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Link-Correlation-Aware Opportunistic Routing with EEC for Effective Packet Recovery

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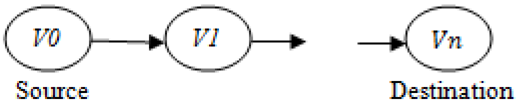
***Abstract*— Packet loss is a serious problem in the wireless networks which use conventional store-and-forward design. This paper proposes a link-correlation-aware Opportunistic routing with EEC. It provides various error recovery strategies with respect to reliability, stability, and energy consumption constraints. Here the error correction process is performed in a distributed manner where selected intermediate nodes participate in error recovery. The EEC scheme effectively detects the errors in the packet recovery so that the errors can be corrected and packet recovery can be efficient with very low latency. The use of opportunistic routing can reduce the decoding delay and reduces the packet delay by forwarding the incoming packets without waiting for the packet sent by its previous receiver to decode it. However, inappropriate assumption in opportunistic routing cause serious estimation errors in the forwarder set selection resulting in further increase in scheduling costs. The link-correlation-aware opportunistic routing overcomes the estimation errors in the forwarder set selection and reduces the scheduling costs. The proposed method is better with low latency recovery and achieves high reliability and stability.**

Keywords— ***Link-layer protocol, Opportunistic routing, EEC, wireless networks***.

I. INTRODUCTION

Anyone who is up to date on the Wireless World will comfortably say that the dependency on Wireless Technology has increased over the last year. The data link layer is positioned just above the physical layer in all the layering models. The data travel from a source to destination, the data may have to travel through wireless physical layer links in the path. The underlying link- layer protocols of wireless network directly manage the physical network link of a computer and also integrate to higher level protocols for handling connections and data. The main functionality of the link layer is to find out the different physical links in the path and work with the link protocols to carry the data. The function of link layer is to facilitate hop-to-hop communication, by carrying data packets.

Wireless link layer protocols such as ARQ (Automatic Repeat reQuest) and HARQ (Hybrid Automatic Repeat reQuest) are to achieve reliability by discarding an erroneous packet at the receiver and perform one or more retransmissions until the packet is error free.



ARQ, HARQ : retransmission at each hop
ACE : packet recovery at each hop
PROPOSED METHOD: packet recovery at key nodes

Fig. 1. Protocols for packet recovery.

As shown in Fig.1., each packet needs to travel through all the nodes in the route, to reach the destination. In ARQ [1] protocol , when the receiver detects an error in a packet, it automatically requests the transmitter to resend the packet. This process continues until the packet is error free or error continues beyond a predetermined number of transmissions. In HARQ [1],the use of ARQ with an error correction technique called soft combining, which no longer discards the received bad data. With the soft combining data packets that aren't discarded anymore. The received signal is stored in a buffer and it will be combined with next retransmission. However, these methods cause high delays and low throughput which leads to degradation in channel bandwidth utilization. Also, decoding in each hop increases reliability and the cost of computation overhead.

Many researches [1], [2] have highlighted the limitations of these link layer protocols and proposed different solutions. These researches consider either ARQ, HARQ or combined approach of both schemes. All of them mostly follow the traditional store-and-forward mechanism. Each data packet must be received and collected by every node before it is forwarded. This mechanism increases stability, but cannot provide high stability due hop-by-hop transmission.

The proposed error correction process is performed in a distributed manner where selected intermediate nodes participate in error recovery. It achieves effective in packet recovery with very low latency, rapid delivery of packets and high throughput with minimum data loss. For this we have to minimize the propagation and transmission delay, queuing delay and energy efficiency. Our work points to determine the key nodes to encode and decode packets in a given route and an encoding/decoding scheme.

