A Reliable multicast routing approach for VANET

***R. Singh[1]** **Rajesh Babu[2]** **Indrani Chatterjee[3]**

[1, 3]Dept. of C.S. & I.T., MJP Rohilkhand University, Bareilly-243006, (India)

[2]RBMI, Bareilly, 243001(India)

Abstract

Safety applications of inter-vehicle and vehicle-to-roadside communication that make use of vehicular ad hoc networks (VANETs) will often require reliable communication that provides guaranteed real-time message propagation. An important aspect of network dynamics is failure handling, as link/node failure due to high mobility of nodes introduces service disruption in wireless network. Since service disruption depends on the reliability of the path, therefore it is important to take reliability into account during multicast member join. In this paper, we have proposed a Fuzzy ARTMAP based QoS based reliable method (QBRM) to address this problem of routing in a dynamic QoS aware Multicast environment. Our simulated results shows that the performance of this QoS-based Reliable Multicast Routing is superior in terms of cost and number of query messages in cases where the average multicast group size was large and the bias of the joining rate was close to one but performed poorly for small groups with respect to greedy algorithms.

Keywords: *Reliable multicast routing, Fuzzy ARTMAP, Real-time applications, VANET.*

1. Introduction

In VANET, mobile node can communicate directly with the lying within its communication range and outside range node require the establishment of multi-hop path. Safety Applications and real-time applications in Vehicular Ad-Hoc Networks (VANETs) pose tough requirements to the communication system: It has to strictly follow given quality-of-service constraints or to get along with very sparse or very dense networks and need to be sent the same date to multiple recipients using multicast communication, without incurring network overloads. For this reason, multicasting typically requires less total bandwidth and less time for delivery of the safety related data than separately unicasting messages to each receiver. So, Multicasting is an effective mechanism for supporting group communication [1].

Development of efficient protocols which establish multicast sessions based on QoS constraints and can handle node/link failures in highly dynamic topology is an important problem. The new challenge is to build a multicast tree with robust path to deliver the multicast data from source to all mobile destinations so that the QoS requirements pertaining to the Service Layer Agreement requirement is satisfied and the cost of the multicast tree and other network resources are minimized without any disruption.

The rest of the paper is organized as follows: Section 2 describes the motivation of research on the basis of previous work done on the line. The problem formulation, system modeling and proposed QoS based reliable method to solve the problem with neural network based Fuzzy ARTMAP algorithm is presented in section 3. The Experimental results and performance of the proposed scheme is evaluated in section 4. Finally, conclusions and future work are described in Section 5.

2. Motivation

In a dynamic multicast session, it is important to ensure that member join/leave will not disrupt the ongoing multicast session, and the multicast tree after member join/leave will still remain near optimal and satisfy the QoS requirements of all on-tree receivers [2]. The reconstruction/incremental change approach for dynamic management of members in multicast tree suffers because of the service disruption due to frequent migration of tree or quality (e.g. tree cost) of the tree maintained may deteriorate over time. Therefore, an on-line multicast routing algorithm must take into account to balance needs to be struck between these two goals by employing a technique that monitors the quality of the tree and triggers tree rearrangement when the quality of the tree degrades below a threshold. For unicasting, one type of failure handling approach is the protection based approach [3] wherein dedicated protection mechanisms, such as redundant (backup) channels operating in hot standby, are employed to cope with failures. The other type is the restoration based approach [4] wherein a dedicated mechanism is used to detect node and link failures. The multicast tree structure is encapsulated within the multicast packets in the Data filed of the datagram [5, 6, 8] to satisfy QoS requirement. However, encapsulation consumes additional bandwidth for each packet in the form of encoding the multicast tree and thus does scale well with the group but have poor path robustness in case of dynamic topology.

We propose a protection based approach wherein protection is provided in a resource efficient manner. While joining the group, each receiver specifies its reliability requirement as a QoS parameter. We assume that the network is divided into several domains and the network tries to satisfy the reliability requirement by providing backup paths within a selected set of domains, if necessary. If the reliability requirement is not satisfied even with backup paths, then the join request is rejected. A simple method for providing reliable connections in real-time communications has been studied in [10] for unicast connections in an intra-domain scenario.

