University of East London

Towards a sustainable and efficient Integrated Dry Ports Network (IDPN): Mashreq countries as a case study

By

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ABSTRACT

The Mashreq countries such as Syria, Lebanon, Jordan and Iraq are facing significant risk of losing their geographical locations as a main transit corridor in Middle East. This is because of the emerging new alternative transit corridors that were raised and developed in the neighboring areas because of the unsettled political situation in the Mashreq region. Nonetheless, although the weak infrastructure connections between Mashreq countries and the fragile legislation environment, it cannot be left unsaid that the major reason behind these lost opportunities on transport and trade is an inefficient operation of the transport corridors network in the Mashreq region due to the lack of logistical services and projects at seaports.

Although all Mashreq governments revealed Dryports as inevitable solution to optimize the distribution of maritime containers and reduce congestion level at seaports, the coordination at the level of decision-makers to improve transport corridors and their operations was completely ignored. This research argues that Mashreq countries should act as one integrated body to save their role as the main transit corridor in the region. They should coordinate at their decision-making level, in terms of establishing an integrated dry-ports network system. The limitations in previous network design models in addressing the communication between decision-makers in different countries had led to the introduction of a number of potential locations within one regional integrated network to bring in an opportunity to develop a new network design model. This can offer a flexible and standard platform that helps make a mutual decision that is not necessarily the optimum for each stakeholder, but it will be satisfied by every end-user.

This Thesis is aimed at demonstrating the feasibility of applying an ontological approach to develop a new model to evaluate dry port location decision within a case study of Integrated Dry Ports Network (IDPN) in Mashreq countries. This proposed IDPN model helps to determine the best regional scenario of integrated dry ports network that adequately link the Mashreq countries transport corridors together, as well as the extensions of these corridors with its Mediterranean neighborhood transport corridors.

An Integrated Dry Port Network (IDPN) model provides a sustainable allocation for the expected increase in container traffic at the region. (IDPN) is a comprehensive network design model based ontological approach to help evaluate dry port locations. It will adequately serve more than one seaport in two different countries. Furthermore, this research defined the role that Mashreq governments could play to facilitate the container allocation among their borders and beyond to enhance transportation corridors in the region.

An ontological approach is proposed because ontologies improve communication and re-use of knowledge by providing a shared understanding that reduces ambiguities and misunderstanding in the terminology adopted in a certain domain. They also support the engineering process of transport solutions by providing a basis for automated specification, analysis, and consistency in checking for alternatives.

First a source Ontology is designated in terms of container movement requirements within a regional hinterland, which depends on stakeholder objectives. Container Movement Route Ontology (CMRO) describes container movement routes for intermodal freight distribution within regional hinterland network. It is a semantic-based representation of transport activities within regional network. It's based on the presence of dry ports in a transportation system to formally define all available scenarios of containers routes which the decision makers should be aware of.

Qualitative and quantitative data were collected to essentially compare between two scenarios of container traffic distribution (a national (vs) regional), where operating strategies have been considered for both existing and planned dry ports interactions with two major containers seaports in the Mashreq region. These are the Latakia seaport in Syria and the Beirut seaport in Lebanon.

Finally, Minimum Cost Flow Mathematical model, was used to validate the developed ontological scenarios. The computational results obtained satisfied the proposed ontological model aimed to reduce transport cost and maintain a maximum flow.

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Abbreviations

AL	Arab League
CMRO	Container Movement Route Ontology
CMR	Container Move Requirements
ESCWA	Economic and Social Committee for Western Asia
EIB	European Investment Bank
HLP	Hub Location Problem
ISMF	Institutional and Sector Modernization Facility
ITU	Intermodal Transport Unit
FAO	Food and Agriculture Organization
MCs	Mashreq Countries
MCF	Minimum Cost Flow Assignment
N.O.S	National Operation Strategy
R.O.S	Regional Operation strategy
TEU	Twenty Equivalent unit
STK	Stakeholders
W.B	World Bank
UIC	International Railways Association

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This work is dedicated in the loving memory of my dad’s soul:
(Al-Shaheed: Badea Mohammad Tarsisi).

Chapter 1

Research Description

1.1 Introduction

The concept of dry ports is a relatively new concept and in its infant stage in Mashreq countries (MCs) namely, Syria, Lebanon, Iraq, and Jordan (Figure 1.1). Mashreq governments who are aware of the significance of dry ports and their benefits have introduced extensive reforms at a multitude of levels to improve the transport systems in their countries. Such reforms aim to establish new dry ports or reactivate the existing ones. In this context, Mashreq countries have improved their policies and regulatory frameworks, and modernized investments in infrastructure. This, in turn, has encouraged the private stakeholders to increase their involvement and take portions of commercial risks of dry ports operation. In addition, the safety, security and environmental aspects of transport have been greatly improved. Furthermore, a substantial portion of the transport infrastructure that is needed is already in place, with plans for future expansion and development.

However, despite many aspects of similarity between Mashreq countries, in terms of seaports productivity, sharing the same maritime Mediterranean coast, as well as short distances between their borders, each country has developed a specific national policy containing a number of candidate dry port locations to meet the expected container volumes individually. The coordination at decision making levels in MCs was ignored. Therefore, a competitive environment between operation policies of Mashreq seaports at a regional level will be generated instead of developing a regional integrated transport operation. However, the difference in opinion at decision makers level will lead to extremely disputed interests at Mashreq region.

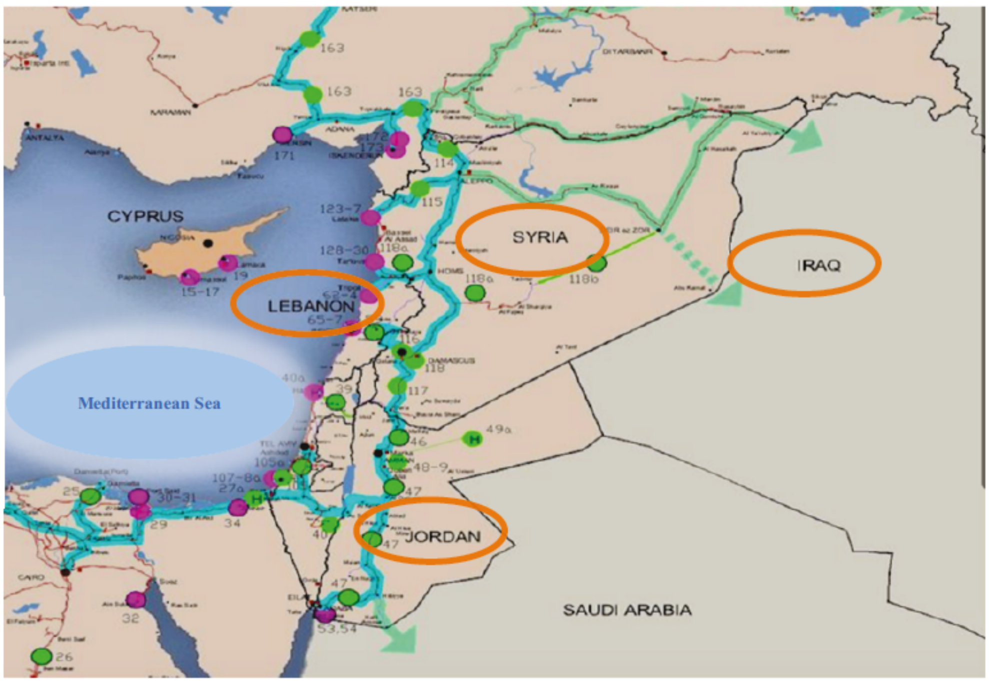


Figure 1.1 Mashreq countries.

(Source: Google maps search, Access on 2015)

The World Bank has indicated in its' study (Regional Cross- Border Trade Facilitation and Infrastructure Study for Mashreq Countries 2011) that the continuous growth in container volumes will be doubled in the Mashreq region in the next 5-8 years, particularly between 2016-2019. On other hand, the lack of storage space capacity in (MCs) seaport yards brings forth extreme operational problems such as congestion as well as higher operational costs. This also creates a major bottleneck from/to seaport land access, which all together influences the performance level of container terminal operation at seaports and strongly suggests the necessary of forwarding the container volumes into the seaports' hinterland.

However, even though each Mashreq country has steered a number of new legislations and significant management procedures at national level to increase the container handling capacity to meet the expected increase in containers traffic, the paucity of seaport yards prevents Mashreq seaports from attaining maximum capacities.

Consequently, moving container traffic and the relevant activities towards a surrounding seaport's hinterland, namely to inland terminals (Dry Port), has been revealed as an unavoidable solution in all Mashreq governments to optimize maritime containers distribution. It is also an efficient way to reduce congestion level at seaports as well as encourage intermodal transport, which in its turn will lead to an efficient operation of (MCs) transport corridors network from a logistic integration solutions point of view.

Nonetheless, Mashreq countries have had only a few opportunities to unify their dry ports projects into one integrated network, such a Euro-Mediterranean Transport project/EU (2007-2013) & (2014-2020) which is believed to be the right platform to build an integrated network of dry ports (Logistics Platforms), as well as several initiatives of ESCWA via a number of regional legislatives and operation policies. These aimed to enhance and facilitate integrated transport operations in the Mashreq region, but the coordination to build such integrated network that can adequately provide a sustainable allocation for the expected increase in container traffic at the region was not seriously discussed until now.

This research aims to develop a sustainable and an efficient Integrated Dry Ports Network (IDPN) that can adequately link the Mashreq countries transport corridors together, as well as the extensions of these corridors with its Mediterranean Neighborhood Transport corridors. This main goal will be presented by developing a model that helps to determine the best regional scenario of integrated dry ports network from an intermodal distribution perspective.

1.2 Research Background

According to (UN-ESCWA 2011) Mashreq countries are considered a main transit corridor due to its geographical location which is allocated along the eastern coast of the Mediterranean Sea. It is also classified as a dry channel to the Arabic and Gulf region, in the Middle East and beyond (Figure 1.2). These countries are facing significant risk of losing their geographical locations because of emerging new alternative transit corridors that have been raised and developed in the neighbouring areas because of the unsettled political situation in Mashreq region (FAO, 2016). Accordingly, the alternative transit corridors will lead to an unavoidable loss of opportunities concerning transport and trade in Mashreq countries' economic levels, unless they rise up and act as an integrated transport system to be able to compete and join the global and regional trade patterns. However, it cannot be left unsaid that the major reason behind losing opportunities on transport and trade is an inefficient operation of the transport corridors network in the Mashreq region due to the lack of logistical service projects at seaports hinterland (World Bank, 2011).

Figure 1.2 Priority Road Transport Corridors in Arab Mashreq

(M40) East-West & (M45) North-South.

(Source: "Impact of Transportation Networks on Trade and Tourism" UN-ESCWA 2011)

On the other hand, the container traffic in the Mashreq region's six seaports (Latakia, Tartous, Beirut, Tripoli, Aqaba, and Um Qasr) have experienced strong growth in the last decade (W.B 2011). Mashreq seaports containers traffic has tripled from approximately

(750000-2,250000) TEU/Twenty Equivalent Unit/ between (2000-2008), with less than one million TEU for each seaport per year (World Bank study 2011).

In this context, the Syrian port of Latakia had the largest growth average with (14.5%) per year followed by Aqaba seaport in Jordan with (13.4%), and Beirut seaport in Lebanon has achieved 9%, while in the case of Tartous Syrian port which has focused on bulk cargo and Iraqi Um Qasr seaport handling a military and project related cargo, both have experienced a fluctuated rate with a small portion of growth among Mashreq ports.

Consequently, to meet the expected increase in container traffic, the Mashreq region needs an efficient operation of transport corridors network between their territories in order to join global and regional trade patterns and not lose overseas container traffic volumes. Therefore, the development of an integrated dry ports network in the Mashreq region is considered as a high priority (ISMF/EU 2008 – World Bank 2011).

In recent years, many efforts at national and regional levels have been taken, in order to enhance the integrated operation of (MCs) transport corridors network especially in terms of stimulating those countries, to establish new dry ports or expand the existing ones.

Organizations such as the Arab League & United Nation Economic and Social commission for Western Asia (UN/ESCWA) have triggered several initiatives to facilitate the movements of passengers and goods between the Mashreq countries corridors. These are based on international standards for both regulation and operation levels. These initiatives aim to harmonize the increasing efforts steered by national government.

1.3 Research Importance:

As per the above-mentioned demonstration, the author believes that to obtain an efficient transport corridors network in the region of Mashreq countries they have to act as one integrated body and coordinate at their decision-making levels in terms of establishing an integrated dry ports network system. By doing so, they will be able to join global and regional trade patterns and not lose overseas container traffic volumes.

Mashreq countries have a location decision problem at the strategic level for network design of container traffic in Mashreq's seaports hinterland. This problem belongs to the network hub location problem (HLP) and deals with the location of hub facilities (dry ports) and the allocation of containers traffic. Thereafter, the strategic objectives should determine the resulting network structure namely number, location, size, function and connection between hubs.

Finally, the existing literature highlights that there are some limitations in addressing the communication between main stakeholders in different countries to introduce a number of potential locations within one regional integrated network. These limitations bring in an opportunity for the research to develop a new decision-making model which can offer a flexible and standard platform that helps make a mutual decision that is not necessarily the optimum for each stakeholder, but it will be satisfied by every end-user.

The following (Table 1.1) and (Figure 1.3) illustrate pre- selected dry ports (existing - planned) and Mediterranean seaport in the Mashreq region, in addition to the main transportation network connection between them:

Table 1.1 Existing and planned dry ports in Mashreq region

Countries	Number of Existing dry port	Number of Planned/understudied dry port	Railway connection	Mediterranean Sea port
Syria	2	4	Connected to Jordan – Lebanon-Iraq	- Latakia Port - Tartous port
Lebanon	0	4 options (under study)	Connected to Syria only	- Beirut port - Tripoli port
Jordan	0	(ongoing feasibility study)	Connected to Syria only and plan to connect Iraq	0*
Iraq	1	1 Under construction	Connected to Syria only and plan to connect Jordan	0**

*Aqaba port in Jordan is on Red Sea. **Um Qasr port in Iraq is on Shatt Alarab waterway.

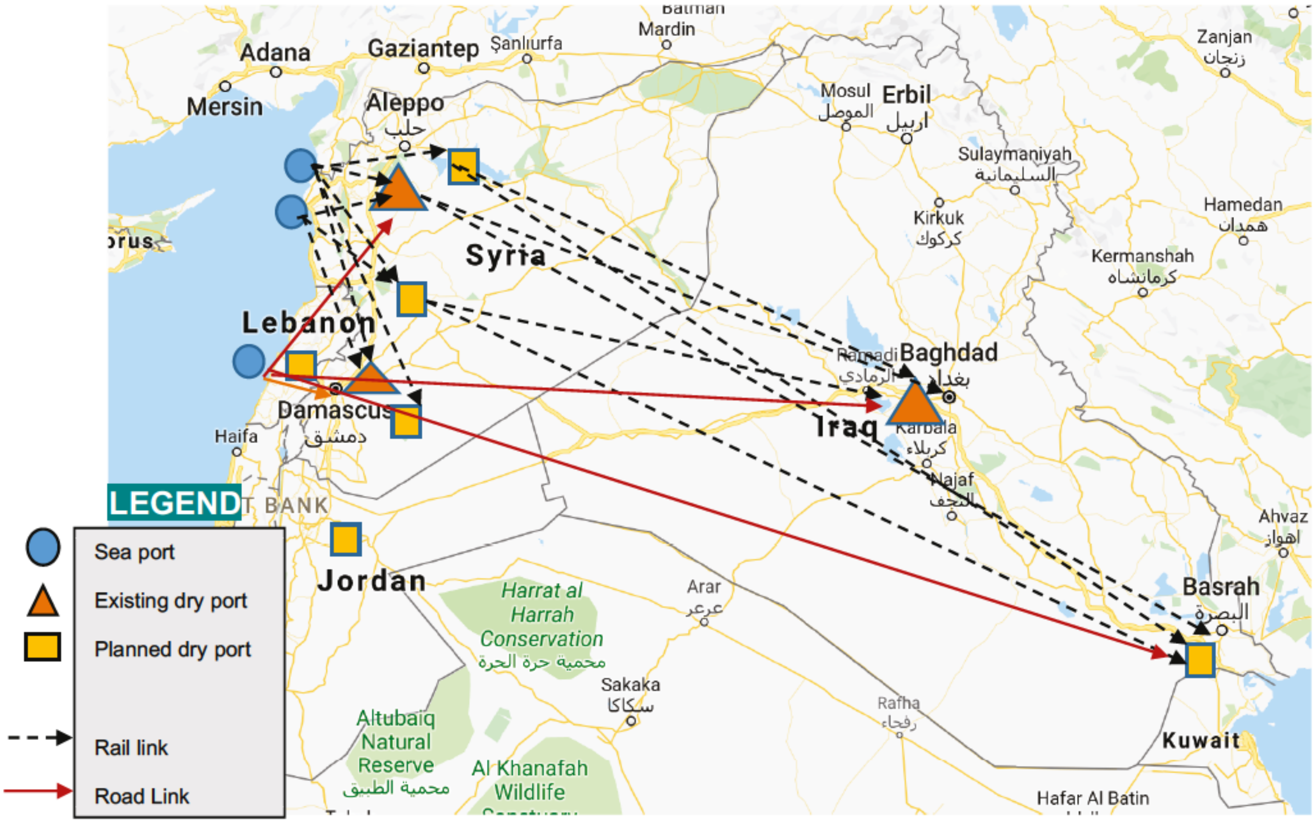


Figure 1.3 Conceptual Integrated Dry Ports Network in the Mashreq Region.

1.4 Research Aim and Objectives

The aim of the research study is to develop a comprehensive model to evaluate dry port location decision within a sustainable and an integrated Dry Port Network (IDPN) in Mashreq countries. Furthermore, this project aims to link the Mashreq countries transport corridors together, as well as the extensions of these corridors with its Mediterranean neighborhood transport corridors.

The expected model will evaluate dry port location decision by investigating the impact of dry port location on containers distribution within a sustainable and an integrated Dry Ports Network (IDPN) that can adequately provide a sustainable allocation for container traffic in the regional hinterland of seaports in Mashreq countries. Furthermore, this thesis aims to define the role that Mashreq governments could be played to facilitate the containers allocation among their borders and beyond to enhance transportation corridors in the Mashreq region.

An ontological approach is believed to have several strong features that address the limitations of existing evaluation models for dry port location decision. To achieve the aim of this research project, this study will focus on the following objectives:

Research Objectives:

1. Study and analyze the current situation of Mashreq countries in terms of dry port location decision and main influencing factors of dry port location implementation from a multi-objective point of view.
2. Demonstrate the feasibility of applying an ontological approach to evaluate the dry port location decision.
3. Develop a new model to evaluate dry port location decision within a case study of Integrated Dry Ports Network (IDPN) in Mashreq countries.

In general, an implementation of the result of this research will most likely lead to a growth in trade commerce and it is expected to generate benefits from the investment in Mashreq the region geographical location as a transit dry channel. In addition, the proposed (IDPN) will contribute to the establishment of an efficient, safe and secure intermodal transport system in the region.

1.5 Contribution to Knowledge:

- This is the first study, to the best of the researcher's knowledge, to critically investigate the importance of a dry ports network in Mashreq countries.
- This is the first study to strategically bridge the transport corridors between the Mashreq region and its Mediterranean neighbourhood.
- This research is the first to Introduce an Integrated Dry Ports Networks for Mashreq countries.
- Developed and introduced a comprehensive model to evaluate dry port location decision within a sustainable and an integrated Dry Port Network (IDPN) in Mashreq countries.

1.6 Layout of the research

This thesis consists of seven chapters. The scope of this thesis is aligned with network hub locations design based on an ontological approach. The basic reason that enthused and induced my research interest is the fact that Mashreq countries are being threatened by losing their geographical location as a transit hub in Middle East region because of an emerging and new alternative transit hub in the Mashreq region neighborhood that would have a serious negative impact on these countries role in terms of transport networks formulation as well as benefits from the development of global and regional trade patterns (ISMF 2008). Although the weak infrastructure connections between Mashreq countries and fragile legislations environment, it cannot be left unsaid that the major reason behind these lost opportunities on transport and trade is an inefficient transport networks operation process (World Bank 2011).

It is believed that the continuous growth in the number of containers at seaports are due to changes in maritime vessel sizes as globalization and maritime evolve. Likewise, the paucity of spaces at seaport yards drives extreme operation problems such as congestion as well as higher operation costs. In turn, these create major bottleneck from/to seaport land access which all together influence the efficiency of the container terminal operation and distribution process at the seaport hinterland and contribute to a loss in massive numbers of transport volumes and flow.

Chapter 1 Provides a brief overview about the research background comprised of the dry port concept in Mashreq countries and key initiatives to develop this new concept in the region. The dry port characteristics, in terms of variety at the decision- maker level leading to highly controversial interests in the Mashreq region, are highlighted. This chapter also presents the objectives and contribution to be fulfilled at the completion of this research.

Chapter 2 presents a wide range of previous studies in network dry port location problems models in the literature review including the up-to-date significant finds in designing network dry port locations. At the end of this chapter, the knowledge gap is reported.

Chapter 3 describes the methodology that applies to this thesis. In this chapter, the model formulation is addressed step-by-step. The research methodology for developing a network design model-based ontological approach is presented. An ontological approach is believed to have strong features fills in the gap of knowledge in the existing dry port location evaluation models.

Chapter 4 demonstrates the task of developing and designing source ontology that describes dry port presence in the energetic hinterland of container seaports. Two key steps of the designing process is explained. First, in conceptualization steps, by using Resource Description Framework (RDF) language, the main concepts (super classes-subclasses) and their properties based on container movement requirement has been developed. Second, in formulation step, where we use the open source software Protégé 5 to model (CMR) ontology concepts and object properties that describe the scenarios of network structure based on a number of strategic objectives properties such as location, size, function and connection.

Chapter 5 in this chapter, the current situation of Mashreq countries has been studied and analyzed in terms of dry port location decision and main influencing factors of dry port location implementation from a multi-objective point of view. “Mashreq Ontology” is built up as a case specific ontology using Protégé 5.

Chapter 6 in this chapter a minimum cost flow assignment is applied by using excel solver. For validation purposes, the minimum cost glow assignment is believed to address the links that provide lowest transportation cost and maximum flows between seaport and candidate dry port locations. Precisely, in the regional hinterland of main container ports in the Mashreq region namely Latakia seaport in Syria and Beirut seaport in Lebanon.

Chapter 7 provides the summary of the conclusion derived from the present research, along with some recommendations and future work.

Chapter 2

LITERATURE REVIEW

2. Literature Review

2.1 Dry port concept

The phenomenon of dry ports (inland intermodal terminal) has attracted many researchers to search and develop the concept of moving seaport activities towards its hinterland network. A variety of dry port concept definitions were emerged pertaining to its characteristics in terms of the connectivity with seaport, location, functions and services. However, among the earliest definitions of dry port concepts the UNCTAD handbook on the Management and Operation addressed it as the following: “A common user facility with public authority status, equipped with fixed installations and offering services for handling and temporary storages of any kind of goods (including containers) carried under customs transit by any applicable mode of transport, placed under customs control and with customs and other agencies competent to clear goods for home use, warehousing, temporary admissions, re-export, temporary storage for onward transit and outright export.” Geneva (1991).

Furthermore, Rose et al (2009) addressed the dry port concept definition as “A dry port is an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport”. (p. 341). However, their definition was based on earlier research on the terminal facilities using the dry port notion (Leveque and Roso 2002). In addition, they stated in their article that such a concept becomes the subject of discussion due to the stretching of the containerization trade and to the serious need of reducing the congestion of goods and containers in the seaports yards.

Rose et al (2009) also discussed three kinds of dry port locations (Close- Midrange- Distant location) that were identified in terms of their geographical location. However, the increased congestion of road haulage on seaport access from/to surrounding areas as well as the critical need for efficient infrastructure that serves these growths in transport volumes, drives main stakeholders to prefer the close dry port location option as a main destination of their goods.

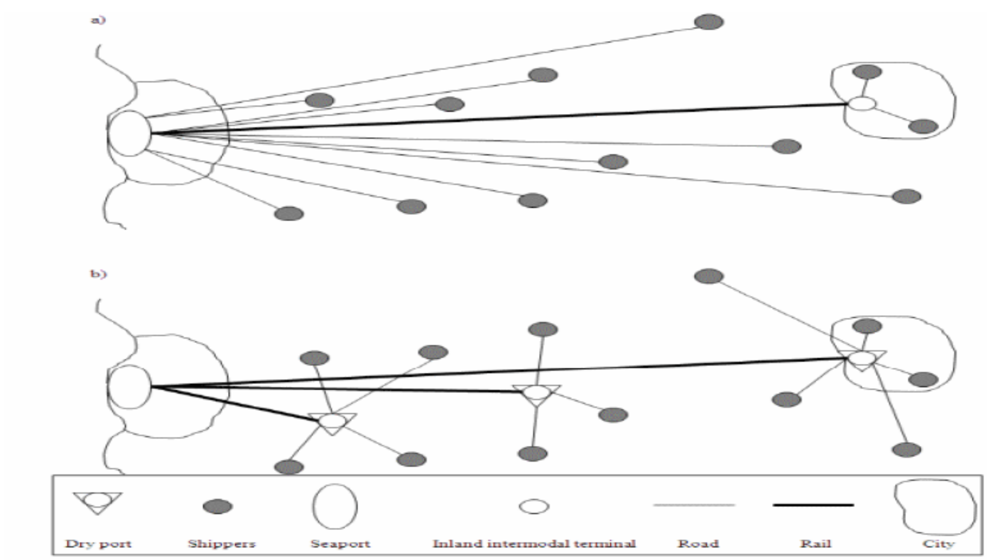


Figure 2.1 Comparison between conventional intermodal terminal and dry port concept. (Source: Roso et al. 2009)

The study resulted to the fact that stakeholders were totally convinced of the ease and flexibility of solving any emergency problems that may occur in their goods (Origin - Destination) journey in case of a close location. In addition, the significance of shifting transport volumes from road to rail transport mode, in terms of economic and environmental aspects, was strongly evidenced.

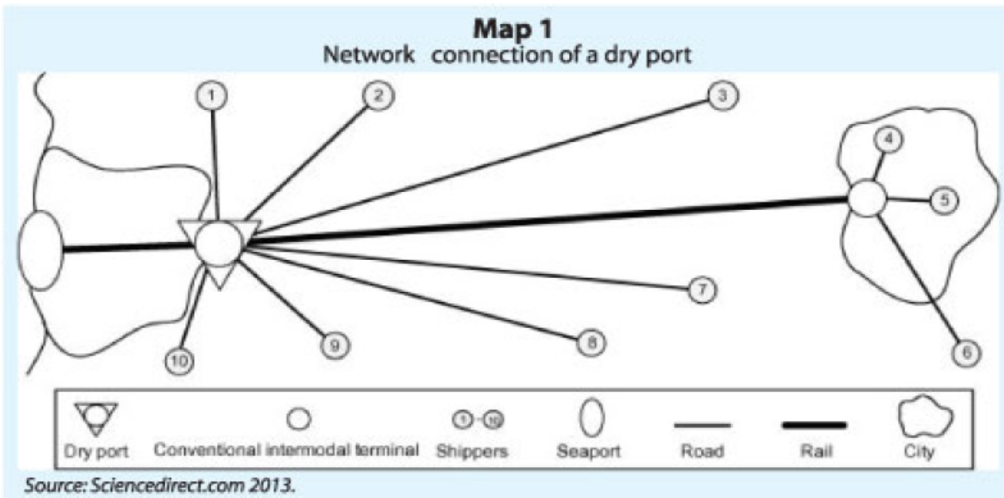


Figure 2.2 Network connections in presence of dry port

(Source: Science direct 2013)

Moreover, (Roso and Lumsden, 2010) reviewed a number of the most existing important dry ports in Europe, Africa and Asia in terms of their definition, functions, location, Impediments and successful factors and addressed one common feature shared amongst all of them, which is the regular railway services from/to seaport. They also stated that all understudied dry ports provided two main services, which are the customer inspection procedures, and creating a new job in their encircled areas. It is worth mentioning, that they found that some developing countries also recognized the promising advantages of dry ports and planned to bring them into reality.

2.2 Influencing factors and key stakeholders

Macharis et al (2004) carried out a review that demonstrated the available opportunities for Operational Research in Intermodal Freight Transport. They argued that by improving and developing multimodal transport systems, particularly by shifting freight transport mode from road to alternative more environmentally-friendly modes of transport such as railways or waterborne, a sustainable and competitive transport network can be obtained. However, their study declared that among the major success factors of dry port operation, of which the location, financial sustainability, efficiency and rail level services from/to dry port is considered, the location is the utmost important factor for dry port operation as it impacts directly and indirectly the main stakeholders who are involved in the operation process. These are terminal user, terminal operator, infrastructure provider and community. Therefore, solving the problem of finding optimal location of intermodal freight terminal is of strategic importance.

Moreover, Sirikijpanichkul and Ferreira (2006) stated that intermodal freight terminals (mentioned as dry ports in this thesis) have direct and indirect impacts on land use and business development. Direct factors influencing terminal location decisions can be viewed from demand and supply perspectives. The former major concerns include a vicinity to markets and industrial areas, rental costs and kinds of dry port, containers and vehicle characteristics. Whilst, in the case of supply perspective the site and space connectivity with seaport's hinterland and access to transportation infrastructure network (e.g. truck routes, railway lines etc.) are the predominant ones.

On the other hand, the community represents indirect influencing factors as it not directly benefits from using the terminals, but its major concern is about environmental impacts for instance (noise, pollution). Finally, they explain the role of these influencing factors in the evaluation process of terminal location decisions, identification evaluation criteria and to form related objective functions.

However, Van Dam et al (2007) argues that the dry port location problem in terms of the presence of many actors with evidently conflicting objectives. They developed an integral model that takes into consideration and satisfies the variety of stakeholder's individual objective functions and then evaluates the general goal by using an agent-based modeling approach (ABM).

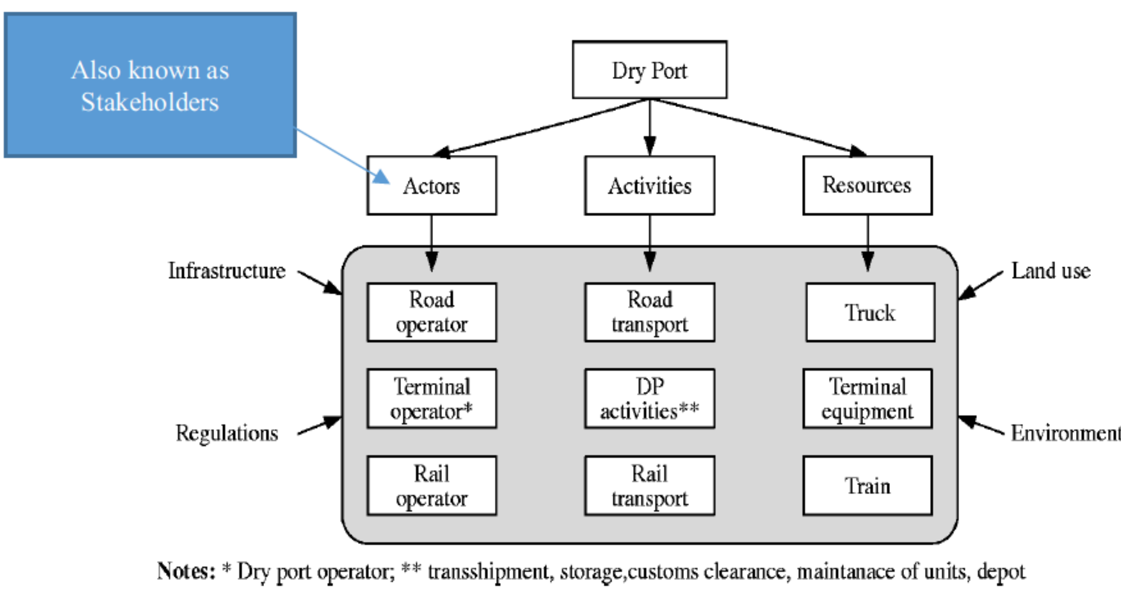


Figure 2.3 Reference model applied on the dry port

(Source: Roso et al. 2009)

Finally, (Roso 2008) identifies general factors that extremely influenced the decision of establishing a dry port namely, infrastructure, land use, regulatory issues and environmental impacts. Qualitative and quantitative data were collected from a comparison between two case studies of both planned and existing inland intermodal terminals in Botany seaport/ Australia of which the close dry port location was selected as a better solution for reducing truck movement on surrounding seaport roads. Thus, a new dry port model that is illustrated in Figure 2.3 is a modified model extracted from (Woxenius, 1998).

2.3 Dry port Background in Mashreq Countries

Although dry ports are a key element for the improvement of the integration and competitiveness of the logistical services of goods transport between land corridors of Mashreq countries, with a view to establishing a regional transport network, it is also considered as a key link between ports on both shores of the Mediterranean and its connection with the European transport network (Figure 2.4). Therefore, it is a feasible method that such Integrated Dry Ports Network (IDPN) should be established based on high coordination between the governments of Mashreq countries.

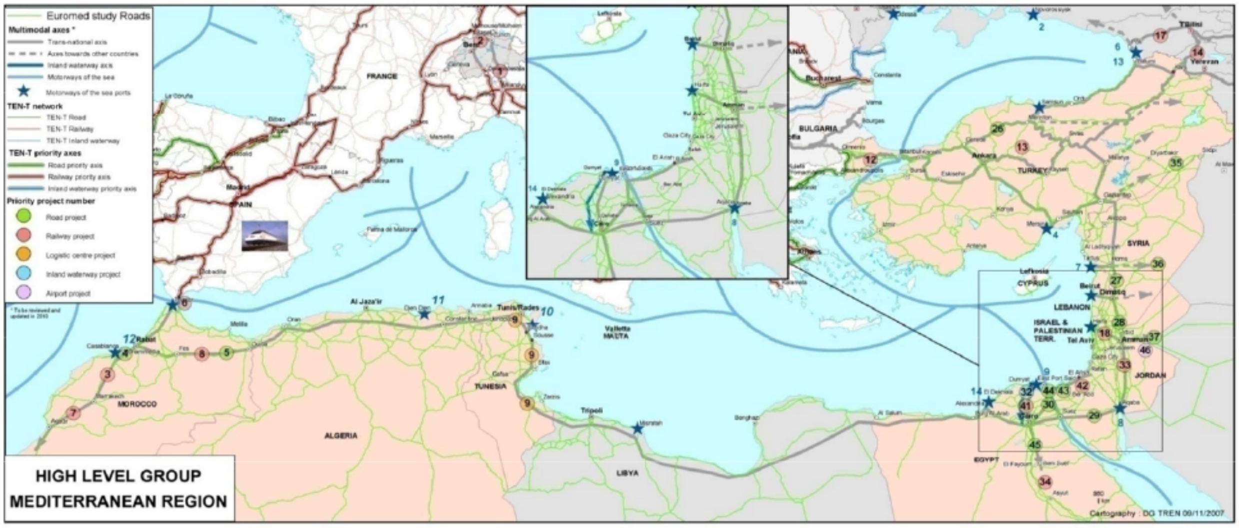


Figure 2.4 Transport networks expansion to the neighboring Mediterranean countries

(Source: Euro-Med Transport Project (2007-2013))

In this context, organizations such as the Arab League & Economic and Social commission for Western Asia (ESCWA) have triggered several initiatives to facilitate the movements of passengers and goods between the Mashreq countries, based on international standards for both regulation and operational levels. However, these initiatives aimed to harmonize the increasing efforts steered by national government.

United Nation, ESCWA (2010), for instance, prepared research showing the importance of harmonizing the administration regulations in the transport sector in ESCWA countries (14 Member including Mashreq countries). In this context, successful stories of the transport sector structures, as well as the current situation in some of ESCWA countries are presented. The study was highlighted in three vital sections according to each transport modal (maritime, road and rail). In addition, the United Nations ESCWA (2011) conducted a survey that acknowledged the main infrastructure projects of (ITSAM:

Integrated Transport System in the Arab Mashreq) elements in the ESCWA fourteenth country, and defined the financing resources for each project. Therefore, The Transport infrastructure financing types such as government budget and privet investment (PPP) models and risks are presented.

The European Union has also notably increased its cooperation efforts with the Mashreq countries as Mediterranean partners in the field of transport, specifically, under the Euro-Med Transport Project throughout applying the RTAP actions (Regional Transport Action Plan (2003-2007). (Euro-Med Transport Project, 2013) evaluated the progress to execute the action (17) which is one of the most important initiatives of RTAP actions that emphasized the necessity of developing logistical platforms in the Mediterranean region. This report appraised the enhancements in regulatory and infrastructure reforms in all transport sectors (maritime, civil aviation, road and rail) in the Mediterranean region (10 countries). However, despite this, it also highlighted the importance of the necessity of establishing logistic platforms in the Mediterranean region, and the enhancements in regulatory and infrastructure reforms. Thus, there is still a need for further improvements and reforms.

On the other hand, the 2009 European Investment Bank (EIB) has prepared the LOGISMED project, which aimed to define a network of logistic platforms in the Mediterranean based on international standards for both infrastructure and quality in logistics services. Logistic platforms were identified as Homs (Syria); Amman or Mafraq (Jordan); Egypt; Djebel west (Tunisia); and Casablanca (Morocco).

Figure 2.5 Syria-Traffic flows (Foreign trade by block of countries)

(Source: LOGISMED Study - EIB 2010)

These logistical platforms are considered to shape the proposed Trans-Mediterranean Transport Network in the future. Furthermore, in 2008 the (EIB) granted a Pre-Feasibility Study and the TOR (Terms of Reference) for the Feasibility Study as a next step in order to build the logistic platform in (Hesia-Homs) in Syria throughout (2008-2010), yet the (EIB) suspended the cooperation with Syria due to the Arab Spring impacts on the Mashreq region in (2012), and has proposed a new initiative (TRANSTRAC) to particularly support preparation of trade and transport corridors for Egypt. Furthermore, the EIB takes into account the necessity of his role to harmonize between LOGISMED Technical Assistant and TRANSTRAC to ensure that future platforms can benefit from relevant activities in TRANSTRAC (Figure 2.5).

Furthermore, according to the European Union/ ISMF/ Multimodal Transport Project (2008), the increasing of prospective transport demand at the Syrian seaports is declared as follows:

- The amount of containers in Tartous Seaport will reach 468000 (TEU) per year by 2015, and stretch to 768000 (TEU) per year by 2025.
- While the quantity of containers for Latakia Seaport is 1,100,000 (TEU) per year until 2015 and (2,000000) (TEU) per year until 2025.

Moreover, the World Bank (2011, p.8) referred to “Many opportunities for trade in the Mashreq countries are being lost because of inefficient trade facilitation processes and procedures, and to a lesser extent because of underdeveloped transport infrastructure”. The World Bank experts summarized the most significant earlier contributions concerning both Transportation and Trade facilitation in the Mashreq region that developed by international bodies such as UNESCWA, UNESCAP, the Arab league states and USAID. Substantial indicators of trade volumes and patterns in the Mashreq region are illustrated. Sections contained in this study are: review of previous studies, trade volumes and patterns in Mashreq countries, as well as recommendations. Annexes provided: Some of recent related reports and studies, trade of Mashreq Countries, and logistics performance of Mashreq countries. Of all the above mentioned, several attempts of regional and international financial bodies were put forth to push Mashreq countries governments to act together as one transportation hub. This would help to meet the anticipated transport volume levels throughout the last period of time. However, there was not even one effective operational study that has been brought about in this context till now in the Mashreq region.

2.3.1 Mashreq Trade Routes and cross borders points

According to the (World Bank Study 2011) Mashreq countries could be joined as global new trade patterns only if they are successful in establishing a comparable port hub with satisfactory depth along with well-known world sea ports. In other words, reduce the transshipment cost and save the door- to- door transportation time that takes one week inside the Mashreq region and lasts up to one month to Asia (West- East Corridor). This will refresh the Mashreq countries role in the international transport corridors map again. The following Figure (2.6), Figure (2.7), Figure (2.8) and Figure (2.9) illustrate the border-crossing points between Mashreq countries and the main trade routes between Mashreq countries to Europe, Asia and Gulf area.

- Route to Asia: West – East corridors (from ports of Latakia, Tartous, Tripoli and Beirut to the Jordanian port of Aqaba via Syria and/or Jordan to Iraq).
- Route to Europe: North – South corridor (Syria and Jordan to Saudi Arabia and the Gulf States).

Figure 2.6 Border-Crossings Points between Mashreq Countries. (WB 2011)

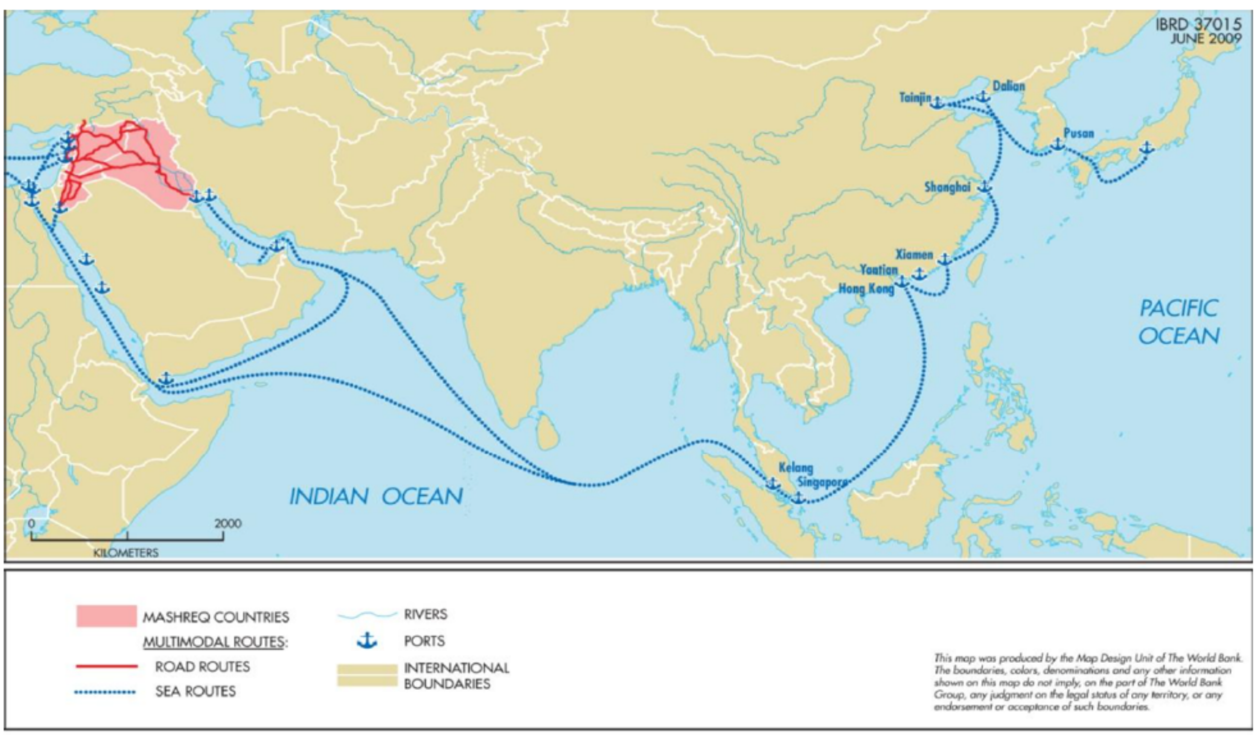


Figure 2.7 Mashreq Countries Trade Routes to Asia. (Source: WB 2011)

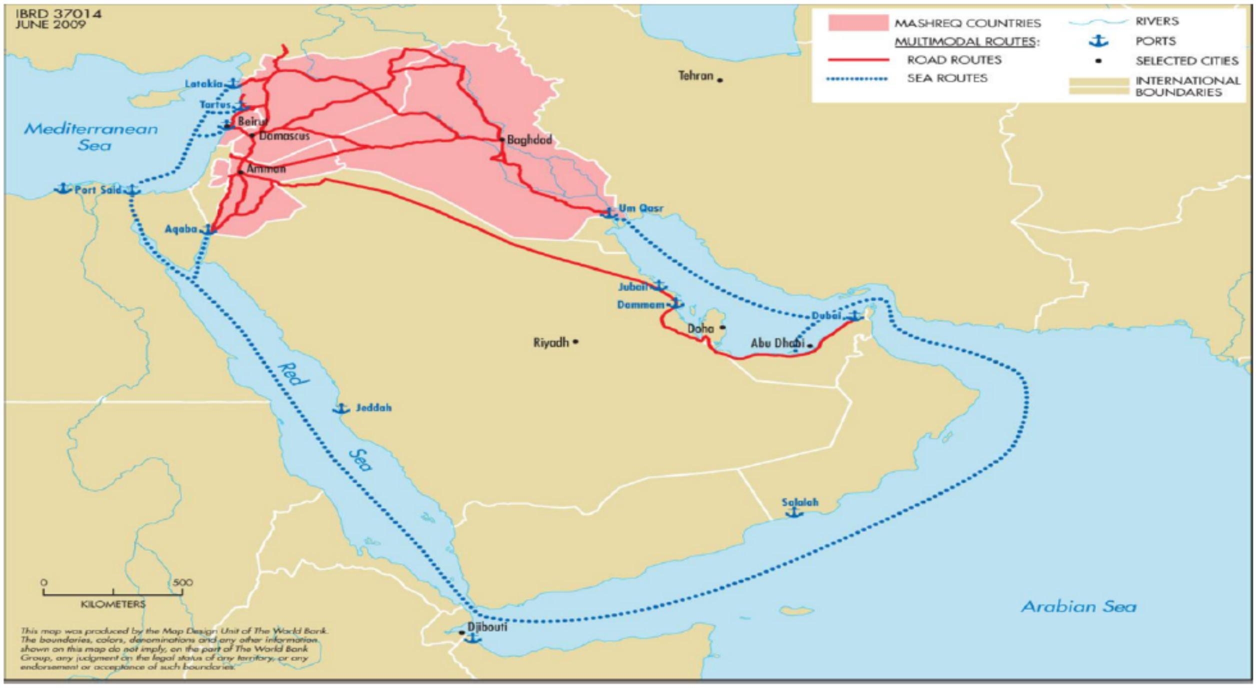


Figure 2.8 Mashreq Countries Trade Routes to Gulf Area. . (Source: WB 2011)

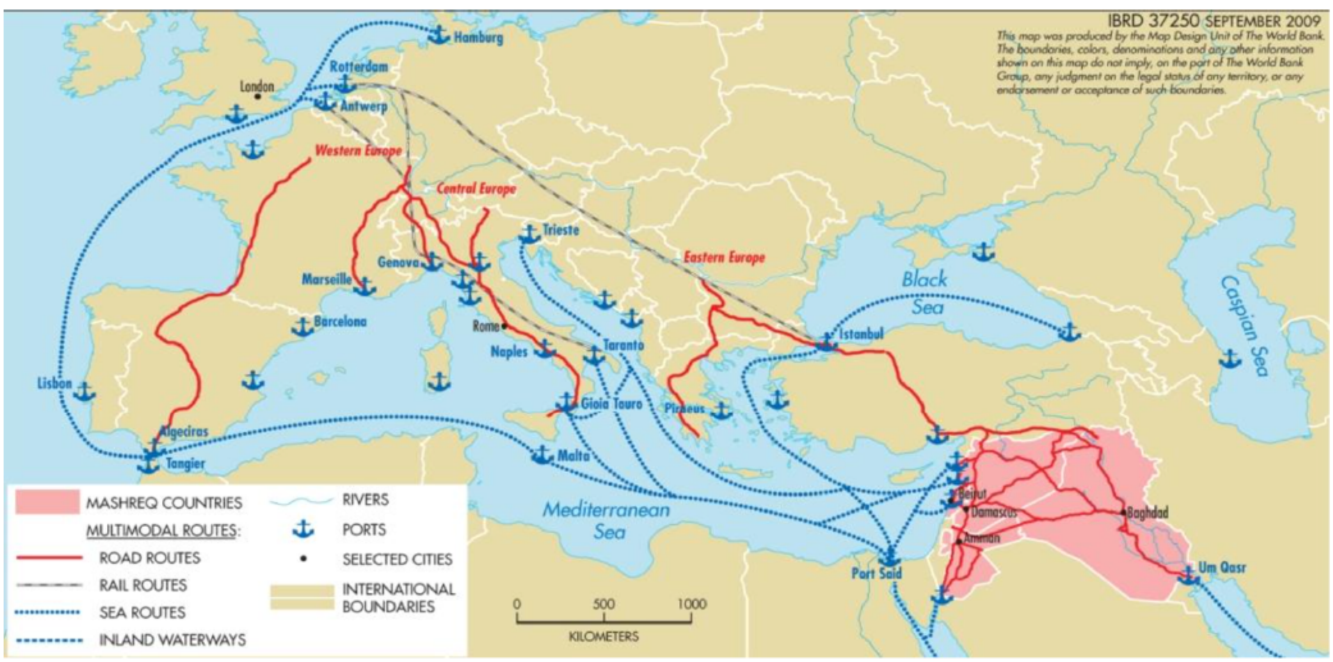


Figure 2.9 Mashreq Countries Trade Routes to Europe.

