Fuzzy Based Optimal QoS Constraint Services Composition in Mobile Ad Hoc Networks

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***Abstract*:** In recent years, computational capability of mobile devices such as Laptops, mobile phones, PDAs, etc., are greatly improved. Implementation of SOA ("Service Oriented Architectures") in mobile ad hoc networks increases the flexibility of using mobile devices. On composing different available services to satisfy end user requirement is a critical challenge in MANETs ("Mobile Ad Hoc Network") due to dynamic topology, Resource heterogeneity, Bandwidth constraint and highly distributed service providers. Existing composition services approaches are not suitable for MANETs due to lack of constraints consideration while choosing services. In this paper, we proposed Fuzzy based optimal QoS constrained Service Composition in MANETs. We consider Energy constraint, hop count, Response time & service throughput as QoS Constraints composing optimal services. We proposed fuzzy logic based system to provide a rating to the services for optimal selection of services. We also considered that each node can provide one or more services. The service composition failure rate will be reduced by selecting optimal services in available services. The simulation result demonstrates that the proposed method outperformed than the traditional AODV in terms of average packet delay, energy constraint, throughput and turnaround time.

***Keywords*:** about Services composition, fuzzy logic, Mobile Ad Hoc Networks, Service rating.

1. Introduction

MANET is an infrastructure-less, multi-hop, temporary, spontaneous, distributed and dynamic network [15]. Wireless networks are broadly categorized as MANETs and mesh networks which use access points [22]. A node in MANET can act as a node as well as a forwarding capability element like a router. There is no centralized administration. Any node in MANET can join and leave network any time on the fly.

Mobile devices processing capability increased drastically. Implementation of services in MANETs will increase the flexibility of using mobile devices [4]. Services are the implementation of SOA. Services are self-descriptive, loosely coupled, self-encapsulated, machine interaction, dynamic loading, and dynamic discovery components. Services are very popular due to its attractive benefits [18],[13],[8]. Deploying services in MANETs is a critical task because MANETs are unstable networks and services are efficient in a stable network.

In recent years, a wide research conducted on Service Discovery in MANETs, but only a few researchers concentrated on service composition in MANETs. The service discovery architectures are broadly categorized as dictionary-based architecture and dictionary-less architecture[27]. A dictionary is a database which stores the information about services available in the network. The dictionary-based architecture, further classified as centralized dictionary architecture and distributed dictionary architecture. In the centralized approach, a few dictionaries are maintained to store the available services information. In the distributed approach, a list of nodes is elected as dictionary nodes and all the dictionaries are synchronized to each other. Centralized approach suffers from the bottleneck problems whereas not in case of distributed approach. The distributed approach is suitable for MANETs. In dictionary less architecture, available services are discovered whenever required on-demand basis. In this paper, we used distributed approach to store available services information. It is very difficult to address the complexities of wireless networks by the centralized approaches. MANETs need distributed approaches for service discovery and composition.

Growing needs of users, single service will not satisfy user requirements but complex services will solve this problem. Creating complex services by combining more than one service is called service composition. Most of the existing service composition architectures are designed for wired infrastructures, where the services are assumed to be that reside over the high bandwidth and reliable communication channels. These architectures are centralized and consist of preconfigured composition managers. The composition manager performs services selection, services composition plan, and execution of services as per the composition. Such architectures are not suitable for mobile ad hoc networks.

Some of the limitations of MANETs are:

1. Mobility: current service composition architectures have lack of support for mobility due to dynamic network topology.
2. The Central point of failure: Centralized service composition approach suffers from bottleneck problem and more prone to single point of failures.
3. Fault management: mobile nodes faults range from service discovery failures, service execution failures and network link failures.

Service Composition architectures for MANETs need to withstand such failures. Service composition is categorized as static and dynamic service composition [17]. In static service composition, everything will be decided before the composition and more manual intervention is needed. Dynamic service composition will do everything automatically at runtime without or little manual intervention. Fully dynamic service composition approach is generally achieved by using AI ("Artificial Intelligence") techniques [20],[14].

In this paper, we propose a Fuzzy-Based Optimal QoS Constrained service composition in MANETs. Users get flexibility to run the applications with required level of cost by selecting optimal level of QoS parameters [23]. We consider QoS metrics for both nodes and Services in MANETs. Throughput & response time are the metrics considered for service and energy constraint and hop count are the metrics considered for nodes. Service composition process success rate depends on degree of service discovery and optimal selection of services based on QoS parameters. Fuzzy based solution for optimal selection of services is presented in this paper. Based on metrics, a rating criterion is proposed for a service in a node to select max rated services for composition. Thus more realistic services are considered for composition thereby reducing the failure rate of service composition.

To counter the problems of existing approaches, the proposed method has the following features.

