Embracing Interference in Wireless Systems

Shyamnath Gollakota

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Michael J. Halvorson

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Embracing Interference in Wireless Systems Shyamnath Gollakota,2014-06-01 The wireless medium is a shared resource If nearby devices transmit at the same time their signals interfere resulting in a collision In traditional networks collisions cause the loss of the transmitted information For this reason wireless networks have been designed with the assumption that interference is intrinsically harmful and must be avoided This book a revised version of the author s award winning Ph D dissertation takes an alternate approach Instead of viewing interference as an inherently counterproductive phenomenon that should to be avoided we design practical systems that transform interference into a harmless and even a beneficial phenomenon To achieve this goal we consider how wireless signals interact when they interfere and use this understanding in our system designs Specifically when interference occurs the signals get mixed on the wireless medium By understanding the parameters of this mixing we can invert the mixing and decode the interfered packets thus making interference harmless Furthermore we can control this mixing process to create strategic interference that allow decodability at a particular receiver of interest but prevent decodability at unintended receivers and adversaries Hence we can transform interference into a beneficial phenomenon that provides security Building on this approach we make four main contributions We present the first WiFi receiver that can successfully reconstruct the transmitted information in the presence of packet collisions Next we introduce a WiFi receiver design that can decode in the presence of high power cross technology interference from devices like baby monitors cordless phones microwave ovens or even unknown technologies We then show how we can harness interference to improve security In particular we develop the first system that secures an insecure medical implant without any modification to the implant itself Finally we present a solution that establishes secure connections between any two WiFi devices without having users enter passwords or use pre shared secret keys **Embracing Interference in Wireless Systems** Shyamnath Venkata Satyasrisai Gollakota,2012 The wireless medium is a shared resource If nearby devices transmit at the same time their signals interfere resulting in a collision In traditional networks collisions cause the loss of the transmitted information For this reason wireless networks have been designed with the assumption that interference is intrinsically harmful and must be avoided This dissertation takes an alternate approach Instead of viewing interference as an inherently counterproductive phenomenon that should to be avoided we design practical systems that transform interference into a harmless and even a beneficial phenomenon To achieve this goal we consider how wireless signals interact when they interfere and use this understanding in our system designs Specifically when interference occurs the signals get mixed on the wireless medium By understanding the parameters of this mixing we can invert the mixing and decode the interfered packets thus making interference harmless Furthermore we can control this mixing process to create strategic interference that allow decodability at a particular receiver of interest but prevent decodability at unintended receivers and adversaries Hence we can transform interference into a beneficial phenomenon that provides security Building

on this approach we make four main contributions We present the first WiFi receiver that can successfully reconstruct the transmitted information in the presence of packet collisions Next we introduce a WiFi receiver design that can decode in the presence of high power cross technology interference from devices like baby monitors cordless phones microwave ovens or even unknown technologies We then show how we can harness interference to improve security In particular we develop the first system that secures an insecure medical implant without any modification to the implant itself Finally we present a solution that establishes secure connections between any two WiFi devices without having users enter passwords or use pre shared secret keys   Shared-Memory Parallelism Can be Simple, Fast, and Scalable Julian Shun,2017-06-01 Parallelism is the key to achieving high performance in computing However writing efficient and scalable parallel programs is notoriously difficult and often requires significant expertise To address this challenge it is crucial to provide programmers with high level tools to enable them to develop solutions easily and at the same time emphasize the theoretical and practical aspects of algorithm design to allow the solutions developed to run efficiently under many different settings This thesis addresses this challenge using a three pronged approach consisting of the design of shared memory programming techniques frameworks and algorithms for important problems in computing The thesis provides evidence that with appropriate programming techniques frameworks and algorithms shared memory programs can be simple fast and scalable both in theory and in practice The results developed in this thesis serve to ease the transition into the multicore era The first part of this thesis introduces tools and techniques for deterministic parallel programming including means for encapsulating nondeterminism via powerful commutative building blocks as well as a novel framework for executing sequential iterative loops in parallel which lead to deterministic parallel algorithms that are efficient both in theory and in practice The second part of this thesis introduces Ligra the first high level shared memory framework for parallel graph traversal algorithms The framework allows programmers to express graph traversal algorithms using very short and concise code delivers performance competitive with that of highly optimized code and is up to orders of magnitude faster than existing systems designed for distributed memory This part of the thesis also introduces Ligra which extends Ligra with graph compression techniques to reduce space usage and improve parallel performance at the same time and is also the first graph processing system to support in memory graph compression The third and fourth parts of this thesis bridge the gap between theory and practice in parallel algorithm design by introducing the first algorithms for a variety of important problems on graphs and strings that are efficient both in theory and in practice For example the thesis develops the first linear work and polylogarithmic depth algorithms for suffix tree construction and graph connectivity that are also practical as well as a work efficient polylogarithmic depth and cache efficient shared memory algorithm for triangle computations that achieves a 2 5x speedup over the best existing algorithms on 40 cores This is a revised version of the thesis that won the 2015 ACM Doctoral Dissertation Award   An Architecture for Fast and General Data Processing on Large Clusters Matei Zaharia,2016-05-01 The past few years have seen a major

