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ENERGY MINIMIZATION FOR MULTI-RESOLUTION MULTI-RELAY MULTICAST NETWORKS

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Abstract: An asynchronous cooperative joint source-channel coding (JSCC) protocol is proposed, aimed at mitigating the complexity and difficulty in signal synchronization in multicast. Taking end-to-end mean square error distortion (EED) as the quality of service (QoS) measure, the problems of JSCC transmission are formulated to minimize the total power consumption where both relay selection and power allocation at the base station (BS) and all the relays are jointly determined. To reduce the computation complexity, a heuristic algorithm for relay selection is presented. Simulation analysis is carried out to show the performance of the proposed system compared to the existing schemes.

Keywords: Superposition coding, wireless multicast, relay placement, successive refinable information,

Introduction

Due to the nature of wireless channels, wireless communication suffers from multipath fading and the time-varying characteristic that causes distortion to the delivered information. This has imposed a stringent limitation on some applications where retransmission is not possible, such as broadcast/multicast. To resolve the problem, Joint source channel coding (JSCC) and cooperative transmissions are two classes of solutions that exploit different design dimensions of communication systems.

With JSCC, scalable source coding (SSC) is paired with superposition channel coding (SPC) by mapping the source symbols to multiple successively refined channel symbols. The source symbols from a common source coding block of different resolutions are superimposed into one JSCC symbol for transmission, such that the receiver can recover up to a specific layer of source symbols according to the channel quality. Due to multi-resolution in nature, JSCC can mitigate various vicious impacts due to fast channel fading and multi-user channel diversity, and perfectly serves the wireless multicast scenario with multi-resolution sources such as scalable videos [1]–[9]. The multi-granularity decoding process based on successive interference cancelation (SIC) allows a receiver of a specific channel quality to obtain information closer to its channel capacity bound.

Literature survey

Many existing works have been presented with regard to increasing reliability of networks. This work presents an account of related work with respect to reliability based on node energy and link dynamics.

Industrial Wireless Sensor Networks: Challenges, Design Principles, and Technical Approaches [1] provides a contemporary look at the current state of the art in IWSNs and

discuss the still-open research issues in this field. Energy has been used as a reliability factor by many research works.
An energy aware routing protocol for real time traffics was presented in [2] for wireless sensor networks. This protocol considers both energy and delay metrics to find an optimal path with minimum energy consumption and minimum end to end delay. The protocol [3] is successful in providing low energy consumption and satisfying low end to end delay which makes it suitable for real time applications. The work in [4] proposed an energy-aware QoS routing protocol for sensor networks which can also run efficiently with best-effort traffic. The protocol finds a delay-constrained path for real-time data in terms of link cost that captures nodes' energy reserve, rate of error and transmission energy. It also optimizes throughput for non-real-time data by adjusting the service rate for both real-time and non-real-time data at the sensor nodes. Reliability, however, takes more than just evaluation and routing based on the energy value of a node. An Improvement of AODV Protocol Based on Reliable Delivery in Mobile Ad hoc Networks was proposed in [5]. This paper presented an AODV with reliable delivery (AODV-RD) which provides a link failure fore-warning mechanism, better route selection and repairing action after primary route breaks basis of AODV-BR that not only optimizes the network performance but improves the quality of communication.

Proposed System

In this paper, we propose Trust based Energy Efficient scheme for Hierarchical Clustering in WSNs (JSCC). JSCC aims to minimize the energy cost and maximize the security in WSN. This network consists of a BS, CHs and numerous sensor nodes that are grouped into clusters. Here all sensor nodes are stationary and locations and communication range of nodes are known. The clusters of sensors can be formed based on the location. Each cluster includes the CH and a set of sensor nodes. Each sensor has two main functions sensing and relaying. Sensors probe their environment and gather data. Then they transmit the collected information to the CH directly in one hop or by relaying via a multi hop path. A CH is in charge of its cluster. It is assumed that each CH can reach and control all the sensors in the cluster. Every CH receives the information from different sensors, processes the data to extract relevant information and then sends it to the BS via multi-hop transmission**.** Therefore, the CH has higher computation power and memory when compared to other sensor nodes.

The information on a sensor node's prior behavior is one of the most important aspects of the communication trust [6]. However, communication channels between two sensor nodes are unstable and noisy, thus monitoring sensor node's behaviors in WSNs based on previous communication behaviors involves considerable uncertainty. The communication trust is calculated based on successful and unsuccessful communication packets.

