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# Mobile Medical Operation Route Planning

K. Somprasonk and R. Boondiskulchok

***Abstract*—**Medical services are usually provided in hospitals; however, in developing country, some rural residences have fewer opportunities to access in healthcare services due to the limitation of transportation communication. Therefore, in Thailand, there are charitable organizations operating to provide medical treatments to these people by shifting the medical services to operation sites; this is commonly known as mobile medical service. Operation routing is important for the organization to reduce its transportation cost in order to focus more on other important activities; for instance, the development of medical apparatus. VRP is applied to solve the problem of high transportation cost of the studied organization with the searching techniques of saving algorithm to find the minimum total distance of operation route and satisfy available time constraints of voluntary medical staffs.

***Keywords*—**Decision Support System, Mobile Medical Service Planning, Saving Algorithm, Vehicle Routing Problem

## I. INTRODUCTION

IN mobile medical unit's service operation of Thailand's Princess Mother Medical Volunteer which aims for providing medical treatment and health sanitation to residences reside in rural or remote areas that scattered geographically over the country, there are 4 distinctive service activities which require efficient planning to reach objectives of the foundation; that is to provide the medical service to remote residences who face difficulties or inadequate opportunities in accessing to healthcare service in local or central hospitals. The services are medical mobile unit, medical dentistry unit, eye-disease unit and medical provisions for special case disease. Currently, these services' operations are planned differently due to the different nature of each individual activities and different involving agents including workplace's political environment which interestingly occurring in most of charitable organizations in Thailand. In this paper, only mobile medical dentistry unit is studied. The overview of operation process of mobile medical dentistry unit can be presented as in Fig. 1 of which the dotted line represents the area where transportation problem can be applied to help ease the work of planning officers.

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The process of generating the operation plan starts from the site selection which derived from the requisition orders of local public health offices which based on how distant the areas are from the town. In site selection phase, it usually takes 1-2 months for sole planning which includes coordinating and communications with local public health offices. There are about 53 public health offices as main customers of the foundation. The local health office will collaboratively work to propose the promising sites for service operation. This task, in present, promising sites are selected mostly on experience of local officers. The tangible criterion for local officers to propose operation sites is using the proportion of expected patients who will come to get healthcare services in the hospitals. After these figures are gained, the area or sites that possess the adequate expected available patients will be proposed to the foundation to plan the operation schedule to serve the expected demand.

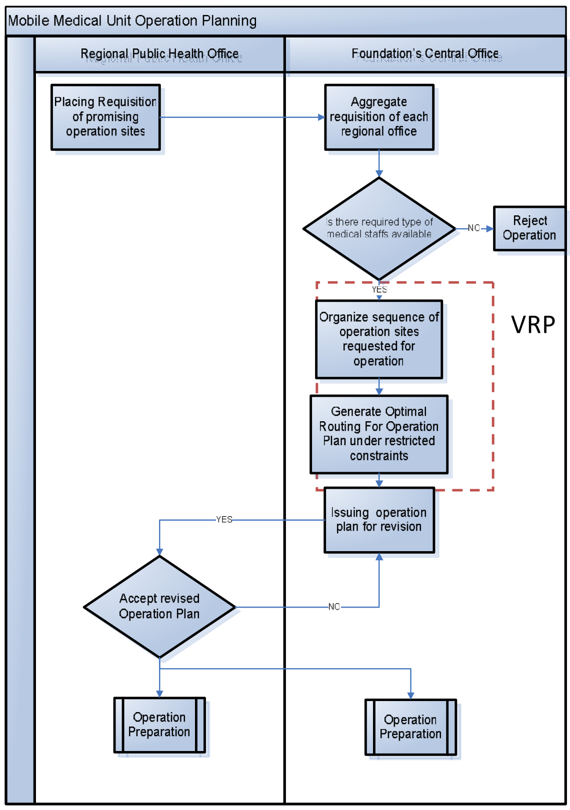


Fig. 1 Structure of operation planning process of mobile medical service

It is very important to note that, because of the foundation are operating under the Ministry of Public Health; approvals of the proposed operation sites must be formally conducted before issuing the request of medical staffs/supplies to the central office of the foundation in Bangkok. At this phase, the real situation follows the content of transportation problem to find the solution that help the foundation can launch the operation plan in a cost effective and well responsive to demand. By using only planning officers' experiences to plan the operation schemes or operation sequences, those sequences may not be organized in cost effective order but rather focused more on the percentage of customer service level. Therefore, for engineering point of view, these 2 parameters should be optimally balanced in order that the foundation can operates at high level of customer service while maintaining affordable cost which allows the foundation to find other important things to invest in such as buying new medical apparatus for dentistry units.

## II. Problem Formation

The planning of medical staffs and supplies distribution for mobile medical service of Thailand's Princess Mother Medical Volunteer Foundation is mostly based on planning officers' experiences and the foundation's best practices for long operating history. This causes confusion and redundancy in planning process leading to high transportation cost which the foundation has failed to realize as well as time wasted on revising distribution plan with its geographically dispersed customers. Moreover, due to the fact that the medical staffs of the foundation which are the most important resources for operations are volunteers whose time is highly valuable. Therefore, in this paper, feasible operation routes for mobile medical service are generated with the objective to minimize distance of each route to deliver medical services at demand nodes with high percentage of customer service level under the constraints of medical resources available time and the capacity of vehicles.

