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# DELAY ANALYSIS OF SCHEDULING FOR MULTI HOP WIRELESS NETWORKS

**Ranjana Kumari and N. Krishnaih**

Dept of CSE, B.V.C Engineering College, Odalarevu, A.P, India

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**ABSTRACT:**

Delay performance of scheduling for multi-hop wireless network in which the routes between source-destination pairs are fixed and new queue grouping technique to handle the multifaceted correlations of the service process resulting from the multi-hop nature of the flows and their mutual allocation of the wireless medium. Wireless system, namely the clique, we design a strategy that is model path delay optimal. The lower bound analysis provides useful insights into the design and analysis of best possible or nearly best possible scheduling policies.

**KEYWORDS:-.** scheduling for multi-hop wireless network, design and analysis, Wireless system.

## INTRODUCTION:

A huge number of studies on multi-hop wireless networks have been committed to system stability while maximizing metrics like throughput or utility. These metrics measure the performance of a system over a long time-scale. For a big type of applications such as video or voice over IP, embedded network control and for system design; metrics like delay are of prime importance. The delay performance of wireless networks, however, has largely been an open trouble. This trouble is disreputably difficult even in the context of wireline Networks, primarily because of the multifaceted interactions in the network (e.g., superposition, routing, departure, etc.) that create its analysis willing only in very special cases like the creation form networks.

The problem is further exacerbated by the communal interference inherent in wireless networks which, complicates both the scheduling mechanisms and their analysis. Some original analytical techniques to calculate useful lower bound and delay estimates for wireless networks with single hop traffic were developed in [12] and also throuput guarantees through maximal scheduling in wireless network were developed in [3]. However, the analysis is not directly appropriate to multi-hop wireless network with multi-hop flows, due to the difficulty in characterizing the departure process at intermediary links.

The metric of interest in this term paper is the system-wide average delay of a packet from the source to its equivalent destination. We present a new, efficient methodology to obtain a fundamental lower bound on the average packet delay in the method under any scheduling strategy. Furthermore, we re-engineer well known development policies to do good delay performance via-a-via the lower bound. In this document, we consider a multi-hop wireless network with multiple source-destination pairs, given routing and traffic information. Each source injects packets in the network, which traverses through the network until it reaches the destination.

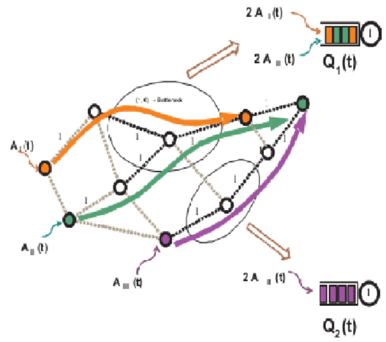
For example, a multi-hop wireless network with three flows is shown in Fig. 1. The exogenous arrival processes AI (t), AI I (t) and AI I I (t) communicate to the number of packets injected in the system at time t. A packet is queued at each node in its path where it waits for an chance to be transmitted. Since the transmission medium is parallel transmissions can interfere with each others' transmissions. The set of links that do not cause interference with each other can be scheduled concurrently, and we call them activation vectors(matchings). We do not impose any a priori limit on the set of allowed activation vectors, i.e., they can characterize any combinatorial interference representation. For example, in aK-hop interference model, the links programmed concurrently are separated by at least Khops. In the example show in Fig. 1, each link has unit capacity; i.e., atmost one packet can be transmitted in a slot. For the above example, we assume a 1-hop interference model. The delay performance of any scheduling policy is primarily bounded by the interference, which causes many bottlenecks to be formed in the network. We established the use of special sets for the purpose of deriving lower bounds on delay for a wireless network with single hop traffic in [12]. In this document, we further generalize the typical concept of a block. In our expressions, we define a (K, X)-bottleneck to be a set of links X such that no more than K of them can simultaneously transmit. Figure 1 shows (1, X) bottlenecks for a network under the 1-hop interference form. In this document, we develop new analytical techniques that focus on the queueing due to the (K, X)-bottlenecks. One of the techniques, which we call the "reduction technique", simplifies the analysis of the queueing upstream of a (K, X)-bottleneck to the study of a single queue system with K servers as indicated in the figure.

