Building Ontology for the Political Domain

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Abstract: *Ontology aims to define the semantics necessary for structuring and interrelating the stages and various activities of the deliberation processes with legal information and participating stockholders. The information can be taken from different domains. A common language is thus needed to describe such information that requires human knowledge for interpretation. Many applications have been developed [5, 16, 18] to provide and enhance delivery of services to citizens and businesses. However, little work has been done in building knowledge-based ontologies that facilitate communication, identify the processes and describe the data of these applications. This research focuses on developing prototype architecture for intelligent DSS that can help top political decision makers. In this paper, we propose this prototype architecture for generating ontology by extracting knowledge from various data sources. We propose to build an ontology using the Protégé-OWL editor to help political decision makers to strengthen bilateral economic relationships.*

Keywords*:* Fuzzy Logic, Protégé, Ontology, Fuzzy-Logic-Based Ontology, Governmental System.

1 Introduction

A lot of knowledge has been generated, organized and digitized in various governmental sectors, but it is still not readily accessible at any time or in one, convenient place for decision makers. Existing relationships between countries can be described from a variety of perspectives, such as historical, respectful, friendly, neighboring, traditional, religious, political and economical. Apart from such a variety of relationships, all nations seek to build bridges of cooperation with other countries in various ways. One way to build these relationships is to strengthen economic relationships, whereby the decision maker must take into consideration many factors and variables that influence the promotion of an economic relationship. This information and these factors are diversified and may be taken from different sectors. From the research viewpoint, the challenges lie in recognizing, finding and extracting these different variables. A conscientious decision-maker who takes responsibility for promoting and strengthening bilateral economic relationships needs access to well-structured information relevant to his/her decisions. Unfortunately, in reality, the actual information is unstructured, non-centric and scattered across different domains, including the political and investment domains. This makes it extremely difficult for the decision maker to understand the concepts, restraints and facts that exist in these domains. Due to the existence of various factors that influence decisions that aim to strengthen economic relationships with other countries, there is an urgent need to develop a proper system that analyzes the data gathered from different sectors and that produces precise and certain outputs that could be useful to the decision makers. In Kuwait, the scattered data mostly lies in various governmental sectors, including the Kuwait Fund for Development, the Kuwait Investment Authority, the Ministry of Foreign Affairs, the Prime Minister's Office, the Embassies of Kuwait and the Decision Maker's Office. Due to the various forms of political data existing in so many contrasting domains, certain imperfections such as imprecision, uncertainty and ambiguity appear. A popular way to handle scattered data is to construct fuzzy ontology, as presented in [20]. Ontology is useful for sharing knowledge, building consensus and building knowledge-based systems. Many projects of ontology are then implemented, such as the Semantic Web. The fundamental problem is to respect the diversity of languages and concept presentations of the world while encouraging the exchange of information. In this paper, we focus on proposing prototype architecture for generating ontology by extracting knowledge from various data sources. These sources may take on various forms, such as textual data, knowledge based data and regular documents.

2 Ontology in the E-government domain

In recent years, many countries have used ontology in e-government projects [4, 16]. Apostolou et al. [2] presented the OntoGov project, which aims to develop an ontology platform in order to facilitate the consistent configuration and reconfiguration of e-government services. More recent work in the field of ontology in governments was presented by Ortiz-Rodriguez [15]. They used a set of government methods of ontology to represent Mexican local government processes. Further work in ontology was conducted by Alexopoulos et al. [1] in order to detect fraud in e-government systems. Other methods of ontology have been built to facilitate transactions between companies across EU countries [8]. In addition, Salhofer et al. [17] described an approach to a model of ontologies for the e-government domain as a basis for an integrated e-government environment.

