

# **DESIGN OF A LOGISTIC MODEL TO HAVE OPPORTUNITIES FOR IMPROVEMENT IN THE DISTRIBUTION OF THE SUPPLY CHAINS OF SOME ORGANIZATIONS OF THE MEXICO STATE, FROM THE INFERENCE OF GOOD PRACTICES**

Celia Nanci Torres Ángeles<sup>1</sup>, Atanacio Villalba Garcia, Gabriela Gaviño Ortiz, Juan Carlos Baltazar Escalona.

Centro Universitario UAEM Valle de México, Boulevard Universitario s/n Prédio San Javier. Ciudad López Mateos. Atizapán de Zaragoza. Estado de México

## **ABSTRACT**

At present, international companies have a 3PL and 4PL logistics system, where thanks to these systems they have been able to position themselves very well in the market. Logistics is a very important tool for organizations because through the distribution of the supply chain they control, the movements, times, preserves, storage and delivery of the product to the customer. The reason for conducting this chapter is to have an alternative logistic model from the shortest route through network optimization as support in organizations, to reduce costs and waiting time for the product or service to its customers. In this analysis you can find a synthesis of the historical development of the main concepts of logistics, as well as their similarities and main differences of the 3PL and 4PL systems, making a review of the proposal from points of view of a location to several destinations in the same state and looking for the shortest route in a feasible and efficient way.

To then implant in the organizations of the state with 1PL and 2PL logistic stratum. Where they can increase their logistics level to 3PL or later to 4PL, using a shorter route model with Dijkstra's algorithm in their supply chain.

**KEY WORDS:** logistics, shortest route, Dijkstra algorithm, optimization, transport, distribution.

**MSC:** 90B22

## **RESUMEN**

Actualmente, las empresas internacionales tienen un sistema logístico 3PL y 4PL, donde gracias a estos sistemas han podido posicionarse muy bien en el mercado. La logística es una herramienta muy importante para las organizaciones porque a través de la distribución de la cadena de suministro que controlan, los movimientos, los tiempos, los productos, el almacenamiento y la entrega del producto al cliente. El motivo de realizar este trabajo es diseñar un modelo logístico alternativo desde la ruta más corta hasta la optimización de la red como soporte en las organizaciones, para reducir los costos y el tiempo de espera del producto o servicio para sus clientes. En este análisis puede encontrar una síntesis del desarrollo histórico de los principales conceptos de logística, así como sus similitudes y diferencias principales de los sistemas 3PL y 4PL, haciendo una revisión de la propuesta desde puntos de vista de una ubicación a varios destinos. en el mismo estado y buscando la ruta más corta de una manera viable y eficiente de las variables propuestas de rutas establecidas.

Luego implantar en las organizaciones del estado con estrato logístico 1PL y 2PL. Donde pueden aumentar su nivel de logística a 3PL o posteriormente a 4PL, utilizando un modelo de ruta más corto con el algoritmo de Dijkstra en su cadena de suministro.

**PALABRAS CLAVES:** Logística, ruta más corta, algoritmo Dijkstra, optimización, transporte, distribución.

## **1. INTRODUCTION**

---

<sup>1</sup> celia\_nanci@live.com.mx<sup>1</sup>; Ing.atanaciavillalba@hotmail.com<sup>2</sup>; gabygortiz@gmail.com<sup>3</sup>; carlos\_baltazar71@yahoo.com.mx<sup>4</sup>

Logistics is a conceived activity, as the flow of materials from one place to another, this research deals with the process of cargo auditing-product assortment taking as reference a Distribution Center (Third Party Logistics) that presents a continuous activity of arrivals and arrivals of trailers, with a population of 100 units per day, which is 100%, and taking a representative sample of 30 units, which corresponds to a single shift of the day.

In the supply chain international, national and local companies today. of distribution.

Companies in Mexico have 1PL and 2PL systems, that is: 1 PL: This is the logistics phase that outsourcing of freight transport and 2PL apart from transport also carries out the storage of products and their own warehouse vehicles.

## **2. PROBLEM STATEMENT**

Currently, companies perform a form of work in a conventional manner, that is, they only engage in transportation or storage. This has not allowed them to develop properly in logistics, based on the internal and external distribution of the organization. That's why we plan to create a logistics model that allows companies to have a more effective method to distribute their products and services.

It is carried out through the good practices of the companies that are in a logistics level of 3PL and 4PL focused on the distribution of the supply chain through the optimization of the route and the shorter network.

### **2.1. Justification**

The Mexican companies of Mexico State usually have a logistic system usually 2PL and some international and national companies located in the Mexican Republic have 3PL. Therefore, the supply chain of organizations, which is composed of all parties directly and indirectly involved for customer satisfaction. This is why the logistic model to be carried out will help to identify the areas of opportunity for distribution in the supply chain of organizations, based on good practices, is applied contexts. By other organizations that provided efficient results and thus be able to apply it in the company so that it provides similar results where it can reach a 3PL system and even 4PL.

Mexico is a country with many small companies which some are in full development. Therefore, this logistic model will help small companies to increase their level in logistics

Research question

How to generate the Dijkstra algorithm from a shorter route simulation and network optimization to improve Mexican companies with 1PL and 2PL logistics systems?

### **2.2. Hypothesis**

With the inference of good practices carried out by organizations with 3PL and 4PL logistic stratum, the distribution of companies in the Mexico State is improved according to their supply chain.

## **3. OBJECTIVES**

### **General purpose**

Introduce the good practices carried out by companies to improve the distribution of their supply chain. Same that allows developing a logistic model that helps the organizations of the State of Mexico to have a 3PL and 4PL logistic stratum.

### **Specific objectives**

- Investigate good practices of organizations with category 3PL and 4PL.
- Design the logistics model with the support of the Dijkstra Algorithm, so that some organizations in the State of Mexico have a 3PL and 4PL logistic level.

## Definitions:

- **3PL system**

The 3PL system means Third Party Logistics, in Spanish third-party logistics or outsourced logistics, which provides transport and storage service to a manufacturer, being only an intermediary for deliveries. It works as outsourcing and they are responsible for managing their own logistics because the orders and invoices are ultimately managed by the manufacturer (ATOX Sistemas de almacenaje 2017).
- **4PL system**

The 4PL system means Fourth Party Logistics is a logistics operator that does not have its own physical resources but provides logistics services for consulting, planning, integration of new technologies, management, location, among others. Acts as a unique interface between the manufacturer and its supply chain (ATOX Sistemas de almacenaje 2017).
- **Client**

A client, from the point of view of the economy, is a person who uses or acquires, on a frequent or occasional basis, the services or products that a professional, a business or a company puts at their disposal (Significados 2017).
- **Design**

A design is the final result of a process, whose objective is to find a suitable solution to a particular problem, but trying as much as possible to be practical and at the same time aesthetic in what is done. To be able to carry out a good design it is necessary to apply different methods and techniques in such a way that it can be expressed in sketches, drawings, sketches or schemes what you want to achieve in order to reach your production and in this way achieve the most ideal and emblematic appearance possible (ConceptoDefinicion.De 2017).
- **Supply chain**

A supply chain is a network of facilities and distribution means whose function is to obtain materials, transform said materials into intermediate products and finished products and distribute these finished products to consumers (GestioPolis 2017).
- **Distribution**

Distribution consists of the task of distributing a certain fractional element or several of the same type or race in an environment destined to receive the distribution. It is by definition, the action of distributing, but to this the correspondence and corresponding organization is added to him for the execution of a plan of correct distribution and in good form (ConceptoDefinicion.De 2017).
- **Transport**

Transportation, means of transfer of people or goods from one place to another. Modern commercial transport is at the service of the public interest and includes all the means and infrastructures involved in the movement of people or goods, as well as the reception, delivery and handling of such goods. The commercial transport of people is classified as passenger service and the goods as merchandise service (ConceptoDefinicion.De 2017).
- **Shortest route**

