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Ontology-Based Approach of E-government for Interoperability

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Abstract: ***There is a need for the exchange and sharing of knowledge between the department of government in the e-government system. Therefore, this paper 'Ontology-Based Approach of E-government' will discuss the scope of interoperability. With the e-government ontology, there will be proper semantics by using web ontology language (OWL) which helps to give clearer relation and semantics. To have an ontology, knowledge management is important and architecture/framework design is essential. The development of the e-government system is to serve citizens and organizations. However, e-government systems with heterogeneous database and distributed in nature have made difficult to integrate or interoperate. Therefore, developing a knowledge base (KB) is the major task that e-government focuses on. With KB definition and description, it will ensure clarity about e-government services. Knowledge management is important for e-government and the use of ontology is an effective way in semantic technologies. This ontology will enhance the processing of services and data between different departments in government. This kind of ontology will give a common understanding of knowledge and interoperability between the different departments of government. It will also offer effective and efficient value towards the e-government services by which citizens will be benefitted eventually.***

Keywords: Heterogeneous Database, Interoperability, Knowledge Base (KB), Semantics, Web Ontology Language (OWL)

I. INTRODUCTION

The role of government is to provide services to the citizens and for e-government services, it includes collecting data and sharing data with the public. The best way to offer services is having e-government by using an application system or information system. There were many systems developed in different departments which resulted in heterogeneous database schema in government, and it was hard to interoperate [2] [4]. Heterogenous databases in government led to the redundancy of data and the challenging to integrate data and process data inside and beyond the department. Systems that were developed for public services were representing the same concept utilizing different terms due to the unavailability of shared knowledge [4]. Hence this kind of heterogeneous system leads to inconsistency. Therefore, it is necessary to have ontology so that common understanding is there among government departments and improve services with interoperability. For the above explanation, this study will discuss some ontology approaches of e-government to offer efficient and effective service and interoperability between the different departments of government. At last, this study will show a common understanding of knowledge management and appropriate architecture/framework design of e-government.

Table 1. Main differences between government and private sectors

	Private sector	Government sector
Success indicator	Based on profit	Based on service quality
Expected openness	Low	High

Above table 1 illustrates both private and government use data but they are different in terms of two parts such as success indicator and openness of data. For the success of the private sector, it was determined by profit and for the government, it was determined by service quality felt by the public. For the openness of data, the government share data and should be open data for better services wherein private sectors produce data depending on their requirement and are a closed system. Therefore, government data being open can enrich transparency and interoperation between government sectors.

A. Background on Ontology and Interoperability

In simple words, ontology can be defined as a basic term, relations, and rule of a concept and interoperability is the capability to exchange and utilize information without human interference. When it comes to knowledge management, an ontology is the proper arrangement of a shared conceptualization [8]. The role of ontology is to obtain knowledge in related areas and give a common understanding of knowledge in that area. So common vocabulary with correct description or meaning of terms will be created by ontology. Therefore, ontology can help in interoperability where sharing and reusing of knowledge between heterogeneous systems and inferring knowledge will be improved. Nowadays many ontologies reuse the other ontologies which are already created and validated.

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B. Ontology of E-Government

The objective of e-government ontology is to share terminology which depicts government essential services. The services operate according to the service logic and government [10]. The service must have input, output, and have a relation with other services logically. E-government systems have the rule to follow, and ontology design is concern about the constraint after having class, properties, and logical relation and its rule can change the input and output.

II. ONTOLOGY: E-GOVERNMENT DOMAIN

A. Ontology Of Knowledge Representation For E-Government Domain

In every government, it is found that there are many sections or departments where there are heterogeneous and distributed information systems with no proper knowledge representation. This has become a challenge for interoperability and integrating heterogeneous data sources [11]. Semantic interoperability allows sharing and interaction of information faster and makes it efficient to perform services. Therefore, for interoperability ontology is required to have common knowledge and semantic technologies to enrich data and services. Ontology will help in the exchange of information to be understandable and interpretable. Nevertheless, developing such an ontology that represents a knowledge base needs a deep understanding of e-government services and domain experts. Furthermore, it requires appropriate tools and methods of semantic technology. Ontology can be developed to represent the e-government knowledge of different departments and to reduce the time and cost of development, existing ontologies can be reused.

