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Combinatorial Optimization and Multistage Decision making Problem Model and solution for Port to Port Transportation schedule

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ABSTRACT: *In applied mathematics literature "Combinatorial Optimization" is a topic consists of finding an optimal object from a finite set of objects. VRP meaning vehicle routing problem combined with TSP or travelling salesman problem and MSP minimum spanning tree problems are some of the examples of Combinatorial Optimization topics. This topic further complicates while route and junctions are assigned with certain constraints.*

The paper also contain an example concerning Petroleum refinery port to port transaction schedule based on the multistage decision making process. The refinery operations Resource solutions are allocating with the proper vessel fleet shuttles from crude petroleum exploring and uploading port to refinery locality port within definite routes periodically, in time inventory schedules.

In the paper we are discussing a multistage decision making model for uniform distribution of energy resource solutions considering the operational resource problems. The algorithmfor solving the problem is a specific combinatorial optimization problem solving technique is focused in the paper.

Key Words: *Combinatorial Optimization, Vehicle Routing Problem, Multi stage decision making.*

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I. INTRODUCTION:

More or less the specific Operational resource problems namely Assignment problem, shunt closure problem, constraint satisfaction problem [1], cutting stock problem[1], technician scheduling problem, travelling salesman problem [1], vehicle rescheduling problem [1], vehicle routing problem and security protection combined problems [2] are indirectly solving by the renewable energy serving agencies while they are procuring the energy resource material.

The Vehicle Routing problem can be assumed as Vessel fleet routing through sea routes to the seaports of petroleum crude storage locality. The combinatorial problem is "What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?" By the way, the problem generalizes travelling salesman problem. One of the objective of the VRP is to minimize the total rout cost.

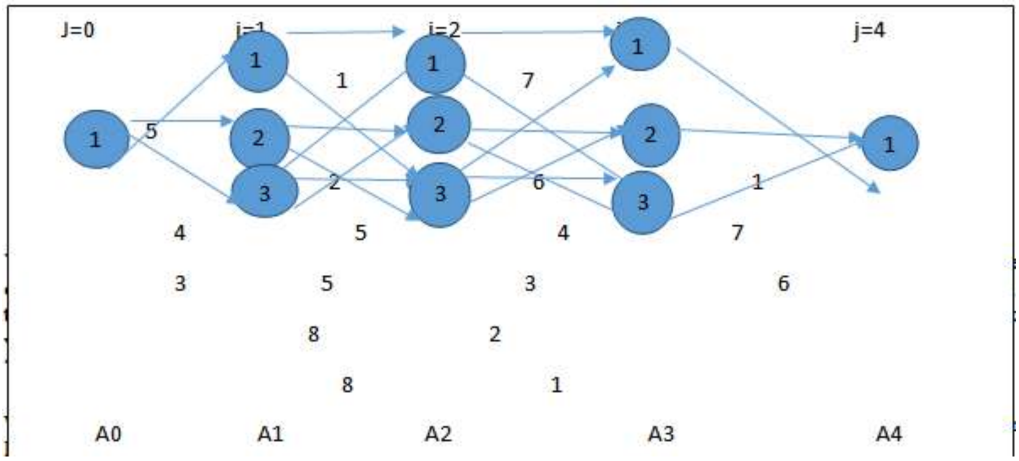
The network supports vehicles routing can be represented paths from the vertex $A_0$to the vertex A_n along directed arcs joining the effective vertices in the intermediary stages representing indexes $j = 1, 2, \dots, (n - 1)$. Each intermediary stage has at most $n - 2$states or vertices. Thus the vehicle routes through the vertices in the n stages. For convenience, we denote subscript j is the index of node vertices and edge arcs. The initial stage $j = 0$ is attached to stage $j = 1$ which has $n - 2$ states of vertices and sequentially connects the final stage $j = n$with arc links.

On each move the vehicle routes from stage j to stage $j + 1$. In the way vehicle passes any one vertex in stage j to one vertex in stage $j + 1$. The possible alternative paths from one stage to the next satge are decided by comparing the arc variable values w_j.