The problem can be considered as one of the variations of classical Vehicle Routing Problems; that is capacitated Vehicle Routing Problem with Time Windows constraints. Vehicle Routing Problem (VRP) [1], [2] is the generalization of Traveling Salesman Problem (TSP) with m salesmen from depot to demand nodes in network as presented in Fig 2. Each node can only be visited only once and total demands in each route must not exceed the capacity of vehicles. Generally, VRPs aim for finding the optimal solutions with minimum total transportation cost [3], [4], [5]. Specific constraints can be added up to increase complexity and variation of the problem. In this paper, the medical resources' available time should be determined as hard constraint since, in practice; these medical resources are voluntarily registered to scheduled operation plan; to reschedule resource operating time will lead to cumbersome consequences of medical staffs changing their free schedules to be able to work at the operation sites. However, in current practice, the operation schedule is timely fixed without consideration of resource available time as well as transportation cost, as a result; the foundation faces obstacles in finding available resources to match with the scheduled operation plan. Moreover, without the consideration in minimizing transportation cost of each route, the foundation has to deliver resources to operation sites without realizing how much it costs for delivering medical resources to operations according to operation plan.

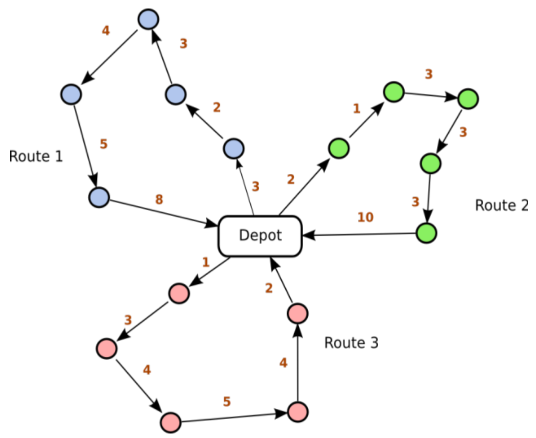


Fig. 2 Vehicle Routing Problem
(http://neo.lcc.uma.es/dynamic/vrp.html)

Mobile dentistry service of the foundation requires dentists from central volunteers because of the dentist shortage in local area. These dentists are voluntarily registered to preferred operation sites from preliminary operating plan that central office sent to individual volunteer in the form of mails; then, the distribution planning officers will group those dentists into team whose available time or available period is identical. The operation of mobile dentist service moves from place to place according to scheduled operation plan. Fig. 3 represents the operation scheme in mobile dentist service.

In order to generate feasible routing as shown in Fig.3 of mobile dentist operation scheme, planning officer receives the location of operation sites or demand nodes from the foundation customers which is individual local public health office. Some of these demand nodes are restricted with time windows or certain operation dates. Therefore, these certain time windows are hard constrained and routing generating must follow these dates in order to satisfy the customers, in this case, local volunteers. Table 1 represents available time of medical staffs in volunteer's registered timetable.

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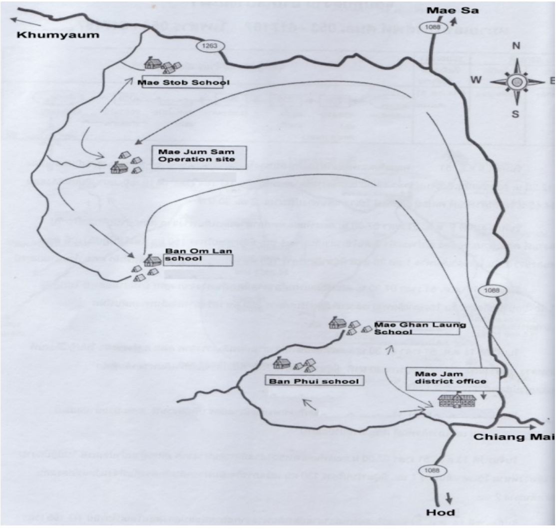



Fig. 3 Operation scheme of mobile dentist service in Mae Jam district, Chiangmai, Thailand

TABLE I
AVAILABLE OPERATING TIME OF MEDICAL STAFFS

| Team | Operation Location | | Available operating time | | Name | Tel. |
|---|---|---|---|---|---|---|
| | District | Province | Start | End | | |
| 1 | Pang Ma Pha | Mae Hong Son | 8 Oct 2008 | 14 Oct 2008 | Jenrira<br>Warapon<br>Patcharin<br>Vilawan<br>Anongnat<br>GamGaew | |
| 2 | Mae Jam | Chiangmai | 15 Oct 2008 | 21 Oct 2008 | Prasert<br>Ulan<br>Sukchai<br>Chainarong<br>Pimpinan<br>Bugha<br>Siriluk | |

## III. LITERATURE REVIEW

Vehicle Routing Problem is one of the most studied problems in logistics and distribution management [2]. Many researches are developed in order to find the optimal solution within acceptable computation time. VRP can be considered as NP hard problem which the computational time will increase in exponential or factorial pattern. There are many research method developed to solve traditional VRPs and its variations. VRPs have developed greatly from the initial traditional concept of Traveling Salesman Problem with m salesmen travelling (m-TSP) to demand places to provide services. The classical VRPs consist of designing the set of least cost vehicle routes that

