A.Kiran Kumar, B. Thikkanna / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp.2155-2158

LOWERBOUND ANALYSIS TO OBTAIN OPTIMALITY AND DELAY ANALYSIS IN WIRELESS NETWORKS

A.Kiran Kumar, B.Thikkanna

Ananthalakshmi Institute of Technology and Sciences, Anantapur (AP), India
{First Author: A.Kiran Kumar, Second Author: B.Thikkanna}

ABSTRACT:

In this paper, we focus on scheduling policies to obtain optimality and delay analysis on wireless networks. In which routes between source and destination not fixed. A general set based interference model is assumed that imposed a constraints on links that can be served simultaneously at any given time. These are used to obtain a fundamental lower bound of any scheduling policy for the system. For clique, a special wireless system, a policy is sample path delay optimal. Lower bound analysis provides useful insight into the design and analysis of optimal or nearly optimal scheduling policies.

INTRODUCTION:

The delay performance of wireless networks, however, a problem. This problem is notoriously difficult even in the context of wire line networks, primarily because of the complex interactions in the network (e.g., superposition, routing, departure, etc.) that make its analysis amenable only in very special cases like the product form networks. The problem is further exacerbated by the mutual interference inherent in wireless networks which, complicates both the scheduling mechanisms and their analysis. The delay performance of any scheduling policy is primarily limited by the interference, which causes many bottlenecks to be formed in the network. We demonstrated the use of exclusive sets for the purpose of deriving lower bounds on delay for a wireless network Now consider the lower bound analysis as an important first step towards a complete delay analysis of wireless systems. For a network with node exclusive interference, our lower bound is tight in the sense that it goes to infinity whenever the delay of any throughput optimal policy is unbounded.. A clique network is a special graph where at most one link can be scheduled at any given time. Using existing results on work conserving queues, we design a delay optimal policy for a clique network and compare it to the lower bound.

II. SYSTEM MODEL

consider a wireless network G = (V,L), where V is the set of nodes and L is the set of links. Each link has unit capacity. There are N flows, each distinguished by its source destination pair (si, di). There is a fixed route (set of links) between the source si and corresponding destination di. Each route is a simple path. Each flow has its own exogenous arrival stream {Ai(t)}1 t=1. Each packet has a deterministic service time equal to one unit. The exogenous arrivals at each source are assumed to be independent. Let A(t) = (A1(t), . . . ,AN(t)) represent the vector of exogenous arrivals, where Ai(t) is the number of packets injected into the system by the source si during time slot t (for i = 1, . . . ,N). Let _ = (_1, . . . , _N) represent the corresponding long-term average arrival rate vector.

The path on which flow i is routed is specified as Pi := (v0i , v1i , . . . , vj i , . . . , v|Pi| i), where vj i is a node at a j-hop distance from the source node si. The source node si is denoted by v0 i and the destination node di by v|Pi| i , where |Pi| is the path length. The packets arriving at each node are queued.

Each node maintains a separate queue for each flow that passes through the node. Let Qj i (t) denote the queue length at node vj corresponding to flow i. After reaching the destination node, each packet leaves the system, i.e. Q|Pi| i = 0. The queue length vector is denoted by Q(t) = (Qj i (t) : i ∈ {1, 2, . . . ,N} and j ∈ {1, 2, . . . , Pi}). Multiple flows can share a link e. A link can be activated in a time slot t only if the corresponding queue is non empty. We use the term activation (scheduling) of a link or a queue interchangeably. At most, one packet is served at a queue in a given time slot. The service structure is slotted.

III. DERIVING LOWER BOUNDS ON AVERAGE DELAY

In this section, we present our methodology to derive lower bounds on the system-wide average packet delay for a given wireless network. At a high level, we partition the flows into several groups. Each group passes through a (K, X)-bottleneck and the queuing for each group is analyzed individually. The grouping is done so as to maximize the lower bound on the system wide expected delay. For flows passing through a given bottleneck (a group), we lower bound the sum of queues upstream and downstream of the bottleneck separately. We *reduce* the analysis of queuing *upstream* of a (K, X)-bottleneck to studying single queue systems fed by appropriate arrival processes. These arrival processes are simple functions of the exogenous arrival processes of the original network. A separate lower bound can be established for the queues downstream of the network. The lower bound on the system-wide average delay of a packet is then computed using the statistics of the exogenous arrival processes. We derive analytical expressions of the lower bounds for a large class of arrival processes. In this section, we first characterize the bottlenecks in the system. Our analysis justifies the reduction of a (K, X)-bottleneck to a single queue system fed by appropriate arrival processes. Finally, we present a greedy algorithm which takes as input, a system with N flows and possibly multiple bottlenecks, and returns a lower bound on the system-wide average packet delay.