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II. RELATED WORK

Packet loss is a serious problem in the wireless networks which use conventional store-and-forward design. Nowadays the link-layer protocol of TCP/IP has taken so many solutions for error recovery to provide reliability for wireless systems. Different wireless communications adopted variety of error recovery mechanisms. Each packet needs to travel through all the nodes in the route, to reach the destination. Different packet recovery mechanisms such as ARQ [1] protocol, when the receiver finds an error in a packet, it automatically requests the transmitter to resend the packet. This process continues until the packet is error free or error continues beyond a predetermined number of transmission and in HARQ [1] , the use of ARQ with an error correction technique called soft combining, which no longer discards the received bad data.

[2] propose Plena , a packet length adaptation scheme exploiting the proposed error estimating codes (EEC) for low-power wireless networks. Here consider two low-power MAC protocols for the energy consumption of different packet length. This work gives closed form solutions for the optimal packet length in terms of energy efficiency. This consumes more time.

In [3] goal of opportunistic routing is to deliver the packet from sender to the destination in fewer hops. In the multi-hop networks, the intermediate nodes act as a helper node to deliver the packet to the destination, they are called forwarders . The selection of these forwarder nodes among the intermediate nodes is very important and has a huge impact on the performance of the opportunistic routing.

[4] opportunistic routing is novel i.e, massively parallel, and it is performed by many nodes simultaneously to maximize the gain while controlling the inter user interference. It can exhibits improvement in overall power–delay. A gain is possible when the receivers can tolerate more interference due to the increased received signal power provided by the multiuser, in other words having more concurrent transmissions. It provides a good traffic management and the bit error rate is high.

[5] takes advantage of the broadcast nature of the wireless medium to increase reliability in communications. Here instead of selecting one node as the next hop forwarder, it selects a set of nodes to forward the packet. In this way, if one of them does not get the packet from the source, another candidate will do it and this avoids the re-transmission from the source. It offers high reliability but this work is not stable and initialization cost is high. The model study the number of re-transmissions and is good for any number of candidates, so the parameters can be easily evaluated when designing an opportunistic routing protocol. As a result, the model can provide guidelines to the researchers for evaluating the influence of the number of candidates and how it relates to the number of re-transmissions and how two parameters(candidate list of each node and maximum number of retransmissions in each node) together contribute to the successful delivery of the data packets.

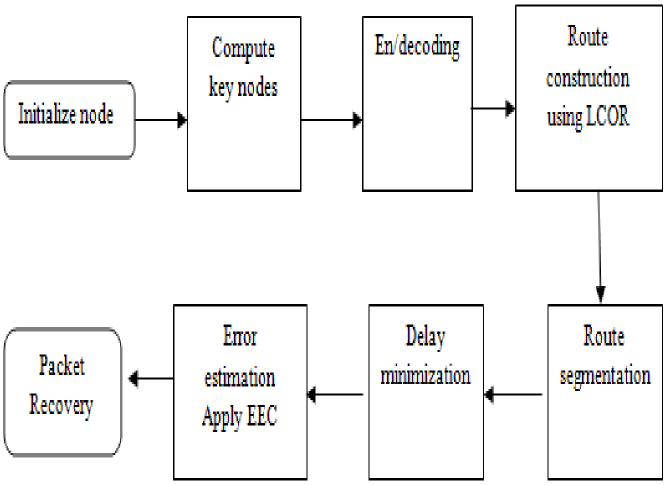

Fig. 2. Architecture of Proposed System

III. SYSTEM MODEL

The proposed system (as shown in Fig.2), is link-correlation-aware Opportunistic routing with EEC. The combined system adapts effectively in the packet recovery with very low latency. EEC allows the instant estimation of the bit error rate in a partially correct packet. It is possible for predicting packet reception ratios (PRRs) at different packet lengths. The EEC scheme detects the errors in the packet recovery and the errors can be corrected and packet recovery can be efficient. The use of opportunistic routing can reduce the decoding delay and also reduces the packet delay by forwarding the incoming packets without waiting for the packet sent by its previous receiver to decode it. The link-correlation-aware opportunistic routing overcomes the estimation errors in the forwarder set selection and reduces the scheduling costs. The link correlation aware metric is proposed to capture the expected number of any-path transmissions using which a new candidate forwarder selection method is developed for effective forwarder set selection. Thus the proposed system performs better than existing with low latency packet recovery, also achieves high reliability and stability.