- Each node or city can only be visited once by only one vehicle
- All vehicles start and end at depot
- Side constraints

The variation of VRPs arise from the side constraints that added up in VRPs such as time windows limited capacity of vehicle, limited numbers of vehicle and multiple depots [2]. However, with its diversified variations and complexity in side constraints, VRPs can be solved using one of these techniques

- Exact Method
  According to Laporte and Nobert [6] surveys on exact algorithm used for solving VRPs, the exact algorithm for VRPs can be classified into 3 categories; direct tree search methods, dynamic programming and integer linear programming. Many researches adapted these approaches to solve the problem [7], [8]; however, it takes very long computation time with no guarantee to be able to find the optimal solutions. Laporte, Mercure and Nobert [9] are able to find the optimal solutions in CVRPs with the network up to 260 vertices. There are other researchers such as Christofides, Mingozzi and Toth[10] who developed k degree center tree and related algorithm using the mixture of linear programming and branch and bound method. Dynamic programming is gaining popularity in finding optimal solution to VRPs. It was first proposed by Elion, Watson-Gandy and Christofides [11]. This method is advantageous for obtaining optimal solutions within acceptable computational time but it cannot be applied to solve large-size problems. According to Held and Krap [as cited in 12], dynamic programming can be applied to solve CVRPs up to 13 vertices.
- Heuristics
  Heuristics search method is the most popular techniques applied to solve VRPs. The most used and applied heuristics is Clark and Wright algorithm [13]. Some are referred Clark and Wright Heuristics as saving algorithm. Some critics said that this heuristics are longer in computational time; however, the complexity of this method can be reduced by carefully planned the input data structure (Golden et al., Nelson et al, Paessens as cited in[14]). The reason why it is the most applied and adapted method for many applications is due to its flexibility in the numbers of vehicle and the ignorance of vehicle fixed cost and fleet size. Another heuristics technique is sweep algorithm which firstly introduced by Wren and Wren and Holiday [as cited in 15]. However, it is the research of Gillett and Miller [as cited in 15] who came up with the name. The general principle of sweep algorithm is the algorithm will first cluster nodes in assigned route zones, then TSP is applied to generate route within the zones or sweep areas.

Another type of heuristics is two phase algorithm which is developed by Christofides-Mingozzi-Toth [16]. Through this heuristics, two alternative solutions for given or required parameters which are set by DSS users are produced and can be selected. It contains two phases of route construction; sequential and parallel.

Later, metaheuristics is developed in the work of Gendreau et al. [17] who stated that these heuristics are considered to be Artificial Intelligence (AI) since the search boundary is wider. Moreover, Local Optimal is fully avoided. This type of heuristics are Tabu Search, Genetic Algorithm (Tan at al [18]), Simulated Annealing (Kirkatrick et al. [as cited in 14]), Hybrid search (Tan at al [20] with the mixture of simulated annealing and tabu search), Ant colony (Dorigo [as cited in 14]), GRASP (Greedy Randomized Adaptive Search Procedures; Kontoravdis and Bard [as cited in 14]). Chaovalitwongse et al [19] applied the GRASP to solve the vehicle routing with time windows (VRPTW) with the consideration of loading sequences of diverse sizes of product into vehicles. According to Laporte [2], the metaheuristics has been proven by many researchers that the algorithm are successfully applied to solve classical VRPs with shortest computational time; it may be the best every developed algorithm for VRPs.

## IV. Computational Methodology

Capacitated vehicle routing problem with time windows are applied to find the feasible solutions of mobile medical dentist distribution with possible lowest travelled distance as well as possible highest customer service level. The numbers of medical staffs to be distributed at each route must not exceed the capacity of vehicle and must satisfy the maximum medical staff requirement of each route. If not, the penalties are added into calculation. At each demand node, if the distributed medical staffs exceed the requirement of each node, penalties are also added in calculation. Total transportation cost of medical staffs distribution is initiated as in (1) for planning officers to evaluate each competent route and make precise decision of choosing appropriate operation route under the assumption that in each 8-hour working day dentists can only operate at only one operation site. Even though transportation cost is usually the objective function which applied as operational framework for many existing industries and logistics operations, the cost function is very complex when applied to be the objective function of Vehicle Routing Problem especially in these paper where transportation cost is affected by many factors; cost for distributing medical staffs along routes and cost of medical staffs' transportation time.

Therefore, in this research, the cost of transportation is varied solely upon distances. Cooper [21] proposed the relationship between transportation cost and distance by developing regression analysis as shown in Fig 4. Form Fig 4, transportation cost is proportional to distance; however, if there are some barriers involving in consideration such as mountains and the curves of roads, this relationship may lead to higher variation. Many other researchers tried to developed the total transportation cost to be objective function in VRP such as Bookbinder and Reece [5], who developed total transportation function with other factors besides distance; vehicle velocity or Thangiah, Potvin and Sun [4], who developed the total transportation cost function with time derived from the consideration of total travel time, waiting time, service time ,characteristics of physical products and delays. In this research, the objective function of VRP is to minimize total distance, then the archived solution will be inserted into (1) for evaluation the total transportation cost of each route.

$$TC_i = CD_i + P_i \qquad (1)$$

$TC_i$ = Total transportation cost which can be in the form of distance, time or monetary unit.

