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Multi-objective Delivery Network Optimization for Myanmar e-Government

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1. INTRODUCTION

e-Government plays a major role worldwide [1]. A current problem in Myanmar is delayed distribution services implemented within an e-government structure. Due to the complicated yet poorly maintained road network and traffic congestions, the effect of the introduction of delivery scheduling systems remains low. To cope with this situation, there is a need to develop a geographic information system (GIS) framework adapted to the Myanmar context. In the presented study, an attempt is made to develop such a framework, utilizing the telecommunication infrastructure existing in the country, as well as GIS web-services freely available online. The Google Maps services are used to interactively solve a multi-objective route optimization problem, using a genetic algorithm. This study thus attempts to propose a solution to the current problem of delayed distribution services in Myanmar. Due to the complicated road network, the efficiency of delivery scheduling systems used in the country is not satisfactory, as the customers often do not receive distributed goods and services in due time. For example, the complexity of the traffic in the Yangon city causes traffic jams not only on the main roads but also in residential wards. In addition, frequent tropical cyclones make it nearly impossible to predict what routes would be damaged by natural disasters. Owing to these reasons, the effect of the introduction of delivery scheduling systems in an e-government framework remains low in Myanmar, compared to the case of developed countries.

This paper describes a multi-objective delivery network [4] optimization system that deploys a genetic algorithm (GA) and utilizes the Google Maps services to interactively solve the scheduling problem. The system is to dynamically calculate optimal delivery routes, delivery transit station locations, the number and type of vehicles to be used, and the number of men required, and to estimate the total time needed to deliver a specific batch of goods in the Yangon city to customers.

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2. OPTIMIZATION PROBLEM

A delivery route network can be represented as a graph. In the graph, nodes stand for delivery stations and customers, while arcs represent roads. Specific schedule constraints are associated with both nodes and arcs [2].

Specifically, a graph G = (V, E) is comprised of a set of nodes V = $\{v_i\}$ and a set of edges $E \in V \times V$ connecting nodes in V. Corresponding to each edge, there is a non-negative number w_{ij} representing the distance from node v_i to node v_j. A path from node v_i to node v_j is a sequence of edges (v_i, v_l, v_m, …v_k, v_j). The routing problem is to find the possible shortest path from start to destination. If 1 denotes the initial node, n denotes the end node of the path, and x_{ij} is an indicator variable defined as follows:

$$x_{ij} = \begin{cases} 1, & if\ edge\ (i,j)\ is\ included\ in\ the\ path \\ 0, & otherwise \end{cases}, \quad (1)$$

finding the shortest path [3]

$$\min \sum_i \sum_j w_{ij} x_{ij} \quad (2)$$

is a simple optimization problem, subject to constraints:

$$\text{s.t} \quad \sum_j x_{ij} \leq 2, \forall i \in V \quad (3)$$

$$\sum_{j \neq k} x_{ij} \geq x_{ik}, \forall (i,k) \in E, \forall i \in (V - \{1, n\}) \quad (4)$$

$$\sum_j x = \sum_j x_{jn} = 1, \forall i, j \in V \quad (5)$$

$$x_{ij} = x_{ji}, \forall (i,j) \in E \quad (6)$$

$$0 \leq x_{ij} \leq 1, \forall (i,j) \in E \quad (7)$$

where constraints (3) and (4) together imply that any node other than 1 and n has either 0 or 2 nonzero incident edges. Constraint (5) makes 1 and n the endpoints of the path. This problem can be solved, using, for example, a genetic algorithm [4].

To satisfy the requirements of this study, the above framework was adapted, re-defining the optimization criterion as the total delivery time calculated, based on the length of the paths and the actual traveling speed achievable for each path at the given time. The required speed data is dynamically retrieved, using the corresponding Google Map API.

Google Map provides a number of Web Service APIs.

There are Google Maps Directions API, Google Maps Distance Matrix API, and Google Maps Geocoding API. The Google Maps Directions API is a service that calculates directions between locations. One can search for directions for several modes of transportation, including driving, walking, and cycling. The Google Maps Distance Matrix API is a service that provides travel distance and time for a matrix of origins and destinations, based on the recommended route between start and end points. The Google Maps Geocoding API is a service that provides geocoding and reverse geocoding of addresses. Geocoding is the process of converting addresses (like street address) into geographic coordinates (like latitude and longitude), which one can use to place markers on a map and to position a map. Reverse geocoding is the process of converting geographic coordinates into a human-readable address. The developed system utilized the listed services to both dynamically supply traffic and route data for calculating the optimal path, and to visualize the result.

The system takes addresses of the central distribution station (the origin), transit (re-loading) stations available, and customers as the input. It then first finds transit stations that would allow to minimize the total delivery time to the customer. The calculations are done for the driving mode, based on current traffic data. For each of the found transit stations, the system then find the optimal delivery schedule that includes path and transportation mode data for each of the associated customer addresses.

3. DEVELOPED PROTOTYPE

The Figure 1 shows an example of solving a delivery route optimization problem with a prototype of the proposed system. In the example problem, there are 9 transit delivery stations and 33 roads leading to 25 customer addresses.

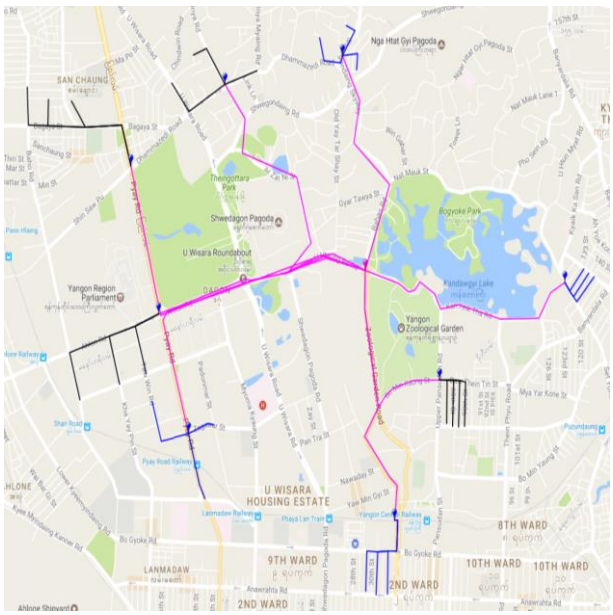

Figure 1. Calculated delivery network

Suggested routes from central post office to delivery transit stations are shown with the pink color. The red color is used to indicate routes where the cycling mode is assumed for the delivery, and blue – for walking mode. The developed prototype uses the pygmaps graphics visualization package, and is implemented in Python.

4. CONCLUSIONS AND FUTURE WORK

In this paper, a prototype of a delivery route optimization system was presented that allows to interactively calculate optimal, in terms of the delivery time, routes for goods and service delivery in the Yangon city. The proposed system is intended for the Myanmar e-Government framework. In future work, it is planned to test the prototype in a simulated experiment. Based on results obtained, it is further planned to extend generated solutions by incorporating delivery time and transportation mode factors into the optimization task solved. Experiments on finding an optimal interaction scenario and user interface for the system are also planned. Based on the experiment, a second prototype would be developed that would include terminal client systems for the delivery personnel.

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