3 Methodology

In the literature, different methodology approaches for building ontology have been proposed [11, 3, 6]. Until now, there has been no standard method for building ontology. The approach described in this paper was adopted from Noy and McGuinness [13] and Fernandez-Lopez's [11] ontology modeling approach. Our ontology will cover the two main important government sectors in Kuwait: the Kuwait Investment Authority (KIA) and the Ministry of Foreign Affairs (MFA). It is important in the first step to know how these two sectors model and present their major trends, actions, norms and principles. It is crucial to describe the domains and the relationship between them and to understand the complexity involved in making decisions and how building ontology can be helpful and beneficial for decision makers. The second step consists of identifying the ontology concepts, including the definition of classes and subclasses, the properties between classes, the classes' shared elements and the description of entities within these classes. This will enable us to describe the domains and the relation between them. Ontology editors create and manipulate ontologies. Examples of such editing tools include Protégé, which is an ontology editor and knowledgebase framework, and Fuzzy Logic Toolbox, which extends the technical computing environment with tools that design systems based on fuzzy logic. Before defining these classes of ontology, we should determine and specify the domain that the ontology will cover and define its goal of use. The third step consists of listing the main terms that will be used in the ontology without considering any overlaps between them. In the fourth step, we choose an approach to define the classes and their hierarchy. There are two different approaches, the top down and the bottom up. This paper will follow the first approach. We start by defining the most general concepts and then add different specifications to those concepts. In the fifth step, we find the properties of classes and the slots, such as intrinsic, extrinsic and relationships between different members of the class. We should mention here that every subclass inherits all slots from superclasses. Step six consists of defining the facets of the slots, such as the cardinality, type, allowed values and instance with the relationship to another instance. Afterwards, we need to define the domain of the slot and the classes to which it is attached. The last step consists of creating the instances by choosing the class and filling in the slot values.

4 Purposes of the Ontology

One of the methods for determining the scope of an ontology is to write a list of questions to which an ontology-based knowledge should respond; such questions will be later subjected to the litmus test: Does 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? Our approach consisted of building a set of questions that need to be answered by the ontology in order to fulfill their purposes. The concepts of the ontology are terms that define the domain or activities carried out in the domain [4]. Starting from this list of questions, the ontology includes information about the different elements and different types of conditions to be taken into account in order to make a recommendation about whether to invest or not invest in a specific country.

5 Existing tools to edit Ontologies

Ontology describes the concepts in the domain as well as the relationships that hold those concepts. Many existing tools are used to edit ontologies. 'Altova Semantic Works' is a visual RDF and OWL editor that auto-generates RDF/XML or nTriples based on visual ontology design, but no open source version is available. Different ontology languages provide different facilities. The most recent development in standard ontology language is OWL, from the World Wide Web Consortium (W3C). Like Protégé, OWL makes it possible for users to describe concepts but it also provides new facilities. It has a richer set of operators (e.g., intersection, union and negation). It is based on a different logical model, which makes it possible for concepts to be defined as well as described. Complex concepts can therefore build definitions out of simpler concepts. Protégé is a free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with ontologies. The Protégé platform supports two main ways of modeling ontologies: via the Protégé-Frames editor or via the Protégé-OWL editor. Protégé ontologies can be exported into a variety of formats, including RDF(S), OWL and XML Schema. "http://www.mkbergman.com/904/listing-of-185-ontology-building-tools/" counted a total of 185 extant tools for editing ontologies. Noman et al. [14] have done a survey of existing ontology editing tools, and the comparison between them is presented in Table 1. The Protégé-OWL editor is used to build our ontology in the bilateral relationship domain.

6 Ontology and semantic relation

In this section, we will specify the practical aspects of drawing a class diagram. This diagram will include the necessary information of classes, such as identifying classes. Identifying classes is fundamental to object-oriented analysis. Through successive iteration, the dynamic interaction will be presented among classes. At this stage, it is important to identify and specify classes correctly. Class specification includes attributes, and each attribute has a different meaning. Common primitive data types include Boolean (true or false), character (any alphanumeric or special character), integer (whole numbers) and floating-point (decimal numbers). Figure 1 presents a diagram for Bilateral Trade Ontology with Semantic or Linguistic Relation.

