Building Fuzzy-Logic Ontology for Political Decision-Makers

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Abstract-- Many applications have been developed in various government departments, aimed at providing and enhancing delivery of services to citizens, businesses, and organizations. However, little work has been done in building a knowledge base on ontologies that facilitate communication between stakeholders and that identify the processes and describe the data of these applications. This paper focuses on developing prototype architecture for intelligent decision support systems that can help top political decision-makers. The system is intended to be used to strengthen bilateral economic relationships between nations. Typically, decisions are influenced by certain factors and variables that are based on heterogeneous and vague information. A commons language is thus needed to describe such information, which requires human knowledge for interpretation. In this research, we propose to use an ontology to integrate vague information from the political and investment domains. The process will begin with the extraction of key concepts and relationships between sets of information, and proceed to integrate fuzzy logic with ontology. The ontology includes information about important concepts in each domain. We will present a case study that contains clear concepts for the political and investment domains, the Object Paradigm ontology (OP) for each concept will be presented in order to capture a high level of knowledge to facilitate the work of decision-makers in the decision-making process of the political field. To build our ontology, we will use the Protégé-OWL editor. In this paper we will present the Ontology for the domain of bilateral economic relationships and demonstrate how using this Ontology we can obtain more suitable solution to solve the uncertainty and reasoning problems in this intelligent decision support system. The intended users are the top political decision-makers.

Keywords-- Decision Support Systems, Fuzzy-Logic-Based Ontology, Government System, Ontology.

I. INTRODUCTION

It is in the interest of every nation to foster good bilateral relationships with other countries. Existing relationships between countries can be described from a variety of perspectives, such as historical, respectable, neighboring, traditional, religious, political, and economic. Independent of these varied contexts, all nations seeks to build bridges of cooperation with other countries in various ways. One such way is to strengthen economic relationships, where many factors and variables that influence the promotion of an economic relationship should be taken into account.

These variables and factors are diverse and may be found in different contexts within various economic sectors. From the researcher's viewpoint, the challenges lie in recognizing, finding, and extracting these different variables. A conscientious decision-maker takes on the responsibility to promote and strengthen bilateral economic relationships that require good access to well structured information relevant to his/her decisions.

Unfortunately, in reality, the actual input for such a decision-making process is quite unstructured, non-centric, and scattered in different domains, including the political and investment domains. It is usually an empirical matter for a decision support process to be able to assess the different factors, variables, and relationships between them in order to reach appropriate conclusions. Examples of different factors and variables that may be assessed in the decision-making process include (but are not limited to) position of the countries, with regard to regional and global issues, security and stability; the ability of the nation to invest; the disclosed position of the nation in the fight against terrorism; the position of the nation on combating weapons of mass destruction; and its position on cooperation and facilitating investment matters.

Due to the existence of various factors influencing decision-making for strengthening economic relationships between countries, there is an urgent need to develop an appropriate system to achieve adequate, yet accurate data gathering and analysis, as well as to produce precise and certain output that is useful to decision-makers. Decision-making is a difficult process due to incomplete elements and imprecise information, and decision-makers must consider a number of objectives simultaneously [19]. In Kuwait, the scattered data is mostly found in various governmental sectors, including the Kuwaiti Fund for Development, Kuwait Investment Authority, Ministry of Foreign Affairs, the Prime Minister's Office, the Embassies of Kuwait, and the decision-maker office. For example, the Ministry of Foreign Affairs is responsible for bilateral relations at the international and regional levels. Information pertaining to agreements with other countries can be found in this sector. On the other hand, information on bilateral trade can be found through the Kuwait Investment Authority. Both sectors fall under different domains and are interdependent with respect to the decision-

making process when it comes to strengthening bilateral relationships. Since traditional empirical decision-making has been an inefficient process, we focus in this paper on generating an ontology.

Ontology can be defined as information in a specific domain, which helps to acquire knowledge and share it [31]. Ontology has been used for several years in Engineering (IC) and Artificial Intelligence (AI) for structuring domain concepts. The concepts are gathered and are regarded as basic building blocks for expressing knowledge in the field it covers. Ontology is useful in sharing knowledge, building consensus, and building knowledge-based systems. Many projects of ontology have been implemented, including the Semantic Web. The fundamental problem is to respect the diversity of languages and concept presentations across the world, while allowing for the exchange of information. Gehrmann et al. [13], [14] introduced the concept of ontology in order to support management system audits.

The primary aim of this paper is to develop prototype architecture for intelligent decision support systems that can help decision-makers in the political domain. A new methodology for an ontology decision support system will be presented. We introduce in this paper the concept of such an ontology and show the characteristics of the decision support system in a particular domain. We propose a system for generating an ontology by extracting knowledge from various data sources. These sources may take various forms, such as textual data, knowledge bases, and normal documents. Different approaches to characterizing or defining fuzzy ontology are studied. One such approach that we adopt in this paper is the construction of fuzzy ontology for a specific domain, which was presented in Inyaem [32].

