THE DEVELOPMENT OF A FUZZY EXPERT SYSTEM TO HELP TOP DECISION MAKERS IN POLITICAL AND INVESTMENT DOMAINS

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A B S T R A C T

The world's increasing interconnectedness and the recent increase in the number of notable regional and international events pose greater and greater challenges for political decision-making, especially the decision to strengthen bilateral economic relationships between friendly nations. Typically, such critical decisions are influenced by certain factors and variables that are based on heterogeneous and vague information that exists in different domains. A serious problem that the decision-maker faces is the difficulty in building efficient political decision support systems (DSS) with heterogeneous factors. One must take many factors into account, for example, language (natural or human language), the availability, or lack thereof, of precise data (vague information), and possible consequences (rule conclusions).

The basic concept is a linguistic variable whose values are words rather than numbers and are therefore closer to human intuition. A common language is thus needed to describe such information which requires human knowledge for interpretation. To achieve robustness and efficiency of interpretation, we need to apply a method that can be used to generate high-level knowledge and information integration. Fuzzy logic is based on natural language and is tolerant of imprecise data. Fuzzy logic's greatest strength lies in its ability to handle imprecise data, and it is perfectly suited for this situation.

In this thesis, we propose to use ontology to integrate the scattered information resources from the political and investment domains. The process started with understanding each concept and extracting key ideas and relationships between sets of information by constructing object paradigm ontology. Re-engineering according to the object- paradigm (OP) provided quality for the developed ontology where conceptualization can provide more expressive, reusable object and temporal ontology. Then fuzzy logic has been integrated with ontology. And a fuzzy ontology membership value that reflects the strength of an inter-concept relationship to represent pairs of concepts across ontology has been consistently used.

Each concept is assigned a fixed numerical value representing the concept consistency. Concept consistency is computed as a function of strength of all the relationships associated

with the concept. Fuzzy expert systems enable one to weigh the consequences (rule conclusions) of certain choices based on vague information. Rule conclusions follow from rules composed of two parts, the *if* antecedent (input) and the *then* consequent (output). With fuzzy expert systems, one uses fuzzy logic toolbox graphical user interface (GUI) tools to build up a fuzzy inference system (FIS) to aid in decision-making. This research includes four main phases to develop a prototype architecture for an intelligent DSS that can help top political decision makers.

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For my husband. Special thanks to my husband. Whatever I could say to my husband in thanks and gratitude is too little. He made all every effort and gave every comfort and contributions to bring me success. I can never describe how much he has given me. He supported me in every way to enhance my studies. I am sure I cannot give every repay him, because he is the king of love and generosity, wisdom and patience.

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SUPPORTING PUBLICATIONS

The following papers have been published as a result of the research carried out during this thesis.

Journal Publications

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Conference Papers

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- Al shayji, S., El Kadhi, N. and Wang, Z., 2011b. On fuzzy-logic-based Ontology Decision Support System for Government Sector,*12th WSEAS International Conference on Fuzzy Systems*, Transylvania University of Brasov, Romania, April 2011, pp.34-41.
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- Al shayji, S., El Kadhi, N. and Wang, Z., 2011a. Fuzzy Cognitive Map Theory for the political Domain, *Federated Conference on Computer Science and Information System, The Fed CSIS'2011 September 19-21*, Szczecin, Poland, IEEE Digital library CEP1185N-ART
- Al shayji, S., El Kadhi, N. and Wang, Z., 2012. Building Fuzzy -Logic Ontology and Fuzzy Inference System In The Political Domain, PwD Doctoral Symposium,21-22 April, 2012.

Chapter One

INTRODUCTION

1.1 OVERVIEW

Most countries of the world have been affected by the global financial crisis to varying degrees. On the other hand, many countries suppress some of the financial losses not only because of the economic crisis, but because of obscure political factors as well; many countries are influenced in ways due to other political factors, such as the political factor that describes the type of bilateral relationship that exists between countries. It is in the interest of every nation to foster good bilateral relationships with other countries. Apart from this variety of relationships, all nations seek to build bridges of cooperation with other countries in various ways. One way is to strengthen economic relationships, where many factors and variables that influence the promotion of an economic relationship should be taken into account.

Existing bilateral relationships between countries can be described from a variety of perspectives, such as historical, weak, respectful, friendly, neighboring, traditional, religious, political, and economic viewpoints. For example, if the description of the bilateral relationship between two countries is "weak," that means there is a risk in promoting a bilateral economic relationship, because the weakness of the bilateral relationship does not enhance the continuity of the economic relationship between the two countries and may lead to the failure of the relationship investment.

Alam Alyawm (2011) is a daily newspaper that described the political relationship between Kuwait and Iraq. In addition, *Alraimedia* (2011) is a daily newspaper that covers the United Kingdom and urged Iraq to form a good relationship with Kuwait. The same newspaper described the type of bilateral relationship between Kuwait and Mongolia. *Alraimedia* (2011)

and *Alwatan* (2011a) described the bilateral relationship between Kuwait and Bosnia. *Alwatan* (2011b) also described the attitude and position of Turkey toward the invasion of Iraq to Kuwait as either positive or negative. All these references are an integral part of the perspective of political thought, as each of them describes the content of the bilateral relationships between countries. These variables and factors are diversified, and may be found in different places in various economic and political domains. Recognition of these factors or variables is important. Some factors may encourage the promotion of investment, and other factors may prevent the promotion of investment or limit investments to specific degrees. Therefore some factors can be considered positive in strengthening the relationship while others are negative.

1.2 CURRENT CHALLENGES

From the research viewpoint, the challenges lie in recognizing, finding, and extracting these different variables. A conscientious decision-maker takes the responsibility to promote and strengthen bilateral economic relationships that require good access to well-structured information relevant to his or her decisions.

Unfortunately, in reality, the actual input to such a decision-making process is quite unstructured, non-centric, and scattered in 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 to strengthen the economic bilateral relationships with other nations. It is usually empirical for a decision-support process to be able to assess the vague factors, variables, and relationships between them to reach appropriate conclusions and proper decisions.

Examples of vague factors and variables that may be assessed in the decision-making process include, but are not limited to: the positions of the countries with regard to regional and global issues, nuclear proliferation, security, and stability; the ability of the nation to invest; the disclosed position of the nation in the fight against terrorism; and the position of the nation on combating weapons of mass destruction. Political decision makers may ask the following questions: Does the country encourage the use of diplomatic dialogue or military options? Does the country encourage the military option more strongly than the diplomatic one? Does the country encourage the military option indirectly? Or are most of the positions of this country neutral towards these issues? Does the country encourage sectarian pluralism and division? Is the security of this country stable? Does the country have political stability? We can get

answers to those questions from the political field. For example, the following tables (Table 1.1 to Table 1.11) describe the how some countries voted toward issues involving Kuwait at the United Nations. These tables include the positions of Jordan, Sudan, Somalia, Libya, Yemen, Pakistan, China, the Russian Federation, the US, and Malaysia. The information in those tables was extracted from political documents (Mansoor 2009); all these tables include linguistic variables.

Table 1.1: Positions of Jordan on Kuwait's case to the United Nations

Year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Jordan
1990	Absent			
1991	Agree	Absent	Agree	
1992		Omission	Agree	
1993		Absent		
1994		Omission		
1995		Omission		
1996		Omission		
1997		Omission		
1998		Omission		
1999		Omission		
2000		Omission		
2001		Omission		

Table 1.2: Positions of Algeria on Kuwait's case to the United Nations

Year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Algeria
1990	Absent			
1991	Agree	Absent	Agree	
1992		Omission	Agree	
1993		Omission		
1994		Omission		
1995		Omission		
1996		Omission		
1997		Omission		
1998		Omission		
1999		Omission		
2000		Omission		

Table 1.3: Positions of Sudan on Kuwait's case to the United Nations

Year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Sudan
1990	Absent			
1991	Absent	Absent	Against	
1992		Against	Omission	
1993		Against		
1994		Against		
1995		Against		
1996		Against		
1997		Against		
1998		Against		
1999		Against		
2000		Against		
2001		Against		

Table 1.4: Positions of Somalia on Kuwait's case to the United Nations

Year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Somalia
1990	Agree			
1991	Absent	Absent	Agree	
1992		Absent	Absent	
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				
2001				

Table 1.5: Positions of Libya on Kuwait's case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Libya
1990	Absent			
1991	Agree	Absent	Absent	
1992		Omission		
1993		Omission		
1994		Against		
1995		Against		
1996		Against		
1997		Against		
1998		Against		
1999		Against		
2000		Against		
2001		Against		

Table 1.6: Positions of Yemen towards Kuwait case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Yemen
1990	Absent			
1991	Agree	Absent	Absent	
1992		Absent	Absent	
1993		Absent		
1994		Absent		
1995		Absent		
1996		Absent		
1997		Absent		
1998		Absent		
1999		Absent		
2000		Absent		
2001		Absent		

Table1.7: Positions of Pakistan on Kuwait's case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Pakistan
1990	Agree			
1991	Agree	Omission	Agree	
1992		Omission	Agree	
1993		Omission		
1994		Omission		
1995		Omission		
1996		Omission		
1997		Omission		
1998		Omission		
1999		Omission		
2000		Omission		
2001		Omission		

Table 1.8: Positions of China on Kuwait's case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-China
1990	Agree			
1991	Agree	Omission	Agree	
1992		Omission	Agree	
1993		Omission		
1994		Omission		
1995		Omission		
1996		Omission		
1997		Omission		
1998		Omission		
1999		Omission		
2000		Omission		
2001		Omission		

Table 1.9: Positions of the Russian Federation on Kuwait's case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Russian Federation
1990	Agree			
1991	Agree	Agree	Agree	
1992		Agree		
1993		Agree		
1994		Agree		
1995		Agree		
1996		Agree		
1997		Agree		
1998		Agree		
1999		Agree		
2000		Omission		
2001		Omission		

Table 1.10: Positions of the US on Kuwait's case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-USA
1990	Agree			
1991	Agree	Agree	Agree	
1992		Agree	Agree	
1993		Agree		
1994		Agree		
1995		Agree		
1996		Agree		
1997		Agree		
1998		Agree		
1999		Agree		
2000		Agree		
2001		Agree		

Table 1.11: Positions of Malaysia on Kuwait's case to the United Nations

year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country-Malaysia
1990	Agree			
1991	Agree	Omission	Agree	
1992		Omission	Agree	
1993		Omission		
1994		Omission		
1995		Omission		
1996		Omission		
1997		Omission		
1998		Omission		
1999		Omission		
2000		Omission		
2001		Omission		

Other questions involve the investment field: Does the country have economic stability? Are the country's neighbors unstable politically or economically? What is the position of the state in cooperating and facilitating investment matters? We can get answers to these questions from the investment domain.

1.3 KEY ISSUES

Many factors and variables should be taken into account to strengthen bilateral economic relationships. In addition, it is essential to be able to understand the complete set of factors and variables, and identify relationships between them, to reach proper decisions. There is no doubt that these factors directly or indirectly affect the decision-making process regarding strengthening the bilateral economic relationships.

The decision-making process is one of the most central and pervasive human activities (Heinrich and Rommelfanger 2002) Making the right decision at the right time, and following up on events and variables sequentially are critical. Indeed, these decisions are influenced by certain factors and variables that are based on scattered, unstructured, heterogeneous, and vague information. A common language is thus needed to describe such information that requires human knowledge for interpretation, and is closer to human intuition such as language (natural or human language), and imprecise data (vague information). The general impression of the basic concept of the political discourse is a linguistic variable whose values are words rather

than numbers. Most of the data is represented as a fuzzy concept and in terms of linguistic qualifiers such as “very,” “little,” “close to,” “very good,” and so on. These kinds of data can be found in minutes of meetings documents, newspapers, satellite channels, and more. The data is set in terms that may vary in the value of the fuzzy linguistic variable; e.g., to specify the value of import or export, or to specify the type of bilateral trade in terms of investment, we can say that the bilateral trade is low, appropriate, expanding, very promising, and so forth.

In the same sense, the bilateral relationship between country X and country Y can be described from a variety of perspectives: “very distinct,” “very old,” “historic and very special,” “based on friendship and respect,” “cooperative,” “historical and distinct,” “not very old,” and the like. It is essential to associate a numerical membership modifier to develop a proper system that can handle the existing concept modifiers in the political field. The decision-maker faces difficulty in accessing all data when it is needed. An estimated eighty percent of the information is hidden in unstructured or semi-structured documents (Dejan et al., 2010). The inevitability of the establishment of the system that follows these variables is major and essential. Maintaining current data is very important for the political decision-maker.

The main objective of such a system is to help the decision-maker to retrieve as quickly as possible the information he or she really needs. A comprehensive inventory of the most important variables of interest to the political decision-maker will help him or her to make the right decision at the right time, and understanding the unstructured information from internal and external resources will help the decision-maker to become aware of the main factors that affect the promotion of economic relations. This overwhelms the political decision-maker with the responsibility of understanding not only the concepts and facts existing in that domain but also their properties, and the relationships between them.

The main aim of the study is to improve the processes involved in the analysis of political and investment data. Due to the existence of various factors influencing decision-making for strengthening economic relationships with other countries, there is an urgent need to develop a proper system to achieve adequate and accurate data gathering and analysis, as well as to produce precise and certain output that is useful to the 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 (Kaaya 2004).

1.4 REGIONAL EVENTS

There are currently revolutions in the Arab world and confusion and change in the political situations still going on in the Middle East. There are demonstrations which are stalled and still continuing in Yemen. Egypt has continuing problems, having become mired in the trial of the former regime and serious sectarian unrest. The *Al Watan* newspaper indicated that the loss of security in Egypt led to the seizure of real estate and investments and the demand for the return of these investments can be achieved only through the Egyptian courts, which takes years. *Salah jodah* (2012) showed the stress tests conducted by a team (Monetary Fund). Eight out of eleven investment companies' capital is negative, in the scenarios most severely, and four companies lost their complete capital in the scenario. While the same reference explained the loss of investments and integrated industries, one company lost 17,606,313 million KD in 2010. Waleed Altabtabaee, a member of the Kuwaiti parliament (Alnahar 2011) pointed out that the losses of Kuwaiti investments abroad amounted to nine billion dinars of the total investment of sixty billion KD. The fall of the Libyan regime led to concern about the state in this regard, delaying the country's economy.

Due to events in the region in recent years, many of the countries have been hit by several political challenges. For example, the invasion of Kuwait by Iraq, which cannot be ignored, and the preoccupation of the Kuwaiti government in finding solutions that satisfy all the political parties on the regional issues have created a negative effect in delaying the country's economy. Former British Prime Minister Tony Blair said in his report about his vision of Kuwait in 2030 that the country still faces challenges in managing economic affairs. The many challenges faced by Kuwait are reflected through perceptions both internal and external; while Kuwait is seen as a country with great potential, it is also seen as a "country of missed opportunities" under the "the rule of the past." Such a perception has a detrimental effect on the influence of the Kuwait International Economic and ambitions, and therefore, Kuwait needs to build on its image as a generous and historic nation and invest more in creating a new progressive image of the country (Hamed Alhsawy, 2012). Therefore, finding factors such as security and stability in the areas in which Kuwait wants to invest is very important to ensure the continuity of the country's economy in a secure, stable environment.

The security factor played a clear role in the dismantling of economic ties between Kuwait and other countries. To highlight the variable of the positions of some countries during the invasion of Kuwait by Iraq, we can say that investment in countries that had positive attitudes during the

invasion would preserve the environment and provide safe investments. These countries were dubbed the "Coalition countries" or "coalition forces" during Operation Desert Storm. The Gulf War from August 2, 1990 until February 28, 1991, commonly referred to as simply the Gulf War, was a war waged by a UN-authorized coalition force from thirty-four nations led by the United States against Iraq. This coalition was established to liberate Kuwait after Iraq refused to withdraw. These forces numbered 960 thousand soldiers, half of them from the US. List of coalition forces by number of military personnel presented in table 1.12.

Table 1.12: Coalition Countries by number of military personnel

List of Coalition forces by number of military personnel		
Country	Number of Personnel	Comments / Major Events
United States	575,000 - 697,000	Operation Desert Shield Battle of Khafji Battle of 73 Easting Battle of Al Busayyah Battle of Phase Line Bullet Battle of Medina Ridge Battle of Wadi Al-Batin Battle of Norfolk Operation Desert Storm
Saudi Arabia	52,000 - 100,000	Operation Desert Shield Battle of Khafji Operation Desert Storm
United Kingdom	53,462	Operation Granby
Egypt	33,600 - 35,000	Operation Desert Storm
France	18,000	Opération Daguet
Syria	14,500	Operation Desert Storm
Morocco	13,000	Security Personnel
Kuwait	9,900	Invasion of Kuwait Operation Desert Storm
Oman	6,300	Operation Desert Storm
Pakistan	4,900 – 5,500	Backup team
Canada	4,500	Operation FRICTION
United Arab Emirates	4,300	Operation Desert Storm
Qatar	2,600	Battle of Khafji
Bangladesh	2,200	(Operation Moru-prantar) Security Personnel including 2 field Ambulance teams
Italy	1,200	Deployed Panavia Tornado strike attack aircraft,Naval deployment
Australia	700	Australian contribution to the 1991 Gulf War
Netherlands	700	Naval deployment; Air Force deployments of Surface-to-Air Missiles to Turkey and Israel
Niger	600	Patroller group
Sweden	525	Field hospital

Argentina	500	Navy / Air Force
Senegal	500	Base Guards
Spain	500 on the field / 3,000 off the coast	Engineers
Bahrain	400	Base Guards
Belgium	400	Base Engineers
Poland	319	Operation Simoom Naval and medical deployment
South Korea	314	Medical and transportation support
Czechoslovakia	200	Operation Desert Shield Operation Desert Storm Czechoslovakia in the Gulf War
Greece	200	Pilots
Denmark	100	HDMS Olfert Fischer (Niels Juel Class Korvet)
New Zealand	100	2 C-130 Hercules transporter aircraft [3]
Hungary	50	
Norway	50	Naval and medical deployment

It is important to associate a numerical membership modifier in many situations in the political domain. For instance, if we want to measure the positions of the country toward the issue of Iraq's invasion of Kuwait, Alshayji et al. (2001c) presented the concept of Iraqi affairs and such issues in their paper. Clearly states differed in their attitudes toward the issue of Iraq's invasion of Kuwait. Table 1.13 includes information about these attitudes that extracted from political text documents.

Table 1.13: Different attitudes towards the issue of Iraq's invasion.

Country	Position
Libya	Immediate withdrawal
Coalition countries	Total rejection and condemnation
Libya	Condemnation of the invasion
Lebanon, Algeria, Jordan, Yemen	Contrary to international legitimacy
Libya, Sudan, Algeria	Rejection of foreign interference
Libya, Sudan, Algeria, Jordan, Yemen	Search for an Arab solution to the crisis
Yemen, Sudan	Demanding the withdrawal of foreign forces from the region
Sudan, Algeria, Jordan, Libya	Lifting the economic embargo on Iraq
	Neutral
Somalia, Sudan	Find a peaceful solution

Taking advantage of past experiences makes it imperative for countries not to fall into the trap of investment losses and gains. For example, Kuwait suffered heavy financial losses and still to

this day has not been repaid. Kuwait has faced different circumstances in the past years, accompanied by radical changes in the state's financial reserves as a result of the Iraqi invasion.

At first glance, Table 1.14 is considered a part of base table. The first row shows that Kuwait has provided a loan to Iraq on 20 September 1990 at a value of 8.500.000.000 KD to implement an electrical project in Basra. This loan was provided two months before the invasion of Iraq on Kuwait which created the Gulf War.

Table 1.14: The total amount of loans and number of projects in Iraq. Note: All Amounts are in Kuwaiti Dinar (1 KD = US$3.40) (Kuwait Fund for Development web site)

Region	Country	Type	No.
Project Name	Amount (KD)	Sign Date	Status
Arab Countries	Iraq	Loan	381
Basra Electric System Project	8,500,000.000	20-05-1990	Cancelled
Arab Countries	Iraq	Loan	23
Samarra Hydro-electric Power Station	2,624,627.664	05-12-1970	Completed
Arab Countries	Iraq	Loan	28
Samawah-um Qasr Cement	3,760,895.655	04-08-1971	Completed
Arab Countries	Iraq	Loan	-
Northern Thermal Power Station	0.000	-	Pipeline

In addition, many of the loans were provided by the state of Kuwait to countries that supported the invasion! These are called "antibody countries" or not from coalition countries because they had negative attitudes during the invasion, such as Yemen and Algeria, which also abstained from voting against Iraq. However, Algeria is exporting oil and gas, and ninety-eight percent of its economy depends on those exports. Algeria is willing to coordinate positions in the framework of OPEC in terms of production and prices.

This raises a number of questions. For example, is the interest of Kuwait to promote economic relations with Algeria? Or will Kuwait give Algeria the opportunity to participate in developmental projects in the state? Or will Kuwait strengthen economic relations with Algeria? In addition, the Kuwaiti Fund for Development provided loans to Algeria in the total amount of 83,494,463 million dollars from 1964 until 1989, and the total amount of $9.797.769 US in 2002. On the other hand, the activity of the investment in Algeria is not successful with General Authority for Investment. However, Kuwait provided financial aid to Algeria with a total amount of 6.867.690 million dollars from 1980 until 2005. Also, there are nineteen

agreements signed between the two countries. These agreements are in several different areas including culture, commercial cooperation, the avoidance of double taxation, economic cooperation, agriculture, and others.

Here is a review of the loans granted by the state of Kuwait through the government sector (Kuwait Fund for Development) for Yemen, Yemen is one of the "antibody countries" that stood against Kuwait during the invasion. Table 1.15 presents some loans provided by Kuwait to Yemen before the invasion of Iraq on Kuwait.

Table 1.15: Loans provided to Yemen before the invasion of Iraq, Note: All amounts are in Kuwaiti Dinar (1 KD = US$3.40) (Kuwait Fund for Development web site)(www.kuwait_fund.org/index.php

Arab Countries	Yemen	Loan	22
Saleef Salt Mine	2,981,471.774	28-07-1970	Completed
Arab Countries	Yemen	Loan	17
Wadi Zabid Pre-investment Survey	320,551.290	06-06-1968	Completed
Arab Countries	Yemen	Loan	205
Program Of Operations Of The Industrial Bank Of Yemen During (1982-30/6/1988)	3,868,639.535	25-01-1982	Completed
Arab Countries	Yemen	Loan	304
Electricity Supply For Earthquake Affected Areas	3,622,967.750	25-05-1986	Completed
Arab Countries	Yemen	Loan	312
Wadi Siham Project	133,426.988	25-11-1986	Completed
Arab Countries	Yemen	Loan	327
Aden Ring Road (stage I)	700,000.000	25-10-1987	Cancelled
Arab Countries	Yemen	Loan	271
Aden Ring Road Stage (i)	2,635,023.346	27-06-1984	Completed
Arab Countries	Yemen	Loan	287
Aden Port Development And Extension	3,410,714.880	22-05-1985	Completed
Arab Countries	Yemen	Loan	255
Wadi Hadramawt Agricultural Development Stage (ii)	2,891,400.059	03-12-1983	Completed
Arab Countries	Yemen	Loan	194
Naqabah-nisab Road	3,000,000.000	27-07-1981	Completed
Arab Countries	Yemen	Loan	140
Wadi Mawr Development (tihama Iii)	3,276,728.510	13-06-1979	Completed
Arab Countries	Yemen	Loan	313
Greater Aden Water Project.	11,540.980	16-02-1987	Completed
Arab Countries	Yemen	Loan	69

Tihama Development Stage (ii)	2,539,791.512	17-01-1976	Completed
Arab Countries	Yemen	Loan	27
Country Wide Agro and Socio Economic Survey and Abyan Delta Preinvestment Study	329,973.440	17-04-1971	Completed
Arab Countries	Yemen	Loan	373
Wadi Hadramawt Agricultural Development Project (Phase Iii).	3,500,000.000	20-12-1989	Cancelled
Arab Countries	Yemen	Loan	68
Taiz-km64 Highway	1,484,133.524	17-01-1976	Completed
Arab Countries	Yemen	Loan	778
The Social Development Fund Program 3rd Phase	14,000,000.000	22-02-2009	Active
Arab Countries	Yemen	Loan	804
Sukatra Island Harbour	11,800,000.000	23-03-2010	Active

It is important to emphasize here again that there are other precise data or variables (vague information) that hinder or promote investment between the two countries and a common language is thus needed to describe such information. The variable of the “type of bilateral agreement” between the two countries plays a role in the promotion of economic relations. For example, new agreements have been made with Libya in 2010. Although there had been no deals with Libya since 1976, 1981 and 1984, six new agreements were made in 2010. Does this mean that the economy has become secure between the two countries? What about the political upheavals that have taken place since the beginning of 2011? Are these factors of security, stability, and sectarianism taken into consideration? To what degree do these factors matter? How can these factors be calculated? Ironically, some borrowing countries demanded a decrease in their loans or drop in benefits, due to the inability of the state to repay the loan or for other unknown reasons, and most surprisingly, some of the “antibody countries” want to drop down their debt at the level of the United Nations.

As was repeatedly demonstrated by Iraq, for example, Iraq made provocative statements banning the construction of the great port of Mubarak in the occupied Kuwait, a clear threat of intervention in the internal affairs of the state. In 1945, the United Nations was founded with the smoke still rising from the rubble of World War II. Placing a high value on peace is what makes this organization's charter prohibit the adoption of the principle of force. At the same

time, the organization's documents endorse non-interference in internal affairs of independent states**.**

Investments play a key role in the process of economic and social development in all nations; however, Kuwait currently plans to implement new development projects (Tony Blair's *Kuwait Vision 2035*) and investment in Kuwait. This investment will be implemented by many friendly countries. There were originally 798 projects in the plan. The number of projects is increasing. Today, the projects have increased to 888. Ninety projects were added to the new development plan to implement it for the next four years. The goal of the development plan is to improve the financial situation and improve the economic situation of trade and reduce dependence on oil revenues. The total cost of the new development plan is 129 billion US dollars [www.futurekuwait.org/new-page-13.htm]. Due to the large amount, the decision-maker will need to be provided a specific DSS and some indicators for building and strengthening the economic bilateral relations with foreign countries. Yet few DSS systems have been delivered in the political domain that can help the political decision maker effectively or support the decision maker in such decisions.

1.5 PROBLEM FORMULATION

A serious problem that the decision-maker faces is the difficulty in building an efficient political decision support system (DSS) with heterogeneous and vague information in the political and investment domains, especially the decision to strengthen bilateral economic relationships with friendly nations. Typically, these critical decisions are influenced by certain factors and variables that are based on heterogeneous and vague information that exists in different domains. For example, a decision maker might have to determine whether to strengthen bilateral economic relationships with friendly nations, especially in light of the recent series of political and economic crises. One can speak about political stability in simple, natural language that is clear and understandable. Most of the political decision makers' documents use linguistic variables whose values are words rather than numbers and therefore are closer to human intuition. A natural language is needed to describe such information, which requires more human knowledge for interpretation.

1.6 EXISTING METHODS

In Kuwait, the scattered data is mostly in the hands of various government agencies and bureaus, including:

1. The Kuwait Fund for Development;
2. The Kuwait Investment Authority;
3. The Ministry of Foreign Affairs;
4. The Office of the Prime Minister; and
5. The Office of the decision-maker.

For example, the Ministry of Foreign Affairs is responsible for bilateral relations at international and regional levels. This bureau can determine the type of relationship with another country, and the information pertaining to agreements with other countries can be found here (the political domain). In addition, information about the issue of terrorism can be found in the Ministry of Foreign Affairs. On the other hand, information on bilateral trade can be found through the Kuwait Investment Authority. This agency is responsible for implementing investments and follow-up bilateral trade with other countries. These agencies may fall under different domains and are interdependent with respect to the decision-making process when it comes to strengthening bilateral relationships.

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 not only understanding the concepts, restraints, and facts existing in that domain but also understanding their properties, the relationship between them, and identifying the location of all data in these sectors as well as their functionalities. Table 1.16 illustrates different sectors (ministries) with different domains and their respective functionalities and responsibilities.

Table 1.16: Different departments in different domains and their respective functionalities and responsibilities.

Sector/ Ministry	Domain	Department	Function / Responsibility
Ministry of Foreign Affairs	Political Domain	Bilateral Agreement	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

In Table 16, we select two departments, political and investment respectively, from two different domains in multiple sectors. The first department is the bilateral agreement department in the political domain which falls under the Ministry for Foreign Affairs' sector. The responsibility of this department lies in assigning agreements between Kuwait and other countries. The second department is the bilateral trade department in the investment domain falling under the Kuwait Investment Authority's sector, which is responsible for most investment transactions between Kuwait and other countries. As shown in Table 1.16, the data and information that are required by a top political decision-maker to strengthen economic bilateral relationships is scattered, vague, heterogeneous, and unstructured.

1.7 AIMS AND OBJECTIVES

1 To detect factors that may be hidden but have a large impact on the economic security of the country. For example, sometimes the political relationship is excellent, but the investment in this country is not successful. This causes waste and the depletion of state funds. On the other hand, sometimes the political relationship is weak, but the investment in this country is successful. Because of that other variables must therefore be taken into account.

2 To help the political decision maker to be able to sequence information from ancient to modern information in most variables. The decision support system requires working

with the most up-to-date data, because incomplete data may slow the decision-making process and may cause heavy financial losses to the state.

3 To assist quick decision-making process. Sometimes quick decisions must be made to accept or reject an investment opportunity.

4 To assist the decision maker in taking multiple inputs (variables). Humans are not as capable of manually taking multiple inputs and cannot do very quick manual calculation to implement a clear system. In addition, humans cannot do the computation of several values and present figures in different ways.

1.8 MOTIVATION

This research is driven by the need to:

1 Analyze and dismantle some of the concepts that affect the promotion of the economic relationship between two countries;

2 Be able to link several variables affecting the stability of the economy at once and collect the results of these variables at the same time;

3 Offset the heavy losses incurred from investment in the states arising from revolutions and other unrest in the world;

4 Offset the absence of concrete classification of political information;

5 Counteract the absence of thought for an active political informational approach to economic development;

6 Identify the factors involved in the characterization of the economic bilateral relationship between countries;

7 Understand the data correctly to extract valuable knowledge from different types of information and understand the impact of such data on political knowledge and on the political future vision in determining future investments;

8 Analyze, manipulate, transform, and combine data to explore the correlations, trends, and patterns for strengthening the economic bilateral relations with other countries.

9 Support the decision-making process by constructing a system to face challenges in creating economic bilateral relations with other countries.

1.10 STRUCTURE OF THE THESIS

Chapter two begins the study by presenting the related work of the relevant theme to the thesis. This chapter is organized as follows: section two introduces related work on ontology; section three illustrates work about fuzzy ontology; section four present the domain of application; section five presents the related work on fuzzy sets and membership; section six highlights on fuzzy logic uses; we cannot ignore the work of ontology in the e-government domain which is presented in section seven; it is important to present the existing tools to edit ontology which are included in section eight; section nine presents the fuzzy cognitive mapping (FCM) concept.

Chapter three presents the methodology of the construction of so-called fuzzy ontology for the specific domain to handle the data imperfection. The mechanism of the construction of the proposed ontology has been explained in detail in *Chapter three*, where we used the same approach for the construction of fuzzy ontology that used by Inyaem (2010). However, we have added some preparation techniques as subsections to his ontology, these subsections include preparations that could be considered integral. These preparation techniques are used to facilitate the implementation of the ontology for the specific domain.

Chapter four begins by generating ontology to represent and organize knowledge from different domains in terms of concepts and properties and generate fuzzy ontology approaches for all domains. Construction of fuzzy ontology for a specific domain is adopted in *chapter four.* This chapter includes all steps of the implementation techniques included within of the construction of the fuzzy ontology in a continuing series. Not dividing the implementation steps will make it easier to demonstrate the mechanism of application and make it clearer for the reader.

Chapter four consists of six main processes which are all detailed independently. The *first process* in this chapter is to determine the input data in specific domains which is presented in section 4.2. The *second process* in this chapter specifies the definition of related concepts in the domain and their relationships which presented in section 4.3. The *third process* in this chapter is to clarify the generation of the domain ontology which presented in section 4.4. Section 4.4 includes illustrative cases of engineering the ontology for the main concepts by using both the

object paradigm method and the Protégé-OWL method. The *fourth process* in chapter *four* is to define the domain ontology extended as fuzzy ontology which presented in section 4.5. The *fifth process* in chapter *four* is applying the fuzzy ontology into the specific domain which presented in section 4.6. *Process six* presents the evaluation in section 4.7.

