allow us to have the time and resources to reach out to more people for data and information.

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OPTIMIZATION OF WORKING PARAMETERS TO IMPROVE THE QUALITY OF PLASTICS IN AN INJECTION MOLDING PROCESS

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Abstract: Improvement is required in any industry to increase the productivity by reducing the defects rate and remove the overall waste produced during manufacturing process. In this research paper, the working parameters are optimised that are responsible for process variation. A plastics manufacturing company, the major problems were flow marks and air bubbles appeared on the surface of mould part a car side mirror plastic cover. Because of these problems, the overall production of company was decreasing that resulted in customer dissatisfaction and company could not achieve its daily production target. The responsible working parameters for process variation are found to be injection pressure, melting temperature along with viscosity and flow rate of molten material during injection moulding process. The injection speed and screw speed are also considered. The analysis of variance (ANOVA) test was conducted to find most critical working parameters. It is identified that response surface methodology (RSM) can be used to optimise the working parameters to improve the quality of moulded part that will increase process efficiency by 50%. The data was collected from four machines to find which machine is causing more problems that is found to be Tederic 450 tone machine. This machine has more problems as compared to other machines. Acrylonitrile Butadiene Styrene (ABS) material is used for the production of car side mirror plastic cover. The Rejection of this moulded part was counted 35% of total rejection. After optimization, the rejection is reduced to 16% is recorded which is significant improvement.

Keywords: Working parameters, RSM, DOE, Injection moulding, injection pressure, flow rate, viscosity

I.INTRODUCTION

Quality is a serious concern not only in production area but also in-service area. Good quality products and services result in smooth business progress, customer loyalty, and low prices. The product with better quality increases the manufacturer's competency in the market and enhances customer demand to make human lives more comfortably. The working parameters are most significant in the production of good quality product in an injection moulding process. The values of working parameters depend upon the type of plastics, the dimensions of the product and dimensional tolerance etc. [1]–[3]. The working parameters such as injection pressure, melt temperature and flow rate are need to be optimised to produce good quality plastic parts [4]. Response surface methodology (RSM) is an eminent method that delivers a well-organised procedure for parametric optimisation [5]. RSM is generally used for the optimisation of the design of products and processes [6].

In an injection moulding process, the melt temperature contributes 16%, injection pressure 12%, flow rate 10% of the total rejection [7], [8]. The Cause and effect matrix and analysis of variance (ANOVA) are constructed to determine which working parameters are most critical and substantial [9]. Through the cause and effect and ANOVA, optimum working parameters could be predicted. The process development in a moulding process, design of experiment (DOE), is used to find the working parameter of the machine, which substantially influences the output of injection moulding operations [10]. The convenient injection moulding machine set-up depends upon the trial and error method or technician or operator's experience [11].

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The trial-and-error method is considered a time consuming and non-cost-effective technique which is not acceptable in the plastics manufacturing industry. The problems and defects related to the quality of plastic products encountered in injection moulding operation include air bubbles, flow marks, flashes, short piece, burns and other surface marks [12], [13]. These defects in moulding operations result from various causes, which comprise the selection of injection moulding machine, pre-processing treatment of the plastic resin before moulding operation, and setting of working parameters of the machineas well as operators' training [14]. The plastic injection moulding process has a number of working parameters that affect the output variablesdirectly. Before the injection moulding process, raw material or plastics resin is passed through different stages, which include material storage and material handling [15].

During the injection moulding process, plastics resin is mixed with recycled or regrind material or master batch that also affects the quality of the product [16].The injection moulding machine maintenance and proper cleaning have a positive effect on the quality of the moulded parts. The plastic resin is dried for 2 to 3 hours before injection moulding [17]. The raw material passes through different temperature barrels, which melt the material and inject it into the mould cavity at a specific injection pressure [18]. The cooling is provided in the mould by circulating coolant, which allows the material to solidify to obtain the desired shape of the moulded part. This cooling also has a significant role in the moulded part shape [19].

Residual stresses from the moulding process are released; causing deformation creates hard fitting and shrinkage defects. Air bubbles or sink marks appear on the surface of moulded parts due to low material flow rate and injection pressure [20], [21]. The primary cause of flow marks and flashes on the surface of the moulded part is mould temperature. The black dots or colour lines appear when improper cleaning of the machine, lubrication leakage, burned material in the barrel, melting temperature and mixing of dust particles or other materials mix with the resin [22].The working parameters can be optimised to improve the quality of the moulded part through RSM.

The injection moulding process has mainly three phases: mould filling phase, cooling phase and ejection phase. The cooling phase has a significant influence on the quality of the product and productivity of the process [23], [24]. During manufacturing of plastics parts, the quality terms of part such as hard fitting, flow marks, flashes, sink marks, shrinkage, air bubbles, mould lines and other surface marks depend upon process working parameters that include melting temperature, injection pressure, mould temperature along with flow rate, viscosity and cooling time, screw speed, cooling temperature, packing pressure or holding pressure, packing duration, fillingtime or injection time, cycle time, injection speed [25].

Poor quality products not only affect the customer relationship but also influence the cost and lead times. Therefore, there is a need to recover the excellence of plastics products to enhance the lifetime of these products to make life more comfortable and save money and improve lead time [26] . In this work, the cover of a side mirror of a car is taken as a case study that encounters many quality defects like shrinkage or hard fitting, air bubbles or voids, flow marks, flashes, short piece, black dots, burns marks, weld lines, warpage, mould lines, sink marks. This moulded part has many complaints and poor feedback from customer that disturb thecustomer relationship with the company. So, this study focuses on improving the quality by optimising responsible working parameters such as injection pressure, viscosity, melt temperature, and flow rate. Flow marks and air bubbles on mould part surface reduce quality of part and lead to rejection from the side customer. Many complaints received from customer due appearance of air bubble and flow marks of the surface of moulded part [27].

Materials and methods

In this research study, response surface methodology (RSM) is applied to optimise the thermal working parameters. Response surface methodology (RSM) is a well-known method to optimise and model prediction. Through this methodology, the relationship between various process parameters and the responses would be calculated according to anticipated standards and the values of parameters.

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Design of experiment (DOE)

In this research study, a full factorial design is selected with responsible working parameters of the injection moulding machine Tederic-450 tone. These four factors are melting temperature, injection pressure, flow rate and viscosity. Before applying this methodology, current performance was estimated and decided which moulded part is more defective and needed to improve its quality**.** Table 2 shows the current performance of the company and the percentage of defective parts. In these parts, car side mirror plastics cover has the highest percentage of rejection. Therefore, this part was taken as a case study to improve the quality of the injection moulding process.

Selection of Material

The plastics resin Acrylonitrile Butadiene Styrene (ABS) grade EA 707 is used to produce car side mirror plastic cover. This study basically focuses on process thermal working parameters that affect the superiority of the product. The ABS material is considered because this part is used to protect and plating necessity for automobile parts source and this substantial is measured to be having high influence strength as well as dimensional constancy.

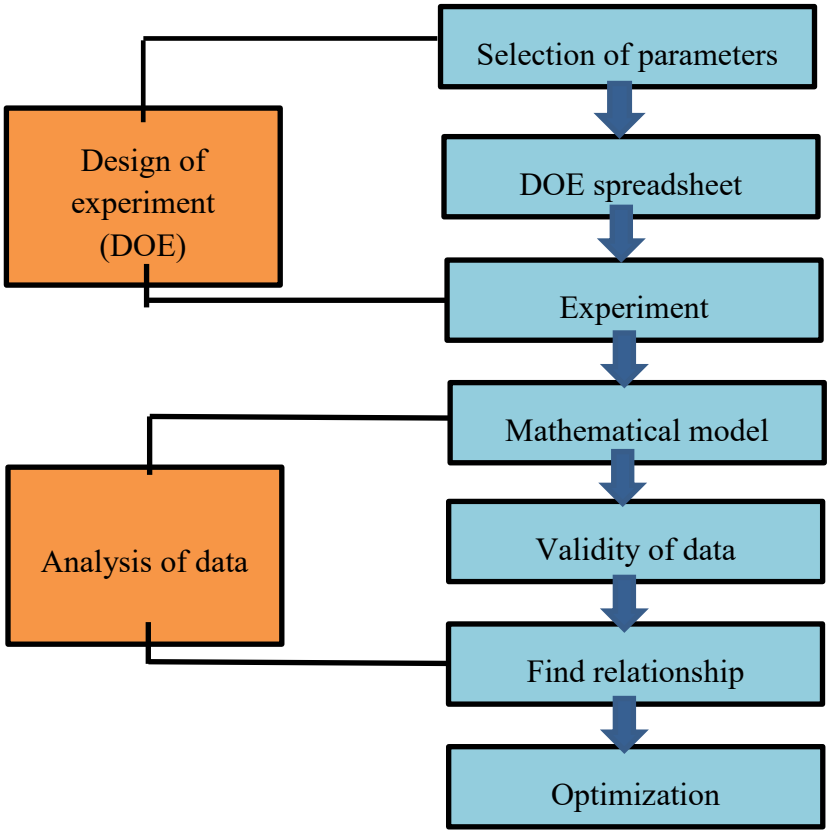

Figure 1: Steps involved in methodology

The elementary optimum parameters are taken from Design Expert software (7.0.0), and experiments are done considering those parameters without compromising the quality requirements. Table 1 shows the properties of material used for moulded part.

Table 1 Properties of material*[28]*

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Properties	Test method	Value
TensileStrength,3.2mm@yield	ASTM D638	450kg/cm²
Specific Gravity	ASTM D792	1.05
Melt Flow Rate@220C/10kg	ASTM D1238	18g/10Min
Tensile Elongation,3.2mm@Yield	ASTM D638	40%
Flexural Modulus,3.2MM	ASTM D790	25000Kg/cm²
Flexural strength,3.2MM	ASTMD790	760Kg/cm²
Moulding Shrinkage (Flow),3.2mm	ASTM D955	0.4- 0.7%

The injection moulding machine

The injection moulding machine that is used in this research study is Tederic-450 ton. This machine has a maximum injection pressure 180-244 MPa, the shot size is 300 grams.

Figure 2 Injection molding machine (Tederic-450 tone)

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Figure 3 Specimen

2.4 Identification of Current performance

Table 2: on-line rejection - total parts produced: 5000

Part name	On-line rejection	On-line x 10^3	%age	Acc.
Car side mirror cover	1650	1.650	33	33
Panel city	1052	1.052	21.04	54.04
Trim wheel	830	0.830	16.6	71
Others	238	0.238	4.76	75.76

Table 2 shows rejection data of injection moulding at 450-ton machines for the month of August2020. This rejection was the highest rejection in comparison to the rejection of the preceding month. In this rejection, car side mirror plastic cover has the highest rejection that is 1650 units, and this is 35% of total rejection. Figure 1 shows on-line rejection for a particular part. As car side mirror plastic cover has the highest rejection, it is taken as a research element.

