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## Multidimensional assignment of services to people with disabilities

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*Abstract* — Medico-social sector includes various sets of institutions and services to support vulnerable people, such as people with disabilities. This sector must ensure personalized support to comply with the needs of each person. This work is based on a multidimensional characterization of services provided by medico-social institutions. The objective is to propose a mathematical model to deal with this multidimensional assignment problem (MAP). The distinctive characteristic of this assignment comes from that a need can be complied with different services and that a service is able to cover different needs at the same time. The proposed two-step model identifies the optimal set of medico-social services that are able to comply with the needs of people with disabilities.

*Keywords*—medico-social sector; assignment of services; ILP; multidimensional assignment problem.

## I. Introduction

In France according to the Article L. 116-1 to 116-4 of the Social and Family Code, the social and medico-social sector should promote autonomy, protection and avoid the exclusion of people with disabilities. To achieve this, the activities proposed by the government to a person must be adapted to the person's needs. Decision-making in the orientation process of people with disabilities requires assistance.

The orientation process in France is carried out by the departmental office of people with disabilities, as follows: A person with disabilities (PD) makes an accompanying request to the departmental office of people with disabilities, a multidisciplinary team (MT) analyses the request and proposes a list of social and medico-social institutions (SMIS) appropriated to the person's needs. Currently, the orientation provided by the MT to a PD focuses on giving a list of institutions that are more or less adapted to the person's needs.

According to the law, from the moment when a person makes a request until a proposal is sent, the process should not take more than 4 months. Some studies [1] show that, in France, in more than 50% of cases, it takes more than 4 months. Moreover, studies show that from the moment when a person receives a proposal until real admission to an institution, the person can be put on a waiting list for more than one year [2].

During the time that the person remains on the waiting list, without accompaniment, his/her situation may worsen and the proposal made by the MT may not be adapted any more at the time the person is admitted to the institution.

The government has developed several missions which point out some of the most important problems of this orientation process [3]. The main problems that can be withheld from these reports are: (a) Places created in the medico-social sector are not fully adapted with the real need of PD, since there is a lack of tools for analysing the people's needs. (b) Services proposed by institutions may not be adapted to the real person's needs. One of the reasons is that institutions are categorized by types of handicap; (c) Not considering the availability of resources in institutions can lead people to stay on a waiting list for a long time. This wait may worsen the situation of the person and the proposed response will not be adapted to their needs any more. (d) The increase of young adults who stay in a place for children, because they do not have a proposition of adapted places to their situation and these people cannot be left without accompaniment. This practice mobilizes resources that should be dedicated to other needs.

The model proposed in this paper comes from a previous work that analyses and understands the orientation process [4]. This analysis is based on the process modelling with all its actors and the interactions between them. This process model allowed identifying the lack of information on the offer of services in a territory, especially when the MT proposes an assignment for the person. It highlighted major elements, which have to be considered when creating an assignment adapted to the needs of the person. Instead of trying to find a place for a PD in one single institution, we propose here to study the attribution of a list of services provided by one or several institutions to answer the needs of a PD. The objective of this work is to create an optimization model to help MT to propose the most accurate list of medico-social services adapted to the needs of each PD. This list has to find the maximum coverage of PDs' needs, according to the existing service offered by the institutions and the resource availability. Ideally, all needs may be covered, but a partial assignment can be proposed to avoid having PD without accompaniment.

This paper begins with a literature review on the assignment methods and the relationship with the case study. Subsequently, we present the assumptions considered in the model. We conclude with a presentation of the model and an analysis on the experimentation carried out, in a case inspired from field reality.

## II. Literature review

The main objective of this work is to propose to a PD with several needs, an adapted list of services of medico-social institutions, while respecting a certain set of constraints. The

model presented in this paper is part of the family of combinatorial optimization problems, specifically to assignment problems, where the aim is matching agents, maximizing or minimizing a specific objective function, subject to costs [5], [6]. If we look at the detail of our problem, we can consider it as a multidimensional assignment problem (MAP), since we are interested in creating a correspondence with several dimensions [7]. This problem is to NP-hard.