The *fourth process* which is 4.5 is particularly complex, and includes four subsections. The first subsection constructs fuzzy logic and membership in a specific domain (political domain) which presented in 4.5.1. The second subsection 4.5.2 constructs a fuzzy logic structure and semantic relations for specific domains (political and investment domains). Traditional empirical decision making has been an inefficient process for example, signing an oil agreement enhances the trade exchange, enhances the consolidation of the bilateral positions, and has a significant positive effect on the consolidation of positions for international and regional levels. For this reason, the third subsection 4.5.3 was added to present the cognitive map theory for the political domain (FCM scheme) to demonstrate the causal interrelationship between certain factors to provide insight and better understanding about the interdependencies of these factors. In addition, to clarify the relationships between concepts, and elucidate the positive or negative effect on each concept while enhancing the knowledge clarification of the relationships fuzzy causal algebra governs causal propagation and causal combination, fuzzy causal algebra for governing causal propagation on FCMs is presented in *Chapter four section 4.5.4.* Along with previous preparation techniques, the stage of displaying what is going in the political mind in the form of a calculation, the fuzzy expert system has also been designed and a technical contribution has been proposed in *Chapter four section 4.5.6* as an inference system, because a fuzzy system enables one to weigh the consequences (rule conclusions) of certain choices based on vague information in one calculation at a time and in great detail.

In *Chapter four* section 4.5.6 presented the fuzzification of the inputs and defuzzification of the outputs are respectively performed by the input linguistic and output linguistic while the fuzzy inference is collectively performed by the rule. The definition of the important variables in political domain was defined, also the membership function Editor is used to define the shapes of all membership function associated with each variable. The Rule Viewer and the Surface Viewer are used for looking at as opposed to editing the FIS. The Rule Viewer is a Matlab technical computing environment-based display of the fuzzy inference diagram. The Rule Viewer helps us as a diagnostic; it can show us which rules are active, or how individual membership function shapes are influencing the results. The Surface Viewer is used to display

the dependency of one of the outputs on any one or two of the inputs; it generates and plots an output surface map for the system.

Chapter five discusses the contribution of the work presented in this thesis and describes the overall benefits of the proposed system in the political domain. Future considerations of new research and related issue are also discussed.

Chapter Two

BACKGROUND

2.1 INTRODUCTION

Information and communication technology (ICT) has radically changed the way governments deliver services to citizens, businesses, and organizations. ICT support consists of providing a large range of government information and services online, such as health care, education, and social services. Use of ICT facilitates online participation in government processes and decision making and helps in reorganizing government processes. Therefore, many applications have been developed in various government departments (Bwalya et al. 2009; Kaaya et al. 2004; Kitwa et al. 2006; Salles et al. 2010) 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 identify the processes and describe the data of these applications.

To make the reader familiar with the previous work carried out through the theme used in this thesis, this chapter focuses on providing the background for the study. It is organized as follows. Section 2.2 is a brief review of several definitions of ontology, but no matter how many definitions there are, it is a single concept. Section 2.3 is a brief review of fuzzy ontology material and how it can serve the researcher. Section 2.4 displays the domain of application that is used for this concept. Section 2.5 is a brief review of the meaning of "fuzzy" and memberships. Section 2.6 presents a brief summary on fuzzy logic uses and the benefits to this use. Section 2.7 presents an important but brief summary on ontology in the e-government domain. The existing tools to edit ontology are highlighted in Section 2.8. This helped make the choice of the appropriate tool for application in this study easier. This study used the Protégé-OWL editor to build the ontology. The need to understand the impact of political changes on the

strengthen the economic relation between nation prompted the use of the fuzzy cognitive mapping (FCM) technique, since economic relations are susceptible to political variables, in Section 2.9. A summary of the chapter is presented in Section 2.10.

2.2 ONTOLOGY

In recent years, a number of developed countries have employed ontology in e-government projects. Applying an ontology-based method is one of the possible solutions that address the following issues: integration of information, lack of clarity of content, and knowledge related to the relationships between different concepts.

Ontology is most simply defined as a set of concepts (classes) and the relationship between these concepts. Ontology can be defined as information in a specific domain that helps to acquire and share knowledge. According to Gruber (1993), ontology is defined as "a formal specification of shared conceptualization." This definition includes important meanings such as explicit, formal, and sharing. Ontology is a formal conception of a particular area of common interest between heterogeneous applications (Silvia et al. 2006). In addition, ontology defined as a specification of a representational vocabulary for a shared domain of discourse, definitions of classes, relations, functions, and other objects (Gruber 1993). According to Gruber (1993), ontology is an explicit specification of conceptualization.

Conceptualization is how we express our views through words, expression of concepts and elements, and relationships between entities. This definition stresses the application of the common ontology in different applications as well as translating a language text or document to defined terms, and is often considered a reusable and shareable model. Ontology is defined as mentioned above, a common vocabulary for people who need to share information in a specific domain. Different ontologies are used in different domains (geography, biology, etc.) to share a common understanding of the structure of information among people or software agents, to analyze domain knowledge, and to enable the reuse of domain knowledge. Geographical ontology can be used for exploration, extraction of information, and inter-operation of geography Information System (GIS) (Nadine et al. 2003).

In our case, we define ontology as a description of concepts in a domain (classed concepts) when the properties of each concept describe various features and attributes of the concept (properties, roles), and slots that describe properties of classes and instances. Similar related work was done by Yuemi et al. (1996), in which they proposed an ontological structure with

their concepts, properties, and 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.

Ontology plays a major role in the formation of information and in the availability of sharing information (Jun et al. 2008). Ontology can provide well-organized knowledge representation (Igacio et al. 2010). Ontology organizes different domain knowledge in terms of concepts, properties, relationships, and axioms. Ontology is used to describe the conceptualization in a certain language, with description methods for domain objects, and the ontology illustrates the concepts and the relationships between them (Ren and Cheng 2008). Ontology organizes classes, subclasses, entities, elements, events, and states, and specifies clear relationships between them. These relationships describe the meaning between them as semantic relationships. (Alasswad et al. 2010).

2.3 FUZZY ONTOLOGY

There are several approaches to construct a fuzzy ontology for a specific domain. One of these approaches is the usage of UML (unified modeling language). Lakshmi and Sambasiva (2009) utilized UML-based analysis and design to model the ontology at the agent level to develop distributed multimedia and collaborative systems, using an ontology diagram to create content messages. UML is an object-oriented graphical modeling language with well-defined syntax and semantics. Fuzzy ontology was presented by Jun et al. (2009), who used ontology to propose a new intelligent algorithm to minimize the number of control steps of overall operations when scheduling is performed, to minimize the usage of hardware components by using priority-function issue in the scheduling process. Fuzzy logic with ontology is employed to obtain a solution that is more suitable as an extension of domain ontology for solving uncertainty problems. A different fuzzy ontology was presented by Jun et al. (2008), who combined ontology with fuzzy logic to present new kinds of fuzzy ontology (intuitionist) models to apply them in knowledge modeling of transportation information.

Fuzzy ontology can provide more choices for attribute descriptions of an object, and has a stronger ability to express uncertainty than an ordinary fuzzy set. Ontological structure was proposed with its concepts, properties, and with some fuzzy linguistic variable ontology by Ren and Chen (2008). In addition, Zimmermann et al. (1999) defined fuzzy relationships as a set of

membership degrees associated with a set of the relationships in the concepts of the domain ontology.

More recent work for fuzzy ontology was presented by (June et al. 2008), who used fuzzy ontology to create an extension of standard ontology. The proposed fuzzy domain ontology consisted of multiple extensions. To assist in presenting these ideas, a concept considered classes in ontology was put forward with a set of properties which include multiple extension; e.g., ontology concept, property, values, linguistic qualifiers to control the strength of a property value, the restriction facts, and the universe of discourse. Jun et al. (2008) explained that the linguistic qualifiers could be "very," "little," "close to," and so on. 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"; therefore, the final value of "price" may be "very cheap" or a little expensive," and in our research, the value of export may be "very low" or “a little high.”

Fuzzy ontology includes a set of inter-concept relationships between concepts, a set of relation properties (concepts properties) and also contains association between concept-pairs. Fuzzy ontology can provide more choices for a description of the attributes of an object. There are several kinds of approaches for constructing a fuzzy ontology. Fuzzy ontology includes a semantic relation as property in ontology between fuzzy concepts, e.g. "low" and "high" have the relation of disjointedness. 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. Adding fuzzy membership to the concepts and the relations of them in the domain ontology can acquire a fuzzy domain ontology, which can be used to describe the semantic features. Note that fuzzy sets have been applied to many fields, including artificial intelligence and decision-making analysis.

2.4 DOMAINS OF APPLICATION

Ontology has been very commonly used in different applications, including the health field, in terms of fighting against malaria, where the concepts and techniques were presented using precise conceptualization. Ontology has been used in image applications; image ontology was presented by Zimmermann et al. (1999), where ontology was used to describe image concepts by defining color, texture, shape, and spatial relations. The authors presented five relationships in their articles, including Is-A, Instance-Of, and Part-Of, with equivalence and association as a

set of constraints. Similar related work for ontology was presented in the engineering domain to define a business model for telecommunication providers and their products and services to achieve the aim of automating changes in telecoms' business models to make them more intelligent. The authors presented class/subclass, relationships between classes/subclasses, and axioms. This work was done by Mutaz et al. (2009), where ontology was applied in the mobile telecommunications domain to build a telecom's ontology; the IBM company ontology was built by conducting different techniques including semi-structured interviewing archived data and combining it with fuzzy logic. Yuemei (1996) combined fuzzy logic rules with ontology to highlight the importance of sharing knowledge with heterogeneous agents to interact in an open environment. Similar related work comes from researchers in the field of geographical information, where intelligent modules are used by those receiving decision supports for spatial analysis functions from multiple sources. It provides users with the necessary knowledge to complete a task with reduced error (Claire et al. 2003).

Ontology has been utilized for several years in the fields of engineering Information Communication (IC) and Artificial Intelligence (AI) for structuring domain concepts. The concepts are gathered and are regarded as basic building blocks for representing knowledge in the field. Ontology is useful for sharing knowledge, achieving consensus, and building knowledge-based systems. Many projects of ontology have been implemented, such as the Semantic Web. The fundamental problem is to respect the diversity of languages and concept presentations of the world, while allowing the exchange of information. Gehrmann and Ishizu (2005, 2008) introduced the concept of ontology to support management system audits.

Relatively speaking, fewer numbers of attempts were found applying ontology to decision-making in the political domain. Inyaem et al. (2010) used fuzzy ontology in the terrorism concept, which is part of the political domain. The authors viewed linguistic variables that serve to approximate the meaning of ambiguous events; they used a suitable characterization for terrorism fuzzy relationships in their properties. Inyaem et al. (2010) used this approach to present a model of thinking for preparing and developing a study to predict actions of terrorist groups in southern Thailand. Their research defined a framework that can help in the decision-making process in a governmental environment. The authors successfully combined fuzzy logic with ontology to obtain a solution that is more suited for solving uncertainty problems in specific domains. They also presented a definition of terrorism fuzzy ontology in their paper.

2.5 FUZZY SET AND MEMBERSHIP

Fuzzy set theory extends the value range of the membership function of classical logic from {0, 1} to (0,1), in which it derives the basic concept of a fuzzy set. For example, to specify age, rather than stating an exact age, one can say a person is very young, young, middle-aged, very old, and so on. 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 using natural languages to provide convenient methodologies to represent human knowledge (Jun et al. 2009). Another paper presenting an idea along a similar theme by Al Shayji et al. (2011c) displayed a fuzzy model by sharing information from political and investment domains to present a high level of knowledge for the political decision-maker. In addition, Alshayji et al. (2011b) used fuzzy semantic relation with a set of properties in the political domain to present country classifications and relation names.

A decision model that facilitates the decision maker's role in the decision-making process in the political field has been created in this thesis. The use of fuzzy sets helps user to understand the basic principles of the expert knowledge more easily (Heinrich and Rommelfanger 2002).

2.6 FUZZY LOGIC USES

Fuzzy logic is used to present imprecise information (Jun et al. 2008). More recent work on developing models based on fuzzy logic was presented by Basha and Ameen (2011) to identify predictor variables that are significant in the act of purchasing. Alshayji et al. (2011b) used fuzzy logic to propose bilateral relation domains to help decision processes in the political domain. To begin with, an ontology can be converted into fuzzy ontology, as defined in section 1.2, where any relationship is a fuzzy relationship accompanied by its weight as defined in Table 2.1 (Muhammad and Bulaish 2006) and Table 2.2 (Silvia and Davide 2006).

Table 2.1: Weight associated with linguistic and semantic relation (Muhammad and Bulaish 2006).

Interpretation	Relation Name	Weight
Linguistics	Synonym	1.0
	Related Term	0.5
Semantic	Same as	1.0
	Kind-of	0.8
	Part-of	0.7
	Contains	0.5
	Associates	0.3

Table 2.2: Fuzzy value assigned to labels (Silvia and Davide 2006).

Label	Value
Little	0.2
Enough	0.4
Moderately	0.6
Quite	0.7
Very	0.8
Totally	1

2.7 ONTOLOGY IN THE E-GOVERNMENT DOMAIN

In recent years, many countries have used ontology in e-government projects (Bettahar et al. 2005; Ralf 2006; Shuppan 2009). Apostolou et al. (2005) presented the OntoGov project that aims to develop an ontology platform 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 Bettahar et al. (2005). Gomez-Perez et al. (2006) presented an ontology-based model to retrieve documents in government efficiently. More recent work on ontology in government was presented by Ortiz and Mexican (2006), who used a set of government ontologies to represent Mexican local government processes. Further work for ontology was presented by Alexopoulos et al. (2008) to detect fraud in an e-government system. Alshayji et al. (2011b) presented ontology in the decision process to help political decision makers in the political domain in e-government. Other ontology has been built to facilitate transactions between companies across EU countries (Herborn and Wimmer 2006). In addition Salhofer et al. (2009) have described an approach to present a model of ontologies for the e-government domain as a basis for an integrated e-government environment.

2.8 EXISTING TOOLS TO EDIT ONTOLOGY

Ontology describes the concepts in the domain as well as the relationships that hold those concepts. 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). Many existing tools are used to edit ontologies. Alshayji et al. (2011b) used Protégé-OWL editing tools in their paper to present the construction of the Ministry for Foreign Affairs organization. *Altova Semantic Works* is a visual RDF and OWL editor that auto-generates RDF/XML or nTriples based on visual ontology design.

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.

Islam et al. (2010) have done a survey of existing ontology editing tools. The comparison between them by Noy and McGuinness (2001) is presented in table 2.3. The Protégé-OWL editor is used to build the present ontology in the bilateral relationship domain.

Table 2.3 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,CLIPS	Pellet
OntoEdit(Free)	√	No	√	√	No	Standalone	RDF(S), DAML+OIL	RDF(S), DAML+OIL,OWL	None
DOE	√	No	√	No	No	Standalone	RDF(S), OWL	RDF(S), DAML+OIL,OWL	None
IsaViz	√	√	√	√	No	Standalone	RDF(S), N-Triple	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
OiLEd	√	√	√	No	No	Standalone	RDF(S), DAML+OIL	RDF(S), DAML+OIL,OWL	Fact
WebODE	√	No	√	√	√	N-tier architecture	RDF(S), DAML+OIL,OWL	RDF(S), CLIPS, DAML+OIL,OWL	PROLOG
Powl	√	√	No	√	√	N-tier architecture	RDF(S), N-Triple	RDF(S), N-Triple	RDQL
SWOOP	√	√	√	√	√	Standalone	RDF(S), OWL	RDF(S), OWL	Pellet
TopBraid Composer	No	No	√	√	√	Client Server	RDBMS,RDF(S),OWL	OWL,RDF(S),XML	Pellet
NeOn Toolki	√	√	√	√	√	Standalone	RDF(S), OWL	RDF(S), OWL	Ontobroker
Morla	√	√	No	√	No	Client Server	RDF(S), OWL	RDF(S), OWL	SPARQL,RDQL
OBO-Edit	√	√	√	√	No	Standalone	OBO File format, OWL	OBO File format,OWL	OBO-Edit Reasoner
Hozo	√	√	√	No	√	Standalone and Client Server	RDF(S), subset of OWL	OWL,RDF(S)	Own Reasoner
OntoBuilder	√	√	√	√	No	Standalone and Client Server	RDF(S), OWL,WSDL	RDF(S), Microsoft BizTalk	Possible
WSMO Studio	√	√	√	√	No	Stanalone	WSML-XML,subset of OWL-DL,RDF(S)	WSML-XML,OWL-DL	MINS,Pellet,IRIS
TODE	√	No	No	No	No	N-tier	RDF(S), OWL,N-Triple	RDF(S), OWL,N-Triple	Jena

2.9 FUZZY COGNITIVE MAPPING (FCM)

FCM is a fuzzy-graph structure for representing causal reasoning with a fuzzy relation to a causal concept (Kosko 1986). Fuzzy cognitive maps are especially applicable in the soft knowledge domain (e.g., political science, military science, history, international relations, and organization theory (Calais 2008). Fuzzy logic generated from fuzzy theory and FCM is collaboration between fuzzy logic and concept mapping. FCM is used to demonstrate knowledge of the causality of concepts to define a system in a domain starting with fuzzy weights quantified by numbers or words (Shaif and Irani 2005). In work by Calais (2008), FCM was used to demonstrate the impact of drug addiction in America.

As a soft-system modeling and mapping approach, FCM combines aspects of qualitative methods with the advantages of quantitative (i.e., causal algebra) methods. In a FCM, the positive (+) and the negative (-) signs above each arrowed line provide a causal relationship whereby each fuzzy concept is linked with another one. In this sense, the FCM is a cognitive map of relations between the elements (e.g., concepts, events, project resources) that enables the computation of the impact of these elements on each other, where the theory behind that computation is fuzzy logic.

Since FCMs are assigned fuzzy non-hierarchic digraphs (Shaif and Irani 2005), metrics can be used for further computations, and causal conceptual centrality in cognitive maps can be defined with adjacency-matrix (Kosko 1986). So far, FCMs have been used by (Alshayji et al. 2011c) to construct a diagram to represent words, ideas, and variables linked and arranged around a central idea to generate and classify ideas to demonstrate the impact of most political variables on each other variables to help the decision-making process in political domain. Khoumbati et al. (2006) developed a FCM-based model to evaluate the adoption of enterprise application integration (EAI) in a healthcare organization, where the FCM simulation was conducted to demonstrate the causal interrelationships between the EAI adoption factors that influence the EAI adoption in healthcare organization (Khoumbati et al. 2006).

2.10 SUMMARY

Chapter two provided an overview of the fuzzy ontology research field. Initially a review of frameworks of fuzzy ontology field was introduced. The review was designed to illustrate important points related to this field which must be understood before starting the construction of fuzzy ontology. In addition, a detailed review of the domain of application was presented to

let the reader know the possible challenges that face the recognition and affection for this applications and let the reader identify the existing applications to determine the applicability of the construct the of fuzzy ontology in a specific domain. The presentation of the literature on fuzzy sets, membership, and fuzzy logic uses provides an opportunity for the reader to recognize these concepts to keep pace with the rest of the argument easily. The previous look in *Chapter one* also provides to the reader the idea of the fuzzy effect; in general *Chapter one* opens to the reader a long-term pattern of thinking, while *Chapter two* highlighted the uses of fuzzy in the e-government domain. The proposed of fuzzy cognitive mapping provided to the reader the possibility of linking other techniques to justify the uses of other special techniques. In fact all previous sections give the reader to imagine the possibility of the implementation of those applications in his domain.

The challenge is that the literature on the construction of fuzzy ontology in the political domain is sparse and neglected; this is enough justification to break into this field to understand its content. It is therefore necessary to describe some of the methods and technique that will help to understand the input and output and display the concepts in the political domain.

Chapter Three

METHODOLOGY

3.1 INTRODUCTION

Chapter two draws for the reader integral drawing frameworks of the fuzzy ontology concept, which include the most important axes and coordinates that must be considered in constructing the model of fuzzy ontology in a specific domain. These axes will help the reader to construct various other models of fuzzy ontology in specific domains. Different methodology approaches for building ontology have been proposed by Fernandez (2003), Beck and Pinto (2003), Calero et al. (2006), Noy and McGuinness (2001), and Fernandez (2003). Another approach presented to build ontology from existing ontologies or from scratch was done by Carelo et al. (2006). Until now, there has been no standard method used for building ontology, especially in the political domain.

The aim of *Chapter three* is to explain the proposed ontology method which enhances the process of construction fuzzy ontology that can help the decision-making process. As highlighted in section 2.4, there are fewer numbers of attempts to apply ontology to help decision-making processes in the field of politics. The spine of the study is the explanation and gradient with following the line of thought in this chapter, using a similar approach to that done by Inyaem et al. (2010); however, the approach in this thesis developed and designed more sub-steps within their approach. The new developed design make the process smoother, more streamlined, and faster for those planning to construct fuzzy ontology in specific domains. More benefits from adding the new design (new sub-steps) are presented in section 3.3. The first stage in our new developed design clarifies the concept for each domain. The aim of the presentation of the concept in each domain is to understand the concept which will contribute to significant and effective contribution in the extraction of the most important political variables

that hinder and influence the political decision-making process to promote bilateral economic relationships with nations. It also contributes to showing the characteristics of the decision support system in a particular domain. The concept for each domain is extracted from various data sources. These sources may have various forms such as textual data, a knowledge base, and regular documents. Ignacio et al. (2010) has characterized the properties of the ontology to represent the knowledge that has been extracted from different texts.

3.2 PURPOSE OF THE ONTOLOGY

Ontology facilitates the communication between the user and the system, and the success of information systems is based on the integration of information. An ontology will use data that enhances the information integration. The ontology highlights the importance of a clear presentation of the concept in each domain. Ontology helps in extracting the data from the concept after the broad presentation. Ontology contributes significantly to the issue of expansion and contraction concepts. It contributes to the integration of information.

A part of approach used here consists of building a set of questions that need to be answered by the ontology to fulfill its purposes: the so-called questions of jurisdiction (Gruninger and Fox 1995). The concepts of the ontology include terms that define the domain or activities carried out in the domain (Bettahar et al. 2005). Starting from this list of questions, the ontology includes information about the different elements and various types of conditions to be taken into account to make a recommendation about whether to invest or not 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 country look forward to the reactivation of the peace process in the Middle East? Does this country intervene in the affairs of other countries, either directly or indirectly? Does this country have an interest in the development of Iranian nuclear capabilities? Is this state interested in security and stability in Iraq? The answers may include anything from yes and no to maybe, sometimes, always, never, not clear, and more. The ontology includes information about important concepts in each domain.

This thesis aims to contribute to raising and enhancing the value of ontology construction by presenting several processes and case studies for the political and investment domains. The cases presented contributed significantly in understanding the concepts and extracting the political variables that influence the decision-making process. The presentation of cases studied

is based on the experience of advisers in the political domain, who know certain variables and rules, and have an idea of what the output should look like. The most important variables (inputs) that drive and head the compass of the political decision (output) were selected based on the experience of advisers in the political domain. Thirty eight interviews have been done with different responsible and decision makers in the domain. Also a questionnaire have been distributed to 38 other responsible in the domain in order to define the important variables for the evaluation part.

Fuzzy logic is proposed because fuzzy logic is based on natural language and is tolerant of imprecise data, which helps one to understand the concepts in the political domain, because this field contains vague concepts. On the other hand, the fuzzy cognitive map theory method in the political domain (FCM scheme) is also proposed to demonstrate the causal inter-relationships between certain variables. In addition, fuzzy expert systems were used to build a fuzzy inference system (FIS) to aid in decision-making and help top political decision makers in strengthening the economic bilateral relationship with nations. Also through the interview, the parts of fuzzy inference system for the advisers in the political domain have been presented and for the advisers in the investment domain who are closely linked to the top political decision maker.

3.3 PROPOSED ONTOLOGY

As we highlighted in Section 1.5 and Section 1.3, the various forms of political data exist in different domains, and the information about political variables found in these different domains are heterogeneous and vague (such as the data presented in Section 1.2), sometimes even immeasurable Therefore, a natural language is needed to describe these data and variables; political variables require human knowledge for interpretation. There appear to be certain imperfections in the data, such as imprecision, uncertainty, and ambiguity.

A seemingly popular way to handle the data imperfection is to construct a so-called fuzzy ontology for a specific domain as presented in Inyaem et al. (2010). The goals of the authors in using their model are to serve the process of decision support. Their aims are presented in Section 2.4. They specified the processes of fuzzy ontology for the terrorism domain, which is comparable to the political domain.

In line with this, Alshayji et al. (2011d), Alshayji et al. (2011a), Alshayji et al. (2011e) have used the same process employed by Inyaem et al. 2010) adapted to the processes of the

construction of bilateral trade ontology, agreement ontology and extended as fuzzy ontology, respectively. Inyaem et al. (2010) used a well-organized model to construct the fuzzy ontology approach in the field of terrorism. The feature of their model is that they characterized the model significantly and they used linguistic variables and ambiguous events. In addition, they used a suitable characterization for terrorism fuzzy relationships in their properties. In fact, they defined a framework that can help in the decision-making process in the governmental environment.

In this regard and coinciding with the previously mentioned features, this study will use the same approach as Inyaem et al. (2010). However, we developed and designed within the steps used in the original model to accelerate the application process for the construction of fuzzy ontology, make the fuzzy ontology construction process be clearer and make a significant and effective contribution in understanding the concepts to simplify the extraction of the most important variables that in some ways affect the political decision-making process. As a result the developed design (subsection) supports the extraction of data that exist in political and investment domains.

Concisely and briefly, this study will use their model for several key reasons. 1) The terrorism domain is considered an integral part of the political domain, because terrorism undermines the political stability; it is a part of political variables, so they involve comparable approaches. 2) The authors used linguistic variables and ambiguous concepts which are similarly compatible to the vague variables used in the political domain and are actually a stumbling block influencing the political decision-making process. 3) The authors successfully combined fuzzy logic with ontology; this is what we need to understand the political changes and their effects on decision process. 4) The authors presented fuzzy ontology construction successfully in a government domain, which is our goal.

Inyaem et al. (2010) used the following steps for the construction of fuzzy ontology:

1. Input the unstructured data;
2. Specify the definition of related concepts in the domain and their relationships;
3. Clarify the generation of domain ontology;
4. Define the domain ontology extended as fuzzy ontology; and

5. Apply the fuzzy ontology onto the specific domain.

While this study will use a similar process, it will develop and design more sub-steps within the steps used by the Inyaem et al. approach. These sub-steps can be considered a part of the construction of fuzzy ontology. The illustrative case studies in *Chapter four* will describe this developed design (sub-steps) in detail. This will clarify the application, achieve the internal integration in the display, and help simplify the extraction of the most important variables that may affect the political decision-making process in strengthening the economic bilateral relationship with nations. The main steps used by Inyaem et al. have been integrated with the new developed design (sub-steps) as follows:

1. Input the unstructured data;

2. Specify the definition of related concepts in the domain and their relationships and describe the concept in each domain;

3. Clarify the generation of domain ontology and Illustrative cases: engineering the ontology for the political and investment concept.

    3.1 Construct object paradigm ontology (OP)

    3.2 Use Protégé-OWL editor;

4. Define the domain ontology extended as fuzzy ontology

    4.1 Construct fuzzy logic and membership in the political domain

    4.2 Construct fuzzy ontology structure and semantic relation in the domain

    4.3 Construct fuzzy cognitive map (FCM)

    4.4 Construct fuzzy expert system

        4.4.1 Methodology

        4.4.2 Data and modeling scenario

        4.4.3 Construction of an FIS

4.4.4 Identification of the variables

4.4.5 Construct the membership function editor

4.4.6 Construction of the rules

4.4.7 Defuzzification of the result;

5. Apply the fuzzy ontology to the specific domain.

Figure 3.1 describes the complete process for the construction of fuzzy ontology for specific domains presented by Inyaem et al.

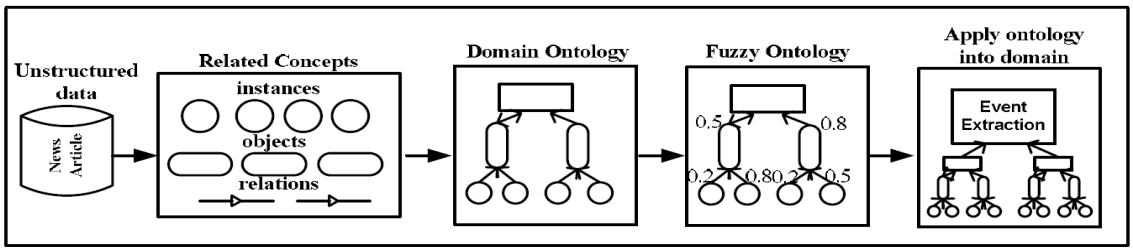

Figure 3.1: Process of construction of fuzzy ontology for specific domains.

We will conduct several case studies in two different domains, including the political and investment domains in the government sector, by following the above steps, due to the similarity and closeness to the political domain in certain situations. The political domains briefly explained in section1.6 are agencies and closely linked to the top political decision maker. These five agencies are the Kuwait Investment Authority (KIA), Ministry of Foreign Affairs (MFA), office of the Prime Minister, Kuwait Fund for Development, and the office of the decision-maker. All of these government bureaus equally impact the political decision-making process. Alshayji et al. (2011b) have proposed a methodology to develop a fuzzy ontology in two government sectors (KIA) and in (MFA) and discussed how to conduct this approach. Also as mentioned above, the data needed by the decision-maker in the political arena is uncertain and scattered. By using ontology, decision makers will be able to make better decisions in less time. This section will start by representing a model diagram consisting of classes, subclasses, and elements that are important in the domain, with their relationship properties. This diagram can be used as an illustrative description for any future needs.

This study will propose an ontology structure with the concepts and properties for these domains. 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. Subsequently, this research will employ a fuzzy ontology as an extension of domain ontology for solving the uncertainty problem in the political domain (Jun et al. 2008). Using this developed model of ontology and fuzzy logic will contribute to sharing information from different domains with others to present a high level of knowledge for the political decision-maker, to create an intelligent decision model that facilitates the decision-making process in the political field. The new developed design including the complete process for the construction of fuzzy ontology for specific domains presented by Inyaem et al. is presented in figure 3.2 .

