CHAPTER 5
LOAD BALANCED SERVICE DISCOVERY USING
STOCHASTIC PROCESS

Load Balancing indicates the necessity to balance the load on the network traffic. Since MANET’s nodes are deployed in uncontrolled environments and they communicate with other nodes, their load is varied based on the various packets such as SREQ, SREP, and SADV etc. which are exchanged inside the clustered network. Thus, load balancing is essential for nodes to ensure balanced clustered network.

Patel (2013) describes the AODV-SD protocol for service discovery architecture of MANET. These protocols don’t provide an appropriate route from a requester to the service provider. Hence, after services are discovered, a route request needs to be initiated in order to access the service. This technique gives efficient, robust and flexible approach to service discovery for MANET that not only discovers a service provider but also at the same time provides a route to access the service. An ad hoc on demand vector is a technique which can be adapted to work in any environment, scalable, flexible and efficient. It does not provide an appropriate route from a requester to the service provider. This technique not only pulls the demand on service provider information but pushes the service advertisements periodically along with routing information. It does not provide efficient communication among the service provider and service requester because of traffic occurring in the network. Several literatures are reviewed and this research work uses the mathematical tool, the markov decision process (Tijms & Henk 1984) is applied for congestion controlled service discovery protocol proposed for balancing the load to avoid congestion in MANETs.
Without proper load balancing mechanisms, there is a probability of in-efficient use of resources that may prompt system breakdown. When load is not balanced, it presents unnecessary delay in packet delivery, and reduces a node’s lifetime. The objective of this chapter is to develop a Load Balanced Cluster Based Service Discovery Model (LB-CSDM) that extends the work to achieve efficient service discovery by using a stochastic process for minimizing congestion and the bandwidth usage and enhance the success rate of the MANET. LB-CSDM aims to find the balanced node with a long life time by letting the intermediate nodes to decide sending the various packets such as SREQ, SADV, SREP, etc. based on the load. To make such uses, the markov process tool tries to find the action that the node can take to maximize the nodes performance. In CSDM-LDA, service discovery method is based on the directory based architecture where the cluster head node (directory) is selected, based on the OC-AHPPSO. During the CSDM-LDA process, the arrival and service rate is considered to prevent the overload on certain nodes. But sometime it may lead network congestion. To solve this problem, markov decision process steady state probability distribution monitors the load of each node dynamically throughout the lifetime of the network. By using this node load, path between provider and requester contain heavily loaded nodes which can be avoided. This will help in maintaining the balanced clustered service discovery protocol.

5.1 STOCHASTIC PROCESS

5.1.1 Markov Decision Process (MDP)

Markov decision process (MDP) is a mathematical framework that has been proposed to formulate and solve decision problems with some properties (Tijms & Henk 1984). It is used to model the situations in which the agent can exactly observe all related aspects of the environment states and make a decision to which action should be taken. The MDP model consists of decision epochs, states, actions, rewards, and transition probabilities.
A MDP Yaser et al. (2011) represents a control problem by using four objects. MDP = (S, A, T, R) where,

- S is the state space that presents all possible states of the system.
- A is the set of actions that can be taken by the agent to go to a new state.
- PF is the transition function that specifies the probability that an action in a state leads to a new state.
- R is the reward function that specifies the expected value of the agent as a function of current state and action.

5.2 LOAD BALANCING FOR CSDM-LDA

Assume that the mobile ad hoc network has ‘N’ number of mobile nodes and the clusters are formed and the cluster head node is elected based on the OC-AHPPSO. Then in the CSDM-LDA method, the CSDM-LDA is applied to allow, exchange and share of each other’s services. All nodes are registers their service to the cluster head node (service directory). It contains service information and routing information of member nodes. Hence, in the proposed system, LB-CSDM is needed to balance the nodes capacity level. Since, each node can act as a service requester, service provider or a service directory.

The Load balancing method is embedded in the CSDM-LDA method. The Figure 5.1 Revathi et al. (2015) shows the system design for load balancing in service discovery for mobile networks.
Load balancing is very important feature for service discovery in MANETs. In fact, for MANETs that have multiple service providers of the same service, it is very important to balance the load among the different service providers while guaranteeing provisioning such as satisfying service requesters queries.