1. A distributed approach is proposed to maintain services information in a node.
2. Max rated services are selected for composition path which satisfies QoS constraints
3. Multiple services are considered in a single node.
4. Fully automated dynamic service composition based on fuzzy logic solution

The paper organized as follows. Section 2 specifies related work. Section 3 describes system model and section 4 represents Fuzzy interference system to calculate rating of a service. Section 5 describes QoS constraint service discovery and service composition. In section 6 presents Simulation results and section 7 presents Conclusion and Future work.

2. Related work

In [7] a dictionary based service discovery protocol is proposed which uses Dezert-Smarandache Theory (DSmT) to calculate trust value of a node by the neighbor node, based on behavior of a node. Evidential theory DSmT is used to handle uncertainty information about a node by taking data from different sources. A trusted node is defaulted if a faulty neighbor provides wrong information about a node. In [6] BeeAdHocServiceDiscovery protocol is proposed on the intelligent behavior of bee metaphor which uses swarm intelligence. Authors consider only the generalized QoS parameters. Specific QoS parameters related to MANETs like bandwidth, mobility, energy and resource constraints are not considered.

In [3] considers user preferences to select top k services in composition based on fuzzy sets. A complex query rewriting algorithm RDF is used to select relevant services for composition. The services are ranked based on Pareto dominance fuzzification. Ranks are computed for entire service composition path. Highest scored path is selected for service composition. This process is not suitable for MANETs.

In [16] proposed a QoS aware service discovery, composition and execution in SSON ("Service Specific Overlay Networks"). MPs ("Media Ports") are organized in SSON according to service type, node stability and quality level of a service. Central point of failure is eliminated by decentralized SSON composition algorithm. Further service discovery is enhanced through fuzzy system.

In [10] an ontology based framework is designed for service composition based on functional and non functional aspects of QoS services. Services are clustered using HCA ("Hierarchical Clustering Algorithm") based on functionalities of services. A bipartite graph is used to discover services semantically. The discovered services are selected using Fuzzy topis for services composition.

In [12] a distributed approach is proposed to find services composition path by using path filtering and path combination. These two methods controls forwarding messages and reduce the searching efficiency. In [1] distributed architecture is proposed for peer-to-peer MANETs for service composition. Table update messages are used for service discovery. The composition process load is distributed among the network for balancing. The problem with this approach is, a new architecture is implemented at every node which leads to great changes in MANET.

In [5] Distributed broker mechanism protocol and distributed service discovery is proposed for dynamic service composition. A distributed composition manager (CM) is elected based on device specific potential values and QoS Parameters. Each composition request is independently assigned to CM. It works on the principle of single composition manager for single composition request. In [2] hierarchical graph based service composition architecture is proposed, where a node represent logical service and edge represent data flow between corresponding nodes.

In [21] a trust based approach and MOO ("Multiple Objective Optimization") is used to select services which maximizes the QoS and minimize the service cost for solving service composition problem. For high user satisfaction, competence and integrity trust parameters are proposed for services composition.

In [24], the trust based service composition in MANETs is proposed. Where the service requesters requesting of services and providers providing services. In case of multiple services are requested, service composition has to be done from multiple service providers. The proposed method finds the trustworthy service composition path to minimise the total energy and time.

In [25] proposes agent based self evolving service composition approach. Five stages of composition process are combined together and consider all phases as a single process. It is a decentralized self evolving approach and studies service relation modification and service migration. This approach is suitable for wired network, but not suitable for MANETs because an integrated five phases of services composition process in one node become in-cumbrance in MANET which contains limited computational capability nodes. In MANETs, maintaining of agents is critical task due to dynamic movement of nodes.

In [26], dynamic service composition is proposed for pervasive environments. In MANETs, each time the environment is changed the service composition process has to be started again from the beginning, which depletion of the system resources and network capacity. The proposed method uses the dynamic and distributed approach to resuming service composition. It deals spatial, temporal constraints and a heuristic method is used for service composition restoration. The drawback with this approach is services are available in hop distance, but in real environments the services are available in multi-hop nature.

3. System model

The proposed method is a QoS constraint service composition based on Fuzzy inference system. Here two parameters Energy and hop count is considered as a QoS metrics for a node and Response time and throughput considered as QoS metrics for services.

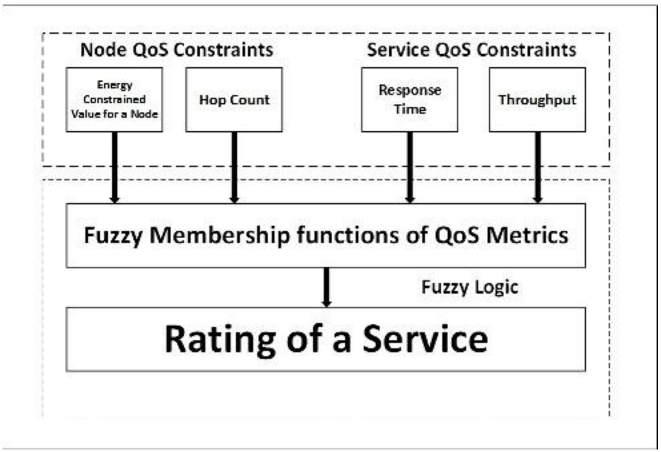


Figure 1. Fuzzy inference model to calculate rating of a service

Composition initiator issues the complex request and in turn splits into atomic services. Atomic services request is forwarded to local Service Registry Node. The local registry node gives the response to the initiator and forwards the request to other registry node. The service request packet keeps forwarding from one registry node to another registry node till the TTL value reaches to zero. The response packet contains energy and hop count metrics about a node and response time and throughput metrics about a service. All these information is collected by composition initiator. These metrics are considered as inputs to fuzzy inference system to calculate rating of services as shown in Figure 1. Using fuzzification and defuzzification methods, rating is evaluated for the available services which are used in service composition.

