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Network Coding for Energy Efficiency in Wireless Networks

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Abstract: mobile ad-hoc networks suffer from the overhearing. Recently network coding is taking part the key role in utilizing the overhearing characteristic of wireless medium. Network coding reduces the number of transmissions and so saving the energy of wireless networks. In this paper we concisely recount the current advances for reducing energy consumption utilizing network coding. We furthermore discuss the challenges and directions of improving energy efficiency using network coding techniques.

Keywords: Network Coding; energy efficiency; mobile adhoc networks; wireless networks; overhearing

I. INTRODUCTION

A mobile ad-hoc network [1] is created of wireless nodes without any infrastructure. Wireless nodes self-organize to create a network over wireless connections. The aim of MANETs is to extend mobility into the realm of autonomous, wireless and wireless domains, where a set of nodes pattern the network routing infrastructure in an ad-hoc fashion. The most of applications of MANETs are in localities where fast deployment and dynamic reconfiguration are necessary and wired network is not accessible. These include military battlefields, crisis search, classrooms and conferences, where participants share data dynamically utilizing their wireless apparatus. These submissions lend themselves well to multicast procedures. In addition, inside a wireless network, it is crucial to decrease the transmission overhead and power consumption.

Energy efficiency[2] is the quantity of battery power of a node consumed to convey messages over a wireless connection. It is a critical design parameter for wireless ad-hoc systems. Here, the properties of the wireless media can be used to improve network throughput, reliability and obvious error tolerance. Current nodes or routers just store and forward packets. Recently varied investigators are applying network coding to effectively improve the presentation the wireless networks. Network Coding [3] is an undertaking expertise that can competently improve the efficiency and capability of multihop wireless systems by exploiting the broadcast environment of the wireless networks. It endows nodes to execute coding procedures on the genuine content. Thus, it facilitates the development of innovative sophisticated connection system architectures and transmission forms. These forms are more apt for a Future Media Internet where mesh capability and better presentation is required. Really, Network Coding has the promise to unleash technologies to help redesigning of future systems and considerably advance their performance, since it allows to trade-off communication capability against computational costs. Although the promise of the Network coding paradigm is nice, there are still many open troubles that forestall a roaring immediate preparation of derived technology in real-world applications. The present packet routing schemes do not take benefit of the network coding, and the advantages of network coding have not been fully utilized.Fig.1 shows the unnecessary overhearing. Here node A wants to send packets to node B. But, node C also overhears the data, which is not necessary for it.

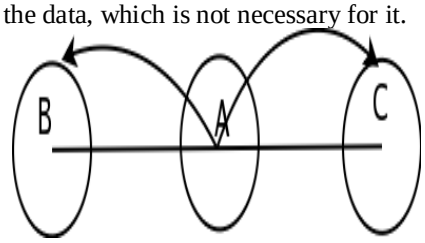

Figure.1.Unnecessary energy consumption

This paper explores an understanding of the potential of network coding for reducing the energy usage in wireless networks. Given a bunch of traffic claims the aim is to send them across a path within the network with the target of minimizing the total power use, while ensuring on the lifetime of the nodes. To quantify the energy savings in wireless networks, the energy consumption of the entire system ought to be designed and analyzed.

The rest of the sections are organized as follows. In section two, some of the prevailing approaches for reducing energy consumption are mentioned. The energy advantages of network coding are discussed in section three. In section 4, we described some existing network coding schemes for reducing energy. Section 5 presents the challenging problems, some directions to resolve them and expected outcomes. Eventually, section five summarizes the conclusions.

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II. RELATED WORK

A wireless ad-hoc network is a wireless computer network where there is no fixed infrastructure. All wireless enabled devices within the range of each other can discover and communicate with each other in a peer-to-peer fashion without involving central access points. In the last few years wireless ad-hoc networks are rapidly gaining importance. The ad-hoc property makes them quite useful in situations where setting up of an infrastructure based network could be difficult, or even impossible. Because of this reason, wireless adhoc networks are being studied especially for their applications in disaster management, military, environment studies, conferences and classrooms etc. Ad-hoc networks are becoming increasingly popular because its deployment is very fast and easy. Since there is no central infrastructure and the mobile devices are moving randomly, gives rise to various kinds of problems, such as routing, energy.

