Urban Distribution Center: Mathematical model for the location in the center of the city of Fes

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Abstract— **We are interested in this writing to the location of logistics platforms necessary for the Transportation of Goods in the City such as the Urban Distribution Centers (CDU). For this, we present in the first part the problem related to the concept of localization of UDCs as well as a state of the art of the problem of localization of logistics platforms. The second part will propose a mathematical modeling methodology that takes into account the location of potential customers of the site. The last part will propose a case study, modeling and optimization using the genetic method using Matlab software, a distribution platform specialized in computer and office supplies in the city of Fez.**

Keywords— Localization, Modeling Urban distribution center, mathematical model, genetic method.

Introduction

With the rapid development of the world economy and the demographic concentration in the city (the inhabitants in the city pass from 52% in 2014 to 67% in 2050), the organization of urban distribution has become essential for the proper functioning of the city. [1,2]. A distribution system based on pooling can not only improve the traffic flow and mobility in the city, but also reduce the costs of urban transport [3,4]. In this system, Urban Distribution Centers (UDCs) find their place increasingly as intermediaries between suppliers and customers. The problem of location of these is a strategic problem and concerns the selection of potential locations of centers and the transportation of products to minimize the total cost of transport.

I. LOCATION OF AN URBAN DISTRIBUTION CENTER

A. Problems

Our job is to determine a site to locate an urban distribution center (UDC). CDUs are groupage-unbundling platforms, usually located a few kilometers from the city center, whose purpose is to manage flows to dense areas [11]. Their main functions are grouping / unbundling of goods, warehousing, distribution of goods in dense areas with less bulky and greener vehicles, and pooling between the different stakeholders. CDUs are often set up by a public initiative, and can be managed by private or public actors.

In most cases, there is no land that can accommodate UDCs. In parallel, the suppliers and customers of the center are known in advance, and we aim through this writing to locate UDCs by minimizing the total costs of transportation. So our problem is a Continuous, Deterministic, Static and Monocritical problem (CDSMo).

B. State of the art of localization problems

Localization models have been studied in various forms for hundreds of years. Even if the contexts in which these models are located may differ, their main characteristics are always the same: customers whose location is well known, spaces whose characteristics are known in advance, equipment and means of transport to availability [12]. Thus, location location is determined by an objective function.
The literature review was developed on thirty articles. The table below lists the most recent references.

Tableau 1: State of the art of location models

Model	**Purpose of the model**	**Objective function**	**Reference**
Deterministic continuous Static probabilistic monocriterion (CSDMo)	Minimize the distance between clients and the platform	Min $\sum_{j=1}^{m} Yij * d(Xj,ai) * wi$	Chandra Ade Irawana et al,2017 [1]
		Min $\sum_{j=1}^{q} \sum_{i \in I} wi * E(dj,xi)$	Derya Dinler et al, 2015 [2]
Discreet determinist Static / Dynamic monocriterion (DDSMo) (DDDMo)	Minimize the distance between clients and the platform	Min $\sum_{j=1}^{m} Yij * dij * wi$	Xiang Hua, et al 2016 [3]
	Minimize total transport time from the platform to the customer	Min $\sum_{a \in A/A'} va * ta(va)$ $+ \sum_{a \in A'} \sum_{i \in I} Zai * va * tai(va)$	Shuaian Wang et al, 2013 [4]
	Maximize the demand for the platform	Max E($\sum_{t=0}^{T-1} Pt(xt,dt,ZAt)$	Joern Meissnera, Olga V.Senichevab , 2018[5]
Discreet determinist Static / Dynamic Multiple criteria (DDSMu) (DDDMu)	Minimize transport costs according to the axes of sustainable development: Cost of implementing the platform Transportation cost related to the vehicle tour Cost of acceptability Cost of congestion Cost of pollution	Min $\sum_{l \in L} cl,selec * ul$ $+ \sum_{l \in L} cl,bethwl$ +3000* $(\sum_{l \in L} \sum_{v \in V} cv,such * (\sum xlvt + \sum ylvt) +$ +3000*($\sum_{v \in V} cv,div((\sum_{l \in L} \sum_{d \in D}(zlvd(first) * Mld + zlvd(la$ $\sum_{d \in D} xvd * distd)$ + +3000*($\sum_{v \in V} Cvpoll((\sum_{l \in L} \sum_{d \in D}(zlvd(first) * Mld + zlvd(l$ $\sum_{d \in D} xvd * distd)$ $+ \sum_{l \in L} clpoll * wl$ $+ \sum_{d \in D} \sum_{v \in V} cdcong * cvcong * xvd$ $+ \sum_{l \in L} clacc * ul$ $+ \sum_{v \in V} Cvacc * (\sum_{d \in D} avd)$	Olivier Guyonet al,2011 [6]
	Minimize transport time and maximize the delivery quantity	Max $\sum_{t \in T} M(t,h)$ +Min $\sum_{h \in H} M(t,h)$	Ilona Jacyna-Gołdaa , Mariusz Izdebski, 2017 [7]
	Minimize the distance between the platform and the customer and maximize the demand	Min $\frac{1}{n} * \sum_{i \in I} \sum_{j=1}^{m} wi * dij * xij$ + Max $\sum_{i \in I} wi * ci$	Mumtaz Karatas, ErtanYakıcı, (2018) [8]
Discreet probabilistic stochastics monocriterion (DPStMo)	Minimize implementation and transportation costs with uncertain demand	Min $\sum_{k \in K} fk * yk + \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} cijkm * wij * xijkm$ Cijkm = $\gamma * dik + \alpha * dkm + \delta * dmj$	MERAKLI(2017)[9]
	Minimizing Implementation Costs and Costs of Vehicle Tours with Uncertain Demand	Min $\sum_{k \in K} \sum_{t \in T}(fkt * ukt + \sum_{q=1}^{Q} gkqt * zkqt) + \sum_{i \in I} \sum_{k \in}$ $+ \sum_{i \in I} \sum_{l \in L} \sum_{j \in J} \sum_{t \in T} \alpha * dkl * yitkl +$ $\sum_{i \in I} \sum_{l \in L} \sum_{j \in J} \sum_{t \in T} \delta * dij * vijtl +$ $\sum_{k \in K} \sum_{t \in T} \sum_{q \in Q} hkqt\, rkqt$	Isabel Correia et al,2018[10]