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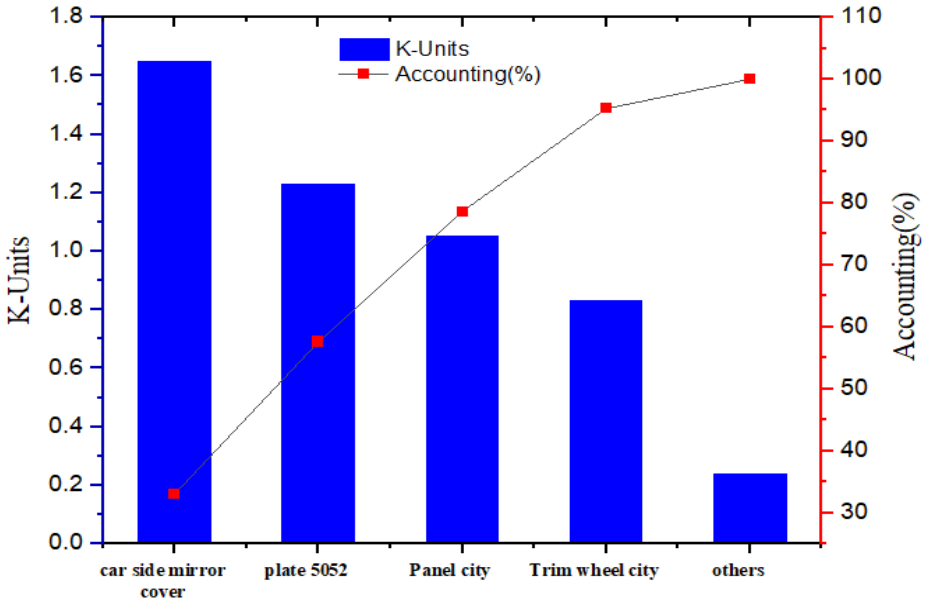

Figure 4: on-line rejection in August 2020

The parts are segregated on the basis of different defects from different injection moulding machines of 450-ton for various parts. These defects were analysed by the Fishbone diagram. The Fishbone diagram is shown in Fig. 5. On the basis of these defective parts, the injection moulding machine is also noted, which has more rejection rate than others. Injection moulding machine Tederic-450 has more rejection. Therefore, this machine is considered for analysis of working parameters. In table 3, major defects are black dots which contribute 35% of total defects, hard fitting contributes 20%, flow marks contribute 8.64%, and air bubbles 11% of total defects due to which parts are rejected. The comparison among machines defected data shows, hard fitting, air bubbles, flow marks, and black dots are still contributing the highest rejectionrate. Tederic-450 ton contributes black dots, air bubbles, flow marks, and hard fitting highest defects compared to other machines. Since Tederic-450 shows the highest rejection rate, its data is used to track down the root cause of hard fitting and black dots. This analysed data is used as a reference for other machines. In figure 5 fishbone diagram is shown that is used to track down the defects during the process.

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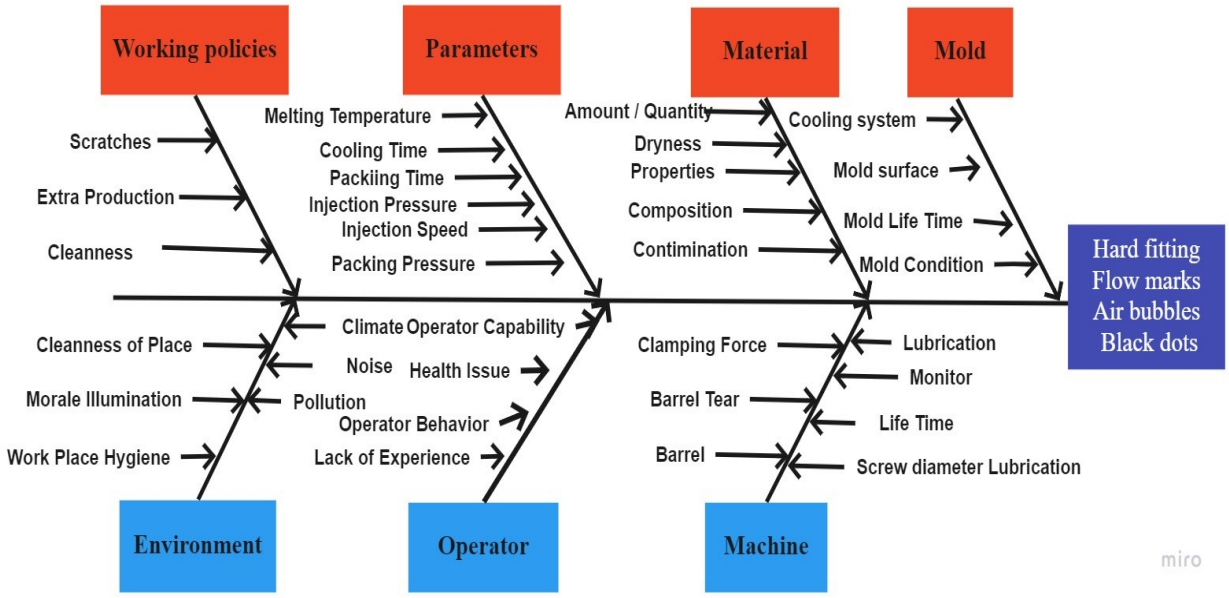

Figure 5: Fishbone diagram to identify the root cause of defects

Table 3: Rejection data based on types of defects

	Machine number						
Defects	**JSW**	**Tederic**	**Engel**	**Husky**	**Sub Total Defects**	**% age**	**Acc.**
Black dots	35	340	270	262	907	35.6	35.6
Hard fitting	2	142	122	266	532	20.9	56.5
Flow marks	0	102	98	20	220	8.6	65.2
Burn marks	15	23	97	0	135	5.3	70.5
Scratches	5	65	77	82	229	9.0	79.5
Short mold	3	62	8	5	78	3.1	82.6
oil/dirt	12	48	34	9	103	4.0	86.6
white marks	0	0	4	0	4	0.2	86.8
air bubbles	45	90	105	65	305	12.0	98.7
Parting bur	2	6	7	0	15	0.6	99.3
others	2	15	0	0	17	0.7	100.0
Total	**121**	**893**	**822**	**709**	**2545**		

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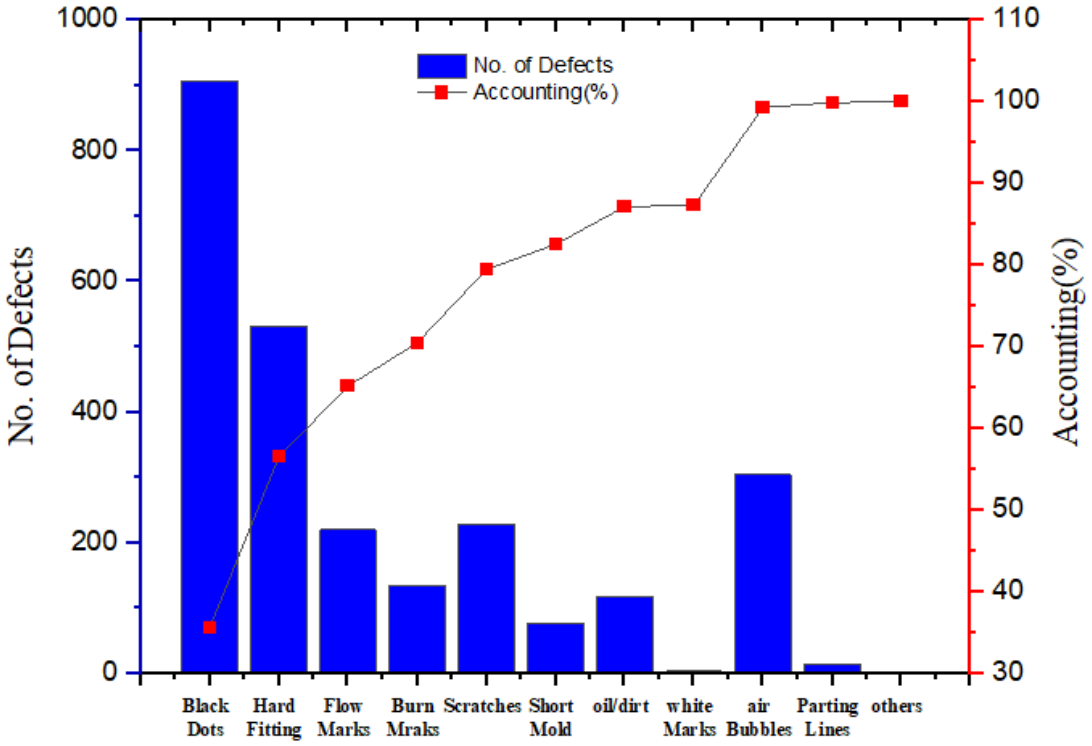

Figure 6: Rejection data based on types of defects

Selection of Process Working Parameters

Based on data analysis, there were four responsible working parameters for quality defects in the moulded part. They are melting temperature, injection pressure. The flow rate and viscosity of molten material are also considered with working parameters. Table 4 shows critical working parameters and their levels.

Table 4 Process Parameters with molten material properties

Parameters	**Level**	
	Minimum	**Maximum**
Melt Temperature	220℃	250℃
Injection Pressure	80 bars	100 bars
Injection speed	20 m/s	26 m/s
Screw speed	18 rev/min	24 rev/min
Flow rate	31.25 g/10 min	39.25 g/10min
Viscosity	1.8×10^{-3} Pa-s	2.33×10^{-3} Pa-s

A. Analysis of Variance (ANOVA)

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The analysis of varianceis applied to find out the proportion of influencing parameters on the defects rate. Analysis of variance (ANOVA) calculates the measures including the degree of freedom (df), the sum of squares (S), degree F-statistic (F), Mean Square (MS) and percentage (P). These results are shown inTable 5.

Table 5 ANOVA results for working parameters

Source	DF	SS	Adjust MS	F	P value (%)
Melt temperature(°C)	4	0.049389	0.013724	5.26	20.45
Injection Pressure (Pa)	4	0.049232	0.0142011	4.99	15.6
Injection speed	4	0.00231	0.02712	19.40	13.89
Screw speed	4	0.01253	0.01527	21.25	11.3
Error	4	0.00967	0.002408		
Total	24	0.558412			
$\mathbf{R^2 = 97.28\% R^2(Adj) = 88.75\%}$					

The analysis of variance (ANOVA) shows how a parameter significance and effect on the defect rate. In the ANOVA test, the percentage of affecting parameters on the defects rate is calculated. Table 6 shows ANOVA test one basis of second degrees mathematical model by using design expert software (7.0.0).We have obtained R-sq and R-sq Adjust for each of the model, Full Quadratic, Linear, Linear-Square and Linear-Interaction. Based on the R-sq and R-sq Adjust depends upon the least square method, the results are reported.The ANOVA results showed that the models on the y-axis are significant because prob>F has a value smaller than 0.05. In this study, backward elimination is chosen because it can remove insignificant terms in order to regulate the quadratic models for defects. In ANOVA results, the value of R^2 is also important to be observed. The quality of regression models is demonstrated by the determination of R^2. The value of R^2 near to 1, that is needed and reasonable concurrence with nearby R^2 is essential.

Table 6 ANOVA test on design expert

Removed	**Estimate**	**Coeff=0**	**Prob>|t|**	**R-squared**	**MSE**
AC	-0.62	-0.059	0.9545	0.7243	758.11
A^2	0.84	0.12	0.9091	0.7238	664.67
D^2	-0.98	-0.15	0.8866	0.7230	592.42
C^2	1.73	0.28	0.7886	0.7207	537.70
C-Inj speed	-2.53	-0.40	0.6953	0.7161	496.76
BC	-6.87	-0.87	0.4016	0.6965	486.88
BD	-11.00	-0.91	0.3822	0.6757	480.25
B-Inj Pressure	-8.92	-8.97	0.3507	0.6523	478.09
AB	17.45	1.45	0.1683	0.5999	513.48
D-Screw speed	9.10	1.48	0.1584	0.5411	552.12
B^2	8.70	1.44	0.4816	0.4816	586.99

Figure 7 shows defects on moulded parts that are selected to eliminate by optimising process parameters. These defects are mentioned as hard fitting, black dots, flow marks and air bubbles.

