ISSN: 0976-3104
SPECIAL ISSUE (ASCB)
Reddy et al.

THE IIOAB JOURNAL

ARTICLE OPEN ACCESS

CLAMR-AN ENHANCED BIO-INSPIRED ROUTING PROTOCOL FOR WIRELESS ADHOC NETWORKS

Pradeep Reddy[1*], Jagadeesh Gopal[1], Arun Kumar Sangaiah[3]

[1]School of Information Technology and Engineering, VIT University, Vellore, TN, INDIA
[2]School of Computer Science and Engineering, VIT University, Vellore, TN, INDIA

ABSTRACT

Establishing communication through portable devices without the dependence on or constraints of any central infrastructure is possible in Ad hoc networks. But this very feature of the absence of a central infrastructure and the random mobility of the devices also give rise to multiple problems involving security and routing. The challenge encountered by multicast routing protocols in this ambience is to envisage creating a multi-hop routing within the constraints of the mobility of the host and the bandwidth. The role of multicast routing in wireless ad hoc networks is very significant and pivotal. We intend presenting in this paper a novel on-demand multicast routing protocol known as Cross-Layered Ant Colony Optimization Multicast Routing Protocol (CLAMR). This selected protocol is an improved and enhanced version of the already existing on-demand multicast routing protocol (ODMRP) with the enhancement of Bio-inspired Ant Colony mechanism. The fundamental mechanism of ODMRP is utilized in the proposed method along with the enhanced features of cross layer, applying ant colony optimization. This CLAMR is a robust and efficient protocol with minimal overhead. The scalability and improved performance levels of the proposed algorithm at higher traffic load in comparison to the existing algorithms are evident from the simulations performed using network simulator 2.

Received on: 17th-Feb-2015
Revised on: 24th-April-2015
Accepted on: 12th– May-2015
Published on: 8th–Aug-2015

KEY WORDS

Cross layered, Ant Colony, ODMRP, Wireless Networks

***Corresponding author:** **Email:** pradeep1417@gmail.com; **Tel.:** + 91-8056600142

INTRODUCTION

Several routing schemes have been projected for the purpose of providing adequate and efficient performance of ad hoc networks. Basing on time based determination of routes; ad hoc routing is classified as proactive [1-4] or reactive routing [1-6]. Routing decisions are continuously made in proactive routing in such a way that the routes are instantly available when transmission of packets is required. Some existing proactive protocols are DBF, DSDV [1] and WRP. Routes in reactive routing protocols [2] are determined on the basis of as-needed i.e., the node requests for a route when there is a need to transmit a packet. TORA, DSR [3], AODV [1], ABR and RDMAR are a few reactive routing protocols. Exchange of routing information in proactive routing consumes a large amount of radio resources. In addition, the validity of the pre-determined routes in an ad hoc network may rapidly be lost corresponding to its rapidly changing topology. Prior studies prove that the reactive protocols are effective in performance when compared with the proactive protocols. In recent years several multicast [6-8] routing protocols along with the existing unicast routing protocols have been proposed for ad hoc networks. Some of the proposed multicast routing protocols are capable of supporting unicast routing also, which itself is a special form of multicast. The two-fold classification of the proposed multicast routing is as tree-based and mesh-based. Tree-based protocols [7, 8, 10] create a tree connecting all its multicast members. Generally, tree-based protocols are considered more efficient in comparison to the mesh-based protocols. But, the absence of an alternate path between the source and destination conditions it as less robust in the contexts of changing topologies. Consequently, failure of every link in a multicast tree may trigger a series of exchanges of control messages for tree re-build. In contrast to the tree-based protocols having only on existing path between any two nodes, mesh-based protocols permit existence of redundant paths between the nodes with their built-in mechanism of provision for alternate paths and as a result failure of a link need not require or initiate a re-computation of a mesh. Mesh-based protocols are proved to be robust as per the previous studies.

ODMRP [6] is a multicast mesh-based ad hoc routing protocol. The source node in ODMRP protocol periodically broadcasts Join Request whenever it has data to be sent in order to discover and maintain the multicast routes. Rest of the nodes, when they receive non-duplicate packet, re-broadcast it. On receiving Join Request, the

ISSN: 0976-3104

multicast group member node replies with a Join Reply. A route is established through all the subsequent replies by the nodes in the reverse path. Use of soft states in ODMRP marks leaving a group in an automatic timeout. As illustrated, reliance of ODMRP on frequent network-wide flooding may result into a problem of scalability particularly when the source nodes are more. More prominent control packet overhead can be perceived in the context of small multicast group in comparison to the total network.

