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Scheduling In Multihop Wireless Networks to Achieve Optimal Throughput

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Abstract— The problem of link scheduling in multi hop wireless networks under general interference constraints. Although the celebrated back-pressure algorithm maximizes throughput, it requires per-destination or per-flow information. It is usually difficult to maintain and obtain this type of information, especially in huge networks, when there are multiple flows and also the back-pressure algorithm keeps exchanging queue length information among adjacent nodes and also maintains a complex data structure at each node that commonly results in poor delay performance. Our goal is to design scheduling schemes that do not use per-destination or per-flow information, exploit only local information, maintain a single data queue for each link, while guaranteeing throughput optimality.
Keywords— Multihop Wireless Networks, Per-link/Per-hop queues, Back-pressure algorithm, Throughput Optimal,Without per-flow information.

I. INTRODUCTION

Link scheduling is critical resource allocation functionality in multihop wireless networks, and also perhaps the most challenging. The seminal work of [1] introduces a joint adaptive routing and scheduling algorithm, called back-pressure, that has been shown to be throughput-optimal. That means it can stabilize the network under any feasible load. This paper focuses on the settings with fixed routes, where the back-pressure algorithm becomes a scheduling algorithm consisting of two components: flow scheduling and link scheduling. The back-pressure algorithm, although throughput-optimal and it needs to solve a Max Weight problem, which requires centralized operations and NP hard in general[2]. To this end, simple scheduling algorithms based on carrier sensing multiple accesses are developed to achieve the optimal throughput in a distributed manner for single-hop traffic and are later extended to the case of multihop traffic leveraging the basic idea of back-pressure. The proposed scheme maintains multiple FIFO queues at the transmitting node of each link. Specifically, any packet whose transmission over link is the kth hop forwarding from its source node is stored at queue. This hop-count information is much easier to obtain and maintain compared to per-destination or per-flow information. For example, hop-count information can be obtained by using time-to-live information in the packet headers. Also, as mentioned earlier, while the number of flows in large network is very large, the number of hops is almost much smaller.A shadow algorithm similar to ref [3] is adopted in our framework, where a shadow queue is associated with each data queue. We are considering the Max Weight algorithm on the basis of shadow queue lengths and show that this per-Hop Queue-based Max Weight Scheduler (HQ-MWS) is throughput-optimal using the fluid limit techniques via a hop-by-hop inductive argument.We propose two schemes based on LQ-MWS using different queuing disciplines. We first combine this with the priority queuing discipline i.e PLQ-MWS, where a higher priority is given to the packet that travels through a smaller number of hops, and later proves throughput optimality of the PLQ-MWS. It is of independent interest that this type of hop-count-based priority discipline increases the stability. However, this, requires that nodes sort the packets according to their hop-count information. We then remove this restriction by combining the LQ-MWS with the FIFO queuing discipline that means with FLQ-MWS and prove the throughput optimality of the FLQ-MWS in the networks where flows do not form loops. Finally, we show through simulations that the proposed scheduling schemes can simply improve the delay performance in most different cases. The schemes with per-link queues are PLQ-MWS and FLQ-MWS both perform well in a wider variety of scenarios, which implies that by maintaining per-link queues not only simplifies the data structure, but also it can contribute to scheduling efficiency and delay performance.

II. RELATED WORK

Literature survey is the most important step in software development process. It is necessary to determine the economy, time factor and company strength before developing the tool. After these things are satisfied, next step is to determine which language andoperating system can be used for developing the tool. Once the programmers start building the tool the programmers need lot of external support. Before building the system the above consideration are taken into account for developing the proposed system.

In 2008--- IEEE Transcation--Scheduling in Multihop Wireless Networks without Back-pressure concentrates on scheduling in multihop wireless networks. The throughput of back-pressure scheduling algorithm is optimal. Here, they proposed a self regulated Max Weight scheduling, where calculation of backpressure is not required . They proved that when the traffic flows are associated with fixed routes and deterministic arrivals the self-regulated Max Weight scheduling throughput is optimal.

In 2009—IEEE Transcation-- A Tutorial on Cross-Layer Optimization in Wireless Networks

Focuses on recent developments in wireless systems approaches for resource allocation problems in wireless systems. Here they have important results by overviewing in the area of channel-aware (opportunistic) scheduling for single-hop(cellular)networks. Then they have described key lessons learned .The main hindrance in extending the work to general resource allocation problems for multihop wireless networks. At the end, a clean-slate optimization- based approach to the multihop resource allocation problem results in a “loosely coupled” cross-layer solution. The algorithms obtained is mapped to transport, network, and medium access control/physical (MAC/PHY) layers of the protocol stack. They are being passed back and forth by coupling through a limited amount of information which results the optimal scheduling component at the MAC layer .Hence needs strongly imperfect (simpler) distributed solutions. They have describe recently developed distributed algorithms along these lines and demonstrated how to use imperfect scheduling in the cross-layer framework .