3. Problem Definition

The problem of building a Reliable optimal tree to satisfy QOS requirements at minimum cost and taking minimum network resources is main interest of researchers. This combinatorial optimization has been modeled as a nonlinear programming problem and trained an artificial neural network is proposed here to solve the problem. The ARTMAP based systematic heuristic approach involves in creation of end-to-end primary paths with optimized resources, and creation of backup paths for selected domains for reliability, if required. This approach will also provide the resources to new group members in case of resource scarce using trade-off. Solution to the QRMR problem involves creation of backup paths in some domains such that the reliability requirement of the receiver is satisfied and the overall cost is minimized. It has two steps:

1. Primary path creation which minimizes cost and satisfies the reliability and bandwidth requirements. If such a path does not exist, then step 2 is carried out.
2. Creation of backup paths in selected domains to satisfy the reliability and bandwidth requirement and to minimize the overall cost. If the requirements are still not satisfied the request is rejected.

The basic idea used in this approach is the reliability of the combined path (parallel combination) is more than the reliability of each of the individual paths. The total reliability of the end-to-end path is

$$Rel = r11 \times r12 \times r13 \times w1 \times w2 \times w3 \times (RelTree)$$

Where, RelTree is the reliability of the path from the on-tree node (N1) to the core (C) of the multicast tree. Note that w2 = 1, since there is no backup path in domain D2. It can be implemented using single pass [11] or two-pass resource [12] reservation mechanism. In this proposal, for the implementation of reliable back up path, we adopt the two-pass scheme as it is resource-efficient. In the two-pass scheme, resources are allocated in the forward pass and excess resources are relaxed in the reverse pass so that the resources are efficiently utilized. We propose a QoS based reliable method (QBRM) for two-pass schemes:

3.1 Proposed QBRM Approach

In the forward pass, backup paths are created based on a prediction of the domain reliability. In the reverse pass backup paths may be created or relaxed. In the forward pass, the decision is made whether to add the backup path for that domain at each ingress router. For this, we use an estimate of the end-to-end reliability of the multicast path called the Domain Reliability Parameter (DRP). Let a join request R =< S, d, B, rr > arrive at the ingress router. Let rs denote the reliability value of the maximum reliable path from the ingress router to the egress router. If $rs \geq \delta \times DRP$, backup path is created and reserved. Otherwise the backup path is not created. We call δ as the QoS factor whose value is in [0, 1].

1. IF $\delta = 0$, THEN
   i. In the forward pass both primary and backup paths are created. The resources are reserved with the Fuzzy ARTMAP algorithm for all domains in the end-to-end path and also allocate the adequate resources to new group members in case of resource scarce using trade-off.

   ii. In the reverse pass, backup paths in some domains are released so that the reliability criterion remains satisfied and the cost is minimized.

   iii. In the reverse pass, Domain Selection Algorithm (mentioned as DSA in the figure) is carried and resources are released for certain domains, such that reliability constraint is satisfied and cost is minimized.

2. ELSE $\delta = 1$, THEN

   i. In the forward pass of this Scheme the backup paths are not created and reserved, but weights of the domains are calculated and they are put in the Join Request similar to the first Scheme.

   ii. To apply the online Weight Calculation Algorithm to this scheme each node needs to store the link from which the Backup Join Request arrives. This is reasonable to do as the backup paths are created per group basis.

iii. If the calculated reliability is below the required reliability of the receiver, it cannot join the multicast group. In this scheme the receiver may be given an option to join the multicast group with a lower reliability.

iv. As in first Scheme, in the reverse pass of this Scheme, we solve the Domain Selection Problem using the weights calculated in the forward pass.

We maintain a flag with each domain weight to indicate whether resources have been reserved along the backup path in the domain or not.

3.2 Fuzzy ARTMAP Algorithm

Step1: *Application, User & Network parameters are given;*
Step2: *Out port = t, Iterate for each output port;*
Step3: *Construct the DS-tree, for each constraint;*
Step4: *If DS-tree not constructed then*
Step5: *If link capacity violated then*
Reduce the bandwidth requirement,
And Go to step 3;
Step6: *else Network delay violated then*

Reduce the Network delay requirement
And Go to step 3;
End;
Step7: *else output is the DS-tree;*
End;

The ARTMAP neural network [9] is an architecture that can learn arbitrary mappings from digital inputs of any dimensionality to outputs of any dimensionality. The proposed algorithm uses a trained ARTMAP to determine the resource combination pertaining to a QoS basket. First, the QoS basket is not one point but a range between a maximum and minimum QoS value. Second, the same QoS basket can be offered by a different apportioning of end nodes and network resources, though at different cost for a member. The algorithm tries to minimize the total cost of the tree by computing a minimum QoS low cost join path for new members utilizing the join request message the neural network based a range of DSCPs.

