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**MATHEMATICAL MODEL FOR DYNAMIC RESOURCE
ALLOCATION OF VEHICLES IN TRANSPORT SECTOR
CONSIDERING THEIR PERIODIC MAINTENANCE**

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ABSTRACT

Literature review revealed that enough work was carried out on dynamic resource allocation in transport sector. However a systematic analysis backed up by rigorous mathematical modelling was not considered in cases where the maintenance of vehicles is considered while making the DRA of vehicles. The allocation of human and physical resources over time is a fundamental problem that is central to management science. In this present work an attempt is made to develop mathematical models to help realizing a systematic dynamic allocation of transport resources considering the number of vehicles being sent to maintenance depo on daily weekly and monthly basis.

Keywords: DRA, Transport Sector, Maintenance, Physical Resources, Mathematical Model.

1. INTRODUCTION

The allocation of human and physical resources over time is a fundamental problem that is central to the present study. For example, a road transportation company must manage personnel and equipment to move shipments in a timely manner in the presence of a variety of dynamic information processes, customer demands, equipment failures, weather delays, and failures of execution. This is a high-dimensional problem since it involves a large number of

resources, each of which must be tracked as it is affected by decisions and uncertainties. This problem assumes bigger dimensions when a number of vehicles are to be sent to maintenance depo for periodic maintenance.

In principle, problems of dynamic resource allocation can be treated as Markov decision processes and solved using dynamic programming algorithms. Textbook dynamic programming algorithms – such as value iteration and policy iteration – typically require compute time and memory that grow exponentially in the number of state variables, the number of decision variables, and the number of random variables that affect the system in each time period. These three “curses of dimensionality” render such algorithms infeasible for problems of practical scale. In this work, a focus is made on formulation of dynamic resource allocation that was originally motivated by problems in transportation but also captures problems arising in a variety of other settings related to periodic maintenance of vehicles. Practical problems formulated in terms of the models typically involve thousands of state variables that describe current resources, thousands of decision variables that determine what is to be done with each resource, and thousands of random variables that influence the state. These random variables capture uncertainties from a variety of sources, such as customer demands, the physical network, and characteristics of the people and equipment used to provide services including equipment breakdowns and no-shows.

2. LITERATURE REVIEW

Yongxi Huang et al [1], worked on sustainable infrastructure system modelling under uncertainties and dynamics. Their work related to DRA of vehicles considering periodic maintenance.

Tom V Mathew et al [2], did extensive work on optimal resource allocation among transit agencies for fleet management. They published their results relating to maintenance of transport vehicles.

Abdullah A. Alabdulkarim et al [3], worked on applications of simulation in maintenance research. They developed mathematical simulation models for DRA in vehicles maintenance.

Itrd et al [4], published their findings on governments involvement in developing and implementing cohesive transport policies. They analyzed economics and administration of traffic and transport planning, global transport polices, information and communication technologies for supporting transport logistics, inter modalities of providing transport structures, skills and training requirements of transport personal, development of transport simulation models, evaluation of performance of transport systems etc. Their conclusions included suggestions leading to better fostering of public and private transport systems, harmonization of regulations, standardization of technologies and practices etc for improving the overall efficiency of integrated transport systems.

Satish et al [5], did extensive work on dynamic coordination for resource planning in trucking operations. They developed a novel multi agent frame work to coordinate dynamic resource allocation of trucks on call pickups. The developed frame includes generation of self interested computational entities called as agents, which receive calls for transport. They concluded that the developed multi agent frame work had improved the overall performance of coordinate systems. They also insisted the need for awareness on mobile communication systems, geographical information systems, root guidance, vehicle routing motivation on the need for simulation studies, research methodologies.

D.G etal [6], worked on traffic management for land transport. Their work included research for increasing the capacity, efficiency and sustainability of transport networks. They concluded that management policies, research programs, policy implications etc form major role in developing efficient transport systems leading to intelligent transport systems. They outlined different objectives of transport networks including effective use of existing infrastructure, reliable and safe transport, matching service demands and vehicles, routing and route guidance, environmental and social trends, development of ITS, data and tools for traffic management etc.

Robert etal [7], did extensive work on integration of urban transport and planning. The need for their work was due to the lack of keeping pace with the explosive increase in traffic and congestion. They concluded that transportation and cities are codependent and dynamically influence each other and demand for travel is derived from social and economic needs. They suggested means for integrating transport and land use in increasingly diverse situations.

Tolga etal [8], made a brief overview of intermodal transportation. Intermodal freight transportation is a chain, made up of several transportation modes which are coordinated between supplier and user. They touched on important issues and challenges in designing, planning, operating transport networks. They tried to integrate the activities of individual transport systems to improve the efficiency of the whole system. Major factors in above operations are the shippers who generate demand, carriers who supply transport services.

