

1983 Invited Address

Solved Problems, Unsolved Problems and Non-Problems in Concurrency

Leslie Lamport¹

This is an edited transcript of a talk given at last year's conference. To preserve the flavor of the talk and the questions, I have done very little editing—mostly eliminating superfluous words and phrases, correcting especially atrocious grammar, and making the obvious changes needed when replacing slides by figures. The tape recorder was not functioning for the first few minutes, so I had to recreate the beginning of the talk.

It's an honor to be invited to speak here at the second PODC conference. I'd like to think that it was because of my work, but I suspect that the real reason is that I tend to be controversial, saying all sorts of things that will offend people and live things up. To paraphrase Isaac Newton:

*If I have received more notice than other men,
it was by stepping on the toes of giants.*

Well, I'll try not to disappoint you.

What I'm going to present here are my own personal views. Needless to say, I don't expect most of you to agree with these views. Saying what is and is not a problem involves prediction—deciding just what will be regarded in the future as the real problems in concurrency. To show how successful I am, I'll just tell you that when Susan Owicki first described Pnueli's use of temporal logic—in a seminar she gave around the summer of '79 or '80—I knew immediately that it was formal nonsense that wasn't really good for anything.² So, with that piece of prognostication to vouch for my abilities as a fortune teller, I'll begin.

¹Work supported in part by the National Science Foundation under grant number MCS-8304455, and by the Army Research Office under grant number DAAAG29-83-K-0033.

²After the talk, I was told that some people didn't get the joke and thought I was insulting Pnueli. In fact, much of my recent research has been based upon Pnueli's work in temporal logic.

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Shared Variables	1965
Semaphores	1968
Monitors	1973
CSP	1978

Figure 1: The history of standard concurrency.

The first unsolved problem I want to talk about is the problem of developing a fundamental theory of concurrency. By a fundamental theory, I mean one that's not based upon arbitrary formal models or specific languages, but one that's really fundamental.

I recently heard a speaker use the phrase "standard concurrency". After listening to him for a while, it turned out that by "standard concurrency" he meant CSP.

Those who cannot remember the past are condemned to repeat it.

George Santayana

The history of standard concurrency is shown in Figure 1. When I started working in concurrency, standard concurrency meant semaphores. (Actually, conditional critical regions started challenging semaphores, but monitors became the standard before conditional critical regions had a chance.) Papers that claimed to be about synchronization were really about semaphores.

Well, synchronization isn't really semaphores, or monitors or CSP. Synchronization is something more fundamental. I don't mean to put down CSP. It's a fine language—or, more precisely, a fine set of communication constructs. Hoare deserved his Turing award. But, so did Dijkstra.

Some of you may think that was way back then, but now we really know what concurrency is all about, and we really know that CSP is the right way of doing things. For those of you who think that way, I'd like to remind you that while we theoreticians are busy studying CSP, people out there in the real world are building Ethernet. And CSP doesn't seem to me to be a very good model of Ethernet.

Anyway, what I really want to talk about is a fundamental theory of synchronization or concurrency. To give you an example of what it is that I would like to see, I'll talk about something that I do understand a little about—

Solved Problems Unsolved Problems And Non Problems In

**Milan Randic, Marjana Novic, Dejan
Plavsic**



Solved Problems Unsolved Problems And Non Problems In:

Solved and Unsolved Problems of Structural Chemistry Milan Randic, Marjana Novic, Dejan Plavsic, 2016-04-21

Solved and Unsolved Problems of Structural Chemistry introduces new methods and approaches for solving problems related to molecular structure. It includes numerous subjects such as aromaticity, one of the central themes of chemistry, and topics from bioinformatics such as graphical and numerical characterization of DNA proteins and proteomes. It also includes **Notes**

and Problems in Number Theory (Volume I) Taha Sochi, 2023-10-22. This book is the first volume of a collection of notes and solved problems about number theory. Like my previous books, maximum clarity was one of the main objectives and criteria in determining the style of writing, presenting and structuring the book, as well as selecting its contents. Modest mathematical background knowledge is required for understanding most of the contents of the book. In fact, the book in most parts requires no more than a college or secondary school level of general mathematics. So the intended readers of the book are primarily college or A level students, as well as junior undergraduate students, e.g. in mathematics or science or engineering. The book can be used as a text or as a reference for an introductory course on this subject and may also be used for general reading in mathematics. The book may also be adopted as a source of pedagogical materials which can supplement, for instance, tutorial sessions, e.g. in undergraduate courses on mathematics or science. **Theories of**