RELATED WORKS

In recent studies, there is an extensive focus on the discovery of multipath and extension of QoS of the on-demand routing protocol in such a way as to address the issues pertaining to the single path routing protocols such as AODV [1, 2, and 9] and DSR [1-6]. Ant colony-based multi-path QoS-aware routing (AMQR) [11, 13, 14, and 15] integrates link-disjoint multipath routing and swarm intelligence to choose multiple paths for providing QoS services [16, 17, 18, 19]. The nature of the ad hoc routing protocols whether proactive or reactive depends on the factor of when the routes are determined. With the process of a continuous exchange of routing information among [20] nodes, the routes to destination are pre-determined in proactive routing protocols. When packets need to be transmitted, immediate availability of routes is ensured. Wireless Routing Protocol (WRP) [1-6] and the Destination Sequenced Distance Vector (DSDV) [2] routing protocol are a few instances of proactive routing protocols [1-6]. In contrast, routes are determined on-demand only in reactive routing protocols. A node sends a query for a route to the network when required to transmit a packet. TORA, DSR and AODV [9] are some much known reactive ad hoc routing protocols. But exclusively proactive or reactive routing protocols do not suit the requirements of MANETs. More frequent changes in network topology than the routing requests are possible in MANETs. In such circumstances, the information of routing generated by the proactive routing protocols stays stale. On the other hand, the reactive routing protocols [1-6] conduct a global search for on-demand route discovery process requiring considerable traffic control. This can easily result in saturation in the bandwidth constrained MANETs in a very short interval of time. So, the literature proposes a number of ad hoc multicast routing protocols which are much more than being just extensions of the unicast routing protocols under reference. This is exactly the opposite of what is experienced in wired networks with the several multicast routing protocols acting just as multicast extension counterparts of their corresponding unicast routing protocols. An ad hoc routing protocol to be robust and efficient, must not depend or rely on any implied unicast routing protocol for determining the route or updates. Extensive work has been done for evaluating the performance of the protocols of routing in ad hoc networks.

PROPOSED MODEL

CLAMR can be interpreted as a QoS enabled multipath routing protocol developed on the basis of the foraging behavior of ant colony [15, 21]. The source generates both the ant agents (called reactive FW_ANT) to find multiple paths to the destination and BW_ANT to set up return paths [18]. The respective qualities of the paths are indicated in the form of pheromone table. NHA is considered as metric during the route discovery phase to assess the goodness of the highly available links and nodes. The NHA is considered for finding the path. The metrics used for the computation of NHA [15, 19] are the availability of nodes and links. The NHA can be explained as the probability to discover the next hops [19], which is the node and link availability for routing on a path.

Next hop availability = Link probability × node probability ------------(1)

At the phase of route discovery, a source node desirous of transmitting information to the destination node first verifies the trusted neighbors. Then such nodes with greater NHA [21] than threshold are selected. Next, the source node initiates broadcasting FANT to all its neighboring trusted nodes having the NHA in order to control the routing overhead.

Any intermediate node receiving the FW_ANT, first verifies if its own address figures in the path field. If the address is present, it discards the FW_ANT at that stage itself to eliminate further loops. Or else it attaches its address to FW_ANT and then initiates broadcasts by its NHA values to all its trusted and stable neighbors. In the process of searching for the destination, the FW_ANT collects delay of transmission of each link, delay of processing at each node, each link's available capacity and visited number of hops. On FW_ANT arriving at the destination node d, the destination node first computes the path preference value, by employing end-to-end delay parameter for only such paths meeting the threshold values prescribed by the user and thus generate BW_ANT.

Visiting nodes in the path are stacked in the FW_ANT. By popping up such nodes present in the stack, the BW_ANT is unicasted to the source node.

The pheromone value [21] gets updated when the backward ant reaches any middle node other than the destination node. The pheromone value gets updated in the routing pheromone table of node i as $T_{i,n}$ [15] and it is updated as

ISSN: 0976-3104

$$T_{i,n} = \left(1 + T_{i,n}\right) P\left(K\right)_d \text{ ------------------------------------ (2)}$$

Where $P\left(K\right)_d$ [15] is the path preference value of the kth path that satisfied the QoS requirements for the destination d.

