TRAFFIC AWARE MULTIPATH COMMUNICATION FOR TIME-CRITICAL APPLICATIONS IN UNDERWATER ACOUSTIC SENSOR NETWORKS

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ABSTRACT:

In this project, we propose an energy efficient and collision aware (EECA) node-disjoint multipath routing algorithm with multipath power-control transmission (MPT) scheme for Acoustic sensor networks. With the aid of node position information, the EECA algorithm attempts to find two collision-free routes using constrained and power adjusted flooding and then transmits the data with minimum power needed through power control component of the protocol. And also, we propose a new multipath power-control transmission (MPT) scheme, which can guarantee certain end-to-end packet error rate while achieving a good balance between the overall energy efficiency and the end-to-end packet delay. MPT smartly combines power control with multipath routing and packet combining at the destination. With carefully designed power-control strategies, MPT consumes much less energy than the conventional one-path transmission scheme without retransmission. Besides, since no hop-by-hop retransmission is allowed, MPT introduces much shorter delays than the traditional one-path scheme with retransmission. We conduct extensive simulations to evaluate the performance of MPT and EECA

***Index Terms*— Applications, energy efficiency, MPT, underwater sensor networks, EECA.**

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I. INTRODUCTION

This paper studies congestion control techniques, and shows that the adverse effects of network congestion can be greatly alleviated when they operate in concert. The first technique is cross layer cognition detection technology to detect the potential congestion timely and effective. Wireless Sensor Networks (WSNs) are networks of tiny,battery powered sensor nodes with limited on-board processing, storage and radio capabilities. So the system must of an energy efficient one. The propagation speed of acoustic signals in water is about 1.5×10^3 in water is about (3×10^8 m/s).Moreover, underwater acoustic channels are affected by many factors such as path loss, noise, multipath fading, and Doppler spread. All these cause high error probability in acoustic channels. In short, underwater acoustic channels feature long propagation delay and high error probability. In such harsh network scenarios, it is very challenging to provide energy-efficient reliable data transfer for time-critical applications (such as pollution monitoring and submarine detection). First, conventional retransmission-upon-failure approaches are hard to satisfy the delay requirements.

MPT is a cross-layer approach. It combines power control with multipath routing and packet combining at the destination. Distributed power-control strategies at the physical layer are used to improve the overall energy efficiency. No hop-by-hop retransmission is allowed in MPT, as that contributes to the low end-to-end delay. In an underwater sensor network, with high probability, multipath routing protocols can find multiple paths between any two nodes because of the relatively high node density (this assumption holds even stronger in the multiple-sink underwater network architecture.

II. ANALYSIS OF MULTIPATH COMMUNICATION

While the majority of the prior research is going on in the field of underwater sensor networks. Then, we briefly review some typical approaches for energy efficiency in wireless sensor networks. After that, we discuss some relevant work on multipath routing as well as packet combining. Underwater sensor network has received significant research interest for the last several years. Almost every layer of the protocol stack has been tackled: medium access control (MAC) and CDMA-based MAC protocols; multihop routing and localization to name a few. Different from previous work, our work in this paper proposes an energy-efficient cross-layer approach for time-critical applications in underwater sensor networks. The other way is to apply power control at the physical layer to reduce the overall energy consumption for one communication event.

The authors of extend the packet-combining scheme into multihop scenarios and investigate its performance in wireless sensor networks. Through experiments, they show that the packet-combining scheme can achieve promising results even in multihop wireless networks. The authors propose a multipath packet-combining scheme for wireless multihop networks. Based on an analysis on the delay characteristics of multipath transmission, they show that the optimal number of paths exists that minimizes the average end-to-end packet error rate under certain delay constraints. In our work, we also propose a simple packet-combining strategy for our MPT scheme. However, our main contribution does not lie in packet combining, and any other packet-combining techniques can be easily incorporated into our scheme.

a. Network model

In this paper, we consider the following multisink underwater sensor network model: Underwater sensor nodes with acoustic modems are densely distributed in a 3-D aqueous space, and multiple gateway nodes with both acoustic and RF modems are strategically deployed at the water surface. Each underwater sensor node can monitor and detect environmental events locally. As shown in Fig. 1, when an underwater sensor node has data to report, it first transfers the data toward one or multiple surface gateway nodes (each is also referred to as a sink) through acoustic links.