Scientific Progress John Losee, 2004-06-01. What is the nature of scientific progress and what makes it possible? When we look back at the scientific theories of the past and compare them to the state of science today, there seems little doubt that we have made progress. But is it a continuous process which gradually incorporates past successes into present theories, or are entrenched theories overthrown by superior competitors in a revolutionary manner? *Theories of Scientific Progress* is the ideal introduction to this topic. It is clearly organized with suggestions for further reading that point the way to both primary texts and secondary literature. It will be essential reading for students of the history and philosophy of science. **A**

Computational Perspective on Visual Attention John K. Tsotsos, 2021-06-22. The derivation, exposition and justification of the Selective Tuning model of vision and attention. Although William James declared in 1890, "Everyone knows what attention is," today there are many different and sometimes opposing views on the subject. This fragmented theoretical landscape may be because most of the theories and models of attention offer explanations in natural language or in a pictorial manner, rather than providing a quantitative and unambiguous statement of the theory. They focus on the manifestations of attention instead of its rationale. In this book, John Tsotsos develops a formal model of visual attention with the goal of providing a theoretical explanation for why humans and animals must have the capacity to attend. He takes a unique approach to the theory using the full breadth of the language of computation, rather than simply the language of mathematics as the formal means of description. The result, the Selective Tuning model of vision and attention, explains attentive behavior in humans and provides a foundation for building computer systems that see with human-like characteristics. The overarching conclusion is that

human vision is based on a general purpose processor that can be dynamically tuned to the task and the scene viewed on a moment by moment basis Tsotsos offers a comprehensive up to date overview of attention theories and models and a full description of the Selective Tuning model confining the formal elements to two chapters and two appendixes The text is accompanied by more than 100 illustrations in black and white and color additional color illustrations and movies are available on the book s Web site

Fundamental Problems and Solutions in Finance Zhiqiang Zhang,2023-04-27 This book provides innovative solutions to fundamental problems in finance such as the valuation of bond and equity the pricing of debt equity and total asset the determination of optimal capital structure etc which are unsolved or poorly solved so far The solutions in this book all have the following features Based on essential assumptions in line with reality the final solutions are analytical solutions with closed form models the forms and variables of the models are determined by strict and objective logic processes rather than chosen or presumed subjectively such as the new growth model for stock valuation the new CAPM accounting for total risk rather than only systematic risk the real solution to optimal capital structure based on the trade off between tax shield and bankruptcy cost In addition these basic solutions or models are adjusted easily to various application scenarios

EBOOK: Information Systems Development: Methods-in-Action FITZGERALD RUSS,2002-06-16

EBOOK Information Systems Development Methods in Action

Solving the Frame Problem Murray Shanahan,1997 In 1969 John McCarthy and Pat Hayes uncovered a problem that has haunted the field of artificial intelligence ever since the frame problem The problem arises when logic is used to describe the effects of actions and events Put simply it is the problem of representing what remains unchanged as a result of an action or event Many researchers in artificial intelligence believe that its solution is vital to the realization of the field s goals Solving the Frame Problem presents the various approaches to the frame problem that have been proposed over the years The author presents the material chronologically as an unfolding story rather than as a body of theory to be learned by rote There are lessons to be learned even from the dead ends researchers have pursued for they deepen our understanding of the issues surrounding the frame problem In the book s concluding chapters the author offers his own work on event calculus which he claims comes very close to a complete solution to the frame problem