After receiving responses from multiple registry nodes, the initiator node runs the QoS constraint Service Composition Algorithm to trace out maximum rated service providers. After completion of composition execution, the results are to be transmitted to service composition initiator.

3.1 Service QoS Constraints

Service performance is defined as how fast a service request can be completed. According to the W3C service performance is defined in terms of execution time, latency, response time, execution time and transaction time.

In this paper we consider two parameters response time and throughput to define service performance.

3.1.1 Response time

Response time is, the time duration between sending of request to and receiving of response. Further, it is divided into service processing time, Network processing time, time consumed for compression and decompression of data, time consumed for encryption and decryption of data and time for data traversing through the protocol stack of source, intermediate and destination nodes.

Response time is represented as:

$$t_{response}(s) = t_{task}(s) + t_{stack}(s) + t_{transport}(s) + t_{cd}(s) + t_{ed}(s) \quad (1)$$

Where

- $t_{response}$(S) – Response time of a service
- t_{task}(S) – Task processing time
- t_{stack}(S) – Time consumed for processing of data in protocol stacks of source, intermediate and destination nodes
- $t_{transport}$(S)– Network transport time
- t_{cd}(S) –Time required for compression and decompression of data
- t_{ed}(S) – Time required for encryption and decryption

3.1.2 Throughput

Throughput is defined as "Number of requests or packets processed per second by a service". We define the throughput of a service as follows:

$$Throughput = \frac{\#\, requests}{time} \quad (2)$$

3.2 Node QoS constraints

In this paper we consider two parameters Energy and hop-count to define node performance.

3.2.1 Evaluation of energy consumption of a Node

Energy consumption of a node is defined in terms of numbers of packet transmitted from one node to another node. $E(p, n_a)$ is the energy necessary to transmit a packet (p) from node n_a to node n_b is

$$E(p,n_a) = E_{tx}(p,n_a) + E_{rx}(p,n_b) + (N+1)E_o(p,n_i) \quad (3)$$

Where

- E_{tx} *is* the amount of energy necessary to transmit from node n_a
- E_{rx} *is* the amount of energy necessary to receive a packet
- E_o is the amount of energy necessary to overhear the packet. The average number of neighboring nodes is *N* that are affected by the transmission from node n_a

Energy consumed by each node is calculated as

$$E_{Node} = E_{ack} + \sum_{i=1}^{4} Cost_{Ei} \quad (4)$$

$$E_{ack} = n \times E(p,n_a) \quad (5)$$

Where

- *n* - Number of control packets
- E_i-{Node Movement, Band Width, Resources, Service Discovery}
- E_{ack} - Time consumed for processing of data in protocol stacks of source, intermediate and destination nodes
- $Cost_{Ei}$ - Cost incurred for various mobility constraints

3.2.2 Hop count

Hop count is defined as "the number of hops or links between the source and destination nodes". Average hop count is considered for overall communicating nodes in MANET. Multi-hop connectivity matrix is used to compute average shortest path hop-count at each point in time [11].

Hop count *h* is

$$h = \frac{\sum_{i=1}^{T} hops_i}{\sum_{i=1}^{T} paths_i} \quad (6)$$

Where

- T is the number of multi-hop matrices
- $hops_i$ is the total number of hops at time i
- $paths_i$ is the number of cells at time i that contain a non-zero entry

4. Fuzzy Interference System to calculate rating of a service

Rating of a service is evaluated using fuzzy Interference system which considers the node hop-count and energy and service throughput & response time as input parameters.

4.1 Procedure for calculating rating of a service

4.1.1 Fuzzification

Fuzzification is a method, which compares input values with membership functions for obtaining the membership values from the past history and converts into linguistic labels. In the proposed methodology, we consider QoS metrics Energy, Hop Count, Throughput & Response Time as fuzzy input crisp variables, and the rating of a service as the fuzzy output variable.

