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BIM for Design Optioneering: An Approach to Future-Proofing Commercial Buildings

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Abstract: ***With the increase in the population and the increasing demands of the people, it has become necessary to plan the building that will fulfil the needs of the people. Future proofing is a concept where one has to make certain changes to amend the needs in the future. In a relation to a building, future proofing is making the building to meet the maximum limit of its whole-life to adapt the unforeseen and the on-going changes. BIM being the most advancing platform for making it easy to plan and design a structure keeping in mind all factors necessary. This research was conducted to take a step in making the commercial building future-proof. For this purpose, the main topics that were taken into considerations were refurbishment in terms of new needs of the people, flexibility which indulges changes to meet the modernization needs and climate adaption. The space efficiency of the building is also taken into account and a building was designed using the Autodesk ReVit tool, a tool from the BIM platform***
Keywords- Refurbishment, Flexibility, space-utilisation, Design Optionnering

I. INTRODUCTION

People involved in the construction industry are being challenged to deliver successful projects even due to the issues of tight budgets, limited manpower, busy schedules, and limited or changing information. The most important disciplines such as architectural, structural and MEP designs have to be well coordinated, as two things can't work at the same place and time. Building Information Modeling aids in fender-bender recognition at the initial stage, identifying the exact location of discrepancies.(Smith, 2007) describes BIM as a concept which forms a mental picture of virtual construction of a building before its actual physical construction, in order to reduce uncertainty, improve safety, work out problems, and intimate the presence of and analyze potential impacts. Sub-contractors from every trade can input critical information into the model before beginning of the construction, with opportunities to pre-fabricate or pre-assemble some systems off-site. Waste can be minimized on-site and products delivered on a just-in-time basis rather than being stock-piled on-site.

Quantities and properties of materials can be extracted easily. We can easily deal and define the scope of the work. Systems, assemblies and sequences can be shown in all together with the entire facility or group of facilities. BIM also prevents errors by enabling conflict or 'clash detection' whereby the computer model visually highlights to the team where parts of the building (e.g.: structural frame and building services pipes or ducts) may wrongly intersect.

According to (Flager D. J., June 2011) Design Optioneering methodology is intended to offer multidisciplinary design teams the potential to systematically explore a large number of design options much more rapidly than currently possible using conventional methods. Design Optioneering involves first defining a range of design options using associative parametric design tools; then coupling this model with integrated simulation-based analysis; and, finally, using computational design optimization methods to systematically search though the defined range of alternatives in search of design options that best achieve the problem objectives while satisfying any constraints.

The literature survey is discussed in section II, Section III proposes mathematical model of the problem, Section IV discusses proposed system and section V discusses conclusion and future work.

II. LITERATURE SURVEY

BIM is a set of software; it has 3D models, and data bases. A typical BIM model is a model of an actual building which consists ofthe computer-generated elements of the model of the actual building or the physical building itself. This enables to understand thebuilding before commencing the construction of it. The information obtained from this model helps in calculating the cost of the project, management of the cost, the man power requirement, the clarification and the impact on the schedule and also the materials

that would be necessary for construction. And this model can also be used in modifying the total cost of the project.

(Hergunsel, 2011) Defines BIM as "The Building Information Model is primarily a three dimensional digital representation of a building and its intrinsic characteristics. It is made of intelligent building components which includes data attributes and parametric rules for each object."

(Andrew Reding, July 2014) has defined BIM as "A digital representation of the physical and the functional characteristics of a building. As such, it serves as a shared knowledge resource for information about a building, forming a reliable basis for decisions during its life cycle from inception onward."

A. Design optioneering

To understand the concept of designing optioneering, what does optioneering mean?