II. DEFINITION OF ONTOLOGY

Ontology is simply defined as a set of concepts (classes) and the relationships between these concepts. Ontology is also defined as an explicit specification of a conceptualization [31], often considered as a reusable and shareable model. Geographical ontology can be used for exploration, for extraction of information, and for interoperation of GIS [24]. Ontology provides a common vocabulary for people who need to share information in a specific domain. Different ontologies are used in different domains (geography, biology) to share common understanding of the structure of information among people or software agents, to analyze domain knowledge, and to enable the reuse of domain knowledge. We add to the root of the definition by suggesting that an ontology is a description of concepts in a domain (classes, concepts) in which the properties of each concept describe various features and attributes of the concept (properties, roles), and of slots that describe properties of classes and instances.

Gruber [31] has defined ontology as an explicit specification of conceptualization. Conceptualization is how we express our views through words, express concepts and elements, and identify relationships between entities. This definition stresses the application of the common ontology in different applications, as well as translating a language text or documentation for defined terms. Similar related work was done by Yuemi et al. [33], in which the authors proposed an ontology structure with the concepts and properties along with some fuzzy linguistic variable ontology. In addition, they specified the definition of a fuzzy relation as a set of membership degrees associated with a set of relations in the concepts of the domain ontology. Fuzzy ontology is based on the concept that each index object is related to every other object in the ontology with a degree of membership assigned to that relationship based on fuzzy set theory.

III. DOMAINS OF APPLICATION

Ontology has been very commonly used in different applications. For instance, it has been applied in the field of health care, in the context of fighting malaria, where the concepts and techniques were presented using precise conceptualization. Zimmermann [34] has combined fuzzy logic rules with ontology to highlight the importance of sharing knowledge with a heterogeneous agent, in order to interact in an open environment. Similar related work comes from researchers in the field of geographical information, where intelligent modules are used by consumers of decision support for spatial analysis functions from multiple sources provides users with the necessary knowledge to complete a task with reduced error [9]. More recent work on fuzzy ontology was presented by J. Zhai et al. [18], where fuzzy ontology was used to create an extension to standard ontology. More work on fuzzy ontology was presented in [35].

The proposed fuzzy domain ontology consisted of a 5-tuple extension. To assist in presentation, a concept considered as a class in ontology was put forward with a set of properties, which include the 5-tuple extension (ontology concept, property values, and linguistic qualifiers to control the strength of a property value, the restriction facts, and the universe of discourse). For example, “price” is a property of the concept “fruit.” The value of the “price” may be either a fuzzy concept, “cheap,” or a fuzzy number, “around 50.” The linguistic qualifiers may be either “very little” or “close to,” or the final value of “price” may be “very cheap” or “a little expensive,” as illustrated by Jun Zhai et al. [18]. Fuzzy ontology can provide more choices for a description of the attributes of an object. It also has a stronger ability to express uncertainty than an ordinary fuzzy set. There are several kinds of approaches for constructing a fuzzy ontology. Note that fuzzy sets have been applied to many fields, including artificial intelligence and decision-making analysis.

IV. ONTOLOGY IN THE E-GOVERNMENT DOMAIN

In recent years, many countries have used ontology in e-government projects [6], [27]. D. Apostolou et al. [3] presented the OntoGov project, which aims at developing an ontology platform in order to facilitate the consistent configuration and reconfiguration of e-government services. A methodology for building ontology in the social care domain within the context of e-government was presented by F. Bettahar et al. [6]. A. Gomez-Perez et al. [15] presented an ontology-based model to retrieve documents efficiently within government. More recent work for ontology in government was presented by Ortiz-Rodriguez [26], who used a set of

government ontologies to represent Mexican local government processes. Further work on ontology was presented by P. Alexopoulos et al. [2], with the aim of detecting fraud in e-government systems. Other ontology has been built to facilitate transactions between companies across EU countries [17]. In addition, P. Salhofer et al. [28] has described an approach to present a model of ontologies for the e-government domain as a basis for an integrated e-government environment

V. METHODOLOGY

In the literature, different methodological approaches for building ontology have been proposed by Fernandez-Lopez [23], Beck and Pinto [5], and Calero C. et al. [8]. Until now, there has been no standard method used for building ontology. The approach described in this paper was adopted from an ontology modeling approach suggested by Noy and McGuinness [25] and Fernandez-Lopez [23]. Another approach to building ontology from existing ontologies, or from scratch, was presented by Carelo C. et al. [8]. Building an ontology is in general iterative process that consists of different steps. The first step requires defining the classes of the ontology and arranging them in a taxonomic hierarchy. After relating the classes and specifying the superclasses and subclasses, we begin the second step, in which we define slots, describe the allowed values for them, and fill in the values for slots. The third step consists of creating a knowledge base by defining individual instances, filling the slots with specific values, and adding restrictions to the slots.

