

The use of the brute-force method for solving the set covering problem

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Abstract. In this paper we propose the brute-force method as a suitable method for solving the set covering problem in high schools and colleges.

Keywords: brute-force method, set covering problem

Given n machines denoted $M\#1, \dots, M\#n$, with prices c_1, \dots, c_n , respectively, and m operations denoted $O\#1, \dots, O\#m$. Each machine can perform one or more of these operations. We call a set of machines a *regular* set, if it contains machines able to perform all operations $O\#1, \dots, O\#m$. The set covering problem is as follows. Find a regular set of machines such that the price of all machines in the set is minimal one. If in addition we have to list all regular sets, sorted by price, we call the problem the *extended* set covering problem.

A set covering problem could be given by the table

	M#1	...	M#j	...	M#n
O#1	a_{11}	...	a_{1j}	...	a_{1n}
...
O#i	a_{i1}	...	a_{ij}	...	a_{in}
...
O#m	a_{m1}	...	a_{mj}	...	a_{mn}
price	c_1		c_j		c_n

where $a_{ij} \in \{0,1\}$ for all $i \leq m, j \leq n$. If $a_{ij} = 1$, the machine M#j can perform operation O#i, and if $a_{ij} = 0$, otherwise. We denote a solution by the notation $x_1, \dots, x_n \rightarrow c$, where $x_j \in \{0,1\}$ for all $j \leq n$ and if $x_j = 1$, machine M#j is in the solution set, and $x_j = 0$ otherwise, and where c is the total price of all machines in the set.

The brute-force solution of the set covering problem is as follows. We list all regular sets of machines and sort them by price.

Since the brute-force method is simple, it allows a simple implementation. I have created a simple computer program by using the programming language PHP. The computer program is used in the examples given below.

In the examples given below, the computer program displays the answer without any delay, that is, for less than 0.1 second. Hence, we could use the brute-force method as a suitable method for solving the set covering problem in high schools and colleges. Also, for the extended set covering problem we obtain the answer without delay. The university students have to study more fast and sophisticated methods, but in the high schools and colleges we could prefer the brute-force method, since it is simple and the students could easily understand and use it.

Example 1. Solve the extended set covering problem given by the following table:

	M#1	M#2	M#3	M#4	M#5
O#1	0	0	1	0	1
O#2	0	1	0	1	1
O#3	1	0	0	1	1
O#4	0	0	1	0	0
price	1	1.2	1.3	1.4	1.5

Solution. The output of the computer program is available for download as supplementary material.

Example 2. Solve the extended set covering problem given by the following table:

	M#1	M#2	M#3	M#4	M#5	M#6
O#1	0	0	1	0	1	0
O#2	0	1	0	1	1	0
O#3	1	0	0	1	1	1
O#4	0	0	1	0	1	1
O#5	1	0	1	0	1	1
O#6	1	0	0	0	1	0
O#7	1	0	1	1	0	1
price	1	1.2	1.3	1.4	1.5	1.6

Solution. The output of the computer program is available for download as supplementary material.

Example 3. Solve the extended set covering problem given by the following table:

	M#1	M#2	M#3	M#4	M#5	M#6
O#1	0	0	1	0	1	0
O#2	0	1	0	1	1	0
O#3	1	0	0	1	1	1
O#4	0	0	1	0	1	1
O#5	1	0	1	0	1	1
O#6	1	0	0	0	1	0
O#7	1	0	1	1	0	1
price	1	1	2	2	3	3

Solution. The output of the computer program is available for download as supplementary material.

Example 4. Solve the extended set covering problem given by the following table:

	M#1	M#2	M#3	M#4	M#5	M#6	M#7	M#8	M#9
O#1	0	0	1	0	1	0	1	1	1
O#2	0	1	0	1	1	0	1	1	0
O#3	1	0	0	1	0	1	1	1	0
O#4	0	0	0	0	1	1	1	1	1
O#5	1	0	1	0	1	1	1	0	1
O#6	1	0	0	0	1	0	0	1	1
O#7	1	0	1	0	0	1	1	1	1
price	1	1	1	1	1	1	1	1	1

Solution. The output of the computer program is available for download as supplementary material.

Example 5. Solve the extended set covering problem given by the following table:

	M#1	M#2	M#3	M#4	M#5	M#6	M#7	M#8	M#9
O#1	0	0	1	0	1	0	1	1	1
O#2	0	1	0	1	1	0	1	1	0
O#3	1	0	0	1	0	1	1	1	0
O#4	0	0	0	0	1	1	1	1	1
O#5	1	0	1	0	1	1	1	0	1
O#6	1	0	0	0	1	0	0	1	1
O#7	1	0	1	0	0	1	1	1	1
price	1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9

Solution. The output of the computer program is available for download as supplementary material.

Example 6. Solve the extended set covering problem given by the following table:

	M#1	M#2	M#3	M#4	M#5	M#6	M#7	M#8	M#9
O#1	0	0	1	0	1	0	1	1	1
O#2	0	1	0	1	1	0	1	1	0
O#3	1	0	0	1	0	1	1	1	0
O#4	0	0	0	0	1	1	1	1	1
O#5	1	0	1	0	1	1	1	0	1
O#6	1	0	0	0	1	0	0	1	1
O#7	1	0	1	0	0	1	1	1	1
price	1	1	2	2	3	3	3	4	4

Solution. The output of the computer program is available for download as supplementary material.

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