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PROJECT SELECTION BY USING CONSTRAINT PROGRAMMING

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ABSTRACT
Project selection is considered as the first essential part of project in the urban transport. Project selection is also considered as a process to evaluate of different transport project ideas and chooses the one with the beneficial priority. Urban transport is one of the most important subjects for urban planner, inhabitants of the city and environment. So, it should be paid attention to the selection of transport projects and should be given priority to projects that will provide the most benefit to livable cities. This paper presents a solution for project selection using constraint programming for urban rail transport for the first time in the literature.
Keywords: Project selection, constraint programming, urban transport

1. INTRODUCTION
Today, many cities face challenges of rapid urbanization. Many factors based on economic, social and technological reasons play an important role in increased urbanization. Developing Turkey Republic carries out breakthrough in the transportation field with mega projects as in many areas. At the same time, there are operating to improve transportation with high-speed train projects for intercity transport and rail system projects for urban transport as well as mega projects. The transportation problem at the beginning of these problems negatively affects the urban life. Istanbul Metropolitan Municipality presents various projects to solve this problem. It is seen as a solution to public transportation in the solution of transportation problem. In this respect, it prioritized its due to the safe and high capacity of the rail systems. In this context, the Istanbul Metropolitan Municipality is presenting various rail system projects in order to expand the existing rail system network and to improve the new rail system. In line with its Transportation Master Plan, Istanbul Metropolitan Municipality has the ambitious vision of expanding the existing rail network to 400 km until 2019 and to 1.000 km in the long term. Thanks to the investments in question, it will be possible to provide the people of Istanbul with reliable, safe and comfortable public transport services with a substantial

increase in the share of the railway mode. Developing metropolitan cities adopt and implement transport strategies that strengthen economic vitality and build more inclusive cities by providing mobility.

Project selection is considered as the first essential part of project in the urban transport. Project selection is also considered as a process to evaluate the different transport project ideas and chooses the one with the beneficial priority. The problem of project selection, which has been studied in many areas in the literature such as transportation project selection [1,2], technology selection [3], strategy selection [4], rail system project selection [5]. Multicriteria decision making and mathematical programming such as goal programming are frequently used in the project selection process. However, no study has been conducted on urban transport project selection using constrain programming. This study using constrain programming to contribute with a new application in the urban transportation for the literature.

2. CONSTRAIN PROGRAMMING

Constraint programming (CP) is a merger of two declarative paradigms: constraint solving and logic programming. Constraint programming is a programming paradigm wherein relations between variables are stated in the form of constraints. Constraints differ from the common primitives of imperative programming languages, the properties of a solution to be found. This makes constraint programming a form of declarative programming [6]. A CP model resembles an integer programming model in terms of syntax. It contains a deceleration of decision variables with their domains, a set of constraints, and possibly an objective function. However, the CP modeling paradigm is much more expressive. In fact, the language is a superset of the integer linear programming modeling language [7].

3. APPLICATION

The city of Istanbul with crowded population is an economic center and have variety civilizations and is the most popular tourist destination in the world. It is a city that has developed with the industry that it has. So, it has some problem due to this development. Urban transportation is the beginning of this problem. The state of the republic of Turkey have some goals around the target year of 2023. In this scope, İstanbul also have some goals to develop the urban transportation with rail system projects such as metro, light rail system, tramway and monorail. The current rail network is targeted to be expended to 482 km until 2019 and 1.000 km in the long-term. With these investments a modern, safe and comfortable transportation will be provided to Istanbulites and share of rail systems in public transportation will increase significantly. Upon the completion of the rail-based transport investments that have recently been speeded up, Istanbul Metropolitan Municipality will soon be serving a greater number of passenger. Operated by the İstanbul Metropolitan Municipality for expected the urban railway network in the metropolitan area, the projects currently are 11 urban railway lines of nearly 160 km. The application is about the evaluation of 30 rail system projects which are included in the plans of Istanbul Metropolitan Municipality [8]. These projects are shown in Table 1.

MATHEMATICAL MODEL

Parameters:

i: projects index i=1…30

d_i: Distance of i. project i=1…30

J_i: Cost of i. project i=1…30

k_i.Travel time of i. project i=1…30

l_i: Benefit of i. project i=1…30

m_i: Number of station i=1…30

Decision variable:

x_i: Select i. projects i=1…30

y_{ij}: Avarage travel time i=1…30, j=1…30

CONSTRAINTS:

Domain

$$0 \leq x_i \leq 30 \qquad i = 1..30 \qquad (1)$$

Ensuring of assigned only a project to a rank

$\text{count}(x_i, j) \leq 1$ i=1…30, j=1…30 (2)

If i. project is j. rank, ensuring to take 1 value of y_{ij} variable.

