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Improving High Data Delivery using Erasure Coding and Packet Replication method in MANET

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Abstract*— Mobile ad hoc networks are self-organizing networks without support from the outside network like base station. In this paper studies about the general two-hop relay (2HR) - (m, n, t) used in MANETs to analyze the packet delivery performance. This scheme combines both the erasure coding and packet replication technique wherein the erasure coding method first we divide group of m packets into n encoded packets in such a way that w is greater than m (n>m), and then these each coded packet is replicated to at most t distinct relay nodes which helps to forward the coded packet to the destination. The original packets are retrieved only when the coded packets are reaches at the destination. Further in this paper a multidimensional Markov chain frame work is developed to understand the packet delivery process and based on that analytical expressions are derived for delivery performance and the corresponding expected packet delivery cost too. Finally this paper conduct extensive simulations and numerical study to illustrate our findings. The result highlights the importance of packet reification parameter t section which lead us to obtain high packet-delivery-ratio performance while maintaining relatively low delivery cost.

***Index Terms*—2HR-(*m*, *n*, *t*) algorithm, erasure coding, replication, Markov chain model.**

I. Introduction

Mobile ad hoc networks are self-organizing networks. MANETs consists of mobile devise communicating over peer-to-peer to wireless links process without support from base station. The applications are found mostly in disaster relief, military communication etc. erasure coding packet delivery scheme is the recently explored technique to improve the packet delivery performance of MANETs in delay tolerant networks (DTNs). Here we developed a fluid model to analyze the delivery performance and corresponding delivery cost.

The each coded packet is delivered to only one relay node and performance improvement is obtained by increasing the number of coded packets. The computational complexity increases of in both

encoding and decoding operations if the number of coded packets are increased. This leads to high consumption of battery power for both the operations. Based on the combination of erasure coding and packet replication recently proposed new scheme for mobile data offloading in cellular based opportunistic vehicular networks. They proved that by combining these two techniques we can improve the data communication efficiency significantly.

II. Related Work

In a general two-hop relay 2HR-(*m*, *n*, *t*) packet delivery scheme the *m* group of packets are encoded into *n* coded (*n*>*m)* packets and the each coded copies are delivered to at most *f* distinct relay nodes. The algorithm covers those only applying erasure coding and packet replication as a special case. In the previous study the study was about delivery delay performance where delivery delay performance is defined as the time elapsed between the time slot when the source node starts to delivery copies for this packet and time slot when the destination node successfully recovers the packet. In this the delivery delay is largely neglected. However delivery expired packets having unwanted information may waste a lot of communication resources.

III. Proposed Work

In this paper the packet lifetime constrain is the very important factor in the packet delivering process without delay in delivery. By employing a Markov chain model the packet delivery ratio and corresponding delivery cost performance were analyzed. Where the packet delivery ratio is defined as the fraction of packet that can be recovered at the destination node before their lifetime expires, and the delivery cost is defined as the power consumed for the transmission and receiving of the packet.

Network model

A time-slotted network which consists of *x* number of mobile nodes randomly moving in a unit square

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where opposite edges are wraparound i.e. when a node moves across one edge, it appears in the opposite side of the network area. See the example network model below in which the network area is evenly divided into $x \times x$ cells.