4. Performance Evaluation

We have conducted extensive simulation studies, using NS [7] to evaluate the effectiveness of the proposed schemes as well as Conservative scheme for members joining the multicast group satisfying QoS and reliability constraints. In the conservative scheme, during the forward pass both primary and backup paths are created and reserved for all domains in the end-to-end path. In the reverse pass, backup paths in some domains are released so that the reliability criterion remains satisfied and the cost is minimized. Network nodes are randomly chosen in a g × g grid. The output corresponds to a utility function that is discrete and corresponds to a cluster. The vigilance parameter is fixed at 0.7 to satisfy the elasticity-plasticity dilemma. Random network topologies are generated based on the given input parameters: Number of nodes, number of links, and number of domains. Number of nodes and number of links are fixed at 40 and 80 per domain, respectively. The number of domains is fixed at 10. The other parameters that are kept fixed during the experimental studies are: (i) Average Link Bandwidth=10Mbps, (ii) Delay = ms, (iii) Average Link Reliability = 0.999. Each simulation point is an average of 10 random observations.

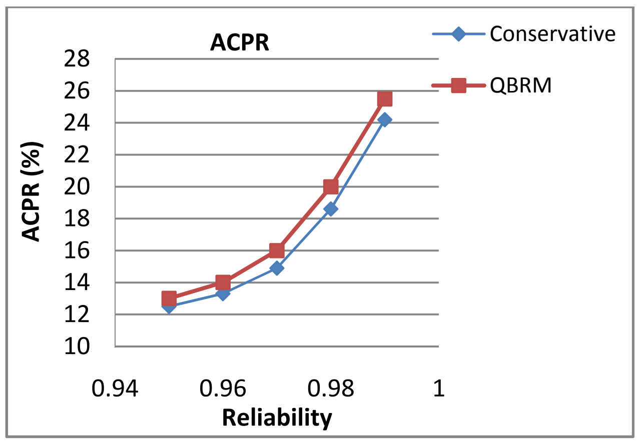

Fig.1 Variation of ACPR.

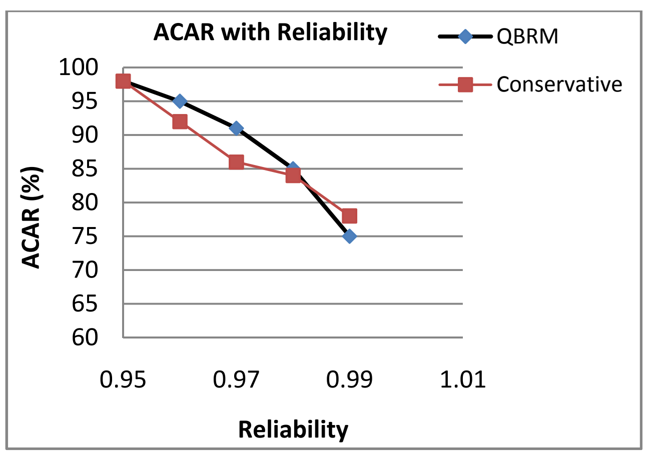

Fig. 2 Variation of ACAR.

In the Figure 1 and 2, variation of Average Cost per receiver (ACPR) and Average Call Acceptance Rate (ACAR) is shown with varying reliability requirements of the connections for optimistic scheme and our proposed QBRM approach. In this set of experiments, the inter-arrival time between the receivers is set at 250ms, and the bandwidth requirement of the connections is 100KB. For low values of reliability requirement (< 0.98), proposed scheme performs better, both in terms of ACAR and ACPR. However, as the reliability requirements of the connections increase (≥ 0.98), value of ACAR decreases gradually but perform batter than Conservative Scheme performs better than the proposed Scheme in terms of ACAR. This happens because at higher reliability requirement (constrained case), Conservative Scheme gains as it reserves resources in the forward path.