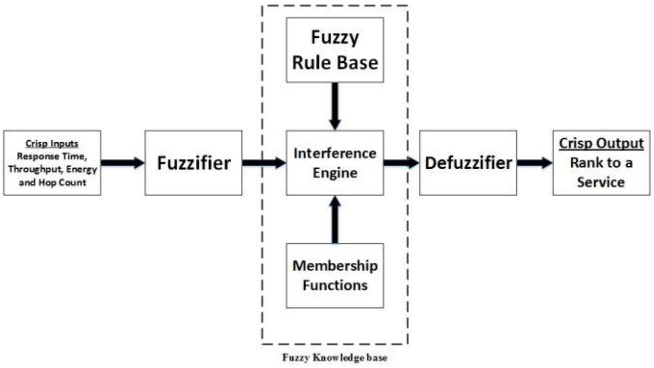
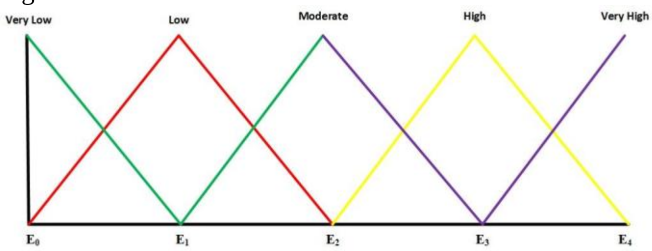


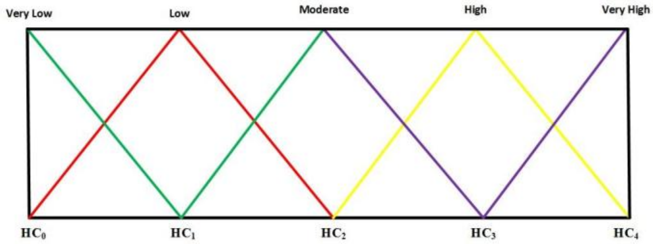
Figure 2. Phases of calculating rating of a service

4.1.2 Fuzzy membership functions

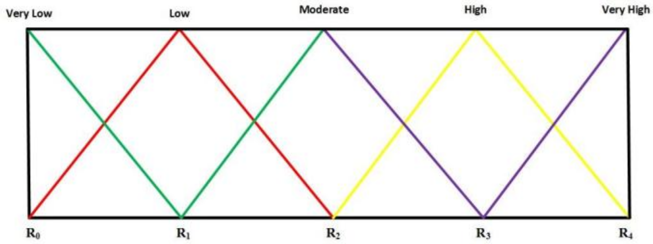
As shown in Figure 2, the crisp fuzzy input variables, Energy, Hop-count, Response time & Throughput are divided into five fuzzy sets as, Very low, low, moderate, high, very high. The output crisp values are generated by the same fuzzy functions. Here we considered triangular membership to calculate rating of the service [9] as shown in Figure 3.



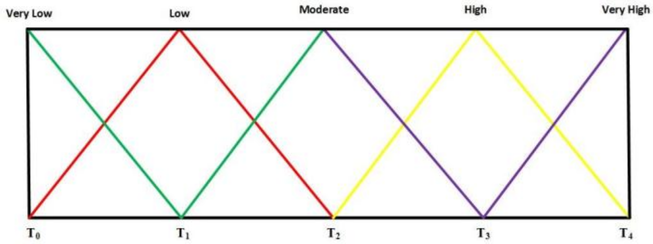
(a) Membership Function for Energy



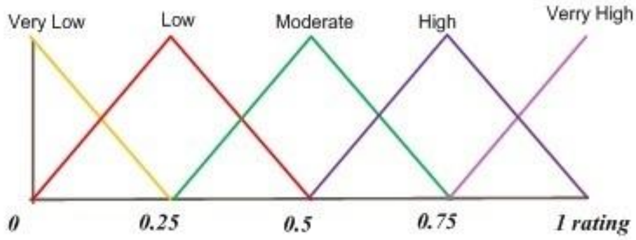
(b) Membership Function for Hop Count



(c) Membership Function for Response Time



(d) Membership Function for Throughput



(e) Membership functions for rating

Figure 3. Fuzzy Membership Functions

4.1.3 Fuzzy Rule Base

Fuzzy rule base is a database of rules, which is formed by the combinations of fuzzy input sets. Each rule is represented by "IF-THEN". Here the fuzzy input variables are 5 sets, so the fuzzy rule base contains maximum of 625(5X5X5X5) rules. Only a few of the rules are presented in table1

Table 1. Fuzzy Rules

Energy	Hop Count	Response Time	Throughput	Rating
Very Low	Very Low	Very Low	Very High	Very High
High	Low	Moderate	Low	Very High
Low	Low	Low	High	High
Low	Moderate	Low	High	High
Moderate	Low	Moderate	High	Moderate
Moderate	Moderate	Moderate	High	Moderate
High	High	Moderate	Low	Low
High	High	High	Low	Low
Very High	High	High	Low	Very Low
Very High	Very High	Very High	Very Low	Very Low