In LB-CSDM load balanced service discovery protocol is a service discovery protocol in directory based MANETs. First, guarantee that service requests are handled equitably by service providers in the clustered network. For this purpose, it is not necessary that the service provider located closer to the CHN is returned as a reply to the service requester. However, any service provider located inside the cluster which is less loaded than the other service providers in the same cluster can handle the service request. Second, since LB-CSDM protocol is integrated into a routing protocol, it guarantees that the routes between service providers and service requesters are not congested. For this purpose, a novel technique that guarantees load balancing on CHNs in the MANET is proposed. In addition to guarantee load balancing among the different component of the MANET, LB-CSDM service discovery protocol
finds service providers and routing paths between service providers and service requesters that satisfy the requests which is specified by the service requester.

In the following the proposed techniques for load balancing and QoS aware service discovery protocol in infrastructure based MANETs is described.

![Figure 5.2 Program Dependence Graph (PDG) of overloaded node](image)

In the following, LB-CSDM will describe how the load balancing decision problem is formulated as an MDP.

Consider that the, total number of nodes in a cluster is 10 equally in clusters in time $T_1$, $T_2$, $T_3$.

\[
T_1 = \{\text{CHN}_1, \text{CHN}_2, \ldots, \text{CHN}_a, \text{1000 bytes} \} \\
T_2 = \{\text{CHN}_1, \text{CHN}_2, \ldots, \text{CHN}_b, \text{800 bytes} \} \quad (5.2) \\
T_3 = \{\text{CHN}_1, \text{CHN}_2, \ldots, \text{CHN}_c, \text{100 bytes} \} \quad (5.3)
\]

Each node transmits 10 packets inside the cluster. Then the total size is $10a$. Each node in a cluster ‘$a$’ can store 1000 bytes data. Similarly, $b$ and $c$ can store 800 bytes and 100 bytes respectively.
Table 5.1 Tolerance limit calculation for clusters

<table>
<thead>
<tr>
<th>T_1</th>
<th>Total number of nodes</th>
<th>Remarks</th>
<th>Task</th>
</tr>
</thead>
</table>
| A   | a * 10               | a_1 10a < 1000  
    |                     | a_2 10a=1000    
    |                     | a_3 10a>1000      | Share/Distribute  
    |                     |                     | Solved          
    |                     |                     | Accept or Share |
| B   | b * 10               | b_1 10b < 800  
    |                     | b_2 10b=800      
    |                     | b_3 10b>800       | Share/Distribute  
    |                     |                     | Solved          
    |                     |                     | Accept or Share |
| C   | c * 10               | c_1 10c < 100  
    |                     | c_2 10c=100      
    |                     | c_3 10c>100       | Share/Distribute  
    |                     |                     | Solved          
    |                     |                     | Accept or Share |

Where, a_1, b_1, c_1 are denote the capacity of the nodes in a particular cluster.

10a >1000 ,10a =1000, 10a= 1000+a1

\[ a = \frac{1000+a_1}{10} \]  (5.4)

Similarly, b and c are evaluated as follows,

\[ b = \frac{1000+b_1}{10} \]  (5.5)

\[ c = \frac{1000+c_1}{10} \]  (5.6)

Substitute, a_1 = b_1 = c_1 = 0 then a=100, b=80, c=10.

\[ a_1 = b_1 \neq c_1 \]

\[ a_1 \neq b_1 = c_1 \]

\[ a_1 \neq b_1 \neq c_1 \]

If a_1 < 1000, then the tolerance limit (TL) for a_1 lies within a-2, a+2.
If b_1 < 800, then the tolerance limit (TL) for b_1 lies within b-2, b+2.
If c_1 < 100, then the tolerance limit (TL) for a_1 lies within c-2, c+2.
Hence, Tolerance limit (TL) is ± 2 for all a_1,b_1,c_1.

