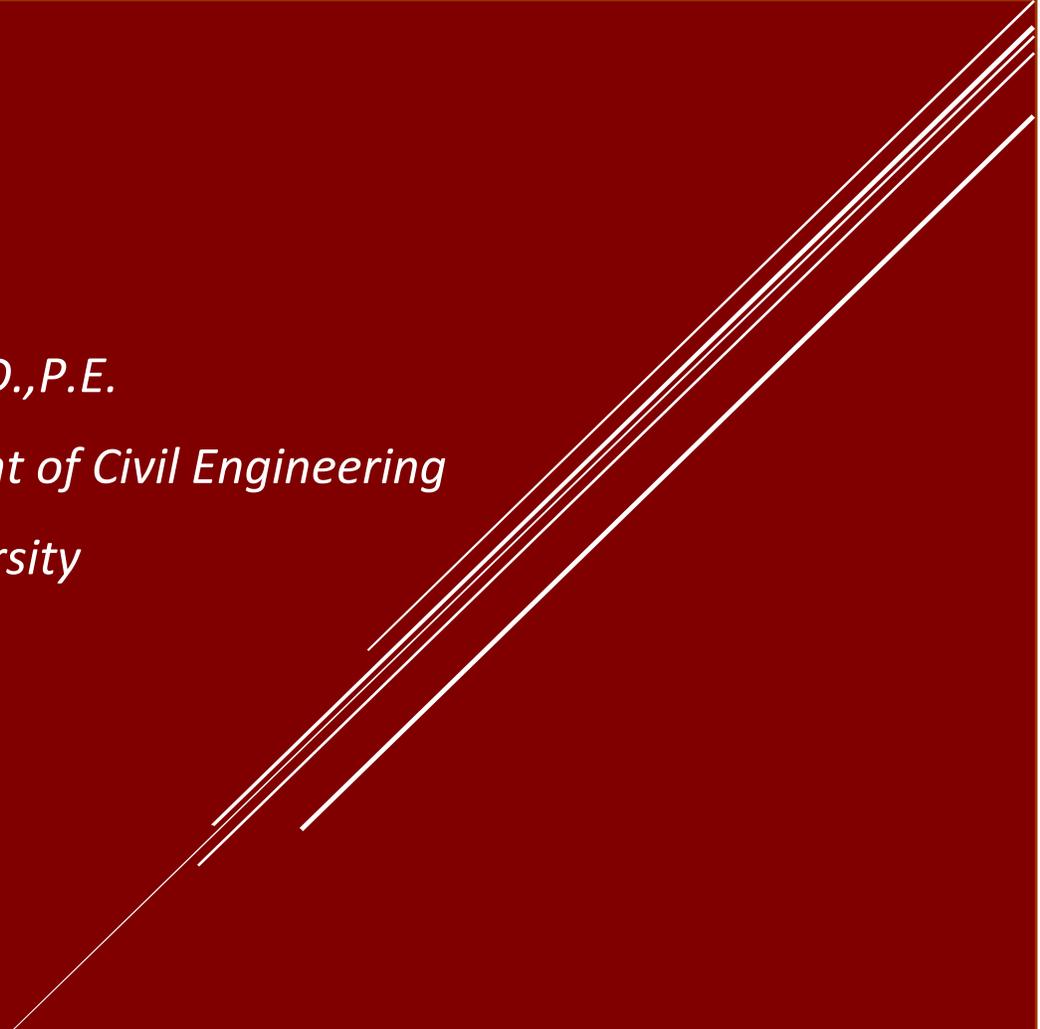


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Considerations in managing the fill rate of the Grand Ethiopian Renaissance Dam Reservoir using a system dynamics approach

Bruce Keith, David N Ford, and Radley Horton

The purpose of this study is to evaluate simulated fill rate scenarios for the Grand Ethiopian Renaissance Dam while taking into account plausible climate change outcomes for the Nile River Basin. The region lacks a comprehensive equitable water resource management strategy, which creates regional security concerns and future possible conflicts. We employ climate estimates from 33 general circulation models within a system dynamics model as a step in moving toward a feasible regional water resource management strategy. We find that annual reservoir fill rates of 8–15% are capable of building hydroelectric capacity in Ethiopia while concurrently ensuring a minimum level of stream flow disruption into Egypt before 2039. Insofar as climate change estimates suggest a modest average increase in stream flow into the Aswan, climate changes through 2039 are unlikely to affect the fill rate policies. However, larger fill rates will have a more detrimental effect on stream flow into the Aswan, particularly beyond a policy of 15%. While this study demonstrates that a technical solution for reservoir fill rates is feasible, the corresponding policy challenge is political. Implementation of water resource management strategies in the Nile River Basin specifically and Africa generally will necessitate a national and regional willingness to cooperate.