Bearing in mind that the current demand for medico-social services exceeds the availability of services, it is clear that not all people with disabilities will have a total response to their needs. This type of situation may be connected with the order acceptance and scheduling decisions in make-to-order systems, Order Acceptance and Scheduling problem (OAS) [8]. The OAS problems seek to accept the orders that maximize the profitability, in a fixed period of time, determined by production scheduling. In our case, the idea is to maximize the number of disabled people accepted in the system with a complete assignment to their needs, based on the best scheduling of the services assigned to the group of people accepted.

The problem of the assignment of services to disabled people is linked with the problem of scheduling with parallel machines [9], [10]. In this problem, a job can be performed in different machines, with the differentiation of time processing and resource consumption given the characteristics of the machines. In our problem, machines are represented by services (different services that can be assigned to respond different needs, with a different impact on needs, given the services characteristics) and the jobs, are represented by the needs of the people (each need requires an assignment, given the situation of the person).

A first scientific contribution of this study is the possibility of proposing one or several services to a person, while these services are offered to other people in the same time that (in parallel). These types of problems can be associated with divergent production systems with co-production (i.e. production of different products at the same time from a single product input) when alternative production processes are available [11]. In the case study, one service can be assigned to several PD according to the resources available in the institution to perform the service. This type of problem can be associated with the production scheduling problem with non-renewable resources [12].

Finally, an important scientific contribution is the application of operations research methods in the medico-social sector (the application of well-known methods in a new sector). It is necessary to highlight the few studies in the medico-social sector, where the benefits of orienting a person to several institutions are studied [13]. A recent study tackles the problem of elaborating optimized action plans in order to improve the overall management efficiency of medico-social institutions, and confirms the lack of use of operations research in the sector medico-social [14]. However, we find in the literature more and more research in the field of elderly people [15], and in the health sector [16].

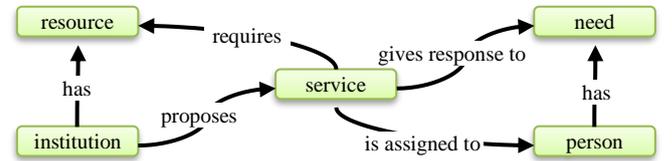
### III. Modelling

#### A. Assumption and notation

The proposed model has the following sets:  $\mathbf{SP}$  is the set of  $\mathbf{P}$  people who looking for an orientation;  $\mathbf{SN}$  is the set of  $\mathbf{N}$  standard needs;  $\mathbf{SS}$  is the set of  $\mathbf{S}$  standard services;  $\mathbf{SI}$  is the set of  $\mathbf{I}$  institutions in a given territory and;  $\mathbf{SR}$  is the set of  $\mathbf{R}$  resources that can be used in a service.

A person  $p \in \mathbf{SP}$  is characterized with various needs. Every need  $n \in \mathbf{SN}$  should receive a response with one or more services. The main objective of the assignment model is to propose to each person  $p$  a list of medico-social services that are adapted to their needs. To manage this assignment, a need  $n$  could be complied with different services  $s \in \mathbf{SS}$ . Those services are able to give response to different needs in the same time. A service  $s$  is proposed by an institution  $i \in \mathbf{SI}$ . The Institution  $i$  has got available resources to offer its services. Proposed services must respect the availability of each resources  $r \in \mathbf{SR}$ . Fig. 1 describes the links between all indexes.

Fig. 1. Entities of the model



In order to fulfil this objective, the following assumptions are defined.

**A1:** We assume there are: (1) a standard list of needs, representing all the possible needs that a person with disabilities can have; (2) and a standard list of medico-social services which represents all the medico-social services that can be offered to a person. This assumption is based on the current situation, since today the French government created these lists for the medico-social sector, which must be integrated in our case [17]. Based on assumption **A1**, the following assumptions are proposed according the information needed in the model.