Our ontology will cover the important concepts for two main government sectors in Kuwait: the Kuwait Investment Authority (KIA), and the Ministry of Foreign Affairs (MFA). It is important to know how these two sectors model and present their major trends; how concepts are broken down into objectives, actions, norms, and principles to enable us to describe the domain and the relationships between them; as well as to understand the complexity when making decisions and to grasp how building ontology can be helpful and beneficial for decision-makers. The second step consists of identifying the ontology concepts, by using object paradigm (OP) ontology by selecting the important concepts in each domain, including the definition of classes and subclasses, characterizing the properties between classes and shared elements, and the description of entities in these classes. In addition, we will present the concept by using OWL ontology editing tools. This will enable us to describe the domains and the relation between them. The aim of conducting the ontology approach is to provide insight into how knowledge is represented and handled through different perspectives and editing tools.

A system will be developed using editing tools for modeling and implementing the ideas and applications of this ontology. Possible editing tools includes Protégé, which is an ontology editor and knowledge base framework, and Fuzzy Logic Toolbox, which extends the technical computing environment with tools for designing systems based on fuzzy logic. A fuzzy logic is used to present imprecise information [18]. More recent work on develop model based on fuzzy logic was presented by R. Basha, and J. Ameen [4], to identify predictor variables that are significant in the action of purchasing. Before defining the classes of the ontology, we determine and specify the domain that this ontology will cover and define its goal of use. An ontology is built to provide answers to specific questions. Competency questions should be asked, such as: Does country X look forward to the reactivation of the peace process in the Middle East? Does country X intervene in the affairs of other countries, either directly or indirectly? The answers may vary from “yes,” “no,” “maybe,” “sometimes,” “always,” “never,” “not clear,”.

The second step consists of verifying the existing ontology in the domain that can be extended. As mentioned before, there are many existing ontologies for different domains, such as the DAML ontology library, the UNSPSC ontology, which provides terminology for products and services, RosettaNet, and other ontologies for different domains (except for the political domain).

The third step consists of listing the main terms that will be used in the ontology without considering overlap between them, such as “war” and “peace”. In the fourth step, we choose the approach to define the classes and the hierarchy. There are two different approaches: the top-down and the bottom-up. In this paper, the first approach will be followed. We start by defining the most general concepts, and then add different specifications for those concepts. In the fourth step, we find the properties of classes and decide, for each term, to which class it belongs, before adding it as a slot, for example, intrinsic or extrinsic relationships between different members of the class. Examples in our case include “controlledBy,” “enable,” “provide,” “affect,” “engaged,” “enrichedBy,”. We should mention here that every subclass inherits all slots from the superclasses. Step five requires defining the facets of the slots, such as the cardinality, type, allowed values, instance (with relationship to another instance), and the domain of the slot, which means defining the classes to which a slot is attached. The last step consists of creating the instances by choosing the class and filling in the slot values.

VI. PROBLEM DEFINITION AND CASE STUDY

A serious problem that the decision-maker faces is the difficulty of building an efficient political decision support system, given that 80% of information is hidden in unstructured or semi-structured documents [11]. The difficulty mainly lies in extracting this information. In this research, we aim to develop a formal method using ontology-based systems to support decision-makers in strengthening economic bilateral relationships, requiring structured information. The existing methods for facilitating decision-making are mostly unstructured and the data are scattered in different domains. This overwhelms the decision-maker with the responsibility of understanding not only the concepts, restraints, and facts existing in that domain, but also their properties, the relationships between them, the location of all data in these sectors, and their functionalities. Table 1 illustrates different sectors with different domains and their respective functionalities and responsibilities.

In Table 1, we select two departments, political and investment, respectively, from two different domains in

multiple sectors. The first department is the Bilateral Agreements department in the political domain, which falls under the Ministry for Foreign Affairs sector. This is the sector responsible for most investment transactions between Kuwait and other countries. The second department is the Bilateral Trade department in the investment domain, falling under the Kuwait Investment Authority sector. The responsibility of this department lies in establishing agreements between Kuwait and other countries. As shown in Table 1, the data and information that are required for a top political decision-maker to strengthen the economic bilateral relationships is scattered, vague, heterogeneous, and unstructured.

