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Stable and Energy Aware Service Discovery in Manet

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Abstract: MANET is perceived as a collection of mobile nodes that are free to move around. With their self-forming nature and their ability to cope with rapid changes of the topology, ad-hoc networks are attractive to a variety of applications. The applications running on MANET nodes can be viewed as services that are subject to requests from other nodes in the network. Service discovery mechanisms let the nodes advertise their services and make use of the needed services of the network. Some proposed solutions rely on the routing protocol to achieve both data forwarding and service discovery. But at any given time, the status of the communication links used in routing between the nodes depends on various factors. Frequent link breaks and repeated transmissions increase the complexity of the service discovery procedure. In order to overcome the above stated issues, a Stable and Energy aware Service Discovery (SESD) in a mobile environment is proposed. The main objective of this method is to provide a signal strength based stable and energy aware routing to provide service discovery with high success rate. Simulation results show the superiority of the proposed method compared to the existing methods.

Key words: Link stability, link strength, residual energy, Mobile Adhoc Networks (MANETs), service discovery

INTRODUCTION

Mobile Ad Hoc networks (MANET) consist of nodes equipped with transceivers that can communicate with one another without any fixed network infrastructure. Nodes in ad hoc network can communicate directly with another node located within its radio transmission range. To communicate with the node outside of its communication range, a sequence of intermediate nodes in ad hoc networks is required to relay messages on behalf of this node, resulting in multi-hop wireless network. The mobility of nodes in the ad hoc network causes variation in the signal strength of the received signals by nodes. Hence, the connectivity in MANET varies dynamically with time. This dynamic connectivity imposes a major challenge in determining the multi-hop route between a pair of nodes. The nodes in MANET offer a variety of services. A service is a facility that is useful for other nodes in a network. Service discovery allows the nodes to advertise their services and to use the needed services available in other nodes (Artail *et al*., 2008). The usual service discovery protocols used in wired networks are not suitable for mobile ad hoc networks.

Service Discovery protocols depend on the underlying service discovery architecture. Service discovery architecture can be classified into directory based architecture, directory less architecture and hybrid architecture (Kozat and Tassiulas, 2004). In directory based architecture the services are registered with a directory and the service requestors are informed about the services through the directories only. Directories are implemented either centralized or distributed. Directory less architecture do not rely on service directory. The service providers and service requestors accomplish their task by broadcasting the necessary information. Hybrid architectures combine both the approaches. The service requestors, if they are aware of service directory in their vicinity, they make use of directory; otherwise broadcasting is used to achieve service discovery. Service discovery modes are classified into proactive, reactive and hybrid. In proactive approach, service providers advertise their services in periodic time interval. Reactive mode makes use of on demand queries from the service requestors to service providers or service directories to find the required service. Hybrid mode allows the usage of both proactive and reactive service discovery modes.

Several service discovery protocols are available. Many protocols are application layer dependent. There are some SDPs that integrate the functionality of routing and service discovery. Such cross layer service discovery

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protocols may use an underlying routing protocol to invoke and get a response from a particular service residing on a particular device. These protocol piggyback service information onto routing messages. Although, the cross layer approach for service discovery reduces the redundant transmissions and saves energy, challenges imposed by this approach concern the instability of the network, very low or even nonexistent caches and resource constraints. Some proposed solutions rely on the routing protocol to achieve both data forwarding and service discovery using broadcast and multicast mechanisms. Konark (Helal *et al*., 2003), Service Rings (Klein *et al*., 2003), GSD (Chakraborty and Joshi, 2002), Allia (Ratsimor *et al*., 2002), DEAPspace (Nidd, 2001) and cross-layer types of service discovery mentioned in (Raghavan *et al*., 2008; Varshavsky *et al*., 2005) are examples. Thus service discovery and routing are quite related to each other.

The major problem of a reliable cross layer service discovery protocol is the stability among the node connection and the energy efficiency among the mobile nodes. Due to the movement of the network nodes, managing the communication link between the source and destination is a challenging task. Specifically, such communication links are usually broken under a high mobility network environment. Therefore, a reliable service discovery approach is needed which makes use of the most stable route, thus reducing the frequency of ongoing service breakage. The stable route improves the network lifetime and minimizes the rerouting frequency where the control and data packets provide higher impact on the mobile networks. In this study, a stable and energy aware service discovery approach based on link stability in a zone based topology is proposed. The major contributions of this study are:

- A hybrid service discovery architecture which uses a directory structure inside the zone and directory less architecture if no service directory is available in the zone is proposed
- Efficient way of organizing service requestor nodes to reduce the control overhead is used
- Establishing and managing the route information through the periodic beacon message for the measurement of link stability count
- Selection of Stable and Energy aware Forwarding Nodes (SEFN) for providing service response
- An overall algorithm for the complete service discovery
- Comparison of performance of the proposed method with the existing method HSDAP (Seno *et al*., 2011)

