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Collaborative Recovery Algorithm to Reduce Loss and Delay in Multicasting

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Abstract:

In this paper, we present Collaborative Opportunistic Recovery Algorithm (CORA) de-signed for multicast multimedia applications with low loss as well as latency constraints in ad hoc networks. CORA is an independent service that can run atop any ad hoc multicast routing protocol. The main features of CORA are localized recovery process, deterministic (as opposed to probabilistic) peer-to-peer recovery, andability to trade off recovery with latency. A key component of CORA is the Cached Packet Distance Vector (CPDV) protocolfor local peer-to-peer loss recovery. CPDV finds and retrieves the nearest copy of the missing packet while providing other useful NACK aggregation features. We use simulation experiments to demonstrate the effectiveness of CORA and explore the tradeoffs of CPDV localized recovery benefits versus memory and processor overhead. In a typical simulation experiment with mobile nodes CORA yields up to 99% delivery ratio as compared to 91% delivery ratio by Gossip. This improvement is achieved with negligible overhead.

Keywords: Ad hoc networks; Multicast; Routing; Reliable.

1. INTRODUCTION:

A mobile ad hoc network (MANET) is a self-organizing mobile network formed by peer nodes using wireless radios. With or without the wired infrastructure, it can establish an instant communication structure for civilian and military applications. Its minimal requirement on deployment time and space is particular useful in a hostile environment, where pre-existing infrastructure cannot be easily acquired or may be damaged/destroyed at any time. Key applications in these scenarios include teleconferencing, disaster relief, data dissemination, and battlefield operations which are group oriented and mission critical, requiring both high data reliability [3][13] and timeliness guarantees. Undoubtedly, reliable multicast [14] is a critical building block to support these applications, even in the presence of random node mobility, frequent route outages, and random external interference.

Reliable multicast has been an active research area in wired IP networks. Various interesting and effective concepts have been proposed in reliable IP multicast protocols including local recovery [16], peer-to-peer recovery, randomized gossip style recovery [2] and NACK aggregation technique [9]. In particular, peer-to-peer recovery approach, where each member peer communicates with other member peers to recover lost packets, attracts our attention since it fits well with MANET multicasting. In MANETs, the probability of location dependent random errors is non-negligible due to wireless link error and node mobility.

Therefore, unless all the receivers have experienced the same loss pattern, it is highly likely that each receiver shows heterogeneous packet reception characteristic. Thus peer members can effectively rectify each other. Moreover, peer-to-peer recovery does not rely on specific nodes (such as the source or designated agents), thus it is robust against node and link failure and dynamic topology changes in the network. Lastly, peer-to-peer recovery tends to evenly distribute recovery overhead to the entire group instead of centralizing at certain nodes, and thus it shows better scalability than source-oriented retransmission mechanism. Applying peer-to-peer recovery in MANETs is however not straightforward. The design choices underlying wired reliable multicast protocols using peer-to-peer recovery mechanism [2] are not apposite for MANETs due to their unique characteristics including mobility, limited bandwidth, random packet errors, and frequent outages. If these wired protocols are applied to MANETs directly, they will incur excessive control overhead for maintaining underlying routing structure and also unreasonable long latency due to frequent route outages and heavily contended broadcast medium.

Recently, Anonymous Gossip [4] and Route Driven Gossip [11] have customized the gossip-style recovery schemes [2] to be fitted in wireless ad hoc networks. In gossip-style approaches, the packet recovery is performed in a peer-to-peer fashion. A receiver attempts to recover lost packets with the aid of a random set of members in the group. In “Anonymous gossip” (AG) [4], each peer member sends gossip-requests to local members with higher probability than to remote members. In “Route Driven Gossip” (RDG) [11], each peer member reuses ad hoc uncast routing path, and sends multiple requests to enhance recovery ratio. However, these solutions are probabilistic and their effectiveness depends on member geographic layout. In particular, if the group members are placed very sparsely and the reliability of gossip-request and retransmission is poor, then these schemes incur the cost of gossiping but fail to improve recovery in a significant way. Our approach named Collaborative Opportunistic Recovery Algorithm (CORA) seeks to achieve deterministic and localized peer-to-peer recovery which maximizes recovery efficiency within bounded latency. In multi-hop wireless communications, localized schemes[7] are always more efficient than non-localized schemes with respect to route outage, broadcast medium contention, and unpredictable wireless link errors. The key component of CORA, namely Cached Packet Distance Vector (CPDV) protocol, can deterministically locate the best/nearest copy of a lost packet and localizes the recovery process to the greatest extent. Since CPDV is a distance vector (DV) type scheme and enforces on demand DV exchange, it incurs minimal storage overhead and communication overhead. The main contributions of this paper are:

(1) a localized peer-to-peer recovery strategy that can recover lost packets from the nearest node that stores a copy; (2) a deterministic CPDV (cached packet distance vector) implementation that realizes the previous goal; (3) a tradeoff study between localized recovery benefits versus memory and processing overhead, and; (4) a mechanism to enforce delay bound compliance. There exists a spectrum of semantics of reliable multicast. At the one end, the strictest reliable multicast semantics, 100% packet delivery guarantee, exists. Looser reliability semantics may allow some packet losses but may have other requirements. Throughout this paper we use the term “reliable” or “reliability” to denote a high packet delivery probability and the term “strong reliability” especially to denote 100% packet delivery.

2. DESIGN OF CORA PROTOCOL:

It is extremely arduous to develop a reliable protocol which achieves both deterministic reliability and bounded-delay guarantee in MANETs. In general, only the second condition bounded delay is strictly demanded in most multimedia (e.g., audio or video) multicasting applications.

Those applications favor bounded latency over strong reliability (100% packet delivery). CORA is designed to support multimedia applications and targets to maximize packet delivery ratio while sustaining bounded latency and minimizing recovery overhead. The design choices of CORA rely on the observations of unique constraints of MANETs which are: (a) High error rate and heavy recovery overhead: The error/loss rate (unrelated to congestion) on wireless link varies over time and it may become unacceptable (e.g., above 40%) [5]; (b) Low cost of promiscuous listening: Shared and broadcast nature of wireless medium allows all neighbors to promiscuously accept packets only with negligible extra processing overhead; (c)High communication overhead and comparablylowstorage/processing cost:

Communication overhead is expensive due to low bandwidth and limited power. Memory access and processing consume much less energy than wireless transmissions, and memory resources are nowadays relatively abundant on mobile nodes [6][10][19]. With these restrictions and characteristics, CORA trades off memory and processing cost for communication overhead by employing cooperative neighbor nodes keeping a short-term data cache and/or CPDV table. The basic mechanism of CORA is a hybrid approach of localized peer-to-peer recovery and source-oriented retransmission mechanism. Similar to the NACK aggregation technique used in IP multi-casting [9], each intermediate forwarder in CORA, i.e., each router on the path back to source, aggregates NACK messages to prevent the potential NACK implosion problem. In this section we introduce CORA. The detailed description of the protocol is presented in Appendix.

2.1 Cached Packet Distance Vector:

CORA creates and maintains a consolidated recovery structure G^1 for each multi-cast group G. This structure G^1 includes three sets of nodes, group members G_m forwarding nodes G_f, and recovery assistant nodes G_{ra}. The recovery assistants are nodes that can hear the packets from a member node. Thus,$G^1= G_mUG_fUG_{ra}$. CORA imposes “short-term data caching” at forwarding nodes and members such that each forwarding node and member keeps the copy of incoming multicast data packets in the cache $Cdata_G$ for T_{max}. A packet in the cache is to be retransmitted if a retransmission request from a multicast receiver for the packet is received. Since a packet in the cache stays only for T_{max}, any retransmission request for the packet received after $T_{max}+T_s$(where $T_s$is the time when the packet is stored in the cache) is to be ignored, i.e. no packet is transmitted for the retransmission request. We recommendT_{max}be a multiple of the round trip time (RTT) along the network diameter. Therationale behind is that recovery (or retransmission) requests for a packet in one’s local cache is expected to be received within a multiple of the RTT after the time when the packet is stored. The time for a packet to travel from a node to a multicast receiver and the time for a retransmission request to travel back from the receiver to the node constitute an RTT.