(Source: Regional Cross- Border trade facilitation study for Mashreq countries, WB 2011)

2.3.2 Main ports and Container traffic in Mashreq Countries

According to the World Bank Regional cross borders trade facilitation study in (2011) the continuous growth in containers volumes will double in the next 5-8 years, namely between 2016-2019. The containers traffic at the Mashreq region's six seaports (Latakia, Tartous, Beirut, Tripoli, Aqaba, and Um Qasr) have experienced a strong growth in the last decade. Mashreq seaport container traffic has tripled from approximately (750000-2,250000) TEU between (2000-2008), with less than one million TEU for each seaport per year (World Bank study 2011). In this context, the Syrian port of Latakia had the largest growth average with (14.5%) per year followed by Aqaba seaport in Jordan with (13.4%), while in the case of Tartous Syrian port which has focused in bulk cargo and Iraqi Um Qasr seaport handling a military and project related cargo, both of them have experienced fluctuating level with a small portion of growth among Mashreq ports. In the Lebanese case, the seaport of Beirut has achieved 9% per year at a domestic level, even though it has experienced a significant growth in the last period due to attract new ship lines as container traffic numbers notably increased (Figure 2.10).

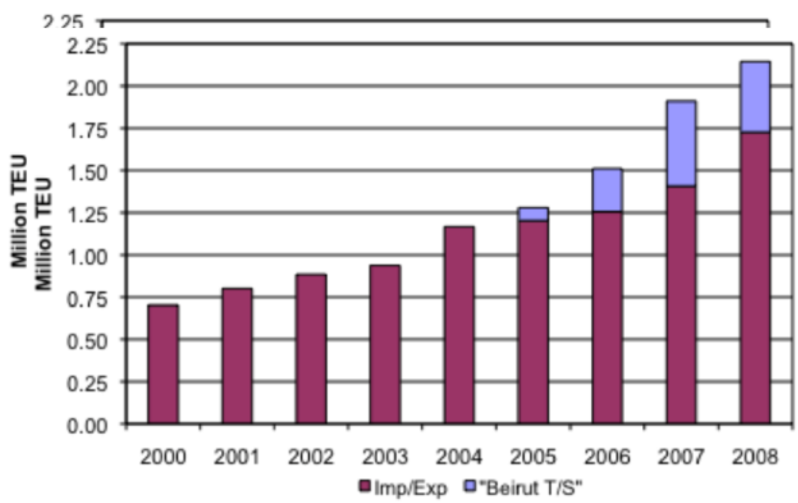


Figure 2.10 Container Traffic in Mashreq Countries Seaports. (WB 2011)

However, many factors have come all together to highlight the importance of an integrated operation of (MCs) transport corridors network. According to the World Bank Regional cross borders trade facilitation study in (2011) the continuous growth in containers volumes will double in the next 5-8 years, namely between (2016-2019). On the other hand, although each of the Mashreq countries has steered a number of new legislations and significant management procedures in order to increase the productivity of the seaport and maximize the containers handling capacity, the paucity of seaports yards prevents Mashreq seaports from attaining the maximum capacities. Furthermore, the lack of storage space capacity in (MCs) seaports yards drives extreme operational problems such as congestion as well as higher operational costs and creates a major bottleneck from/to seaport land access, which all together influence the performance level of container terminals operation and strongly suggests the necessary of forwarding the container volumes into the seaport's hinterland, otherwise they will face a massive loss of container flows.

2.3.3 Main railway networks in Mashreq countries

2.3.3.1 Syria Railway network

The Syrian railway network consists of two discrete single-track systems with no electrification and limited rolling stoke Figure (2.11) The first one is a standard gauge of (1.485 mm) with (2460 km) length that operated under the governmental "Syrian Railways" authority (CFS), and the second one is narrow gauge (1.050 mm) of (250km) operated under the authority of "Hijaze Syrian Railway". The main routes are:

- North- South railway: Turkish borders/Meydan Ecbys – Jordanian borders/ Dara'a

(via Aleppo, Homs- Maheen and Damascus)

- West- East railway: Latakia port – Al Kamishli (via Aleppo, Al-Rakka, Deir-Ez-Zor and Hasakah).

Additional Routes:

- Latakia – Tartous - Homs
- Damascus – Sarghaya- Beirut (narrow gauge/ Hedjaz Railway)
- Aleppo - Al-Rai at Turkish border,
- Qamyshli – Yaaruobia at Iraqi border.
- Maheen- Rabiya at Iraq border
- Jordan 1,050 mm and new line 1,435 mm under construction)
- Qamishli-Nusaybin at Turkish borders

However, the old railway of Damascus – Sarghaya to Lebanon and Damascus – Dara'a to Jordan should convert to a standard gauge (1.435 m) in order to reactivate railways connection to adjacent countries.

Table 2.1 Syrian Railways Systems (Source: Syrian Railways Technical Study 2010)

Railway Authority	Axle weight (tones)	Design speed (km/h)	Length (km)	Gauge (m)
CFS	20	- 120/ passengers - 100/ cargo	2.460	1.435
Hijaze Railway	17	60	250	1.050

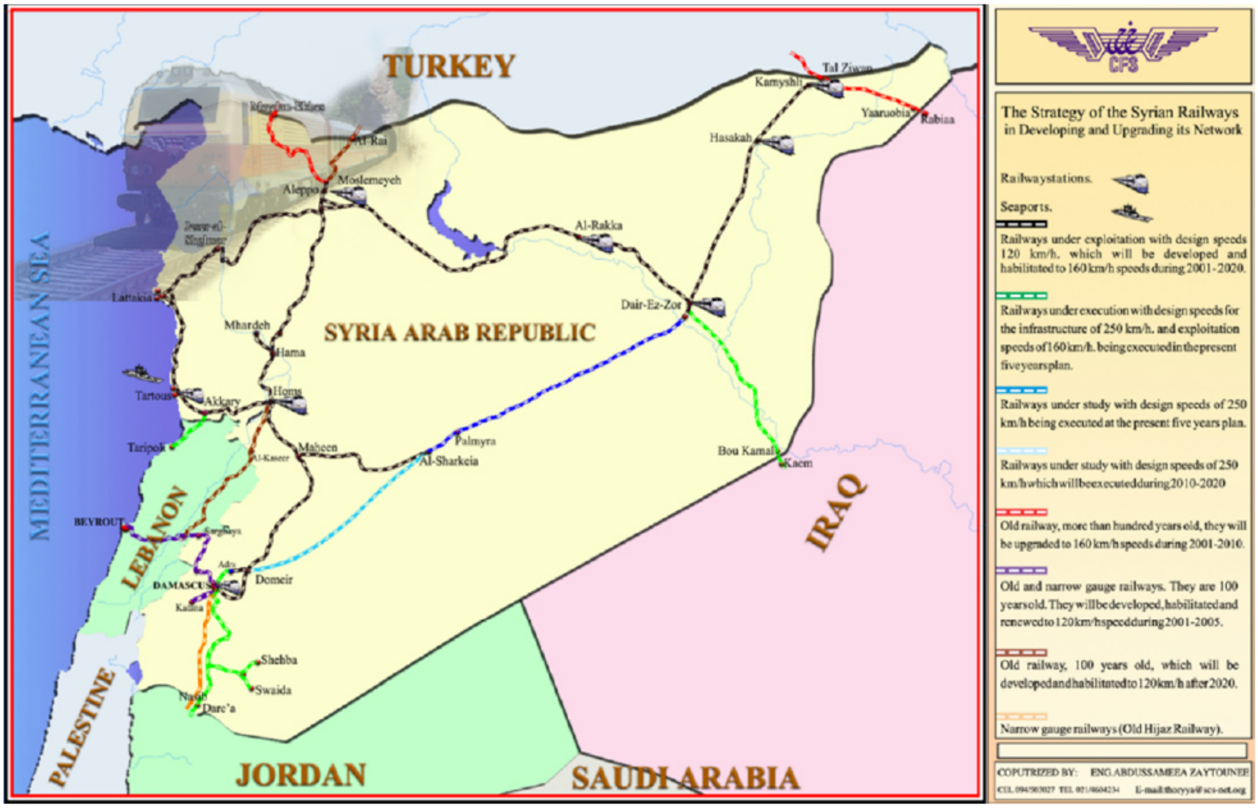


Figure 2.11 Syrian Railways Network (Source: Syrian railways CFS Technical Study 2008)

2.3.3.2 Railways Network in Lebanon

Lebanese railway network includes three main directions:

- Al Naqoura- Saida- Beirut –Tripoli- Northern Syrian border
- Rayak- Syrian border - Homs
- Beirut- Rayak – Syrian border

Although the Lebanese railway network is neglected and disused as a result of the last civil war, the Lebanese government has rehabilitated the old railway network to a significant degree of which many feasibility studies have been made to refresh the railway transport system in Lebanon especially towards Syrian border via Tripoli port.

Table 2.2 Lebanese Railways Systems

Railway Authority	Axle weight (tones)	Design speed (km/h)	Length (km)	Gauge (m)
Lebanese gov	-	-	233	1.435
Lebanese gov	-	-	91	1.435
Hijaze Railway	-	-	82	1.050

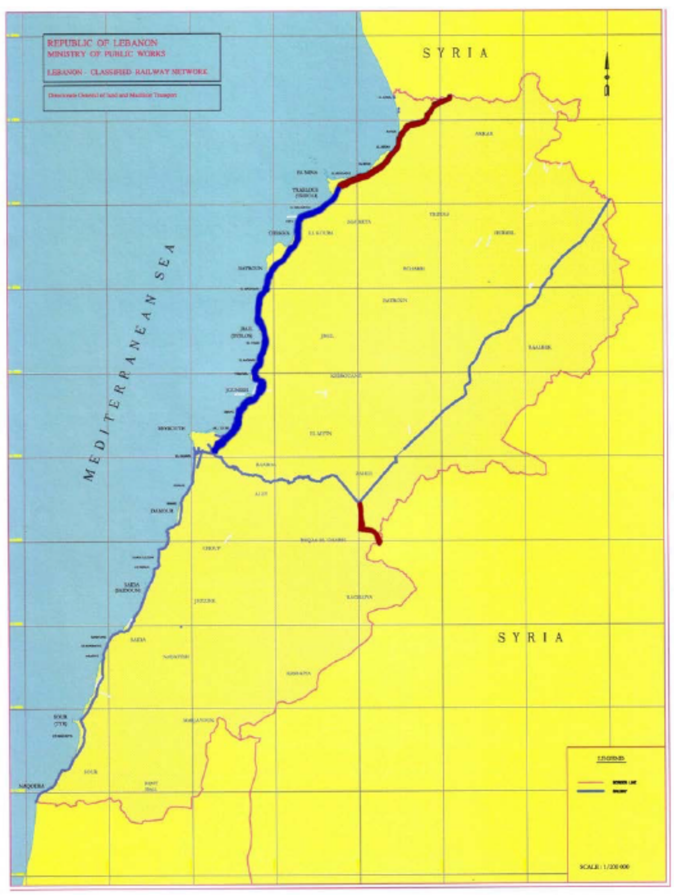


Figure 2.12 Railway Network in Lebanon.

(Source: UIC Study “Opportunities for Rail Transport Between South East Europe and

Middle East 2008)

2.3.3.3 Railways Network in Jordan

The Jordanian railway is the old and shortest in the region with approximately (524 km) length and (1.050 m) narrow gauge single track and no electrified system. Furthermore, railways in Jordan are part of the old Hijaz Railway from Syrian border/ Dara'a down towards Amman.

The operation, management and maintenance of railways in Jordan are accountable for two governmental authorities namely:

- Hijaz Jordan Railway (HJR) for the North-South axis from Syrian border- Amman to Al Abiad phosphate mine in the south.
- While Aqaba Railway Corporation (ARC) is responsible for transport of the phosphate from major sites of Al Hassa and Al Abiad to Aqaba port.

The Jordanian government has alerted to the importance of completely rehabilitating the connections with adjacent countries, but the unrealistic financial expense of railway network constructions and limitations in sources seem very difficult even though an official national plan was set up for modernization the North – South Hijaz railway with the Syrian border to Amman via Al Zarka then toward Aqaba port. However, the only railway connection with Syria now is through the old Hijaz Railway mentioned before.

2.3.3.4 Railways network in Iraq

The total length of the Iraqi railways network is (2339 km) with standard gauge of (1435 mm) Figure (2.13). However, the main international connections with the adjacent countries are:

- with the Syrian border at Al Yaarubiya border point
- with Turkey via Syria Al Yaarubiya border point
- with Iran a new connection from Kerman/ Iran to Diyal/ Iraq) is under construction.

Iraqi main axis are as follows:

- North-South axis extends from the Syrian border/ Yurubiyah to Baghdad and finally to Umm Qasr port.
- The axis Baghdad - Al fallujah - Habbaniya - Al Ramadi East - Hit - Haqlaniyah - Anah - Al- Qaim - Qusaybah on the Syrian border at Abu Kamal is expected to be connected with the Syrian rail network once the Deir-Elzor – Abu-Kamal link is completed.

Figure 2.13 Iraqi Railways Network. (Source: UIC Study "Opportunities for Rail Transport Between South East Europe and Middle East 2008)

Table 2.3 RAIL NETWORK INTERCONNECTIONS & LIMITATIONS

Countries	Railway Connection	Capacity	Operation
Turkey-Syria	Two mixed use connections – the one at Meydan – Ekbes is the commonly used, the other at Qamishli / Nusaybin	-	-
TURKEY - IRAQ	No rail connection (only through Syria)	-	-
SYRIA - IRAQ	One single connection for mixed use at Yaarubiah. Second link to be established shortly at Al Bou Kamal (Syrian link under construction Deir Ez Zor – Al Bou Kamal)	**Limited**	-
SYRIA – LEBANON	No current connections due to severely damaged Lebanese network – three connections in the past to the Syrian rail network	-	-
SYRIA – JORDAN	The Hedjaz railway network they share is of metric gauge, old and in heavy need for upgrading.	**Limited**	**Need to update to standard gauge**
IRAQ - JORDAN	No rail connection		

(Source: United International Union of Railways/ UIC "Multimodal Transport Potential in Middle East – Opportunities for Rail Transport Between South East Europe and Middle East", 2008).

2.3.4 Dry ports in Mashreq Countries

2.3.4.1 Existed Dry Ports

There are three dry ports in Mashreq countries under operation, two dry ports in Syria, namely: Sbenih Dry port in Damascus and Maslamia Dry port in Aleppo. Table (2.4) presents a number of the dry port's characteristics. They are as follows:

Table 2.4 Existed Dry Ports in Syria- Characters and services.

Dry port	Location	Operation	Service	Capacity
Sbenih	Damascus	Since 2005 by CFS	Load-Unload and costumer clearance	560000 (Ton) (150) TEU per Day
Maslamia	Aleppo	Since 1999 by CFS	Load-Unload and costumer clearance	500000 (100) TEU per Day

Abu Ghraib dry port is a new dry port which is under operation since June 2013. The French company CMA CGM Group (private company) announced the opening of its new bonded Dry Port near Baghdad (30 km), to facilitate its customers' business in Iraq. Currently, Abu Ghraib dry port provides costumer clearance services for shippers to facilitate their cargo traffic within and beyond Iraqi lands.

The Dry Port is ideally connected to the Mashreq inland transportation network, with a possible railway connection of 3km away from the dry port's location and fast in bond transit from Umm Qasr port in south of Iraqi territories . The storage facilities for full containers, (LCL) and refrigerated cargo benefited from 24 hours security services, keeping the cargo safe at all times.

However, the Abu Ghraib dry port encourages the development of commercial activities and the creation of new businesses in this strongly developing market. In addition, Table (2.5) presents a number of Dry port main characteristics as follows:

Table 2.5 Abu Graib Dry port Characters and services.

Warehousing	Added value services	Inland Transport	Characteristics
Storage facilities for dry and reefer cargo	Provide Customs clearance for cargo coming from all borders	Highways & Railway connections	Total surface (165,000 m2)
Logistics solutions tailored to customers' needs	Clear procedures Less expenses	Provides transit from all Iraqi borders (Umm Qasr, Trebil, Zakho, Al Walid)	Yard surface (90,000 m2) (80) Reefer plugs
24/24 surveillance and security	Close to home Easy to monitor by clients	Customized deliveries to clients' premises	Capacity (16,000 TEU)

2.3.4.2 Planned Dry Ports

A)- Candidates Dry port in Syria:

According to the Syrian Ministry of Transport, Table (2.6) outlines the key features of the four planned dry ports in Syria, covering the country's essential and commercial and productive regions:

Table 2.6 Candidate dry ports in Syria

Candidate Location	Location	Designed Capacity (Million TEU per year)	Owned by	Service
Hessia	Industrial city near Homs	6-10	Syrian Railways	Loading-Unloading
Adra	Industrial city near Damascus	4-6	Syrian Railways	Loading-Unloading
Sheikh_Najar	Industrial city in Aleppo	6	Syrian Railways	Loading-Unloading
Deir-Alzor	Industrial city in Deir-Alzor	6	Syrian Railways	Loading-Unloading

The Syrian authorities provided logistics services by adopting the concept of dry port, for a number of reasons including:

1. The need to improve conditions for the receipt and distribution of goods entering Syria, in particular via seaports from crossing borders with neighbouring countries (Turkey, Jordan, Lebanon).
2. The inevitability of improving the management of internal distribution logistics services, in particular by directing the transport professions and committees in Syria towards professionalism and indirectly the commercial distribution sector.
3. Logistics in export commodities are needed: Syria has a level of industrial infrastructure and achievements in several sectors. These industries are aimed first at the domestic market and then at neighbouring countries. However, the number of multinational companies based in Syria is increasing (their entry conditions have recently been facilitated) and high quality logistic services must be provided to support the image of Syrian products in international markets. Figure 2.14 illustrated the Candidate Locations dry ports in Syria

Figure 2.14 Candidate Locations dry ports in Syria

(Source: Hesia feasibility study EIB 2008)

B)- Candidates Dry ports in Lebanon:

In relation to Candidates Dry ports in Lebanon, the Ministry of Transport in Lebanon has performed a feasible study funded by EU, aimed at finding the best option to set up a national plan to build a number of dry ports. According to their basic strategy, the suggested dry port should handle container traffic, General Cargo (GC) and dry bulk as there is a potential to serve Neighboring countries in the future. The four options which were conducted by the study to adopt a basic strategy are as follows:

1. Option (1): in the proposed reclamation area of the Port of Beirut (POB.
2. Option (2): a dry port at close proximity to the port, plus one border-based dry port
3. Option (3): two dry ports in a suburb of Beirut and one regional dry port at Rayak.
4. Option (4): a regional hinterland location at Chtoura

As seen above, the fourth option suggests a regional dry port can cater to domestic and transit traffic. The proposed locations are Tripoli, Said and Chtoura.

Figure 2.15 Dry port Location in Chtoura /Bekka valley (Source: Google maps 2018)

Figure (2.15) showed the location of a suggested dry port in Chtoura, which is expected to serve the Mountain of Lebanon and could attract Damascus cargo traffic extending further to Iraq and Jordan. While Tripoli (Figure 2.16), with preliminary cost estimation of 140 MUSD, is expected to attract transit traffic that is bound for the Tartous and Latakia seaports of Syria. However, the Lebanese side assumed that by (2022) the Tripoli dry port will have complete railway connection with Beirut and Chtoura city. Finally, (Figure 2.17) showed the third location in Sida.

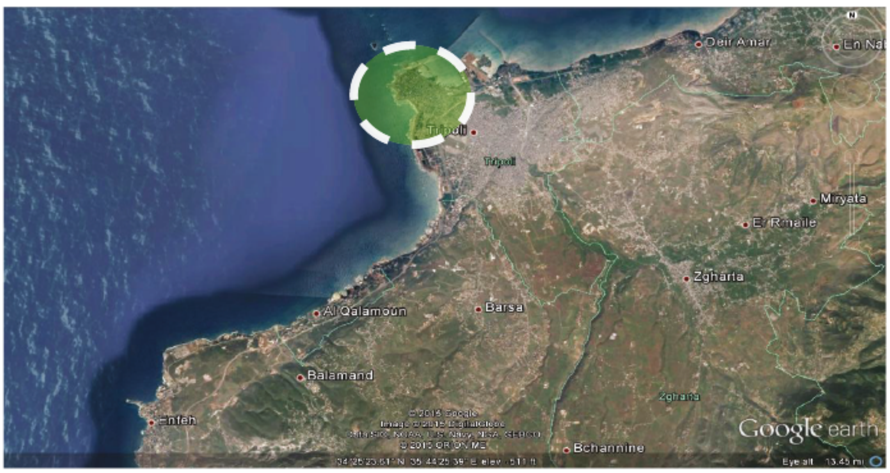


Figure 2.16 Candidate Location in Tripoli (Source: Google maps 2018)

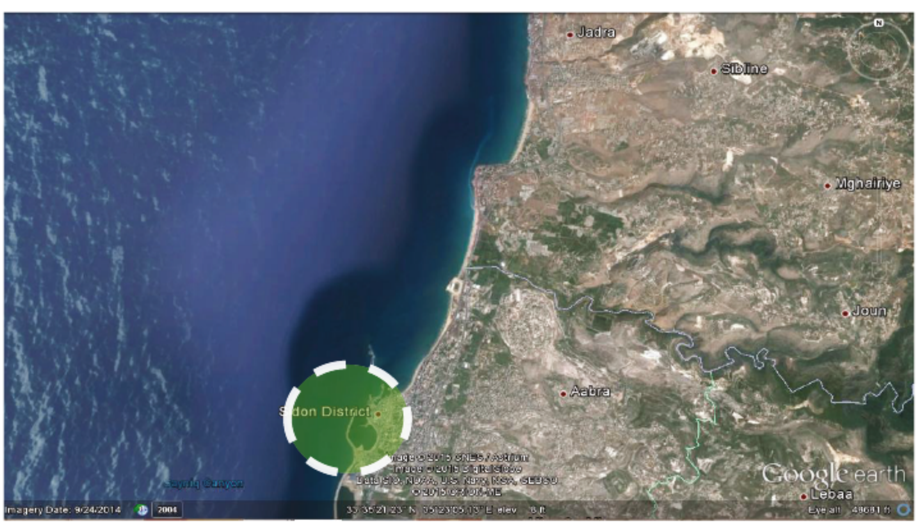


Figure 2.17 Candidate Location in Sida (Source: Google maps 2018)

C)- Dry ports in Jordan:

According to the Jordanian Ministry of Transport, a feasibility study funded by EU/MEDA MOS Transport Project, has announced that the proposed dry ports projects in Jordan are as follows:

1. **Suggested Dry port In Amman Area**

   A new dryport will be located in (Al-Madouneh) Area, near Amman Development Corridor and new Amman Ring Road.

This suggested dry port will be connected to the planed Railway Project corridor and can be served by road and rail. Figure (2.18) displays the Amman Dry port suggested location.

Figure 2.18 Suggested location for Amman Dry port.

(Source: Jordanian Ministry of transport 2017)

2. **Suggested Dry port in Mafraq Area:**

Mafraq area located in Irbid governorate in the north of Jordan Figure (2.19) shows the logistic part (blue) from King Hussein Ben Talal Development Area (KHBTDA). The Ministry of Transport in Jordan intends to ensure that this dry port is served by the newly planned railway project, Cargo Airport and by Road - Rail and Air Transport.

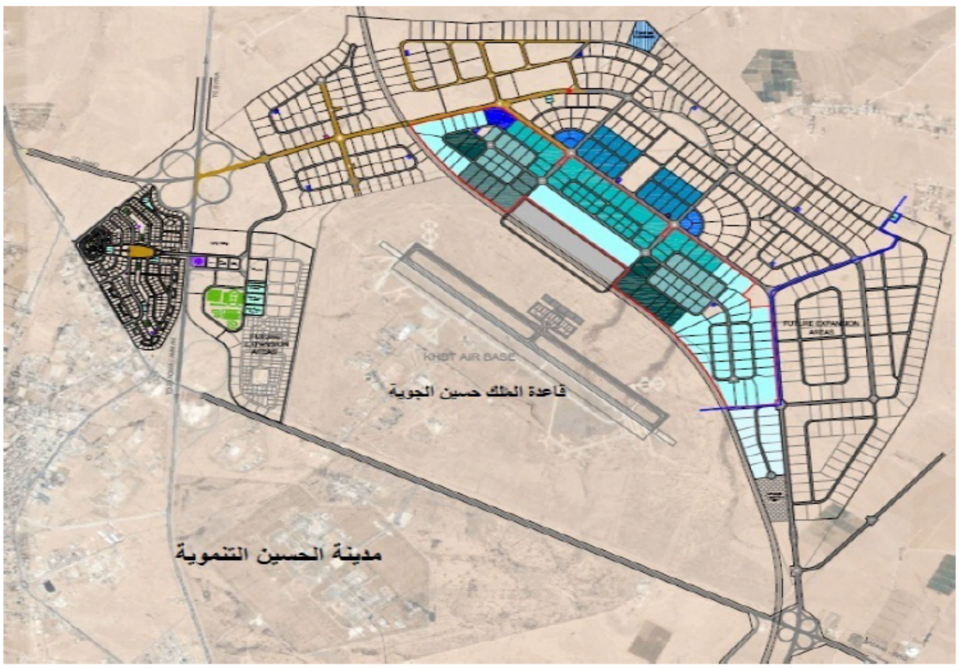


Figure 2.19 Suggested location for Mafraq dry port. (Source: Jordanian Ministry of transport 2017)

2.4 Worldwide Selected Dry ports

Development of dry port concept worldwide is seen as a way to ease congestion, remove capacity constraints and foster local/regional economic development in many countries. Dry ports extend the hinterland of a seaport terminal and becomes an integral part of the overall supply chain. It is the central/local governments who promote the project and attract private investment through concession agreements. Appropriate institutional mechanisms and legal frameworks are prerequisites for the successful implementation of dry port projects. Most of the dry ports are multi-modal facilities devoted primarily to handle containers. The international experience offers three types of dry ports: seaport-based (satellite), city- based (regional load centre) and border-based (transshipment hubs).

2.4.1 Dry ports in Europe

Some of the important dry ports in operation are shown in figure (2.20) and their key features are summarized in Table (2.7) in terms of location, gateway seaports attached, and connectivity with the sea terminals and services offered.

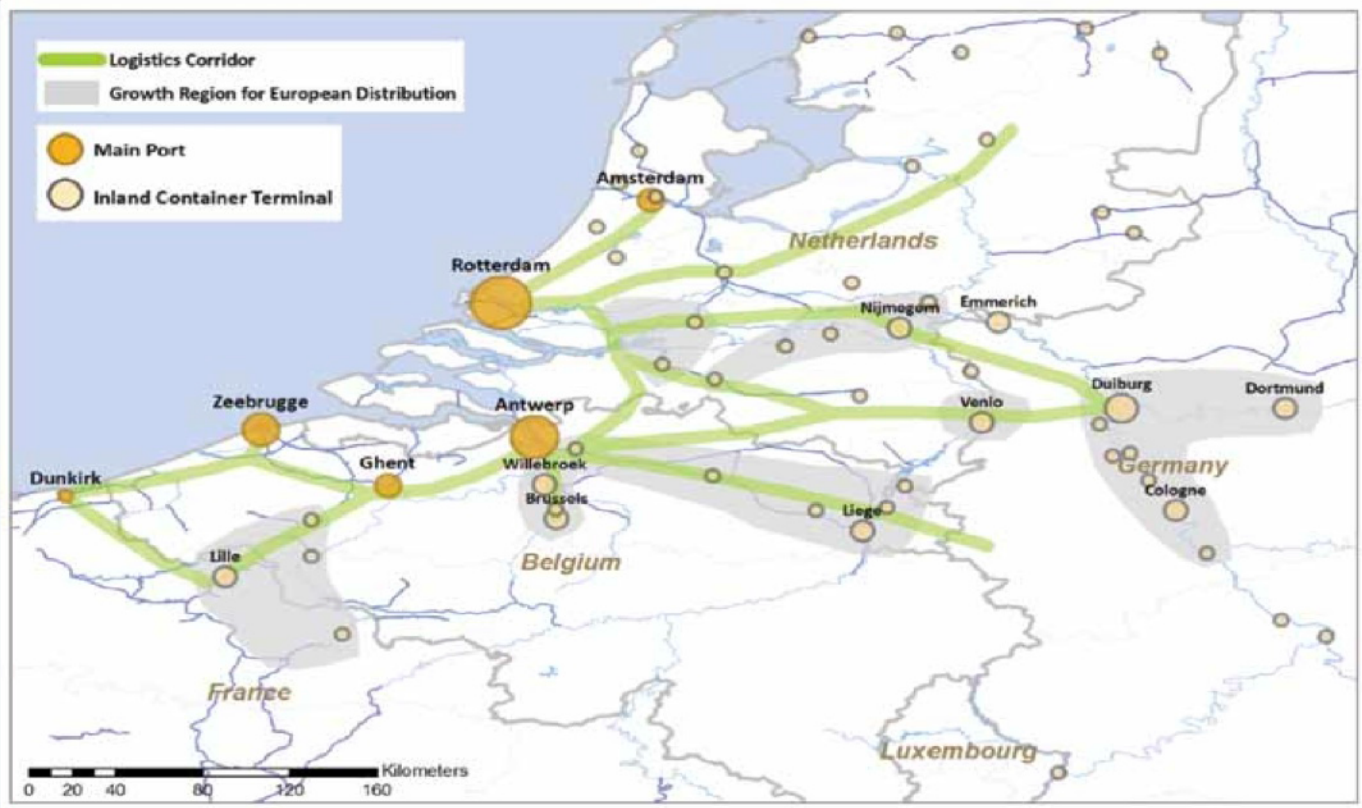


Figure (2.20) Inland Container Terminal and Growth region for Europe distribution.

(Source: Pre-feasibility Study for Dry Port Development in Lebanon- MOS Project 2013)

Table (2.7) Typical characteristics of European dry ports

Dryport	Location	Maritime gateway	Connection	Services
Muizen	Belgium	Antwerp, Rotterdam and Dunkerque	Highway Regular railway	Loading –Unloading- Intermodal facility (Road&Rail)

Mouscron	Lille/Belgium (close to French border)	Antwerp, Rotterdam and Dunkerque	Railways	Loading –Unloading-Intermodal facility (Road&Rail)
Coslada	**Spain**	Algeciras, Bilbao, Barcelona and Valencia	Highways and airplane. Regular rail service between PUERTO Seco de Madrid and 4 ports modal from road to rail.	Storage and distribution, management of stock, division and consolidation of loads, customs management, modal interchange.
Venlo Trade Port	Southeast Netherlands	Rotterdam	Waterways, Road and Rail (Daily high-speed container shuttle service between Venlo and the rail service centre at the port of Rotterdam).	Fully integrated road and rail transhipment facilities including a barge terminal on the Meuse River (Dry Bulk long term).

2.4.2 North America - Virginia

Virginia Inland Port west of Washington D.C. in the USA is 220 miles from the Virginia seaport. All typical dry port functions are carried out by an intermodal container transfer facility. Containers are brought in by trucks from various American States and loaded to the railway car in which the container served all typical functions for transport to the seaport.

2.4.3 Asia - China

Dry ports in China differs according to their location and function. They are classified as:

- **Seaport-based dry ports** which are owned or controlled by the public sector, where the local municipality government plays a facilitating role to provide customs clearance service function of dry ports. A large number of seaport-based dry ports serve as satellite terminals of a seaport in the coastal regions. For instance, one example of this kind of dry port in China is (Shijiazhuang) dry port located in Northeast China/ Huabei province. (Tianjin) port authority proposed this project with the approval of central, provincial and municipal governments. The dry port is a state-owned corporation (Shijiazhuang Inland Port Company Limited). It is developed following the tool port investment model.
- **City-based dry ports** are developed inland in response to the growing domestic economy. These facilities tend to get located in logistic parks or export processing zones, as they are located within a larger logistics cluster, which serves as a major production/consumption centre. The initial investment is from the government for developing basic infrastructure and later on private investment which is attracted through concession agreements. Many local governments develop city-based dry ports in the regional hinterland as a way to foster regional economic development. (Xian) dry port located within the (Xian International Trade and Logistics Park) is an excellent model in Central China. Public Private Partnership/PPP is the investment model used for the development with Xian Municipal Government being the project promoter.
- **Border-based dry ports** are served as a transhipment center with customs

clearance services. They are located in the border areas of Western China adjacent to Russia, Central Asia and the (ASEAN) Region. As the distance between these dry ports and seaports are over (2000 km), they act as trans-modal centers catering to trade by road and rail. Local governments adopt a concession route to attract private investment according to the limitations of a central government fund. (Kunming)Dry Port, which is part of Export Processing Area within Kunming National Economic and Technological Development Zone, is a good example. It is located within (Yunnan) province close to Southeast Asia bordering Laos, Vietnam and Myanmar. The location is strategic in that road, rail, air and inland waterways are accessible to the Xian dry port. The Municipal government has developed the basic infrastructure and Yugang Logistics Company, which is a joint venture company, is the dry port operator.

2.5 Dry port location decision Models

2.5.1 Hub Location Problems

Alumur et .al (2008) presented the state of the art of hub location problem (HLP). Hub location problems are concerned with finding the best solution to the problem of container routing between origin and destination pairs by locating dry port facilities and allocating the hinterland nodes to an optimum dry port.

The key task of dry port facilities is to provide consolidated services to containerized volumes that have the same origin and different destinations, and at the same time are combined with container shipments that have different origin and heading to the same destination.

Alumur et .al (2008) explained two main types of dry port networks: single allocation and multiple allocation. The main difference is that the incoming and outgoing routing traffic passes through a single hub in the former, whereas the flows pass through more than a dry port in the latter.

Alumur et.al (2008) only examines the problem of the location of dry port nodes in the hinterland network, since their study did not cover the problem of the location of hub nodes on the plane, where such studies may be referred to as: (O'Kelly 1986a, and (O'Kelly 1992b), Campbell 1990),(O'Kelly and Miller 1991), and(Aykin and Brown 1992).

Cullinane et al (2000) have pointed out "while the expansion of reach on the maritime side of a port's operational environment is clearly recognized and relatively widely analyzed, the process of a port's spatial development of its hinterland (other than simply the fact of its expansion) has received considerably less attention" (pp9-10).

However, the main cause which persuaded (Farhani et al. 2013) to conduct a survey on Supply Chain Network Design (SCND) was the absence of a main element in supply chain networks designing process which is the competitiveness assumption, even though it has a highly and effective impact on the final price of the product in any supply chain. In this context, (Farhani et al. 2013) stated in their study that most of the literature deals with a signal supply chain (SC) and ignores the exciting competitor SCs and future emerging ones. However, they continued, that few research papers considered both aspects of design and competition. Their aim was to build a comprehensive model that tackle Supply Chain Network Design (SCND) problems in general. Therefore, their research outcome was a general framework for modelling the competitive Supply Chain Network Design (SCND) problems from a managerial point of view.

Furthermore, (Ye et al. 2010) have formed a structure of Container Terminal Logistic Operation System (CTLOS) based on the concept of Multi Agents, starting with shaping an organization structure of system target. In addition, the decision and operation agents structures are addressed, and the mechanism of communication between them to collaborate and coordinate in the best way is illustrated as well. Furthermore, a particular interest of negotiation communication network among different agents in the same group, whose composition is blackboard system and mailbox service, is presented. Finally, they have taken the wharf apxron subsystem (WAS) in a specific container terminal in Shang Hai as an example. By using the Anylogic software tool they were able to illustrate the comparison of simulation data and the result, which shows the effectiveness of the modeling technique and the ability of multi agents system (MAS) operation mechanism to mitigate the potential dwell time for container ships in the port as much as possible.
(Ozcylan et al. 2014) mentioned also in the abstract that: “described an integrated model that jointly optimizes tactical and strategic decisions of closed-loop supply chain (CLSC). The strategic level decisions relate to the amount of goods flowing on the forward and reverse chain. The tactical level decisions concern balancing disassembly lines in the reverse chain. The objective is to minimize costs of transportation, purchasing,

refurbishing and operating the disassembly workstation. Numerical examples are presented using a proposed model." (p.324).

However, the lack of research in modelling inland terminals (dry ports) was the main reason behind (Iannone, 2011) interesting to illuminate the dry port role in the management of supply chain and port hinterland network logistics as well. He updated the interior port model that was developed by (Iannone and Thore, 2010). Based on a brief identification of port-hinterland container logistics and the dry port concept, the requirements of developing the inward interport model are addressed. All economic, social and environmental constraints and variables that framed the relationship between primal and duel liner programming are demonstrated and integrated in one objective structure.

The problem explicated the ability to optimize an ideal economic tool that helps decision makers and strategic planning levels of port hinterland container networks to offer the best containers distribution from the seaport to the inland final destination. Therefore, (Iannone, 2011) ambition was to develop an academic programming model that enables the measurement of the TBL (Triple Bottom Line) elements: (social, economic and environment) as evidence of the dry ports concept sustainability. Thus, he developed a hypothetical mathematical model that optimized the multimodal distribution process of containers (load-unload) from sea gates to the final destination through more than one dry port and rail fright station. Although their paper gained just one citation from the author himself until now, it can be considered a basic stage for this proposed research in order to develop new models to introduce the efficient role of dry ports in Mashreq countries in terms of supply chain management and international trade as well.

In addition, Iannone's article (2013) presented critical appraisal for a massive number of literature reviews concerning optimization models developed by academics that deal with the design of port-hinterland container networks from a shipper's point of view. However, obstacles and demands to provide broader network design modelling are acknowledged, and he provided 75 references that clearly presented the new concept of dry ports and extended gateway as an inevitable solution to eliminate the containers pressure in sea port yards.

While, (Cheon et al., 2010) used the Malmquist Productivity Index model (MPI) to improve the robustness influence of restructuring ports ownership and reform regulatory issues on ports proficiency and productivity. In this context, a database of approximately 100 key ports around the world in terms of ports ownership and commercial entities structure are collected. They provided an interesting measurements of productivity factor that gave strong evidence of the impact of restructuring regulatory procedures in persuaded privet sectors (as major stakeholders) to get more involvement in terminal management processes and container load and unload activities.

2.5.2 Network flow models

(Van Dam et al. 2007) used an agent- based model (ABM) approach to develop a support tool for decision makers in order to plan the intermodal freight terminal location choices. They build a conceptual design network by using an ontological method, taking into consideration five main stakeholders which are: hub users and operators, terminal operators, infrastructure providers and particularl communities benefits. In their paper, they justified the (ABM) approach as a suitable way to develop a flexible system that can replicate itself in which the overall system behavior is derived from the behavior of each system component. This, in turn gave the model an exceptional way to cope with several actors' objectives. In other words, the (ABM) approach is considered a very suitable way to build an interdependent negotiation environment that consists of actions and interactions and relationships between several network actors which, from the researcher's point of view, will pave the road in establishing a conceptual network design that can adequately serve this research objective.

On the other hand, a new approach has been revealed to enhance the concept of multimodal transportation modelling system that can serve the port-hinterland container network design in terms of container distribution logistics services. (Becker and F.Smith, 1997) developed the main OZONE ontology in order to provide a general ontological framework to model the planning and scheduling problems of multimodal transportation in terms of military purposes. They addressed a detailed list of the main constraints for implemented transportation activities taking into consideration the movement needs in both peace and war times, and transportation resources and services which are introduced as well. However, their study was not enough because it explicated the multi-modal Transportation ontology for military purposes only.

Moreover, (Marcal de Oliveira et al., 2013) manipulated the personalized data of users that drew from transportation ontology in order to produce a new software (user interface/UI) which offers even more interactive transportation systems. Model -Driven Architecture (MDA) and Transport (routes & types) are illustrated specifically to design the new application of personalization user interfaces.

Pulina (2014, pp. 224-229) established an ontology for container terminals in terms of yard storage and quayside operations which will help design a knowledge base for decision Support System (DSS) on a daily bases from the author's point of view. First, he addressed container terminal systems which compose of three parts, namely: storage and handling and landside and quayside systems. Then he builds an ontology to represent container terminal main operations in order to monitor key performance indicators (KPIs) in terms of (DESCTOP) Decision for Support Container Terminal Operations.

Although we consider his ontology as a very good start for our research, we could say that he did not address the expansion side of the operations into seaport hinterland as an integral part of logistic services which is one of the most important performance indicators from a logistic solutions point of view.

However, Taha (2007) in the 8th edition of his book (Operation Research: An Introduction) focused on the algorithmic and practical use of operation research techniques by using theory, applications and computations.

(Taha, 2007) addressed the linear programming solutions with Excel Solver and provided coverage of a mathematical programming language (AMPL) syntax. He explained how to use the Excel Solver software to minimize or maximize LP objectives functions after formulating attributes and constraints of LP models in order to obtain the optimal solution. Furthermore, (Taha, 2016) in the 10th edition continued his work as he provided details clarified as a significant tool of operation research, including decision-making deterministic and probabilistic. However, in this research finding, LP solutions with Excel Solver has decided to be used as it is a suitable technique to find the optimal solution of LP objective function. Excel Solver is used to calculate and verify minimum transport costs associated with maximization flow for each distribution scenarios. It is a capable technique used to reduce transport cost and maintain a maximum flow at integrated dry port networks in the Mashreq region.

In this thesis, the Mathematical Minimum-Cost Flow (MCF) network model was selected for its ability to examine and compare two main distribution scenarios of operation strategies (national vs regional), which will be clarified in detail in Chapter 6. The scenario of this problem can be described as follows. For the MCF problem, the existing literature review usually deals with it in an integer programming model with properly selected objective functions. However, the integer programming problem is an NP-hard class. Thus, the computing time will dramatically increase as the scale of the problem increases. The theoretical analysis shows that an MCF network problem requires a strongly polynomial runtime to be solved; see the survey in (K Ahuja et al. 1993) and it will be more efficient to apply the MCF model than the integer programming one. Therefore, to minimize the scale of computing time, it was decided to build up available distribution scenarios based on a number of fundamental questions that designated ontology should be able to answer.

2.6 Research gab

Amongst several attempts to determine location decision of a dry port in terms of containers allocation into regional seaport hinterland, just a few efforts pointed out the dry port location impacts on the actors (stakeholders) decision at strategic level to find several locations to distribute goods to real markets within seaport hinterland with cross borders points. Finally, this research attempts to introduce the satisfied scenario of sustainable and integrated Dry Ports Network (IDPN) by developing an ontological model that can assess the impact of dry port location on container distribution (origin/seaport-destination/dry port) process into regional seaport hinterland.

Reasons behind thesis study:

1. Almost all of the studies in this concept deal with cost and time separately, just a few number tried to solve the problem as a multi-objective problem. However,

according to the demonstrated literature review the operational research studies on conflicting objective, it is very rare and not enough.

2. It is strongly recommended and worthwhile to study a multi-objective problem from real life examples (case studies) as it will bring out and discover the needed requirements.

2.7 Ontology Approach

2.7.1 Introduction

Ontologies were first familiar in research operations as a knowledge of engineering, database design, knowledge representation and information (modeling, integration, retrieval and extraction). Nowadays, ontology is used for many purposes such as medicine, electronic commerce, multi-agent systems, natural language translation and a new area of interest in the semantic web domain.