Literature review: This sstudy presents some of the related works on stable link, energy efficiency based multicast routing protocols and service discovery protocols for MANETs. Rango *et al*. (2012) proposed a link stability and energy aware routing protocol in distributed wireless networks. Here, a multi objective mathematical formulation for joint stability and energy is presented. Biradar and Manvi (2012) presented a neighbor supported reliable multipath multicast routing in MANET. A mesh of multipath routes is created from the source to destinations based on the high reliability pair factor. The reliability pair factor is based on the node power level, mobility and received signal strength among nodes. The multipath multicast mesh routes are discovered based on the minimum value of reliability pair factor and information transfer from source to destinations. Torkestani and Meybodi (2011) introduced a link stability based multicast routing protocol for wireless mobile adhoc networks. A weighted multicast routing algorithm is proposed and the mobility parameters are defined as random variables with unknown distribution. Here, the multicast routing problem is converted into an equivalent Steiner tree problem. The random weight linked with a communication link is the link's expected duration time. A learning automata based algorithm is used to solve the proxy Steiner tree problem. This algorithm estimates the most stable multicast route across mobile hosts.

Wu *et al*., (2009) proposed a reliable routing mechanism based on neighbor stability among mobile nodes. A routing mechanism based on link lifetime estimation is introduced. The nodes received signal strength is estimated based on Newton interpolation polynomial. The reference points are used to compute the link lifetime and they are selected based on the method of interception. With the constraint of link lifetime and node hop count, the source nodes formulate the route hop by hop. Xia *et al*. (2014) applied a link stability estimation mechanism for multicast routing. This estimation is based on the received signal strength among the mobile nodes. This scheme is integrated with the MAODV protocol to formulate the stability based multicast routing protocol. This protocol can recognize a number of available stable routes and it can adapt to network topology changes. R. Biradar *et al*. (2010) proposed link stability based multicast routing scheme in MANET. Here, the multicast mesh is formulated based on the route request and reply messages. The link stability maintenance database is updated for every node with the help of multicast routing information cache. The forwarding nodes are selected based on the high stability links.

Song *et al*. (2012) discussed about the link stability based on the link connectivity changes among the mobile nodes. This procedure gets performed on the network layer without the need of the lower layer data or peripheral devices. A variable sized sampling window is adopted to estimate the link transition rates. The estimation scheme is not restricted to particular network topologies or mobility models. This routing method adjusts the operating mode based on the estimated link stability. Zadin and Fevens (2013) introduced a method to maintain the path stability with node failure in mobile adhoc networks. This scheme modifies the stability protocol in the presence of node failure in order to improve the use of MANET applications by discovering the stable communication channels with improved lifetime. Priyadsrini *et al.* (2012) formulated an efficient route discovery in MANET with improved route lifetime. Here, three algorithms are used to calculate the stability of the route. It can be computed by considering the energy drain of the mobile nodes and the mobility rate.

Banerjee and Dutta (2010) discussed about the link stability and node energy for local route repair in MANET. In case of link breakage among two nodes, the method instructs the source node to broadcast the route repair message within its transmission range to rectify the broken link. After rectifying, the established route sends the repair acknowledgement message to the source node. The acknowledgement message includes the id of the destination node, geographical positions, radio ranges and residual energy for the selected path. Moreover, the stability factor is estimated based upon the relative velocities of the selected nodes and the history of the survival of the link. The optimal route is selected based on the residual energy, link stability and number of hops. Kant and Awasthi (2010) utilized a stable link based multicast routing scheme in MANET. The node selection process is based on the mobility prediction and battery power ratio methodology to construct the stable route for packet transmission. Mocito *et al.* (2011) proposed a topology stability aware multicast routing in MANET. It exploits locally perceived mobility conditions to improve the use of stable routes.

Katsigiannis *et al.* (2006) proposed architecture for service discovery based on SLP extensions, remaining energy resources and minimum number of hops in the service provisioning path. The service discovery is based on a decentralized approach and an application layer algorithm. Ververidis and Polyzos (2005) proposed extended ZRP: a routing layer based service discovery protocol for mobile ad hoc networks. A node requesting service is simultaneously informed about the service provider and route to the service provider without creating additional messages. Artail *et al.* (2008) created a service discovery model on top of the network layer in the TCP/IP stack. It takes the benefit of using the latest routing information and performs a search using Minimum Distance Packet Forwarding algorithm. Tsai *et al.* (2009) proposed a service discovery protocol based on 2-D hierarchical grid structure. It makes use of transmitting trajectory to improve the efficiency of the registration and discovery.A provider registers its service along a predefined register trajectory. When a requestor wants to access a service, it discovers the service toward the maximum grid level. The requestor canobtain the reply from the directories. The empty area problem for low node density is also addressed.

