Back- Pressure Algorithm Using Shadow Queues in Communication Networks

Arathy Sankar, Rahul Jiwane

Computer Engineering, Pillai Hoc College of Engineering and Technology

Abstract- Network coding has been recently applied to wireless networks to increase throughput. Back-pressure type algorithms based on the algorithmby Tassiulas and Ephremides have recently receivedmuch attention for jointly routing and scheduling over multi-hopwireless networks. we explore the performance of backpressure routing and scheduling for TCP flows over wireless networks. TCP and backpressure are not compatible due to a mismatch between the congestion control mechanism of TCP and the queue size based routing and scheduling of the backpressure framework.
We decouple the routing and scheduling components of the algorithm by designing a probabilistic routing table that is used to route packets to per-destination queues. The scheduling decisions in the case of wireless networks are made using counters called shadow queues.
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Index Terms- Back-pressure algorithm,Congestion control, Probabilistic routing table, Shadow queues.

I. Introduction

Network has recently been shown to improve performance compared to that of routing for multicasting information over wired and wireless networks. Most of the work in network coding to date assumes a flow model for transmission in which sources generate, at fixed rates, data that is then transmitted over a network with fixed link capacities. However, in real networks, traffic is usually bursty because either the sources generate traffic in bursts or the network nodes employ queuing and scheduling across multiple sessions.

Wireless systems have emerged as a ubiquitous part of modern data communication networks. demand for these systems continues to grow as applications involving both voice and data expand beyond their traditional wireline service requirements. Inorder to meet the increasing demand in data rates that are currently being supported by high-speed wired networks composed of electrical cables and optical links, it is important to fully utilize the capacity available in wireless systems, as well as to develop robust strategies for integrating these systems into a large scale, heterogeneous data network.

Dynamic algorithms with network coding for multicast in wired and time-varying wireless networksshowed that random network coding can be applied in such a dynamic setting[1].

Routing, scheduling, and power control in networks with bursty traffic has recently received significant attention in the context of wireless networks. Much of the recent work in this area builds on the ideas that describe algorithms for routing and scheduling flows using queue sizes, or differences in queue size between the queues at the source and the destination of a link, as the metric to select between different flows. Such an approach is usually said to be back-pressurebased since heavily loaded nodes downstream push back and slow down the flow coming down from nodes upstream. Such a back-pressure approach is generally optimal in the sense that it allows transmission at the maximum possible arrival rates into the network for which the queues at the various network nodes are still stable. We presented dynamic algorithms with network coding for multicast in wired and time-varying wireless networks.

We summarize our main results below.
- Using the concept of shadow queues, we decouple routingand scheduling. A shadow network is used to update aprobabilistic routing table which packets use upon arrivalat a node. The back-pressure-based scheduling algorithmis used to serve FIFO queues over each link.
- The routing algorithm is designed to minimize the average number of hops used by packets in the network.This idea, along with the scheduling/routing decoupling,leads to delay reduction compared with the traditionalback-pressure algorithm.

II. System overview- Backpressure Algorithm

The backpressure algorithm was introduced in [1] as ascheduling policy that maximizes the throughput of wirelessmultihop networks. Assuming slotted time, the basic idea ofbackpressure scheduling is to select the “best” set of noninterferinglinks for transmission at each slot. We now describethis idea in a 4-node network with two flows, black and gray,from node to , depicted in Fig. 1. Each node maintainsa separate queue for each flow. For each queue, the numberof backlogged packets is shown. Assume that we have twolink sets, and , shown ascontinuous and dashed lines, respectively. The links in each setdo not interfere and can transmit in the same time slot.

Backpressure routing is an algorithm for dynamically routing traffic over a multi-hop network by using congestion gradients. The algorithm can be applied to wireless communication networks, including sensor networks, mobile ad hoc networks (MANETS), and heterogeneous networks with wireless and wireline components. Backpressure principles can also be applied to other areas, such as to the study of product assembly systems and processing networks. This article focuses on communication networks, where packets from multiple data streams arrive and must be delivered to appropriate destinations. The backpressure algorithm operates in slotted time. Every time slot it seeks to route data in directions that maximize the differential backlog between neighboring nodes. This is similar to how water flows through a network of pipes via pressure gradients.

The backpressure algorithm can be applied to multi-commodity networks (where different packets may have different destinations), and to networks where transmission rates can be selected from a set of (possibly time-varying) options. Attractive features of the backpressure algorithm are: (i) it leads to maximum network throughput, (ii) it is provably robust to time-varying network conditions, (iii) it can be implemented without knowing traffic arrival rates or channel state probabilities. However, the algorithm may introduce large delays, and may be difficult to implement exactly in networks with interference. Modifications of backpressure that reduce delay and simplify implementation are Improving Delay and Distributed Backpressure.