The assignment problem is one of the combinatorial optimization problem. In reference of Vehicle Routing problem the assignment problem can be modified for Assigning number of fleets to specific seaports and is similar to the assigning number of tasks to number of agents. If number of seaports equal to number of fleet vessels, any sea port storage facility is greater or equal to contained material of fleet vessels, the concerned seaport can be assigned to specific fleet vessels. Assignment cost optimality is decided with the application of Hungarian algorithm [3].

1. Multistage Least cost path determining model

The seaports in India are Koyali, Mumbai, Mangalore, Kochi, Chennai, Tatipaka, Vizag, Paradip, and Haldia. These port authorities and oil companies (list is enclosed in the Appendix -B) import crude or refined petroleum throughfleet vessels transport system.The second routing problem consists with the container train assignment from seaports to distant refineries in India. The list of refinery companies and location map location name refinery capacity are mentioned in the web. In this section we assume an example of network graph in which the seaports represent nodes in the graph mentioned bellow. The arcs are transition paths connecting node to node. The number levels to arc consists of costs in lakhs. The problem is to select a sequence of nodes in such a way that minimize the costs.



There are nine seaports in India having facilities for Crude petroleum storage. The above graph has five stages of nodes. Excluding the starting node the remaining nodes represent more than one seaport for material transactions. From the graph w_4 is the variable weight assigned to stage four or A4 and can have numeric values w_4 =1 or 7 or 6. Then the prior nodes are $x_3 = 1$, 2 or 3.

Thus $F_4(x_4) = F_4(1) = \min[1 + F_3(1), 7 + F_3(2), 6 + F_3(3)]$;

$= \min_{w_4}[w_4 + F_3(x_3)]$.

Where $F_3(x_3)$ has three possible options, $F_3(1)$, $F_3(2)$ and $F_3(3)$, depending on the values of w_4. Moreover,

$F_3(1) = \min[7 + F_2(1),\ 5 + F_2(2)]$

$$F_3(2) = \min[6 + F_2(1), \quad 4 + F_2(2),\ 2 + F_2(3)]$$

$$F_3(3) = \min[3 + F_2(2), \quad 1 + F_2(3)$$

The above expressions can be written in the form $F_3(x_3) = \min_{w_3}\ [w_3 + F_2(x_2)]$

The three values of $F_3(x_3)$ are calculated with possible values of w_3 and possible values of $F_2(x_2)$ depending on w_3.

In a similar manner particular values of $F_2(1), F_2(2), F_2(3)$ can be calculated with the following relations.

$$F_2(1) = \min\ [1 + F_1(1), 4 + F_1(2)]$$

$$F_2(2) = \min\ [2 + F_1(1), 5 + F_1(2), 8 + F_1(3)]$$

$$F_2(3) = \min\ [5 + F_1(2), 8 + F_1(3)]$$

In general form, the expressions can be written as $F_2(x_2) = \min_{w_2}[w_2 + F_1(x_1)]$.

Finally $F_1(1) = 5, F_1(2) = 4, F_1(3) = 3$; in general $F_1(x_1) = w_1$ and derived with the general recursion formula

$F_j(x_j) = \min_{w_j}[w_j + F_{j-1}(x_j - 1)]$forj $= 4,3,2$ with $F_1(x_1) = w_1$

This can be summarized to determine $F_4(x_4)$ recursively as follows

$$F_1(1) = 5, F_1(2) = 4, F_1(3) = 3$$

$F_2(1) = \min(6, 8) = 6$, $F_2(2) = \min(7, 9, 11) = 7$ and $F_2(3) = \min(9, 11) = 9$

$F_3(1) = \min(13,\ 12) = 12$, $F_3(2) = \min(12, 11, 13) = 11$, $F_3(3) = \min(10, 10) = 10$

$F_4(1) = \min(13, 18, 16) = 13$. Which is the least cost path.