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Air Bubbles

Flow marks

Figure 7 Defects on the surface of parts

Table 7 ANOVA test for working parameters

Source	Sum of squares	df	Mean square	F-Value	Prob>F
Model	76376.86	14	5455.49	52.53	<0.0001
A-Melt temp	34.66	1	34.66	0.33	0.08845
B-Inj pressure	3339.43	1	3339.43	32.15	0.0713
C-Inj speed	7706.34	1	7706.34	74.20	0.0601
D-Screw speed	24.78	1	24.78	0.24	0.07425
AB	44.88	1	44.88	0.43	0.5353
AC	27.79	1	27.79	0.27	0.6234
AD	1233.33	1	1233.33	11.88	0.0137
BC	77.72	1	77.72	0.75	0.4202
BD	2.55	1	2.55	0.025	0.8806
CD	29.54	1	29.54	0.28	0.6130
$\mathbf{A^2}$	156.56	1	156.56	1.51	0.2655
$\boldsymbol{B^2}$	1514.57	1	1514.57	14.58	0.0088
$\boldsymbol{C^2}$	14.08	1	14.08	0.14	0.7253
$\boldsymbol{D^2}$	123.63	1	123.63	1.19	0.3171
Residual	623.14	6	103.86		
Cor total	77000.00	20			

The F =3.37 which is equal to 0.05 (or 95% confidence level) for a level of significant parameters. Melting temperature [F=8.845< F = 3.37], injection pressure [F=7.13>F=3.37] and Cooling temperature [F =2.35 < F = 3.37] has not given a significant effect process variation. The injection speed [F =7.45> F = 3.37], screw speed [F =6.1> F = 3.37] have given a significant consequence to the defects rate and meld temperature is giving the highest significant level.

The melting temperature contributes the most rate esteems that is 20.45% track by ambient temperature 11.17%, flow rate13.89%, injection pressure 15.6%, and viscosity 11.3% as the influence factor for defects. Cooling time only contributed 0.46%, and lastly, cooling temperature contributed 1.85%. The cooling temperature and cooling time have no significant effect on the process variation. These results ANOVA are tabulated in table 5.

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Table 8 DOE to adjust working parameters

Sr.	Melt Temperature, X1	Injection Pressure, X2	Injection speed, X3	Screw speed, X23	Response (Y)
1	+1	-1	-1	+1	260
2	-1	-1	-1	+1	250
3	+1	+1	-1	-1	238
4	-1	+1	-1	+1	110
5	+1	-1	+1	-1	100
6	-1	-1	+1	-1	90
7	-1	+1	+1	+1	85
8	+1	+1	+1	+1	80
9	-1	-1	-1	+1	75
10	+1	-1	-1	+1	72
11	-1	+1	-1	-1	70
12	+1	+1	-1	-1	65
13	-1	-1	+1	-1	60
14	+1	-1	+1	-1	50
15	-1	+1	+1	+1	30
16	+1	+1	+1	+1	22

Second degree polynomial for optimisation

The RSM approaches the solution which is theoretical and practical methods arecombinedessentially to develop an acceptable functional relationship between the input parameter and the response y,Input parameters are symbolised by A, B, C……AC, BC,B^2, D^2, E^2. In this study, we have taken up statistical modelling to build similarity
between the response y and independent variables.

$$Y = \beta_0 + \beta_1 A + \beta_2 B + \beta_3 C + \beta_{12} D + \beta_{13} AC + \beta_{23} BC + \beta_{11} B^2 + \beta_{22} D^2 + \beta_{33} E^2 \quad (1)$$

$$Y = 0.32120 - 3.534696e^{-004} A + 9.60220e^{-004} B - 0.018898C + 3.45567e^{-003} D + 4.56277e^{005} AC$$
$$+ 5.38240e^{-005} BC - 1.3027e^{-005} B^2 - 5.01132e^{-005} D^2 \quad (2)$$

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Where A is melting temperature (°C), B is injection pressure (MPa), C is injection speed (m/s), and D is screw speed (m/s). The common method used in RSM is the regression method. Design Expert (7.0.0) is used for the RSM analysis with the central composite design (Face centred) to determine which regression will suit our data.

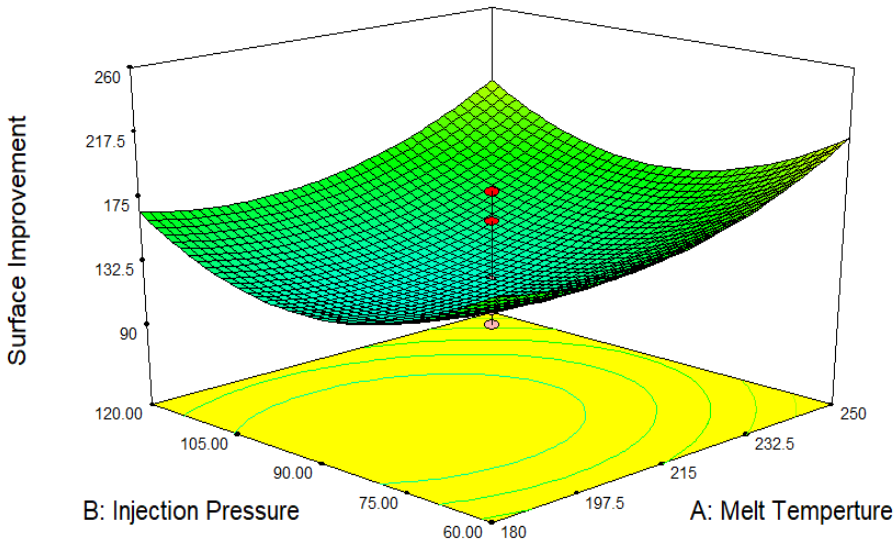

Figure 8: Contour plots between Injection Pressure and Melt temperature

In figure 8: Plot shows the relationship between viscosity and melt temperature. It is plotted between injection pressure, flow rate, melt temperature and viscosity of molten material. The above plotting is constructed by using Design Expert software.

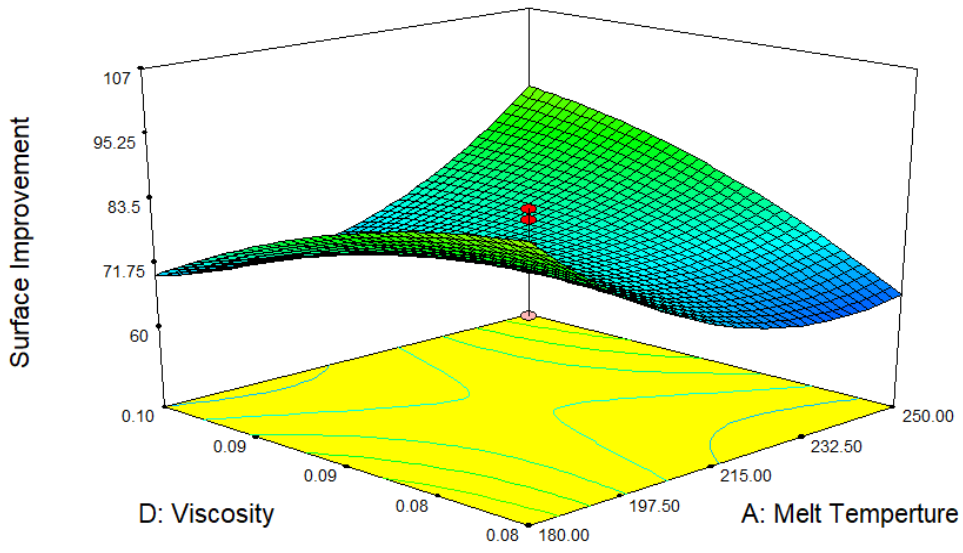

Figure 9: Contour plots between melt temperature and viscosity

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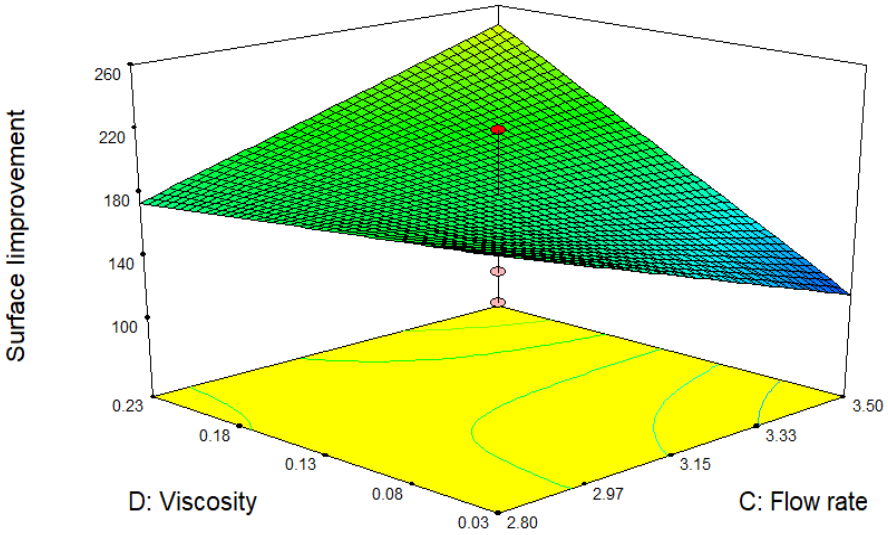

Figure 10 **Contour plots between flow rate and viscosity**

Results and analysis

Table 8 shows the factorial design in which four factors that are also known as parameters with two levels are selected. This matrix is constructed in design expert software (7.0.0). This factorial design shows parameters setting on which responses are obtained for each factor.

ANALYSIS OF BLACK DOTS, AIR BUBBLES AND FLOW MARKS

In the root cause of black dots, there are five significant factors that are responsible for black dots as following material, method, environment, operator and machine. The machine is one of the factors which must be responsible for black dots. Black dots that appear on moulded parts may be due to machine contribution. For example, improper working parameters setting causes carbonised screw. A damaged barrel or screw is also responsible for black dots. Flow marks appear on the surface of the moulded part due to mould temperature beyond the limit. Mould temperature beyond limit does not allow material to solidify in a given cycle time, leading to flow marks on the surface of the part. There should be proper cooling in the mould through cooling channels due to which molten material quickly in given cycle time. The air bubbles appear due to air trapped in the mould cavity when molten material is injected into the mould. The mass flow rate is also responsible for air bubbles in the moulded part. An improper flow rate of molten material causes air bubbles on the surface of plastics parts. Table 11 shows the S/N ratio for black dots, flow marks and air bubbles that are removed by optimising responsible parameters. These results are taken by using Minitab 2017.Table 12 shows recommended setting for optimum parameters.