1) Assumptions related to people with disabilities (PD)

**A2:** A team evaluates the situation of each PD and determine his/her needs and the criticality of each need. The way to present this information is based on a point system with a scale ranging from 0 to 10, where 0 means that the PD does not have the need and 10 means that the need is at its most critical level and requires more attention, time and resources. Table 1 shows an example where the person 2 has the needs 6 and 9, respectively with 5 points (average criticality) and 9 points (highest criticality).

Notation in the model:  $N_{p,n}$  is the number of points that services must accumulate to answer the need  $n$  of the person  $p$ .

**A3:** Each person has limitations in relation to the institutions that may come to propose him/her. Notation in the model:  $DT_p$  is the maximum distance tolerated by person  $p$ , from his reference address to an institution.  $IT_p$  is the maximum number of different institutions that the person  $p$  tolerates in a proposed assignment.

Table 1. PD's needs

		People									
		1	2	3	4	5	6	7	8	9	10
Needs	1	0	3	0	0	0	0	0	9	0	2
	2	2	0	4	5	0	5	0	0	0	7
	3	3	1	9	7	0	5	5	3	3	1
	4	0	3	0	1	2	3	5		9	0
	5	3	0	0	0	0	0	0	2	5	0
	6	4	5	1	4	0	0	0	0	1	3
	7	0	5	2	0	2	0	1	1	1	0
	8	0	1	1	0	0	4	5		3	1
	9	0	9	5	4	0	1	2	3	9	2
	10	2	9	1	1	0	1	0	0	0	5
	11	1	0	5	9	1	0	0	3	0	1
	12	2	0	9	2	4	3	0	0	4	1
	13	5	0	0	5	0	1	4	2	5	9
	14	9	0	0	0	2	4	0	0	0	3
	15	0	0	9	1	9	0	0	0	9	9
	16	0	0	9	0	0	0	0	0	0	0
	17	0	0	5	3	1	1	2	2	0	1
	18	3	0	7	1	0	2	0	0	0	1
	19	2	4	9	2	4	0	9	0	1	7
	20	2	0	0	0	4	9	1	0	3	3

2) Assumptions related to services

We assume that the characteristics of each service are known beforehand.

**A4:** A service can contribute to answer one or several needs with a certain number of points. This number of points is represented by a scale of 0 to 10 points, similar to the scale used for the needs of the person. Effectively if a service contributes to 10 points means that the service is very specialized in that need and 0 if the service does not contribute to the need at all.

A contribution of this work is to propose to the person one to several services to answer a need, at the same time that these services can contribute in the answer of other needs. For example, person 1 requires 5 points to have coverage of his/her need 13 (see Table 1). This need can be covered by a single service such as service 9, or by a group of services such as service 1 regrouped with service 7 (see Table 2). Moreover, if service 9 is chosen, this service can contribute, in the same time, to cover need 19 of person 1 with 4 points.

Notation in the model:  $RSN_{s,n}$  is the number of points that service  $s$  contributes to respond to need  $n$ .

**A5:** A need can be covered by a combination of several services. There are different ways to support a specific need. So, a need might be complied with a pool of different services. To be able to evaluate how services interact themselves, it is necessary to consider the compatibility between services. If services are compatible for one need, the number of expected points will be the sum of individual contributions.

If services are not compatible for one need, this number will be the maximum value of individual contributions. For example, let's consider that a person is assigned to service 3 and service 8 to support need 4 (see Table 2). If services 1 and 2 are compatible, the person will have 12 points for need 4. On the other hand, if services 3 and 8 are not compatible, the person will have 8 point only.

