Investigating an Adaptive Network Coding Control protocol for Multihop-Multipath Networks for Network Reconfigurability.

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***Abstract*—one of the challenges in current designs of wireless networks is that of guaranteeing end to end delivery of high priority data or packets in multi-path multi-hop networks for medical use especially for nodes with mobility. There are various solutions based on traffic engineering which are applied in wired networks to guarantee end to end delivery of packets. With mobile wireless networks, the environment is highly dynamic, therefore with different scenarios having multiple paths or routes in the network, the node has to adapt to the network for dependable delivery of priority packets. In so doing, a level of Qos can at least be guaranteed. This paper reviews some of the techniques to achieve adaptive network coding, and the objective is to implement adaptive network coding in multi-hop, multipath network for high reliability and dependability. As a preliminary study we investigate an Adaptive Network coding scheme in a Binary tree fashion with the root being the convolution coder for its feasibility. The objective is to design a control protocol to be used to adapt to the error changes that occur in the network thereby increasing performance.**

Keywords- Network; Dependability; Mobile Networks; Adaptive Network Coding;

I. BACKGROUND

There are a number of considerations in which adaptability can be achieved. It depends to some extent on the capability of the nodes involved in sending of data. Capabilities including Buffer size, Storage size, processing speed, memory etc. This information helps in making better routing decisions or networking coding decisions.

In order to implement our protocol design, there are a number of approaches that can be taken: State Machine approach. We can model using finite state machines for the errors which are experienced by our network. This state information can then be propagated throughout the network and the network in this case is considered as one entity. The reconfigurability occurs depending on the different states of the nodes in the Network.

There are a number of key technologies in the literature and those available which are implemented. In order to achieve our objective we have to redesign MAC layer and Routing protocol adaptation. In our study the routing protocol we consider is Dynamic MANET on-demand routing protocol (AODVv2 formally DYMO).

Cognitive abilities of the nodes in this context is in required to make routing decisions based on the surrounding. Furthermore Adaptivity is based on priority of packets and priority of the sending Node. We assume knowledge of topology information. Our protocol works as follows: a capability map is made for each node. Each node has to register the type of traffic that it will be sending during the course of its lifetime. Therefore we classify a node based on the type of traffic it sends.The highest priority nodes carry one type of traffic only while nodes which carry different traffic types have a lesser priority.

The network has two states: Infrastructure mode and Adhoc node. The network closely monitors traffic, and looks for certain traffic patterns which can cause the network to change from one network node to the other. The default mode in this case being Infrastructure Mode. This switching from one mode to another has a delay associated with it and the switching delay has impact on the quality of service.

We categorise our traffic Qos based on: Delay, Minimum Data rate and Maximum Data rate. In order to evaluate the performance of our protocol, each packet is inspected to determine its Qos level and hence its priority. For example if we have seven levels of Qos for a packet, we can generate 128 power sets. Our algorithm is based on these outputs for the type of nodes in the network. The assumption is that each node carrying traffic falls in one of the 128 power sets given a 7 level priority qos . These nodes are then regrouped into fewer categories depending on the combination of traffic capability. The other type of classification is simply based on traffic type without paying particular attention to the type of node which sent the traffic, as long as the traffic itself fits in a particular category.

II. LITERATURE REVIEW

There are several papers which have studied network coding in the literature. The authors in [1] consider Opportunistic routing in wireless mesh networks with segmented network coding while [2] looks at coding applied to Wireless Mobile Ad-hoc Networks. This is closely related to the study in this paper because of the mesh networks being applied and thus multiple routes are considered.

In [3] the joint use of physical-layer network coding (PNC) and multiuser decoding (MUD) to boost throughput of multi-packet reception systems is studied. The salient feature in these papers is that the Network architecure/system model mostly is based on the butterfly model, as well as not taking care of error models to have a realistic network. Adaptive Network coding has been used in various types of Networks to provide various goals which include improving delay and throughput among other things. Various schemes have been adopted based on different techniques.

In [4], the authors adopt a scheme that adapts the amount of redundancy based on output link quality and packet importance for scalable video traffic. Their approach uses nested windows inspired by unequal protection schemes for scalable video coding.

The Work in [5] to achieve adaptability is based on maximising the energy efficiency as well as exploiting the variable modulation order. The proposed schemes is applied to different satellite communications scenarios with different Round Trip Times (RTT).Packet transmission is adaptated based on the channel variation and corresponding erasures allows for significant gains in terms of throughput, delay and energy efficiency.

The authors in [6] use a technique called Neighbour's Overhearing Link quality Measurement (NOLM) which allows the intermediate node to measure the quality of the overhearing channel of each of its one-hop neighbours in an indirect manner. The adaptive approach is by the network coding-based forwarding and aims at improving the robustness and the reliability of the network in the unreliable wireless environment.

The work in [7] studies adaptive network coding (NC) for real-time traffic over a single-hop wireless network. In their study, the block size for NC is adapted based on the remaining time to the deadline .It generalized the analysis to multiple flows with hard deadlines and long-term delivery ratio constraints.