OPTIONEEERING = 'OPTION'+ 'EERING'

Optioneering is a process implemented when alternative or competing need to be explored rapidly for the most viable solution to a complex problem. This process is usually based on multiple criteria. Hence it is a form of value engineering. Value engineering is referred to "value management" or "value methodology" (VM), and "value analysis" (VA). Value engineering is a structured problem-solving process based on function analysis - understanding something with so much of clarity that it can be described in two words, the active verb and measurable noun without shortening the meaning of the same. For example, the function of a pencil is to "make marks". This then helps in considering what else can make marks. From a paint brush, mascara, a diamond on glass to the marks in the sand by the stick, one can then clearly decide upon which alternative solution is most appropriate. Most commercial and open source [6] platforms are developed for Cloud monitoring as well as services are developed so that it can help Consumers to assess the performance and the reliability of Cloud services.

B. In use flexibility

Flexibility is the possibility to adjust policy at its various design, implementation and delivery stages to make it better adapted to local contexts, actions carried out by other organisations, strategies being pursued, and challenges and opportunities faced(Giguère and Froy, 2009, pp. 13-14). The concept of flexibility is often used in the architectural fields. However, it is invariably the facilities management profession that inherits the building solution; it is these professionals who incur the end results of inflexible or flexible solutions. In this respect, buildings are not one-shot products, but an evolving solution. A flexible building design is the one that can adapt in response to changing changes(Hahn, 1990). But in case of commercial building spaces should be flexible enough to accommodate organization change. Moving organizations and the changing amount of floor and space used, is expensive and also cumbersome. Thus, existing spaces should be both expandable and also contractible, and the means for distinguishing types of flexibility are needed. A building may have three flexibilities:

Service flexibility which is important to the users of the building,(Heikkila, 2008)

Modifiability which interests the owner specially,(Heikkila, 2008)

Long-term adaptability is the key factor especially for the urban structure and the cultural environment.(Heikkila, 2008)

Transformability.

C. Refurbishment

Building refurbishment describes activities ranging from minor works to replacement of services and cover-ups, which alter the interior and/or exterior of a building but fall short of demolition and rebuilding. There is andesire for refurbishment in the current economic climate owing to the financial advantages / time savings of refurbishment compared to building new. An estimate was done for the current redundant office space in United Kingdom(Hergunsel, 2011) much of which was constructed between 1960s and 1980s. These buildings have potential to meet the standards required in 21st century, if refurbished in correct manner. Using jobless office building and converting them into flats, hotels or student accommodations; this scheme is gaining rapid interest. The technical details of the replacement or refurbishment of building services and the structural modifications are to be considered that are commonly encountered during the refurbishment of concrete buildings. It explains need to refurbish, condition surveys, relation between structural and services work, refurbishment options, modification options to illustrate feasibility of the considered options. The refurbishment market is as huge as new build market and is predicted to grow faster. Approximately 10% of office space is refurbished in some way every year. The increasing importance of optimization of business space and environmental conditions within it has raised the level of refurbishment making it as a profession.

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D. Life cycle assessment (lca)

The embodied energy and carbon of a building are one part of the overall energy and carbon of the building, measured over its complete life (life cycle). So it is important, firstly, to introduce the terms energy and carbon, and then describe the concept of life cycles and their assessment, before discussing in more detail embodied energy and carbon.