Furthermore, our analysis needs only the exogenous inputs to the system and thereby avoids the require to characterize departure processes on in-between links in the network. For a big category of input traffic, the lower bound on the expected delay can be computed using only the statistics of the exogenous arrival processes and not their sample paths. To achieve a lower bound on the system wide average queueing delay, we consider queueing in several bottlenecks by comforting the interference constraints in the system. Our relaxation approach is novel and leads to non-Trivial lower bounds. It is also probable to derive stochastic upper bounds on the average delay of the network using the techniques of Lyapunov drifts [8]. We were capable to obtain sharper upper bounds in [12] by a different Lyapunov function, but we do not follow them here because they focus on a detailed scheduling scheme. Our focus on the other hand, is to derive a fundamental bound on the performance of any policy. Moreover, our lower bound techniques captures the effect of statistical multiplexing of packets due to several flows passing through a common (K, X)-bottleneck, which cLyapunov drifts. As a result, the upper bounds computed using these techniques [8] tend to be quite loose in most practical scenarios [12].

We consider the lower bound analysis as an essential first step towards a complete delay analysis of multi-hop wireless systems. For a network with node limited interference, our lower bound is tight in the sense that it goes to infinity whenever the delay of any throughput optimal policy is unbounded. For a tandem queuing network, the average delay of a delay optimal policy proposed by [31] numerically coincides with the lower bound provided in this document. A clique network is a particular graph where at most one link can be scheduled at any known 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. We will see that although delay optimal policies can be derivative for some simple networks like the clique and the tandem, deriving such policies in general, is very multifarious. Instead, we re-engineer a well known throughput optimal scheduling policy known as the back-pressure policy and express that for certain representative topologies, its delay performance is close to the basic lower bound.

Finally, we also present a case where neither back-pressure policy nor the shadow queue approach (proposed in [2]) are close to the lower bound. For this case, we propose a new handcrafted policy whose delay performance is actually close to the lower bound, thus representative that the lower bound study provides useful insights into the design and analysis of optimal and not be analyzed by the method of source to its corresponding destination We present a new, systematic methodology to obtain a fundamental lower bound on the average packet delay in the system under any scheduling policy. Furthermore, we re-engineer well known scheduling policies to achieve good delay performance viz-a-viz the lower bound.

**Fig. 1.** A typical multi-hop wireless network with multiple flows, each having exogenous arrivals at the source. Some of the important bottlenecks have been highlighted [13]




In this document, we examine a multi-hop wireless network with several source-destination pairs, given routing and traffic information. Each source injects packets in the network, which traverses through the network until it reaches the destination. For example, a multi-hop wireless network with three flows is shown in Fig. 1. The exogenous arrival processes AI (t), AI I (t) and AI I I (t) correspond to the number of packets injected in the system at time t. A packet is queued at each node in its path where it waits for an chance to be transmitted. Since the transmission medium is shared, parallel transmissions can interfere with each others' transmissions. The set of links that do not cause interference with each other can be scheduled simultaneously, and we call them activation vectors (matchings). We do not impose any a priori Limit on the set of allowed activation vectors, i.e., they can describe any combinatorial interference model.

For example, in a K-hop interference model, the links scheduled concurrently are separated by at least Khops. In the example show in Fig. 1, each link has unit capacity; i.e., atmost one packet can be transmitted in a slot. For the above example, we assume a 1-hop interference model .The delay performance of any scheduling policy is primarily Restricted 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 with single hop traffic in [12]. In this paper, we further generalize the typical notion of a bottleneck. In our terminology, we define a (K, X)-bottleneck to be a set of links X such that no more than K of them can concurrently transmit.

