International Journal of Applied Computer Technology and Information Systems: Volume 9, No.2, October 2019 - March 2020

Roadside Service Availability Algorithms for Sharing Linear Shophouses in a Smart City

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Abstract— Intelligent city service or sometimes we called Smart city service, is a form of new concept in providing service with digital technology, application program and information with interactive communication in increasing the efficiency and quality of community services to help faster services and reduce cost or consumption which can serve efficiently to higher population in the city which make people's life quality and lives better. The Roadside Service Availability –RSA algorithm [1] can be implemented to share resources of business entities in a smart city. The business entities can be digitalized their commercial service with address, GPS location, service type, availability, etc. The city must establish a central server to consolidate business service in the community so that a business entity can register their profile as defined by the operator. Then a user can construct a request vector to identify the availability of a desired service by mobile or internet enabling device with RSA Algorithm at the server. In this paper, we propose three algorithms using the following heuristics: first come first serve, shortest service time first, and total shortest service time that can assist passengers in a vehicle to get the requested services from groups of shophouses that align along a long segment of a highway.

Keywords - Roadside Service Availability; Matching Algorithm; Consolidated Services

I. Introduction

The innovation concept will be fused with existing GPS navigation information, and additional layers of mobile application and real time community services availability as extending the functionality. To address this problem, we introduced the Smart Roadside Services System - SRSS, a location-aware and Roadside Service Availability-RSA Algorithm [1] as matching algorithm with mobile application-layer to communication protocol designed to support the establishment of distributed, ad-hoc, best-effort service infrastructures to define location-aware queries seeking and integrating information from requestor location and community service facilities in the radius of service by taking advantage of the current on-board GPS navigation systems and real time traffic report from the current Google GPS and Map Navigation system. In addition, this research assume that the city administration (as part of Smart City Program) are in the process to build city services data base enhanced from points of interest in the Map application to the Consolidated Service Availability System - CSAS, in order to propose the real time availability of business entity services in the area to user in the city.

Under the context of share economy, there are some successful systems disrupting the traditional businesses. The well-known success stories are Uber, Airbnb, and Grab. For Uber, the model is that a mobile app is used by the consumer to submit a trip request to a central system. The central system then broadcasts the request to the vicinity of the requester for the cars that have been registered with the system. The Airbnb is the business sharing model of accommodation in the hospitality industry. The Uber is the economic sharing model of taxi for transportation business. We consider the economic sharing model for the business entities along the route of street, highway as fixed location business entities. The target for business sharing is to increase the utilization of the business or increase the traffic of the business similar to Smart City service concepts as sharing community resources. The key consideration at present is that, the business entities in a city is in passive mode to be found. Each business entity such as a gas station, a coffee stand, a medical clinic, a pharmacy store, a bank,, etc., residing on a street side in city, We may assume that a person in a car, or walking on a pedestrian walkway, does not know or see them unless they are familiar with that locality. It is difficult to find the business that they want to contact. In another scenario, The Google search will be a helpful resource, but it is not in official or reliable method to a certain extent since it is designed in a very generic sense lacking specific assistant [5].

II. Previous Work

There is limited and a small number of research papers published on the aspect of sharing the entities or services. In [1], Context-Aware Roadside Service Availability System can be applied to support business sharing model is for any fixed location business entity. All these types of business sharing are to increase the utilization of the business or increase the traffic of the business. Hence, maximum efficiency is possible with consequence of generating high incomes and returns and providing convenient for the consumers to find them. Parasitical V. [1] has proposed a model and algorithm for passengers in a vehicle in a congested road to request services from roadside business establishments.

On the other hand, S. Kim and Y. Yoon, explored a recommendation system for sharing economy based on multidimensional trust model using Tensor Factorization and Skyline algorithm [4]. Most of the published research work is in the area of studying the economic aspects of the sharing economy as exemplified by the following reviews. The sharing economy, as pointed out by Herald Heinrichs, can provide a new approach to sustainability. Seoul is raised as an example of Sharing City [2]. G. Zervas and D. Proserpio [3] conducted an empirical study on the impact of Airbnb service entry into the state of Texas over the five-year period from 2003 to 2013, they found that there is an impact on decreasing in total hotel revenue. However, the benefit to overall tourism industry might be true in the sense that Airbnb generates the demand for cheap accommodation for the travelers and consequently increase the travel and tourism spending.