Table 1: A comparison of ontology editing tools

Tools	Free	Open Source	Java Based	Extensibility	collaboration	Archtecture	Import Languages	Export Languages	Tools
Protégé	√	√	√	√	No	Standalone	RDF(S),OWL	RDF(S),OWL,CLI	Pellet
OntoEdit(Free)	√	No	√	√	No	Standalone	RDF(S),DAML	RDF(S),DAML+OI	None
DOE	√	No	√	No	No	Standalone	RDF(S),OWL	RDF(S),DAML+OI	None
IsaViz	√	√	√	√	No	Standalone	RDF(S),N-	RDF(S),N-Triple	Jena
Ontolingua	√	No	No	No	√	Client Server	CLIPS, DAML+OIL	CLIPS, DAML+OIL	ATP
Altova SemanticWorks TM	No	No	No	No	No	Standalone	RDF(S),OWL	RDF(S),OWL	Built-in Reasoner

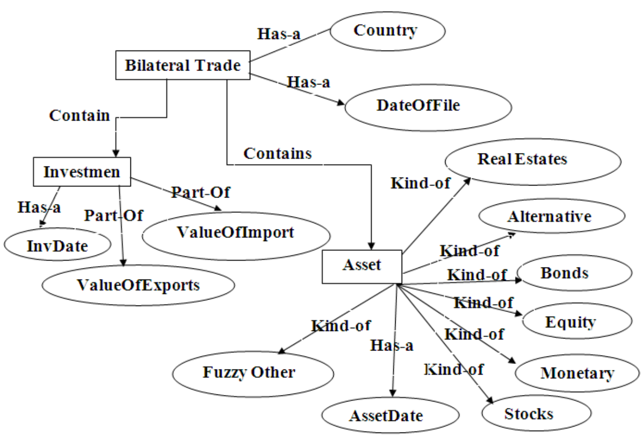

Figure 1: Bilateral trade ontology with semantic Relations.

7 Fuzzy Set and Membership

The aim of this section is to present a proposal that integrates fuzzy logic in ontology. Undoubtedly, the success of fuzzy logic applications describes vague information in addition to drawing our attention to addressing certain applications in government sectors, since such information needs a common language to describe its concept.

Fuzzy set and fuzzy logic allows users to model imprecise and vague data. Fuzzy logic can combine different priority functions. Fuzzy logic allows any value between 1 and 0 as a logic value. Fuzzy logic is based on natural languages in order to provide convenient methodologies to represent human knowledge [12]. The fuzzy membership value μ is used for the relationship between the objects in question, where 0‹μ‹1, and μ correspond to a fuzzy membership relation, such as “low,” “medium” or “high,” for each object. The purpose of fuzzy control is to influence the behavior of a system by changing the inputs or outputs to that system according to a rule or set of rules under which the system operates.