Container Movement Ontology Domain Knowledge:

This Ontology describes all available container movement from seaport to its destination via adry port based on the stakeholders' objectives (CM Requirements).

To Demonstrate the feasibility of applying an ontological approach to evaluate the dry port location decision, we did the following:

2.7.2 Why Ontology:

Why using an ontology? What are the strong features of an ontology that are believed to create a communication platform?

- No misunderstanding should be possible so that a shared language is needed

- An ontology offers:
- classes structure/ oriented source-value structure.
- A language to define systems
- An interface to communicate

To build a powerful ontology (re-useable ontology) it is important to use generic descriptions as much as possible. In other words, an influential ontology should facilitate the reuse and sharing the domain knowledge by experts.

Ontologies have been widely used in the past years to describe in an abstract, but accurate way, concepts shared and exchanged among different users, systems, or even people using oral communications. And they have long been praised for their efficient use in the comprehension, representation, exchange, share, and integration of domains and concepts (Gruber, 1993) and (Frank, 1997).

Ontologies provide thorough understanding of location decision domain knowledge base, especially when the decision involves multiple stakeholders with multiple criteria. These describe main concepts and relationships, and a set of constraints on how these concepts in the language fit together to form consistent domain models.

Ontologies avoid problems, such as inconsistency and poor misunderstanding among communicating parties. An ontology provides a language that enables actors to communicate in sharing a standard platform that provides an negotiable environment. However, when two actors in a model communicate about certain concepts, it is of the utmost importance that they give the same interpretation to the meaning and use of these concepts. Therefore, it is very critical to unambiguously specify each concept and its meaning. Furthermore, ontologies are formal descriptions of concepts and their properties (relationships) that are not only machine-readable but also machine-understandable (Gruber 1995). Generally speaking, ontologies serve to map user-interpretable descriptions of application domain to application system functionality.

2.7.3 What is ontology:

2.7.3.1 Ontology Definition:

An ontology contains unambiguous formal specifications of the terms in a certain domain of knowledge. In other words, it is a formal specification of a conceptualization. However, a commonly agreed definition of ontology has been given by (Gruber, 1993): "Ontology is an explicit specification of a conceptualization" (Gruber, 1993)

while in the philosophical disciplines ontologies refers to scientific studies and the nature of being and they are first referred to in a philosophical logic by (Guarino, 98) as: "Ontology as a particular system of categories accounting for a certain vision of the world" (Guarino, 1998)

Another identification of ontology is stated by (Van Dam 2009) as: "Ontologies are formal descriptions of entities and their properties, relationships, constraints and behavior, that are not only machine-readable but also machine-understandable." (Dam 2009)

However, ontologies usually consist of three main parts namely: classes (concepts), and constraints as well as relationship between classes (properties). The ontologies are developed as a useful means of capturing knowledge and they could be described as a computational language for defining the main components in the socio-technical system and the relationships between them (Noy & Mcguiness 2001).

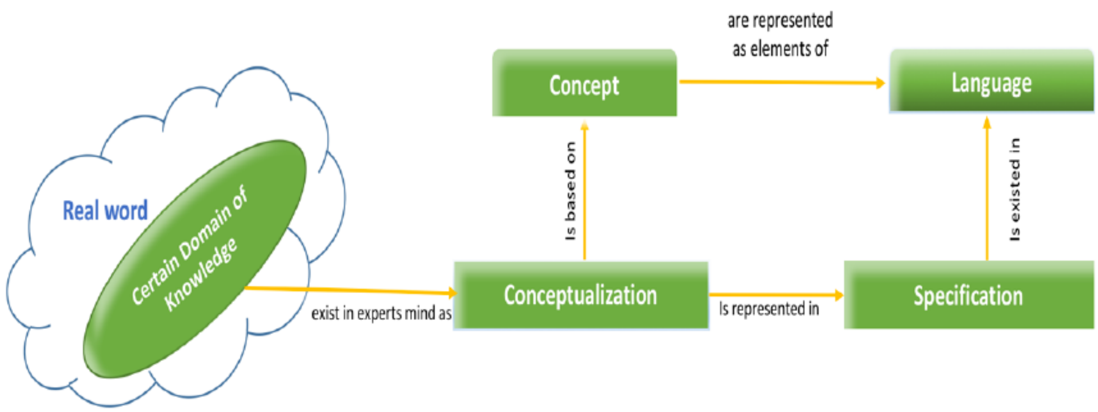


Figure 2.21 Ontology Conceptualization

The literature contains many definitions of an ontology. However, in the engineering world, an ontology is a declarative formal representation that includes a set of logical statements that describes a certain domain of knowledge, and how the main concepts are related to each other via a set of objective properties, and how they can or cannot be related to each other.

2.7.3.2 Ontology main components and Standard

To model the ontology's concepts, several techniques have been used to represent owl ontologies. In terms of developing the first order logic, one can mention (Gruber, 1993), (Baader et al., 2003) who presented a description logics handbook, while the software engineering techniques and database technologies are described by (Cranefield and Purvis, 1999). However, five types of components were used to formalize the scope of ontological knowledge, according to (Gruber, 1993) these are: concepts, relations, functions, axioms and instances and two types of ontological structures which are defined as follows:

a)- To model lightweight ontologies, an ontology structure **O** is defined as:

O= {C, I, R}

Where is:

- **C**: **C**oncept or (Class), and could be any object from real life as action, task, strategy, function reasoning process, etc.
- **I: I**ndividual or (Instance) represented actual objects that are elements of concepts.
- **R: R**elations display a binary interaction types between concepts of ontology.

b)- To model heavyweight ontologies an ontology structure **O** is defined as:

O= {C, I, R, F, A}

Where is:

- **C, I** and **R**: have same description as above mentioned.
- **F: F**unctions are a special case of relations where the set of functions defined on the set of concepts and that

- **A**: **A**xioms is first order logic predicates that constrain the meaning of concepts, relationships and functions.

Concepts in an ontology are structured into (is-A) hierarchy relationship which allows inheritance hierarchy to be exploited in the structure. For example, If **B** (is_a) sub-Class of **A**, and **C** (is_a) sub-Class of **B** then **C** (is_a) sub-Class of **A** as well. It can be denoted by (A→B) and B→C then, A→C.

2.7.4 Principles design of Ontology

The formal ontology design proposed by (Gruber, 1993) should meet the criteria for the principles showed in the table (2.8) in the context of the guidance and evaluation of the ontology design:

Table 2.8 Principles design of Ontology

Principle	Description
Coherence	Coherence ontology means that the defined axioms and informal concepts described by ontology in natural language documentation, should logically be consistent. i.e., the ontological coherence depends on accepting inferences that are correspondence with the definitions.

Clarity	The clarity depends on formulating all of an ontology's defined terms independently to be objective and documented with natural language. The ontology should effectively be reported by the intended meaning of defined terms. i.e., while the conceptualization usually occurs to satisfy real life concepts or from computational requirements, the definition should be independent of social or computational context.
Extendibility	All defined axioms and concepts in the ontology should be able to share and anticipate. In other words, extendable ontology means that domain experts will be able to add and design new terms for special uses based on existing definitions without revising the ontological vocabulary.
ontological commitment	The ontology should require a minimum ontological commitment to support the activities intended for the sharing of knowledge.
Encoding bias	A specific symbol - level of encoding should be used at a minimum level in the conceptualization phase. As knowledge - sharing agents can implement in different systems and styles of representation.

2.7.5 Ontology languages and Tools

Data and knowledge languages are an important part of ontology. In ontology, various computer languages play an important role. In this section, we explain the web - standard languages.

2.7.5.1 RDF and RDF Schema

Resource Description Framework (RDF) was developed by the World Wide Web Consortium (W3C) as a language for processing metadata. RDF provides the interoperability for applications to exchange machine-understandable information on the web as mentioned in (Lassila and Swick, 1999). However, RDF includes three basic object types: (Subject, Predicate, Object).

Where is:

- **Subject** is the resource (URI or a blank node) from which the arc leaves,
- **Predicate** is the property that labels the arc,
- **Object** is the resource or literal pointed to by the arc.

2.7.5.2 Web Ontology Language (OWL)

OWL (Web Ontology Language) is developed by the World Wide Web Consortium. According to (McGuinness and van Harmelen, 2004) OWL is considered the most recent development in standard ontology languages since 2004. OWL describes concepts as it has a richer set of operators like intersection, union and negation. It is based on a different logical model which helps build up the complex definition out of describing a set of related simple concepts. OWL is designed for the applications to process the content of information instead of just presenting information to humans. By providing additional vocabularies along with formal semantics, OWL facilitates greater machine interpretability of web content than that supported by XML, RDF or RDFS. Furthermore, OWL provides three increasingly expressive sublanguages designed for use by specific communities of implementers and users. Finally, OWL Lite supports those users who primarily need a classification hierarchy and simple constraints.

2.7.5.3 Ontology Tool Protégé 5

Many programs have been developed for the development of ontology, notably: OntoLingua, WebOnto, Protégé, OilEd and OntoEdi. Most of these tools provide an integrated environment for the creation and editing of ontologies, error and inconsistency checks (using a reasoner), browsing multiple ontologies, sharing and reusing existing data by mapping different ontological entities. These tools, however, are influenced by traditional knowledge representation (KR) based on ontology engineering methodologies with steep learning methods, which make it difficult to use for the development of casual web ontology. In this section, the most popular ontology development tools (Protégé 5) was presented.

Protégé 5 was developed for the acquisition of knowledge by the Stanford Medical Informatics Group (SMI) at Stanford University. Protégé 5 has thousands of users around the world using the system, as freely available, for projects ranging from the modeling of guidelines for the cancer protocol to the modeling of nuclear power stations. In addition, Protégé 5 provides a graphical and interactive environment for designing a knowledge based ontology as it allows the user to develop a number of management tasks based on a certain domain of knowledge. Ontology developers can quickly access relevant information whenever they need it and can use direct manipulation to navigate and manage ontology. The controls of the tree allow quick and easy navigation through a class hierarchy.

The most Protégé 5 advantages are the plug-ins which are additional modules that extend to the Protégé system's core. The Protégé Plug-ins library contains contributions from developers all over the world. Most plug-ins fall into one of the three categories:

1. Back-ends that enable users to store and import knowledge bases in various formats.

2. Slot Widgets, which are used to display and edit slot values or their combination in a domain-specific and task-specific ways.

3. Tab Plug-ins, which are knowledge-based applications usually tightly linked with Protégé knowledge bases.

For this thesis, container movement ontology was designated by Protégé 5, thanks to plug-ins like (OntoViz) which provides a convenient graphical visualization of ontological models.

Furthermore, this approach allows a reasoner to check whether all the concepts in the ontology are fit under the correct definition. Therefore, it is possible for a reasoner to organize and maintain the system hierarchy in a correct way particularly when it comes to dealing with cases where classes might have more than one supper class.

Protégé which is a free and open source software was used by (Kone Vam Dam 2009) in supporting many standard languages for sorting ontologies such OWL and RDFS which are both based on XML. In addition, Protégé used a graphical user interface (GUI) for entering class definition, and user defininition forms for entering information about instances. Finally, Version control would be used to keep track of the latest version of Protégé online.

2.7.6 Ontologies in relation Domain:

Due to their ability to share knowledge bases, knowledge organization and interoperability between different systems, ontologies have been used in many fields and studies (e.g. medical domain, tourism domain, Transport and Logistics etc. ...).

In view of (Bermejo and Alonso, 2006), ontology is widely used because it provides particular benefits summarized as follows:

1. Ontologies clarify the structure of knowledge: By performing an ontological analysis of a domain, it allows defining an effective vocabulary, assumptions and the underlying conceptualization.

2. Ontologies help in knowledge scalability: knowledge analysis can result in large knowledgable bases. Ontologies help to encode and manage in a scalable way.

3. Ontologies allow knowledge sharing and reuse: by associating terms with concepts and relationships in the ontology as well as syntax for encoding knowledge in them, ontologies allow further users and agents to share and reuse such knowledge.

4. Ontologies increase the robustness of an agent–based system: agents can draw on ontological relationship and commitment to reason about novel or unforeseen events in their domain.

5. Ontologies, that focus on the domain of software engineering of agent– based systems do help development teams and software processes, and may even render useful during exploitation phases as a foundation of cognitive understanding and integration of agents including cognitive self-reflection capabilities

2.7.6.1 Ontologies in Transportation

In this section, the up-to date ontological studies on transportation research are addressed. However, an ontological approach which used to build knowledge in certain domains was in transportation studies for many purposes.

Zhai (2007, pp. 787-796) claimed that by using ontology to integrate transportation information collected from diverse data sources, more valuable databases can be established in order to solve the lack of data exchange among transport management systems. First, he addressed the domain ontology for (ITS) intelligent transportation system and then developed a system architecture that consisted of three main layers namely: application system layer, ontology server and data base layer and heterogeneous data layer. Furthermore, he presented the main technique for transforming different heterogeneous data into XML (Extensible Markup Language) document among the layer's system. Finally, he recommended ontology as a good tool to establish an integrated information platform for transport systems management in which many local ontologies that generated from XML documents can be formed a global ontology. However, even though this paper is for (ITS) aggregated information, it has considered as good evidence of the ability of demonstrating ontology in transport management domain.

Pulina (2014, pp. 224-229) established an ontology for container terminals in terms of yard storage and quayside operations which designed a knowledge base for Decision Support System (DSS) on a daily bases form the author's point of view. First, he addressed container terminal systems which compose of three parts namely: storage and handling, landside and quayside systems, then he builds an ontology to represent container terminal main operations in order to monitor key performance indicators (KPIs) in terms of (DESCTOP) Decision for Support Container Terminal Operations.

Despite this, we consider that Pulina's ontology has a strong relation with our research. Although, we could argue that he did not address the expansion side of operations into seaport hinterland as an integral part of logistic services supply chain which is one of the most important performance indicator from logistic solutions point of view.

(Van Dam, K.H., 2009) developed a software framework to build up an agent based model for socio-technical systems. However, after inventory and structure phases was completed an ontology was used to formalize the system in which he recommended this approach to be used in modelling socio-technical system. Furthermore, he applied intermodal terminal location decision as a case study.

2.7.6.2 Ontology in Logistics

(Grubic and Fa, 2010) introduced a review, analysis and synthesis of a supply chain's competitive environment. In a supply chain competitive environment, the information sharing among supply chain partners using information systems is a competitive tool. Supply chain ontology has been proposed as an important medium for attaining information systems' interoperability. Ontology has its origin in philosophy, and the computing community has adopted ontology in its language. Their paper presented a study of state of the art research in supply chain ontology and identifies the outstanding research gaps.

(Grubic et al. 2010) study identifies six supply chain ontological models from a systematic review of literature. A seven-point comparison framework was developed to consider the underlying concepts as well as an application of the ontological models. The comparison results were then synthesized into nine gaps to inform future supply chain ontology research. This work is a rigorous and systematic attempt to identify and synthesize the research in supply chain ontology.

Meanwhile, (Daniele and Pires, 2013) specified an ontological approach to logistics. An ontological approach helps to improve communication and foster knowledge, reuse and to facilitate the integration of existing systems. Ontologies have been used as a powerful means to foster collaboration, both within the boundaries of an individual enterprise and outside these boundaries. (Daniele, 2013) argued that the use of ontologies can be beneficial for enterprise interoperability in the logistics domain to support the development process of software solutions. He suggested an ontological approach for logistics that balances the trade-off between precision and pragmatism, by combining top-down and bottom-up practices for ontology engineering.

Ontology of Transportation Networks were discussed in (Lorenz et al, 205) over three main parts. The first part is a comprehensive survey on efforts for geographic information. The second part contains a description of the Geographic Data Files (GDF) standard. The final one was on how to store geographic information for intelligent transport systems.

2.8 Summary

An overview of the dry port concept background in Mashreq countries is provided in this chapter, which comprises of both existing and planned projects in the region. This chapter also provides previous research related to Hub Location Problem (HLP) including up to date results in terms of design models of network dry port location. In addition, the knowledge gap and foremost reasons behind the study have been disclosed.

Finally, as this research is aimed to design a network model based on an ontological approach, several definitions of ontology were demonstrated starting from philosophy to operation research field, which is undoubtedly consider as machine- understandable rather than machine-readable. Key principles of an ontological design were also discussed and analyzed.

Chapter 3

Research Methodology

3.1 Introduction

As previously mentioned in the literature review, a significant number of preceding models for dry port location decision have been developed for selecting the optimal location in the seaport hinterland, while there were limitations in addressing the communication between main players (stakeholders) to introduce a general decision for several locations within an integrated network. These limitations bring in an opportunity to develop a new network design model based on a negotiable environment which can offer a flexible and right platform to make a mutual decision that is not necessarily the optimum selection for each one but it is satisfy every player without compensations (trade-offs). Therefore, to build a such negotiable environment an Integrated Dry Port Locations Network (IDPN) design model based ontological approach is believed to have strong features that enable one to fill in the gap of knowledge in the existing models.

3.2 Research Approach

To meet the objectives of this research, this work is structured in a number of work packages, which analyze the research's input and output based on number of independent indicators and available statistics which are developed according to the research modelling steps.

The researcher, at the first stage, believes that a more practical method, such as using the induction approach will serve outline gaps as an outcome of evaluating and gathering data. However, a Systematic Literature Review (SLR) is conducted by using a combination of keywords to build a comprehensive research on SCOPUS and Journals of Transportation Research Part A, D, E. Firstly, a minimal process to distinguish between the findings: (conference papers, editorials, Articles, Press Articles, etc.) is applied. Furthermore, to sort and minimize papers per their relation to the main subject of the research, a more effective use of key words and phrases that adhere to the field of research is used to repeat the same research with (Scholar.google.com). Then, a comprehensive analysis is developed to appraise the papers independently. On the other hand, at the second stage, a quantitative approach adapted as a research method to tackle the major problem of containers distribution within intermodal transport process. Many available techniques such as e-mails, phone, and skype are conducted due to data collection process requirements.

3.3 Data Collection

The researcher conducted a comprehensive review of available secondary data about the Mashreq region in terms of current dry ports projects. In this context, the data gained, either from the free of charge statistic and the annual reports of related regional and international organizations, or through subscriptions in which Mashreq countries are members, such as the following:

i. International Union for Railways/ UIC.
ii. ESCWA regional studies.

iii. International Road Federation/IRF.
iv. International Road Transport Union IRU.
v. Arab union for Land Transport.
vi. Arab league statistics and Transport annual reports.
vii. ISMF (Institutional and Sector Modernization Facilities)/ Multi-Modal Transport Project/ Syria (2008).
viii. Euro-Med Transport Project (2007-2013)/ Syria –Lebanon and Jordan.

As mentioned above, qualitative and quantitative real historic raw data were collected between (2005-2011) from four countries in the Mashreq region, namely: Syria, Lebanon, Jordan and Iraq. The data will be used as an input to test and evaluate the developed ontology named as Container Movement Route Ontology (CMRO).

In addition to this, the data will also be used in the Mathematical Minimum Cost Flow (MCF) model, to test and validate output scenarios obtained from the CMRO. The MCF model was chosen for its ability to examine and compare two main distribution scenarios of operation strategies (national (vs) regional). Two container seaports, Latakia in Syria and Beirut in Lebanon, were selected for their locations in Mashreq hinterlands to implement distribution scenarios of operation strategies.

Finally, Excel Solver program will be used to compute the cost and the flow in each distributed scenario. It is a satisfied solution to reduce transport costs and maintain a maximum flow at integrated dry port network in Mashreq region.

3.4 Source Ontology Design:

The aim of designing a dry port locations network is to identify sufficient number of dry ports in the energetic hinterland in relation to their location, capacity, and mainly the connections to seaports as well as between themselves. However, such a network in MCs regional hinterlands is not a green filed area as it is restricted by the planned (national candidate's pre- selected locations) and existed dry ports and their transport connections to the main container seaports.

Container Movement Route Ontology (CMRO), will demonstrate sustainable distribution scenarios of containerized flows within MCs hinterland based on transport activities interacting with facility locations (seaport -dry port and demand destination), which may vary depending on stakeholder objectives, transport infrastructure availability, and government program laws and regulations.

The ontology provides a conceptual template for government authorities in the transport sector to describe their operations. The authors propose an ontology-based decision framework for managing changes in government services. The approach uses formal methods to attain consistency when changes are discovered. In addition, it enables decision-makers to respond to changes by using design rational knowledge. Finally, this research introduces an ontology to manage and sustain Container Movement Routes in Mashreq Countries (CMRO). The (CMRO) will be designed based on the following two fundamental phases used to develop any ontology (Conceptualization & Formulation).

3.4.1 Conceptualization

In the conceptualization phase, a source ontology is developed to illustrate and display the container movement requirements within the regional hinterland depending on stakeholder objectives. It is a semantic-based representation of transport activities within regional network, based in the presence of dry ports in the transportation system to formally exploit all available scenarios of container routes which the decision makers should be aware of.

However, in the conceptualization phase, attributes will be developed using Web Ontology Language/OWL and Resource Description Framework/RDF as follows:

1. Define the concepts that explain the network structure elements, which contain nodes (which referred as Facility location in our model), and links between them to formally explicit the Integrated Dry Ports Network (IDPN) configuration.
2. Define the concepts to explain the containerized flows regarding two different operation strategies, which are national and regional. Container distribution scenarios will be addressed based on a number of strategic objectives properties such as location, transport service, transport activities, function and connection.

At the end, both defined concepts, mentioned above, will form the CMRO domain of knowledge (Conceptual Ontology).

3.4.2 Formulation

In the formulation phase, the main concepts of CMRO and their relationships will be modelled to visualize all available scenarios of containers routes. CMRO components will be modelled using open source software called Protégé 5, where a number of main Description Logic/DL queries will be introduced to illustrate network elements (Nodes and Links), and all available container movements routes scenarios.

An Owl ontology consists of classes, sub-classes, object properties, data properties and individuals will be created using Protégé 5 software. First, a hierarchy tool will be used to create a set of class and sub-classes that represent CMRO's main concepts. Then number of characteristics that describe concepts behavior, such as (Functional, Symmetric, transitive cardinality…etc.) will be added to avoid any ambiguities in ontology mechanism. Second, the number of object properties will be addressed in the relationship between CMRO concepts. Third, a number of data properties will be developed to represent main characteristics of classes and sub-classes. Then, a Reasoner, which is a check tool in Protégé 5 software, will be used to ensure that all the sub-classes are fit under the correct super-classes in relation to CMR Ontology main principles.

Finally, a number of Description Logics/ DL will be developed in relation to the main questions of the ontology's conceptualization to provide answers that demonstrate the Network Ontology elements and movement ontology scenarios.

3.5 CMRO Implementation

The historical data, as mentioned earlier in this chapter, will be used to feed the designated CMRO to produce container distribution scenarios in the Mashreq region.

To determine Initial Distribution Solutions or scenarios, the CMRO will be fed with a number of inputs from the real world to address the transport network in the Mashreq countries hinterland and demonstrate the container movement routes at both national and regional operation strategy for container volumes distribution scenarios.

CMRO's classes and sub-classes, such as (Facility_Location, Seaport, Dryport, Link, Container_Shipment, …etc.) will be assigned Data Properties such as Flows/TEU associated by unit cost, distance, and link type (road or rail). To ensure that all the sub-classes are fit under the correct super classes per CMRO main principles a (Reasoner) tool will be run. During the final step, based on Description Logics (DL) that describes the satisfactory rules of a preferable scenario for Integrated Dry Ports Network/IDPN, a set of preliminary national and regional containers movements route scenarios will be produced.

3.6 Validation Scenarios:

To validate the CMRO outputs and achieve meaningful results, the following two main scenarios, in terms of the relationship between a seaport and a dry port, will be used for comparison:

1. National Operation Strategy (N.O.S) in which the national authority of a seaport can move containerized volumes only to its national dry port network.
2. Regional Operation Strategy (R.O.S) in which the national authority of a seaport can transfer containerized volumes to any dry port within the regional hinterland.

Finally, the following diagram address a summary of the research methodology as presented in Figure 3.1.

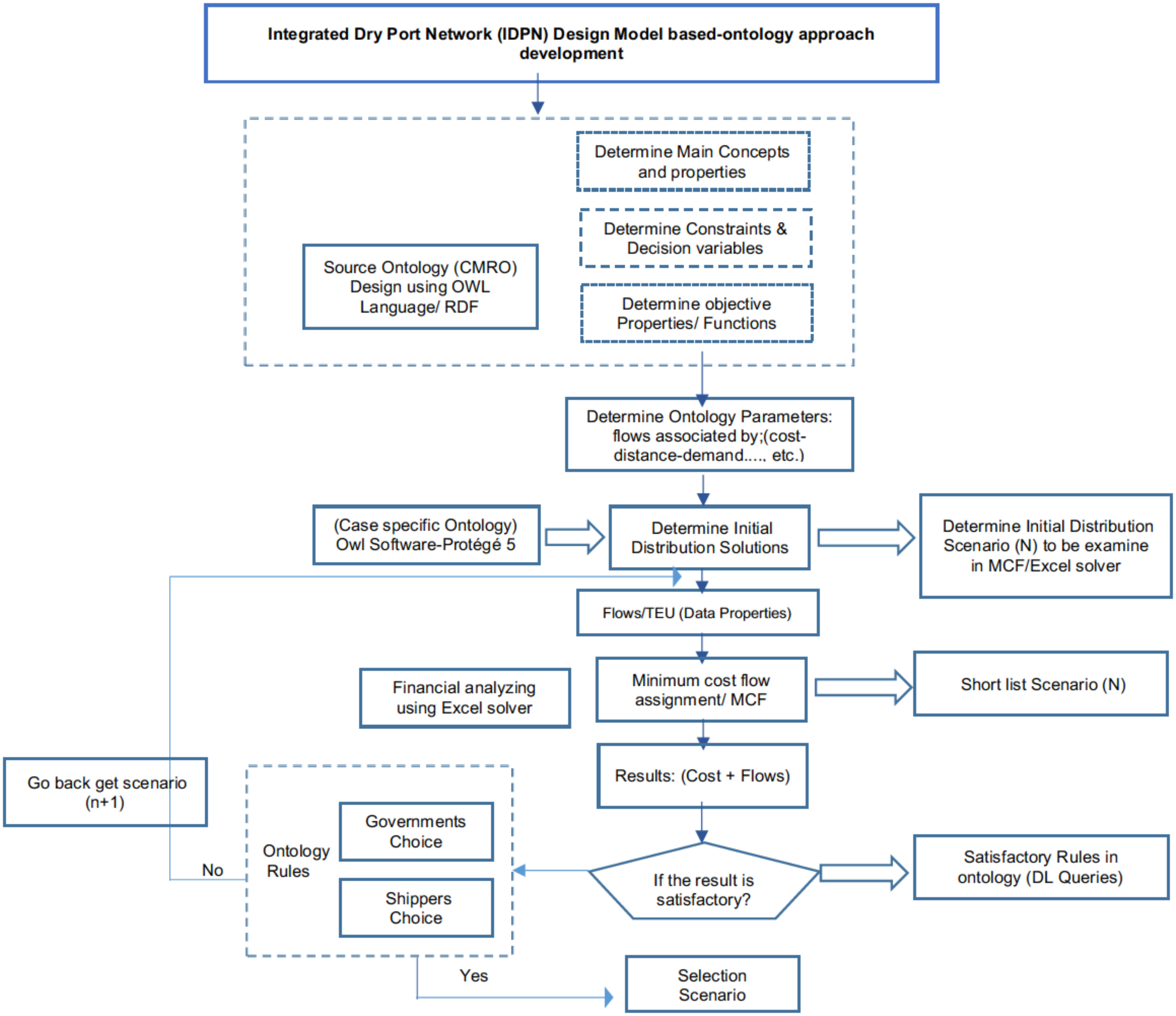


Figure 3.1 Network Hub Locations Design Methodology

3.7 IDPN design model development

To meet the objectives of this research, this work is structured in a number of work packages. First, a systematic literature review will be conducted and historical data between (2005-2011) will be collected. Then, a source ontology will be designed over (conceptualization- formulization) levels. Finally, for validation purposes, CMRO will be implemented through a case specific ontology in order to generate available scenarios of container movement within integrated hinterland. Furthermore, Excel Solver will be used to calculate and verify minimum transport costs associated with the maximum flow distribution for obtained scenarios.

3.7.1 Design Source Ontology – CMRO

At conceptualization level, a resource description framework language (RDF) will be used to structured key concepts definition demonstrating their relationship and object properties as follows:

1. Basic Questions of source ontology CMRO will be established concerning,

   A)- Questions to describe transport network.

   B)- Questions to explain container movement within an integrated network.

2. Source ontology's glossary will be developed to clarify major concept descriptions.
3. Basic concepts and relationship of container movement route ontology will be specified including facility locations and the transport connections between them according to : (Concept Definition - Object Properties- Relationship).
4. Network Ontology, that explained transport network structure, and Movement ontology that explain the movement within integrated network will be clarified.

Furthermore, as a result of conceptualization level all CMRO concepts will be gathered to produce CMRO Map. Consequently, at Formulization level an open source software Protégé 5 will be used to structure and visualize the CMRO concepts, where a Protégé OWL Tutorial/ Camel Back notation/ Stanford University will be followed to illustrate initial CMRO class hierarchy as result. Finally, the Description Logics/ Syntax, which provide a share understanding platform to be used by domain experts in the future, will be clarified in appendix (1) followed by (Horrocks et al.2004) and Manchester OWL Syntax.

3.7.2 Case Specific Ontology (For Mashreq Countries)

To generate the available scenarios of container distribution in the Mashreq regional network, a case specific ontology of CMRO will be built depending on Mashreq Data (Instances-Data Properties). Moreover, a historical data of container traffic imported at Latakia and Beirut seaports between (2005-2011) will be analyzed and observed in terms of demand destinations to main cities in Mashreq region.

On the other hand, the data obtained in previous step will be used as input to train the case specific ontology. Finally, DL Queries to answer main CMRO's questions in terms of network structure will be examined to obtain available container distribution scenarios.

3.7.3 Minimum Cost Flow Assignment

In order to test, verify and calculate the available scenarios, the scene will be set up as follows:

a. To validate the CMRO outputs and achieve meaningful results a Regional Operation Strategy alongside National Operation Strategy of available container distribution routes in Mashreq region will be run and compared.

b. Excel Solver will be used to calculate and verify minimum transport costs associated with the availability of flow distribution for obtained scenarios.

c. Finally, A number of new generated scenario depends on the link's type and distance between candidates dry ports and sea ports in Syria and Lebanon will be examined in order to determine sufficient dry ports location in each countries.

Chapter 4

Design Model Development Based- Ontology Approach

4.1 Introduction

This chapter demonstrates the four steps implemented to design the ontological model for a regional network:

First, defining a set of questions that the ontology should be able to answer, i.e., these are the ontology's requirements. Second, defining the concepts that will be part of the ontology, their properties and relationships. Third, formally specifying definitions and constraints of the concepts identified using Resource Description Framework /RDF Language as formalism. Fourth, implementing the specifications in Protégé- OWL (based on Description Logic DL Queries service). It is possible, by using Reasoner in Protégé 5, to test the competency of the ontology by proving complete theorems based on formulating questions in the first step. Finally, *Manchester OWL* Syntax was followed to produce a syntax that could be used to describe classes and properties in Protégé - OWL.

The model focuses on achieving a sustainable distribution of container traffic. We consider strategic planning problem of defining sustainable transport route for container traffic within an integrated regional hinterland. First a source ontology is designated in terms of container movement requirements and transport activities within a regional hinterland that depends on stakeholder objectives. Then, an experimental framework built upon a case specific ontology inspired by regional cases in the Mashreq region is developed in the next chapter and computational results of the model are discussed and analyzed.

4.2 Problem formulation and definitions:

In this research, we argue that the ontology approach will provides a comprehensive understanding of a container's distribution domain knowledge that helps decision makers in the Mashreq region evaluate dry port location decision, especially when this decision involves several stakeholders with often conflicted objectives.

For a regional network of dry port locations focusing on the distribution of container volume starting from seaport through dry ports to their destination, there are two main types of components in a given network: **nodes** and **links**. Nodes include seaports, dry ports (planned- existed) and hinterland destination of containers (demand centers). Links connect the container traffic from seaports to their destination either directly or through dry ports.

Nodes which will be referred to as (Facility Location) include the following:

1. **S**: Sea port nodes (Origin).
2. **H_p, H_e:** Dry port nodes (respectively, planned and existed dry ports)
3. **D:** Hinterland destinations nodes (demand centres = destination).

Links:

Links are Infrastructure (road or rail) connections between origin nodes (seaports) and destination through dry ports as follows:

- L_{Ro}**:** Road Link that have road infrastructure connections between nodes
- L_{Ra}**:** Rail link that have rail Infrastructure connections between nodes (seaports)

(Figure.4.1) illustrats the conceptual integrated network of dry port locations where the network contains of given nodes (N) on which a set of origin-destination and candidate locations of dry ports will be identified, as well as the connection between them /Links (L) including rail and road transport modalities. The main attribute of interest is the flow between origin-destination links connection associated with (cost, distance, time, etc.).

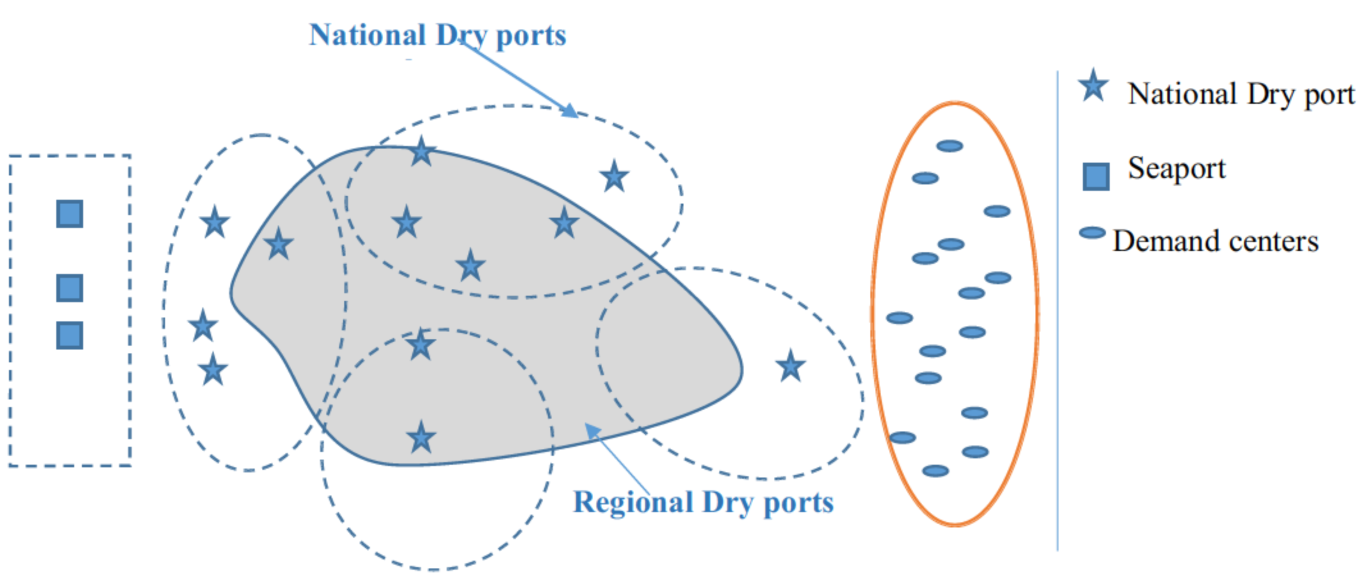


Figure 4.1 Conceptual Integrated Dry Port Locations Network

4.3 Model Assumptions:

For a regional seaport-dry port network of freight distribution as mentioned above, with a single type of commodity, namely the Intermodal Transport Unit (ITU) which is wildly known as a container, the process of location-allocation contains two steps and is as follows: in step (1): the government's role (terminal owner) is to materialize developing new dry ports or rehabilitate existing ones, and providing an infrastructure of network connections, taking into consideration the shipper's (terminal user) choice to transfer their shipments.

In step (2) shippers (terminal user) can choose any route to transfer their container shipments from the seaport to demand centers either directly or through dry port. Thus, when governments planning to develop several dry port locations within a regional hinterland, they should take into consideration the shipper's choice in order to achieve the main objective of minimizing the regional logistics cost.

With regards of the relationship between seaport and dry port, two scenarios of operation strategy can be considered:

1. Regional Operation Strategy (R.O.S) in which the national authority of a seaport can transfer containerized volumes to any dry port within the regional hinterland.
2. National Operation Strategy (N.O.S) in which the national authority of a seaport can move containerized volumes only to its national dry port network.

In addition, the following assumptions have been made:

- The locations of nodes (S

- seaport –dryport) are pre-determined by involved governments, as a list of national candidates of dry port locations and main container seaport in the Mashreq region which has been set up individually.
- The main infrastructure of transportation link between seaport and dry ports are defined as the Mashreq region is not a green field area.
- The annual container volume (2005-2011) imported to the two-container seaports in the region, namely: Latakia in Syria and Beirut in Lebanon are known.
- Container transportation cost, by rail or road, is considered, while we don't conceder fixed cost of dry port construction and transportation link maintenance cost.
- The container transportation unit cost doesn't change in relation to container volumes.

In this thesis, multimodal itineraries of containers traffic is analyzed, where a change of transport modality can occur only in dry port nodes. While in terms of container movement direction, we consider only single dry port itineraries, namely the origin-dry port-destination path, considering that the origin of container traffic movement is only from the maritime gateway (seaport) as well as excluding direct connection between origin-destination nodes and between the dry ports themselves.

As an example, container volumes can leave seaport nodes by road transport services using trucks, and heading to a different dry port node where the change to rail transport mode can be accrued, and then continue their trip to their final destination by train. This prospect allows containerized flows to leave origin nodes in different modalities to reach dry port nodes where the change can be accrued and reach their destination with the available transport mode.

4.4 Ontological Approach

As our focusing is to design an integrated network of dry port location depending on a sustainable distribution of container traffic, we argue that the ontological approach will provide a comprehensive understanding of a container distribution scenario domain of knowledge that helps decision makers in the Mashreq region, with often conflicting objectives, to evaluate dry port location by investigating the sustainable scenarios of container traffic.

The ontological approach of this thesis is aimed at analyzing the network transport system to identify the network structure by addressing key concepts and their relationship between them. Therefore, a strong insight into the domain of knowledge will include the following elements:

- A list of main concepts (classes and subclass) involved in the distribution process.
- A list of relationship (objective properties) between the domain's concepts depends on transport activity.
- A list of data properties.
- Determine decision variables (transport service- operation policy)
- Determine main parameters of transport activity (flows- associated with transport cost-distance)

4.5 Source Ontology Design:

The aim of designing a dry port locations network is to identify sufficient dry ports in the energetic hinterland in relation to their location, capacity, and mainly the connections to seaports and as well as between themselves. However, such a network in MCs regional hinterlands is restricted by the planned (national candidate's pre- selected locations) and existed dry ports and their transport connections to the main container seaports in MCs regional hinterland, namely: Latakia port in Syria and Beirut port in Lebanon. In addition, the expected increase of container volumes and the shipping demand within the zone of influence of each location as well. Therefore, the demand – supply relationship and the choice behavior of main stakeholders namely: (terminal user- terminal owner - and community) should be carefully modelled to meet customer demands across regional hinterland and beyond.

In few words, source ontology which will be called Container Movement Route Ontology (CMRO), will demonstrate sustainable distribution scenarios of containerized flows within MCs hinterland based on transport activities interacting with facility locations (seaport - dry port and demand destination), which vary depending on the stakeholder’s objectives.

Source ontology (CMRO), is a semantic-based representation of transport activities within regional network based in presence of dry ports in transportation system, to formally explicate all available scenarios of containers routes which the decision makers should be knowledgeable about. However, the (CMRO) will be designed in two phases, which are: conceptualization and formulation.

In the conceptualization phase number of main questions that the ontology should provide answers for, glossary and definition of main ontology concepts have been developed by using Web Ontology Language/OWL and Resource Description Framework/RDF. Furthermore, in the formulation phase the ontological elements have been modelled using open source software Protégé (5) and a number of main Description Logic/DL queries have been introduced to illustrate network elements (Nodes and Links) and available container movements.

4.5.1 Conceptualization

As mentioned previously in the literature review (Section 2.5.1), ontology is an ambiguous environment that has been developed as a useful means of capturing knowledge (Noy & Mcguiness 2001), and they could be considered as a computational language for defining the main components and the relationships between them to explain a certain domain of knowledge (Gruber 1993).

Therefore, it is important to carefully define and determine the scope of ontology. However, “Conceptualization” is the longest step in the construction of an ontology as it, 1) defines the domain of knowledge that relies heavily on the knowledge of expertise to answer the main questions the ontology build to answer 2), introduces all concepts and their properties by putting all of them together in a specific glossary 3) finally, describes all ontology’s concepts, attributes, relations and constraints.

4.5.1.1 Basic Questions of Source ontology

In relation to developing the basic questions that ontology must be able to answer, we depend heavily on the researcher's knowledge expertise and the status quo in the Mashreq region, which will be explained in detail in the next chapter. In this step, two fundamental questions regarding the distribution process in the integrated dry port network are classified.

A)- Questions to describe Transport Network:

1. How to address the transportation network' components (Nodes-Links)?
2. What are the transport services availability at facility location including seaport and dry port facility locations?
3. How to define all relevant terms of distribution scenarios in presence of dry ports facilities in location-allocation system?
4. What are the available transportation routes of container traffic within both the national and regional network?
5. Which of the dry port candidate's locations are to maintain a sustainable distribution scenario?

B)- Questions to explain Container Movement within Integrated network:

1. What are the actions of transport activity within a related facility location in the network?
2. What are the possibilities of container movement scenarios in presence of dry ports?

3. Who are the main stakeholders? And how can they decide on their shipment routes (transport services availability at facility location)?
4. What is the beneficial distribution scenario choice for main players?

4.5.1.2 Source ontology's Glossary

In regarding to the utmost related concepts, we developed the ontology's glossary that contains explanation and descriptions of the main concept as it is stated in the following table:

Table 4.1. Glossary of Source Ontology

Concept	Definition
Facility Location	- A geographical place which may be classified as origin or destination in distribution scenario
Link	- Link is a connection between origin nodes and destination through dry ports
Infrastructure	- Any road or rail link connection between nodes
Transport service	❖ Road Transport service ❖ Rail Transport service ❖ Multi-modal Transport service.
Transport Activity	❖ Road Activity ❖ Rail activity
Transport's Means	❖ Long vehicle ❖ Locomotive

Container Shipment	Container Shipment (CS) is a certain amount of containerized flow (TEU) shipped in Containers.
Stakeholder	Stakeholders represent main player or decision –makers in distribution process, namely, terminal owner, terminal user and community.
Transport Route	Transport route is a set of links thst connect origin to destination of which each transport route (TR) Consist of sections $\sum$ (i.j) Link ❖ RO-RO Link ❖ RO- RA Link ❖ RA-RO Link ❖ RA-RA Link

4.5.1.3 Basic Concepts and relationship of Container Movement Route Ontology:

To be able to answer the first group of questions we must ask: 1. What are the main components of the transportation network (nodes-links) and 2. How to define all relevant terms of distribution process in presence of dry ports facilities in transportation system? We believe that the best way to describe the components of the transport network is to develop a workflow- based knowledge that explains the domain of knowledge.

In this regard, we provide an overview of the transport network system which contains a set of nodes and links between them by using the Resources Description Framework language/RDF (which explained earlier in the literature review- section (2.4.3)).

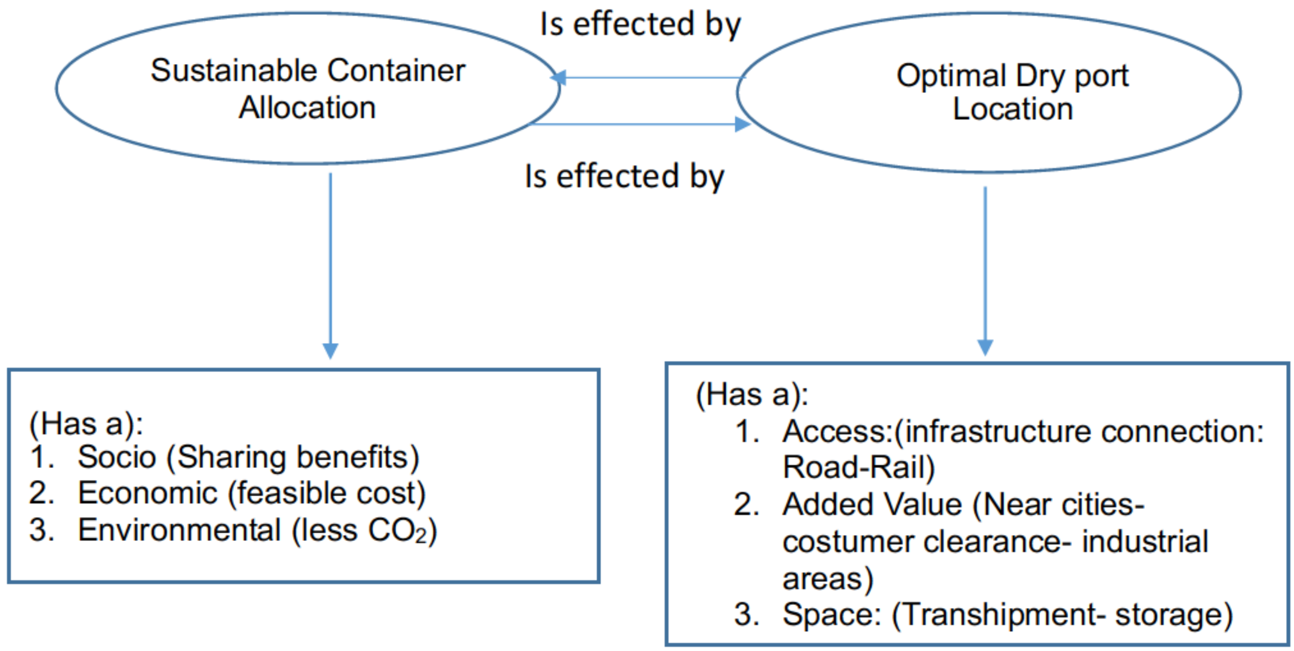
Our construction is modelled as a workflow of basic relationships between optimal dry port location for container allocation (our model is based on container movement). Since our focus is on the design of an integrated seaport-dry port network, we have dedicated the main facilities locations (seaport, dry port) and designated the relationships between them depending on the location-allocation relationship fact which is illustrated in (Figure.4.2), to find the answers that the ontology is looking for:

1. Container allocation decision effected by the best dry port location
2. Dry port location decision effected by optimal container allocation

Our ontology can be understood as a formal representation of ontology described by a graph, as the Resource Description Framework/ RDF language is a data model in which its basic building blocks are represented as:

(Resource-Property-Value) Triple.