The main objective of this research is to give high throughput, to minimize delay and minimize error rate of transmission for the current scenario. The main intent of this work is to provide a best route and consider the problem of how to design an efficient method for transmission at maximized throughput with minimum energy consumption, minimum bit error rate and minimum delay for every transmission.

A. Network Creation

Consider a wireless network composed of N nodes. It is denoted by V=$\{v_1, v_2 \dots v_N\}$ .A traffic flow is from a source node to a destination node traverses over a predetermined set of routes. Let R=$\{r_1, r_2, \dots, r_k\}$ be the set of transmission routes. Each route r_k carries a data stream with arrival rate λ_k. Here use $r_k = \{v_{k1}, \dots, v_{knk}\}$ represents the node sequence in r_k $(v_{k1}, \dots, v_{knk} \in V)$,where n_k is the number of nodes in r_k .

B. Setting Key nodes and Encoding/Decoding Delay

The en/decoding load of a node , denoted by $L(n_i)$ and it is the sum of the arrival rates for all the packet streams i.e, responsible for en/decoding. A key node of route r_k is a node responsible for en/decoding the packets travelling along the route. Matrix X=$(x_{i,k})_{N\times K}$ [1] denotes whether is a key node in r_k

$$x_{i,k} = \begin{cases} 1, & v_1 \text{ is the key node in } r_k \\ 0, & v_1 \text{ is the key node in } r_k \end{cases} \quad (1)$$

In each route segment, the sender encodes the packets, and the receiver decodes the packets. The receiver node is responsible for decoding for its route segment.

C. Compute Delay and Encoding/Decoding Load

The arrival rate of stream be denoted as $\lambda_{i,k}$,where v_i is responsible for en/decoding in r_k . Then, $\lambda_{i,k} = \lambda_k \times x_{i,k}$. The average delay when a packet crosses v_i with route segment vector n_i be denoted as $D(n_i)$. Then, the total average packet delay decoding at v_i within a unit time equals [1] $\overline{D(n_i)}\,\Sigma_{k=1}^{K}\lambda_{i,k}$.The average en/decoding load of v_i is denoted as $\overline{L(n_i)}$ and the average en/decoding load of all the nodes in V is denoted as $\overline{L(N)}$. Then ,$\overline{L(N)} = \frac{\Sigma_{k=1}^{K}\overline{L(n_i)}}{N}$. Following formula used for calculate average delay and en/decoding Load.

Delay Calculation

$$\overline{D(n_i)} = \overline{D_q(n_i)} + \overline{D_{p\&t}(n_i)} \quad (2)$$

Where, $\overline{D_q(n_i)}$ is Queuing delay

$$\overline{D_q(n_i)} = \frac{\Sigma_{p=1}^{p}\Sigma_{k=1}^{k}\lambda_{i,k}^{p}\ (n_{i,k})\times Wque(n_i)}{\Sigma_{k=1}^{k}\lambda_{i,k}^{1}\ (n_{i,k})} \quad (3)$$

$\overline{D_{p\&t}(n_i)}$ is Propagation and transmission delay

$$\overline{D_{p\&t}(n_i)} = \Sigma_{k=0}^{t-1}\left(2D_p(n_i) + D_{ACK}(n_i) + D_t^{i,k}(n_i)\right) + D_p(n_i) + D_t^{i,k}(n_i) \quad (4)$$

$Wque(n_i)$ – waiting time of queue P - packet recoded times

$D_{ACK}(n_i)$ -Transmission delay of ACK packets

$2D_p(n_i)$ -Propagation delay $D_t^{i,k}(n_i)$ -Transmission delay

En/Decoding Load Calculation

En/Decoding Load standard deviation

$$\sigma(N) = \sqrt{\Sigma_{i=1}^{N}(\overline{L(n_i)} - \overline{L(N)})^2} \quad (5)$$

