A scheme for probabilistically reliable multicast routing in wireless mesh networks

Author:
Zhao, Xin; Chou, Chun; Guo, Jun; Jha, Sanjay

Publication details:
32nd IEEE international conference on local computer networks, Proceedings
pp. 213-214
0769530001 (ISBN)

Event details:
32nd IEEE international conference on local computer networks
Dublin, Ireland

Publication Date:
2007

Publisher DOI:
http://dx.doi.org/10.1109/LCN.2007.92

32nd IEEE Conference on Local Computer Networks

A Scheme for Probabilistically Reliable Multicast Routing in Wireless Mesh Networks

Xin Zhao, Chun Tung Chou, Jun Guo and Sanjay Jha
School of CSE, The University of NSW, Sydney, Australia
{xinzhao, ctchou, jguo, sanjay}@cse.unsw.edu.au

1. Introduction

Wireless mesh network (WMN) is a promising technology for deploying wireless infrastructure to provide wireless broadband access. High-speed wireless meshes will enable a whole new range of exciting broadcast/multicast applications, such as IP-TV and video-on-demand (VOD). There are some researches on multicast in WMNs. Ruiz et al. [3] study multicast tree in terms of minimizing the number of broadcast transmissions in WMNs utilizing the *wireless multicast/broadcast advantage* [4]. Chou et al. [1] studied minimizing broadcast latency using the multi-rate nature of radio. In [6], a Resilient Forwarding Mesh (RFM) approach is proposed for protecting multicast sessions from link or node failures by establishing a pair of node-disjoint paths for each multicast destination. Common assumption in all the above papers is the binary packet reception model. However, in the real wireless scenario, due to the nature of radio propagation and interference, the deterministic model such as binary packet reception is not realistic. In [2], the authors study some multicast metrics in wireless mesh networks, such as ETT, ETX, PP, METX and SPP. However, this paper does not take reliability into consideration.

In this paper, we use reliability in a probabilistic sense and we identify the reliability of a multicast session with the packet successful delivery probability from the source to the multicast destinations.

2. Reliable Probabilistic Multicast Routing

We propose a scheme called Probabilistically Reliable Multicast Routing (PRMR) to improve the reliability of multicast routing in wireless mesh networks. PRMR uses directional link packet delivery rate as a link-quality-based routing metric in choosing the forwarding nodes for different multicast sessions. In order to increase the reliability for the multicast sessions, PRMR establishes a pair of disjoint paths from source to each destination.

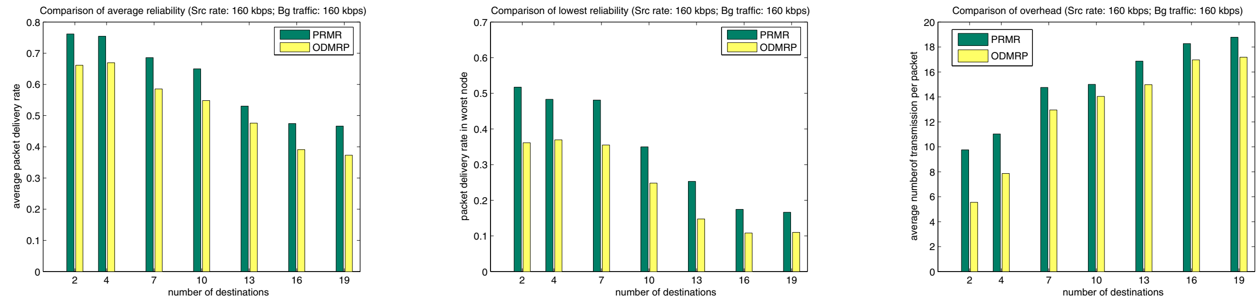
However, disjoint paths increase the number of forwarding nodes for the multicast, and increases the number of broadcast transmissions accordingly. Adding broadcast transmissions in one multicast session will increase the overhead of the multicast so that it would reduce the throughput of the whole network. Therefore, a mechanism to control the total number of broadcast transmissions is necessary. Utilizing the wireless multicast/broadcast advantage [4], PRMR reduces the number of additional forwarding nodes caused by the disjoint paths.