B. Semantic Technologies for Knowledge Base

Semantic web was introduced by Tim Berneers-Lee, with a vision of an advanced web where information has a well-defined meaning. An ontology represents the foundation of Web semantic [1]. With ontology, the knowledge base is created for any domain and the common understanding is developed for better interoperability.

Why do we need semantic technologies to build a KB?

Nowadays, most people use web applications for services that is why many e-government information systems are developed or published. These e-government systems are developed without semantic technology where there is heterogeneity issue which makes the automatic use of services difficult. Thus, ontology will help to capture the needed information for services and build the knowledge base for e-government.

C. Ontology Representation Language - Web Ontology Language (OWL)

The language is based on XML where Resource Data Framework (RDF) / RDF Schema, Web Ontology Language (OWL) [7], and SPARQL [9] are used.

OWL is created by World Wide Web Consortium (W3C) for managing information on the web [11]. OWL is built on Resource Description Framework (RDF) and written in XML. With OWL automatic reasoning is stronger because of complete information and logic relation. In OWL, object-oriented style is applied such as class and property, and illustrates the relationships between classes and properties. OWL has three sublanguages: OWL Lite, OWL DL (includes OWL Lite), and OWL Full (includes OWL-DL) [6].

Web Ontology Language is used to design and develop ontology and its components are as follows:

1) *Class or concept*
2) *Instance or individual*
3) *Relation or property or attribute*
4) *Axiom or constraint or rule*

D. The Role of Ontologies on the Web

Ontologies shares a common understanding of a domain which led to semantic interoperability. It helps to overcome differences in vocabulary and map between ontologies. Ontologies are helpful for the organization and navigation of websites and improving the accuracy of web searches by looking for the pages that relate to the exact concept in an ontology.

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III. RELATED WORK

A. Application of Moroccan E-government

Achieving interoperability was challenging and the Moroccan e-government suggested a model which aims to build a knowledge base [3]. The model follows three steps:

1) Transformed the services to web services since many services did not use web service technology. The model proposes to identify essential services and necessary information. For that, the government gathered and integrated information from citizens and departments.
2) Developing ontologies was focused on organizational, legal, and domain ontologies. At first, organization and legal was carried out to enhance knowledge that depicts the Moroccan government. Secondly, after the definition and knowledge were ready and understandable, the domain ontology was established to model the domain-specific ontology.
3) The government used tools (OWL-S for e-Government Management System) to develop, enhance and change the ontology description.

B. Thailand's Excise Department

The excise department deals with taxes charged on some goods and services which are usually unnecessary or expensive such as tobacco, beverage, petroleum, etc.

Lack of global schema for e-government and explicit knowledge on product category was challenging for service operation by the department [2]. Hence enterprise ontology was developed to show the global schema of the department since heterogeneity of system within department led to difficulties in data sharing and interoperation between systems within and across the department. The ontology was developed with reasoning concept, and it enhances interoperation of data and supports the department by recommender service (for example like when we take 5 liters of wine then how much tax the person must pay is generated or recommended by the ontology).

C. Enterprise Ontology Development

The enterprise ontology is a cohesive representation of data schema, and it helps to reduce the ambiguity about data. Following is some application of enterprise ontology [2] in the excise department:

1) *Form consolidation:* It helps the user's input to be corrected without inconsistency of the form field.
2) *Content Repository:* Classes and properties related to each other for services are organized in the same resource.
3) *Recommender System:* The ontology provides a reasoning service about product tax, and it was based on mapping rules.
4) *Linked Open Data Portal:* Since openness of data is important, data from databases mapped to ontologies are shared over the portal in Resource Description Framework format (RDF) where SPARQL can be used to interrogate data to enable data reuse and integrate across departments.