The Communication Trust of every node is calculated in equation 1.

$$TC_i = \frac{2m+n}{2} \qquad (1)$$

Where $m = \frac{s}{s+us+1}$

$$n = \frac{1}{s+us+1}$$

s →Successful communication packet

us →Unsuccessful communication Packet

In this paper the Energy Trust is calculated based on the residual energy and Geographical Average Energy of each sensor node. Geographical Average Energy of node is calculated by following formula.

$$GAE(r) = \frac{\sum_{i=1}^{cn} RE_i(r)}{cn} \qquad (2)$$

r → Cluster round Number

$RE_i(r)$ → Residual Energy

cn →Number of nodes in the Cluster

The Trust Energy is obtained from the equation (3) below.

$$TE_i = p\frac{E_i(r)}{GAE(r)} \qquad (3)$$

p →Desired percentage of CH

The overall Trust of each node is evaluated by equation (4) below.

$$T_i = \frac{TC_i + TE_i}{2} \qquad (4)$$

JSCC selects the CH based on the threshold that is calculated by the suggested percentage of CH for whole network. In each round, the trust probability values ranges between 0-1. The Threshold value is determined in equation (5).

$$THi = \frac{T_i}{1 - T_i(r \bmod 1/T_i)} \quad if\ i \in S \qquad (5)$$

Where

S →Sensor nodes that not does not select the CH in previous round

The figure 1 shows that the illustration of the trust routing in WSN. The CH is chosen based on Communication trust and Energy Trust of each sensor node. If the Trust value is greater than the Threshold, that node is selected as a CH. The Source transmits the data to BS through the trusted CH node. The trusted path does not choose the untruthful nodes therefore the source transmit secure data to BS.

The figure 2 describes the flowchart of JSCC scheme. In this scheme, the clusters are formed based on the location. Every sensor node computes the Communication Trust and Energy Trust. The Communication Trust value is calculated based on the successful and unsuccessful communication packets. The Energy Trust is estimated based on the Residual energy and Geographical Average Energy. If the Trust value is greater than the threshold, that node is selected as a CH. Finally, the sensor node transmits the data to BS through the trusted CH.

Simulation Analysis

Network simulator is used to perform simulation between the TMA and the JSCC protocols. NS-2 used programming in Object Oriented Tool Command Language (OTCL) and C++ for simulation of various wired and wireless scenarios.

Packet Delivery Rate

Packet Delivery Rate (PDR) is the ratio of number of packets delivered to all receivers to the number of data packets sent by the source node. The PDR is calculated by Equation 6.

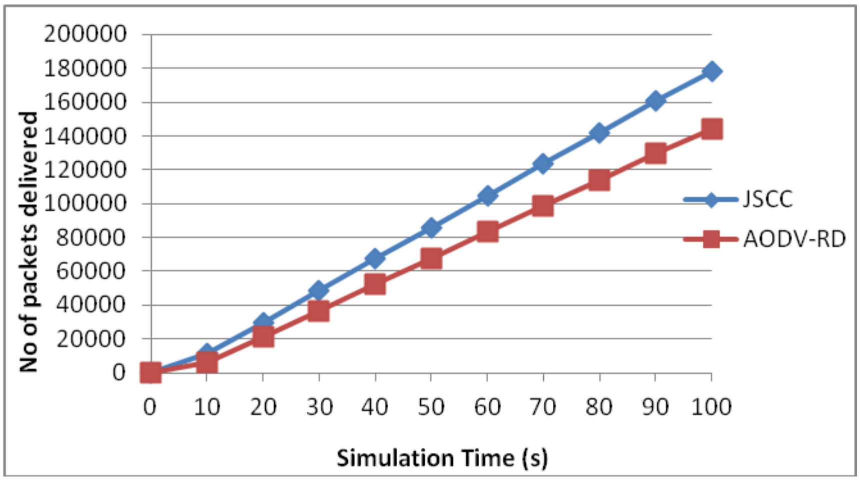

Fig. 3 Packet Delivery Rate

The figure 3 shows the PDR of the proposed scheme JSCC is higher than the PDR of the existing method TMA. The greater value of PDR means the better performance of the protocol.

Packet Loss Rate

The Packet Loss Rate (PLR) is the ratio of the number of packets dropped to the number of data packets sent.

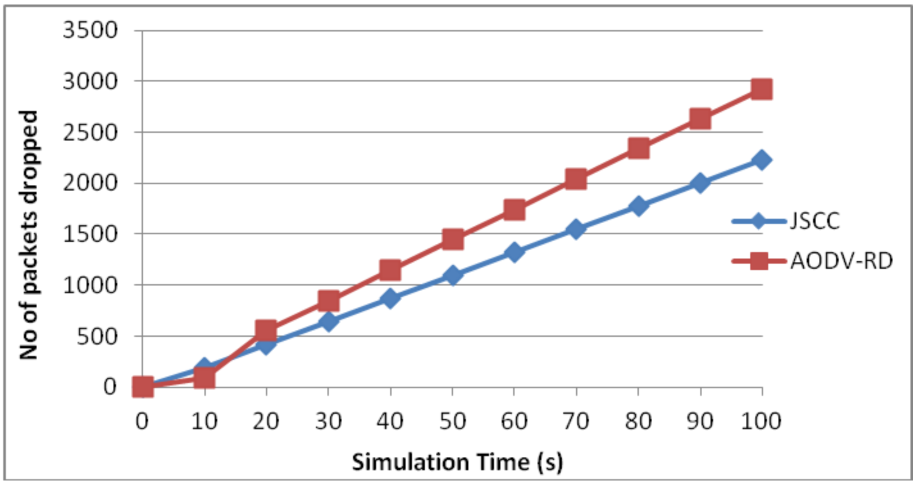

Fig. 4 Packet Loss Rate

The PLR of the proposed scheme JSCC is lower than the existing scheme TMA in Figure 4. Lower the PLR indicates the higher performance of the network.