Data caching at a member node is straightforward as members must assemble the file anyway [11]. Data caching at forwarding nodes is used to improve the success ratio of local recovery by redundancy and to suppress unnecessary retransmissions at each forwarding node. In CORA, each node in G^1(promiscuously) listens to the multicast traffic, maintains Cached Packet Distance Vector (CPDV) routing table for the group G ($CPdv_G$), and makes available its own CPDV table to other nodes to help recovering their lost packets within minimal distance and latency. The CPDV table keeps track of the min hop distance and path to each cached packet sequence number. Unlike traditional distance vector schemes, CPDV implements content based addressing, i.e., the index is not a destination address but a packet sequence number. Fig. 1 shows a simple illustration of CPDV.

Node C stores min hop paths (of length = 1) to packets 1, 3, and 4. Note that CORA/CPDV assumes that a multicast data packet can be distinguished by a unique identifier, hsource address sequence numberi, e.g., H1 stands for packet number 1 from node H. The sequence number field is increased by 1 at the sender for each new packet. CPDV is not updated proactively with explicit messages thus avoiding extra communication overhead. Rather, CPDV routing information is obtained reactively and opportunistically. CORA nodes exploit control message CPDV is not updated proactively with explicit messages thus avoiding extra communication overhead.

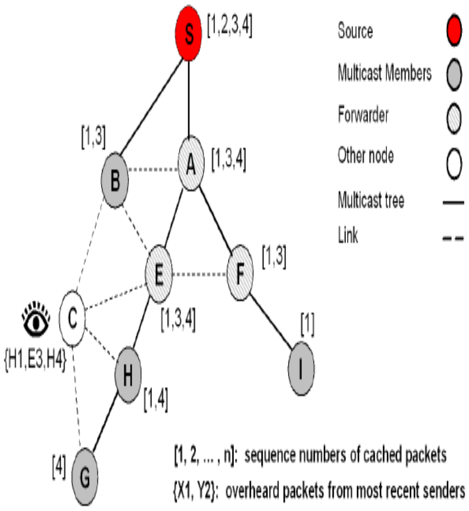

Fig.1: A sample scenario

Rather, CPDV routing information is obtained reactively and opportunistically. CORA nodes exploit control message piggyback and promiscuous listening to acquire CPDV routing information as follows: (1) By (over)hearing a data packet, a node knows the packet sender has the packet; (2) Nodes can piggyback their own CPDV metrics in control messages like NACKs. Other nodes overhearing these control messages can compute appropriate CPDV metrics. The piggyback communication overhead is small because each CPDV metric consumes tiny space (8-bit hop count in our simulation).

CORA relies on an independently designed underlying multicast protocol that pro-vides shortest paths to a source as part of a multicast tree (e.g., ODMRP (On Demand Multicast RoutingProtocol) [8] and MAODV (Multicast Ad Hoc On-Demand Distance Vector [18]). If such shortest path tree does not exist, it is often possible to modify the underlying protocol to acquire it (e.g., MCEDAR (Multicast Core-Extraction Distributed Ad hoc Routing)[17] and CAMP (Core-Assisted Mesh Protocol [12]). Thus, CORA can run with any MANET multicast protocol that embeds a source tree.

3. CORA RECOVERY OVERVIEW

Upon detection of a packet loss (e.g., a skipped sequence number) a multicast group member initiates the loss recovery process which includes two sequential steps:

1 **Localized peer-to-peer recovery:** A member first tries to recover missing packets in its locality. This procedure is further divided into three sequential sub steps:

(a) **CPDV recovery:** If the lost packet sequence number has a valid entry inCPDV, the member initiates explicit request to the neighbor pointed in the CPDV entry. The retrieval may require a few hops as directed by CPDV.

(b) **Local query:** For lost packets with invalid CPDV entries (i.e., CPDV met-ric for that packet is 1), the member tries to collect CPDV entries for the missing packets from one-hop neighbors. In the mean time, local query also carries available CPDV entries at the member to distribute multicast state information. This is implemented by an efficient QUERY/REPLY handshake: the member broadcasts a short QUERY, and any neighbor sends back a short reply (after a random backoff to prevent collisions) if it has cached some of the lost packets or knows where they are. CPDV update metrics are piggybacked in both query and reply messages.