C = Fixed proportion which is identical in every route

$D_i$ = Travel distance of each route

$P_i$ = Penalties added when distributed medical staffs exceed or below each node requirement in each route; penalties function can be shown as (2)

$$P_i = E\sum_{j=1}^{j=n}\left|S - R_j\right| \qquad (2)$$

E = Fixed proportion of penalties which is identical whether medical staffs are exceed or below individual requirement

n = demand nodes

$R_j$ = Requirement of medical staffs at each node j

S = Size of medical staffs' batch

Since the cost function is very complicate to use as objective functions for routing solution, to lessen those complexity, only distances are accounted into calculation. Then, after gaining routes which contribute acceptable traveled distance, costs are calculated using formation in (1) as well as penalty formation in (2). After that, another important criterion for planning officers to make decision on choosing operation routes is the percentage of customer service level which derived from the proportion of total customers in each route and the cumulative expected numbers of patients to receive medical service, in this case, medical dentistry.

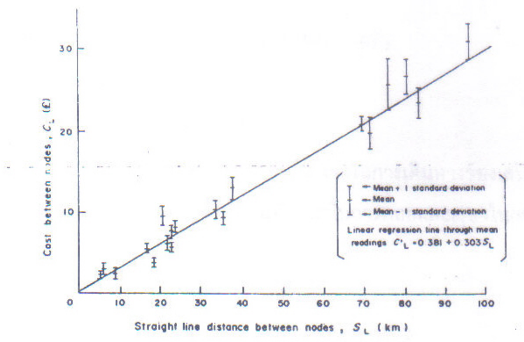



Fig. 4 Linear relationship between transportation cost and distance [21]

Another constraints in finding operation route solution is the available operation time of medical staffs (in this case; dentists). As described before that these staffs' time is valuable. Therefore, in searching route solution, total time including traveling time and operation time must not start before the beginning of available period of medical staffs and must not end before the operating period. However, for allowing the acquisition of feasible solution, this constraint is to ensure, as in real practice, the exploitation of medical staffs' available time. This is because of the fact that, the foundation seeks for available medical volunteers who are usually busy and have to make vacation leaves to be operating at certain operation. These medical staffs are to provide treatments for rural residences at rural areas. Each time of operation, the foundation must be sure that the numbers of expected patients are sufficient and cost-acceptable to operate in specified area. By applying vehicle routing problem for generating routes for planning officers to make the decision in using the most optimum routes which fit under required criteria and contribute acceptable transportation cost is one of the ways for the foundation to easier issuing operation plan.

To summarize, the constraints can be listed in priorities as follow;

- Each distributed medical staffs in each route must not exceed the capacity of vehicles
- Each distributed medical staffs in each route (can be considered as batch) is generally equals to the maximum requirement of certain nodes within the routes and that requirement must not exceed the maximum capacity of vehicle. If exceeds, penalty is added in consideration
- There will be some certain nodes with fixed operation date which cannot be postponed or start before due date
- The total time spent including travel time and operation time cannot exceed the available period of available operation time of medical staffs; This constraint can be able to violated but with acceptable span

From the literature review of how to find optimization solution to the capacitated vehicle routing problem with time windows (CVRPTW), many algorithms are developed to help finding the solution to this NP hard computational problem. In this research, saving algorithm (13) is applied to help finding feasible solution to the problem. Saving Algorithms has been proven that it can find the optimal solution within acceptable computational time [2]. Moreover, in this application studied in this research, there are fewer than 50 nodes of the total possible nodes in the system. Therefore, saving algorithms is the most promising for its uncomplicated structure and is good enough for finding optimal solution in acceptable computing time. Moreover, it can be easily developed as model in Decision Support System.

The structures of saving algorithm applied in this research can be classified into 3 main steps as listed below. Fig. 5 shows the process of finding solution.

*Step 1: Preliminary routing using saving algorithm*

*Step 2: Routing improvement using shortest path*

*Step 3: Adjusting nodes in routing*

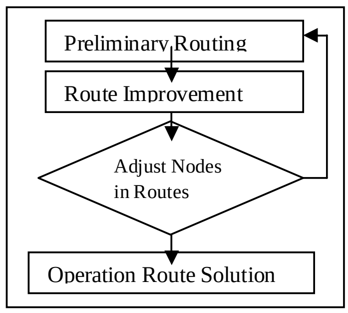



Fig. 5 Structure of heuristics for finding optimal solution

*Step 1: Preliminary routing using saving algorithm*

The saving Algorithm follows these basic principles. Firstly, choosing route from initial node i to any destination node j. Then saving distance are stringed from the maximum to minimum. After that, routes are generated by adding saving distances between each pair nodes until reaching optimal routes which comply with all constraints. The techniques for finding saving distances are Sequential Saving Heuristics, Parallel Saving Heuristics and Generalized Saving Heuristics [22]. In this research, the Sequential Saving Heuristics (SS) is applied to solve CVPTW as presented in the application. SS is the heuristics developed to generate route by adding up nodes (which is not currently in the route) to be at the end of route with the order of maximum saving distances. However, these added nodes must still allow route to meet all constraints and conditions. This method [as stated in 22] has several advantages especially in the content of the utilization of vehicles in each route since the new routes are generated only when the maximum capacity of previous vehicle is closely reached.