Artificial Intelligence series

Convex Analysis and Variational Problems ,1976-01-01

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Doing Integrated History and Philosophy of Science: A Case Study of the Origin of Genetics Yafeng Shan,2020-08-17 This book offers an integrated historical and philosophical examination of the origin of genetics The author contends that an integrated HPS analysis helps us to have a better understanding of the history of genetics and sheds light on some general issues in the philosophy of science This book consists of three parts It begins with historical problems revisiting the significance of the work of Mendel de Vries and Weldon Then it turns to integrated HPS problems developing an exemplar based analysis of the development and the progress in early genetics Finally it discusses philosophical problems conceptual change evidence and theory choice Part I lays out a new historiography serving

as a basis for the discussions in part II and part III Part II introduces a new integrated HPS method to analyse and interpret the historiography in Part I and to re examine the philosophical issues in Part III Part III develops new philosophical accounts which will in turn make a better sense of the history of scientific practice more generally This book provides a practical defence of integrated HPS the best way to defend integrated HPS is to do it *Humor and Laughter, Playfulness and Cheerfulness: Upsides and Downsides to a Life of Lightness* Willibald Ruch, Tracey Platt, René T. Proyer, Hsueh-Chih Chen, 2019-08-12 The emergence of Positive Psychology has highlighted the importance of studying the good life and how to attain it Positive life outcomes such as well being thriving flourishing and happiness were discussed and investigated Among them different orientations to happiness were identified such as a life of pleasure life of meaning and life of engagement Other outcomes such as subjective and objective fulfillment in life or societal recognition have been less studied Among the characteristics that facilitate positive outcomes the VIA classification of strength and virtues distinguishes 24 strengths with humor playfulness being one of them Only a small segment of humor entered the definition of humor as character strengths namely the parts that contain some goodness Humor as a character strength facilitates a lot of positive outcomes such as positive emotions and positive relationships and there is a lightness accompanying humor playfulness The field is broader though and transcends the definition of humor as used in positive psychology in at least two ways First there is actually a family of overlapping but still distinct concepts with different research traditions We include next to humor and types of humor also laughter playfulness and cheerfulness We think that more research is needed on how they do overlap and what makes them distinct Second while positive psychology is interested in the goodness of we do want to stress that there is the need to study the non virtuous parts as well That is laughter may not only be expressing amusement but scorn directed at people humor may be benevolent but there is also sarcasm and playfulness may elicit positive emotions but also risk prone and immature types of behavior Therefore the aim of this Research Topic was to collect current perspectives on humor playfulness laughter and cheerfulness in both adults and children to study their full diversity but also interrelations and overlapping features to introduce new instruments or ways for their assessment in future studies and to study their causes and consequences in a variety of life domains We encouraged studies on differences due to gender or nationality the embodiment in different groups e g class clowns psychiatric patients or whether or not they can be trained We also welcomed contributions from adjacent disciplines e g education leisure studies or therapy counseling and different regions of the earth The outcome is a set of 33 manuscripts from altogether 101 authors Not all areas are covered and not all aims were met while we made progress there is much left to do In this sense the merging of these topics may be the first milestone but like every milestone it only marks the beginning of a long journey *Lost and Found* Ross W. Greene, 2016-03-28 Implement a more constructive approach to difficult students *Lost and Found* is a follow up to Dr Ross Greene s landmark works *The Explosive Child* and *Lost at School* providing educators with highly practical explicit guidance on implementing his