A. Energy Constraints in Ad-Hoc Wireless Networks:

Routing[5] is one of the key issues in MANETs because of highly dynamic and distributed nature of nodes. Especially energy efficient routing is most important because all the nodes are battery powered. Failure of one node may affect the entire network. If a node runs out of energy the probability of network partitioning will be increased. Therefore energy depletion is become one of the main threats to the lifetime of the ad hoc network. So routing in MANET should be in such a way that it will use the remaining battery power in an efficient way to increase the life time of the network. For example, all the packets from 0-3, 1-4, 2-5, in Fig.2 will be routed through the central node. This will lead to a relatively early death of the central node. Similarly, in fig.3 using shortest-hop routing, traffic from A to D will always be routed through E.E's energy reserves will be drained faster and then F will be disconnected from network. A to D traffic should also use the B-C path extending networks life

B. Motivation:

Routing in networks operates in a similar manner as the transportation problem. Here the aim is to transport a given commodity in a cost-efficient fashion. In the case of media communication over the Internet the goods to be transported are packets of bits representing multimedia information. Conventionally, data is compressed and recovered at the edges. Cost is defined according to a given cost of routes or by adjusting to the flows. More importantly this conventional model does not generally make use of the fact that the commodity being transported is made up of bits representing chunks of media. The latter is a key aspect since bits can be manipulated, coded and transmitted in a fashion that is very different from other less operable commodities. The fact that in current Networked Electronic Media approaches, routing in networks operates in a manner akin to the transportation problem opens a very promising research field.

Here, the properties of the media and the fact that bits can be operated on, is exploited to achieve significant improvements in network throughput, reliability and fault tolerance. Current nodes or routers just store and forward packets. That is, today's networks are all based on the same fundamental principle: the network forwards data but the information itself is processed only at the end-nodes .The network coding paradigm breaks this assumption by enabling intermediate nodes to process and combine incoming packets into one or more outgoing packets. This idea has generated significant interest originally in the information theory and computer science communities and more recently in the networking community, when it was demonstrated that it can improve the performance of peer-to-peer and wireless mesh networks.

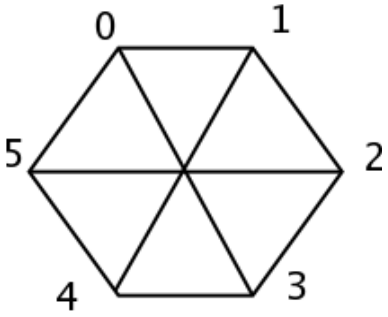

Figure.2.Energy consumption

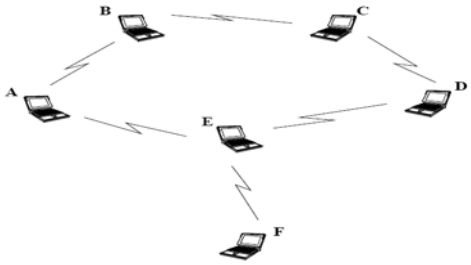

Figure.3.enegry awareness in routing

C. Limitations of current approach:

Previous work[4] on minimizing energy consumption in networks has focused on, e.g., minimum cost routing, power control algorithms and cross-layer protocol design. However, exiting new opportunities arise from the advent of network coding. Network coding is a promising technology that can effectively improve the efficiency and capacity of multihop wireless networks by exploiting the broadcast nature of the wireless medium. However, current packet routing schemes do not take advantage of the network coding, and the benefits of network coding have not been fully utilized.