IN 2010—IEEE Transcation-- On Combining Shortest-Path and Back-Pressure Routing Over Multihop Wireless Networks Tassiulas and Ephremides have proposed Back-pressure-type algorithms based on the scheduling over multihop wireless networks and for jointly routing. This approach has a tremendous weakness in routing. The traditional back-pressure algorithm explores all almost correctly paths between each source and destination. It requires extensive exploration in order to maintain stability when the network is over loaded, under light or moderate loads, packets may be sent over unnecessarily long routes.The algorithm could not be efficient in case of routing convergence times and end-to-end delay. They proposes a new routing back-pressure algorithm that assure network stability (throughput optimality).It selects a set of optimal routes based on *shortest-path information* adaptively thereby minimizing average path lengths between each source and destination pair. The proposed algorithm selects a set of routes according to the traffic load compared to the traditional back-pressure algorithm.

IN 2011—IEEE Transcation-- Joint Rate Control and Scheduling in Multihop Wireless Networks Discuss the problem of optimal data rate allocation to a group of users in a multihop wireless network .So they proposed a dual optimization relating through which the rate control problem it can be decomposed. The proposed mechanism fully utilize the capacity of the network ,improve the quality of service to the users and maintain fairness.

IN 2012—IEEE Transcation-- Fair TDMA scheduling in wireless multihop networks

Here, the communication between two end-nodes is carried out by hopping over multiple wireless links. The fact each node need to transmit its own traffic band traffic on behalf of other nodes, leading to unfairness rates of the nodes among the communication .

III.SYSTEM DESIGN

A. Existing System

The throughput-optimization was proposed in the existing system where it stabilizes load of the network. The weight of a link is calculated as product of the link capacity and maximum “back-pressure” among flows in link and explains Max Weight problem in the back-pres-sure algorithm.

Disadvantages

Per-flow or per-destination information is required, which is usually difficult to achieve and maintain, in large networks.

At each node separate queues are maintained for each flow.

B. Proposed System

The proposed system is developed for scheduling policies with per-hop queue and the goal are to reduce per flow information requirement; structure of queue, reducing delay potentially is achieved by shadow algorithm.

1) Advantages Of Proposed System: Maintaining per-link queues.

Performance is improved.

IV.DESIGN CONSIDERATIONS

A. System Model

We consider a multihop wireless network described by a directed graph, which denotes the set of nodes and set of links. Consider nodes as wireless transmitters or receivers, and wireless channels as links between two nodes. Time-slotted system is assumed with a single frequency channel. Consider link capacity of link, i.e., link can transmit at most packets during a time-slot if there is no interfere with transmission at the same time. The stream of packets is sent from a source node to a destination node. At the source, packets are injected and traversed through multiple links to the destination via

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multihop communications. Assume that each flow has a single instance and loop-free route that the route of flow has length of hop from the source to destination, denotes the flow of route for hop link, and denotes the cardinality of a set. Let denote the length of the longest route over all flows.

B. Data Flow Diagram

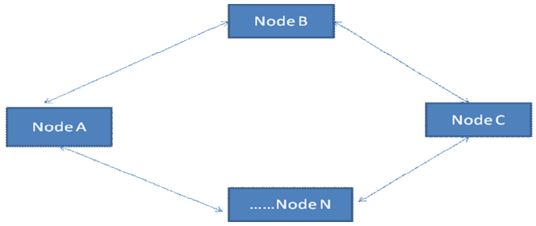

Fig. 1

C. System Architecture

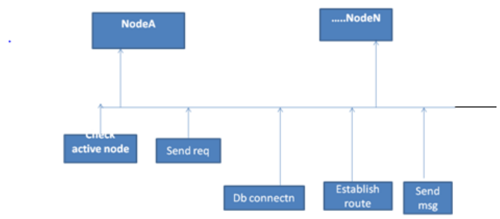

Fig. 2

We start with the description of queue structure, and specify the scheduling scheme based on per-hop queues and a shadow algorithm. Consider that transmitting node of each link, a single FIFO data queue is maintained for packets whose kth hop is link ,Such queues are called *per-hop* queues. For notational convenience, we also use to denote the queue length of at time-slot. Let denote the service of at time-slot, which takes a value of (i.e., 1 in our setting) if queue is active, or 0 otherwise. Let denote the cumulative number of packet departures from queue up to time-slot, and let be the number of packet departures from queue at time-slot. Since a queue may be empty when it is scheduled, we have for all time-slots. Let denote the cumulative number of packets transmitted from the hop to hop for flow up to time-slot.

V. IMPLEMENTATION

Implementation is that the stage of the project once the theoretical style is turned out into operating system. So it is thought-about to be the most essential stage in achieving a triple-crown new system and in giving the user, confidence that the new system can work and be effective. The implementation stage involves careful designing, investigation of the existing system and it's constraints on implementation, planning of ways to realize changeover and analysis of transmutation ways.