IV. METHODOLOGY

A. Ontology Development Process

Ontology development is all about defining terms in the domain and relationships between them. In short, the process can be as to define class/concept in the domain, arranging in the hierarchy (class-subclass hierarchy), and defining attributes and properties with constraints if required. Steps involved in ontology development [8]:

1) *Decide Scope:* The domain of ontology should cover based on what ontology will be used for and should answer the Competency Questions (CQ) using ontology after being developed.
2) *Consider Reuse:* There are many existing ontologies developed and used. To save time and effort building ontology, other ontologies can be reused which has been validated.
3) *List Terms:* Listing of terms and related properties of terms will help to know what terms are needed to be defined and in the case of e-government, it will help to know what services to define.
4) *Identify Classes:* The main concept in the domain is defined by the class which has a collection of similar properties. Classes are represented in a taxonomic hierarchy like class-subclass order. For example, a Taxpayer is a subclass of citizens. Classes can be developed by the top-down, bottom-up, and combined methods.
5) *Discover Properties:* The properties are like defining attributes of class and showing the relationship to classes or instances. For example, every Citizen will have id_no, name, D.O.B, etc. With this, the subclass will inherit the properties of the superclass.

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6) *Specify Constraints:* Constraints deals with the properties which define or limit values of properties. For example, the name of the citizen is a string (which means the name of the citizen cannot be a number).
7) *Build Instances:* Creating instances of the class is like adding a row in a table in the database with the correct attribute of that datatype. With the reasoning concept in ontology, an instance of a subclass is an instance of a superclass.

The above steps can be performed for e-government to provide service from different sections or departments with common knowledge.