Figure 1 shows (1, X) bottlenecks for a network under the 1-hop interference model. In this document, we develop new analytical techniques that focus on The queueing due to the (K, X)-bottlenecks. One of the techniques, which we call the "reduction technique", simplifies the analysis of the queueing upstream of a (K, X)-bottleneck to the learn of a single queue system with K servers as indicated in the figure. Furthermore, our analysis needs only the exogenous inputs to the system and thereby avoids the need to characterize departure processes on midway links in the network. For a large class of input traffic, the lower bound on the expected delay can be computed using only the statistics of the exogenous arrival processes and not their sample paths. To obtain a lower bound on the system wide average queueing delay, we analyze queueing in multiple bottlenecks by relaxing the interference constraints in the system. Our rest approach is new and leads to nontrivial lower bounds. It is also possible to develop stochastic upper bounds on the average delay of the network using the techniques of Lyapunov drifts [8].

We were capable to obtain sharper upper bounds in [12] by using a different Lyapunov function, but we do not follow them here because they focus on a specific scheduling scheme. Our focus on the other hand, is to derive a fundamental bound on the performance of any policy. Moreover, our lower bound Techniques captures the effect of statistical multiplexing of packets due to several flows passing through a common (K, X)-bottleneck, which cannot be analyzed using the method of Lyapunov drifts. As a result, the upper bounds computed using these techniques [8] tend to be quite loose in most practical scenarios [12].We consider the lower bound analysis as an important first step towards a complete delay analysis of multi-hop wireless systems. For a network with node special interference, our lower bound is tight in the sense that it goes to infinity when-ever the delay of any throughput optimal policy is abundant. For a tandem queueing network, the average delay of a delay optimal policy proposed by [31] numerically coincides with the lower bound provided in this paper.

A clique network is a special graph where at most one link can be scheduled at any given time. Using presented results on work conserving queues, we design a delay optimal policy for a clique network and evaluate it to the lower bound. We will see that even though delay optimal policies can be resultant for some simple networks like the clique and the tandem, deriving such policies in general, is very complex. Instead, we re-engineer a well known throughput optimal scheduling policy known as the back-pressure policy and display that for certain representative topologies, its delay performance is close to the fundamental lower bound. Finally, we also present a case where neither back-pressure policy nor the shadow queue approach (proposed in [2]) is close to the lower bound. For this case, we design a new handcrafted policy whose delay performance is actually close to the lower bound, thus demonstrating that the lower bound analysis provides useful insights into the design and analysis of optimal or nearly optimal scheduling policies.

We now summarize our main contributions in this paper:

• Development of a new queue grouping technique to handle the complex correlations of the service process resulting from the multi-hop nature of the flows. We also introduce a novel concept of (K, X)-bottlenecks in the network.

• Development of a new technique to reduce the analysis of queueing upstream of a bottleneck to studying simple single queue systems. We derive sample path bounds on

a group of queues upstream of a bottleneck.

• Derivation of a fundamental lower bound on the system wide average queuing delay of a packet in multi-hop wireless network, regardless of the scheduling policy used, by analyzing the single queue systems obtained above.

• Extensive numerical studies and discussion on useful insights into the design of optimal or nearly optimal scheduling policies gained by the lower bound analysis. We begin with the description of the system model. We then present our methodology for obtaining reductions and using them to lower bound the system-wide average delay of packets .We next address the question of designing delay-efficient schedulers. We then provide concrete examples illustrating the methodology and comparison of the back-pressure policy to the lower bound. We also describe how the proposed approach differs fundamentally from the existing techniques and can be used to gain deeper understanding of the scheduling policies for wireless networks.

**EXISTING SYSTEM:**

We consider a simple distributed scheduling strategy, *maximal scheduling*, and prove that it attains a guaranteed fraction of the maximum throughput region in arbitrary wireless networks. The guaranteed fraction depends on "interference degree" of the network which is the maximum number of sessions that interfere with any given session in the network and do not interfere with each other. Depending on the nature of communication, the transmission powers and the propagation models, the guaranteed fraction can be lower bounded by the maximum link degrees in the underlying topology, or even by constants that are independent of the topology. The guarantees also hold in networks with multicast communication and an arbitrary number of frequencies. We prove that the guarantees are tight in that they cannot be improved any further with maximal scheduling.