E. Efficiency and effectiveness

It is seen that there is a limited and also a confused understanding in the concepts of the terms effectiveness and efficiency in the areas of planning and designing, despite both being well urbanized and treated in a modern-day literature. Conceivably the reason for this situation could be because efficiency and effectiveness have not been defined or differentiated in a more disciplined manner, also because there is yet to be a definite systematic approach to appraise efficiency and effectiveness. The statement that architectural facilities space and design outcomes are efficient or effective appears to be derived, unreservedly or clearly, by the very restrictive phenomenon such as comfort, aspect and aesthetics. It is observed that the concepts of efficiency and effectiveness have not been clearly understood in architectural facilities space planning and design, even when both are well developed. Quite often, the methodologies used to examine the concepts are not the most appropriate (Keogh and D'Arcy 1998) because the terms efficiency and effectiveness have not been defined and differentiated by disciplines, there are no definite objective steps evolved as yet to interpret or measure these two terms in architectural facilities space planning and design and consequently when compared with other dispensations, the concept of efficiency and effectiveness have not been sufficiently captured and exploited in the process. Apart from these dimensions, the objective of efficiency in space planning and design is to maximize the available space for core functions while minimizing it for marginal or the non-core functions. Non-core functions spaces are the areas that mainly include circulation, partition, and column locations and such other spaces that facilitates or support operations. Thus we can say that the core functions space is the total space available or the area minus non-core functions spaces. On the other hand, the effectiveness objective of space planning and design is to make sure that the available space is ready to use for the performance of the desired core functions, with minimum limitations but maximum facilities by the non-core functions.

F. Revit

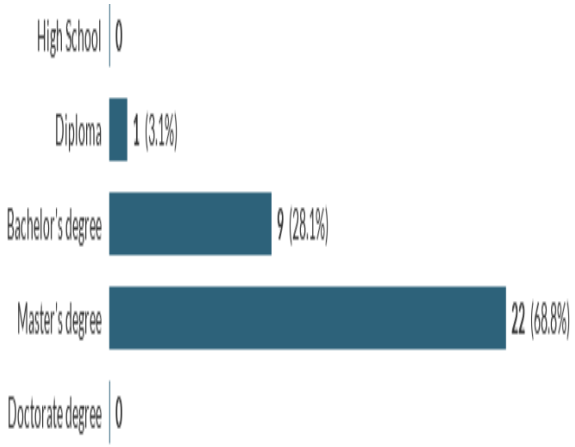
Revit is considered as one of the best-known and also the present market leader for BIM in architectural design. This platform was first introduced to the market by Autodesk in the year 2002. Revit is a family of integrated products that presently includes Revit architecture, Revit structure, and Revit MEP. Revit is a tool that provides an easy way to use interface with drag-over hints for each operation and smart cursor. It has one of the largest set of associated applications including; Facility Management: AutoDesk FM Desktop, Archibus (IFC).

III. DATA COLLECTION AND ANALYSIS

The following section contains the analysis of the results that were obtained including the descriptive method of analysing the data, the information obtained. Here the questions from the survey will be outlined and also containing the data found.

A. Data collection: Questionnaire data

Question 1: What is your highest qualification?



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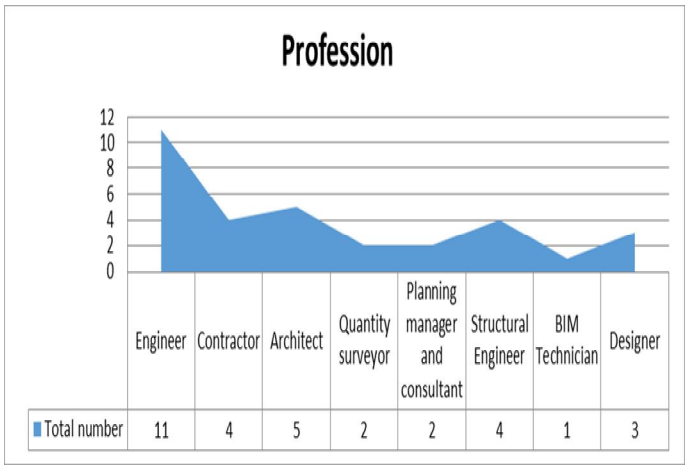
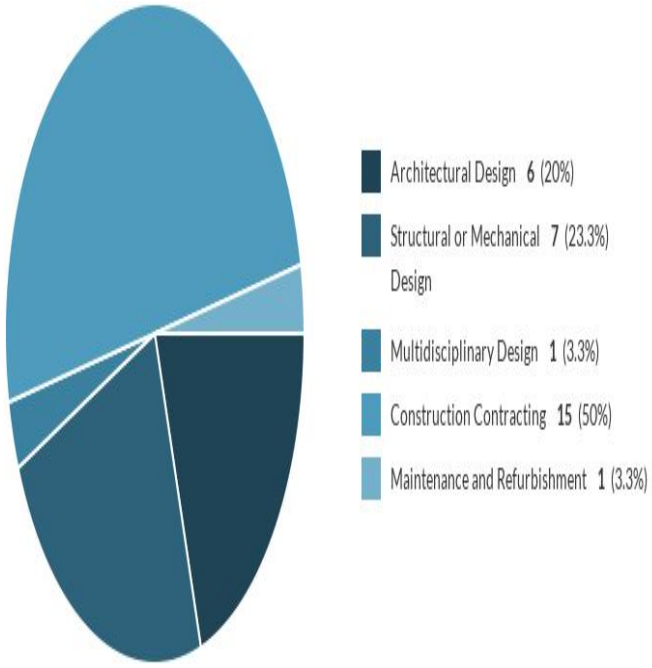
Question 2: What is your profession?



