Indonesian Journal of Electrical Engineering and Informatics (IJEEI)
Vol. 11, No. 4, December 2023, pp. 1082~1096
ISSN: 2089-3272, DOI: 10.52549/ijeei.v11i4.5024

The Impact of Semantic Web and Ontology to Improve E-Government Services: A Systematic Review

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Article Info

Article history:

Received Aug 16, 2023
Revised Dec 1, 2023
Accepted Dec 14, 2023

Keywords:

E-government ontology
Semantic web
Electronic-government services
Semantic Web Ontology
E-government Ontology

ABSTRACT

The semantic web and ontology are extensions of the World Wide Web that aim to make data more interconnected and machine-readable. This systematic review examined researched publications published between 2018 and 2023 and indexed in Google Scholar and Science Direct. 23 records were chosen and classified into six groups: information and retrieval, knowledge archiving, interoperability, enhancing public and employee services, barriers to ontology application, and use of ontologies to apply the regulations. This study explored the semantic web and ontology used to enhance e-government services. It found that improving ontology for searched and information retrieval processes could help computers retrieve accurate results, improve interoperability and integration, and provide a knowledge base for terms used in building databases and applications. However, more research is needed to effectively integrate ontology into existing systems and extend these approaches to real-world contexts. Future research should focus on presenting an applied model of e-government technology and conducting continuous evaluations.

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1. INTRODUCTION

As a consequence of developments in the public sector over the past twenty years, several governments all over the world have been motivated to use information technology to improve their services[1]. This has led to the creation of various e-government initiatives, which aim to provide citizens with more efficient and accessible public services through digital technologies [2]. These initiatives have been successful in reducing bureaucratic processes and improving transparency in government operations [3]. "E-government" refers to the government's endeavor to supply services online [4]. At least 23 periodicals now publish research on this issue, which is now often referred to as "eGovernment" by researchers in the field [5]. E-government is also known as the use of information and communication technology (ICT) to change the relationships that exist between the public sector and its constituents on an internal and external level to improve accountability, efficiency, cost-effectiveness, and constituent participation [6] [7]. The electronic government uses the web to

deliver services to the general public, and as the web has developed over the past 25 years, numerous changes have been made to its structure and the delivery of services, leading to the creation of the semantic web[8] [9]. The semantic web is a development of the existing web since it gives information a more meaningful representation for both computers and people [10]. It allows for the automated annotation, discovery, publishing, promotion, and creation of services, as well as the description of materials and services in machine-readable form [11]. A key element in resolving the issue of semantic heterogeneity and enabling semantic interoperability between various web applications and services is the philosophical concept of ontology, which is associated with the semantic web. Ontologies are used to support interoperability and common understanding between the various parties [11] [12]. Throughout the past twelve years, one of the most active industries for Semantic Web development has been e-government. In e-government, ontology-based Semantic Web technologies are the focus of in-depth research. They show how several ontology models are utilized in e-government research and projects to describe and specify e-government services and accomplish their semantic integration and interoperability [13]. Increased access to information and services in e-government can lead to social and economic growth, improved participation and communication in policy and decision-making processes, and support for vulnerable populations [14]. Semantic Web technologies, such as ontology-based models, are being extensively researched and utilized in e-government to describe and integrate services and ensure interoperability[15]. These technologies enable the consistent and coherent organization and linking of data over the web, providing a foundation for efficient and effective e-government systems [16]. The development of e-government platforms based on Semantic Web technologies has the potential to enhance the delivery of services, improve transparency, and create a more accountable administrative process [17]. By leveraging the power of the Semantic Web, e-government can contribute to the strategic goals of countries, including increasing competitiveness and improving the well-being of citizens [18].

E-government provides its services through an electronic portal, allowing citizens to access government services and information conveniently and efficiently from anywhere at any time [19]. This digital platform aims to improve public services' capability and accessibility, especially in rural communities where there may be a digital divide[20]. Furthermore, e-government can reduce administrative costs and improve transparency in government operations [21]. Through these portals, which include all different government institutions, the success and quality of these services are often dependent on the ability to integrate the various systems of government institutions that provide services through digital e-government Furthermore, e-government can also enhance citizen participation in the decision-making process by providing a platform for feedback and suggestions. This can lead to a more inclusive and responsive government that better serves the needs of its citizens [22]. Integrating an information system in any sector for e-government involves overcoming obstacles related to the structural and semantic sharing of information. The use of the semantic web and ontologies can help facilitate the sharing and exchange of information between different organizations and applications, leading to a more efficient and effective e-government system [23]. The semantic web and ontologies play an active role in knowledge exchange and administration, enabling better representation and understanding of information across organizations [24]. By leveraging these technologies, e-government systems can better meet the needs of citizens by improving the sharing and integration of information for applications and services [25]. As a result, e-government services must model, re-engineer, and process governmental sharing and processing to enable information distribution depending on the citizen and location. Ontology-based Semantic Web technology has presented fascinating solutions to the aforementioned technical challenges. The semantic web, which is built on ontology, allows apps to communicate with one another to extract information or execute activities that integrate to deliver services via the e-government site. The use of semantic web technology in e-government sites has improved the efficiency and accuracy of information exchange between different applications. However, it is important to ensure that the information and statistics shared through these systems are reliable and accurate to avoid any potential errors or misinformation. The semantic web plays a significant role in extracting data and filtering acceptable material. It also aids in the establishment of relationships between different types of data. On the other hand, ontologies play an important role in the semantic web since they assist in improving interoperability, which is a key difficulty for many e-government projects [26]. Ontology creation is a critical activity for semantic data integration. Ontologies provide a shared understanding of the domain, which helps to ensure that data is interpreted consistently. They also enable automated reasoning and decision-making, making it easier to identify patterns and relationships within complex datasets. Ontologies can help with data integration efficiency. The goal of a data integration system is to give consistent access to a group of heterogeneous data sources while relieving the user of the need to understand how data is structured at the sources and how it is to be reconciled to answer queries [27].