$(x_i = j) = y_{ij}$ i=1…30, j=1…30 (3)

Constraint 1: Ensuring the budget constrain

$\sum_{i=1}^{30} j_i y_{ij} \leq Budget\ Scenario$ budget scenario=1,2,3 i=1…30, j=1…30 (4)

Constraint 2: The constraint that indicating the travel time

$\sum_{i=1}^{30} k_i y_{ij} \leq \sum_{j}^{30} y_{ij*}\, 60$ i=1…30, j=1…30 (5)

Constraint 3: The constraint that access to most station

$\sum_{i=1}^{30} m_i y_{ij} \geq 100$ i=1…30, j=1…30 (6)

Constraint 4: Access to longest distance

$\sum_{i=1}^{30} d_i y_{ij} \geq 200$ i=1…30, j=1…30 (7)

OBJECTIVE FUNCTION

Ensuring the maximum benefit

$max\ Z = \sum_{i=1}^{30} l_i * x_i$ (8)

Table 1. Alternatives rail system projects [8]

No	Name of Line	Rail System Type	Station Number	Distance (km)	Travel Time (min.)	Approximate Cost (Million $)	Benefit
1	M1	Metro	19	24,5	37	1.835	949
2	M2	Metro	9	9	13,5	435	330
3	M3	Metro	38	63,5	115,3	3.521	259
4	M4	Metro	5	7,4	11,5	370	5.072
5	M5	Metro	12	14,3	22	810	88
6	M6	Metro	4	14,3	22	808	622
7	M7	Metro	12	13	19,5	710	1.021
8	M8	Metro	5	6,2	10	320	99
9	M9	Metro	10	9,7	15	450	97
10	M10	Metro	7	7,6	12	380	444
11	M11	Metro	2	4,1	6	240	63
12	M12	Metro	6	6,9	10,5	350	403
13	M13	Metro	11	13	19,5	720	82
14	M14	Metro	10	16,3	25	980	51
15	M15	Metro	11	14	21	942	87
16	M16	Metro	11	18	27	1.085	622
17	M17	Metro	4	5,5	8,5	350	403
18	M18	Metro	13	28	42	1.420	444
19	M19	Metro	14	55,5	166,5	3.025	742
20	M20	Metro	5	9,7	14,5	1.030	68
21	M21	Metro	5	5,5	8,5	341	267
22	H1	Monorail	17	15	40	240	92
23	H2	Monorail	9	7,3	12,5	175	587
24	L1	Rail system	9	10,9	16,5	1.280	240
25	L2	Rail system	5	32	32	2.340	260
26	L3	Rail system	9	12,3	19	1.475	578
27	L4	Rail system	7	33	33	2.380	250
28	L5	Rail system	13	22,3	34	2.400	785
29	T1	Tramway	14	10,1	30	888	150
30	T2	Tramway	6	3	9	202	120

The mathematical model is solved according to the separately for three different budget scenarios with IBM ILOG CPLEX 12.6.2 program and the solution results are given in Table 2. At the same time, this table also shows the priority order of the project.

Nine metro projects and two monorail projects under the 10.000 budget were chosen which results in a total benefit 9.314. When these projects are selected, the budget is fully utilized. Also, when the

budget scenario is changed, the sorting, selection, number of station, access to max. distance and benefit are increase and changed. In Table 3 shows the other scenarios.

Table 2. Selected projects and the priority orders

Budget	Ranking	The Priority Order of Selected Projects													
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
10.000	Projects	M4	M7	M19	H2	M10	M12	M2	M21	M3	M9	H1	---	---	---
12.000		M4	M7	M19	M16	M6	H2	M10	M17	M12	M2	M21	M3	T2	H1
15.000		M4	M7	M1	M19	M16	M6	H2	L3	M10	M12	M17	M2	M21	M3

Table 3. The budget scenarios

Budget Scenario	Total Station Number	Total Distance (km)	Total Travel Time (min.)	Total Cost (Million $)	Total Benefit
10.000	132	200,4	424,8	9.997	9.314
12.000	143	217,2	454,3	11.184	10.362
15.000	152	250,3	483,3	14.860	12.299

4. RESULTS AND DISCUSSION

In this study, we selected transport projects for urban transport and developing metropole Istanbul by using constrain programming for the first time in the literature. Projects selection is a major decision-making process for urban transport. It helps in selecting projects when a number of promising alternatives exits, difficult in carry out the task with the budget constraints, suitable rail system type, optimal station number or optimal location of station, maximum distance and minimum travel time. The constraint programming provides an integrated framework to select a set of projects in the alternative solution of mathematical programming. This study and method can be applied to any projects selection situation in other fields or disciplines. At the same time, this subject is very important for other in public institutional and also in private sector. The use of multicriteria decision making methods such as analytic hierarchy process and TOPSIS with constraint programming can be suggested for the future studies.

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