IV. DESIGN OF DELAY EFFICIENT POLICIES

We address the important question of designing a delay-efficient scheduler for general wireless networks. We will see that although delay optimal policies can be derived for some simple networks like the clique, deriving such policies in general is extremely complex. Intuitively, such a scheduler must satisfy the following properties.

A. Clique

A clique network is one in which the interference constraints allow only one link to be scheduled at any given time.
Design a scheduling policy that minimizes the total number of packets in the system at all times for every sequence of arrivals. This is also known as *sample path delay optimality*. In particular, we will show that for the given network, scheduling the packet which is closest to its destination is optimal.

B. Back-Pressure Policy

The back-pressure policy may lead to large delays since the backlogs are progressively larger from the destination to the source. The packets are routed only from a longer queue to a shorter queue and certain links may have to remain idle until this condition is met. Hence, it is likely that all the queues upstream of a bottleneck will grow long leading to larger delays. A common observation of the optimal policies for the clique and the tandem network is that increasing the priority of packets which are close to the destination reduces the delay.

A throughput-optimal scheduling policy.
Define the differential backlog of flow i passing through a link

$$\boxed{\nabla Q_i^e = (Q_i^{j_i})^\alpha - (Q_i^{j_i+1})^\alpha, \qquad \text{for some } \alpha > 0.}$$

as
For each link, the flow with the maximum differential backlog is chosen.
The link-scheduling component schedules the activation vector with the maximum weight at every time slot.

Flow Scheduling
For each link $e \in L$, find the flow with the maximum differential backlog

$$f_e^*(t) = \operatorname*{argmax}_i \nabla Q_i^e \tag{27}$$

Assign weights to every link

$$w_e = \max(\nabla Q_{f_e^*}^e, 0) \tag{28}$$

Link Scheduling
Schedule the maximum weighted matching

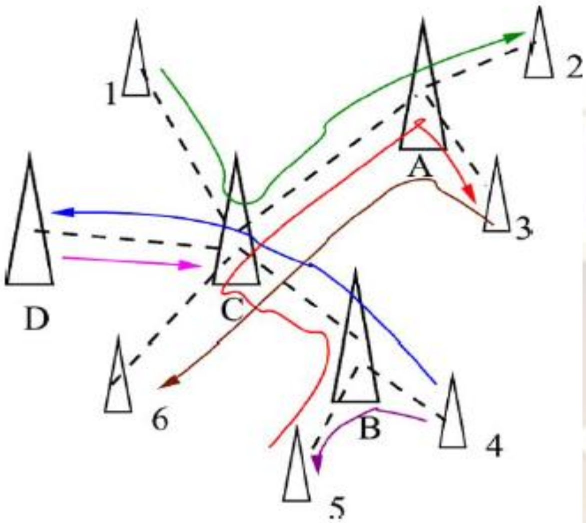
$$\mathbf{I}(t) = \operatorname*{argmax}_{\mathbf{J} \in \mathcal{J}} \langle \mathbf{w}, \mathbf{J} \rangle \tag{29}$$

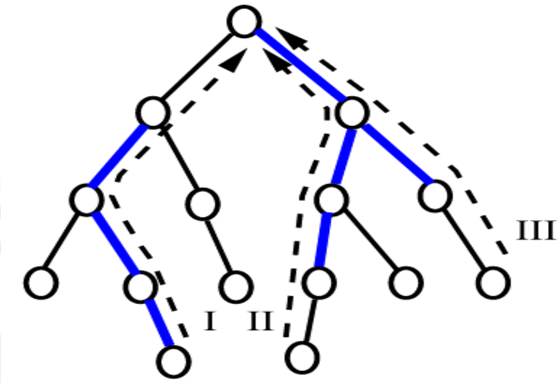
where for two vectors $\mathbf{x}$ and $\mathbf{y}$, $\langle \mathbf{x}, \mathbf{y} \rangle = \sum_l x_l y_l$ denotes the inner product.