Table 9 Summary of Results

Run	1	2	3	Mean	MSD	S/N Ratio
1	1.015	1.213	1.06	1.096	3.625	-0.822
2	0.939	1.137	0.984	1.02	3.144	-0.204
3	0.868	1.066	0.913	0.949	2.722	0.422
4	0.863	1.061	0.908	0.944	2.692	0.47

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5	0.882	1.08	0.927	0.963	2.801	0.298
6	0.872	1.07	0.917	0.953	2.748	0.381
7	0.808	1.006	0.853	0.889	2.393	0.983
8	0.895	1.093	0.94	0.976	2.879	0.178
9	0.808	1.006	0.853	0.889	2.391	0.985
10	0.94	1.138	0.985	1.021	3.148	-0.209
		Total Mean		**9.7**	**28.543**	**2.482**

Table 10 Recommended setting of factors

Factors	**Levels**	
	Minimum	**Maximum**
Melt Temperature(°C)	225	230
Injection Pressure (bars)	80	90
Injection speed (m/s)	35.3	39.25
Screw speed (rev/min)	24	32

CONFIRMATION EXPERIMENT

The confirmation experiments S/N ratio was calculatedusing the responsetable S/N ratio dependent upon following calculations:

$$Z = \bar{Z} + (B3 - Z) + (H3 - Z) + (G3 - Z) + (A3 - Z) + (C2 - Z) + (F3 - Z) + (E1 - Z) + (D1 - Z)$$

$$= 0.43 + 0.42 + 0.21 + 0.18 + 0.15 + 0.08 + 0.03 + 0.01 + 0.00$$

$$= 1.5$$

The injection moulding process has improved and reduced the 16.5% defects rate by using this optimum setting of factors, asshown in Table 13.

Table 11 Results of Confirmation

Run	**1**	**2**	**3**	**Mean**
1	0.63	0.83	0.68	0.71
2	0.62	0.84	0.66	0.71
3	0.64	0.82	0.65	0.70
			Total Mean	**0.71**

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Table 12 Comparison after and before optimization

Factors	x-direction		y-direction		z-direction	
	Before	**After**	**Before**	**After**	**Before**	**After**
Melt Temperature (°C)	**220**	**230**	**220**	**230**	**220**	**240**
Injection Pressure (bar)	**80**	**100**	**80**	**90**	**80**	**95**
Injection speed	**20**	**25**	**20**	**25**	**20**	**25**
Screw speed	**16**	**18**	**18**	**20**	**22**	**24**
Flow rate (g/s)	**2.912**	**3.125**	**2.745**	**3.224**	**2.957**	**3.139**
Viscosity (Pa-s)	1.8×10^{-3}	2.3×10^{-3}	1.9×10^{-3}	2.02×10^{-3}	1.8×10^{-3}	2.48×10^{-3}

In Table 15, the comparison is made after and before improvement on the basis of data collection that shows significant development in the moulding process.

Table 13 Comparison of defective parts after and before improvement

Problem	**After**	**Before**
Hard Fitting	52	270
Flow marks	55	120
Black dots	48	122
Air bubbles	40	85
Flashes	13	85
Colour line	6	73

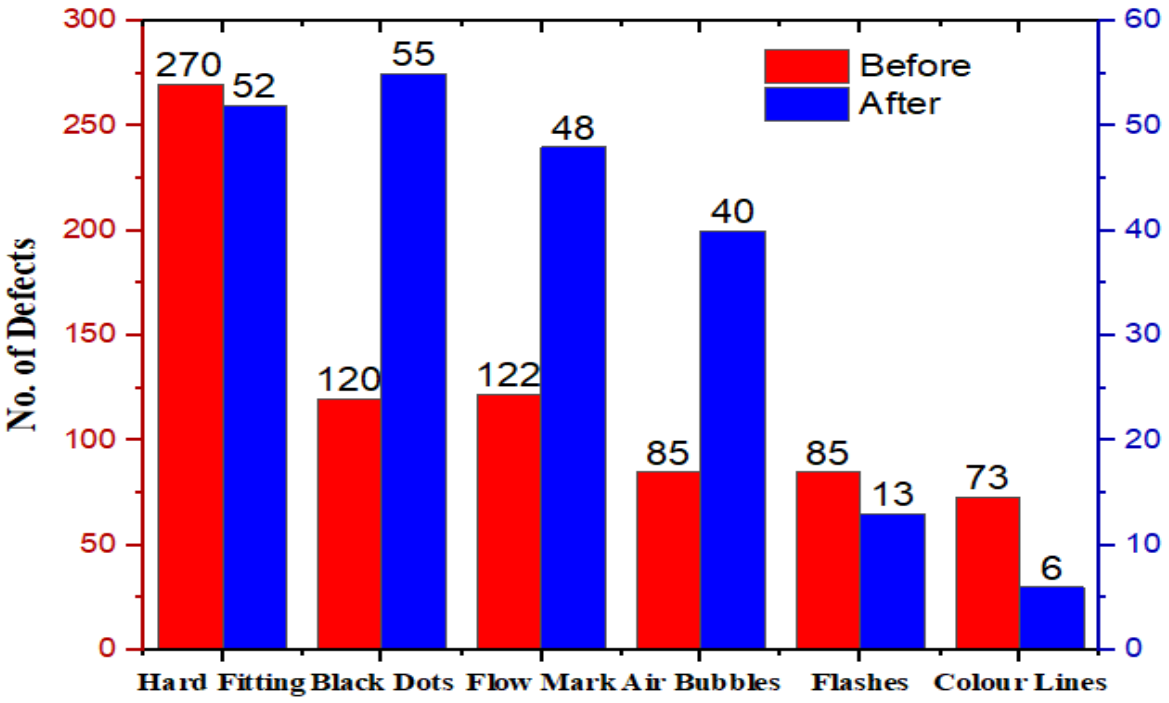

Figure 11: Defective parts after and before improvement

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Conclusion

In this research study, the working parameters including melting temperature, injection pressure, injection speed and screw speed are optimised to improve the quality of the injection process using response surface methodology (RSM). The optimum working parameters are obtained by adjusting their values through which the quality of the car mirror plastic cover is improved significantly. The conclusion of this studyhas contribution of melting temperature 20.45%, injection pressure 15.6%, injection speed 13.89% and screw speed is 11.3 %. The optimum process parameters gained through response methodology (RSM) has improved. The process has16.5% improved, and the rejection rate has reduced 50% of total rejection. It will ensure the manufacturers to start production with a better starting data and also could decrease material production and time consume through this study. The selection of suitable range of parameters between each level is significant to give more effect in this study.Various manufactures producing same type of materials give a slight diverse value of consequence.The improvement that we made will be beneficial to the company, and it will enhance the profitability of the company. It will also increase the overall performance of the injection moulding process. In future, the quality of plastics parts can be improved by changing mould cooling channels and focusing on the material. This case study can be applied to all plastics manufacturers to enhance product quality and save company time.

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QUALITY OPTIMIZATION OF OSPFV3 AND EIGRP FOR IPV4 AND IPV6 IN HIERARCHICAL NETWORK ENVIRONMENT USING GNS3 TOOL

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Abstract: **In network world, due to shortage of IP addresses in version 4, a new version of IP address, namely IPv6, has come into play, but due to non-exchange ability between IPv4 and IPv6, different routing protocol is come to play for IPv6 that is RIPng, OSPFv3 and EIGRP for IPv6 in the place of RIP, OSPFv2 and EIGRP in IPv4 environment. Transmission of data is based on the routing protocol which selects the best routes in network world. Two types of interior routing protocol which selects the best routes in network world that is distance vector and link state. In this research we compare two types of routing protocol are chosen as the simulation base that is OSPFv3 (Link state) and EIGRP IPv6 (Distance Vector) in terms of convergence and router CPU usage. These routing protocols are mostly used in network as well as internet. In this project, we are going to use GNS3 to simulate and compare OSPF and EIGRPv6 with authentication and without authentication in large hierarchical network using ipv4 and ipv6 environment. On top of everything, as a second step GNS3 simulator installed. Familiarity with GNS3 is essential to achieve this research study. As a second step, a certain hierarchical routing scheme scenarios will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required results in terms of CPU processing power and convergence time. Later, OSPFv3 and EIGRP IPv6 with authentication implemented and configured to get results for a comparison in terms of resources usage and convergence. As a final stage overall results of the research study compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication.**
Keywords**:** GNS3, IPv4, IPv6, OSPFv3, EIGRPV6.

I. INTRODUCTION

There are many researchers who consider EIGRP routing protocol faster as compared to OSPF in IPv4 environment, in terms of convergence, resource usage (detail provided in Review chapter). If we implement authentication on both routing protocols still EIGRP is faster than other routing protocol because both routing protocol are using the same MD5 authentication. Time has come to shift to IP v6 networks. In IPv6 separate routing protocols have been created, that is OSPF V3 and EIGRP V6 [1]. Still OSPFv3 is slower than EIGRP without authentication, however but if we implement authentication, OSPFv3 has been found outperforming the EIGRP V6 for at-least flat networks in terms of convergence. However, the same has not been studied in hierarchical networks. The main goal my thesis is to measure and compare performance of these two protocols (ie: OSPFv3 and EIGRPv6) in hierarchical enterprise networks in terms of convergence and resource utilization, with and without authentication.

- **IP Addresses:** Internet Protocol Addresses are used to uniquely identify devices on the network. Presently there are two versions of IP addresses viz. IPv4 and IPv6 that can be used on the internet. IPv4, being the oldest and de-facto industry standard, is getting exhausted. The later IPv6 promises to offer more features in addition to providing a much larger range of unique addresses. Unfortunately, IPv6 is not backward compatible with IPv4 and hence may not co-exist (i.e.: a host with IPv6 address may not communicate with another host with an IPv4 address) [2].
- **IPV4 :** The IPv4 address is 32 bit long, in four octets. It is defined in two parts which are network portion and host portion. Due to increasing demand of network equipment in world currently running IPv4 became short. Due to shortage of IP address categories in classes (A, B, C, D, E) and some IP address ranges are defined for private and public purpose for example form A Class 10.0.0.0 to 10.255.255.255 from B Class 172.16.0.0 to 172.31.255.255 and form C Class 192.168.0.0 to 192.168.255.255) are reserved for private use purpose. Submitting also introduced in

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IPv4 address but after also these solutions the shortage of IP address did not cover. To recover the shortage of IP address a new version of IP is introduced that is IPv6.

- **IPv6:** Internet has evolved into a most important resource, not only computers and network devices but in the near feature everything will be connected to the internet, which means your shoes, trees, mountains, cows, animals, human, building, bulb, traffic signal and much more will be connected to internet. It would be very overwhelming for IPv4, with only 32 bits, to provide unique addresses to such a large number of devices. The Internet Protocol version 6 (IPv6) has been developed as the subsequent group network layer protocol, to overcome the issues of IPv4 addresses. IPv6 contains 128 bits which means that it can provide unique addresses to 340 undecillion devices and seems to be more than sufficient for even the distant future. The IPv6 protocol is managed by IETF.
- **Routing protocols:** Defining static paths would have been sufficient if the links in the network were made once and for all and may not be broken or changed later. However due to the dynamic nature of the network topology, routing protocols are required to automatically adapt to changes in network routes and provide for all the valued data. Routing protocols periodically exchange routing information with neighboring routers in order to keep their routing tables up to date. With this exchange, routers to learn important information about the remote network just to add points to their routing tables. Depending on the protocol and its logic is the best way to any network is identified and stored in the routing table. This is a big advantage of dynamic routing protocols as network topology changes very often. Dynamic routing protocols require less administrative pressure as compared to static route. However, there is overhead associated with dynamic routing protocols that part of the router's resources will be devoted to run the Protocol itself; these resources include CPU time and network bandwidth.