Collaborative Proactive Solutions CPS Problem Solving model with behaviorally challenging students While the first two books described Dr Greene s positive constructive approach and described implementation on a macro level this useful guide provides the details of hands on CPS implementation by those who interact with these children every day Readers will learn how to incorporate students input in understanding the factors making it difficult for them to meet expectations and in generating mutually satisfactory solutions Specific strategies sample dialogues and time tested advice help educators implement these techniques immediately The groundbreaking CPS approach has been a revelation for parents and educators of behaviorally challenging children This book gives educators the concrete guidance they need to immediately begin working more effectively with these students Implement CPS one on one or with an entire class Work collaboratively with students to solve problems Study sample dialogues of CPS in action Change the way difficult students are treated The discipline systems used in K 12 schools are obsolete and aren t working for the kids to whom they re most often applied those with behavioral challenges Lost and Found provides a roadmap to a different paradigm helping educators radically transform the way they go about helping their most challenging students Wonderful Solutions and Habitual Domains for Challenging Problems in Changeable Spaces Moussa Larbani,Po-Lung Yu,2016-08-24 This book introduces a new paradigm called Optimization in Changeable Spaces OCS as a useful tool for decision making and problem solving It illustrates how OCS incorporates searches and constructively restructures the parameters tangible and intangible involved in the process of decision making The book elaborates on OCS problems that can be modeled and solved effectively by using the concepts of competence set analysis Habitual Domain HD and the mental operators called the 7 8 9 principles of deep knowledge of HD In addition new concepts of covering and discovering processes are proposed and formulated as mathematical tools to solve OCS problems The book also includes reformulations of a number of illustrative real life challenging problems that cannot be solved by traditional optimization techniques into OCS problems and details how they can be addressed Beyond that it also includes perspectives related to innovation dynamics management artificial intelligence artificial and e economics scientific discovery and knowledge extraction This book will be of interest to managers of businesses and institutions policy makers and educators and students of decision making and behavior in DBA and or MBA **Encyclopaedia of Mathematics** M. Hazewinkel,2013-12-01 Encyclopedia of Creativity Mark A. Runco,Steven R. Pritzker,2020-04-12 Creativity influences each of our lives and is essential for the advancement of society The first edition of the successful Encyclopedia of Creativity helped establish the study of creativity as a field of research in itself The second edition published in 2011 was named a 2012 Outstanding Academic Title by the American Library Association s Choice publication Featuring 232 chapters across 2 volumes the third edition of this important work provides updated information on the full range of creativity research There has been an enormous increase in research on the topic throughout the world in many different disciplines Some areas covered in this edition include the arts and humanities business education mental and physical health neuroscience

psychology the creative process and technology Fundamental subjects are discussed such as the definition of creativity the development and expression of creativity across the lifespan the environmental conditions that encourage or discourage creativity the relationship of creativity to mental health intelligence and learning styles and the process of being creative Creativity is discussed within specific disciplines including acting architecture art dance film government interior design magic mathematics medicine photography science sports tourism and writing A wide range of topics are covered Here is a partial overview by topic Business and organizational creativity Advertising Creative Economies Creativity Consulting and Coaching Corporate Creativity Creativity Exercises Entrepreneurship Group Dynamics Innovation Leadership Management of Creative People Patents Teams and Training The Cognitive Aspects of Creativity Altered and Transitional States Analogies Attention Breadth of Attention Cognitive Style Divergent Thinking Flow and Optimal Experience Knowledge Logic and Reasoning Metacognition Mental Models Memory Metaphors Mind Wandering Mindfulness Problem Finding Problem Solving and Remote Associates The Creative Process Attribution Constraints Discovery Insight Inspiration Intentionality Motivation Risk Taking and Tolerance for Ambiguity Education Children s Creativity Education Intelligence Knowledge Metacognition Play Prodigies Programs And Courses Talent And Teaching Creativity Neuroscience Research Cellular Matter Grey Matter Cellular Density EEG Functional Magnetic Resonance Imaging Fmri Music and The Brain Pupillometry Systems The Cerebellum and Transcranial Electrical Stimulation Psychology The Big 5 Personality Characteristics Bipolar Mood Disorders Childhood Trauma Depression Deviance Dreams Emotions Expressive Arts Grit Introversion Jungian Theory Mad Genius Controversy Openness Schizotypy Suicide Therapy and Counseling Trauma and Transcendence and Transforming Illness and Visual Art Social Aspects of Creativity Awards Birth Order Criticism Consensual Assessment Diversity Eminence Families Friendships and Social Networks Geeks Mentors Millennials Networking Rewards And Sociology Society and Creativity Awards Climate For Creativity Cross Cultural Creativity Destruction Of Creativity Law And Society Social Psychology Social Transformation Voting War and Zeitgeist Technology Chats Computational Creativity Computerized Text Analysis Gaming Memes Networks and Maps and Virtual Reality

