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AUGMENTING THE THROUGHPUT OPTIMALITY PERFORMANCE OF DYNAMIC BACK PRESSURE ALGORITHM

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Abstract— **In the wireless networks, the routing process is the one of the major concern and it is the fundamental process in the ad hoc networks. To aid this exertion, we proposed an experimental assessment of backpressure mechanisms for Wired and wireless networks. In this project, we used three algorithm Dynamic Back Pressure, Back Pressure, and Enhanced algorithm. By this proposed system, we addressed routing problems and also improve the throughput and delay that are mainly caused by the packets at the node transmission. The Backpressure routing is a compact and increased throughput for wireless networks, but undergoes increased delays. In routing, the backpressure algorithm is known to afford throughput optimality with dynamic traffic. The important assumption in the backpressure algorithm is that all nodes are benevolent and observe the algorithm rules leading the information exchange and principal optimization requirements. In the proposed system, we demonstrate that how the node is stabilize at the backpressure algorithm routing and also by jointly alleviating the virtual trust queue and the real packet queue. The backpressure algorithm not only accomplishes flexibility, but also tolerates the throughput performance under security attacks. This system is mainly enhances the node behavior at the time of communication and also it improves the node security at the time of many threats in the wireless applications.**

***Index Terms*— Wireless networks, Routing process, Backpressure, Throughput, Time delay and Network traffic.**

I. INTRODUCTION

The recent developments made in the routing systems of Wireless Sensor Networks (WSNs) have increased the usage growth of wireless technologies. The evolution made in multiple-path routing, back-pressure routing has facilitated better routing systems than the single-routing systems. Indeed, it guarantees to achieve the network capacity and so its throughput performance cannot be bettered by any algorithm. While maximizing network throughput, back-pressure routing comes with no guarantee on network delay. Indeed certain features of the back-pressure routing algorithm suggest that long delays will be common. Firstly, back-pressure routing uses queue buildup at nodes to create a “gradient” within the network that guides routing [1]. However, this may come at the cost of increased queuing delay. Secondly, back-pressure routing tends to explore all paths in a network, including paths with loops and “dead-end” paths that cannot lead to the desired destination. Hence, packets generally may not take the shortest path to their destination, thereby leading to additional delay.

Unfortunately, analytic results on the delay performance of these algorithms are difficult to establish and only relatively weak qualitative or asymptotic bounds are available. To our knowledge, there is no useful theoretical, simulation, or experimental results available that characterize the delays induced by packet reordering which, as we will see in this paper, is a major factor affecting the performance of current back-pressure routing algorithms due not only to their multi-path nature but also to the ubiquity of routing loops. Further, while back-pressure algorithms offer substantial throughput performance gains, the ease or otherwise with which this potential might be realized in practical networks is currently unclear.

Even though the back-pressure algorithm delivers maximum throughput by adapting itself to network conditions, there are several issues that have to be addressed before it can be widely deployed in practice. As stated in the original paper [2], the back-pressure algorithm requires centralized information and computation, and its computational complexity is too prohibitive for practice. Much progress has been made recently in easing the computational complexity and deriving decentralized heuristics. Besides complexity and decentralization issues which have received much attention recently, the back-pressure algorithm can also have poor delay performance. To understand that, we consider two different network scenarios: one in which the back-pressure algorithm is used to adaptively select a route for each packet, and the other in which a flow's route is chosen upon arrival by some standard multi-hop wireless network routing algorithm such as DSR or AODV and the back-pressure algorithm is simply used to schedule packet.

The rest of the paper is organized as follows: Section II describes the related work; Section III presents the proposed work; Section IV presents the experimental results and analysis and finally, concludes in Section V.

II. RELATED WORK

This section presents the survey of backpressure algorithms by other researchers. There has been a long-standing interest on maximizing data transfer for satellite networks [3]. Most work focuses on the design of constellation parameters and advocates the utilization of ISLs [4]. For the remaining, there are efforts on developing routing and scheduling algorithms for maximizing throughput. These proposals are either heuristic attempts or evaluated only in simplified simulation scenarios. None of them backtrack to a concrete theoretical framework. Also, we notice that a group of work enhances routing algorithms for satellite networks with load balancing schemes. Their throughput performance relies on passive route adjustment to congestion or traffic prediction. Moreover, the idealized traffic distribution and topology assumptions limit the algorithm scalability. Besides, there are routing algorithms designed for the above hybrid satellite network [5]. Regardless of throughput performance, few consider to decouple link variability from routing decision for better responsiveness to traffic load. Therefore, these drawbacks motivate us to seek for an alternative approach grounded in network throughput optimization theory.