If the node’s capacity reaches the tolerance level, then apply MDP to balance the load on each node. From the Figure 5.2 a_3, b_3, and c_3 complete their jobs and accept or share to carry out some tasks either processing SREQ,SADV or SREP messages. But all other remaining nodes want to do the...
jobs in the $a_3$, $b_3$, and $c_3$. Then automatically the nodes get overloaded. Consequently the performance degradation comes. To avoid that balance, the load on a CHN, SPN and between SRN and SPN. The following sections explain how the load balancing is done within the cluster.

### 5.2.1 Load Balancing on CHN

During CSDM-LDA, all the nodes are communicated with the CHN in a cluster. In CSDM-LDA method, a cluster head node receives SREQ and SADV from the service requester and service provider node respectively as shown in Figure 5.3. If many requesters and providers specify the same CHN, then the load on CHN for many requests and advertisements will be high.

The following Equation 5.7 is used to identify the capacity of the CHN

$$C_{CHN_{i,T_j}} = \frac{\text{Total number of reply sent}}{\text{Total number of requests and advertisements received}} \quad (5.7)$$

Where $C_{CHN_{i,T_j}}$ – Capacity of the $i^{th}$ CHN at time $T_j$.

Load ($Ld_i$) of the node is evaluated based on $C_{CHN_{i,T_j}}$ at time $T_j$, if it exceeds the TL, then it needs to be balanced.

In order to balance the load on nodes in the cluster, the steady state probability distribution mechanism, is proposed and it helps to share the load (SREQ and SADV) of the $CHN_i$ to the next nearest cluster $CHN_j$ and provide the services without any congestion and delay depending on the priority. The Figure 5.3 shows the decision making system of $CHN_j$. 
**Figure 5.3 Markov decision process model for CHN$_i$**

CHN$_i$ pass two parameters to an MDP procedure to get the action ‘A’ that should be taken in the current time (T$_j$). These parameters at the arrival and service rate are considered to prevent the overload on certain nodes. The load Ld$_i$ (based on the arrival rate and service rate) is calculated based on the capacity of the node. The current state ST$_i$ of the CHN$_i$ is the parameters of MDP. The load Ld$_i$ is the number of packets in the interface queue of the node i which includes SREQ, SADV packets. It is used to safeguard CHN$_i$ from occurrences of congestion, and etc. by preventing heavily loaded nodes to be a part of a CHN$_i$. ST$_i$, which includes CHN$_i$ and CHN$_j$ depends on the action either share or accept. If the ST$_i$ is CHN$_i$ then chance to share the arrived packet is increased and vice versa.

**Step 1: State**

A set of possible states for each CHN in the clustered network are ST =$\{\text{share, Accept}\}$ based on the last action performed by the CHN$_i$ and CHN$_j$.

State ST =$\{\text{Share, Accept}\}$

- Service availability =$\{\text{SREQ,SADV}\}$

**Step 2: Action $A_c$**

The Equation (5.8) and (5.9) define about the set of actions to be taken when the CHN becomes heavily loaded by receiving SREQ and SADV are
A1 = \begin{cases} 
0 & \text{SREQ is share} \\
1 & \text{SREQ is Accept} 
\end{cases} \quad (5.8)

A2 = \begin{cases} 
0 & \text{SADV is share} \\
1 & \text{SADV is Accept} 
\end{cases} \quad (5.9)

A_1 = 0 \text{ and } A_2 = 0 \text{ then the CHN}_i \text{ is not to accept SREQ and SADV.}

**Step 3: Transition Probability function (PF) construction**

- Transition Probability function (PF) specifies the probability of reaching the next state depending only on current state and actions as follows.

\[ PF_{ij} = \text{prob}(\text{next} = j \mid \text{current} = i, \text{Action A1}) \]

\[ PF_{i2}^{A2} = \text{prob}(\text{next} = j \mid \text{current} = i, \text{Action A2}) \quad (5.11) \]

This PF is constructed based on the arrival and the service rate of the node. The state transition graph and the transition matrix are shown in Figure 5.5 and table 5.3 respectively.