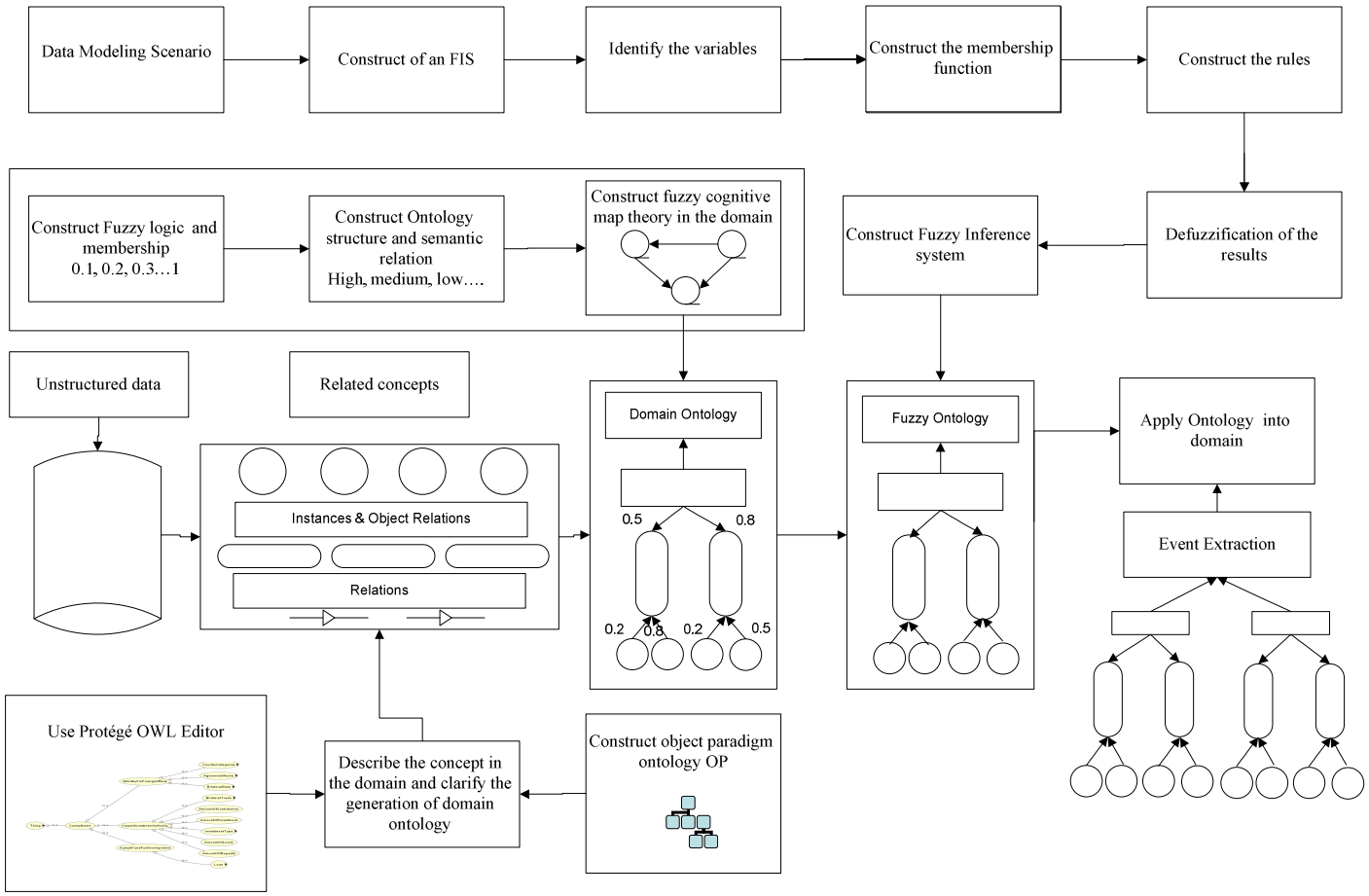

Figure 3.2: Processes of the new developed design of construction of fuzzy ontology for specific domains

The new developed and designed process is based on object paradigm (OP), and use the Protégé-OWL editor. The construct fuzzy cognitive map theory (FCM), and construct fuzzy inference system (FIS) used during this process will be explained in detail in chapter four during the implementation.

3.3.1 DESCRIBE THE CONCEPTS IN EACH DOMAIN

It is important in this process to know how to model the important sectors that are related to the domain and describe their domains to enable one to understand the domain concepts and identify the relationships between them. This process includes the generation of the ontology for each domain to integrate the scattered information resources from the political and investment domains, because the location of such information can be in different domains. The ontology includes information about important concepts in political and investment domains. Such concepts in such domains have been described by Alshayji et al. (2011b; 2011c). It is necessary to determine and specify the domains that this ontology will cover and define the objectives of its use. The process of the ontology will start by extracting key concepts and knowledge from different domains (political and investment domains) in government agencies and identifying the relationships between sets of information to understand the complexity involved in making decisions and how building ontology can be helpful and beneficial for decision makers in extracting different variables and understanding the most important variables in political and investment domains, in addition to understanding the impact of different variables on other variable in different domains.

This process is followed by constructing both the object paradigm ontology (OP) method and building an ontology by using the Protégé-OWL editor. The aims of this process will be explained more clearly in the next section.

3.3.2 CONSTRUCT OBJECT PARADIGM (OP) PARADIGM ONTOLOGY AND USE PROTÉGÉ-OWL EDITOR (CLARIFY THE GENERATION OF DOMAIN ONTOLOGY)

This process consists of verifying the existing ontology in the domain that can be extended, including the integration of fuzzy logic with ontology. Construct object paradigm requires defining the classes of the ontology and arranging them in a taxonomic hierarchy. Analysis of the ontology model using an object paradigm (OP) ontology approach provides more clarity in the results of the conceptualization as presented in Al Asswad et al. (2010). More work has been done by Alshayji et al. (2011d; 2011a) that presented clear conceptualization of the construction of object paradigm in investment domain to present bilateral trade in the investment domain and constructed object paradigm to present agreement ontology in the political domain respectively.

This thesis will use object paradigm the same method used by Al Asswad et al. (2010) to construct the ontology. Construction of the OP approach includes analyzing the concepts, the relationships that exist within the concept, including the definition of classes and subclasses, characterizing the properties between classes and shared elements, and describing the entities in these classes. Several case studies in the agencies that are related to political decision makers presented through fuzzy logic with ontology in the political and investment domains in the government sector. The case studies contained clear concepts for the political and investment domains via using the object paradigm ontology (OP) method. Each concept will be presented to capture a high level of knowledge to facilitate the work of decision makers in the political field. OP Ontology also enables the description of relationships between concepts.

The aim of conducting the ontology approach is to provide an insight into how knowledge is represented and handled via different perspectives and editing tools. Possible editing tools to present and build our ontology include the Protégé-OWL editor, an ontology editor and knowledge-based framework. The aim of using OWL is to integrate the concepts of the political and investment domains together. According to the World Wide Web Consortium (W3C), the most recent development in standard ontology language is OWL (Islam et al. 2010). Like Protégé, OWL makes it possible for users to describe concepts; Protégé also provides new functions and has a richer set of operators (e.g., intersection, union, and negation). This thesis defines the most general concepts in selected domains such as “Agreement” and adds different specifications and properties of those concepts. These

properties include the following: "controlled by," "enable," "provide," "affect," "engaged," and "enriched by."

As mentioned above, the basic concept in the political domain is linguistic variable factors (natural language) and is closer to human intuition and needs human language for interpretation. Therefore, it is important to understand the interdependencies of these variables. Thus, to the development of ontology requires implementing the process of cognitive map theory in the process of construction of a fuzzy ontology for a specific domain

3.3.3 CONSTRUCT FUZZY COGNITIVE MAP THEORY AND FUZZY CAUSAL ALGEBRA (DEFINE THE DOMAIN ONTOLOGY EXTENDED AS FUZZY ONTOLOGY)

Fuzzy cognitive map theory in the political domain is proposed to demonstrate the causal interrelationships between certain variables to provide insight and better understanding about the interdependencies of these variables/factors. Furthermore, FCM is especially applicable in the soft knowledge domains e.g., political science, military science, history, international relations, and political elections at governmental levels (Calais 2008). In addition, fuzzy causal algebra can be used to govern causal propagation on FCMs to elucidate the positive and negative effect of these variables on the other variables while enhancing the knowledge clarification of the relationships. In addition, FCM graph structure allows systematic causal propagation (forward and backward chaining) and arrows sequentially contribute to the convenient identification of the causes, effects, and effected factors.

3.3.4 CONSTRUCT FUZZY EXPERT SYSTEM

As mentioned above, when making most critical decisions, decision makers must take many factors into account: language (natural or human language), the availability or lack of precise data (vague information), and possible consequences (rule conclusions). Fuzzy expert systems enable one to weigh the consequences (rule conclusions) of certain choices based on vague information. Rule conclusions follow from rules composed of two parts, the *if* antecedent (input) and the *then* consequent (output).

With fuzzy expert systems, one uses fuzzy logic toolbox graphical user interface (GUI) tools to build a fuzzy inference system (FIS) to aid in decision-making. The fuzzy logic toolbox extends the technical computing environment with tools that design systems based on fuzzy logic. Construction of an inference system works by identifying the five MATLAB GUI tools

which are best suited to building, editing, and monitoring an FIS for the political domain, particularly with regard to supporting decision makers and determining whether strengthening bilateral economic relationships between friendly nations is warranted.

The decision regarding whether or not to strengthen economic relationships requires structured information. Examples of information that may be assessed in the decision-making process include competency questions such as the following: Is country X good or weak in terms of the political stability? What type of bilateral relations country x does with country y? The answer may involve a description such as “good,” “weak,” “neighbor,” and so on. Does country X intervene in the affairs of other countries, either directly or indirectly? The output of the answers may vary from “yes” and “no” to “maybe,” “sometimes,” “always,” “never,” “not clear,” and more.

This scenario requires assigning a degree of membership to every variable assigned to that relationship based on the fuzzy set theory (Inyaem et al. 2010). Fuzzy logic can allow any value between 1 and 0 as a logic value. The fuzzy membership value μ is used for the relationship between the objects, where $0<\mu<1$ and μ corresponds 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 to that system according to a rule or set of rules under which that system operates.

Again, this thesis focuses on developing prototype architecture for intelligent decision support systems that can help top political decision makers in the political domain. The aim in this thesis is to obtain a solution that is more suitable for solving the uncertainty and reasoning problems in this intelligent decision support system.

3.4 SUMMARY

New methods to construct fuzzy ontology in a specific domain to handle the data imperfection were presented in *Chapter three*, where the presentation and the goals of the construction of fuzzy logic used by Inyaem et al. (2010) were explained. In addition, the features of their model were characterized, the integration of the process by adding new sub steps within Inyaem et al.’s process was presented, the reason for using the sub-steps has been clarified, and the justification of the uses of the sub-steps were explained in detail. The advantages and benefits of developed designed new sub-steps of the construction were explained in Sections 3.3.1, 3.3.2, 3.3.3, and 3.3.4. In general, the main point of adding such sub-steps within the main

processes of Inyaem et al.'s method is to make the process smooth, clear, and related integrally, and achieve the integration of the information where these sub steps can help in the process of construction of fuzzy ontology for a specific domain.

Chapter Four

DOMAIN ONTOLOGY CONSTRUCTION

4.1 INTRODUCTION

Chapter three identified the new developed process included in the model of the construction of fuzzy ontology in specific domain added to those used by Inyaem et al. (2010). This new process should accelerate the clarification of the application process, as well as achieve internal integration in the display, and this addition will apply a significant contribution in the extraction of the most important variables that influence the political decision maker to promote the bilateral economic relationship with nations. In general this is a framework of fuzzy ontology construction that can contribute significantly in extract the main variables and help in the decision-making process in the governmental environment. *Chapter four* will follow and pursue the implementation of the previous main steps and sub-steps in practical ways by conducting and presenting illustrative case studies in government sectors. The next subsections will present the same the main steps used by Inyaem et al. and the new developed designed (sub-steps) for the process of fuzzy ontology construction in the political field.

4.2 INPUT THE UNSTRUCTURED DATA

The first step in this process is to input the unstructured data. The initial development of this input as presented by Alshayji et al. (2011d; 2011e) proposes a set of questions as presented in section 3.3.4 that are asked during the process of decision making for strengthening bilateral economic relationships with other nations. Table 4.1 below depicts an initial attempt to formalize these unstructured data inputs, the types of concept and domains illustrated in Table 4.1.

Table 4.1 Unstructured data input tabular illustration in two different domains.

Sectors	Kuwait Investment Authority	Ministry for Foreign Affairs-political domain
	Concept on Type of Imports	Concept on Peace Affairs
	Concept on Type of Exports	Concept on Iran Affairs
	Concept on Type of Financial Aid	Concept on Nuclear Affairs
	Concept on Financial Contributions	Concept on Middle East Affairs
	Concept on Support Facilities for Investment	Concept on Terrorisme

For this type of data, most of the answers may be in the form of: "yes," "no," "maybe," "never," "not clear," "strong," "very strong," and so on. Unfortunately, in reality the actual input to such a decision making process is quite unstructured, vague, and heterogeneous. This makes it extremely difficult for the decision maker to understand the concepts and facts existing in these domains with their properties and relationships. There is an urgent need to develop a proper system to achieve adequate yet accurate data gathering and analysis, and produce precise and certain outputs useful to the decision makers. Completing the process will require: 1) specifying the definition of related concepts in the domain and their relationships, 2) clarifying the generation of domain ontology, 3) extending the domain ontology to fuzzy ontology, and 4) applying the fuzzy ontology into the specific domain of political decision making for strengthening the bilateral economic relationships with other nations.

4.3 SPECIFY THE DEFINITION OF RELATED CONCEPT IN THE DOMAIN AND THEIR RELATIONSHIPS

This section focuses on generating ontology. Ontology can be defined as information which includes the classes and objects in a specific domain which help acquire knowledge and share it. Before defining the classes of ontology, one should determine and specify the domain that this ontology will cover and define its goal of use. This approach consists of building a set of questions that need to be answered by the ontology to fulfill its purpose. Starting from this list of questions, the ontology includes information about different elements and different types of conditions that need to be taken into account when making a recommendation about whether or

not to invest in a specific country. The following section will explain the concept of each individual domain separately.

4.3.1 THE CONCEPT OF THE OFFICE OF THE DECISION-MAKER (POLITICAL DOMAIN)

The aims of this section are to have a clear conceptualization of certain concepts, while considering the relationships that exist within the office of decision-maker to view the content of some key sectors of the Office of Decision-Maker that can help top political decision makers in Kuwait in strengthening the bilateral economic relationships between Kuwait and friendly nations. As noted previously, there are many factors and variables that influence the promotion of the economic relationships with a nation, and these variables should be taken into account; also, these variables and factors are diversified and may be found in different places and across various political and economic government sectors. Therefore ontology is appropriate to create an ontology knowledge base that can facilitate the political decision process and to integrate the scattered information resources from various political and investment domains.

The domains considered in this thesis include the Ministry of Foreign Affairs, the Prime Minister's Office, the Kuwait Investment Authority, and the Kuwait Fund for Development because the concept of bilateral agreements exist in the Ministry of Foreign Affairs, the type and the status of the bilateral agreement affects the result of the meeting of the Prime Minister's Office with nations, and the results of meeting with nations affects the decisions of the competent authorities to strengthen the economic bilateral relationships which for investment and investment projects fall under the Investment Authority and the Kuwait Fund for Development (see Figure 4.1). It is worth mentioning that the latter sector (Kuwait Fund for Development) also combines social, political, and economic domains, and this sector includes the social domain because the objectives of its establishment are to serve poor countries and help them in their development. In all cases, all these domains fall under different domains and they are interdependent for the decision-making process when it comes to strengthening bilateral relationships. Defining the main ontology for each domain will enhance the decision of the decision-maker (see Figure 4.1). More details about the link between mentioned sectors were presented in Section 1.2 and Section 1.6.

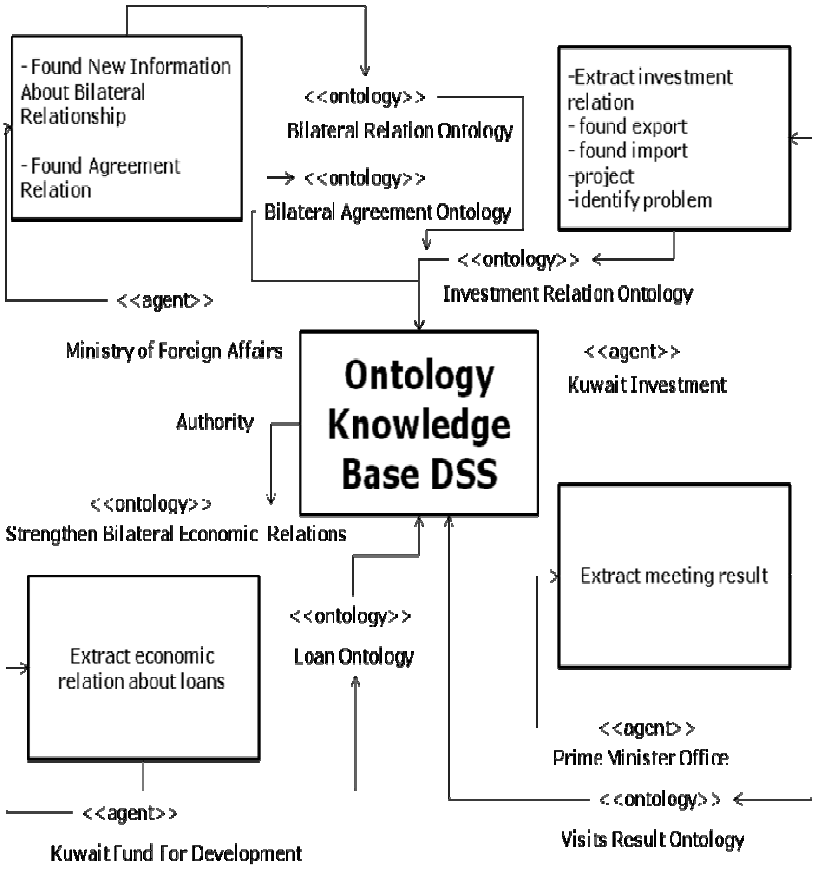

Figure 4.1: The office of political decision making ontology

4.3.2 THE CONCEPT OF THE PRIME MINISTER'S OFFICE DOMAIN (POLITICAL DOMAIN)

The Prime Minister's Office is responsible for transferring the results of official visits with other countries to political decision makers, and the results of the visit may be negative or positive. If the result of the visit is negative, this mean there is a great challenge. Perhaps the investment is not successful in the country, which may lead to the failure of the investment relationship and it will cost the state greatly through the depletion of state funds. Sometimes there is an intimate and close bilateral relationship, but there are risks in promoting the economic relationship between two countries. This means it is very important to analyze the position of the state in the Prime Minister's Office Domain.

4.3.3 THE CONCEPT OF THE KUWAIT FUND FOR ARAB ECONOMIC DEVELOPMENT (INVESTMENT DOMAIN)

This government sector is the first institution in the Middle East that took an active role in international development efforts. The Kuwait Fund extends loans on concessionary terms to finance development projects in developing countries. In addition, the Fund subscribes in the

capital of international and regional development institutions. Today, the Kuwait Fund forms a solid bridge of friendship and solidarity between the State of Kuwait and developing nations. Tables 4.2 and 4.3 illustrate the contribution of this sector to other regions. This sector was selected because it includes the main information about loans, assets, and the like with foreign countries, by analyzing some data of Kuwait's loans and rules for granting these loans in term of understanding the factors which impact the decision making process in the investment with foreign countries. The provision of loans is an integral part of the country's economy.

Table 4.2: The type of the projects and the quantities provided by KFD

Type	quantity	Rate
ENERGY	1101.7	24.22%
SOCIAL	138.6	3.04%
INDUSTRY	384.8	8.46%
AGRIGULTURE	618.3	13.59%
MISCELLANEOUS	457	1.00%
TRANSPORTATION	1576.5	34.66%
WATER AND SEWAGE	443.7	9.75%
DEVELOPMENT BANK	136.7	3.00%
TELECOMMUNICATION	102.1	2.24%

Table 4.3: The name of the region with the number of the projects provided by KFD

Region	number of projects	rate %
Arab countries	2501.2	45.99%
West African countries	433	9.52%
Asian and European countries	281.3	6.18%
Central, South, and East African countries	351.7	7.73%
East Asia and the Pacific countries	871.7	19.16%
Latin America and the Caribbean countries	109.3	2.40%

4.3.4 THE CONCEPT OF THE GENERAL AUTHORITY FOR INVESTMENT (INVESTMENT DOMAIN)

This government sector includes some data regarding exports and imports (bilateral trade concept), sometimes exports are "high" and sometimes imports are "low," and so on. Therefore the concept in this domain needs to be analyzed between two countries, because "high," "low," and "medium" are linguistic variables that need human interpretation. Changes in these variables impact the amount of investment with nations.

4.3.5 THE CONCEPT OF THE MINISTRY OF FOREIGN AFFAIRS (POLITICAL DOMAIN)

The Ministry of Foreign Affairs is responsible for bilateral relations at international and regional levels. A description of the bilateral relations over the past and information regarding international agreements, as well as their dates, names, and status can be found in the Ministry of Foreign Affairs sector. In addition, this sector includes information about countries, such as security and the political stability of the countries, and concerns the positions of the state regarding several regional issues. Some of these variables were presented in section 1.2, by which different factors and variables in this domain may be assessed in the decision-making process.

In the Ministry of Foreign Affairs domain, one might ask questions during the decision-making process when attempting to strengthen bilateral economic relationships with other nations, especially about bilateral relation, nuclear affairs, Iraqi affairs, peace in the Middle East, the fight against terrorism, and the concept of the agreement. For example, one might ask the following: Is this country interested in security and stability? Does this country intervene in the affairs of other countries? Will the strengthening of bilateral economic relationships lead to a reactivation of the peace process in the Middle East? The following subsections consider a part of the concept of the Ministry of Foreign Affairs.

4.3.5.1 THE CONCEPT OF THE BILATERAL RELATIONSHIPS BETWEEN COUNTRIES

Existing bilateral relationships between countries can be described from a variety of perspectives, such as historical, weak, respectful, friendly, neighboring, traditional, religious, political, and economic aspects. The relations between neighboring countries have been explained by Alshayji et al. (2011c). For example, if the description of the bilateral relationship between two countries is “weak,” that means there is a risk in promoting the bilateral economic relationship, because the weakness of the bilateral relationship does not enhance the continuity of the economic relationship between the two countries and may lead to the failure of the relationship investment.

To understand the bilateral relations of a country toward another, one might ask certain questions during the decision-making process (deciding whether to support or help the strengthening of bilateral economic relationships with other nations). For example, the friendly relations between two neighboring countries can turn sour due to several economic and

diplomatic reasons. The Iraqi invasion of Kuwait provides an example: If an invasion occurs between two neighbors (x and y) and country z wants to make an investment with country x, this means country x has to consider many elements before making a decision to strengthen the economic relationship. For example, was country z against the invasion? Did country z support the invasion? Does country z undertake efforts to end the crisis over country x or country y's security plan? Does country z interfere in country x or country's internal affairs? Does country z endeavor to ensure the unity and the independence of country x or country y or both of them? Did country z vote to resolve the issue concerning country x or country y? Does this country support the withdrawal of US troops from country x or country y under their security plan? Was this country against (or support) the recent invasion?

4.3.5.2 THE CONCEPT OF NUCLEAR AFFAIRS

As presented by Alshayji et al. (2011c), to understand the position of other countries concerning nuclear issues requires taking into account a great deal of information. Consider the cases that 1) country y deals with the nuclear power issue; and 2) the investment might be with country x. For example, does country x have an interest in the development of nuclear power? Does country x have a special relationship with one that has nuclear power? Does country y intervene in country x internal affairs? Does country x receive benefits from funding sources from y? Is country x keen to solve the nuclear issue with country y peacefully? Is country x keen to call on y to disclose its nuclear reactors to international inspectors? Does country x agree with country y about the use of nuclear reactors for military purposes? Does country x agree with y about the use of nuclear reactors for peaceful purposes? Does country x have economic investments in or other relationships with country y? Does y spend indirectly on country x? Does country x agree with y provocative? Does country x agree with the positive international resolutions on the nuclear dossier? Does country x refuse to engage in military action against y? Does country x refuse to participate in an economic blockade against y? Does country x support y politically? Does country x have an established relationship with y?

To answer these questions, one might use common primitive data types, such as the Boolean "yes," "no," "sometimes," "always," and "never." As mentioned above, the Ministry of Foreign Affairs sector includes descriptions of the bilateral relations of other countries over time and information concerning international agreements, with dates and names. One can describe existing bilateral relations from a variety of perspectives using a set of properties including the following: "historical," "respectful," "friendly," "solid," "common interests," "excellent," "very

good," "good," "acceptable," "weak," "diplomatic," "political," "economic," "political and economic," "strongly supports," "sometimes supports," "never supports," "opponent," and "unclear."

4.3.5.3 THE CONCEPT OF MIDDLE EAST PEACE

Alshayji et al. (2011c) gave a clear presentation for the concept of the Middle East. To understand a country's position regarding the issue of peace in the Middle East, one might ask certain questions during the decision-making process (deciding whether to support or help to strengthen bilateral economic relationships with other nations). For example, does this country support the Arab Peace Initiative? Does this country work to unify Arab stances? How would one describe this country's position on the reactivation of the peace process? Does this country look forward to seeing stability in the region? Does this country have a positive position regarding the challenges facing the region (yes, no, sometimes, or never)? What is this country's position on dialogue and negotiation (positive or negative)? How would one describe this country's position on the European Peace Initiative (positive or negative)? Does this country have interests in common with other countries in the region? Answers to these questions could include "yes," "no," "sometimes," "never," and "not clear." At the same time, the position toward Palestinian issues is a part of the concept of Middle East peace. One might ask certain questions during the decision-making process. For example, what is this country's position on the occupation of Palestine? Does this country interfere in Palestine's internal affairs? Does this country work for the realization of the Palestinian people's rights? Does this country take the initiative to ensure a peaceful Palestine? Does this country support efforts for Palestinian reconciliation? Does this country seek a comprehensive peaceful solution to help Palestine?

4.3.5.4 THE CONCEPT OF RELATIONS BETWEEN NEIGHBORING COUNTRIES

Again this concept was presented by Alshayji et al. (2011c). To understand the position of the country toward Iraqi affairs, there are some possible questions that may be asked during the process of decision-making in the strengthening of bilateral economic relationships with other nations. For example, was this country against the brutal Iraqi invasion of Kuwait? Did this country support the Iraqi invasion of Kuwait? Does this country undertake efforts to end the crisis over Iraq's security plan? Does this country interfere in the internal affairs of Iraq? Does this country make efforts toward the unity and the independence of Iraq? Does this country seek to divide Iraq? Does this country agree that democracy prevails in Iraq? Does this country

have targets in Iraq? Does this country act to dominate Iraq? Does this country help Iraq to meet its international obligations? Is this country against Iraq meeting its international obligations? Did this country vote to resolve the Kuwait issue concerning border markers? Did this country vote to return documents to Kuwait? Did this country vote to find the remains of missing Kuwaitis? Did this country vote for the right of Kuwaiti compensation? Did this country vote for the rights of Kuwait to its claims? Does this country support the withdrawal of US troops from Iraq under the Iraqi security plan? Did this country support the intervention of foreign forces in pre-liberation Iraq? Does this country support the intervention of foreign forces in Iraq after liberation?

4.3.5.5 THE CONCEPT OF THE FIGHT AGAINST TERRORISM

Determining the position of the country toward the fight against terrorism is an integral part of political decision-making in the promotion of a bilateral economic relationship. To understand the position of the country toward terrorism issues, political decision makers need answers for several questions, such as: Does this country contribute to the support of terrorism? Does this country have a multi-party system? Does this country support diplomatic dialogue in resolving the issues of terrorism? Does this country fight the proliferation of weapons of mass destruction? Does this country stand against terrorism? Does the country encourage the use of nuclear energy for military purposes? Does the country support the application of anti-terrorism laws? Is this country committed to anti-terrorism agreements? Is this country against the Islamic orientation? Does this country believe that terrorism arises from Islamic thinking? Does this country help Islamic countries with their issues? Does this country direct its energies toward peaceful development? Does this country support Islamic interfaith dialogue? Answers for the previous questions include: “yes,” “no,” “sometimes,” ”never,” and “not clear.”

As mentioned in the introduction, the information about agreement with other countries can be found in the Ministry for Foreign Affairs domain. This paper will explain the concept of the agreements 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 the next section.

4.3.5.6 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. The existence and more importantly the types of agreements between countries are important to enhancing the relationship between them. Alshayji et al. (2011a) presented the concept of the agreement in the political domain. Political decision makers are interested in covering many questions about agreements 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 for 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 4.4.

Table 4.4: Types of data concerning agreements

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

4.4 CLARIFY THE GENERATION OF DOMAIN ONTOLOGY

After viewing the intellectual understanding, the presentation of the main concept and understanding the nature of the information in all sectors associated with the process of political decision towards strengthening the bilateral economic relationships with nations, this section will present the concept from another perspective, a concept of dismantling the data to clarify the relationship between some of the concepts and better serve the information systems and

thereby the decision maker in the political field or domain. The aim of this section is to present different illustrative cases in different domain to understand the concepts in the domain properly. Understanding the concept in the domain properly will contribute significantly in understanding the variables in those concepts. Understanding the variables in those concepts will help us in extracting the main and important variables. Extracting the most important variables will facilitate the stage of construction the fuzzy expert system and make all subsections fall under this construction smoothly.

This section, using object paradigm ontology and Protégé OWL ontology is a preparation stage for Section 4.4. This will begin engineering the main variables into ontology. Those variables include but are not limited to, such as agreement ontology, position ontology, the loan ontology and the bilateral trade ontology. These are some of the many variables that influence a political decision maker and are close to the political decision process. These variables were selected because one goal of this paper is to select different variables from different domains and close to (political and investment). Their concepts are presented in both object paradigm ontology and OWL ontology. The aims of conducting both ontology approaches were presented in section 3.3.1 and 3.3.2. This part will display only some of the variables to define for the reader how to understand the content and improve the ability to provide a clear presentation of the concept. Also, to improve the ability to enhance the possibility of dismantling and analyze a number of important variables, this thesis will display again the main variables that affect the political decision process in a different presentation in Section 4.5.4 and Section 4.5.6.4.

There are numerous practical aspects to presenting the concept. This concept will include the necessary information of classes, such as identifying classes. At this stage, it is important to identify and specify classes correctly. Class specification includes attributes, and each attribute has a different meaning.

Re-designing according to the object-oriented paradigm (OP) will provide quality for the developed ontology where conceptualization can provide more expressive, reusable object and temporal ontology. Al Asswad et al. (2010) used OP for an identity analysis mechanism and philosophy that is based on ontology extension. This process starts by selecting the important concept, followed by analyzing its spatial and temporal dimension to clarify the result of the conceptualization and properties that exist within the ontology while capturing changes over time. In the following sub-sections, there are different main government sectors of leaders that can support the joint decision to strengthen a bilateral economic relationship. This thesis will

clarify the generation of domain ontology by constructing some ontology for the important concepts in these sectors and engineer these concepts based on object paradigm ontology. These concepts must be taken into account when the decision maker strengthens an economic relationship with a nation. The most important illustrative cases for these concepts are presented in the following sections.

4.4.1 ILLUSTRATIVE CASE: ENGINEERING AGREEMENT ONTOLOGY IN THE MINISTRY OF FOREIGN AFFAIRS (POLITICAL DOMAIN) BY CONSTRUCTING AN OBJECT PARADIGM ONTOLOGY AND USING THE PROTÉGÉ OWL EDITOR

The aim of this section is to obtain a clear conceptualization of the bilateral agreement concept, and will implement all the main steps in this domain. These steps are as following:

a) Use a similar approach for the construction of the OP ontology which was presented in Alaswad et al. (2010) to provide more expressive concept and demonstrate the concept of the domain, as mentioned in section 4.3.5.6. It is essential that the political decision maker should be interested in understanding the agreements concluded between the two countries, because of that we presenting a model of the agreement concept in the Ministry of Foreign Affairs;

b) Present some properties and relations that hold the agreement concept, to have a complete framework of a bilateral agreement based on ontology; and

c) Present the agreement concept by using Protégé OWL editing tools ontology to explain the relations between individuals, super class, and sub-classes. A feature of OWL is that these super class and sub-class relationships can be computed automatically.

A. THE FIRST STEP USING OBJECT PARADIGM (OP) ONTOLOGY

The construction of bilateral agreement by using object paradigm ontology was presented by Alshayji et al. (2011a). According to 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, "Agreement" is a class in which "DateState" is only one state of the agreement class. Therefore, the "Agreement" concept leads to linking different dimensions 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 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. This process 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. 4.2).

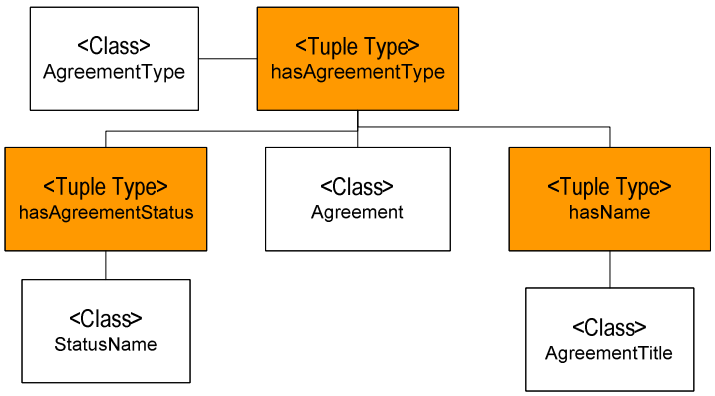

Fig. 4.2: designing the properties that related to an agreement.

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 to capture the date to track change over time, the ontology is designed to include the “date State” state along within the “DateAssignment” event in the OP ontology. Within the OP ontology, 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. 4.3). This allows one to consider 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.