change in computing systems as growing data volumes and stalling processor speeds require more and more applications to scale out to clusters Today a myriad data sources from the Internet to business operations to scientific instruments produce large and valuable data streams However the processing capabilities of single machines have not kept up with the size of data As a result organizations increasingly need to scale out their computations over clusters At the same time the speed and sophistication required of data processing have grown In addition to simple queries complex algorithms like machine learning and graph analysis are becoming common And in addition to batch processing streaming analysis of real time data is required to let organizations take timely action Future computing platforms will need to not only scale out traditional workloads but support these new applications too This book a revised version of the 2014 ACM Dissertation Award winning dissertation proposes an architecture for cluster computing systems that can tackle emerging data processing workloads at scale Whereas early cluster computing systems like MapReduce handled batch processing our architecture also enables streaming and interactive queries while keeping MapReduce s scalability and fault tolerance And whereas most deployed systems only support simple one pass computations e g SQL queries ours also extends to the multi pass algorithms required for complex analytics like machine learning Finally unlike the specialized systems proposed for some of these workloads our architecture allows these computations to be combined enabling rich new applications that intermix for example streaming and batch processing We achieve these results through a simple extension to MapReduce that adds primitives for data sharing called Resilient Distributed Datasets RDDs We show that this is enough to capture a wide range of workloads We implement RDDs in the open source Spark system which we evaluate using synthetic and real workloads Spark matches or exceeds the performance of specialized systems in many domains while offering stronger fault tolerance properties and allowing these workloads to be combined Finally we examine the generality of RDDs from both a theoretical modeling perspective and a systems perspective This version of the dissertation makes corrections throughout the text and adds a new section on the evolution of Apache Spark in industry since 2014 In addition editing formatting and links for the references have been added   *On Monotonicity Testing and the 2-to-2 Games Conjecture* Dor Minzer,2022-12-06 This book discusses two questions in Complexity Theory the Monotonicity Testing problem and the 2 to 2 Games Conjecture Monotonicity testing is a problem from the field of property testing first considered by Goldreich et al in 2000 The input of the algorithm is a function and the goal is to design a tester that makes as few queries to the function as possible accepts monotone functions and rejects far from monotone functions with a probability close to 1 The first result of this book is an essentially optimal algorithm for this problem The analysis of the algorithm heavily relies on a novel directed and robust analogue of a Boolean isoperimetric inequality of Talagrand from 1993 The probabilistically checkable proofs PCP theorem is one of the cornerstones of modern theoretical computer science One area in which PCPs are essential is the area of hardness of approximation Therein the goal is to prove that some optimization problems are hard to solve even approximately Many

hardness of approximation results were proved using the PCP theorem however for some problems optimal results were not obtained This book touches on some of these problems and in particular the 2 to 2 games problem and the vertex cover problem The second result of this book is a proof of the 2 to 2 games conjecture with imperfect completeness which implies new hardness of approximation results for problems such as vertex cover and independent set It also serves as strong evidence towards the unique games conjecture a notorious related open problem in theoretical computer science At the core of the proof is a characterization of small sets of vertices in Grassmann graphs whose edge expansion is bounded away from 1   *Heterogeneous Computing* Mohamed Zahran,2019-05-29 If you look around you will find that all computer systems from your portable devices to the strongest supercomputers are heterogeneous in nature The most obvious heterogeneity is the existence of computing nodes of different capabilities e g multicore GPUs FPGAs But there are also other heterogeneity factors that exist in computing systems like the memory system components interconnection etc The main reason for these different types of heterogeneity is to have good performance with power efficiency Heterogeneous computing results in both challenges and opportunities This book discusses both It shows that we need to deal with these challenges at all levels of the computing stack from algorithms all the way to process technology We discuss the topic of heterogeneous computing from different angles hardware challenges current hardware state of the art software issues how to make the best use of the current heterogeneous systems and what lies ahead The aim of this book is to introduce the big picture of heterogeneous computing Whether you are a hardware designer or a software developer you need to know how the pieces of the puzzle fit together The main goal is to bring researchers and engineers to the forefront of the research frontier in the new era that started a few years ago and is expected to continue for decades We believe that academics researchers practitioners and students will benefit from this book and will be prepared to tackle the big wave of heterogeneous computing that is here to stay   **Computational Prediction of Protein Complexes from Protein Interaction Networks** Sriganesh Srihari,Chern Han Yong,Limsoon Wong,2017-05-30 Complexes of physically interacting proteins constitute fundamental functional units that drive almost all biological processes within cells A faithful reconstruction of the entire set of protein complexes the complexosome is therefore important not only to understand the composition of complexes but also the higher level functional organization within cells Advances over the last several years particularly through the use of high throughput proteomics techniques have made it possible to map substantial fractions of protein interactions the interactomes from model organisms including Arabidopsis thaliana a flowering plant Caenorhabditis elegans a nematode Drosophila melanogaster fruit fly and Saccharomyces cerevisiae budding yeast These interaction datasets have enabled systematic inquiry into the identification and study of protein complexes from organisms Computational methods have played a significant role in this context by contributing accurate efficient and exhaustive ways to analyze the enormous amounts of data These methods have helped to compensate for some of the limitations in experimental datasets including the presence of biological and technical