Chakraborty and Joshi (2006) proposed Group-based Service Discovery (GSD) based on the concepts of bounded advertising of services in the vicinity, peer-to-peer dynamic caching of service advertisements and service group-based selective forwarding of discovery requests. Services are described using the Web Ontology Language (OWL). The results show that GSD scales very well with increasing request load and network size. Kopena *et al.* (2005) addressed the key problems of service-based computing in manet such as service registration, service discovery and service choreography. The system uses a population of random walk service discovery agents whose task is to report service locations and capabilities to the local service registries. Kim *et al.* (2011) proposed appropriate service discovery architecture according to the characteristics of clusters. Stable clusters are constructed by analyzing the mobility of nodes. Seno *et al.* (2011) proposed a hierarchical service discovery and advertisement protocol (HSDAP) implemented in the routing layer by extending the cluster-based routing protocol (CBRP) to improve service management hierarchy. HSDAP Queries Services by combining Service Request (SREQ) packets with routing packets to reduce overhead and energy consumption.

From the related works, it is understood that the stability of links plays an important role in maintaining a successful path for communication between nodes. Also service discovery can be achieved by incorporating the service discovery architecture with the network layer routing features. Therefore a stable link based service discovery in zone structure reduces unnecessary retransmissions, reduces the energy consumption of nodes and improves the success ratio of service discovery.

MATERIALS AND METHODS

Protocol overview and network model: This study describes the working procedure of the proposed stable and energy efficient service discovery protocol in MANET and the network model used for performing service discovery.

Protocol overview: The process of service discovery in MANET is carried out based on the signal strength of the received beacons. The routing information is found from the Service Information Storage (SIS) and Stable Link Record (SLR) maintained at the nodes. Each node maintains the SIS and SLR which stores the updated periodic information of services and links received from beacons. SLR of each node maintains the link stability value, residual energy of the neighbors. Link stability is the count of the number of beacons successfully received with a reception power greater than the threshold P_{Th} taken over a time interval T which is set as 20s.

The information in the SIS and SLR are used for identifying the stable and energy aware routes. The service request and service response transmission are carried through Stable and Energy aware Forwarding Nodes (SEFN). Each node selects the node with highest link stability value from SLR as its next forwarding node SEFN. If two or more nodes have the same stability value, then the node with highest residual energy is chosen as SEFN. Table 1 presents the list of notations used in Algorithm 1. Algorithm 1 describes the overall layout of the proposed method.

Table 1: List of notations

Symbol	Description
ZA	Zone Administrator
SP	Service Provider
SR	Service Requestor
SP_Identification_Req	Request to identify Service Providers
SD	Service Directory
SDSN	Service Descriptor Storage Node
SR_Group	Service Requestor Group for scalable service delivery
SM	Service Manager
Serv_Req	Service Request
SID	Service ID
SDesc	Service Description
TTL	Time To Live
Serv_Res	Service Response
SIS	Service Information Storage
SLR	Stable Link Record

Algorithm 1: Stable and Energy Efficient Service Discovery in MANET:

Begin

//Network Formation and ZA Election
1: Initialize the number of mobile nodes
2: Divide the network area into contiguous zones
3: Each node maintains the record (Stable link, Link Strength, Residual energy, Service Description)
4: For each zone in the network,
5: Elect ZA (Refer Section 3.2)
6: End for

//SD Formation and SDSN Election
7: ZAs broadcast SP_Identification_Req packets inside the zone to identify the SPs
8: SPs reply to its corresponding ZA with SP_INFO (N_POS, SID, SDesc)
9: ZAs construct Service Directory (SD)
10: If Zone contains SP
11: Elect Service Descriptor Storage Node (SDSN)
12: ZA exchanges SD with neighbor ZAs
13: ZA handovers SD to SDSN
14: Else
15: No action required
16: End if

// SR Clustering
17: The first node requesting service initiates SR Clustering
18: If SRs are located within the transmission range R and have request for same SID
19: Add SR into the single SR_Group
21: Else
22: Construct a new SR_Group
23: End if
24: Repeat the clustering steps 22-28 until all SRs are allocated into SR_Groups

// SM Election
25: For each SR in SR_Group
27: Calculate the distance of SR from SDSN.
28: SM = min-distance (SR) and stable (SR)
29: End for