We develop a new adaptive routing algorithm built upon the widely studied back-pressure algorithm. We decouple the routing and scheduling components of the algorithm by designing a probabilistic routing table that is used to route packets to per-destination queues. The scheduling decisions in the case of wireless networks are made using counters called shadow queues. The results are also extended to the case of networks that employ simple forms of network coding. In that case, our algorithm provides a low-complexity solution to optimally exploit the routing–coding trade

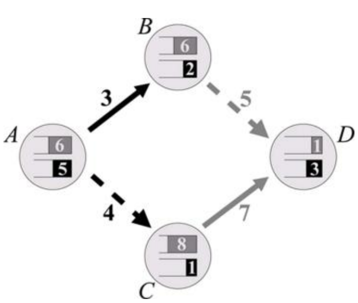

Fig. 1. Backpressure scheduling in a network with two flows, black and gray, from to . Links in sets (continuous) and(dashed) can be scheduled in the same slot.

III. Independent Sources Case: Problem and Approach

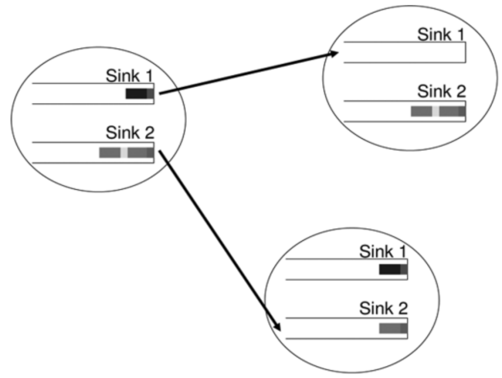

Fig. 2. An example illustrating a physical broadcast transmission with two virtual transmissions, for a multicast session with two sinks. Each oval corresponds to a node. The left node broadcasts a physical packet received by the two right nodes, one of which adds the packet to the virtual queue for sink 1, and the other, to the virtual queue for sink 2.

A. Wired Networks

We first describe the capacity region and back pressure policy for independent sources on wired networks, deferring proofsof the results to Section V, which generalizes these results tothe wireless case. We present these results separately for thewired case as they are simpler and provide useful intuition. Themain difference between the wired and wireless scenarios is thatin a wired network all links are point-to-point links with fixedtransmission rates, whereas in a wireless network, links could bepoint-to-multipoint with mutually dependent transmission rates.

A. Notation

We denote by the capacity of link . We use to denote average virtual flow rate, over link , fromto . We use to denote average physical flow rate forsession over . For brevity of notation, we use theconvention that any term with subscript equals zero unless, and any term with superscript equals zero unless

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B. Capacity Region With Intrasession Network Coding

Let be the set of all source rate vectors such that thereexist variables satisfying The variables for a (session, sink) pair define a flow carrying rate at least from each source node toin which virtual flow that is intended for is notretransmitted away from network coding allows flows fordifferent sinks of a common multicast session to share capacityby being coded together [1], so the total usage of linkby session need only be as large as the maximum virtual usageby individual sinks of the session.The flow constraints given above provide a characterization of the capacity region.

C. Achievability

The following back-pressure policy stabilizes the network for all input rates within the capacity region. It is a special case of the back-pressure policy for wireless networks described and analyzed. The intuition behind the policy is that
it chooses, for each link at each time slot, the session with the maximum total weight of virtual transmissions, summed over the session's sinks.
Back-Pressure Policy for Wired Networks: For each time slot and each link we have the following.
• Session scheduling: one session is chosen.

B. Use of Simulation software

Existing Back-pressure algorithm is only reducing the queue and packet delay in the network. But it is not address the congestion control in high speed network. So we need to concentrate the back pressure with congestion control based packet priority in the network. Back-pressure with shadow queue is used. It leads the reduction of delay in networks.

IVPROPOSED SYSTEM

The routing algorithm is designed to minimize the average number of hops used by packets in the network. This idea, along with the scheduling/routing decoupling, leads to delay reduction compared with the traditional back-pressure algorithm. The algorithm can be applied to wire line and wireless networks. Extensive simulations show dramatic improvement in delay performance compared to the back-pressure algorithm.
Using the concept of shadow queues, we partially decouple routing and scheduling. A shadow network is used to update a probabilistic routing table which packets use upon arrival at a node. The same shadow network, with back-pressure algorithm, is used to activate transmissions between nodes; however, first, actual transmissions send packets from FIFO per-link queues and, second, potentially more links are activated, in addition to those activated by the shadow algorithm.

V CONCLUSION

The back-pressure algorithm, while being throughput optimal, is not useful in practice for adaptive routing since the delay performance can be really bad. In this paper, we have presented an algorithm that routes packets on shortest hops when possible, and decouples routing and scheduling using a probabilistic splitting algorithm built on the concept of shadow queues introduced. By maintaining a probabilistic routing table that changes slowly over time, real packets do not have to explore long paths to improve throughput, this functionality is performed by the shadow "packets." Our algorithm also allows extra link activation to reduce delays.
The algorithm has also been shown to reduce the queueing complexity at each node and can be extended to optimally tradeoff between routing and network coding.

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AUTHORS

First Author – Arathy Sankar , M.E Pursuing, B.E in Computer Engineering, Pillai HOC College of Engineering And Technology, arathy11sankar@gmail.com.
Second Author –Rahul Jiwane, M.E in Computer Engineering,Pillai HOC College of Engineering And Technology