Position aware and QoS based Service Discovery using TOPSIS for Vehicular Network

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Abstract:

Vehicular network is a challenging research area due to the wide variety of applications to provide driving comfort and road safety for the passengers. It is one of the building blocks of intelligent transportation system that helps to take decisions while travelling. There are numerous services provided by different service provider in the vehicular network. There are also some service providers providing similar services but with different Quality of Service parameters. Vehicles while traveling needs to discover services with desired QoS parameters in their region of interest. A Service discovery methodology is required to find the appropriate service provider who provides the service with the desired quality of service requirements by the service requester. This study proposes Position Aware and QoS based Service Discovery Protocol using TOPSIS (PQoSVSDP). Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is one of the multi criteria decision making methods for selecting appropriate service providers matching the quality parameters on the request of service requester. Simulation has been performed using the proposed method. The TOPSIS based service discovery on the vehicular network has been found to be efficient with reduced service discovery time.

Keywords: Vehicular network; Service Discovery; QoS; TOPSIS; PQoSVSDP

1. Introduction

The vehicular adhoc network is an interesting research area under the category of the Mobile adhoc network. The vehicular network receives attraction due to its wide range of application. In a vehicular network the participating vehicles uses Wi-Fi and WiMAX for effective communication between vehicles with dynamic mobility. Vehicular network is the building block of intelligent transportation system. The vehicular network system consists of two components: RoadSide Units (RSU), and vehicles [6]. The communications on the vehicular network are vehicle to vehicle communication and vehicle to roadside unit communication. It helps the driver to take smart decisions while travelling. The radio service used by VANET is called Dedicated Short Range Communication (DSRC), which has a communication range of 1000 meters [2].

Road safety and driving comfort are the two important applications in the vehicular network [13]. Road safety applications are broadcast services which inform the driver about emergency situations, traffic and route. The driving comfort applications are transaction based services providing information and entertainment such as nearest restaurant, gas station, tourist spot, etc. The core motivation of vehicular network is to provide safety and comfort for people who travel. Numerous accidents take place every year, if people are alerted with messages at proper time, the number of accidents can be reduced. These services are provided by various service providers and the drivers or passengers may not aware of the provider that provides the services according to their needs.

Service discovery protocols (SDP) are network protocol allowing automatic detection of service providers offering various services [2]. Service discovery is essential to find out the service provider that provides services that meets the user’s requirements. The aim of the study is to develop an efficient service discovery protocol which takes less service discovery time.

2. Related Work

N. Klimin, et al, 2004 had proposed a hybrid approach for location based service discovery protocol for MANET [7]. Both reactive and proactive methods [7] were combined together to form hybrid protocol that utilized geocast addressing of control messages for location based service discovery. Marios D. Dikaiakos, et al, 2005 had proposed Vehicular Information Transfer Protocol (VITP) a service discovery protocol [8]. It was an application layer communication protocol designed to establish distributed adhoc infrastructure over VANET

[8]. VITP provided traffic oriented and location based service discovery which made use of vehicular sensor and GPS system. The drawback of VITP was the increased dropping rate of the service request when the distance between the service provider and service requester increases [2].

Brijesh Kadri Mohandas, et al, 2008 had proposed Address Based Service Resolution Protocol (ABSRP) that discovered services in vehicular network [2]. It was a transaction based service discovery which explored the presence of roadside units. ABSRP was independent of network layer routing protocol.

B. Ramakrishnan, et al, 2010 had proposed a service discovery mechanism for the vehicular network in the absence of road side units [12]. For efficient data communication a clustering model was introduced, which considered Simple Highway Vehicular Model. A clustering model was developed. The cluster area was constant; the size of the cluster changed only during unavoidable situations like sudden increase in the number of vehicles. The cluster head was selected using cluster creation algorithm for SHWM [12]. Each cluster head contained the service description available in the network and all cluster head would be updated with new services entering in the network. If a node required a service, it contacted its local cluster head and the cluster head searched in its local database. If the service was available in the local database it would return to the requesting node otherwise the cluster head synchronized itself with other cluster head's to search for the service and reply accordingly.