// Service Request (Serv_Req) Handling
30: Serv_Req(SID, TTL) is forwarded by SM to SDSN.
31: If the requested SID is in SD
31: SDSN forwards the Serv_Req to SP
32: SP provides Serv_Res to SDSN (uses Stable Link Neighbor Nodes)
32: Else
33: SDSN forwards Serv_Req to neighbor SDSNs.
34: Step 33 is repeated until TTL becomes 0.
35: End if

// Stable and Energy aware Service Discovery
36: If SP found
37: SDSN forwards the Serv_Res to SM (uses Stable Link Neighbor Nodes)
38: SM broadcasts the response to all individual SR in its subgroup.
39: **End**

Network model: The network formation is based on the non-overlapping contiguous zones Du et al., (2003). Each node maintains SLR table. ZAs are elected for each zone. The identification of multicast participants (MCPs) in each zone is managed by ZAs. The ZAs are selected based on three selection factors:

- Residual energy
- Link stability and
- Link strength

These values are stored and periodically updated in the SLR. Each ZA is selected such that it has highest residual energy and has more number of stable neighbors. ZA is found out based on the link stability value stored in the SLR. The sum of the number of stable links for all the neighbors in the radio range of each node is calculated for each node. The average of this stability value is considered for the selection of ZA. ZA is a node that has the highest average value of number of stable links. Based on the SLR table, the ZAs are periodically elected and updated.

Service discovery procedure: This study presents the details of directories created in each zone, clustering of Service Requestors, Service Request handling by Service Managers and the communication of the Service Response through Stable and Energy aware Forwarding Nodes.

Service directory(sd) formation and service descriptor storage node election: Service storage depends on the directory based architecture. The zone based architecture reduces the complexity of maintaining the directory and improves the success ratio. Zone Administrators broadcast SP_Identification_Req packets inside the zone to identify the Service Providers. The nodes that wish to act as Service Providers, reply to its corresponding Zone Administrator with SP_INFO (N_POS, SID, SDesc). SP_INFO is an XML structure Tyan and Mahmoud (2004) and helps in the efficient matching of the service providers as per the needs of the requestor. ZA upon receiving the service information from the service providers construct Service Directory (SD). ZA exchanges Service Directory with neighbor ZAs and elect Service Descriptor Storage Node (SDSN) for its corresponding zone if service providers are available in that zone. SDSNs are only elected at zones which include the SPs. Even if any of the ZAs fails or crashes, SDSN continues its service.

The dynamic nature of the network does not affect the performance because the physical proximity of service requestors and SDSNs are nearer since zone based structure is considered. ZA then handovers SD to SDSN. Further storage of service information and providing results to service requests are managed by SDSNs. This reduces the load of ZAs.

Service requisition and service discovery: Service requisition is handled by the service managers elected inside each zone. Service request handling and service reply delivery are forwarded through the stable and energy aware forwarding nodes.

SR Clustering and SM election: The first node requesting service initiates SR Clustering. If SRs are located within each other’s radio range and have requested for same SID they are grouped into single SR_Group. Otherwise a new SR_Group is constructed. All SRs become part of SR_Groups. This avoids separate processing for the same service request inside the zone and thus reduces the number of control packets. Service manager is selected for each SR_Group for further handling of service queries. SM is a node which is at a minimum distance from SDSN of that corresponding zone and is having maximum residual energy among the SR_Group.

Service request handling and service discovery: Route is found between SM, SDSN and then between SDSN and SPs using SEFNs as mentioned in Section 3.1. The route finding process considers only the stable links. SM acts as a representative for the service requestors and sends the service request Serv_Req containing SID, TTL to SDSN through the route. SDSN checks to see ifthe requested SID is in SD maintained by it. If it can find a service provider for the requested service, SDSN forwards the Serv_Req to the corresponding SP. In case SDSN inside the zone cannot find a service provider, it forwards Serv_Req to neighbor SDSNs. The forwarding processes can continue until TTL becomes 0. If TTL becomes 0, NO_Serv reply mentioning that no service is found is sent back to the SM and SM can restart the discovery process after waiting for a random amount of time.

If Service Provider is successfully found, the Serv_Req is handed over to SP. SP replies with a service response Serv_Res to SDSN. SDSN forwards the Serv_Res to SM. SM conveys the Serv_Resto all individual SR in its SR_Group using a single broadcast. The Service Providers are initially identified with the help of ZA and then they are handled by SDSN. Service request and response handling are taken care by SM. Hence the load is shared among the nodes and the lifetime of the nodes increases. Also, all the communication is carried out through the Stable and Energy aware Forwarding intermediate nodes. Therefore the success ratio increases.

