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ADAPTIVE MODULATION AND CODING BASED FRAME WORK TO OPTIMIZE INTERFERENCE CANCELLATION ON MULTI-HOP WIRELESS NETWORKS

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Abstract

Wireless networks consist of a number of nodes, which communicate with each other over wireless channels. Unlike wired networks, wireless networks have limited bandwidth, and are much more susceptible to environmental effects such as wireless interference. As a result, it is difficult to transmit information reliably at high data rates. The problem is further compounded by the quality of service (QoS) requirements such as minimum delay and maximum throughput imposed by current and future applications. That said, recent advances in coding techniques, communication protocols and architectures give the promise of future wireless networks that will proliferate high quality wireless applications. Nevertheless, distributed cross-layer design in spirit of exploits simple rate allocation schemes and relies on message passing to coordinate terminals, incurring severe signaling overhead often comparable with the amount of information that is to be exchanged in centralized schemes. Under this assumption, we compute the optimal network performance obtainable by simultaneous optimization of end-to-end rates, routing and physical layer parameters (node schedule without reuse, transmit powers and decoding order at the receivers). The method is applied to a simple network scenario and performance benefits of multi-user detectors and cross layer coordination over alternative schemes are evaluated.

Keywords: NC-Network coding ; SIC-Successive Interference Cancellation ; OG-Offline Generation ; CG-Column Generation ; RSS-Received Signal Strengths ; MWNs-Multi hop Wireless Networks ; QoS- Quality Of Service ; SINR-Signal to Interference Plus Noise Ratio

1. INTRODUCTION

To understand these issues, we investigate the advantages of employing multi user detectors (MUD) within a CDMA/TDMA framework and we compare the optimal performance with what can be achieved by nodes equipped with single user detectors. To this end, we consider a simplified medium access scheme where nodes take turns receiving data from all their neighbors Network coding (NC) and successive interference cancellation (SIC) have been shown to improve the throughput of multi hop wireless networks (MWNs). NC enables a node to transmit multiple packets concurrently as a single coded packet, while SIC allows multi-packet reception (MPR) by removing interference. However, emphasis of the work done so far has been determining maximum throughput of such networks without giving consideration to QoS requirements. Maximization of the throughput may lead to paths in the network that experiences very high packet delays. The objective of this thesis is the minimization of average packet delay in a MWN for a given traffic demand matrix with joint application of NC and SIC techniques. We formulate a cross-layer optimization that performs scheduling, routing, and more importantly capacity allocation in a way that the average packet delay is minimized. Our optimization model considers thoroughly all feasible NC and MPR opportunities in the network and allows nodes to encode up to 4 packets together

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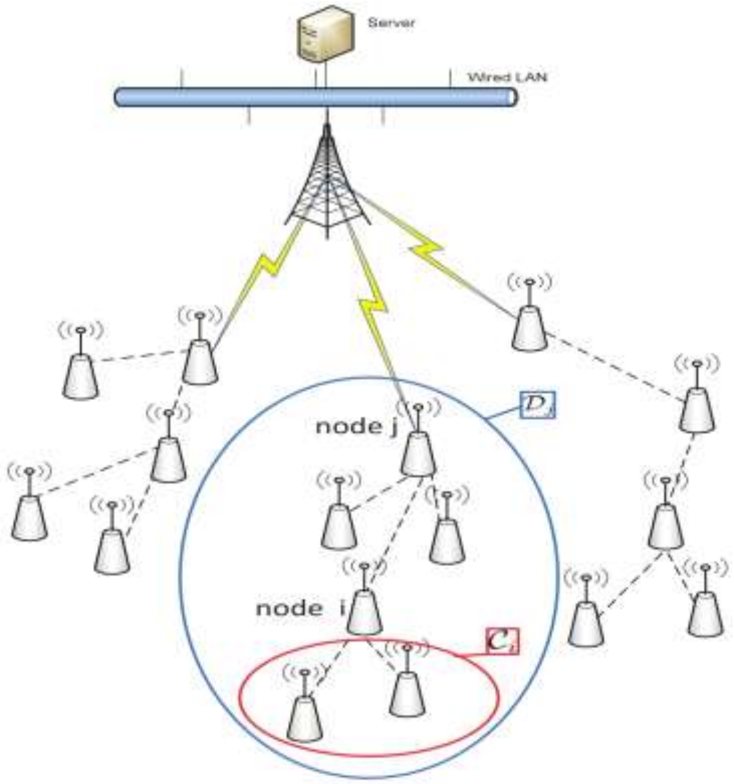

Figure: 1.1 Multi hop Network

. We consider a network that uses conflict-free scheduling and has multi-path routing capability. The method is valid both in the presence and the absence of opportunistic listening on any wireless network topology and any pattern of traffic. We present numerical results to evaluate the performance of the proposed scheme. The results are also compared to that of the previous studies that treat NC and SIC separately. Our findings indicate that significant throughput improvement can be achieved by a winning combination of NC and SIC techniques.