And, it could be represented as a graph-based statement, where the RDF language is made up of a (*property*) the relationship between (*resource)* the subject of the statement and (*Value)* the object of the statement.



(Figure.4.2) Location-Allocation Relationship

In our model the main building blocks are: *(Containet_Shipment_Requirement, STK_Objectives Transport_service, Transport_Activity, Link, and Facility Location)*. However, to represent main building blocks (Concept/ Classes and Subclasses) we use circle shapes, the directed arrows stand for relations between classes that are expressed by words *(has_a), while* between classes and subclasses expressed by words *(is_a*. Lastly, Object Properties are represented by arrows labeled with name of property.

In addition, to denote an ontology's individuals we build up green boxes for (data type) classes and subclasses associated with green arrows to express relations of an individual to ontology class. Such graphs can be generated by using (OntGraph) plug-in in Protégé

5 (mentioned in Literature review section 2.2.5).

4.5.1.4 Ontology Components

An Owl ontology consist of classes, properties and individuals. However, the following section will provide sufficient information on the main component of the CMR ontology.

A)- Classes

Ontology contains a set of classes (in OWL Class uses as concrete representation of word concept), that contain number of individuals (instances). Classes are described using formal description for state key requirements for membership of the class. For instances, the class *(Facility_Location)* would contain all the instances that are at a facility location in our ontology such like, *(Dryport)*, (*Seaport)* and *(destination)*.

Moreover, classes have hierarchical relationship with super-classes and sub-classes, which is also known as (taxonomy). In our case, for example *(Domain_Entity) (is_A)* superclass of *(Facility_location)* class, and *(Dry port)* class is a subclass of (*Facility_location)* class. This says that all dry port are facility locations, and all members of the class dry port are member of the class facility location.

One of the strong features of OWL language is that it is a hierarchal relationship between (superclass-subclass) and can be computed automatically by Reasoner. Figure 4.3 shows a representation of some classes containing individuals – classes are represented as circles or ovals.

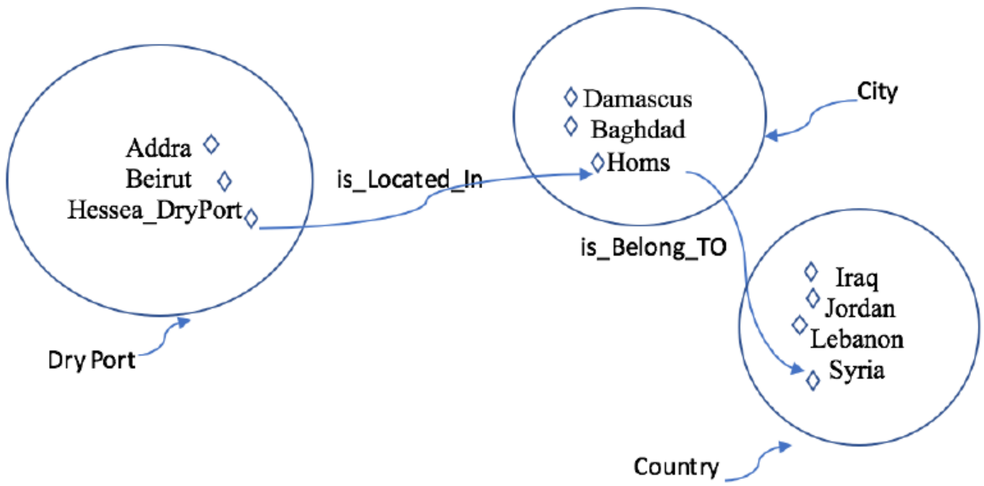


Figure 4.3: Representation classes contains individuals.

B)- Individuals

Individuals (instances) represent objects of the domain which we are interested in.

Table 4.2 shows some individuals in some domain.

Table 4.2 some individuals in same domain.

Class	Individuals	
	Seaport	Dry port
Facility location	Latkia_SeaPort	Addra_DP
	Bierut_SeaPort	Hessea_DP
		Baghdad_DP
		Bierut_DP

C)- Properties

Properties are a binary relationship between two classes, precisely between the individuals that belong to this specific class. For example, the property (is_Located_In) will connect the individual (Hessea_DryPort) ∊ (DryPort) class to individual (Homs) ∊ (City) class, while property (Provide_Service_To) will connect the individual (Hessea_DryPort) ∊ (DryPort) class to individual (Container_Shipment_n)) ∊ (Container_Shipment) class. This is represented in (Figure 4.4).

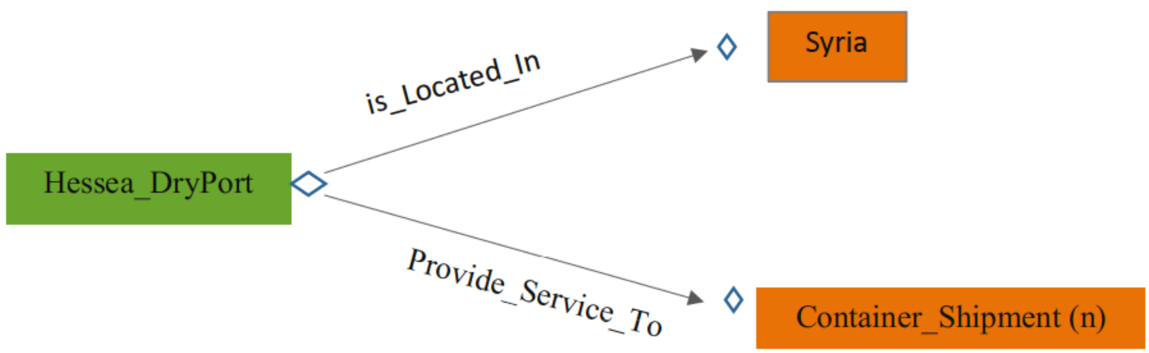


Figure 4.4: Representation of Classes contains individuals.

Furthermore, properties have inverse property. For example, the property (is_Performed_By) has domain of (Transport_Activity) class, and takes its individuals from range ∊ (Transport_Equipment) class which contains {Vehicle, Locomotive}. This property has an inverse property (is_Accomplish_A) which has a domain of (Transport_Equipment) class, and takes its individuals from range ∊ (Transport_Activity) class which contains {Road Activity, Rail Activity}.

As we mentioned before there are two main types of properties, object properties and Datatype properties. Object properties are relationship links to two individuals, while datatype properties link individuals to data value (XML Schema Datatype value or an rdf literal which has a type integer or string …etc.).

They also have “property characteristics” which is (functional) when they have a single value, and they can also be either transitive or symmetric. This information was explained in detail in the literature review section (2.7). Figure 4.3 shows a representation of some properties linking some individuals together.

4.5.1.5 Building (CMR) Ontology

This section describes how to create an ontology of Container Movement Route that can represent all the necessary knowledge of transport activities within an integrated network. The use of ontology allows us to design Container Movement Routes domain of knowledge, namely the main classes and their properties, to monitor transportation cost in relation with travel distance and maximum flows.

In summary, transport activity moves the container which will be mentioned as (TEU) Twenty Equivalent Unit, from the storage yard in the seaport (facility location) which is performed by transport equipment that travels on (link) to the candidate dry port (facility location) where the modality change can occur and then continue its trip to its destination. In relation to transport activity there are only two transport activities to move (TEUs) from seaport to dry port, namely: road transport activity and rail rransport activity.

An ontology domain of knowledge describes the distribution scenario in integrated dry port networks to attain a sustainable traffic for containerized flows within the regional hinterland.

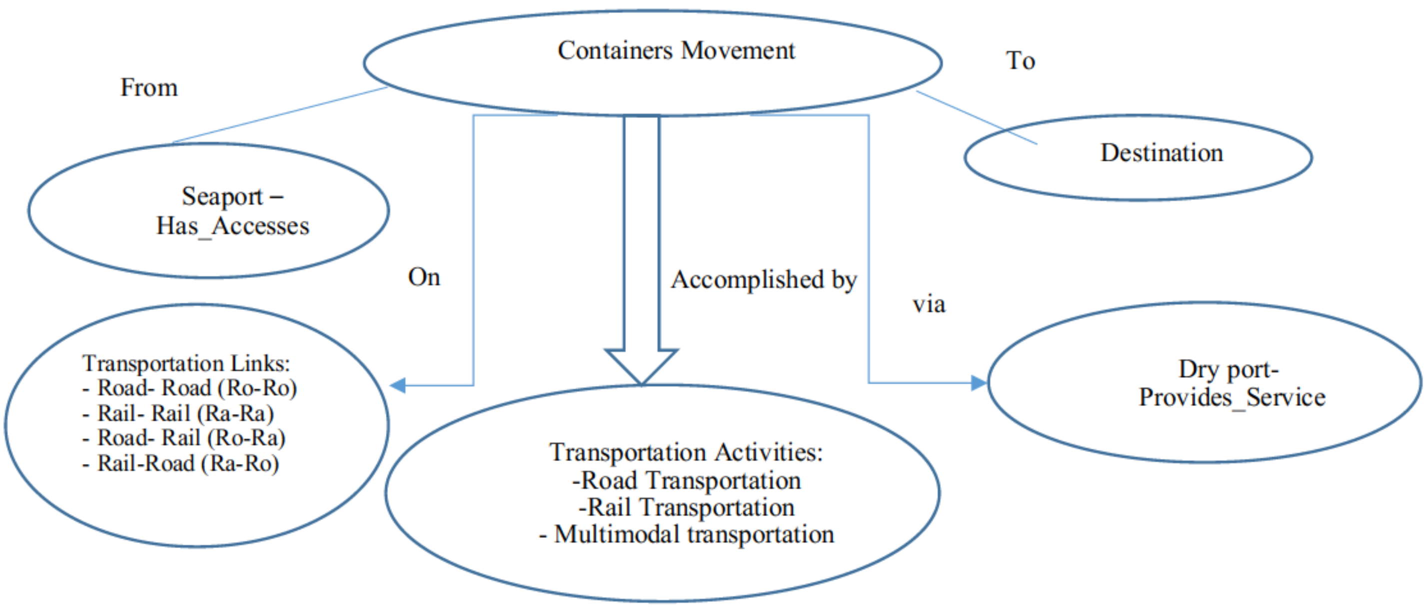


Figure 4.5 Distribution scenario of container allocation (Ontology domain)

A)- Network Ontology

First, we build up a **Network Ontology** that explains the network structure itself, which contains of nodes (which are referred to as facility location in our model) and links between them. Then, a **Movement ontology** is built to explain the movement of containerized flow (container distribution) in two different configurations of national and regional scenarios.

Depending on Resource Description Framework/RDF language (class –property- value), the main concepts of facility locations in network configuration and the connections between them was defined as follows:

1. Facility Location/ Nodes

1.1 Concept Definition:

Facility location is a facility place containing three kinds of sites: seaport, dry port and demand centre. Regarding CMR ontology, each facility location might be classified as origin or destination in distribution scenario, unless the seaport facility which is recognized only as origin in relation to movement direction. However, facility location subclasses are displayed in the Figure 4.6:

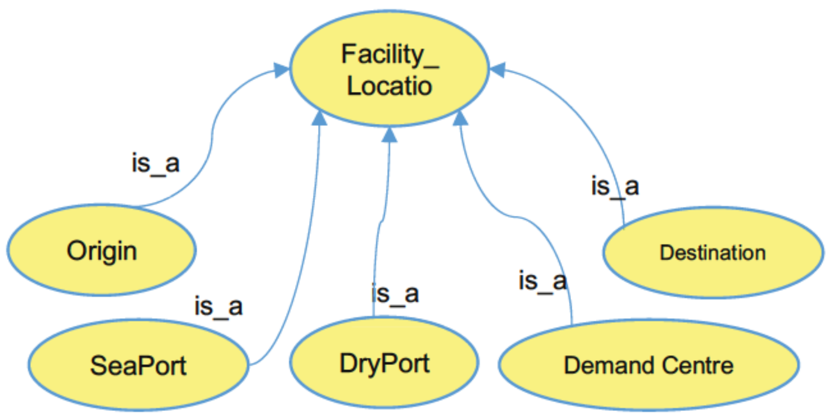


Figure 4.6 Displaying the hierarchy for class (facility location)

1.2 Object Properties:

The (Facility_Location) concept has several defining object properties that are demonstrated as follows:

(Facility_Location) is_Located_In (City)

(City) is_Located_In (Country)

(Facility_Location) is_Located_In (Country)

(Facility_Location) is_A_StartPoint_Of (Link)

(Facility_Location) is_An_EndPoint_Of (Link)

(Facility_Location) is_A_StartPoint_Of (Transport_Route)

(Facility_Location) is_An_EndPoint_Of (Transport_Route)

(Facility Location) has_A_Coordinate_Points (Latitude)

and

(Facility Location) has_A_Coordinate_Points (Longitude)

1.3 Relationship with another concepts/ Object Properties:

Table 4. 3 Displaying (Facility_Location) class object properties

Facility_Location Relationship with another **Class**	**Sub Class**	**Object Property**	**Domain**	**Range**
Link	- Road T.A - Rail T. A	- (has_A_StartPoint) - (has_An_EndPoint)	Link	Facility_Location
Geographical Location	City	is_Located_In	Facility_Location	City

Geographical Location	Country	is_Located_In	Facility_Location	Country
Transport_Activity	- Road T.A - Rail T. A	Interacts With	Facility_Location	(T.A)
Coordinate_Points	- (Latitude) - (Longitude)	has_A_Coordinate_Points	Facility_Location	Coordinate_Points
Transport_Route	- Ro-Ro - Ro-Ra - Ra-Ro - Ra-Ra	- (has_A_StartPoint) - (has_An_EndPoint)	Transport_Route	Facility_Location

2. Links

2.1 Concept Definition:

A **Link** is infrastructure (road or rail) that connects between two facility locations, precisely between origin nodes (seaports) and destination nodes, through dry port nodes as follows:

- **L_{Ro}:** Any link object that has infrastructure some road infrastructure connection between nodes.
- **L_{Ra}:** Any link object that has infrastructure some rail infrastructure connection between nodes.

2.2 Object Properties:

A **Link** has several defining properties:

(Link) has_A_StartPoint some (Facility_Location)

and

(Link) has_An_EndPoint some (Facility_Location)

(Link) has_A_infrastructrueType some (Road)

or

(Link) has_A_infrastructrueType some (Rail).

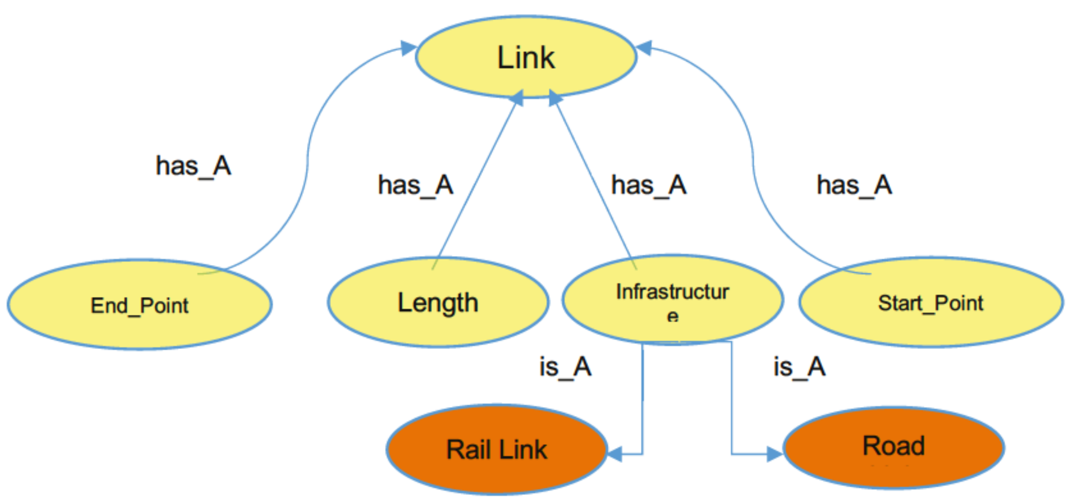


Figure 4.7 Displaying the hierarchy for Class (Link)

2.3 (Link) class relationship with another concepts/ Object Properties:

Table 4. 4 Displaying (Link) class object properties

Link Relationship with another **Class**	**Sub Class**	**Object Property**	**Domain**	**Range**
Transport_Activity	- Road T.A - Rail T. A	Excuted_On	(T.A)	Road Link or rail link
Facility Location	- Sea Port - Dry Port - Destination	has_A_StartPoint	Link	Facility Location
Facility Location		has_An_EndPoint	Link	Facility Location
Infrastructure	- Road - Rail	has_A_infrastructrue	Link	Infrastructure
Infrastructure		has_A_infrastructru	Link	Infrastructure

3. Infrastructure:

3.1 Concept Definition:

An Infrastructure **type** can be road infrastructure or rail infrastructure that connects between two facility locations

- **Road Infrastructure:** Any Infrastructure object that has infrastructure some Road connection between Facility locations.
- **Rail Infrastructure:** Any Infrastructure object that has infrastructure some Rail connection between Facility locations.

3.2 Objective Properties:

(Infrastructure) (is_a) some (Road)and(Infrastructure) (is_a) some (Rail, and its relationship with class (Link) has explained above-mentioned.

B)- Movement Ontology

As we mentioned earlier in section (4.5.1) the conceptualization level must carefully define key concepts of a certain domain to describe all attributes and relationships between concepts over Network Ontology concepts and Movement Ontology. In this section, the main concepts of Movement Ontology which include: (Container Shipment (CS), (Transport Service (T.S) , Transport Activity (T.A) , Transport Route (T.R) and Stakeholders (STK)) will be explained and analyzed as follows:

First, the key concept of container shipment is introduced in this chapter, while the rest of Movement Ontology concepts are Included in Appendix (1).

4. Container Shipment (CS):

4.1 Concept Definition:

Container Shipment (CS) is a certain amount of containerized flow (TEU) shipped in containers.

4.2 Objective Properties:

The `(Container_Shipment)` concept has two main significant object properties that demonstrated as follows:

4.2.1 (Container_Shipment) (CS) has_A (Container Shipment_Requirment) some (Objective) and some (Specifications) and some (Transport_ModeServices)

where is:

- Domain is (CS)
- Range is (Container Shipment Requirements) which is illustrated in detailed in Figure 4.8.

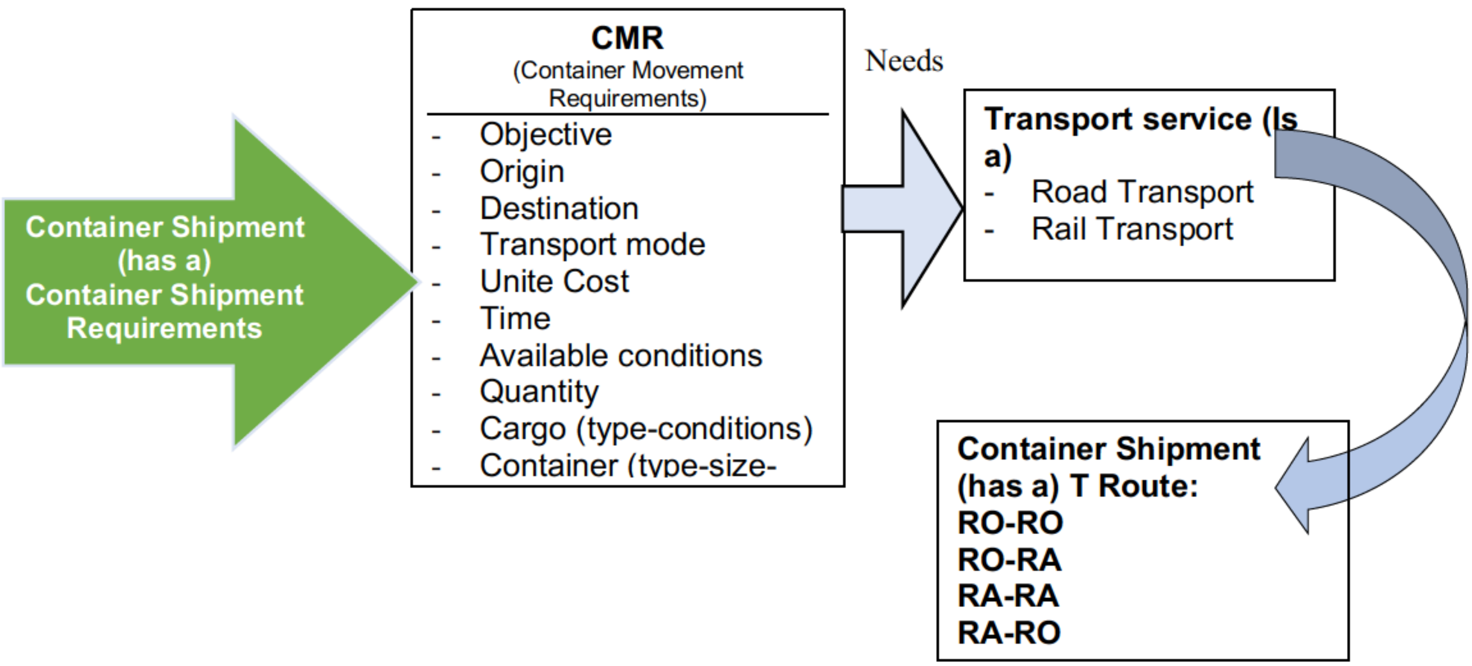


Figure 4.8 Displaying the movement domain of knowledge

4.2.2 (Container_Shipment) has_A (Transport_Route) some Transport Route (TR).

where is:

- Domain is (CS)
- Range is (TR) which is:
  - Road Transport Route (RO-RO) or,

- Rail Transport Route (RA-RA) or,
- Multi modal Transport Route (RO-RA) or,
- Multi modal Transport Route (RA-RO).

4.5.1.6 Ontology Mapping

In this final step, we gathered all the concepts in one map that help to demonstrate the whole idea of Container Movement ontology, where we merged the main concepts of the network ontology and the Movement ontology concepts.

The expected scenarios will comprise of the following elements:

- S: Set of sea port nodes (origin).
- H_e, H_p: Set of dry port existed and candidate Location respectively.
- D: Set of destination/D.
- CS: Incoming containers Shipments to Mediterranean Sea by (TEU).
- L: Infrastructure Links (connections between nodes) Road links - Rail links.
- Transport unit cost
- Transport service type: (Road-Rail and Multimodal transport).
- Transport Routes:
    1. Rail-Rail (Ra-Ra)
    2. Rail-Road (Ra-Ro)
    3. Road-Road (Ro-Ro)
    4. Road-Rail (Ro-Ra)

The resulted scenario will be examined in Minimum cost flow assignment using Excel Solver software to calculate the transport cost for each available route between origin and destination. Consequently, the lowest cost route will include the preferable candidate dry port that should be used to serve the shipments with lowest cost.

The ontology outputs should describe all the available distribution scenarios of a certain container shipment (n) as clarified in the following table:

For example,

Container Movement Route	Origin (Seaport)	Destination	Via Dry port	Transport Service	Link (Type-Length)	Unite Cost
CMR (1)	Latakia (Seaport)	Iraq (Abu-Graib Dryport)	Addra Dryport	Rail Transport	Ra-Ra 320 Km	(2.4) S.P per Km

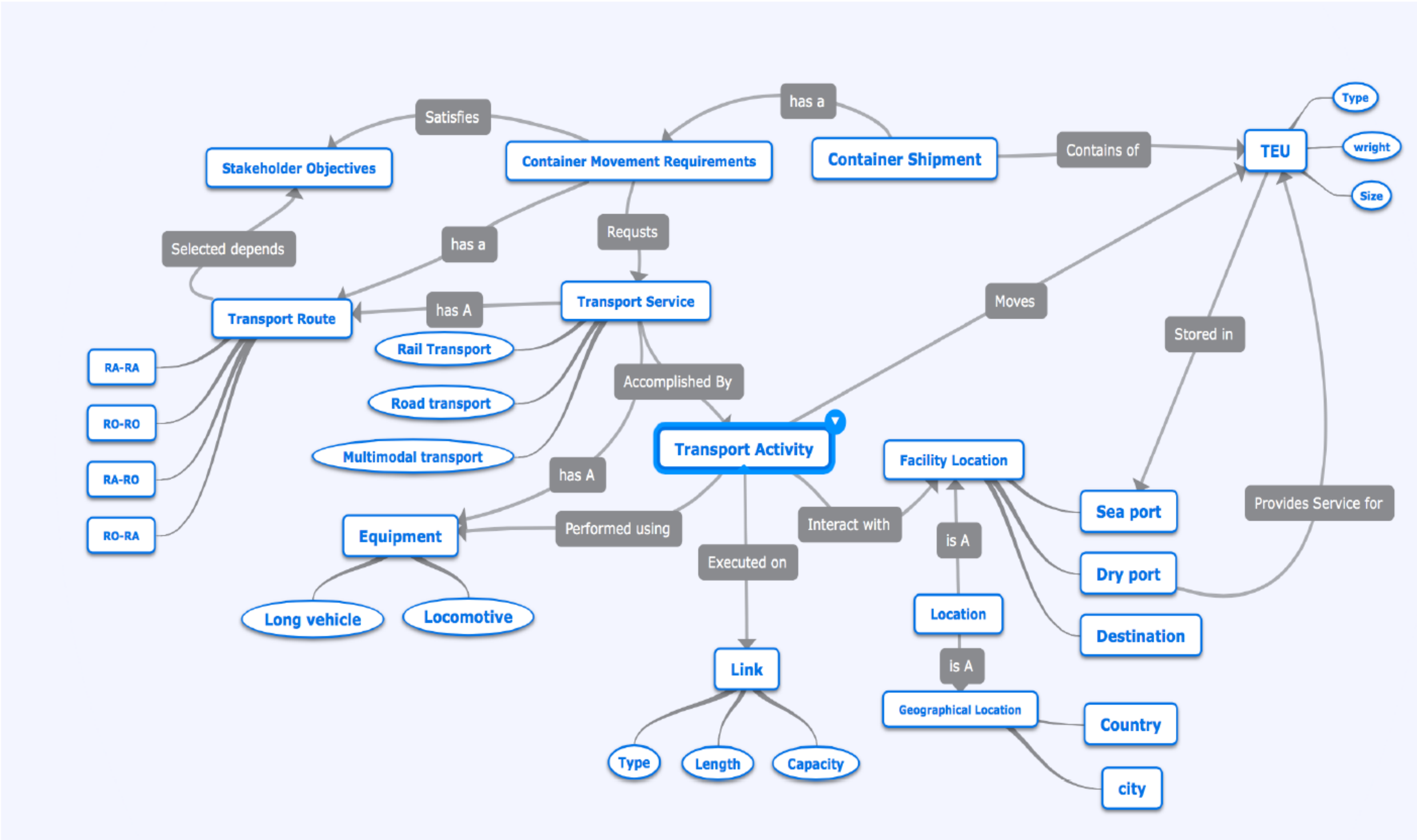


Figure 4.11 Container Movement Route Ontology Mapping.

4.5.2 Formulation

The OWL ontology, described earlier enabled us to design the knowledge domain of container movement routes using concepts and their relationships that hold between those as demonstrated in section 4.5.1. However, to visualize the developed CMRO, open source software Protégé 5 was used to define concepts as classes & subclasses and relationships as object properties. This in its turn, will provide the necessary information required to describe all available container distribution routes.

To describe a container's distribution process within the given network, we focused on explaining the process of transport activity concepts. A transport activity describes movements of containers from the storage yards in a seaport using a transport equipment on connection Links to destination throughout candidate dry port. Therefore, evaluating the transport activity process, will allow us to identify the lowest transport costs, in relation to travel distance with maximum flows, for each link within the integrated dry port network. Doing so, a container's distribution scenario which has the lowest cost and maximum flow, will be considered a sustainable distribution within a regional hinterland.
Protégé 5 is an open source software that supports OWL ontology language. The highly configurable user interface provides a rich environment to create, modify and share ontologies for collaborative viewing between experts in certain domain of knowledge. The several set of operators such as, union, intersection and negation in Protégé 5 make it possible to define and describe complex concepts out of simpler concepts.

Moreover, all the statements of CMRO can be checked and examined whether it is mutually consistent or not by using a (Reasoner) tool which can recognize what subclasses are fit under which classes. Therefore, the reasoner can particularly be useful is some cases when sub-class has more than super-class to maintain the correction in hierarchal relationships between an ontology's components.

Finally, the main steps to implement source ontology in Protégé 5 are described by a number of tasks which are illustrated in detail in appendix (1) covering two section (4.5.2.1) and section 4.5.2.2 that cover the Description Logics/ DLs Syntax.

4.6 Summary

An ontological approach of flow network design based on container movement requirements was introduced in this chapter in order to satisfy multiple stakeholders objectives. Precisely, a source ontology of container movement route (CMRO) was built over two major steps that describe all available container movement routes in the presence of dry ports within an energetic hinterland of seaport. First, at the conceptualization level, main concepts (super classes- subclasses) and their properties were developed by using Resource Description Framework (RDF) language and a CMRO Map was formulated. Furthermore, to visualize (CMRO) at a formulization level, an open source software protégé 5 was used to model (CMRO) concepts and its objective properties. Finally, a new solution for the problem of negotiating between stakeholders at the decision-maker level was delivered. CMRO offers a new approach to the design network configuration by providing a corporate platform to optimize the negotiation process to design flow movement within a regional and national transport network. The proposed CMRO solution creates an environment enabling all negotiating stakeholders to avoid any misunderstandings during the negotiation process.

Chapter 5
CMRO Implementation

Case Specific Ontology

(The Implementation of Mashreq Ontology)

5.1 Introduction

After modeling CMRO services as DLs syntax in the previous chapter, in this chapter a case specific ontology of CMRO will be implemented to obtain the available scenario of container distribution in the Mashreq regional network.

First, data were collected to study and analyze the current situation of Mashreq countries in terms of dry port location decision and the main influencing factors of dry port location implementation from a multi-objective point of view. Then, CMRO will be fed with Mashreq data to build up certain cases of CMRO as case specific ontology. Finally, description logics query (DLQ) service will be executed by reasoning the CMRO results in order to obtain distribution scenarios of two main scenarios of operation strategy (National-regional).

As explained in detail in Chapter Four (section 4.5), a theoretical idea of building up the case specific ontology depends on an extra level of generic ontology (which is source ontology in our case) and can be added to formulate a certain case of CMRO. This, will result in a strong framework of the thesis theory and will form a basic structure for building a

flexible model for the Integrated Dry Ports Network IDPN.

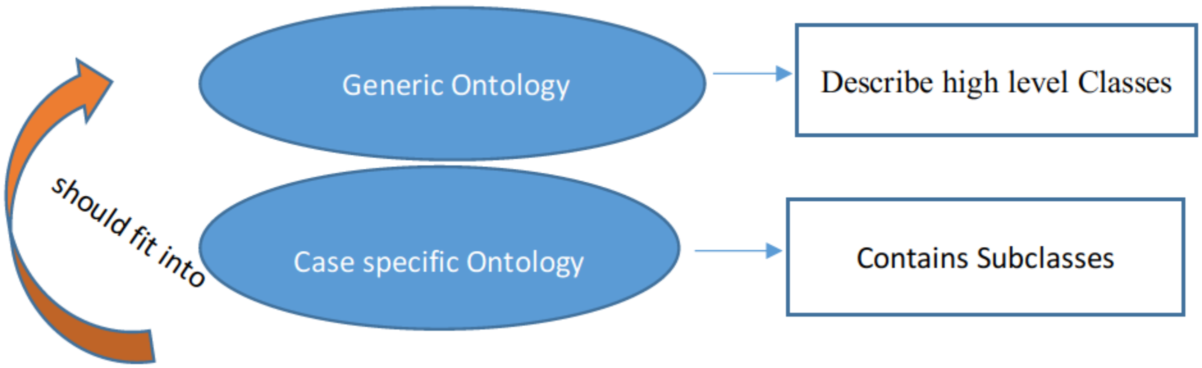


Figure 5.1 Case Specific Ontology

In this chapter, row data of the transport system were collected in four Mashreq countries in order to persuade the Source ontology to carry out a certain case study. As explained in detail in section (5.2) to (5.6), data on the planned and existing railway network and dry ports as well as seaports have been identified in order to for the validation of the CMRO model in Chapter 6.

5.2 Data Collection in Mashreq countries

5.2.1 Latakia Seaport in Syria:

5.2.1.1 Total Traffic at Latakia Seaport:

Table 5.1 Total Traffic at Latakia Seaport (2005-2011)

Thousands Tons

Year	2005	2006	2007	2008	2009	2010	2011
Total Traffic	7322	8093	7821	8062	9562	87[illegible]	[illegible]
Import	6239	6931	6349	6800	8286	7399	6843
Export	1083	1162	1472	1262	1276	1317	1097
Transit	183	227	146	180		180	162

Thousands Tons

Total traffic

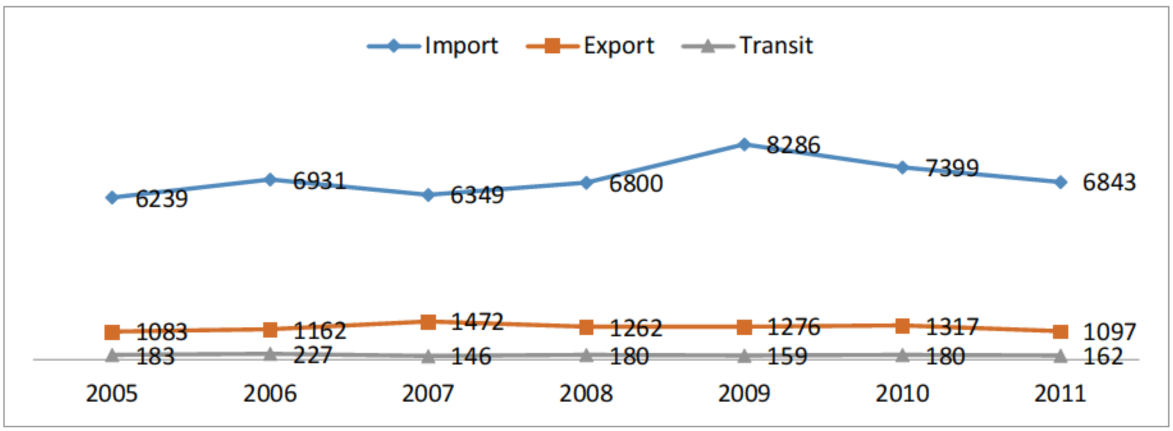


Figure 5.2 Import & Export Traffic at Latakia Seaport (2005-2011)

Table 5.2 Total Incoming /Outgoing Traffic (Containerized & Bulk cargo) (2005-2011)

Tons

Year	2005	2006	2007	2008	2009	2010	2011
Containerised Cargo	3860590	4703678	5390787	5629872	6085280	5775178	5176022
Bulk Cargo	3461378	3389471	2429894	2431870	3478188	2893148	2764182
Total	7321968	8093149	7820681	8061742	9563468	8668326	7940204

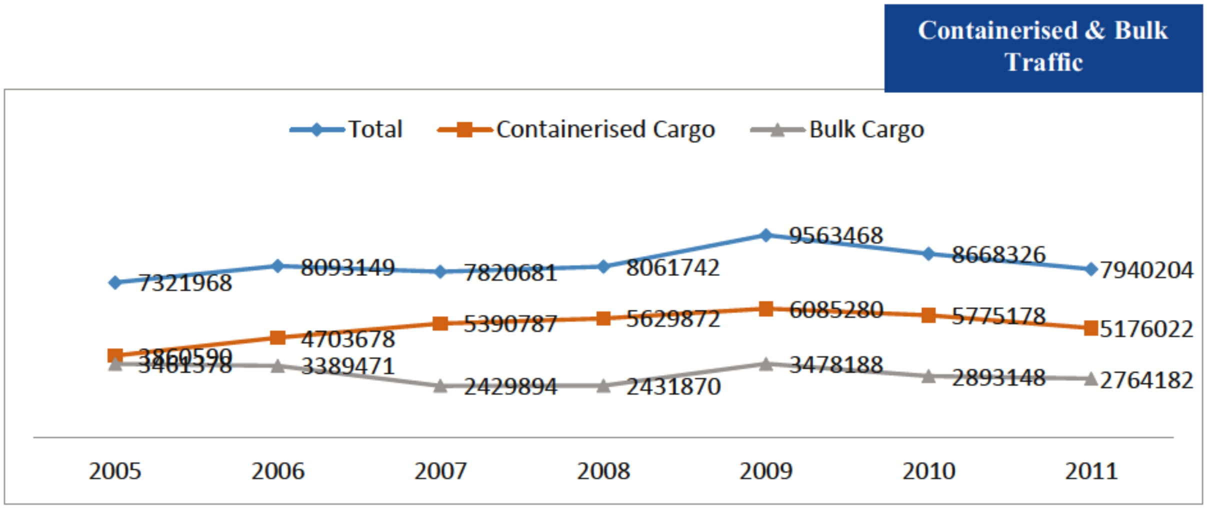


Figure 5.3 Containerized & Bulk cargo Traffic at Latakia Seaport (2005-2011)

5.2.1.2 Container Traffic at Latakia Seaport in Syria:

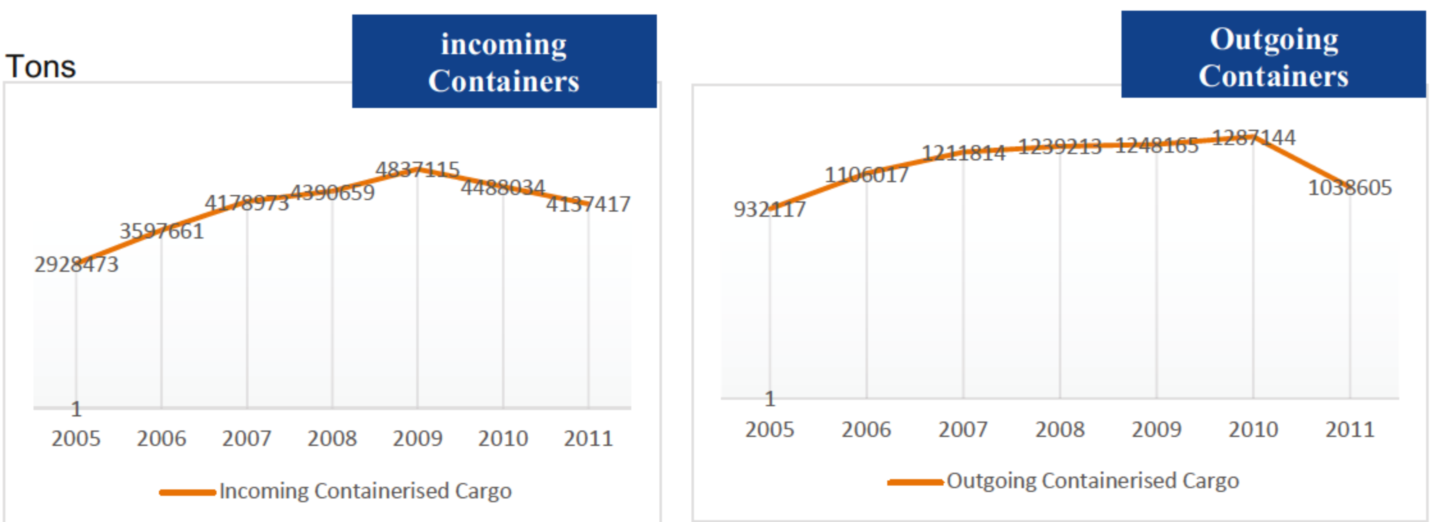


Figure 5.4 Incoming & outgoing Containerized Traffic at Latakia Seaport (2005-2011)

A)- Incoming Containers Traffic:

Table 5.3 Incoming (Loaded- Empty) Containers Traffic at Latakia Seaport (2005-2011)

	Year						
(Units)/TEU	2005	2006	2007	2008	2009	2010	2011
Loaded	191988	238086	270256	284177	313185	291910	261033
Empty	938	940	756	1080	990	316	315
Total	192926	239026	271012	285257	314175	292226	261348

	Year						
Tons	2005	2006	2007	2008	2009	2010	2011
Loaded	2926411	3595572	4177286	4388282	4834937	4487339	4136724
Empty	2062	2089	1664	2377	2178	695	693
Total	2928473	3597661	4178950	4390659	4837115	4488034	4137417

B)- Outgoing Containers Traffic:

Table 5.4 Outgoing (Loaded- Empty) Containers Traffic at Latakia Seaport (2005-2011)

	Year						
(Units)/TEU	2005	2006	2007	2008	2009	2010	2011
Loaded	51327	54729	53501	53842	49361	58785	41918
Empty	146516	178215	208724	229097	262329	234394	218645
Total	197843	232944	262225	282939	311690	293179	260563

	Year						
Tons	2005	2006	2007	2008	2009	2010	2011
Loaded	636809	709830	752620	734526	671041	771477	557586
Empty	295308	396722	459194	504686	577124	515667	481019
Total	932117	1106552	1211814	1239212	1248165	1287144	1038605

5.2.1.3 Transit Traffic from Latakia Seaport to Mashreq Countries:

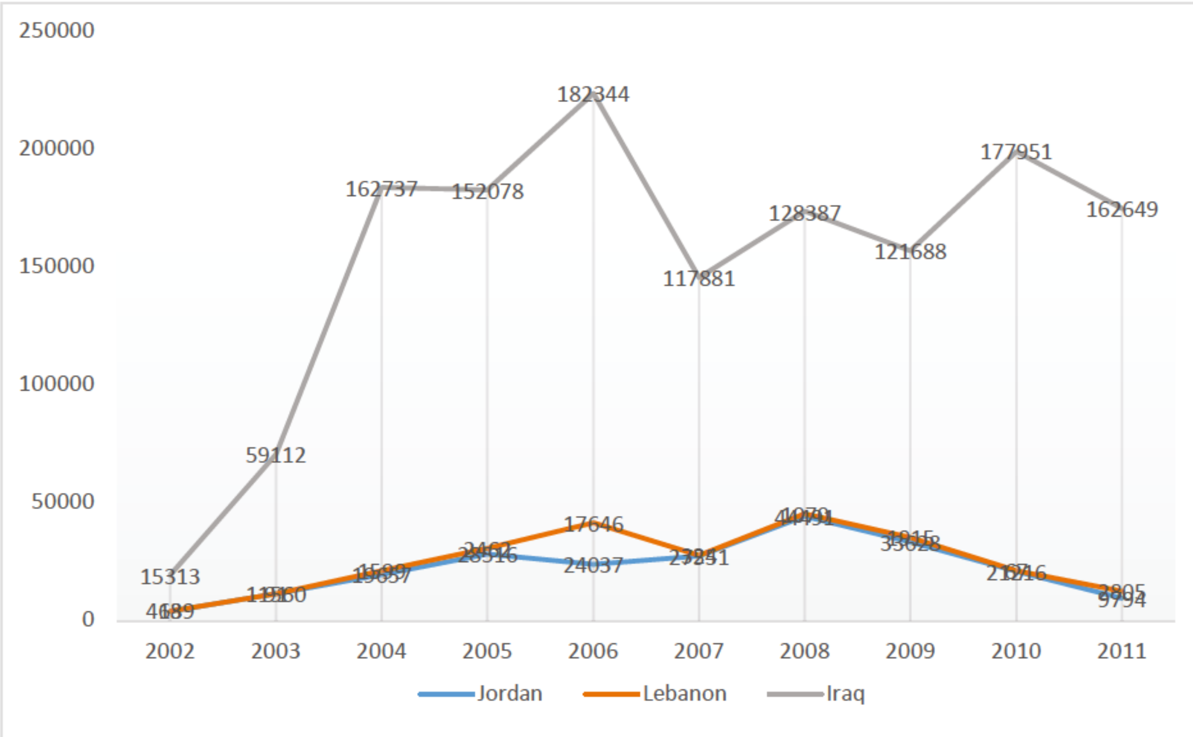


Figure 5.5 Transit from Latakia Port to Mashreq Countries (2002-2011)

5.2.2 Tartous Seaport in Syria:

5.2.2.1 Total Traffic at Tartous Seaport:

Table 5.5 Total Traffic at Tartous Seaport (2005-2011)

Thousands Tons

Year	2005	2006	2007	2008	2009	2010	2011
Total Traffic	12375	12767	12584	12939	14123	13439	11437
Import	9643	9773	9636	10767	12426	10709	9250
Export	2732	2994	2948	2172	1697	2730	2187
Transit	2760	1945	1679	1886	2336	1632	1589

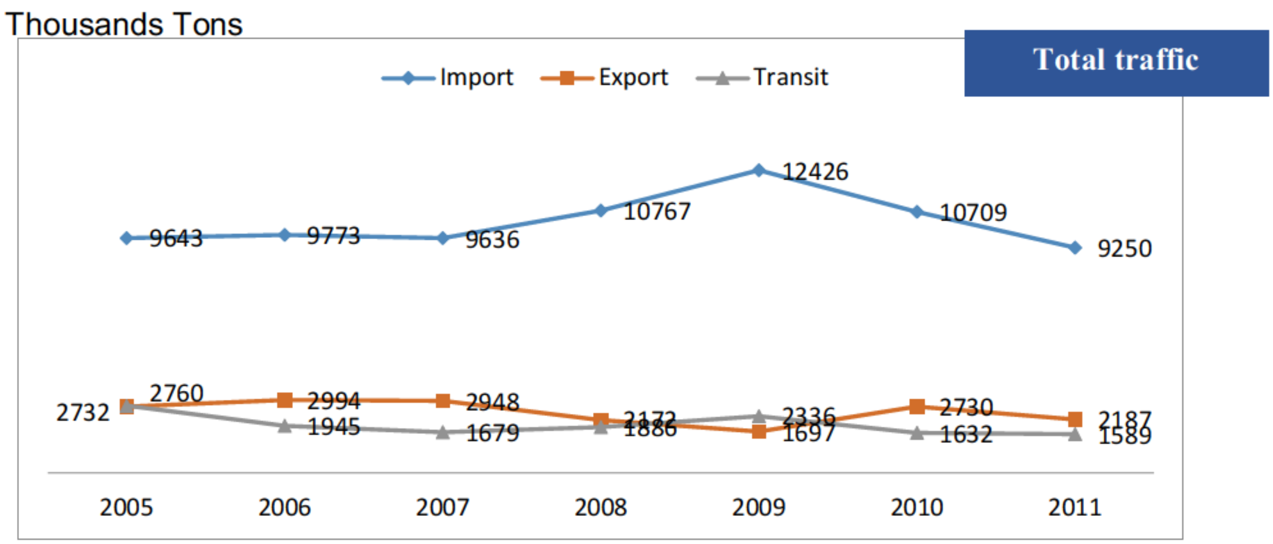


Figure 5.6 Import & Export Traffic at Tartous Seaport (2005-2011)