Through this systematic review, we seek to respond to this question: How may ontology and the semantic web enhance e-government services and applications? To fully address the study topic, we shall evaluate the body of current literature and combine the results. Future studies and applications in this field will be guided by the findings of this review.

2. RESEARCH METHOD

2.1 Search Strategy

For this systematic research, we followed the PRISMA [28] framework for Systematic literature Review, and we developed a search strategy to identify relevant literature. This search strategy was tailored to two databases (Google Scholar and Science Direct), and the search terms used were the following: "ontology" AND "government" OR "ontology" AND "electronic government" OR "government" AND "semantic web "OR "electronic government " AND "semantic web ". All research spanned from database inception until 2023 and included journal articles, and review papers, published in English only.

2.2 Selection Criteria

The selection criteria were based on the PRISMA statement [28]. The search mainly focused on mapping existing literature on ontology in e-government in the field of Computer Science and Information Systems. The search span was from the year 2018-2023. All articles before 2018 were excluded from the search. After a search, we found 2871 records. A total of 2472 research articles were excluded at this stage. There were 399 records extracted at this stage.

2.3 Quality Assessment

This study is based only on original research articles, review papers, and conference papers. To maintain the quality of the review, all duplications were checked thoroughly. The quality and relevance of the academic literature included in the review process were ensured by carefully examining the abstracts of the articles before analysis and purification. A careful evaluation of each research paper was carried out at a later stage. The next exclusion criteria were to limit the papers published in English only. There was only one article in the non-English language was found and was excluded from the study. Furthermore, after the filtration of duplicate records, 201 more articles were removed, and another 168 articles were removed du The full text of the articles is not available. We selected 23 articles after assessing each article on the aforementioned inclusion and exclusion criteria. Figure 1 displays the literature that was included and excluded at each level. (PRISMA statement).

2.4 Data Extraction

In the data extraction phase, 23 articles were selected and the characteristics extracted were:

1. The article must be original papers, reviews, and conference papers.
2. The article must be in English language and from the field of computer science and information systems.
3. Extracted articles were published between 2018-2023.

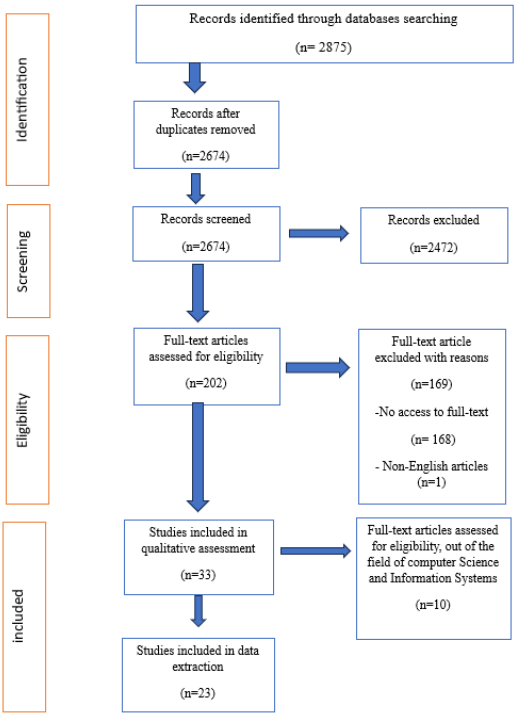

Figure 1 displays the literature that was included and excluded at each level. (PRISMA statement)

3. RESULTS AND DISCUSSION

3.1. RESULTS

The search procedure consisted of searching in the Google Scholar and Science Direct databases based on the inclusion and exclusion criteria described in the methodology, and the result was the inclusion of 23 studies in this systematic review after excluding a group of studies that did not meet the inclusion criteria or contained the exclusion criteria, as illustrated by the final number of studies included in the review, as shown in Figure 1. Figure 2 depicts the Research articles distribution published years included in this systematic review, with the total number of publications for each year indicated (2018-2023).

Previous studies contributed to finding an answer to the systematic review question by clarifying how ontology helped improve e-government services, and we divided this contribution into six groups, each of which is concerned with a specific aspect of e-government services, to make the results presented clearly. Searching and information retrieval, Archival Knowledge, Interoperability and integration, Improving public and employee services, Challenges and ranking, Rules and Compliance are among the classifications.