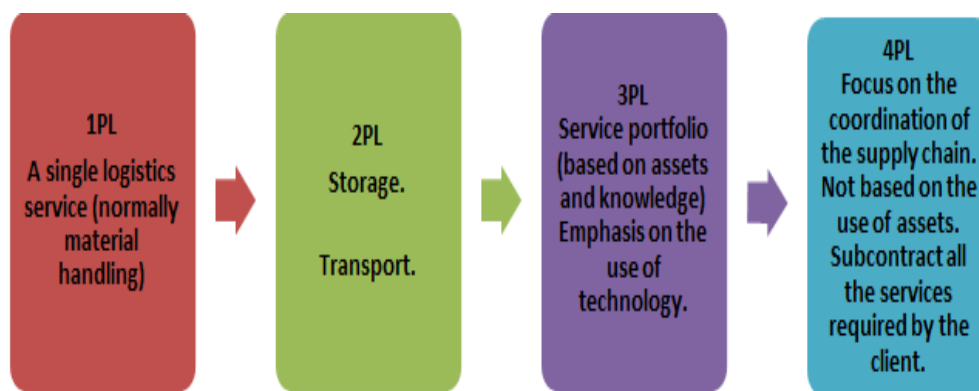
The method of the shortest route is a linear programming method, which allows finding the solution to an optimization problem that results from a combinatorial and different applications, the objective of this method is to find short or lower cost routes, as the case may be, that goes from a specific node to each of the other nodes in the network (Modelos Lineales de Optimización 2017).

**Table 1.** It shows national and international companies in their logistic position.

1PL (Boletín industrial. com 2017)	2PL	3PL	4PL
Asociación Mexicana de Distribuidores de Maquinaria, A.C. Ameco Services S RL CV Distribuidora de Ingeniería en Polipastos industriales SA de CV Alment Industrial SA de CV Asociación Mexicana Distribuidora de Maquinaria AC. Corporación Raymond de México SA de CV Dilco SA Dyfasa SA de CV	GLACO almacenamiento, distribución, logística y maquila en general (GLACO 2017). LOGITEC Consolidación, Almacenaje y Distribución (LOGITEC 2017). ARMEX almacenamiento, conservación, aseguramiento, control, distribución y comercialización (ARMEX 2017).  ALMER almacenaje, financiamiento y distribución (ALMER 2017). GRUPO RACKESA fabricación y distribución de sistemas de almacenamiento (GRUPO RACKESA 2017).	Zimag logistic (Zimag 2017). DHL (DHL 2017). Fedex Preparación manejo de envíos (FedEX Express 2017). Ryder (Ryder Ever better 2017). UPS Supply Chain Solutions (UPS Supply Chain Solutions 2017). C.H Robinson (C.H Robinson 2017). <b>Schenker</b> Invalid source specified.Invalid source specified.Invalid source specified.Invalid source specified..	4PL México Comprometidos con la excelencia (4PL MÉXICO 2017) .  4PL, promotor del “core business” (4PL, PROMOTOR DEL “CORE BUSINESS” 2017) .  Compass operador logístico 4PL, desarrollo de proveedores y manufactura, logística internacional y aduanas (COMPASS 2017).

Source: Own elaboration, 2017

**Image 1.** Activities carried out in different companies.



Source: Handpro (Handling & Process). Recovered from <http://www.handpro.es/es/fourpl>

#### 4. METHODOLOGICAL DESIGN

Using the information of good practices of the companies, a logistic model will be designed so that the companies acquire a level 3PL or 4PL with greater benefits in their distribution of the supply chain.

**1. Research of good practices of organizations with category 3PL and 4PL.**

- **Conduct a study of international organizations with 3PL and 4PL logistic level.**

**3PL COMPANIES**

**Ryder** (Ryder Ever better 2017).

Companies rely on Ryder because they have the experience and resources to manage their most important fleet, transport and supply chain functions better than they can on their own. Regardless of the size of your company or the industry you serve, Ryder has a solution to help you with your most complex transportation or logistics challenges.

- **Transportation Management.**
- **Optimization of the supply chain.**
- **Storage and Distribution**

Based on five principles to satisfy your customers day by day, which are:

1. Standardization.
2. Involvement of the staff.
3. Build with quality.
4. Short delivery times.
5. Continuous improvement.

**DHL** (DHL 2017).

DHL designs Supply Chain and implements innovative contract logistics solutions for market leading companies in a wide range of industries. The transfer of products from manufacturing plants to warehouses, between facilities and distributors, can represent more than half of their total logistics costs.

- **Logistic services.**
- **Network design and optimization.**
- **Transport planning and optimization.**

Recognized in the field of Human Resources for its good talent recruitment practices as well as organizational development issues, which seeks and recruits the necessary talent to participate for two years in all areas of the company.

**UPS Supply Chain Solutions** (UPS Supply Chain Solutions 2017).

UPS operates the world's largest package delivery network serving more than 200 countries and territories around the world.

- **Distribution technology.**
- **Improve the accuracy of the warehouse inventory.**
- **Warehousing and Distribution Services**

**C.H Robinson** (C.H Robinson 2017).

C.H. Robinson Europe is a leading freight forwarding provider in Europe, with a dynamic network of offices across Europe. Since 1993 they offer their customers a flexible, reliable and quality service that differs from other competitors.

- **Optimize your supply chain in search of results.**
- **A plan of procedures to achieve continuous improvements.**

**Schenker** (Schenker 2017).

Schenker USA has an integrated multimodal transport network, strategic warehouses and distribution centers, information technology systems of the global supply chain and visibility tools that collectively deliver excellence.

- **Superior of Transportation Management.**
- **Storage.**
- **SCHENKER lead logistics**

#### **EMPRESAS 4PL**

**4PL Mexico, committed to excellence** (4PL MÉXICO 2017).

Leader in the provision of services for the supply chain and re-manufacturing for the General Industry whose purpose is to satisfy and exceed the expectations of the clients.

It covers everything from the Design of Logistic Architecture to the Management of Indicators with intermediate services such as storage, re-manufacturing, assembly, packaging, supply and transportation.

- **Services to the automotive industry.**
- **Material Storage and Transportation.**

**4PL Promoter of Core Business** (4PL, PROMOTOR DEL "CORE BUSINESS" 2017).

The evolution of globalization subject's operators to develop sophisticated services such as the 4 PL creates integration when offering operations with added value.

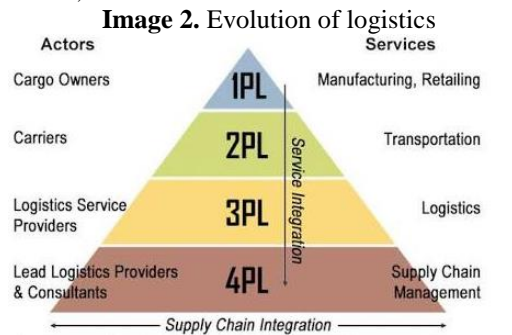
- In the supply chain there is a search for a greater degree of perfection and motivates companies to recognize their business in logistics, and elaboration of improvement in products, that is, core business.
- Supply chain.

**Compass 4PL Logistics Operator, Supplier Development and Manufacturing, International Logistics and Customs** (COMPASS 2017).

It executes the logistics and customs activities required in the processes of foreign trade and distribution, so that it ensures that the product moves safely and quickly from its point of loading to its final destination

- The solution is delivered in a comprehensive manner or as individual services.
- **International shopping.**

It keeps up with the new and better logistics practices of the industries, working in different sectors such as: industrial, food, mining, construction, etc.