Table 5.6 Total Incoming Traffic (Containerized & Bulk cargo) at Tartous Seaport (2005-2011)

Tons

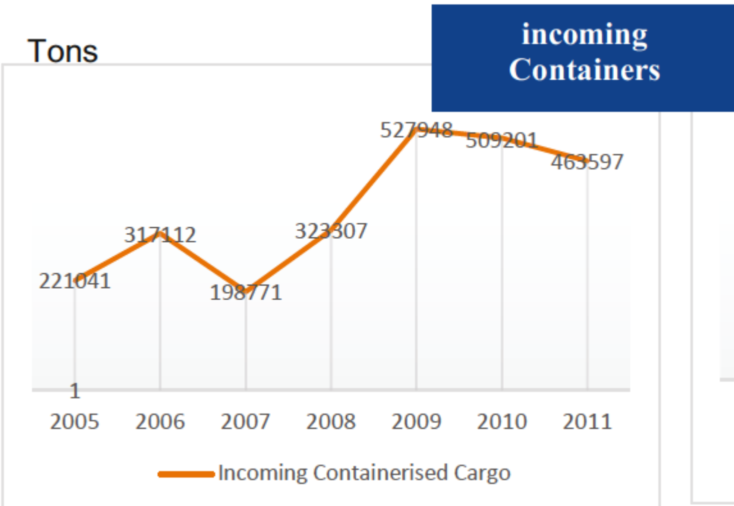
Year	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Containerised Cargo	221041	317112	198771	323307	527948	509201	463597
Bulk Cargo	9422233	9455742	9436789	10443206	11897593	10207690	8786433
Total	**9643274**	**9772854**	**9635560**	**10766513**	**12425541**	**10716891**	**9250030**

Table 5.7 Total Outgoing Traffic (Containerized & Bulk cargo) at Tartous Seaport (2005-2011)

Tons

Year	2005	2006	2007	2008	2009	2010	2011
Containerised Cargo	55570	46729	38366	58222	67082	78973	64673
Bulk Cargo	906240	824215	607066	272245	222329	415791	151789
Phosphate	1,769,909	2,122,989	2,302,102	1,841,895	1,408,055	2,237,509	1,970,175
Total	**2731719**	**2993933**	**2947534**	**2172362**	**1697466**	**2732273**	**2186637**

5.2.2.2 Container Traffic at Tartous Seaport:



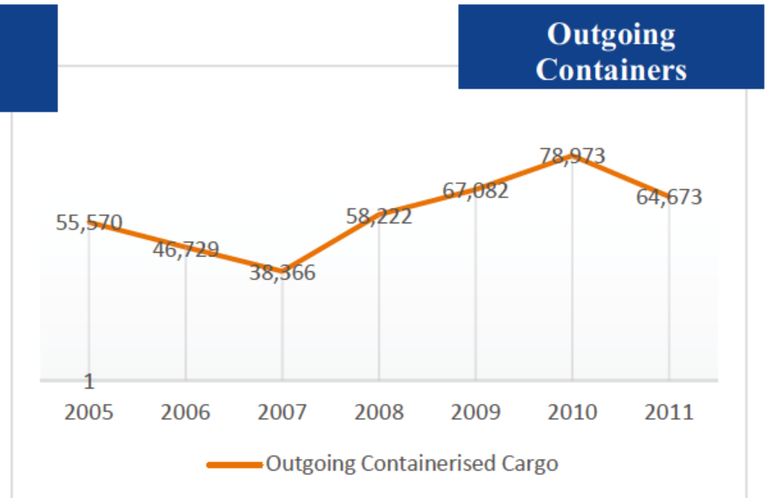


Figure 5.7 Incoming & outgoing Containerized Traffic at Tartous Seaport (2005-2011)

A)- Incoming Containers:

Table 5.8 Incoming (Loaded- Empty) Containers Traffic at Tartous Seaport (2005-2011)

	Year						
(Units)/TEU	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Loaded	15439	19490	14170	21128	31681	28890	26918
Empty	4	0	0	386	752	1745	664
Total	15443	19490	14170	21514	32433	30635	27582

	Year						
Tons	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Loaded	221033	317112	198771	322819	526340	505636	462211
Empty	8	0	0	541	1608	3565	1368
Total	221033	317112	198771	323360	527948	509201	463579

B)- Outgoing Containers:

Table 5.9 Outgoing (Loaded- Empty) Containers Traffic at Tartous Seaport (2005-2011)

	Year						
(Units)/TEU	2005	2006	2007	2008	2009	2010	2011
Loaded	1312	921	849	959	559	709	790
Empty	14706	18238	13725	19079	29616	31513	25827
Total	16018	19159	14574	20038	30175	32222	26617

	Year						
Tons	2005	2006	2007	2008	2009	2010	2011
Loaded	24279	7434	8735	17535	5853	11534	10162
Empty	31291	39295	29631	40687	61229	66349	53511
Total	55570	46729	38366	58222	67082	77883	63673

5.2.2.3 Transit Traffic from Tartous Seaport to Mashreq Countries:

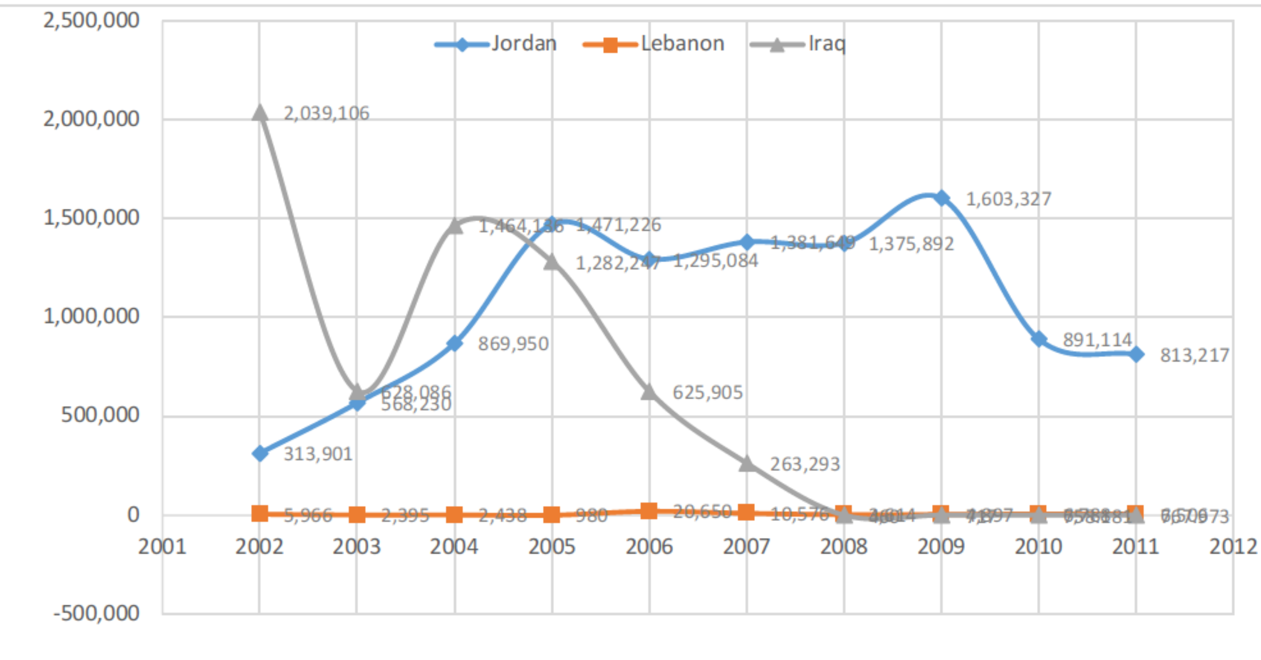


Figure 5.8 Transit from Tartous Port to Mashreq Countries (2002-2011)

5.2.3 Beirut seaport (POB) in Lebanon:

Table 5.10 Total Import Traffic to Beirut Seaport (2005-2011)

Tons

Year	2005	2006	2007	2008	2009	2010	2011
Containerised Cargo	1.939.4	1.823.3	2.390.8	2.740.7	3.069.4	3.284.9	3.333.1
None-Containerised Cargo	1.810.6	1.736.8	2.034.9	2.164.8	2.585.0	2.372.5	2.549.7
Total	3.750.0	3.560.1	4.425.7	4.905.5	5.654.4	5.657.4	5.882.8

Table 5.11 Total Export Traffic from Beirut Seaport (2005-2011)

Tons

Year	2005	2006	2007	2008	2009	2010	2011
Containerised Cargo	442.4	400.5	502.6	571.9	475.3	500.3	534.6
None-Containerised Cargo	315.1	316.9	393.7	272.5	193.7	320.6	289.2
Total	757.5	717.4	896.3	844.4	669.0	820.9	823.8

5.2.4 Seaports main Features in terms of Containers operation:

Table 5.12 Displaying seaports main features in terms of containers operation

Features/Unite	Beirut Port	Latakia Port	Tartous Port
Port Area (Sq.m)	2.000.000	2.800.000	3.000.000
Container Yards (Sq.m)	500.000	690.000	252.000
Approach Channel Depth (m)	15.5	14.5	14.5
Designated Capacity (Million)	9.0	5.6	12.0
Containers Designated Capacity (TEU/Year)	700	800	600
Maximum Vessels Depth (m)	15.5	12.30	12.20
Work Hours (hour/Day)	24	24	24
Containers operations (TEU/Day)	1200	600	400
Number of Containers Quays	2	2	1
Length of Containers Quays (m)	880	775	545

5.3 CMRO Implementation

In this step, we will apply Query service to obtain distribution scenarios. First, CMRO will be fed with Mashreq data in Protégé 5, then DLs quires will be implemented to reason the CMRO results.

5.3.1 CMRO/ Mashreq case specific ontology

CMRO will be represent in a certain case in Mashreq countries after adding all data that is collected mentioned above.

5.3.2 Description Logics Queries

In this step, after completing the setting up of the Description Logics Syntax as demonstrated in previous chapter (Task 12), we are now continuing to model and obtain the result of our CMRO as DL queries for each class.

Query service will answer the fundamental questions regarding the distribution process in the integrated dry port network. These questions have been addressed earlier in the previous chapter (section 4.5.1.1), in two groups as follows:

A)- Questions to describe Transport Network:

1. What is the approach to address the transportation network' components (nodes-links)?
2. How to define all relevant terms of distribution scenarios in the presence of dry port facilities in a location-allocation system?
3. Who are the main stakeholders? And how can they decide on their shipment routes?
4. What are the available transportation routes of container traffic within both: the national and regional network?

B)- Questions to Explain Container Movement within an Integrated Network:

1. What are the transport activities and actions within the related facility location in the network?

2. What are the possibilities of container movement scenarios in the presence of dry ports?

3. What is the beneficial distribution scenario choice for main players?

4. Which of the dry port candidate's locations are to maintain a sufficient distribution scenario?

5.4 Summary

In this chapter, a case specific ontology of Mashreq countries was built up by the implementation of CMRO. To obtain the available scenarios of container distribution in Mashreq regional network, a case specific ontology of CMRO has been built depending on Mashreq Data. (Instances-Data Properties). A historical Data Analysis for container traffic at Latakia Seaport and Beirut seaport was analyzed. Then, the data obtained in the previous step was used as input to train the case specific ontology. Finally, Description Logics DL Queries to answer main questions (network structure only) in order to generate available movement scenarios (national vs Regional operation).

Chapter 6

VALIDATION AND APPLICATION

6.1 Introduction

In this stage, our work is divided into two steps. First a “Mashreq Ontology” is built up as a case specific ontology, second a Minimum Cost Flow Assignment is applied by using Excel solver.

For validation purposes, the Minimum Cost Flow Assignment is believed to address the links that provide the lowest transportation cost and maximum flows between seaport and candidate dry port locations. Precisely, in the regional hinterland of main container ports in the Mashreq region namely: Latakia seaport in Syria and Beirut seaport in Lebanon.

The Minimum Cost Flow Assignment is considered as an effective way to find the best location facility within a linear programming solver, as it measures the total cost of links and address the link that provide maximum flows over a network. A short list of links from each seaport to each Mashreq countries (Syria- Lebanon- Jordan and Iraq) will be calculated using (Excel solver software) depending on Mashreq network attributes (Origin- Destination Links matrix, link type(road-rail), unite cost, traffic flow, capacities, etc.).

Several attempts have been made in the optimization network flow models domain. Main conventional models to evaluate location decision in terms of network dry port locations design have been explained in the literature review. These included the following:

- Short path problem

- Dijkstra’s Algorithm
- Transport problem
- Assignment problem

The optimal model for solving our problem could be a mixed integer problem (MPI), but we select a minimum cost flow assignment as the (MIP) solution provides exactly one solution, where we should examine at least several scenarios concerning the sovereignty of the Mashreq countries.

6.2 Model formulation:

As we mentioned previously in Chapter Four, in (section 4.2 Problem formulation and definitions), there are two main types of components in conceptual regional network of dry port locations: **nodes** and **links** on which a set of origin-destination and candidate locations of dry port are identified, as well as the connection between them /Links (L) including rail and road transport modalities.

Where is:

Nodes (Facility Location):

1. **S**: Sea port nodes (Origin).
2. **H_p, H_e:** Dry port nodes (respectively, planned and existed dry ports)
3. **D:** Hinterland destinations nodes (demand centres = Destination).

Links:

1. **L_{Ro}:** Road Links between nodes
2. **L_{Ra}:** Rail links between nodes

6.2.1 Movement Direction:

1. Containers distribution direction movement start originally from seaport facility location to their destination (demand centres) through planned and existing dry ports.
2. There is no direct connection. Links between origin-destination as nodes are connected the container traffic from seaports to their destination only through dry ports.

The main attribute of interest is the flow between origin-destination links connection associated with (cost, distance, time, etc.).

Decision variable about operation policy X= {0,1} where x equals 1 if the distribution within regional hinterland and x equal 0 if under national operation.

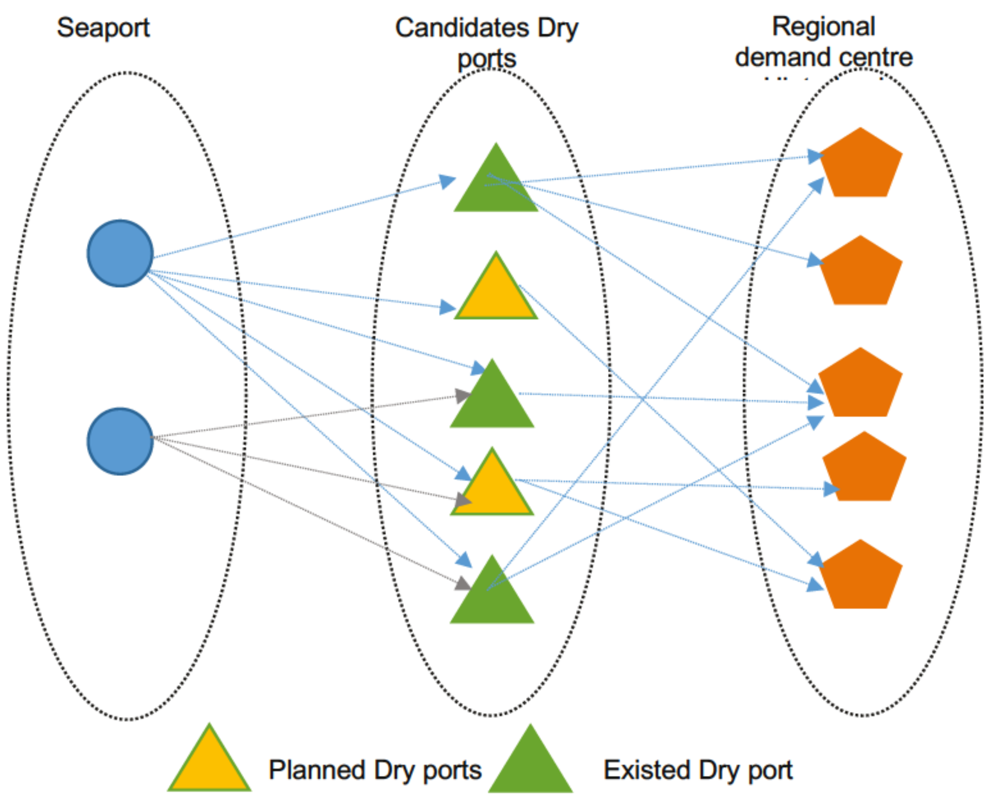


Figure 6.1 Network Flow in Seaport- Dryport allocation System

6.2.2 Model problem and Assumptions:

To identify the model problem, the first model's assumptions and conclusions (Table 6.1) are considered as follows:

Table 6.1 Minimum Cost Flow Description

Model Domain	Description
Domain solution	Discrete
Source determining the number of hubs to locate	endogenous
Number of hub nodes	Multiple hubs
Nodes capacity	Capacitated hub nodes
Dry port locating cost	No cost
Allocation	Multiple allocation
Connection between non-hub nodes	no connection
Objective function	Mini-Sum
Cost of connecting non-hub nodes to hub nodes	variable cost.
Decision variables	binary variables

6.2.3 Model Main Assumptions:

The Domain solution of our model is discrete as the candidate locations of dry port nodes are a series of specific nodes within supply –demand network and not all the network nodes. While, the source determining the number of hubs to locate is endogenous as the number of dry port nodes to locate is not known and will be determined as part of the solution. Furthermore, several hub nodes, multiple hubs, and (capacitated hub nodes) have been considered as each hub node capacity is limited. In relation to the cost our main concern, it is about transport cost without considering cost for locating dry port nodes.

In addition:

- Multiple allocation, as each non-hub node could be assigned to more than one hub node
- There is no direct connection between non-hub nodes.
- The objective function is Mini-Sum as the total transportation cost incurred by location hub nodes and allocation non-hub nodes to hub nodes is minimized.
- The cost of connecting non-hub nodes to hub nodes is variable cost.
- All decision variables of the model are binary variables (0-1).

Finally, the transport costs are as follows:

1. $C1=C_{Ro}+ C_{Ro}$
2. $C2=C_{Ro}+C_{Ra}$
3. $C3=C_{Ra}+ C_{Ro}$
4. $C4=C_{Ra}+C_{Ra}$

In this work, we consider only the multimodal single hub itineraries namely, origin- dryport-Destination, focusing on divided container shipments between different modalities including rail and road modalities and different dry port nodes. Thus, to be able to compute the transportation cost we need to address the multimodal single hub itineraries carefully.

As our aim is to increase the usage of railway modality and making the railway system as efficient as possible by using the existing infrastructure we consider two different transport modes, road transport and rail transport which give us four options to transfer containerized freight in each Origin-Dryport-Destination itinerary. Precisely, as follows:

- Vehicle- Vehicle (m_1): when a container shipment transfers from origin node to dry port node by road transport, and then continues its trip again by road transport to destination node.
- Vehicle -Train (m_2): when container shipment transfers from origin node to dry port node by road transport, and then continues its trip by rail transport to destination node.
- Train- Vehicle (m_3): when container shipment transfers from origin node to dry port node by rail transport, and then continues its trip by road transport to destination node.
- Train-Train (m_4): when a container shipment transfers from origin node to dry port node by rail transport, and then continue its trip again by railway transport to destination node.

Therefore, for each multimodal single hub itinerary we compute the following costs:

4. ${}^{m1}C_{ohd}=C_{oh}\,(V) + C_{hd}\,(V)$
5. ${}^{m2}C_{ohd}=C_{oh}\,(V) + C_{hd}\,(T)$
6. ${}^{m3}C_{ohd}=C_{oh}\,(T) + C_{hd}\,(V)$
7. ${}^{m4}C_{ohd}=C_{oh}\,(T) + C_{hd}\,(T)$

considering transport modality K= {V, T} where (V= Vehicle) and (T= Train) respectively.

6.2.4 Model Inputs

Main inputs of this model are as follows:

- F_{ij} : Container volume or flows between origin (i) and destination (j)

- C_{ij} : Unit transport cost between node (i) and node (j).

6.2.5 Model Outputs

The outputs of this model are as follows:

- Transport Cost to satisfy demand for a given network

- X_j = a hub is located at node j.

- Z^{km} = flows from origin O to destination D uses hubs at candidate locations in k

6.2.6 Decision variables:

The decision variables in relation to operation policy are binary variables as follows:

- X э {0,1}, where is X= 1 if K dry port is used from regional set of dry ports, and 0 otherwise
- Yэ {0,1}, where is y=1 if K dry port location is used from National set of dry ports, and 0 otherwise

6.2.7 Objective functions and constraints:

In this section, we proposed Intermodal Dry Port Location for the selection of dry port location nodes within multimodal logistic networks. In relation to the present problem, the main decision is about the number of dry ports located together with modalities of transport to use for moving the required volume of container shipments from origin-destination pairs through the pre-selected dry port nodes.

Therefore the objective function of the model is as follows:

$$\min_{x} \sum_{oh} \sum_{hd} (c_{oh} X_{oh} + c_{hd} X_{hd}) + \sum_{od} c_{od} x_{od} \qquad (1)$$

Subject to:

$$\sum_{oh} X_{oh} \leq \text{ capacity at dry port node } \quad \forall\ h \in H \qquad (2)$$

$$\sum_{oh} X_{oh} = \sum_{hd} X_{hd} \quad \forall\ h \in H \qquad (3)$$

$$\sum_{oh} X_{ohd} + \sum_{od} X_{od} = \text{flow in (arrivals at port)} \ \forall\ o \in O \qquad (4)$$

$$\sum_{hd} X_{hd} + \sum_{od} X_{od} = \text{consumption at cities and } d_{out)} \ \forall\ d \in D \qquad (5)$$

$$X_{oh}, X_{hd}, X_{od} \geq 0 \qquad (6)$$

6.3 Mashreq Network:

In Chapter Five, we analyzed and studied the status quo of Mashreq seaport-dry port distribution systems with a single type of commodity (container). The process of location-allocation relays on the government's role which is responsible for developing several dry port locations within the regional hinterland, taking into consideration the shipper's choice to attain objective of minimizing the regional logistics cost.On the other hand, shippers choose the available feasible routes to shift their cargo out of seaport's yards either directly or through dry port.

In this chapter, the CMRO query results validate the relationship between seaport and dry port in regional hinterland of Mashreq seaports. first, we consider two scenarios of operation strategy:

1. National Operation Strategy (N.O.S) in which the national authority of a seaport can move containerized volumes only to its national dryport network.
2. Regional Operation Strategy (R.O.S) in which the national authority of a seaport can transfer containerized volumes to any dry port within regional hinterland.

A historical data of annual containers (TEU and Tons) imported to Latakia and Beirut seaports over a period (2005-2011) of years, in addition to the row data of MCs seaports, dry ports capacities and railway & road network, will be used to figure out the minimized transport cost for both national base scenario and regional base scenario into applying a mathematical model of minimum cost flow.

Consequently, distribution scenarios resulted from DL Query service of the CMRO will be examined. First, a base scenario of current distribution system in terms of national operation strategy for Latakia seaport in Syria and Beirut seaport in Lebanon will be examined into MCF/Excel solver to identify the cost and associated flows of the available containers distribution within the current network. Then, a compression between a national base scenario and a regional base scenario will be conducted.

Container distribution scenarios will be introduced to essentially include:

1. **(National base Scenario):** where seaports can send their containerized cargo only via operated dry ports within the national hinterland.
2. **(Regional base Scenario):** where all seaports can send containers volumes through operated dry ports in the regional hinterland.

Then, additional scenario will be examined (Third Scenario), considering the regional base scenario with a new dry ports candidates in MCs that are at a distance from seaports of less than 200 km. Furthermore, the final scenario (Fourth Scenario), will be tested, where at least one pre- selected dry port location from each MCs will be considered to be added to the regional base scenario.

Excel solver software will be used to determine the minimum transport costs associated with the availability of flow distribution for each scenario. Finally, a compression between minimized transport costs associated with flow distribution is discussed in relation to each scenario. The satisfied scenario will then be addressed to determine a sufficient number of dry ports.

In relation to transport costs, we assume that the transport cost of containerized flows will benefit from a 50% discount if traveled through dry ports, as the vehicles will be fully loaded thanks to the consolidation of cargo in dry port. Otherwise if containers moved directly from the seaport by road the transport cost will be doubled. We consider that railway lengths are equal to road lengths in case of existing railway sections in the given network.

6.3.1 Row Data for Mashreq Countries:

Demands for each city have been calculated depending on total income containers to both seaports in Latakia and Beirut, and each city population as follows:

$$\text{Demand} = \frac{\text{City population}}{\text{Total cities populations}} \times \text{Total incoming containers}$$

The total incoming flow of containers to Latakia & Beirut seaports are presented in the table (6.2) for three period covering (2005-2011) years:

Table 6.2 Total incoming container to Latakia & Beirut seaports

Year	Node flow coefficients		Year			Year	Node flow coefficients	
2005		Tons	2008			2011		Tons
	Latakia_SP	2928473		Latakia_SP	4390659		Latakia_SP	4137417
	Beirut_SP	1939400		Beirut_SP	2740700		Beirut_SP	3333100
	Total income	4.867.873		Total income	7.131.359		Total income	7470517

Syria

Table 6.3 Demands for Syrian Cities depends on population.

Node	Type	Population (inhabitant)	Demand In 2005 (Ton)	Demand In 2008 (Ton)	Demand In 2011 (Ton)
Damascus	City destination	1711000	225843.60	330857.40	346592.54
Aleppo Governorate	City destination	4868000	642552.11	941328.95	986097.31
Homs Governorate	City destination	1803000	237987.15	348647.51	365228.73
Latakia Governorate	City destination	1890000	249470.72	365470.77	382852.08
Tartous	City destination	283571	37429.98	54834.35	57442.19
Eastern district	City destination	2085427	275266.13	403260.64	422439.18

For Syria, we consider main cities (Damascus, Homs governorate, Aleppo Governorate and Eastern district which included: (Deir-Alzor= 239.196, Qamishli= 184231, Raqqa =150000, Hasakah= 1512000).

Lebanon

Table 6.4 Demands for Lebanese Cities depends on population.

Node	Type	Population (inhabitant)	Demand In 2005 (Ton)	Demand In 2008 (Ton)	Demand In 2011 (Ton)
Sida	City destination	163554	21588.33	31626.56	33130.68
Tripoli	City destination	229398	30279.41	44358.869	46468.52
Bekaa Valley	City destination	540000	71277.35	104420.22	109386.31
Balbak	City destination	82608	10903.85	15973.97	16733.67
Beirut	City destination	1916100	252915.795	370517.75	388139.08

Jordan

Table 6.5 Demands for Jordanian Cities depends on population.

Node	Type	Population (inhabitant)	Demand In 2005 (Ton)	Demand In 2008 (Ton)	Demand In 2011 (Ton)
Irbid	City destination	1770158	233652.17	342296.83	358576.01
Amman	City destination	4008000	529036.33	775030.08	811889.48
Aqaba	City destination	188160	24836.197	36384.65	38115.05

Iraq

Table 6.6 Demands for Iraqi Cities depends on population.

Node	Type	Population (inhabitant)	Demand In 2005 (Ton)	Demand In 2008 (Ton)	Demand In 2011 (Ton)
Baghdad	City destination	7665000	1011742.38	1482187.01	1552677.86
Mosul	City destination	664221	87673.91	128440.93	134549.41
Basrah	City destination	2150000	283789.45	415747.17	435519.56
Anbar	City destination	1561000	206044.34	301851.78	316207.46
Nineveh Governorate	City destination	3300000	435583.80	638123.57	668471.8786

6.3.2 National Base Scenario

In relation to a national Operation Strategy, the national authority of Latakia seaport can move containerized volumes only to its national dry port network. While the Beirut seaport can transfer flows directly to cities by road since there are no dry ports in Lebanon that are under operation nowadays. The way to transfer the incoming containerized flows outside Lebanon is only through Syrian borders as the Lebanese territories are connected to Syrian borders by a highway network. Thus, we consider that all containers imported originally to Beirut seaport are transfered domestically or abroad via a road network.

Table (6.7) and Table (6.8) illustrate seaport, dry port nodes and cities destination in four Mashreq counties/ MCs, as follows:

The dry port nodes matrix for container shipments origin from Latakia and Beirut seaport at national level, are as follows:

Table 6.7 National dry port nodes in relation to seaports.

Nodes	Sea ports	Existed Dry ports	Capacity
	Latakia_SP	Sbenih_DP	560000
	Latakia_SP	Maslamia_DP	500000
	Beirut_SP	-	-

Table 6.8 Cities destinations in Mashreq countries.

Mashreq County	City destination					
Syria	Damascus	Aleppo Governorate	Homs Governorate	Latakia Governorate	Tartous	Eastern District
Iraq	Baghdad	Mosul	Anbar-Ramadi	Basrah	Nineveh Governorate	-
Lebanon	Beirut	Tripoli	Sida	Bekka Valley	Baalbek	-
Jordan	Amman	Irbid	Aqaba	-	-	-

Figure (6.2) and (6.3) showed national distribution option for both Beirut seaport in Lebanon and Latakia seaport in Syria.

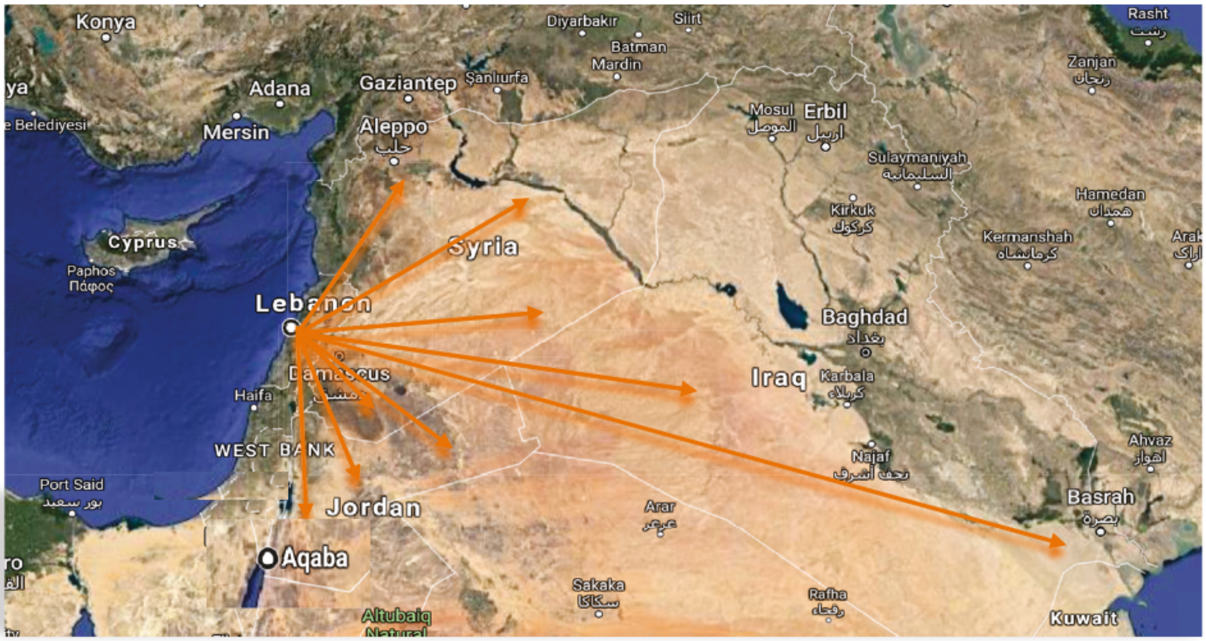


Figure 6.2 National scenario from Beirut seaport by road connections.

Road connections denoted as →

The result of minimum cost flow by using Excel solver are illustrated all outflows from Latakia seaport to each national dry port locations, of which the existing dry ports are: Sbenih in Damascus south of Syria, and Maslamia in Aleppo city/ North in Syria. The results are illustrated in the following pages in table (6.9).

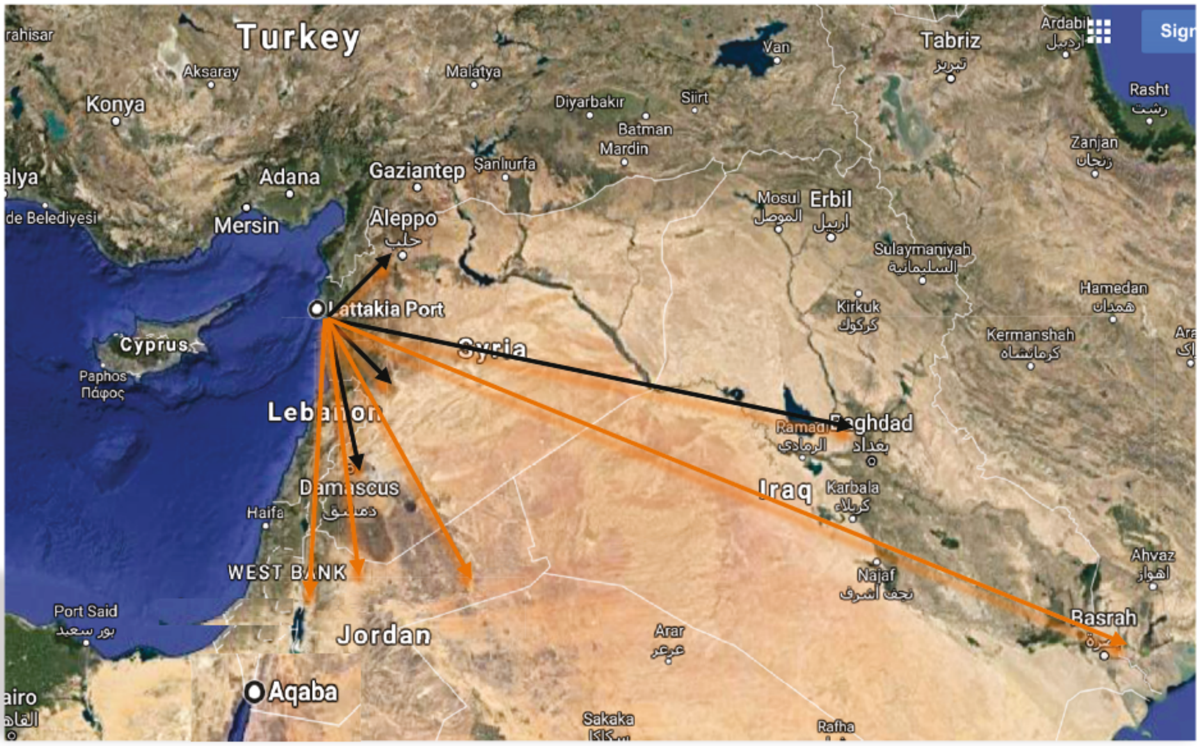


Figure 6.3 National scenario from Latakia seaport by Rail & Road connections

Road connections denoted as

And Rail connection represented as

Table 6.9 Container Traffic from Latakia and Beirut seaports only via national dry port by Road&Rail .

Link Origin	Link Destination	Road-Length/Km	Cost	MinCFlow	Rail-Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_SP	Sbenih	356	2.4	0	356	1.6	560000	0	318976000
Latakia_SP	Maslamia	181	2.4	500000	296	1.6	0	217200000	0
Sbenih_DP	Damascus	13	2.4	0	13	1.6	0	0	0
"	Aleppo Governorate	366	2.4	0	366	1.6	0	0	0
"	Homs Governorate	170	2.4	0	170	1.6	0	0	0
"	Latakia Governorate	342	2.4	0	342	1.6	0	0	0
"	Tartous	260	2.4	0	260	1.6	0	0	0
"	Eastern district/Syria	459	2.4	0	459	1.6	0	0	0
"	Sida	153	2.4	0	-	-	-	0	-
"	Tripoli	192	2.4	0	-	-	-	0	-
"	Bekaa Valley	102	2.4	0	-	-	-	0	-
"	Baalbek	106	2.4	0	-	-	-	0	-
"	Beirut	121	2.4	0	-	-	-	0	-
"	Irbid	131	2.4	0	-	-	-	0	-
"	Amman	194	2.4	126527.135	-	-	-	58911034.3	-
"	Aqaba	517	2.4	24836.1965	-	-	-	30816752.6	-
"	Baghdad	842	2.4	202592.329	-	-	-	409398579	-
"	Mosul	879	2.4	0	-	-	-	0	-
"	Basrah	1354	2.4	0	-	-	-	0	-
"	Anbar-Ramadi	726	2.4	206044.339	-	-	-	359011656	-
"	Nineveh Governorate	852	2.4	0	-	-	-	0	-

Link Origin	Link Destination		Road-Length/Km	Cost	MinCFlow	Rail-Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Maslamia_DP	Damascus		379	2.4	0	379	1.6	0	0	0
"	Aleppo Governorate		22	2.4	0	22	1.6	0	0	0
"	Homs Governorate		208	2.4	0	208	1.6	0	0	0
"	Latakia Governorate		198	2.4	0	198	1.6	0	0	0
"	Tartous		268	2.4	0	268	1.6	0	0	0
"	Eastern district/Syria		406	2.4	0	406	1.6	0	0	0
"	Sida		435	2.4	0	-	-	-	0	-
"	Tripoli		308	2.4	0	-	-	-	0	-
"	Bekaa Valley		352	2.4	0		-		-	
"	Baalbek		318	2.4	0	-	-	-	0	-
"	Beirut		391	2.4	0	-	-	-	0	-
"	Irbid		514	2.4	0	-	-	-	0	-
"	Amman		578	2.4	0	-	-	-	0	-
"	Aqaba		900	2.4	0	-	-	-	0	-
"	Baghdad		1052	2.4	0	-	-	-	0	-
"	Mosul		611	2.4	87673.912	-	-	-	128565025	-
"	Basrah		1563	2.4	0	-	-	-	0	-
"	Anbar-Ramadi		936	2.4	0	-	-	-	0	-
	Nineveh Governorate		583	2.4	412326.088	-	-	-	-	-

Link Origin	Link Destination		Road-Length/Km	Cost	MinCFlow	Rail-Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_SP	Damascus		334	4.8	0	334	3.2	0	0	0
"	Aleppo Governorate		181	4.8	0	181	3.2	642552.108	0	372166181
"	Homs Governorate		177	4.8	0	177	3.2	237987.151	0	134795922
"	Latakia Governorate		3.8	4.8	0	3.8	3.2	249470.724	0	3033564
"	Tartous		85	4.8	0	85	3.2	37429.9802	0	10180954.6
"	Eastern district/Syria		541	4.8	0	541	3.2	275266.129	0	476540722
"	Sida		264	4.8	0	-	-	-	0	-
"	Tripoli		148	4.8	0	-	-	-	0	-
"	Bekaa Valley		307	4.8	0	-	-	-	-	
"	Baalbek		273	4.8	0	-	-	-	0	-
"	Beirut		4.2	4.8	0	-	-	-	0	-
"	Irbid		855	4.8	0	-	-	-	0	-
"	Amman		532	4.8	402509.193	-	-	-	1027847476	-
"	Aqaba		855	4.8	0	-	-	-	0	-
"	Baghdad		1021	4.8	0	-	-	-	0	-
"	Mosul		799	4.8	0	-	-	-	0	-
"	Basrah		1533	4.8	0	-	-	-	0	-
"	Anbar-Ramadi		906	4.8	0	-	-	-	0	-
"	Nineveh Governorate		772	4.8	23257.7155	-	-	-	86183790.6	-

Link Origin	Link Destination		Road-Length/Km	Cost	MinCFlow	Rail-Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Beirut_SP	Damascus		113	4.8	225843.602	-	-	-	122497570	-
"	Aleppo Governorate		369	4.8	0	-	-	-	0	-
"	Homs Governorate		186	4.8	0	-	-	-	0	-
"	Latakia Governorate		230	4.8	0	-	-	-	0	-
"	Tartous		143	4.8	0	-	-	-	0	-
"	Eastern district/Syria		537	4.8	0	-	-	-	0	-
"	Sida		80	4.8	21588.3253	-	-	-	8289916.9	-
"	Tripoli		44	4.8	30279.4101	-	-	-	6395011.42	-
"	Bekaa Valley		52	4.8	71277.3497		-	-	-	
"	Baalbek		87	4.8	10903.8506	-	-	-	4553447.99	-
"	Beirut		62	4.8	252915.796	-	-	-	75267740.8	-
"	Irbid		307	4.8	233652.168	-	-	-	344309835	-
"	Amman		629	4.8	0	-	-	-	0	-
"	Aqaba		934	4.8	0	-	-	-	0	-
"	Baghdad		919	4.8	809150.051	-	-	-	3569322703	-
"	Mosul		1446	4.8	0	-	-	-	0	-
"	Basrah		890	4.8	283789.448	-	-	-	1212348521	-
"	Anbar-Ramadi		892	4.8	0	-	-	-	0	-
"	Nineveh Governorate		839	4.8	0	-	-	-	0	-
								Total Cost=	9571329891	

6.3.3 Regional Base Scenario

In relation to regional operation strategy, a national authority of Latakia seaport can move containerized volumes to either its national dry ports (Sbenih, Maslamia), or to regionally operated dry ports in MCs hinterland such as the Abu Ghrab dry port in Iraq. While, in this case, Beirut seaport can use all the regions dry ports including (Sbenih, Maslamia in Syrian territories and Abu_Ghraib in Baghdad city/ Iraq as well) to transfer flows to cities and destinations by road, since there is no railway network in Lebanon that are under operation nowadays. For a regional base scenario, nodes Matrix is as follows:

Table 6.10 Regional dry port nodes in relation to seaports in MCs region.

Nodes	Sea ports	Dry ports			
	Latakia Seaport	**Syrian**	**Lebanon**	**Jordan**	**Iraqi**
	Beirut Seaport	Sbenih	-	-	Baghdad/ Abu Graib
		Maslamia	-	-	-

The following Figure (6. 4) shows the regional container movement routes scenario. And Table (6.11) presented in detailed the result of excel solver for calculating the flows of container traffic from Latakia and Beirut seaports via under-operation dry ports in MCs regions by road & rail. (See Appendix (3))

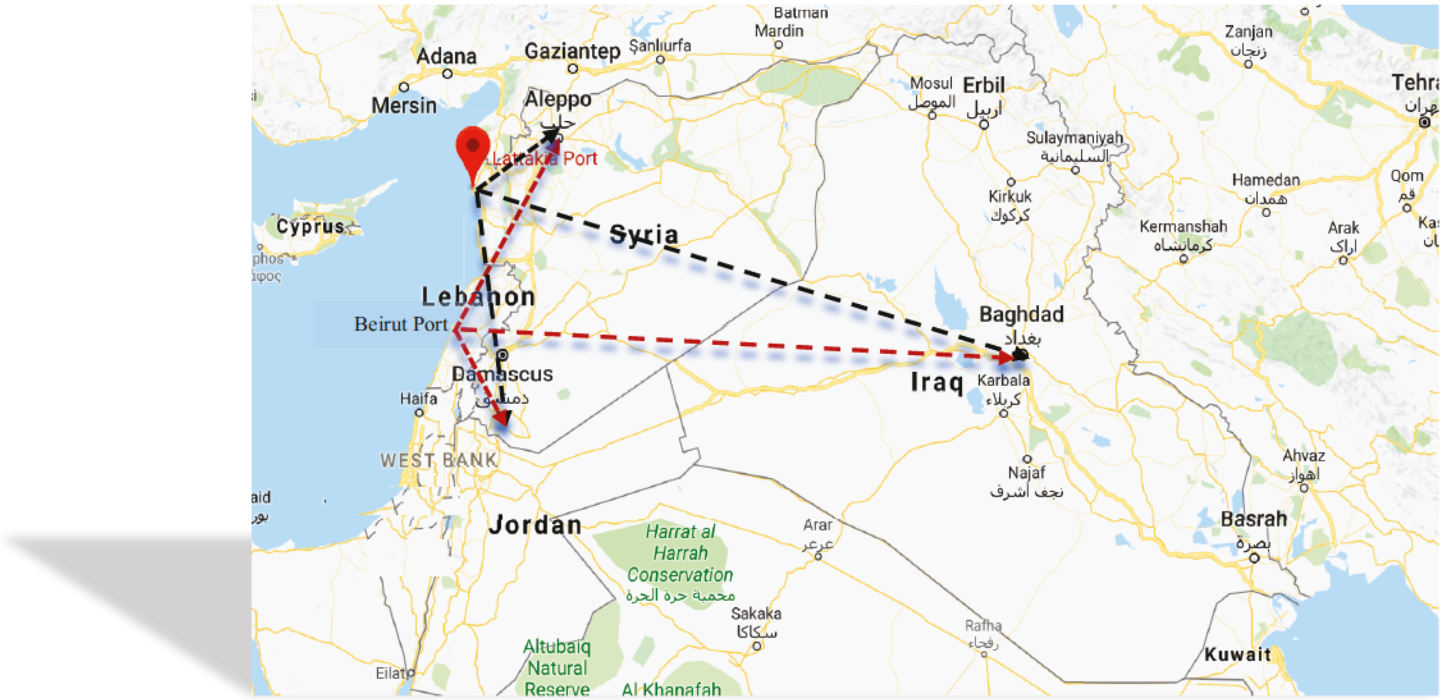


Figure 6. 4 Regional Base Scenario.