Figure 2 shows the research articles distribution published years

3.1.1 Searching and Information Retrieval

Studies have shown the great role that ontology and the semantic web play in improving search and retrieval processes for e-government applications, and this seems clear through the studies of Rastogi et al. [29] design of an ontological information retrieval model for real estate documents to improve the efficiency and accuracy of information retrieval of real estate document. They used an ontological approach to develop a model that can retrieve relevant information from a large corpus of real estate documents. The study used Protégé software to build the ontology and evaluated the model's performance using precision, recall, and F-score metrics. To improve the quality and effectiveness of e-government services Alazemi et al. [30] developed a semantic-based e-government framework using domain ontologies that can semantically model the relation between government services and domain ontologies. The study used Protégé software to build the ontology and evaluated the framework's performance using a case study of the Kuwait region.

For e-government services, Ordiyasa et al. [31] presented an adaptive ontology based on cross-phrase identification. They aimed to improve the efficiency of cross-phrase identification in e-government services by developing an ontology that can adapt to the changing needs of users. The study used Protégé software to build the ontology and evaluated its performance using a survey of 100 e-government service users and structural equation modeling (SEM). A semantic search tool that can understand users' queries and retrieve relevant information from a large corpus of e-government documents was developed by Shehu & Xhina [32] to improve the accessibility and efficiency of e-government services by developing a semantic search tool that can understand users' queries and retrieve relevant information from a large corpus of e-government documents. The study used Protégé software to build the ontology and evaluated the tool's performance using precision, recall, and F-score metrics. H. Wang et al. [33] proposed an ontology automation construction scheme for Chinese e-government thesaurus optimization to improve the quality of thesaurus used in Chinese e-government services by developing an ontology automation construction scheme that can automatically extract and construct thesaurus concepts and relations. The study used Protégé software to build the ontology and evaluated the scheme's performance using thesaurus construction and optimization metrics. The relevance of ontology and the semantic web in enhancing search services and information retrieval in e-government applications is evident to us. We discover that the studies were involved in both the type of ontology and the tools used to generate the ontology. It is also evident that the ontology was built using several methodologies, as indicated in Table 1.

Table 1. shows searching and retrieval of information studies

Author(s)	Aim of study	Methodology	Type of ontology	Tools	Result(s)
Rastogi et al [29]	To improve the efficiency and accuracy of real estate document retrieval	ontology-based approach	Domain ontology	Protégé	Improved precision, recall, accuracy, and efficiency of document retrieval
Alazemi et al. [30]	To improve the efficiency and effectiveness of e-government services in the Kuwait region	Ontology-based approach with semantic web technologies	Domain ontology	Protégé and SPARQL	improved the efficiency and effectiveness of e-government services in the Kuwait region
Ordiyasa et al. [31]	To improve the accuracy and efficiency of e-government services	Ontology-based approach with cross-phrase identification technique	Domain ontology	Protégé	improved the accuracy and efficiency of e-government services
Shehu & Xhina [32]	To address the challenges users face in accessing e-government public services in Albania due to the lack of semantic interoperability and searchability	a design science research approach to develop and evaluate the semantic search tool	Domain ontology	Protégé And Apache Jena Fuseki	The developed semantic search tool improved the accuracy and efficiency of search results and provided a more user-friendly interface for users
H. Wang et al. [33]	To address the challenges of manually constructing and maintaining a large-scale ontology for Chinese e-government thesaurus optimization	a knowledge engineering approach	Domain ontology	Protégé	The developed ontology construction scheme reduced the time and cost of constructing and maintaining the ontology and improved its accuracy and consistency

3.1.2 Archival Knowledge

An ontology for knowledge representation and reasoning in Chinese government archives is presented by Z. Wang et al. [34]. The ontology is designed to facilitate the management and retrieval of information from government archives, which contain a vast amount of historical and administrative data. The authors argue that traditional methods of organizing and accessing this information are inadequate, as they do not take into account the complex relationships between different types of data. The ontology is based on a conceptual model that includes four main components: entities, attributes, relationships, and rules. Entities refer to the various types of data found in government archives, such as documents, organizations, people, and events. Attributes describe the characteristics of these entities, such as their date of creation or their author. Relationships capture the connections between entities, such as the fact that a document was created by a particular person or organization. Rules specify how these entities and relationships can be combined to form meaningful queries or analyses. The authors demonstrate the usefulness of their ontology through several case studies involving different types of government archives. For example, they show how it can be used to identify patterns in administrative decision-making over time or to trace the evolution of certain policies or practices. They also discuss some of the challenges involved in implementing the ontology in practice, such as ensuring consistency across different archival collections or dealing with incomplete or ambiguous data. Overall, the article provides a valuable contribution to the field of knowledge representation and reasoning in government archives. Developing an ontology that takes into account both the complexity and diversity of archival data, offers a promising approach to improving access to this important historical resource.