Question 3: What kind of organization do you work for?

The question was designed to know the type of the organization do the respondents work. This could give an idea of what people working in different organization think.



Question 4: How long have you worked in this field?

Different people have different work experiences. The experience varies between one to nine years and above. Most of the respondents have a work experience minimum of one year and maximum three years and these people account for 41.9 percent of the total number. Respondents having work experience between three to six years are about 35.5 percent of the total number. The number goes on decreasing with increase in number of years. 16.1 percent of the respondents have work experience of six to nine years in this field. Merely 6.5 percent of people have worked for more than nine years in this field. It is seen that vey less number of people have noticeable work experience in this particular field.

Question 5: Do you consider Refurbishment important? Why?

When people were asked to answer this question, majority of them reverted back with a yes. The responses of the people varied from person to person. The number of people the ones who gave the reason that refurbishment is important because it is cheaper option as compared to other development options.

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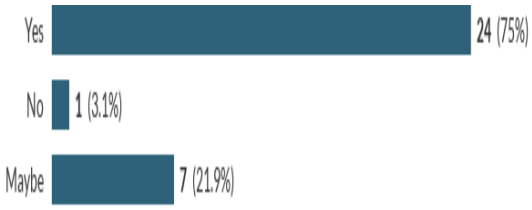
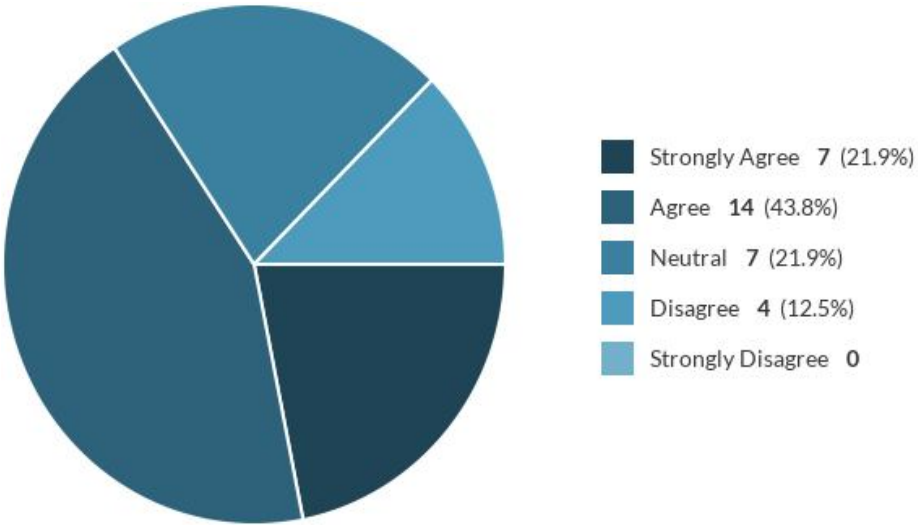
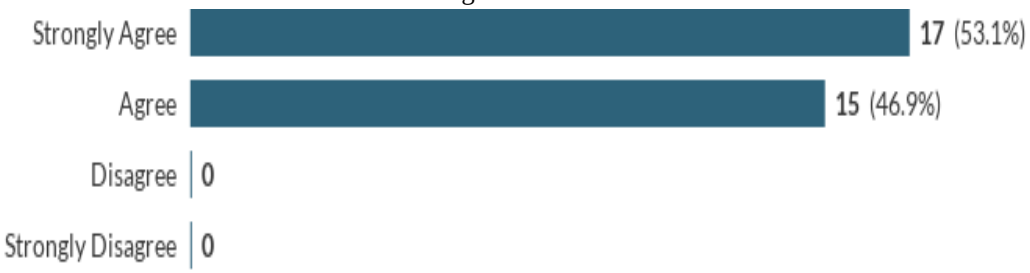
Question 6: Refurbishment is a cost effective option for old buildings.