Table 2. Relationship services-needs

		Services									
		1	2	3	4	5	6	7	8	9	10
Needs	1	0	0	6	0	0	4	0	0	0	0
	2	0	0	0	6	0	0	0	0	0	4
	3	6	0	0	0	0	0	0	6	0	0
	4	0	0	4	0	0	0	0	8	0	0
	5	0	8	0	0	0	0	0	0	10	0
	6	0	0	0	6	0	0	0	0	0	4
	7	10	0	0	0	0	0	6	0	0	0
	8	0	0	6	0	0	0	0	0	0	4
	9	0	6	0	0	0	0	0	0	0	4
	10	5	0	0	0	0	0	5	0	0	0
	11	0	0	0	6	0	0	4	0	0	0
	12	0	0	8	0	0	0	0	0	0	4
	13	4	0	0	0	0	0	6	0	8	0
	14	0	10	0	0	0	0	0	4	0	0
	15	8	0	0	0	0	0	0	0	0	10
	16	0	0	0	0	0	5	0	5	0	0
	17	0	0	0	0	10	0	0	0	0	0
	18	0	0	10	0	0	0	0	0	0	0
	19	10	0	0	0	0	0	0	0	4	0
	20	0	0	0	0	0	8	8	0	0	6

Table 3. Compatibility between services, resources availability in institutions and Relationship services-resources, services-institutions

		Services										Resources					
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6
Services	1	0	1	1	1	0	0	0	1	0	1	0	4	0	3	0	0
	2	1	0	0	0	0	0	1	0	1	0	4	0	0	0	0	1
	3	1	0	0	1	1	1	0	1	0	0	0	0	5	0	0	1
	4	1	0	1	0	0	0	1	0	0	0	4	0	0	0	1	0
	5	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0
	6	0	0	1	0	1	0	0	1	1	0	0	0	3	0	0	1
	7	0	1	0	1	0	0	0	0	0	0	3	0	3	0	0	1
	8	1	0	1	0	1	1	0	0	1	1	0	5	0	0	0	1
	9	0	1	0	0	1	1	0	1	0	1	0	0	0	0	1	1
	10	1	0	0	0	0	0	0	1	1		0	5	0	10	1	1
Institutions	1	0	0	1	1	1	0	1	1	1	1	15	15	15	15	3	4
	2	1	1	1	1	1	0	0	0	0	0	15	15	15	15	3	4
	3	1	1	1	0	1	0	1	1	0	1	15	15	15	15	3	4
	4	1	1	1	1	1	1	0	1	0	0	15	15	15	15	3	4
	5	0	0	1	0	1	0	1	1	1	1	15	15	15	15	3	4

An example of a binary matrix of compatibility is illustrated in Table 3. The compatibility between two services is represented by a symmetric matrix, where 1 means that the two services are compatible and 0 means that the services are not compatible. It is important to note that a service is defined by a specific activity that consumes resources (in hours or in quantity) during a standard period. This is why, a service is not compatible with itself. For example, a service can be: a speech therapy of 2 hours per week. If we propose twice the same service to a person, it means that the person will receive a speech therapy, 4 hours per week. That feature is considered as another service.

Notation in the model:  $RSS_{\hat{s},s}$  is equal to 1 if service  $\hat{s}$  is compatible with service  $s$ ; 0 otherwise.

**A6:** A service may require the use of resources, with a quantitative consumption (Table 3 relationship services-resources).

The units of measure of the consumption of resources by a human, depends on the type of resources (Table 3). With human resources the units of consumption will be represented in hours (for example service requires 3 hours working time of a social worker), and for material resources the units of consumption will be represented in quantity (for example a service requires one bed).

Furthermore, some services do not consume any resources like the Service 5 in Table 3. The assignment of this kind of service to a PD will not consume any material or human resources of the institution. However it will help to choose an institution among others to answer a PD's needs (for example, if the institution has an adapted kitchen or offers free access to a green space).

Also, we consider that a type of service could be proposed either with one resource or with another resource. In the data matrix these situations are considered in different rows, as if they were different services, even if they provide the same support to the PD. For example, a service that can be offered with a psychologist or a social worker, in our data tables will be considered as 2 services that offer the same amount of points to the same needs, but they consume different resources.