2. RELATED SYSTEM

Recently, there is a growing interest in exploiting interference (rather than avoiding it) to increase network throughput. In essence, such an interference exploitation approach allows overlap among transmitting signals and relies on some advanced physical (PHY) layer schemes to remove or cancel interference. In particular, the so-called successive interference cancellation (SIC) scheme. SIC is a simple and powerful technique to mitigate interference. To date, most of research results on SIC were limited to simple network settings. This paper explored SIC for multi-hop wireless network. After quantifying the fundamental limitations of SIC, we propose a joint optimization framework of SIC at PHY layer, link layer scheduling, and network layer routing for a multi-hop wireless network. Throughput rigorous mathematical development, we characterized an optimization framework through a set of constraints across the PHY, link, and network layers.

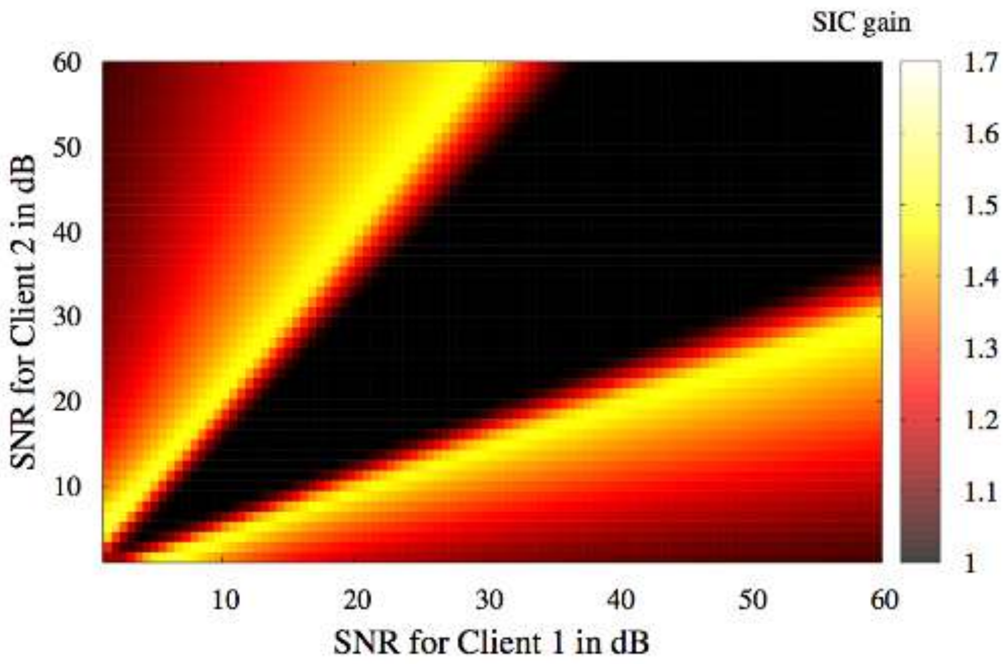

Figure : 2.1 Two transmitters to the same receiver: SIC gains most when RSSs are such that the resulting bitrates are the same for both transmissions.

To demonstrate the utility of this framework, we applied it to study a network throughout optimization problem. Our numerical results affirmed the efficacy of this framework and gave insights on the optimal operation of SIC in a multi-hope wireless network. The findings in this paper fill an important gap on how to optimally use SIC in a multi-hop wireless network.