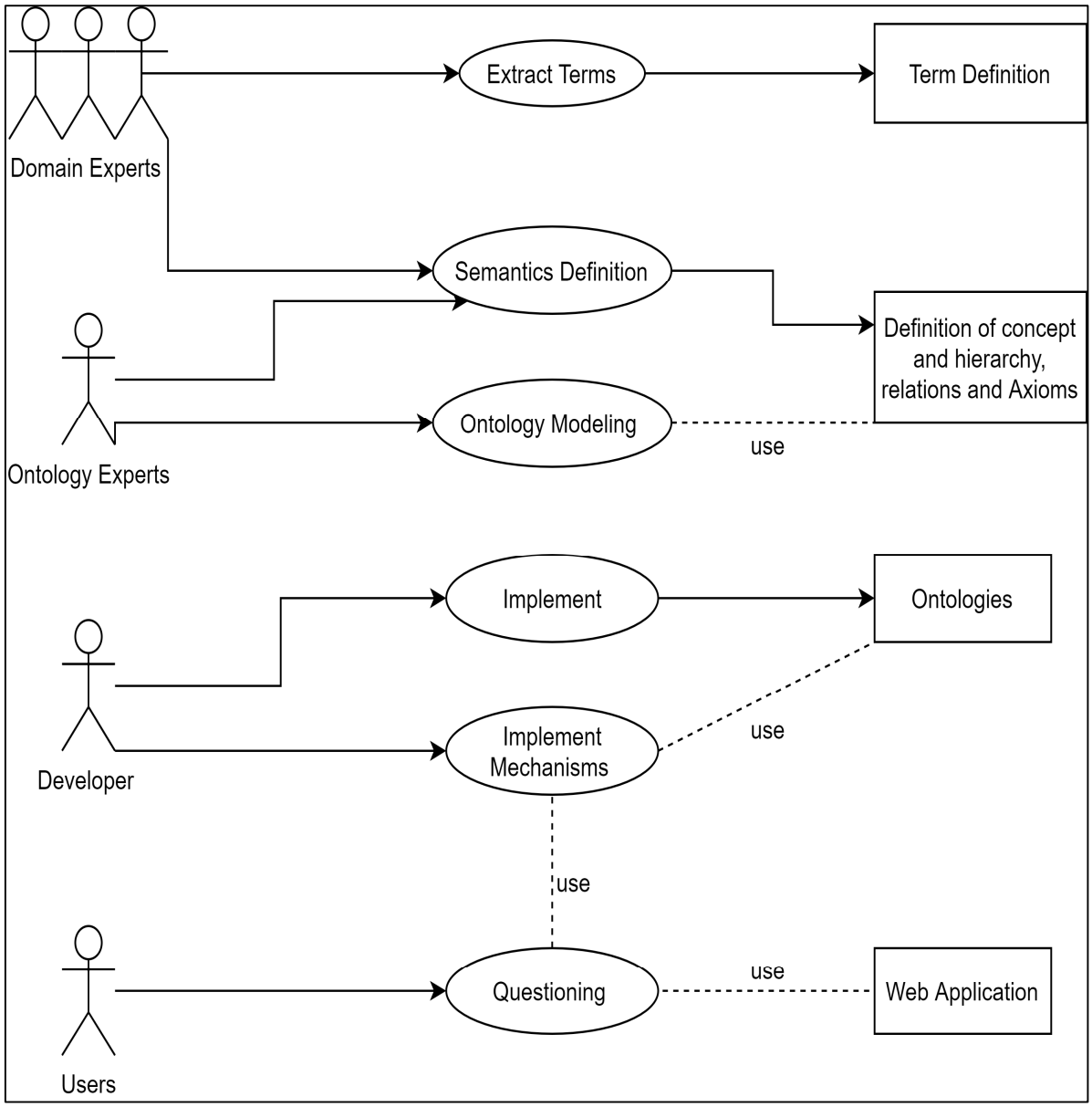


Figure 1. Ontology Development Methodology

This methodology needs domain experts and must follow the process shown in figure 1. For term definition, experts can use different tools to obtain term definition and semantic definition which are usually from documents or filling up the form. For ontology modelling, ontology experts use the definition of classes, properties, or relationships between them, and axioms or constraints. For Implementation, developers implement the ontology model as per the above steps and for this target, OWL Protégé can be used since it is one of the powerful tools. For mechanism implementation, appropriate ontology management mechanisms will be created for the ontology developed. Then after these users can use tools such as reasoner, SPARQL for ontology questioning, and OWL-API to create and manipulate ontology.

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V. DISCUSSION

There are many ontologies developed which have supported the creation of the knowledge base for the e-government field. However, there are many issues attached to e-government requirements. To address these issues e-government interoperability framework is applied to concentrate on services. Usually, the services are different in the e-government system, the framework helps in common understanding between domains.