Table 2. Fuzzy sets of QoS parameters

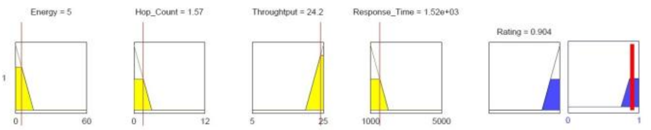
QoS Parameters	Very Low	Low	Moderate	High	Very High
Energy(J)	0 -15	0 - 30	10 - 40	20 - 50	30- 60
Hop Count	0 - 3	0 - 6	3 - 9	5 - 12	9 - 15
Response Time(ms)	1000 - 2000	2000 - 3000	3000 - 4000	3000 - 5000	4000 - 5000
Throughput	5 - 10	5 - 15	10 - 20	20 - 25	25- 30

4.1.4 Fuzzy Inference System to evaluate rating of a service

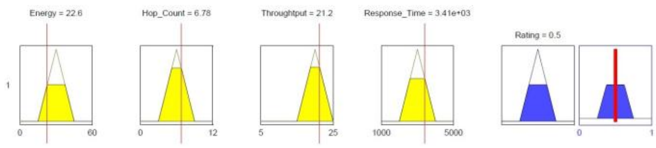
In the fuzzification process, the max-min rule is used to combine crisp input values (response time, energy, throughput and hop count). In the Figure 4, we applied two fuzzy rules for fuzzification and the fuzzy set intervals are discussed in the table2.

Fuzzy Rules

1. Rule *1: If(Energy is Very Low, Hop-count is Very Low, Throughput is Very High, and Response time is Very Low) then (Rating is Very High)*
2. Rule *2: If(Energy is Moderate, Hop-count is Moderate, Throughput is High, and Response Time is Moderate) then (Rating is Moderate)*



(a) Rule1



(b) Rule2

Figure 4. Defuzzification evaluation of service rating

Let the input crisp values of energy, hop-count, throughput, and response time of an application are like 5 J, 1.57, 24.2 and 1.52e + 03 respectively as shown in Figure 4(a). In each rule, find the degree of membership value of every input value (i.e. intersecting point of corresponding fuzzy set triangular wave). Identify the minimum degree of membership value of all input values and consider corresponding shaded portion in the output fuzzy set. Union all output fuzzy set's shaded portion and apply Center of Gravity defuzzification method to evaluate crisp node and service rating. Similarly rule 2 is represented as shown in Figure 4(b).

4.1.5 Defuzzification

The output fuzzy set value is converted into crisp output value in defuzzification process. Center of gravity is one of the popular defuzzification methods as shown in equation (7) and for the example shown in Figure 4(a), the output crisp value of rating is 0.904.

$$COG = \frac{\int_0^1 \mu(t)tdt}{\int_0^1 \mu(t)dt} \quad (7)$$

4.2 Node Architecture of a Service in MANET

A new node model, where a node may contain more than one service reducing the involvement of number of nodes in the service composition is proposed in this section.

A node in ad hoc network can be defined in view of services as

$$N = (N_{id}, \{S_1, S_2, \dots S_n\}, E_{Node}) \quad (8)$$

Where

- N_{id} Node ID, Node can be identified uniquely ie., IP Address of a node.
- $\{S_1, S_2, \dots S_n\}$ Services present in a node
- Each service $S_j = (S_{id}, S_{ip}, S_{op}, S_{Res}, S_{Thr}, C)$
- S_{id} Service ID, service can be identified uniquely
- S_{ip} Service Input
- S_{op} Service output
- S_{Res} Service response time
- S_{Thr} Service Throughput
- C Other Constraints
- E_{Node} Node Energy

Figure 5, shows nodes with multiple services.

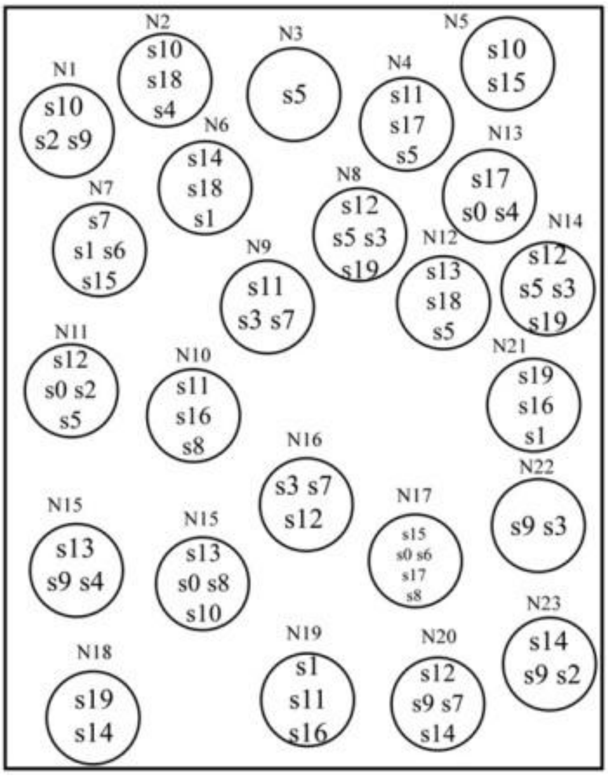


Figure 5. Nodes in MANET with multiple services

5. QoS Constraint Service Discovery and Service Composition

5.1 Service Discovery

Here we brief the service discovery process that is considered in our earlier research work [19]. A huge number of mobile devices can join and leave the network on the fly. It becomes hard to maintain a centralized repository where the information regarding the nodes and the corresponding services could be maintained. Also as the network is formed dynamically there would be no guarantee on its life time. So this leads us to propose a methodology where the service discovery process could be handled with an effective decentralized mechanism.