**LIMITATIONS OF EXISTING SYSTEM:**

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.

**PROPOSED SYSTEM:**

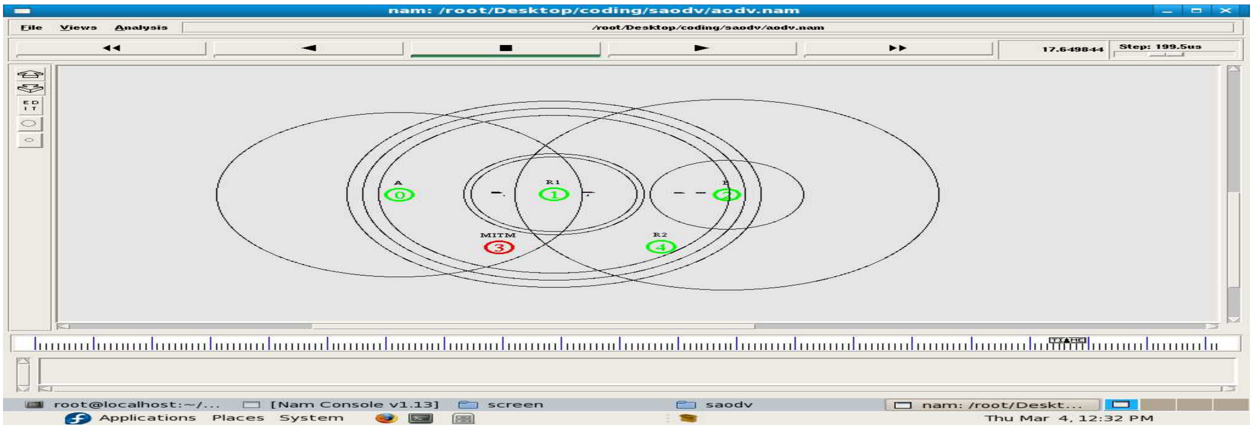
We consider the lower bound analysis as an important first step towards a complete delay analysis of multi-hop wireless systems. For a network with node exclusive interference, our lower bound is tight in the sense that it goes to infinity whenever the delay of any throughput optimal policy is unbounded. For a tandem queueing network, the average delay of a *delay optimal* policy proposed numerically coincides with the lower bound provided in this paper.

We are able to apply known techniques to obtain a sample path delay-optimal scheduling policy. We also obtain policies that minimize a function of queue lengths at all times on a sample path basis. Further, for a tandem queueing system, we show numerically that the expected delay of a previously known delay-optimal policy coincides with the lower bound.

**ADVANTAGES OF PROPOSED SYSTEM:**

We show that our analysis captures the essential features of the wireless network and is useful since, in many cases, we can design a policy that performs close to the lower bound. Perhaps, the most important advantage of the lower bound is that it can be used for analyzing a large class of arrival processes using known results in the queueing flows.

