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Distributed Network Coding Based Opportunistic Routing Scheme

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ABSTRACT

Recent research has shown that the performance of opportunistic routing and network coding in wireless networks is greatly impacted by the correlation among the links. However, it is difficult to measure the correlation among the links, especially because of the time-varying behavior of the wireless links. Therefore, it is crucial to design a distributed algorithm that does not require the explicit knowledge of the channels' states and can adapt to the varying channel conditions. In this paper, we formulate the problem of maximizing the throughput while achieving fairness under arbitrary channel conditions, and we identify the structure of its optimal solution. As is typical in the literature, the optimal solution requires a large amount of immediate feedback messages, which is unrealistic. We propose the idea of performing network coding on the feedback messages and show that if the intermediate node waits until receiving only one feedback message from each next-hop node, the optimal level of network coding redundancy can be computed in a distributed manner. The coded feedback messages require a small amount of overhead as they can be integrated with the packets. Our approach is also oblivious to losses and correlations among the links as it optimizes the performance without the explicit knowledge of these two factors

I. INTRODUCTION

Wireless multihop networks play major roles in almost every field of our lives. One of the unique properties of wireless links is the poor link quality. For example, recent studies [1] have shown that 50% of the operational links in Roofnet [2] have loss rates higher than 30%. Therefore, a major challenge for deploying wireless multihop networks is to design a transmission protocol that handles the lossy behavior of the wireless links efficiently. An efficient way of handling losses in wireless multihop networks is to exploit the diversity among the links. Opportunistic routing [3] is the first trial to perform this exploitation. In opportunistic routing, there is no specific path from the source to the destination. Any node that overhears the packet can relay it. Take Fig. 1 as an example in which source node s wants to send packets to the destination d. The labels on the links represent their delivery rates. If we use traditional shortest path routing, the link between s and the chosen relay node will be the bottleneck, and the achievable rate will be upper bounded by 0.1. On the other hand, if we allow the node that receives the packet to forward it, the achievable rate will be $1 - (1 - 0.1)f$, which is a huge improvement over shortest path routing. The main challenge that faces the deployment of opportunistic routing is dealing with the case of when two relay nodes overhear the same packet. The work in [3] resolves this problem by assigning priorities to the nexthop forwarders, such that the node with higher priority will transmit first. All of the other next-hop forwarders have to listen to the transmission to decide whether one of the packets, overheard by a lower priority node, has been overheard by a higher priority node. If so, the lower priority node will not be responsible for forwarding the packet. Performing opportunistic routing requires coordination among the links and the design of a specialized MAC protocol. The two links are positively correlated or correlated as termed in [6]. This means that if one link is inactive, the other one will be the same. Case 3: The two links are negatively correlated or uncorrelated as termed in [6]. This means that if one of the links is active, the other one will be inactive. We use the following simple strategy. Each node stops the transmission of packets when it is sure that its next-hop nodes have collectively received the same number of linearly independent packets to what it has received. For simplicity, we assume that the batch. We formulate the problem of utility maximization for multiple unicast sessions that uses network coding-based opportunistic routing on an arbitrary wireless multihop network and use the duality approach to come up with the optimal distributed solution. • We identify the challenges of implementing the optimal distributed algorithm to come up with a more practical algorithm. The practical algorithm works in a batchby-batch manner and performs network coding on the feedback messages to exploit the broadcast nature of wireless links in the reverse direction. This reduces the number of feedback messages and eliminates the need for immediate feedback information. The algorithm is universal as it takes onto account the loss rates and the correlations among the links without the need to explicitly measure them. • We prove that the batch-by-batch algorithm converges to the optimal solution. • We present simulation results for our algorithm under different wireless settings and show its superiority regardless of the channel’s characteristics. T