Source: Mexican Transportation. Recovered from <http://www.transporte.mx/que-es-3pl-y-4pl/>

- **Identify good practices.**

**Criteria taken to identify a good practice:**

- **Innovative component: find innovative ways to respond to the problems defined** (Opciones de Inversión Social Privada de Naturaleza Empresarial en Educación Básica 2017).
- **Relevance:** contribute to solve a problem or need identified as a priority and do so with strategies that responds to the needs and particularities of the context (Opciones de Inversión Social Privada de Naturaleza Empresarial en Educación Básica 2017).
- **Defined, tested and replicable methodologies:** A good practice has methodologies that have been carefully selected to transform the prioritized situation, are proven or in process and in the best of

cases have been or is being evaluated (Opciones de Inversión Social Privada de Naturaleza Empresarial en Educación Básica 2017).

- **Visible and measurable results:** the experiences have clear, measurable and verifiable results, and these results, in the best of cases, are sustainable and have strategies that keep the transformations in force (Opciones de Inversión Social Privada de Naturaleza Empresarial en Educación Básica 2017).
- **Transferability of learning:** good practices have a lot of reflections and important learning, they have learned and capitalized the error, and they have made adjustments when it has been necessary. It is possible to learn from the learning of these good practices and transfer knowledge to the contexts in which you want to intervene (Opciones de Inversión Social Privada de Naturaleza Empresarial en Educación Básica 2017).

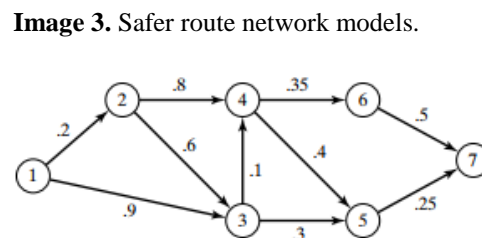
## 2. Design a logistics model with 3PL and 4PL level with support of shorter route and optimization networks.

### Theory

There are a multitude of situations, in operations research that can be modeled and solved as networks mediating nodes connected in branches. Recent surveys report that up to 70% of the mathematical problems in the real world can be represented as related models such as networks (Taha 2004).

Algorithm of the shortest route (situation 2).

Determination of the shortest route between two cities, in a road network.



Source: Taha, H. A. (2004)

### Algorithm of Dijkstra

Its purpose is to determine the shortest routes between the source node and all other nodes in the network. Let  $U_j$  be the shortest distance from source node 1 to node  $i$ , and define  $d_{ij}$  ( $\geq 0$ ) with the length of the arc  $(i, j)$ . Then the algorithm defines the label of an immediate posterior node  $j$  as:

$$[u_j, i] = [u_i + d_{ij}, i], d_{ij} \geq 0$$

The label of the start node is  $[0, -]$ , which indicates that the node has no processor (Taha 2004).

The node labels in the Dijkstra algorithm are of two kinds: temporary and permanent. A temporary label is modified if a shorter route to a node can be found. When you see that you can not find better routes, change the status of the temporary label to permanent (Taha 2004).

**Step 0.** Label in source node (node 1) with the permanent label  $[0, -]$ . Match  $i = 1$ .

**Step i.**

- Calculate the temporary tags  $[u_i + d_{ij}, i]$  for each node  $j$  that can be reached from node  $i$ , as long as it does not have permanent labels. If the node  $j$  is already labeled with  $[u_j, k]$  by another node  $k$ , and if  $u_i + d_{ij} < u_j$ , substitute  $[u_j, k]$  with  $[u_i + d_{ij}, i]$ .
- If all the nodes have permanent labels, stop. Otherwise, select the label  $[u_r, s]$  that has the shortest distance ( $= u_r$ ) among all the temporary labels (the ties break arbitrarily). Make  $i = r$  and repeat step  $i$ .

In relation to other methods, the dijkstra model is very efficient in optimizing costs in the distribution of services and products. For example, **Camino Euler**: This method has advantages in the first selections, but in the last steps you can choose the edges of large length, therefore the minimum cost is not found. For this reason, the Dijkstra algorithm evaluates each node looking for the most optimal until the network of roads is finished. Also the difference that the Dijkstra algorithm can be programmed in simulations without repeating the vertices, and that the Euler path does not do that that way.

**Table 2.** Expenditure database

DATE	COMPANY	STATE	LOCATION	DISTANCE KM	SERVICE			EQUIPMENT	CONVEYANCE	BASE EXPENSES				
					ACTIVITY	VISITS TO THE YEAR	TRAVELS VIA TRAVEL			ADMINISTRATION (4/4)	H.H.		PAY PER DAY LABORADO	
											TECHNICAL A	TECHNICAL B		
6/1/17	LA ITALIANA SA DE CV (Lisa)	Puebla	19°03'39.3"N 98°12'05.8"W	161	Poliza A	12	13	Auto	\$5,220	\$21.3	\$301.4	\$230.8	\$250	
6/1/17	SERVICIOS ALIMENTICIOS AVANZADOS S.A. DE C.V.	Puebla	19°10'31.7"N 98°23'43.3"W	144	Poliza A	12	2	Auto	\$5,220	\$21.3	\$301.4	\$230.8	\$250	
9/1/17	PROSEMSA SA DE CV	México	19°17'56.5"N 99°31'48.8"W	61	Poliza C	4	4	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
9/1/17	QUALAMEX SA DE CV	México	19°23'11.9"N 99°34'17.0"W	76.4	Poliza C	4	4	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
13/1/17	GELITA MEXICO S DE RL DE CV	México	19°17'33.3"N 99°33'00.4"W	62.1	Poliza C	4	3	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
13/1/17	FABRICA DE GALLETAS LA MODERNA	México	19°18'47.2"N 99°38'03.7"W	72.9	Calibración	1	4	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
23/1/17	PRODUCTOS RICH SA DE CV (Ocoyoacac)	México	19°16'46.9"N 99°29'21.4"W	57.1	Calibración	1	8	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
23/1/17	SABRITAS S DE RL DE CV (Vallejo)	CDMX	19°29'09.3"N 99°09'44.6"W	29.6	Poliza E	2	56	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
26/1/17	LA ITALIANA SA DE CV (Gisa)	Puebla	19°03'39.4"N 98°12'05.8"W	161	Poliza A	12	5	Auto	\$5,220	\$21.3	\$301.4	\$230.8	\$250	
26/1/17	PRODUCTOS NIPON SA DE CV	CDMX	19°23'40.5"N 99°04'43.7"W	43.7	Poliza E	2	7	Auto	\$696	\$21.3	\$301.4	\$230.8	\$250	
14/2/17	MOLINO HARINERO SAN BLAS S.A. DEC.V.	Puebla	19°03'43.2"N 98°12'06.7"W	162	Poliza A	12	1	Auto	\$5,220	\$21.3	\$301.4	\$230.8	\$250	
22/2/17	PRODUCTOS RICH SA DE CV (Pantitlan)	CDMX	19°24'37.0"N 99°04'02.9"W	42.5	Calibración	1	7	Auto	\$696	\$21.3	\$301.4	\$230.8	\$250	
3/3/17	PRONUMEX S DE RL DE CV	México	19°24'19.2"N 99°42'50.7"W	90.7	Poliza C	4	9	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
7/4/17	INDUSTRIA DE ALIMENTOS NUTRACEUTICOS FUNCIONALES DE MEXICO SA DE CV	Querétaro	20°45'19.8"N 100°26'45.4"W	26.8	Poliza C	4	3	Auto	\$2,320	\$21.3	\$301.4	\$230.8	\$250	
26/4/17	DUALMEX SA DE CV	CDMX	19°21'43.1"N 99°04'41.4"W	48.8	MPU	1	2	Auto	\$696	\$21.3	\$301.4	\$230.8	\$250	
27/4/17	UNILEVER DE MEXICO	México	19°17'12.2"N 99°32'33.3"W	60.5	Poliza A	12	11	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
11/5/17	SABRITAS VERACRUZ	Veracruz	18°51'55.7"N 97°03'33.2"W	304	Calibración	1	25	Auto	\$3,480	\$21.3	\$301.4	\$230.8	\$250	
26/5/17	CONDIMENTOS NATURALES TRES VILLAS SA DE CV	México	19°23'07.7"N 99°34'24.1"W	76.3	Poliza E	2	2	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
9/6/17	CHUPA CHUPS INDUSTRIAL MEXICANA S.A. DE C.V.	México	19°22'22.1"N 99°34'09.9"W	74.1	Poliza C	4	7	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
26/6/17	DISTRIBUIDORA Y CONVERTIDORA INDUSTRIAL S.A. DE C.V.	Querétaro	20°31'57.9"N 99°53'51.4"W	163	Calibración	1	1	Auto	\$2,320	\$21.3	\$301.4	\$230.8	\$250	
26/6/17	LA ITALIANA SA DE CV (Irapuato)	Guanajuato	20°42'22.3"N 101°21'02.8"W	301	Poliza C	4	1	Auto	\$2,900	\$21.3	\$301.4	\$230.8	\$250	
6/7/17	SUN VALLEY FOODS SA DE CV	Chihuahua	30°26'35.9"N 107°54'55.7"W	1721	MPU	1	2	Auto	\$9,280	\$21.3	\$301.4	\$230.8	\$250	
15/8/17	VISTA DEL SOL FOODS SA DE CV	Chihuahua	30°27'01.8"N 107°54'57.6"W	1721	MPU	1	1	Auto	\$9,280	\$21.3	\$301.4	\$230.8	\$250	
15/8/17	INDUSTRIAS DE ALIMENTOS NUTRIWELL SA DE CV	México	19°19'59.6"N 99°34'32.1"W	68.9	Poliza C	4	6	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250	
29/8/17	GOMEZ CUETARANOS S.A. DE C.V.	CDMX	19°28'46.4"N 99°11'50.2"W	23.1	Calibración	1	3	Auto	\$696	\$21.3	\$301.4	\$230.8	\$250	