The determination of a routing protocol includes:

- Learning of remote networks
- Keep the actual/real routing information
- Choose the best path to the destination (Remote) network.

a. Interior Gateway Protocols (IGP)

- Intermediate System to Intermediate System
- Enhanced Interior Gateway Routing Protocol
- Open Shortest Path First
- Routing Information Protocol

b. Exterior Gateway Protocols (EGP)

- **Border Gateway Protocol:** There are several ways to differentiate (IGP and EGP) routing protocols in terms of converges time when changes occur in the topology and other factor are scalability, the use of CPU and RAM resources end to end delay and overhead costs. In this research, we are only concern with OSPFv3 and EIGRP for IPv6.
- **OSPF:** OSPF protocol is an Interior Gateway Protocol, developed by IETF. It is an open standard routing protocol. OSPF protocol is broadly used routing protocol in huge enterprise networks. OSPF is a routing protocol link state, which by means of SPF algorithm, which calculates the shortest path to the AS. There are 3 version of OSPF (OSPFV1, OSPFV2 and OSPFV3). The OSPF protocol is based on the Link State Database and That database is a logical tree structure of the network structure. SPF algorithm also known as Dijkstra's algorithm. link cost based on channel capacity. With the high bandwidth allocated lower cost. The LSDB who regularly by the router sends Hello packets out of their neighbor router interface and wait for reply to maintenance. If no response is received within the time limit, in light of the changes to the link state is updated LSDB. OSPF router link state change notification advertised LSDB though Link state advertisement (LSA) in same area. Upon receiving the router LSA update LSDB own copy, and accordingly recalculate the route cost. OSPF protocol uses a hierarchical structure is divided into zones or area, in order to ensure LSDB not grow too large area. Due to LSA limitation with are, it helps low bandwidth usage, low memory, and processing usage by OSPF. In OPSF each region is marked with a unique 32-bit area ID, which is not compatible with IPv4 dotted-decimal format and address. In OSPF domain backbone area is Area 0, all other must connect to the Area 0. In addition, OSPF protocol is to establish and maintain three separate tables: Contains a list of neighboring routers in the next table contains a list of all routes in the topology table and contains the best route in the routing table. The main mechanisms of OSPV2 and OSPFv3 are same with some modifications. OSPFv2 is for IPv4 only and in terms of authentication and encryptions it supports MD5 and OSPFv3 is for IPv6 only and in terms of authentication and encryptions it supports IPsec.
- **EIGRP:** Initially, Enhanced Interior Gateway Routing Protocol (EIGRP) is owned by CISCO but since 2020 it become open protocol means other vendor can implement this protocol. It is implemented science 1992 and uses DUAL (Diffusion Update Algorithm). In is enhanced version of IGRP which is replaced in 1993. It is said as Advance

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distance vector routing protocol because it has some advance feature than distance vector. It calculates the most efficient among all possible eventualities track. It has faster convergence than OSPF by default. EIGRP mostly used in medium to large network and it send triggered update. EIGRP is based on bandwidth(k1), delay(k3), reliability(k2), load(k4) and MTU(k5). Routers should be found that once a neighbor router unreachable failure, Neighbor Discovery and Recovery uses hello packets periodically, if neighbor found alive via using hello packet. Neighbor router will begin to run when the router to exchange information. Requirements to ensure the EIGRP DUAL algorithm by default and ordered delivery of data packets for transmission and reliable transport control protocol, which is used in the EIGRP, to avoid routing loops by recalculating routes. DUAL tracking the optimal path for all routes and testing, which will be added to the routing table of efficiency and cost. Also exists, the backup route can in the case of the best route is discarded in use. Protocol Dependent Modules for the network layer protocol encapsulated IP packets. Defining an additional route from the routing table, such as necessary. PDMs make sure that EIGRP offers provision for numerous routed protocols. EIGRP is for IPv4 only and in terms of authentication and encryptions it supports MD5 and EIGRP for IPV6 is for IPv6 only and in terms of authentication and encryptions it also supports MD5. As a second step, a certain hierarchical routing scheme scenarios will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required results in terms of CPU processing power and convergence time. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, [3] but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3.

II. REVIEW OF LITERATURE

A. 2.1 A Comparison of OSPFv3 and EIGRPv6:

Authors [3] compare two routing protocol OSPFv3 and EIGRPv6 cisco small network of IPv6 enterprises. Author found that EIGRPv6 performed better on all tests when configuring point topologies without authentication compared to OSPFv3. Therefore, the main conclusion from the results of this document is that when comparing OSPFv3 and EIGRPv6 within a small network of IPv6 enterprises, EIGRPv6 is a faster protocol because it has better startup and re-convergence than OSPFv3. However, The MD5 validation method used by EIGRPv6 has a negative impact on performance, IPSec has significantly improved the performance of OSPFv3. As a second step, a certain hierarchical routing scheme scenario will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required results in terms of CPU processing power and convergence time [4]. Later, OSPFv3 and EIGRP IPv6 with authentication implemented and configured to get results for a comparison in terms of resources usage and convergence. As a final stage overall results of the research study compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3. The greatest amount of data packets arrives and the lowest amount of delay from bottom to bottom. OLSR (Optimized Link State Routing Protocol} performance is not significantly degraded even with high network load. On the other hand, OSPF should achieve a significant turnover and a low end-to-end lag as a tool to remove more network packets. On the other hand, EIGRP converges faster than OSPF network. EIGRP can quickly acquire topology and updates.

B. A Comparative Study of Routing Protocols:

In this research study addresses the problem of routing protocols and address space and other factors. Soon, the picture is much less obvious. As a final stage overall results of the research study compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study

compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3. The simulation results indicate that the IS-IS protocol exceeds the other two at the time of the e-mail response response and the response time on the http page. The connection test between IPv4 and IPv6 network has been successfully performed [5]. The dual stack transition mechanism provides communication results for both IPv4 and IPv6 protocols [6]. In a single IPv4 network that used only an IPv6 network, the transition mechanism was able to communicate, but in the tunnel, this shows that the use of OSPF bandwidth and better connection to the OSPF / ISIS network is lower than the OSPF network bandwidth usage. EIGRP is less networked by EIGRP using EIGRP / IS-IS than EIGRP As a second step, a certain hierarchical routing scheme scenarios will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required results in terms of CPU processing power and convergence time [6]. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3. The IS-IS input interval between EIGRP / IS-IS networks is too fast in IS-IS networks or OSPF / ISIS networks. IS-IS networks, on the other hand, have fewer downtime than the AJRP / ISIS or OSPF / IS-IS networks. Then EIGRP / IS-IS networks are fast enough to learn all the lines in the network from IS-IS networks or OSPF / IS-IS networks. IS IS networks are becoming less of the two networks. Network response time is better than using other EIGRP / IS-IS combinations compared to other networks using OSPF, IS-IS, EIGRP and OSPF / IS-IS [7]. Networks that use EIGRP / IS-IS will display other responses of network mail using other HTTP products and OSPF, EIGRP, IS-IS, and OSPF / IS-IS. On the other hand, networks that use OSPF / IS-IS networks provide amusing responses in both situations. Therefore, OSPF, EIGRP, IS-IS, OSPF / IS-IS, EIGRP / IS-IS provides the latest users with access to HTTP and e-mail applications. Simulation is the same at the start of all other networks at the start. After a few minutes, the network will show better performance than any other network using OSPF / IS-IS networks. This study will investigate the performance of different turn signals, EIGRP / IS-IS exceeds other protocols [7]. In the second case, the First Open Open Protocol (V3) (OSPFv3) applies. In the third case, the combination of two protocols should be implemented in a network. The author took the OPNET simulator to analyze the routing protocol progress [8]. In this study, the author presented a comparative study on selected routing protocols such as IS-IS, OSPFv3 and IS-IS and OSPFv3. Comparative analysis is implemented real-time on the same network with different protocols. Performance is measured according to some parameters designed to detect the impact of routing protocols. In this paper, the simulation results show that IS-IS is superior to the other two at the end of the video. Under jitter conditions, OSPFv3 is better than the other two [9]. The researcher compared common IPv6 and IPv4 routing protocols, OSPF and EIGRP. Comparison shows that EIGRP is a routing protocol and has advantages over OSPF. OSPF has compensations in large networks with scalable scalability [10]. These data are collected using simulations to compare the exact performance of the comparison of the protocol [11]. In this study, the three known routing protocols, RIPv2, EIGRP, and OSPF have been studied and analyzed based on the bandwidth used during convergence, using real-time network equipment. In addition, to solve the problem of selecting the best routing protocol based on the network specifications / requirements, it is also necessary to test its unequal load balancing capabilities. The same agreement may not apply to various networks. This depends entirely on the network environment and business needs [12]. The comparison of the routing protocols based on the optimal resource utilization is based on the result of the selection of the correct protocol for the bandwidth-compatible network that considers uneven load balancing and bandwidth usage during real-time convergence. Linking with bottlenecks or unequal costs becomes easier. Such as RIPv2, EIGRP and OSPF, features to be studied include convergence time, scalability, latency completion and finishing, different network topologies such as stars, rings, and networks are being tested in experiments [13]. Link state routing protocols are an important component of the Internet today and will continue to support this role in the future. It is interesting to detect how the link state protocol affects the future of the

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Internet, as millions of computers are expected to scale significantly to the Internet, where wireless sensors communicate with each other wirelessly with billions of energy / CPU / memory [14]. In a massive wireless sensor network, you can imagine a hybrid approach in which state connection protocols are used within a small routing and interconnected domain using a remote distance approach.

III. METHODOLOGY

This research study is based on developing a test bed to achieve simulations of OSPF3 and EIGRP v4 and v6 with-authentication and -without authentication and to compare routing performance between two in hierarchical networks scenario. As a first thing, first an overview of research methods shall be taken. Later on, this research study related work shall serve as a guideline for the rest of the work related with this research project. On top of everything, as a second step GNS3 simulator shall be installed. As a second step, a certain hierarchical routing scheme scenario will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required results in terms of CPU processing power and convergence time. Later, OSPFv3 and EIGRP IPv6 with authentication implemented and configured to get results for a comparison in terms of resources usage and convergence. As a final stage overall results of the research study compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3. Familiarity with GNS3 is essential to achieve this research study. As a second step, a certain hierarchical routing scheme scenario will be created. Secondly, OSPFv3 and EIGRP IPv4 and IPv6 without authentication will be implemented and configured to get the required results in terms of CPU processing power and convergence time.