Where, $\overline{L(n_i)}$ is en/decoding load

$$\overline{L(n_i)} = \Sigma_{k=1}^{k}\Sigma_{p=1}^{p}\lambda_{i,k}^{p}\ (n_{i,k}) \quad (6)$$

$\overline{L(N)}$ is average en/decoding load

$$\overline{L(N)} = \frac{\Sigma_{i=1}^{N}\overline{L(n_i)}}{N} \quad (7)$$

D. Link- Correlation -Aware Opportunistic Routing and Route Segmentation

The nodes are consistently distributed in the plane and edges are added according to the probability that depends on the distance between the nodes. The network size is N×K where N is number of nodes and K is number of routes. Consider both the single-hop and multi-hop scenarios. In this system , where a sender *s* has *n* initial candidate forwarders to the destination *d*. The sender *s* transmits packets to the destination *d*. Opportunistic routing obtains significant benefit when link qualities are low. That's because when link quality is high, the forwarder set is not so necessary and its function is almost the same as the best link. The performance of Opportunistic routing is quite close to the traditional shortest path routing under such scenarios. In the following simulations, it focuses on low link quality scenarios. Both the links from the source to the forwarder set and the links from the forwarder set to the destination are set to be lossy. In our experiments, the default size of the candidate forwarder set is two and getting routes for every fixed iterations for low and high level traffic.

E. Estimate Error with EEC

The EEC method has three procedures, for encoding at the sender, decoding at the receiver, and estimating BER at the receiver, respectively. These procedures are all randomized. The sender and the receiver should use the same random seed to initialize their pseudo-random number generators, so that they generate the same random sequence.

IV. SIMULATION ENVIRONMENT

Conclusions are based on the results captured by extensive simulation of a network model which implements the proposed method. The method is implemented using MATLAB and it evaluates the performance of the system. The performance results are then compared in terms of delay, queuing delay, throughput and energy consumption. The purpose of this work is to provide a best route and consider how to design an efficient algorithm for transmit at maximized throughput with minimum energy consumption, minimum bit error rate and minimum delay for every transmission. Also here randomly choose nodes connecting source node and destination node as the route.

Fig. 3 shows the propagation & transmission delay and queuing delay. The queuing delay increases as the rate of each data stream increases and the propagation & transmission delay remains constant.

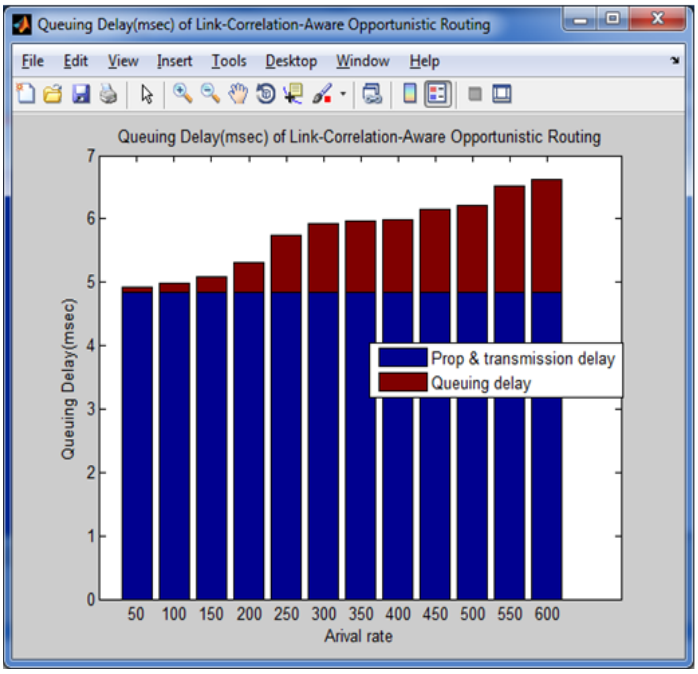

Fig.3. Queuing delay of proposed system

Fig. 4 shows the queuing delay with and without using EEC versus packet arrival rates. From the figure, see that the delay reduced significantly. This is due to some reasons i.e, EEC decreases the no: of retransmissions by estimating BER of the packets.