Network coding[8] applied to energy constrained networks reduces the total energy consumed for a given amount of information across the network. Existing coding aware routing protocols discover regions in the network where there is a high probability for mixing the packet and divert all traffic toward them. As a result, a few key nodes in the network handle high amount of traffic while others are left idle. Since residual energy depletes very fast due to network coding, key nodes die quickly compared to other nodes in the network. This leads to significant imbalance in residual energy of the nodes across the network which may result in reduced network lifetime even though a majority of the nodes are still alive and left with high residual energies.

III. NETWORK CODING

Network Coding[3] aims at adding *"intelligence"* and computational power to the nodes. It enables nodes to execute coding operations on the actual content. Thus, it facilitates the development of novel advanced communication system architectures and transmission models. These models are more suitable for a Future Media Internet where network capacity and better performance is required. Network coding is a new paradigm that allows the intermediate nodes in a network to create new packets by combining the packets received on their incoming edges. Indeed, Network Coding has the potential to unleash technologies to help redesigning of future networks and substantially improve their performance, since it allows to trade-off communication capacity against computational costs.

Although the potential of the Network Coding paradigm is great, there are still many open problems that prevent a successful immediate deployment of derived technology in real-world applications. The following four examples of selected key research challenges outline the need for focused research in Network Coding to fully exploit its potential. In the past decade, remarkable progress has been made in the area of network coding in terms of theory, code design, and applications. However from an energy perspective, there have been fewer efforts on understanding the impact of energy levels of a node on coding of packets at network layer to improve the network life time.

Network coding has been considered as an effective strategy for improving the performance of wireless networks. However, most existing work studied network coding based on fixed route. Meanwhile, due to the limitation of the energy capacity of wireless networks, prolonging the network lifetime is a crucial task. Much attention has been paid on energy efficiency of routing protocols in wireless ad hoc networks. Since transmission or receiving of data packets and control packets will drain the energy which is powered by the batteries, designing energy efficient communication techniques is one of the most important challenges for wireless ad hoc networks Network coding has been considered as an effective strategy for improving the performance of wireless networks. Network coding [11] is a promising technique to improve network throughput .it allows mixing of packets at intermediate nodes. The basic idea of network coding is illustrated with an example in fig.4.Fig.4.shows the benefits of network coding .It reduce the number of transmissions from 4 to 3, which increases the coding gain.

D. Reducing energy consumption with network coding:

Network coding[17] reduces the energy consumption of wireless networks by utilizing the broadcast nature of wireless medium. In wireless networks ,when a node transmits a packet ,all the neighbor nodes which are in the transmission range of that node can also overhears the packets. These overheard packets can be used to perform encoding and decoding and to improve the coding opportunities. It helps to improve the coding gain. Energy benefit is the ratio of minimum energy consumption of nay routing to the minimum energy consumption with network coding based solution. In fig.5,Node C transmits the coded packets p1+p2+p3+p4, and hence the A, B, F, G can decode its required packets by using the XOR operation.