However, this method may not lead to the shortest distance travelled and workload is uneven for each vehicle [13]. Therefore, in this research, after the preliminary route is generated through SS, shortest path problem is applied to find the shortest path or sequences of visited nodes in the route with the neglect of balancing vehicle workload in the system. Despite the fact that the shortest path may not be acquired using SS, but SS can be helpful for entrepreneurs or users (in this case, planning officers) to easily determined the required number of vehicles and it can be easily developed into decision model in Decision Support System(DSS) which will be further developed through further research of this case.

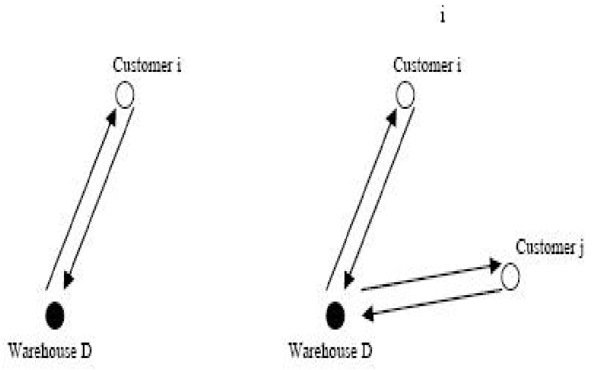
Fig. 6 represents the calculation of saving distances in consecutive steps and Fig. 7- 8 shows the structure of Heuristics search method developed in finding optimal solution for this case. Moreover, the conversion of travelled distance into time for checking whether travelled time is within the limitation of available operating time of medical staffs can be presented as in (3)

$$T=\frac{\text{distance x road condition x congestion}}{\text{average speed x driver's productivity}} \quad (3)$$

T = Travel time

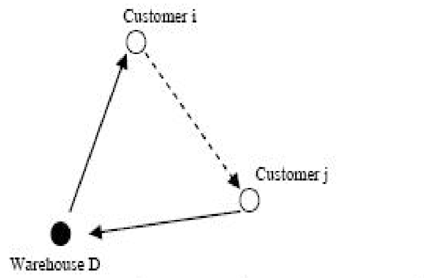
The travel time formation is applied from the Speed Function (developed by Shen [23]). According to Shen, if distance between two points is known, the average speed and approximate travel time can be calculated with some adjustments of factors affecting traveling speed; Road condition, Driver's Productivity and Traffic congestion. However, in this research, those 3 factors have little effects on travel time; therefore, the travel time can be easily calculated using formation as (4).

$$T=\frac{\text{distance}}{\text{average speed}} \quad (4)$$



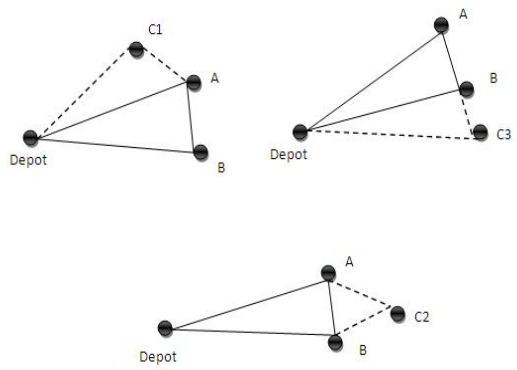

a) Transportation formation of depot to each customer

$$s(i, j) = 2d(D, i) + 2d(D, j) - [d(D, i) + d(i, j) + d(D, j)]$$
$$= d(D, i) + d(D, j) - d(i, j)$$




b) Transportation formation of depot to multiple customers in one routes

$$S = [d_{1C_3} + d_{C_31} + d_{1A} + d_{AB} + d_{B1}] - [d_{1A} + d_{AC_3} + d_{C_3B} + d_{B1}]$$
$$S = d_{1C_3} + d_{C_31} + d_{AB} - d_{AC_3} - d_{C_3B}$$




c) Saving distances calculation when adding nodes to set of preliminary route

Fig. 6 Method for searching set of nodes in routes using saving algorithm.

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The working procedure of heuristics starts from the calculation of saving distance of each pair nodes $s_{ij}$, then the order or sequences of nodes in routes is introduced. At this stage, nodes that are to be from into sequences in each route must satisfy all constraints stated above. The first set of nodes to be integrated in each route is set of nodes which is not yet organized into any route before and possesses the highest saving distance; then investigate whether the maximum requirement of all nodes in the set exceeds the maximum capacity of vehicle, then continue to do the same for another set of nodes, if there is no other set of nodes to be added into routes, then reject these first set of nodes. For determining the next set of nodes in route, at the end of each preliminary route, find the next existing nodes with highest saving distances. Then check whether the new added nodes are still within the allowance of limitation of required constraints; capacity of vehicle and available period of medical staff, if not, another vehicle is applied to do the task.