Ant colony optimization for ODMRP

In the mesh based ODMRP multicast, packets are transmitted to the destination by employing the concept of a forwarding group. It can be termed a 'reactive protocol' as it makes use of 'on-demand' procedures for dynamically building up routes and maintaining multicast group membership. The drawbacks inherently present in tree protocols, such as intermittent connectivity, configurations of tree and computations of shortest paths can be avoided through the use of mesh topology. For the maintenance of multicast group members, ODMRP makes use of a soft-state approach. Explicit control information is not required to desert the group. We intend to provide an elaborate explanation of the functioning the process of mesh creation of enhanced ODMRP duly considering the ant colony optimization. The network is flooded with FW-ANT message whenever the source node has data to transmit. The intermediate node, after receiving a (non-duplicate) FW-ANT packet, stores and updates the information regarding the upstream node. The Intermediate nodes continue to flood the FW-ANT packet. After receiving the FW-ANT packet, the receiver builds the PHEROMONE TABLE and transmits the BW-ANT to its neighbors. Then, all the nodes receiving the BW-ANT packets verify their individual IDs against the ID contained in the BW-ANT packet. If a matching is found, the node becomes the forwarding member of the group by setting the FG_Flag (Forward Group Flag). Further propagation of FW-ANT packet continues, till it arrives at the source. Through the broadcasting of FN-ANT [15, 21] packets at regular intervals, the senders maintain an update of the multicast group. The following data structures are required to be maintained by each host that runs ODMRP:

•**Routing table** – Each node reactively creates a route table and maintains it. When a non-duplicate FW-ANT containing high pheromone value is received, corresponding entry is inserted or updated. The node stores the information regarding the destination and the subsequent hops to the destination. Next hop information during the transmission of BW-ANT is provided by the route table.

•**Forwarding group table** – The multicast group information is stored in the forwarding group table by the node acting as a forwarding group node of a multicast. It records the group ID of the multicast and the time stamp.

• **Trust Pheromone table** – It is a table that contains the trust value of the neighbors depending on the threshold value from end-to-end delay.

•**Neighboring Information table** – This table contains the required information about all the set of neighbors in any specific network.

This table contains the required information about all the set of neighbors in any specific network.

Cross layer model

MAC and NETWORK layers are fused in the proposed cross layered model in order to achieve a cross layer factor. The load of the node and the bandwidth available for a specific node are calculated. We derive a cross layer factor *clfact* [16] on the basis of these calculations. This cross layer factor can be used as a metric for determining the path from source to destination. Use of the enhanced ODMRP mechanism with Ant Colony Optimization [20, 21] can find all the source- to- destination corresponding routes in network layer. We compute the length of the node and the available bandwidth in each node of the specific routes.

Let B(s) be the available bandwidth at source node s. and B(r) is the available bandwidth at receiver node r, then

B(s,r) = Min(B(s), B(int1), B(int2)……B(r)) -----------------------------(3)

Where B(s,r) is the available bandwidth for the entire link between source node and receiver node.

Then, apply this mechanism of cross layer to the paths provided by the network layer and select such route having effective *clfac* for the given data rates. In comparison to the original ODMRP mechanism, we get more efficiency and reduced overhead.

1. Calculate the node load for a node i in the network.

$$nodeload_i = \frac{queue\_len_i}{queue\_len\_nodes} \text{ --------------------------(4)}$$

2. Calculate the available bandwidth for a node i

THE IIOAB JOURNAL
ISSN: 0976-3104

$$Bdw_i = Bdw_{ch} * \left(\frac{t_i}{tot\_time} \right) * 0.8 \text{ ------------------------ (5)}$$

Where Bdw_i is the bandwidth of node i, Bdw_{ch} is the channel bandwidth and 0.8 is the weight factor.

3. Apply cross layer design over network and Mac layer parameters.

$$clfactor = (Max(Bdw_i, nodeload_i)) \text{ -------------------- (6)}$$

Recovery of intermediate node failure

On identification of any route-disruption resulting out of the mobility of the subsequent node along that specific route, the network layer at an intermediate node (referred from now on as FP or failure point) dispatches a packet, indicating Path Failure Notification (PFN) to the source. When the PFN packet is received, every intermediate node invalidates a particular route and blocks further traffic of packets through that route to that specific destination. However, the PFN can be discarded, if the intermediate node has knowledge of any alternate route, which can be utilized for further support in communication. Or else, the node just disseminates the RFN towards the source. The source shifts into snooze mode after the receipt of PFN and carries out subsequent recovery mechanism. The source continues to be in the snooze mode till it receives the restoration notification of the route through the packet of a Route Re-establishment Notification (RRN).