European conference [9], developed novel schemes for managing urban traffic congestion and released the same as a summary document. They developed policy oriented research based recommendations for effectively managing traffic congestion in large urban areas. They analyzed the nature, scope and measurement of congestion and developed management policies. Their report aimed to focus on strategic vision and guidance necessary to manage congestion in such a way as to reduce the overall impact on individuals, families and society.

Asif fiaz [10], worked on improving rural road transport systems and listed the following conclusion which included need for re examining the concept of rural accessibility, rural road connectivity, critical role of rural roads in crisis management, need for further refining engineering and technical guide lines for planning , execution of work fare programs, sustainability in all interacting dimensions etc.

Cobo etal [11], worked on the conceptual structures of intelligent transport systems (ITS). They developed an automatic method for detecting hidden themes and their effect over a period of time. This method combined performance analysis and science mapping.

Yanfeng etal [12], developed a smart parking system based on dynamic resource allocation. Their work was based on mixed integer linear program at each destination in a time driven sequence. They conducted that this approach reduced traffic congestion in urban areas and exploited technologies for searching parking space availability, resulting in performance improvement over existing parking behavior.

Sada siva Prasad etal [13], identified the issues and challenge related dynamic resource allocation policies in road transport sectors. They have suggested the various steps to be taken for improving the efficiency of functioning of road transport sector and suggested methods of road transport sector and suggested methods for the same. They touched upon mobile cloud computing application for addressing above issues.

B.Sai etal [14], applied cloud computing techniques in dynamic resources allocation for solving scheduling problems on virtual machines. Their method compared well with existing methods.

Cobo et al [15], worked on the conceptual structures of intelligent transport systems (ITS). They developed an automatic method for detecting hidden themes and their effect over a period of time. This method combined performance analysis and science mapping.

Litman, T. et al [16], did extensive work on evaluating accessibility for transportation planning and submitted his conclusions.

Safe et al [17], worked on clean, and affordable transport for development, with special reference to safety of the transport systems.

ESCAP et al [18], analysis emerging issues in transport sector and suggested transport and millennium development goals.

Keller, G. et al [19], worked on low volume roads engineering leading to best management practices in transport sector.

Yanfeng et al [20], developed a smart parking system based on dynamic resource allocation. Their work was based on mixed integer linear program at each destination in a time driven sequence. They conducted that this approach reduced traffic congestion in urban areas and exploited technologies for searching parking space availability, resulting in performance improvement over existing parking behavior.

Sarkar, A et al [21], developed a sustainable rural roads maintenance system in India.

2.1 ISSUES AND CHALLENGES RELATED TO DEVELOPMENT OF MATHEMATICAL MODEL FOR DRA IN ROAD TRANSPORT SECTORS CONSIDERING PERIODIC MAINTENANCE OF VEHICLES

1. Since mathematical models are to be developed, a systematic analysis of the factors involved must be made.
2. All assumptions relating to the number of vehicles to be sent for daily weekly and monthly maintenance made must be clearly mentioned.
3. A suitable language for coding backed up by a sound algorithm is very essential.

3. SCOPE AND OBJECTIVE OF PRESENT WORK

The scope of the present work is to analysis in detail the maintenance structure of the transport system with the objective of keeping sound dynamic resource allocation of vehicles considering the daily, weekly and monthly maintenance of vehicles.

4. PRESENT WORK

4.1.1 Development of the mathematical model

A suitable transport sector is identified as mentioned in the previous section and all the factors effecting the random variables such as customer demands, the physical network, and characteristics of the passenger and transport equipment used to provide services (e.g., equipment breakdowns and no-shows) are listed out. The above ideas are analysed through a small example given below.

4.1.2 Generalized mathematical model

Let the number of roots be “R” and the number of vehicle in each root the “V” and capacity of each vehicle be “C”.

The roots vary from $R_1, R_2, \dots, R_r$.

The vehicles in each root varying from $V_1, V_2, \dots, V_v$.

The capacity of the vehicles is fixed and is equal to C .

The total availability of transport facility to the users at any given point of time will be equal to $r \cdot v \cdot C$.

Let the total demand or the total number of users be D .

Now let us consider the following three cases.

Case 1: When the total demand $D =$ total availability of transport facility namely $r \cdot v \cdot C$.

Case 2: When the total demand $D >$ total availability of transport facility namely $r \cdot v \cdot C$.

Case 3: When the total demand $D <$ total availability of transport facility namely $r \cdot v \cdot C$.

Case 1, corresponds to the static situation where a static scheduling which does not vary with time is considered.