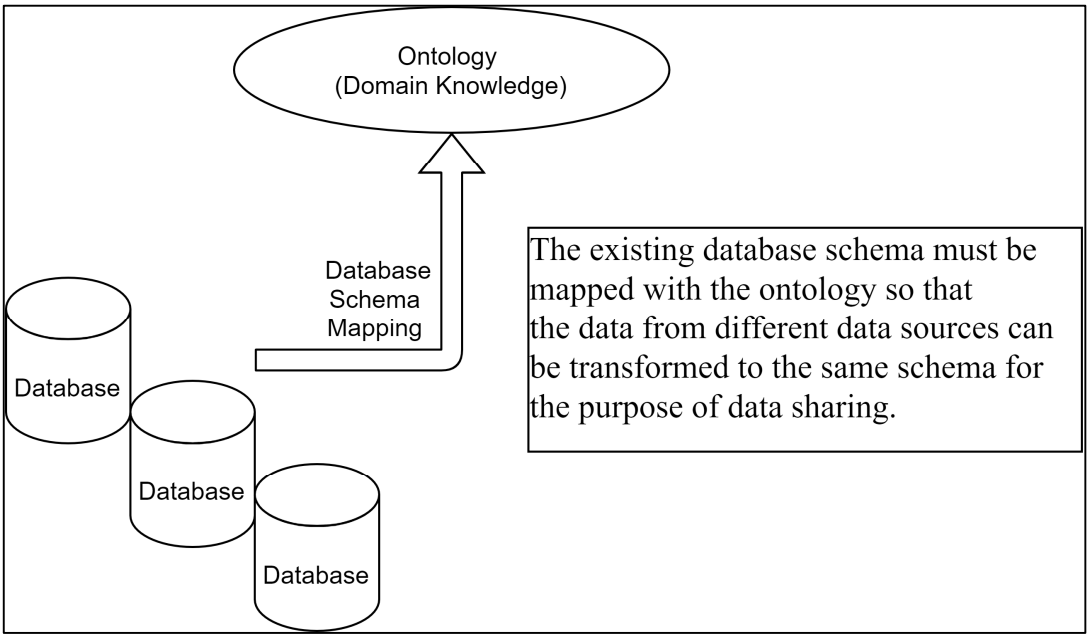


Figure 2. Data to Knowledge Mapping Framework

The ontology framework for government based on knowledge management has provided data taxonomy with better classification and retrieval. It even helps in representing unified schema or global schema for data interoperability among government departments. Ontology framework can support rules and rule-based knowledge can be used as an intelligent system such as the recommender system discuss [2] in Thailand's excise departments.

E-government requirements must satisfy interoperability and integration, the semantic definition of services should include:

1) *Who manages the service and which rules are applied to data and services?*
2) *Dynamic nature in the case for a change of rule by the law of government for services provided.*
3) *Developed data and services should link to each other [5].*

Semantic language like OWL does not capture the importance of the semantic definition of data or service [4]. OWL allows the machine to interpret the definition of data, but human interpretation does not match while integrating complete definition.

A. E-government Ontology Approach

To develop an ontology for e-government, a knowledge base is crucial for e-government where it consists of ontologies from a different domain to be considered as follows:

1) *Organizational Ontology:* The knowledge of the organization or department structure of government is essential to create an e-government knowledge base. Each department or section in government can have a different structure and each structure will have numerous levels with roles and responsibilities. Therefore, all this knowledge must be described and updated when it is changed.
2) *Legal Ontology:* Same as Organizational, the legal feature is also important for the knowledge base. Each government has its protocols to administer public services. These protocols are described using legal documents and to change or modify, it needs expert's advice or domain expert is needed.
3) *Domain Ontology:* To improve the e-government knowledge base, domain knowledge is important for the integration of different departments or sections in government. For some public services and information, some of the departments have to work together or share information to provide services to the public.

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VI. CONCLUSIONS

In this study, the e-government knowledge base plays an important role to develop an ontology for interoperability. The knowledge base is created from other ontologies such as organization, legal, and domain. The main purpose of the study on the ontology of e-government was to achieve the concept of interoperability and integration between departments or sections in government. Certainly, with the knowledge base, public services of each department can be described and manage in a good manner such that ontology offers services to the public according to government protocols.

After comparing different approaches and work that applied semantic technology, ontology in e-government has improved services description. Moreover, to show how the approach is effective and efficient, the model for Moroccan e-government with a knowledge base signifies how the challenge of interoperability is reduced. The proposed model helped in developing the ontologies for Moroccan e-government since the model focus on documents and citizens related to Moroccan. As future work, a knowledge base can be developed based on other different ontologies such as public service ontology (PSO), and plan to create a one-stop portal for e-government with one ontology by implementing an algorithm of mapping data.

Data sharing is important in e-government and in reality, it is observed that are many inconsistent data in the different functional department in government because of repeated data or heterogeneous database. Ontology of e-government can provide interoperability and integration data. At the same time, OWL will help in sharing data and developing e-government ontology and it will offer support for government management and e-government in the future.