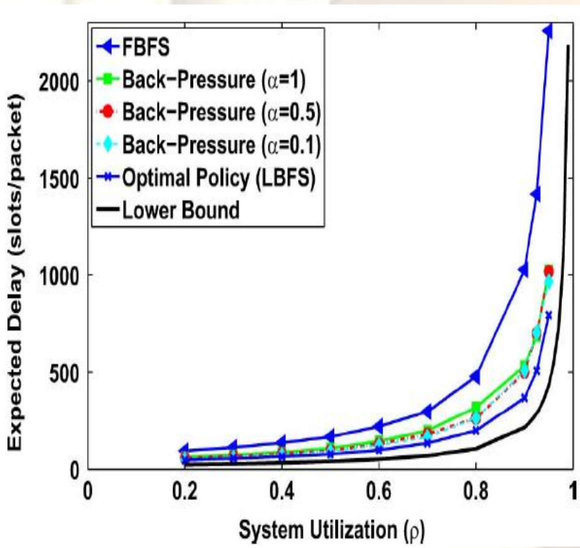
V. ILLUSTRATIVE EXAMPLES

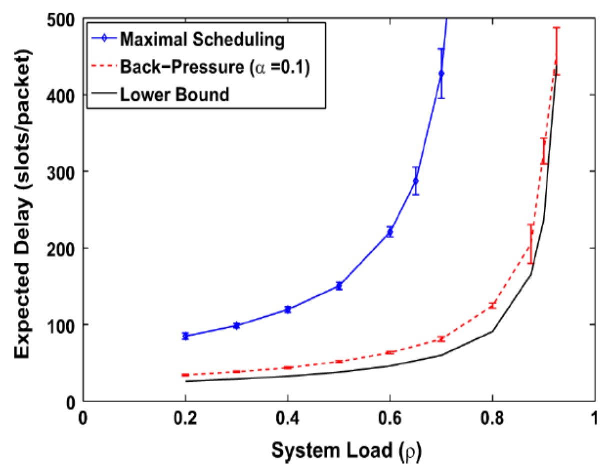
Clique

Tree topology









Conclusion:

This paper develops a new approach to reduce the bottlenecks in a wireless to single-queue systems to carry out lower bound analysis. The analysis is very general and admits a large class of arrival processes. The analysis can be readily extended to handle channel variations.

REFERENCES

[1] H. Balakrishnan, C. Barrett, V. Kumar, M. Marathe, and S. Thite. The distance-2 matching

problem and its relationship to the maclayer capacity of ad hoc networks. *IEEE Journal on Selected Area in Communications*, 22, 2004.

[2] L. Bui, R. Srikant, and A. L. Stolyar. Novel architectures and algorithms for delay reduction in back-pressure scheduling and routing. *INFOCOM Mini-Conference*, 2009.

[3] P. Chaporkar, K. Kar, and S. Sarkar. Throughput guarantees through maximal scheduling in wireless networks. In *43rd Annual Allerton Conference on Communication, Control, and Computing*, 2005.

[4] J. G. Dai and W. Lin. Maximum pressure policies in stochastic processing networks. *Operations Research*, 53:197–218, 2005.

[5] J. G. Dai and W. Lin. Asymptotic optimality of maximum pressure policies in stochastic processing networks. Preprint, October 2007.

[6] H. Dupuis and B. Hajek. A simple formula for mean multiplexing delay for indep endent regenerative sources. *Queueing Systems Theory and Applications*, 16:195–239, 1994.

[7] A. Feldmann, N. Kammenhuber, O. Maennel, B. Maggs, R. D. Prisco, and R. Sundaram. A methodology for estimating interdomain web traffic demand. In *IMC*, 2004.

[8] L. Georgiadis, M. J. Neely, and L. Tassiulas. *Resource Allocation and Cross-Layer Control in Wireless Networks, Foundations and Trends in Networking*, volume 1. Now Publishers, 2006.

[9] G. R. Gupta. *Delay Efficient Control Policies for Wireless Networks*. Ph.D. Dissertation, Purdue University, 2009.

[10] K. Sundaresan and S. Rangarajan. On exploiting diversity and spatial reuse in relay-enabled wireless networks. In *International Symposium on Mobile Ad Hoc Networking and Computing*, 2008.

[11] L. Tassiulas and A. Ephremides. Stability properties of constrained queueing systems and scheduling policies for aximum throughput in multihop radio networks. *IEEE Trans. Aut. Contr.37*, 37(12):1936–1948, 1992.

[12] L. Tassiulas and A. Ephremides. Dynamic scheduling for minimum delay in tandem and parallel constrained queueing models. *Annals of Operation Research, Vol. 48, 333-355*, 1993.

[13] V. J. Venkataramanan and X. Lin. Structural properties of ldp for queuelength based wireless scheduling algorithms. In *45th Annual Allerton Conference on Communication, Control and Computing*, 2007.

[14] T. Weller and B. Hajek. Scheduling nonuniform traffic in a packetswitching system with small propagation delay. *IEEE/ACM Trans. Netw.*,5(6):813–823, 1997.

[15] Y. Xi and E. M. Yeh. Optimal capacity allocation, routing, and congestion control in wireless networks. In *International Symposium on Information Theory*, July 2006.

[16] L. Ying, R. Srikant, A. Eryilmaz, and G. E. Dullerud. A large deviations analysis of scheduling in wireless networks. *IEEE Transactions on Information Theory*, 52:5088–5098, 2006.