Alireza Souri, et al, 2012 had utilized fault tolerant techniques to improve the reliability and efficiency of the service discovery protocols [1]. Fault-Tolerant Location-Based Vehicular Service Discovery Protocol (FLocVSD) was based on a cluster-based infrastructure of Road Side units. The failure handling technique utilized in FLocVSD made the service discovery effective in the presence of network component failure. Satoru Noguchi et al, 2011 had proposed a location aware service discovery, [14] that exploited IPv6 multicast on top of IPv6 GeoNetworking specified by the GeoNet project. GeoBroadcast mechanism efficiently propagated service discovery messages to a subset of nodes inside a relevant geographical area. It used multi hop approach for service discovery, which reduced the success rate.

P.W.H.M. Hornman, 2010 studied and compared several solutions used in vehicle to vehicle communications for the support of QoS parameters [3]. Several criteria's were derived in order to perform comparison; each QoS solution could satisfy a subset of the derived criteria. According to the author, resource reservation and behavior adaptation were two ways essential to provide QoS for network application [3]. K.R.Nanthagobal and C. Chandrasekar, 2012 had proposed a location aware service discovery protocol for next generation wireless network [9]. The client had to be aware about their current location and mobility pattern. The base station with best available bandwidth would be selected as best base station. There was a QoS prediction server (QPS) [9] which contained all information about clients, servers and the services which were currently running. Based on the request send by the client the QPS search with service number and QPS would add the matching servers to find QoS constraint and forward the request to appropriate server. The QoS server processes the request and sends the reply to client.

Kaouther Abrougui, et al, 2012 had proposed an efficient load balancing and QoS based location aware service discovery protocol (QoSLocVSDP) [6]. QoSLocVSDP provided load balancing for service providers providing same services, and also for routing paths between service providers and service requesters. It permitted the selection of service provider and routing path which satisfied the QoS parameter desired by the service requester. It integrated service information into the network layer and used diverse channels [6]. QoSLocVSDP had four phases: service advertisement phase, service request propagation phase, leader election and service reply generation phase and service reply propagation phase. The protocol made sure that route between service providers and service requesters does not get congested [6].

Factors influencing vehicular adhoc network are listed below:

- Scalability [5]: It is the ability of the service discovery mechanism to work effectively with varying loads without degradation in performance.
- Packet delivery ratio [11]: It is the ratio of number of packets send to number of packets delivered successfully. It indicates the success rate of service discovery protocol.
- Security [5]: The security level is set as 3 in a 5 point scale value. The level of security can be varied based on the performance of the service provider.
- Average Response time [6]: It measures the average time to get valid service reply in response to a service request.
- Average load [6]: It is the ratio of load on vehicular component such as service providers and roadside unit.
- Bandwidth usage [6]: It is the measure of the bandwidth used to send and receive service queries.

3. Vehicular Network Environment

Fig. 1. A Sample Vehicular network environment

A sample VANET environment is shown in the Fig. 1. based on Manhattan traffic model [1]. The network consists of two types of components: Roadside Routers (RR) and Road Vehicles (RV). And there will be Service providers available in the region to provide various services; here there are ten Service Providers (SP) providing services such as Restaurant, Gas Station, Service Station and Free parking spot.

The ten service providers (SP) created in the simulation are Restaurant1 (RTR1), Restaurant2 (RTR2), Restaurant3 (RTR3), Restaurant4 (RTR4), Gas Station1 (GS1), Gas Station2 (GS2), Service Station 1 (SS1), Service Station 2 (SS2), Free Parking1 (FP1) and Free Parking (FP2).

SP = {RTR1, RTR2, RTR3, RTR4, GS1, GS2, SS1, SS2, FP1, FP2}

Roadside Routers (RR) forms backbone to the vehicular network, RRs has two or more radio interface for sending and receiving data. RRs are randomly distributed in two sides of the road, it does not have any predefined structure and the density of RRs has to increase in congested areas. Vehicular network uses connection less approach for sending and receiving packets.

Road Vehicles (RV) consists of any vehicles equipped with wireless interface move in two dimensional plane. Vehicles will generate the service request message for the service upon the requirement.

