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Improved broadcasting in Wireless Sensor Networks using Linear Coding

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Abstract: The use of wireless applications is increasing in our day to day life. These applications are bestowed upon with the necessity of delivering the packets with in their deadlines. These deadlines are known as the delay constraints. The nature of the wireless links may be a reliable one or an unreliable one depending on the environment in which they are deployed. Hence there must be a mechanism which ensures that the demands of the clients are satisfied and the packets are delivered within their deadlines irrespective of the links nature. The use of network coding in association with the scheduling policy can help achieve this objective which is suggested in this work. The work of designing a scheduling policy is reduced to finding a policy that is used to ensure the demands of the clients being satisfied. The scheme uses linear coding to produce better performance than the traditional policies. The number of transmissions reduced helps to preserve the energy associated with the nodes.

Keywords: Wireless Networks, Delay constraints, Network coding..

1. INTRODUCTION

With advancement in technology it is seemingly becoming important to serve the delay constrained flows wirelessly. The wired networks are getting replaced by wireless networks. Along with the replacement the reliability also varies drastically. The wireless links are usually unreliable in nature. In order to guarantee the throughput over wireless links we need to specifically consider the unreliable nature of the links. Attempts were made to overcome the unreliable nature of wireless links by making use of feedback information. The clients acknowledge the base station by replying with the ACK packets or by using negative ACK's. The solution also increased the overhead incurred in collecting the feedback information.

Usage of network coding towards wireless networks proves to be a feasible approach. Network coding can be effectively used in designing a scheduling policy as we have proposed in our model. The model takes into account the throughput requirement of each client i.e. their demands per flow. We develop a maximizing criteria that will ensure that the policy used under this criteria will give maximum probability of delivery of the data packets from a flow.

The growing utility of the wireless networks in mobile environment has necessitated the quality of service to be improved. These measures are to be delivered in terms of the data packets that are used in transmission over the Wireless networks. This work focuses on the broadcasting policies used in wireless networks to broadcast the delay constrained traffic. In delay constrained traffic the packets need to be delivered to the client within the specified time interval. These are known as delay constraints. Many of the existing work methodologies focus on unicast broadcasting and pay least attention on broadcasting in multi-client environment.

The objective of the proposed work is to ensure that broadcast is efficiently carried out in delay constrained traffic. In order to achieve this network coding is employed. The packets can be coded using the network coding mechanism. This work uses linear coding and XOR coding. The work also aims at studying the network performance with and without feedback information. The ideology behind this study is to show that using network coding in broadcasting delay constrained traffic is feasible and efficient than the one that uses the feedback scheduler. This objective is achieved by developing a sufficiency condition rather than designing a new scheduling policy. The existing policy is modified to satisfy this sufficiency condition and then the broadcasting of the data packets takes place.

With the emergence of wireless technologies and mobile devices, it is anticipated that there will be a growing need for using wireless networks for serving delay-constrained flows, such as VoIP and multimedia streaming. This work addresses the wireless network broadcast in delay constrained traffic. This can be extended to implement the scheme in wireless sensor networking environment. The striking area of wireless sensor networks is its effective utilization of energy. The WSN's can function effectively with optimum usage of energy. WSN's are characterized by varying traffic patterns due to their wireless nature and sensor node mobility. These traffic patterns necessitate the need to adopt delay constraints to the packets that are to be delivered over wireless links. Another factor that severely affects the functioning of WSN's is the Access point Starvation. When the data that needs to be transferred over the wireless links becomes increasingly more , congestion control needs to be adopted.

II. RELATED WORK

Prasanna Chaporkar and Alexandre Proutiere have investigated the use of network coding (NC) in wireless multi-hop networks for unicast sessions. They studied the systems that employs network coding and built simple and realistic examples of networks where NC reduces the throughput performance. This happens when the NC schemes are greedy in the sense that all opportunities to combine and broadcast packets are exploited.