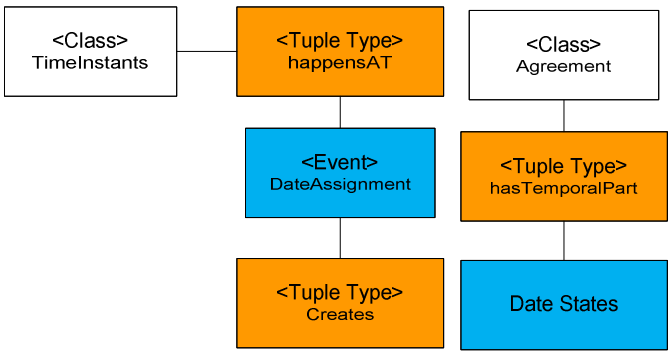

Fig. 4.3: designing the relationship that relating to the agreement

More details enable the ontology to provide a more faithful presentation of the phenomenon's abstract. To encapsulate more intelligence, our developed ontology captures events 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.4.4.

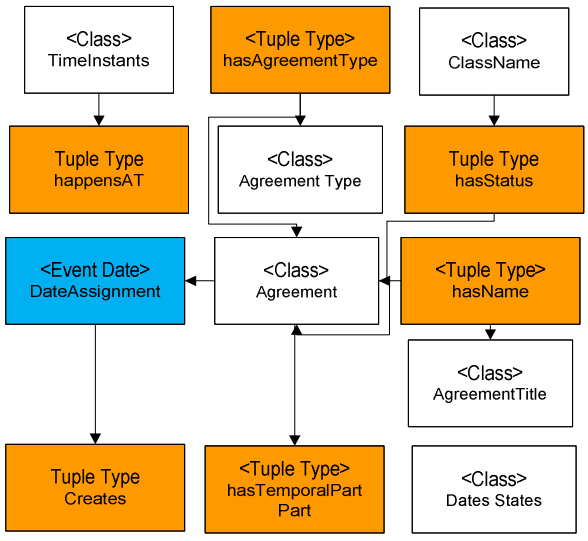

Fig. 4.4: The OP Agreement ontology

B. PRESENTING SOME PROPERTIES AND RELATIONS BETWEEN THE AGREEMENT CONCEPTS

This section will propose a complete framework of a bilateral agreement domain based on ontology. It 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 common language to describe its concepts. Table 4.5 presents 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 4.5.

Table: 4.5: Important concepts of agreement.

Type of Agreement	Level of the Convention	Date	History of the Convention	Status of the Convention
The Convention on the promotion and protection of investment	Strong			not support
Double Taxation Convention.	Good			not support
Cooperation in the military field	Very strong			not support
Protection and military defense	Very strong			not support
Buy weapons	Very strong			not support
Combating weapons of mass destruction	Very strong			not support
Cooperation in the field of energy	Excellent			not support
Exchange of import and export	Very strong			not support
Relations with oil	Excellent			not support
Gas exchange	Excellent			not support
Economic relations and investment	Excellent	19985		Ineffective
Cooperation protocol with the Federation of Chambers of Commerce and Industry	Strong	1999	Medium	Support
Avoid double taxation	very good	1990	Old	Support
Encouragement and protection of mutual investment	Strong	1980	Old	Support
Joint committee for cooperation	very good	2009	New	Ongoing

Memorandum of understanding on civil aviation	very good	2009	New	Effective
Cooperation in the fields of cultural, scientific and medical basis of the principle of respect and equal rights	Good	2009	Medium	Effective
Economic and industrial cooperation	very good	1972	Old	Not renewed
Regulation of air transport relations	very good	1969	Old	Not renewed
Promote and protect investment	very good	1989	Old	Ineffective
Communications, mail, and telecommunications terminal equipment	Good	1993	Old	Not renewed
Environment protection	very good	2009	New	Effective
Aviation and tax exemption	good	1990	Old	Not renewed
Mutual recognition of certificates of tonnage of the vessels trade between the two countries.	good	1980	Old	Not renewed
Defense cooperation and the development of friendly relations.	very good			not support
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
Cooperation in the field of sports	good	2009	New	Effective

The re-engineering concept allows for the capture of more details, achieving a more natural description of the concept. In cooperation with Protégé OWL (Ontology Web Language), the OP ontology makes the description of the concepts easier and more precise. This pair of tools can help the developer describe the concepts with more facilities and more features, so the descriptions will be more precise. The next section will present the concept of the agreement by using OWL editing tools ontology.

C. PRESENTING THE AGREEMENT CONCEPT BY USING PROTÉGÉ OWL EDITING TOOLS ONTOLOGY.

Using Protégé OWL editing tools ontology to capture knowledge about some domain of interest, complex concepts can be built up out of definitions of simpler concepts. OWL ontology consists of individuals, properties, and classes. Individuals represent the objects in the domain in which we are interested: Figure 4.5 presents some individuals in the political and investment domains. Also, individuals are known as the domain of discourse and as instances. Individuals can be referred to as "instances of classes."

OWL properties represent individual relationships. There are three types of properties, object properties, data type properties and annotation properties. Object properties are relationships that link two individuals together. Datatype properties link an individual to an XML Schema data type value; in other words, they describe relationships between an individual and a data value. Annotation properties can be used to add information (metadata-data about data). For this study, the properties are created by using object properties. Properties are binary relations on individuals: a binary relation is a relation between two things, for example, the property hasName, might link some individuals together: 'CountryName' and 'Agreement'. Several of the object properties have been created to explain the relations between individuals, such as hasAffected,' 'hasAgreement,' 'hasImpact', hasIncrase', 'hasName,' 'hasDate,' 'hasEncourage,' 'hasEnhance.' and so on.

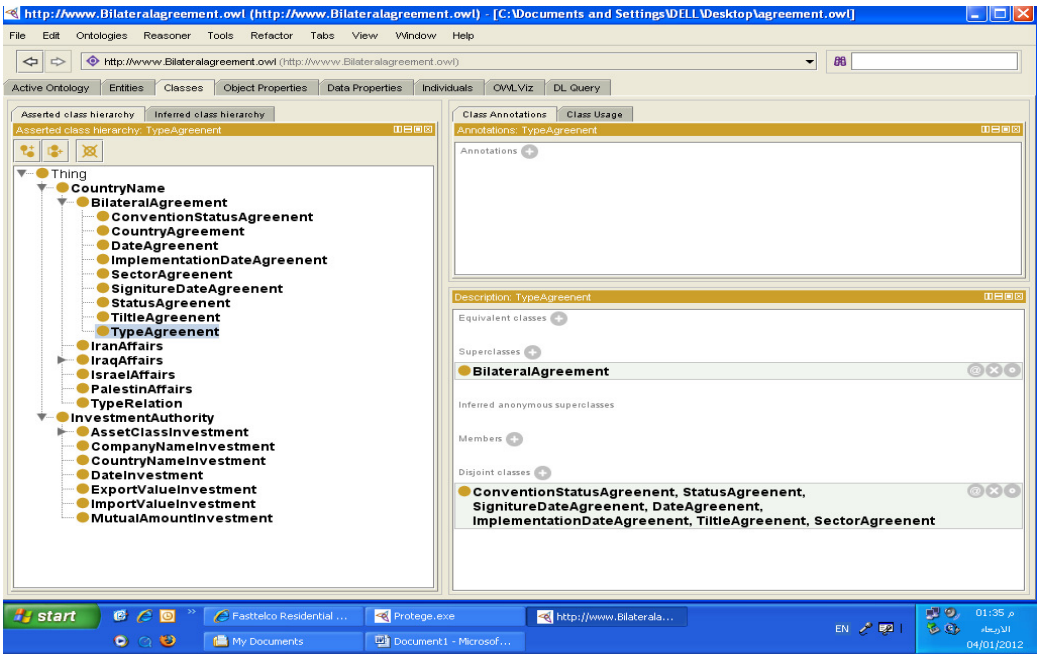

Figure 4.5: Some individuals in the political and investment domains

OWL classes are interpreted as sets that contain properties. The properties are described using formal (mathematical) descriptions that state precisely the requirements for membership of the class. For example, the class 'CountryName' could contain all the properties that are related to 'CountryName' in our domain of interest. Classes may be organized into a super class-subclass hierarchy, which is also known as taxonomy. As mentioned previously, an ontology contains classes–the class Thing is the class that represents the set containing all individuals. Because of this, all classes are subclasses of Thing. For example, consider the classes 'CountryName' and 'InvestmentAuthority'–InvestmentAuthority might be a subclass of 'CountryName,' so 'CountryName' is the superclass of 'InvestmentAuthority.' Also, 'CountryName' is the superclass of the 'BilateralAgreement.' The present analysis uses further subclasses of bilateral agreement, such as DateAgreement, StatusAgreement, TypeAgreement, and more (see figure 4.6). All members of the class 'BilateralAgreement' are members of the class 'CountryName.'

Indeed, when constructing very large ontologies with upwards of several thousand classes in them the use of a reasoner to compute subclass-subclass relationships between classes becomes almost vital. One of the key features of OWL-DL is that these superclass-subclass relationships can be computed automatically by a reasoner; the job of the reasoner is computing and maintaining multiple inheritances. Without a reasoner, it is very difficult to keep large ontologies in a maintainable and logically correct state. The inferred hierarchy should be computed and appear similar to the picture shown in Figure 4.6, which shows the OWLViz display of the asserted and inferred hierarchies. Furthermore, the logical model allows the use of a reasoner which can check whether or not all of the statements and definitions in the ontology are mutually consistent and can also recognize which concepts fit under which definitions. The reasoner can therefore help to maintain the hierarchy correctly. This is particularly useful when dealing with cases where classes can have more than one parent.

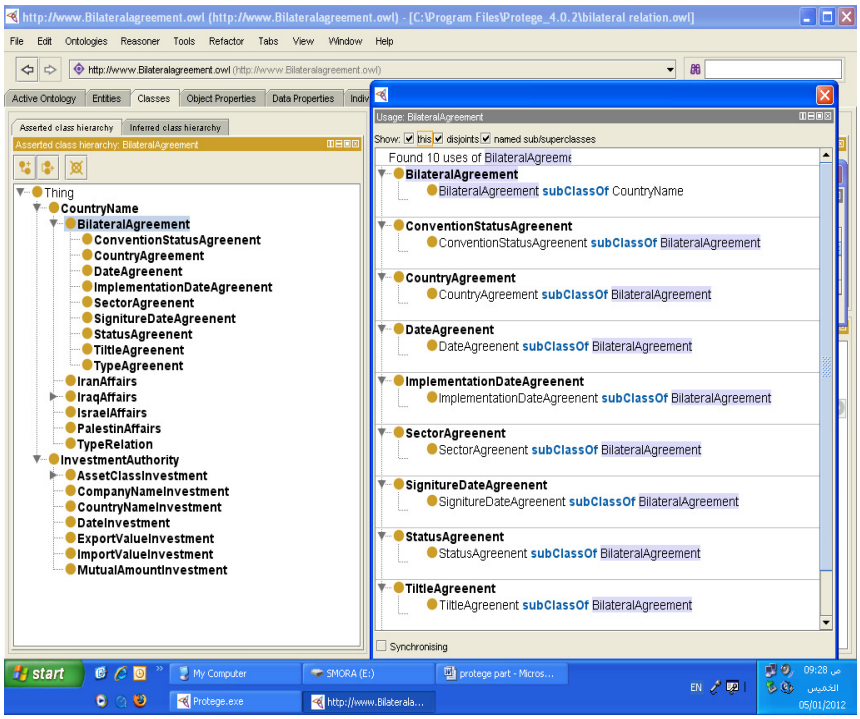

Figure 4.6: Bilateral agreement class has different subclasses concept

Classes are a concrete representation of concepts. In OWL, classes are built up of descriptions that specify the conditions that must be satisfied by an individual for it to be a member of the class. Automated classification has been done by a reasoner. Figure 4.7 presents CountryName as a class in the political domain. The CountryName class links with investment and political subclasses and the Bilateral Agreement is a subclass from the political domain linked with some subclasses from the investment domain such as import and export.

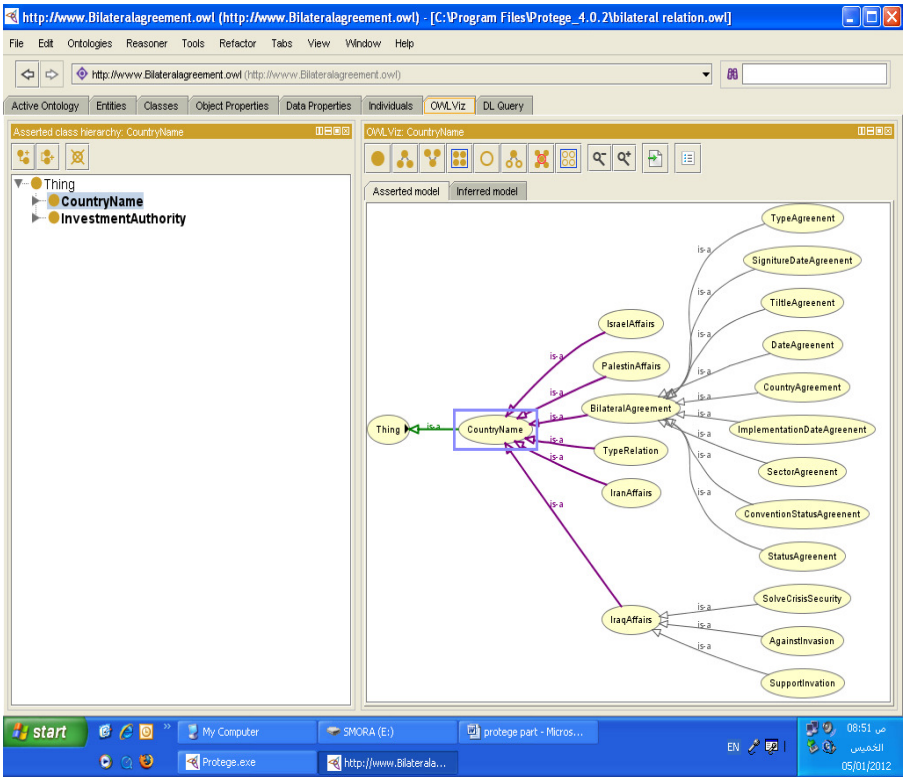

Figure 4.7: OWLViz display of the asserted and inferred hierarchies.

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 Figure 4.8. The model of the Ministry for Foreign Affairs structure presented by the Protégé-OWL editing tool is represented in Figure 4.9. The model ontology of the agreement type concept is represented by the Protégé-OWL editing tool in Figure 4.10.

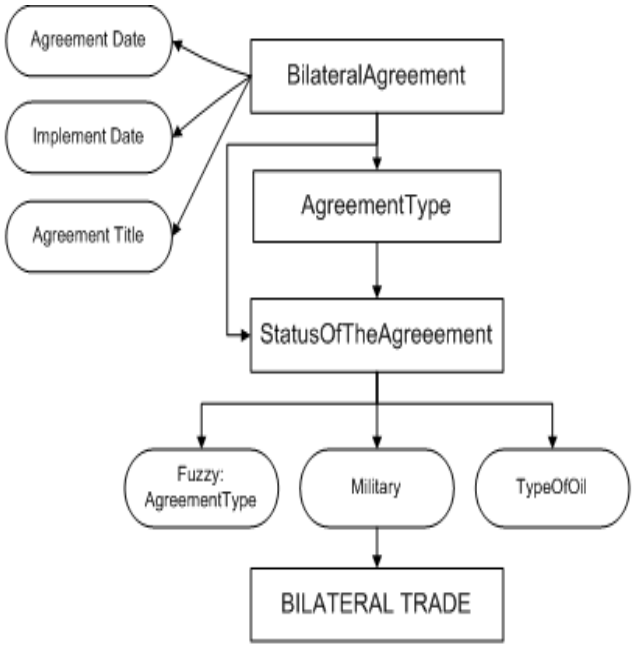

Fig. 4.8: A model of agreement ontology

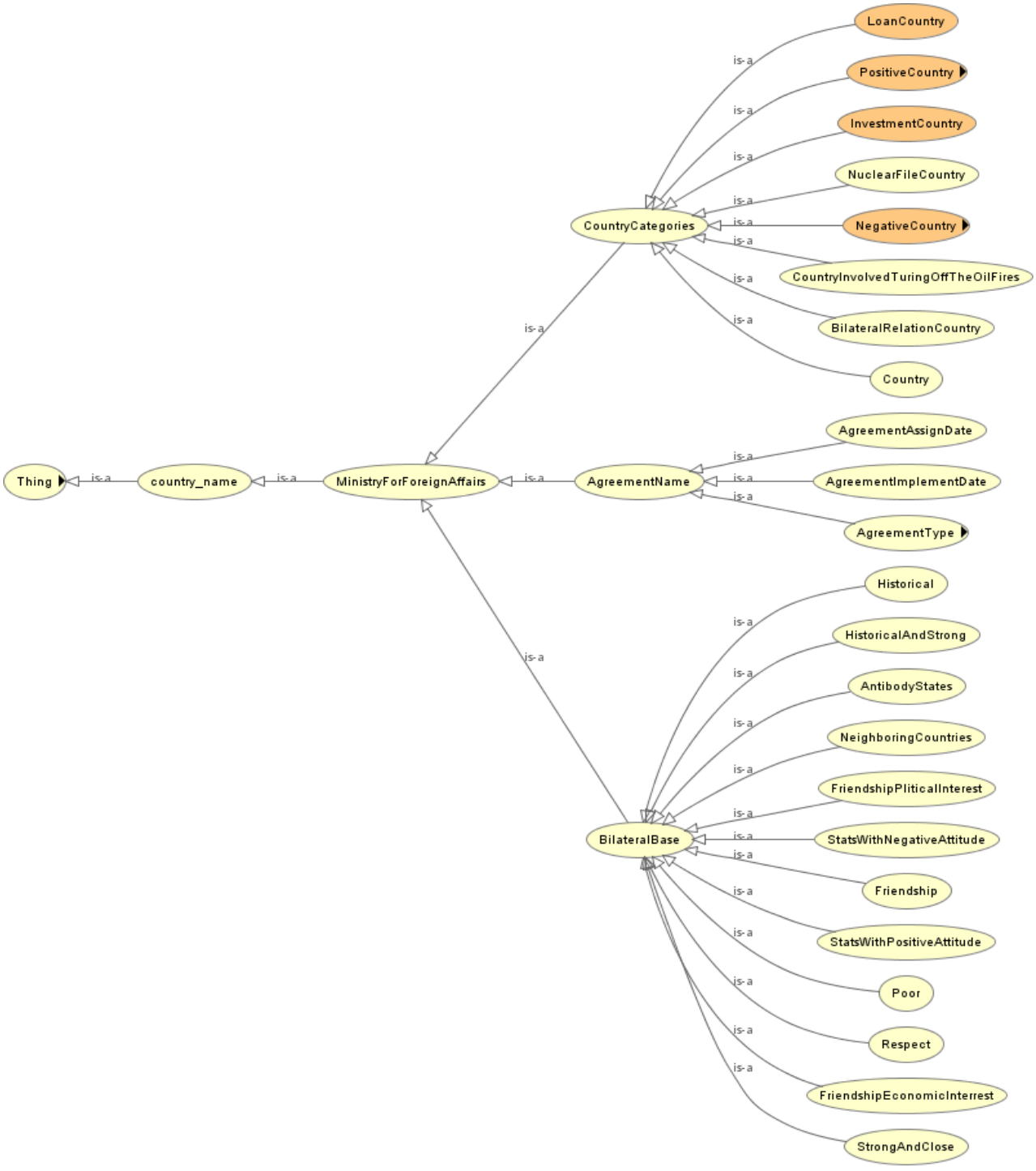

Fig. 4.9: Model of the Ministry for Foreign Affairs organization presented by Protégé-OWL ontology editing tool

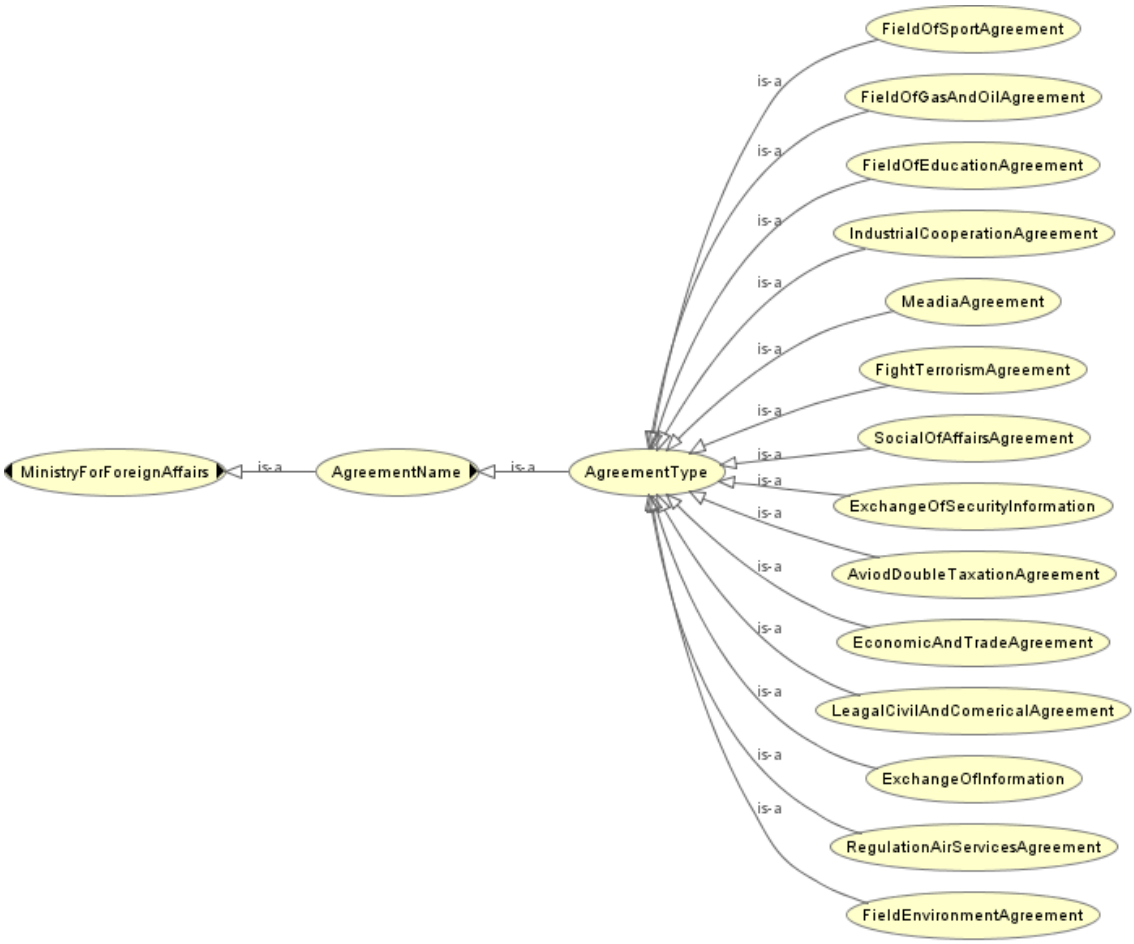

Fig. 4.10: Model of the agreement type concept presented by Protégé-OWL ontology editing tool

4.4.2 ILLUSTRATIVE CASE: ENGINEERING THE OFFICE OF THE DECISION MAKER ONTOLOGY (POLITICAL DOMAIN)

The political decision maker, in terms of creating and strengthening the economic bilateral relationship with other countries, needs to organize different factors and indicators from different domains to support and guide the decision maker with expertise knowledge and certain information to make better decisions in strengthening bilateral economic relationships with other countries. This is necessary because decision support systems require large-scale data analysis facilities for making efficient decisions. Making the right decision at the right time with the most up-to-date data is very important for political decision support. The main objective of applying ontology is to help the political decision office retrieve the information it really needs as quickly as is possible (Garces et al. 2006). Also, analysis of heterogeneous information from internal and external sources will help a political decision maker to know the main factors that affect the promotion of economic relations. Ontology methods can capture

information from several different systems to facilitate sharing with different parties and identifying the shared information. The proper decisions in strengthening economic cooperation with other countries are very important for many reasons, such as security, stability, and the prosperity of the country both locally and globally. Sometimes, the political relationship is excellent, but the investment in the country is not successful. This situation can cause waste and the depletion of state funds. Other times, the political relationship is weak, but the investment in this country is successful. Political decision makers have to keep all data up-to-date, which may delay the decision-making process and cause heavy financial losses to the state. In either case, political decision makers need to make proper decisions to strengthen economic relationships with friendly nations, to achieve successful investments in the right places.

Each state is different from others in its connections with Ministry of Foreign Affairs, Kuwait Investment and with Kuwait Fund for Development (see Fig. 4.11) and each state has different data classification (country categories, Figure 4.12).

Figure 4.11: Each 'countryName' class has a different connection

Figure 4.12: Each country has a different category.

The OP considers everything as objects. To present a model of this domain by using OP ontology, this thesis will analyze the office of the decision maker's concepts and the relationships that hold these concepts. As the political decision maker deals with each country individually, when each country has different issues in the Ministry for Foreign Affairs, the developer should link different dimensions through this process, or to be more semantically precise, the engineering process links the "security" class to the "stability" class by the tuple type "hasStability" (see figure 4.13). On the other hand, each country has different positions on different issues, and to track these different positions, the "Position" class is linked to the "Terrorism," "NuclearIsues," "GCC," "PalestineAndIsrael," "Iraq," and "Iran" classes by the "hasPositionName" tuple type. Within OP ontology, the "Relation" class is linked to the "BilateralRelationName" and "BilateralRelationDate" classes through the tuple types "hasRelationType" and "hasBilateralRelationDate," respectively, as these descriptions can change only if changes happen to the position itself. At the same time, the "Agreement" class is linked to the "AgreementName" and "AgreementStatus" classes through the tuple types "has Agreement" and "has AgreementStatus," respectively, as the status of the agreement can change if changes happen in agreement with one another.

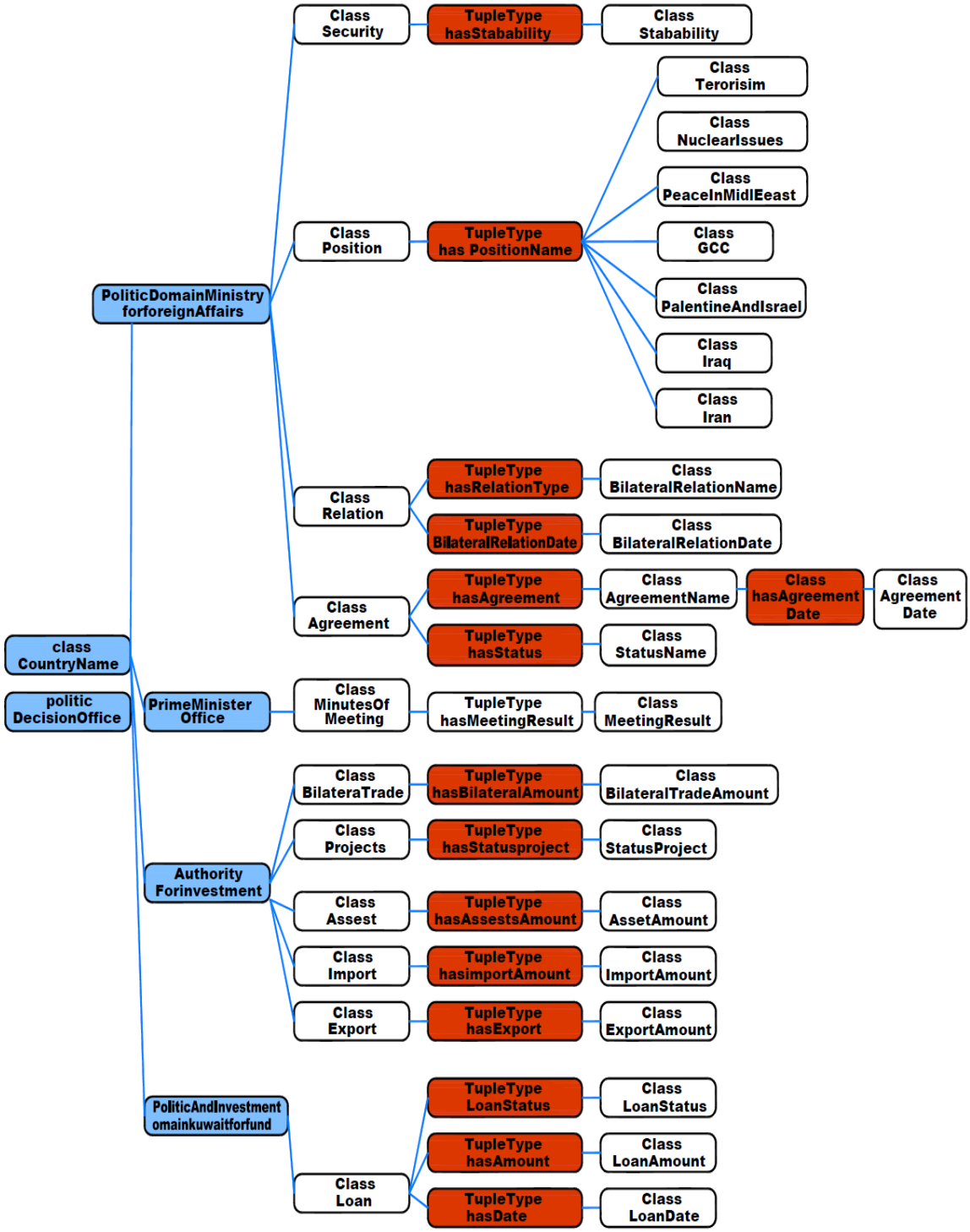

Figure 4.13: Political office OP ontology.

4.4.3 Illustrative case: engineering a position ontology in the Prime Minister's Office (political domain)

One can recognize that a position is actually an apposition of what happened in the country during a specific period of time. Based on mechanisms, philosophy, and an extension of the

demonstration of the concept of the position of each state toward several issues, this paper will describe the position concept of the country from the Prime Minister's Office. According to OP, the process started by the selection of the position concept, followed by analysis of the position concept, is undertaken to capture more details and descriptions or to abort this concept while considering the relationships that exist within the position ontology. For instance, the position of the country related to any number of issues that arise in Kuwait may be assessed in the decision-making process. These issues include but are not limited to the position of inquiries about nations with regard to regional and global issues, security and stability, the ability of the nation to invest, the disclosed position of the nation in fight against terrorism, and the position of the nation on combating weapons of mass destruction. It is important to track the positions for each country. One can recognize that a position is actually the position of the country during a specific period of the country's history.

It is possible to extract the information about the position of the country from the minutes of meetings from the Prime Minister's Office. To have a clear conceptualization of the position, the model "position" is a class for which the "DateState" state is only one state of the position class. Therefore, the "position" class is linked to the "DateStates" state through the "hasTemporalPart" tuple type, and the position concept leads to several linked dimensions through this process. To be more semantically precise, the engineering process links the "position" class to "TitleOfSubject," "CountryName," and "PositionType" classes through the tuple types "hasSubject," "hasName," and "hasPositionType," respectively. Figure 4.14 presents a model of the position concepts.