3.1.3 Interoperability and integration

Interoperability and integration of government services using ontology refers to the seamless sharing and exchange of information between different government agencies and systems. government services can be connected and integrated more efficiently. This enables improved collaboration, streamlined processes, and enhanced citizen experience. Through the use of ontology, governments can achieve a more holistic and interconnected approach to delivering services, resulting in greater efficiency and effectiveness in service provision. As illustrated in Bastola & Shakya's [35] study, the objective was to develop a domain ontology for issuing certificates of citizenship in Nepal. The methodology used was a knowledge engineering approach, and the ontology was created using Protégé software and OWL language. The key finding was that the ontology

improved the accuracy and efficiency of citizen certificate issuance. Also, Tshering [36] proposed an ontology-based approach for e-government interoperability. The objective was to enhance the interoperability of e-government systems. The ontology was developed using Protégé software and OWL language, and the methodology used was a semantic web approach. The study found that the ontology improved the interoperability of e-government systems.

The ontology witch proposed by Shehu & Xhina [37] provided a structured framework for organizing and categorizing the various e-government services offered in Albania. This allowed for easier navigation and access to the services by citizens, ultimately resulting in increased efficiency and effectiveness in service provision. Additionally, the semantic web approach enabled better integration and interoperability between different e-government systems, further enhancing the overall quality of service delivery. Overall, the study demonstrated the potential of ontologies in improving public e-government services and highlighted the importance of adopting such approaches for better governance. To enhance the accuracy and efficiency of e-government services Jami & Zubair [38] developed a semantic web-based e-government system. The methodology used was a semantic web approach, and the ontology was created using Protégé software and OWL language. The key finding was that the system improved the accuracy and efficiency of e-government services. Also, Ortiz-Rodriguez et al. [39] proposed the EGODO ontology for sharing legal documentation across e-government. The objective was to enable the sharing, retrieving, and exchanging of legal documentation across e-government. The ontology was developed using Protégé software and OWL language, and the methodology used was a semantic web approach. The study found that the ontology enabled the sharing, retrieving, and exchanging of legal documentation across e-government.

The introduction of semantic reusable web components in e-government systems proved to be a significant step towards achieving better interoperability. By implementing a semantic web approach, Žitnik et al. [40] were able to enhance the efficiency and effectiveness of these systems. The evaluation of these components using metrics like response time and accuracy further validated their positive impact on the interoperability of e-government services. Overall, this study highlights the importance of adopting such approaches for achieving seamless governance and efficient service delivery. Alshehab et al. [41] designed and implemented an ontology for semantic integration sharing in e-government domains. The objective was to enable the semantic integration sharing of e-government domains. The ontology was created using OWL language, and the methodology used was not specified. The study found that the ontology enabled the semantic integration sharing of e-government domains. Alshehab et al. [41] designed and implemented an ontology for semantic integration sharing in e-government domains. The objective was to enable the semantic integration sharing of e-government domains. The ontology was created using OWL language, and the methodology used was not specified. The study found that the ontology enabled the semantic integration sharing of e-government domains.

To address interoperability challenges and enhance e-government services through the use of ontology-based frameworks and models Tshering et al. [42] propose a framework for Bhutan's e-government that utilizes an ontology developed using Protégé. The paper demonstrates the concept of a Single Source of Truth, enabling data reusability and collaboration. However, it lacks discussion on the practical implementation and impact of the framework on e-government services. Kurniawan et al. [43] the Ecosystem Pie Model to design an ontology development ecosystem for Indonesian e-government. The paper proposes a model that supports cross-domain government ontology services but lacks a detailed discussion on practical implementation and evaluation. Brys et al. [44] extend the Ontology for Electronic Government (EGO) and apply it to the electronic government context of the Province of Misiones, Argentina. The paper integrates existing ontologies and supports new features for describing e-government services, but it does not address implementation challenges. Lastly, Haridy et al. [45] propose a domain ontology using OntoUML for the Egyptian e-government. The paper creates a computable web ontology with better understandability measurements but lacks a discussion on practical implementation and evaluation. Overall, these papers contribute to improving e-government services, but further research is needed to bridge the scientific gaps and evaluate the practical implementation and impact of these approaches. All of them presented a model based on ontology to achieve integration and interoperability, but they struggled with the practical implementation of this model in a way that enables its utilization in electronic government applications that citizens interact with.

As shown in Table 2, the previous studies differed in the methodology used to design the ontology, as well as the types of the resulting ontologies, but the studies agreed on the tools used in developing the ontologies. The contribution of ontology is to improved collaboration, and streamlined processes, and the citizen experience we reviewed above shows that governments can achieve a more holistic and interconnected approach to service delivery, leading to more efficient and effective service delivery.