noise and the relative paucity of credible interactions In this book we systematically walk through computational methods devised to date approximately between 2000 and 2016 for identifying protein complexes from the network of protein interactions the protein protein interaction PPI network We present a detailed taxonomy of these methods and comprehensively evaluate them for protein complex identification across a variety of scenarios including the absence of many true interactions and the presence of false positive interactions noise in PPI networks Based on this evaluation we highlight challenges faced by the methods for instance in identifying sparse sub or small complexes and in discerning overlapping complexes and reveal how a combination of strategies is necessary to accurately reconstruct the entire complexosome

Hardness of Approximation Between P and NP Aviad Rubinstein,2019-06-07 Nash equilibrium is the central solution concept in Game Theory Since Nash s original paper in 1951 it has found countless applications in modeling strategic behavior of traders in markets human drivers and electronic routers in congested networks nations in nuclear disarmament negotiations and more A decade ago the relevance of this solution concept was called into question by computer scientists who proved under appropriate complexity assumptions that computing a Nash equilibrium is an intractable problem And if centralized specially designed algorithms cannot find Nash equilibria why should we expect distributed selfish agents to converge to one The remaining hope was that at least approximate Nash equilibria can be efficiently computed Understanding whether there is an efficient algorithm for approximate Nash equilibrium has been the central open problem in this field for the past decade In this book we provide strong evidence that even finding an approximate Nash equilibrium is intractable We prove several intractability theorems for different settings two player games and many player games and models computational complexity query complexity and communication complexity In particular our main result is that under a plausible and natural complexity assumption Exponential Time Hypothesis for PPAD there is no polynomial time algorithm for finding an approximate Nash equilibrium in two player games The problem of approximate Nash equilibrium in a two player game poses a unique technical challenge it is a member of the class PPAD which captures the complexity of several fundamental total problems i e problems that always have a solution and it also admits a quasipolynomial time algorithm Either property alone is believed to place this problem far below NP hard problems in the complexity hierarchy having both simultaneously places it just above P at what can be called the frontier of intractability Indeed the tools we develop in this book to advance on this frontier are useful for proving hardness of approximation of several other important problems whose complexity lies between P and NP Brouwer s fixed point market equilibrium CourseMatch A CEEI densest k subgraph community detection VC dimension and Littlestone dimension and signaling in zero sum games   Verified Functional Programming in Agda Aaron Stump,2016-02-01 Agda is an advanced programming language based on Type Theory Agda s type system is expressive enough to support full functional verification of programs in two styles In external verification we write pure functional programs and then write proofs of properties about them The proofs are separate external artifacts

typically using structural induction In internal verification we specify properties of programs through rich types for the programs themselves This often necessitates including proofs inside code to show the type checker that the specified properties hold The power to prove properties of programs in these two styles is a profound addition to the practice of programming giving programmers the power to guarantee the absence of bugs and thus improve the quality of software more than previously possible Verified Functional Programming in Agda is the first book to provide a systematic exposition of external and internal verification in Agda suitable for undergraduate students of Computer Science No familiarity with functional programming or computer checked proofs is presupposed The book begins with an introduction to functional programming through familiar examples like booleans natural numbers and lists and techniques for external verification Internal verification is considered through the examples of vectors binary search trees and Braun trees More advanced material on type level computation explicit reasoning about termination and normalization by evaluation is also included The book also includes a medium sized case study on Huffman encoding and decoding   **Semantic Web for the Working Ontologist** James Hendler,Fabien Gandon,Dean Allemang,2020-08-03 Enterprises have made amazing advances by taking advantage of data about their business to provide predictions and understanding of their customers markets and products But as the world of business becomes more interconnected and global enterprise data is no long a monolith it is just a part of a vast web of data Managing data on a world wide scale is a key capability for any business today The Semantic Web treats data as a distributed resource on the scale of the World Wide Web and incorporates features to address the challenges of massive data distribution as part of its basic design The aim of the first two editions was to motivate the Semantic Web technology stack from end to end to describe not only what the Semantic Web standards are and how they work but also what their goals are and why they were designed as they are It tells a coherent story from beginning to end of how the standards work to manage a world wide distributed web of knowledge in a meaningful way The third edition builds on this foundation to bring Semantic Web practice to enterprise Fabien Gandon joins Dean Allemang and Jim Hendler bringing with him years of experience in global linked data to open up the story to a modern view of global linked data While the overall story is the same the examples have been brought up to date and applied in a modern setting where enterprise and global data come together as a living linked network of data Also included with the third edition all of the data sets and queries are available online for study and experimentation at data world swwo   **Code Nation** Michael J. Halvorson,2020-04-22 Code Nation explores the rise of software development as a social cultural and technical phenomenon in American history The movement germinated in government and university labs during the 1950s gained momentum through corporate and counterculture experiments in the 1960s and 1970s and became a broad based computer literacy movement in the 1980s As personal computing came to the fore learning to program was transformed by a groundswell of popular enthusiasm exciting new platforms and an array of commercial practices that have been further amplified by distributed computing and the