Notation in the model:  $RSR_{s,r}$  is the number of units of resource  $r$  consumed by service  $s$ .  $SP_{s,i}$  is equal to 1 if service  $s$  is proposed by institution  $i$ ; 0 otherwise.

### 3) Assumptions related to institutions

**A7:** Proposed Services to a PD may belong to one or more institutions (Table 3 relationship services-institutions).

**A8:** As resources are constrained, it is necessary to know the resource availability in each institution upon decision-making (Table 3 relationship institutions- resources). The unit of availability is the same as in the assumption **A6**.

Notation in the model:  $RA_{i,r}$  is the availability of resource  $r$  in institution  $i$ .

### **A9:** Parameters that must be known beforehand

$D_{i,p}$  is the distance between institution  $i$  and the reference address of person  $p$ . The compatibility between the services presented in the assumption **A5**, implies that the points offered by the services proposed to the person to each need, depends on the compatibility of the proposed service combination. Therefore it is useful to elaborate a pre-treatment which allows to generate all possible combinations of services and calculates, for each of these combinations, the number of points that it contributes to each need.

The number of possible combinations that this pre-treatment must generate is of order  $(2^{ns} - 1)$ , where  $ns$  represents the number of services. For example, for a total of 3 services (s1, s2 and s3), the total number of possible combinations is  $(2^3 - 1) = 7$ . c1 (s1), c2 (s2), c3 (s2, s1), c4 (s3), c5 (s3, s1), c6 (s3, s2), c7 (s3, s2, s1). Also it is necessary to calculate the number of points that the combination contributes to each need. This calculation is performed respecting the compatibility of services presented in assumption **A5**. The calculation is made using the parameters  $RSN_{s,n}$  and  $RSS_{s,s}$ . Note that **SC**, set of all possible

combinations of services, with cardinality  $(2^{ns} - 1)$ , where  $ns$  represents the total number of services.

Notation in the model:  $SB_{s,c}$  is equal to 1 if the service  $s$  does belong to combination of services  $c$ ; 0 otherwise.  $RCN_{c,n}$  is the number of points that combination of services  $c$  contributes to respond to need  $n$ .

## B. Binary decision variables

We use the following decision variables:

$X_{s,i,p} = 1$  if the service  $s$  of the institution  $i$ , is assigned to the person  $p$ ; 0 otherwise.

This decision variables is sufficient to define the allocation problem. In order to facilitate constraint description, we also consider the following binary variables related to variables  $X_{s,i,p}$ :  $Y_{i,p}$  is equal to 1 if at least one service of the institution  $i$  is assigned to the person  $p$ , 0 otherwise;  $U_{c,p}$  is equal to 1 if the combination of services  $c$ , is assigned to the person  $p$ , 0 otherwise; and  $W_p$  is equal to 1 if the model proposes a complete assignment to the Person  $p$ , 0 otherwise.

## C. Model

The model considers that the availability of resources is known at the moment of the assignment. The search for a solution is done in 2 steps. The first step tries to maximize the number of people with a complete response (prioritizing people with a critical situation). In a second step, a partial response is looking for the people who do not have a complete response in the first step. In this second step, we propose services that respond to some needs of PD, depending on the availability of remaining resources.

1) Step 1: Find a complete assignment for the maximum number of people regarding their needs.

a) Objective function: Maximize the number of needs (weighted by the number of points) covered by proposing complete answers.

$$\text{Maximize } \sum_{p=1}^P \sum_{n=1}^N (W_p * N_{p,n}) \quad (1)$$

### b) Constraints

$$W_p * DT_p \geq D_{i,p} * Y_{i,p} \quad \forall i, p \quad (2)$$

$$\sum_{i=1}^I Y_{i,p} \leq IT_p \quad \forall p \quad (3)$$

$$SP_{s,i} \geq X_{s,i,p} \quad \forall s, i, p \quad (4)$$

$$\sum_{c=1}^C U_{c,p} \leq 1 \quad \forall p \quad (5)$$

$$\sum_{i=1}^I X_{s,i,p} \geq \sum_{c=1}^C (U_{c,p} * SB_{s,c}) \quad \forall s, p \quad (6)$$