Question 7: Refurbishment is better alternative than redevelopment.



Question 8: Flexibility is essential for a modern commercial building



Question 9: A flexible building would save cost and time during refurbishment

Question 10: Why, according to you, should a building be flexible?

Response of the people differs according to their different views and opinions. A building should be flexible so that it can be moulded for different uses. This will allow for multiple uses in future.

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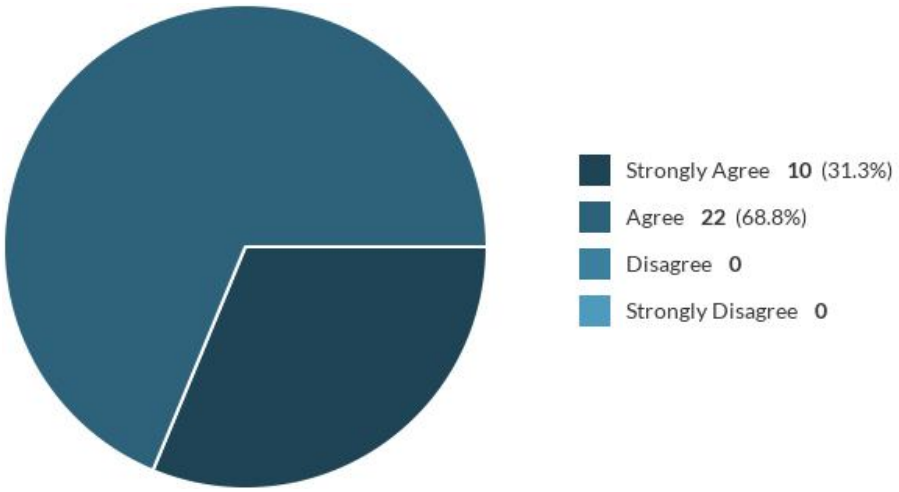
Question 11: What are the characteristics of a flexible commercial building?

An ideal flexible commercial building has all the characteristics which it should possess. In the survey conducted people gave different responses. Many of them said that the main characteristic of a flexible commercial building is that it can adapt to and changes that are made to it in short term as well as in long term span.

Question 12: Do you think that the changes in the occupancies for future use should be considered during the design phase?

Question 13: Designing a flexible commercial building can be a cost-effective option when refurbishing the building in future.



Question 14: What makes a commercial building efficient (in design)?

Indeed all the efficiency factors play an important role in making a commercial building efficient. But different people have different opinions about it. Some say that cost minimization makes it efficient. It is not the main factor that makes a structure efficient. A good prediction about its future needs beforehand helps making a structure efficient. Along with this its ability to meet the needs of variety of types of accommodations plays important part.

Question 15: What makes a commercial building effective (in design)?

An effective commercial building is the one which can be used to its most at one time that is one that is used for number of purposes at same time.