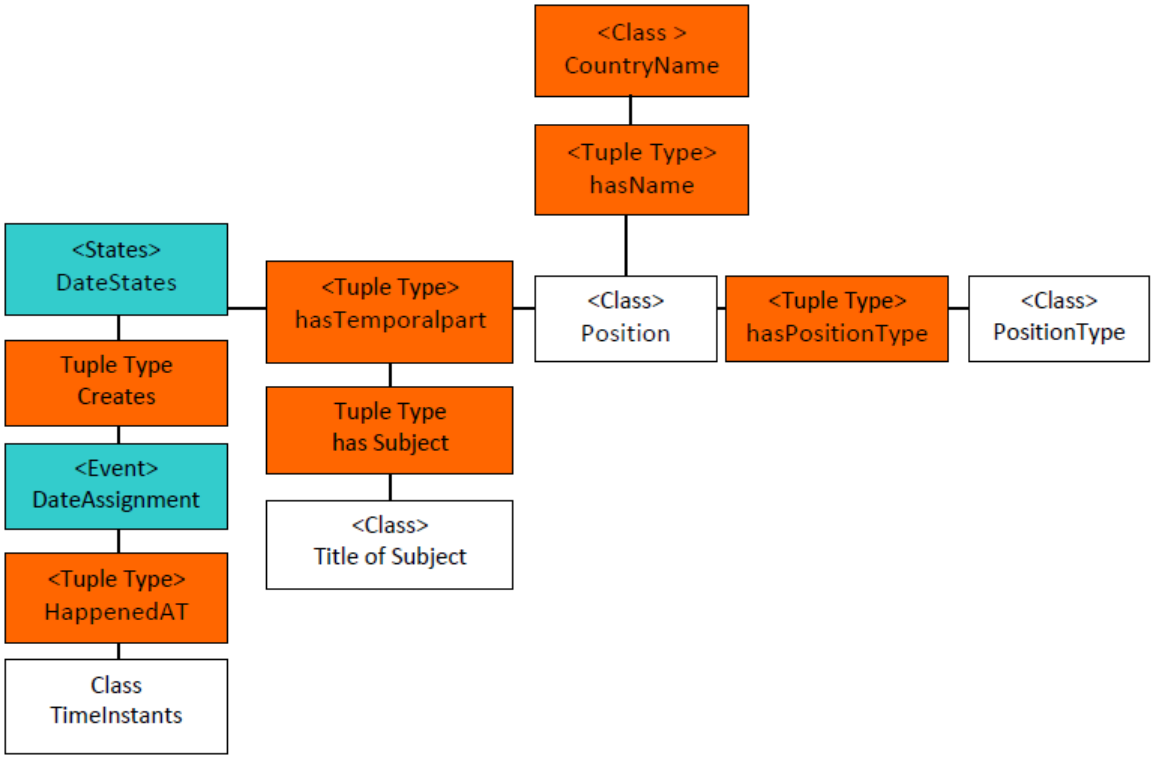

Figure 4.14: OP ontology related to the position concept

To monitor the position from the minutes of the meeting, the "MinutesResult" class is linked to the "position," "CountryName," and "Title" through the tuple types "hasPositionType," "hasCountryName," and "hasSubject," respectively, as these descriptions can change only if changes happen to the minutes' results (see Figure 4.15).

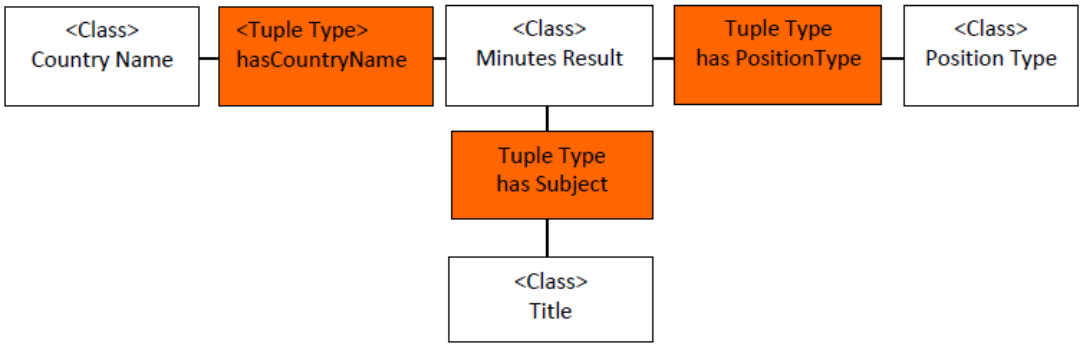

Figure 4.15 the designing properties related to the minutes of the meeting in the Prime Minister's Office

4.4.4 ILLUSTRATIVE CASE: ENGINEERING A LOAN ONTOLOGY IN THE KUWAIT FUND FOR DEVELOPMENT (INVESTMENT DOMAIN)

The OP (Object Paradigm) considers everything an object, including dimension. Two features of the OP are identified as an analysis mechanism and a philosophy that is based on extension. To demonstrate the concept of the domain, this study will use a similar approach for the

construction of OP ontology that presented in Al Asswad et al. (2010). The re-designing concept allows for the capture of 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. This team allows one to describe the concepts with more facilities and more features, so the descriptions will be more precise.

The Loan Object Paradigm ontology approach enables one to describe the domains and the relationship between them while taking into account some requirements that promote and increase the value of the concept, such as expressiveness, fidelity, and temporality. Therefore, this paradigm allows for tracking changes in ontology for future needs. It can also include the extendibility of the ontology so it can be expanded for further requirements.

The OP process begins by selecting the concept and then analyzes its spatial and temporal dimensions. The process's aim is to obtain a clear conceptualization of the loan while considering the relationships that exist within the loan ontology. The loan is granted by the state, which is linked via a relationship. Thus, in the OP ontology, 'Loan' is a class wherein 'AmountState' is only one state of the Loan class. Therefore, the 'Loan' class links to 'AmountState' through the 'hasTemporaPart' tuple type. The Loan concept then proceeds to link different dimensions through this process. To be more semantically precise, the engineering process links the 'Loan' class to 'LoanNumber,' 'LoanType,' ' Project,' 'StatusName,' and 'Date' through the tuple types of 'hasNumber,' 'hasType,' 'hasStatus,' and 'hasDate,' respectively (see Figure 4.16).

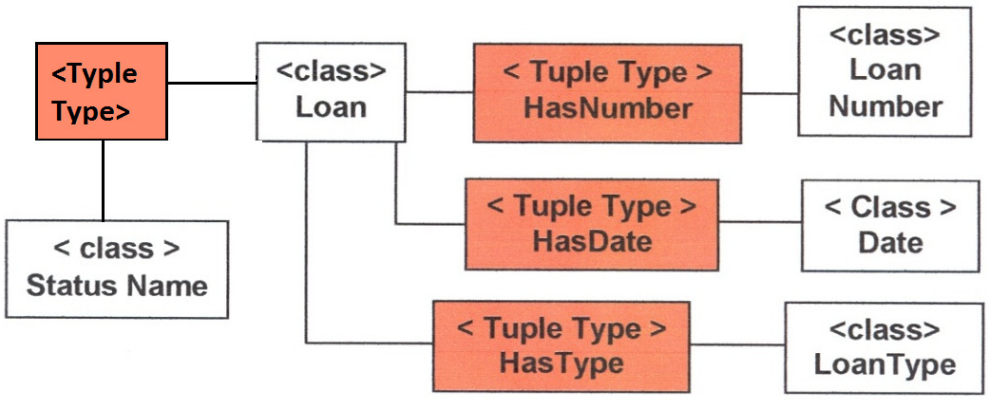

Figure 4.16.The designing properties related to loans

The amount of the loan refers to the value of the loan and must not exceed more than fifty percent of the total amount of the project. OP considers the temporal dimension and thus enables us to track changes in the loan over time. Within the OP ontology, 'AmountStates' is

linked to the 'Amount' class through the 'AmountAt' tuple type. In turn, the 'Amount' class is linked to the 'Numbers' class and the 'Currencies' class by the 'ValueAt' and 'hasUnit' tuple types, respectively. To capture the moment when the amount assignment happens, the 'TimeInstants' class is connected to the 'AmountAssignment' event by the 'happenedAt' tuple types. On the other hand, the 'AmountStates' is linked with the class 'Loan' through the tuple type 'hasTemporal Part' (see Figure 4.17).

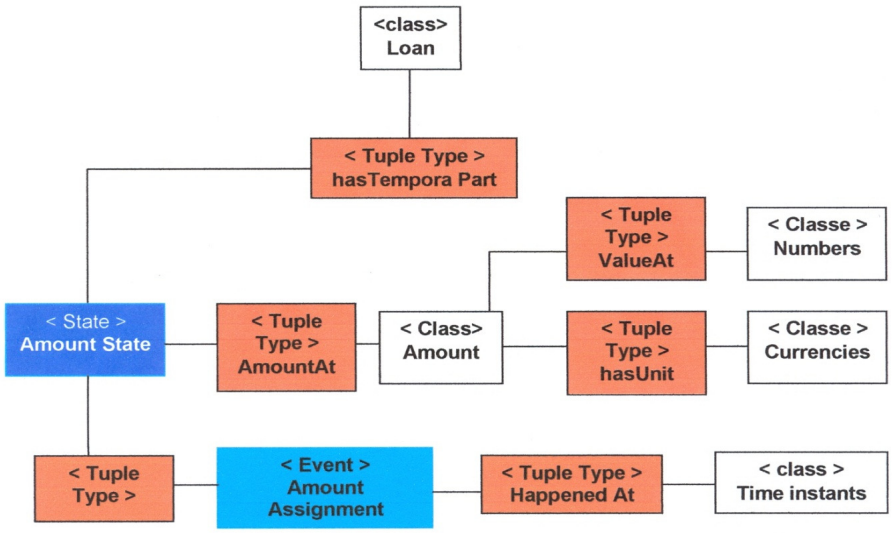

Figure 4.17: The designing part related to loan amount

The loan is submitted on a specific date, so this date requires an analysis for each status description of the loan. To capture that date, the 'Loan' class is linked to the 'Date' class through the 'hasDate' tuple type. In addition, to capture the number of the loan, the 'Loan' class is linked to the 'LoanNumber' class through the 'hasNumber' tuple type. There are four different types of loan: loan, grant, government grant, or technical assistance. To capture these criteria, the 'Loan' class is linked to the 'LoanType' class through the 'hasType' tuple type. Since the loan has been disbursed to serve a particular project in a particular sector, it is necessary to analyze the project concept, which includes the number and the name of the project. Again, to be more semantically precise, the engineering process links the 'Title' class and the 'ProjectNumber' class to 'Project' through the tuple types 'hasName' and 'hasNumber.' The project must serve different sectors, such as infrastructure, agriculture, irrigation, transport, communications, energy, water supply, sewage treatment, education, and health. To capture the different types of sectors, "SectorName' is linked to the 'Project' class through the 'hasSector' tuple type. Mainly, the type of sector is a part of the project. The continuity of the loan depends on the state of the

project, and the loan may be canceled or delayed when the project is halted. Because of this dependency, it is necessary to track the status of the project using the following status descriptions: pipeline, active, complete or cancelled. To track the changes over time, this model includes the 'ProjectStates' state along with a 'ProjectAssignment' event in the OP ontology. Also within the OP ontology, the 'ProjectStates' is linked to the 'Project' class though the 'hasTemporalPart' tuple type. Furthermore, the temporal status must be logged and must capture the time at which the project assignment happens, so the 'TimeInstants' class is connected to the 'ProjectAssignment' event by the 'happensAt' tuple type (see Figure 4.18).

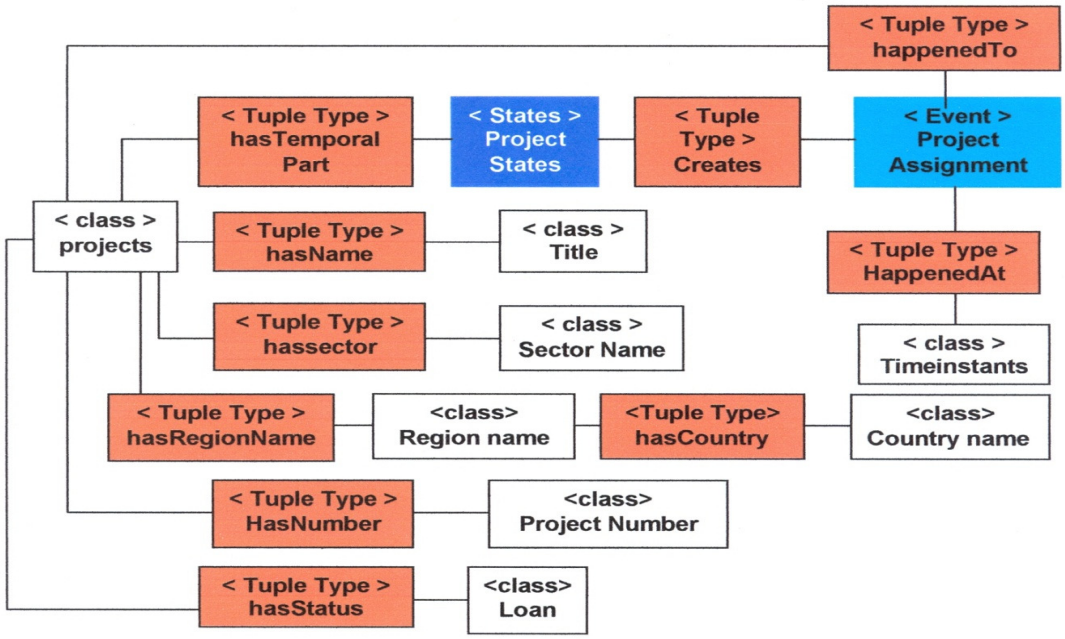

Figure 4.18: The designing part related to domain

In terms of a particular status, if the project is cancelled or pipelined, the 'StatusName' class is linked to the 'Project' class through the 'hasStatus' tuple type. Basically, the loan is also dedicated to certain areas in three regions: Arab countries, Central Asian and European countries, and East South Asian and Pacific countries. To monitor regions within a particular country, the 'RegionName' class links to the 'Project' class through the 'hasRegion' tuple type. In addition, it is necessary to specify the names of the countries in this region to capture the names of the countries. Therefore, the 'CountryName' class is linked to 'RegionName' through the 'hasCountry' tuple type (see Figure 4.19).

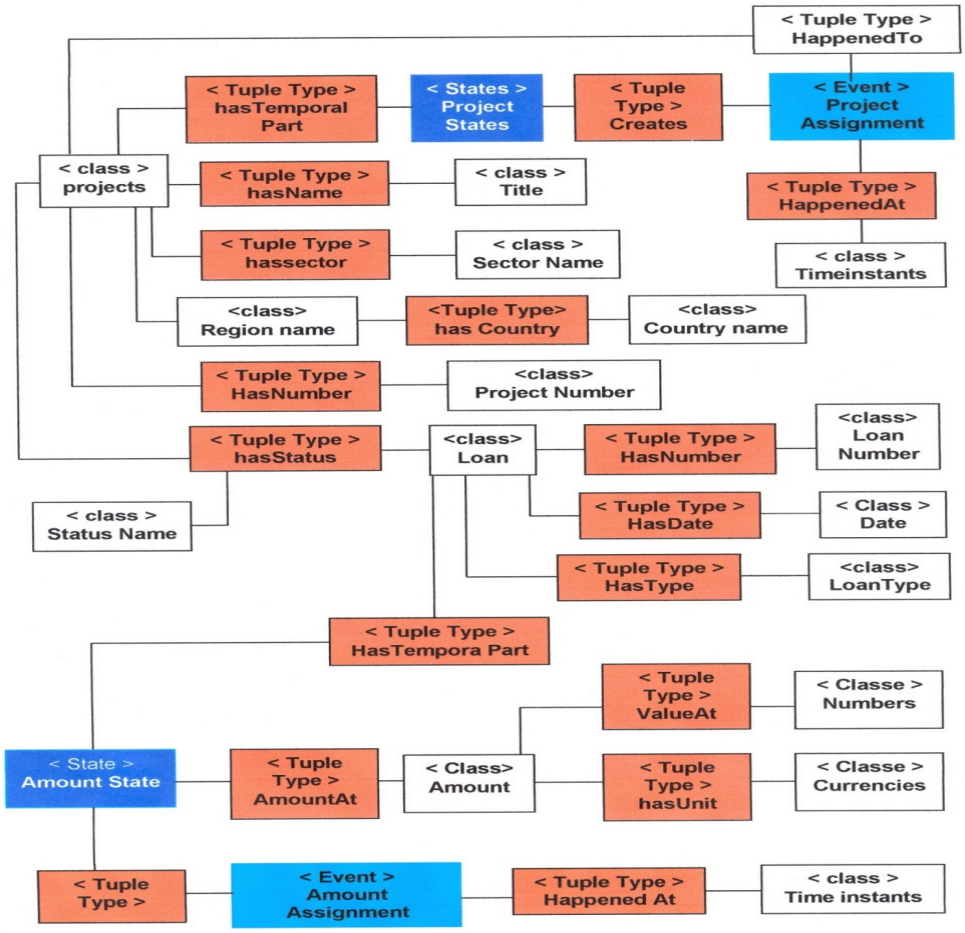

Figure 4.19: The OP loan ontology

4.4.5 ILLUSTRATIVE CASE: ENGINEERING (THE BILATERAL TRADE CONCEPT) IN THE GENERAL AUTHORITY FOR INVESTMENT (INVESTMENT DOMAIN)

Analogous to the above, the re-engineering process of OP ontology is presented for the Kuwait Investment Authority sector (The bilateral trade concept) in Figure 4.20. This process will start by selecting a concept, followed by analyzing its dimensions to clarify the result of conceptualization and properties that exist within the ontology. Following OP ontology, this model presents all the classes and properties respectively for the bilateral trade concept between countries.

The bilateral trade concept is to clarify amongst trade between nations, include the value of import, the value of export, and the date of the trade. Arguably, this is more consistent with the real world in that most countries have economic activity that is associated with several countries based on Memoranda of Understanding (MOUs) between the countries. Bilateral trade in the State of Kuwait may have a number of different activities with other countries. For example, the country may have different values with other countries including imports, exports,

assets, equities, bonds, alternatives, and real estate. Moreover, new assets of trade may be applied with different titles.

Using OP has advantages in this area where it everything is considered as objects. OP also can provide dimensions for an object (the concept and relevant details), by considering the semantics of changes to objects through 'states' and 'event.' Using OP permits an analysis of the concept and the capture of future needs. Figure 4.20 presents the OP for the bilateral trade domain.

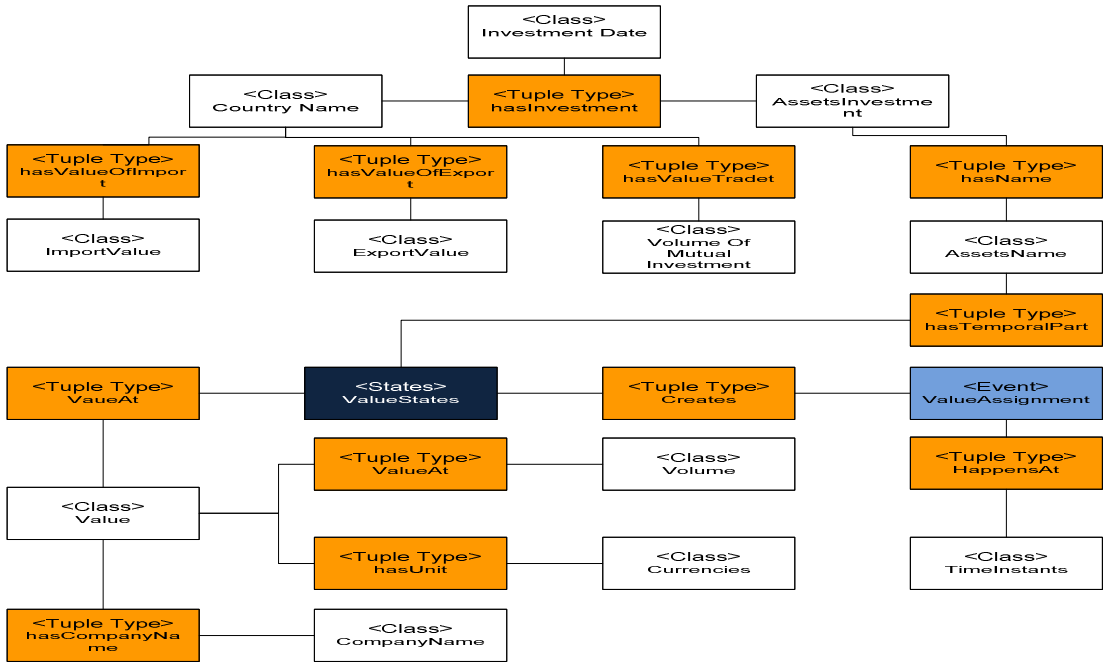

Fig.4.20: Object paradigm ontology (OP) for bilateral trade (Kuwait Investment Authority)

Analysis of the ontology model using OP approach provides more clarity in the result of the conceptualization. OP includes analyzing both concepts and relationships that exist within the ontology. The re-engineering process for bilateral trade links ‘Country Name' class, 'Date' class through the tuple types 'hasName', 'hasDate' respectively. These descriptions could track change if it happens to the countries name. To be semantically and more precise, this model re-engineers the process 'Import Value' and 'Export Value' through the tuple types 'hasValueOfImport', 'hasValueOfExport'. 'Country Name' is class linked to 'Asset Investment', 'Volume of mutual investment’ through the 'hasInvestment' tuple type, 'has Value Trade'. As the OP considers the temporal dimension, thus allows capturing of changes over time. The ontology includes a 'Value States' state along with a 'ValueAssigment' event in the OP ontology. Within the OP ontology,'Value State' is linked to the ‘Values' class through the

'ValueAt' tuple type. In turn, the 'Value' class is linked to the 'Volume' class and the 'Currencies' class by the 'Value At' and 'hasUnits' tuple types, respectively. To capture the time at which the volume assignments is happening, the 'TimeInstants' class is connected to the 'ValueAssignment' event by the 'happenensAt' tuple type, and 'Value' class link 'CompanyName' class through 'hasCompanyName.'

4.5 DEFINE THE DOMAIN ONTOLOGY EXTENDED AS FUZZY ONTOLOGY

Section 4.4.1 presented three steps in engineering agreement ontology in the Ministry of Foreign Affairs (political domain) to obtain a clear conceptualization of the bilateral agreement concept using OP ontology, presenting some properties and relation that hold agreement concepts, and presenting the agreement concept by using Protégé OWL editing tools ontology. It also presented the aims of these steps. Now it is necessary to enhance the ontology structure into a fuzzy ontology. The enhancement of the ontology structure into a fuzzy ontology structure will verify the existing ontology in the domain that can be extended and combine a fuzzy relation by its weight.

The aim of this section is the enhancement of ontology structure into fuzzy ontology structure. This section consists of verifying the existing ontology in the domain that can be extended. Traditionally, concepts are described in an ontology using a properties framework. For example, this thesis presented the agreement ontology in the Ministry of Foreign Affairs , the aims of selected agreement concept was presented in sections 4.3.5.6 and 4.4.1, also more details about a political domain presented in Section 4.4.2. The designing of the bilateral agreement ontology was presented in Figure 4.4.

According to Jun et al. (2008) fuzzy ontology is to assist in presenting the concept with assets of properties. 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.

As mentioned in Section 2.5, fuzzy logic is used to present imprecise information and help to identify predictor variables. Section 4.4.1 presented the agreement ontology in the Ministry of Foreign Affairs as a political domain to obtain a clear conceptualization of the bilateral

agreement concept. The next step is to achieve the enhancement of the ontology structure into a fuzzy ontology structure to verify the existing ontology in the domain that can be extended and combine a fuzzy relation by its weight. To begin, that ontology can be converted into a fuzzy agreement ontology in which any relation is a fuzzy relation accompanied by its weight as defined in Table 4.6 and Table 4.7, the semantic relation that defines the agreement status and the agreement type concepts, respectively.

Table 4.6:.Weight associated with the semantic relations that define 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 4.7: Weight associated with the semantic relationships that define 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

4.5.1 CONSTRUCT FUZZY LOGIC AND MEMBERSHIP IN A POLITICAL DOMAIN

The aim of this section is to present a proposal that integrates fuzzy logic in ontology. The success of fuzzy logic applications lies in their ability to handle and describe vague information in addition to drawing attention to address certain applications in government sectors, since the information presented within governmental sectors is generally vague. That vague information requires a common language to describe its concepts. Fuzzy logic is especially useful in government applications, as presented in Section 2.7. In recent years, the number and variety of applications of fuzzy logic have increased significantly, as presented in Section 2.4. The previous section clarified that the most basic variables underlying fuzzy logic are linguistic variables. The variables in the political domain are linguistic variables whose values are words rather than numbers. Although words are inherently less precise than numbers, intuition the meaning of words more easily than that of numbers. Furthermore, computing with words

exploits the tolerance for imprecision inherent in language. Undoubtedly, in the political domain, one would not find information in a document that provides a precise definition for a fuzzy value. It would be equally unlikely to find a numerical characterization of the relations between country x and country y, but one might find a linguistic qualifier such as the following information in such a document: "country x has a good relation with country y," "country x has a very good relation with country y," or "country x has weak relation with country y."

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 degree membership belonging to a set. Fuzzy logic is based on natural languages to provide convenient methodologies to represent human knowledge (Muhammad and Bulisha 2006). The fuzzy membership value μ is used for the relationship between the objects in question, where $0<\mu<1$, and μ corresponds to a fuzzy membership relation, such as "low," "medium," or "high," for each object.

4.5.1.1 CASE STUDY –BILATERAL RELATIONSHIP

A bilateral relationships case was presented by Alshayji et al. (2011c). The type of the bilateral relationship has a significant impact on determining the quality of bilateral agreements and the status of the bilateral agreement of renewal or non-renewal. Also, strong bilateral relationships will enhance the investment relationships and encourage strengthening the economic bilateral relationships between nations. Therefore, the bilateral relationship is useful as a case to present the construction of fuzzy logic and membership in the political domain. This construction will contain three steps: 1) provide a complete framework based on ontology in a particular domain, 2) add a degree of membership to all terms in the ontology, and 3) generate an extension of the domain ontology with a fuzzy concept.

The first step will provide a complete framework based on ontology in a particular domain. The proposed bilateral relationships domain ontology contains vague descriptions. Table 4.8 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 relations 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 (Claire et al. 2003). Table 4.8 presents the first step in the political approach, which extends the domain's ontology into a bilateral relationship domain to generate fuzzy ontology. Some concepts included in this domain are "CountryClassification," "RelationName," and "CountryName," 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.

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 as mentioned previously in chapter 1 section 4. Such definitions are used for the decision making process when it comes to strengthening the bilateral economic relationships between Kuwait and other nations. These 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 can employ a variety of perspectives with a set of properties, including "historical," "respectable," "coalition countries," "antibody states" and "friendly."

Table 4.8: 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. A common language is thus needed to describe 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 (the definition of coalition countries has been explained in 1.4. 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, 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 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 1.12 and again Table 4.9, 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, and other representations of a country's position. The "Coalition countries" class includes linguistic terms such as "Agree," "Abstention," "Disagree," and so on. 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.

Realistically and logically this linguistic variable needs to be proposed by expert rules that allow for qualities and characteristics such as a fuzzy inference system that is capable of activating top political decisions to strengthen the bilateral economic relationships with friendly nations.

Table 4.9: The “coalition countries” class by generating different subclasses

Year	Voted on the resolution of human rights in Kuwait	Voted on the resolution of human rights in Iraq	Voted on a resolution effects on the environment of the invasion	Country
1990	Absent			
1991	Agree	Absent	Absent	
1992	Disagree	Absent	Absent	
1993	Disagree	Absent		
1994		Absent		
1995		Absent		
1996		Absent		
1997		Absent		
1998		Absent		
1999		Absent		
2000		Absent		
2001		Absent		

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.

This model uses a similar ontology to the one presented by Alshayji et al. (2011b) 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 suited for solving the uncertainty of problems in these intelligent decision support systems. The first step breaks down the concept of the investment indicator. The “InvestmentIndicatorName” (output) class has different properties that can be described from a variety of perspectives, such as “encourage,” “limit,” “prevent,” "encourage with strong," “caution,” and others. Fuzzy values are assigned to the “InvestmentRelation” class in the bilateral relationship domain (see Table 4.10).

Table 4.10: 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 4.11 presents the proposed "InvestmentIndicatorName" class with linguistic and semantic properties for each country.

Table 4.11: Fuzzy logic assigned to "CountryName" and "InvestmentIndicator."

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

4.5.2 CONSTRUCT FUZZY ONTOLOGY STRUCTURES AND SEMANTIC RELATIONS FOR POLITICAL AND INVESTMENT DOMAINS:

In this scenario, Alshayji et al. (2011b) introduced a fuzzy ontology approach in both political and investment domains. They applied this approach to two main important government sector representatives in Kuwait: the Kuwait Investment Authority (investment domain) and the Ministry of Foreign Affairs (political domain). 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 domains and the relations between them. The aim of conducting the fuzzy ontology approach is to provide insight into how knowledge can be represented and handled, so the decision maker has support from an intelligent decision process.

An ontology can be converted into fuzzy ontology by adding the relation weight to any fuzzy relation, as presented in Shuppan (2009) and Yuemei (1996). This ontology includes the weight for every relation (see Figure 4.22). Figure 4.22 presents an ontology diagram for the political and investment domains, Ministry for Foreign Affairs and the Kuwait Investment Authority (bilateral trade). This ontology contains the classes and subclasses in the concept of the bilateral trade.

Figures 4.22 present a fuzzy version of the ontology in diagrams to explain the relationships between the Ministry for Foreign Affairs and the Kuwait Investment Authority. This maps out 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 "Bilateral Trade". Class is linked to different attributes such as "Real Estates", "Alternatives" and any further fuzzy concept can be added in the future. Because of that we add "fuzzy other" class. In the other hand the "Investment Class" linked to different attributes such as "InvDate" to clarify the date of the investment with such countries. The "MinistryOfForeignAffairs" class is divided 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," "ValueOfAssistance," "ValueOfGrants," and "LoanValue." On the other hand, the type of relationship between the two countries has an impact on the continuity of a 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. This model presents the integration of data across different sectors and produces a seamless system that enables valid design support for top political decision makers by employing natural language. Figure 4.21 shows the semantic relation and fuzzy ontology for political and investment sectors respectively. In this ontology, every relation is associated with its linguistic or semantic weight

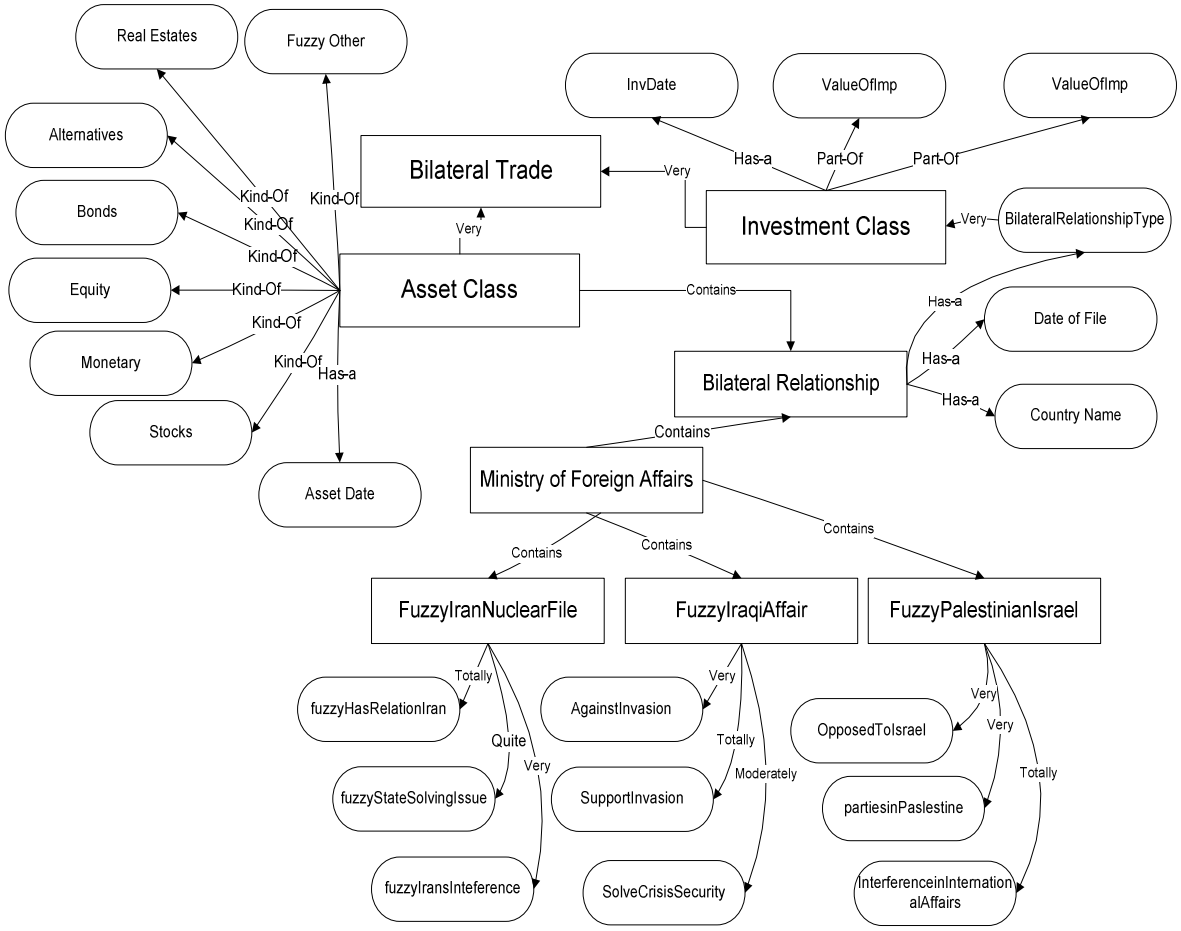

Figure 4.21: Semantic ontology for the relation between the Ministry for Foreign Affairs and the Kuwait Investment Authority (political and investment domains)

This model integrates the fuzzy logic membership as a value that reflects the strength of an inter-concept relationship, and is consistently used to represent pairs of concepts across ontology, in which the concept consistency is dealt with by means of a fixed numerical value. Concept consistency is computed as a function of all the relationships associated with the concept.

