Services Recommendation on Intercity Motorway

Precha Prasansri, Suchai Thanawastien and Prinya Tantaswadi

School of Science and Technology, Shinawatra University, Pathum Thani 12160, Thailand
Email: pree08102510@gmail.com; suchai.th@gmail.com; prinya@siu.ac.th

***Abstract* - Intercity motorway is a control-accessed highway in which the exits and entrances are all fixed along the route of the motorway. In this model, it is rather difficult for the motorists to remember or know what businesses there are on certain exits. The Motorway Travel Information System (MTIS) is designed to assist motorists in accessing services on the route and direction of travels. The services are a few rest areas with services and a number of exits. MTIS is context-aware in terms of time and location. So, the MTIS can warn and alert motorist on certain services based on the context and on the request. The system requires the data collection of all the business entities on each of the exits must be registered with the MTIS service so that when a request is issued by the motorist the MTIS can find an exit or a group of exits that can satisfy the requests of the motorists. Several heuristics are presented to find the services satisfying the motorist's request.**

Keywords - Intercity motorway, context aware, heuristics, matching algorithm, FCFS, shortest service time first.

I. INTRODUCTION

The intercity motorway has control entrances and exits. There are rest areas with shopping row houses, and there are also some rest areas without shop houses but restrooms are available. Usually, there will be two routes, one going out from the city and one going back to the city.

Let us assume that there are N entrances and there are M exits on the route going out from one city to other cities. The U -turn from one route to the other can be a horseshoe U-turn or a U-turn realized by exiting the intercity motorway and then finding the nearest entrance to the motorway in the opposite route to re-enter the motorway. In development the application of supporting travel information system on Intercity Motorway, the infrastructure comprises of the internet, cloud servers, mobile applications as depicted in Figure 1. The main concept of this paper has not been investigated by any published paper before.

II. CONTEXT-AWARE PROCESSING

For a traveler on the intercity motorway, The Motorway Travel Information System (MTIS) will use context aware data based on Time, destination as follows:

1) Compute the arrival time to each exit points, rest areas.
2) The forward direction as we travel, the digital compass will use this context to provide warning if we drive on the wrong direction.
3) The time context that is aware of human behavior in the sense that people will behave differently in certain days, or period of days.

- The context of having 7 days in a week, Saturday and Sunday differ from Monday to Friday.
- In a month, there are 30 or 31 days with possible holidays and compensated holidays, resulting in long weekend.
- The seasonal aspects in a year comprising, summer season, rainy season, and mild winter season.

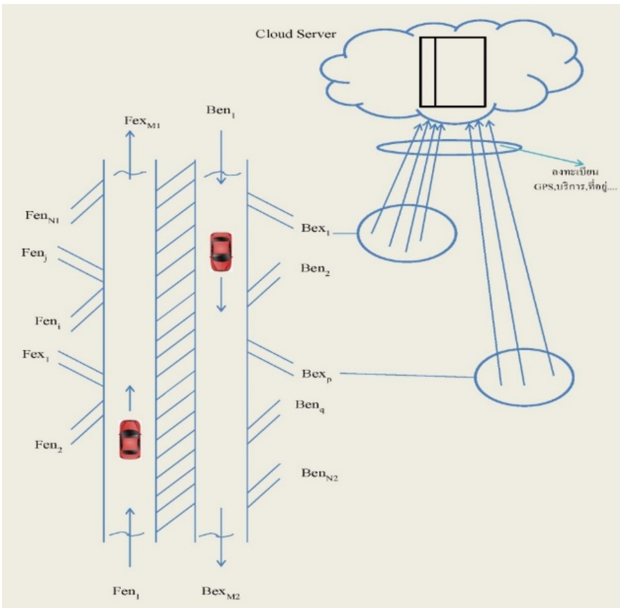

Figure 1. A model of the intercity motorway showing the entrance points, and exit points. The information of each of these points consists of name, GPS location. The horse-shoe U-turn, and the exit-entrance U-turn [1].