The authors also observed that if NC and scheduling are designed separately, then the throughput gain expected from NC may not be achieved. These observations have demonstrated the need of adaptive schemes that use NC opportunities only when they can provide performance benefits. It seems also critical that the scheduling choices and the NC decisions should be coupled. Hence, they developed a generic framework to design joint optimal NC and scheduling schemes and applied this framework to propose an optimal scheduling scheme adapted to COPE. They designed XOR-Sym, a new NC scheme, and its associated optimal scheduling scheme. XOR-Sym exhibits a lower complexity than that of COPE but yet offers similar performance gains.

Harsha Gangammanavar and Atilla Eryilmaz analyzed the problem of optimal dynamic coding and rate-control for broadcasting deadline-constrained traffic with average delivery ratio constraints over time-varying wireless channels. In this system they put forward a novel policy that utilizes a combination of pricing and finite-horizon dynamic programming strategies to jointly optimize the operation of the following two components: a dynamic rate allocation policy, which manages the incoming traffic flow rates so as to maximize their weighted sum, and a dynamic coding window selection policy, which satisfies the flows' individual delivery ratio requirements.

Wei Pu, Chong Luo, Feng Wu, and Chang Wen Chen are the authors who proposed the work of QoS-Driven Network Coded Wireless multicast. In this research, the QoS-driven network coding problem was analyzed . A large deviation principle was used to establish the relationship among source rate, link-condition, QoS requirement ,and network code. Using this relationship, under given QoS requirements, the authors solved the optimal network code construction problem. The proposed network code supports maximal source rate without violating the QoS requirements. These results constitute the foundations for future designing and implementing network coding based wireless multicast protocols.

III.THE DESIGN

We consider a wireless system where there is one base station broadcasting several flows with delay constraints to a number of wireless clients. We denote by I the set of flows, and by N the set of clients. This model is based on the design that considers unicast flows with delay constraints, to model both delay constrained broadcast flows and unreliable wireless links. We assume that time is slotted and numbered as $\tau \epsilon (1,2,3, \ldots \ldots)$.

We model the traffic patterns of flows as an irreducible Markov chain with finite states and assume that, in the steady state, the probability that the subset of flows generates packets is . Each packet generated by any flow has a delay constraint of time-slots; that is, it needs to be delivered to its client within the same interval that it is generated. At the end of each interval, packets generated at the beginning of that interval expire and are dropped from the system. Thus, the delay undergone by successfully delivered packet is at most time-slots.

A.THE FRAMEWORK

The scheduling policy that is to be designed is based on the following condition which is known as the sufficiency condition.

$\Sigma_{i \in I, n \in N} d_{i,n}(k) + q_{i,n}(k)$

I-Set of flows

N- number of clients

$d_{i,n}(k)$ – Expected delivery debt of each client

$q_{i,n}(k)$ – timely throughput requirement of each client

B. ALGORITHM:

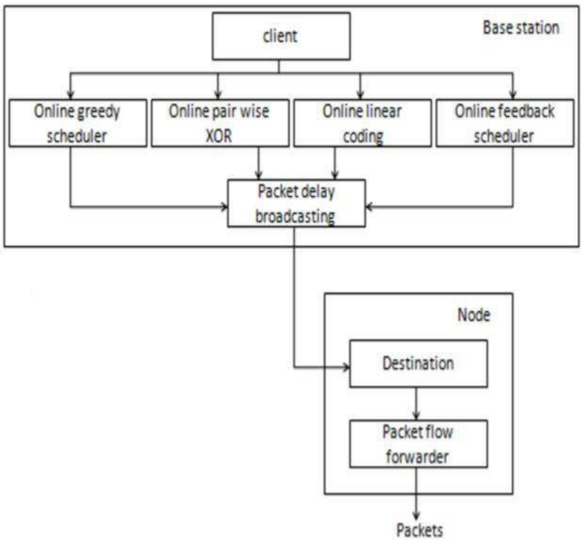
LINEAR CODING

1.begin
2.schedule t_i transmissions
3. sort t_i as $t_1 \geq t_2 \geq t_3$………
4.create two subset of flows L_1 and L_2
5.combine packets from the flows L_1 and L_2
6.broadcast the flows from the combination of packets from L_1 and L_2.
7.end

B. THE SYSTEM ARCHITECTURE

As shown in the architectural diagram initially the BS broadcasts the packets with the scheduling policy available its system. The system irrespective of its broadcasting policy satisfies the sufficiency condition as explained in the framework and then schedules the packets.