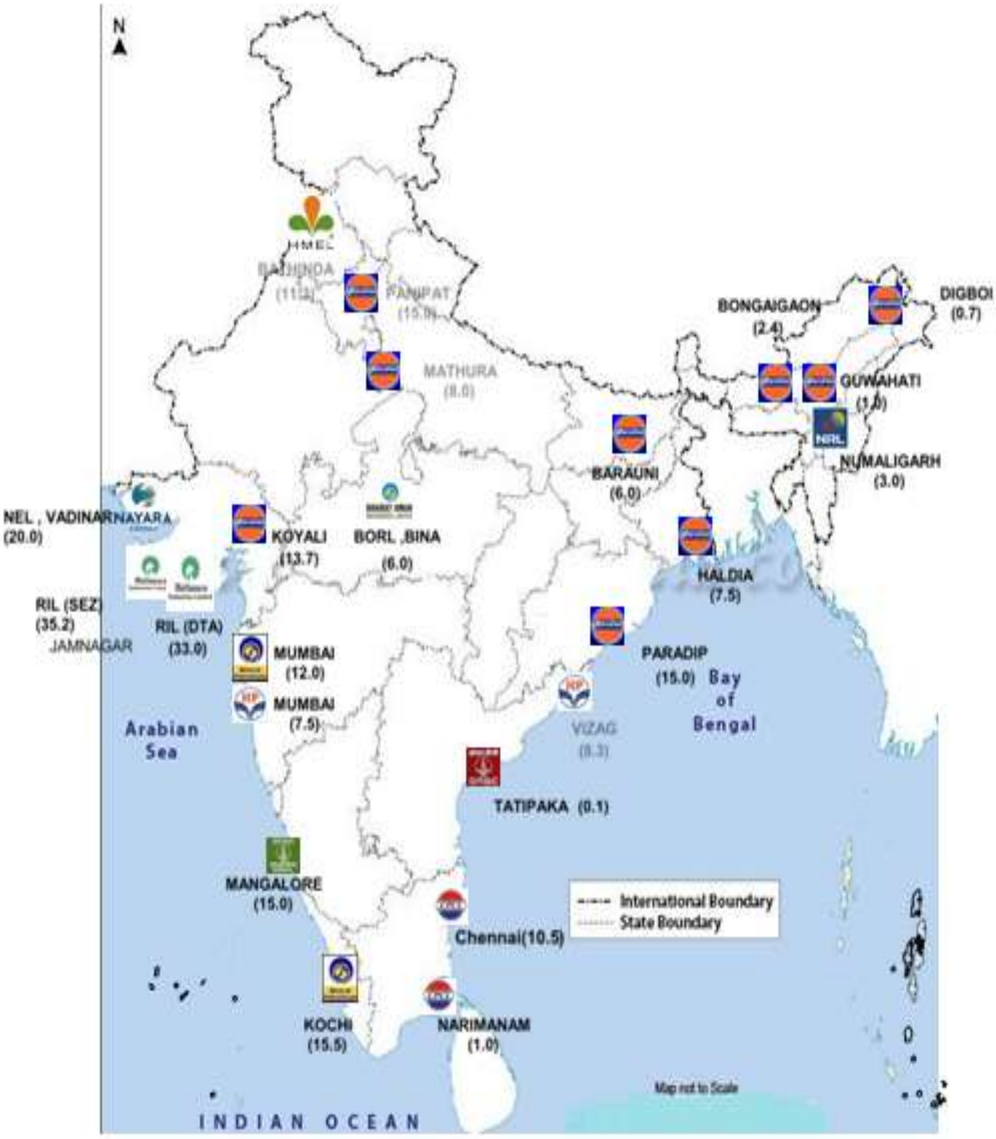
The significant feature of the procedure is that once the minimum $F_j(x_j)$ for a particular value of x_j or a particular value of jth stage is computed, in subsequent computations of paths to x_{j+1} through the value of x_j, only the minimum path to it already computed and need to be taken into consideration. Other alternative paths to x_j may be ignored. This is similar to Bellman's principles of optimality [4].