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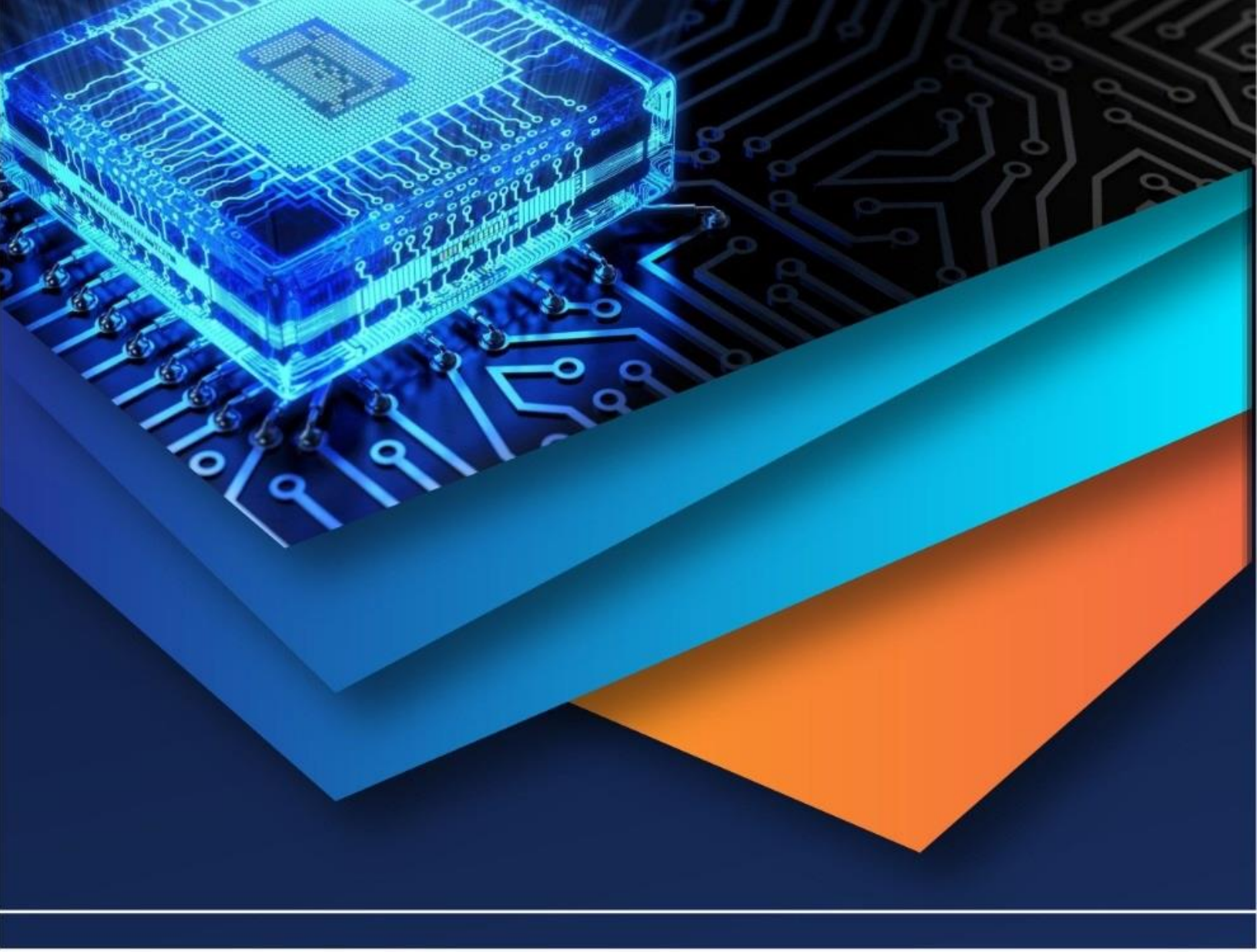
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