Algorithm 1 Reliable Probabilistic Multicast Routing

Given: $G = (V, E)$; $D = \{d_1, ..., d_J\}$; s; $\{C_{i,j}\}$
for all $d \in D$ **do**
    Find a shortest path P_d from s to d
    $F \leftarrow F \bigcup InterNode(P_d)$
end for
for all $n \in F$ **do**
    Update the cost of all out-going links $C_{n,x} \leftarrow 0$
end for
for all $d \in D$ **do**
    Temporarily remove all upstream links from the networks, then find a shortest path B_d from s to d according to new $\{C_{i,j}\}$
    for all $n \in B_d$ **do**
        Update the cost of all out-going links $C_{n,x} \leftarrow 0$
    end for
    $F \leftarrow F \bigcup InterNode(B_d)$
    Recover the upstream links into the network
end for

Algorithm 1 is the heuristic of PRMR. Here the network is denoted by $G = (V, E)$ as a directed graph. D is the set of multicast destinations, and s is source. The link cost $C_{i,j} = -\log p_{i,j}$, where the packet delivery rate of a directed link $\langle i, j \rangle$ is denoted as $p_{i,j}$. F is the set of forwarding nodes. $InterNode(X)$ is a function of X which returns the set of intermediate forwarding nodes in X from source to destination, where X is either P_d or B_d, which denote the disjoint path-pair from source to a destination node d.

0742-1303/07 $25.00 © 2007 IEEE
DOI 10.1109/LCN.2007.92



(a) Average reliability (b) Lowest reliability (c) Overhead

Figure 1. Comparison between PRMR and ODMRP

3. Simulation Experiments

We used Qualnet to simulate our scheme. We choose ODMRP [5], the state-of-the-art multicast protocol in wireless network as a benchmark to compare the performance. The source node sends a multicast constant bit rate (MCBR) traffic to all multicast destinations. In order to introduce the probability of collision, several random constant bit rate (CBR) flows are chosen as the background interference traffic. We compare three objectives in experiments. The first objective is *average reliability* which is the mean value of the packet delivery rate for all destinations. The *lowest reliability* is another important reliability objective to reflect the worst packet delivery probability for all destinations. It is the lowest reliability to all users. To study the *overhead* of PRMR, we examine the average number of transmissions for each data packet. We simulate the multicast sessions with different multicast group sizes from 2 to 19. For each group size scenario, we randomly choose ten topologies to run the simulation.

Figure 1 shows the results for different multicast group sizes in a 20-node network when the source rate is 160kbps and background traffic rate is 160kbps as well. The results show that PRMR always outperforms ODMRP. It achieves 20% improvement in average reliability. For the destination with the worst reliability, PRMR gains over 30% improvement compared with ODMRP. When group size is small, such as 2 or 4, PRMR consumes over 50% more forwarding nodes than ODMRP. This is because when group size is small, the destination is likely to be far away from each other, so that it is hard to utilize the wireless broadcast advantage to find shared forwarding nodes for each destination. When the group size is increased, the destinations are closer to each other. Then it is easier for PRMR to find forwarding nodes in common by wireless broadcast advantage. In large group size cases (16 and 19 destinations), PRMR only consumes around 2 more transmissions than ODMRP, whereas it achieves more than 20% reliability improvement in both average reliability and lowest reliability.

4. Conclusion

In this paper, we proposed a probabilistically reliable multicast routing (PRMR) which uses link packet delivery rate as the link-quality-based metric to find paths from source to destinations. In order to increase the reliability of the multicast session, we use a pair of disjoint paths to connect the source to each destination. We reduce the total number of forwarding nodes by exploiting the wireless broadcast advantage. Our experiment results show that PRMR can increase the average reliability by up to 25% and the node with the lowest reliability by up to 50% in comparison with ODMRP.

Acknowledgments

This project is supported by Australian Research Council (ARC) Discovery Grant DP0664791.

References

[1] C. T. Chou, A. Misra, and J. Qadia. Low latency broadcast in multi-rate wireless mesh networks. *IEEE JSAC Special Issue in Multi-hop Wireless Mesh Networks*, 2006.

[2] S. Roy, D. Koutsonikolas, S. M. Das, and Y. C. Hu. High-throughput multicast routing metrics in wireless mesh networks. In *Proc. ICDCS2006)*, page 48, July 2006.

[3] P. M. Ruiz and A. F. Gómez-Skarmeta. Heuristic algorithms for minimum bandwidth consumption multicast routing in wireless mesh networks. In *Proc. ADHOC-NOW*, pages 258–270, 2005.

[4] J. Wieselthier, G. Nguyen, and A. Ephremides. On the construction of energy-efficient broadcast and multicast trees in wireless networks. In *Proc. INFOCOM*, page 585, 2000.

[5] Y. Yi, S.-J. Lee, W. Su, and M. Gerla. On-demand multicast routing protocol (odmrp) for ad hoc networks. Internet-Draft, draft-ietf-manet-odmrp-04.txt, feb 2003.

[6] X. Zhao, C. T. Chou, J. Guo, and S. Jha. Protecting Multicast Sessions in Wireless Mesh Networks. In *Proc. LCN2006*, pages 467–474, Nov 2006.