Use of Path Failure Timer checks the source from remaining in the snooze mode indefinitely expecting the arrival of an RRN that could either have been delayed or lost. This timer starts on the source receiving the first PFN. On expiry of the Path Failure Timer, the frozen timers start (as if they received an RRN) and permit the congestion control mechanism of the TCP to take care of the failure.

RESULTS AND DISCUSSION

Radiographic For the purpose of simulation, we utilized NS-2 [22] network simulator. A network model of 50 randomly placed nodes covering an area of 1000m x 1000m figure in our simulation. The simulator functions with a range of 250 meters radio propagation with channel capacity of 2 Mbits/Sec. The size of the multicast group varies with one source in each group sending at the rate of 20 Packets/Sec. 300 seconds of simulation is executed in each simulation. We collected data and averaged over the results arrived at by changing the send numbers in different multiple runs for each changing scenario.

The proposed model utilized the following metrics in order to estimate the performance of the proposed CLAMR mechanism:

•**Packet Delivery Throughput**: This can be described as a corresponding quantification of data packets received at the destination and the dispatched data packets by the CBR sources.

•**End-to-End Delay of Data Packets**: It is the delay in time between the times of packet origin at the source and packet reaching at the destination. We do not consider the enrooted lost data packets here. But the delay metric certainly considers the delays cropping up due to route discovery, queuing and transmission. Performance of our approach is evaluated by a comparison against the approaches of ODMRP and CL-ODMRP. The performance of the proposed system in comparison to the methods already in existence explicitly appears to be much enhanced as can be perceived from **Figure–1** and **Figure–2**.

The performance of the protocol is further evaluated in varying network scenarios such as the speed of node moving, size of the multicast group and multicast group number.

Node moving speed: 20 multicast destinations are set in this simulation with only 1 source sending the data packets. The rate of traffic generation is 10 packets per second.

Figure-1 illustrates the performance of packet delivery ratio of CLAMR with CL-ODMRP and ODMRP, respectively, in varying moving speeds. A similarity in performance can be perceived with CL-ODMRP and ODMRP while the speed of the node moving is low. High mobility of the node, generating high dynamics in a built forwarding structure is the reason for this.