4.5.3 CONSTRUCT FUZZY COGNITIVE MAP THEORY (FCM) IN POLITICAL DOMAIN: FCM MODEL FOR EVALUATION

As mentioned in Section 3.3.3, Fuzzy cognitive map theory (FCM) is especially applicable in the description of sensitive content domains e.g., political science, military science, history, international relations, and political elections at governmental levels (Calais 2008). Alshayji et al. (2011c) presented FCM as an example in the political domain to demonstrate the causal interrelationships between certain variables or factors to provide insight and better understanding about the interdependencies of these variables or factors. For example, F4 is one of the most critical factors in this fuzzy cognitive map. In addition the threat of terrorism (F3) is

the major negative cause of political stability. The value -1 represents full negative causal effect, whereas +1 full positive causal effect. Zero denotes no causal effect. An FCM is a clear design for graphically representing state variables within a dynamic system through links that signify cause and effect relationships using fuzzy weight quantified via numbers or words (Sharif and Irani 2005). Experts can translate such variables into numeric values and present them graphically to show which factors are contributory and to what degree they contribute. The main advantage of FCM is its flexibility. It can always accept additional variables, so factors can be included at any time.

Nine steps are employed in designing a cognitive map: (1) identification of factors, (2) specification of relationships, (3) levels of all factors, (4) intensities of causal effects, (5) changeable factors versus dependent factors, (6) simulating the fuzzy cognitive map, (7) modifying the fuzzy cognitive map, (8) simulating the modified fuzzy cognitive map, and (9) conclusion. More description about these steps was presented in Calais (2008). These flexible and efficient steps have been extensively used for planning and decision-making in numerous fields such as politics and the Middle East crisis (Calais 2008). In the present model, when preparing a fuzzy cognitive map, the first step entails the identification for factors (concepts) and the following fourteen factors (concepts) are selected based on several events in the region. The regional and international events have contributed to the increasing challenges factors face in political decision making, particularly the decision to strengthen bilateral economic relationships with friendly nations. Figure 4.22 presents the FCM model that provides insight into factors influencing such decisions, where (F1) means the degree of promoting bilateral economic relationships with friendly nations security and stability, (F2) the political stability, (F3) the threat of terrorism, (F4) the threat of nuclear war, (F5) the threat of provocation, (F6) the multiple parties involved, (F7) the multiple ethnic groups involved, (F8) the multiple sects involved, (F9) the loans, (F10) other financial aid, (F11) the nation regional and international attitudes, (F12) peace in the Middle East, (F13) the status of agreement, and (F14) the type of agreement. Additional variables are presented in Figure 4.22 to show the reader the difficulties that influence the top political decision maker and as a demonstration of how one might shorten the list of variables and summarize them even better for the reader to follow other steps easily.

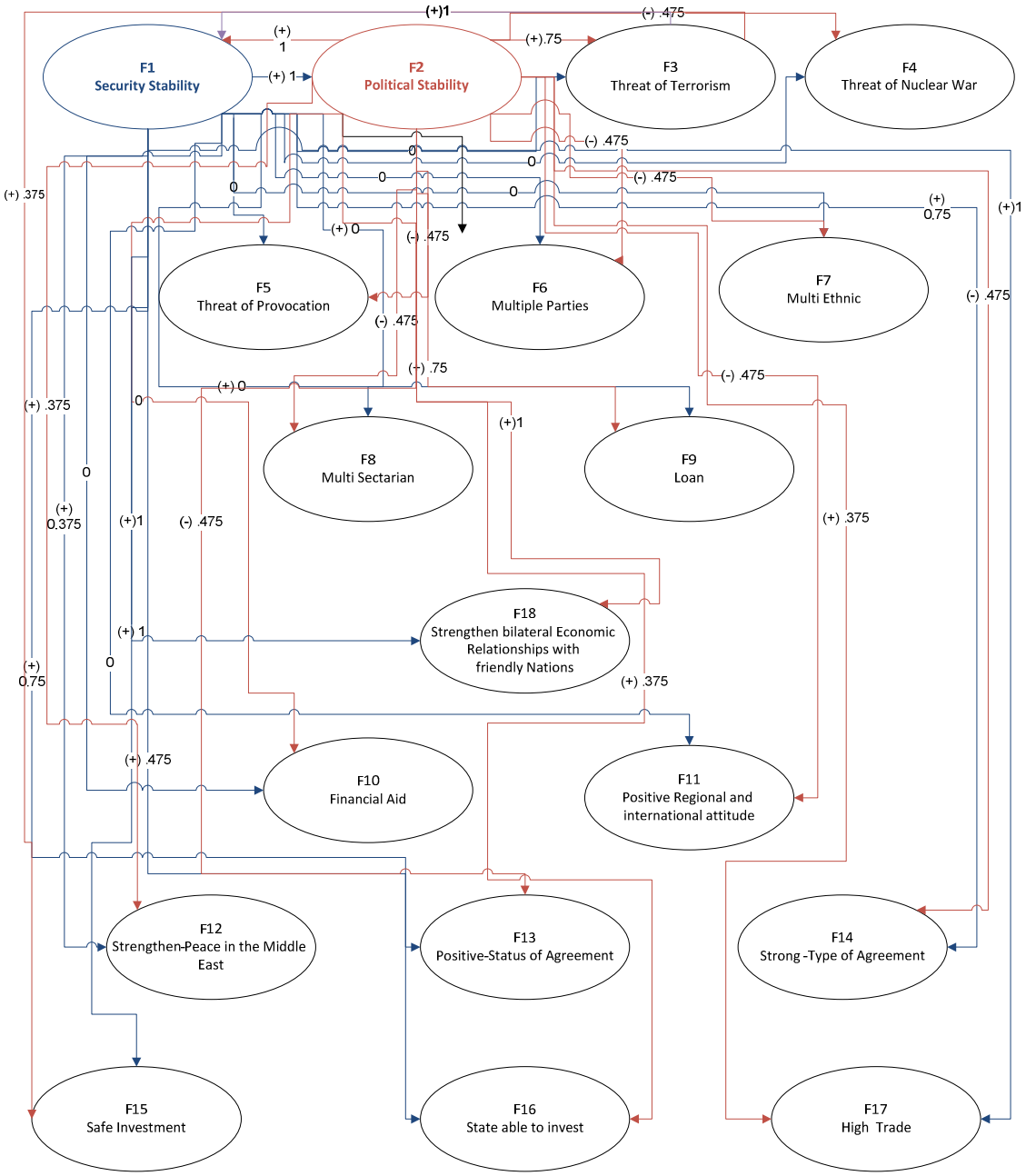

Fig. 4.22 FCM model presenting certain factors in the political and investment domains.

To summarize the extent of the used approach, the same approach in table 4.12 applied by Sharif and Irani (Sharif and Irani, 1999) has been used. Table 4.12 presents causal degree used to demonstrate an FCM model in a political domain.

Table 4.12: Causal weight used for FCM model

Des	degree
Never	0
Not Much	0.125
Sometimes	0.375
Usually	0.475
Very much	0.75
Always	1

The same degree presented in table 4.12 has been used to shows a number of initial rows vectors (connection-matrix) demonstrations to present the interrelation of some factors with other factors. Table 4.13 presents the variables and the relationship between them. For example, table 4.13 shows clearly the negative impact of factor (4) that represents the threat of nuclear war on factor (1) strengthen the economic relationship. The goal set for this hypothetical fuzzy cognitive matrix is to determine how the threat of nuclear war and others variables impact to strengthen economic bilateral relationship.

Table 4.13: Connection-matrix presentation of factors (U:usually; VM: very much; ST: sometimes; NM: Not Much).

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18
F1	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	0	0	0	(+) 0.375 ST	(+) 0.75 VM	(+) 0.75 VM	(+) 1 A	(+) 1 A	(+) 0.475 U	(+) 1 A
F2	(+) 1 A	(+) 1 A	(-) VM	(-) 0.475 U	(-) 0.475 U	(-) 0.475 U	(-) 0.475 U	(-) 0.475 U	(+) 0.75 VM	0	(-) 0.475 U	(+) 0.375 ST	(-) 0.475 U	(-) 0.475 U	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 1 A
F3	(-) 1 A	(-) 1 A	0	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(-) 0.475 U	(-) 0.75 VM	(-) 0.475 U	(-) 0.75 VM	(-) 0.375 ST	(-) 0.75 VM	(-) 0.75 VM	(-) 0.75 VM	(-) 1 A	(-) 1 A
F4	(-) 1 A	(-) 1 A	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(-) 0.75 VM	(-) 0.75 VM	(-) 0.125 NM	(-) 1 A	(-) 0.475 U	(-) 0.75 VM	(-) 1 A	(-) 1 A	(-) VM	(-) 1 A
F5	(-) 0.75 VM	(-) 0.75 VM	(+) 0.75 VM	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	0	0	(-) 0.375 ST	(-) 0.375 ST	(-) 0.375 ST	(-) 0.475 U	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM
F6	(-) 0.75 VM	(-) 0.75 VM	(+) 0.75 VM	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	0	0	(-) 0.375 ST	(-) 0.375 ST	(-) 0.375 ST	0	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM
F7	(-) 0.75 VM	(-) 0.75 VM	(+) 0.75 VM	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	0	0	(-) 0.375 ST	(-) 0.375 ST	(-) 0.375 ST	0	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM

F8	(-) 0.75 VM	(-) 0.75 VM	(+) 0.75 VM	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	0	0	(-) 0.375 ST	(-) 0.375 ST	(-) 0.375 ST	0	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM
F9	(+) 0.375 ST	(+) 0.375 ST	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	(-) 0.125 NM	0	0	(+) 0.375 ST	(+) 0.475 U	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U
F10	(+) 0.475 U	(+) 0.475 U	(-) 0.375 ST	(-) 0.75 VM	(-) 0.475 U	0	0	0	(+) 0.375 ST	0	(+) 0.375 ST	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(-) 0.125 NM	0	(-) 0.125 NM	(+) 1 A
F11	(+) 0.375 ST	(+) 0.375 ST	0	(-) 0.125 NM	(-) 0.125 NM	0	0	0	(+) 0.475 U	(+) 0.475 U	(+) 0.125 NM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 1 A
F12	(+) 0.375 ST	(+) 0.375 ST	(-) 0.375 ST	(-) 0.475 U	(-) 0.475 U	(-) 0.475 U	(-) 0.475 U	(-) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 1 A
F13	(+) 0.375 ST	(+) 0.125 NM	0	(-) 0.375 ST	(-) 0.375 ST	0	0	0	(+) 0.375 ST	(+) 0.475 U	(+) 0.375 ST	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 1 A
F14	0	0	0	(-) 0.375 ST	(-) 0.375 ST	0	0	0	(+) 0.375 ST	(+) 0.475 U	(+) 0.375 ST	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 1 A
F15	(+) 0.75 VM	(+) 0.475 U	(+) 0.475 U	0	0	0	0	0	(+) 0.375 ST	(+) 0.375 ST	(+) 0.375 ST	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 1 A
F16	(+) 0.75 VM	(+) 0.75 VM	(-) 0.75 VM	(-) 0.75 VM	(-) 0.75 VM	0	0	0	(+) 0.375 ST	0	(+) 0.375 ST	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	0	(+) 0.75 VM	(+) 1 A
F17	(+) 0.375 ST	(+) 0.375 ST	0	(-) 0.125 NM	(-) 0.125 NM	0	0	0	(+) 0.475 U	(+) 0.475 U	(+) 0.475 U	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	0	(+) 1 A
F18	(+) 0.375 ST	(+) 0.375 ST	0	0	0	0	0	0	(+) 0.75 VM	(+) 0.75 VM	(+) 0.475 U	(+) 1 A	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	(+) 0.75 VM	0

4.5.4 USE OF FUZZY CAUSAL ALGEBRA TO CLARIFY THE RELATIONSHIPS BETWEEN FACTORS:

This part seeks to clarify the relationships between concepts, and elucidate the positive or negative effects on each concept while enhancing the knowledge clarification of the relationships. Furthermore a FCM graph structure allows systematic causal propagation, (i.e. forward and backward chaining) and arrows sequentially contribute to the convenient identification of the causes, effects, and affected factors. FCM allows knowledge bases to expand by connecting additional concepts. Fuzzy causal algebra governs causal propagation and causal combination on within FCM (Kosko 1986). Fuzzy logic algebra is created by abstracting operations from multiplication and addition that are defined on a fuzzily partial set P of causal values (Kosko 1986). The algebra that is developed depends only on the partial ordering on P, the range set of the fuzzy causal edge function e, and on general fuzzy-graph properties (connections).

Kosko (1986) presented the indirect and total causal effects on cognitive maps in Herborn (2006). Kosko explained the causal effect on cognitive node C_i to concept C_j, say $C_i \rightarrow C_{k1} \rightarrow \ldots \rightarrow C_{kn} \rightarrow C_j$, which can be denoted with ordered indices as $(i,k_1,\ldots.k_n,j)$. Then the indirect effect from C_i to C_j is the causality C_i imparts to C_j. The total effect of C_i on C_j is all the indirect effect causality that C_i imparts to C_j. The operations of indirect and total effect correspond to multiplication and addition of real numbers and a causal calculus of signs (+ and -). Interpreting the indirect effect operator, I, as some minimum operator and the total effect operator, T, as some maximum operator, these operators depending only on P's partial order and the simplest of these operators are the minimum and the maximum values. Formally, let there be m-many causal paths from C_i to C_j: (i, kl1, kl2…klni, j) for $1 \leq l \leq m$, let Il (C_i,C_j) denote the indirect effect of concept Ci on concept Cj on the lth causal path. Let $T(C_i,C_j)$ denote the total effect of C_i on C_j over all m causal path. Then

$I_l\,(C_i,C_j) = \min\{\, e(C_p,C_{p+1}) : (p, p+1) \in (i,k^1_1,\ldots,k^1_{n1}, j)\}$,

$T(C_i,C_j) = \max_{1 \leq l \leq m} I_l(C_i, C_j)$

Where p and p+1 are contiguous left-to-right path indices.

Hence, the indirect effect amounts specify the weakest causal link in a path and the total effect operation amounts to specifying the strongest of the weakest links. To clear the form of relational variables and make it easier for the reader, this demonstration uses a smaller number of variables. The variables that will be displayed in Table 4.14 are extracted from Table 4.13.

Table 4.14: Connection-matrix for some variables

	F1	F2	F3	F4	F5	F6	F7
F1	(+) 0.475 Usually	(+) 0.475 Usually	(+) 0.475 Usually	(+) 0.475 Usually	(+) 0.475 Usually	(+) 0.475 Usually	(+) 0.475 Usually
F2	(+) 1 Always	(+) 1 Always	(-) Very Much	(-) 0.475 Usually	(-) 0.475 Usually	(-) 0.475 Usually	(-) 0.475 Usually
F3	(-) 1 Always	(-) 1 Always	0	(+) 0.75 Very Much	(+) 0.75 Very Much	(+) 0.75 Very Much	(+) 0.75 Very Much
F4	(-) 1 Always	(-) 1 Always	(+) 0.75 Very Much	(+) 0.75 Very Much	(+) 0.475 Usually	(+) 0.475 Usually	(+) 0.475 Usually
F5	(-) 0.75 Very Much	(-) 0.75 Very Much	(+) 0.75 Very Much	(+) 0.375 Some times	(+) 0.375 Some times	(+) 0.375 Some times	(+) 0.375 Some times
F6	(-) 0.75 Very	(-) 0.75 Very	(+) 0.75 Very	(+) 0.375 Some	(+) 0.375 Some	(+) 0.375 Some	(+) 0.375 Some
F7	(-) 0.75 Very	(-) 0.75 Very	(+) 0.75 Very	(+) 0.375 Some	(+) 0.375 Some	(+) 0.375 Some	(+) 0.375 Some

The concept variables are represented by nodes, such as: C1: threat of nuclear war, C2: security stability, C3: nation's regional and international attitudes, C4: type of the agreement, C5: status of the agreement, C6: relation type, and C7: strengthen investment indicators. Figure

4.23 has seven variables that describe the impact of some conditions on strengthening bilateral economic relationships and causal variables, for example ($C_1 \rightarrow C_2$, $C_{1)}$ that are said to impact C_4. This is apparent because C_1 is the causal variable where C_4 is the effect variable. Suppose that the causal values are given by p {none ≤ some ≤ much ≤ a lot}. The FCM appears below:

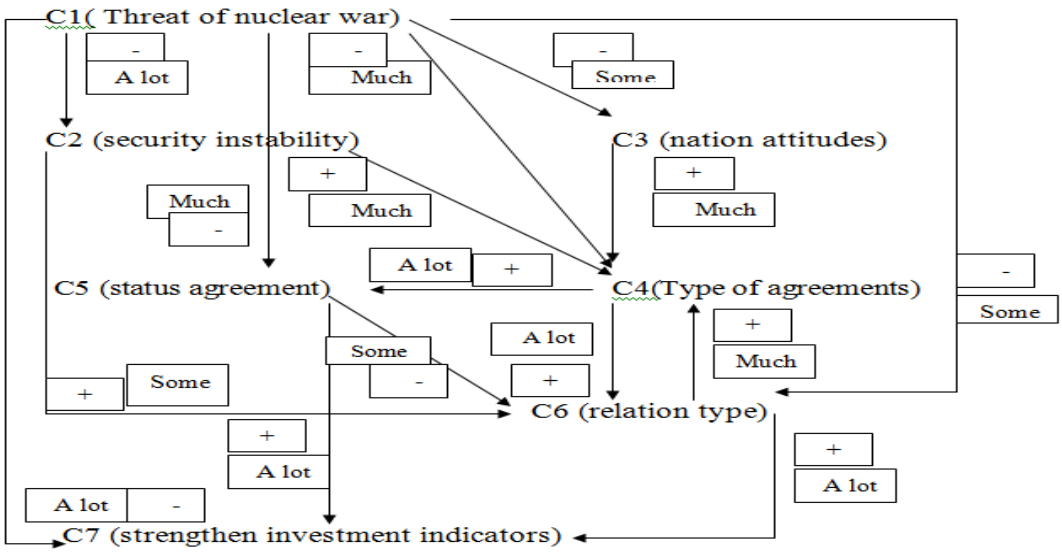

Fig. 4.23: A fuzzy cognitive map on the impact of strengthening economic bilateral relationship.

In Figure 4.23, phrases such as "much" and "a lot" denote the causal relationship between concepts. A fuzzy rule, causal link, or connection is defined by each arrow in the figure: a plus (+) represents a causal increase and a negative (-) represents a causal decrease. The causal paths from C1 to C7 are nine, the direct effect is (1,7), so the eight indirect effects of C1 to C7 are: (1,2,4,5,6,7), (1,2,4,6,7), (1,2,6,7), (1,4,5,6,7), (1,3,4,6,7), (1,3,4,5,6,7), (1,4,6,7), and (1,6,7). The eight indirect effects of C1 on C7 can be described as follows:

$I_1 (C_1,C_7)$ = min { e_{12},e_{24},e_{45},e_{56},e_{67}} = min {a lot, much, a lot, some, a lot} = some

$I_2 (C_1,C_7)$ = min{e_{12}, e_{24},e_{46},e_{67}} = min {a lot, much, a lot, a lot} = much

$I_3 (C_1,C_7)$ = min {e_{12},e_{26},e_{67}} = min{a lot, some, a lot} = some

$I_4(C_1,C_7)$ = min{e_{14},e_{45},e_{56},e_{67}} = min {much, a lot, some, a lot} = some

$I_5(C_1,C_7)$ = min{e_{13},e_{34},e_{46},e_{67}} = min {some, much, much, a lot} = some

$I_6(C_1,C_7)$ = min{e_{13},e_{34},e_{45},e_{56},e_{67}}= min{some, much, much, some, a lot} = some

$I_7(C_1,C_7)$ = min {e_{14},e_{46},e_{67}} = min{much, a lot, a lot} = much

$I_8(C_1,C_7) = \min\{e_{16},e_{67}\} = \min\{\text{some, a lot}\} = \text{some}$

Thus the total effect of C_1 on C_7 is $T(C_1,C_7) = \max\{ I_1(C_1,C_7), I_2(C_1,C_7), I_3(C_1,C_7), I_4(C_1,C_7), I_5(C_1,C_7), I_6(C_1,C_7), I_7(C_1,C_7), I_8(C_1,C_7)\} = \max\{\text{some, much, some, some, some, some, much, some}\} = \text{much}$.

Therefore, C1 impacts much causality to C7. Now that the fuzzy conceptual C_i has been computed, the advantage is that the causal quality is established.

4.5.5 CONCLUSION

A method of making use of this kind of information is needed, especially in the political domain to help decision makers strengthen bilateral economic relationships between friendly nations. In the political domain, associating a numeric membership modifier to many situations is often necessary. Fuzzy logic allows users to model imprecise and vague data, combine different priority functions, and use any value between 1 and 0 as a logic value. It is based on natural languages to provide convenient methodologies for representing human knowledge (Muhammad and Bulaish 2006). Fuzzy logic is comprehensible, flexible, and tolerant of imprecise data.

Alshayji et al. (2011b) presented a fuzzy ontology describes the relationships between the political domain and the investment domain with the semantic relations presented in Figures 4.19 and 4.20. This paper presents the integration of data across different sectors and produces a seamless system permitting valid design support for top political decision makers by employing natural languages. One can convert an ontology into a fuzzy ontology by adding a relation weight to any relation, as discussed in Shuppan (2009) and Yuemei (1996).

Previous efforts were aimed at clarifying the internal political relations among countries and the large amounts of important information about countries that exist in various governmental sectors. Such information must take into account several variables that affect, to varying degrees, other variables. The use of FCM helped to clarify the relationships between these variables, and aids understanding of the impact of some variables in the political domain on some variables in the economic domain by using fuzzy causal algebra. Each country has different relationships with other countries in its links between the political domain and investment domain. For example, Kuwait may be closely linked to some friendly countries are closely linked through the Ministry of Foreign Affairs, but have no links through the General

Authority for Investment. At other times, the countries may be closely linked with the Ministry of Foreign Affairs as well as with the General Authority for Investment.

The goal here ultimately is to strengthen our investment in the right place in the right time. The identification of the variables that influence the enhancement of the investments relationships with nations must be considered. Authorized research into the reason for either strengthening or not promoting investment relations with friendly countries must be undertaken. What prevents investments from strengthening the relationship with nations? Is it the political instability? Or is it the absence of positive attitudes, the lack of bilateral agreement, or the weakness of the type of the bilateral relationship? Research is needed on the effect of each of these variables prior to the strengthening of a bilateral economic relationship.

As mentioned earlier, each country has different kind of links with other nations, some such links via agreements and the types of the agreements and the status of the agreements are also important; they are noteworthy variables that must be taken into account. Each country has its own special variables and its special linkages with particular political and economic sectors. Therefore, the previous presentation (figures) of the relations aimed at clarifying the content of these sectors and the formulation of the ties linking such sectors to extract the variables in these domains and understand the impact of these variables in one domain on those variables in another domain. In addition, this chapter mentioned other variables such as bilateral relations and how bilateral relations impact different bilateral dimensions and so on. Although previous work provided a solid foundation, it stimulated the search to apply an intelligent system with the capability of computing vague variables. There is still need to move forward to apply a system that is capable of drawing rule conclusions from consequences of rules which are unlimited in number but can provide an *if* antecedent (input) and *then* consequent (output). In the field of artificial intelligence, neuro-fuzzy refers to combination of artificial neural networks and fuzzy logic. Neuro-fuzzy system (the more popular terms is used henceforth) incorporates the human-like reasoning style of fuzzy systems through the use of fuzzy sets and linguistic model consisting of a set of IF-THEN fuzzy rules. The next section will clarify this concept in detail. The next step will present the construction of the fuzzy inference system in the political domain.

4.5.6 CONSTRUCT FUZZY EXPERT SYSTEM IN THE POLITICAL DOMAIN

4.5.6.1 INTRODUCTION

Although previous work provided a solid foundation, it is stimulated to apply an intelligent system with the capacity of computing vague variables. After understanding the concept, extracting the main variables, and illustrating the effect of those variables on one another. The next step is to apply a method that can deal with dismantling each variable to several parameters. For example, the country goes through several phases in terms of the variable of "political stability." Sometimes the country is stable for a period and unstable in another. In this situation the political decision maker could describe the "political stability" in several phases as "very good" in a specific time or "good" in another time or "weak" in the current time. The implication of this issue for the present question is the political decision maker is considering carefully whether to invest or not invest in states in different phases of stability. For another example, the variable of "bilateral relation" between country x and country y, as presented in Section 5.5.1.1, this variable can be described as "strong," "very good," or "weak," and so on, so there is need for a method that allows adding several parameters is needed. Also, political decision makers would be aided by a system that would allow them to formulate constructive rule conclusions by dealing with vague variables as described and drawing conclusions in the form of an *if* antecedent (input) and *then* consequent (output). The fuzzy expert system illustrated in the next process will help achieve this and contribute in the presentation of several variables in varying degrees.

Fuzzy expert system is a collection of membership functions and rules used to draw conclusions from (often imprecise) data, for example, if (Security is poor) and (PoliticalStability is poor) then (investment is never). A rule assigns a membership function to each variable. The rules in fuzzy expert systems usually take the following form: *if* antecedent (input) and *then* consequent (output). Rule conclusions are consequences of that system of rules. Fuzzy Logic Toolbox Matlab Software does not limit the number of rules (inputs or variables).

The process by which one chooses specific values for input variables to compute the values of the output variables is referred to as inferencing, or the inference process. In a fuzzy expert system, the inference process is a combination of four sub processes: fuzzification, inference, composition, and defuzzification. Defuzzification is optional.

As mentioned previously, a serious problem that faces decision makers is building efficient political decision support systems (DSSs) with heterogeneous factors to determine whether to strengthen bilateral economic relationships with friendly nations, especially in light of the recent series of political and economic crises. Since such decisions are based on vague information and linguistic variables, these variables must be analyzed in way that can be handled by the political decision maker and enhance the political decision process. For example, before making a decision to promote investment, a decision maker might ask whether country X is politically stable. This question is especially meaningful with respect to countries whose political situations are experiencing a drastic transformation, such as Egypt, Libya, and Yemen. This is also true with regard to countries that have experienced serious environmental disasters (like Japan) and those facing the world's disapprobation (like Iran with its nuclear program). One can speak about political stability in simple natural language that is clear and understandable. For example, if security is poor and political stability is poor, and then investment is imprudent. Fuzzy logic is based on natural language and is tolerant of imprecise data. Based and building on the experience of advisers in the political domain who_know certain rules and have an idea of what the output should look like, this thesis has selected the most important variables (inputs) that drive and direct the compass of political decisions (outputs).

4.5.6.2 METHODOLOGY

This method uses the fuzzy logic Toolbox graphical user interface (GUI) tools from the MATLAB environment to build a fuzzy inference system (FIS) for the political domain. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. Using MATLAB, one can solve technical computing problems faster than with traditional programming languages, such as C, C++, and Fortran.

This thesis uses five fuzzy logic GUI tools to build, edit, and monitor FISs for the political domain to help political decision makers to build efficient political positions regarding whether to strengthen bilateral economic relationships with friendly nations (see Figure 4.24).

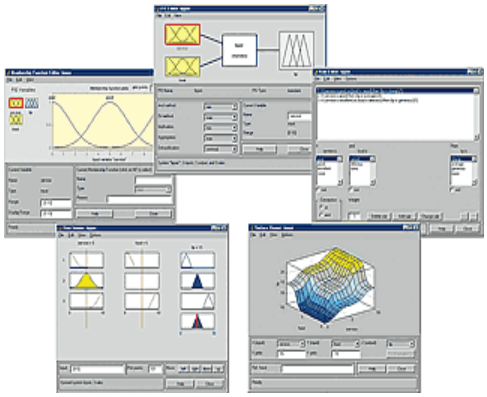

Figure 4.24: The five primary GUI tools for building, editing, and monitoring FISs.

The five primary GUI tools are listed below:

1. FIS editor: Displays general information about the FIS.

2. Membership Function Editor: Allows users to display and edit the membership functions associated with the input and output variables of the FIS.

3. Rule Editor: Allows users to view and edit fuzzy rules using one of three formats, full English-like syntax, concise symbolic notation, or indexed notation.

4. Rule Viewer: Allows users to view details about the FIS to help them to diagnose the behavior of specific rules or study the effect of changing input variables.

5. Surface Viewer: Generates a 3D surface from two input variables and the FIS's output.

These GUI tools are dynamically linked. Any changes to the FIS using one of them can affect the others. Users can have any or all of them open for any given system. These GUI tools can all interact and exchange information. Any one of them can read and write both to the workspace and to a file (the read-only viewers can still exchange plots with the workspace and save them to a file). For any FIS, any or all of these five GUIs may be open. If more than one of these editors is open for a single system, the various GUI windows are aware of the others and, if necessary, update related windows. Thus, if the names of the membership functions are changed using the Membership Function Editor, those changes are reflected in the rules shown in the Rule Editor. The editors for any number of different FIS systems may be open simultaneously. The FIS Editor, the Membership Function Editor, and the Rule Editor can all

read and modify the FIS data, but the Rule Viewer and the Surface Viewer do not modify the FIS data in any way.

The fuzzy editor handles high-level issues for the system: input and output variables and their names. Fuzzy Logic Toolbox Software does not limit the number of inputs. However, the number of inputs may be limited by the machine's available memory. The Membership Function Editor is used to define the shapes of all the membership functions associated with each variable. The Rule Editor is used to edit the list of rules that define the system's behavior. The Rule Viewer and Surface Viewer are used for looking at and editing the FIS. The Rule Viewer is a MATLAB technical computing environment-based display of the fuzzy inference diagram; it can show which rules are active or how individual membership function shapes influence the results. The Surface Viewer is used to display the dependency of one of the outputs on any one or two of the inputs. It generates and plots an output surface map for the system.

4.5.6.3 DATA AND MODELING SCENARIO

The first step is to hypothesize a parameterized model structure (relating inputs to membership functions and rules to output, to membership functions, and so on). The next step collects input/output data in a form that would be usable to apply fuzzy inference to a system.

The goal is to apply fuzzy inference to a system for which the developer already has a collection of input/output data to use for modeling. Parameters could be chosen so as to tailor the membership functions to the input/output data to account for these types of variations in the data values.

Fuzzy Logic Toolbox software computes the membership function parameters that best allow the associated FIS to track the given input/output data. The Fuzzy Logic Toolbox function that accomplishes this membership function parameter adjustment is called adaptive neuro-fuzzy inference system (anfis). Using a given input/output data set, the toolbox function anfis constructs a fuzzy inference system whose membership function parameters are tuned (adjusted) using either a back propagation algorithm alone or in combination with a least squares type of method. This adjustment allows fuzzy systems to learn from the data they are modeling. Fuzzy controllers are appropriate here because they are very robust, easily modified, capable of taking multiple inputs, simple, and very quick to implement. The first primary GUI tool can be used to construct a FIS for the decision process (inputs and output) described in the next sections.

4.5.6.4 FIRST STEP: CONSTRUCTION OF AN FIS EDITOR

The FIS Editor displays information about an FIS. Figure 4.28 displays this editor. The names of each input variable are on the top left and the output variable on the top right. Below the diagram is the name of the system and the type of inference used. The present research used the default Mamdani-type inference. Mamdani's principle takes the input values and finds where their sets intersect. At the bottom right is the area that displays the name of an input or output variable, its associated membership function type, and its range. Figure 4.25 presents six inputs and one output.