International Perspectives on Gender and Mathematics Education

Olof Steinthorsdottir, Helen J. Forgasz, Joanne Rossi Becker, Kyeonghwa Lee, 2010-06-01 Why a book on gender issues in mathematics in the 21st century Several factors have influenced the undertaking of this project by the editors First an international volume focusing on gender and mathematics has not appeared since publication of papers emerging from the 1996 International Congress on Mathematical Education Keitel 1998 Surely it was time for an updated look at this critical area of mathematics education Second we have had lively discussion and working groups on gender issues at conferences of the International Group for the Psychology of Mathematics Education PME for the past four years sessions at which stimulating and ground breaking research has been discussed by participants from many different countries Some publication seemed essential to share this new knowledge emerging from a wider variety of countries and from different

cultural perspectives Third some western countries such as Australia and the USA have experienced in recent years a focus on the boy problem with an underlying assumption that issues of females and mathematics have been solved and are no longer worthy of interest Thus it seemed timely to look more closely at the issue of gender and mathematics internationally When the idea for this volume first emerged invitations were issued to those regularly attending the working and discussion groups at PME Potential authors were charged to focus on gender issues in mathematics and were given wide scope to hone in on the issues that were central to their own research efforts or were in receipt or in need of close attention in their own national or regional contexts

Foundations of Knowledge Acquisition Alan L. Meyrowitz, Susan Chipman, 2007-08-19

One of the most intriguing questions about the new computer technology that has appeared over the past few decades is whether we humans will ever be able to make computers learn As is painfully obvious to even the most casual computer user most current computers do not Yet if we could devise learning techniques that enable computers to routinely improve their performance through experience the impact would be enormous The result would be an explosion of new computer applications that would suddenly become economically feasible e g personalized computer assistants that automatically tune themselves to the needs of individual users and a dramatic improvement in the quality of current computer applications e g imagine an airline scheduling program that improves its scheduling method based on analyzing past delays And while the potential economic impact of successful learning methods is sufficient reason to invest in research into machine learning there is a second significant reason studying machine learning helps us understand our own human learning abilities and disabilities leading to the possibility of improved methods in education While many open questions remain about the methods by which machines and humans might learn significant progress has been made

Graphs and Algorithms in

Communication Networks Arie Koster, Xavier Muñoz, 2009-12-01 Algorithmic discrete mathematics plays a key role in the development of information and communication technologies and methods that arise in computer science mathematics and operations research in particular in algorithms computational complexity distributed computing and optimization are vital to modern services such as mobile telephony online banking and VoIP This book examines communication networking from a mathematical viewpoint The contributing authors took part in the European COST action 293 a four year program of multidisciplinary research on this subject In this book they offer introductory overviews and state of the art assessments of current and future research in the fields of broadband optical wireless and ad hoc networks Particular topics of interest are design optimization robustness and energy consumption The book will be of interest to graduate students researchers and practitioners in the areas of networking theoretical computer science operations research distributed computing and mathematics

Status, Network, and Structure Jacek Szmataka, John Skvoretz, Joseph Berger, 1997 This book challenges

much that has been written about the decline of sociology as a vital essential area of inquiry into the human condition Against this Greek chorus of woe these papers show by example that sociology can make progress select significant problems

and cumulate an integrated and coherent set of findings and theoretical understandings Although the twenty papers in the book engage a wide variety of issues they are united by their adherence to one of the most active and successful traditions in sociology the group process tradition Group process research programs can examine tractable problems posed by social psychological phenomena for which sociology has the best methods of study they have the potential for a hardware based technological research front that discovers new phenomena and they come closest of all approaches in sociological research to using cognitive criteria in the choice of problems and to studying immutable phenomena The overall aim of the book is to provide models for researchers struggling to develop construct and integrate coherent sociological theory and knowledge The papers are grouped around three themes 1 the problem of theory construction in sociology including what is meant by theory and the methods of testing it particularly empirical testing 2 the extension and elaboration of existing theories of group processes notably in the study of status sentiment and the comparison process and 3 the theoretical issues at the intersection of social structures the pattern of connection in social networks and the process of rational choice

Problems in Applied Mathematics Murray S. Klamkin, 1990-01-01 A compilation of 380 of SIAM Review s most interesting problems dating back to the journal s inception in 1959

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