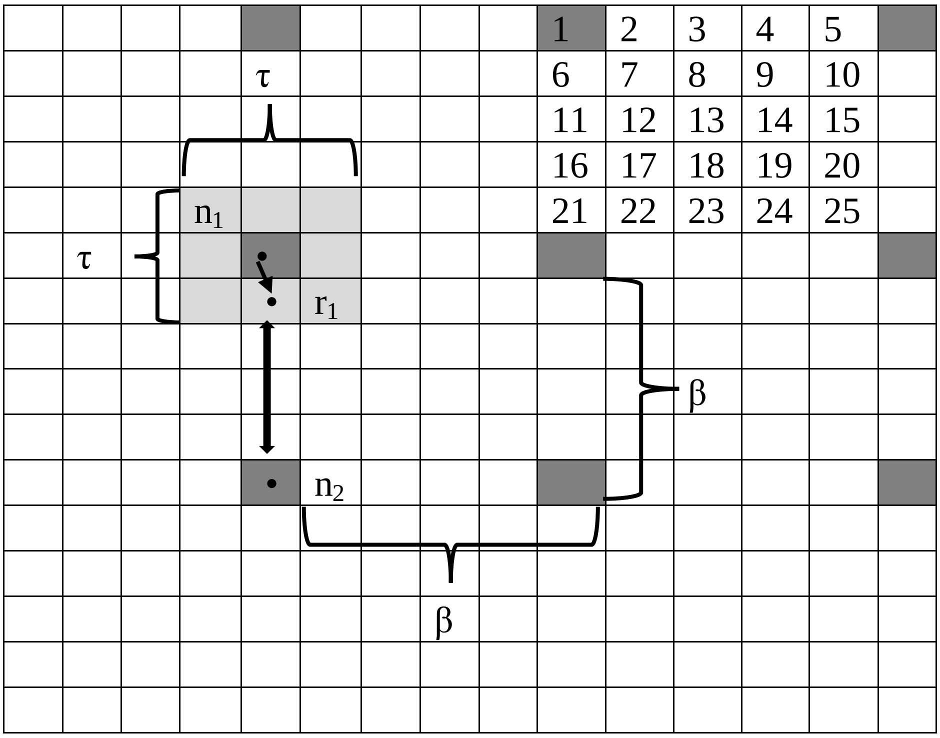

Fig.1. network model and an example of transmission scheduling with the case x=15, τ=2, and β=5.

The network node move according to the independent identically distributed mobility model (i.i.d). Under this mobility model, at the beginning of each time slot, every node independently and uniformly choses one of the x^2 cells to move in it and stays for the rest of time slot.

Main contributions

I. Firstly a multidimensional Markov chain model was developed to model the packet delivery process.

II. For the developed Markov chain model under a given packet lifetime the analytical expressions for both packet delivery ratio and packet delivery cost were derived.

III. Finally simulation studies were conducted to verify the efficiency of developed delivery ratio and delivery cost results with provided numerical results to demonstrate our theoretical findings.

The three steps of algorithm can be described like below.

Source-to-destination: If the local of Tx is not empty, then Tx retrieves a fresh coded packet and transmits the coded packets to Rx. Otherwise if there exists a fresh coded packet in its waiting –for-ACK queue, then the Tx transmits the coded packet to Rx.

Source-to-relay: If Rx is an available relay node, then Tx transmits to Rx a copy of head-of-line coded packets

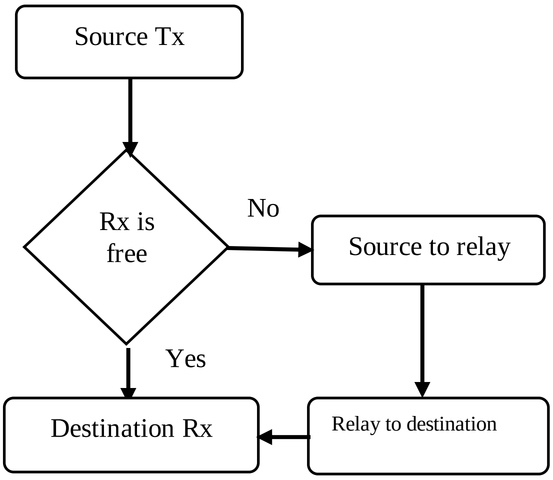

Fig.2. 2HR algorithm flow chart

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in its local queue. If f copies of coded packets have been distributed out, then Tx pops up the coded packet from the local queue and pushes it into the waiting-for-ACK queue.

***Relay-to-destination*:** If Tx carries a fresh coded packet destined for Rx, then Rx transmits the coded packets to Rx.

Markov chain model:

The traffic flow of packet transmission in a step wise process is described in the figure.3.