4. Position aware and QoS based Service discovery Protocol using TOPSIS

The PQoSVSDP consists of four phase [6]:

- i Service advertisement phase: In service advertisement phase the service providers send service provider advertisement (SP_Adv) messages to nearby components such as RR and RV. The SP_Adv message consists of service information, routing information and also adds its corresponding quality parameters. On receiving SP_Adv, RR adds the service information in service table and routing information in routing table [6].
- ii Service request propagation phase: In service request propagation phase, a QoS based request (QoS_REQ) message is generated and sends by the vehicle (RV) that wants to find service provider in region of interest. The request message will be propagated toward the road components in the region of interest.
- iii Leader election and service reply generation: The leader election and service reply generation phase is initiated on receiving QoS_REQ message from the service requester. A leader RR is elected in the region of interest and the leader is responsible for unique QoS based service reply generation.
- iv Service reply propagation: In service reply propagation phase, the QoS based service reply message generated by the leader RR will propagate towards the service requester.

In this paper TOPSIS (Technique for order of preference by similarity of ideal solution) a multi criteria decision method has been adopted. TOPSIS is used in leader election and service reply generation phase for decision making which improves the performance of existing service discovery protocol. The service reply messages are generated considering various QoS parameters and their weights as requests by the service requester. The service providers are selected on the basis of most matching solution for the request and parameters like load balancing, energy efficiency, etc. The leader RR is chosen by taking into consideration all possible parameters available and the service provider are selected upon the best matching QoS parameter desired by the service requester.

Technique for Order of Preference by Similarity to Ideal Solution Method

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method to identify solutions from a finite set of alternatives [4]. The basic principle of TOPSIS is based on choosing alternative that have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. The underlying concept of TOPSIS is that the most preferred alternative should not only have shortest distance from ideal solution, but also the longest distance from negative-ideal solution [4]. It evaluates a decision matrix in several steps starting by normalizing columns and then multiplying values in columns is by corresponding criterion's weights. The TOPSIS method assume each criterion tend towards a monotonically increasing or decreasing utility [10].

The TOPSIS procedure is carried out as following [4]:

Step 1: Creation of Estimation Matrix

First create an estimation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria given as X_{ij}, therefore a matrix $\left(X_{ij}\right)_{m\times n}$ is generated.

Step 2: Normalization of Matrix

The matrix $\left(X_{ij}\right)_{m\times n}$ is then normalized to form the matrix.

$R = \left(r_{ij}\right)_{m\times n}$, using the normalization method

$r_{ij} = \frac{x_{ij}}{pmax(v_j)}, i = 1, 2, \dots, m\ j = 1, 2, \dots, n$ where $pmax(v_j)$ is themaximum possible value of the indicator $v_j, j = 1, 2, \dots n$.

Step 3: Calculate the weighted normalized decision matrix

$T = \left(t_{ij}\right)_{m\times n} = \left(w_j r_{ij}\right)_{m\times n}, i = 1, 2, \dots m$ where $w_j = W_j / \sum_{j=1}^{n} W_j, j = 1, 2, \dots n$ so that $\sum_{j=1}^{n} w_j = 1$,and W_j is the original weight given to the indicator $v_j, j = 1, 2, \dots, n$

Step 4: Determine the best and worst case alternative

Determine the worst alternative (A_w) and the best alternative (A_b)

$A_w = \{\langle \max(t_{ij} | i = 1, 2, \dots, m) | j \in J_- \rangle, \langle \min(t_{ij} | i = 1, 2, \dots, m) \mid j \in J_+ \rangle\} \equiv \{t_{wj} | j = 1, 2, \dots, n\}$,

$A_b = \{\langle \min(t_{ij} | i = 1, 2, \dots m) | j \in J_- \rangle, \langle \max(t_{ij} | i = 1, 2, \dots, m) \mid j \in J_+ \rangle\} \equiv \{t_{bj} | j = 1, 2, \dots n\}$ where,

$J_+ = \{j = 1, 2, \dots, n | j$ associated with the criteria having a positive impact, and

$J_- = \{j = 1, 2, \dots, n | j$ associated with the criteria having a negative impact.

Step 5: Calculate the L2-distance between the target alternative i and the worst condition A_w

$d_{iw} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{wj})^2}, i = 1, 2, \dots, m$ and the distance between the alternative i and the best condition A_b

$d_{ib} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{bj})^2}, i = 1, 2, \dots, m$ where d_{iw} and d_{ib} are L2-norm distances from the target alternative i to the worst and best conditions, respectively.

Step 6: Calculate the similarity to the worst condition

$$s_{iw} = \frac{d_{ib}}{d_{iw} + d_{ib}}, 0 \le s_{iw} \le 1, i = 1, 2, \dots, m$$

s_{iw}= 1 if and only if the alternative solution has the worst condition; and

s_{iw}= 0 if and only if the alternative solution has the best condition.