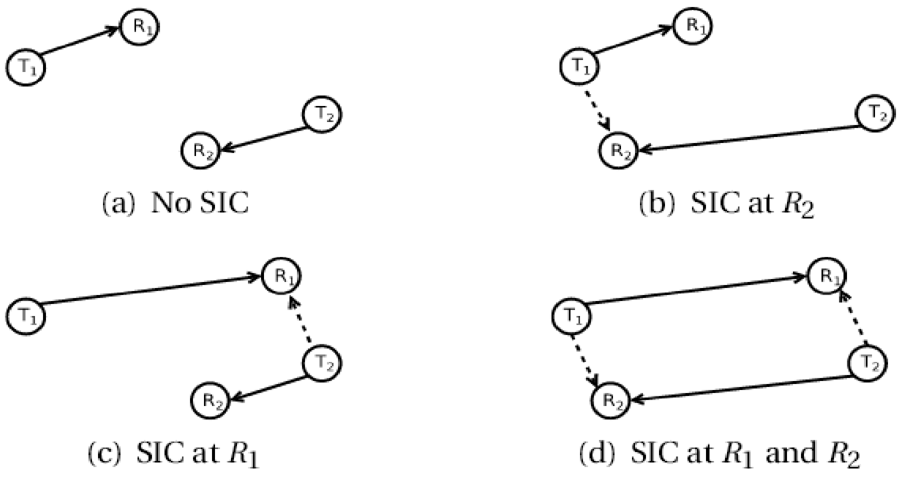

Figure: 2.2 two transmitters to different receivers: signal of interest (solid) and strong interference (dashed)

We considered fixed modulation and coding and thus there is a single SINR threshold and a single rate. Based on how the next-hop nodes obtain the other native packets, inter-session NC may be divided into two subcategories. In the first subcategory, next-hop nodes only use their previous transmissions to decode the coded packet; typically, this category is referred to as

NC without opportunistic listening. In the second one, next-hop nodes in addition to the previous transmissions may use the overheard packets to decode the coded packet; this category is referred to as NC with opportunistic listening. Next to NC, successive interference cancellation (SIC) has gained much popularity to save bandwidth in wireless networks; this technique has attracted an increasing interest to improve performance of higher layers in MWNs. SIC is a physical-layer technique that improves the performance by exploiting interference in lieu of avoiding it; i.e., IC allows multi-packet reception (MPR) by removing interference. SIC enables decoding of multiple signals in a sequential manner to either remove interfering signals or receive multiple packets simultaneously.

3. EXISTING SYSTEM

TDMA schedule that dictates what node should act as receiver at any given point in time. Each node receives data from (possibly all) its neighbors, while the other transmitters stay silent. Formulation of a cross-layer optimization to determine the minimum packet delay in TDMA-based networks. The theoretical framework is presented as a joint multi-path routing and conflict-free scheduling problem. Further, the power control constraints are presented as an extension. Two decomposed model, OG and CG problems, are presented for large sized networks. Further, we compare the performance of these two methods.

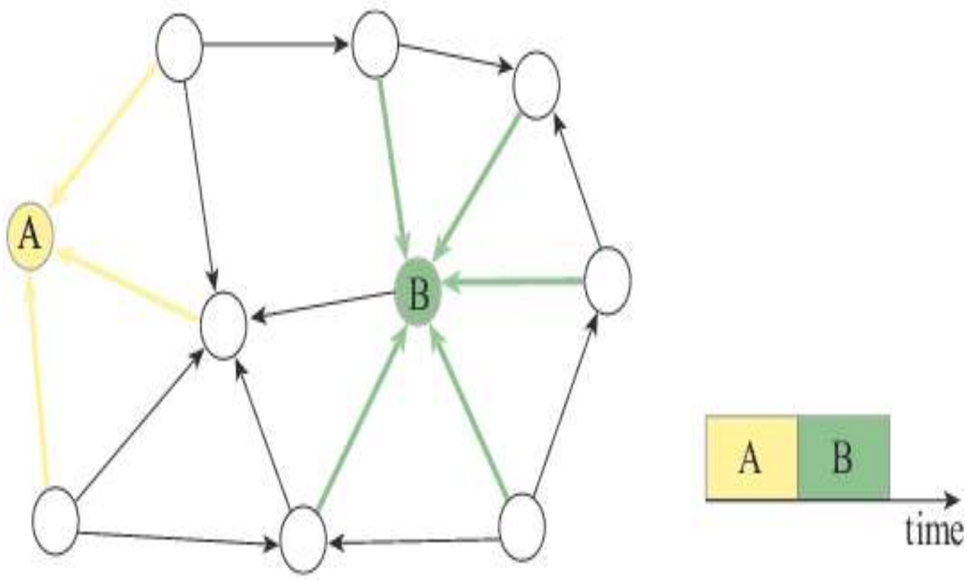

Figure: 3.1 Multi User Detectors

Our optimization model considers thoroughly all possible NC and MPR opportunities in the network. We consider all feasible NC models in which the coding node is allowed to encode up to 4 packets. The analysis is applicable to any given MWN topology with any pattern of concurrent traffic flows; further, it is valid both with and without opportunistic listening. Note that SIC indirectly improves the performance of NC by allowing the routing of the flows to be closer to each other, which results in an increase in number of NC opportunities in the network. This benefit of SIC comes from allowing MPR and itigating the interference in the network.