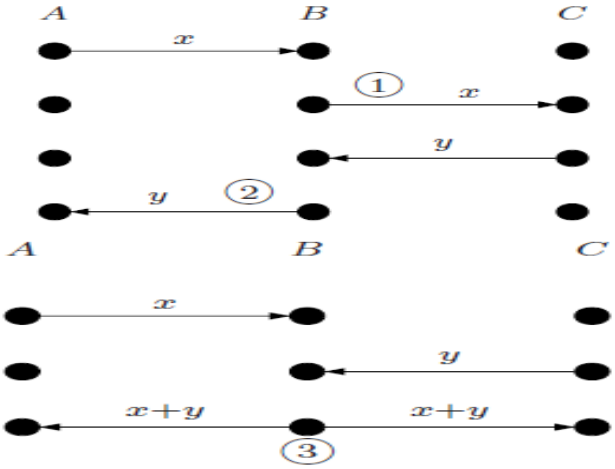

Figure 4. Network Coding

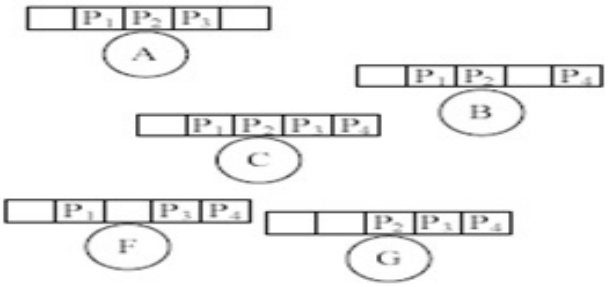

Figure.5. Benefits of network coding

E. COPE architecture:

CoOPE[18] architecture implements the wireless network coding. It maintains a FIFO queue for each neighbor and two virtual queues for grouping the packets into small and large packets.

COPE is a procedure to mix the packets at routers. The COPE is an architecture that inserts a network coding scheme between IP and MAC layer, which detects coding opportunities and exploits them to forward multiple packets in a single transmission. The COPE protocol can work for non delay tolerant applications. In this work we have made an attempt to find the network coding for delay tolerant applications. We have been defining the packet delay time to each packet. Based on the packet delay time our approach is evaluating the network code.

The working of COPE protocol is as follows: When packets come from MAC layer, it identifies which native packets XOR-ed and their also next hops. So all the information of coded packet after transmission, it contains in reception report. Each report identifies a source, the last IP sequence number received from that source, and a bit-map of most recent packets seen from that source. After receiving the encoded packets, the acknowledgement came from network layer; it identifies a neighbor, an end point for the ACK map and bit-map of ack-ed packets.

Fig. 6 shows that the best coding scenario can be selected so that the maximum number of neighbors benefitted. Therefore, we can reduce the number of transmissions. Here B can send coded packets to its neighbor nodes. Nodes A, C, D shows the packets available with that node. B want to send packets p1, p2, p3, p4 to A, C, C, D respectively. Now if we perform mixing of packets

at node B as p1+p2 using xor operation and broadcast, then only C can decode and get p2.node B can perform p1+p3 then both A and C can decode and get P1 and p3 respectively. To maximize the number of packets delivered in a single transmission B can mix p1, p3, p4 and broadcast then nodes A, C and D can decode and get p1, p3, p4 respectively. That is at node A, we get p1=p4+p3+p1+p3+p4.

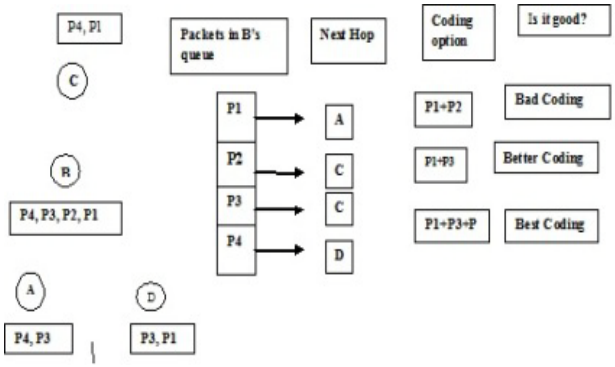

Figure.6. COPE protocl architecture.

IV. ENERGY EFFICIENT ROUTING SCHEMES

A number of previous works have addressed the issue of energy conservation in ad hoc networks. This section provides a brief summary of energy saving approaches in ad hoc networks.

EECAR [24] is an energy-efficient coding aware routing (EECAR) mechanism. It improves energy efficiency. EECAR can identify potential coding opportunities under "two-hop" coding conditions and increase the network lifetime. An energy-efficient coding-aware metric (EECAM) is presented to detect coding opportunities within two-hop neighbors and elects nodes with high remaining energy. The EECAR mechanism is implemented in ns-2. Simulation results show that the proposed EECAR strategy attain high throughput gains and prolongs the network lifetime. It proposed a new energy-efficient coding aware routing protocol which incorporates potential coding opportunities and energy efficiency into route selection. It is the first routing system combining network coding and the survivability of networks into route selection. Simulation results demonstrate that the proposed mechanism achieves high performance in increasing the network throughput and prolonging the network lifetime as compared with COPE.