VII. PURPOSES OF THE ONTOLOGY

One of the methods for determining the scope of ontology is to write a list of questions to which an ontology-based system should respond, called questions of jurisdiction [16]. It will later form the litmus test: Does the ontology contain sufficient information to respond to this kind of question? Do the responses require a particular level of detail or the representation of a particular domain? These jurisdictional issues are examples, which do not need to be exhaustive. Our approach consists of building a set of questions that need to be answered by the ontology in order to fulfill its purpose. The concepts of the ontology are terms that define the domain or activities carried out in the domain [6].

Starting from this list of questions, the ontology includes information about the different elements and different types of conditions to be taken into account for making a recommendation about whether or not to invest in a specific country. Here are some possible questions asked during the process of decision-making in the strengthening of bilateral economic relationships with other nations: Does this state have an interest in the development of the Iranian nuclear issue? Is this state interested in security and stability in Iraq? The answers may vary from "yes," to "no," "maybe," "sometimes," "always," "never," "not clear,".

VIII. PROPOSED ONTOLOGY

Ontology plays a major role in the availability and sharing of information [18]. As mentioned above, the data needed by decision-makers in the political arena is uncertain and scattered. By using ontology, decision-makers will be able to make better decisions in less time. We will start by representing a model diagram consisting of classes, subclasses, and elements that are important in the domain, with relationship properties. This diagram can be used as an illustrative description for any future need. We will propose an ontology structure with the most important concepts and properties. Fuzzy ontology is based on the concept that each index object is related to every other object in the ontology with a degree of membership assigned to the relationship based on fuzzy set theory. We will employ a fuzzy ontology as an extension of domain ontology for solving the uncertainty problem in the political domain. Using this developed model of ontology and fuzzy logic, we will share information from different domains with other domain as presented in table 1.

Table 1. Domains with their responsibilities

Sector/ Ministry	**Domain**	**Department**	**Function / Responsibility**
Ministry of Foreign Affairs	Political Domain	Bilateral Agreements	1) Assigns agreements between Kuwait and other countries
			2) Includes type of agreement
			3) Includes state of agreement
			4) Status of agreement
			5) Execution date of agreement
Kuwait Investment Authority	Investment Domain	Bilateral Trade	1) Responsible for most investment transactions between Kuwait and other countries
			2) Includes type of imports
			3) Includes type of exports
			4) Includes value of imports
			6) Includes investment in assets, bonds, stocks, real estate, alternatives

S. Al shayji et al. presented Fuzzy model by sharing information from political and investment domains in order to present a high level of knowledge for the political decision-maker[35]. We create a decision model that facilitates the decision-maker's role in the decision-making process in the political field. U. Inyaem et al. specified the processes of fuzzy ontology for the terrorism domain [32]. The terrorism domain has comparable attributes with the political domain. Hence, we will use a similar approach for the construction of fuzzy ontology. The first step in this process is to enter the unstructured data. We have started developing this input by proposing the following set of questions that are asked during the process of decision-making for strengthening bilateral economic relationships with other nations. Table 2 depicts an initial attempt to formalize these unstructured data inputs.

Table 2. Unstructured data input tabular illustration

Sectors	Kuwait Investment Authority	Ministry for Foreign Affairs
	Answers on Type of Imports	Answers for Questionnaire on Peace Affairs
	Answers on Type of Exports	Answers for Questionnaire on Iran Affairs
	Answers on Type of Financial Aid	Answers for Questionnaire on Nuclear Affairs
	Answers on Financial Contributions	Answers for Questionnaire on Middle East Affairs
	Answers on Support Facilities for Investment	Answers for Questionnaire on Terrorism

After this step, we complete the process by (a) specifying the definition of related concepts in the domain and their relation, (b) clarifying the generation of domain ontology, (c) extending the domain ontology to fuzzy ontology, and (d) applying fuzzy ontology to the specific domain of political decision-making for strengthening bilateral economic relationships. Fig. 1 depicts the complete process of the construction of fuzzy ontology, making use of the specific domain [32].

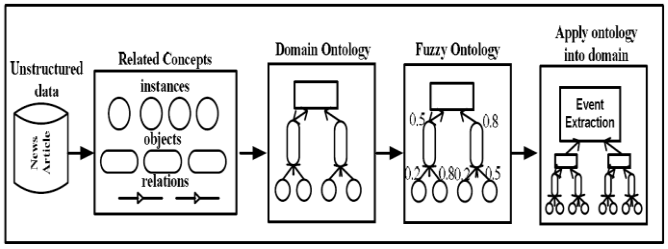

Fig.1 Process of construction of fuzzy ontology for the specific domain

The object paradigm ontology (OP) for bilateral trade is presented in Fig 2. As mentioned previously in table 2, there are several questions that may be asked during the process of decision-making for strengthening bilateral economic relationships with other nations; we will explain the concept in details for the most important questions presents in politic domain. The type of questions was addressed in [35]. Next section presents the concept of the bilateral agreement concept in politic domain. Agreement can change if changes happen in agreement with one another. We mentioned in the introduction that the information about agreement with other countries can be found in the Ministry for Foreign Affairs domain. We will explain the concept of the agreement in detail, identify the proper ontology concepts for them (e.g., classes and subclasses), characterize the properties between them, describe the entities in those classes, and describe the domain and the relationships between them in section 9.

