Performance Analysis of Channel-aware Multichannel CSMA in Wireless Networks

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Abstract—Need arises to increase the network throughput by broadening the bandwidth. One effectively approaches are multichannel technique in which multiple separate frequency channels are used for communications. In this paper we describe a channel-aware multichannel random access based on non-persistent CSMA scheme, where each user only has knowledge of its own channel gain. Through the theoretical model and simulation results, we confirm that the proposed algorithm can mitigate traffic congestion and has the advantage of giving high network throughput and delay performance.

Keywords-multichannel random access; channel-aware; Markov channel model; non-persistent CSMA; throughput; delay

I. INTRODUCTION

In wireless communication networks, Medium Access Control (MAC) schemes are used to control the access of active nodes to a shared channel. As the throughput of the MAC schemes may significantly affect the overall performance, some researchers proposed to split, either in time or in frequency, the single shared channel to multiple. It has been shown that using multiple channels instead of a single channel can improve throughput greatly [1], [2]. For a long time, random access has been a popular approach for medium access control. Local area networks (LANs) and wireless local area networks (WLANs) use carrier-sensing multiple access with collision detection (CSMA/CD) and with collision avoidance (CSMA/CA) protocols, respectively. Essentially, there are two variants of CSMA: p-persistent CSMA scheme and non-persistent. In this paper, we will focus on non-persistent CSMA.

Both variants of CSMA have been extensively studied over the past there decades. Throughput and delay characteristics were derived for slotted and unslotted channels, under finite and infinite population models [3], [4]. While much research has been devoted to the CSMA in single-channel environments, our work focuses on the multichannel CSMA like in [5], in which the multichannel CSMA is analytically compared with the channel-banding approach. Several MAC protocols have been proposed for multichannel transmission in wireless network [6]-[8]. But these papers are not considered influence of the channel gains.

In this paper, we consider a variation of the CSMA protocol, channel-aware multicahnnel CSMA. We consider an uplink model where a group of users are all communicating to a single receiver, such as an access point in a wireless LAN or a base station in a cellular setting. We assume each user only has knowledge of its own fading level, but no knowledge of the fading levels of the other users in the cell. Users access the uplink using a simple variation of the CSMA random access protocol [3], which we call channel-aware CSMA. With this protocol, users randomly transmit with a transmission probability that is based on their channel gain. Thus in this paper, focusing on this performance tradeoff, we first have a theoretical analysis on the throughput and delay performances of the channel-aware multichannel CSMA, and then have a simulation to confirm our analysis. Our contribution is to introduce the CSI to access process. And we establish theoretical model to predigest the MAC process and analytical measure by considering the fading channel as Markov model.

We organize the remainder of this paper as follows. Section II illustrates channel-aware multichannel CSMA techniques and the Markov channel model. In Section III, we have a theoretical analysis about channel-aware multichannel non-persistent CSMA. In section IV we use simulation to evaluate the performances and compare the simulation and theoretical results. Section V conclusions this paper.

II. SYSTEM MODEL

A. Channel Model

As a consequence of propagation effects, such as multipath and fading, wireless channel could be affected by correlated errors which can be easily described by means of Markov models [9]. As illustrated in Fig. 1, in the Markov model, the channel alternates between Good state and Bad state. It is assumed that the channel state processes remain in the same state within a slot.

The simpler Markov model used to characterize correlated errors is the first-order two-state Markov model, giving a representation of the error process at the packet level. If we denote with 0 and 1 the successful and erroneous transmission of a packet, respectively, the transition matrix for error process is:

$$P = \begin{Bmatrix} P_{00} & P_{01} \\ P_{10} & P_{11} \end{Bmatrix} \qquad (1)$$

Performance Analysis Of Multichannel And Multi Traffic On Wireless Communication Networks

Karin Nielsen-Saines

Performance Analysis Of Multichannel And Multi Traffic On Wireless Communication Networks:

Performance Analysis of Multi-Channel and Multi-Traffic on Wireless Communication Networks Wuyi Yue,Yutaka Matsumoto,2002-02-28 This book attempts to present exact and approximate analytical solution methods and techniques using queueing theory in the complex multimedia traffic systems with procedures of random multiple access schemes In particular this book presents how to approximate the system performance of discrete time multimedia networks the probability distribution of the interarrival time of internetwork packets at the adjacent network and the higher moments of the transmission departure distribution and delay in wireless multimedia communication environment In general the modeling of discrete time multimedia communication systems are more complex than that of continuous time systems because multiple state changes can occur from one time unit to the next This complicates the analysis of the model This book also discusses numerical results that illustrate the applications of the theory and various properties **Performance Analysis of Multi-Channel and Multi-Traffic on Wireless Communication Networks** Wuyi Yue,Yutaka Matsumoto,2007-05-08 With the rapidly increasing penetration of laptop computers and mobile phones which are primarily used by mobile users to access Internet s vices like e mail and World Wide Web WWW access support of Internet services in a mobile environment is an emerging requirement Wireless n works have been used for communication among fully distributed users in a multimedia environment that has the needs to provide real time bursty traffic such as voice or video and data traffic with excellent reliability and service quality To satisfy the huge wireless multimedia service demand and improve the system performance efficient channel access methods and analytical methods must be provided In this way very accurate models that faithfully reproduce the stochastic behavior of multimedia wireless communication and computer networks can be constructed Most of these system models are discrete time queueing systems Queueing networks and Markov chains are commonly used for the p formance and reliability evaluation of computer communication and m ufacturing systems Although there are quite a few books on the individual topics of queueing networks and Markov chains we have found none that covers the topics of discrete time and continuous time multichannel mul traffic queueing networks On the other hand the design and development of multichannel mul hop network systems and interconnected network systems or integrated n works of multimedia traffic require not only such average performance m sures as the throughput or packet delay but also higher moments of traffic departures and transmission delay **Performance Analysis of Multi-Channel and Multi-Traffic on Wireless Communication Networks** Wuyi Yue,Yutaka Matsumoto,2014-01-15 *Resource Management and Performance Analysis of Wireless Communication Networks* Shunfu Jin,Wuyi Yue,2021-03-15 With the diversification of Internet services and the increase in mobile users efficient management of network resources has become an extremely important issue in the field of wireless communication networks WCNs Adaptive resource management is an effective tool for improving the economic efficiency of WCN systems as well as network design and construction especially in view of the surge in mobile

device demands This book presents modelling methods based on queueing theory and Markov processes for a wide variety of WCN systems as well as precise and approximate analytical solution methods for the numerical evaluation of the system performance This is the first book to provide an overview of the numerical analyses that can be gleaned by applying queueing theory traffic theory and other analytical methods to various WCN systems It also discusses the recent advances in the resource management of WCNs such as broadband wireless access networks cognitive radio networks and green cloud computing It assumes a basic understanding of computer networks and queueing theory and familiarity with stochastic processes is also recommended The analysis methods presented in this book are useful for first year graduate or senior computer science and communication engineering students Providing information on network design and management performance evaluation queueing theory game theory intelligent optimization and operations research for researchers and engineers the book is also a valuable reference resource for students analysts managers and anyone in the industry interested in WCN system modelling performance analysis and numerical evaluation **Cellular Networks** Agassi Melikov,2011-04-26 Wireless cellular networks are an integral part of modern telecommunication systems Today it is hard to imagine our life without the use of such networks Nevertheless the development implementation and operation of these networks require engineers and scientists to address a number of interrelated problems Among them are the problem of choosing the proper geometric shape and dimensions of cells based on geographical location finding the optimal location of cell base station selection the scheme dividing the total net bandwidth between its cells organization of the handover of a call between cells information security and network reliability and many others The book focuses on three types of problems from the above list Positioning Performance Analysis and Reliability It contains three sections The Section 1 is devoted to problems of Positioning and contains five chapters The Section 2 contains eight Chapters which are devoted to quality of service QoS metrics analysis of wireless cellular networks The Section 3 contains two Chapters and deal with reliability issues of wireless cellular networks The book will be useful to researches in academia and industry and also to post gradute students in telecommunication specialitiies **Networking -- ICN 2005** Pascal Lorenz,2005-04 The two volume set LNCS 3420 3421 constitutes the refereed proceedings of the 4th International Conference on Networking ICN 2005 held in Reunion Island France in April 2005 The 238 revised full papers presented were carefully reviewed and selected from 651 submissions The papers are organized in topical sections on grid computing optical networks wireless networks QoS WPAN sensor networks traffic control communication architectures audio and video communications differentiated services switching streaming MIMO MPLS ad hoc networks TCP routing signal processing mobility performance peer to peer networks network security CDMA network anomaly detection multicast 802 11 networks and emergency disaster and resiliency Multidimensional Queueing Models in Telecommunication Networks Agassi Melikov,Leonid Ponomarenko,2014-08-09 The increasing complexity of telecommunication networks requires us to develop adequate

mathematical models We must find their characteristics optimize them subject to chosen criteria and develop the corresponding control algorithms Multidimensional queueing models are used to design and optimize modern and next generation networks NGN The central problem of the related mathematical theory is to apply multidimensional and large size queueing models to improve efficiency In this book new methods are successively developed and applied to solve related problems The book is recommended for researchers engaged with the mathematical theory of telecommunications traffic