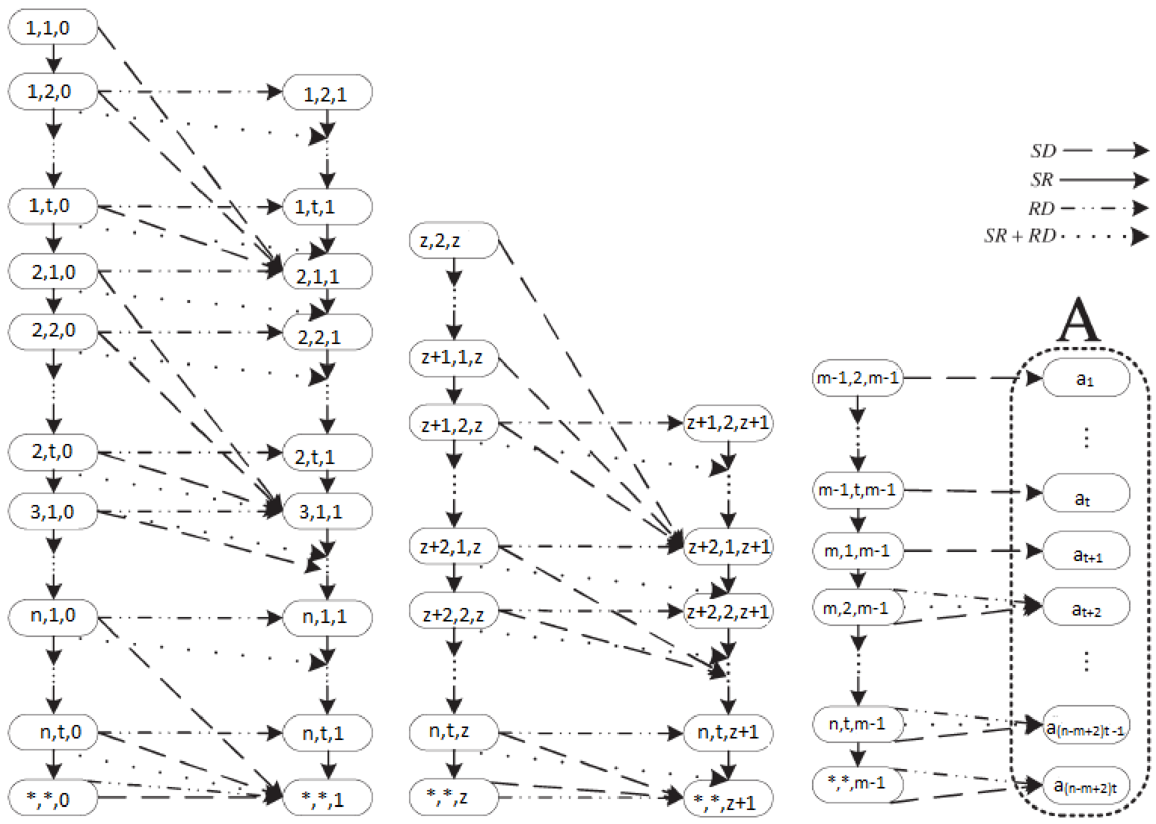

Fig.3. absorbing Markov chain for 2HR-(m, n, t) algorithm.

The source and destinations of the transmission process is taken as S and D respectively. The use of (x, y, z) denotes that the S is delivering the yth ($1 \le y \le t$) copy of xth ($1 \le x \le n$) coded packet and D has received z ($0 \le z < m$, $z \le x$) distinct coded packets. Let ($*$, $*$, k) transient state of the S has finished the distribution of coded packets but D has received only ($0 \le z < m$). The current state is (x, y, z) only one of the following transition case will occur in the next time slot. a) The SR case wh ere transmits the yth copy xth coded packet to an available relay node and none of the other relay nodes transmits a fresh coded packets to D; b) the RD case, where a busy relay node transmits a fresh coded packet to D and S does not conduct a source to relay transmission; c) the SR+RD case, where S transmits the yth copy xth coded packet to an available relay node and a busy relay node transmits a fresh coded packet to D at the same time; and d) the SD case, where S transmits fresh coded packet directly to D. A denotes a set of absorbing states. The transition back to each state is not drawn for simplicity. (1) State transition diagram for z=0. (2) State transition diagram for $1 \le z \le m$-2. (3) State transition diagram for z=m-1.

Definitions:

Packet delivery ratio:

For a given life constrain, the delivery ratio is defend as the probability that the destination node can recover the original packets of the group before the life time expires.

Expected packet delivery cost:

The delivery cost of a group is defined as the total transmission and receiving power consumed until either the lifetime expires or the destination node recovers the original packets of this group

IV. .RESULTS

The overhead graph in Fig:4 is plotted for speed v/s control overhead and the overhead is defined as the number of routing packets that is required to select in order to send the packets to one of the relay nodes with minimum number of packets. The control overhead also be named as Normalized Routing Load. We calculate the NRL by using the formula which states that the in NRL of any network and is defined as the ratio of number of routing packets that the source node is allowed to send the relay nodes to the number of routing packets that has been received by the one of the nearest relay nodes. The formula can be simply given as

NRL= Number of routing packets /No.of received data packets

In order decide the routing algorithm and overhead analyse the NRL must be as less as possible. It just decides the effective usage of network resource and the power consumption for transmission and recession.

The Average delay graph in Fig:5 is plotted for speed v/s average delay where the delay is defined as the delay occurred in reaching the destination node of a coded packet between the slot allotted for both sender and receiver as the time elapses between them. The simple formula can be given as average end-to-end delay *AD= last packet transmission time/ no.of packets received.*

The packet delivery ratio graph in Fig:6 is plotted for speed v/s packet delivery ratio and the PDR is defined as the ratio of number of packets sent over received. The formula can be given as

PDR= packets received/ packets sent.