## RESULT: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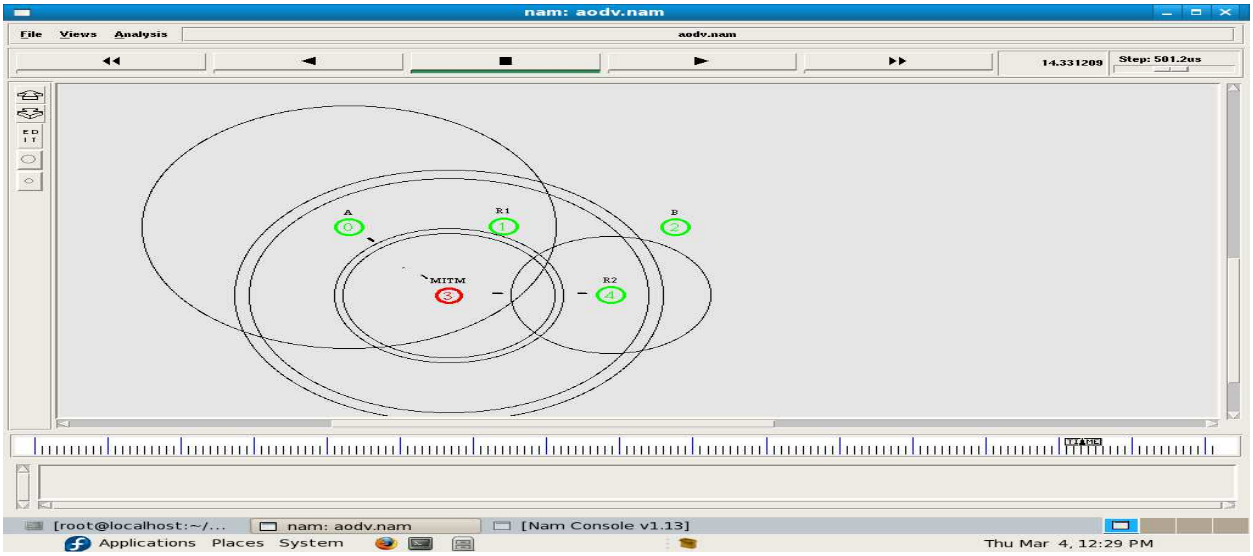
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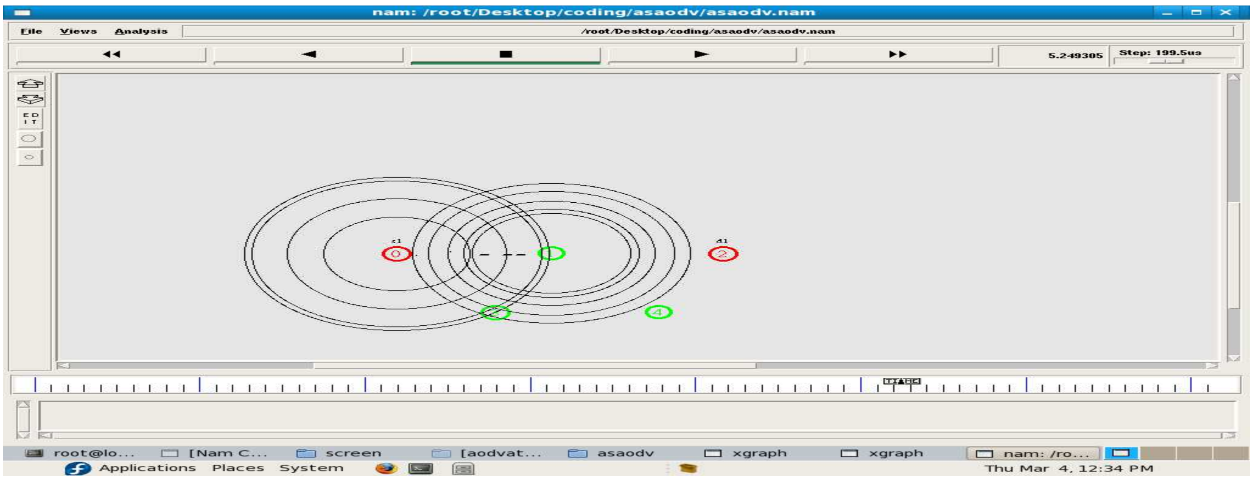
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## CONCLUSION

The delay analysis of wireless networks is largely an open problem. In fact, even in the wire line setting, obtaining analytical results on the delay beyond the product form types of networks has posed great challenges. These are further exacerbated in the wireless setting due to complexity of scheduling needed to mitigate interference. Thus, new approaches are required to address the delay problem in multi-hop wireless systems. To this end, we develop a new approach to reduce the bottlenecks in a multi-hop wireless to single queue systems to carry out lower bound analysis.

## FUTURE ENHANCEMENTS:

In this paper we have shown that delay analysis for multi hop wireless networks in a simulator, in future it can be applied in real time Network /LAN. By using this we can get the exact Results for Delay analysis.

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