The service discovery in the MANET is done by categorizing the nodes participating as Service Registry, Service Providers, Service Request Nodes and intermediate nodes. The topology contains the nodes belonging to one of the categories as stated above. The discovery process is executed repeatedly whenever a new node gets into the network or else an existing one leaves or expires.

5.2. QoS Constraint Service Composition

In this section, we propose service composition by considering the node constraints as well service constraints. After service discovery process, Composition requester will get all the required services. Composition initiator will get all Nodes Energy Index value E_{Node} and hop-count h distance from the composition initiator to service provider. Composition initiator also gets response time & throughput of all related services. These QoS constraints are normalized by fuzzy logic and a matrix is established between nodes and its services which specifies rating of a service R as shown below.

$$\begin{pmatrix} R_{11} & R_{12} & R_{13} & \dots & R_{1n} \\ R_{21} & R_{22} & R_{23} & \dots & R_{2n} \\ R_{31} & R_{32} & R_{33} & \dots & R_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ R_{m1} & R_{m2} & R_{m3} & \dots & R_{mn} \end{pmatrix}$$

Each row specifies a set of similar services provided by the different nodes with different rating values. Each column specifies a set of services provided by a node.

The QoS constraint service composition algorithm generates composition path by considering the optimal atomic services provided by the outsourced service providers. First it lists out all the required maximum fuzzy normalized rated services S_1, S_2, S_3 ,... S_n. After that a service composition path and service composition execution plan established. For example composition initiator sends request to service S_1 present in node N_1. After processing of service S_1, S_1 handover the composition plan to S_2 present in node N_2.

Using AODV ("Ad Hoc on Demand Distance Vector Routing Protocol") routing protocol S_1 find out route for N_2 where the service S_2 is present. This process continues until completion of Service composition. Finally the service composition results are to be transferred to composition initiator. Empirically it has been found that the algorithm devised here has shown profound result in finding a QoS Constraint optimal service composition path. The methodology used over here takes the parameters of the service into consideration and filters the nodes list obtaining the list of nodes that are able to provide the requested service. Unlike any other mechanism this approach has lead a way to serve a complex service request in an efficient way.

Algorithm 1: Service Composition Algorithm(Rating, m, n)

```
Procedure ServiceCompositionAlgorithm(N, m, n)
//Rating[1 : m; 1 : n] is the rating of the services
//MaxRating[i; j] maximum rated services
//n is number of nodes in composition
//m is the number of services
for i ← 1 to m
{
    MaxRating[i]→0;
    for j ← 1 to n
      {
       if Rating[j, i] > MaxRating[i] then
       MaxRating[i]  ← j;
       }
}
 Composition path is MaxRating[1 : m];
 for i ← 1 to m -1
   {
        Execute Service(MaxRating[i]);
        Append Input Output;
        Create Composition Request Packet to
      MaxRating[i+1] Service;
      Hand Over Composition Request(MaxRating[i+1]);
   }
Transfer Composition Results to Initiator;
```

For example, matrix consists of rating of each service.

$$\begin{pmatrix} 0.58 & 0.84 & \infty & 0.48 & 0.64 \\ 0.75 & \infty & 0.80 & 0.62 & \infty \\ 0.90 & \infty & \infty & \infty & \infty \\ \infty & 0.75 & 0.54 & \infty & \infty \end{pmatrix}$$

As shown in Figure 6, Node N_1 contains three services S_1, S_2, S_3. Node N_2 contains two services S_1, S_4. Node N_3 contains two services S_2, S_4. Node N_4 contains two services S_1, S_2. Node N_5 contains only one service S_1. Among these nodes, for Service S_1 node N_2 selected because maximum fuzzy rated services, for Service S_2 node N_3 selected, for Service S_3 node N_1 selected, for Service S_4 node N_2 selected. The optimal service composition path as shown in Figure 7 is $N_2 \rightarrow N_3 \rightarrow N_1 \rightarrow N_2$.