Question 16: How do you think a commercial building can be made future proof?

Future proofing of a building is very important issue in today's world and it has been since long time. A commercial building can be surely made future proof. Some said that by considering sustainable design techniques and proper designing the proofing of a commercial structure can be done easily.

Question 17: In what ways can a commercial building designed to adapt to climate change?

Adaptation to climate change is an important thing a building's characteristics should possess. One of the ways that was seen esponse was to consider the climate of the area to its extreme limits to check the design sustainability.

Question 18: Would a commercial building of today be fit-for-purpose in 50-100 years?

Some people clearly say that today's buildings are fit-for-purpose in long term span. Some say that if the risk assessment is proper and sustainability and framework is proper than it can be said fit.

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IV. PROPOSED SYSTEM

A. System Overview

For developing the demand of heavy automation, this framework mainly deploy products in cloud based environments which involves the management of various aspects of cloud resources along with development of the automated components for managing operational aspects of cloud. This operational aspects are the recovery, backup, patching, installation and upgradation of softwares.

B. Contruction of the scheme

Cloud computing enables companies to consume resources on-demand as a utility just like electricity instead of building and maintaining computing infrastructures in-house. This is due to a number of technical reasons, that includes improvement of energy efficiency, optimization of hardware and software resources utilization [4], elasticity, performance isolation and on-demand service schema as well. Provisioning resources on public cloud providers like AWS is click-easy unlike traditional cycle of securing budget, procurement, setting up your environment through physical assets, testing and then releasing infrastructure for use. This is significant saving of manpower and time. Cloud providers such as AWS provide high availability, speed, scalability and security for your environment.

Also, organizations need to pay for the amount of storage[11] they are actually consuming or amount of time the infrastructure is used, and all this without the worries of upgrades or availability of hardware and cost commitments. Although, there are a lot of benefits of using infrastructure provided by AWS, any organization utilizing it for hosting needs to automate and manage various operational aspects such as backups, recovery, security, installation / upgrade or removal of software, manage inventory, monitoring and alerts, cost etc. Ansible is a Python based IT automation tool that enables such automation with its modules that can be extended or integrated as needed.

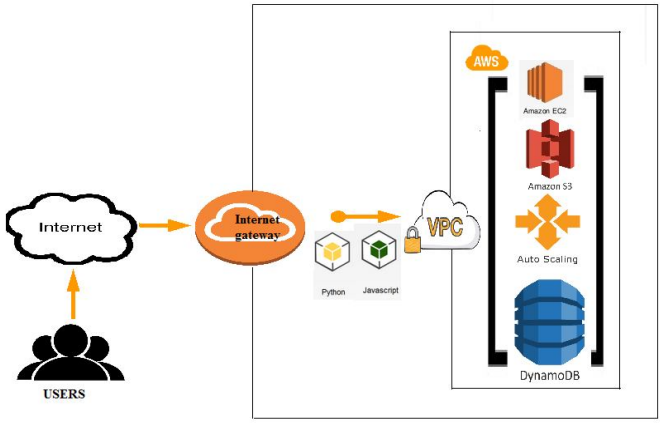

Fig.2. Architecture of system

As Ansible is Python based, it can integrate with AWS using BOTO APIs to manage AWS resources and UI can be developed to render infrastructure aspects in a presentable way and achieve click to complete deployments/monitoring. Boto is a Python package which provides interfaces to Amazon Web Services [12]. Boto supports various services provided by AWS like EC2, S3, Autoscaling, DynamoDB, Elastic load balancing, etc. Amazon EC2[13] (Elastic Cloud Compute) eliminate the need to invest in computing hardware up front which saves money. EC2 is use to launch virtual machine and also can configure all of the associate security and networking setting. Amazon EC2 is a virtual environment called as “instance”. Instance type have wide range varying as CPU power, amount of money, storage size and networking capacity. Amazon S3[14] (simple storage service) is mainly used for storage.