Internet The resulting society can be depicted as a Code Nation a globally connected world that is saturated with computer technology and enchanted by software and its creation Code Nation is a new history of personal computing that emphasizes the technical and business challenges that software developers faced when building applications for CP M MS DOS UNIX Microsoft Windows the Apple Macintosh and other emerging platforms It is a popular history of computing that explores the experiences of novice computer users tinkerers hackers and power users as well as the ideals and aspirations of leading computer scientists engineers educators and entrepreneurs Computer book and magazine publishers also played important if overlooked roles in the diffusion of new technical skills and this book highlights their creative work and influence Code Nation offers a behind the scenes look at application and operating system programming practices the diversity of historic computer languages the rise of user communities early attempts to market PC software and the origins of enterprise computing systems Code samples and over 80 historic photographs support the text The book concludes with an assessment of contemporary efforts to teach computational thinking to young people **Cross-layer Channel Allocation Algorithms for Wireless Ad Hoc Networks** Marzieh Veyseh,2011 *Exploiting Cross-technology Interference for Efficient Network Services in Wireless Systems* Ruogu Zhou,2014 **Interference in Mobile Wireless Systems** Asrar U. H. Sheikh,Michael Honig,1998 Communications in Interference Limited Networks Wolfgang Utschick,2016-02-04 This book offers means to handle interference as a central problem of operating wireless networks It investigates centralized and decentralized methods to avoid and handle interference as well as approaches that resolve interference constructively The latter type of approach tries to solve the joint detection and estimation problem of several data streams that share a common medium In fact an exciting insight into the operation of networks is that it may be beneficial in terms of an overall throughput to actively create and manage interference Thus when handled properly mixing of data in networks becomes a useful tool of operation rather than the nuisance as which it has been treated traditionally With the development of mobile robust ubiquitous reliable and instantaneous communication being a driving and enabling factor of an information centric economy the understanding mitigation and exploitation of interference in networks must be seen as a centrally important task *Interference in mobile wireless systems* Asrar U. H. Sheikh,1997 *Interference Avoidance for Wireless Systems* Dimitrie C. Popescu,2002 **Fading and Interference Mitigation in Wireless Communications** Stefan Panic,Mihajlo Stefanovic,Jelena Anastasov,Petar Spalevic,2013-12-11 Fading and Interference Mitigation in Wireless Communications will help readers stay up to date with recent developments in the performance analysis of space diversity reception over fading channels in the presence of cochannel interference It presents a unified method for computing the performance of digital communication systems characterized by a variety of modulation and detection types and channel models The book includes coverage of multichannel reception in various fading environments influence of cochannel interference and macrodiversity reception when channels are simultaneously affected by various types of fading and shadowing Full-Duplex Wireless

Communications Systems Tho Le-Ngoc,Ahmed Masmoudi,2017-07-02 This book introduces the development of self interference SI cancellation techniques for full duplex wireless communication systems The authors rely on estimation theory and signal processing to develop SI cancellation algorithms by generating an estimate of the received SI and subtracting it from the received signal The authors also cover two new SI cancellation methods using the new concept of active signal injection ASI for full duplex MIMO OFDM systems The ASI approach adds an appropriate cancelling signal to each transmitted signal such that the combined signals from transmit antennas attenuate the SI at the receive antennas The authors illustrate that the SI pre cancelling signal does not affect the data bearing signal This book is for researchers and professionals working in wireless communications and engineers willing to understand the challenges of deploying full duplex and practical solutions to implement a full duplex system Advanced level students in electrical engineering and computer science studying wireless communications will also find this book useful as a secondary textbook **Interference Avoidance Methods for Wireless Systems** Dimitrie Popescu,Christopher Rose,2014-01-15

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