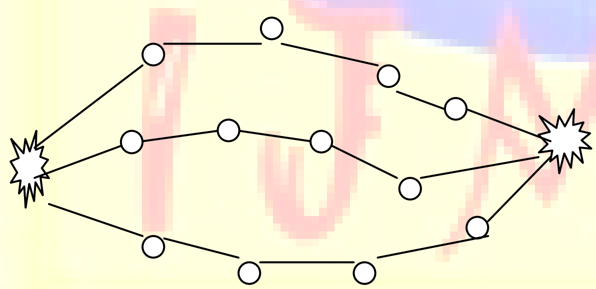


Fig. 1. Network model.

Then, these surface gateway nodes relay the received data to the control center through radio links. Compared to the acoustic links in water, surface radio links are much more reliable, faster, and more energy-efficient. Considering that radio signal propagation is orders of magnitude faster than acoustic signal propagation, it is safe to assume that surface gateways can send packets to the control center in negligible time and with relatively small energy consumption In this way, all the surface gateways (or sinks) form a virtual sink.

c. MPT Description

MPT can be divided into the following three parts: multipath routing, source initiated power-control transmission, and destination packet combining. First, the source node (any underwater sensor node in our network model can be a source node) initiates a multipath routing process to find paths from the source to the destination (in our network model, the control center can be the destination). Through this route-finding process, the source will get to know some network parameters such as path length and the number of available paths. Based on this knowledge, the source node selects some paths and calculates the optimal transmitting power for each node along the selected paths. Then, it sends the same packet along the selected paths. Intermediate nodes on these selected paths will relay the packet with specified transmitting power parameters (carried in the packet header). When the destination receives all copies of the packet (some copies may get corrupted), it performs packet combining to recover the original packet.

b.Multipath Routing

When the source node has some packets to send, it will flood a "Route Request" message to the destination. Any intermediate nodes who receive this "Route Request" for the first time will forward it. When the destination receives "Route Request" messages, it will reply "Route Reply" messages reversely along the paths of the corresponding "Route Request" messages.

The destination can also make pathselection. For example, it can select node-disjoint paths and send "RouteReply" back on them. After the source node receives the "Route Reply" messages, the routes between the source and the destination are established. Since most of existing multipath routing protocols will cache the routing information at the nodes , there is no need to repeat the whole routing process for every packet.

d.Source-Initiated Power-Control Transmission

In this phase of MPT, the same packets sent from the source node are transmitted by the intermediate nodes along all the selected paths using the specified transmission power. The packet format is shown in Fig. 3. Every packet should include the source identification (Source ID), the destination identification (Destination ID), as well as the packet sequence number (Sequence No.) in the packet header.

The source node should also include power parameters in the packet header. In addition,we assume some coding schemes with strong error correction capability, such as forward-error coding (FEC), are used in the header of every packet. In this way, the header part of every packet can be decoded correctly with high probability. Since the packet header is usually much smaller than the data part,the overhead incurred in the header error correction process is almost negligible. For the large data part, we do not use any error-correction coding schemes because of their inefficiency in fading environments. However, some error-detection coding schemes, such as cyclical redundant checking (CRC), are still used in the data part to check data errors.

e. Destination Packet Combining

When the destination receives a copy of the original packet from one path (the data part of this copy may be corrupted during the transmission process), it first checks whether this copy is correct

or not. If there is no error with this copy, the destination successfully receives the original packet. Otherwise, the destination will keep this corrupted copy in its buffer. After multiple corrupted copies of the original packet are received, the destination will combine them to recover the original one.

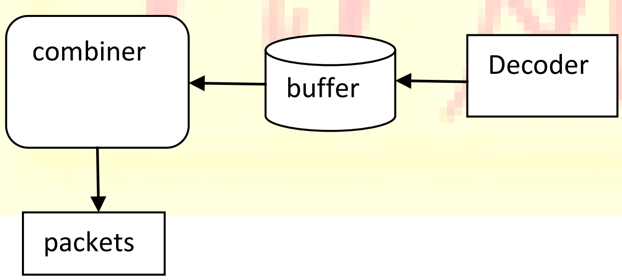


Fig. 4. Packet combining at the destination.