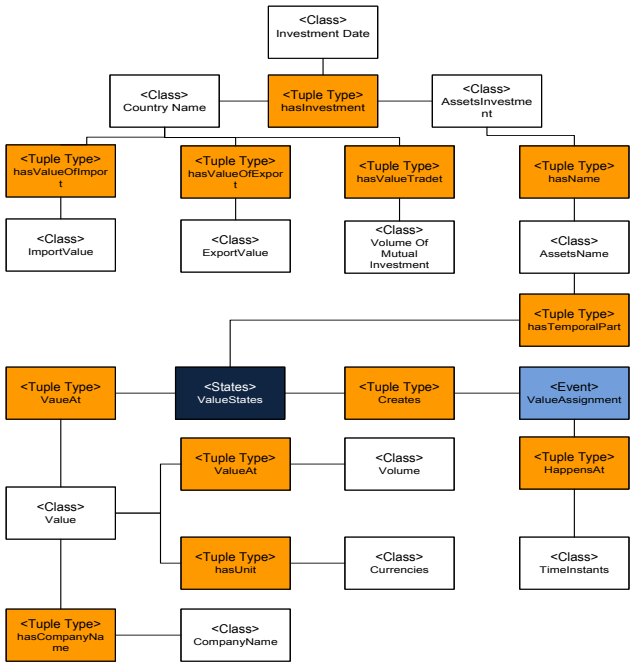

Fig. 2 Object paradigm ontology (OP) for bilateral trade

IX. THE CONCEPT OF THE AGREEMENT

It is obvious and essential that the political decision-maker should be interested in understanding the agreements concluded between the two countries, as well as their types and their histories. There is no doubt that the existence of agreements between countries is very important to enhancing the relationship between the two countries and, more importantly, the types of these agreements. Political decision-makers are interested in covering many questions about agreement in the decision-making process, including, but not limited to: Is there a joint ministerial committee with this country? Are there any oil deals with this country? Are there any oil agreements with this country? Is there an agreement in the military field with this country? Is there an agreement with this country to provide weapons? Is there an agreement on cooperation in maritime forces? Are there agreements on cooperation between aviation forces of the countries? Is there an agreement in the field of investment with this country? Is there an agreement in the field of health with this country? Is there an agreement in the cultural field with this country? Is there an agreement in the field of education with this country? Is there an agreement on air transport with this country? Is there an agreement in the area of development with this country? Answers to the previous questions are presented in table 3.

X. ILLUSTRATIVE CASE: ENGINEERING AGREEMENT ONTOLOGY IN THE MINISTRY OF FOREIGN AFFAIRS

The aim of this section is to obtain a clear conceptualization of the bilateral agreement concept, while considering the relationships that exist within the agreement ontology. In addition, in this section, as a first step, we present

a model of the agreement concept in the Ministry of Foreign Affairs by using Object Paradigm (OP) ontology, the use of OP for ontology conceptualization can provide more expressive and reusable Object Paradigm ontology. To demonstrate the concept of the domain, we will use a similar approach for the construction of Object Paradigm ontology, which was presented in [36] .

Table 3. Types of data concerning agreement

Agreement Name/Type	Level	Year	Submit	Situation
Aviation and tax exemptions	Good	1990	Old	Not renewed
Mutual recognition of certificates of tonnage of the vessels of trade between the two countries.	Good	1980	Old	Not renewed
Defense cooperation and the development of friendly relations	Very good			Not supported
Exhibitions between the two countries	Good	2006	New	
Cultural exchange	Good	2008	New	Effective
Tourism cooperation	Good	2009	New	Effective
Cooperation in scientific research	Good	2009	New	Effective
Cooperation in the field of media	Good	2009	New	Effective

The re-engineering concept allows us to capture more details, achieving a more natural description of the concept. In cooperation with Protégé OWL, the OP ontology makes the description of the concepts easier and more precise. With this team, we can describe the concepts with more facilities and more features, so there is no doubt that our descriptions will be more precise. We present the concept by using OWL editing tools ontology.