6.3.4 Result and Discussion

As presented in Chapter Five, in regards to the relationship between seaport and existing dry ports in the Mashreq region, two base scenarios of container movement routes (CMR) are taken into account to monitor the change in behaviour of a transport network:

(1) CMR of National Base Scenario, where a seaport can only send containers to national dry ports.

(2) CMR of Regional Base Scenario, where a seaport can partner with any number of existing dry ports in the Mashreq region and send containers to them.

6.3.4.1 CMR of National Base Scenario

In terms of the national base scenario, the results obtained from the MCF Model in (Table 6.9) which presents the optimal solution is illustrated separately in table (6.12) and table (6.13). Whereas, Latakia_SP can move containers only to under-operation dry ports in Syria and cannot use any other under-operation dry ports in MCs region. Consequently, to satisfy the demand of all cities both domestically and abroad, containers that are moved by available rail and road connections are as follows:

Table 6.12 Flows from Seaports to operated national Dry ports by Road & Rail.

Containers Origin	Dryport Destination by Rail			Dryport Destination by Road		
	Sbenih_DP	Maslamia_DP	Abu Graib_DP	Sbenih_DP	Maslamia_DP	Abu Graib_DP
Latakia_SP	560000	0	N/A	0	500000	N/A
Beirut_SP	N/A	N/A	N/A	N/A	N/A	N/A

This is considering the movement direction of the container allocation and the non–existence of dry ports currently operated in Lebanon.

Table 6.13 Flows from operated National Dryports to Cities destinations.

Dry port Destination	City Destination	Link Type	Flows	Cost	Demand (2005)
Sbenih_DP	**Amman**	**Road**	126527.135	58911034.3	529036.329
Sbenih_DP	**Aqaba**	**Road**	24836.1965	30816752.6	24836.1965
Sbenih_DP	**Baghdad**	**Road**	202592.329	409398579	1011742.38
Sbenih_DP	**Anbar-Ramadi**	**Road**	206044.339	359011656	206044.339
Maslamia_DP	**Mosul**	**Road**	87673.912	128565025	87673.912
Maslamia_DP	**Nineveh Governorate**	**Road**	412326.088	576926662	435583.804

Subsequently, the CMRs resulted from the National Base Scenario are as follows:

A)- For Sbenih_DP:

CMR (S_n):

- Latakia_SP → Sbenih_DP, Sbenih_DP → : - Amman

→ - Aqaba

→ - Baghdad

→ - Anbar

CMR	From	Via	By	To	By	Flows	Cost
CMR (S_{n1})	**Latakia_SP**	**Sbenih_DP**	**Rail**	**Amman**	**Road**	126527.135	58911034.3
CMR (S_{n2})	"	"	"	**Aqaba**	"	24836.1965	30816752.6
CMR (S_{n3})	"	"	"	**Baghdad**	"	206044.339	359011656
CMR (S_{n4})	"	"	"	**Anbar**	"	206044.339	359011656

- Beirut_SP → Sbenih_DP (N/A)

B)- For Maslamia_DP:

CMR (M_n):

Latakia_SP → Maslamia_DP, Sbenih_DP → : - Mosul

→ - Nineveh Governorate

CMR	From	Via	By	To	By	Flows	Cost
CMR (M_{n1})	Latakia_SP	Maslamia_DP	Road	Mosul	Road	87673.912	128565025
CMR (M_{n2})	"	"	"	Nineveh	"	412326.088	576926662

- Beirut_SP → Maslamia_DP: (N/A)

C)- For Abu Graib_DP:

CMR (A_n):

- Latakia_SP ⟶ Abu Graib_DP: (N/A)
- Beirut_SP ⟶ Abu Graib_DP: (N/A)

In addition, the remaining quantity of containers Origin from Latakia SP was either transferred directly domestically by the railway network or moved by road links to neighboring cities such as Iraq and Jordan.

Table 6.14 Containers movement Origin from Latakia_SP Without dry port.

Containers Origin	City Destination	Flows	Link Type	Cost	Demand
Latakia_SP	Aleppo Governorate	642552.108	**Rail**	372166181	642552.108
Latakia_SP	Homs Governorate	237987.151	**Rail**	134795922	237987.151
Latakia_SP	Latakia Governorate	249470.724	**Rail**	3033564	249470.724
Latakia_SP	Tartous	37429.9802	**Rail**	10180954.6	37429.9802
Latakia_SP	Eastern district/Syria	275266.129	**Rail**	476540722	275266.129
Latakia_SP	Amman	402509.193	**Road**	1027847476	529036.329
Latakia_SP	Nineveh Governorate	23257.7155	**Road**	86183790.6	435583.804

By contrast, due to a complete lack of dry ports or railway network under-operation in Lebanon, all container volumes origin from Beirut_SP moved by the Lebanese highway network connected to the Syrian border to meet domestic and transit demand as follows:

Table 6.15 Containers movement origin from Beirut_SP without national dry port.

Containers Origin	City Destination	Flows (Ton)	Link Type	Cost (S.P)	Demand (Ton)
Beirut_SP	Damascus	225843.602	**Road**	122497570	225843.602
Beirut_SP	Sida	21588.3253	**Road**	8289916.9	21588.3253
Beirut_SP	Tripoli	30279.4101	**Ro**	6395011.42	30279.4101
Beirut_SP	Bekaa Valley	71277.3497	**Ro**	17790826.5	71277.3497
Beirut_SP	Baalbek	10903.8506	**Ro**	4553447.99	10903.8506
Beirut_SP	Beirut	252915.796	**Ro**	75267740.8	252915.796
Beirut_SP	Irbid	233652.168	**Ro**	344309835	233652.168
Beirut_SP	Baghdad	809150.051	**Ro**	3569322703	1011742.38
Beirut_SP	Basrah	283789.448	**Ro**	1212348521	283789.448

6.3.4.2 CMR of Regional Base Scenario

While in terms of the regional base scenario, the results from MCF model have been illustrated in table (6.16) and table (6.17). In a regional operation strategy, seaports in Lebanon and Syria move containers to all under-operation dry ports in MCs, namely: Sbenih, Maslamia and Abu Graib. As demonstrated in the following table (6.16):

Table 6.16 Flows from seaports to operated dry ports in MCs by Road & Rail.

Containers Origin	Container Destination by Rail			Container Destination by Road		
	Sbenih_DP	Maslamia_DP	Abu Graib_DP	Sbenih_DP	Maslamia_DP	Abu Graib_DP
Latakia_SP	0	0	-	0	0	110000
Beirut_SP	-	-	-	560000	500000	0

Table 6.17 Flows from operated regional Dry port to cities destinations.

Dry port Destination	City Destination	Link Type	Flows (Ton)	Cost (S.P)	Demand (2005) (Ton)
Sbenih_DP	Aqaba	Road	24836.19651	30816752.62	24836.1965
Sbenih_DP	Baghdad	Road	535163.8035	1081459014	1011742.38
Maslamia_DP	Baghdad	Road	364512.7302	920321741.3	1011742.38
Maslamia_DP	Mosul	Road	87673.91199	128565024.5	87673.912

Maslamia_DP	Nineveh Governorate	**Road**	47813.35777	66900450.19	435583.804
Abu Graib_DP	**Baghdad**	**Road**	110000	7656000	1011742.38

Subsequently, CMR results in Regional Base Scenario are as follows:

A)- For Sbenih_DP:

CMR (S_r):

- Latakia_SP → Sbenih_DP = (0)

- Beirut_SP → Sbenih_DP, Sbenih_DP → : - Aqaba

→ - Baghdad

CMR	From	Via	By	To	By	Flows	Cost
CMR (S_{r1})	Beirut_SP	Sbenih_DP	Road	Aqaba	Road	24836.19651	30816752.62
CMR (S_{r2})	"	"	"	Baghdad	"	535163.8035	1081459014

B)- For Maslamia_DP:

CMR (M_r):

- Latakia_SP → Maslamia_DP = (0)

- Beirut _SP → Maslamia_DP, Maslamia_DP → : - Baghdad

→ - Mosul

→ - Nineveh Governorate

CMR	From	Via	By	To	By	Flows	Cost

CMR (M_{r1})	Beirut_SP	Maslamia_DP	Road	Baghdad	Road	364512.7302	920321741.3
CMR (M_{r2})	"	"	"	Mosul	"	87673.91199	128565024.5
CMR (M_{r3})	"	"	"	Nineveh	"	47813.35777	66900450.19

C)- For Abu Graib_DP:

CMR (A_r):

- Latakia_SP → Abu Graib_DP, Abu Graib_DP →: - Baghdad

CMR	From	Via	By	To	By	Flows	Cost
CMR (A_{r1})	Latakia_SP	Abu Graib_DP	Road	Baghdad	Road	110000	7656000

- Beirut_SP → Abu Graib_DP = (0)

Furthermore, the rest quantity of containers orginally from Latakia SP was dived over two categories, directly by the railway network by domestic demand, and by road links to neighboring cities such as Beirut, Amman , Anbar and Nineveh.

Table 6.18 Containers movement origin from Latakia_SP without regional dry port.

Containers Origin	City Destination	Flows (Ton)	Link Type	Cost (S.P)	Demand (Ton)
Latakia_SP	Aleppo Governorate	642552.1077	**Rail**	372166180.8	642552.108
Latakia_SP	Homs Governorate	237987.1508	**Rail**	134795922.2	237987.151

Latakia_SP	Latakia Governorate	249470.7238	**Rail**	3033564.002	249470.724
Latakia_SP	Tartous	37429.98023	**Rail**	10180954.62	37429.9802
Latakia_SP	Eastern district/Syria	275266.1287	**Rail**	476540722	275266.129
Latakia_SP	Beirut	252915.7957	**Road**	5098782.442	252915.796
Latakia_SP	Amman	529036.3286	**Road**	1027847476	529036.329
Latakia_SP	Anbar-Ramadi	206044.3386	**Road**	896045619.6	206044.339
Latakia_SP	Nineveh Governorate	387770.4458	**Road**	1436922164	435583.804

In Lebanon, on the other hand, the Beirut SP continued to move the same amount that was moved when applying a national operation strategy with a difference in two cases:

1. The container numbers to Beirut city dropped from (252915.796) to (0) because Latakia_SP had met the demand for Beirut city in this scenario.
2. And the amounts transferred to Baghdad decreased from (809150.051 Ton) with cost of (3569322703 S.P) to (2065.846254 ton) with cost of (9112860.997 S.P)

Lastly, the result showed that despite the large savings of (924581841 S.P) about one billion Syrian pounds in total transportation costs with (9571329891 S.P) for the national base scenario and (8646748050 S.P) for the regional base scenario, Latakia seaport manages to use the railway network to distribute containers within Syria and road connections for transit traffic, while Beirut seaport benefits from having its containerized volumes transferred to dry ports in Sbenih and Maslamia.

6.3.5 The Third Scenario

The DL query service in chapter five provides an answer in regards to the relationship between seaport and dry port candidates. Two dry port candidates were proposed to be added to the regional network of Mashreq.

First, (Hesia) dry port located in Homs city/Syria was identified as being about 200 km from the Latakia and Beirut seaports. Second, a suggested dry port was identified in (Tripoli) in Lebanon, as it is far less than 150 km from the Latakia and Beirut seaports. Table (6.19) showing the distances between candidate dry ports and seaports as follows:

Table 6.19 Candidates dry port locations in third scenario

Seaport	**candidates dry port**	**Distance ≦ 200 Km**
Latakia_SP	Hesia_DP	195 Km
Beirut_SP	Hesia_DP	194 Km
Seaport	**candidates dry port**	**Distance ≦ 150 Km**
Latakia_SP	Tripoli_DP	148 Km
Beirut_SP	Tripoli_DP	80 Km

The third scenario was examined over two parts. In the first part, which is presented in table (6.20), only the dry port of Hessia in Syria was added to the regional base scenario. While in the second part, we add the dry port of Tripoli, which demonstrates the minimum cost flow result of the given network in Table (6.21).

A)- The Third Scenario Part (1)

The following matrix nodes are presented in the third container movement route (CMR) scenario part (1)

Nodes	Sea ports	Dry ports			
		Syria	Lebanon	Jordan	Iraqi
	Latakia Seaport	Sbenih	-	-	Baghdad/ Abu Graib
	Beirut Seaport	Maslamia	-	-	-
		Hessia_DP			

B)- The Third Scenario part (2)

For this scenario, nodes matrices included are Hessia and Tripoli dry ports as follows:

Nodes	Sea ports	Dry ports			
		Syrian Dp	Lebanon	Jordan	Iraqi
	Latakia Seaport				
	Beirut Seaport	Sbenih	Tripoli	-	Baghdad/ Abu Graib
		Maslamia	-	-	-
		Hessia_DP			
		-			
		-			

The result of minimum cost flow by using Excel Solver are illustrated in Table (6.20) and present the third scenario including Hesia dry port- part (1). While, Table (6.21) present the third scenario including (Hesia & Tripoli) dry ports- part (2) respectively. (See Appendix (3))

6.3.6 Result and Discussion of Third scenario

The results obtained from the MCF model were illustrated in Table (6.22) and Table (6.23) for the third scenario part (1). Where, Latakia_SP met the capacity of Maslamia_DP through road connections and select Hessia_DP to shift a large number of containers. Beirut_SP, on the other hand, met Sbenih DP and Abu Graib DP full capacities by road, and moved to Hessia_DP (909507.5 ton). They are listed as follows:

Table 6.22 Flows from Seaports to Candidate Dry ports in Third Scenario Part (1) by Road & Rail.

To Dryport Destination	Containers Origin from			
	Latakia_SP		Beirut_SP	
	Road	Rail	Road	Rail
Sbenih_DP	0	0	560000	N/A
Maslamia_DP	500000	0	0	N/A
Abu Graib_DP	0	0	110000	N/A
Hessia_DP	0	1246104.392	909507.462	N/A

Table 6.23 Flows from Candidate Dryports in Third Scenario part (1) to City Destinations.

Dry port Destination	City Destination	Link Type	Flows	Cost	Demand (2005)
Sbenih_DP	**Irbid**	**Road**	6127.474856	1926478.095	233652.168

Sbenih_DP	**Amman**	**Road**	529036.3286	246319314.6	529036.329
Sbenih_DP	**Aqaba**	**Road**	24836.19651	30816752.62	24836.1965
Maslamia_DP	**Mosul**	**Road**	64416.19648	94459910.52	87673.912
Maslamia_DP	**Nineveh Governorate**	**Road**	435583.8035	609468857.9	435583.804
Abu Graib	**Baghdad**	**Road**	110000	7656000	1011742.38
Hessia_DP	**Irbid**	**Road**	227524.6932	142521467.8	233652.168
Hessia_DP	**Baghdad**	**Road**	901742.38	1878509726	1011742.38
Hessia_DP	**Mosul**	**Road**	23257.71551	43036076.77	87673.912
Hessia_DP	**Basrah**	**Road**	283789.4477	941953935	283789.448
Hessia_DP	**Anbar**	**Road**	206044.3386	372363328.7	206044.339
Hessia_DP	Homs Governorate	**Rail**	237987.1508	14088839.33	237987.151
Hessia_DP	Eastern district	**Rail**	275266.1287	170885212.7	275266.129

Subsequently, the CMRs resulted from the third scenario with the presence of Hessia dry port, are as follows:

A)- For Sbenih_DP:

CMR (S_3):

- Latakia_SP → Sbenih_DP: (0)

- Beirut_SP → Sbenih_DP, Sbenih_DP →: - Irbid

→ - Amman

→ - Aqaba

CMR	From	Via	By	To	By	Flows	Cost
CMR ($S_{3,1}$)	**Beirut_SP**	**Sbenih_DP**	**Road**	**Irbid**	**Road**	6127.474856	1926478.095
CMR ($S_{3,2}$)	"	"	"	**Amman**	"	529036.3286	246319314.6
CMR ($S_{3,3}$)	"	"	"	**Aqaba**	"	24836.19651	30816752.62

B)- For Maslamia_DP:

CMR (M_3):

Latakia_SP → Maslamia_DP, Maslamia_DP → : - Mosul

→ - Nineveh Governorate

CMR	From	Via	By	To	By	Flows	Cost
CMR ($M_{3,1}$)	Latakia_SP	Maslamia_DP	Road	Mosul	Road	64416.19648	94459910.52
CMR ($M_{3,2}$)	"	"	"	Nineveh	"	435583.8035	609468857.9

- Beirut_SP → Maslamia_DP: (0)

C)- For Abu Graib_DP:

CMR (A_3):

- Latakia_SP → Abu Graib_DP: (0)

- Beirut_SP → Abu Graib_DP, Abu Graib_DP →: - Baghdad

CMR	From	Via	By	To	By	Flows	Cost
CMR ($A_{3,1}$)	Beirut_SP	Abu Graib_DP	Road	Baghdad	Road	110000	7656000

D)- For Hessia_DP:

CMR (H_3):

- Beirut_SP → Hessia_DP + Latakia_SP → Hessia_DP
- Hessia_DP → : - Homs Governorate

→ - Eastern district

→ - Irbid

→ - Baghdad

→ - Mosul

→ - Basra

→ - Anbar

CMR	From	Via	By	To	By	Flows	Cost
CMR ($H_{3,1}$)	Latakia_SP & Beirut_SP	Hessia_DP	Road	Homs	Rail	110000	7656000
CMR ($H_{3,2}$)	"	"	"	Eastern district	"		
CMR ($H_{3,3}$)	"	"	"	Irbid	Road	227524.6932	142521467.8
CMR ($H_{3,4}$)	"	"	"	Baghdad	"	901742.38	1878509726
CMR ($H_{3,5}$)	"	"	"	Mosul	"	23257.71551	43036076.77
CMR ($H_{36,}$)	"	"	"	Basrah	"	283789.4477	941953935
CMR ($H_{3,7}$)	"	"	"	Anbar	"	206044.3386	372363328.7

On the other hand, the results obtained from the MCF model for the third scenario part (2) were the same four all four candidates in part (1), with the exception of Hessia_DP which changed due to the presence of Tripoli_DP. This is as follows:

Table 6.24 Flows from Seaports to Candidate Dry Ports in Third Scenario Part (2) by Road & Rail.

To Dryport Destination	Containers Origin from			
	Latakia_SP		Beirut_SP	
	Road	Rail	Road	Rail
Sbenih_DP	0	0	560000	N/A
Maslamia_DP	500000	0	0	N/A
Abu Graib_DP	0	0	110000	N/A
Hessia_DP	0	1246104.392	409507.462	N/A
Tripoli_DP	0	N/A	500000	

And the CMRs resulting from the third scenario are as follows, along with Hessia DP and Tripoli DP:

A)- For Sbenih_DP:

CMR ($S_{3'}$):

- Latakia_SP → Sbenih_DP: (0)

- Beirut_SP → Sbenih_DP, Sbenih_DP →: - Irbid

→ - Amman

CMR	From	Via	By	To	By	Flows	Cost
CMR ($S_{3',1}$)	Beirut_SP	Sbenih_DP	Road	Irbid	Road	30963.67136	9734978.276
CMR ($S_{3',2}$)	"	"	"	Amman	"	529036.3286	246319314.6

B)- For Maslamia_DP:

CMR ($M_{3'}$):

Latakia_SP → Maslamia_DP, Maslamia_DP → : - Mosul

→ - Nineveh Governorate

CMR	From	Via	By	To	By	Flows	Cost
CMR ($M_{3',1}$)	Latakia_SP	Maslamia_DP	Road	Mosul	Road	87673.91199	128565024.5
CMR ($M_{3',2}$)	"	"	"	Nineveh	"	412326.088	576926662.3

- Beirut_SP → Maslamia_DP: (0)

C)- For Abu Graib_DP:

CMR ($A_{3'}$):

- Latakia_SP → Abu Graib_DP: (0)

- Beirut_SP → Abu Graib_DP, Abu Graib_DP → : - Baghdad

CMR	From	Via	By	To	By	Flows	Cost
CMR ($A_{3',1}$)	Beirut_SP	Abu Graib_DP	Road	Baghdad	Road	110000	7656000

D)- For Hessia_DP:

CMR ($H_{3'}$):

- Beirut_SP → Hessia_DP + Latakia_SP → Hessia_DP
- Hessia_DP → : - Homs Governorate
  → - Eastern district
  → - Baghdad
  → - Basra
  → - Anbar

CMR	From	Via	By	To	By	Flows	Cost
CMR ($H_{3',1}$)	Latakia_SP & Beirut_SP	Hessia_DP	Road	Homs	Rail	237987.1508	14088839.33
CMR ($H_{3',2}$)	"	"	"	Eastern district	"	275266.1287	170885212.7
CMR ($H_{3',3}$)	"	"	"	Baghdad	Road	901742.38	1878509726
CMR ($H_{3',4}$)	"	"	"	Basrah	"	34571.85642	114750905.8
CMR ($H_{3',5}$)	"	"	"	Anbar	"	206044.3386	372363328.7

E)- For Tripoli_DP:

CMR (T_3):

- Latakia_SP → Tripoli: (0)

- Beirut_SP → Tripoli_DP, Tripoli_DP →: - Irbid
  → -Aqaba
  → -Basrah
  → -Nineveh

CMR	From	Via	By	To	By	Flows	Cost
CMR ($T_{3,1}$)	Beirut_SP	Tripoli_DP	Road	Irbid	Road	202688.4967	155664765.4
CMR ($T_{3,2}$)	"	"	"	Aqaba	"	24836.19651	42082451.36
CMR ($T_{3,3}$)	"	"	"	Basrah	"	249217.5913	872660317.8
CMR ($T_{3,4}$)	"	"	"	Nineveh	"	23257.71551	45212998.94

Finally, the results show that the two seaports in Syria and Lebanon have chosen to move 2/3 of their containers to be distributed by Hessia DP, despite Tripoli's dry port close to both Beirut and Latakia seaport, as it has potentially significant capacity to receive a huge number of containers. However, if we consider the difference between the third scenario part (1) and part (2), the total transport savings are too small. As shown in the following table.

Table 6.25 Total Transport Cost in Third Scenario

Scenario	Total Cost Of Road Transport	Total Cost Of Rail Transport	Total Cost Of Transport
Third Scenario part (1)	5575076077	959139321.9	6534215399
Third Scenario part (1)	5519690703	959139321.9	6478830025

On the other hand, if we compare total cost savings in third scenario with savings in the national base scenario or regional base scenario, it would be recognizable as demonstrated in table (6.26).

Table 6.26 Total Cost Transport Differences between National and Regional Base Scenario with the Third Scenario.

Scenario	Total Cost Of Road Transport	Total Cost Of Rail Transport	Total Cost Of Transport
National Base Scenario	8255636547	1315693344	9571329891
Regional Base Scenario	7650030707	996717343.6	8646748050
Third Scenario	5519690703	959139321.9	6478830025

6.3.7 The Fourth Scenario

One of the main challenges of this study is to propose one candidate dry port subject in each Mashreq country. As shown in previous chapter, Mafraq dry port in Jordan was identified as a dry port candidate to be added to the Mashreq's regional network. Jordan's new dry port candidates meet the two conditions of: 1. at one least dry port from each country 2. and has a link distance less than 500 km away from the seaports of Latakia and Beirut.

In this scenario, in addition to the (Hesia_DP) in Syria and (Tripoli_DP) in Lebanon, a third dry port in Jordan was proposed to be added to the regional base scenario. Table (6.27) showing distance from seaports is as follows:

Table 6.27 Candidates dry port locations in Fourth scenario

Seaport	candidates dry port	Distance ≦ 500 Km
Latakia_SP	Mafraq_DP	472Km
Beirut_SP	Mafraq_DP	248Km

For the fourth scenario, nodes Matrix is as follows:

Nodes	Sea ports	Dry ports			
		Syria	Lebanon	Jordan	Iraqi
	Latakia Seaport	Sbenih	Tripoli	Mafraq	Baghdad/ Abu Graib
	Beirut Seaport	Maslamia	-	-	-
		Hessia_DP			

The results of minimum cost flow by using Excel Solver are illustrated in Table (6.28) that addressed Container Traffic from Latakia and Beirut seaports via candidate dry ports in the fourth scenario region by road & rail (see Appendix 3).

6.3.8 Result and Discussion of Fourth Scenario

The largest amount of Beirut_SP container traffic in this scenario went to Tripoli_DP in Lebanon and Mafraq_DP in Jordan. On the other hand, Latakia_SP met the full capacity of Maslamia_DP and movement by rail to Hessia_DP (1283534.373Ton). This is as follows:

Table 6.29 Flows from Seaports to Candidate Dry Ports in Fourth Scenario by Road & Rail.

To Dryport Destination	Containers Origin from			
	Latakia_SP		Beirut_SP	
	Road	Rail	Road	Rail
Sbenih_DP	0	0	560000	N/A
Maslamia_DP	500000	0	0	N/A
Abu Graib_DP	0	0	110000	N/A
Hessia_DP	0	1283534.373	0	N/A
Tripoli_DP	0	0	378105.7813	N/A
Mafraq_DP	0	0	787524.6932	N/A

And the CMRs resulting from the fourth scenario are as follows:

A)- For Sbenih_DP:

CMR (S_4):

- Latakia_SP → Sbenih_DP: (0)

- Beirut_SP → Sbenih_DP, Sbenih_DP →: - Damascus

→ -Basrah

→ - Anbar

CMR	From	Via	By	To	By	Flows	Cost
CMR ($S_{4,1}$)	Beirut_SP	Sbenih_DP	Road	Damascus	Rail	225843.6024	4697546.929
CMR ($S_{4,2}$)	"	"	"	Basrah	"	128112.0591	416312947.1
CMR ($S_{4,3}$)	"	"	"	Anbar		206044.3386	359011655.5

B)- For Maslamia_DP:

CMR (M_4):

Latakia_SP → Maslamia_DP, Maslamia_DP → : - Mosul

→ - Nineveh Governorate

CMR	From	Via	By	To	By	Flows	Cost
CMR ($M_{3',1}$)	Latakia_SP	Maslamia_DP	Road	Mosul	Road	64416.19648	94459910.52
CMR ($M_{3',2}$)	"	"	"	Nineveh	"	435583.8035	609468857.9

- Beirut_SP → Maslamia_DP: (0)

C)- For Abu Graib_DP:

CMR (A_4):

- Latakia_SP → Abu Graib_DP: (0)

- Beirut_SP → Abu Graib_DP, Abu Graib_DP → : - Baghdad

CMR	From	Via	By	To	By	Flows	Cost

CMR ($A_{4,1}$)	Beirut_SP	Abu Graib_DP	Road	Baghdad	Road	110000	7656000

D)- For Hessia_DP:

CMR (H_4):

- Latakia_SP → Hessia_DP → Hessia_DP → : - Homs Governorate
  → - Eastern district
  → - Baghdad

CMR	From	Via	By	To	By	Flows	Cost
CMR ($H_{4,1}$)	"	"	Road	Homs	Rail	106525.864	6306331.15
CMR ($H_{4,2}$)	"	"	"	Eastern district	"	275266.1287	170885212.7
CMR ($H_{4,3}$)	"	"	"	Baghdad	Road	901742.38	1878509726

E)- For Tripoli_DP:

CMR (T_4):

- Latakia_SP → Tripoli_DP: (0)

- Beirut_SP → Tripoli_DP, Tripoli_DP →: - Homs
  → - Tartous
  → - Tripoli
  → - Mosul
  → -Basrah

CMR	From	Via	By	To	By	Flows	Cost

CMR ($T_{4,1}$)	Beirut_SP	Tripoli_DP	Road	Homs	Road	131461.2868	32497230.1
CMR ($T_{4,2}$)	"	"	"	Tartous	"	37429.98023	5524665.081
CMR ($T_{4,3}$)	"	"	"	Tripoli	"	30279.41011	290682.337
CMR ($T_{4,4}$)	"	"	"	Mosul	"	23257.71551	46775917.43
CMR ($T_{4,5}$)	"	"	"	Basrah	"	155677.3887	545119944.2

F)- For Mafraq_DP:

CMR (F_4):

- Beirut_SP → Mafraq_DP → Mafraq_DP → : - Irbid
  → - Amman
  → - Aqaba

CMR	From	Via	By	To	By	Flows	Cost
CMR ($F_{4,1}$)	Beirut_SP	Mafraq_DP	Road	Irbid	Road	233652.168	28038260.16
CMR ($F_{4,2}$)	"	"	Road	Amman	"	529036.3286	83799354.46
CMR ($F_{4,3}$)	"	"	Road	Aqaba	"	24836.19651	23127466.19

Finally, the results show a small saving in total transport costs in the fourth scenario as Mafraq_DP receive main containerized volume from Beirut_SP and distributed it to satisfy domestic demand in Amman, Irbid and Aqaba. The following table (6.30) demonstrats the differences in total transport cost (road & rail) as follows:

Table 6. 30 Total Transport Cost of Container Movement Scenarios

Scenario	Total Cost Of Road Transport	Total Cost Of Rail Transport	Total Cost Of Transport
National Base Scenario	8255636547	1315693344	9571329891
Regional Base Scenario	7650030707	996717343.6	8646748050
Third Scenario	5519690703	959139321.9	6478830025
Fourth Scenario	5325608598	957551559.	6283160158

6.4 Conclusion

Many researchers are attracted by the increased competition between a dynamic system of regional seaport - dry port networks to optimize the system configuration. By focusing on the relationship between seaports and dry ports in this chapter, a network - based ontology model for optimizing the regional seaport - dry port system was developed and an efficient programming solution method was proposed. Minimum cost flow/ MCF assignment is applied for validation purposes, the MCF believed to address the links that provide lowest transportation cost and maximum flow between seaport and candidate dry port locations. Precisely, in the regional hinterland of main container ports in the Mashreq region namely: Latakia seaport in Syria and Beirut seaport in Lebanon. First, the scene has been set up in order to test, verify and calculate the CMRO outputs and achieve meaningful results according to the regional and national Operation Strategies. Then, Excel Solver was used to calculate and verify minimum transport costs associated with the availability of flow distribution for obtained scenarios.

Chapter 7

Conclusion

7.1 Summary

The final chapter is the conclusion, it summarizes this thesis and the efforts to develop an integrated Dry Port Network/IDPN design model based on an ontological approach to evaluate dry port location decision within an integrated hinterland that involves a number of neighboring countries.

The thesis problem was about snowballing transport distribution system complexity in decision making level, especially, when some of main stakeholders take decision about a certain container shipment route that meets their own objective without concern about other STK's objectives. Therefore, container traffic allocation decision experience significant negative effects on transport cost and flows volumes in general. This in turn, explains why making a decision is complex, with often conflicted objectives as the final decision should satisfy the general goal of reducing costs and increasing flow at the same time.

At an early stage, main limitations and challenges of up-to date practices in the Network Design models of dry ports were addressed. The conventional models for the location evaluation of intermodal freight terminal location reported a shortage in decision-maker levels in terms of conflicted objectives between stakeholders. Moreover, familiar models did not concern the problem of sovereignty between adjacent countries that share the same maritime gate and maintained the same import-export flows categories.

In this thesis, we carried out the up-to-date literature review on the current situation in the Mashreq region as part of the major contribution of our work. Our concern was to provide the status quo of a dry port presence in the transport network system of the Mashreq region as a new concept necessary to develop and adapt to enrich the investment environment in such transit countries.

In our work, we have carefully studied how to determine which strategy is best in a given situation so that we have an understanding of the relationship between the system elements. We therefore personally believe that it is not possible to make decisions without an insight into the direct and indirect effects of the location of the facility, since they are less visible to avoid.

7. 2 Conclusion

Based on the above demonstration work in this thesis, and as a result of the ever-growing request for satisfying the customers, improving quality, and cutting transaction cost, this study argues that it is possible to state that in the coming years dry ports will assume greater importance than seaports. Therefore, the study of this phenomenon in Mashreq countries will be of great strategic importance.

This thesis demonstrates a feasibility of applying a distribution of scenarios in the regional hinterland to evaluate dry port location decisions based on operating strategies. The thesis also presents a comparison between regional and national scenarios based on the availability of a transport network of conditions in the region throughout a case study. The result of comparison analysis showed a significant save in transport operation costs across the region.

This work also contributed to introduce a new model for the planning of dry port location evaluation, and to the integration of dry port networks by introducing a new model that helps decision makers at the strategic level to evaluate dry port location decision within Integrated Dry Ports Network (IDPN) at the regional hinterland of Mediterranean seaports in Mashreq countries.

Finally, the study of the dry port phenomenon in Mashreq countries will be of strategic importance as dry ports will assume greater importance than seaports in the future. This thesis has contributed to serve as a road map to pave the way for stakeholders in the Mashreq region (both private and government levels) to plan their dry port location choice.

7.3 Future research Directions

Based on the problems identified in this thesis and the outcomes of the research, it is recommended to carry out following future works:

1. This research applies (CMRO) as a source and reusable ontology for available distributed scenarios generated in regional hinterland of four Mashreq countries to observe the performance of our flexible ontology. There are opportunities for

expanding the seaports hinterland to merge more number of Mashreq countries.

2. Results of this research obtained with assigned ontology regarding the annual statistics of import container traffic to two container seaports, while it is also feasible to test and challenge (CMRO) approach for two container traffic directions (import & export) to the Mashreq area.
3. The future work should concentrate on enhancing the mapping of various types of data properties and functionality of Container Movement Route Ontology to serve other significant indicators of network flows, such as assessing time delays in seaport yards and the time required to load container handling.

Finally, future researches should continue to develop source ontology design in container terminal applications with multiple experiments.

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Appendix (1):

- **Movement Ontology Concepts.**
- **CMRO implementation in Protégé 5.**
- **Description Logics Syntax**

- **Movement Ontology**

5. Transport Service (T.S)

5.1 Concept Identification:

Transport service is the mean to transport container shipments from seaport to its destination via dry port and it has three main modes:

where is:

- Road Transport Service: Any Transport_Service object accomplished_By Transport_Activity some Road_Transport_Activity and has Transport Equipment some Long_Vehicle.
- Rail Transport Service: Any Transport_Service object accomplished_By Transport_Activity some Rail_Transport_Activity and has Transport Equipment some Locomotive.
- Multimodal Transport Service: Any Transport_Service object accomplished_By Transport_Activity some Road_Transport_Activity and some Rail_Transport_Activity and has Transport Equipment some Locomotive and some Long_Vehicle

5.2 Objective Properties:

`(Transport_Service)` has several defining object properties as follows:

- `(Multimodal_Transport_Service)` Accomplished_By some `(Rail_Transport_Activity) and` Accomplished_By some `(Road_Transport_Activity)`

`(Road_Transport_Service)` Accomplished_By some `(Road_Transport_Activity)`

and

has_Equipment some Long_Vihecle)

and

(has_Unit_Cost some Road_Unit_Cost)

(Rail_Transport_Service) Accomplished_By some

Rail_Transport_Activity)

and

has_Equipment some Locomotive)

and

(has_Unit_Cost some Rail_Unit_Cost)

(Transport_Service) has_a (Unit_Cost)

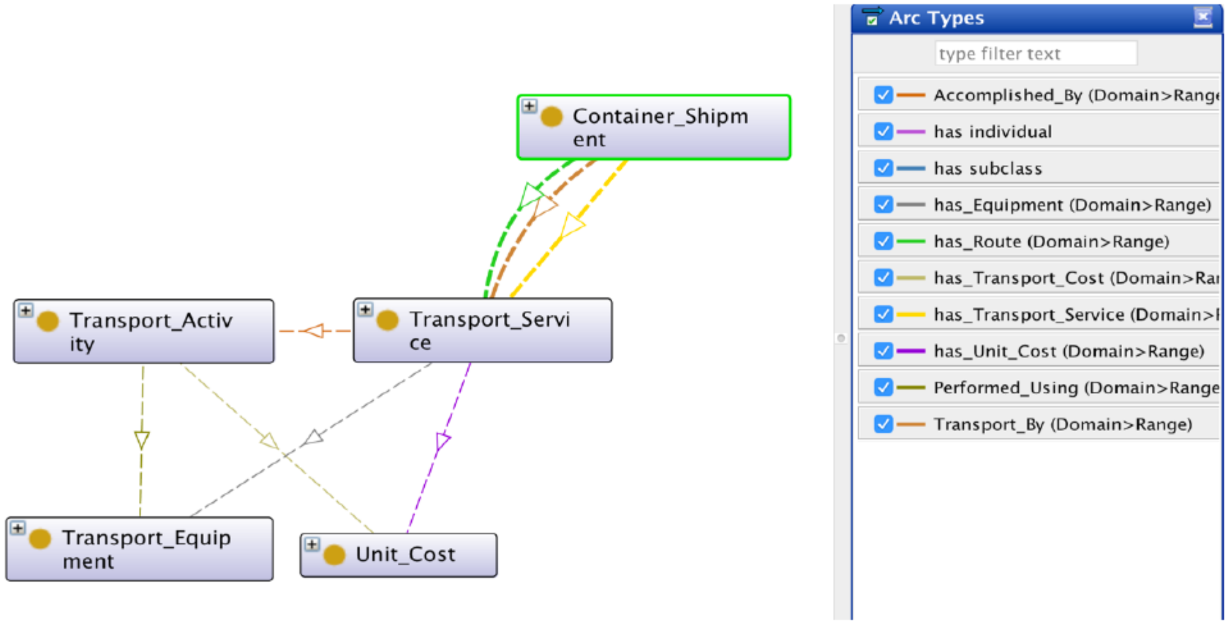


Figure 4.9 Transport service concept hierarchal relationship.

5.3 (Transport Service) class relationship with another concepts/ object properties:

Table 4. 5 Displaying (Transport Service) class object properties.

Transport Service Relationship with another **Class**	**Sub Class**	**Object Property**	**Domain**	**Range**
Transport Activity	- Road T.A - Rail T. A	Accomplish_By	(T.S)	(T.A)
Unite Cost	- Road Unite Cost - Rail Unite Cost	has_A	(T.S)	Unit Cost

Container Shipment	- TEU - CMR	Transports	(T.s)	Container Shipment
Equipment	- Long vehicle - Locomotive	Has_A	(T.S)	Equipment

6. Transport Activity:

6.1 Concept Identification

Transport activities is set of activity networks that when executed would fulfill the container requirement. Transport activity moves containers from seaport by transport equipment which travel on (Link) to interact with candidate dry port (facility location).

Where is:

- Rail Transport Activity: is any Transport_Activity object has Link some Rail_Link and has Cost some Rail_Cost.
- Road Transport Activity: is any Transport_Activity object has Link some Road_Link and has Cost some Road_Cost

6.2 Objective Properties:

(Transport_Activity) has several defining object properties as follows:

(Transport_Activity) Moves Container (Included number of Container (Flows)

(Transport_Activity) Executed on Link

`(Transport_Activity)` Interact with Facility Location

`(Transport_Activity)` Performed using Equipment

Transport Activity **Is Accomplish** Transport Service which is (invers of: Transport Service **Accomplished By** Transport Activity)

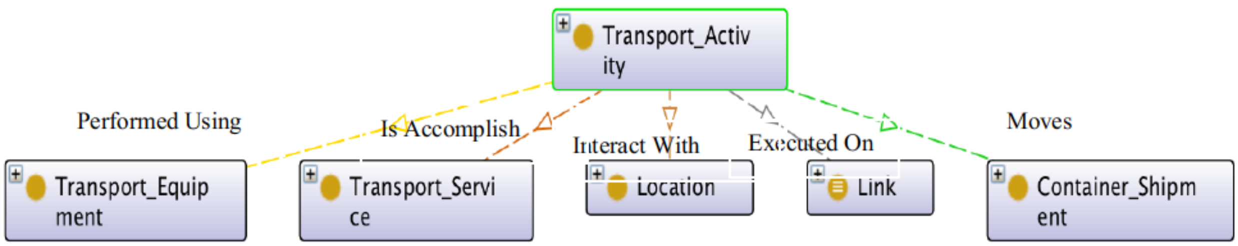


Figure 4.10 Transport Activity concept hierarchal relationship.

6.3 (Transport Activity) class relationship with another concepts/ Object Properties:

Table 4.6 Displaying (Transport Activity) class object properties

Transport Activity Relationship with another **Class**	**Sub Class**	**Object Property**	**Domain**	**Range**
Link	- Road link - Rail link	Executed On	(T.A)	Link
Container Shipment	- TEU - CMR	Moves	(T.A)	Container Shipment
Transport Service	- Road transport - Rail transport - Multimodal transport	Is Accomplish a	(T.A)	Transport Service
Equipment	- Long vehicle - Locomotive	Performed Using	(T.A)	Equipment
Facility Location	- Sea Port - Dry Port - Destination	Interact With	(T.A)	Facility Location

7. Transport Route (T.R):

7.1 Concept Identification

- Transport Route is a set of Links connect Origin to Destination of which Each Transport Route (TR) **Consist of** sections ∑ (i.j) Link
    - RO-RO Link
    - RO- RA Link

- RA-RO Link
- RA-RA Link

Where is:

- Road Transport Route: is any Transport_Route object has Link only Road Link.
- Rail Transport Route: is any Transport_Route object has Link only Rail Link.
- Multimodal Transport Route: is any Transport_Route object has Link some Rail Link and Road Link.

7.2 Object Properties:

(Transport_Route) class has several defining object properties as follows:

`(Road_Transport_Route)` Consist_Of only `(Road_Link)`

`(Rail_Transport_Route)` Consist_Of only `(Rail_Link)`

`(Multimodal_Transport_Route)` Consist_Of some `(Rail_Link)`

`and Consist_Of some (Road_Link)`

`(Transport_Route)` has_A_StartPoint some `(Facility_Location = some Origin = some SeaPort)`

`and`

`(Transport_Route)` has_An_EndPoint some `(Facility_Location = some DryPort or = some Destination)`

8. Stakeholder (STk):

8.1 Concept Identification

Stakeholders represent main player or decision –makers in distribution process, Namely, Terminal owner, Terminal User and community.

8.2 Object Properties:

- (Stakeholder) class has several defining object properties as follows:

has an Objective some Objective

- Domain is (STK):
  - User
  - Service Provider
  - Community
- Range is (Objective) which are:
  - User Objective = Minimize Transport Cost
  - Service Provider Objective = Maximize Flows
  - Community Objective = Shift from Road Transport to Rail transport service.

- **Implementing Source Ontology in Protégé 5**

Task (1): Annotations

By using ‘Annotations’ tool from ‘Active Ontology’ tab, the CMRO given a name as every ontology has a Unique Resource Identifier (URI) and definition as follows, "A Container Movement Route Ontology CMRO describes Container Movement Route Scenarios within Integrated Dry Port Network (IDPN), that can provide an efficient and sustainable allocation of container traffic at seaports regional hinterland, based on Stakeholder's Multi-objectives." as shown in Figure (4.12).

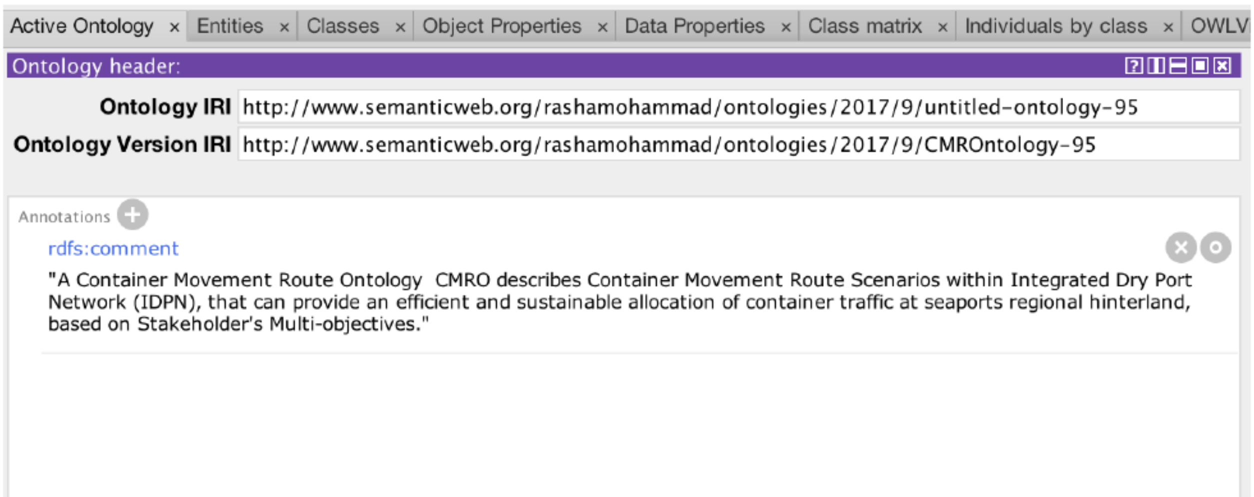


Figure 4.12 The Ontology Annotation view- as indicated by the comment annotation.

Task (2): create Classes

As mentioned earlier in the literature review, classes are the main building blocks of an OWL ontology. In Protégé, empty ontology contains only one class '**Thing'** and all the classes that created in the ontology are subclasses of 'Thing' Class. Classes are carried out using "Class Tab", While subclass are created by using (Create Class Hierarchy) tool. Both classes and subclasses need to disjointed as subclasses inherited the same Characteristics of their Supper-class, doing so, any ambiguous situation would be avoided.

To name the OWL classes, ProtégéOWLTutorial/ CamelBack notation/ Stanford University was followed. All CMRO components should start with a capital letter without spaces between words or alternatively, underscores were used to join words. For instance, 'Infrastructure', 'Transport_Service' and 'A_StartPoint'. However, it is highly recommended to keep the ontology consistent.

First, a 'DomainEntity' class is created and then, CMRO concepts are created as subclass of 'DomainEntinty' as follows:

1. Select '**Class tab'** from **'Entity'** tab, then press '**Add'** icon. Then in a dialog that appear enter 'Domain entity' and hit return.
2. Repeat the same process to add 'Container_Movement_Requirements' class and hit return.
3. In this step, instead of re-selecting 'DomainEntity' and using the **'Add subclass'** button to add the rest of CMRO's classes, '**Add sibling class**' button can be used to add 'Contaier_Shipment', Location', 'Stakeholders' and 'Link'.

A class hierarchy which could be called as taxonomy as well, will be s shown as in Figure (4.13).