$$X_{s,i,p} \leq \sum_{c=1}^C (U_{c,p} * SB_{s,c}) \quad \forall s, i, p \quad (7)$$

$$Y_{i,p} * \sum_{s=1}^S SP_{s,i} \geq \sum_{s=1}^S X_{s,i,p} \quad \forall i, p \quad (8)$$

$$W_p * N_{p,n} \leq \sum_{c=1}^C (U_{c,p} * RCN_{c,n}) \quad \forall p, n \quad (9)$$

$$RA_{i,r} \geq \sum_{s=1}^S \sum_{p=1}^P (X_{s,i,p} * RSR_{s,r}) \quad \forall i, r \quad (10)$$

$$X_{s,i,p}, Y_{i,p}, U_{c,p}, W_p \in \{0, 1\} \quad \forall s, i, c, p \quad (11)$$

Constraints (2) ensure that institutions, which are part of the proposed assignment to the person, are in the perimeter

tolerated by the person. Constraints (3) ensure that a person will not be assigned to more than a maximum number of institutions. Constraints (4) ensure that the assignment includes services proposed by institutions. Constraints (5) ensure that a maximum of one combination of services is proposed to a person. Constraints (6) and (7) ensure that the services offered to people are part of the combination of services. Constraints (8) ensure that the sum of the services available at institution  $i$  and assigned to person  $p$  cannot exceed the total number of services offered by institution  $i$ . Constraints (9) ensure that the combination of proposed services covers all needs of the person. Constraints (10) ensure that the assigned services of each institution do not consume more than the available resources.

2) Step 2: Find a partial assignment for people without a full accompaniment, using the remaining available resources. This means that the assignment proposed to the person does not satisfy all his/her needs entirely.

At this step the model presented above remains mostly the same, but now the index  $p \in \mathbf{RP}$ , where  $\mathbf{RP}$  is a subset of  $\mathbf{SP}$  for people without a full accompaniment in the step 1. The parameter  $RA_{i,p}$  is recalculated with the resources available after assignment in the first step. Other changes in this step 2 are with the objective function and constraints (2) and (9). In this step the variable  $W_p$  is not used, in its replacement the following variable is proposed.  $V_{p,n}$  is equal to 1 if an assignment is proposed for the person  $p$  for need  $n$ , 0 otherwise.

a) Objective function: Maximize the number of covered needs among all the people.

$$\text{Maximize } \sum_{p=1}^P \sum_{n=1}^N (V_{p,n} * N_{p,n}) \quad (12)$$

b) Constraints

$$DT_p \geq D_{i,p} * Y_{i,p} \quad \forall i, p \quad (13)$$

$$V_{p,n} * N_{p,n} \leq \sum_{c=1}^C (U_{c,p} * RCN_{c,n}) \quad \forall p, n \quad (14)$$

$$V_{p,n} \in \{0, 1\} \quad \forall p, n \quad (15)$$

Constraints (2) are replaced by constraints (13) and constraints (9) are replaced by constraints (14). Constraints (13) ensure that institutions that are part of the proposed assignment to the person, are in the perimeter tolerated by the person. Constraints (14) ensure that the combination of services proposed cover the need  $n$  of the person  $p$ .

#### IV. Computational experiment

The data used in this experiment are presented in Table 1, Table 2 and Table 3. This data have been generated to be representative of a real case but with a reasonable size, allowing to be solved with an exact method. The results presented below were obtained after the implementation of the model in the program IBM ILOG CPLEX Opt. Studio, Version: 12.5.

The instance represents a situation including 10 people with disabilities looking for an assignment of services in a network of 5 institutions. Each institution proposes up to 7 services

from a list of 10 standard services (Number of combinations is  $(2^{10} - 1) = 1023$ ). Furthermore, each person can have a maximum of 16 different needs from a list of 20 standard needs. We assume that the five institutions are in the tolerated perimeter of all people and each institution uses up to 6 resources.