II RELATED WORK

A Simple Opportunistic Adaptive Routing protocol (SOAR) to explicitly support multiple simultaneous flows in wireless mesh networks. SOAR incorporates the following major components to achieve high throughput and fairness: adaptive forwarding path selection to leverage path diversity while minimizing duplicate transmissions, priority timer-based forwarding to let only the best forwarding node forward the packet, local loss recovery to efficiently detect and retransmit lost packets, and adaptive rate control to determine an appropriate sending rate according to the current network conditions [13]. The Least-Cost Any Path Routing (LCAR) problem: how to assign a set of candidate relays at each node for a given destination such that the expected cost of forwarding a packet to the destination is minimized. The key is the following trade-off: increasing the number of candidate relays decreases the forwarding cost, but on the other, it increases the likelihood of “veering” away from the shortest-path route. apply LCAR to low-power, low-rate wireless communication and introduce a new wireless linklayer technique to decrease energy transmission costs in conjunction with any path routing. Simulations show significant reductions in transmission cost to opportunistic routing using single-path metrics [4]. Increase the number of candidate relays decrease the forwarding cost. Link layer protocol randomly selects which receiving node will forward a packet. In wireless networks it is less costly to transmit a packet to any node in a set of neighbours than to one specific neighbour. Increase the candidate decrease the forwarding cost but increase the overhead. Flooding delivers a message from one node to all the other nodes inside the network. Direct acknowledgement per receiver leads to high collision [20]. To address the issues utilize link correlation. Collective Flooding (CF), which utilize the link correlation to achieve flooding reliability using the concept of collective ACKs. CF requires only 1-hop information at each node, making the design highly distributed and scalable with low complexity. The mechanism of collective ACKs allows the sender to infer the success of a transmission to a receiver based on the ACKs from other neighbouring receivers by utilizing the link correlation among them. The localized opportunistic routing (LOR) protocol, which utilizes the distributed minimum transmission selection (MTS-B) algorithm to partition the topology into several nested close-nodesets (CNSs) using local information. LOR can locally realize the optimal opportunistic routing for a largescale wireless network with low control overhead cost. Since it does not use global topology information, LOR highlights an interesting trade-off between the global optimality of the used forwarder lists and scalability inferred from the incurred overhead [8]. Efficient QoS-aware GOR (EQGOR) protocol for QoS provisioning in WSNs. EQGOR selects and prioritizes the forwarding candidate set in an efficient manner, which is suitable for WSNs in respect of energy efficiency, latency and time complexity. Evaluate EQGOR by comparing it with the multipath routing approach and other baseline protocols through ns-2 simulation and evaluate its time ISSN 2347-3983 International Journal of Emerging Trends in Engineering Research, Vol.4. No.2, Pages : 13-19 (2016) Special Issue of ICCECT 2016 - Held at The Savera, Chenna, India

http://www.warse.org/IJETER/static/pdf/Issue/iccect2016sp03.pdf 15 complexity through measurement on the MicaZ node [3]. Evaluation results demonstrate the effectiveness of the GOR approach for QoS provisioning in WSNs. EQGOR significantly improves both the end-to-end energy efficiency. Multi-hop communication between two end nodes is carried out through a number of intermediate nodes whose function is to relay information from one point to another. Instead of pre-selecting a node to be nexthop forwarder, a candidate forwarders are selected to deliver packets [15]. If neighbour nodes are close enough to each other forwarder packets would be heared and duplicates are avoided. Nodes are to be prioritized, so that nodes with highest priority forwards the packet to the destination. So that the nodes with low priority will not send the packets. So that duplication of the packets of the packets in the receiver are avoided. On minimizing energy consumption and maximizing network lifetime for data relay in onedimensional (1-D) queue network. Following the principle of opportunistic routing theory, multihop relay decision to optimize the network energy efficiency is made based on the differences among sensor nodes, in terms of both their distance to sink and the residual energy of each other. Specifically, an Energy Saving via Opportunistic Routing (ENS_OR) algorithm is designed to ensure minimum power cost during data relay and protect the nodes with relatively low residual energy [10]. To overcome the traditional routing limitations, and to increase the capacity of current dynamic heterogeneous wireless networks, the opportunistic routing paradigm has been proposed and developed in recent research works. Motivated by the great interest that has been attributed to this new paradigm within the last decade, a comprehensive survey of the existing literature related to opportunistic routing [2]. A taxonomy for opportunistic routing proposals, based on their routing objectives as well as the optimization tools and approaches used in the routing design. Hence, five opportunistic routing classes are defined an, namely geographic opportunistic routing, link-state-aware opportunistic routing, probabilistic opportunistic routing, optimization-based opportunistic routing, and cross-layer opportunistic routing. Priority-Energy Based Data Forwarding Algorithm(PEDF) which empowers the node to choose the most suitable packet forwarding path, based on the priority of the packet and the current energy status of the forwarding node. The algorithm hence dynamically adapts to the prevailing energyscenario of the network and takes routing decisions accordingly, based on packet priority [16]. Minimizing delay, minimizing energy utilization, maximizing throughput and maximizing network lifetime. The advantage is that duplication of packets gets avoided. The disadvantage are if power level gets decreased then workload also decreased automatically. In this chapter explained about the literature survey. Source node forwards the packet to the intermediate nodes and the intermediate nodes forwards the packet to the destination node. Since the links are correlated all the intermediate nodes receives the packet and send to the destination node. So duplication of packets occur in the destination node. To avoid duplication of packets, the node has to be prioritized. So that node which is having the highest priority forwards the packet. If more number of candidate nodes are selected, the performance of the design gets reduced. To improve the performance of the design opportunistic routing protocol is used.