Table 2. shows Interoperability and integration studies

Author(s)	Aim of study	Methodology	Type of ontology	Tools	Result(s)
Bastola & Shakya [35]	To develop a domain ontology for issuing certificates of citizenship in Nepal	Knowledge engineering approach	Domain ontology	Protégé software, OWL language	The ontology improved the accuracy and efficiency of citizen certificate issuance.
Tshering [36]	To enhance the interoperability of e-government systems	Semantic web approach	Ontology-based approach	Protégé software, OWL language	The ontology improved the interoperability of e-government systems.
Shehu & Xhina [37]	To improve the quality and effectiveness of e-government services	Semantic web approach	Semantic web ontology	Not specified	The ontology improved the quality and effectiveness of e-government services.
Jami & Zubair [38]	To enhance the accuracy and efficiency of e-government services	Semantic web approach	Semantic web ontology	Protégé software, OWL language	The system improved the accuracy and efficiency of e-government services.
Ortiz-Rodriguez et al. [39]	To enable the sharing, retrieving, and exchanging of legal documentation across e-government	Semantic web approach	EGODO ontology	Protégé software, OWL language	The ontology enabled the sharing, retrieving, and exchanging of legal documentation across e-government.
Žitnik et al. [40]	To enhance the interoperability of e-government systems	Semantic web approach	Semantic reusable web components	Not specified	The components improved the interoperability of e-government systems.
Alshehab et al. [41]	To enable the semantic integration sharing of e-government domains	Not specified	Not specified	OWL language	The ontology enabled the semantic integration sharing of e-government domains.
Tshering et al. [42]	To support semantic interoperability in Bhutan's e-government	Semantic web approach	Ontology-based approach	Protégé software, OWL language, SPARQL	The framework enables semantic interoperability data reusability and collaboration.
Kurniawan et al. [43]	to support the development and operation of cross-domain government ontology services for semantic interoperability in e-government systems	Ontology development ecosystem model	Cross-domain ontology	Ecosystem Pie Model	proposes an ecosystem model for ontology development in e-Government.
Brys et al. [44]	to describe e-government organizational units and services in the Open Government Data and Services context	semantic technologies to describe e-government units and services	Domain ontology	Not specified	Improves government management, service delivery, and decision-making processes. - Extension of the Ontology for Electronic Government (EGO) enables real-world use cases
Haridy et al. [45]	to solve a variety of interoperability problems and is evaluated by the OntoMetrics quality metrics	OntoUML for building an Ontology-driven conceptual model	Domain ontology	OWL language	The proposed Ontology has better understandability measurements.

3.1.4 Improving public and employee services

Semantic web ontology can enhance public and employee services by facilitating efficient and effective delivery of services. This approach allows government agencies to categorize and organize information, making it more accessible and understandable for both the public and employees. This results in streamlined processes, reduced administrative burden, and improved user experience. Additionally, semantic web ontology enables better data integration and interoperability, allowing different government systems to

exchange information, and enhancing the overall quality of e-government services. Benaddi et al. [46] developed an ontology model for public services in Morocco, called PSOM-eGovMa, using the 5W1H approach. The model includes over 200 classes organized into six main categories: actors, services, time, location, reasons, and processes. The study found that the ontology model provides a comprehensive representation of public services in Morocco. And improving public service delivery in Morocco, such as facilitating data sharing between different government agencies, enabling more efficient and effective service delivery, by supporting the development of new e-government services.

An ontology-based governance framework for managing employee services in enterprises was presented by Tzagkarakis et al. [47], based on an ontology that defines concepts, relationships, and rules governing employee services. The results showed that the framework improved service delivery, increased transparency and accountability, and reduced costs associated with managing employee services. Table 3 shows a Comparison between previous studies in terms of methodology, objectives, and results, as well as the tools used in building the ontology.

Table 3. shows Improving public and employee services studies

Author(s)	Aim of study	Methodology	Type of ontology	Tools	Result(s)
Benaddi et al. [46]	To develop an ontology model for public services in Morocco	5W1H approach	Public services ontology	Protégé software, OWL language	The ontology model provides a comprehensive representation of public services in Morocco.
Tzagkarakis et al. [47]	To develop a governance model for employee services	Semantic web approach	Employee services ontology	Protégé software, OWL language	The ontology model improved the management and delivery of employee services.

3.1.5 Challenges and Ranking

The application of ontology in e-government is accompanied by many challenges that must be paid attention to and known precisely so that researchers can consider them when building an ontology of e-government. Some of these challenges were discussed by Alshehab et al.[48] in their study, which summarized these challenges as the lack of awareness and understanding of semantic web technologies among e-government stakeholders, data quality issues, privacy and security concerns, technical limitations, and collaboration between government agencies, IT professionals, researchers, and citizens. Finally, they concluded the article by highlighting the need for collaboration between government agencies, IT professionals, researchers, and citizens to overcome these challenges and promote the adoption of semantic web approaches.

To achieve the principle of quality, there must be a classification of the e-government ontologies. The relevance of e-government ontologies and their ranking on the semantic web is discussed by Fonou-Dombeu [49]. The author proposes a ranking system based on three criteria: popularity, relevance, and quality. The top-ranked ontology was found to be the European Union Public Sector Information (EU PSI) ontology, followed by the Dublin Core Metadata Initiative (DCMI) Government Domain Vocabulary and the UK Government Data Standards Catalogue (GDS). The author also notes that some of the lower-ranked ontologies may still be useful for specific purposes or in certain contexts. Overall, this article highlights the importance of e-government ontologies in facilitating communication and data exchange between government agencies and departments. The proposed ranking system provides a useful tool for determining which ontologies are most relevant and useful in specific contexts.