MPU Unique Preventive Maintenance

Keep going

Continuation

ANNUAL TRAVEL EXPENSES	VWORKERS A YEAR		EXPENSES DURING 2017					COMMISSION FOR SERVICE	TOTAL COST
	TECHNICAL A	TECHNICAL B	ADMINISTRATION (%)	H.H.		PAY PER DAY LABORADO			
				TECHNICAL A	TECHNICAL B				
\$31,320	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 3,500	\$ 9,360	\$ 50,179.56	
\$31,320	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 3,500	\$ 1,440	\$ 42,259.56	
\$812	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 2,880	\$ 7,763.24	
\$812	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 2,880	\$ 7,763.24	
\$812	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 2,160	\$ 7,043.24	
\$812	1	1	\$ 21.3	\$ 301	\$ 231	\$ 1,500	\$ 360	\$ 2,475.54	
\$812	1	1	\$ 21.3	\$ 301	\$ 231	\$ 750	\$ 720	\$ 2,460.54	
\$406	3	3	\$ 63.9	\$ 904	\$ 692	\$ 750	\$ 20,160	\$ 22,601.62	
\$31,320	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 3,500	\$ 3,600	\$ 44,419.56	
\$31,320	3	3	\$ 63.9	\$ 904	\$ 692	\$ 3,500	\$ 2,520	\$ 37,250.62	
\$31,320	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 7,000	\$ 720	\$ 46,789.56	
\$696	1	1	\$ 21.3	\$ 301	\$ 231	\$ 500	\$ 630	\$ 2,379.54	
\$1,624	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 6,480	\$ 14,425.24	
\$9,280	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 540	\$ 16,141.24	
\$696	2	2	\$ 42.6	\$ 603	\$ 462	\$ 1,000	\$ 720	\$ 3,523.08	
\$4,872	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 7,000	\$ 7,920	\$ 27,541.56	
\$3,480	1	1	\$ 21.3	\$ 301	\$ 231	\$ 500	\$ 2,250	\$ 6,783.54	
\$812	3	3	\$ 63.9	\$ 904	\$ 692	\$ 1,500	\$ 720	\$ 4,692.62	
\$1,624	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 5,040	\$ 12,985.24	
\$5,800	1	1	\$ 21.3	\$ 301	\$ 231	\$ 1,500	\$ 90	\$ 7,193.54	
\$5,800	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 720	\$ 10,591.24	
\$4,640	2	2	\$ 42.6	\$ 603	\$ 462	\$ 500	\$ 720	\$ 6,717.08	
\$4,640	2	2	\$ 42.6	\$ 603	\$ 462	\$ 500	\$ 360	\$ 6,357.08	
\$1,624	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 4,320	\$ 12,265.24	
\$696	1	1	\$ 21.3	\$ 301	\$ 231	\$ 500	\$ 270	\$ 2,019.54	
								\$ 404,622.06	

Source: Own elaboration, from Information of the company Grupo Hefixtalo S.A. de C.V.

### Grupo Hefixtalo S.A. de C.V.

Company that emerged in 2005 and is dedicated to the sale, rental and repair of metal detectors, whose mission is to provide customers, through our technical skills, comprehensive solutions for the resolution of needs related to the detection of metals, that allow them to provide their consumers with healthy, safe and high quality products; thus becoming a source of inspiration for the achievement of constant improvement in the manufacture and quality of products (Hefixtalo 2017)

Metal detectors are used in the food industry, and they are looking to extend to the pharmaceutical industry.



Within the services are work policies that consist of preventive maintenance, reviews and calibrations; so you have to allocate and schedule travel routes that is where you have losses sometimes because the exit is scheduled, without analyzing the expenses that this can generate.

Therefore, the topic to discuss within the company is the analysis of the trips that were made during the year 2017 and analyze the most critical points that affect the organization.

Therefore, the topic to discuss within the company is the analysis of the trips that were made during the year 2017 and analyze the most critical points that affect the organization.

According to the application of the Dijkstra algorithm, temporary and permanent iterations are determined for the organization. The shortest routes are carried out, by states taking into account the number of companies and the teams that each one handles. A network model was designed, grouping the companies by location State, considering that the distances would have to be close, taking into account the physical effort of the workers, mainly because if they were sent to perform the services in a single trip, they would not be within the Company to perform other internal activities.

According to the above, it was applied in the Dijkstra algorithm to determine the shortest route by State, as shown below:

### Puebla State:

**Table 3 .Data of the companies located in the State of Puebla**

Company	State	Location	Service	Conveyance	Equipment Policy	KM
LA ITALIANA SA DE CV (Gisa)	Puebla	19°03'39.3"N 98°12'05.8"W	policy A	Car	13	161
SERVICIOS ALIMENTICIOS AVANZADOS S.A. DE C.V.	Puebla	19°10'31.7"N 98°23'43.3"W	policy A	Car	2	144
LA ITALIANA SA DE CV (Gisa)	Puebla	19°03'39.4"N 98°12'05.8"W	policy A	Car	5	161
MOLINO HARINERO SAN BLAS S.A. DEC.V.	Puebla	19°03'43.2"N 98°12'06.7"W	policy A	Car	1	162
<b>TOTAL TEAMS</b>					<b>21</b>	

Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017



**Image 4.** Optimalroute of the companies of the State of Puebla

Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

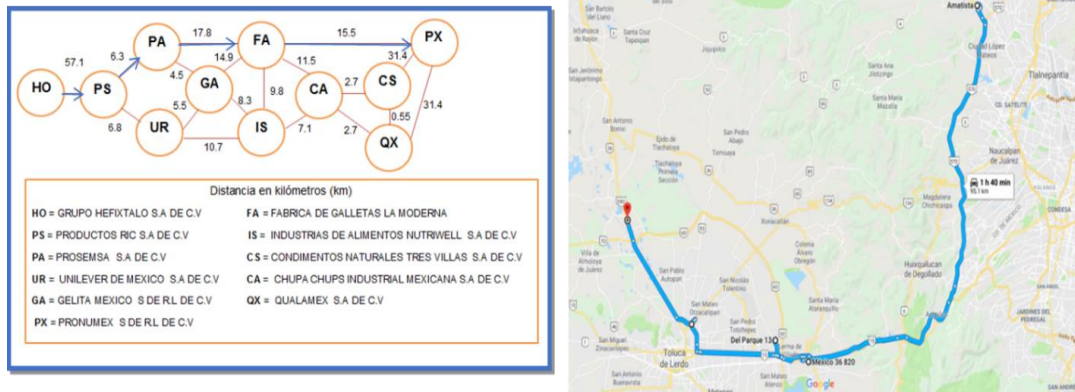
### México State:

**Table 4.** Data of the companies located in the State of Mexico

Company	State	Location	Service	Conveyance	Equipment Policy	Equipment Calibration	KM
PROSEMSA, SA DE CV	Mexico state	19°17'56.5"N 99°31'48.8"W	Policy C	Car	4		61.0
QUALAMEX, SA DE CV	Mexico state	19°23'11.9"N 99°34'17.0"W	Policy C	Car	4		76.4
GELITA MEXICO, S DE RL DE CV	Mexico state	19°17'33.3"N 99°33'00.4"W	Policy C	Car	3		62.1
FABRICA DE GALLETAS LA MODERNA	Mexico state	19°18'47.2"N 99°38'03.7"W	Calibration	Car		4	72.9
PRODUCTOS RICH, SA DE CV (Ocoyoacac)	Mexico state	19°16'46.9"N 99°29'21.4"W	Calibration	Car		8	57.1
PRONUMEX, S DE RL DE CV	Mexico state	19°24'19.2"N 99°42'50.7"W	Policy C	Car	9		90.7
UNILEVER DE MEXICO	Mexico state	19°17'12.2"N 99°32'23.3"W	Policy E	Car	11		60.5
CONDIMENTOS NATURALES TRES VILLAS, SA DE CV	Mexico state	19°23'07.7"N 99°34'24.1"W	Policy A	Car	2		76.3
CHUPA CHUPS INDUSTRIAL MEXICANA S.A. DE C.V.	Mexico state	19°22'22.1"N 99°34'09.9"W	Policy C	Car	7		74.1
INDUSTRIAS DE ALIMENTOS NUTRIWELL, SA DE CV	Mexico state	19°19'59.6"N 99°34'32.1"W	Policy C	Car	6		68.9
<b>TOTAL TEAMS</b>					<b>52</b>		

Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

**Image 5.** Optimum route of companies in the State of Mexico



Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

**Chihuahua, Veracruz, Querétaro and Guanajuato States:**  
**Table 5.** Data of the companies located in the States of Chihuahua, Veracruz, Querétaro and Guanajuato

Company	State	Location	Service	Conveyance	Equipment Policy	Equipment MPU	Equipment Calibration	KM
SUN VALLEY FOODS,SA DE CV	Chihuahua	30°26'35.9"N 107°54'55.7"W	MPU	Auto / Truck		2		1721
VISTA DEL SOL FOODS,SA DE CV	Chihuahua	30°27'01.8"N 107°54'57.6"W	MPU	Auto / Truck		1		1721
SABRITAS VERACRUZ	Veracruz	18°51'55.7"N 97°03'33.2"W	Calibration	Auto / Truck			25	304
LA ITALIANA SA DE CV (Irapuato)	Guanajuato	20°42'22.3"N 101°21'02.8"W	Policy C	Car	1			301
INDUSTRIA DE ALIMENTOS NUTRACEUTICOS S.A DE C.V	Querétaro	20°45'19.8"N 100°26'45.4"W	Policy C	Car	3			267
DISTRIBUIDORA Y CONVERTIDORA INDUSTRIAL S.A. DE C.V.	Querétaro	20°31'57.9"N 99°53'51.4"W	Calibration	Car			1	163
<b>TOTAL TEAMS</b>						<b>33</b>		

Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

**Image 6.** Optimum route of companies in the States of Chihuahua, Veracruz, Querétaro and Guanajuato



Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

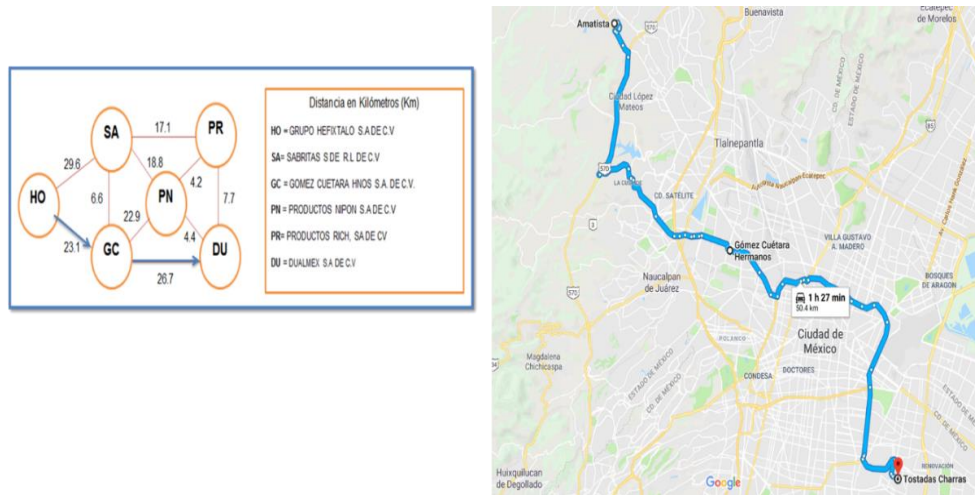
**Mexico City:**

**Table 6.** Data of the companies located in Mexico City

Company	State	Location	Service	Conveyance	Equipment Policy	Equipment MPU	Equipment Calibration	KM
SABRITAS S de RL DE CV (Vallejo)	Mexico City	19°29'09.3"N 99°09'44.6"W	Policy C	Car	56			29.6
PRODUCTOS NIPON SA DE CV	Mexico City	19°23'40.5"N 99°04'43.7"W	Policy C	Car	7			43.7
PRODUCTOS RICH, SA DE CV (Pantitlan)	Mexico City	19°24'37.0"N 99°04'02.9"W	Calibration	Car			7	42.5
DUALMEX SA DE CV	Mexico City	19°21'43.1"N 99°04'41.4"W	MPU	Car		2		48.8
GOMEZ CUETARA HNOS S.A. DE C.V.	Mexico City	19°28'46.4"N 99°11'50.2"W	MPU	Car			3	23.1
<b>TOTAL TEAMS</b>						<b>75</b>		

Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

**Image 7. Optimum route for companies in Mexico City**



Source: Own elaboration, data provided from Grupo Hefixtalo S.A. de C.V., 2017

To carry out this route, the Dijkstra model was made, which determines the following results:

**Table 7. Results of the Dijkstra Model for each State**

Puebla				Mexico																																																									
<table border="1"> <thead> <tr> <th>VERTEX</th> <th>FINAL</th> <th>TEMPORARY</th> </tr> </thead> <tbody> <tr> <td>H</td> <td>0</td> <td>0</td> </tr> <tr> <td>G</td> <td>161</td> <td>161</td> </tr> <tr> <td>S</td> <td>144</td> <td>144</td> </tr> <tr> <td>L</td> <td>161.002</td> <td>161.002</td> </tr> <tr> <td>M</td> <td>161.402</td> <td>161.402</td> </tr> </tbody> </table>				VERTEX	FINAL	TEMPORARY	H	0	0	G	161	161	S	144	144	L	161.002	161.002	M	161.402	161.402	<table border="1"> <thead> <tr> <th>VERTEX</th> <th>FINAL</th> <th>TEMPORARY</th> </tr> </thead> <tbody> <tr> <td>HO</td> <td>0</td> <td>0</td> </tr> <tr> <td>PS</td> <td>57.1</td> <td>57.1</td> </tr> <tr> <td>PA</td> <td>63.4</td> <td>63.4</td> </tr> <tr> <td>UR</td> <td>63.9</td> <td>63.9</td> </tr> <tr> <td>GA</td> <td>67.9</td> <td>67.9</td> </tr> <tr> <td>FA</td> <td>81.2</td> <td>81.2</td> </tr> <tr> <td>IS</td> <td>74.6</td> <td>74.6</td> </tr> <tr> <td>CA</td> <td>81.7</td> <td>81.7</td> </tr> <tr> <td>CS</td> <td>84.4</td> <td>84.4</td> </tr> <tr> <td>QX</td> <td>84.4</td> <td>84.4</td> </tr> <tr> <td>PX</td> <td>96.7</td> <td>96.7</td> </tr> </tbody> </table>				VERTEX	FINAL	TEMPORARY	HO	0	0	PS	57.1	57.1	PA	63.4	63.4	UR	63.9	63.9	GA	67.9	67.9	FA	81.2	81.2	IS	74.6	74.6	CA	81.7	81.7	CS	84.4	84.4	QX	84.4	84.4	PX	96.7	96.7
VERTEX	FINAL	TEMPORARY																																																											
H	0	0																																																											
G	161	161																																																											
S	144	144																																																											
L	161.002	161.002																																																											
M	161.402	161.402																																																											
VERTEX	FINAL	TEMPORARY																																																											
HO	0	0																																																											
PS	57.1	57.1																																																											
PA	63.4	63.4																																																											
UR	63.9	63.9																																																											
GA	67.9	67.9																																																											
FA	81.2	81.2																																																											
IS	74.6	74.6																																																											
CA	81.7	81.7																																																											
CS	84.4	84.4																																																											
QX	84.4	84.4																																																											
PX	96.7	96.7																																																											
Chihuahua, Veracruz, Querétaro and Guanajuato				Mexico City																																																									
<table border="1"> <thead> <tr> <th>VERTEX</th> <th>FINAL</th> <th>TEMPORARY</th> </tr> </thead> <tbody> <tr> <td>HO</td> <td>0</td> <td>0</td> </tr> <tr> <td>SV</td> <td>304</td> <td>304</td> </tr> <tr> <td>LI</td> <td>301</td> <td>301</td> </tr> <tr> <td>DC</td> <td>163</td> <td>163</td> </tr> <tr> <td>IA</td> <td>245.3</td> <td>245.3</td> </tr> <tr> <td>SF</td> <td>1734</td> <td>1734</td> </tr> <tr> <td>VS</td> <td>1734.8</td> <td>1734.8</td> </tr> </tbody> </table>				VERTEX	FINAL	TEMPORARY	HO	0	0	SV	304	304	LI	301	301	DC	163	163	IA	245.3	245.3	SF	1734	1734	VS	1734.8	1734.8	<table border="1"> <thead> <tr> <th>VERTEX</th> <th>FINAL</th> <th>TEMPORARY</th> </tr> </thead> <tbody> <tr> <td>HO</td> <td>0</td> <td>0</td> </tr> <tr> <td>SA</td> <td>29.6</td> <td>29.6</td> </tr> <tr> <td>GC</td> <td>23.1</td> <td>23.1</td> </tr> <tr> <td>PN</td> <td>46</td> <td>46</td> </tr> <tr> <td>PR</td> <td>46.7</td> <td>46.7</td> </tr> <tr> <td>DU</td> <td>49.8</td> <td>49.8</td> </tr> </tbody> </table>				VERTEX	FINAL	TEMPORARY	HO	0	0	SA	29.6	29.6	GC	23.1	23.1	PN	46	46	PR	46.7	46.7	DU	49.8	49.8									
VERTEX	FINAL	TEMPORARY																																																											
HO	0	0																																																											
SV	304	304																																																											
LI	301	301																																																											
DC	163	163																																																											
IA	245.3	245.3																																																											
SF	1734	1734																																																											
VS	1734.8	1734.8																																																											
VERTEX	FINAL	TEMPORARY																																																											
HO	0	0																																																											
SA	29.6	29.6																																																											
GC	23.1	23.1																																																											
PN	46	46																																																											
PR	46.7	46.7																																																											
DU	49.8	49.8																																																											

Source: Own elaboration

To determine if the results obtained above are adequate, it was verified using an Excel plugin "Solver", as the results are shown below:

**Table 8.** Results with Solver to check Model Dijkstra

Puebla			
SINCE	UNTIL	ROUTE	DISTANCE
H	G	1	161
H	S	0	144
S	G	0	32
S	L	0	32.2
G	L	1	0.002
L	M	1	0.4
TOTAL DISTANCE		161.402	

RESTRICTIONS		
NODE	FLOW	CURRENT ENTITY
H	1	1
S	0	0
G	0	0
L	0	0
M	-1	-1

Mexico			
Chihuahua, Veracruz, Querétaro and Guanajuato			
SINCE	UNTIL	ROUTE	DISTANCE
HO	PS	1	57.1
PS	PA	1	6.3
PS	UR	0	6.8
PA	GA	0	4.5
PA	FA	1	17.8
UR	GA	0	5.5
UR	IS	0	10.7
GA	FA	0	14.9
GA	IS	0	8.3
FA	IS	0	9.8
FA	CA	0	11.5
FA	PX	1	15.5
IS	CA	0	7.1
IS	FA	0	9.8
CA	CS	0	2.7
CA	QX	0	2.7
CS	PX	0	31.4
CS	QX	0	0.55
QX	PX	0	31.4
QX	CS	0	0.55
TOTAL DISTANCE		96.70	

RESTRICTIONS		
NODE	FLOW	CURRENT ENTITY
HO	1	1
PS	0	0
PA	0	0
UR	0	0
GA	0	0
FA	0	0
IS	0	0
CA	0	0
CS	0	0
QX	0	0
PX	-1	-1

Mexico City			
SINCE	UNTIL	ROUTE	DISTANCE
HO	SA	0	29.6
HO	GC	1	23.1
SA	PN	0	18.8
SA	GC	0	6.6
SA	PR	0	17.1
GC	PN	0	22.9
GC	DU	1	26.7
GC	SA	0	6.6
PN	DU	0	4.4
PN	PR	0	4.2
PN	SA	0	18.8
PN	GC	0	22.9
PR	DU	0	7.7
PR	PN	0	4.2
PR	SA	0	17.1
DU	PR	0	7.7
DU	PN	0	4.4
DU	GC	0	26.7
TOTAL DISTANCE		49.8	

RESTRICTIONS		
NODE	FLOW	CURRENT ENTITY
HO	1	1
SA	0	0
GC	0	0
PN	0	0
PR	0	0
DU	-1	-1

Source: Own elaboration

As it was observed previously in Table 8, the data obtained in both the Dijkstra and Solver models are the same, therefore, the optimal route is obtained, from this the Total costs will be obtained, observed in Table 9,

with the established routes, as shown below, and it will be possible to verify if the cost decreased or remains similiary.

In addition, it is considered that the nodes (companies) that were not visited in the routes starting from the last found node of the route becomes the Dijkstra model, eliminating the nodes already traveled, until all the nodes of the diagram are completed; in this way the services of all the clients are satisfied.