The backpressure algorithm, also known as MaxWeight [6], has brought theoretical prosperity for backpressure based stochastic optimization. The improvement of its framework is still continuing. Basically, it uses the maximum backlog differentials as link weights. With a maximum-weight matching, it can schedule and route any input traffic within the network capacity region stably. It provably maximizes throughput, which can be derived by either Lyapunov drift or Lagrange duality. Lay is the Achilles' heel of the backpressure-type algorithms, due to loops or extensive exploring of routes. To restrict detours, researchers incorporate the shortest path concept into the traditional backpressure algorithm. Enhanced backpressure routing is proposed in [7] via a shortest path bias, which is used in a heuristic manner. In [8], the routing problem is formulated by minimizing the average number of hops between sources and destinations. Accordingly, the queue structure on each node is expanded for hop information. Though its delay improvement is significant, in a dynamic topology it has to frequently reconstruct queues based on the updates of the employed shortest path algorithm. Similarly, in [10], a shorter path is preferred by minimizing total link rate. Its routing decision [11] is affected by backlog differential minus a threshold. But the selection of the threshold is nontrivial especially in a dynamic network. To address the loop problem, in [12], the authors define the running average net rate of commodity traffic traversing a link and restrict network topology by eliminating links with zero net rates. In this way, route construction is loop-free. But unnecessary detour still exists.

Essentially, the backpressure algorithm requires gradients to pump flows. When input traffic is low or packets spread out in the network, flows easily get stuck due to low gradients. Thus, several algorithms are proposed to maintain the gradients for flows, in order to reduce delays. In [13], BCP (Backpressure Collection Protocol) uses finite queues and drops packets when a queue is full. Then the discards are placed into the corresponding underlying virtual queue so as to keep the gradient. Cooperating with the Last-In-First-Out (LIFO) queue policy, the later packets are sent over the existing gradient. The utility-delay tradeoff analysis of LIFO backpressure is given in [14]. In [15], shadow queue is proposed to activate links in decoupled routing and scheduling. To maintain gradients, the arrival rate of a shadow queue is enlarged by a certain coefficient of the actual rate. However, from our experimental results, we find that those transforms of gradients are not flexible enough in a dynamic network.

III. PROPOSED WORK

This section presents the working model of our proposed backpressure algorithms. The main objectives of our proposed study are to reduce the network traffic and also time delay in achieving optimal performances. The proposed backpressure algorithms composes of

A. *System Modelling:*

Consider a set of N network nodes with L potential transmission links of a node pair (a, b). The nodes that receives the packets within stipulated time is given as $A_n^{(c)}\ t$ where, t denotes the time slot of n packets in C networks. The packets considered as commodity packets. Henceforth, the arrival time, waiting time and receiving time of the packets in the networks are monitored and maintained. Each packet is represented with header field and its unique identity. Let $\mu_n^{(t)} \in \{0,1\}$ represents aggregated volume of packets used for transmission and receiving purposes. It operates on Time Division Multiple Access (TDMA) in $x_n^{(t)} \in \{0,1\}$ in which 0 represents the presence of packets and 1 represents the absence of the packets. Based on the transmission link, the packets are delivered with optimal power utilization. It defined in network state as follows,

$$X_n^t = X_n(S(t))$$

$$q_{nk}^t = q_{nk}(S(t))$$

Each node slot represents the set of potential receivers for node n with time slot t. The network is composed for all N-1 nodes. It is given by the subset of determined function as:

$$q_n\, \mu_n(t) = q_n(s(t))$$

A) Time slot window for packet transmission systems:

The time taken between each node is described for representing the information analysis process. The activities performed by transmission node n with its intended receiver k within stipulated time period are illustrated. The probability rate and its information control are passed among the nodes. It takes control over the information by using header of the transmitted packets. Every potential receiver node then provides immediate ACK/NACK feedback to the transmitter, informing the transmitter if the packet was successfully received. The absence of an ACK signal is considered to be equivalent to a NACK (this treats the case when the receiver node did not detect any transmission). The transmitter node accumulates all of the ACK responses, and then transmits a final message that informs the successful receivers of all other successful receivers. This final transmission possibly also provides instructions for future packet forwarding.