A. Human Needs During a Trip

The data from human interactions on a trip such as the decision of where to have lunch or to stop and shop can be a consensus involving everyone in the vehicle, or from a single decision by a dominant person in that trip party.

While traveling, members will have urgent requirements such as need to find a restroom, need to find a drugstore, need to fill gasoline, need to find a restaurant, or other needs. These requirements may be from different trip members. So, in general, the situation or need will be resolved by what facility lies ahead. The MTIS must be able to recommend a solution for what that group of people needs or wants.

In relating to the interaction between a motorist and the environment, let us examine this scenario. From Bangkok going to Wang Num Kaew (WNK), by using motorway to find highway 304 in Chachoengsao, and the traveler desires to be in WNK before 18.00pm. Hence in this trip, we have to be familiar with where to exit from the motorway in order to get to Chachoengsao first before locating highway 304. During the trip google map might not provide clear and usable information that can be understood by a novice user. In many cases, the motorists will miss the exits (without proper road sign and information) and need to find a u-turn that is far away to get back to point so the motorist can make the proper exit. Hence, context information that would help motorists who needs to interact with the environment that is not designed with clear and precise information or contains ambiguous information to navigate to the right destination is critically important.

Another problem when traveling is encountering an accident and reporting it. When driving on intercity motorway, if there is an accident on your side of the road or on other side, motorist can use the MTIS app on their mobile phone camera to take a picture and it will be sent to the MTIS server on the cloud. The motorist reporter can annotate with their voice describing the scene and reporting on the level of severity of the accident. The system will check for additional reports to confirm it is a real case. If only one report is received, it will be flagged for further investigation by an officer at the intercity motorway control center.

When traveling in an area that is not familiar, knowing where to stop for food and other services can be difficult. To address this problem, the MTIS system will provide information regarding what is available at any given exit. Businesses who want to be on the MTIS platform must register with the MTIS server. The motorist will be able to find a business that they can patron. In doing so, a motorist can identify the service he wants in advance. Unlike in the pass, a motorist has no way to know what type of businesses were at a particular exit. If the desired service is at the other side of the motorway, then the MTIS must figure out a route that allow the motorist to get the service by taking the constraint of the arriving time at the destination into consideration.

III. MTIS CONTROL ALGORITHM

Assume that there are N exits on the motorway, numbered E (i, j_i) or simply Exit(i), where i = 1 to N, is the index of the exits from the first exit ME (1, j_1), after the entrance to the motorway and ji is the number of registered business entities clustered at Exit(i). Let us call the registered business entities at Exit(i), a group of businesses, Gi. For simplicity, each business entity is registered with the MTIS Server (MTISS) specifying the main service provided by each business entity and GPS location. Let di be the distant between the Exit (i) and Exit (i+1). Figure 1 shows an example of these business groups on the exits.

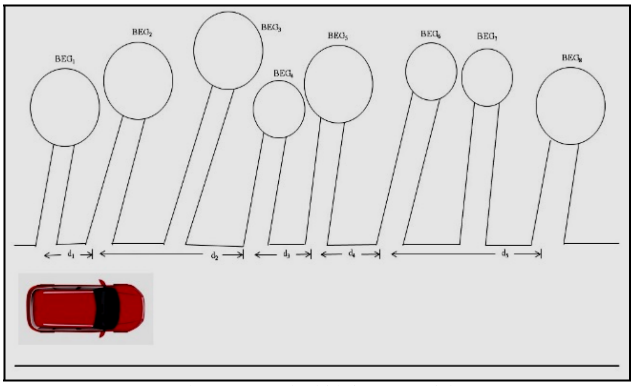

Figure 2. Typical highway model.

A. Multiple Requests from a Motorist.

As for the request vector constructed by the passenger of a vehicle whose passengers are seeking services from business entities at an Exit (i). Let the request vector comprise of a number of ordered pair (s_i, t_j), where s_i is the request type of service, and t_j is the expected duration of service.