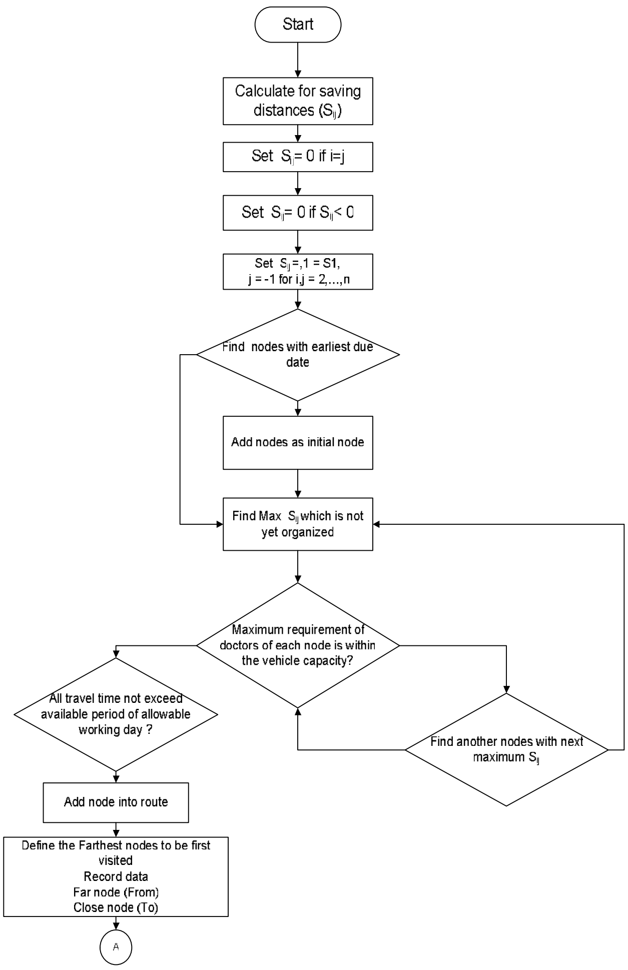


Fig. 7: Structure of Heuristics search method to find optimal solution for mobile medical operation routing

*Step 2 Route improvement*

Since in the preliminary route generating, available operating time of medical staffs and some certain fixed due dates of operation sites, only within route adjustment is allowed for computerized adjustment while between route improvement can be manually adjusted by the users of DSS. In order to perform route improvement step, many techniques such as 2-opt route adjustment Heuristics, Tabu search [18] or local optimization are available in recent literature. However, since the size of problem in this case is not as large as problems suitable for those techniques. Therefore, in this research, shortest path problem is sufficient and suitable for route improvement. One of the most widely used algorithm to find the solution for the shortest path problem is Dijiktra's Algorithm [24], which a greedy algorithm which solves single source shortest path problem.

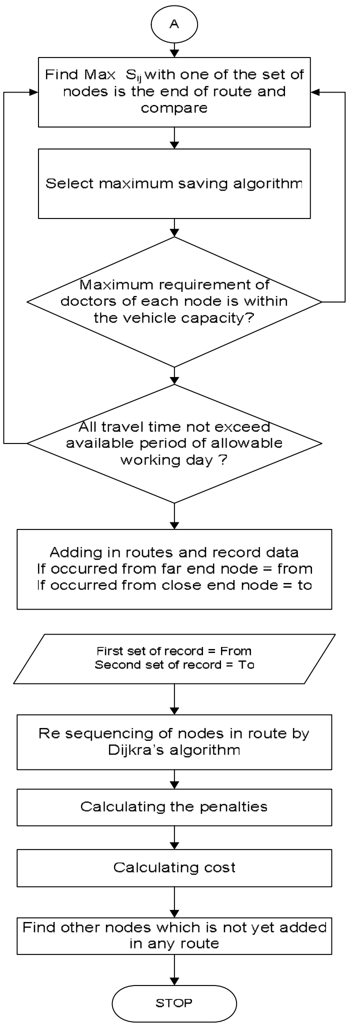


Fig. 8: Structure of Heuristics search method to find optimal solution for mobile medical operation routing (cont.)

Dijiktra's Algorithm finds the solution by keeping the cost d[v] of each node at v. These costs represent the shortest path between source node s and v [24]. Dijiktra's Algorithm complies with this research concept that each vehicle always leaves from the depot. However, the disadvantage of Dijiktra's Algorithm is that the computational time follow O ($n^2$) when n is the number of nodes. Therefore, some data structure modifications are needed to enhance the efficiency of the algorithm as in Fig.9.

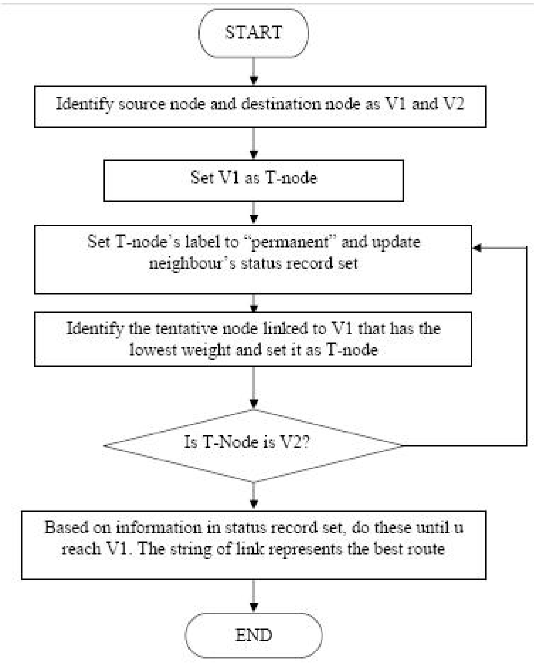


Fig. 9 Flowchart of Dijiktra's algorithm [25]