Two-way network coding [23] is used to minimize energy consumption. The problem is solved using linear programming. Backpressure algorithm is developed to solve the problem in a distributed manner. The performance of the algorithm is calculated in simple topology and random topologies. Simulation results show that the convergence time increases as the number of nodes in the network, and the energy cost per packet can be saved up to 30% by using two-way network coding. The energy needed to transmit a bit of information can be reduced using network coding [9].It solves the minimum energy multicast problem using a linear program and lower energy-per-bit.[25] Reduces energy consumption by combining network coding with Connected Dominating Set (CDS)-based broadcasting. It increases coding opportunities by increasing the number of intersect flows. It develops a NCDS to reduce energy consumption. It incorporates network coding over connected dominating set. The experimental results show that NCDS improves up to 161% gains compared to *blind flooding*, and 37% gains compared to *CDS based broadcasting* without network coding.

V. CHALLENGES AND DIRECTIONS

Network coding can be used an energy minimization technique. Network coding reduces the energy consumption by minimizing the number of transmissions required to communicate a given amount of information across the network. However, network coding does not come for free: it adds complexity, increases processing and storage costs, and requires that we need to re-think the protocol stack. Currently, the full potential and limitations of network coding in the Internet are still poorly understood. We should design novel network coding mechanisms to solve practical problems in each area and evaluates the cost-benefit tradeoffs. Identify the common building blocks and studies deployment and architectural issues maximizes the coding opportunity by finding the coding possible path for every packet in the network.

Given a set of traffic demands the goal is to route the demands across the network with the objective of minimizing the total energy consumption while providing guarantees on the lifetime of individual nodes. Existing coding aware routing protocols discover regions in the network where there is a high probability for mixing the packet and divert all traffic toward them. As a result, a few key nodes in the network handle high amount of traffic while others are left idle. Since residual energy depletes very fast due to network coding, key nodes die quickly compared to other nodes in the network. This leads to significant imbalance in residual energy of the nodes across the network which may result in reduced network lifetime even though a majority of the nodes are still alive and left with high residual energies.

Aggressive application of network coding adversely affects the network lifetime. We need to consider this trade off .The existing throughput based network coding approaches cannot be applied to energy-constrained networks. Therefore, develop a system to select the qualified path based on power consumption in the node, number of internodes and traffic load in the network. We need to compare, for example, the amount of energy required if network coding is used to the energy consumption of plain routing. In addition, we need to consider the tradeoff between the energy consumption reduction offered by network coding with other performance measures like throughput and delay. We prove that applying ideas from network coding allows realizing significant benefits in terms of energy efficiency for the problem of broadcasting, and proposing very simple algorithms that allow realizing these benefits in practice.

Theoretically quantify the energy savings that network coding can offer. Since energy efficiency has paramount importance in wireless access because of the limited energy resources, we should also introduce transmission and coding energy costs and discuss the optimization trade-offs involving the throughput and energy measures. The algorithms and protocols can be optimized to the ad-hoc networking scenario. Performance and complexity of the

network coding based algorithms and protocols can be investigated and compared to the performance and complexity of traditional routing algorithms and protocols. We need to address several fundamental questions that develop on these themes. We should take a complete view of these ideas by not only developing the underlying theory but also through validation on wireless network simulators.

VI. CONCLUSION AND FUTURE WORK

Network coding endows additional practical, scalable and energy efficient wireless network. These potentialities arrive with a need for rethinking our MAC, routing, and transport protocols. It reduces the energy consumption of wireless networks. The supreme intend of this study is to choose the qualified path based on power consumption within the node, number of internodes and traffic load inside the network we tend to mentioned a number of the open problems and directions for finding them. We tend to believe that our future study will overwhelm these trials and integrate network writing into the wireless network design to effectively use it for improved energy efficiency.

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