A. The First Step Using Object Paradigm (OP) Ontology

According to object paradigm (OP) ontology, the process is started by selection of the concept, followed by analysis of the "Agreement" concept, with its spatial and temporal dimensions. The agreement is assigned to a state that is linked with another state by a relationship. Thus, in the OP ontology, we model "Agreement" as a class in which "DateState" is only one state of the agreement class. Therefore, the "Agreement" concept leads us to link different dimension through this process, and each agreement has a different title and different types with which to capture the name of each agreement. For example, the "Title" class is linked to the "Agreement" class through the tuple type "hasName."

Principally, the name of each agreement has a different type, such as "Oil agreement," "Taxation agreement," "Security agreement," and to capture the type of each agreement, the "AgreementType" class is linked to the "Agreement" class through the "hasAgreementType" tuple type. In the case of an agreement being ineffective or not renewed, this result requires that the agreement be given special status because the continuity of the agreement depends on events or on some situation that has happened between the countries. The agreement may be cancelled or delayed, and in order to monitor the status, it is necessary to track the status of each agreement. To follow this, the "StatusName" class is linked to the "Agreement" class through the "hasAgreementStatus" tuple type.

We will explain not only the agreement concept, but also the properties (i.e., relationships) that exist within the agreement concept. To be more semantically precise, the process links the "AgreementTitle," "AgreementType," and "StatusName" classes through the tuple types "hasName," "hasType," and "hasStatus," respectively, as their descriptors can change only if changes happen to the agreement (see Fig. 3).

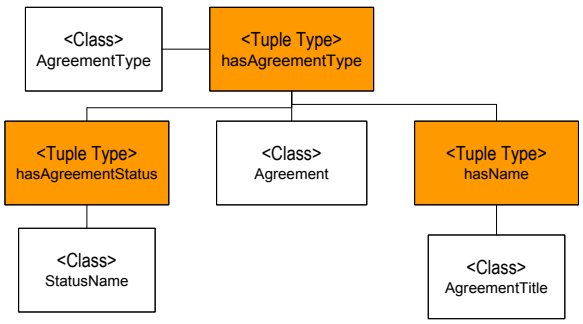

Fig. 3 Engineering properties relating to agreement.

As the OP considers the temporal dimension, it thus enables changes over time and as a result of the agreement being submitted on a specific date. This date requires an analysis for each agreement, and in order to capture the date to track change over time, we engineer the ontology to include the "date State" state along within the "DateAssignment" event in the OP ontology. Within the OP ontology, in order to capture the time at which the date assignment has happened, the "TimeInstants" class is connected to the "DateAssignment" event by the "happensAT" tuple type (see Fig. 4).

We considered the important issues in the bilateral agreement concept by presenting the objects and the changes in their properties over time. Objects can go through different states that form the temporal parts of these objects, and these states are created and dissolved by events. Thus, information enhances the semantic presentation such that enhancements may also significantly affect the quality and performance of the implemented software system.

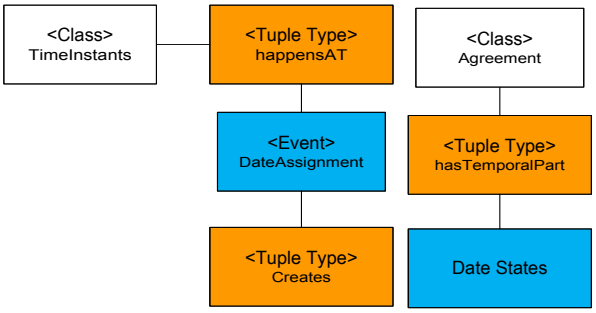

Fig. 4 Relation relating to the agreement

More details enable the ontology to provide a more faithful presentation of the phenomenon's abstract. To encapsulate more intelligence, we developed our ontology to capture things in the past, present, and potential future. Furthermore, our model responds to changes because of the inclusion of the temporal dimension. Any change happening to an object can be presented via states and events. The construction of the bilateral agreement ontology is illustrated in Fig. 5.

B. Presenting Some Properties and Relation that Hold Agreement Concept

In this section, we will propose a complete framework of a bilateral agreement domain based on ontology. We will describe the bilateral agreement concepts and the relations that hold these concepts. The proposed bilateral agreement domain ontology contains vague information; this information needs a commons language to describe its concepts. Table 4presents different classes with different properties in the bilateral agreement domain. For example, "Strong," "Good," "Very good," and "Excellent" are properties of the concept "AgreementType," which describes the level of the agreement. Thus, "NotSupport," "Ineffective," "Support," "Effective," and "Ongoing" are properties of the concept "StatusName," which describes the status of the agreement between two countries in the bilateral agreement domain. These properties require common knowledge for interpretation. For instance, political decision-makers pay attention to messages such as the status of the agreement and the type of the agreement. Agreement concepts are presented in Table 4.