*Figure 5.4 State transition graph for CHN load balancing*

- If the node is in Share state

\[ PF_{00} = PF_0 = \left( \frac{\lambda_1}{\lambda_{\text{max}}} \right) \times \beta + \left( \frac{\psi_1}{\psi_{\text{max}}} \right) \times (1 - \beta) \quad (5.12) \]

\[ PF_{01} = 1 - PF_0 \quad (5.13) \]

- If the node is in Accept state
Where,
\[ PF_{00} = \text{prob}(\text{next} = \text{CHN}_i \| \text{current} = \text{CHN}_j, A1 = 0, A2 = 0) \]
\[ PF_{01} = \text{prob}(\text{next} = \text{CHN}_i \| \text{current} = \text{CHN}_j, A1 = 0, A2 = 1) \]
\[ PF_{10} = \text{prob}(\text{next} = \text{CHN}_i \| \text{current} = \text{CHN}_j, A1 = 1, A2 = 0) \]
\[ PF_{11} = \text{prob}(\text{next} = \text{CHN}_i \| \text{current} = \text{CHN}_j, A1 = 1, A2 = 1) \]

\[ \beta = \text{the weighted coefficient value that is taken from the arrival rate of CHN}_i \text{ and it is adaptive based on the maximum arrival rate } \lambda_{\text{max}}. \]
\[ df = \text{discount factor that the accept state has lesser probability to accept again } 0 < \beta, df < 1. \]

**Step 4: Reward Function (R) Evaluation**

The reward values that the state earns when it performs a PF from the current to the next state are shown in table 5.2

- If the action is A1=0 and A2=0, then the node earns +1 points regardless of the current state.
- If the action is A1=1 and A2=1 then the node earns +3 points regardless of the current state.
- When the \( \lambda \) is increased, that guarantees that the request will be rebroadcasted by relatively CHN which can receive the SREQ or SADV with high rate.

<table>
<thead>
<tr>
<th>State</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SREQ_Accept</td>
</tr>
<tr>
<td>Accept</td>
<td>+3</td>
</tr>
<tr>
<td>Share</td>
<td>+3</td>
</tr>
</tbody>
</table>

Table 5.2 Reward function matrix
The coefficient value $\beta$ is used to distribute the priority between arrival rate and the service rates. The service rate is given a large priority when deciding to rebroadcast or not to make the discovered routes more stable and the load is considered to save the heavily loaded nodes from congestion. The $\beta$ value is chosen adaptively based on the maximum service rate. It is decreased when the arrival rate is high because the congestion level is increased.

The df value is used to avoid congestion in the slow arrival rate nodes group. So, when a CHN node is in a forward state, the chance to forward a new request (SREQ) is decreased. It should be chosen carefully to achieve balance among arrival and service rate and congestion. As a result, LB-CSDM technique guarantees load balancing on CHNs in any number of requests and advertisement messages by many SRN and SPN.

### 5.2.2 Load Balancing on the Path between SPN and SRN

In LB-CSDM protocol, the routing path established between a service requester and its correspondent service provider is the fastest path, i.e. the path from which the CHN has received the first request message. In LB-CSDM, the fastest path is not necessarily chosen. If the fastest path is congested, LB-CSDM is able to generate an alternative path which is less congested than the fastest path and select a stable route with a long lifetime by letting the intermediate nodes to decide whether to broadcast or drop the SREP packets based on their speed and routing load in order to establish an efficient communication between the service provider and the service requester. To make such decision, LB-CSDM uses the Markovian Decision Process (MDP) tool trying to find the best action that the node can take to maximize the overall network performance. LB-CSDM modifies the route discovery phase specifically and the propagation of SREP packets of the original reactive protocols. Route replay and maintenance are same as the original protocol.
LB-CSDM aims to solve the load balancing problem by dealing with the dynamic topology feature of ad hoc networks and distribute the load among all nodes in the network. This scheme takes into account the speed and the traffic load of each node. The speed of a node is considered so as to prevent a high-speed node from participating in the route discovery process. This leads to finding a more stable route, and it reduces the routing overhead. But, this may lead to network congestion and concentrate on routing load on certain nodes (high-speed nodes). To solve this problem, LB-CSDM monitors the traffic load of each node dynamically throughout the lifetime of the network. By monitoring the node load, routes that contain heavily loaded nodes can be avoided.