RESULTS AND DISCUSSION

Performance analysis: In this study, the performance of the proposed method is experimented and compared with the existing method HSDAP (Seno *et al*., 2011) based on the performance metrics mentioned in HSDAP. The experimentations were conducted in NS2. A MANET is designed by uniformly and randomly distributing the mobile nodes within the simulation area of size 1000 X 1000m. The radio parameters are chosen from the specification of the Lucent 2.4 GHz IEEE 802.11 WaveLAN PC “Bronze” (2Mbps) Card (Awerbuch *et al*., 2004) for comparison with the already existing method. Two ray ground propagation model parameters A_T, $A_R$and C are set to 1. All nodes use omnidirectional antennas.

The energy model mentioned by Feeney and Nilsson (2001) and Seno *et al*. (2011) is set in the simulation environment.

Table 2: Simulation parameters

Parameter	Value
Network area	1000 X 1000m
Simulation time	9000s
Mobility model	Random way point
Traffic type	Constant bit rate
Transmission radius	250m
Capture threshold	10
Receiving threshold P_{Th}	-91dBm
Bandwidth	2 Mbps
Packet size	512bytes
Pause time	4s
Idle power	0.843W

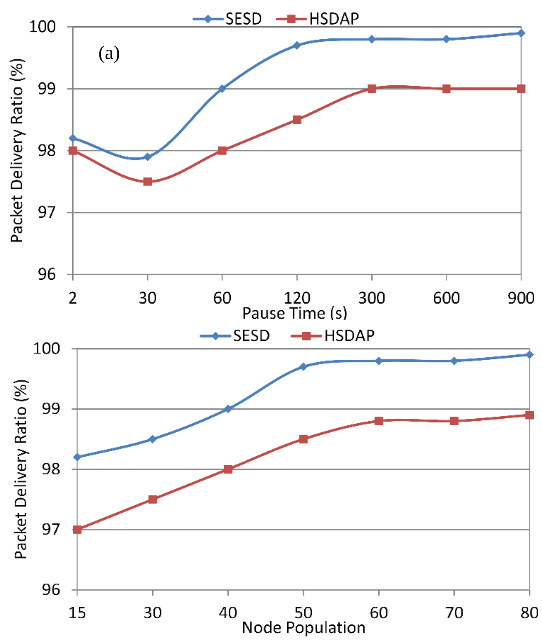

Fig. 1: a) Packet Delivery Ratio (PDR) vs Pause Time for the proposed SESD with HSDAP; b) Packet Delivery Ratio (PDR) vs Node Population for the proposed SESD with HSDAP

The mobility model for each node is considered to be the random waypoint model. The speed of the nodes varies between 0m/s to 20m/s. IEEE 802.11 Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) Distributed Coordinated Function (DCF) is used as the MAC protocol to avoid collisions. Constant Bit Rate traffic is used. The packets are transmitted at the rate of 20packets/s. The packet size is fixed to 512 bytes and transmitted through a channel capacity of 2 Mbps. The beacon interval is set to 2s. Beacons are observed over a time period T which is set to 20s. Each node is modeled and assumed to be aware of its mobility information with the help of a reliable positioning system. Services are randomly assigned to the nodes. The simulation experiment is run for 900s. The performance is evaluated

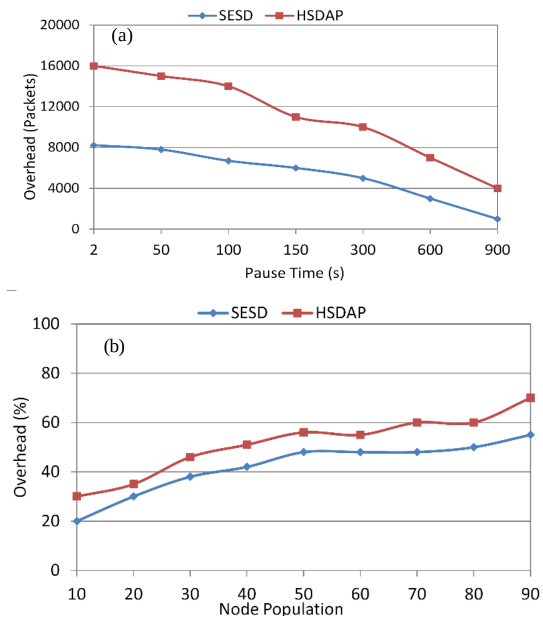

Fig. 2: a) Control overhead vs pause time for the proposed SESD with HSDAP; b) Control overhead vs node population for the proposed SESD with HSDAP

based on the following metrics such as: packet delivery ratio, control overhead, mean delay, service success ratio, average memory utilized and energy consumption. Table 2 presents the major simulation parameters used for analyzing the performance of the proposed method.

Packet delivery ratio: Packet Delivery Ratio (PDR) is defined as the ratio of average number of packets received by the destination and the average number of packets sent. The higher values of the packet delivery ratio infer the efficiency of the routing technique.