III. Implementation of RSA matching algorithm and Smart City Services

The proposed model is a business entity is a fixed location business establishment with an address. It can be a shop house, a department store, a hospital, a coffee shop, an apartment. The RSA architecture is designed to support open visibility of the business entity in a narrower band of search economy. Here the architecture as shown in Figure 1 consists of a cloud server with Smart Roadside Service System- SRSS application in cloud-server form. The business entity-BE will be registered with SRSS providing the GPS location, types of service, opening time, etc., The system will implement a taxonomized service map to facility search and identification. Let RV be "request vector "from a user or group of users who want to identify s business entity defined as (r1, r2, ..., rs). This request vector be constructed and sent from the mobile phone to the Consolidated Service Availability Server –CSAS in Figure 1. The RSA matching algorithm will then generate the matched business entities and send to the user with GPS location of the business entity. Once a business entity is selected, the google map API will set up the route from the current user location to the business entity's location.

BE is set of p business entity {BE1, BE2,..BEp} , each with attributes (GPS location, service type, opening time, address, phone, URL). Let GPS (BEn) be the GPS location of BEn, SERVICE(BEn) be the type of service of BEn . As mentioned that the request vector RE=(r1, r2,..,rs), in which r1 is the request of main service type needed and r2 to rs are secondary service types needed that the business entities satisfying these requests should be in the vicinity of the business entity offering r1 service. To find the solution, we must first find business entity with r1 service then we need to consider all the business entities within the radius of q meters centering on the BE(r1). This basically a special case of more general request vector. We want to find out if the secondary requests can be satisfied by the business entities within the circle radius q.

The next step is to identify the degree of matching between the requests r2 to rs and the set BEC. If the requests r2 to rs are all in BEC, then BE(r1) is the solution. Otherwise, find the number of non-matching services in RV, Nj. We will repeat this process to find the next BE that satisfy r1, and has the Nj=0 for the solution, or Nj is the number of non-matching requests. At the end of this process the list of Nj will provide us information to select the BE that has the least number of non-matching requests as the best solution. This concept is illustrated in Figure 2.

There are a number of business entity types labelled h1 to h9 in the city. The request vector, RV= (h5, h4, h1, h2). First, we find BE with service h5 and the circle has h5, h1, h2, h1, h3. In this case N1=1. We repeat this process every time a BE with service h5 is found, then we have N2=1, N3=3, N4=1, N5=0. In this case the solution is at the circle with N5=0 since all the BES in the request vector are in that circle centering at h5.

IV. RSA Algorithm Matching for Linear Row of Business Entities

Assume that there are G shophouse groups on a road segment, numbered BEij, where i = 1 to G, is the index of a shophouse group and j is the number of shophouses in Group i. For simplicity, let us assume that the number shophouses in each group is equal to j=J. Each shophouse is registered with the City Consolidated Service Availability System (CSAS) specifying the main service provided by each shophouse. Let di be the distant between the shophouse group BEij and BEi+1 j. Figure 3 shows an example of these shophouse groups authors and affiliations

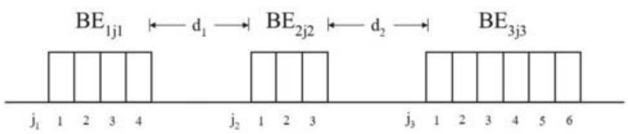

Figure 3. Shophouse groups and the associated variables.

As for the request vector constructed by the passenger of a vehicle whose passengers seeking services from roadside shophouses, let each passenger specify an ordered pair (ri, tj), where ri is the request type of service, and tj is the expected duration of service.

For example, a request vector from 5 passengers in a car might look like (r1, t1) (r2, t2) (r3, t3) (r4, t4) (r5, t5). Then the Roadside Service System must choose the shophouses groups with services satisfying all the requests. Let the shophouse Be1 to Be5 have the following services. BES1 = (r3, …), BES2 = (r1, r2, r4, …), BES3 = (r1, r5, …), BES4 = (r2, r3, r4, …), BES5 = (r4, r5, …), Figure 4 shows one of the possible solutions. In general, the heuristic that we can implement can be: (1) First come first serve; (2) Shortest service first, (3) Total shortest service time.