In MPT, we use a simple packet-combining technique, which is illustrated in Fig. 4. Assuming the destination receives copies of the same pack et from m*paths, for the th bit in this packet, it determines its output b_i ,

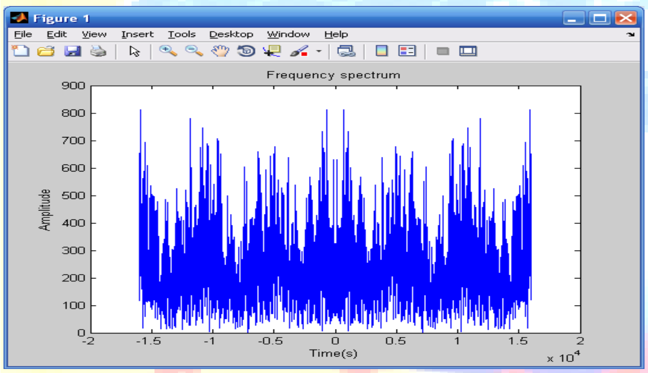
$$b_i = 1, \geq m^*/2$$

$$b_i = 0, \leq m^*/2$$

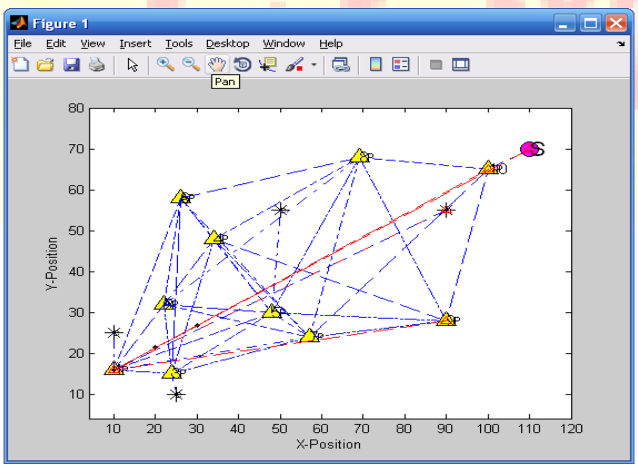
where`b_{ik} denotes the th copy of the i_{th} bit. Simply put, if the bits in the majority of the copies are "1," then the corresponding bit of the original packet is decoded as "1"; otherwise, it is decoded as "0." We choose this "majority voting" method mainly because of its simplicity.

III.SIMULATED RESULT

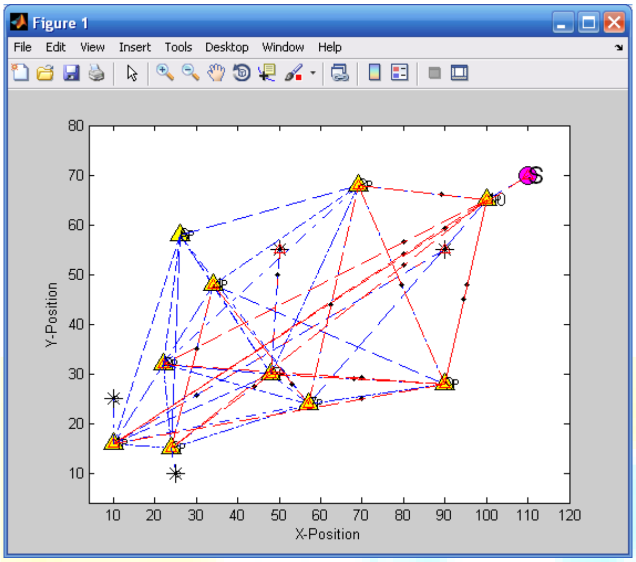
a) Frequency Spectrum



b) Connection Establishment



c) **Multipath Transmission**



IV. OPTIMIZING ENERGY DISTRIBUTION

In this section, we will first describe the channel model and formulate the energy distribution optimization problem. We will then show how the source node optimally distributes energy along one path and multiple paths. Finally, we summarize the overall energy distribution process.

V. CONCLUSION

In this paper, we propose a energy efficient and collision aware (EECA) node-disjoint multipath routing algorithm with multipath power-control transmission (MPT) scheme, for time-critical applications in underwater sensor networks. MPT combines the power-control strategies with multipath routing protocols and packet recovery at the destination. Without retransmission at the intermediate nodes, MPT can achieve low end-to-end packet delay. With power control at the physical layer, MPT can achieve relatively high energy efficiency. For time-critical applications in energyconstrained underwater sensor networks, MPT is a promising transmission scheme for a good balance between packet delay and energy efficiency.

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