Keywords Nile River Basin, Grand Ethiopian Renaissance Dam, reservoir fill rates, system dynamics

Bruce Keith, DN Ford, and R. Horton (2017) “Considerations in managing the fill rate of the Grand Ethiopian Renaissance Dam Reservoir using a system dynamics approach” *Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*

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Sustainable campus improvement program design using energy efficiency and conservation

Vahid Faghihi Amir R. Hessami, David N. Ford

Reducing energy consumption is critical to improving campus sustainability. Both increased efficiency of built infrastructure and conservation by users can contribute. This work investigates feedback in the design of energy improvement programs that exploit both efficiency and conservation by developing a system dynamics model. The model formalizes the paid-from-savings approach and is validated using a sustainability program at a major university. Model simulations use five program designs, two forms of performance (energy savings and monetary savings), and capital requirements to test four hypotheses. This research indicated the existence of a trade-off space of program designs in which the preferred design will depend upon specific objectives. Other conclusions partially support improved performance with more investment and recommend the use of conservation to fund efficiency under capital constraints. A feedback analysis provides a richer explanation of the drivers of program success. The scientific contributions include an improved understanding of campus sustainability improvement program design, a formal dynamic model for program design, and an innovative staged design as an advanced solution to the dynamic challenges of designing campus sustainability improvement programs.

Keywords: Sustainable campus; Energy efficiency; Energy conservation; Built infrastructure; System dynamics; Paid from savings

Faghihi, Vahid, Hessami, A. and Ford, D.N. "Sustainable campus improvement program design using energy efficiency and conservation". *Journal of Cleaner Production*. in press (2014): published on line December, 2014.

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An Industry/Academia Partnership for Construction Project Control Education

Dr. David N. Ford and Michael R. Nosbisch

The effective and efficient education of construction project control engineers requires the integration of industry practice with academic theory. In 2008, AACE corporate sponsor, Parsons Corporation, and the Construction Engineering and Management Program at the Zachry Department of Civil Engineering, at Texas A&M University, partnered to develop a graduate level Engineering Project Control course. The course uses an actual Parsons project as the basis to bridge from construction project control theory to practice. Case studies repeatedly place student teams in realistic project control practice circumstances in which they apply a variety of project control tools and methods to the Parsons project. Post-case discussions transfer learning across teams and link practice and theory. The critical roles of deep understanding of an actual project, streamlined project information, and creating safe places for experimentation for learning have been revealed over four years of teaching the course. Future work can use other actual projects, develop computer based tools to accelerate project control learning, and develop similar approaches for practicing project controllers. This article was presented at the 2012 AACE International Annual Meeting in San Antonio as DEV.1072.

Key Words: Construction, education, project control, practice and theory

Ford, D.N and MR Nosbisch. "An Industry/Academia Partnership for Construction Project Control Education". *Cost Engineering*. March/April, 2013. pp. 34-39.

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The impact of public policy and societal risk perception on U.S. civilian nuclear power plant construction

Timothy TRB Taylor, TRB, David N. Ford, and Ken Reinschmidt

Due to the increasing demand for energy in the United States, the Nuclear Regulatory Commission is currently reviewing permit applications for 26 new nuclear power reactors. However, the previous generation of U.S. civilian nuclear plant construction experienced significant cost and schedule overruns. Previous research identified “regulatory ratcheting” (continuous, retroactive change in nuclear plant regulations) as one of the primary causes of this poor performance. Regulatory ratcheting was enabled by the nuclear industry’s two-step permitting and licensing process for civilian power plant construction (10 Code of Federal Regulations Part 50), which allowed society’s perception of the risks associated with nuclear plant operation to impact nuclear plant construction. How will public policy and societal risk perception affect the next generation of U.S. civilian nuclear plant construction? This question is investigated using a dynamic simulation model of the public policy and social feedback processes that impact U.S. nuclear plant construction. The research reveals that proposed strategies to address public policy and societal issues, such as a new nuclear regulatory process and smaller, less expensive reactors, may not prevent cost and schedule overruns on the planned next generation of nuclear plants. Results point to the critical role societal perceptions of nuclear power risk play in nuclear construction project success.