In the following, explain how load balancing service discovery protocol generates less congested path while propagating the SREP. First define the cost of a routing path as the sum of loads on each component of the routing path. In order to generate less congested path between a service provider and a service requester, implement the following technique. After a service request is propagated to the cluster and handled by the CHN, a service provider is chosen and a unique reply is generated. This sent to the service requester from the CHN. An intermediate node forwards the received reply message only if: (i) the node is closer to the service requester than the CHN from which it has received the reply message, and (ii) Prevents the high speed nodes to be a part of the selected route and distribute the load among the nodes evenly and improve the performance in terms of end-to-end delay, delivery ratio and network throughput.

In this way, it is guaranteed that the reply message is not flooded in the MANET and the routing path returned to the service requester is a less congested one among all the possible routing paths between the service provider and the service requester. If the current intermediate node has to propagate the reply message, it adds to the reply message, its ID, its capacity,
its load, and the link load between itself and the previous node. The service requester sends a connection message to the service provider through less congested routing path including its eventual load. Thus, each intermediate component updates its load accordingly.

5.2.3 Load Balancing on SPN

The load on an SPN is the number of SREQs handled by the SPN during simulation time. In LB-CSDM, SRN receives the SREP the information of the optimized service’s SPN either locally or globally. If many service requesters specify the same SPN<sub>0</sub>, then the same service provider SPN<sub>0</sub> would be returned to these service requesters, even if there are other service providers located in the desired Cluster. Thus, the service provider SPN<sub>0</sub> would be overloaded while the other service providers located in the cluster are under loaded which can affect the performance of the overloaded service provider. In order to overcome this drawback and provide an efficient service discovery in a mobile network, it is very important to balance the load among the service providers to give better service for each requester without delay. The arrival of service requester is Poisson with rate $\lambda$.

The sequential queue diagram for load balancing on the service provider (SPN) is given in Figure 5.5. The service time for service provided by the service provider is exponentially distributed with mean $1/ \psi$. The service time for $\psi_1$ and $\psi_2$ are exponentially distributed. To balance the load by using the service provider using the steady state probability distribution of sequential

![Sequential queue diagram for load balancing on Service provider (SPN)](image-url)
queue diagram model. Each service provider has the certain capacity for providing service for requested node. If the capacity of the nodes exceeds the TL consider it is overloaded, then that particular provider node distributes its workload to the nearby neighbouring node for efficient communication between the service provider and service requester.

5.3 EXAMPLE OF LB-CSDM

Arrival of a service request is poisson with rate $\lambda$. The service time for service is exponentially distributed with mean $1/\psi$. Arrival of service request is higher than the service provider, and then only can balance the load. i.e., $\lambda = 3$, $\psi = 2$. ST$_{ij}$ state changes from i to j which means state changes from one state to another state. The set of states, ST = {st$_{1}$, st$_{2}$,...,st$_{r}$}. The process starts in one of these states and moves successively from one state to another. Each move is called a step. If the chain is currently in state st$_{i}$, then it moves to state st$_{j}$ at the next step with a probability denoted by PF$_{ij}$, and this probability does not depend on which states the chain was in before the current state.

Figure 5.6 State transition diagrams for mathematical evaluation using infinitesimal generator
The probabilities $P_{Fij}$ are called transition probabilities. The process can remain in the state it is in, and this occurs with probability $P_{Fi}$. An initial probability distribution, defined by $ST$, specifies the starting state. Usually, this is done by specifying a particular state as the starting state. The state transition diagram for the mathematical problem is given in Figure 5.8. Assume, that there are four service requesters $\lambda = 4(0, 1, 2, 3)$ and three node states of the service providers $\psi = 3(1, 2, 3)$. The arrow represents the possible transitions; for this example, it is assumed that $s_{21}$ and $s_{13}$ are equal to 0.