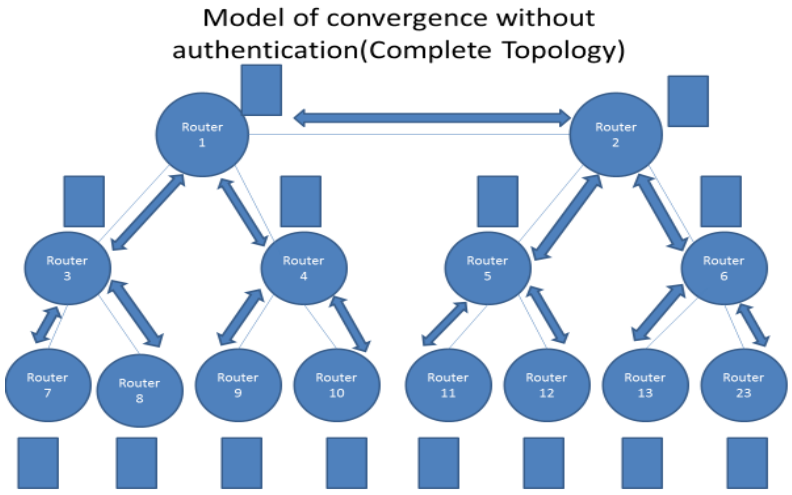

Fig 1: Model of Convergence OSPFv3 and EIGRP IPv4 and IPv6 without authentication

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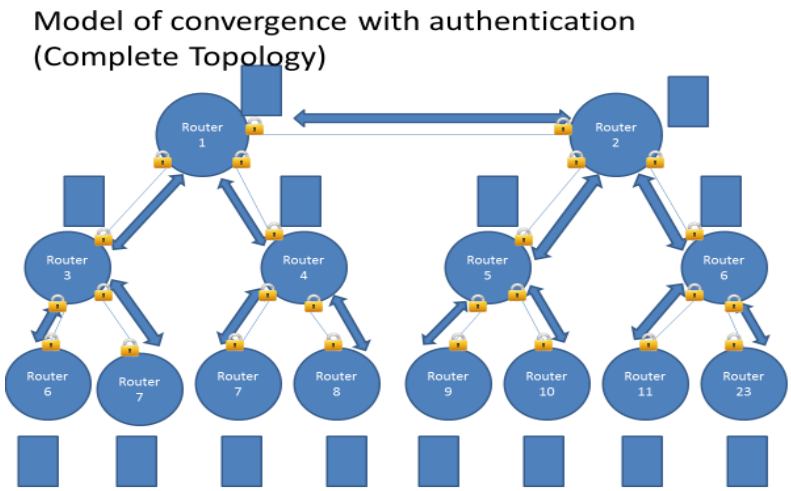

Fig 2: Model of Convergence OSPFv3 and EIGRP IPv4 and IPv6 with authentication

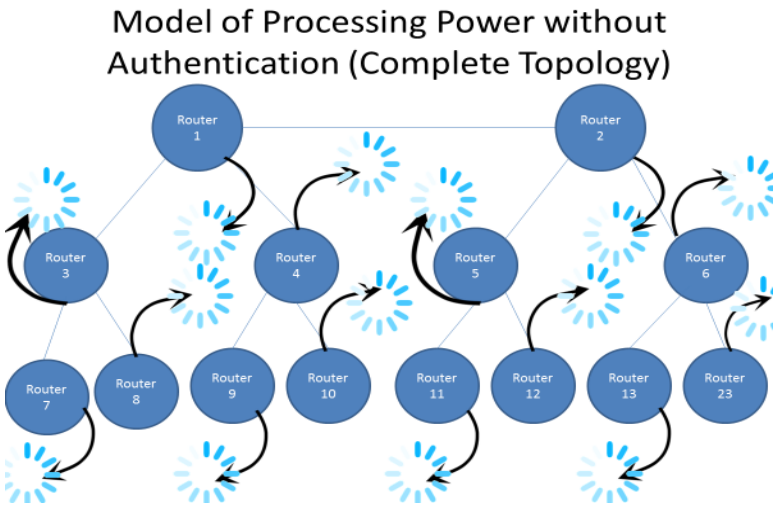

Fig 3: Model Processing Power of OSPFv3 and EIGRP IPv4 and IPv6 Without Authentication

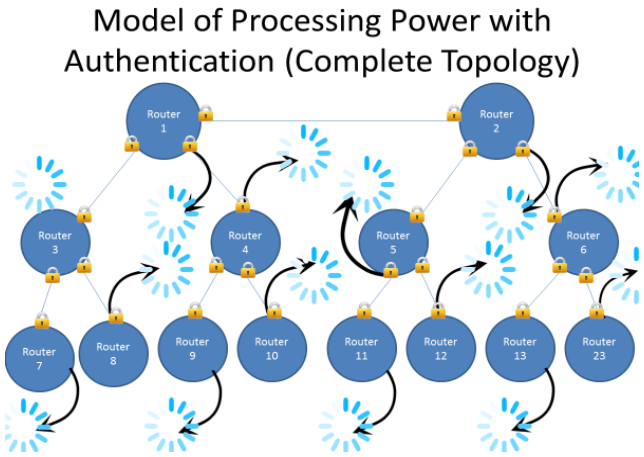

Fig 4: Model Processing Power of OSPFv3 and EIGRP IPv4 and IPv6 with authentication

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Later, OSPFv3 and EIGRP IPv4 and IPv6 with authentication will be implemented and configured to get results for a comparison in terms of resources usage and convergence. As a final stage overall results of the research study will be compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result will be drawn and presented in the thesis and a final comparative analysis is going to be presented in tabular format.

IV. RESULTS

In this section, the detailed test results are presented along with their analysis. To achieve this research work, all tests were conducted using the research parameter such as: firstly, processing power with and without authentication on EIGRP for IPv6 routing protocol and OSPFv3, secondly, measure convergence time with authentication and without authentication on EIGRP for IPv6 and OSPFv3. In this research we utilized fourteen (14) routers having model number C7200 with IOS 15.1 version in hierarchal environment in GNS3 simulation environment by following exactly the actual topology. In this research work, routing scenario for 21 networks using fourteen (14) number of routers have been implemented using GNS3 simulation environment by running OSPFv3 and EIGERP for IPv4 and IPv6 by focusing two different setups one with-authentication and one without-authentication. In the following diagram, network architect for the above-mentioned details are presented.

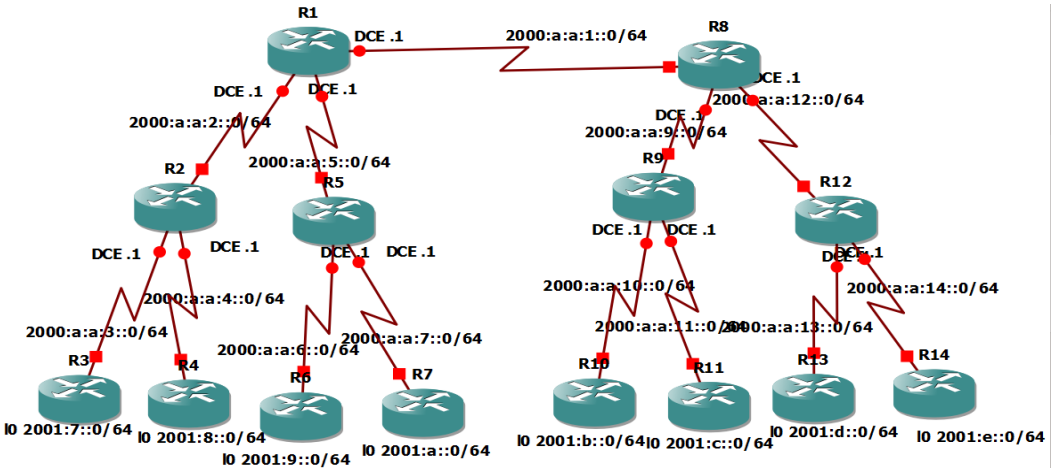

Fig 5: OSPFv3 and EIGERP for IPv4 and IPv6 by focusing two different setups

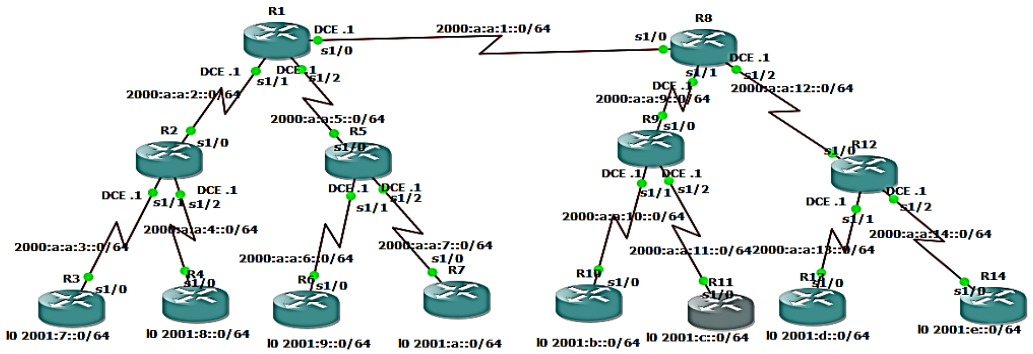

Fig 6: OSPFv3 and EIGERP for IPv4 and IPv6 by focusing two different setups Following is result

OSPFv3 and EIGERP for IPv4 and IPv6 by focusing two different setups small description of above network architecture is presented in the following. As a second step, a certain hierarchical routing scheme scenarios will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required

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results in terms of CPU processing power and convergence time. Later, OSPFv3 and EIGRP IPv6 with authentication implemented and configured to get results for a comparison in terms of resources usage and convergence. As a final stage overall results of the research study compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3.

A. Following is result of Router 1:

Table I – Result Router 1

Router 1	**Without authentication**					
	Convergence		**Processing in %**			
	Time	Sec	Time	5sec	1min	5min
EIGRP for IPv4	1st	16	1st	1.51	0.24	0.05
	2nd	16	2nd	0.87	0.12	0.02
	3rd	16	3rd	0.87	0.26	0.07
	Avg	16	Avg	1.08	0.2	0.04
EIGRP for IPv6	1st	6	1st	2.07	0.31	0.11
	2nd	6	2nd	2.31	0.38	0.0 8
	3rd	6	3rd	2.35	0.39	0.12
	Avg	6	Avg	2.24	0.36	0.1
	With authentication					
	Convergence		**Processing in %**			
	Time	Sec	Time	5sec	1min	5min
EIGRP for IPv4	1st	23	1st	1.67	0.17	0.04
	2nd	23	2nd	1.75	0.36	0.09
	3rd	23	3rd	2.97	0.25	0.05
	Avg	23	Avg	2.13	0.26	0.06
EIGRP for IPv6	1st	6	1st	2.95	0.39	0.09
	2nd	6	2nd	2.64	0.3	0.06
	3rd	6	3rd	2.95	0.26	0.05
	Avg	6	Avg	2.84	0.31	0.06

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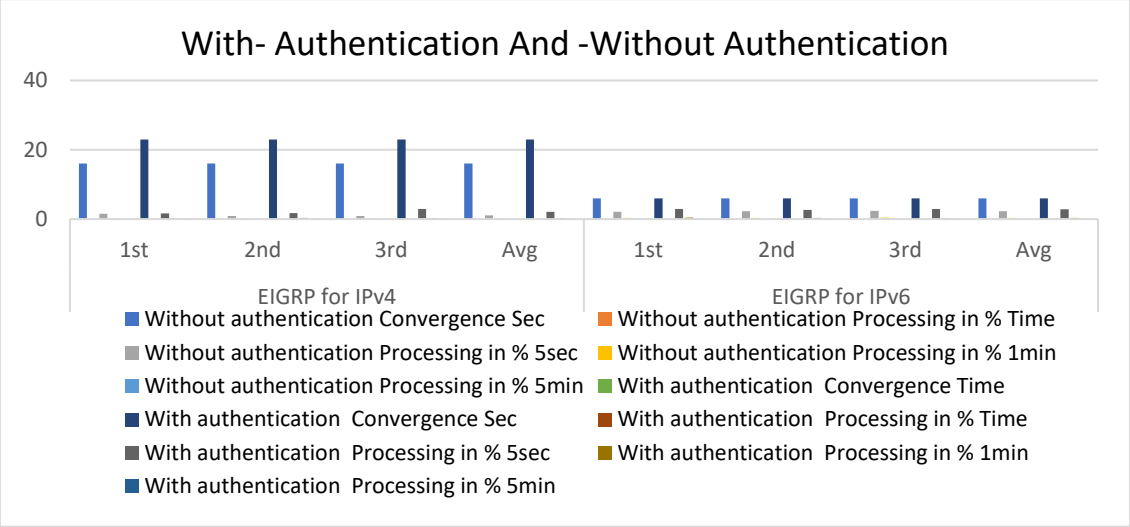

Fig 7: On Router 1 average result of Processing in % on OSPF With Authentication and Without Authentication

Fig 1: On Router 1 we found average result of Processing in % on OSPF with authentication and without authentication 1.08 for 5 seconds 0.20 for 1 min and 0.04 for 5 min while in with authentication 2.13 for 5 seconds, 0.26 for 1 min, 0.06 for 5 min and on EIGRP for IPv4 without authentication 2.24 for 5 seconds, 0.36 for 1 min and 0.10 for 5 min while with authentication 2.84 for 5 sec, 0.31 for 1 min and 0.06 for 5 min. Convergence time for OSPFv3 is 16 sec without authentication and 23 seconds with authentication while in EIGRP for IPv4 and IPv6 convergence time 6 sec with and without authentication in hierarchal environment.