Table 4 presents a comparison in the application of the model (with its two 2 steps) in two scenarios: Scenario 1 considers that people can only go to one single institution (which is the current situation). Scenario 2 considers that it is possible for people to go to up to 2 institutions (this scenario shows the advantages when more institutions are allowed to be part of the solution). It is important to note that for each of the scenarios and each stage, CPLEX finds a solution in less than 15 seconds with the data set proposed.

To analyse the performance solutions, 3 indicators have been defined. The first one is related to the entirety of the solution: (A) *number of people with a complete assignment in the first step*. Two indicators are related to the solution proposed to each person: (B) *number of needs covered / number of total needs*; (C) *number of points covered / number of total points*. (A) is the most important indicator in reference to the others, since the medico-social sector currently tries to propose complete assignments to people with disabilities. Results are as follows: with scenario 1; (A) = 4 people (40%); in scenario 2 (A) = 5 people (50%). For people with a complete assignment, in this first step, the indicators B and C are 100%. With this indicator (A), we can see that proposing solutions with more than one institution causes positive effects on the number of people with a complete assignment. Today, the orientation process does not work in this way, since it tries to match PD with places within one institution. In that way, our model, considering the assignment of services to PDs in its first step, presents an interesting contribution for this sector (the possibility of considering more institutions in a complete assignment). In our experimentation related to 10 demands, we went from 4 to 5 people with a complete assignment.

Table 4. Results for scenarios 1 and 2

		Step 1		Step 2		
Indicators		B	C	B	C	
Results scenario 1	People	1	12/12	38/38		
		2			6/9=67%	17/40=43%
		3			9/14=64%	35/76=46%
		4			3/13=23%	12/45=27%
		5	9/9	29/29		
		6			6/12=50%	18/39=46%
		7	9/9	34/34		
		8	8/8	25/25		
		9			7/12=58%	30/53=57%
		10			7/16=44%	20/56=36%
Results scenario 2	People	1	12/12	38/38		
		2			0/9=0%	0/40=0%
		3			8/14=57%	43/76=57%
		4	13/13	45/45		
		5	9/9	29/29		
		6			5/12=42%	13/39=33%
		7	9/9	34/34		
		8	8/8	25/25		
		9			5/12=42%	20/53=38%
		10			4/16=25%	14/56=25%

To improve this solution, decision-maker can modify parameters to identify different alternatives, for example by changing the number of institutions tolerated by PD. Another parameter, in which the decision-maker can act, is the possibility of increasing the geographical perimeter tolerated by PD. In this experiment, all institutions are in the perimeter of PD. In real life the medico-social institutions are found throughout a large territory. That is why extending the admitted perimeter will allow expanding the possibilities of finding a complete assignment.

The other step of the presented model aims to give a partial response to people without answers after the first step. The possibility of proposing a relaxed solution reduces the break of the accompanying path (to prevent that the PD stays without accompaniment, a situation that is sought to avoid in the medico-social sector). Nevertheless, we can see that an improvement in step 1 can reduce possibilities in step 2. For example, in Table 4, PD 2 stays without accompaniment in scenario 2, whereas he/she has got a partial assignment in scenario 1.

As in the first step, decision maker can act with parameters such as the maximum number of institutions that can participate to one answer, in order to improve the relaxed solution.

We can note that this relaxed solution may be a temporary one. Indeed, this model considers only one period of time. As we said, a person can stay without accompaniment. A multi-period model would improve the assignment. It would be able to find complete assignments for all people over a time horizon and not within a single period.

## V. Conclusions and prospects

Currently, the assignment of disabled people is based on a single institution solution and takes into account places only and not real need among its complete aspect. In order to improve assignment decision process, we propose a mathematical model that is able to combine the services of several institutions to propose a more complete solution. Those solutions can be composed by a set of services provided by several institutions. In a second step, the approach is able to find partial assignments with the availability of resources remaining after the first step.