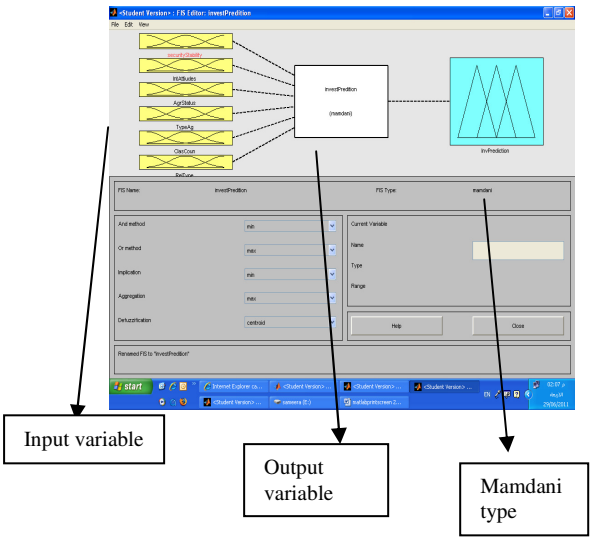

Figure 4.25: FIS editor

To start building the FIS, a user would type the command "fuzzy" in the MATLAB prompt. The generic untitled FIS Editor opens with one input labeled input 1 and one output labeled output 1. Cognitive theory presented by Alshayji et al. (2011b) indicates that several variables affect the political decision of whether to strengthen bilateral economic relations with friendly nations. Therefore, it is necessary to examine the most important variables. For example, some countries would view political stability as the most important. However, priorities and concerns vary from country to country. This model used thirteen variables, fifteen inputs, and one output. The following factors (inputs) are based on an interpretation of recent regional and international events: security, political stability, threat of terrorism, threat of nuclear weapons, threat of provocation, loans, financial aid, regional attitudes, international attitudes, support for peace in the Middle East, status of agreement, type of agreement, country classification, and relation type (Alshayji et al. 2011a, Alshayji et al. 2011b, Alshayji et al. 2011c, Alshayji et al. 2011d, Alshayji et al. 2011e). The output was set to investment promotion. As mentioned in section 3.2, the most important variables (inputs) that drive and head the compass of the political

decision (output) were selected based on the experience of advisers in the political domain, based on the result of the interviews and the result of the distributed questionnaire. The next section will discuss each of these variables.

4.5.6.5 IDENTIFY VARIABLES

In this section, the different used variables are identified. As following the fifteen different variables:

F1-Security: All countries are unique. Their security might be high, moderate, or weak. Security is determined by whether the country suffers from sectarian pluralism. Security increases investment opportunities.

F2-Political Stability: Political stability, or the absence of frequent regime changes, strengthens bilateral relations, increases opportunities, and allows for the development of mutual trust between the two countries.

F3-Threat of Terrorism: The threat of terrorism threatens economic interests, reduces investment opportunities, undermines security, and diminishes one country's confidence in another.

F4-Threat of Nuclear Weapons: The threat of nuclear weapons undermines security, threatens capacity investment, and hinders the continuity of economic relations between the two countries.

F5-Threat of Provocation: The threat of provocation destabilizes mutual trust and undermines security, which leads the country to focus on security issues rather than issues of investment.

F6-Loan: Exchange of loans among nations contributes to the consolidation of bilateral relationships and trust and allows for investment opportunities between the two countries

F7-Financial Aid: Financial aid contributes to opportunities for investment, especially in infrastructure sectors, because countries that need financial assistance are often developing.

F8-Regional and International Attitudes: Positive regional and international attitudes between states encourage investment opportunities and overall cooperation.

F9-Support for Peace in the Middle East: Countries that strengthen security in the Middle East obtain more investment opportunities than countries that undermine security or stability there because lack of security in the Middle East affects oil interests and increases the influence of enemies in the region.

F10-Status of Agreement: Status of the Convention between the States is limited to support, withdraw support, or end the agreement. All conditions affect the index of investment promotion and thus the quality of economic relationships with the other country.

F11-Type of Agreement: Trade in oil and weapons promote investment more than the exchange of exhibitions and scholarships.

F12-Country Classification: Country classification has become customary. Countries are classified based on their political alliances, attitudes (positive or negative), and political beliefs.

F13-Relation Type: Relation type indicates the basis for the relationship between two countries: friendship, respect, investment, proximity, or religion. This basis's being strong and positive strengthens economic relationships between them.

Output-Indicator for Investment Promotion: This indicator helps the decision maker choose whether to limit or encourage investment with country X.

All countries are unique. To make decisions about how they interrelate, decision makers must identify and define the variables that are most important to the situation. Those who attempt to create a DSS through fuzzy cognitive mapping must do the same (Calais 2008).

A variable can change, passing into one of several phases. For example, a state could enjoy political stability for a long time but then suddenly destabilize. Therefore it was necessary to identify the different aspects of each variable. For example, the variable "security" could be poor, good, or very good. And, as mentioned, countries can change from stable to unstable. Rules must be written to account for these varying statuses. For example, country X might have one rule, while country Y has six. Country X might be stable, while country Y might have poor or good stability.

It is therefore imperative to examine most of variables, such as Security" and "PoliticalStability" to present their value in one form for each country separately. It is possible

to integrate all membership for each variable in each rule for each country separately to obtain the final result, which will help political decision makers decide whether to cut off or increase investment, end, or consolidate the bilateral economic relationship with this country.

The next section defines the membership functions associated with each variable.

4.5.6.6 SECOND STEP: CONSTRUCT THE MEMBERSHIP FUNCTION EDITOR

The Membership Function Editor is the tool that allows the user to display and edit all of the membership functions associated with all of the input and output variables for the entire FIS. In the political domain, it is unlikely to find a document with a precise definition of fuzzy value, but usually a linguistic qualifier can be found. For example, one would not find the following information in any document: "Country X has a relation with country Y with a value of 0.7." However, a document could say the following: "Country X has a good relation with country Y," "Country X has a very good relation with country Y," or "Country X has a very weak relation with country Y." A method to make use of this kind of information was needed, as was the ability to associate a numerical membership modifier to the many possible situations in the political domain.

The Membership Function Editor allowed for the selection of both the type of membership function and the number of membership functions associated with the selected variable. For example, the variable "security" includes poor, good, and very good (see table 4.15). In the lower right corner of the window are controls allowing users to change the name, type, and parameters (e.g., the shape) of the membership function after it is selected. These membership functions can be manipulated in two ways. Users can utilize the mouse to select a particular membership function associated with a given variable quality, such as "good" for the variable "security," and then drag the membership function from side-to-side. This action affects the mathematical description of the quality associated with that membership function for a given variable. The Membership Function Editor shares some features with the FIS Editor. In fact, all five basic GUI tools have similar menu options.

The computation of fuzzy values was presented in Calegari and Ciucci (2010) in different ways, where fuzzy values are assigned through the two functions g: f (Concept U Instance) x (Properties U Prop-Val) → (0,1) and h: Concepts U Instances → (0, 1). The most known are the min-max operators. Considering the previous function, it may necessary to compute the truth value of two different variables. For example, if one selects the variable "country

classification" and then selects a membership coalition country with regional or international attitudes leading to rejection and condemnation, the function will be as follows: "Coalition country" AND "Total rejection and condemnation." If it is known that f (Country, Coalition)=1 and f(Position, Total rejection and condemnation)=0.8, then (f (Country, Coalition) AND f(Country, Total rejection and condemnation))=min{1,0.8}=0.8 (Calegari and Ciucci 2010).

For instance, if one describes the relation between country X and country Y as "slightly good," where "slightly" is different from "good," one would need to change or use another modifier, raising or reducing the fuzzy membership of property to manage the result. A decision maker needs to devise approaches to determine a specific number for a specific pattern of relation that can help him or her support the decision made. This model used five primary GUI tools from MATLAB to build, edit, and monitor FISs in the political domain. In addition, it used fuzzy controllers because they are very robust, easily modified, capable of taking multiple inputs, simple, and very quick to implement for certain inputs. Memberships for certain inputs are presented in Tables 4.15 to 4.27.

Input 1 (security) has three values for its membership function: poor, good, and very good (see Table 4.15. The membership Function Editor allows us to display and edit the membership functions associated with the input and output variables as showed in figure 4. 26.

Table 4.15 Description of the membership function for the input "security"

Security (F1)	Membership degree
Poor	0
Good	0.5
Very good	0.7

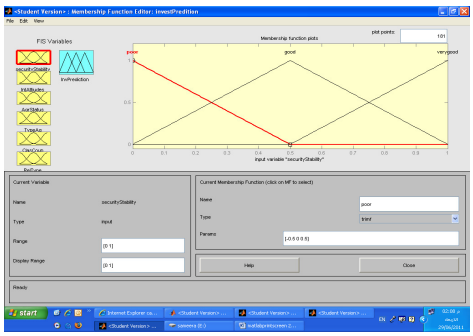

Figure 4.26: The Membership Function Editor presenting input 1, which includes three values for its membership function.

Input 2 (political stability) has three values for its membership function: poor, good, and very good (see Table 4.16), and the membership functions associated with the input and output variables (see Figure 4.27).

Table 4.16: Description of the membership function for the input "political stability"

Political stability (F2)	Membership degree
poor	0
Good	0.5
Very good	0.7

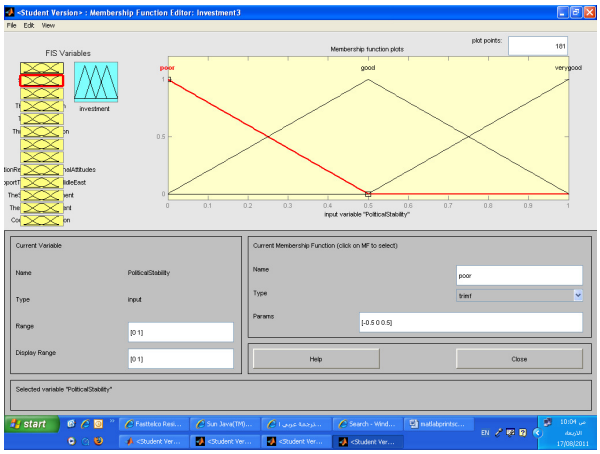

Figure 4.27: The Membership Function Editor presenting input 2, which includes three values for its membership function.

Input 3 (threat of terrorism) has three values for its membership function: low, medium, and high (see Table 4.17 and Figure 4.28).

Table 4.17: Description of the membership function for the input "threat of terrorism"

Threat of terrorism (F3)	Membership degree
Low	0
Medium	0.3
High	0.7

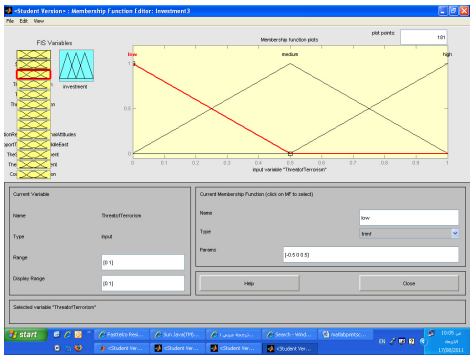

Figure 4.28: The Membership Function Editor presenting input 3, which includes three values for its membership function.

Input 4 (threat of nuclear weapons) has three values for its membership function: low, medium, and high (see Table 4.18).

Table 4.18: Description of the membership function for the input "threat of nuclear weapons"

Threat of nuclear weapons (F4)	Membership degree
Low	0
Medium	0.3
High	0.7

Input 5 (threat of provocation) has three values for its membership function: low, medium, and high (see Table 4.19).

Table 4.19: Description of the membership function for the input "threat of provocation"

Threat of provocation (F5)	Membership degree
Low	0
Medium	0.3
High	0.7

Input 6 (loans) has three values for its membership function: weak, medium, and strong (see Table 4.20).

Table 4.20: Description of the membership function for the input “loan”

Loans (F6)	Membership degree
Weak	0
Medium	0.3
Strong	0.7

Input 7 (financial aid) has three values for its membership function: weak, medium, and strong (see Table 4.21).

Table 4.21: Description of the membership function for the input “financial aid”

Financial aid (F7)	Membership degree
Weak	0.3
Medium	0.7
Strong	1

Input 8 (regional and international attitudes) has five values for its membership function that describe positions on some relevant issues of regional and international obligations towards the state: never, sometimes, usually positive, very much, and A strong (see Table 4.22 and Figure 4.29).

Table 4.22: Description of the membership function for the input “regional and international attitudes”

Regional and international attitudes (F8)	Membership degree
Never	0
Sometimes	0.5
Usually positive	0.7
Very much	0.9
A strong	1

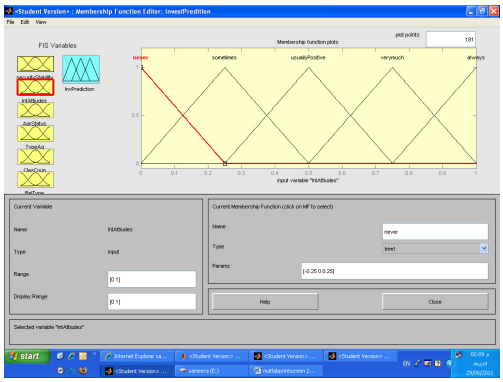

Figure 4.29: The Membership Function Editor presenting input 8, which includes five values for its membership function.

Input 9 (support for peace in the Middle East) has three values for its membership function: not much, usually positive, and strong (see Table 4.23).

Table 4.23: Description of the membership function for the input "support for peace in the Middle East"

Support for Peace (F9)	Membership degree
Not much	0.4
Usually positive	0.7
Strong	1

Input 10 "status of agreement" is very important, as it describes whether if the agreement is old and needs to renewed, the agreement is effective as it is, and so on. It has four values for its membership function: ineffective, not renewed, supported, effective (see Table 4.24 and Figure 4.30).

Table 4.24: Description of the membership function for the input "status of agreement"

Status of agreement (F10)	Membership degree
Ineffective	0
Not renewed	0.4
Supported	0.7
Effective	1

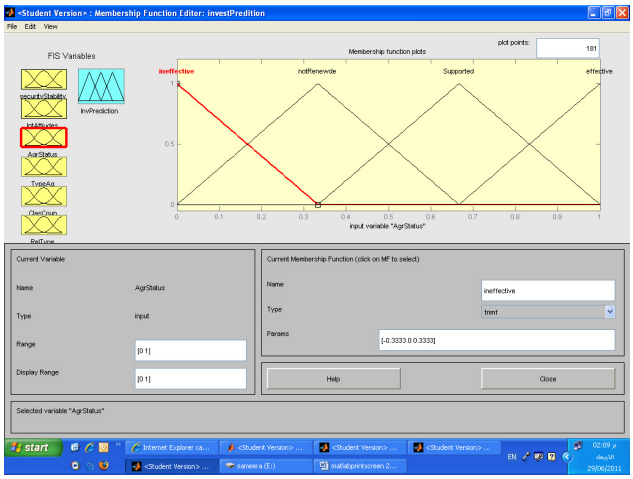

Figure 4.30: The Membership Function Editor presenting input 10, which includes four values for its membership function.

Input 11, "type of agreement," indicates the strength of the agreement based on its type (e.g., petroleum-based=excellent and culture=weak). It has six values for its membership function: weak, good, very good, strong, very strong, and excellent (see Table 4.25 and Figure 4.31).

Table 4.25: Description of the membership function for the input "type of agreement"

Type of agreement (F11)	Membership degree
Weak	0.2
Good	0.5
Very good	0.7
Strong	0.8
Very strong	0.9
Excellent	1

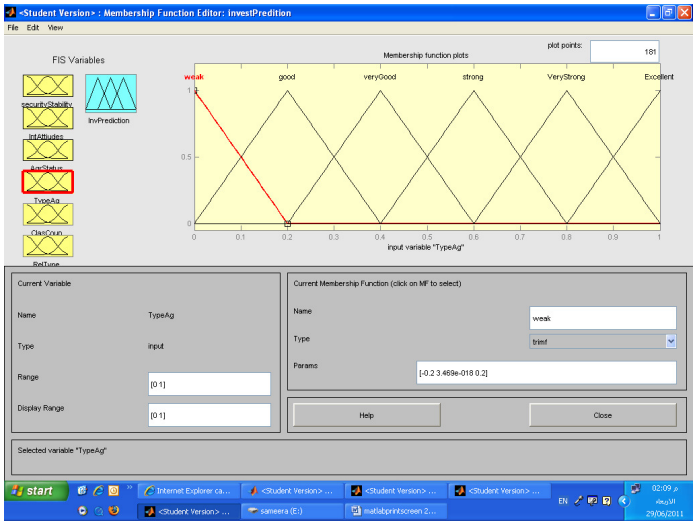

Figure 4.31: The Membership Function Editor presenting input 11, which includes six values for its membership function.

Input 12, “country classification,” indicates whether the state is a coalition or crisis country and is based on several criteria. For example, states in crisis are those that have recently suffered from environmental crises, while coalition countries are those that have positive attitudes for (solidarity with) the other country. This division of nations contributes to the success of the investment. It has eight values for its membership function: crisis country, sectarian, Arab country, EU country, voted positively in UN, GCC country, investment country, and coalition countries (see Table 4.26 and Figure 4.32).

Table 4.26: Description of the membership function for the input “country classification”

Country Classification (F12)	Membership degree
Crisis country	0.1
Sectarian	0.2
Arab country	0.4
EU country	0.6
Voted positively in UN	0.7
GCC country	0.8
Investment country	0.9
Coalition	1

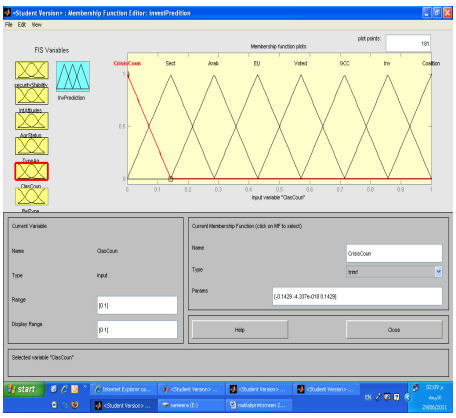

Figure 4.32: The Membership Function Editor presenting input 12, which includes eight values for its membership function.

Input 13, “relation type,” indicates the current bilateral relation between country X and country Y. This relation can be described in a variety of ways. For example, country X has a weak relation with country Y or country X has an investment relation with country Y, and so on. It

has nine values for its membership function: weak, respect, culture, religion, neighbor, friend, history, investment relation, and strong (see Table 4.27 and Figure 4.33).

Table 4.27: Description of the membership function for the input “relation type”

Relation type (F13)	Membership degree
Weak	0.1
Respect	0.2
Culture	0.3
Religion	0.4
Neighbor	0.5
Friend	0.6
History	0.7
Investment relation	0.8
Strong	0.9

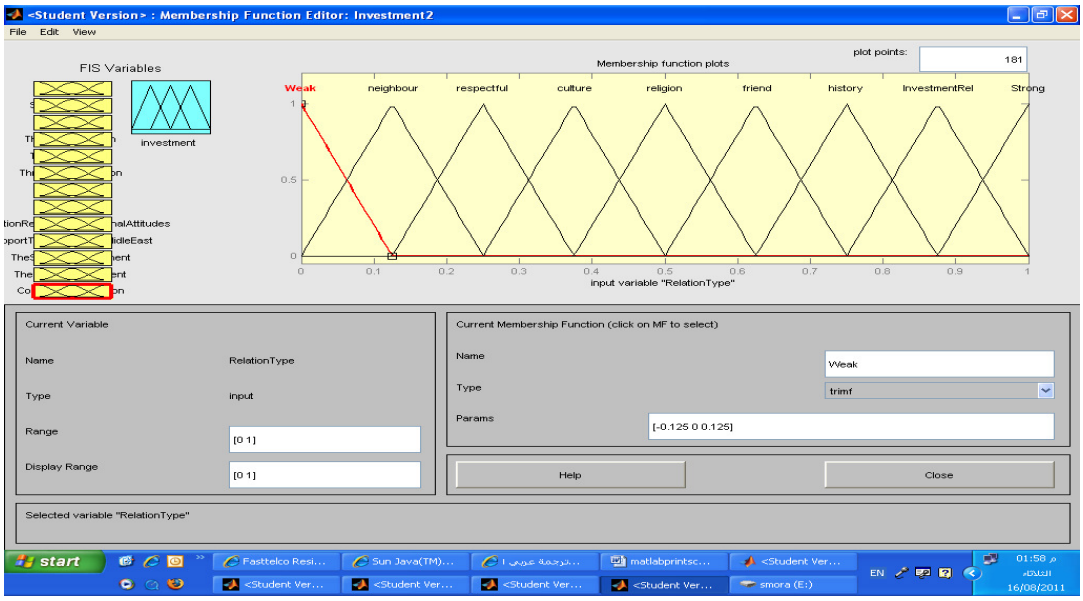

Figure 4.33: The Membership Function Editor presenting input 13, which includes nine values for its membership function.

The output, “indicator for investment,” helps the decision maker in the decision-making process, indicating whether investment should be limited or encouraged. It has seven values for its membership function: never, cut, limit, caution, not encourage, encourage, opportunity (see Table 4.28 and Figure 4.34).

Table 4.28: Indicators that can help decision makers make investment decisions

Indicators for Investment-output	Membership degree
Never	0
Cut	0.1
Limit	0.2
Caution	0.4
Not encourage	0.5
Encourage	0.6
Opportunity	1

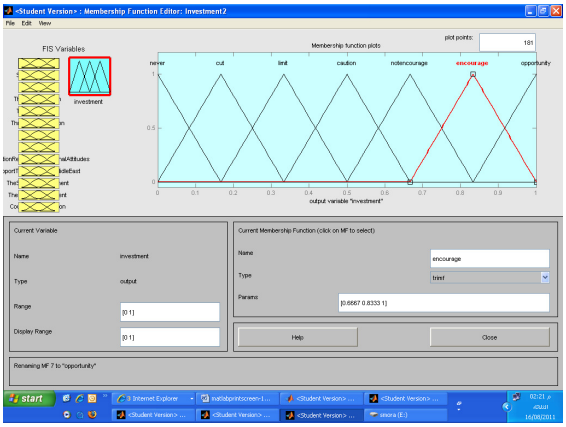

Figure 4.34: The Membership Function Editor presenting the output, which includes nine values for its membership function.

The type of the memberships for all variables is a triangular built-in membership function (trimf). The triangular curve is a function of a vector x and depends on three scalar parameters a, b, and c, as given by

F(x, a, b, c)= 0, x <= a

x-a/b-a, a<=x<=b

c-x/c-b, b<=x<=c

0 c<=x

Or more compactly, by f(x, a, b, c) = max{min(x-a/b-a, c-x/c-b),0}.

After naming all the variables and providing the membership functions with appropriate shapes and names, it is necessary to enter the rules. To call the Rule Editor, users can type “ruleedit” on the command line or select edit and then rules.

4.5.6.7 THIRD STEP: CONSTRUCT THE RULES-RULE EDITOR

Constructing rules using the graphical Rule Editor interface is fairly self-evident. Based on the input and output variables defined with the FIS Editor, the Rule Editor allows users to construct the rule statements automatically from the GUI. Users can do the following:

1 Create rules by selecting an item in the input and output variable box and select a connection item; choose none as one of the variable qualities to exclude that variable from a given rule; and/or choose not under any variable name to negate the associated quality;

2 Delete any rule;

3 Edit a rule by changing the selection in the variable box (that is, by clicking change rule);

4 Specify a weight for a rule by inputting a desired number between 0 and 1 in weight (MATLAB assigns the value 1 for any qualities without weights).

Similar to the FIS Editor and Membership Function Editor, the Rule Editor has a menu bar and a status line. The menu items allow users to open, close, save, and edit a fuzzy system using the five basic GUI tools. From the menu, users can also set the format for the display by selecting option> format and set the language by selecting option> language. For example to insert the first rule in the Rule Editor, select the following:

- “Poor” under the variable “Security”
- “Poor” under the variable “PoliticalStability”
- The “and” radio button in the connection block
- “Never” under the output variable “investment”

Then click add rule (See Figure 4.38).

The resulting rules are as follows:

1) if (Security is poor) and (PoliticalStability is poor) then (investment is never) (1)

The numbers in the parentheses represent weights. As stated previously, states may pass through several phases of political stability, so it is possible to add more than one rule for one country. The rules can explain the country's status in terms of political stability, bilateral relationship level, bilateral agreement strength, threat of nuclear weapons, whether the country is a coalition country or in crisis, and so on.

Users can follow a similar procedure to insert the rest of the rules. Suppose that for country X, several variables are important. Users can add different membership types and values derived from these variables. It is possible to select any kind of variable for each country and add an unlimited number of rules using the Rule Editor. For example, country X contains eight rules (including step one above):

1. if (Security is good) and (PoliticalStability is medium) and (ThreatOfTerrorism is medium) then (investment is cut) (1)

2. if (Security is good) and (PoliticalStability is medium) and (StatusOfAgreement is ineffective) and (TypeOfAgreement is weak) then (investment is limit) (1)

3. if (Security is verygood) and (PoliticalStability is medium) and (StatusOfAgreement is ineffective) and (TypeOfAgreement is verygood) and (CountryClassification is CoalitionNation) and (RelationType is friend) then (investment is Encourage) (1)

4. if (Security is verygood) and (PoliticalStability is medium) and (ThreatofTerrorism is medium) and (StatusOfAgreement is Supported) and (TypeOfAgreement is verygood) and (CountryClassification is InvestmentNation) and (RelationType is history) then (investment is StrongEncourage) (1)

5. if (Security is verygood) and (PoliticalStability is medium) and (ThreatOfTerrorism is high) or (ThreatOfNuclearWeapons is high) or (ThreatOfProvocation is high) or (Type ofAgreement is good) or (CountryClassification is ArabNation) then (investment is limit) (1)

6. if (Security is verygood) or (ThreatOfTerrorism is high) or (Country Classification is sectarian then (investment is limit) (1)

7. if (Security is poor) or (TypeOfAgreement is verygood) then (investment is limit) (1)

Figure 4.35 presents all these rules in verbose form.

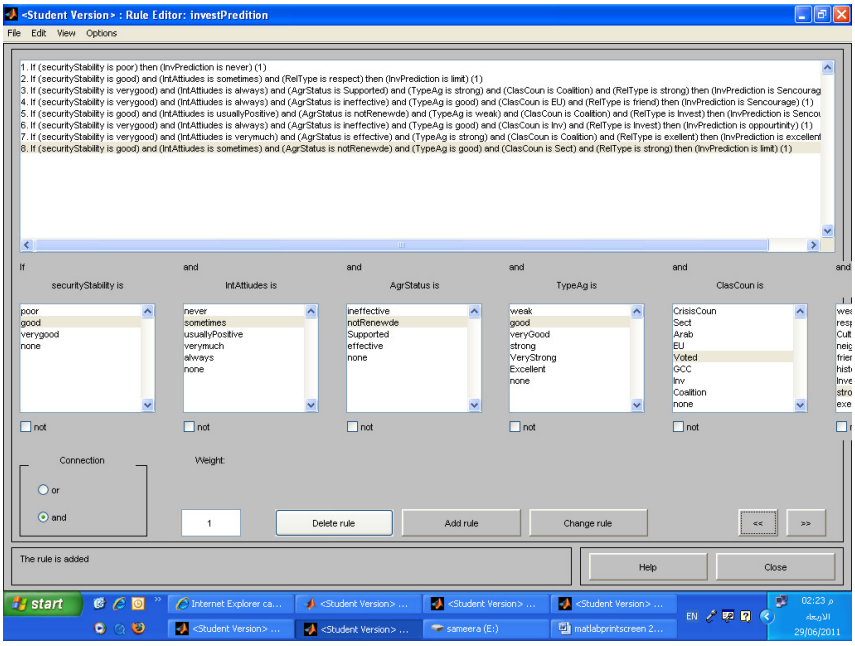

Figure 4.35: Rules in the Rule Editor in verbose form.

The above rules are in the verbose form. They can be transformed into symbolic form as follows:

(Security == poor) | (PoliticalStability == poor) => (investment = never) (1)

The symbolic form is slightly more language-neutral because it does not depend on terms like *if* and *then*. Also, the user can change the format to index; this would result in an extremely compressed version of the rules in a matrix where the number of rows is the number of rules and the number of columns is the number of variables:

(Rules)

1 1 0 0 0 0 0 0 0 0 0 0 3, 1 (1): 1

2 2 2 0 0 0 0 0 0 0 0 0 3, 3 (1): 1

2 2 3 0 0 0 0 0 0 0 0 0 3, 2 (1): 1

2 2 1 2 2 0 0 0 0 0 0 0 3, 2 (1): 1

2 2 0 0 0 0 0 2 1 0 0 0 3, 4 (1): 1

2 2 0 0 0 0 0 2 1 4 5 0 3, 6 (1): 1

2 2 3 3 3 0 0 2 1 3 3 0 3, 3 (1): 2

2 2 3 3 3 2 1 2 1 3 2 0 3, 4 (1): 2

The version of the rules used per the machine is as follow:

- The first thirteen columns in the structure correspond to the input variables.
- The next column (column 14) corresponds to the number of the value for the membership function for the output variable. For example, in the first row of column 14 is a 3, which represents the third value {limit} from the membership function: {never, cut, limit, caution, not encourage, encourage, opportunity}.
- Column 15 displays the weight applied to each rule.
- Using such functions in the political domain provides the opportunity to choose a membership value with infinite accuracy, at least to explain the strength and weaknesses of an expression. For example, to describe bilateral relations between countries, the user can add two or more different fuzzy value (OR, AND) operators. Thus, column 16 is shorthand, indicating whether this is an OR(2) rule or an AND(1) rule.

Reading across the first row, a literal interpretation of rule 1 is “input 1 is MF1 (the first value for the membership function associated with input 1). This means that from the first input (security) I selected {poor}, the value for the membership function associated with input 1: {poor, good, very good}. Continuing across, MF1 from input 2 was selected, and so on. This model excluded all the inputs with a zero value from a given rule. Row 1 column 14 then indicates that output 1 should be MF1 {never} and possesses a weight of 1.

The symbolic format does not consider the terms *if*, *then*, and so on. The indexed format does not even bother with variable names. Obviously the functionality of this system does not depend on how well the operator named the variables and membership functions. The whole point of naming variables descriptively is, as A, to make the system easier to interpret. It is probably easier to continue with the verbose format. As this point, the FIS has been completely defined: the variables, the membership functions, and the rules necessary to calculate the investment indicator.

4.5.6.8 RULES VIEWER

Rules viewer allows users to view details about the FIS to help them to diagnose the behavior of specific rules or study the effect of changing input variables. The next step, then is to use the Rule Viewer to display a roadmap of the whole fuzzy inference process (see Figure 4.36). These results are based on the fuzzy inference diagram described in the Fuzzy Editor section.

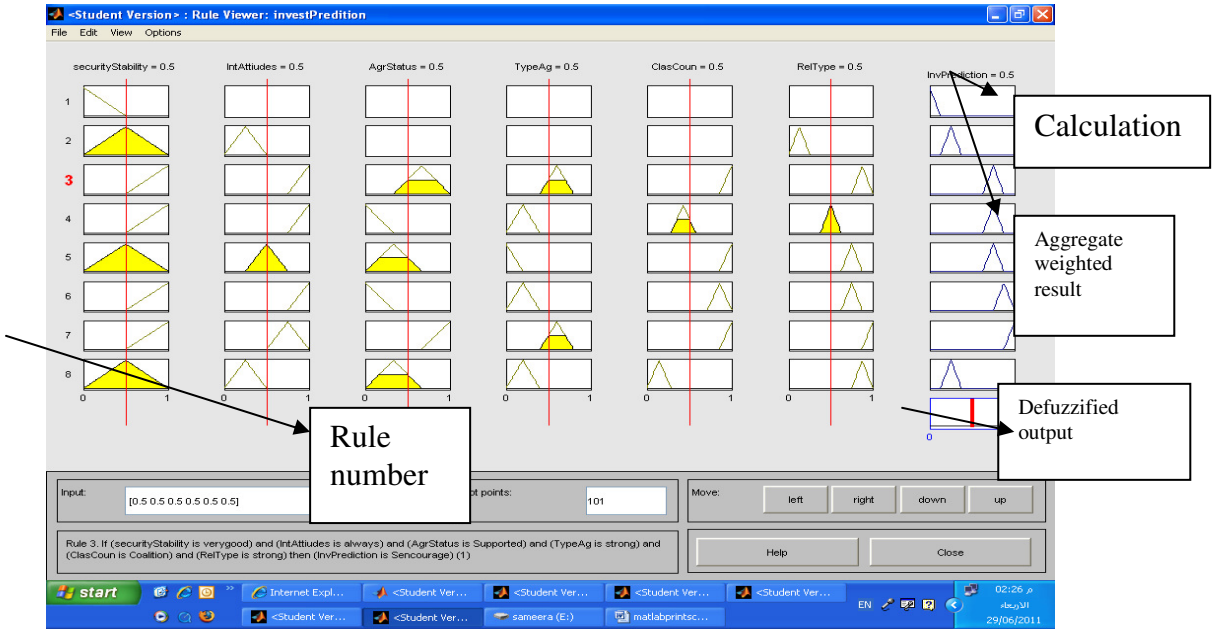

Figure 4.36: Fuzzy inference diagram containing eight rules.