In the first step of our research, we extend the domain’s ontology to generate fuzzy ontology. This fuzzy concept includes a set of membership degrees in each concept: the political and investment domains with the relationships between them. The first step will provide a complete framework based on ontology in a particular domain. The proposed bilateral relation domain ontology contains vague descriptions. Table 2 presents different classes with different properties in the bilateral relation domain. For example, “StrongFriend” is a property of the concept and “RelationName” describes the name of a relation in the bilateral relation domain. Thus, “StrongFriendRespect,” “WeakRespect,” “Respect” and “StrongFriend” are properties that describe the type of relation between two countries, which require human knowledge for interpretation. The second step consists of adding a degree of membership to all terms in the ontology without overloading the problem. The third step consists of generating an extension of the domain ontology with a fuzzy concept [7]. Table 2 presents the first step in the political approach, which extends the domain’s ontology into a bilateral relationship domain in order to generate fuzzy ontology. Some concepts included in this domain are “CountryClassification,” “CountryName” and “RelationName,” where the “CountryName” class describes different classifications of countries, the “RelationName” class describes the type of relation between two countries and the “CountryName” class includes groups of different countries. A concept is considered to be a class in ontology with a set of properties in the bilateral relationship domain. In addition, the political decision-maker should consider various forms of information, such as textual data, knowledge base and regular documents. Certainly, extracting knowledge from various data sources can be described by a common language that requires human knowledge. For example, “coalition countries” includes all the states that had a positive attitude toward the State of Kuwait during the Iraqi invasion. This means that “coalition countries” represent the countries that condemned Iraq’s invasion, participated in the coalition forces and participated in reconstructing the country after the Liberation (see Table 3). Such definitions are used for the decision making process when it comes to strengthening the bilateral economic relationships between Kuwait and other nations. Such decisions are influenced by certain definitions and well defined concepts. In addition, different criteria for certain factors and variables are not described by degrees of interval [0.1] but described by linguistic terms. For example, to describe the concept of the “existing bilateral relation” as classes between countries, it can be described from a variety of perspectives with a set of properties, including “historical,” “respectable,” “coalition countries,” “antibody states” and “friendly.”

Table 2: Examples of semantic relations in “CountryClassification” and “RelationName” classes.

Country Classification	Relation name	Country name
Coalition countries	Strong-Friend-Respect	a b c d e f
sectarian States	Respect	J k l
investment states	Strong-friend	b c d ea g y t
Arab states	Respect-culture	a b x b p k d
EU states	Strong-respect-friend	a b c d r
GCC	History-neighbour- Religion	A b d f c
States voted in favour of the issue of Kuwait	Encourage very strong	A b c e
Crisis States	weak	G w

These properties cannot be evaluated and are sometimes even immeasurable. A commons langue is thus needed to describe such properties that require human knowledge for interpretation. For example, “coalition countries” is a property of the concept “existing relationship.” The value of the “country classification” class, such as “coalition countries,” has a fuzzy concept. Its link with the linguistic “RelationName” property is also a fuzzy concept. This does not help the decision maker to measure the “RelationName” fuzzy concept’s link with another fuzzy concept. This makes it extremely difficult for the decision maker to understand the concepts, restraints and facts. A decision support process must be empirical in order for the decision maker to assess the different fuzzy factors, fuzzy variables and the relationship between them in order to reach proper decisions. Therefore, coalition countries have more investments than other countries but are the measurement for other classifications. Examples of different factors and variables that may be assessed when defining the “coalition countries” are presented in Table 3, which illustrates the positions of states towards the issue of Kuwait in front of the United Nations. It includes the vote on the resolutions of the Security Council in the United Nations, such as the vote on the resolution of human rights in Kuwait during the Iraq invasion, etc. The “Coalition countries” class includes linguistic terms such as “Agree,” “Abstention,” “Disagree,” etc. Most factors and variables that are described are extracted from the political domain. Correspondingly, there are many existing variables in the investment field. Certain variables have a direct impact on strengthening the economic bilateral relationship-fuzzy concept, such as “prevent” or “reduce.” These variables also have an impact on the political bilateral relationship. They cannot be evaluated, because such inputs are very inaccurate and need human interpretation. The existing information includes linguistic variables for the evaluations. This linguistic variable can be proposed by expert rules and fuzzy inference for the decision making process.

Table 3: The “coalition countries” class by generating different subclasses

Year	Voted the resolution of human rights in Iraq	Voted the resolution of human rights in Kuwait	Voted the resolution of implication on the	Demanded the withdrawal of foreign forces from the region	Called for the lifting of economic embargo	Addressed the issue of Kuwait
1990		Absent		Agree		No
1991	Abstention	Agree	Absent			No
1992	Abstention		Absent			No
1993	Disagree			Agree	Agree	
1994	Disagree			Agree	Agree	
1995	Disagree			Agree	Agree	
1996	Disagree			Agree	Agree	
1997	Disagree			Agree	Agree	
1998	Disagree			Agree	Agree	
1999	Disagree			Agree	Agree	
2001	Disagree					