In the first set of experiments as shown in Fig. 1(a) packet delivery ratio is measured in terms of increased pause time. As the pause time increases the PDR of the proposed SESD results higher packet delivery ratio than the existing protocol HSDAP. Since SESD determines its path based on stable link PDR is better than HSDAP. As the node population increases the number of requests may increase. But the SMs managing SR_Groups covers most of the node in range and (Fig. 1b) hence the PDR of SESD is better than HSDAP. In addition, the proposed link stability mechanism reduces the link failures and finds the most stable path providing an assured better PDR.

Control overhead: Control overhead is measured against the varying pause time. It is defined as the number of control messages exchanged by the nodes in establishing the communication route. The graph in Fig. 2a shows

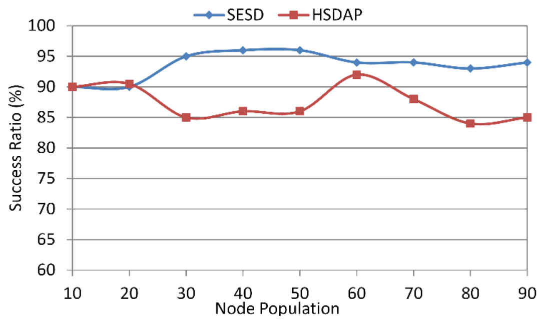

Fig. 3: Service success ratio vs node population for the proposed SESD with HSDAP

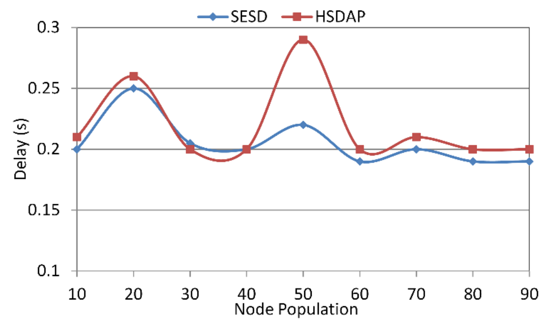

Fig. 4: Delay vs node population for the proposed SESD with HSDAP

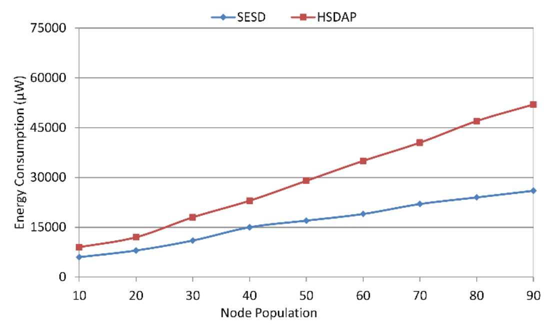

Fig. 5: Energy Consumption Analysis for the proposed SESD with HSDAP

that overhead is less than HSDAP. The overhead is less because the routes are established based on signal strength with the expectation to provide a stable route for a long duration and hence the percentage of failures are less in SESD. Fig. 2(b) shows the percentage of control overhead incurred as the node population increases. As ZAs are used to manage the zone information, SESDs are used for service handling and SESDs are elected in only those zones which contain the SPs, the lifetimes of nodes are extended and thus the frequent reelection processes in zones are reduced. Even if ZA gets crashed, the ongoing servicing is not affected because of the presence of SDSN. Also, even the number of nodes increases, they are handled successfully because of their coverage by the SMs. Hence, the proposed method requires lesser control packets for the entire servicing than the existing protocol.

Service success ratio: Service success ratio is measured by the number of successful service replies got by the SMs from SDSN. The search for the availability of services is initially carried out inside the zone by checking the SDSN of the corresponding zone. If service is not available inside zone, then the search continues in neighbor SDSN until either service is found or TTL becomes 0. Fig.3 shows that the service success ratio of SESD is better than HSDAP. SESD utilizes stable and energy aware route for service discovery. Therefore the failure of links is mitigated and the path established for service discovery is stable and the reply can reach the requestors with high possibility of success.

Delay: Delay is defined as the average time taken during the service discovery process. The time utilized to build a route is also included in this metric. Fig.4 shows the comparison of the delay for the proposed SESD and the existing HSDAP protocol. The result shows that SESD achieves more or less the same delay of HSDAP. The proposed SESD has a slightly lesser delay than HSDAP because SMs reach their corresponding SRs in a single broadcast. Even if the number of SRs in a SR_Group is more, the time to deliver service to each SR is reduced by single broadcast.