In order to take into account multi-period decisions, development has to be done to propose to people with disabilities who makes a demand a complete assignment to their needs, considering the possibility to offer services in later periods depending on the availability of resources in institutions and in each period.

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## References

[1] CNSA, “Dixième année de mobilisation : les MDPH engagent leur transformation,” 2016.

[2] MDPH calvados, “Étude des situations en liste d’attente dans les SAVS et les SAMSAH.” 2013.

[3] D. Piveteau, S. Acef, F.-X. Debrabant, D. Jaffre, and A. Perrin, “« Zéro sans solution » : le devoir collectif de permettre un parcours de vie sans rupture, pour les personnes en situation de handicap et pour leurs proches,” 2014.

[4] A. F. Mosquera Varela, L. Trilling, and T. Monteiro, “Managing the accompanying path of people with disabilities in a medico - social network: a method to create a process model based on autonomous actors point of views,” *International Federation of Automatic Control World Congress*. Toulouse, France, 2017.

[5] S. I. Gass and M. C. Fu, Eds., *Encyclopedia of Operations Research and Management Science*. Boston, MA: Springer US, 2013.

[6] B. Korte and J. Vygen, *Combinatorial Optimization*, vol. 21. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012.

[7] R. E. Burkard and E. Çela, “Linear Assignment Problems and Extensions,” in *Handbook of Combinatorial Optimization*, Boston, MA: Springer US, 1999, pp. 75–149.

[8] C. Oğuz, F. Sibel Salman, and Z. Bilgintürk Yalçın, “Order acceptance and scheduling decisions in make-to-order systems,” *Int. J. Prod. Econ.*, vol. 125, no. 1, pp. 200–211, 2010.

[9] J. Yoo and I. S. Lee, “Parallel machine scheduling with maintenance activities,” *Comput. Ind. Eng.*, vol. 101, pp. 361–371, 2016.

[10] P. Györgyi and T. Kis, “Approximation schemes for parallel machine scheduling with non-renewable resources,” *Eur. J. Oper. Res.*, vol. 258, no. 1, pp. 113–123, 2017.

[11] J. Gaudreault, J.-M. Frayret, A. Rousseau, and S. D’Amours, “Combined planning and scheduling in a divergent production system with co-production: A case study in the lumber industry,” *Comput. Oper. Res.*, vol. 38, no. 9, pp. 1238–1250, Sep. 2011.

[12] J. E. C. Arroyo and J. Y.-T. Leung, “Scheduling unrelated parallel batch processing machines with non-identical job sizes and unequal ready times,” *Comput. Oper. Res.*, vol. 78, pp. 117–128, 2017.

[13] G. Osorio, T. Monteiro, L. Trilling, and F. Albert, “Multi-criteria assignment policies to improve global effectiveness of medico-social service sector,” *Eng. Appl. Artif. Intell.*, vol. 61, pp. 21–34, 2017.

[14] B. Chabane, M. Basseur, and J.-K. Hao, “R 2-IBMOLS applied to a practical case of the multiobjective knapsack problem,” *Expert Syst. Appl.*, vol. 71, pp. 457–468, Apr. 2017.

[15] H. Liimatta, P. Lampela, P. Laitinen-Parkkonen, and K. H. Pitkala, “Effects of preventive home visits on older people’s use and costs of health care services: A systematic review,” *Eur. Geriatr. Med.*, vol. 7, no. 6, pp. 571–580, 2016.

[16] B. Maenhout and M. Vanhoucke, “An integrated nurse staffing and scheduling analysis for longer-term nursing staff allocation problems,” *Omega*, vol. 41, no. 2, pp. 485–499, 2013.

[17] CNSA, DGCS, and Ministère des Affaires sociales et de la Santé, “Les nomenclatures de besoins et de prestations détaillées.” SERAFIN-PH (Services et Établissements: Réforme pour une Adéquation des Financements aux parcours des Personnes Handicapées), 2016.