ISSN: 0976-3104

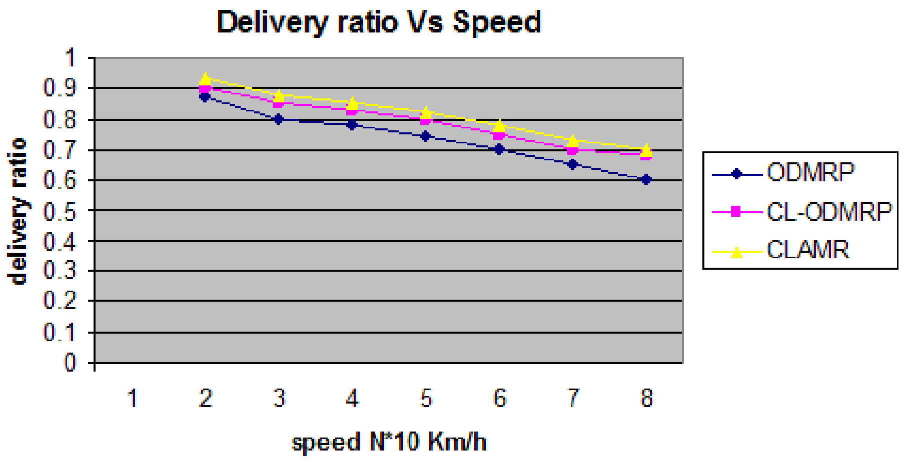


Fig: 1. Packet delivery rate vs speed

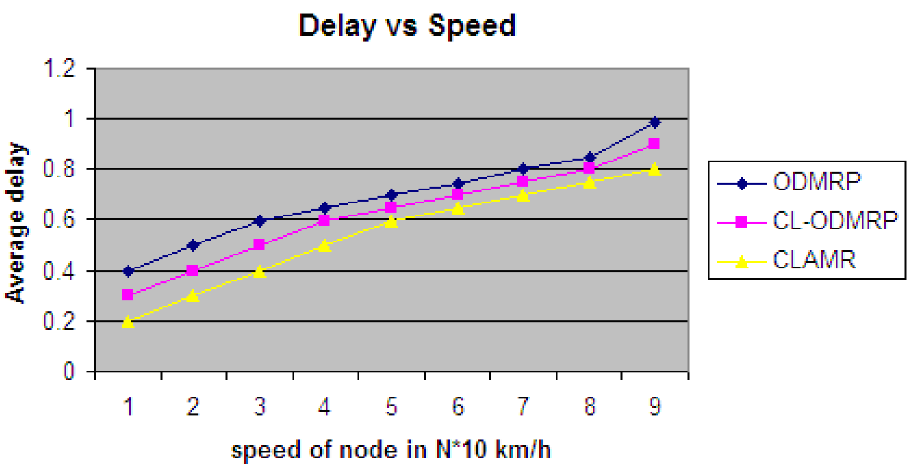


Fig: 2. Comparison of Average delay with CLAMR

Figure-2 displays a comparison of the average delay of CLAMR against CL-ODMRP and ODMRP, respectively in the context of different moving speeds. A reduction of delay upto 15% as against ODMRP can be achieved through the introduction of cross layer- based ant colony optimization strategy CLAMR.

CONCLUTION

In this paper, the proposed model Cross-Layered Ant Colony Optimization Multicast Routing Protocol (CLAMR) utilizes the nature inspired ant colony optimization algorithm to find multiple paths during the route discovery phase. A QoS factor has been included to find goodness of the path. The QoS factor is obtained from the cross layer technique. The proposed model yields effective throughput and less delay with the optimizations.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

ACKNOWLEDGEMENT

None.

FINANCIAL DISCLOSURE

No financial support was received to carry out this project.

REFERENCES

[1] Ade SA, Tijare PA. [2010] Performance Comparison of AODV, DSDV, OLSR and DSR Routing Protocols in Mobile Ad Hoc Networks, *International Journal of Information Technology and Knowledge Management*. July-December 2010. 2 :545–548

[2] SS Tyagi. RK Chauhan Performance Analysis of Proactive and Reactive Routing Protocols for Ad hoc Networks International *Journal of Computer Applications* (0975 - 8887) Volume 1 - No. 14.2010.

[3] C Siva Ram Murthy and BS Manoj.[2004] Ad Hoc Wireless Networks Architectures and Protocols, PRENTICE HALL, 2004.

[4] Abolhasan M, Wysocki TA, Dutkiewicz E. [2004]'A review of routing protocols for mobile ad hoc networks', *Elsevier J Ad hoc Netw*, 2: 1–22

[5] Luo J, Ye D, Xue L, Fan M. [2009]'A survey of multicast routing protocols for mobile ad-hoc networks', *IEEE Commun Surv Tuto,* 11 (1): 78–91

[6] Nasipuri A, Das SR. [1999] 'On-demand multipath routing for mobile ad hoc networks'. *Proc. Eighth Int. Conf. on Computer Communications and Networks*, 64–70.

[7] Gerla M, Lee Y, Park J, Yi Y. [2005]'On demand multicast routing with unidirectional links'. Proc. IEEE WCNC'05, 2162–2167

[8] Zhang B, Mouftah HT.[2006] 'Destination-driven shortest path tree algorithms', *J High Speed Network.* 15(2):123– 130

[9] Park J, Moh S, Chung I.[2008] 'A multipath AODV routing protocol in mobile ad hoc networks with SINR-based route selection'. *IEEE* Int. Symp. Wireless Communication Systems, ISWCS'08, 21–24 October 2008, 682–686.

[10] Lee SJ, Gerla M. [2001]'Split multipath routing with maximally disjoint paths in ad hoc networks'. *IEEE* Int. Conf. on Communications, 10:3201–3205.

[11] Misra S, Obaidat MS, Dhurandher SK, Verma K, Gupta P. [2009] Using ant-like agents for fault-tolerant routing in mobile ad-hoc networks. *ICC*, 1–5.