Energy consumption: The proposed SESD uses only the most stable and energy aware nodes to forward the packets. The number of failures is reduced and henceforth, the necessity of energy utilization for packet retransmission is almost alleviated. Fig.5 shows the comparative analysis of the energy utilization for the proposed SESD with HSDAP. SESD balances the load by utilizing ZA, SDSN and SM. HSDAP also achieves load balancing with the help of Cluster Heads (CHs). But SESD employs SMs with further reduces the load by one step and hence the work of all nodes is reduced a bit. This results in overall reduced energy consumption than HSDAP.

CONCLUSION

In this study, a stable and energy aware zone based service discovery protocol is proposed. A service discovery method allows the mobile nodes to advertise their own capabilities to the network and helps to automatically locate the services with the requested attributes. The zone based structure helps to improve the network performance in mobile environment. The ZA helps to update and manage the zone information. SDSNs are used to for maintaining service storage. SR_Groups and SMs are used for performing service discovery successfully. The stable and energy aware paths are established by selecting the SEFNs which possess the higher values of link stability among the neighbor nodes. This ensures better quality of links and it reduces the possibility of link failures and the overhead to formulate the paths. The proposed method is implemented and compared with the existing HSDAP protocol. The major parameters to analyze the network performance during service discovery is simulated and examined. The proposed SESD performs better and results stable performance than the existing protocols. It provides uninterrupted services to the mobile participants.

RECOMMENDATION

In future several QoS parameters can be considered in making routing decisions for achieving service discovery without affecting the performance of the system.

REFERENCES

Artail, H., K.W. Mershad and H. Hamze, 2008. DSDM: A distributed service discovery model for manets. Parallel Distrib. Syst. IEEE. Trans., 19: 1224-1236.

Awerbuch, B., D. Holmer and H. Rubens, 2004. High Throughput Route Selection in Multi-Rate Ad Hoc Wireless Networks. In: Wireless on-Demand Network Systems. Roberto, B., C. Marco and L.C. Renato (Eds.). Springer Berlin Heidelberg, Berlin, Germany, ISBN: 978-3-540-20790-0, pp: 253-270.

Banerjee, A. and P. Dutta, 2010. Link stability and node energy conscious local route-repair scheme for mobile ad hoc networks. Am. J. Applied Sci., 7: 1139-1147.

Biradar, R., S. Manvi and M. Reddy, 2010. Link stability based multicast routing scheme in MANET. Comput. Networks, 54: 1183-1196.

Biradar, R.C. and S.S. Manvi, 2012. Neighbor supported reliable multipath multicast routing in MANETs. J. Network Comput. Appli., 35: 1074-1085.

Chakraborty, D. and A. Joshi, 2002. GSD: A novel group-based service discovery protocol for MANETS. Proceedings of the 4th IEEE Conference on Mobile and Wireless Communications Networks, July 2002, IEEE Xplore Press, USA., pp: 140-144.

Chakraborty, D., A. Joshi, Y. Yesha and T. Finin, 2006. Toward distributed service discovery in pervasive computing environments. Mobile Comput. IEEE. Trans., 5: 97-112.

De Rango, F., F. Guerriero and P. Fazio, 2012. Link-stability and energy aware routing protocol in distributed wireless networks. IEEE Trans. Parallel Distrib. Syst., 23: 713-726.

Du, H., H. Hassanein and C. Yeh, 2003. Zone-based routing protocol for high-mobility MANET. Proceedings of the IEEE CCECE 2003 Canadian Conference on Electrical and Computer Engineering, May 4-7, 2003, IEEE, Queen's University, Canada, ISBN: 0-7803-7781-8, pp: 1055-1058.

Feeney, L.M. and M. Nilsson, 2001. Investigating the energy consumption of a wireless network interface in an Ad Hoc networking environment. Proceedings of the 20th Annual Joint Conference of the IEEE Computer and Communications Societies, April 22-26, 2001, Anchorage, AK, USA., pp: 1548-1557.

Helal, S., N. Desai, V. Verma and C. Lee, 2003. Konark-a service discovery and delivery protocol for ad-hoc networks. Proceedings of the 2003 IEEE Conference on Wireless Communications and Networking WCNC, March 20, 2003, IEEE, New Orleans, Louisiana, ISBN: 0-7803-7700-1, pp: 2107-2113.

Kant, K. and L.K. Awasthi, 2010. Stable link based multicast routing scheme for MANET. Proceedings of the 2010 International Conference on Computational Intelligence and Communication Networks (CICN), November 26-28, 2010, IEEE, Bhopal, India, ISBN: 978-1-4244-8653-3, pp: 296-300.

Katsigiannis, C.I., D.A. Kateros, E.A. Koutsoloukas, N.D. Tselikas and I.S. Venieris, 2006. Architecture for reliable service discovery and delivery in manets based on power management employing SLP extensions. Wirel. Commun. IEEE., 13: 90-95.