It is difficult for the decision maker to understand the dimensions of these linguistic variables while deciding to strengthen bilateral economic relations with this country. Identifying those variables related to this definition would enhance many decisions. Achieving the integration of information with rich concepts undoubtedly helps the political decision maker in making the appropriate and correct decisions. We propose to use ontology to integrate these scattered data from political and investment domains by extracting key concepts and relations between sets of information and by integrating fuzzy logic with ontology to obtain a solution that is more suitable for solving the uncertainty of problems in these intelligent decision support systems. In the first step, we need to break down the concept of the investment indicator. The “InvestmentIndicatorName” class has different properties that can be described from a variety of perspectives, such as “encourage,” “limit,” “prevent,” etc. (see Table 4).

Table 4: Fuzzy values assigned to “InvestmentRelation” class in the bilateral relationship domain.

Investment Relation	Weight
Encourage	0.2
Limit	0.4
Prevent	0.3
Encourage with strong	0.8
Caution	0.6
Warned	0.7
Opportunity	0.5

Therefore, a need emerges for giving different interpretations according to the context. Table 5 presents the proposed “InvestmentIndicatorName” class with linguistic and semantic properties.

Table 5: Fuzzy logic assigned to “CountryName” and “InvestmentIndicator.”

Country name	Relation name in bilateral relation domain "Investment Indicator"
A	Encourage very strong
B	Weak
C	encourage
D	prevent
F	Caution
E	carful
F	Encourage with caution

8 Fuzzy ontology structures

An ontology can be converted into fuzzy ontology by adding the relation weight to any fuzzy relation, as presented in [12, 19]. This ontology includes the weight for every relation (see Figure 2).

9 Case studies methodology

In this research, we introduce a fuzzy ontology approach and apply this approach to two main important government sector representatives in Kuwait: the Kuwait Investment Authority and the Ministry of Foreign Affairs. It is very important to understand how these sectors presented their major trends and broke their concepts down into objectives, actions, norms and principles. This will help us to identify the appropriate ontology concepts, including classes and subclasses, to characterize the properties between classes, to share all elements, to describe the entities in those classes and to explain the domain and the relation between them. The aim of conducting the fuzzy ontology approach is to provide insight into how knowledge can be represented and handled so that the decision maker has support from an intelligent decision process.

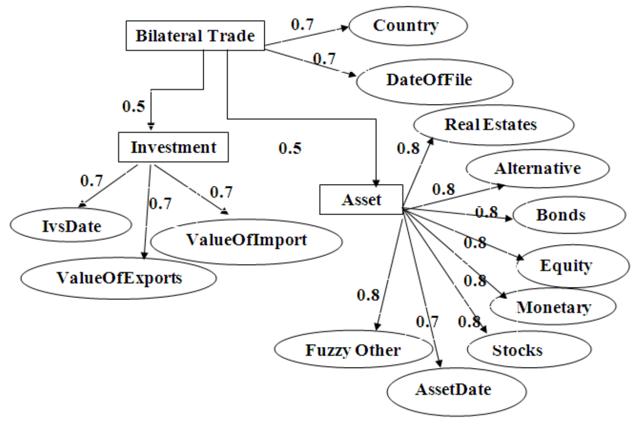

Figure 2: Ontology representing bilateral trade domain.