BE_1	BE_2	BE_3	BE_4	BE_5
r_3	r_1 r_2 r_4	r_1 r_5	r_2 r_3 r_4	r_4 r_5

Figure 4. The service profile of 5 groups of consecutive shophouse showing only services that relevant to the example request vector.

A. Algorithm 1: First come first service heuristics (FCFS)

Let the request vector be (ri,tj), i=1 to k, tj is the expected service duration for ri. Then, the first step is to compute the intersection of the request set and service set of each of the shophouse groups. Shophouse Service Matching Algorithm:

1) Let the request set of size L be RE = (s1, s2, s3, s4, s5,..,sL), where si is (ri, tj)

2) Let us represent each shophouse by a business entity BE, that offer a specific service of type BESJ = (BES1, BES2,..,BESJ)

3) Assume that there are G groups of linear shophouses BESgl g=1..G, l=1..L

4) Let let Mg be the number of elements in the intersection of the request set and the business entity type of shophouse in a group of shophouses.

For g = 1 to G
If REg subset of BESg then solution is BEg exit
Otherwise intersecting set BESg with Set RE
RIGg = BESg intersect RE
End

5) inate 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.

6) starting from the last intersecting group RIGg, g=G,

For each request in this group,
If it presents in any group that comes before
Then eliminate that request from this group.

7) rform this elimination successively until all duplicated requests are eliminated. This concept is shown in Figure 5 and Figure 6.

BE_1	BE_2	BE_3	BE_4	BE_5
r_3	r_1 r_2 r_4	r_1 r_5	r_2 r_3 r_4	r_4 r_5

(a) The shophouse group service profile.

BE_1	BE_2	BE_3	BE_4	BE_5
r_3	r_1 r_4		r_2 r_3	

(b) The matching service rendered by each group for each request.
Figure 5. Example of using FCFS heuristic.

BE_1	BE_2	BE_3	BE_4	BE_5
	r_1		r_3 r_4	r_5

Figure 6. Example of using FCFS heuristic, on the fly

8) Alternatively, the FCFS heuristics can be accomplished on the fly by sequentially search for the group satisfying the remining request.

For g = 1 to G
If REg subset of BESg then solution is BEg exit
Otherwise intersecting set BESg with Set RE
RIGg = BESg intersect RE
REg = REg-RIGg, REEg = REg and update SHG (r1, Gj)
If REg = empty then exit
End

B. Algorithm 2: Shortest service time first

In this algorithm, the request vector elements will be organized using the service time and sort the requests in ascending order of the service time. Then the algorithm must perform service request matching with services of each shophouse group.

1) 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 Gi , find the max subset of RE containing r1, r2, .., rj
Set r1, r2,…,rj in shophouse group Gi
Set RE = rj-1 to rk
End

2) om 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 = [(r1, t1), (r2, t2), (r3, t3), (r4, t4), (r5, t5)],
Sorted RE = [(r4, t4), (r1, t1), (r3, t3),(r2, t2), (r5, t5)].

The requests will be serviced on each shophouse group as follows.

BE_1	BE_2	BE_3	BE_4	BE_5
	r_4	r_1	r_3 r_2	r_5

Figure 7. Example of Algorithm 2: shortest service time first.

C. 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 shophouse group to the next shophouse group that has services matching the requests. The total time can be minimized by packing the service requests to a minimum number of consecutive shophouse groups.

1) For a shophouse group with q service requests matched. The time to render the service is 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 shophouse group, are not additive.

For a request vector RE trying to find services in the next G consecutive shophouse groups,
let Mg be the number of elements in the intersection of the request set and the business entity type of shophouse in a group of shop houses.
For g = 1 to G
If REg subset of BESg then solution is BEg ; exit
Otherwise intersecting set BESg with Set RE
RIGg = BESg 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.

2) The subsets from the above algorithm using the request vector as specified in Algorithm 1, is shown in Figure 6. After eliminating the duplicated elements, the results requests matching in each group is shown in Figure 8.