Step 7: Rank the alternatives according to $s_{iw} (i = 1, 2, \dots, m)$.

Different criteria's such as load balancing, energy efficiency, power level, distance are considering for the selection of the leader RR. An evaluation matrix will be formed to select leader RR based on selected criteria's and best case and worst case conditions will be evaluated using TOPSIS. The leader RR will be selected accordingly to handle the service request.

There will be many service providers providing same service with different characteristics and quality. The service requester may specify the quality of service they require for the service they are requesting. In this technique, evaluation of these attributes will be done inside the leader RR. And appropriate service provider will be selected that meets all quality requirements.

5. Simulation Evaluation

The vehicular network environment was simulated using C# and SQL server using Microsoft visual studio integrated development environment (IDE) 2010 in .net framework. Ten service providers providing various services are created and placed in different locations. Routers are placed in different locations of the road to cover entire area.

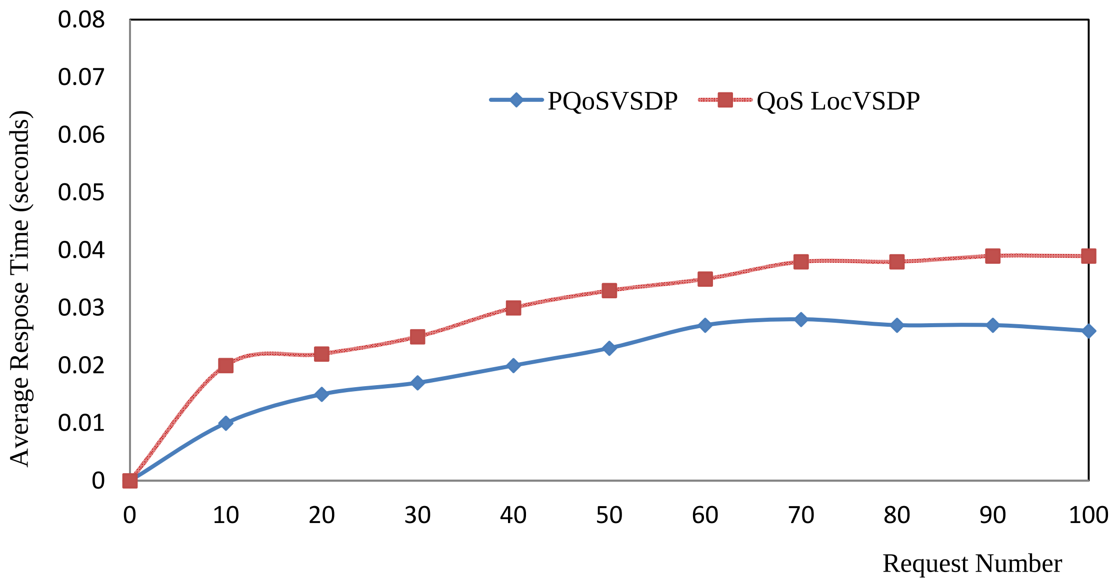

Fig. 2. Average Response Time if the Requested Service exists

Fig. 2. illustrates the average response time of service discovery transaction when the requested service exist in the region of interest. The number of service request will be varied from 0 to 100 and its corresponding average response time is obtained. Average response time of PQoSVSDP is compared with QoS LocVSDP and graph has been plotted. It is evident the graph that PQoSVSDP takes less time compared to QoS LocVSDP to receiving response upon the service request. Reduction of service discovery time improves the performance of the service discovery protocol.

Fig. 3. illustrates the average response time taken for service discovery when there is no service provider exist in the region of interest that providing the requested service. A range of 0 to 100 service request message is generated where the service provider will not be available to satisfy those requests, and there average response time is obtained. Even if service provider providing the requested service is not available in the region of interest, PQoSVSDP takes less time to give response compared to QoS LocVSDP.