B. Following is the result of Router 2:

Table 2 - Router 2 Result

Router 2	**Without authentication**					
	Convergence		Processing in %			
	Time	Sec	time	5sec	1min	5min
EIGRP for IPv4	1st	16	1st	0.79	0.2	0.05
	2nd	16	2nd	1.03	0.27	0.06
	3rd	16	3rd	1.27	0.16	0.04
	Avg	16	Avg	1.03	0.21	0.05
EIGRP for IPv6	1st	6	1st	1.71	0.12	0.03
	2nd	6	2nd	1.36	0.1	0.02
	3rd	6	3rd	1.83	0.14	0.03
	Avg	6	avg	1.63	0.12	0.02
Router 2	**With authentication**					
	Convergence		**Processing in %**			
	Time	Sec	Time	5sec	1min	5min
EIGRP for IPv4	1st	23	1st	2	0.17	0.03
	2nd	23	2nd	2.79	0.24	0.04
	3rd	23	3rd	1.43	0.15	0.07
	Avg	23	Avg	2.07	0.18	0.04
EIGRP for IPv6	1st	6	1st	2.15	0.38	0.08
	2nd	6	2nd	3.52	0.28	0.05
	3rd	6	3rd	2.43	0.29	0.06
	Avg	6	Avg	2.7	0.31	0.06

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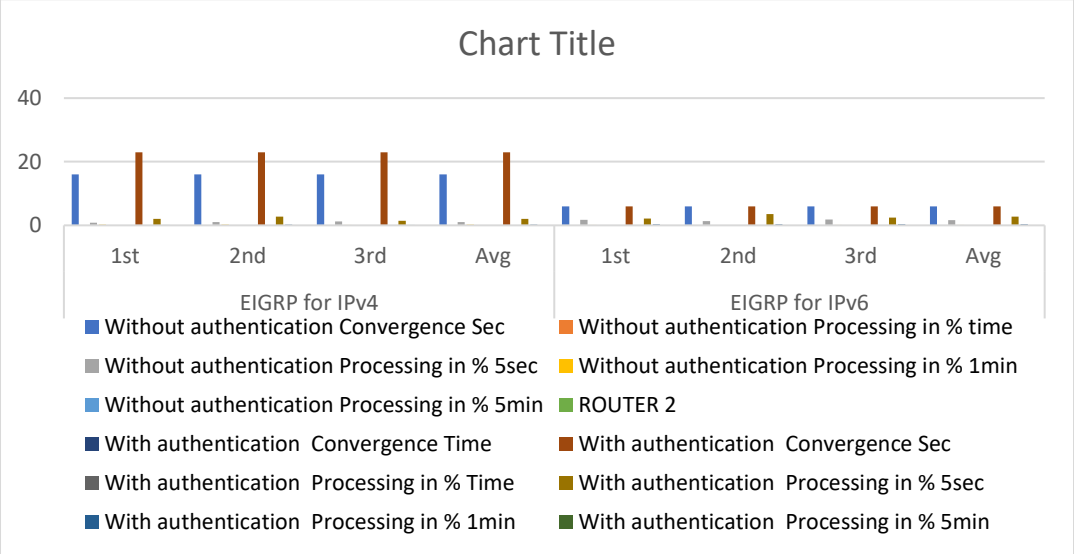

Fig 8: On Router 1 average result of Processing in % on OSPF With Authentication and Without Authentication

On Router 2 we found average result of Processing in % on OSPF without authentication 1.03 for 5 seconds 0.21 for 1 min and 0.05 for 5 min while in with authentication 2.07 for 5 seconds, 0.18 for 1 min, 0.04 for 5 min and on EIGRP for IPv6 without authentication 1.63 for 5 seconds, 0.12 for 1 min and 0.02 for 5 min while with authentication 2.7 for 5 sec, 0.31 for 1 min and 0.06 for 5 min. Convergence time for OSPFv3 is 16 sec without authentication and 23 seconds with authentication while in EIGRP for IPv4 and IPv6 convergence time 6 sec with and without authentication in hierarchal environment.

V. CONCLUSION

This research study is based on developing a test bed to achieve simulations of OSPF3 and EIGRP v6 with- and -without authentication and to compare routing performance between two in hierarchical networks scenario. As a first thing first, an overview of research methods is taken. Later, this research study related work shall serve as a guideline for the rest of the work related with this research project. On top of everything, as a second step GNS3 simulator installed. Familiarity with GNS3 is essential to achieve this research study. As a second step, a certain hierarchical routing scheme scenario will be created. Secondly, OSPFv3 and EIGRP IPv6 without authentication implemented and configured to get the required results in terms of CPU processing power and convergence time. Later, OSPFv3 and EIGRP IPv6 with authentication implemented and configured to get results for a comparison in terms of resources usage and convergence. As a final stage overall results of the research study compared to analyze the research parameters which are with and without authentication on both routing protocols. At the end of this research study, the result is drawn and presented in the thesis and a final comparative analysis presented in tabular format. In this Research study compare two parameters, CPU utilization and Processing power with and without authentication. We found that OSPFv3 uses less power as compared to EIGRP for IPv6 without authentication in hierarchal environment, but it takes more time to converge and with authentication it is also found that it ospfv3 uses less power as compared to EIGRP for IPv6 while EIGPR for IPv6 is faster than OSPFv3.

Therefore, it may be use where your need fast convergence with or without authentication in hierarchal environment, EIGRP is best solution for that while convergence is not issue than or where a low CPU power issue on same environment, OSPFv3 is better solution.

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FOG COMPUTING IN INTERNET OF THINGS

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Abstract: **Internet of Things envisions a talk able platform for heterogenous devices. It implies devices with heterogenous capabilities are communicating over a common platform. Many supporting technologies exist to complement this idea. One such technology is Fog Computing. Fog Computing indicates that there is a horizontal platform that sits between devices and the Central Cloud. This intermediary layer enhances system performance and provides immediate response to the connected modes for transactional operations, thereby reducing the network traffic that is routed towards the Cloud. This paper provides an overview of Fog Computing in Internet of Things.**

Keywords: ***Fog Computing, Internet of Things, 5G Networks***

I. INTRODUCTION

While driving and thinking about meeting in next 30 minutes at office, a thought came into your mind if you switched off heating system. IoT is where devices and systems are connected over internet for purpose of sharing and processing data. These devices and systems include simple home appliance to delicate industrial tools, where engineers control distantly. This network is becoming increasingly complex with an inclusion of more devises in network and resultantly, exponential growth in data is observed. [1].

Fog computing is a decentralized computing architecture that have data storage and processing units at edge of clouds. Fog computing can be seen as extension of cloud computing, in which infrastructure is decentralized in a way that data can be stored and processed in edges. It aims to provide faster response times, reduce network bandwidth usage, and improve the overall efficiency of data processing and storage [2].

Fog computing and IoT are closely related, as Fog computing can be used to support the processing and analysis of the massive amounts of data generated by IoT devices. Relation between IoT and fog computing reconceptualize the computing and data processing. By bringing the computing power closer to the Edge, Fog computing can reduce the latency and bandwidth required for data transfer, making it possible to process and analyze data in real-time [3].

Fog computing also enables IoT devices to operate more efficiently by offloading some of the processing tasks to nearby Fog nodes, reducing the workload on the devices and extending their battery life. This can be particularly useful in applications such as smart cities, where large numbers of IoT devices are deployed in a small area [4]. Overall, Fog computing and IoT are complementary technologies that can be used together to create more efficient and effective systems for processing and analyzing data in real-time, especially in applications where low latency and high reliability are critical [5].

The paper is structured as follows: Introduction and literature review is presented in the Section 1 and 2. The relation between the Fog Computing and IoT is presented in Section , followed by conclusion in last section.

II. LITERATURE REVIEW

A) Internet of Things (IoT)

The Internet of Things (IoT) is a term used to describe the interconnectivity of devices, objects, and people through

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the internet. The IoT is transforming the way people interact with technology, and it has the potential to revolutionize various industries. In this literature review, we will examine the current state of the IoT, its challenges, and opportunities, and explore some of the latest trends and developments in the field [6].The IoT is growing at an incredible pace. According to a report by Gartner, there will be 25 billion connected devices by 2021. These devices range from wearable technology, smart homes, and smart cities to connected cars, healthcare devices, and industrial IoT applications. The widespread adoption of IoT devices has resulted in a massive amount of data being generated every day, which has led to new challenges for organizations to process, store, and analyze the data [7].The architectural details for Internet of Things (IoT) is depicted in Figure 1.

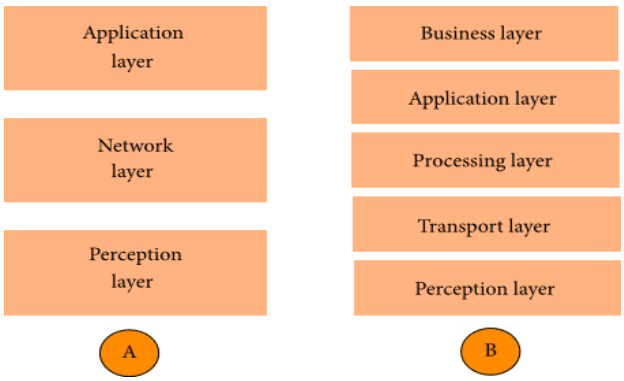

Figure 1: Layered Architecture of IoT [8]

Security in IoT is important of many challenges. The proliferation of connected devices has created a vast attack surface, making it easier for hackers to exploit vulnerabilities in the system. In addition, IoT devices are often deployed with little or no security measures, making them an easy target for cybercriminals. Another challenge is the standardization of IoT devices and protocols. With so many devices, it is difficult to create a unified protocol that can ensure interoperability between devices [9].

Despite the challenges, the IoT presents a significant opportunity for businesses and organizations. With IoT, businesses can gain valuable insights into their operations, improve efficiency, reduce costs, and improve customer satisfaction. In healthcare, IoT devices can improve patient outcomes, reduce costs, and provide better patient care. Smart cities can improve traffic flow, reduce energy consumption, and enhance public safety [10].