Problem

- The problem of estimating signal energies during a training period has been dealt with in. It remains to be seen what performance gains can be achieved with the multistage receiver over the conventional demodulator.
- The near-far problem is therefore alleviated. The conventional receiver on the other hand, degrades due to a strong interfering signal.
- Service providers are dependent on the broadband services which are beyond their control. So, trouble shooting may become an issue.

4. PROPOSED SYSTEM

Cross-layer Optimization Framework

This Project are now ready to formulate the cross-layer optimization problem that will determine the optimal delay in TDMA-based MWNs, which employ both NC and SIC techniques. This optimization will determine the TDMA schedule that minimizes the average packet delay in the network that jointly applies NC and SIC techniques where schedule will determine active set of ISs and their slot assignment in the frame. We note that the solution does not include all the ISs and therefore not all the broadcast links. If a broadcast link is not included in any IS then related coding structures are not being utilized. The coding elements at a node may be encoded into different coding structures. Thus from the available choices optimal solution will choose to activate those broadcast links and consequently those coding structures that result in minimum packet delay. We note that in practice each broadcast link may have either a virtual or real queue. In the virtual queue approach, all the incoming packets may be stored in a global queue.

If during a slot a broadcast link will be served according to the schedule, then if possible a coded packet of that link is encoded from the packets in the global queue and then transmitted. Thus the packets in the global queue to be served by the same broadcast link may be considered to form a virtual queue. In the real queue approach, a node maintains physically separate queue for each broadcast link. As explained in the previous section, a packet may participate in different coding structures each being served by its own broadcast link. Since the pricing model finds the ISs by minimizing the reduced cost at each trial, the primary ISs found by the pricing model has the most improvement on the RMP objective function, and this improvement gradually diminishes at the subsequent iterations. Thus, one may halt the PP when the reduced cost becomes close to zero. In this method, defining different conditions of termination on the objective function of PP may generate different minimum length schedules.

Rewards

- Power control is not flexible enough to cope with the evolving interference issue
- Does not provide high rates
- Then detect the best of the signals and continue until all signals are detected

5. SYSTEM MODULE

- **Signal to-Interference-Plus-Noise Ratio (SINR) Model**
- **Throughput-Optimal Scheduling**
- **Distributed Resource Allocation**

Signal to-Interference-Plus-Noise Ratio (SINR) Model

At the physical layer, under the classical SINR model, a receiving node treats all the other concurrent (unintended) interfering transmissions as noise when deciding whether or not the underlying intended transmission is successful. This is not a trivial problem as the set of interfering transmissions is usually coupled with upper layer scheduling and routing algorithms. In the context of SIC, not only one needs to deal with such coupling with upper layer algorithms, one also has to deal with multiple transmissions, in the sense that one has to decode those stronger signals before decoding its own signal (in a sequential order). This sequential decoding imposes significant difficulty in developing a tractable model for mathematical programming.

Throughput-Optimal Scheduling

At the link layer, a scheduling algorithm (i.e., interference avoidance scheme) is needed to address the limitations of SIC at the physical layer. Note that such scheduling algorithm is also coupled with routing in a multi-hop network environment. How to design an optimal scheduling algorithm to fulfill certain network performance objective in this context is a new and non-trivial problem. In general terms, throughput is the maximum rate of production or the maximum rate at which something can be processed. When used in the context of communication networks, such as Ethernet or packet radio, throughput or network throughput is the rate of *successful* message delivery over a communication channel. The data these messages belong to may be delivered over a physical or logical link or it can pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second (p/s or pps) or data packets per time slot.

The throughput of a communication system may be affected by various factors, including the limitations of underlying analog physical medium, available processing power of the system components, and end-user behavior.

Distributed Resource Allocation

It develop a distributed resource allocation scheme with the two-stage queuing structure and a novel three-way handshake, and show that the proposed distributed link scheduling scheme still achieves the optimal throughput.

6. CONCLUSION

The previous work on NC only studies maximization of the throughput without giving consideration to the average packet delay in the network, which is an important performance measure. In this work, we have presented a performance modeling that minimizes the average packet delay of MWNs based on modeling of a node as an M/G/1 queueing system with exponentially distributed packet lengths. The theoretical framework provides a systematic method to take full advantage of benefits associated with NC, and is applicable to any given network topology with any pattern of concurrent traffic flows. We compared the performance of NC both with and without opportunistic listening, and showed that NC reduces the average packet delay in the network; more importantly, NC extends the stable operating region of the network. The strength of this model comes from its handling of variable length packets and no need of tight synchronization in the network. On the other hand, it has weakness of giving service to nodes interfering with each other in random order.

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