A. LQ-MWS With Priority Discipline

We develop a scheduling scheme by combining LQ-MWS with priority queuing discipline, called *PLQ-MWS*. Regarding priority of packets at each per-link queue, we define *hop-class* as follows: A packet has hop-class if the link where the packet is located is the th hop from the source of the packet. When a link is activated to transmit packets, packets with a smaller hop-class will be transmitted earlier; and packets with the same hop-class will be transmitted in a FIFO fashion. PLQ-MWS is throughput-optimal. We provide the outline of the proof and refer to our online technical report [4] for the detailed proof. Basically, we follow the line of analysis for HQ-MWS using fluid limit techniques and induction method. Since a link transmits packets according to their priorities (i.e., hop-classes or hop-count from their respective source nodes), we can view packets with hop-class at link as in a subqueue (similar to the per-hop queues under HQ-MWS). Now, we consider the data queues in the fluid limits. Since the exogenous arrival process satisfies the SLLN, the instantaneous arrival to shadow queue will be at least for each link . This implies that the service rate of shadow queue is no smaller than due to the stability of the shadow queues under PLQ-MWS; and 2) the highest priority is given to sub queue when link is activated to transmit. Since the arrival rate of sub queue is , the service rate is strictly greater than the arrival rate for subqueue , establishing its stability. Similarly, we can show that the hop-class- subqueues are stable for all , given the stability of the hop-class- subqueues for all . Therefore, we can show the stability of the data queues via a hop-by-hop inductive argument. This immediately implies that the fluid limit model of the joint system is stable under PLQ-MWS. The key intuition of these counterexamples is that by giving a higher priority to packets with a larger hop-count in one station, the priority discipline may impede forwarding packets with a smaller hop-count to the next-hop station, which in turn starves the next-hop station. On the other hand, PLQ-MWS successfully eliminates this type of inefficiency by giving a higher priority to the packets with a smaller hop-count and continues to push the packets to the following hops. Note that PLQ-MWS is different from HQ-MWS, although they appear to be similar. HQ-MWS makes scheduling decisions based on the queue length of each per-hop shadow queue. This may result in a waste of service if a per-hop queue is activated but does not have enough packets to transmit, even though the other per-hop queues of the same link have packets. In contrast, PLQ-MWS makes decisions based on the queue length of each per-link shadow queue and allows a link to transmit packets of multiple hop-classes, avoiding such an inefficiency. The performance difference due to this phenomenon will be illustrated . Furthermore, the implementation of PLQ-MWS is easier than HQ-MWS since PLQ-MWS needs to maintain only one single shadow queue per link. Another aspect of PLQ-MWS we would like to discuss is about the *hop-count-based priority discipline* in the context of multiclass queueing networks (or wireline networks). In operations research, stability of multiclass queueing networks has been extensively studied in the literature (e.g., see [5] and the references therein). To the best of our knowledge, however, there is very limited work on the topic of "priority enforces stability" [6]–[8]. In [6] and [7], the authors obtained sufficient conditions (based on linear or piecewise linear Lyapunov functions) for the stability of a multiclass fluid network and/or queueing network under priority disciplines.

However, to verify these sufficient conditions relies on verifying the feasibility of a set of inequalities, which in general can be very difficult. The most related work to ours is [7]. There, the authors showed that under the condition of "Acyclic Class Transfer," where customers can switch classes unless there is a loop in class transfers, a simple priority discipline stabilizes the network under the usual traffic condition (i.e., the normalized load is less than one). Their priority discipline gives a higher priority to customers that are closer to their respective sources. Interestingly, our hop-count-based priority discipline (for wireline networks) is similar to the discipline proposed in [8]. However, there is a major difference in that while [8] studies stability of wireline networks (without link interferences) under the usual traffic condition, we consider stability of wireless networks with interference constraints that impose the (link) scheduling problem, which is much more challenging.

In wireless networks, the service rate of each link depends on the underlying scheduling scheme, rather than being fixed as in wireline networks. Hence, the difficulty is to establish the usual traffic condition by designing appropriate wireless scheduling schemes. In this paper, we develop PLQ-MQS scheme and show that the usual traffic condition and then stability can be established via a hop-by-hop inductive argument under the PLQ-MWS scheme .

B. LQ-MWS With FIFO Discipline

In this section, we develop a scheduling scheme, called *FLQ-MWS*, by combining the LQ-MWS algorithm developed in Section IV-A with *FIFO* queueing discipline (instead of priority queueing discipline) and show that this scheme is throughput-optimal if flows do not form loops. We emphasize that FLQ-MWS requires neither per-flow information nor hop-count information.

VI. CONCLUSIONS

In this paper, we developed scheduling schemes with per-link or per-hop queues and a shadow algorithm is used to achieve the overall goal of by removing per-destination or per-flow information requirement, exploiting only local information, simplifying queue structure and potentially reducing delay. We showed throughput optimality of the proposed scheduling schemes that use only the already available hop-count information by using fluid limit techniques via an inductive argument.Further we simplified the solution by using FIFO queueing discipline with per-link queues and showed that schemes are also throughput optimal in networks without flow-loops. The problem of proving throughput optimality in general networks with algorithms (like FLQ-MWS) that use only per-link information remains an important open and challenging problem. Furthermore, it is also worthwhile to investigate the problem with dynamic routing and see if per-flow and per-destination information can be removed even when routes are not fixed.

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