(c) CPDV retry: CPDV recovery is performed again if there is no reply duringthe local recovery step. There is no “second chance”(of local query) for packets not recoverable from this retry.

step2 Source recovery: For packets still missing after the local recovery, the member sends a NACK to its upstream node toward the source until all the lost packets are recovered or the delay bound expires. In MANETs, the probability of packet loss is not negligible and thus a NACK for every single loss may cause NACK implosion. To avoid the problem, NACKs are deferred, aggregated, and paced at the receivers and redundant NACKs are suppressed at intermediate nodes on their way to the source.

4. RESULTS AND ANALYSIS

In this section, performance of CORA is investigated under various conditions using ns-2. The simulation study consists of two parts: performance comparison of CORA with existing schemes with respect to changing number of receivers and performance comparison of CORA with existing schemes with respect to changing mobility. The simulation model is presented in Table 1.

Table 1 Simulation Model

MAC	**802.11 DCF**
Propagation	TwoRayGround
Adhoc Routing	CORA
Node’s Transmission Range	350m
Bandwidth	2 Mbps
No. of nodes	100
Area	1500 X 1500
Simulation time	200 sec

To evaluate the performance of CORA, existing schemes GOSSIP, RALM and UDP are used. Through this experiment, we assume a single multicast group of variable size (from 10 to 50 nodes), with a single source. The traffic load if very light, so no loss is caused by congestion. All losses are caused by random interference or by mobility(if any). The traffic source is a CBR (Constant Bit Rate) application with 5Kbytes/sec rate using 512 bytes fixed packet size.

4.1 Performance Comparison in static scenarios:

In this comparison we used scenarios with staticnodes, i.e., no mobility, and simulate random errors by randomly dropping thepacket upon receiving a packet at the MAC layer. Whenever a new packet comesin, each node decides whether it will accept or drop the packet based on the givenerror probability.

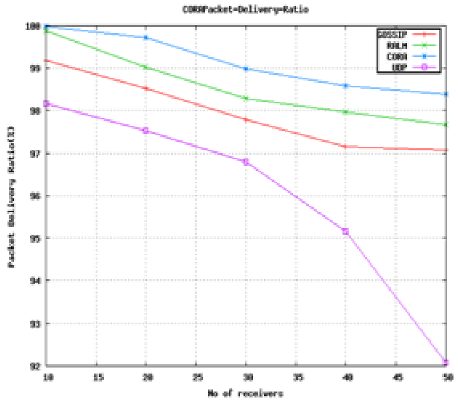

Fig. 2: Packet Delivery Ratio Comparison in static scenario

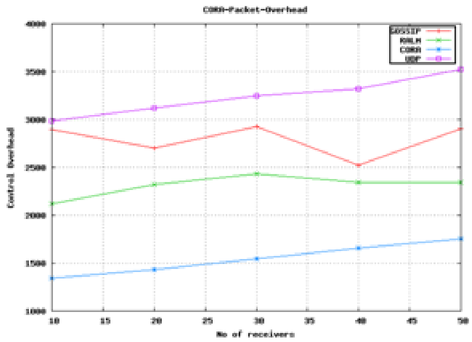

Fig. 3: Control Overhead Comparison in static scenario

The results shown in Figures 2 to 4 demonstrate the efficacy of CORA compared to other protocols. CORA improves the packet delivery ratio and throughputcompared to UDP with very small (less than 10%) extra overhead.In fact, the extraoverhead of CORA decreases because of the increase in thecapability of NACK/retransmission aggregation. As the group becomesdenser, the success probability of local recovery will grow.