Figure 3 presents the Ontology diagram to explain the relation between the Ministry for Foreign Affairs and the Kuwait Investment Authority. We can see in this figure different links between the different classes of the ontology. For example, the “MinistryOfForeignAffairs” class is directly linked to the “BilateralRelationship” class. The “BilateralRelationship” classes have different attributes, such as “StartDate,” “BilateralRelationType,” etc. The “MinistryOfForeignAffairs” class is subdivided into the “FuzzyIranNuclearFile” class, “FuzzyIraqiAffair” class and the “FuzzyPalestinianIsrael” class. In addition, “MinistryOfForeign Affairs” has strong links, relations and influences on the activity of the “KuwaitInvestmentAuthority.” The relationship of trade in the “KuwaitInvestmentAuthority” has the different attributes of “ValueOfImport,” “ValueOfExport,” “ValueOfAsistance,” “ValueOfGrants,” and “LoanValue.” On the other hand, the type of relationship between the two countries has an impact on the continuity of the loan. The Ministry of Foreign Affairs handles the workflow for multiple files, such as Iraqi affairs, Iranian affairs and Palestinian affairs. The answers to these functioning files usually take the form of “yes,” “no,” “strong,” “very strong,” etc. In this context, we propose prototype architecture for an intelligent decision support systems that can help top political decision makers to strengthen bilateral economic relationships. We present the integration of data across different sectors and produce a seamless system that enables valid design support for top political decision makers by employing natural language. Figures 3 and 4 show the semantic relation and fuzzy ontology for political and investment sectors.