It is safe, secure, highly scalable object storage mainly use to store and retrieve any amount of data at anytime from anywhere on web. Amazon S3 provide standards-based REST and SOAP web service API. Amazon ELB (Elastic load balancing) automatically distribute incoming web traffic across multiple EC2 instance. If any one instance fail, ELB automatically redirect traffic to another running instance. Amazon DynamoDB is a fully managed NoSQL database service. The research work will involve developing UI

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based automation for provisioning EC2 instances and other related aspects and collecting its information for monitoring/tracking. It will also involve developing automation for viewing information of snapshots and volumes attached to EC2 instances and scheduling backups using cron.

C. Methodology

Methodology for solving a problem of various aspects for managing cloud resources in cloud based environments like automated deployments, backups, monitoring, restore are as follows:

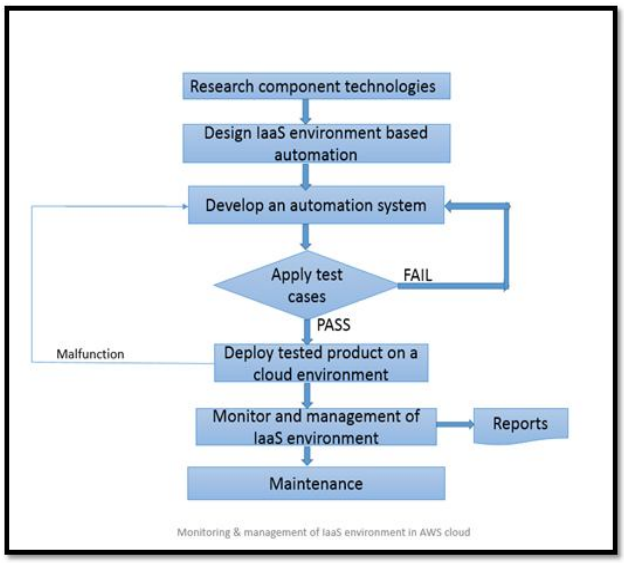

Fig.3. Flow of system

Phase I: Design and develop AWS environment based automation-

This phase involves development of IaaS environment based automation using various technology like python, ask, JQuery, Angular JS and Unix OS. Using different test cases, developed automation will be tested and accordingly modifications will be carried out. Further tested product will be deployed on a cloud based environment to manage various areas of cloud resources such as automated deployments, monitoring, backups, restore and retention.

Phase II: Monitoring and managing AWS based environment-

This phase will focus mainly on Monitoring and managing of IaaS environment such as monitoring of physical hardware resource, monitoring of storage resources such as available storage memory and CPU, Altering and notification of automated system. This all monitoring operations will be carried out on AWS cloud architecture. AWS provides services like Amazon EC2, Amazon S3, Amazon CloudWatch, Amazon CloudFront and so on. This infrastructure service can be manage and monitor using BOTO API's through Python based tools such as Ansible which can be use as front end with user interface.

V. EXPERIMENTAL SET UP AND IMPLEMENTATION

For such management of cloud platform, PyChrm IDE is used for python programming. Until now backup scheduling is performed and their frequencies are stored in database using cron functionality. Addition of new deployment is done along with the creation of new customers. The performance parameter can be considered in this system as storage space, efficiency and metadata overhead.

VI. CONCLUSION AND FUTURE WORK

The proposed web based cloud manager framework represents a practical approach to easily adopt the IaaS model based services. It mainly focuses on how cloud computing can adopt the IaaS environment in a cost effective way. Various AWS resources like Amazon S3, Amazon EC2, Amazon EBS, Auto Scaling, Amazon SQS, Dynamo DB are studied.

Our proposed scheme develops automation of cloud for operational aspects which will reduce manual overhead management of numerous resources in cloud. It provides benefits such as minimization of human intervention. Various areas of managing cloud

resources such as automated deployments, backups, monitoring, restore and retention are focused.