There are 57 plots nested in Figure 4.36. The seven plots across the top of the figure in the first row represent the antecedent and the consequent of the first rule, the seven plots across in the second row represent the antecedent and the consequent of the second rule, and so on. Each rule is a row of plots, and each column is a variable. The rule numbers are displayed on the left of each row. The user can click on a rule number to view the rule in the status line.

- The first six columns of plots show the membership functions referenced by the antecedent, or the if-part of each rule.

- The last column of plots shows the membership function referenced by the consequent, or the then-part of each rule.

- The eighth plot in the seventh column of plots represents the aggregate weighted decision for the given inference system.

The decision will depend on the input values for the system. The defuzzified output is displayed as a bold vertical line on this plot.

- The variable and their current values are displayed at the top of the columns.

- In the lower left is a text field input in which the user can enter specific input values. The user can also adjust these input values by clicking on any of plots for each input and moving the red line horizontally to the point he or she has clicked. Alternatively, the user can click and drag this line to change the input values. When the user releases the line, a new calculation is performed, and the user can see the whole fuzzy inference process take place:

    - Where the index line representing “Security” crosses the membership function line “Security is poor” in the upper left plot determines the degree to which rule one is activated.

Each characterization for each variable is specified with respect to the input index line in this manner. Following rule one across the top of the diagram, the consequent “investment is never” has been truncated to exactly the same degree as the (composite) antecedent: This is the implication process in action. The aggregation occurs down the fifth column, and the resultant plot is shown in the single plot appearing in the lower right corner of the plot field. The defuzzified output value is represented by the thick line passing through the aggregation fuzzy set.

4.5.6.9 FOURTH STEP: DEFUZZIFY THE RESULT

Now it is necessary to determine what to do with the results from the rules and the fuzzy sets. The user creates rules to find the corresponding output rule. The rule is then cut off by the alpha

cut, giving us several trapezoidal shapes. These shapes are added together to find their total center.

4.6 APPLY THE FUZZY ONTOLOGY TO THE SPECIFIC DOMAIN.

4.6.1 TEST 1

Suppose there is country Y with five different rules:

* if (Security is good) and (PoliticalStability is medium) and (ThreatOfTerrorism is medium) then (investment is cut) (1)

* if (Security is good) and (PoliticalStability is medium) and (StatusOfAgreement is ineffective) and (TypeOfAgreement is weak) then (investment is limit) (1)

* if (Security is verygood) and (PoliticalStability is medium) and (StatusOfAgreement is ineffective) and (TypeOfAgreement is verygood) and (CountryClassification is CoalitionNation) and (RelationType is friend) then (investment is Encourage) (1)

* if (Security is verygood) and (PoliticalStability is medium) and (ThreatofTerrorism is medium) and (StatusOfAgreement is Supported) and (TypeOfAgreement is verygood) and (CountryClassification is InvestmentNation) and (RelationType is history) then (investment is StrongEncourage) (1)

* if (Security is verygood) and (PoliticalStability is medium) and (ThreatOfTerrorism is high) or (ThreatOfNuclearWeapons is high) or (ThreatOfProvocation is high) or (Type ofAgreement is good) or (CountryClassification is ArabNation) then (investment is limit) (1)

The above rules can be transformed in verbose forms.(see Figures 4.37 and 4.38).

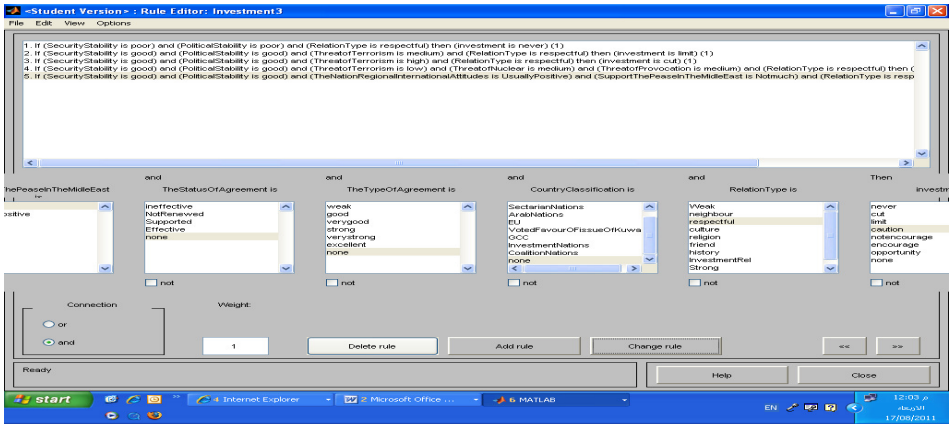

Figure 4.37: Five rules in the Rules Editor, with rules in the verbose form.

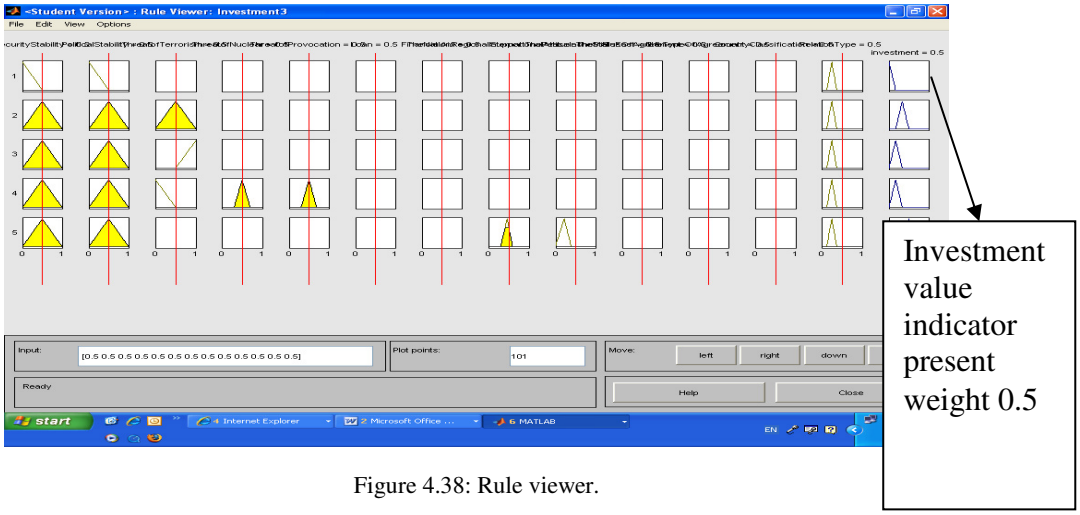

Figure 4.38: Rule viewer.

The system will recalculate the membership and present a new result based on the rules that have been selected. This will generate a compressed version of the rules:

(Rules)

1 1 0 0 0 0 0 0 0 0 0 0 3, 1 (1): 1

2 2 2 0 0 0 0 0 0 0 0 0 3, 3 (1): 1

2 2 3 0 0 0 0 0 0 0 0 0 3, 2 (1): 1

2 2 1 2 2 0 0 0 0 0 0 0 3, 2 (1): 1

3 3 0 0 0 0 0 3 3 4 5 8 3, 7 (1): 1

These rules form a different matrix based on the selection of variables and membership values.

Now one can easily adjust the variables. For example, the user could add three more based on the status of each country and the decision maker's vision to help him get different results (see Figure 4.39).

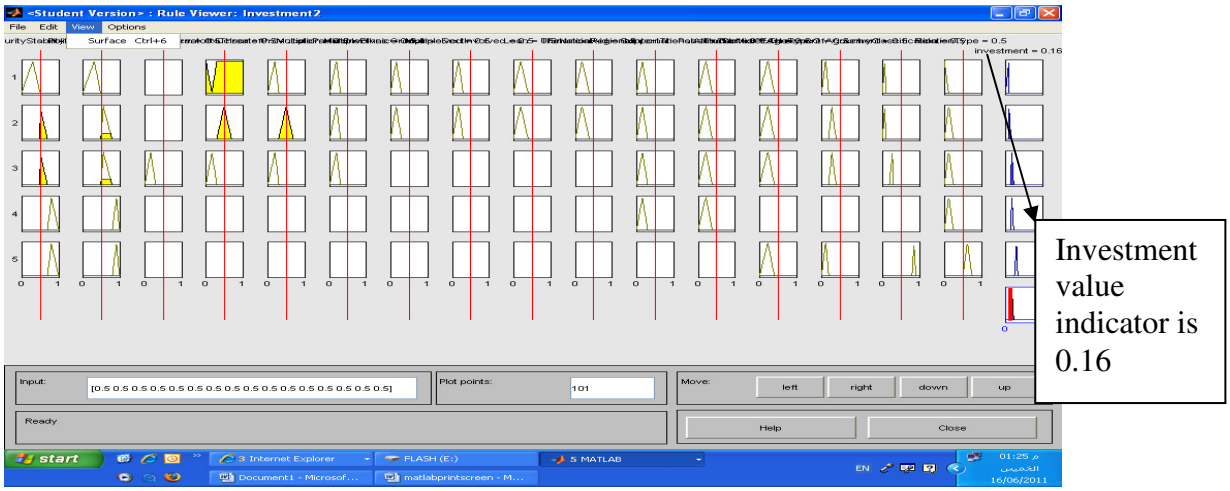

Figure 4.39: Rule Viewer showing a different result for the investment indicator output.

4.6.2 TEST 2

Decision makers in some countries are interested in identifying variables and rules specific to the country in question, so more work has been done to demonstrate the use of two inputs, "security" and "threat of terrorism," as well as the output investment indicator, membership function editor allow us to display and edit the membership function associated with the input and output variables (see Figure 4.40).

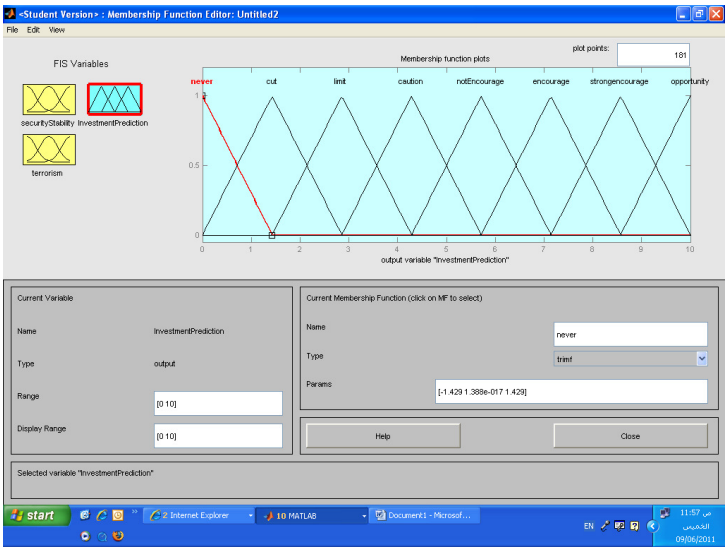

Figure 4.40: Two inputs (security and threat of terrorism) and one output (investment).

This is an addition of just three rules. The result is illustrated in Figure 4.44. The FIS has been completely defined and the rules calculated. The three plots across the top of the figure represent the antecedent and consequent of the first rule. Each rule is represented by an arrow of plots. The rule numbers are displayed on the left of each rule. The aggregation occurs down the third column, and the resultant aggregate plot is shown in the single plot appearing in the lower right corner of the plot field. The defuzzified output value is represented by the thick line passing through the aggregate fuzzy set (See figure 4.41). This is an example of an aggregation operation included in a fuzzy inference system to get an overall ranking of an alternative.

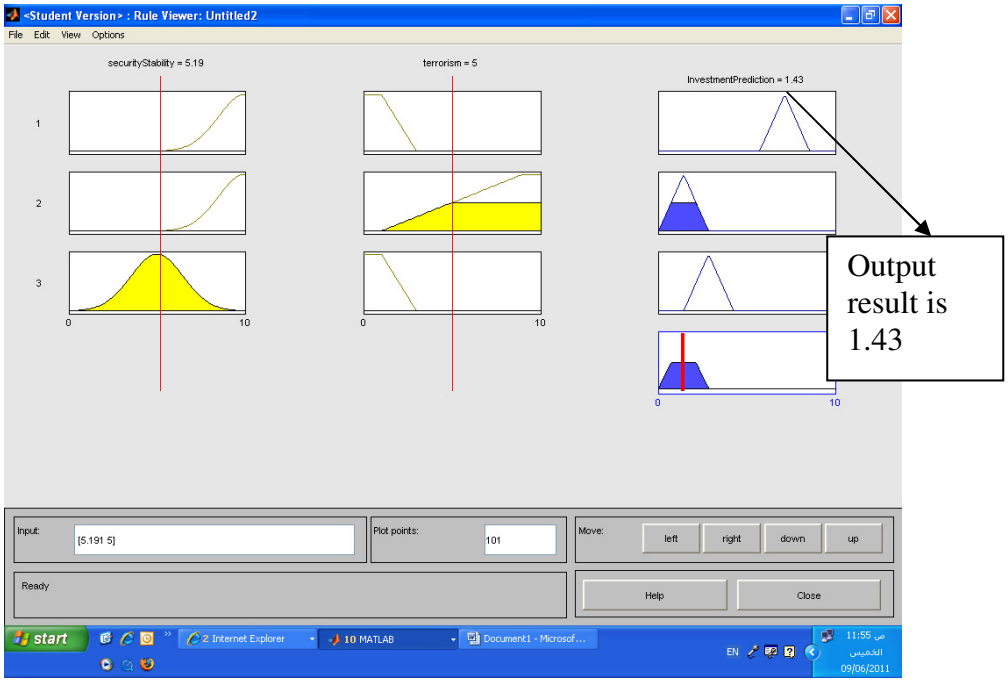

Figure 4.41: Aggregation of three rules, six plots, two inputs (security and threat of terrorism), and the result (investment=1.43).

Here the rules are modified using the same number of variables and adding one more rule (see Figure 4.42).

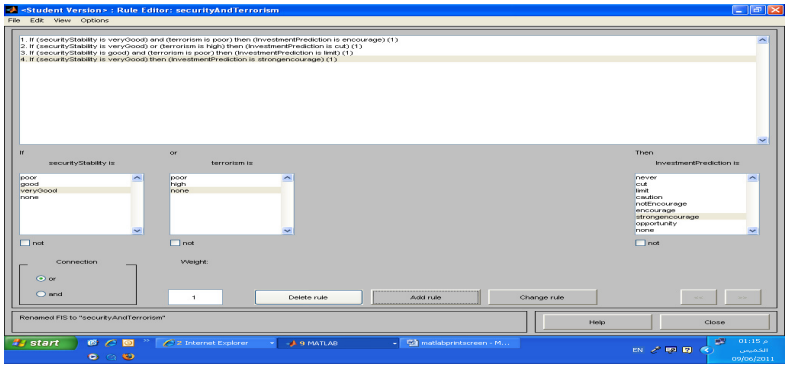

Figure 4.42: Editing the rules using the same two inputs and one output.

When the user edits the rules and adds one more, the rules and results are recalculated (see Figure 4.43). The Rule Viewer again displays a roadmap of the whole fuzzy inference process based on the fuzzy inference diagram. The three plots across the top of the figure represent the antecedents and consequent of the first rule. The rule numbers are displayed on the left of each rule. The aggregation occurs down the third column, and the resultant aggregate plot is shown in the single plot appearing in the lower right corner of the plot field. The defuzzified output value is represented by the thick line passing through the aggregate fuzzy set (see Figure 4.43).

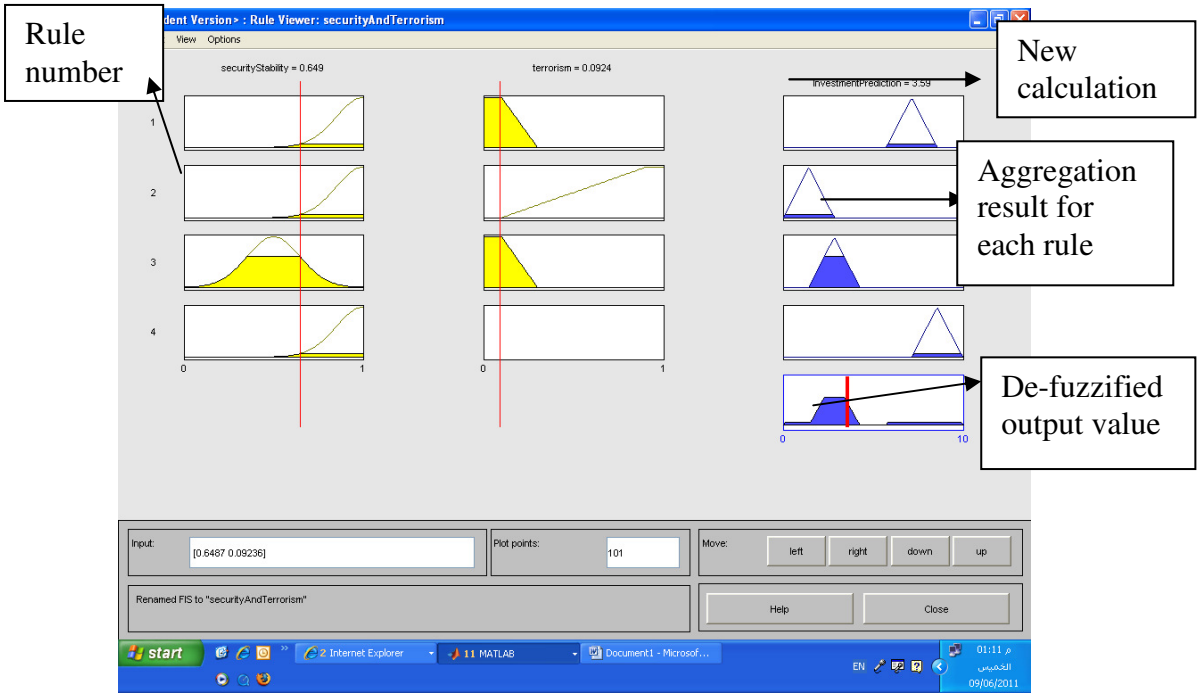

Figure 4.43: New calculation after editing the rules.

Opening the Surface Viewer reveals a 3D curve that represents the mapping from security and threat of terrorism to investment output. Accordingly, the Surface Viewer is equipped with

drop-down menus, x (input), y (input), and z (output), that let the user select any two inputs and any one output for plotting. Below these menus are two input fields (x grids and y grids) that let the user specify how many x-axis and y-axis grid lines to include. To create a smoother plot, one can use the plot point field to specify the number of points on which the membership functions are evaluated in the input or output range. By default, the value of this field is 101 (see Figures 4.44 and 4.45). Clicking evaluate initiates the calculation, and the plot is generated after the calculation is completed. To change the x-axis or y-axis grid after the surface is in view, the user can change the appropriate input field and press enter. The surface plot is updated to reflect the new grid settings.

4.6.3 SURFACE VIEWER

The Surface Viewer has a special capability that is very helpful in the case of two (or more) inputs and one output: the user can grab the axes using the mouse and reposition them to get a different 3D view of the data. If the user has a four input one output system and would like to see the output surface, the Surface Viewer can generate a 3D output surface where any two of the inputs vary. Two of the inputs must be held constant because computer monitors cannot display a five-dimensional shape.

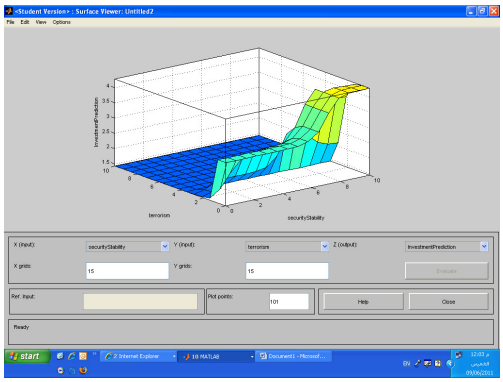

Figure 4.44: Connection between two variables and the impact on output (investment)

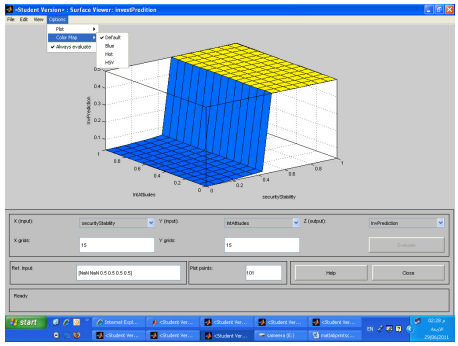

Figure 4.45: Surface viewer using fuzzy inference.

4.7 EVALUATION

As mentioned before, different interviews with decision makers in the political domain have been done to be able to identify the different variables that should be taken into consideration when making a decision. Also different questionnaire have been distributed to different person working in the domain in order to specify the importance of making available such ontology that will help them making decision in different fuzzy situation.

The questionnaire has been distributed to a sample of 31professionals from various political and Investment Institutions of Kuwait, as follows: political Domain (PD), consultant in Kuwait Embassies (CON), Kuwait for Development Domain (KFD), and Ministry for Foreign Affairs (MFA). The ranges of their ages were between 17 and 30. The *scale* was devised as a broad measure of evaluating political and economic investment, security and political stability, etc.

Each item was presented in four incremental levels, numbered from 0 to 3. Item number one is as follows:

1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly Agree.

The response alternative was 5-point Liker format, from 1 “Strongly Disagree” to 5”Strongly Agree”. The higher score indicated a high degree of importance.

Alpha reliability of the 33 item scale was .94.

This sample comprised 3 subgroups as follows: PD+CON (*n*=12), KFD (*n*=9), MFA (*n*=10). The result of our study is mentioned in table1 and table2.

Table 1: Mean (M) and standard deviations (SD) of the scales by Investment

	PD+CON		KFD		MFA		F	df	p
	M	*SD*	*M*	*SD*	*M*	*SD*			
Scale Name	137.2	17.66	110.6	12.81	110.70	8.22	13.50	2	.000

Table 2: Scheffe multiple comparisons test.

Variable	Group 1	Group 2	Mean Difference (1-2)	*p*
Scale	PD+CON	KFD	26.50	.001
		MFA	26.46	.001

Note: PD = Political domain; CON = Consultant
KFD= Kuwait Fund for Development; MFA=Ministry for Foreign Affairs

Chapter five

CONCLUSIONS AND FUTURE WORK

5.1 CONCLUSION

This study introduced a novel system that applies fuzzy ontology to a new specific domain of political and economic relations through enhancement of existing ontological structures. It proposed a fuzzy ontology approach and discussed how to conduct this approach in five important government bureaus in Kuwait: the Kuwait Fund for Development, the Kuwait Investment Authority, the Ministry of Foreign Affairs, Office of the Prime Minister and the office of the top political decision-maker. The ontology includes information about important concepts in each domain. To build this ontology, it is very important to understand how these five agencies present their concepts. Using two different methods (such as OP and OWL) of ontology that assist in the presentation of the ontology for each concept. The aim of conducting the fuzzy ontology approach is to provide an insight into how knowledge can be represented and handled to support the decision-maker with help from the intelligent DSS processes.

However, important decisions to make investments in another country depend on large amounts of information gathered from heterogeneous data, for instance, increasing the bilateral economic relationships of a country with other countries can be accomplished by increasing and strengthening the types of bilateral relationships, strengthening the quality of bilateral agreements, and so on.

Applying fuzzy ontology to the investment domain by assigning degree to different concepts contributed to significant contributions in understanding more about political variables that affect the promotion of economic bilateral relations with friendly nations. Developing a system based on implementing a fuzzy ontology in the investment and political domains enables the

decision-maker to formulate intelligent political and economic decisions for strengthening the bilateral economic relations that will produce good returns on investment.

Object paradigm ontology (OP) with respect to important concepts provides a high level of knowledge and facilitates the work of decision makers in the political field. Ontology that uses the Protégé-OWL editor allows for the capture of more details, achieving a more natural description of that concept. In addition, Protégé-OWL helps describe the relationships between the concepts in different domains. The use of different ontology's, such as Object paradigm and the Protégé-OWL ontology contribute to understanding how different bureaus present their concepts.

The application of Fuzzy Cognitive Map theory is effective in the presentation of the variables and their effects because it demonstrates the interrelationships of variables that political decision makers must take into account when deciding whether to support or not support the strengthen bilateral relationships between friendly nations.

The use of MATLAB contributed in a wonderful and charming process to create variables, membership functions, and rules (in the political domain), and then alter the rules to vary the results (in a way, brainstorming). For example, at one point, it was possible to add two more rules to the bottom of the list, thereby changing the shape of the overall output without needing to undo what had already been done. In these ways, MATLAB makes modifications to the DSS (based on commonsense statements) relatively easy. Moreover, using logic rules, the maintenance of the structure of the algorithm decouples along fairly clean lines.

The decision of whether to strengthen bilateral economic relations with friendly nations might change from day to day and vary from city to city or country to country, but the logic underlying some of the variables is the same; e.g., if the country in question has poor security, the investment should be reconsidered. The use of fuzzy logic allows for the language that is clearest to humans (natural language) and provides the opportunity to add high-level comments. What is amazing is that the language also has meaning for machines, which is why fuzzy logic is a very successful technique for bridging the gap between people and machines. The FIS (fuzzy inference system) is a model that maps input characteristics to input membership functions, input membership functions to rules, rules to a set of output characteristics, a set of output characteristics to output membership functions, and output membership functions to a single-valued output or a decision associated with that output.

5.2 CONTRIBUTION

This thesis presents a new fuzzy inference system from scratch, and applies this inference system to the political domain to help the political decision maker to strengthen bilateral economic relationships with other countries. The fuzzy inference system contributes to understanding the context, angles, and perspectives that are important to understand the impact of political variables in strengthening bilateral economic relationships. The proposed technique efficiently utilizes algorithms to access, integrate, and manage political and investment information at the international level. The presentation of different concepts enables the reader to understand the domain and encourages the researcher and the reader to explain the concept in any available way.

Using object paradigm ontology and Protégé-OWL methods in to create an ontology contributed to understanding the domain as well as the relation between objects, classes, and so on; it also contributed to simplifying the concept and making it very clear, and contributed significantly by extracting the main variables that affect the political decision process in strengthening the economic bilateral relationships with nations. Also, these applications help save time for the researcher instead when searching to find a suitable way and method to dismantle and analyze the linguistic concepts. These approaches assisted the researcher to understand how to how to present the concept and facilitate implementation. The presentation of integration of fuzzy logic with ontology in political and investment domains enhances the clarity of the natural concepts in such domains and encourages us to shed light on other, more difficult domains like parliament, social fields that influence political decision, and political sites from the Internet. The presentation of multiple cases in different domains and multiple illustrative cases proposed in *this thesis* facilitate the way for the researcher to understand vague concepts and provide him the confidence to reach any domain.

Utilizing fuzzy logic based on natural language contributed to the understanding of the linguistic and imprecise data existing in the political area, extracting the most important variables. The research in virtually dismantling political variables is very rare. However, the defuzzified output that has been done improves the success of using fuzzy logic, which lies in its ability to handle imprecise (natural, vague) data. Really fuzzy logic is perfectly suited for this situation.

The utilization of the fuzzy cognitive mapping (FCM) scheme provides insight and better understanding about the interdependencies of political variables (vague data). Furthermore, FCM is particularly applicable in the soft-knowledge domains such as political science. There is no doubt that imprecise factors and their effects on each other contribute to shaping the political decision-making process. Utilizing FCM contributed encourages the researcher to discuss in following research the variables that exist in the Kuwaiti parliament, as it is an integral part of the political field.

In the field of artificial intelligence, neuro-fuzzy refers to combinations of artificial neural networks and fuzzy logic. Neuro-fuzzy system (the more popular terms is used henceforth) incorporates the human-like reasoning style of fuzzy systems through the use of fuzzy sets and a linguistic model consisting of a set of if-then fuzzy rules. The use of fuzzy expert systems in *t* which builds a fuzzy inference system (FIS) is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computing. FIS contributed significant effectiveness because it allows different flexible vital applications. The confidentiality of its success lies in the ease of use by the end user and by the operator. In addition, its success lies in the secret of the calculations that automate dealing with imprecise language and vague information.

Fuzzy expert systems have also been designed to weigh the consequences (rule conclusions) of certain choices based on vague information. For example, the nature of Kuwaiti-Iraqi bilateral relations and the history of progressing through different levels has been painful in the past, is useless in the recent past, and quite unfortunate in reality (Alshayji et al. 2011c). Now we are able to weigh the consequences (rule conclusions) of certain choices based on vague information, such as the type of relationship, while the current manual system is unable and does not allow constructing the rule statements automatically. However, we were able to pursue those variables by constructing rules using the graphical Rule Editor.

The interface is self-evident. The fuzzy logic Toolbox software that used in this thesis does not limit the number of inputs, which allows a decision maker to add unlimited variables. Based on the descriptions of the input and output variables defined with the FIS Editor, the Rule Editor allows to construct the rule statements automatically. We achieved a significant advantage by applying the FIS Editor, the FIS Editor handles the high-level issues for the system.

Now a top political decision-maker will be able to:

1. Develop a proper system that analyzes the data gathered from different sectors and produces precise and certain outputs that could be useful to decision makers;

2. Develop prototype architecture for intelligent decision support system that can help top political decision makers by dealing with heterogeneous factors based on a linguistic concept whose values are words rather than numbers and therefore closer to human intuition;

3. Introduce a novel ontology approach in integration of unstructured information;

4. Build a fuzzy inference system (FIS) for the political domain;

5. Link to several linguistic variables in a different sequence or simultaneously in line with the synchronization input with fast adjustments;

6. Achieve collaboration by generating ontology between different domains in government sectors by extracting knowledge from various data sources to understand the complexity involved in making decisions and how building ontology can be helpful and beneficial for decision makers;

7. Acquire the ability to understand the language of political variables that are scattered in political documents and develop the ability to analyze and understand their impact on the political decision-making process to enhance decisions;

8. Develop the ability to analyze the linguistic political variables to different levels of parameters and the ability to dismantle them according to the needs of decision makers;

9. Develop the ability to get rule conclusions which are consequences of unlimited rules;

10. Develop the ability to define the shapes of all the membership functions associated with each variable, and the ability to edit the list of rules that define the system's behavior;

11. Achieve a technical computing environment-based display of the fuzzy inference diagram;

12. Decrease the risk management to direct state investments;

13. Create a system that can calculate linguistic variables rapidly and present graphic displays that are impossible to create manually;

14. Construct a fuzzy inference system that can help political decision makers whose membership function parameters are tuned (adjusted) using either a back propagation algorithm alone or in combination with a least squares method; Humans cannot construct a manual inference system;

15. Present graphics in a political domain that include high-level functions for 2D and 3D data visualization, image processing, and graphics presentation;

16. Access to rapid digital results that cannot be calculated manually;

17. Predict the knowledge to determine the direction of the economic compass;

18. Achieve speed in creating short programs for use in large, complex applications;

5.3 FUTURE WORK

Different techniques to demonstrate some of political factors and their impact on the political field itself and the impact of political factors on the social side have been proposed in this thesis. In the future the information from the Internet must also be taken into account. In the political domain, it's difficult to make decision and specify rules that should be applied in all cases. In fact, the decision maker should make his decision based on non defined elements and fuzzy information. This information sometimes is not available in the same domain, because there are different relationships between the political domain and other different domains. Different anthologies for different domains that allow those fuzzy situations should be built and should have relationships between each others to make the accurate information available when needed. The most important task in the future is to test the ontology designed in different real-world use-cases. Several implementation details should be finalized in order to make those tests. Also an interface should be created to provide an easy access to the data in the system and some controls should be added.

In addition, I can engage the sense of community represented by the people by understanding parliamentary input. Since the parliament represents the people, understanding the input of parliament can help the political decision-maker understand and guide the future vision for the country. Achieving understanding between the legislative

and executive branches will contribute to the stability and security of the country and region, and enable the people to live in prosperity.

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