In [8][9] primary system comprised multiple sources and multiple destinations, whereas the secondary system comprised multiple sources, multiple relays and a single destination. A closed form expression for the end-to-end outage probability for the secondary system is derived while assuming the presence of interference constraints between the two sub-systems. Based on the diversity order analysis, framework for adaptive network coding is proposed. The proposal involves using a small encoding set size for low link quality and a large encoding set for good link quality. It is observed that having a small set size increases the probability of having relay cooperation at the expense of some loss in coding gain, while using a large encoding set size decreases the probability of having relay cooperation. The proposed adaptive network coding scheme achieves gains of more than 4 dB as compared to conventional fixed network coding schemes.

The authors in [10] consider cooperative communication in a two-way relay network and propose a spectrally efficient adaptive partial repeated network coding scheme. Mutual information (MI) model is used to adaptively optimize the amount of data needed to be network encoded.

From this review it can be seen that channel information is key to achieving adaptive network coding.

III. PROPOSED SYSTEM DESCRIPTION

Fig.1 shows the general architecture the proposed adaptive network coding basic building block in order to achieve adaptive coding. This module is placed between the MAC layer and the Network layer of the Mobile node. Therefore a cross layer methodology needs to be considered to obtain best performance of the control protocol.

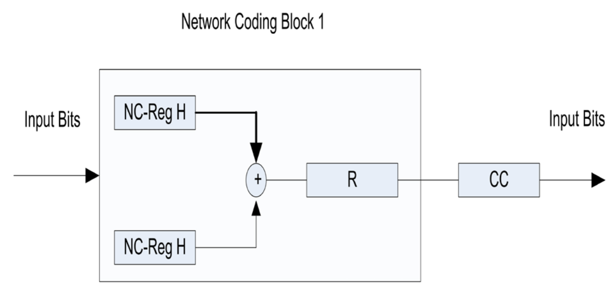

Figure 1. Network Coding Block

The system comprises of different simple building blocks. And the whole module is made based on Binary tree architecture. The Module is made up the following sub modules:

A. *Network Coding Block:*

In this paper we adopted Linear Network coding to evaluate the protocol performance and caliberate the parameters after which Non-Linear Network coding will be considered in future works. This is the main block which performs the network coding function. Fig.1 and 2 shows the main building block of the module. It consists of three registers NC–Reg H and NC- Reg L which are the registers to hold High priority traffic and Low priority traffic respectively.

The third register R, stores the result of the performed network coding. Once the coding of the packets are done, depending on the state of the Node and channel, the coded packets can be sent directly through the wireless channel. However in our study, the network coded packets are sent sent to the convolution coder for channel coding as shown in Fig.3.

Most off the references to channel coding don't include the network how the packets are protected from channel erros.The Networwork coding register blocks are four in total .These are grouped as follows: HH, HL, LH and LL, where the first letter represents the register on top and the second letter represents the bottom register. Where H stands for High priority buffer and L stands for Lower priority register. For example if we have HH, this means that the top and bottom priority registers all have high priority packets or bits. The Other block present in the module is an ordinary convolution coder.

B. Achieving Adaptive Coding

We consider a two state machine (Fig.2) .There are three types of nodes considered in this network. The source node, the intermediate nodes and the destination node.To evaluate our protocol; a snaphot of the moment traffic reaches an Intermediate node to be relayed to other nodes is considered. Two parameters are used to decide:

- The Node asses its own capability in terms of available registers to perfom network coding, it processing capability which has an impact on coding delay.
- During route discovery, each node stores a record of the multiple routes to a destination that it has in its routing table has well as the routing cost.
- The Node has to determine what type of node it is: is it a Source node, an Intermediate or a destination node.

C. Error Model

To evaluate our protocol we make use of the Gilbert-Elliot burst noise model for burst errors shown in Fig.2.Channel is in bad state represents a high probability of error, while the good state represents a low probability or error.

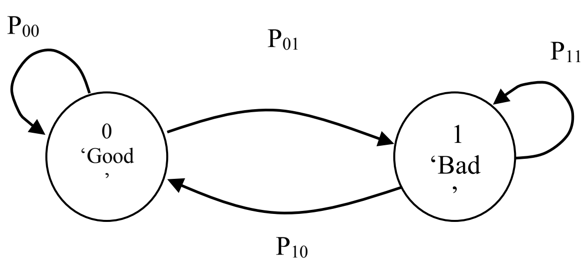

Figure 2. Two state Hidden Markov Model

We use this model and the state information to make our coding decision for each path and whether our module performs network coding or not.