III PROPOSED WORK Wireless links are not independent so that they are correlated. Instead of pre-selecting a particular node to forward the packet, a set of candidate nodes are chosen to forward the packets. So that the transmission time to forward the packets gets reduced. Since the links are correlated all the nodes in the group of candidate nodes will forward the packet to the destination. 16 packets will occur in the destination. So that this duplication of packets gets avoided by prioritizing the nodes in the group of candidate nodes [15]. So that, the node with highest priority forwards the packet to the destination. Since the links are correlated all the nodes in the group will hear upon the transmission of the packets to the destination by higher priority nodes in the group. Upon hearing this transmission nodes with lowest priority will drops the packets. So that duplication gets avoided. If one path gets failure then the packet which was send by the sender will not reach the destination, when links are positively correlated. When links are negatively correlated, even-though path gets failed the packet will reach the destination by another path. So when links are negatively correlated, the packets will not get dropped. The values of link correlations are -1, 0 and 1. Negatively correlated link is -1, positively correlated link is 1 and uncorrelated link is 0 [15].

IV CANDIDATE FORWARDER SELECTION

Instead of pre-selecting a particular node to forward the packet, a set of candidate nodes are chosen to forward the packet. So that the transmission time for sending the packets gets reduced [15]. A source node forwards the packet to the set of candidate nodes which are close to the destination. And all the nodes in the group will receive the packet which was send by the sender because the links are correlated. They send acknowledgement to the source node after receiving the packets. All the nodes will send the received packets to the destination. So that duplication of packets occur in the destination [1][5][10][11]. To avoid the duplication of packets, nodes in the group are prioritized. So that node with highest priority forward the packet to the destination. And the destination node send the acknowledgement to the source node after receiving the packets which was send by the source node[9]. Table 1 : Multipath Candidate Selection **Algorithm multipath_candidate_selection ( )**

Input : nodes with max EAX values

Output : Selection of candidate key

EAX : Expected Any-path transmission

F ← Candidate set F ← max (EAX) DAG ← E(s , d)

DAG : Directed Acyclic Graph if min (EAX (s , d)) then eliminate E (s , d) else include E (s , d) E (s , F , d) = α + β // α captures the expected number of transmissions for successfully transmitting a packet from s to atleast one of the candidates and getting one acknowledgement /β captures the expected number of transmissions for delivering the packets from candidate to the destination loop (F ← max (EAX)) In multipath candidate selection algorithm the input is packet with minimum Expected Any-path transmission and the output is selection of candidate key. F is the candidate set. The node which is having the maximum Expected Any-path transmission count (EAX) is added to the candidate set.

V PRIORITY BASED PACKET FORWARDING Source node forwards the packet to the destination node with the help of intermediate nodes. Instead of preselecting a particular node to forward the packets, a set of candidate nodes are selected to forward the packets. Since the links are correlated all the nodes in the candidate set will receive the packets. So all the nodes in the candidate set forwards the packet to the destination nodes. So that duplication of nodes occur in the destination. And they send the acknowledgement to the source node after receiving the packets[16]. To avoid the duplication of nodes in the destination priority is used for nodes. So node with highest priority forwards the packet to the destination. Since links are correlated all the nodes in the candidate set hear the transmission of the packets[13][19]. Upon hearing the transmission of the packets all the nodes with lowest priority drops the packets. So that duplication of packets gets avoided in the destination node. And the destination node send the acknowledgement to the source node after receiving the packet which was send by the source node[3][4][7][9]. In priority based packet forwarding the input is assign priority to nodes and the output is highest priority forwards packet. Here u is assigned as urgent packet, h as highly important packet, m as moderately important packet and l as less important packet. If node n is urgent packet then forward the packet else forward the packet which is highly important packet else forward the packet which is moderately important else forward the packet which is less important packet. Otherwise drop the packets.

Algorithm priority_based_packet_forwarding

input : assign priority to nodes

output : highest priority forwards packet

u : urgent packet

h : highly important packet

m : moderately important packet

l : less important packet n ← node if n ← u then forward u else if n ← h then forward h else if n ← m then forward m else if n ← l then forward l else drop packet end if In priority based packet forwarding the input is assign priority to nodes and the output is highest priority forwards packet. Here u is assigned as urgent packet, h as highly important packet, m as moderately important packet and l as less important packet. If node n is urgent packet then forward the packet else forward the packet which is highly important packet else forward the packet which is moderately important else forward the packet which is less important packet. Otherwise drop the packets.

VI CONCLUSION

In this paper, we have developed a distributed opportunistic routing algorithm that uses network coding. ExCODE is proposed in this paper, which is an extended network coding opportunity discovery scheme. It can effectively extend the region of coding discovery to the n-hops, and can exploit more coding opportunities. Through the comparison and analysis between ExCODE and COPE, ExCODE can indeed discover more coding chance than COPE, and can be applied in any kind of wireless routing protocols to enhance the coding-aware function. Our future work is about to practice ExCODE in a real network to test its performance, such as a wireless sensor network that is built up by Sun Spot sensors.

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