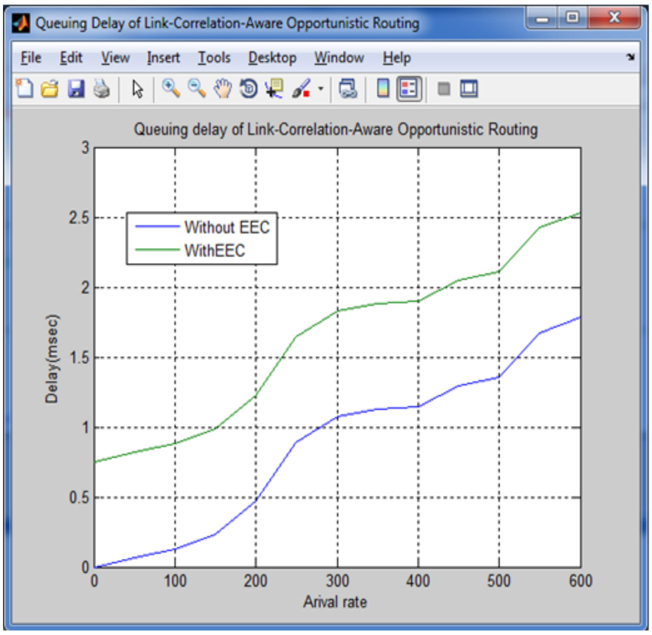

Fig. 4. Queuing delay of proposed system with EEC

Fig. 5 shows the energy consumption for all nodes in the network. The coordinate *(x, y)* (1 ≤ *x* ≤ 9, 1 ≤ *y* ≤ 9) shows the position of each node in the network.

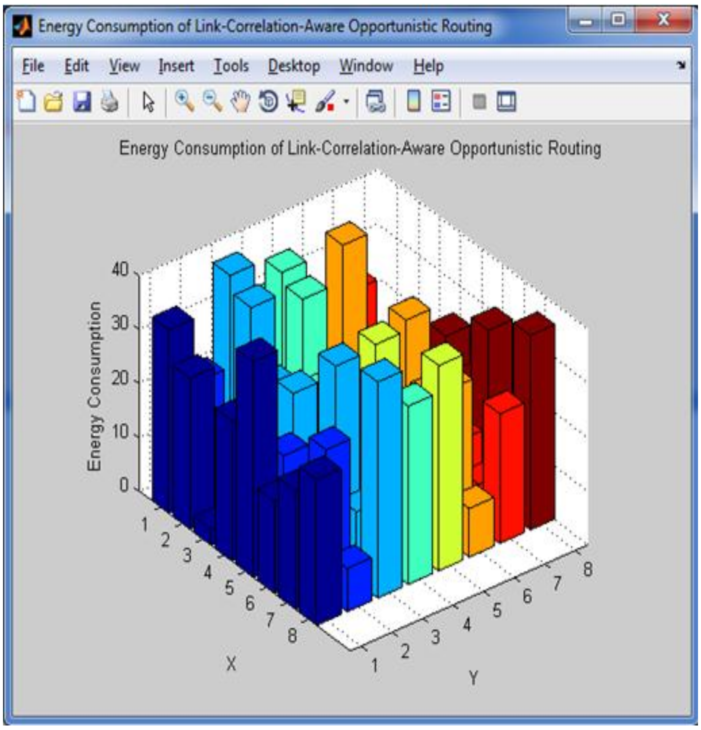

Fig. 5. Energy consumption of proposed system

Fig. 6 shows the comparison of existing system[1] and proposed system on the basis of delay.From the graph it is clear that the proposed system with EEC performs better by reducing the delay than existing system .