3.1.6 Rules and Compliance

The implementation of e-government regulatory standards ensures transparency, efficiency, and accountability in the functioning of government processes. These standards are crucial in promoting public trust and confidence in the government's ability to handle sensitive information and deliver services effectively. Without regulatory standards, there is a risk of inconsistency, data breaches, and potential misuse of resources, which can undermine the credibility of the government and hinder progress in the digital transformation of public services. In this study, Hasan et al. [50] cover the creation of an ontology-based framework for meeting e-government regulatory standards. The framework aims to assist government agencies in complying with regulatory requirements by providing a structured and standardized approach to managing compliance information. The framework is based on an ontology, which is a formal representation of knowledge that defines concepts and relationships between them. The ontology used in this framework is designed specifically for e-government regulatory compliance and includes concepts such as regulations, compliance obligations,

and compliance assessments. The article outlines the various components of the framework, including the ontology itself, a compliance management system, and a compliance assessment tool. The compliance management system allows government agencies to manage their compliance information in a centralized location, while the assessment tool provides a way to evaluate their level of compliance with specific regulations. The article also discusses the benefits of using an ontology-based approach to regulatory compliance. These include improved consistency and accuracy in managing compliance information, increased efficiency in assessing compliance levels, and better communication between government agencies and other stakeholders. Overall, the article presents a comprehensive framework for e-government regulatory requirements compliance that leverages ontologies to provide a structured and standardized approach to managing regulatory information.

The concept of an ontology-based framework provides a promising solution to address the challenges posed by inconsistent regulatory standards in e-government. By utilizing a standardized and structured ontology, government agencies can establish a common language and framework for defining and enforcing regulatory standards. This not only ensures consistency but also enables efficient data management and analysis, reducing the risk of data breaches and misuse of resources. Therefore, a comprehensive solution that incorporates an ontology-based framework is crucial in meeting e-government regulatory standards and facilitating the seamless digital transformation of public services. Bhatta et al. [51] describe the deployment of ontology-based knowledge management in Nepal's income tax system. The authors argue that traditional knowledge management approaches are inadequate for managing the vast amount of information and data generated by the income tax system. They propose an ontology-based approach that uses a formal representation of tax-related concepts and their relationships to facilitate knowledge-sharing and decision-making. The authors describe the development of an ontology for the income tax domain, which includes concepts such as taxpayer, income sources, deductions, exemptions, and tax rates. They also discuss the use of semantic web technologies such as RDF and OWL to represent and query the ontology. The article presents a case study of how the ontology-based approach was used to improve tax compliance in Nepal. The authors describe how the ontology was used to develop a knowledge base that guides tax laws and regulations, as well as tools for calculating taxes and submitting returns. They also discuss how the ontology was used to develop a chatbot that can answer taxpayers' questions about their taxes. The authors conclude that ontology-based knowledge management has significant potential for improving tax administration in Nepal and other developing countries. They suggest that further research is needed to explore how this approach can be scaled up and integrated with other systems and processes in the income tax system.

3.2. DISCUSSION

Previous research has examined the impact of the semantic web and ontology on enhancing e-government services, which rely heavily on the information systems of governmental ministries, agencies, and affiliated institutions that cater to the public, be it individuals or organizations. An analysis of prior studies reveals that they have made notable contributions to the enhancement of e-government services across various domains, such as information retrieval and search capabilities, archival knowledge management, interoperability, and integration, as well as the improvement of services provided to the public and government employees. Furthermore, these studies have addressed challenges, ranking, rules, and compliance relevant to e-government services. The current investigation is focused on the research conducted from 2018 to 2023, which spans five years. These investigations have played a significant role in enhancing e-government applications through the utilization of the semantic web and ontology.

Ontologies are used to create a structured representation of knowledge within a specific domain, which can then be used to improve information retrieval and decision-making processes. In terms of methodology, all the papers used ontologies as a central component of their approach. They differ in terms of the specific techniques used to develop and apply these ontologies. For example, Rastogi et al. [29] used a combination of manual and automated methods to develop their ontology, while Alazemi et al. [30] focused on using domain experts to create their ontology. The results of each paper also vary depending on the specific objectives and research questions being addressed. For instance, Shehu & Xhina [32] developed a semantic search tool for e-government public services in Albania, which was found to significantly improve search accuracy compared to traditional keyword-based approaches. In contrast, Ordiyasa et al. [31] focused on developing an adaptive ontology that could be updated based on user feedback. Despite these differences, there are also some common themes across the papers. For example, many of them highlight the importance of using ontologies to improve information retrieval in e-government contexts. They also emphasize the need for effective collaboration between domain experts and technical specialists to develop accurate and useful ontologies. One potential scientific gap that emerges from this analysis is the need for more research into how ontologies can be effectively integrated into existing e-government systems. While many of the papers discuss theoretical approaches or prototype systems, there is less discussion about how these approaches can be scaled up or

integrated into real-world e-government contexts with existing legacy systems and data structures. Overall, these scientific articles provide valuable insights into how ontologies can be used to improve information retrieval and decision-making processes in e-government contexts. However, further research is needed to explore how these approaches can be effectively implemented in practice.

The semantic web and ontologies have allowed for improvements to the e-government archive. Ontology supports reasoning tasks such as information retrieval, classification, and semantic analysis, as well as knowledge representation. Through their research, Z. Wang et al. [34] created an ontology for the knowledge contained in Chinese government archives to represent and make sense of it. One area of science lacking in this work is the empirical assessment of how well the developed ontology performs in tasks involving knowledge representation and reasoning about Chinese government archives. While the authors provide a detailed description of the ontology and its potential applications, they do not provide any empirical evidence to support their claims. Future research could address this gap by conducting user studies or other forms of evaluation to assess the effectiveness of the ontology in practice.