Computational Science - ICCS 2007 Yong Shi,2007-05-18 Part of a four volume set this book constitutes the refereed proceedings of the 7th International Conference on Computational Science ICCS 2007 held in Beijing China in May 2007 The papers cover a large volume of topics in computational science and related areas from multiscale physics to wireless networks and from graph theory to tools for program development **Resource Allocation in Next Generation Wireless Networks** Wayne Li,Yi Pan,2006 Next generation wireless and mobile communication systems are rapidly evolving to satisfy the demands of various network users Due to the great success and enormous impact of IP networks high speed transmission is now possible for both indoor and outdoor wireless systems internet access and web browsing have become the ruling paradigm for next generation system It is envisioned that new generation wireless networks and hand held terminals will support a wide variety of multimedia services such as multimedia web browsing video and news on demand mobile office system stock market information and so on to mobile users anywhere anytime in an uninterrupted and seamless way with low powered handsets The characteristics of wireless links as well as the desire to maintain connectivity while on the move offer significant challenges to provisioning quality of service and the related performance is of central interest Since the resources such as time frequency and code in the wireless segments of such networks are very limited over dimensioning the network resource is equivalent to poor capital investment while congestion at busy hours could mean lost calls and lost revenues It is therefore critical for wireless network designers to utilise these resources efficiently and effectively In response to the above demand for next generation wireless and mobile communication systems this book aims at providing a timely and concise reference of the current activities and findings in the relevant technical fields The primary goal is to address the key technical issues pertaining to the integrated new systems and present novel technical contributions The book contains 14 invited chapters from prominent researchers working in this area around the world **High Performance Computing - HiPC 2000** Mateo Valero,Viktor K. Prasanna,Sriram Vajapeyam,2003-06-29 This book constitutes the refereed proceedings of the 7th International Conference on High Performance Computing HiPC 2000 held in Bangalore India in December 2000 The 46 revised papers presented together with five invited contributions were carefully reviewed and selected from a total of 127 submissions The papers are organized in topical sections on system software algorithms high performance middleware applications cluster computing architecture applied parallel processing networks wireless and mobile communication systems and large scale data mining **Advances in Queueing Theory and Network Applications** Wuyi Yue,Yutaka

Takahashi,Hideaki Takagi,2009-05-17 Advances in Queueing Theory and Network Applications presents several useful mathematical analyses in queueing theory and mathematical models of key technologies in wired and wireless communication networks such as channel access controls Internet applications topology construction energy saving schemes and transmission scheduling In sixteen high quality chapters this work provides novel ideas new analytical models and simulation and experimental results by experts in the field of queueing theory and network applications The text serves as a state of the art reference for a wide range of researchers and engineers engaged in the fields of queueing theory and network applications and can also serve as supplemental material for advanced courses in operations research queueing theory performance analysis traffic theory as well as theoretical design and management of communication networks

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Wireless Communication with Artificial Intelligence Anuj Singal,Sandeep Kumar,Sajjan Singh,Ashish Kr. Luhach,2022-09-16 This reference text discusses advances in wireless communication design challenges and future research directions to design reliable wireless communication The text discusses emerging technologies including wireless sensor networks Internet of Things IoT cloud computing mm Wave Massive MIMO cognitive radios CR visible light communication VLC wireless optical communication signal processing and channel modeling The text covers artificial intelligence based applications in wireless communication machine learning techniques and challenges in wireless sensor networks and deep learning for channel and bandwidth estimation during optical wireless communication The text will be useful for senior undergraduate graduate students and professionals in the fields of electrical engineering and electronics and communication engineering   **Proceedings & Exhibition--future Access** ,2005   *High Performance Computing* ,2000   Modeling and Analysis of Voice and Data in Cognitive Radio Networks Subodha Gunawardena,Weihua Zhuang,2014-03-14 This Springer Brief investigates the voice and elastic interactive data service support over cognitive radio networks CRNs in terms of their delay requirements The increased demand for wireless communication conflicts with the scarcity of the radio spectrum but CRNS allow for more efficient use of the networks The authors review packet level delay requirements of the voice service and session level delay requirements of the elastic interactive data services particularly constant rate and on off voice traffic capacities in CRNs with centralized and distributed network coordination Some generic channel access schemes are considered as the coordination mechanism and call admission control algorithms are developed for non fully connected CRNs Other key topics include the advantages of supporting voice traffic flows with different delay requirements the mean

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