The sufficiency condition ensures the designated client is sure to receive the packets within the constraints specified with the packets. Then the intermediate module in the architecture forwards the packets to the flow forwarder. The packet flow forwarder forwards the packets to the specified clients destination address.



THE CLIENT MODULE

This module involves the base station and the clients that the base station stays in connection with. The base station broadcasts the packets. Before broadcasting the packets the base station employs various network coding mechanisms. The system at the base station may employ any network coding mechanism. The sufficiency condition which we derived in an expression is satisfied and the flow that satisfies this sufficiency is selected for broadcasting the packets generated by these flows.

THE CHANNEL CLASSIFIER MODULE

This module in our work classifies the channel based on its reliability. This reliability is the value of the probability with which the channel is able to transmit the packets across its channels to the clients. This probability value is based on the feedback information received from the clients. The packets once transmitted over the network are required to obtain the feedback information from the clients in terms of the ACK packets or negative ACK's. The feedback is not obtained on the regular basis. Instead it is obtained infrequently from the clients and a probability value is generated. This probability value is used to classify the channel with a value that can be used to estimate the reliability of the transmitting channel.

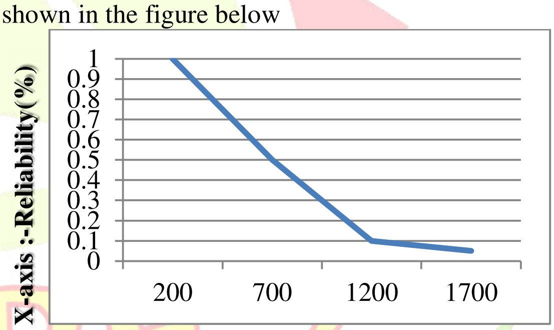
THE INTERMEDIATE NODE MODULE

This module is involved in transmitting the data packets that are received from the base station to the destined clients. This is known as the packet flow forwarder. These nodes are the one that are used to guide the packets to their destined locations. The nodes have the address location of the specified nodes and they forward the packets to the nodes that further guide them to their destined locations. These nodes simply act as forwarding agents in a network and the packets that are received from the broadcasting flow from the BS are disseminated into the network by these nodes.

The packet flow forwarder can be assigned with a buffer that can store the data packets before sending them over the network. The packets are then forwarded to the specified destination. Various algorithms that the system is equipped to employ can be used to identify the shortest path by the intermediate node to use. The base station can be equipped with various shortest path algorithms which it depends on the client and the base station that are agreed upon.

IV.PERFORMANCE ANALYSIS

The proposed scheduling policies are implemented using the network simulator 2 (ns2). The algorithms are implemented using the shadowing module in ns2. We compare their performances to a round-robin scheduling policy. We use the Shadowing module in ns-2 to simulate the unreliable wireless links between the base station and clients. In the Shadowing module, the link reliability decreases as the distance between two wireless devices increases. The relationship between the link reliability and the distance is shown in the figure below



Y-axis:-Distance(m)

A.Deterministic arrivals and symmetric topology

The figure shows the graph obtained for the deterministic arrivals with symmetric topology. The graph is a representation of the packets comparison from 2 set of flows. The flows represent the packets from these set of flows are broadcasted by using the proposed and existing scheduling policies. It is clear that the linear coding outperforms all the algorithms. Round robin has no deviation in the graph since it does not take into account the client's throughput requirement. Therefore it simply schedules the data packets. The graph is plotted for the arrivals with predefined number of flows in the packets. Symmetric topology means that the BS is centred at a position with specified coordinates in the region.