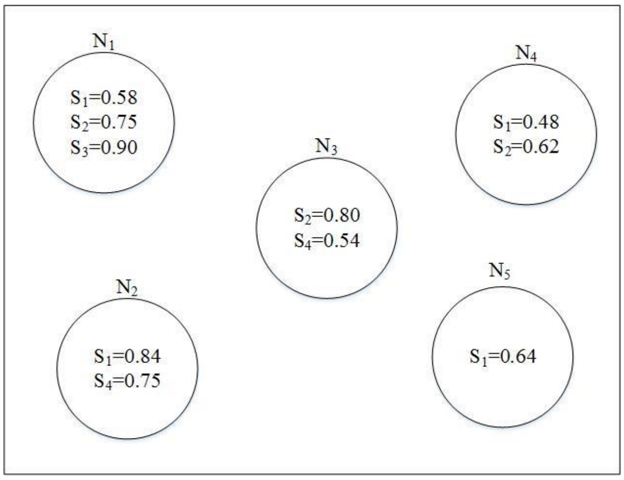


Figure 6. Nodes with multiple services and fuzzy rating values

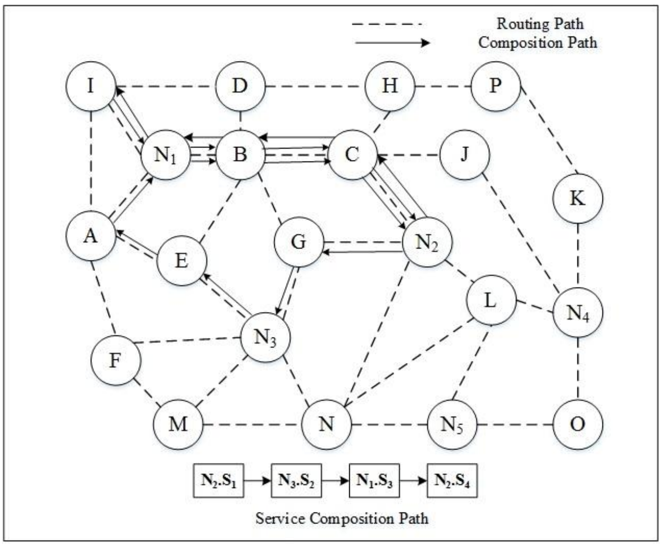


Figure 7. Service Composition Path

6. Simulation Results

The number of services involved in composition verses Average packet delay, throughput, energy and turnaround time is discussed in this section. The network size is to be 80 Nodes. Table 3 summarizes the simulation setup.

Table 3. Simulation Setup

Parameter	**Value**
Number of nodes	80
Simulation Time	150 Seconds
Wifi standard	802.11b
Wifi rate	DsssRate1Mbps
Transmission range (R)	45m
Routing protocol	AODV
Number of concrete services	120
Size of composition plan	5 (Abstract Services)

6.1 Average Packet Delay verses Number of services

In Figure 8, shows the average packet delay of proposed method and traditional AODV, it is observed that average packet delay can be decreased when stable nodes are present in transmission path. The proposed method increases life time of the network and decreases average packet delay by considering the least energy constraint services and least hop count nodes in composition path. As the results shows that decreased average packet delay reduces the failure rate of the services composition process.

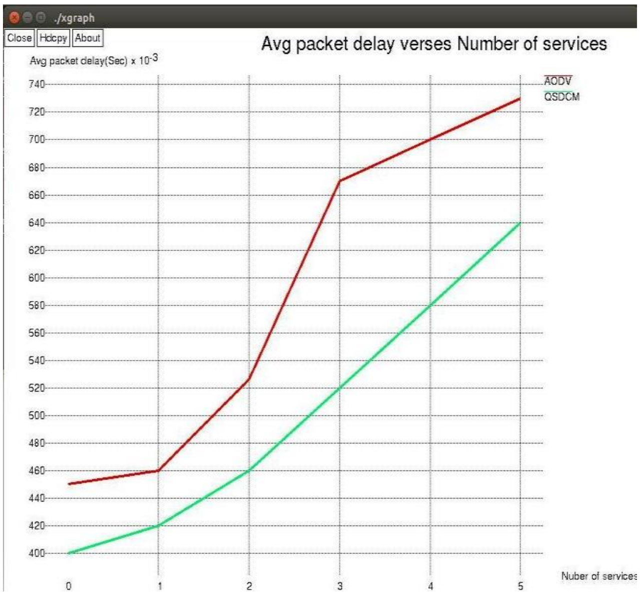


Figure 8. Average Packet Delay verses Number of services

6.2 Throughput verses Number of services

In Figure 9, shows the throughput ("Number of packets delivered per unit of time") of proposed method and traditional AODV, it is observed that throughput decreases as the number of services involved in composition increases. Throughput can be affected by various parameters like, hop count, response time of a service, and number of nodes involved in composition process. The proposed method increases the throughput by considering the least hop count nodes, least response time and considers multiple services in a node. Thus a node can contribute more than one service in composition process. Hence it reduces the packet overhead; it improves overall throughput of a service composition process.