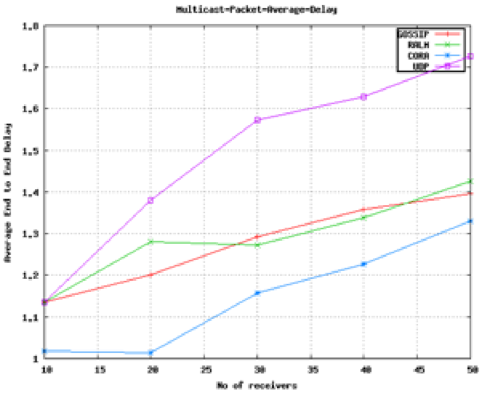

Fig. 4: End-to-end delay in static comparison

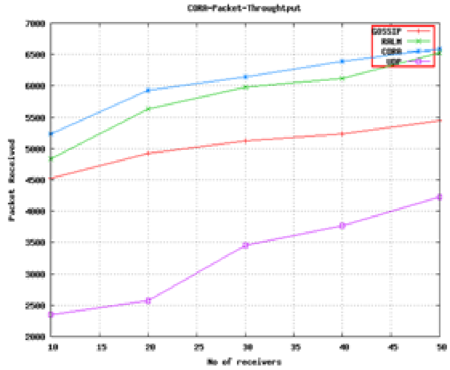

Fig. 5: Throughput comparison in static scenario

The recovery efficiency of CORA is better than that of GOSSIP. As shown in Fig. 3, the control overhead of CORA is lower than thatof GOSSIP. Also, CORA achieves higher delivery ratio and lower average packetlatency than GOSSIP as shown in Fig. 2 and 4. In fact, the delivery ratio ofGOSSIP slightly degrades with group size due to the increase of control overhead.This implies that CORA is more scalable to the group size than GOSSIP approachbecause of efficient CPDV mechanism.

Results show that RALM is not suitable for constantbit rate applications such as periodic dissemination and fixed rate multimedia.Since RALM is designed for 100% reliability, it favors reliability over throughputand overhead and incorporates TCP-like congestion control where a RALM sourcereduces the transmission rate upon receiving NACK messages from receivers. As aresult, RALM achieves lower latency and higher packet delivery ratio than CORA,but it suffers from significantly degraded throughput as shown in Fig. 5. Notably,even with far better throughput, CORA achieves delivery ratio and end-to-end latencycomparable to RALM.

4.2 Performance comparison in mobile scenario:

In this case, we evaluate the benefits introduced by key CORA designfeatures, namely, CPDV mechanism, and data cache at forwarding nodes and optimization/refinement scheme.We compare CORA with (1) CORA/SRC: CORA withoutCPDV mechanism (no local recovery) so that only NACK aggregation and data recoveryat forwarding nodes on the source tree are used; (2) CORA/NACK: same asCORA/SRC, but without data caching at forwarding nodes. Thus, only NACKaggregationtechnique is used with end to end retransmission; (3) CORA/OPT:CORA with the earlier mentioned optimization/refinement technique.

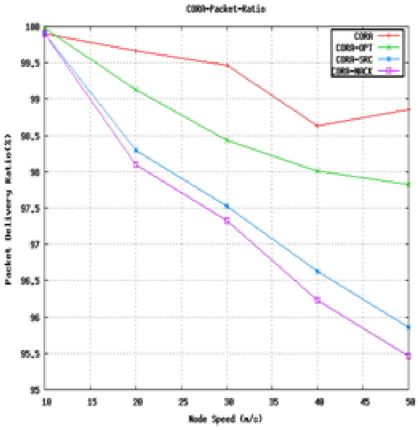

Fig. 6:Packet delivery ratio comparison for mobile scenario

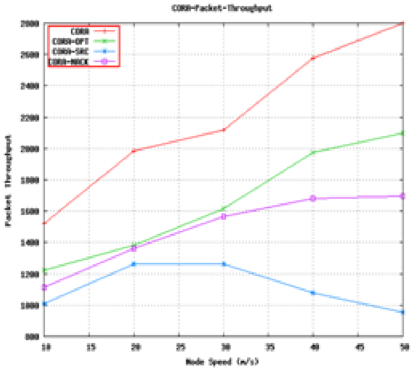

Fig.7: Throughput comparison for mobile scenario

In this experiment, we use node mobility without random error where each nodemoves following random-way point model with min speed “0” and max speed “x”(x = 10 to 50 meter/sec) and 0 pause time. A single group with a source and 10 groupmembers is used in this case. Figures 6 and 7 illustrate the comparison results. First, Fig. 6 shows that localized CPDVdirected recovery in CORA greatly improves robustness to mobility as comparedto CORA/SRC and CORA/NACK. This is explained by the fact that the CPDVscheme allows each receiver to recover packets from the nearest point so that thesuccess probability of retransmission can be maximized. Since CPDV recovery is the most unique feature ofCORA, this result tells us that there is significant advantage in using it. Fig. 7 indicates the improvement in throughput with CORA compared to other mentioned approaches.