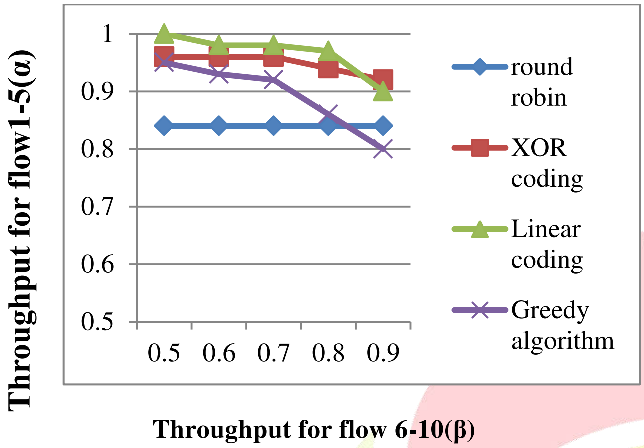


Fig 3. Deterministic arrivals and symmetric topology

All the simulation results that the graph depicts are implemented using the following scenario. We consider the scenario where a base station is broadcasting10 delay-constrained flows to 20 clients that are evenly distributed in a 780 1040 area. We consider two different topologies and timely-throughput requirements of clients. The first one is called the symmetric topology. In the symmetric topology, the base station is located at the centre of the domain, i.e., at position. The timely-throughput requirements of each client are for flows 1–5, and for flows 6–10. That is, we set if , and if , where and are tuneable variables to reflect that clients may have different timely-throughput requirements for different flows. The other topology that we consider is called the asymmetric topology, where the base station is located at position. Furthermore, clients in different regions may subscribe to different flows. The timely-throughput requirements of flows subscribed.

The simulation graph reveals that the algorithm that uses network coding outperforms the traditional algorithms such as the round robin policy and the MD5 algorithm. The difference in performance deviation is due to the fact that the client's requirements are not taken into consideration by the traditional scheduling policies. The sufficiency condition as proposed in our base paper ensures the demands of the clients to be met and the usage of network coding reduces the number of transmissions. The reduction in the number of transmissions encourages better usage of the energy in the wireless networks. Network coding can improve throughput, robustness, complexity, and security. The most well-known utility of network coding—and the easiest to illustrate— is increase of throughput. This throughput benefit is achieved by using packet transmissions more efficiently, i.e., by communicating more information with fewer packet transmissions.

V.CONCLUSION

We have analyzed and studied the problem of broadcasting the delay constrained traffic in wireless mobile environment. The proposed scheme considers the timely requirement of the clients and schedules the packets to be delivered to the clients within the specified time interval.

The work reduces the overhead of designing the policy to identifying the policy that satisfies the sufficiency condition that we developed in this paper. Therefore the existing policies can be modified to suit the requirements of the delay constrained traffic and the client needs without having the overhead of gathering the feedback from the clients.

Network coding can also be extended to wireless networks and, in wireless networks, it becomes even easier to find examples where net- work coding yields a throughput advantage over routing. Each stage of erasure coding, whether it uses a block code or a convolutional code, incurs some degree of delay because the decoder of each stage needs to receive some number of packets before decoding can begin. Thus, if erasure coding is applied over every link a connection, the total delay would be large. But applying extra stages of erasure coding is simply a special form of network coding it is coding applied at intermediate nodes. Network coding can be used to provide robustness against packet losses, which can be translated into throughput gains. Besides robustness against random packet losses, network coding is also useful for protection from non-ergodic link failures.

Wireless sensor networks are an emerging area of networks that is gaining much importance in the technological advancement. In some of the sectors that uses the wireless sensor networks as the base need to ensure that the data collected by the sensors are required to be sent to the base station in a specified time limit. This scenario necessitates the delay constrained traffic to be taken into consideration in the wireless sensor networking environment. This will greatly reduce the human intervention in a environment where only sensors play the role of data collection and uploading the data to the base station.

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