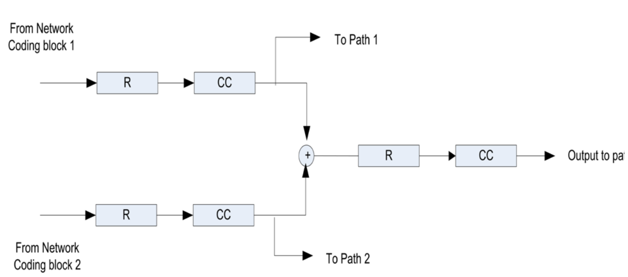

Figure 3. Convolution Coding block

IV. PRELIMINARY OBSERVATION AND DISCUSSIONS

There are a number of issue which were observed in the result obtain in the evaluation of the proposed adaptive network coding in multipath and mutlihop Mobile Networks. The protocol depends on the error states or the occurrence of errors for it to operate based on these changes. If the channel experiences much error due to packet loss which signifies a congested network, the node switches into the network coding state. There are two states being considered when the node adapts. Based on these changes, we use the state to select the function used for network coding as well as whether the node is mobile or stationary. This procedure is important to classify the error that the channel is facing. Error due to multipath fading channels or errors due to congestion. In very good channel conditions, network coding is not applied but we only consider when the channel becomes bad thereby having a very high probability of error.

From our preliminary investigation shown in Fig.4 and Fig.5, we observe that the node experiences oscillation in its state. When the channel is good, the adaptive algorithm remains in one state. However, our algorithms performs poorly when having burst errors in the channel.However,we have established one fact that the node is able to change state due to the error occurrences. Our next task in future work is to closely look and work on the oscillations arising out of burst error.

There are a number of factors we have not yet determined for our adaptive algorithm which is key. One of them is the mobility of the node. Our objective is to combine mobility state with that's of the channel state to make intelligent network coding decisions.

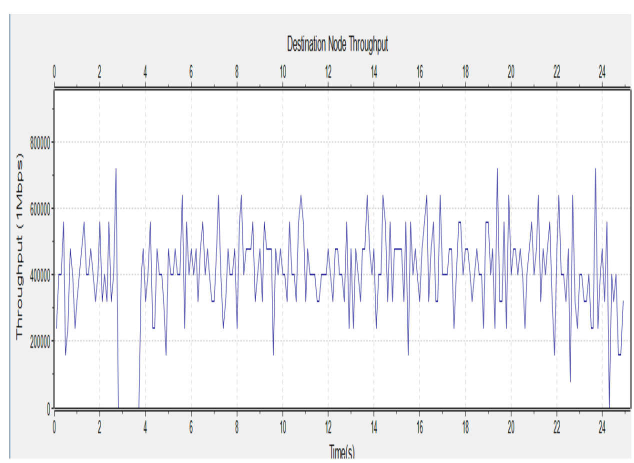

Figure 4. Observed Througput

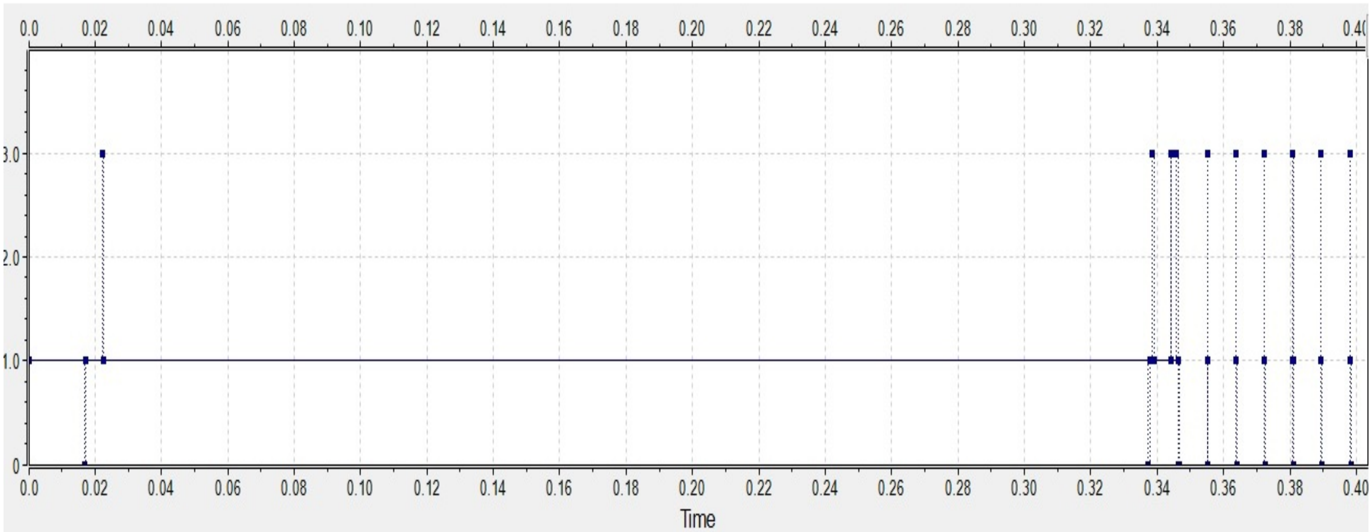

Figure 5. Node state Changes due to Error Information

V. CONCLUSION AND FUTURE WORK

In this paper we investigated the various techniques used of Adaptive Network coding.We also evaluate our candidate proposal for adaptive network coding structure for Network reconfigurability and dependability of Mobile Network which Carry Multimedia traffic with different Qos level.

Our future work will involve considering the mobility state of the model as well as handling the channel oscillations in our preliminary observations.

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