Kim, Y.S., Y.S. Shim and K.H. Lee, 2011. A cluster-based web service discovery in MANET environments. Mob. Inf. Syst., 7: 299-315.

Klein, M., B.K. Ries and P. Obreiter, 2003. Service rings: A semantic overlay for service discovery in ad hoc networks. Proceedings of the 14th International Workshop on Database and Expert Systems Applications, September 1-5, 2003, IEEE, Karlsruhe Institute of Technology, Germany, ISBN: 0-7695-1993-8, pp: 180-185.

Kopena, J., E. Sultanik, G. Naik, I. Howley, M. Peysakhov *et al*., 2005. Service-based computing on manets: Enabling dynamic interoperability of first responders. Intell. Syst. IEEE., 20: 17-25.

Kozat, U.C. and L. Tassiulas, 2004. Service discovery in mobile ad hoc networks: An overall perspective on architectural choices and network layer support issues. Ad Hoc Networks, 2: 23-44.

Mocito, J., O. Denysyuk, L. Rodrigues and H. Miranda, 2011. Topology stability-aware multicast protocol for MANETs. Proceedings of the 2011 IEEE 36th Conference on Local Computer Networks (LCN), October 4-7, 2011, IEEE, Bonn, Germany, ISBN: 978-1-61284-926-3, pp: 287-290.

Nidd, M., 2001. Service discovery in DEAP space. Pers. Commun. IEEE., 8: 39-45.

Priyadsrini, S., T.M. Navamani and V. Mahadevan, 2012. An Efficient route discovery in manets with improved route lifetime Int. J. Inf. Electron. Eng., 2: 493-496.

Raghavan, B., J. Harju and B. Silverajan, 2008. Service Discovery Framework for MANETs using Cross-Layered Design. In: Wired/Wireless Internet Communications. Harju, J., G. Heijenk, P. Langendorfer and A.S. Vasilios (Eds.). Springer Berlin Heidelberg, Berlin, Germany, ISBN: 978-3-540-68805-1, pp: 152-163.

Ratsimor, O., D. Chakraborty, A. Joshi and T. Finin, 2002. Allia: Alliance-based service discovery for ad-hoc environments. Proceedings of the 2nd International Workshop on Mobile Commerce, September 28, 2002, ACM, New York, USA., pp: 1-9.

Seno, S.A.H., R. Budiarto and T.C. Wan, 2011. A routing layer-based hierarchical service advertisement and discovery for MANETs. Ad Hoc Networks, 9: 355-367.

Song, Q., Z. Ning, S. Wang and A. Jamalipour, 2012. Link stability estimation based on link connectivity changes in mobile ad-hoc networks. J. Network Comput. Appl., 35: 2051-2058.

Torkestani, J.A. and M.R. Meybodi, 2011. A link stability-based multicast routing protocol for wireless mobile ad hoc networks. J. Network Comp. Appl., 34: 1429-1440.

Tsai, H.W., T.S. Chen and C.P. Chu, 2009. Service discovery in mobile ad hoc networks based on grid. Veh. Technol. IEEE. Trans., 58: 1528-1545.

Tyan, J. and Q.H. Mahmoud, 2004. A network layer based architecture for service discovery in mobile ad hoc networks. Proceedings of the Canadian Conference on Electrical and Computer Engineering, May 2-5, 2004, IEEE, Ontario, Canada, ISBN: 0-7803-8253-6, pp: 1379-1384.

Varshavsky, A., B. Reid and E.D. Lara, 2005. A cross-layer approach to service discovery and selection in MANETs. Proceedings of the IEEE International Conference on Mobile Adhoc and Sensor Systems Conference, November 7, 2005, IEEE, Washington, D.C., USA., ISBN: 0-7803-9465-8, pp: 8-466.

Ververidis, C.N. and G.C. Polyzos, 2005. Extended ZRP: A routing layer based service discovery protocol for mobile ad hoc networks. Proceedings of the Second Annual International Conference on Mobile and Ubiquitous Systems: Networking and Services, July 17-21, 2005, IEEE, Athens, Greece, ISBN: 0-7695-2375-7, pp: 65-72.

WU, D.P., M.Q. WU and Z. Yan, 2009. Reliable routing mechanism based on neighbor stability for MANET. J. China Universities Posts Telecommun., 16: 33-39.

Xia, H., S. Xia, J. Yu, Z. Jia and E.H.M. Sha, 2014. Applying link stability estimation mechanism to multicast routing in MANETs. J. Syst. Archit., 60: 467-480.

Zadin, A. and T. Fevens, 2013. Maintaining path stability with node failure in mobile ad hoc networks. Procedia Comput. Sci., 19: 1068-1073.