For example, a request vector from 5 passengers in a car might look like (s_i, t_j), i=1 to 5, and j = 1 to 5. Then the MTIS Service Server must choose the business entity group in one of the Exits with services satisfying all the requests. Let the Business Entity Groups at the exits be BEG_1 to BEG_5 have the following services:

$BEG_1 = (s_3, \ldots)$
$BEG_2 = (s_1, s_2, s_4, \ldots)$
$BEG_3 = (s_1, s_5, \ldots)$
$BEG_4 = (s_2, s_3, s_4, \ldots)$
$BEG_5 = (s_4, s_5, \ldots)$

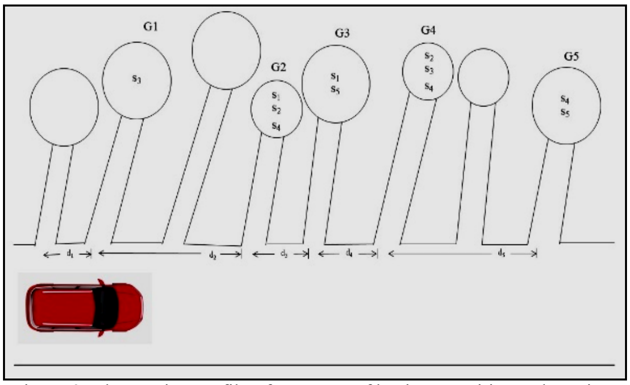

Figure 3. The service profile of 5 groups of business entities and services that are relevant to the example request vector.

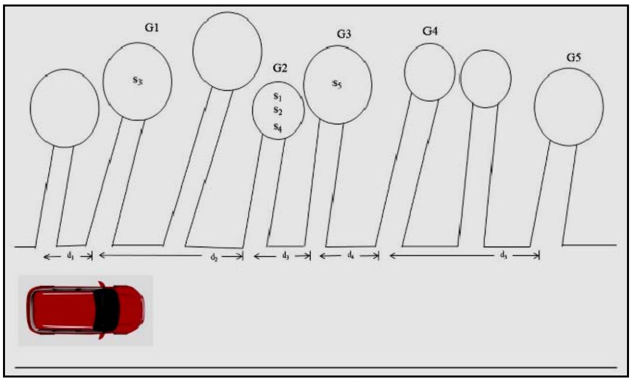

Figure 4. The business entity service profile serving the request S_1, S_2, S_3, S_4, S_5.

Algorithm 1: First come first service heuristics (FCFS)

Let the request vector be (s_i,t_j), i=1 to k, t_j is the expected service duration for s_i. Then, the first step is to compute the intersection of the request set and service set of each of the business entity groups.

Let the request set of size L be RE = $(s_1, s_2, s_3, s_4, s_5,..,s_L)$, where s_i is (s_i, t_j)

Let us represent each shop house by a business entity BE, that offer a specific service of type BESJ = $(BES_1, BES_2,..,BES_J)$

Assume that there are G groups of business entities BES_{gl} g=1..G, l=1..L

Let M_g be the number of elements in the intersection of the request set and the business entity type of business entity in a group of business entities.

For g = 1 to G
If RE_g subset of BES_g then solution is BE_g exit
Otherwise intersecting set BES_g with Set RE
RIG_g = BES_g intersect RE

Elimination of the duplicated service topologically since a request can be satisfied by the services from many groups. Logically, for first come first serve heuristic, we should get the service from the first group that has that service.

Starting from the last intersecting group RIGg , g=G , for each request in this group. If it is present in any group that comes before, then eliminate that request from this group. Perform this elimination successively until all duplicated requests are eliminated. This concept is shown in Figures below.