Consider, $\lambda = 3 (0, 1, 2)$ and $\psi = 2 (1, 2)$ and the state changes from $S_i$ to $S_j$, $S_0 = \frac{1}{2} \pi q = 0$ is a transition probability function (PF). Where, $\pi q = 0$ is the sum of the state of the rate matrix using an infinitesimal generator. $\sum \pi = 1$, i.e., $\pi_1 + \pi_2 + \cdots + \pi_n = 1$ and the PF is written as,

Substitute the values for $\lambda = 3$ & $\psi = 2$ in Equation 5.1, the transition probability matrix (PF) of $\pi q$ is written as,

$$
\pi q = \begin{bmatrix}
-3 & 0 & 3 & 0 & 0 & 0 \\
0 & -3 & 0 & 3 & 0 & 0 \\
2 & 0 & -5.5 & 0.5 & 3 & 0 \\
0 & 2 & 0 & -5.5 & 0.5 & 3 \\
0 & 0 & 2 & 0 & -2.5 & 0.5 \\
0 & 0 & 0 & 2 & 0.5 & -2.5
\end{bmatrix}
$$

(5.17)

After substituting the values in the matrix resultant matrix as in Equation 5.17 using the transition probability matrix i.e., $\pi q = 0$; where $\pi q$ is the sum of the transition probability matrix (PF).

$$
-3\pi_1 + 3\pi_3 = 0 \\
-3\pi_2 + 3\pi_4 = 0 \\
2\pi_1 - 5.5\pi_3 + 0.5\pi_4 + 3\pi_5 = 0 \\
2\pi_2 - 5.5\pi_4 + 0.5\pi_5 + 3\pi_6 = 0 \\
2\pi_3 - 2.5\pi_5 + 0.5\pi_6 = 0
$$
Using above seven transition probability matrix Equation (5.17), one can find the solution for the load balancing on SPN & SRN which means that each requester gets less routing path to connect appropriate service provider for efficient communication. Similarly, LB-CSDM can solve the load balancing problem in CHN and on Service provider.

5.4 RESULTS AND DISCUSSION

This section presents the simulation conducted to evaluate and compare the performance of LB-CSDM method with AODV-SD (Patel 2013) using a MANET emulator implemented in java language. 802.11 MAC is used as a wireless medium with a data transmission rate of 11 Mbps and a transmission range of 50 m to 300 m. DSDV routing protocol is used to route the communication packets between CHN and the member nodes in the network. Various test assessments have been carried out to evaluate LB-CSDM method. Assume that SRNs sends the service request (SREQs) within the cluster.

In addition to that 10 service providers are found in the cluster and they offer the service requested by the service requestors in the ad hoc network. The service requests arrival time follows a Poisson process. In the simulation tests, number of SREQs is defined by the number of SRN’s request. Different metrics such as success hit ratio, response time, bandwidth, and load are used to evaluate the performance of LB-CSDM algorithm with AODV-SD.

Figure 5.7 shows the number of SREQ handled by the SPN inside the cluster. Let consider, 150 request sent by the SRNs. In the AODV-SD handles, 96% of the SREQ is handled by SPN 2. But in LB-CSDM every SPN placed inside the cluster handles at most 10% of the total SREQ is generated.
during the period T. The AODV-SD finds the nearest SPN to handle the SREQ. This information is obtained from the SREP reply packet. But in LB-CSDM, SREP contains information about the lightly loaded node to handle the SREQ within the cluster. So 99% of the overall SREQs are managed by SPN2, whereas LB-CSDM handles at most 10% of SREQ by each SPN within the cluster during the simulation time. This shows that the proposed LB-CSDM does well in balancing the load among the various SPNs.