[12] Arun Kumar BR, Lokanatha C Reddy, Prakash.S.Hiremath. [2008] Performance Comparison of Wireless Mobile Ad-Hoc Network Routing Protocols *[JCSNS International Journal of Computer Science and Network Security*.8 (6):

[13] Misra S, Venkata Krishna P, Bhiwal A, Singh Chawla A, Wolfinger BE, Lee C.[2011] 'A learning automata-based fault-tolerant routing algorithm for mobile ad-hoc networks', *J Supercomput.*. 1–20, doi: 10.1007/s11227-011-0639-8

[14] Mehfuz S, Doja MN. [2008]. Swarm intelligent power-aware detection of unauthorized and compromised nodes in MANETs', *J Artif Evol Appl*, vol. 2008, article 3 (January 2008), Article ID 236803, 16 pages, doi: 10.1155/2008/236803

[15] P Venkata Krishna, V Saritha, G Vedha, A Bhiwal, AS Chawla.[2012] Quality-of-service-enabled ant colony-based multipathrouting for mobile ad hoc networks, *IET Commun* 6(1): 76– 83

[16] P Venkata Krishna and Iyengar.[2007] A Cross Layer Based Qos Model For Wireless And Mobile Networks *Journal of Mobile Communication* 1 (4): 114–120.

[17] P Venkata Krishna. [2008]A study of quality of service metrics for wireless systems, Ph. D thesis, VIT University,

[18] Zou Yuanyuan, Tao Yang.[2012] A method of selecting path based on neighbor stability in Ad Hoc network, Computer Science and Automation Engineering (CSAE), 2012 *IEEE International Conference* on , .2:675–678, 25–27 ay 2012

[19] Reddy CP, Krishna PV. An efficient bandwidth management framework for wireless mesh networks, Innovative Computing Technology (INTECH), 2012 Second International Conference on, 102,106, 18–20 Sept. 2012 doi: 10.1109/INTECH.2012.6457765

[20] Reddy Ch P, Venkata Krishna P. [2014]Cross layer based congestion control in wireless mesh networks (2014) Bulgarian Academy of Sciences, *Cybernetics And Information Technologies* , 14(2): July, 2014. DOI: 10.2478/cait-2014–0020.

[21] Reddy Ch P, Venkata Krishna P. [2014] Ant-inspired level-based congestion control for wireless mesh networks. *Int J Commun. Syst doi*: 10.1002/dac.2729

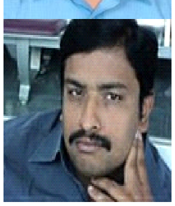
[22] NS-2, the NS Manual (fonnally known as NS Documentation).

[23] Available at http://www. isi.edu/nsnam/ns/doc.

ABOUT AUTHORS

Dr. Pradeep Reddy.CH *is currently working as Associate Professor with School of Information Technology and Engineering, VIT University, Vellore, India. He has a total of 8 years of experience in both teaching and research. He received his B. Tech in Computer Science and Engineering from PBR VITS, JNTU in 2004, Andhra Pradesh, India and M. Tech in Computer Science & Engineering from VIT University, Vellore, India. He did his Ph.D. in Computer Science and Engineering from VIT University, Vellore in 2014. His research interests include Mobile Technologies, Wireless Networks and Open Source Technologies. He has published several papers in national and international refereed journals and conferences. He is a member of various professional organizations such as CSI, ACM and IAENG.*

Dr. Jagadeesh Gopal *is currently working as Division Chair, Software Engineering with School of Information Technology and Engineering, VIT University, Vellore, India. He has a total of 15 years of experience in both teaching and research. He completed his B. Tech in Computer Science and Engineering and M. Tech in Information Technology. He is pursuing his Ph.D from VIT University, Vellore. His research interests include Software Engineering, Soft Computing, Wireless Networks. He has published several papers in national and international refereed journals and conferences. He is a member of various professional organizations such as CSI, ACM, ISTE and IAENG.*



Dr. Arun Kumar Sangaiah *obtained his Doctor of Philosophy (Ph.D.) in Computer Science and Engineering from VIT University, Vellore, Tamil Nadu, India. He is presently working as a Associate Professor in School of Computing Science and Engineering, VIT University, India. His experience and areas of interest focus on Software Engineering, Soft Computing, Wireless Networks, Bio-Informatics, and Embedded Systems. He has author of more than 100 publications in different journals and conference of National and International repute. Dr.Arun Kumar is member of international advisory board of IJIIT (IGI publisher) and editorial board member of IJIES, Japan. Also, he has served a special guest editor of various international journals (Inderscience, Hindawi, IGI publishers). He is active member for Compute Society of India. He has guided many research students and post-graduate students in the field of software engineering, communication networks, ad hoc networks, database, and soft computing techniques.*