Case 2, corresponds to $D > r \cdot v \cdot C$ in this case the vehicles are fully loaded to the full capacity C and is given by $C = D / r \cdot v$.

The balance of $D - r \cdot v \cdot C$ is allotted to the rest of the vehicles in the corresponding routes on first come, first served basis.

Case 3, corresponds to $D < r \cdot v \cdot C$. In this case the vehicles are partially loaded and is given by $C_p = D / r \cdot v$.

Consider the case of a traffic situation, where there are five routes ($R_1, \dots, R_5$). The no of vehicles in each route is 2 and the capacity of each vehicle in all the roots is 50 ($c=50$). Let there be 4 clouds in each route with a total of $4 \times 5 = 20$ clouds ($C_1, C_2, \dots, C_{20}$). The demand in route R_1 is expressed as DR_1 which can be less than $c=50$ or equal to $c=50$ or greater than $c=50$, Similarly in other routes the demands are DR_2, DR_3, DR_4 and DR_5 . A fluctuation in demand means the values of $DR_1, \dots, DR_5$ are either more than or less than c . The above variables are listed in mathematical terms as described below.

4.1.3. In addition, in most of the transportation problems the DRA of vehicles catering to the daily, weekly and monthly maintenance is required.

Normally there are two types of maintenance namely need based maintenance and preventive maintenance. Our present work relates to need based maintenance and DRA of vehicles to The various assumptions made for developing a mathematical model for DRA considering vehicles maintenance considering a particular case.

Let there be nearly 400 buses. Number of busses are nearly 400. All 400 busses/day are coming to the depot for daily maintenance require 45 minutes service time. With one mechanic & one helper before they branch off to their respective routes. Roughly 60 busses/day are coming to the depot for weekly maintenance may require 3 hours (average) service time. With two mechanics & 2 helpers.

Roughly 15 busses/day are coming to the depot for monthly maintenance may require 7 hours (average) service time with 2 mechanics & 3 helpers.

Normally the allocation of buses for maintenance in depot is done under the following platforms.

Daily maintenance busses requires nearly 45 minutes. (PLAT FORM 1) Weekly maintenance busses requires 3 hours. (PLAT FORM 2) Monthly maintenance busses requires nearly 7 hours (PLAT FORM 3)

Let there be total N buses covering n routes and the buses in each routes $n_1, n_2, \dots$

Let 10% of the buses require maintenance at any given point of time. Hence the total number of buses requiring maintenance will be $0.1 N$. Further let us assume that 10% of this $0.1 N$ buses require daily maintenance, 40% of this $0.1 N$ require weekly maintenance and the balance 50% of this $0.1 N$ require monthly maintenance.

Now the problem of DRA of buses for daily, weekly and monthly maintenance is summarize as given below.

Consider the case of daily maintenance

If the buses to be maintained under this category is less than or equal to 10% of $0.1 N$, then no DRA is require since the system is design for the same.

If the buses to be maintained under this category is more than 10% of $0.1 N$ then DRA is require since the system is not design for the same. Hence necessarily a few buses in some route or other will fall shot and the central traffic manager will be contacted for dynamic allocation of buses as required.

The other two cases namely weekly and monthly maintenance can be analysed and dynamic resource allocation of buses can be made accordingly.

4.1.4 Algorithm for dynamic resource allocation for maintenance of vehicles using mobile cloud computing techniques

4.1.5 Algorithm

- a) Choose the number of buses coming for daily, weekly and monthly maintenance.
- b) Based on the mobile communication information the total demand for maintenance is noted down.
- c) If the demand is normal, let the vehicles move normally. This corresponds to static scheduling.
- d) The central traffic manager selects the nearest cloud and processes the vehicles allocation based on the demand and releases the orders to the respective mobile stations.
- e) If a particular cloud fails, the traffic manager shifts to another nearest cloud for information. The orders may be in the form shown in next step.
- f) If the demand for maintenance in a route is more than normal then the vehicles in the less demand routes are diverted to the current routes based on the information available with the traffic manager.
- g) If the demand for maintenance is less than the is less than the normal then the problem requires least attention.

5. RESULTS AND DISCUSSIONS

- a. A detailed DRA plan considering the daily, weekly and monthly maintenance of vehicles is presented.

- b. The various assumptions made with respect to the number vehicles under various maintenance categories are mentioned.
- c. For a given particular situation the number of vehicles for maintenance is compared with the normal demand and accordingly the cloud manager issues necessary instructions for a satisfactory DRA of vehicles for maintenance.

6. CONCLUSIONS

The major contribution of the present work is to analysis the DRA of vehicles under maintenance plan and to divert the required vehicles in various routes considering the maintenance of vehicles.

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