The Throughput graph in Fig:7 is plotted for speed v/s average throughput and the average through formulated can be given as

*Average throughput: no.of bytes received * 8 /(end time–start time)*

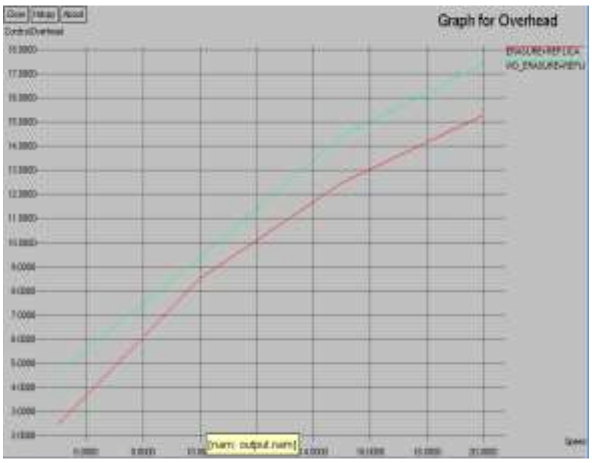

Fig.4.Speed vs Overhead

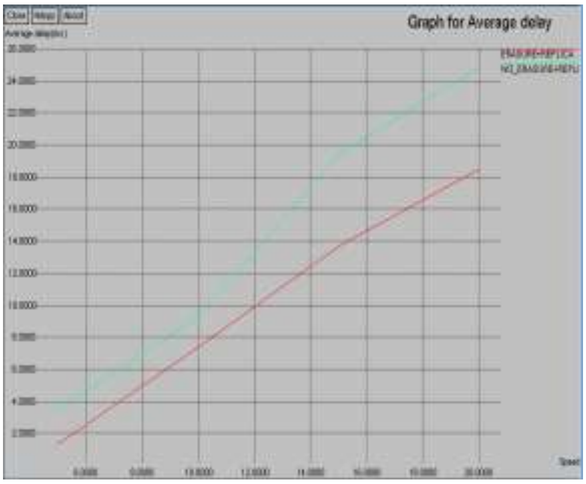

Fig.5. Speed vs Average dealy

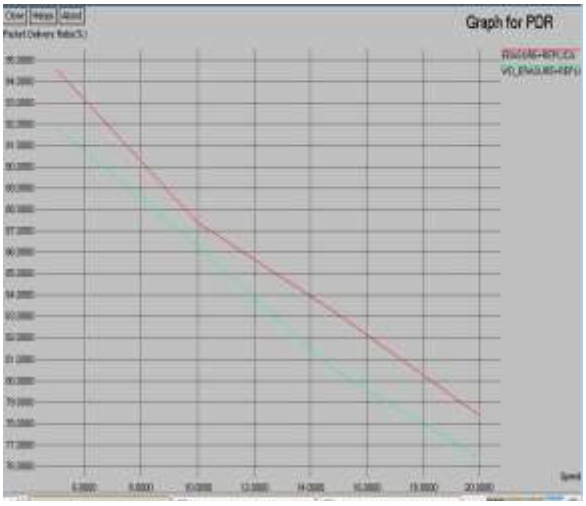

Fig.6. Speed vs PDR

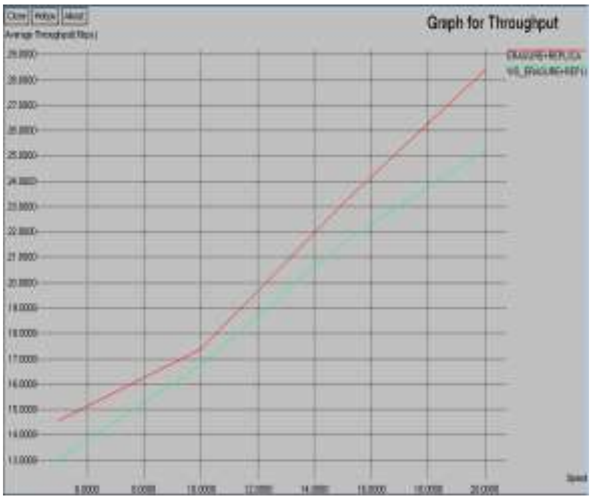

Fig.7. Speed vs Average throughput

V. CONCLUSION

This paper has investigated the packet delivery ratio and cost performance in MANETs under a general 2HR-(m, n, t) packet delivery scheme that combines erasure coding and packet replication techniques. A Markov chain framework was developed to model the packet delivery process under the

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2HR- (m, n, t) scheme, based on which analytical expressions of the packet delivery ratio/cost can be obtained. Extensive simulations demonstrate that our theoretical results can accurately predict the packet delivery ratio/cost performance under the 2HR-(m, n, t) scheme. Our results indicate that, as replication parameter t increases, the delivery ratio first increases and then decreases; therefore, parameter f should be carefully selected to achieve a high packet delivery ratio performance while maintaining a relatively low delivery cost. This paper has inspired us that the Markov chain framework can be an effective way to analyze the complicated packet delivery behavior in large scale MANETs. It is reasonable to expect that the theoretical framework developed in this paper can help us to explore the packet delivery performance in other networking scenarios as well. In particular, we would like to highlight the following possible directions. One interesting direction is to study how the considered routing algorithm works in realistic mobility traces. Another interesting direction is to evaluate the impact of buffer

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