*Step: 3 Adjust nodes in routing*

This step is designed for planning officers to manually cut off some nodes in the system which failed to encourage cost effective for operation or the DSS to automatically cut off the least possessed demand in each route since the optimal route received from computation may not adequately and effectively satisfy the minimum percentage of customer service level defined by planning officers or the foundation policy. The formation of the expected percentage of customer service level can be present in (5)

$$\%CLS = \frac{\text{cumulative expected customers of each routes}}{\text{total expected number of customer in the region}} \quad (5)$$

## V. Result, Summary and Suggestion

The input data for operation route planning can be shown as in Table 3. With the order requisition of total 45 operation sites and some of them have certain due date, therefore, these nodes will be first taken into account as the initial set of nodes(earliest due date nodes and depot) for the calculation of saving distance. Distance matrix is generated using the real road distance between nodes derived from the map application; Google map as shown in Fig. 11. Some locations of nodes in input data cannot be defined into the map database of the application. Therefore, the location in the nodes is district area which is possible closet to identified nodes. After routes are satisfactorily generated, the total cost of transportation cost and percentage of the customer service level will be computed and compare with the previous planning result by experienced planning officers.

TABLE II
COMPUTATIONAL RESULT EXAMPLE

| | N | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Old | route | 1-2-3-4-5 | 6-7-8-9-10 | 11-12-13-14-15 | 16-17-18-19-20 |
| | D | 673 | 894 | 873.2 | 994 |
| | S | 6 | 6 | 6 | 5 |
| | P | 60 | 60 | 36 | 24 |
| | TC | 261.9 | 328.2 | 297.96 | 322.2 |
| | N | 1 | 2 | 3 | 4 |
| New | route | 36-38-39-37-40-43 | 16-23-18-34-10 | 7-3-9-41 | 11-12-13-14-15 |
| | D | 232 | 335 | 156 | 873.2 |
| | S | 6 | 5 | 6 | 6 |
| | P | 288 | 64 | 32 | 96 |
| | TC | 357.6 | 164.5 | 78.8 | 357.96 |

From the computational result (in Table 2) of applying vehicle routing problem to help planning operation plan with data in Table 3 as input data, the new generated routes for operation plan lead to the reduction in transportation cost by 15% of previous approach. However, the percentage of customer service level is less than using the experienced approach by planning officers. Therefore, it can be summarized that the reduction in customer service level is due to the fact that some requested operation sites can not satisfy the set up constraints. For example, some operation sites' dentist requirements are so different from other operation sites that they cannot be added into specific routes. As a consequence, the expected patients of those operation sites cannot be served leading to lower customer service level. However, with the adjustment of routing methodology using shortest paths is again focusing on the total distance travelled within the initial feasible solution. Even though some certain nodes in the routes are cut off and rerouting with the remaining nodes, the customer service is only acceptable but not very high. Therefore, in order to enhance the solution of the problem in customer service level, some terms should be added in the cost function. However, at this rate, with the percentage of customer service level accounted for 95% is satisfactory for the foundation at such competitive cost.

Even though, the available period of medical staffs is applied as constraints for route planning, the medical staffs' time table for scheduling of specific person to be operating at certain location is excluded from consideration because to put the time table of each medical staffs as side constraints of VRP may lead to the circumstance that heuristics may be unable to find feasible solution for cost effective operation routes. Therefore, by using this methodology, only sequences of operation sites are generated in order for planning officer to match the operation date with the time table of medical staffs voluntarily registered in a cost effective way. In computation, based on the knowledge from observation of real operations, Each route have certain total time spent no greater than 5 working days (8 hours per day) including travel time; this dues to the fact that each batch of medical staffs (team) can only operate within maximum of 5 consecutive days.

## VI. Further Research

After the planning officers decide which operation route is cost effective and able to deliver treatments to as many patients as possible, the information of preliminary operation plan; site location, medical volunteer, source of medical volunteer and requirement of medical staffs/supplies at each site is known. This information will be transferred to following step of distribution method planning. At this stage, medical staffs with the realization of medical staffs' time table will be selected from sources which enable total transportation cost (distance) to be minimized and to be able to satisfy 100% CSL (Customer Service Level) for delivering all requirements of each demand node. The distribution method planning is designed for the development of the Decision Support System (DSS) for planning officers at central office. The structure of planned DSS can be illustrated as Fig 10. Users of DSS in distribution method planning can choose 3 types of delivery methods; direct shipping, hub and spoke and milk run method in order to support the operation at operation site on time required, well responsive to demand and cost competitive.