Table 4. Important concepts of agreement

Type of Agreement	Type of the Agreement	Date	History of the Agreement	Status of the Agreement
Promotion and protection of investment	Strong			Not Supported
Double Taxation.	Good			Not Supported
Cooperation in the military field	Very Strong			Not Supported
Protection and military defense	Very Strong			Not Supported
Buy weapons	Very Strong			Not Supported
Combating weapons of mass destruction	Very Strong			Not Supported
Cooperation in the field of energy	Excellent			Not Supported
Exchange of imports and exports	Very Strong			Not Supported
Relations with respect to oil	Excellent			Not Supported
Avoid double taxation	Very Good	1990	Old	Supported
Encouragement and protection of mutual investment	Strong	1980	Old	Supported
Promote and protect investments	Very Good	1989	Old	Ineffective
Cultural exchange	Good	2008	New	Effective
Tourism cooperation	Good	2009	New	Effective
Cooperation in scientific research	Good	2009	New	Effective

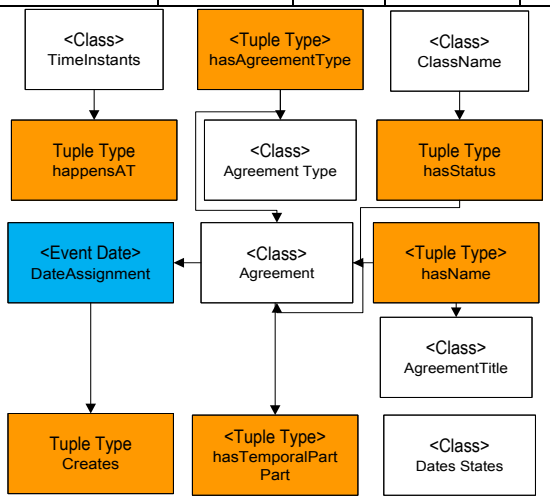

Fig. 5 The OP Agreement ontology

C. *Presenting the Agreement Concept by Using OWL Editing Tools Ontology*

Ontology can be viewed as a model of a domain that defines the concepts existing in that domain, their properties and the relationships between them, and is typically represented as a knowledge base. Agreement ontology specifies structural organization of agreements in terms of parts such as "agreement date", "implementation date", "agreement title", "agreement type", "agreements status", and so on. See Fig. 6. The construction of the Ministry for Foreign Affairs structure presented by the Protégé-OWL editing tool is represented in Fig. 7. The ontology of the agreement type concept is represented in Fig. 8.

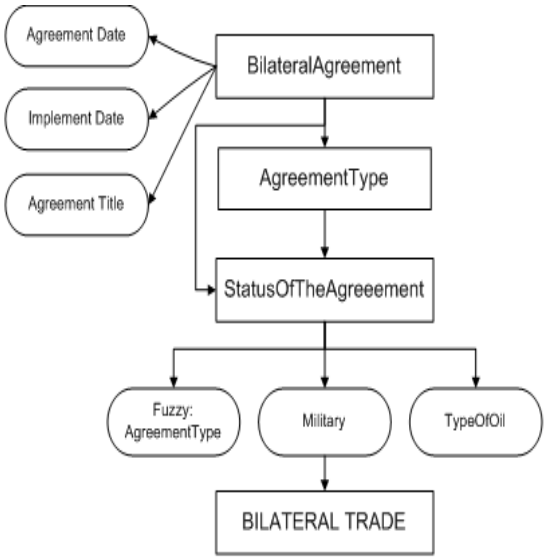

Fig. 6 A model of agreement ontology

D. *Enhancement of Ontology Structure into Fuzzy Ontology Structure*

Traditionally, concepts are described in an ontology using a properties framework. An ontology organizes knowledge in terms of Concepts (C) defined for the domain, Properties (P), by which these properties are defined as instance, and Relations (R) as a set of binary semantic relations between concepts. The fuzzy ontology structure is created as an extension of the standard ontology structure. In the proposed design of a fuzzy ontology, a concept descriptor is presented as a fuzzy relation that encodes the degree of a property value using a fuzzy membership function. Ontology can be converted into a fuzzy ontology in which any relation is a fuzzy relation accompanied by its weight as defined in Table 5 and Table 6, the semantic relation that defines the agreement status and the agreement type concepts, respectively.