Ontologies can be used to improve interoperability, information sharing, and decision-making in e-government systems. Tshering et al. [42] propose a framework for Bhutan's e-government using Protégé, demonstrating data reusability and collaboration. Kurniawan et al. [43] use the Ecosystem Pie Model for Indonesian e-government but lack detailed discussion on practical implementation. Brys et al. [44] apply the Ontology for Electronic Government to Argentina but do not address implementation challenges. Haridy et al. [45] propose a domain ontology for Egyptian e-government but lacks practical implementation. Bastola & Shakya [35] used the methontology methodology to develop an ontology for issuing certificates of citizenship, and Tshering [36] used the protégé tool to develop an ontology-based approach for e-government interoperability. And a combination of interviews and a literature review to develop an ontology for public e-government services in Albania. The objectives of these articles are similar, as they all aim to improve e-government systems through the use of ontologies. The results vary depending on the specific domain being studied and the methodology used. For example, Jami & Zubair [38] developed a semantic Web-based e-government system that improved information retrieval and decision-making for citizens. Ortiz-Rodriguez et al. [39] developed an EGODO ontology that allows for sharing, retrieving, and exchanging legal documentation across e-government systems.

The articles by Benaddi et al. [46] and Tzagkarakis et al. [47] both discuss the development of ontology models to improve public and employee services. Both studies use ontology modeling methodology to create their respective models. Benaddi et al. [46] use the 5W1H approach to develop an ontology model for public services in Morocco. Tzagkarakis et al. [47] use a similar approach but focus on employee services governance. The objective of Benaddi et al. [46] is to develop an ontology model for e-government services in Morocco, aiming to improve the quality of public services. Tzagkarakis et al. [47] aim to improve employee service governance through an ontology model. The studies differ in scope and application, with Benaddi et al. [46] focusing on e-government services in Morocco and Tzagkarakis et al. [47] focusing on employee service governance more broadly. Benaddi et al. [46] on improving the quality of public services, while Tzagkarakis et al. [47] focus on improving the efficiency of employee service governance. Both studies use ontology modeling to improve public and employee services, but they differ in scope and application. The scientific gap lies in their objectives and focus.

Semantic web approaches in e-government services are the focus of two articles by Alshehab et al. [48] and Fonou-Dombeu [49]. Fonou-Dombeu [49] surveyed experts to identify challenges in applying semantic web approaches to e-government web services and proposed a ranking method for evaluating e-government ontologies on the semantic web. Alshehab et al. [48] also identified challenges in applying semantic web approaches to e-government services and emphasized the need for more research in this area. Fonou-Dombeu [49] evaluated e-government ontologies and found differences in quality and relevance. Both articles aimed to address challenges in applying semantic web approaches to e-government services, but Fonou-Dombeu [49] focused on evaluating ontologies while Alshehab et al. [48] emphasized the need for further research.

The two aforementioned scholarly articles authored by Hasan et al. [50] and Bhatta et al. [51] focus their attention on the practical implementation of ontology in the realm of government regulations and compliance. Hasan et al. [50] put forth an innovative framework that is grounded in ontology to facilitate the achievement of regulatory requirements compliance in e-government. Conversely, Bhatta et al. [51] have a thought-provoking knowledge management system that leverages ontology to enhance income tax processes in Nepal. While Hasan et al. [50] establish an all-encompassing framework that ensures seamless and efficient adherence to government regulations, it is worth noting that the findings of their research demonstrate the efficacy of the proposed framework in assessing compliance status. On the other hand, the primary objective of the study conducted by Bhatta et al. [51] is to enhance knowledge management in the sphere of income tax administration, with the results indicating that users found the system to be highly beneficial. Both studies undoubtedly illuminate the potential of ontologies in enhancing the operational efficiency of government

entities, albeit with divergent areas of focus. Nevertheless, it is imperative to acknowledge the presence of a research gap in the scientific field regarding the investigation of how ontologies can effectively integrate regulatory compliance and knowledge management within government agencies.

Table 4. summarizes the contributions of the studies included in answering the study question