The principles essentially states that in a multistage process without feedback, whatever the previous states and decision are, The subsequent decisions must from the optimal policy with respect to the current state. A Process without feedback means subsequent decisions do not affect the states arising from decisions previously taken.

II. CONCLUSION:

The import costs mentioned in the form of network arc levels are tentative and not actual costs. The actual costs are available to the refinery company, seaport authority and oil importer companies. The statements made in the multistage least cost path determining model is synthesized in the form of graph network and algebraic form of solution process. If the graph is more complicated with larger number of vertices and arcs a geometrical representation is hardly convenient and a numerical approach is called for. Therefore the data in tabular version of the problem description and problem solving procedure, which involves purely numerical computation starting and iterating tables are needed. Some of the examples such as transit nodeand arc value, state transformations, recursive operation pre and post operation numeric representation are also found in the standard Operations Research books. The tabular numerical data description is also useful for writing Computer program for solving the Combinatorial Optimization and refinery operations resource problem.
The Appendix A display the map of petroleum refinery in India and Appendix B mentions the list of Petroleum refinery companies operating in India.

Appendix-A



Appendix-B

S. No.	NAME OF THE OIL COMPANY	STATE	LOCATION OF REFINERY	CAPACITY (MMTPA)
1	INDIAN OIL CORPORATION LIMITED (IOCL)	BIHAR	BARAUNI	6.0
2		GUJARAT	KOYALI	13.7
3		WEST BENGAL	HALDIA	7.5
4		UTTAR PRADESH	MATHURA	8.0
5		HARYANA	PANIPAT	15.0
6		ASSAM	GUWAHATI	1.0
7		ASSAM	DIGBOI	0.7
8		ASSAM	BONGAIGAON	2.4
9		ODISHA	PARADIP	15.0
		IOCL TOTAL		**69.2**
10	USTAN PETROLEUM CORPORATION LIMITED (HPCL)	MAHARASTRA	MUMBAI	7.5
11		ANDHRA PRADESH	VISAKH	8.3
12	HPCL-HINDUSTAN MITTAL ENERGY LIMITED (HMEL) (JV)	PUNJAB	BATHINDA	11.3
		HPCL-TOTAL		**27.1**
13	BHARAT PETROLEUM CORPORATION LIMITED (BPCL)	MAHARASTRA	MUMBAI	12.0
14		KERALA	KOCHI	15.5
15	BPCL-BHARAT OMAN REFINERIES LIMITED (BORL) (JV)	MADHYA PRADESH	BINA	6.0
		BPCL-TOTAL		**33.5**
16	CHENNAI PETROLEUM CORPORATION LIMITED (CPCL)	TAMIL NADU	MANALI	10.5
17		TAMIL NADU	CAUVERY BASIN	1.0
		CPCL-TOTAL		**11.5**
18	NUMALIGARH REFINERIES LIMITED (NRL)	ASSAM	NUMALIGARH	**3.0**
19	OIL & NATURAL GAS CORPORATION LIMITED (ONGC)	ANDHRA PRADESH	TATIPAKA	0.1
20	ONGC-MANGALORE REFINERIES & PETROCHEMICALS LIMITED (MRPL)	KARNATAKA	MANGALORE	15.0
		ONGC TOTAL		**15.1**
		PSU/ JV Total		**159.4**
21	RELIANCE INDUSTRIES LIMITED (RIL)	GUJARAT	JAMNAGAR (DTA)	33.0
22		GUJARAT	JAMNAGAR (SEZ)	35.2
23	NAYARA ENERGY LIMITED (NEL)	GUJARAT	VADINAR	20.0
		PVT Total		**88.2**
ALL INDIA				**247.6**

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[1]. https://en.wikipedia.org/wiki/Combinatorial_optimization

[2]. https://en.wikipedia.org/wiki/Vehicle_routing_problem

[3]. Taha H. A., Operations ResearchAn Introduction, Pearson. Eighth edition. 2007.

[4]. Chander Mohan and Kusum Deep, Optimization Techniques, New age publisher, 2017.

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