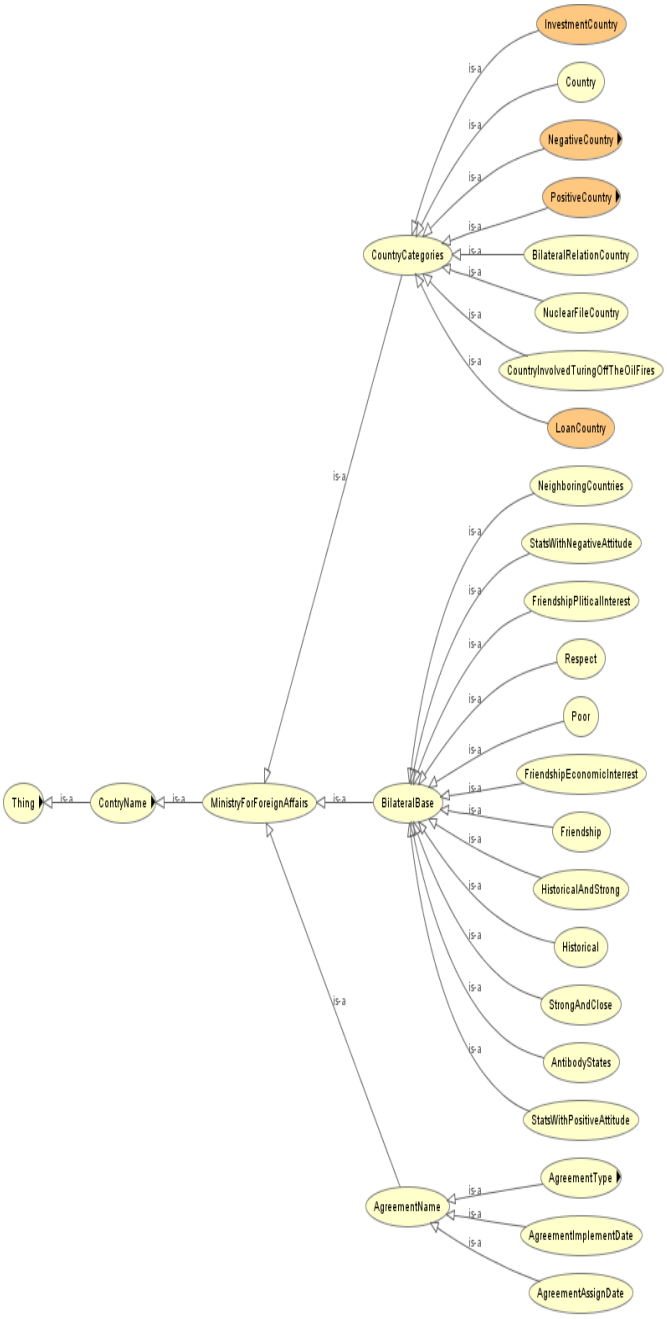

Fig. 7 The construction of the Ministry for Foreign Affairs organization presented by Protégé-OWL ontology editing tool

Fig. 8 Construction of the agreement type concept presented by Protégé-OWL ontology editing tool

Table 5. Weight associated with the semantic relations that defined the status of agreement

Relation Name in Agreement Status Concept	Weight
Effective	0.1
Not renewed	0.2
Ineffective	0.3
Supported	0.4
Not supported	0.5

Table 6. Weight associated with the semantic relationships that defined the type of agreement

Relation Name in Agreement Type Concept	Weight
Strong	0.1
Very good	0.2
Excellent	0.3
Good	0.4
Weak	0.5

XI. FUTURE DIRECTIONS

In this paper, we introduce the proposal to develop a fuzzy ontology approach and discuss how to conduct this approach in two main government sector representatives in Kuwait: the Kuwait Investment Authority and the Ministry of Foreign Affairs. The ontology includes information about important concepts in each domain. We present a case study that contains clear concepts for political and investment domains. Object paradigm ontology (OP) is presented with respect to important concepts in order to present a high level of knowledge to facilitate the work of decision-makers in the decision-making process of the political field. We build an ontology using the Protégé-OWL editor in the domain of bilateral economic relationships in Kuwait to obtain a solution that is more suitable for solving the uncertainty and reasoning through problems in this intelligent decision support system. The intended users are the top political decision-makers. The ontology helps to understand how these two sectors represent their concepts. This will help in identifying the proper ontology concepts for them (e.g., classes and subclasses), characterizing the properties between them, sharing all elements, describing the entities in those classes, and describing the domain and the relationships between them.

The aim of conducting the fuzzy ontology approach is to provide an insight into how knowledge can be represented and handled in order to support the decision-maker, with help from the intelligent decision process. Different methods and questionnaires may be used to assess the validity of the method and approach. We conclude that we can develop a system based on implementing a fuzzy ontology for the investment and political domain that will enable the decision-maker to make intelligent political and economic decisions for bilateral economic relations, thus offering a fair return on investment for such a system. For future work we will propose some techniques to demonstrate the impact of some variables from political domain on the variables on the investment domain.

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