**Table 9. Calculation of Total Costs from the routes obtained previously**

DATE	COMPANY	STATE	LOCATION	DISTANCE KM	SERVICE	EQUIPMENT	CONVEYANCE	BASE EXPENSES					
								TRAVELS VIA TRAVEL	ADMINISTRATION (4%)	TECHNICAL A	TECHNICAL B	PAY PER DAY LABORADO	
6/1/17	LA ITALIANA SA DE CV (Lisa)	Puebla	19°03'39.3"N 98°12'05.8"W	161	Póliza A	12	13	Auto	\$1,740	\$21.3	\$301.4	\$230.8	\$250
6/1/17	SERVICIOS ALIMENTICIOS AVANZADOS S.A. DE C.V.	Puebla	19°10'31.7"N 98°23'43.3"W	144	Póliza A	12	2	Auto	\$1,740	\$21.3	\$301.4	\$230.8	\$250
14/2/17	MOLINO HARINERO SAN BLAS S.A. DEC.V.	Puebla	19°03'43.2"N 98°12'06.7"W	162	Póliza A	12	1	Auto	\$1,740	\$21.3	\$301.4	\$230.8	\$250
26/1/17	LA ITALIANA SA DE CV (Gisa)	Puebla	19°03'39.4"N 98°12'05.8"W	161	Póliza A	12	5	Auto	\$5,220	\$21.3	\$301.4	\$230.8	\$250
7/4/17	INDUSTRIA DE ALIMENTOS NUTRACEUTICOS FUNCIONALES DE MEXICO SA DE CV	Querétaro	20°45'19.8"N 100°26'45.4"W	267	Póliza C	4	3	Auto	\$2,320	\$21.3	\$301.4	\$230.8	\$250
11/5/17	SABRITAS VERACRUZ	Veracruz	18°51'55.7"N 97°03'33.2"W	304	Calibración	1	25	Auto	\$3,480	\$21.3	\$301.4	\$230.8	\$250
26/6/17	DISTRIBUIDORA Y CONVERTIDORA INDUSTRIAL S.A. DE C.V.	Querétaro	20°31'57.9"N 99°53'51.4"W	163	Calibración	1	1	Auto	\$2,320	\$21.3	\$301.4	\$230.8	\$250
26/6/17	LA ITALIANA SA DE CV (Irapuato)	Guajuato	20°42'22.3"N 101°21'02.8"W	301	Póliza C	4	1	Auto	\$967	\$21.3	\$301.4	\$230.8	\$250
6/7/17	SUN VALLEY FOODS, SA DE CV	Chihuahua	30°26'35.9"N 107°54'55.7"W	1721	MPU	1	2	Auto	\$3,093	\$21.3	\$301.4	\$230.8	\$250
6/7/17	WISTA DEL SOL FOODS, SA DE CV	Chihuahua	30°27'01.8"N 107°54'57.6"W	1721	MPU	1	1	Auto	\$3,093	\$21.3	\$301.4	\$230.8	\$250
29/8/17	GOMEZ CUETARA HNOS S.A. DE C.V.	CDMX	19°28'46.4"N 99°11'50.2"W	23.1	Calibración	1	3	Auto	\$348	\$21.3	\$301.4	\$230.8	\$250
23/1/17	SABRITAS S de RL DE CV (Vallejo)	CDMX	19°29'08.3"N 99°09'44.6"W	29.6	Póliza E	2	56	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250
28/1/17	PRODUCTOS NIPON SA DE CV	CDMX	19°23'40.5"N 99°04'43.7"W	43.7	Póliza E	2	7	Auto	\$696	\$21.3	\$301.4	\$230.8	\$250
26/4/17	DUALMEX SA DE CV	CDMX	19°21'43.1"N 99°04'41.4"W	46.8	MPU	1	2	Auto	\$348	\$21.3	\$301.4	\$230.8	\$250
22/2/17	PRODUCTOS RICH, SA DE CV (Pantitlan)	CDMX	19°24'37.0"N 99°04'02.9"W	42.5	Calibración	1	7	Auto	\$696	\$21.3	\$301.4	\$230.8	\$250
9/1/17	PROSEMSA, SA DE CV	México	19°17'56.5"N 99°31'48.8"W	61	Póliza C	4	4	Auto	\$102	\$21.3	\$301.4	\$230.8	\$250
9/1/17	QUALAMEX, SA de CV	México	19°23'11.9"N 99°34'17.0"W	76.4	Póliza C	4	4	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250
13/1/17	GELITA MEXICO, S DE RL DE CV	México	19°17'33.3"N 99°33'00.4"W	62.1	Póliza C	4	3	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250
13/1/17	FABRICA DE GALLETTAS LA MODERNA	México	19°18'47.2"N 99°38'03.7"W	72.9	Calibración	1	4	Auto	\$102	\$21.3	\$301.4	\$230.8	\$250
23/1/17	PRODUCTOS RICH, SA DE CV (Ocoyoacac)	México	19°16'46.9"N 99°29'21.4"W	57.1	Calibración	1	8	Auto	\$102	\$21.3	\$301.4	\$230.8	\$250
3/3/17	PRONUMEX, S DE RL DE CV	México	19°24'19.2"N 99°42'50.7"W	90.7	Póliza C	4	9	Auto	\$102	\$21.3	\$301.4	\$230.8	\$250
26/5/17	CONDIMENTOS NATURALES TRES VILLAS, SA DE CV	México	19°23'07.7"N 99°34'24.1"W	76.3	Póliza E	2	2	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250
9/6/17	CHUPA CHUPS INDUSTRIAL MEXICANA S.A. DE C.V.	México	19°22'22.1"N 99°34'09.9"W	74.1	Póliza C	4	7	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250
27/4/17	UNILEVER DE MEXICO	México	19°22'22.1"N 99°34'09.9"W	74.1	Póliza A	12	11	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250
15/8/17	INDUSTRIAS DE ALIMENTOS NUTRIWELL, SA DE CV	México	19°19'59.6"N 99°34'32.1"W	68.9	Póliza C	4	6	Auto	\$406	\$21.3	\$301.4	\$230.8	\$250

ANNUAL TRAVEL EXPENSES	EXPENSES DURING 2017							COMMISSION FOR SERVICE	TOTAL COST
	TECHNICAL A	TECHNICAL B	ADMINISTRATION (4%)	H.H.		PAY PER DAY LABORADO			
\$10,440	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 3,500	\$ 9,360	\$ 29,299.56	
\$10,440	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 3,500	\$ 1,440	\$ 21,379.56	
\$31,320	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 7,000	\$ 720	\$ 46,789.56	
\$31,320	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 3,500	\$ 3,600	\$ 44,419.56	
\$9,280	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 540	\$ 16,141.24	
\$3,480	1	1	\$ 21.3	\$ 301	\$ 231	\$ 500	\$ 2,250	\$ 6,783.54	
\$5,800	1	1	\$ 21.3	\$ 301	\$ 231	\$ 1,500	\$ 90	\$ 7,193.54	
\$5,800	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 720	\$ 10,591.24	
\$1,547	2	2	\$ 42.6	\$ 603	\$ 462	\$ 500	\$ 720	\$ 3,623.75	
\$1,547	2	2	\$ 42.6	\$ 603	\$ 462	\$ 500	\$ 360	\$ 3,263.75	
\$348	1	1	\$ 21.3	\$ 301	\$ 231	\$ 500	\$ 270	\$ 1,671.54	
\$406	3	3	\$ 63.9	\$ 904	\$ 692	\$ 750	\$ 20,160	\$ 22,601.62	
\$31,320	3	3	\$ 63.9	\$ 904	\$ 692	\$ 3,500	\$ 2,520	\$ 37,250.62	
\$348	2	2	\$ 42.6	\$ 603	\$ 462	\$ 1,000	\$ 720	\$ 3,175.08	
\$696	1	1	\$ 21.3	\$ 301	\$ 231	\$ 500	\$ 630	\$ 2,379.54	
\$203	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 2,880	\$ 7,154.24	
\$812	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 2,880	\$ 7,763.24	
\$812	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 1,500	\$ 2,160	\$ 7,043.24	
\$812	1	1	\$ 21.3	\$ 301	\$ 231	\$ 1,500	\$ 360	\$ 2,475.54	
\$812	1	1	\$ 21.3	\$ 301	\$ 231	\$ 750	\$ 720	\$ 2,460.54	
\$406	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 6,480	\$ 13,207.24	
\$812	3	3	\$ 63.9	\$ 904	\$ 692	\$ 1,500	\$ 720	\$ 4,692.62	
\$1,624	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 5,040	\$ 12,985.24	
\$4,872	14	14	\$ 298.1	\$ 4,220	\$ 3,232	\$ 7,000	\$ 7,920	\$ 27,541.56	
\$1,624	6	6	\$ 127.7	\$ 1,809	\$ 1,385	\$ 3,000	\$ 4,320	\$ 12,265.24	
TOTAL								\$ 354,152.39	
DIF								\$ 50,468.67	

Keep going

Source: Prepared by the authors, based on Company Information Grupo Hefixtalo S.A. of C.V.