Average Delay

The average delay is defined as the time difference between the current packets received and the previous packet received.

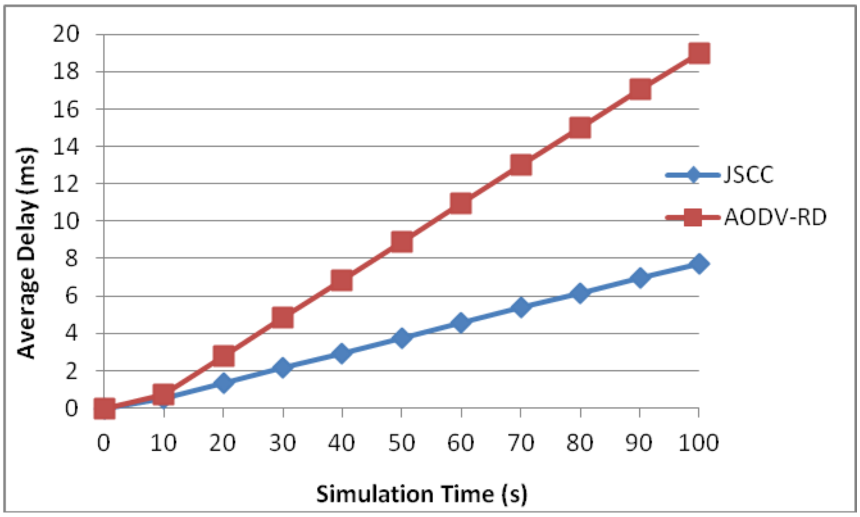

Fig. 5 Delay

Figure 5 shows that the delay value is low for the proposed scheme JSCC than the existing scheme TMA. The minimum value of delay means that higher value of the throughput of the network.

Throughput

Throughput is the average of successful messages delivered to the destination.

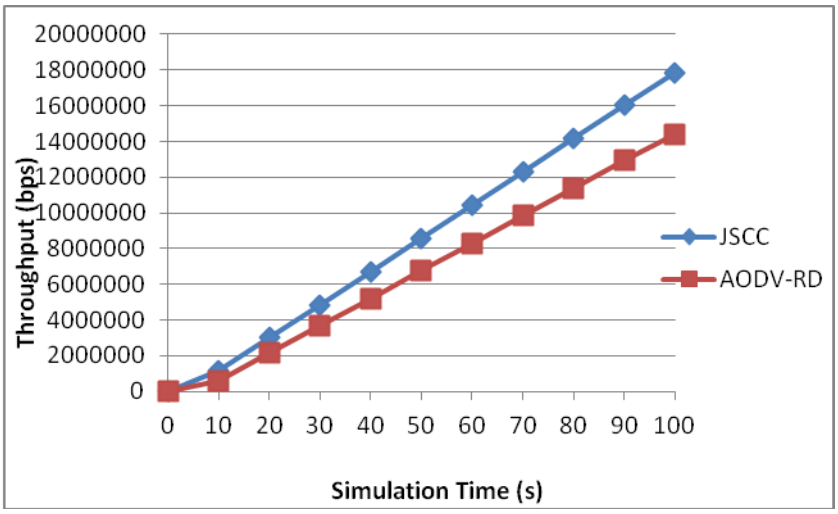

Fig.6 Throughput of TMA and JSCC

Figure 6 shows that proposed scheme JSCC has greater average throughput when compared to the existing scheme TMA.

Conclusion

The paper studied a multi-relay aided joint source-channel coding (JSCC) multicast network containing a source, multiple decode-and-forward relays, and multiple destination nodes. Due to the difficulty in synchronizing the relay transmission, an asynchronous JSCC two-slot multicast protocol was introduced, along with an optimal DFE structure where the associated SINR of all layers can be determined based on MMSE criterion. EED at the destination nodes was taken as the performance metric for the system optimization, subject to the power level and power ratio assigned to each layer at the transmitters. An optimization problem to minimize total power consumption was formulated and solved, where the transmit power level, power assigning ratio for all layers, and relay selection can be jointly determined.

The simulation results showed that the proposed multirelay aided multi-resolution design yields merits in suppressed energy usage against its counterparts in all the considered scenarios with the same QoS requirement. In particularly, we found that with two resolutions the total energy usage could be considerably reduced due to finer granularity of quality provisioning in presence of a large number of receivers with multi-user channel diversity. Our analysis and observations provide insights in designing 5G protocols by taking both JSCC and cooperative communication into account.

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