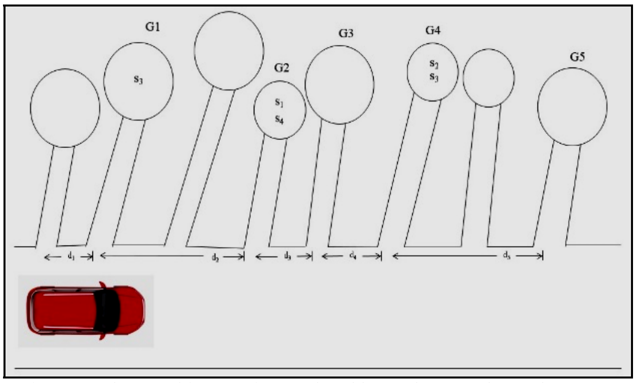

Figure 5. The matching service rendered by each group for each request assuming S2 at G2 not available.

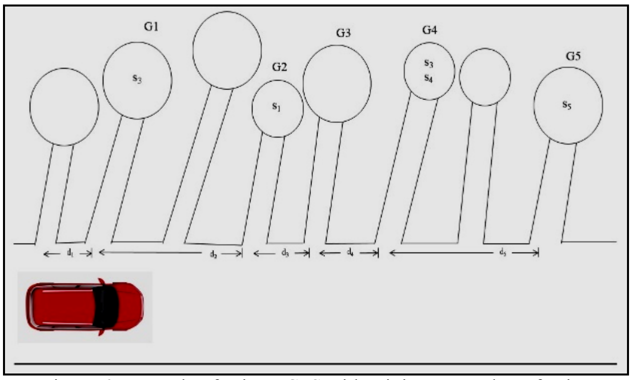

Figure 6. Example of using FCFS with minimum number of exits.

Alternatively, the FCFS heuristics can be accomplished with minimum number of exits by sequentially searching for the minimum of the group number of satisfying the request for example if we choose the service from G_1, G_2, ang G_3 which request 3 Exit. But if G3 ang G4 are choose then only 2 exits are needed to satisfy the 5 requests.

For g = 1 to G

If RE_g subset of BESg then solution is BE_g exit
Otherwise intersecting set BES_g with Set RE
RIG_g = BES_g intersect RE

REg = REg-RIGg, REEg = REg and update SHG (r1, Gj)

If REg = empty then exit

End

It not satisfied, set RE = REE_g, number of exit = number of exit +1, and reiterate the above algorithm

Algorithm 2: Shortest service time first

In this algorithm, the request vector elements will be organized using the service time and will sort the requests in ascending order of the service time. Then the algorithm must perform service request matching with services of each shop house group. Then it will sort the request vector, RE, in ascending order based on the expected service time:

Do i = 1 to k
Let us treat the RE as an ordered set:

For G_i , find the max subset of RE containing S_1, S_2, .., S_j

Set S1, S2, . Sj in business entity group G_i
Set RE = rj-1 to rk

End

From the algorithm 2, the services matched from each group of shophouses must be the ascending order of request service time as seen in the following example.

Assume that,

Input request vector, RE = [(s_1, t_1), (s_2, t_2), (s_3, t_3), (s_4, t_4), (s_5, t_5)],

Sorted RE = [(s_4, t_4), (s_1, t_1), (s_3, t_3), (s_2, t_2), (s_5, t_5)].

The requests will be serviced on each shop house group as follows.

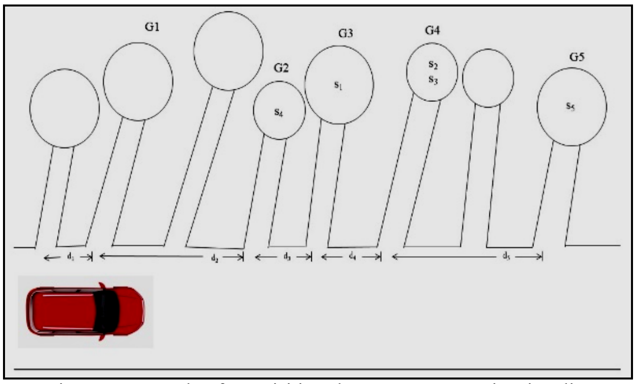

Figure 7. Example of Requisition shorter request service time list

Algorithm 3: Total shortest request service time

The total service request service time is the sum of all services and the travel time from a shop house group to the next shop house group that has services matching the requests. The total time can be minimized by packing the service requests to a minimum number of consecutive shop house groups.