II. Mathematical formulation for localization

Our problem of locating the CDU is an urban problem. He is interested in optimizing the cost of goods transport in the city. For that, it relies on two big sets:

• A set of clients for the CDU, represented by companies, wholesalers and individuals

• A set L of potential sites that can accommodate a CDU

The mathematical model can be written in the following form:

$$\text{Min} \sum_{j=1}^{m} \sum_{i \in I} \left(Yij . wi . C(Xj, ai, T) \right) \quad \forall\, i \in I;\ j = 1, \dots, m \qquad (1)$$

Subject to

$$\sum_{j=1}^{m} Yij = 1 \quad \forall\, i \in I \qquad (2)$$

$$\sum_{i \in I} (Yij . wi) \leq Qj \quad \forall\, j = 1, \dots, m \qquad (3)$$

$$Yij \in \{0,1\}, \quad \forall\, i \in I;\ j = 1, \dots, m \qquad (4)$$

$$Xj \in R^2, \forall\, j = 1, \dots, m \quad \forall\, j = 1, \dots, m \qquad (5)$$

Settings and set:

I: all potential sites

J: all customers

ai: (xi^a, yi^a) customer location coordinates j

wi: customer demand

T: fuel price per liter

Qj: capacity of the site

d (Xj, Ai): the distance between the provider i and the site j

d (Xj, Al) = √ ((xj-xia) 2 + (yj-yai) 2))

C (Xj, ai, T): Transport cost

C (Xj, ai, T) = T * d (Xj, Ai)

Variables of decisions:

Yij: 1 if client j is assigned to i, 0 otherwise

Xj: coordinates of the sites, Xj(xj,yj) $\in R^2$

Xj(xj,yj) $\in R^2$

The objective function (1) aims to minimize transport costs. Constraint (2) ensures that each demand point is serviced by a single facility. The constraint (3) ensures that the capacity constraints of the installations are satisfied. Constraints (4) and (5) refer to the binary nature of the variables.

III. Study case: a CDU specialized in the distribution of computer and office supplies to the city of Fes

A. *Parameter of the model:*

- Customers: The clients of the platform are divided into two categories:
- Professionals: they can be companies or wholesalers. They are represented by the industrial zones of the city and the densely commercial areas.
- Individuals: Anyone can resort to ordering office supplies. They are represented by areas of high population density.
- Customer demand: To determine the customer's request, we used a survey made by the ARSEG bureau specializing in office supplies. The study shows that each company spends a little around 188 euros (2000dh) for each office of 25m3, and that these supplies occupy a little near 6m3 per office. The study also shows that supplies are distributed 70% for professionals and 30% for individuals.
- The Cartesian coordinates of the customers: in order to determine the coordinates of the customers, and after identifying them, one used the site twcc.fr. This tool is used to convert GPS coordinates to Cartesian coordinates according to standard markers.

  PS: the distances between its zones and the platform are calculated in bird's eye view.

Table 2: Cartesian coordinates of the different zones.

area	Place	X	Y
Industrial area	Zone industriel Dokkarate	533.50	382.85
	Zone industriel Bensouda	532.12	378.62
	Zone industriel Sidi Brahim	538.35	380.98
	Fès shore	540.69	378.76
	Zone industriel Ras El Ma	528.79	374.45
Area of high population density	Talaa	538.45	384.84
	Saada	536.40	380.81
	Dokkarate	535.94	382.46
	Rcif	539.12	384.82
	Avenue Mohammed V	537.04	381.60
High commercial density area	Avenue Mohammed Zerktouni	537.08	382.00
	Ancienne médina	539.22	385.18
	Bab Ftouh	539.86	384.73
	Bensouda	531.92	380.45
	Ben Debbab	536.26	384.63

B. Solution method and results

Several optimization methods exist. We chose to use the genetic algorithm, given its ease of programming, in addition to its effectiveness in the problem of simple location at a level, capacity, static and nonlinear.
We chose as software for solving the MATLAB problem. This software allows thanks to its toolbox module allows to have results for this kind of problem.
The optimal location determined by the software is the area containing the point S (536.25, 381.75). This point is located on Allal Ben Abdellah Avenue. This position minimizes the distances between the platform and the customers. But at the same time, the place is located on a large artery of the city.
This location will therefore minimize transport costs. At the same time, the location is accessible only by road, nuisance can be observed following the current traffic supported in the area in addition to that which will be generated by the platform:

- Social nuisances such as congestion and stress for drivers and residents
- Economic losses due to the loss of time caused by congestion
- in addition to local environmental nuisances in the area.

In addition, the location is located on an area where installation costs will be very important given the price per square meter.

Conclusion

In this article, we have proposed a mathematical model for a strategic problem of urban logistics: the location of urban distribution centers. A concrete case has been proposed, modeling and optimization by the genetic algorithm on Matlab software.

It has been noticed that, despite the optimization of distances between the platform and the customers, several other parameters can intervene and change or modify the location.

As an extension of our work, it will be useful to take into account during the modeling several other factors that influence the choice of the optimal location.

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