Title	References	How may ontology and the semantic web enhance the integration of e-government services and applications?
Searching and information retrieval		
Ontological Design of Information Retrieval Model for Real Estate Documents	[29]	Providing a unified and shared understanding of information. Enabling semantic interoperability. Allowing discovery and composition of services. Facilitating query expansion and mediation.
SEMANTIC-BASED E-GOVERNMENT FRAMEWORK BASED ON DOMAIN ONTOLOGIES: A CASE OF KUWAIT REGION	[30]	
Adaptive Ontology based on Cross Phrase Identification in e-Government	[31]	
A Semantic Search Tool for E-government Public Services in Albania	[32]	
An ontology automation construction scheme for Chinese e-government thesaurus optimizing	[33]	
Archive Knowledge		
An Ontology for Chinese Government Archives Knowledge Representation and Reasoning	[34]	Facilitating knowledge discovery and composition. Promoting knowledge sharing and reuse. Supporting intelligent knowledge services.
Interoperability and integration		
Developing Domain Ontology for Issuing Certificate of Citizenship of Nepal	[35]	Improving accessibility and interoperability. Enabling automated processing.
Ontology-Based Approach of e-government for Interoperability	[36]	
Modeling an Ontology for Public e-government Services in Albania	[37]	
Semantic Web-based E-Government System	[38]	
EGODO Ontology: Sharing, Retrieving, and Exchanging Legal Documentation Across E-Government	[39]	
Semantic reusable web components: A use case in e-government interoperability	[40]	
SEMANTIC INTEGRATION SHARING FOR GOVERNMENT DOMAINS ONTOLOGY: DESIGN AND IMPLEMENTATION USING OWL	[41]	
Enabling Semantic Interoperability in Bhutan's E-Government: An Ontology-based Framework	[42]	
Designing An Ecosystem Model for E-Government Ontology Development Using Ecosystem Pie Model	[43]	
LEGO: Linked electronic government ontology	[44]	
Ontology-driven conceptual model and domain ontology for Egyptian e-government	[45]	
improve public services and employee services		
Ontology Model for Public Services in Morocco Based on 5W1H Approach: PSOM-eGovMa	[46]	Enabling automation. Improving government efficiency and effectiveness.
Ontology-Based Governance for Employee Services	[47]	
Challenges and ranking		
CHALLENGES OF APPLYING SEMANTIC WEB APPROACHES ON E-GOVERNMENT WEB SERVICES: SURVEY	[48]	Promoting reusability. Improving integration challenges. Evaluating and ranking ontologies.
Ranking E-government Ontologies on the Semantic Web	[49]	
Regulations and Compliance		
An Ontology-based Framework for e-government Regulatory Requirements Compliance	[50]	Ensuring regulatory compliance.
Ontology-based knowledge management in income tax of Nepal	[51]	

The use of Semantic Web and ontology has proven to be beneficial for enhancing e-government services in various areas, including but not limited to integration, interoperability, information and data retrieval, and archive processing. These innovative techniques facilitate the users in effortlessly searching for and accessing pertinent information. Nevertheless, certain challenges must be overcome to successfully implement these technologies. These challenges encompass concerns about security, costs, and standardization. Numerous prior investigations have indicated that the actual application of Internet models in e-government portal applications is lacking, thereby necessitating the addressing of data security and confidentiality concerns. To advance the field, future research endeavors should concentrate on tackling these challenges and further delving into the modeling, provision, and management of future Internet services. Furthermore, the protection and analysis of data must be given due consideration. Additionally, it is imperative to continue the exploration of the application of semantic web techniques in the evaluation of software accessibility. Moreover, conducting studies with a greater impact within this realm should be pursued relentlessly.

The studies included in this research have made significant contributions towards answering the study question as illustrated in Table 4.

4. CONCLUSION

Previous studies contributed to finding an answer to the question of the systematic review by explaining how ontology helped improve e-government services. These contributions are Searching and information retrieval, Archival Knowledge, Interoperability and integration, Improving public and employee services, Challenges and ranking, Rules, and Compliance each concerned with a specific aspect of e-government services. In search and information retrieval, ontology helped provide a unified and shared understanding of information, enabled semantic interoperability, allowed the discovery and formation of services, and facilitated the expansion of query and mediation. In the field of knowledge and archiving, it helped facilitate the discovery and formation of knowledge by encouraging knowledge sharing and reuse and supporting intelligent knowledge services. The ontology also helped in general interoperability and integration, improvement of public services and employee services, challenges and arrangements, and rules and compliance among the classifications. More research is needed on how to effectively integrate ontology into existing e-government systems, and there is less discussion about how to extend or integrate these approaches into e-government contexts in reality with legacy systems and existing data structures, which requires further studies and research. While many articles describe the development and application of ontologies as improving interoperability and integration between different e-government applications, few provide empirical evidence that they improve interoperability, information sharing, or decision-making. Future research should focus on evaluating the effectiveness of ontology in e-government systems by presenting actual applications. Some of the barriers to semantic web applications and ontology in e-government services are a lack of awareness and understanding of semantic web technologies among e-government stakeholders, data quality issues, privacy and security concerns, technical limitations, and collaboration between government agencies, IT professionals, researchers, and citizens. However, these obstacles and challenges can be addressed through scientific research and the continuous improvement of semantic web applications and ontologies in e-government services.

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Badraldeen Hassan Altahir, an individual who was brought into this world in the year of 1993, completed his higher education at the esteemed Omdurman Islamic University (Sudan, Omdurman) in the year of 2014, where he obtained a highly regarded Bachelor of Science degree in the field of Information Systems. Displaying an insatiable thirst for knowledge, he then pursued a Master of Science degree from the very same institution, Omdurman Islamic University (Sudan, Omdurman), and accomplished this feat in the year 2017. Presently, he finds himself engrossed in the pursuit of his doctoral studies at NU Neelain University (Sudan, Khartoum) within the department that specializes in the intricate domain of Information Systems. Notably, he has assumed the role of an esteemed Lecturer within the Information Systems department, housed within the esteemed College of Computer Science & Information Technology, Omdurman Islamic University (OIU), and he has been actively fulfilling this role since the year of 2017.

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