5. CONCLUSION:

In this paper, we presented Collaborative Opportunistic Recovery Algorithm (CORA), a controlled loss, bounded delay multicast protocol. CORA applies to multicast sources with a fixed data rate. It attempts to minimize packet loss rate by exploiting local recovery, with bounds on latency and overhead. The centerpiece of CORA is an efficient local recovery mechanism based on Cached Packet Distance Vector (CPDV). Simulation studies clearly demonstrate the efficacy of CPDV and CORA compared to other reliable multicast approaches.

REFERENCES:

1. Scalable networks, http://www.scalable-networks.com.

2. K. P. Birman, M. Hayden, O. Ozkasap, Z. Xiao, M. Budiu, and Y. Minsky. Bimodal multicast. ACM Transactions on Computer Systems, 17(2):41–88, 1999.

3. J. W. Byers, M. Luby, M. Mitzenmacher, and A. Rege. A Digital Fountain Approach to Reliable Distribution of Bulk Data. In Proceedings of ACM SIGCOMM, pages 56–67, 1998.

4. R. Chandra, V. Ramasubramanian, and K. P. Birman. Anonymous Gossip: Improving Multicast Reliability in Mobile Ad-Hoc Networks. In Proceedings of ICDCS, pages 275–283, 2001.

5. D. S. J. DeCouto, D. Aguayo, B. A. Chambers, and R. Morris. Effects of loss rate on ad hoc wireless routing. Technical report MIT-LCS-TR-836, March 2002.

- D. Koutsonikolas and Y. C. Hu. The case for fec-based reliable multicast in wireless mesh networks. In Proceedings of IEE/IFIP DSN, 2007.

- B. Levine and J. Garcia-Luna-Aceves. Improving Internet Multicast with Routing Labels. In Proceedings of IEEE ICNP, pages 241–250, 1997.

- J. R. Lorch and A. J. Smith. Software Strategies for Portable Computer Energy Management. IEEE Personal Communications Magazine, 5(3):60–73, 1998.

- J. Luo, P. T. Eugster, and J.-P. Hubaux. Route Driven Gossip: Probabilistic Reliable Multicast in Ad Hoc Networks. In Proceedings of IEEE INFOCOM, 2003.

- J. Nonnenmacher, M. S. Lacher, M. Jung, E. Biersack, and G. Carle. How bad is reliable multicast without local recovery. In Proceedings of IEEE INFOCOM, 1998.

- O. Ozkasap, Z. Genc, and E. Atsan. Epidemic-based Approaches for Reliable Multicast in Mobile Ad Hoc Networks. SIGOPS Oper. Syst. Rev., 40(3):73–79, 2006.

- J.-S. Park, D. S. Lun, Y. Yi, M. Gerla, and M. Medard´. Codecast: A network coding based ad hoc multicast protocol. IEEE Wireless Communications, 13(5), 2006.

- S. Paul, K. K. Sabnani, and S. B. J. C. Lin. Reliable Multicast Transport Protocol (RMTP). IEEE Journal on Selected Areas in Communications, 15(3):407–421, 1997.

- V. Rajendran, K. Obraczka, Y. Yi, S.-J. Lee, K. Tang, and M. Gerla. Combining source and localized recovery to achieve reliable multicast in multi-hop ad hoc networks. InProceedings of IFIP Networking, 2004.

- E. Shih, P. Bahl, and M. Sinclair. Wake on Wireless: An Event Driven Energy Saving Strategy for Battery Operated Devices. In Proceedings of ACM MOBICOM, pages 160–171, 2002.

- T. Speakman, D. Farinacci, and et. Al. PGM Reliable Transport Protocol Specification. IETF Internet Draft, draft-speakman-pgm-spec-05.txt, November 2000.

- M. Stemm and R. H. Katz. Measuring and reducing energy consumption of network interfaces in hand-held devices. IEICE Transactions on Communications, E80-B(8):1125–1131, 1997.

- K. Tang, K. Obraczka, S.-J. Lee, and M. Gerla. Reliable Adaptive Lightweight Multicast Protocol. In Proceedings of IEEE ICC, 2003.

- Z. Xiao and K. Birman. A randomized error recovery algorithm for reliable multicast.In Proceedings of IEEE INFOCOM, 2001.