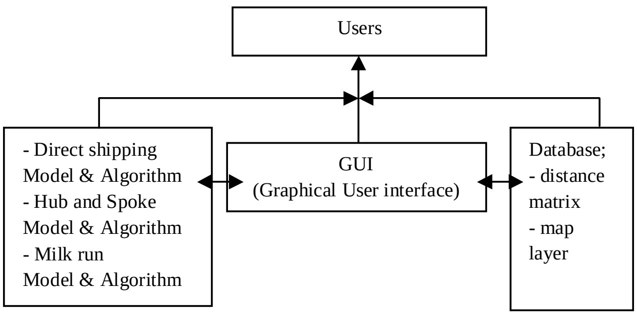


Fig. 10 Structure of DSS for medical staffs and supplies Distribution planning

TABLE III
INPUT DATA FOR OPERATION ROUTE PLANNING

| Site | Name of location | Required | Customers | Due Date |
|---|---|---|---|---|
| 1 | Tung yua | 5 | 200 | |
| 2 | Meung Gut | 5 | 200 | 24 Sep 2008 |
| 3 | Hui Fak Dap | 6 | 300 | |
| 4 | Kae noi | 6 | 250 | |
| 5 | Regional School | 3 | 150 | |
| 6 | Ban Sam Meun | 5 | 200 | |
| 7 | Num Ru | 5 | 200 | |
| 8 | Hau Mae Muang | 5 | 200 | |
| 9 | Hua Num Dang | 6 | 250 | |
| 10 | Hua Pra Chao | 3 | 100 | 7 Oct 2008 |
| 11 | Satop | 5 | 200 | |
| 12 | Jumsam | 6 | 300 | |
| 13 | Ohm Lan | 5 | 200 | |
| 14 | Kgan Luang | 6 | 300 | |
| 15 | Ban Put | 5 | 200 | |
| 16 | Mae Long Tai | 5 | 200 | |
| 17 | Oh Lo kee Lang | 5 | 200 | |
| 18 | Pha Deng | 5 | 200 | |
| 19 | Tee Le Pe Dee | 5 | 200 | |
| 20 | Long Pae | 3 | 150 | |
| 21 | Tung Ting | 5 | 200 | |
| 22 | Mae Ang Kang | 5 | 200 | |
| 23 | Chan | 5 | 200 | |
| 24 | Mare Pok Bon | 5 | 200 | |
| 25 | Doi Luang | 3 | 150 | |
| 26 | Lang Pa sa | 5 | 230 | |
| 27 | Sop lan | 5 | 200 | |
| 28 | Hui Kai Pa | 5 | 200 | |
| 29 | Lu Ku Do | 6 | 300 | |
| 30 | Hui Kanoon | 3 | 150 | |
| 31 | Pa Ka Chae | 5 | 200 | |
| 32 | Mum Ou Jo | 5 | 200 | |
| 33 | Tung Ton Kyou | 5 | 200 | |
| 34 | Le to | 5 | 200 | |
| 35 | Tee Le Pe Dee | 3 | 150 | |
| 36 | Hui Nam Khun | 6 | 250 | 18 May 2008 |
| 37 | Khon Muang | 3 | 150 | |
| 38 | Hui Nam Rin | 5 | 200 | |
| 39 | Hui Pong | 5 | 200 | |
| 40 | Hui Ee Co | 3 | 150 | |
| 41 | Hui Pa Kak | 6 | 250 | |
| 42 | Ban Mae Na Wang | 6 | 250 | |
| 43 | Pang Poi | 6 | 250 | |
| 44 | Pong Jok Mai | 6 | 250 | |
| 45 | Vien Pa | 6 | 320 | |

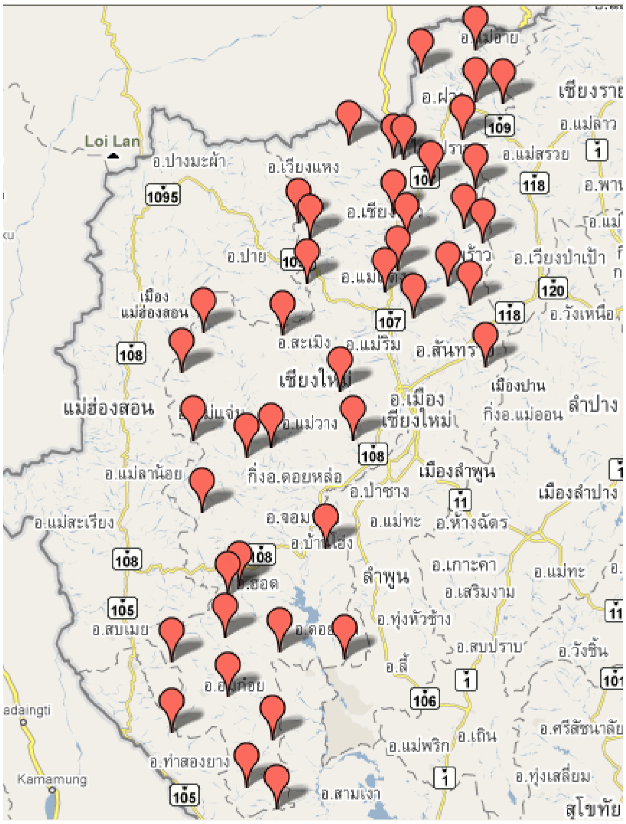


Fig. 11 Google Map application

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