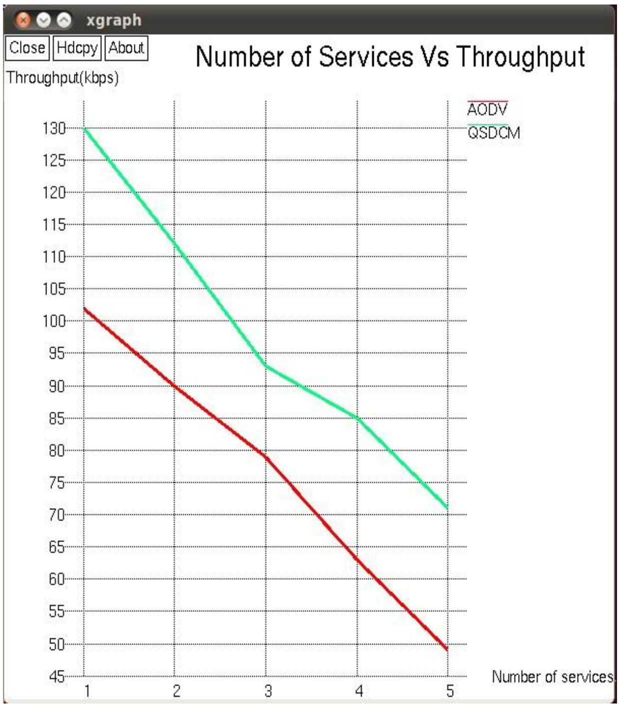


Figure 9. Throughput verses Number of services

6.3 Energy verses Number of services

In Figure 10, shows the energy consumed versus number of services. As the results shows that, proposed method will consume less energy for services composition by considering least energy constraint services compared with the traditional AODV. Network life time is increased by considering least energy services; hence the service failure rate is reduced as more live nodes are present in the network.

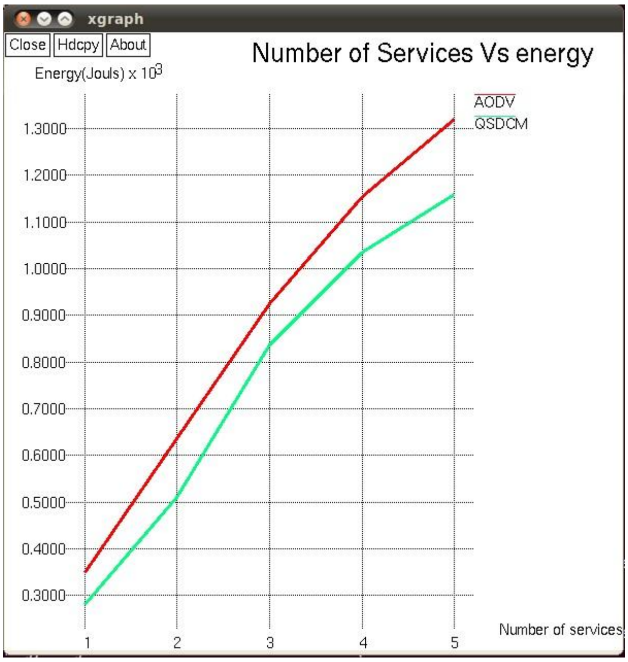


Figure 10. Energy verses Number of services

6.4 Turnaround time verses Number of services

In Figure 11, shows the turnaround time versus the number of services involved in composition. The proposed method results in better turnaround time compared to the traditional AODV as it selects optimal services by using fuzzy approach.

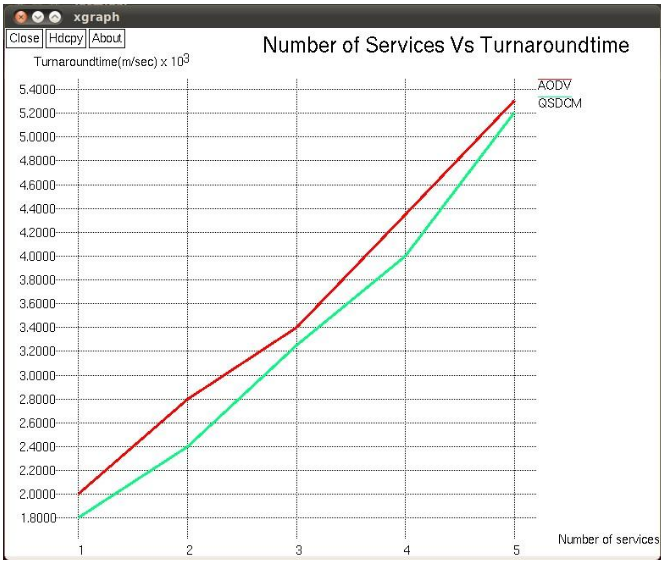


Figure 11. Turnaround time verses Number of services

Our proposed method out performs better than the traditional AODV. In AODV it selects the available services for composition and will not consider any constraint but our proposed method will consider optimal services with required QoS constraints rated with fuzzy systems.

7. Conclusion and Future Work

Existing service composition approaches in MANET's does not consider QoS constraints both at node and service layer. In this paper a fuzzy based approach for service composition is proposed where we considered QoS metrics energy and hop-count at node and response time and throughput at the service layers and apply fuzzy rules to select maximal optimal service during the service composition. Our approach is scalable and adaptable to highly dynamic networks. Simulation results shows that the proposed approach has better performance compared to AODV. In future work, we plan to consider fault tolerant in service composition in MANETS to minimize the service failure rates.

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