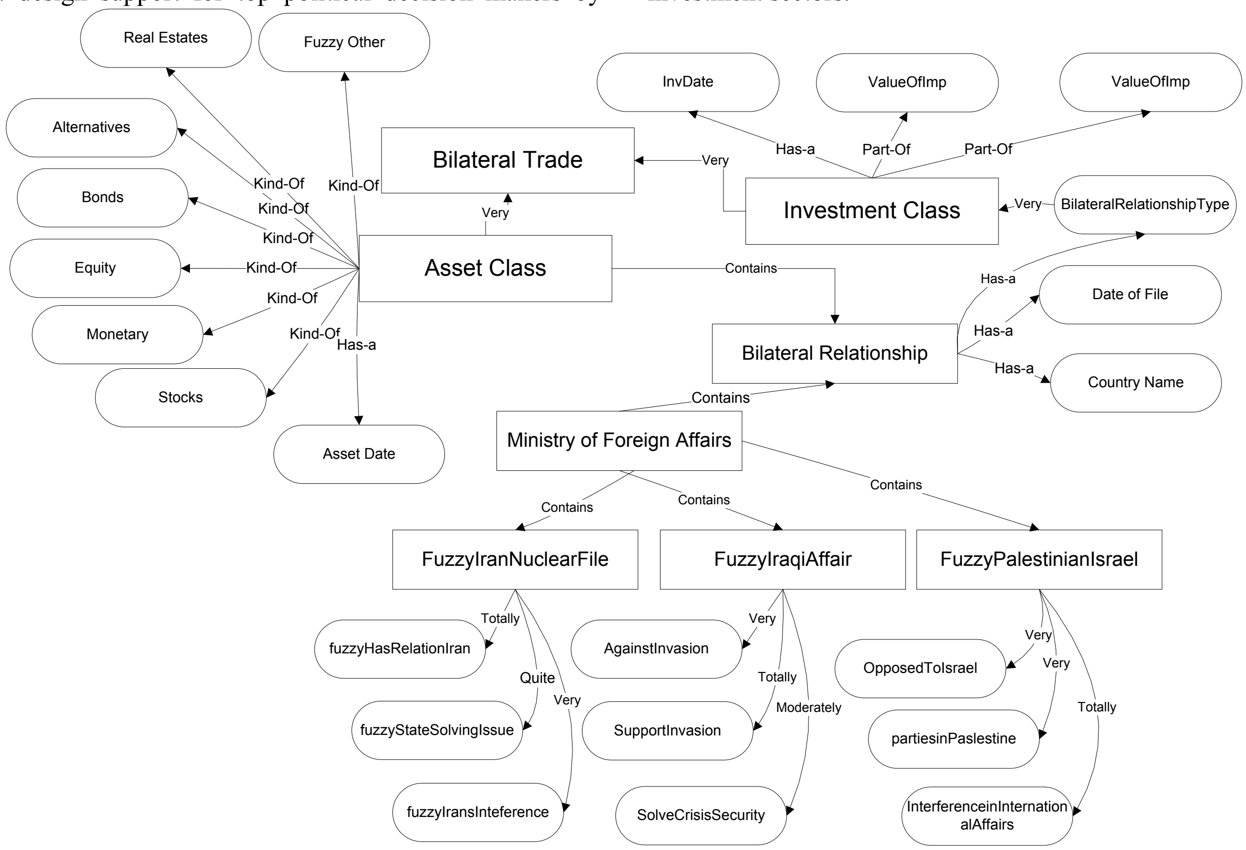

Figure 3: Semantic ontology for the relation between the Ministry for Foreign Affairs and the Kuwait Investment Authority.

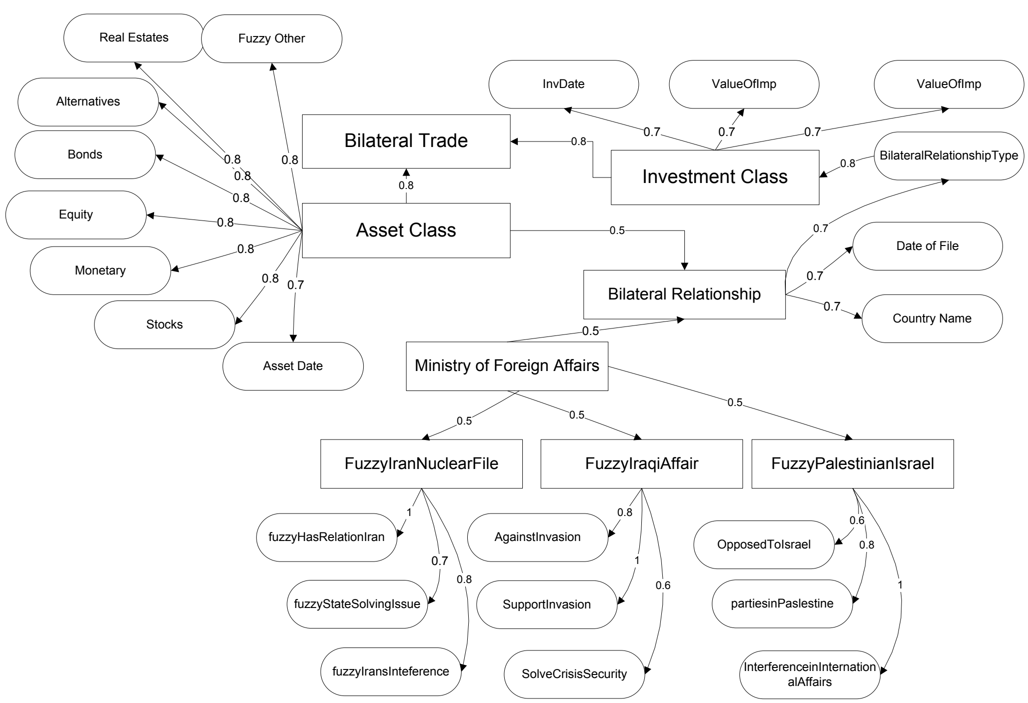

Figure 4: Fuzzy ontology for the relation between the Ministry for Foreign Affairs and the Kuwait Investment Authority.

10 Conclusion

In this paper, we propose a methodology to develop a fuzzy ontology approach and discuss how to conduct this approach in two main important government sectors in Kuwait: the Kuwait Investment Authority and the Ministry of Foreign Affairs. To build this ontology, it is very important to understand how these sectors represent their major trends by breaking these sectors down into objectives, actions, norms and principles. This helps to identify the proper ontology concepts for each sector, to characterize the properties between them, their sharing elements, the entities in those classes and the domain and the relationships between them. The aim of conducting the fuzzy ontology approach is to provide insight into how knowledge can be represented and handled in order to provide the decision maker with aid from an intelligent decision process.

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