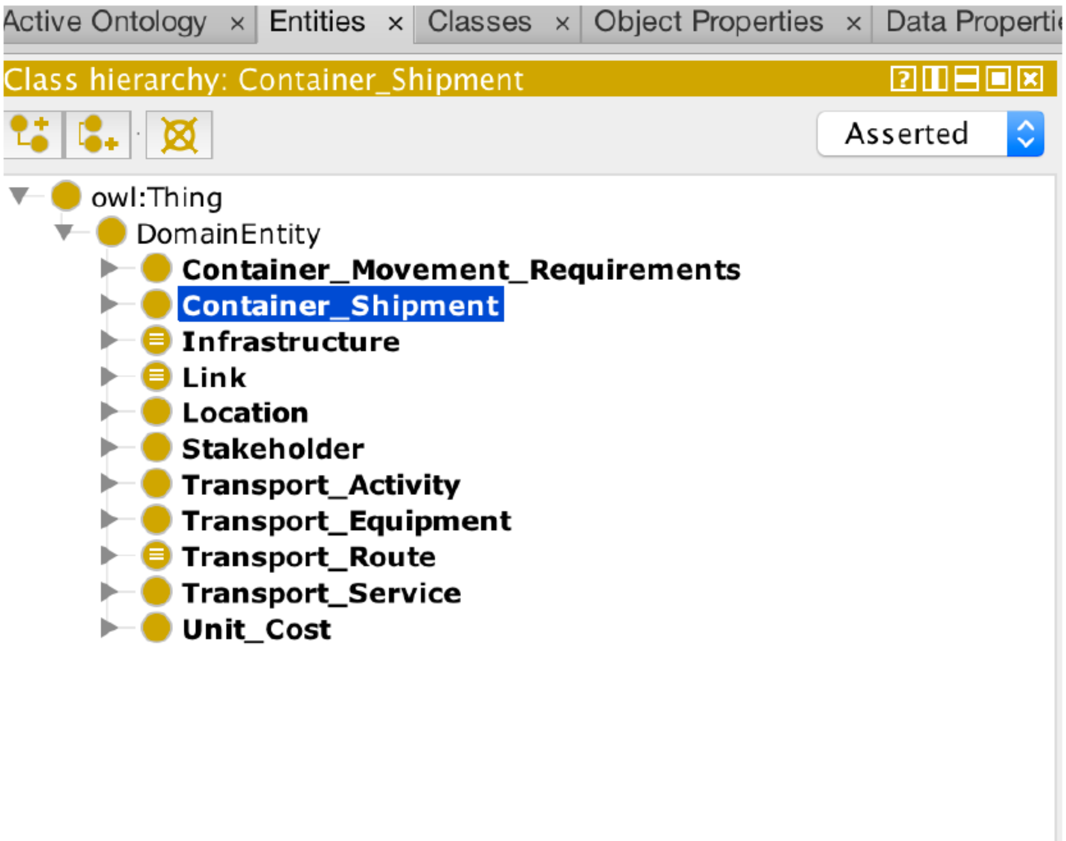


Figure 4.13 The initial CMRO class hierarchy

Task (3): Disjoint Classes

It is very important to disjoint classes so that an individual (object) cannot be instance of more than one of these classes. In CMRO, for example, 'Facility_Location" and 'Geografical_Location' have been disjointed from each other. This ensure that instances which asserted to be member of one of them cannot be member of the other one. An individual cannot be member of 'DryPort' which is subclass of 'Facility_Location" and may has values such as (Addra_DP, Baghdad_DP ...etc.) and at the same time member in

'City' which is subclass of 'Geografical_Location' and has values such as (Damascus, Beirut, AL Basra ...etc.), because it makes no sense for an individual to be both 'DryPort' and 'City' at the same time. Figure (4.14) display the example explained in this section.

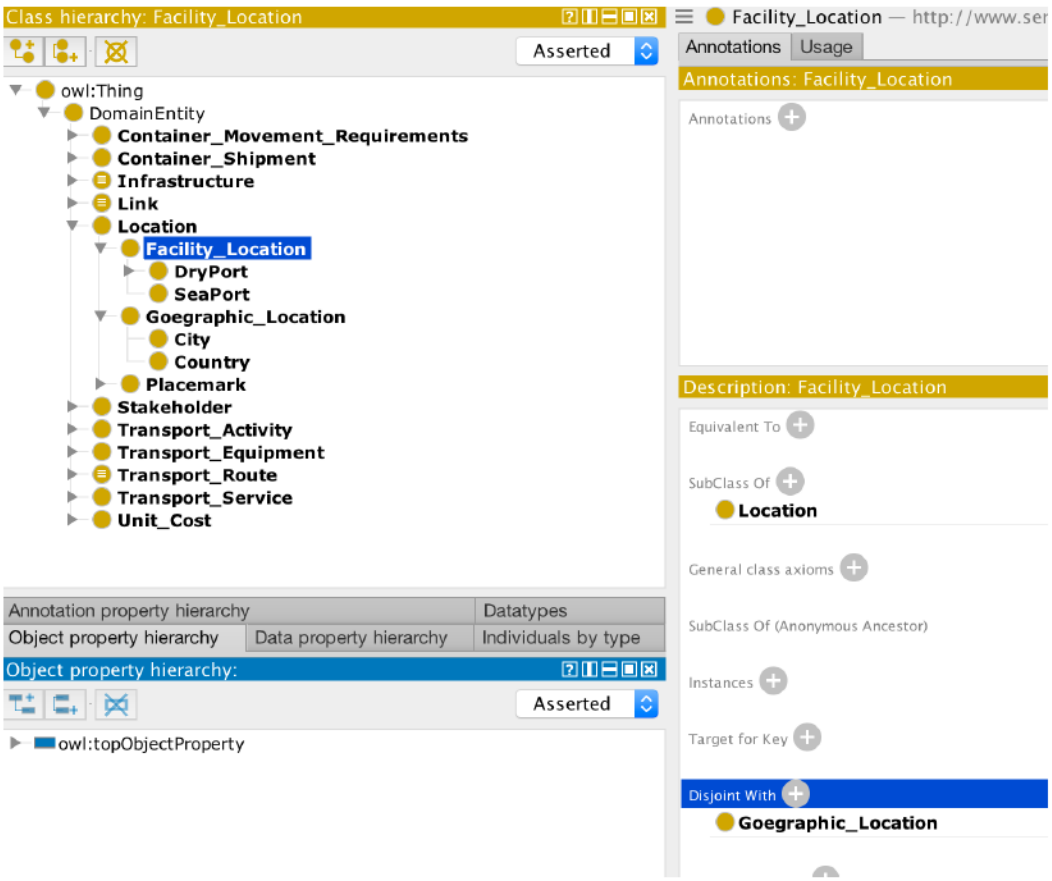


Figure 4.14 Display the disjoint of 'Facility_Location" and 'Geografical_Location' in CMRO

Task (4): Create Subclasses:

To explain the way that we followed to add subclasses, subclasses of 'Link' class has been illustrated as follows:

1. Select the class 'Link' in the class hierarchy.

2. Press ‘Add subclass’ tab, and type in the text area ‘Road_Link’ and hit enter.

3. Repeat the same steps to create ‘Rail_Link’

4. disjoint ‘Road_Link’ and ‘Rail_Link’ subclasses.

Then, the rest classes and subclasses of CMRO has been carried out as displayed in Figure (4.15).

Figure 4.15 present CMRO Class Hierarchy

Task (5): Create object Properties:

As explained earlier in the literature review section (2.5), There are two types of properties 'Object Property' which represent relationship between two individuals and 'Datatype Properties' that characterize relationship between individuals and data values. In this task, the object property 'has_A_StartPoint' was explained to illustrate how to create a new 'Object Properties' following the next steps:

6. ensure that 'Link' class is selected, switch to **'Object Properties'** tab
7. Press **'Add Object Property'** button, then add name for a new property. In this case, type a 'has_A_StartPoint' using **'Name dialog'** that pops up when hitting **'Add'** button.
8. In **'Description'** tab, select **Domains (intersection)** tab and press **'Add'** icon, then from 'Class hierarchy' tab dedicate class 'Link' as the domain.
9. In **'Description'** tab, select **Ranges (intersection)** tab and press **'Add'** icon, then from 'Class hierarchy' dedicate class 'Facility_Location' as range.
10. Repeat same process to 'Add' 'has_An_EndPoint' as a second object property for 'Link' class with Domain 'Link' and range 'Facility_Location'.

Noting that, for naming 'Object Properties' it is recommended to start with small letter for first word and capital letter for remaining words with no spaces between them as shown in Figure (4.16).

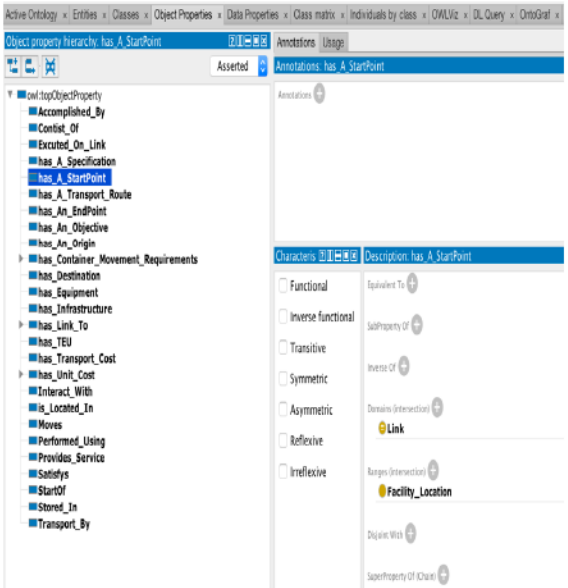


Figure 4.16 Display object properties

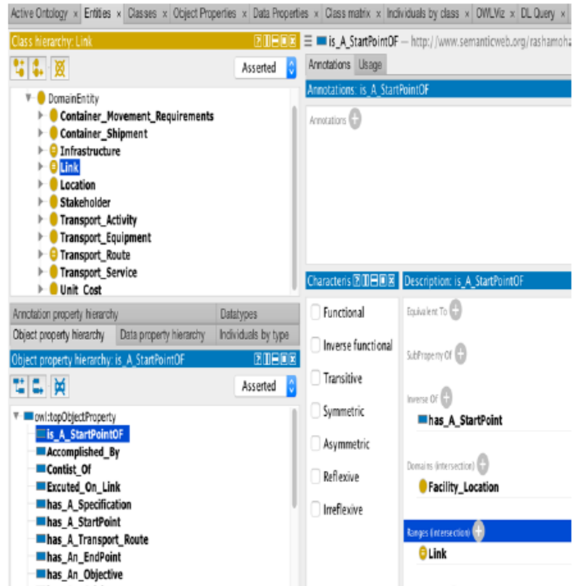


Figure 4.17 Display Inverse properties

Task (7): Create Inverse Properties

As a continues of the example that explained in previous task, an Inverse property 'is_StartPointOf' can be specified using the **'inverse Property'** button in **'Description'** tab of the 'has_A_StartPoint' object property, where the domain for the first property is the range for its inverse, and vice versa as can be seen in Figure (4.17).

In CMRO, some inverse object properties can be used to infer the same result but in other way around. For example, in our network if a link (N) has a start point from (A) facility location then, because of the inverse property (is_A_StartPointOf) we can infer that the (A) facility location is the start of link (N).

Task (8): Add Object Property Restrictions

Number of properties characteristics was added to help explain the property behavior and classified as follows in table (4.7):

Table 4.7 Object Property Restrictions

Property Characteristic	**Functional**	**Symmetric**	**Transitive**	**Irreflexive**	**Reflexive**
Is_Located_In	√	-	√	√	-
has_A_StartPoint	√	-	-	-	-
has_An_EndPoint	√	-	-	-	-
has_Objective	√	-	-	-	-
has_Infrastructure	√	-	-	-	-
has_Transport_Cost	√	-	-	-	-
Satisfies	√	-	√	√	-

Task (9): Add Object Property Restrictions

General types of OWL Ontology restrictions are either Existential restrictions (also known as Some value forms) or Universal restrictions (Only values forms). Where the former, describes a class that have at least one relationship with certain property. For example,' has_infrastructure' some road infrastructure describes all of individuals in class 'Link' that has Road infrastructure.

An example, for property expressions from (Link) class hierarchy view have been illustrated in Figure (4.18).

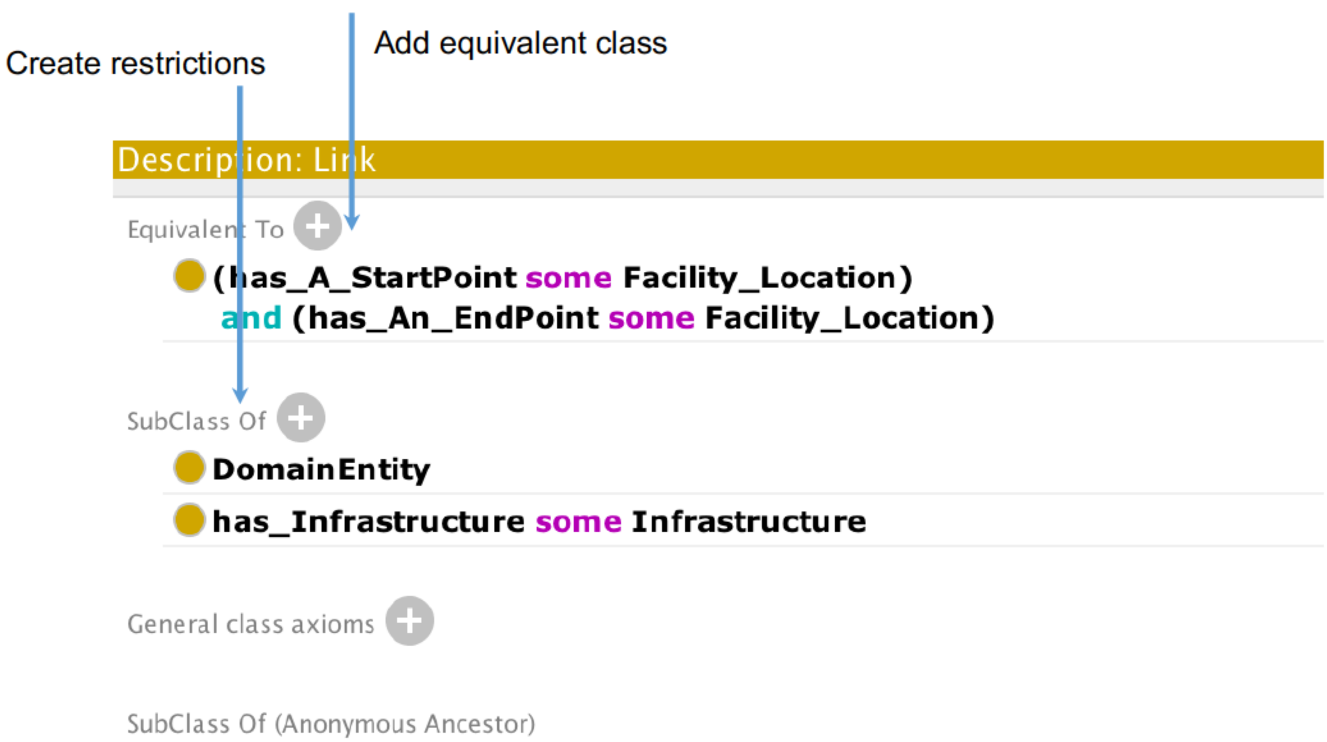


Figure 4.18 Display Class restriction view

Another example of Transport route demonstration of is applied in Figure (4.19), (4.20) and (4.21).

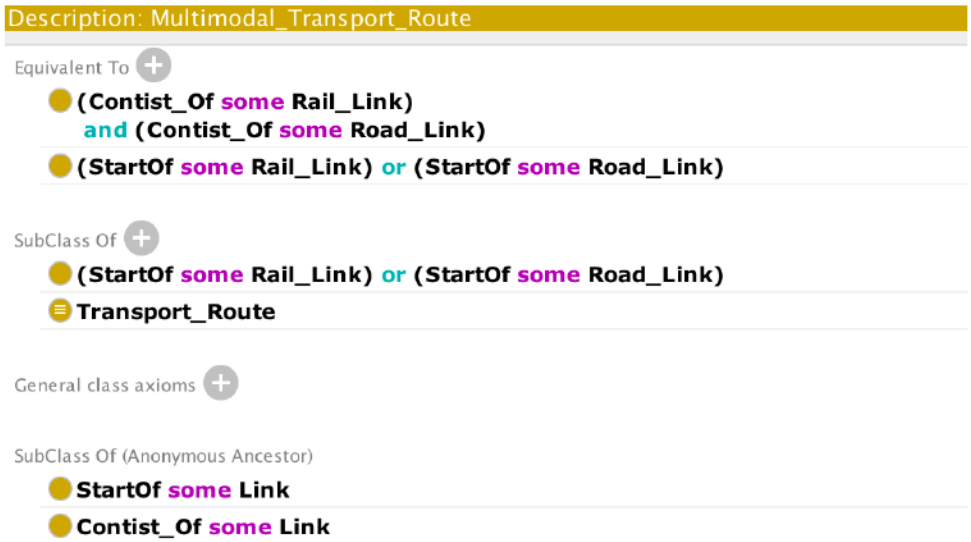
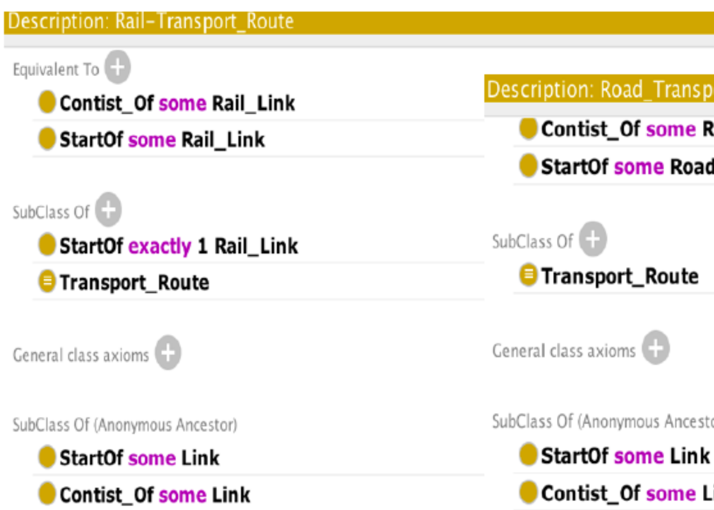


Figure 4.19 Multi Modal Transport Route Restriction



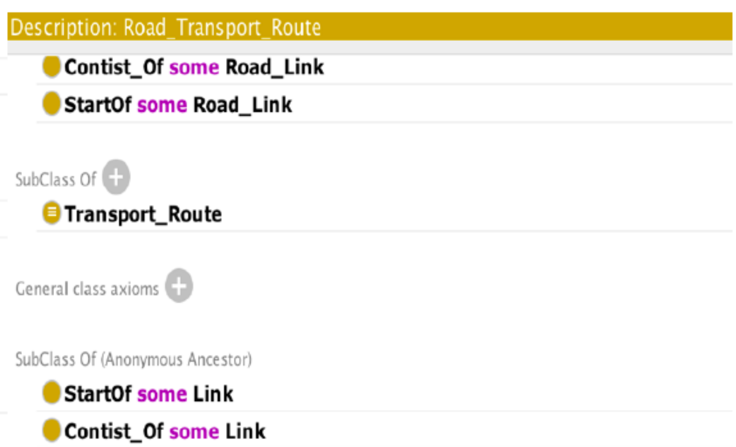


Figure 4.20 Restrictions on Rail Transport Route **Figure 4.21** Restrictions on Road Transport Route

Task (10): Datatype Properties

'Datatype Properties' represent relationship between individuals and data values. In this task, the datatype property 'has_Latitude' was illustrate as seen in the Figure (4.22).

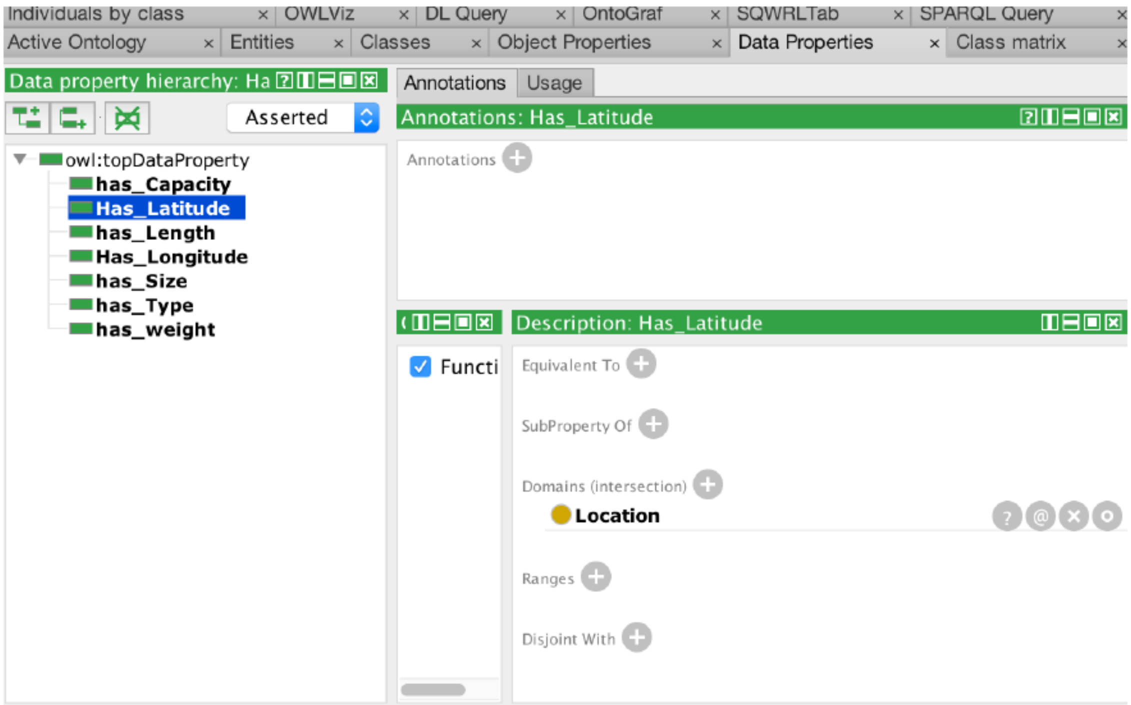


Figure 4.22 Data properties Taxonomy.

Task (11): Using a Reasoner

The 'Reasoner' toll is one of the strong features of Protégé 5 as it used to examine the consistency of tree class hierarchy. This in its turn, make it possible for a reasoner to compute the inferred ontology class hierarchy.

In addition, by performed such test a reasoner tool can check whether or not a class is fin under the right superclass. Based on the class description, the' Start Reasoner ' tool would check whether each class is followed by the same subclass content. Figure (4.23) shows 'Reasoner' tool.

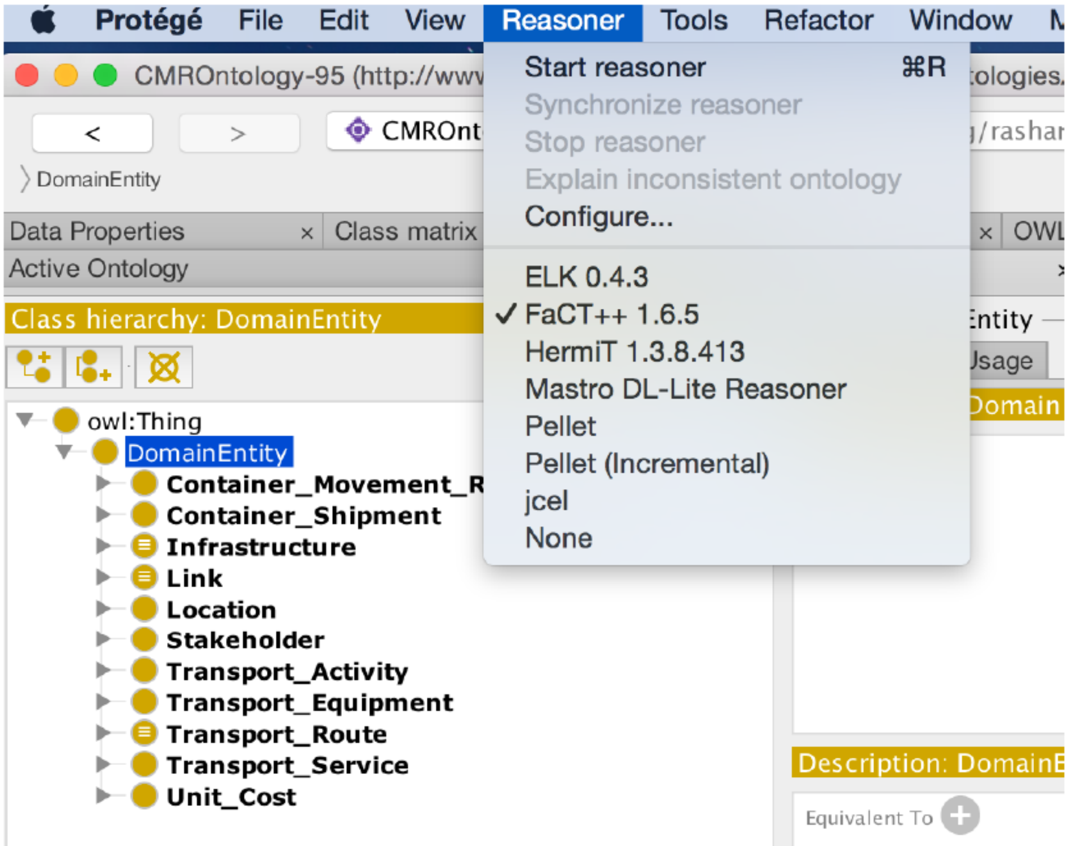


Figure 4.23 The Reasoner mechanism

- **Description Logics (DLs) Syntax:**

- Description Logics/ DLs Syntax:

Description Logics (DLs) is considered as one of the most important tools that provides a common understanding, defining and integrating for OWL ontologies. The (DLs) have coherent syntax that provide an easy shared understanding to use by experts in certain domain of knowledge, as they are compatible with existing Web standers such as (RDF and RDFs). Thus, the CMRO is described by using the Description Logic (DL) queries followed by (Horrocks et al. 2004) and *Manchester OWL* Syntax to produce a syntax that could be used to describe classes and properties in Protégé - OWL.

In fact, we are describing our CMRO model using *Manchester OWL* Syntax expressive description logics, where C is Class and P is Property. Table (4.8) shows conversion between OWL definitions and DL syntax to describe our ontology model.

Table 4.8 Conversion between OWL and DL syntax

OWL Syntax	DL syntax	*Manchester OWL* Syntax
SubClassOf	$C1 \sqsubseteq C2$	-
EquivalentClass	C1 = C2	-
ComplementOf	$\neg$ C1	**NOT** C_1
Intersection Of (and)	$C1 \sqcap C2$	C_1 **And** C_2
UnionOf (or)	$C1 \sqcup C2$	C_1 **or** C_2
one of	$\{a\} \sqcup \{b\}$	{a b …}
SomeValuesFrom	$\exists$ P C	P **SOME** C

allValuesfrom	$\forall$ P C	P ONLY C
minCardinality	N P	P MIN 3
maxCardinality	$\leq$ N P	P MAX 3
Cardinality	= N P	P EXACTLY 3
HasValue	$\exists$ P {a}	P VALUE a

In addition, the syntax of restriction expression (re) for both object property and datatype property, that we used to describe CMRO, is displayed in the table (4.9) below:

Table 4.9 Restriction Expressions

Restriction expression	Cardinality	Universal	Existential	Value
(re)	Only	Min	Some	value
(re)	-	Max	-	-
(re)	-	Exactly	-	-

After represented the approach to formulate Description Logics syntax in Protégé 5, now we are continuing the modeling of our CMRO using DLs syntax structure.

CMRO provides necessary information required to describe all available container distribution routes, that decision-makers should be informed about based on transport Activity process. However, by set up the DLs expressions of available containers distribution within the given network based on transport activity, transport costs of certain route and amount of container traffic, can be monitored.

First, we will start with the Tansport_Activity class, which represents all Activities that transfer containers between facilities locations that represent origin-destination pairs in the system. Transport_Activity individuals {Road_Activity, Rail_Activity} are performed by {Transport_Equipment} on specific {Transport_Route}. Properties of (Tansport_Activity) class are: Moves, Executed_On, is_Accomplish, Interact_With, Performed_Using.

$$\text{Interact\_With} \sqcup \text{Performed\_Using} \sqcup \text{is\_Accomplish} \sqcup \text{Executed\_On} \sqcup \text{Moves} \sqsubseteq \textit{Tansport\_Activity}$$

$$\{\text{Road\_Activity, Rail\_Activity}\} \sqsubseteq \text{Tansport\_Activity}$$

Tansport_Activity class moves container {*TEU*} subclass of Container_Shipment class, starting from containers origin {NmeSeaport} to destination {City} throughout dry port {NameDryPort}. *TEU* class Property is:

$$\textit{TEU} \sqsubseteq \textit{Container\_Sipment}$$

$$\text{Integer} \exists \text{ has\_Size} \sqsubseteq \textit{TEU}$$

$$\text{Literal} \exists \text{ has\_Type} \sqsubseteq \textit{TEU}$$

$$\text{Decimal} \exists \text{ has\_Weight} \sqsubseteq \textit{TEU}$$

Container_Shipment class has year operation denoted how many containerized flows {TEU} went out from origin seaport per year.

$$TEU \sqcup has\_Weight\ per\ year \in \{integer, Ton\}$$

$$TEU \sqcup has\_Size\ per\ year \in \{integer, Number\}$$

Tansport_Activity class executed on *Link* class starting from freight origin in {NmeSeaport} and heading to {DestinationCity} throughout {NameDry port}. *Link* class is:

$$Road\_Link \sqcup Rail\_Link \sqsubseteq Link$$

$$Facility\_ocation \exists\ has\_A\_StartPoint \sqsubseteq Link$$

$$Facility\_ocation \exists\ has\_An\_EndPoint \sqsubseteq Link$$

And Link has Datatype Property as follows:

$$Link \sqsubseteq Domain\_Entity$$

$$Decimal \exists\ has\_Length \sqsubseteq Link$$

$$Literal \exists\ has\_Type \sqsubseteq Link$$

class Tansport_Activity is accomplished *Transport_Servise* class which has individuals {Road_Servise, Rail_Servise}. *Transport_Servise* class is:

$$Road\_Servise \sqcup Rail\_Servise \sqsubseteq Transport\_Servise$$

And Transport service has Datatype property as follows:

$$Transport\_Servise \sqsubseteq Domain\_Entity$$

$$Decimal \; \exists \; has\_ \; unit\,Cost \sqsubseteq Transport\_Servise$$

$$unit\,Cost \in \{Road\_Unitcost, Rail\_UnitCost\}$$

class Tansport_Activity performed by Tansport_Equipment class which has two individuals {LongVehicle, Locomotive}. Tansport_Equipment class is:

$$\{Locomotive, LongVehicle\} \in Transport\_Servise$$

Tansport_Activity class interact with *Location* class which has individuals {*Facility_Location*, *Geographical_Location*, *Placemark*}. *Location* class Property is:

$$Facility\_Location \sqcup Geographical\_Location \sqcup Placemark \sqsubseteq Location$$

$$\{Country, City\} \in Geographical\_Location$$

$$\{Latitude, Longitude\} \in Placemark$$

$$\{SeaPort, DryPort\} \in Facility\_Location$$

$$Literal \; \exists \; has\_ \; Facility\_LocationName \sqsubseteq Facility\; location$$

$$Facility\_LocationName \in \{country, city, seaport, dryport,\}$$

Both Country class and City is a subclass of geographical Location class which has an attribute called (CityName). An individual City is {city} and it has a property is_Located_In with the class Country.

$$\{Country, City\} \in Geographical\_Location$$

$$City \sqsubseteq \exists \text{ is\_Located\_In}. Country \{country\}$$

Only individual {Syria} and individual {Lebanon} of Country class has a property has_A_SeaPort.

$$SeaPort \{LatakiaPort\} \sqcup is\_Located\_In\ Syria$$

$$SeaPort \{BeirutPort\} \sqcup is\_Located\_In\ Lebanon$$

$$DryPort \{H_p, H_e\} \sqcup is\_Located\_In\ City$$

$$SeaPort \sqcup is\_Located\_In\ City$$

$$City\ \exists \text{ is\_Located\_In}. Country \{country\}$$

Where is:

H_p, H_e are Planned and existed dry Ports respectively.

Example;

Addra_DP *is_Located_In Syria*

BeirutPort_SP *is_Located_In Lebanon*

Appendix (2):Description Logics Queries (DLs) Results

5.3.3 Description Logics Queries/ DLs Results

1- Facility Location Query service:

(Facility_location) and Property (is_LocatedIn) Value

(Geographical_Location)

Facility_location ∈ {SeaPort, DryPort}

(Geographical_Location) ∈{Country, City}

Result (1.1):

Dl query:

(Facility_location= DryPort) **and** is_LocatedIn **Value**

(Geographical_Location= Country= Syria)

Country ∈ {Syria, Lebanon, Jordan, Iraq}

Reasoner ⟶ /Executed/

Results:

All Dry Ports Instances that located in Syria. (i.e.: Addra_Dp, Hssea_Dp, SHiekh_Najar_Dp…. etc.)

Result (1.2):

Dl query:

(Facility_location= SeaPort) **and** is_LocatedIn **Value**

(Geographical_Location= City= Beirut)

```
city ∊ {Damascus, Homs, Beirut, Baghdad, … etc.}

Reasoner ⟶ /Executed/

Results:

All Sea Ports Instances that located in Beirut City. (i.e.:
Beirut_Sp, …)
```

By using plug in called (into graph) in Protégé 5, we can illustrate the class (Facility Location) and its property, restrictions and neighborhood) as shown in figure (5.8).

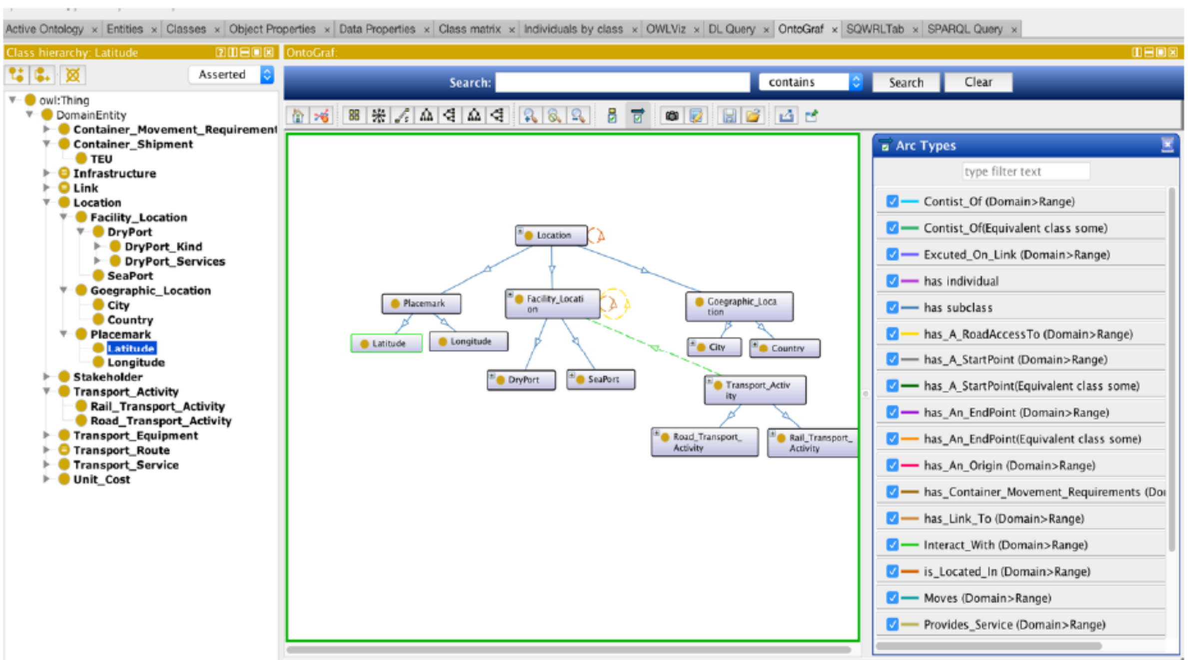


Figure 5.9 Facility location interactions in Protégé 5

2. Link Query service:

2.1 Link Start Point

```
(Link) and Property (has_A_StartPoint) Value (Location)
```

Latakia_SeaPort some Facility_Location

With:

Domain: Link and Range: Location

Link ∊ (Rail_Link, Road_Link}

Location ∊ {Geographical_Locatio, Facility_location}

(Geographical_Location) ∊{Country, City}

Facility_location ∊ {SeaPort, DryPort}

Result (2.1):

Dl query: (Link) **and** has_A_StartPoint **Value** (SeaPort = Latakia)

Domain: Link and **Range:** Facility_Location

Reasoner ⟶ /Executed/

Results:

All Link Instances that start from Latakia seaport in Syria. (i.e.: Latakia_SP_To_Adra_Dp, Latakia_SP_To_Hssea_Dp, SHiekh_Najar_Dp…. etc.)

2.2 Link End Point

(Link) and Property (has_An_EndPoint) Value (Location)

Links has_An_EndPoint some Location

Link ∊ (Rail_Link, Road_Link}

Location ∊ {Geographical_Locatio, Facility_location}

(Geographical_Location) ∊{Country, City}

Facility_location ∊ {SeaPort, DryPort}

Result (2.2):

Dl query: (Link) **and** has_An_EndPoint **Value** (DryPort = Adra_DP)

Domain: Link and **Range:** Facility_Location

Reasoner ⟶ /Executed/

Results:

All Link Instances that ended at Adra_DP in Syria. (i.e.: Latakia_SP_To_Adra_Dp, Latakia_SP_To_Hssea_Dp, SHiekh_Najar_Dp…. etc.)

2.3 Link Infrastructure

(Link) and Property (has_An__Infrastructure) Value (Infrastructure)

Rail_Links has Infrastructure some Rail

With:

Domain: Link and Range: Infrastructure

Link ∊ (Rail_Link, Road_Link}

Infrastructure ∊ {Rail, Road}

Result (2.3):

Dl query: (Link) **and** has_An_Infrastructure **Value** (Road= Latakia to Homs)

Domain: Link and **Range:** Infrastructure

Reasoner ⟶ /Executed/

Results:

All Link Instances that have road Infrastructure start from Latakia to Homs city in Syria. (i.e.: Latakia_SP_To_Adra_City, Latakia_SP_To_Hssea_City, etc.)

the class (Link) and its property, restrictions and neighborhood shown in figure (5. 10)

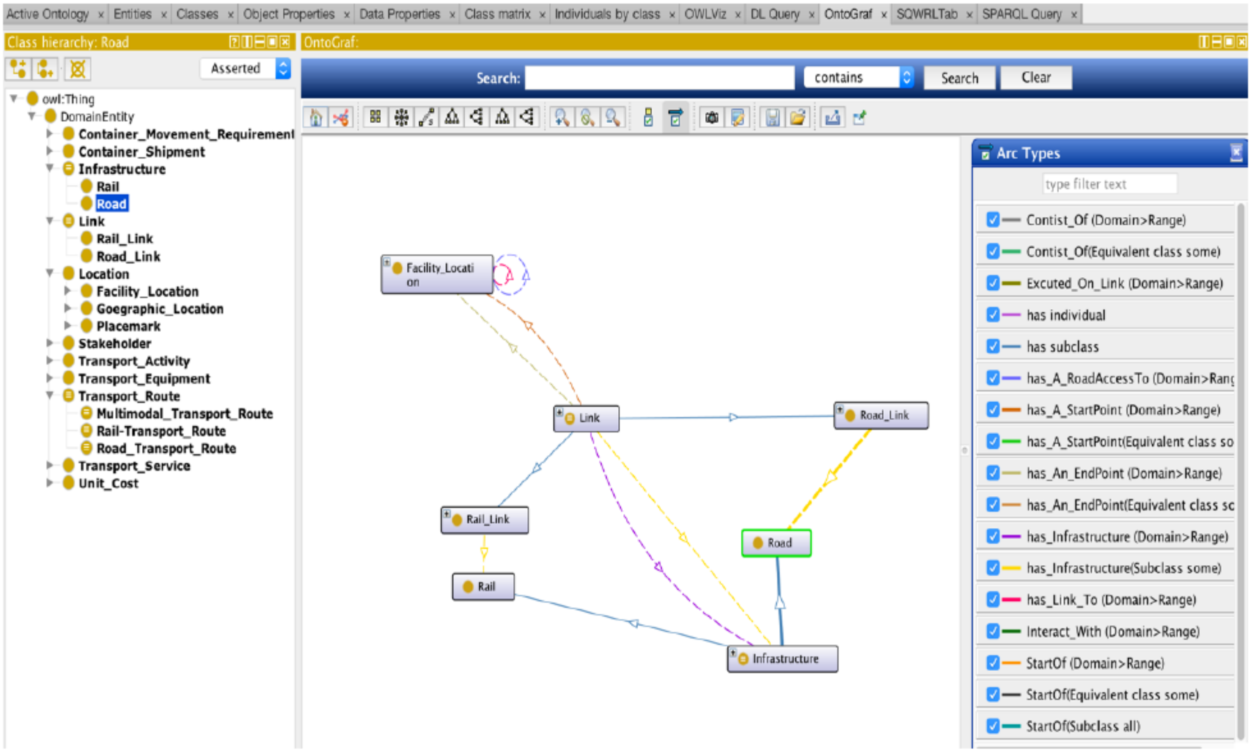


Figure 5.10 Modelling class link in Protégé 5

3. Transport Route Query service:

Transport route included of two section, where is the first one starts from container origin at (Facility Location= seaport) and end up in (Facility Location= dry port), while the second section is start from (Facility Location= dry port) and heading to (Location= destination).

3.1 Section one (Seaport-Dryport) Links:

```
(Link) class and Property (has_A_StartPoint) Value
(Facility_location = Seaport) and Property (has_An_EndPoint) Value
(Facility_location = Dryport)
```

```
Facility_location ∊ {SeaPort, DryPort}
```

Result (3.1):

```
Dl query: (Link) and has_A_StartPoint Value (SeaPort = Latakia)
And has_An_EndPoint Value (DryPort = Adra_DP)
Domain: Link and Range: Facility_Location
Domain: Link and Range: Facility_Location

Reasoner ⟶ /Executed/
Results:
All Link Instances that start from Latakia seaport in Syria and
end at Adra DryPort.
```

3.2 Section two (Dryport-Destination) Links:

(Link) class and Property (has_A_StartPoint) Value (Facility_location = DryPort) and Property (has_An_EndPoint) Value (Geographical_location = City)

Facility_location ∈ {SeaPort, DryPort}

(Geographical_Location) ∈{Country, City}

Result (3.2):

```
Dl query: (Link) and has_A_StartPoint Value (DryPort= Adra_DP)
And has_An_EndPoint Value (City = Baghdad)
```

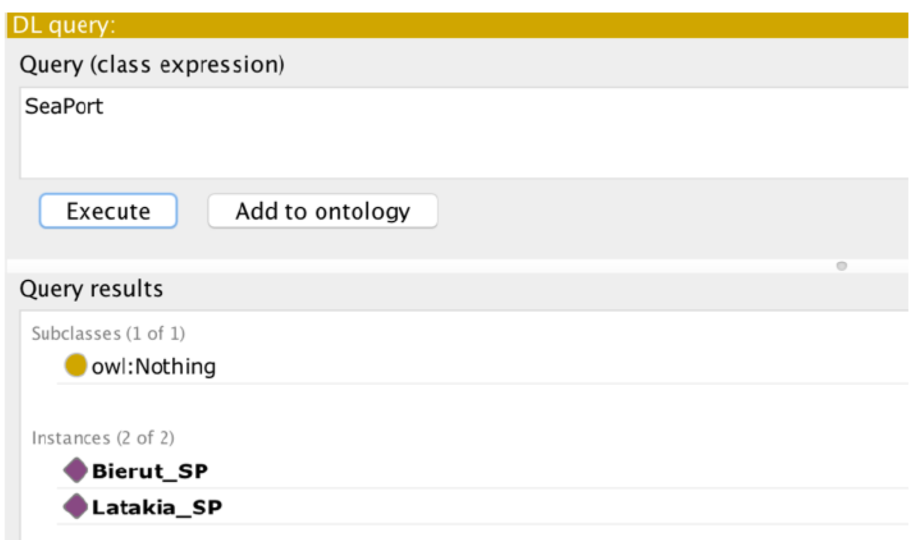
```
Domain: Link and Range: Facility_Location

Domain: Link and Range: Geographical_Location


Reasoner ──▶ /Executed/

Results:

All Link Instances that start from Adra Dryport in Syria and end
at Baghdad City.
```

5.4 Result and discussion

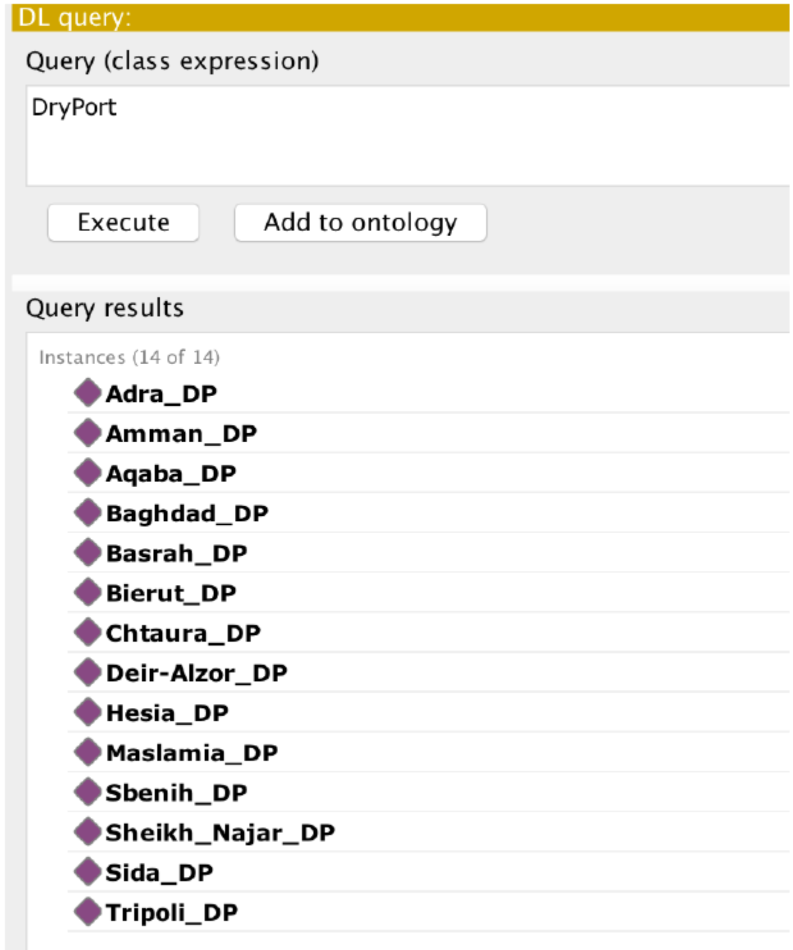
Now to enrich the CMRO, we will ask the ontology about provide all Rail links that start from Latakia seaport and end at national dry port as follows:

Step (1): Issue DL query for facility location, seaport and dry port the answer will like the follows:

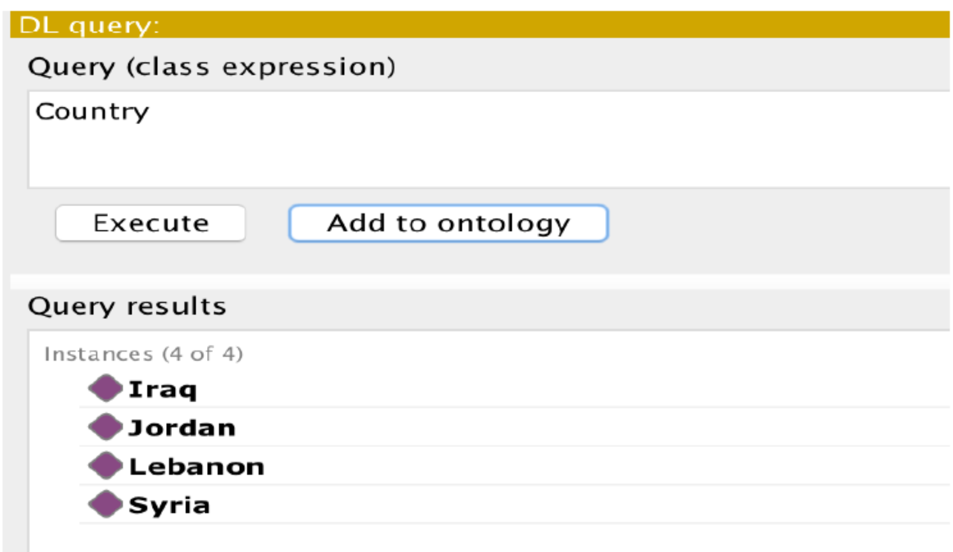
we count (2) Sea ports.