Making the calculations corresponding to the optimal route found by the Dijkstra model, it can be seen that organizations can share their per diem expenses per trip between themselves, that is, if the route found passes through 4, 3 or 2 companies are sharing their travel expenses, resulting in savings between them and for the organization. Therefore the total expenses for the year 2017 were \$ 354, 152.39.

#### 4. CONCLUSIONS

When we talk about good practices we are selecting those strategies, models or methods that have generated the desired result. The opportunity to infer different logistic organizations according to the level of operations,

contributed to the obtaining of a model that is based on the classic problem of transportation with a source and several destinations.

For that reason realizing the Dijkstra model in the organization Grupo Hefixtalo SA de CV the following results were obtained, total cost without applying the Dijkstra model of \$ 404,622.06, when this model is plicated the amount of \$ 354,152.39 is obtained in which there is a difference of \$ 50, 469.67, which corresponds to a saving for the company, which can be used for other activities, likewise implementing this model in the organizations of the State of Mexico allows to increase its logistics extract and share with other organizations its logistics through nodes (companies) to perform your tours, storage and routes. Reflecting on 3PL and 4PL strategies, contributing to the costs shared by a contractor and multiple subcontractors, considering or not filling all available spaces to load and represent savings for service users, as long as the source and destination are shared. They also keep payments to the worker for the activities carried out. Therefore, this type of strategies used by 3PL and 4PL companies helps them to be more competitive in the national and even international markets, so companies in the Mexican state can compete more in the market.

The optimization of resources is even more important when strategic alliances and networks of organizations are achieved.

**RECEIVED: JULY, 2018**  
**REVISED: DECEMBER, 2018**

## REFERENCES

- [1] 4PL MÉXICO . (2017, 12 6). Empresa con sistema logístico 4PL. Retrieved from 4PL MÉXICO: <http://www.4pl-mexico.com/>
- [2] 4PL, PROMOTOR DEL "CORE BUSINESS". (2017, 12 6). Empresa con sistema logístico 4PL. Retrieved from 4PL, PROMOTOR DEL "CORE BUSINESS": <http://t21.com.mx/logistica/2015/08/10/4pl-promotor-core-business>
- [3] ALMER. (2017). Empresa con sistema logístico 2PL. Retrieved from ALMER: <http://www.almer.com.mx/>
- [4] ARMEX. (2017). Empresa con sistema logístico 2PL. Retrieved from ARMEX: <http://www.armexsa.com.mx/index.html>
- [5] ATOX Sistemas de almacenaje. (2017). ¿Qué es 3PL y 4PL? Retrieved from ATOX Sistemas de almacenaje: <http://www.atoxgrupo.com/web/site/noticias/3pl-y-4pl>
- [6] Boletín industrial. com. (2017). Empresas con sistema logístico 1PL. Retrieved from Boletín industrial. com: <http://www.boletinindustrial.com/categoria.aspx?ctid=10239>
- [7] C.H ROBINSON. (2017). Empresa con sistema logístico 3PL. Retrieved from C.H Robinson: <https://www.chrobinson.com/>
- [8] COMPASS. (2017). Empresa con sistema logístico 4PL. Retrieved from COMPASS: <http://compass4pl.com/>
- [9] CONCEPTDEFINICION.DE. (2017). Definición de Transporte . Retrieved from ConceptoDefinicion.De: <https://definicion.de/transporte/>
- [10] CONCEPTDEFINICION.DE. (2017). Definición de Diseño. Retrieved from CONCEPTDEFINICION.DE: <http://conceptodefinicion.de/disenio/>
- [11] CONCEPTDEFINICION.DE. (2017, 09 22). Definición de Distribución. Retrieved from ConceptoDefinicion.De: <http://conceptodefinicion.de/distribucion/>
- [12] DHL. (2017, 11 5). Empresa con sistema logístico 3PL. Retrieved from DHL: <http://www.dhl.com.mx/es/logistica.html>
- [13] FEDEX EXPRESS. (2017). Empresa con sistema logístico 3PL. Retrieved from FedEx Express: <http://www.fedex.com/mx/track/>
- [14] GESTIOPOLIS. (2017). Gestión de la cadena de suministros. Retrieved from GestioPolis: <https://www.gestiopolis.com/gestion-de-la-cadena-de-suministros/>
- [15] GLACO. (2017). Empresa con sistema logístico 2PL. Retrieved from GLACO: <http://www.glaco.com.mx/>
- [16] GRUPO RACKESA. (2017). Empresa con sistema logístico 2PL. Retrieved from GRUPO RACKESA: <https://gruporackesa.com/>
- [17] HEFIXTALO. (2017). Hefixtalo. Retrieved from Hefixtalo: <http://www.hefixtalo.com.mx/>

- [18] LOGITEC. (2017). Empresa con sistema logístico 2PL. Retrieved from LOGITEC:  
<http://www.logisticaycalidad.com.mx/>
- [19] MODELOS LINEALES DE OPTIMIZACIÓN. (2017). Ruta más corta. Retrieved from Modelos Lineales de Optimización: [opti-lineal.blogspot.com/2014/06/ruta-mas-corta.html](http://opti-lineal.blogspot.com/2014/06/ruta-mas-corta.html)
- [20] OPCIONES DE INVERSIÓN SOCIAL PRIVADA DE NATURALEZA EMPRESARIAL EN EDUCACIÓN BÁSICA. (2017). Identificación de Buenas Prácticas o Estrategias Existentes. Retrieved from Opciones de Inversión Social Privada de Naturaleza Empresarial en Educación Básica: [http://www.redeamerica.org/guias/guiaeducacion/elque\\_c.html](http://www.redeamerica.org/guias/guiaeducacion/elque_c.html)
- [21] RYDER EVER BETTER . (2017). Empresa con sistema logístico 3PL. Retrieved from Ryder Ever better : <https://ryder.com/>
- [22] SCHENKER. (2017, 10 25). Schenker. Retrieved from Schenker:  
<https://www.dbschenker.com/global>
- [23] SIGNIFICADOS . (2017, 09 22). Qué es Cliente. Retrieved from Significados :  
<https://www.significados.com/cliente/>
- [24] TAHA, H. A. (2004). *Investigación de Operaciones* 7a. Edición. In H. A. Taha, Modelos de Redes. Pearson Educación, Mexico.
- [25] UPS SUPPLY CHAIN SOLUTIONS . (2017). Empresa con sistema logístico 3PL. Retrieved from UPS Supply Chain Solutions : <https://www.ups-scs.com/>
- [26] ZIMAG. (2017). Empresa con sistema logístico 3PL. Retrieved from Zimag:  
<http://www.sezimag.com.mx/>

•