![Figure 5.7 Load balancing on service providers of the LB-CSDM and the AODV-SD](image)

Figure 5.7 Load balancing on service providers of the LB-CSDM and the AODV-SD

Figure 5.8 shows the load balancing on CHNs in the network of AODV-SD and the LB-CSDM respectively for 150 SREQ. There are 6 CHNs (1, 7, 13, 19, 25, and 33) which are placed in the network. In AODV-SD, all the SREQ are managed by single CHN ID 7. But in LB-CSDM, SREQ is managed equally by all the CHN in the network. If the respective SRN’s cluster CHN is overloaded, each CHN handles the 30% of SREQ messages. Hence, LB-CSDM balancing the processing SREQ loads by various CHNs in the network.
Figure 5.8 Evaluation of load balancing on CHN of the LB-CSDM and the AODV-SD

Figure 5.9 Number of request Vs. Success rate

Figure 5.9 shows the average fraction of successful service exchange or sharing for comparison of AODV-SD and LB-CSDM inside the cluster. In AODV-SD protocol takes the SREQ but its success rate is lesser than 64%. But in LB-CSDM it distributes the SREQ when it increasing the load level hence the success rate is higher. In LB-CSDM method, three service providers providing the requested service exist in the cluster specified in the service request queries. This technique uses steady state probability distribution.
which achieves almost 100% as success rate in the discovery of at least 90% of the service providers in the requested cluster. The main reason behind the high success rate in LB-CSDM protocol is due to a unique service reply generated by the CHN in the desired cluster to be returned to the requesting node and the reply could contain either service provider information or an indication that the node does not have the requested service in its service table.

![Graph showing connection rate vs number of requests for AODV-SD and LB-CSDM](image)

**Figure 5.10 Number of request Vs. Connection rate**

Figure 5.10 indicates the average percentage of successful service connections; i.e., the service requester is able to connect the service provider through the intermediate nodes. In AODV-SD, service connection between the service provider and service requested is complicated because of overloaded/congestion occurring in the mobile network, which leads to degrading the communication between SPN and the SRN. Using LB-CSDM, the first path is not chosen necessarily. Because if the first path is congested, then load balancing in service discovery using Markov process is able to produce an alternative path which is less congested than the first path and order to provide an efficient communication between the service provider and the service requester.
Figure 5.11 shows the average time of successful request transactions. It measures the gone time for getting a valid service reply in response to a service request sent by a node. By using the AODV-SD, requested node sends the service request message to provider node due to congestion occur in the routing path between SPN and SRN which led to more time taken to send the reply to the requesters. But in LB-CSDM, it considers many factors such as transmission and message processing delay. It allocates the workload for each SPN; if the capacity of the corresponding SPN is overloaded then it distributes the services to the nearby SPN to reduce congestion in the network. It shows that the average response time of successful transactions in LB-CSDM method is in order milliseconds for a number of requests ranging from 10 to 100.
5.5 SUMMARY

Figure 5.12 shows the bandwidth needed to satisfy the client service requests for comparing of AODV-SD and LB-CSDM inside the cluster. In AODV-SD protocol, it leads to increase in congestion in the network and minimizes the response time. The bandwidth usage of this LB-CSDM method is used when three different service providers of the requested service exist in the desired cluster. Notice that for AODV-SD protocols, the bandwidth usage increases with an increase in the number of requests. Every node has to send a neighbour discovery message every one second, which incurs a useless overhead in the MANET. In the proposed LB-CSDM protocol, there is no need for neighbour discovery for the good functioning of the protocols. During the query phase and the reply phase, a large number of messages are exchanged to increase the bandwidth usage in the MANET.

In this chapter, the load balanced service discovery for CSDM-LDA is presented, by using stochastic process. Since, the nodes are unbalanced; the balanced factors between the nodes are computed for service discovery. The LB-CSDM is used to evaluate load balancing on cluster head node, among service requester and service provider, and on service provider. The stochastic process is applied for load balancing. The mobile nodes may have different
load level. If it exceeds their level at that time load balancing is needed. Using the LB-CSDM nodes, load is distributed based on the steady state probability distribution. Simulations are carried out to investigate the load balancing values and the goals that have been achieved by this new system which are as:, congestion is much reduced when observed in terms of response time, the success rate in spite of minimum bandwidth utilization by satisfying the service requester’s requests. LB-CSDM uses at least 90% less bandwidth than AODV-SD, and its average response time is at least 10% lower than AODV-SD for successful requests. When compared to the existing approach, the service discovery success ratio is improved by 23% by LB-CSDM.