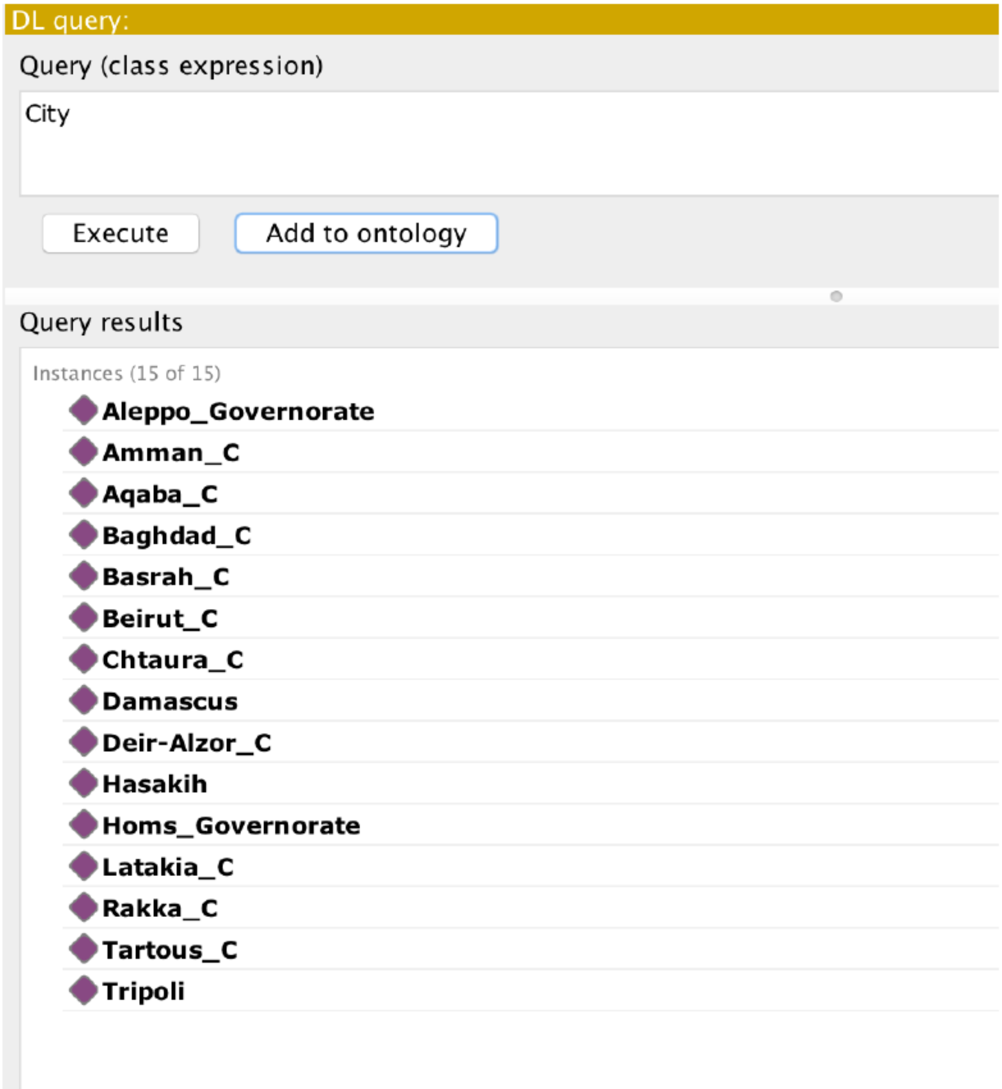
And (14) Dry ports



And (4) countries

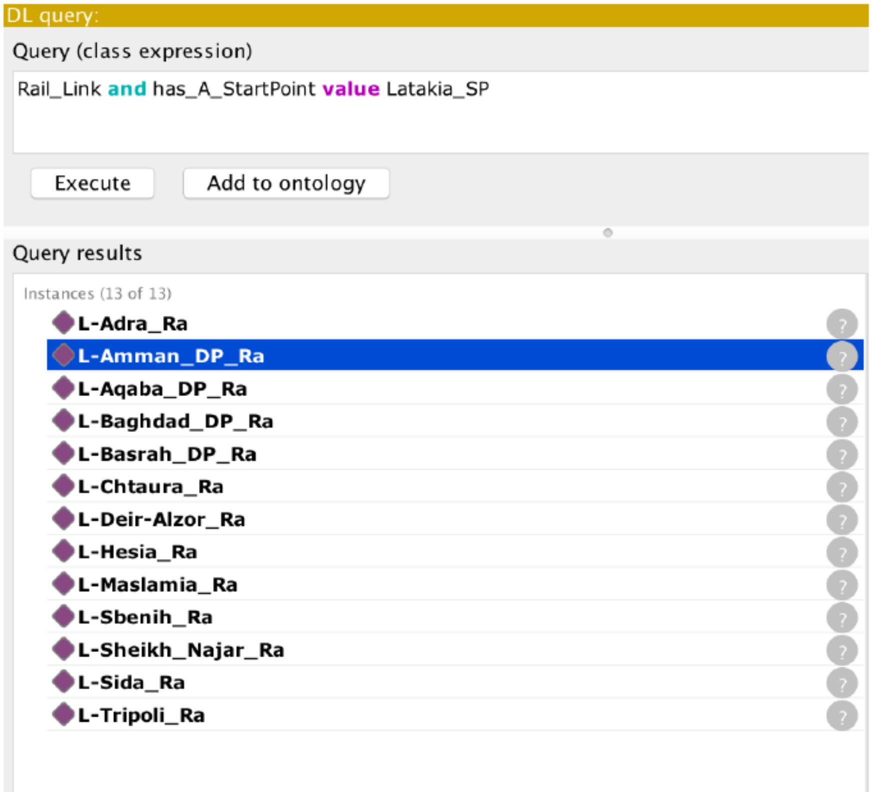


And (15) cities.

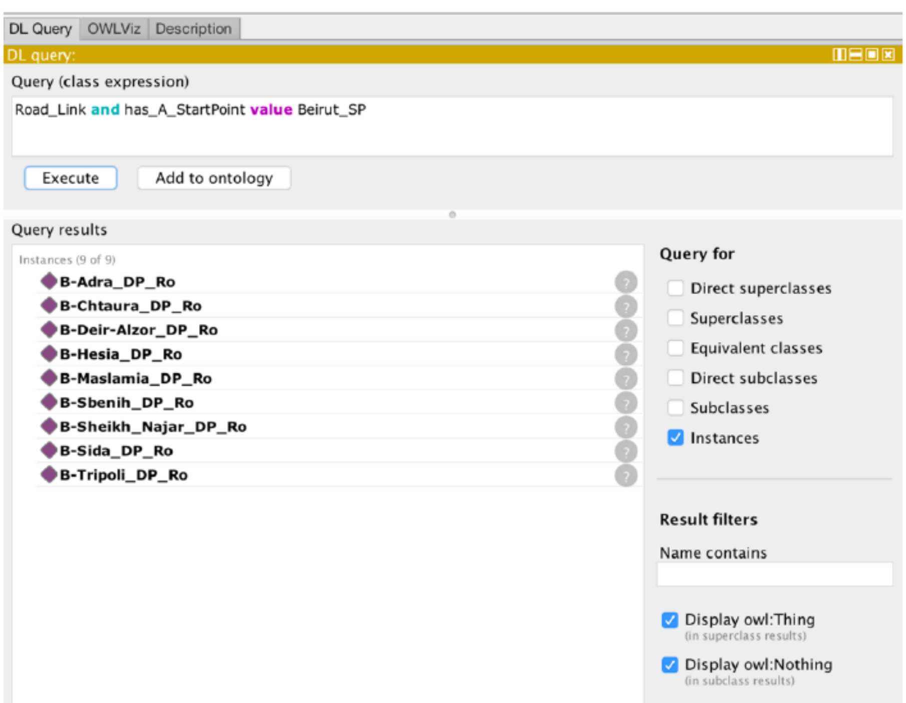


Step (2): Ask for Rail and Road links start from Seaport:

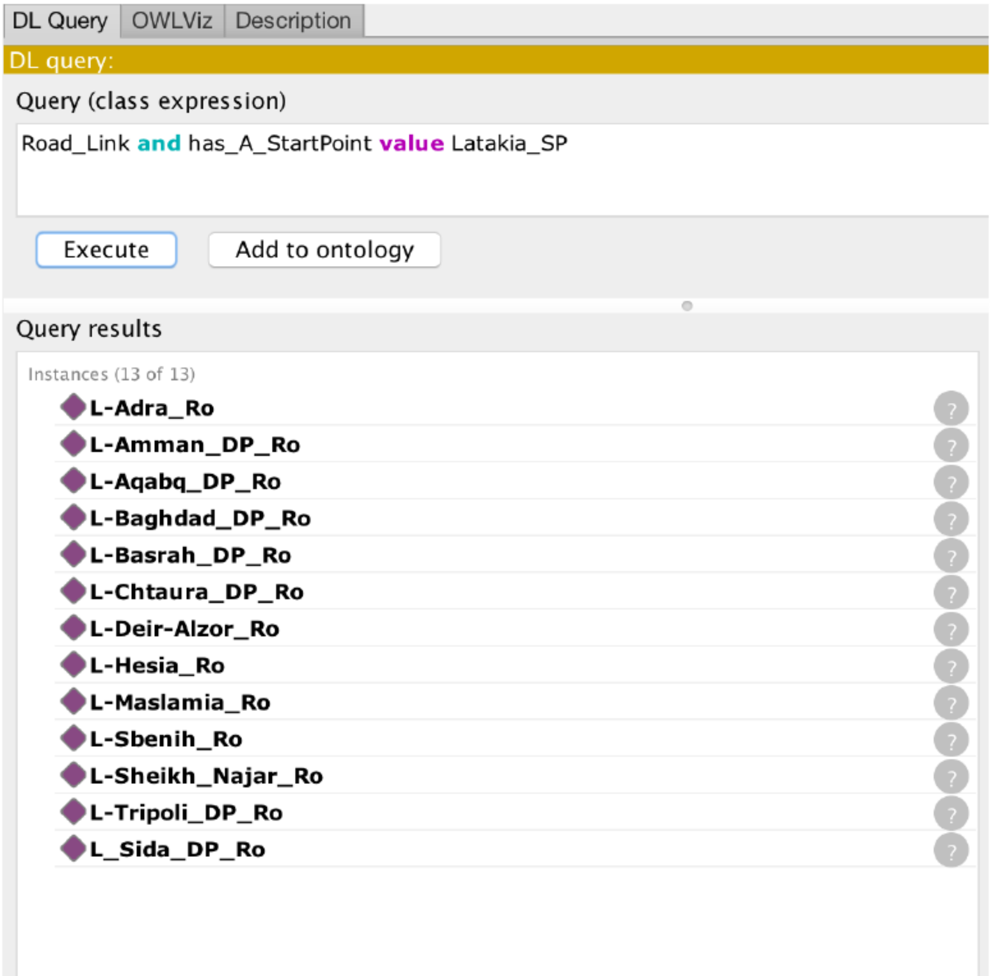
1)- Rail links starts from Latakia:



2)- Road links starts from Latakia:



3)- Road links starts from Beirut Seaport:



Appendix (3): Excel Slover Results

Table 6.11 Container Traffic from Latakia and Beirut seaports via under-operation dry port in MCs region by Road&Rail

Link Origin	Link Destination	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_Sp	Sbenih	2.4	0	356	1.6	0	0	0
Latakia_Sp	Maslamia	2.4	0	296	1.6	0	0	0
Latakia_Sp	Abu Graib	2.4	110000					
Beirut_SP	Sbenih	2.4	560000					
Beirut_SP	Maslamia	2.4	500000					
Beirut_SP	Baghdad	2.4	0					
Sbenih_DP	Damascus	2.4	0	13	1.6	0	0	0
"	Aleppo Governorate	2.4	0	366	1.6	0	0	0
"	Homs Governorate	2.4	0	170	1.6	0	0	0
"	Latakia Governorate	2.4	0	342	1.6	0	0	0
"	Tartous	2.4	0	260	1.6	0	0	0
"	Eastern district/Syria	2.4	0	459	1.6	0	0	0
"	Sida	2.4	0				0	
"	Tripoli	2.4	0				0	
"	Bekaa Valley	2.4	0				0	
"	Baalbek	2.4	0				0	
"	Beirut	2.4	0				0	
"	Irbid	2.4	0				0	
"	Amman	2.4	0				0	
"	Aqaba	2.4	24836.19651				30816752.62	
"	Baghdad	2.4	535163.8035				1081459014	
"	Mosul	2.4	0				0	
"	Basrah	2.4	0				0	

"	Anbar-Ramadi		2.4	0				0	
"	Nineveh Governorate		2.4	0				0	
Maslamia_DP	Damascus	379	2.4	0	379	1.6	0	0	0
"	Aleppo Governorate	22	2.4	0	22	1.6	0	0	0
"	Homs Governorate	208	2.4	0	208	1.6	0	0	0
"	Latakia Governorate	198	2.4	0	198	1.6	0	0	0
"	Tartous	268	2.4	0	268	1.6	0	0	0
"	Eastern district/Syria	406	2.4	0	406	1.6	0	0	0
"	Sida	435	2.4	0				0	
"	Tripoli	308	2.4	0				0	
"	Bekaa Valley	352	2.4	0				0	
"	Baalbek	318	2.4	0				0	
"	Beirut	391	2.4	0				0	
"	Irbid	514	2.4	0				0	
"	Amman	578	2.4	0				0	
"	Aqaba	900	2.4	0				0	
"	Baghdad	1052	2.4	364512.7302				920321741.3	
"	Mosul	611	2.4	87673.91199				128565024.5	
"	Basrah	1563	2.4	0				0	
"	Anbar-Ramadi	936	2.4	0				0	
	Nineveh Governorate	583	2.4	47813.35777				66900450.19	

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_SP	Damascus	334	4.8	0	334	3.2	0	0	0
"	Aleppo Governorate	181	4.8	0	181	3.2	642552.1077	0	372166180.8
"	Homs Governorate	177	4.8	0	177	3.2	237987.1508	0	134795922.2
"	Latakia Governorate	3.8	4.8	0	3.8	3.2	249470.7238	0	3033564.002
"	Tartous	85	4.8	0	85	3.2	37429.98023	0	10180954.62
"	Eastern district/Syria	541	4.8	0	541	3.2	275266.1287	0	476540722
"	Sida	264	4.8	0				0	
"	Tripoli	148	4.8	0				0	
"	Bekaa Valley	307	4.8	0				0	
"	Baalbek	273	4.8	0				0	
"	Beirut	4.2	4.8	252915.7957				5098782.442	
"	Irbid	855	4.8	0				0	
"	Amman	532	4.8	529036.3286				1350947169	
"	Aqaba	855	4.8	0				0	
"	Baghdad	1021	4.8	0				0	
"	Mosul	799	4.8	0				0	
"	Basrah	1533	4.8	0				0	
	Anbar-Ramadi	906	4.8	206044.3386				896045619.6	
	Nineveh Governorate	772	4.8	387770.4458				1436922164	

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Beirut_SP	Damascus	113	4.8	225843.6024				122497569.9	
"	Aleppo Governorate	369	4.8	0				0	
"	Homs Governorate	186	4.8	0				0	
"	Latakia Governorate	230	4.8	0				0	
"	Tartous	143	4.8	0				0	
"	Eastern district/Syria	537	4.8	0				0	
"	Sida	80	4.8	21588.32527				8289916.905	
"	Tripoli	44	4.8	30279.41011				6395011.415	
"	Bekaa Valley	52	4.8	71277.34967				17790826.48	
"	Baalbek	87	4.8	10903.85056				4553447.993	
"	Beirut	62	4.8	0				0	
"	Irbid	307	4.8	233652.168				344309834.8	
"	Amman	629	4.8	0				0	
"	Aqaba	934	4.8	0				0	
"	Baghdad	919	4.8	2065.846254				9112860.997	
"	Mosul	1446	4.8	0				0	
"	Basrah	890	4.8	283789.4477				1212348521	
"	Anbar	892	4.8	0				0	
"	Nineveh Governorate	839	4.8	0				0	

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Abu Graib_DP	Damascus	827	2.4	0				0	
"	Aleppo Governorate	854	2.4	0				0	
"	Homs Governorate	834	2.4	0				0	
"	Latakia Governorate	1012	2.4	0				0	
"	Tartous	930	2.4	0				0	
"	Eastern district/Syria	526	2.4	0				0	
"	Sida	961	2.4	0				0	
"	Tripoli	938	2.4	0				0	
"	Bekaa Valley	928	2.4	0				0	
"	Baalbek	924	2.4	0				0	
"	Beirut	928	2.4	0				0	
"	Irbid	864	2.4	0				0	
"	Amman	822	2.4	0				0	
"	Aqaba	1152	2.4	0				0	
"	Baghdad	29	2.4	110000				7656000	
"	Mosul	421	2.4	0				0	
"	Basrah	549	2.4	0				0	
"	Anbar-Ramadi	92	2.4	0				0	
"	Nineveh Governorate	523	2.4	0				0	
							Total Cost	**8646748050**	

Table 6.20 Minimum cost flow result of the third scenario including Hesia dry port/ part (1).

Link Origin	Link Destination	Road Length/Km	MinCFlow	Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_Sp	Sbenih_DP	356	0	356	1.6	0	0	0
Latakia_Sp	Maslamia_DP	181	500000	296	1.6	0	217200000	0
Latakia_Sp	Baghdad_DP	1014	0			0	0	0
Latakia_Sp	Hessia_DP	195	0	195	1.6	1246104.392	0	388784570.5
Beirut_SP	Sbenih_DP	121	560000			0	162624000	0
Beirut_SP	Maslamia_DP	389	0			0	0	0
Beirut_SP	Baghdad_DP	902	110000			0	238128000	0
Beirut_SP	Hessia_DP	194	909507.462			0	423466674.3	0
Sbenih_DP	Damascus	13	0	13	1.6	0	0	0
"	Aleppo Governorate	366	0	366	1.6	0	0	0
"	Homs Governorate	170	0	170	1.6	0	0	0
"	Latakia Governorate	342	0	342	1.6	0	0	0
"	Tartous	260	0	260	1.6	0	0	0
"	Eastern district/Syria	459	0	459	1.6	0	0	0
"	Sida	153	0			0	0	0
"	Tripoli	192	0			0	0	0
"	Bekaa Valley	102	0			0	0	0
"	Baalbek	106	0			0	0	0
"	Beirut	121	0			0	0	0
"	Irbid	131	6127.474856			0	1926478.095	0
"	Amman	194	529036.3286			0	246319314.6	0
"	Aqaba	517	24836.19651			0	30816752.62	0
"	Baghdad	842	0			0	0	0
"	Mosul	879	0			0	0	0

Link Origin	Link Destination	Road Length/Km		MinCFlow	Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Basrah	1354		0			0	0	0
"	Anbar-Ramadi	726		0			0	0	0
"	Nineveh Governorate	852		0			0	0	0
Maslamia_DP	Damascus	379	2.4	0	379	1.6	0	0	0
"	Aleppo Governorate	22	2.4	0	22	1.6	0	0	0
"	Homs Governorate	208	2.4	0	208	1.6	0	0	0
"	Latakia Governorate	198	2.4	0	198	1.6	0	0	0
"	Tartous	268	2.4	0	268	1.6	0	0	0
"	Eastern district/Syria	406	2.4	0	406	1.6	0	0	0
"	Sida	435	2.4	0			0	0	0
"	Tripoli	308	2.4	0			0	0	0
"	Bekaa Valley	352	2.4	0			0	0	0
"	Baalbek	318	2.4	0			0	0	0
"	Beirut	391	2.4	0			0	0	0
"	Irbid	514	2.4	0			0	0	0
"	Amman	578	2.4	0			0	0	0
"	Aqaba	900	2.4	0			0	0	0
"	Baghdad	1052	2.4	0			0	0	0
"	Mosul	611	2.4	64416.19648			0	94459910.52	0
"	Basrah	1563	2.4	0			0	0	0
"	Anbar	936	2.4	0			0	0	0
	Nineveh Governorate	583	2.4	435583.8035			0	609468857.9	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_SP	Damascus	334	4.8	0	334	3.2	0	0	0
"	Aleppo Governorate	181	4.8	0	181	3.2	642552.1077	0	372166180.8
"	Homs Governorate	177	4.8	0	177	3.2	0	0	0
"	Latakia Governorate	3.8	4.8	0	3.8	3.2	249470.7238	0	3033564.002
"	Tartous	85	4.8	0	85	3.2	37429.98023	0	10180954.62
"	Eastern district/Syria	541	4.8	0	541	3.2	0	0	0
"	Sida	264	4.8	0			0	0	0
"	Tripoli	148	4.8	0			0	0	0
"	Bekaa Valley	307	4.8	0			0	0	0
"	Baalbek	273	4.8	0			0	0	0
"	Beirut	4.2	4.8	252915.7957			0	5098782.442	0
"	Irbid	855	4.8	0			0	0	0
"	Amman	532	4.8	0			0	0	0
"	Aqaba	855	4.8	0			0	0	0
"	Baghdad	1021	4.8	0			0	0	0
"	Mosul	799	4.8	0			0	0	0
"	Basrah	1533	4.8	0			0	0	0
	Anbar-Ramadi	906	4.8	0			0	0	0
	Nineveh Governorate	772	4.8	0			0	0	0
Beirut port	Damascus	113	4.8	225843.6024			0	122497569.9	0
"	Aleppo Governorate	369	4.8	0			0	0	0
"	Homs Governorate	186	4.8	0			0	0	0
"	Latakia Governorate	230	4.8	0			0	0	0
"	Tartous	143	4.8	0			0	0	0
"	Eastern district/Syria	537	4.8	0			0	0	0
"	Sida	80	4.8	21588.32527			0	8289916.905	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Tripoli	44	4.8	30279.41011			0	6395011.415	0
"	Bekaa Valley	52	4.8	71277.34967			0	17790826.48	0
"	Baalbek	87	4.8	10903.85056			0	4553447.993	0
"	Beirut	62	4.8	0			0	0	0
"	Irbid	307	4.8	0			0	0	0
"	Amman	629	4.8	0			0	0	0
"	Aqaba	934	4.8	0			0	0	0
"	Baghdad	919	4.8	0			0	0	0
"	Mosul	1446	4.8	0			0	0	0
"	Basrah	890	4.8	0			0	0	0
"	Anbar-Ramadi	892	4.8	0			0	0	0
"	Nineveh Governorate	839	4.8	0			0	0	0
Baghdad_DP	Damascus	827	2.4	0			0	0	0
"	Aleppo Governorate	854	2.4	0			0	0	0
"	Homs Governorate	834	2.4	0			0	0	0
"	Latakia Governorate	1012	2.4	0			0	0	0
"	Tartous	930	2.4	0			0	0	0
"	Eastern district/Syria	526	2.4	0			0	0	0
"	Sida	961	2.4	0			0	0	0
"	Tripoli	938	2.4	0			0	0	0
"	Bekaa Valley	928	2.4	0			0	0	0
"	Baalbek	924	2.4	0			0	0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Beirut	928	2.4	0			0	0	0
"	Irbid	864	2.4	0			0	0	0
"	Amman	822	2.4	0			0	0	0
"	Aqaba	1152	2.4	0			0	0	0
"	Baghdad	29	2.4	110000			0	7656000	0
"	Mosul	421	2.4	0			0	0	0
"	Basrah	549	2.4	0			0	0	0
"	Anbar-Ramadi	92	2.4	0			0	0	0
"	Nineveh Governorate	523	2.4	0			0	0	0
Hessia_DP	Damascus	126	2.4	0	126	1.6	0	0	0
"	Aleppo Governorate	233	2.4	0	233	1.6	0	0	0
"	Homs Governorate	37	2.4	0	37	1.6	237987.1508	0	14088839.33
"	Latakia Governorate	193	2.4	0	193	1.6	0	0	0
"	Tartous	127	2.4	0	127	1.6	0	0	0
"	Eastern district/Syria	388	2.4	0	388	1.6	275266.1287	0	170885212.7
"	Sida	229	2.4	0			0	0	0
"	Tripoli	136	2.4	0			0	0	0
"	Bekaa Valley	137	2.4	0			0	0	0
"	Baalbek	109	2.4	0			0	0	0
"	Beirut	196	2.4	0			0	0	0
"	Irbid	261	2.4	227524.6932			0	142521467.8	0
"	Amman	325	2.4	0			0	0	0
"	Aqaba	648	2.4	0			0	0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Baghdad	868	2.4	901742.38			0	1878509726	0
"	Mosul	771	2.4	23257.71551			0	43036076.77	0
"	Basrah	1383	2.4	283789.4477			0	941953935	0
"	Anbar-Ramadi	753	2.4	206044.3386			0	372363328.7	0
"	Nineveh Governorate	744	2.4	0			0	0	0
								5575076077	959139321.9
									6534215399

Table 6.21 Minimum cost flow result of the third scenario including (Hesia + Tripoli) dry ports/ part (2).

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_Sp	Sbenih_DP	356	2.4	0	356	1.6	0	0	0
Latakia_Sp	Maslamia_DP	181	2.4	500000	296	1.6	0	217200000	0
Latakia_Sp	Baghdad_DP	1014	2.4	0				0	0
Latakia_Sp	Hessia_DP	195	2.4	0	195	1.6	1246104.392	0	388784570.5
Latakia_Sp	Tripoli_DP	148	2.4	0				0	0
Beirut_SP	Sbenih_DP	121	2.4	560000				162624000	0
Beirut_SP	Maslamia_DP	389	2.4	0				0	0
Beirut_SP	Baghdad_DP	902	2.4	110000				238128000	0
Beirut_SP	Hessia_DP	194	2.4	409507.462				190666674.3	0
Beirut_SP	Tripoli_DP	80	2.4	500000				96000000	0
Tripoli_DP	Damascus	189	2.4	0				0	0
"	Aleppo Governorate	272	2.4	0				0	0
"	Homs Governorate	103	2.4	0				0	0
"	Latakia Governorate	148	2.4	0				0	0
"	Tartous	61.5	2.4	0				0	0
"	Eastern district/Syria	467	2.4	0				0	0
"	Sida	125	2.4	0				0	0
"	Tripoli	4	2.4	0				0	0
"	Bekaa Valley	106	2.4	0				0	0
"	Baalbek	112	2.4	0				0	0
"	Beirut	81.5	2.4	0				0	0
"	Irbid	320	2.4	202688.4967				155664765.4	0
"	Amman	384	2.4	0				0	0
"	Aqaba	706	2.4	24836.19651				42082451.36	0
"	Baghdad	947	2.4	0				0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Mosul	838	2.4	0				0	0
"	Basrah	1459	2.4	249217.5913				872660317.8	0
"	Anbar-Ramadi	832	2.4	0				0	0
"	Nineveh Governorate	810	2.4	23257.71551				45212998.94	0
Sbenih_DP	Damascus	13	2.4	0	13	1.6	0	0	0
"	Aleppo Governorate	366	2.4	0	366	1.6	0	0	0
"	Homs Governorate	170	2.4	0	170	1.6	0	0	0
"	Latakia Governorate	342	2.4	0	342	1.6	0	0	0
"	Tartous	260	2.4	0	260	1.6	0	0	0
"	Eastern district/Syria	459	2.4	0	459	1.6	0	0	0
"	Sida	153	2.4	0				0	0
"	Tripoli	192	2.4	0				0	0
"	Bekaa Valley	102	2.4	0				0	0
"	Baalbek	106	2.4	0				0	0
"	Beirut	121	2.4	0				0	0
"	Irbid	131	2.4	30963.67136				9734978.276	0
"	Amman	194	2.4	529036.3286				246319314.6	0
"	Aqaba	517	2.4	0			0	0	0
"	Baghdad	842	2.4	0			0	0	0
"	Mosul	879	2.4	0			0	0	0
"	Basrah	1354	2.4	0			0	0	0
"	Anbar-Ramadi	726	2.4	0			0	0	0
"	Nineveh Governorate	852	2.4	0			0	0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Maslamia_DP	Damascus	379	2.4	0	379	1.6	0	0	0
"	Aleppo Governorate	22	2.4	0	22	1.6	0	0	0
"	Homs Governorate	208	2.4	0	208	1.6	0	0	0
"	Latakia Governorate	198	2.4	0	198	1.6	0	0	0
"	Tartous	268	2.4	0	268	1.6	0	0	0
"	Eastern district/Syria	406	2.4	0	406	1.6	0	0	0
"	Sida	435	2.4	0				0	0
"	Tripoli	308	2.4	0				0	0
"	Bekaa Valley	352	2.4	0				0	0
"	Baalbek	318	2.4	0				0	0
"	Beirut	391	2.4	0				0	0
"	Irbid	514	2.4	0				0	0
"	Amman	578	2.4	0				0	0
"	Aqaba	900	2.4	0			0	0	0
"	Baghdad	1052	2.4	0			0	0	0
"	Mosul	611	2.4	87673.91199			0	128565024.5	0
"	Basrah	1563	2.4	0			0	0	0
"	Anbar-Ramadi	936	2.4	0			0	0	0
	Nineveh Governorate	583	2.4	412326.088			0	576926662.3	0
Latakia_SP	Damascus	334	4.8	0	334	3.2	0	0	0
"	Aleppo Governorate	181	4.8	0	181	3.2	642552.1077	0	372166180.8
"	Homs Governorate	177	4.8	0	177	3.2	0	0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Latakia Governorate	3.8	4.8	0	3.8	3.2	249470.7238	0	3033564.002
"	Tartous	85	4.8	0	85	3.2	37429.98023	0	10180954.62
"	Eastern district/Syria	541	4.8	0	541	3.2	0	0	0
"	Sida	264	4.8	0				0	0
"	Tripoli	148	4.8	0				0	0
"	Bekaa Valley	307	4.8	0				0	0
"	Baalbek	273	4.8	0				0	0
"	Beirut	4.2	4.8	252915.7957				5098782.442	0
"	Irbid	855	4.8	0				0	0
"	Amman	532	4.8	0				0	0
"	Aqaba	855	4.8	0				0	0
"	Baghdad	1021	4.8	0				0	0
"	Mosul	799	4.8	0				0	0
"	Basrah	1533	4.8	0				0	0
	Anbar-Ramadi	906	4.8	0				0	0
	Nineveh Governorate	772	4.8	0				0	0
Beirut_SP	Damascus	113	4.8	225843.6024				122497569.9	0
"	Aleppo Governorate	369	4.8	0				0	0
"	Homs Governorate	186	4.8	0				0	0
"	Latakia Governorate	230	4.8	0				0	0
"	Tartous	143	4.8	0				0	0
"	Eastern district/Syria	537	4.8	0				0	0

"	Sida	80	4.8	21588.32527				8289916.905	0
"	Tripoli	44	4.8	30279.41011				6395011.415	0
"	Bekaa Valley	52	4.8	71277.34967				17790826.48	0
Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Baalbek	87	4.8	10903.85056				4553447.993	0
"	Beirut	62	4.8	0				0	0
"	Irbid	307	4.8	0				0	0
"	Amman	629	4.8	0				0	0
"	Aqaba	934	4.8	0				0	0
"	Baghdad	919	4.8	0				0	0
"	Mosul	1446	4.8	0				0	0
"	Basrah	890	4.8	0				0	0
"	Anbar-Ramadi	892	4.8	0				0	0
"	Nineveh Governorate	839	4.8	0				0	0
Baghdad_DP	Damascus	827	2.4	0				0	0
"	Aleppo Governorate	854	2.4	0				0	0
"	Homs Governorate	834	2.4	0				0	0
"	Latakia Governorate	1012	2.4	0				0	0
"	Tartous	930	2.4	0				0	0
"	Eastern district/Syria	526	2.4	0				0	0
"	Sida	961	2.4	0				0	0
"	Tripoli	938	2.4	0				0	0
"	Bekaa Valley	928	2.4	0				0	0
"	Baalbek	924	2.4	0				0	0
"	Beirut	928	2.4	0				0	0

"	Irbid	864	2.4	0				0	0
"	Amman	822	2.4	0				0	0
"	Aqaba	1152	2.4	0				0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Baghdad	29	2.4	110000				7656000	0
"	Mosul	421	2.4	0				0	0
"	Basrah	549	2.4	0				0	0
"	Anbar-Ramadi	92	2.4	0				0	0
"	Nineveh Governorate	523	2.4	0				0	0
Hessia_DP	Damascus	126	2.4	0	126	1.6	0	0	0
"	Aleppo Governorate	233	2.4	0	233	1.6	0	0	0
"	Homs Governorate	37	2.4	0	37	1.6	237987.1508	0	14088839.33
"	Latakia Governorate	193	2.4	0	193	1.6	0	0	0
"	Tartous	127	2.4	0	127	1.6	0	0	0
"	Eastern district/Syria	388	2.4	0	388	1.6	275266.1287	0	170885212.7
"	Sida	229	2.4	0				0	0
"	Tripoli	136	2.4	0				0	0
"	Bekaa Valley	137	2.4	0				0	0
"	Baalbek	109	2.4	0				0	0
"	Beirut	196	2.4	0				0	0
"	Irbid	261	2.4	0				0	0
"	Amman	325	2.4	0				0	0
"	Aqaba	648	2.4	0				0	0
"	Baghdad	868	2.4	901742.38				1878509726	0
"	Mosul	771	2.4	0				0	0

"	Basrah	1383	2.4	34571.85642	114750905.8	0
"	Anbar-Ramadi	753	2.4	206044.3386	372363328.7	0
"	Nineveh Governorate	744	2.4	0	0	0
					5519690703	959139321.9
					6478830025	

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Table 6.28 Container Traffic from Latakia and Beirut seaports via candidates dry port in the Fourth Scenario region by Road&Rail.

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
Latakia_Sp	Sbenih_dP	356	2.4	0	356	1.6	0	0	0
Latakia_Sp	Maslamia_DP	181	2.4	500000	296	1.6	0	217200000	0
Latakia_Sp	Baghdad_DP	1014	2.4	0				0	0
Latakia_Sp	Hessia_DP	195	2.4	0	195	1.6	1246104.392	0	400462724.3
Latakia_Sp	Tripoli_DP	148	2.4	0				0	0
Latakia_Sp	Mafraq_DP	472	2.4	0				0	
Beirut_SP	Sbenih_dP	121	2.4	560000				162624000	0
Beirut_SP	Maslamia_DP	389	2.4	0				0	0
Beirut_SP	Baghdad_DP	902	2.4	110000				238128000	0
Beirut_SP	Hessia_DP	194	2.4	0				0	0
Beirut_SP	Tripoli_DP	80	2.4	378105.7813				72596310.02	0
Beirut_SP	Mafraq_DP	248	2.4	787524.6932				468734697.4	
Mafraq_DP	Damascus	142	2.4	0				0	
"	Aleppo Governorate	496	2.4	0				0	
"	Homs Governorate	301	2.4	0				0	
"	Latakia Governorate	469	2.4	0				0	
"	Tartous	391	2.4	0				0	
"	Eastern district/Syria	589	2.4	0				0	
"	Sida	283	2.4	0				0	
"	Tripoli	323	2.4	0				0	
"	Bekaa Valley	233	2.4	0				0	
"	Baalbek	236	2.4	0				0	
"	Beirut	251	2.4	0				0	
"	Irbid	50	2.4	233652.168				28038260.16	
"	Amman	66	2.4	529036.3286				83799354.46	

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Aqaba	388	2.4	24836.19651				23127466.19	
"	Baghdad	831	2.4	0				0	
"	Mosul	1112	2.4	0				0	
"	Basrah	1342	2.4	0				0	
"	Anbar-Ramadi	715	2.4	0				0	
"	Nineveh Governorate	954	2.4	0				0	
Tripoli_DP	Damascus	189	2.4	0				0	0
"	Aleppo Governorate	272	2.4	0				0	0
"	Homs Governorate	103	2.4	131461.2868				32497230.1	0
"	Latakia Governorate	148	2.4	0				0	0
"	Tartous	61.5	2.4	37429.98023				5524665.081	0
"	Eastern district/Syria	467	2.4	0				0	0
"	Sida	125	2.4	0				0	0
"	Tripoli	4	2.4	30279.41011				290682.337	0
"	Bekaa Valley	106	2.4	0				0	0
"	Baalbek	112	2.4	0				0	0
"	Beirut	81.5	2.4	0				0	0
"	Irbid	320	2.4	0				0	0
"	Amman	384	2.4	0				0	0
"	Aqaba	706	2.4	0				0	0
"	Baghdad	947	2.4	0				0	0
"	Mosul	838	2.4	23257.71551				46775917.43	0
"	Basrah	1459	2.4	155677.3887				545119944.2	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Anbar-Ramadi	832	2.4	0				0	0
"	Nineveh Governorate	810	2.4	0				0	0
Sbenih_DP	Damascus	13	2.4	0	13	1.6	0	0	4697546.929
"	Aleppo Governorate	366	2.4	0	366	1.6	0	0	0
"	Homs Governorate	170	2.4	0	170	1.6	0	0	0
"	Latakia Governorate	342	2.4	0	342	1.6	0	0	0
"	Tartous	260	2.4	0	260	1.6	0	0	0
"	Eastern district/Syria	459	2.4	0	459	1.6	0	0	0
"	Sida	153	2.4	0				0	0
"	Tripoli	192	2.4	0				0	0
"	Bekaa Valley	102	2.4	0				0	0
"	Baalbek	106	2.4	0				0	0
"	Beirut	121	2.4	0				0	0
"	Irbid	131	2.4	0				0	0
"	Amman	194	2.4	0				0	0
"	Aqaba	517	2.4	0				0	0
"	Baghdad	842	2.4	0				0	0
"	Mosul	879	2.4	0				0	0
"	Basrah	1354	2.4	128112.0591				416312947.1	0
"	Anbar-Ramadi	726	2.4	206044.3386				359011655.5	0
"	Nineveh Governorate	852	2.4	0				0	0
Maslamia_DP	Damascus	379	2.4	0	379	1.6	0	0	0

"	Aleppo Governorate	22	2.4	0	22	1.6	0	0	0
Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Homs Governorate	208	2.4	0	208	1.6	0	0	0
"	Latakia Governorate	198	2.4	0	198	1.6	0	0	0
"	Tartous	268	2.4	0	268	1.6	0	0	0
"	Eastern district/Syria	406	2.4	0	406	1.6	0	0	0
"	Sida	435	2.4	0				0	0
"	Tripoli	308	2.4	0				0	0
"	Bekaa Valley	352	2.4	0				0	0
"	Baalbek	318	2.4	0				0	0
"	Beirut	391	2.4	0				0	0
"	Irbid	514	2.4	0				0	0
"	Amman	578	2.4	0				0	0
"	Aqaba	900	2.4	0				0	0
"	Baghdad	1052	2.4	0				0	0
"	Mosul	611	2.4	64416.19648				94459910.52	0
"	Basrah	1563	2.4	0				0	0
"	Anbar-Ramadi	936	2.4	0				0	0
	Nineveh Governorate	583	2.4	435583.8035				609468857.9	0
Latakia_SP	Damascus	334	4.8	0	334	3.2	0	0	0
"	Aleppo Governorate	181	4.8	0	181	3.2	642552.1077	0	372166180.8
"	Homs Governorate	177	4.8	0	177	3.2	0	0	0
"	Latakia Governorate	3.8	4.8	0	3.8	3.2	249470.7238	0	3033564.002

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Tartous	85	4.8	0	85	3.2	37429.98023	0	10180954.62
"	Eastern district/Syria	541	4.8	0	541	3.2	0	0	0
"	Sida	264	4.8	0				0	0
"	Tripoli	148	4.8	0				0	0
"	Bekaa Valley	307	4.8	0				0	0
"	Baalbek	273	4.8	0				0	0
"	Beirut	4.2	4.8	252915.7957				5098782.442	0
"	Irbid	855	4.8	0				0	0
"	Amman	532	4.8	0				0	0
"	Aqaba	855	4.8	0				0	0
"	Baghdad	1021	4.8	0				0	0
"	Mosul	799	4.8	0				0	0
"	Basrah	1533	4.8	0				0	0
	Anbar-Ramadi	906	4.8	0				0	0
	Nineveh Governorate	772	4.8	0				0	0
Beirut_SP	Damascus	113	4.8	0				0	0
"	Aleppo Governorate	369	4.8	0				0	0
"	Homs Governorate	186	4.8	0				0	0
"	Latakia Governorate	230	4.8	0				0	0
"	Tartous	143	4.8	0				0	0
"	Eastern district/Syria	537	4.8	0				0	0
"	Sida	80	4.8	21588.32527				8289916.905	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Tripoli	44	4.8	0				0	0
"	Bekaa Valley	52	4.8	71277.34967				17790826.48	0
"	Baalbek	87	4.8	10903.85056				4553447.993	0
"	Beirut	62	4.8	0				0	0
"	Irbid	307	4.8	0				0	0
"	Amman	629	4.8	0				0	0
"	Aqaba	934	4.8	0				0	0
"	Baghdad	919	4.8	0				0	0
"	Mosul	1446	4.8	0				0	0
"	Basrah	890	4.8	0				0	0
"	Anbar-Ramadi	892	4.8	0				0	0
"	Nineveh Governorate	839	4.8	0				0	0
Baghdad_DP	Damascus	827	2.4	0				0	0
"	Aleppo Governorate	854	2.4	0				0	0
"	Homs Governorate	834	2.4	0				0	0
"	Latakia Governorate	1012	2.4	0				0	0
"	Tartous	930	2.4	0				0	0
"	Eastern district/Syria	526	2.4	0				0	0
"	Sida	961	2.4	0				0	0
"	Tripoli	938	2.4	0				0	0
"	Bekaa Valley	928	2.4	0				0	0
"	Baalbek	924	2.4	0				0	0
"	Beirut	928	2.4	0				0	0
"	Irbid	864	2.4	0				0	0

"	Amman	822	2.4	0				0	0
"	Aqaba	1152	2.4	0				0	0
"	Baghdad	29	2.4	110000				7656000	0
"	Mosul	421	2.4	0				0	0
"	Basrah	549	2.4	0				0	0

Link Origin	Link Destination	Road Length/Km	Cost	MinCFlow	Rail Length/Km	Cost	MinCFlow	Cost Road	Cost Rail
"	Anbar-Ramadi	92	2.4	0				0	0
"	Nineveh Governorate	523	2.4	0				0	0
Hessia_DP	Damascus	126	2.4	0	126	1.6	0	0	0
"	Aleppo Governorate	233	2.4	0	233	1.6	0	0	0
"	Homs Governorate	37	2.4	0	37	1.6	106525.864	0	6306331.15
"	Latakia Governorate	193	2.4	0	193	1.6	0	0	0
"	Tartous	127	2.4	0	127	1.6	0	0	0
"	Eastern district/Syria	388	2.4	0	388	1.6	275266.1287	0	170885212.7
"	Sida	229	2.4	0				0	0
"	Tripoli	136	2.4	0				0	0
"	Bekaa Valley	137	2.4	0				0	0
"	Baalbek	109	2.4	0				0	0
"	Beirut	196	2.4	0				0	0
"	Irbid	261	2.4	0				0	0
"	Amman	325	2.4	0				0	0
"	Aqaba	648	2.4	0				0	0
"	Baghdad	868	2.4	901742.38				1878509726	0
"	Mosul	771	2.4	0				0	0
"	Basrah	1383	2.4	0				0	0

"	Anbar-Ramadi	753	2.4	0	0	0
"	Nineveh Governorate	744	2.4	0	0	0
					5325608598	957551559.8
					6283160158	