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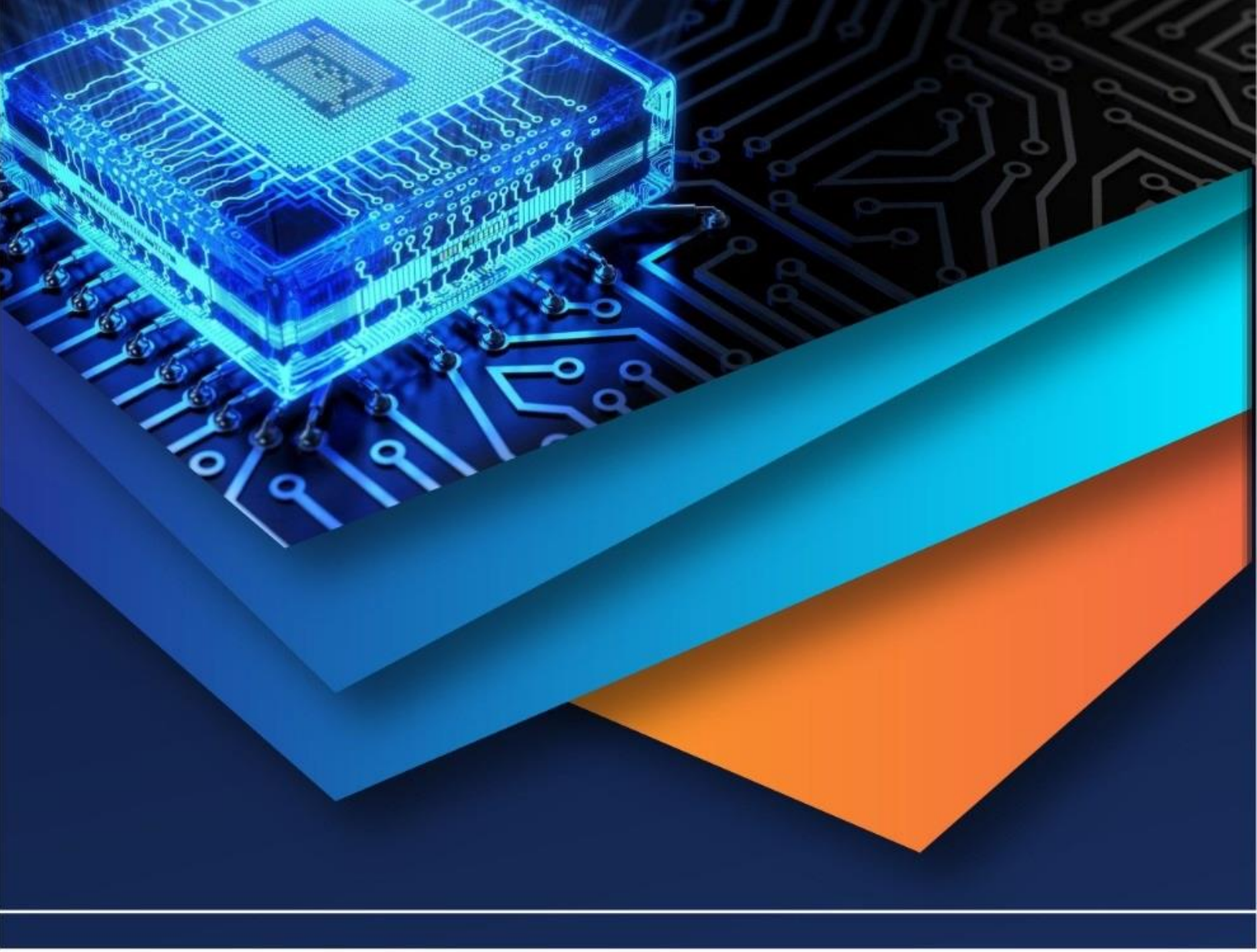

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