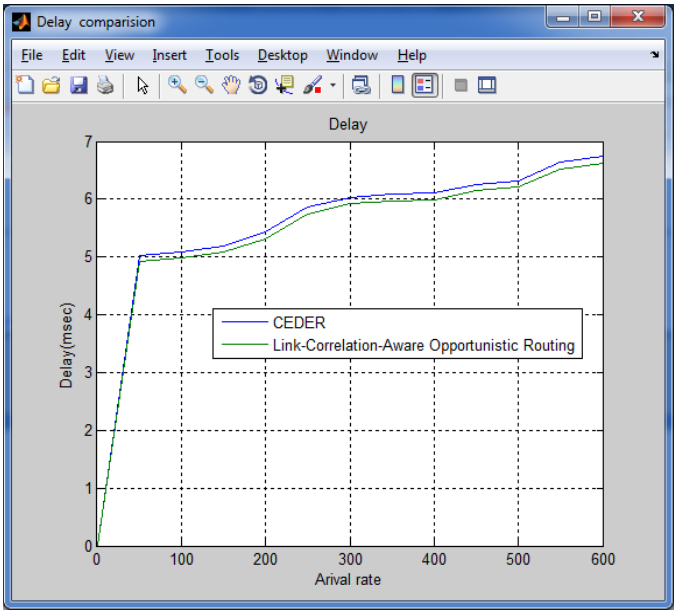

Fig. 6. Delay comparison

Fig. 7 shows the comparison of existing system and proposed system on the basis of throughput. From the graph it is clear that the proposed method with EEC performs better than existing with EEC in terms of throughput.

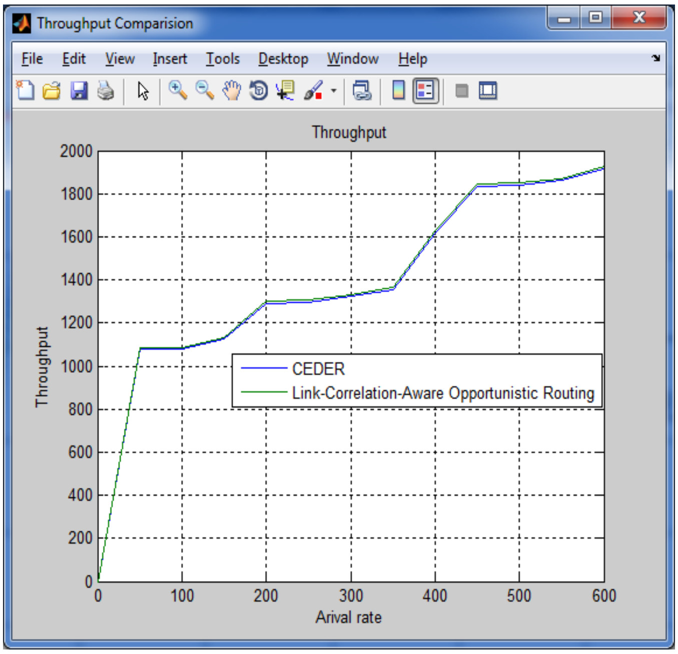

Fig. 7. Throughput comparison

V. CONCLUSION

In this paper, we proposed link-correlation-aware Opportunistic routing based with EEC. It is formed by combining the existing work with the link-correlation aware opportunistic routing and EEC schemes. The combined work adapts effectively in the packet recovery with very low latency. The distributive strategy helps in determining the lost packets all over the wireless network. The EEC scheme effectively detects the errors in the packet recovery so that the errors can be corrected and packet recovery can be efficient. The link-correlation-aware opportunistic routing overcomes the estimation errors in the forwarder set selection and reduces the scheduling costs by exploiting the diverse low correlated forwarding links. Thus the proposed method performs better than existing with low latency packet recovery and also achieves high reliability and stability.

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