BE_1	BE_2	BE_3	BE_4	BE_5
	r_1 r_4	r_5	r_2 r_3 r_4	r_4 r_5

(a) The initial intersecting rets

BE_1	BE_2	BE_3	BE_4	BE_5
	r_1 r_4	r_5	r_2 r_3	

(b) After The elimination
Figure 8. Example of Algorithm 3

The proposed RSA algorithms implementing with SRSS- Smart Roadside Service System in this paper works on the business establishments that have been registered with the CSAS server in a Smart City. The user sends a request vector using r1 to specify the main target service to be located, and the remaining requests are the locations in the vicinity of a place that they want to visit, most likely within the walking distant, after visiting the main service. In our algorithms, , the shophouse service matching algorithm can also be set up to facilitate the identification of a service rows as the nature of business establishments in a city is the row of shops aligned linearly along the side of a street. In this case, we want to find the shophouse row with maximum matching of what a user wants or a group of shophouses that have services satisfying all users.

V. CONCLUSION

The concept of sharing community resources or service business entity in a smart City is proposed in this paper. Specifically, the services that align linearly by the shophouses on the roadside of a highway. The business benefits are for the smart city to help the citizens, special the travelers to find the desired business establishments faster than using google search. Since google is a wideband search providing a wide spectrum of information items for the users to choose. Identifying the target items is a time-consuming task. This paper presents a new sharing concept for static search and dynamic search for travelers who move along the road to find the target roadside service providers. This aspect of roadside services and sharing economy has not been proposed before. The algorithm presented can be used as the foundation for creating a new service that adds the economic benefits to the city and hence can be established as a startup business with some venture capital funding. Our suggestion for the future work is to find the algorithm that can share all classes of city establishments and the routing algorithm to locate the right establishment for a user. Also, recommendation algorithm can also be integrated to provide a layer of intelligence for the user to find the establishment that might be interested to the user.

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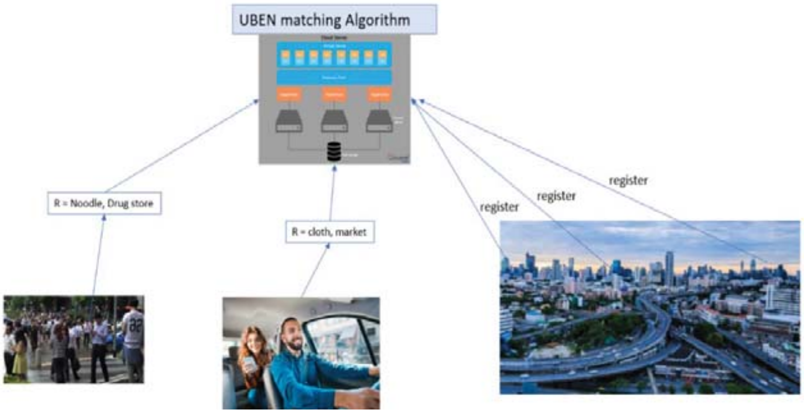

Figure 1. Business sharing system in a smart city

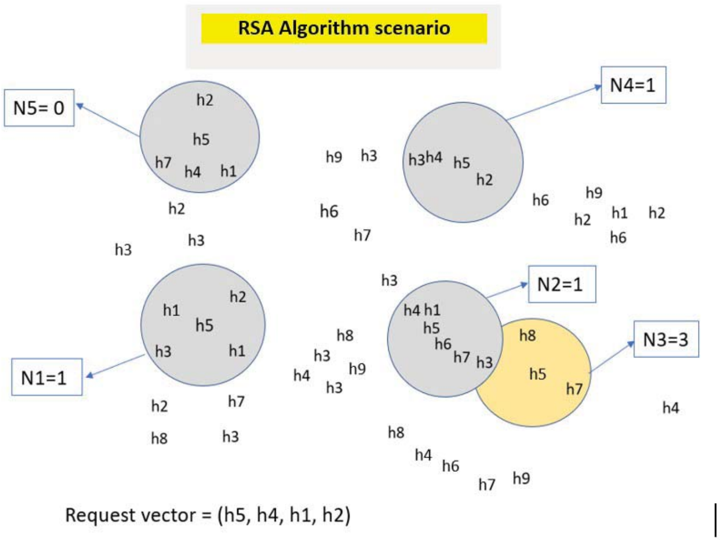

Figure 2. RSA algorithm scenario [1].