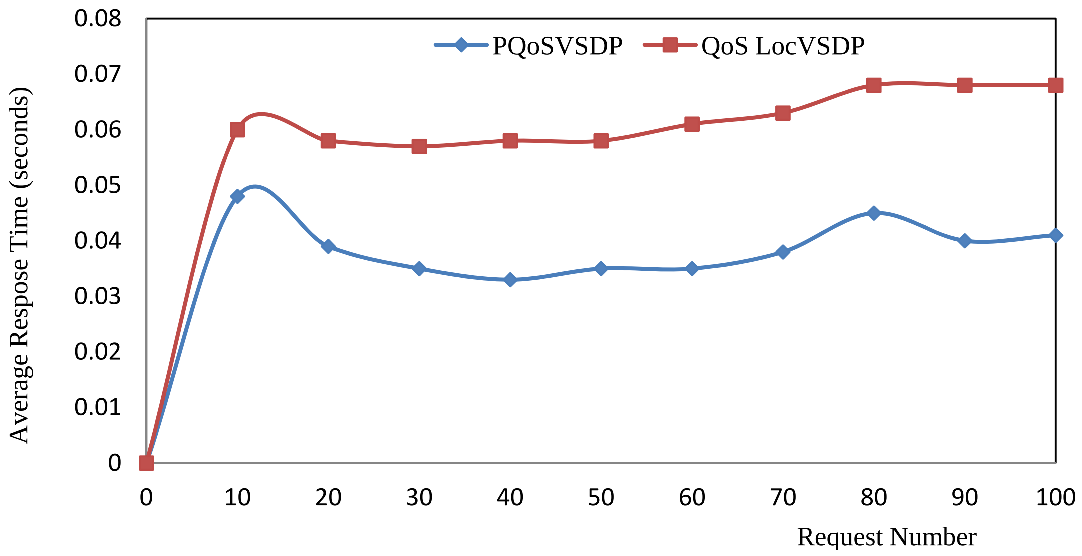

Fig. 3. Average Response Time if the Requested Service Does not exist

Fig. 4. indicates the success rate of a range requests varying from ten to hundred where the requested services exist in the region of interest. If the service provider providing the requested service exists in the region of interest PQoSVSDP achieves almost 98 percent success rate in the discovery of appropriate service provider and delivering the reply message.

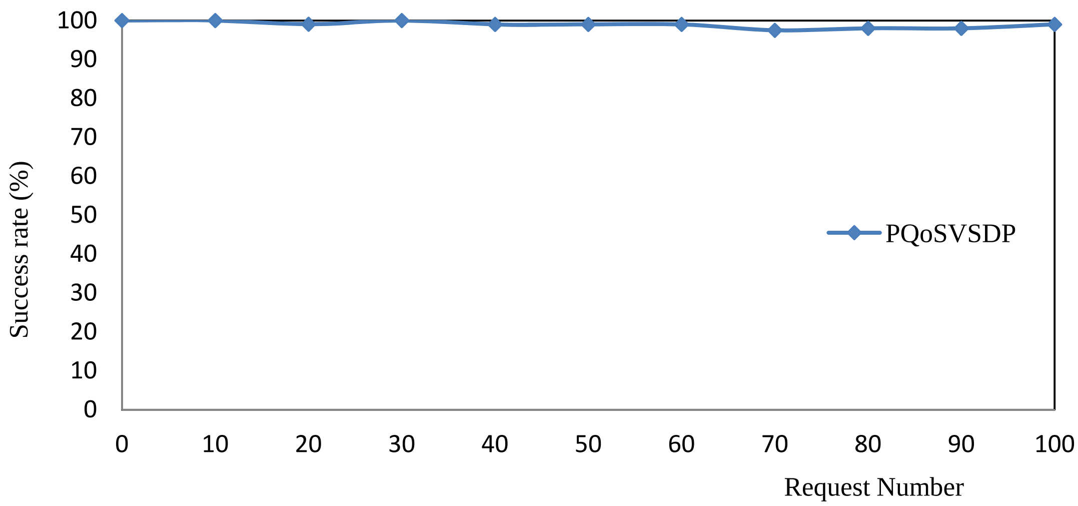

Fig. 4. Success rate if the Requested Service exists

6. Conclusion

In this study TOPSIS, a multi criteria decision making method is introduced in the leader election and service discovery generation phase in the service discovery protocol for the vehicular network. This method will helps to make ideal solution in selection the leader RR and the service provider upon the request of the service provider. It will select best suiting the routing path and service provider considering the desired QoS parameters in the service requester's request. And there by it reduces the service discovery time. Thus proposed protocol shows high performance than the existing service discovery protocols in vehicular adhoc network.

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