5. Conclusions

Reliability is an important QoS parameter to manage the network dynamics in case of failure handling, as link/node failure introduces additional constraint service disruption in wireless network for multicast routing. While joining the group, each receiver specifies its reliability requirement. In this paper we have advocated the use of Reliable tree maintenance as a mechanism for handling group dynamics in QoS multicasting. The reliability of the path is provided by introducing protection based QBRM approach as discussed in section 3, wherein protection is provided in a resource efficient manner. The basic idea used in this approach is the reliability of the combined path is more than the reliability of each of the individual paths. The primary and backup paths are created based on a prediction of the domain reliability to minimize the overall cost. Our simulation study demonstrates the proposed scheme has achieved our goal and also provided the reliable path with resource trade-off in case of scarce successfully. The outcome of this research will enrich the state-of-the-art research in QoS multicasting leading to the successful implementation of the same over the Internet.

References

[1] S. Deering, “Multicast Routing in Internet-works and Extended LANs,” SIGCOMM ’88, Stanford, CA, Aug. 1988, pp. 55–64.

[2] J. Hou and B. Wang, “Multicast routing and its QoS extension: Problems, algorithms and Protocols," IEEE Networks, Jan./Feb. 2000.

[3] R. Sriram, G. Manimaran, and C. Siva Ram Murthy, “An integrated scheme for establishing dependable real-time channels in multihop networks," in Proc. ICCCN, pp.528-533, 1999.

[4] J. Anderson, B. Doshi, S. Dravida, and P. Harshavadhana, “Fast restoration of ATM networks," IEEE J. Select. Areas Communications, vol.12, no.1, pp.128-116, Jan. 1994.

[5] R. Bless, K. Wehrle, “A Router Extension to Support Multicast in Differentiated Services Networks," IETF Internet Draft draft-bless-diffServ-mcast-routerext-00.txt, Jul. 2001.

[6] R. Bless, K. Wehrle, “Group Communication in Differentiated Services Networks," Internet QoS for the Global Computing 2001 (IQ 2001), Workshop at CCGRID 2001, Brisbane, Australia, pp. 618-625, May 2001.

[7] Network Simulator-ns (version-2), Available at www.mash.cs.berkeley.edu/ns/.

[8] R. Sriram, G. Manimaran, C. Siva Ram Murthy, “A Rearrangeable Algorithm for the Construction of Delay constrained Dynamic Multicast Trees,” IEEE/ACM Trans. Net., vol. 7, no. 4, Aug. 1999, pp. 514–29.

[9] A Carpenter, S. Grossberg, N. Markuzon, H. Reynolds, and D. B Rosen, "Fuzzy ARTMAP: A neural network architecture for incremental supervised learning of analog multidimensional maps," IEEE Transactions on Neural Networks, vol. 3, no. 5, Sept. 1992, pp. 698-712.

[10] Madhavarapu Jnana Pradeep and C. Sive Ram Murthy, “Providing Differential Reliable Connections for Real Time Communication in Multihop Networks," in High Performance Computing Conference, 2000.

[11] S. Shenker, L. Breslau, "Two issues in reservation establishment," Computer Communications Review, vol.25, no.4. pp.14-26, 1995.

[12] A. Banerjea, D. Ferrari, D. Mah, M. Moran, D. Verma and H. Zhang, "The Tenet real-time protocol-suite: design, implementation, and experiences," in Technical Report TR-94-059, International Computer Science Institute, November 1994.

R. Singh received the Ph. D. in Computer Science and Engineering from Lucknow University/Institute of Engineering & Technology Lucknow, India after completing B. Engg. in Electronics Engineering. He is a doctoral investigator at MJP Rohilkhand University, Bareilly, U.P. Technical University, Lucknow and Singhania University, Jaipur. After number of years with the research and development wing of different industries at various positions since 1991, he joined as a faculty for the Department of Computer Science & Information Technology, MJP Rohilkhand University, Bareilly (India) in Dec 1997 and is currently working as an Associate Professor & In charge central computer centre of the Department, CS & IT. He has also served as a head of the department of CS & IT and a visiting Professor at various Technical Collages/Universities in India. He has been associated various Journals as a reviewer and Chair the session/Invited speakers in various conferences. His Research interests are in the area of Routing issues in the Wired and Wireless Network, QoS provisioning for Service Level Agreements in IP networks, Software Architectures with admission control schemes for Real time communication over the Internet, Acoustic communications in Under-water Sensor Network and issues related to Datamining Techniques. He is also a Member International Society for Computers and Their Applications (ISCA), Cary, NC 27511-4216, USA and an Associate Member of Institute of Electronics & Telecommunication Engineers, N. Delhi (India).