For a shop house group with q service requests matched. The time to render the service is the longest service time of the request in that group. So, the more request fall into the same group, all the requests can be serviced in parallel, hence, the service times, in this case of being in the same shop house group, are not additive.

For a request vector RE trying to find services in the next G consecutive shop house groups, let M_g be the number of elements in the intersection of the request set and the business entity type of shop house in a group of shop houses.

For g = 1 to G

If RE_g subset of BES_g then solution is BE_g ; exit
Otherwise intersecting set BES_g with Set RE
RIG_g = BES_g intersect RE

End

For Mg >= 2

If any subset RIGg whose requests are all covered by elements in other RIGg, then delete that subset.

If a subset with requests Mg-2 >= n, then if m out of n of these requests were covered, then delete these m requests, 1<= m <=n.

If a subset with requests Mg = 2, then it one of two requests is covered by upstream services, then delete that requests.

The subsets from the above algorithm using the request vector as specified in Algorithm 1, is shown in Figure 7. After eliminating the duplicated elements, the results requests matching in each group is shown in Figure 8.

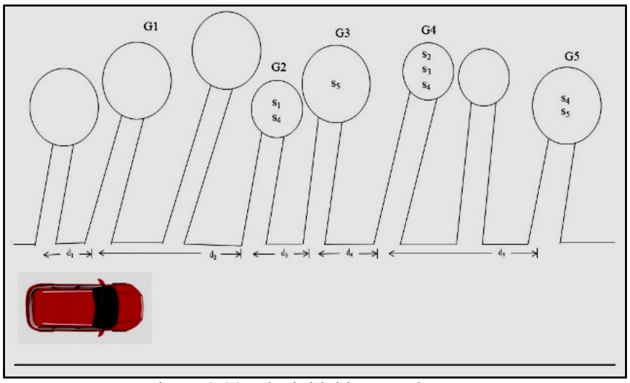

Figure 8 (a). The initial intersecting sets.

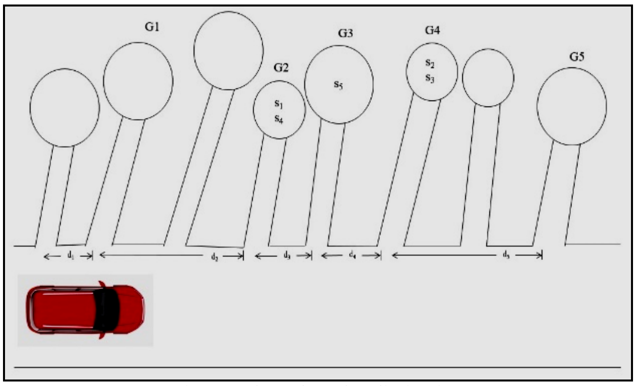

Figure 8 (b). After The elimination

So, the system can provide valuable information to the people in the vehicles. It can tell them what services are available at which exits and the time needed for the process. This can be very helpful to the individuals and their requests. The implementation of the MTIS can provide travelers with information and create a better driving experience.

IV. CONCLUSION

In this paper, we have proposed three heuristic algorithm to manage the information needed by a motorist travelling on an intercity motorway in Thailand. The algorithms are implemented by registering all the business entities at each of the exits. The server contains the service profiles and location of each of the busines entities. The motorist can make a request vector containing many services needed by the passengers in the car. The MTIS will use the request vector to plan the services at the identified exits for the motorists. Here, many options are possible. In this paper, three heuristics are used to find the exits with the requested services. Moreover, during the travel, the context aware system will make recommendation where to stop for breakfast, lunch or dinner, and also can recommend certain tourist attractions that can be accessed through certain exits, and can be back on the motorway again. The future research can use deep learning or AI to provide a more comprehensive services for the motorists. In addition, augmented reality can also be introduced so that the motorists can use the mobile phone to scan the area on the side beyond the motorway to find if there are any businesses worth visiting or seeking help in some emergency situation.

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