Edge computing is a recent development in the IoT. Instead of transferring data to a central location for processing, edge computing processes data at the network's edge, nearer to where it is generated. The amount of data that needs to be communicated across the network can be decreased, data security can be improved, and latency can be decreased [6]. The application of machine learning and artificial intelligence (AI) is a further development in the IoT. (ML). These technologies can help organizations to analyze the vast amount of data generated by IoT devices and gain insights into their operations. AI and ML can also help to improve the accuracy of predictions and automate decision-making processes [11].
The IoT is transforming the way people interact with technology and creating new opportunities for businesses and organizations. However, the rapid growth of IoT devices has also led to new challenges, including security, standardization, and data management. Despite these challenges, the IoT presents significant opportunities for organizations to improve efficiency, reduce costs, and enhance customer satisfaction. With the latest trends in edge

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computing, AI, and ML, the IoT is poised to become even more transformative in the years to come [12].

B) Enabling technologies for IoT (Internet of Things)

There are several enabling technologies for enabling IoT. Few notable ones are discussed below:

- *Wireless Sensor Networks (WSNs):* These networks are made up of low-cost, battery-powered, and wireless sensors that can be used to collect data from the environment and send it to a central location [13].
- *RFID ("Radio Frequency Identification")* technology*:* This technology uses radio waves to identify and track objects in real-time. RFID tags can be attached to objects, and the information they contain can be read remotely [14].
- *Cloud computing*: This technology provides a platform for storing, processing, and analyzing large amounts of data from IoT devices. It enables real-time data processing and analytics, making it an essential component of IoT [3].
- *Edge computing*: This technology makes it possible to process and analyze data closer to the devices that are producing it, at the network's edge. This makes it excellent for Internet of Things applications by lowering latency and bandwidth needs. [4].
- *Big Data Analytics*: This technology involves the use of advanced analytics tools and techniques to process and analyze large amounts of data generated by IoT devices. It enables real-time decision making and provides valuable insights into customer behavior and preferences [15].
- *Artificial Intelligence (AI):* AI algorithms can be used to analyze data from IoT devices and make predictions based on the data. It enables predictive maintenance, anomaly detection, and other intelligent applications [13].
- *Blockchain technology*: Security and transparency is of great importance in storing and sharing data. Blockchain technology assures security while storing and sharing data in computing structure. It enables secure transactions, data sharing, and identity verification [2].
- *5G Networks*: With the use of this technology, data may be processed and analysed closer to the sources of the data, at the network's edge. This is perfect for IoT applications since it lowers latency and bandwidth needs. It also enables the deployment of IoT devices in remote areas where traditional connectivity is not available [15].

These enabling technologies have a vital role in the development and deployment of IoT applications. By leveraging these technologies, organizations can build innovative solutions that improve business operations, enhance customer experiences, and drive growth.

C) Fog Computing

According to authors [16],Fog is a node closer to the source, which can improve latency, reduce bandwidth requirements and enhance the overall efficiency of distributed systems. The architectural details for Fog Computing are given below in Figure 2.

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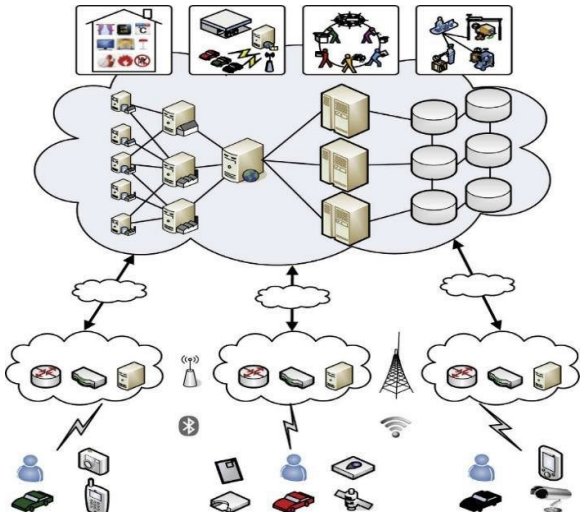

Figure 2: Three Layered Approach to Fog Architecture [17]

However, like any technology, Fog computing has its own set of challenges that need to be addressed to ensure its successful implementation. Few notable challenges are mentioned below:

- *Security*: One of the significant challenges [16]in Fog computing is security. In Fog computing, data is processed and analyzed at the edge, which means it is closer to the source and potentially more vulnerable to security breaches. Fog nodes, gateways, and sensors are susceptible to cyber-attacks. To secure the Fog computing environment, it is crucial to implement robust security measures at the edge devices and gateways. This includes securing data transmission, securing the hardware and software, ensuring the authenticity of the fog nodes and gateways, and protecting against malware and cyber threats.
- *Resource Management*: Another significant challenge in Fog computing is resource management. Fog nodes have limited resources compared to cloud servers, which makes it challenging to run complex applications on them. The lack of processing power, memory, and storage can make it difficult to handle data-intensive applications, leading to performance issues. To address this challenge, Fog computing requires efficient resource management techniques that can allocate and utilize resources effectively. This includes dynamic resource allocation, load balancing and task scheduling [15].
- *Interoperability*: Interoperability is another significant challenge in Fog computing. Fog nodes, gateways and sensors are often developed by different vendors, using different technologies and standards. This can create compatibility issues that can hinder the seamless operation of the fog computing environment. To ensure interoperability, Fog computing requires standardized protocols and interfaces that enable different devices to communicate and exchange data seamlessly [14].
- *Scalability*: Fog computing needs to be scalable to handle the growing demand for computing resources. As more devices are connected to the network, the volume of data generated increases, and the demand for processing power and storage capacity increases as well. To address this challenge, fog computing requires scalable architectures that can add and remove nodes dynamically and can scale up or down according to the demand [14].
- *Privacy*: Privacy is another significant challenge in fog computing. Fog computing involves processing and analyzing data at the edge, which can raise privacy concerns. The data collected by the sensors and devices at the edge can be sensitive and personal, and its analysis can reveal sensitive information about

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individuals or organizations. To address this challenge, Fog computing requires privacy-preserving techniques that can protect the confidentiality of data while still allowing analysis to be performed [5].

Fog computing is a promising paradigm that can enhance the efficiency and performance of distributed systems. However, it is not without its challenges. Addressing these challenges requires a concerted effort from researchers, developers, and policymakers to develop robust security measures, efficient resource management techniques, standardized protocols, scalable architectures, and privacy-preserving techniques. By addressing these challenges, Fog computing can unlock new possibilities for the Internet of Things, smart cities, and other emerging applications.

III. FOG COMPUTING AND IOT

I. *Fog Computing as an Enabling Technology for Internet of Things*

Fog computing is a new approach to processing this data that is designed to take advantage of the growing network of edge devices in the IoT. Rather than sending all of the data generated by these devices to a central server or Cloud for processing, Fog computing distributes the processing across multiple Edge devices [18].

The benefit of fog computing is that it can lessen the quantity of data that needs to be transferred across the network, hence lowering latency and enhancing performance. As a result of the ability to process data locally on Edge devices, it can also assist in lowering the cost of data transmission. [12].

Fog computing and the IoT are both part of a larger trend towards distributed computing and Edge computing, which are changing the way we think about computing and data processing. As these technologies continue to evolve, they are likely to have a significant impact on a wide range of industries, from healthcare and manufacturing to transportation and energy [3].

Fog Computing and the Internet of Things (IoT) are two rapidly growing areas of research and development that are transforming the way we collect, process and analyze data.

II. *Their Complimentary Role*

One of the characteristics of the Cloud Computing is global centralization having single server. Low latency restricts many IoT applications, for instance video surveillance. Localization in fog computing enables low latency. Both localization and globalization, in fog computing and cloud computing respectively, are necessary for many applications, especially those involving analytics and Big Data. This topic was raised earlier in relation to smart traffic lights. Here, we focus on Smart Grid, whose data topologies provide as additional examples of this interaction.

The data produced by sensors at girds and devices is received by fog collectors placed at the edge. Some of this data refers to real-time processing-required protection and control loops. (from milliseconds to sub seconds). The data is gathered, processed, and control orders are sent to the actuators by the first tier of the fog, which is intended for machine-to-machine (M2M) communication. Additionally, it filters the data for low-level consumption and transfers the remaining data to higher tiers.

The second and third tiers cover systems and procedures, as well as visualization and reporting (human-to-machine [HMI] interactions). (M2M). These interactions, which are all a part of the Fog, occur at timescales ranging from seconds to minutes (real-time analytics), and even days. (transactional analytics). The Fog must therefore accommodate a variety of storage types, ranging from ephemeral at the lowest rung to semi-permanent at the highest tier. We also see that the geographic coverage is bigger and the time scale is longer the higher the tier.

The Cloud, which is utilised as a repository for data with a permanence of months and years and which serves as the foundation for business intelligence analytics, offers the most comprehensive, global coverage. This is an example of a dashboard or report in an HMI environment that shows key performance indicators.

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The statistics below demonstrate the importance of Fog computing and the IoT and their potential to transform various industries. They also highlight the challenges and opportunities associated with these technologies, and the need for continued research and development in this field [19].

III. Recent Statistis

There are several statistics and reports that indicate that Fog computing is one of the key enablers for IoT. Here are a few:

- The global market for fog computing is anticipated to increase from USD 22.8 billion in 2019 to USD 92.4 billion by 2024, at a Compound Annual Growth Rate (CAGR) of 32.2% over the forecast period, according to a Markets and Markets analysis. This growth is attributed to the increasing demand for real-time computing for IoT applications [20].
- A survey conducted by Gartner in 2019 found that 75% of IoT projects are expected to include Edge computing and Fog computing by 2022. This indicates that organizations are increasingly recognizing the importance of fog computing in enabling IoT applications [21].
- A report by Grand View Research found that the use of Fog computing in IoT applications is expected to reduce network latency by up to 95%. This can significantly improve the performance and reliability of IoT applications, making them more suitable for real-time use cases [9].
- A survey conducted by Forbes in 2019 found that 72% of organizations believe that Fog computing is essential for IoT applications. This indicates that fog computing is widely recognized as a key enabler for IoT [22].

Overall, these statistics indicate that Fog computing is a crucial technology for enabling IoT applications. Its ability to provide real-time computing, reduce network latency, and improve the reliability of IoT applications makes it an essential component of the IoT ecosystem [23].

IV. CONCLUSIONS

This paper presents an overview of Internet of Things and its association with Fog Computing. The paper covers the importance of Fog computing and provides valid statistics to prove the fact that Fog computing will be one of the defining technologies in the Future. The paper also discusses the challenges faced by the Fog Computing paradigm and those faced by IoT. Major challenges faced while envisioning IoT can be successfully resolved by implementing Fog Computing.

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CHIEF EDITOR'S NOTE

Dear Readers,

On behalf of the Board of PJETS and editors, I am glad to present the Volume 10, Issue 1 of the journal. The journal, established in September 2011, has now published 19 issues; two issues in a year. The journal is now getting indexed in many research and academic indexes.

The mission of PJETS is to provide a platform to the researchers, faculty and students to spread their findings. The main goal is to link authors from different professions, for example academia and non- academia in particular and encourage them to share their research. We fortunately succeeded in developing a new editorial review board comprising of reputed scholars and researchers national and international level, from academia and non-academia.

I take this opportunity to thank the authors for sending their manuscripts for review and publications in PJETS. The reviewers' contribution to publish quality research in PJETS is very much appreciated. We are expanding our editorial board for addressing the gaps and further enriching this journal.

Dr. Muhammad Abbas