B. Control Decision Variables:

The goal is to design a control algorithm that stabilizes the network traffic whenever possible. Let $H_{nk}(t)$ be the random variable 1 for transmitted packets with the receiver k or else zero. Based on ACK/ NACK received, the nodes are selected. The following conditions are to be satisfied for controlling the traffic systems,

$$\beta_{nk}^{(c)}(t) \in \{0,1\} \quad , \quad \beta_{nk}^{(c)}(t) \leq \mu_n^{(c)}(t) H_{nk}(t)$$
$$\beta_{nn}^{(c)}(t) = 0 \quad , \quad \sum_{k=1}^{N} \beta_{nk}^{(c)}(t) \leq 1$$

Packets are stored at every node according to their commodity, and we define U (c) n (t) as the current number of commodity c packets in node n at the beginning of slot t.

C. Capacity of the network and its minimal time:

Every timeslot t, each network node n observes the queue backlogs in each of its potential receiver nodes $k \in K_n(t)$, and observes the current link channel probabilities associated with its receivers. Each node n determines if $\chi_n(t) = 1$ (i.e., it determines if a transmission opportunity is available on the current slot). After receiving ACK/NACK feedback about the successful recipients of the transmission, node n shifts responsibility of packet forwarding to the successful receiver k with the largest positive differential backlog W (c ∗ n(t)) nk (t). If no successful receivers have positive differential backlog, node n retains responsibility of the packet.

IV. EXPERIMENTAL RESULT AND ANALYSIS

This section presents the experimental analysis of our proposed algorithm.

A. Random Transmitter selection:

Consider a network where a node cannot transmit and receive on the same timeslot, and where all transmissions take place with power P_{tran}. Furthermore, assume a simple collision model, where every timeslot each node within reception range of a given transmitter has at most J other nodes that can act as interferers of this transmission. The reception probability of a node is zero during any timeslot when it is transmitting or when it is attempting to receive while an interferer is also transmitting. By using this formula,

$$M_n(I(t), c, S(t)) \triangleq \sum_{b=1}^{|\mathcal{K}_n(t)|} W_{n,k(n,c,t,b)}^{(c)}(t) \hat{\phi}_{n,k(n,c,t,b)}(I(t), S(t))$$

In the case when only node n transmits, all other nodes are in receive mode, and the reception events and corresponding ACK/NACK feedback takes place according to the reception probabilities associated with the network channels (not including collision effects). Let k be the node that would be selected in this no-collision scenario (possibly being node n itself).

B. Delayed feedback:

In general cases, the task of back-pressure is to learn efficient routes, where incoming data "pushes" old data in directions of least resistance. However, when the network is lightly loaded, many packets may be routed in inappropriate directions before enough backlog builds up to suggest alternative routes. An extreme example is the case when a single packet arrives to an empty network. This packet could be routed randomly back and forth and might never reach its destination. One approach that potentially reduces delay in these situations is to impose an additional constraint that restricts routing options to directions that make progress toward the destination. However, such additional constraints might reduce network capacity, and can restrict adaptation in cases of link failures.

C. Average Power constraints:

Hence, it can easily be adapted to optimize general utility metrics as well as to satisfy general constraints. In particular, optimization of general utility and fairness metrics can be achieved in cases when the input rate matrix is either inside or outside of the capacity region Λ by using the optimal flow control techniques.

V. CONCLUSION

Backpressure scheduling and routing, in which packets are preferentially transmitted over links with high queue differentials, offers the promise of throughput-optimal operation for a wide range of communication networks. However, when the traffic load is low, due to the corresponding low queue occupancy, backpressure scheduling/routing experiences long delays. In this paper, we propose an improved backpressure algorithm which reduces the network traffic and minimizes the time delay. Each node needs to compute the minimum next-hop queue length, which involves a minimization over no more than N queue lengths. In addition, for each commodity, each node needs to carry out two sets of subtractions (one set for the queue lengths of the next-hop neighbors and the other set for the minimum next-hop queue length of the next-hop neighbors), involving no more than 2N operations. Experimental analysis has shown the analysis of our proposed backpressure algorithm.

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