Keywords: public policy, nuclear power, risk management, dynamic models, system analysis, simulation models

Taylor, TRB., Ford, DN, Reinschmidt, K. “The impact of public policy and societal risk perception on U.S. civilian nuclear power plant construction”. *ASCE Journal of Construction Engineering and Management*. In press, 2012..

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Science, Engineering, and Technology in the Policy Process for Natural Systems Risk Mitigation

Timothy R. B. Taylor, David N. Ford, S. Yvon-Lewis, and Erik Lindquist

Increased societal risks due to the anthropogenic degradation of natural systems often require public policy action to mitigate. For example, increased skin cancer risks associated with anthropogenic stratospheric ozone depletion led to public policies limiting the emission of many ozone depleting substances. Natural-societal system interaction is complex and often requires expert knowledge and technology to develop effective societal risk mitigation policies. However, available knowledge and technology is not always successful in increasing policy maker attention to or understanding of these risks. The current work uses a system dynamics model of a feedback system that describes the stratospheric ozone depletion case to identify high leverage points for altering system behavior. Model analysis suggests that the rate at which policy makers' attention to depletion natural system risk is increased has a significant influence on the development of knowledge and technology to mitigate societal risks.

Keywords: public policy, technology, stratospheric ozone depletion, statistical screening, system dynamics

Taylor, TRB., Ford, D.N., Yvon-Lewis, S., and Lindquist, E. "Science, engineering, and technology in the policy process for mitigating natural-societal risk". *System Dynamics Review*. 27(2):173-194. April-June, 2011.

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Sequence and Timing of Three Community Interventions to Domestic Violence

Hovmand Peter S. and Ford David N.

Community responses to domestic violence typically involve the introduction of multiple interventions. Yet very little is known about the impact of the timing and sequencing of these interventions on community outcomes. A reason for this is the inherent limitations of traditional methods in social science. New methods are needed to understand the effect of varying the sequence and timing of interventions. This study responds to the issue by introducing system dynamics as a method for modeling community interventions. The paper presents a model of domestic violence cases moving through a criminal justice response, and uses the simulation model to evaluate the impact of implementing three interventions—mandatory arrest, victim advocacy, and changes in level of cooperation—on two system-level outcomes: improving offender accountability and increasing victim safety. Results illustrate the complex nature of these relationships. Implications for community practice and future research are also discussed.

Keywords: coordinated community response, domestic violence, system dynamics, victim advocacy, mandatory arrest

Hovmand, PS and Ford, D.N. "Sequence and Timing of Three Community Interventions to Domestic Violence" *American Journal of Community Psychology*. 44(1-2):261-72, September, 2009.

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Victims arrested for domestic violence: unintended consequences of arrest policies

Peter S. Hovmand, David N. Ford, Ingrid Flom, and Stavroula Kyriakakis

Domestic violence is a major social problem. In the United States, the failure of communities and police departments to intervene resulted in a push to implement pro and mandatory arrest policies for domestic violence. These policies have led to an unexpected increase in the number of victim arrests. Competing explanations have been offered. This paper describes the development of a system dynamics model of victim arrests. Results of model structure analysis suggest that these policies may have created or strengthened a crossover mechanism that shifts the risk of arrests in domestic violence cases from aggressors to victims. Model analysis also demonstrates how the changing role of cooperation between advocates and police can help explain the trends in victim arrests. Implications for research and policy are discussed.

Keywords: mandatory arrest, criminal justice, intimate partner violence, domestic violence, domestic abuse, wife battering

Hovmand, PS, Ford, D.N., Flom, I., and Kyriakakis, S., "Victims Arrested for Domestic Assault: Unintended Consequences of Arrest Policies." *System Dynamics Review*. 25(3):161-181. July-Sept., 2009.

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Risk-Aversion in Water Allocation Policies in Semi-Arid Regions

David N. Ford and Jennifer M. Andersen

The critical role of water infrastructure systems in sustainable development and the limitations of supply management have increased the importance of demand management in meeting water needs. As an integral part of demand management in water-stressed regions, water allocation policies address the competition among user groups for scarce water resources. This paper presents a dynamic simulation model of a water system in semi-arid regions and analyzes the effectiveness of allocation policies in meeting two objectives: satisfy current demands and preserve adequate supply for future use. Field data identified risk aversion in managers, as reflected in their allocation policies, as a potentially important influence on policy effectiveness. The model was tested with data and policies from the island of Cyprus. Sensitivity analyses reveal the important role of managerial expectations and responses to supply and demand in determining system performance. Analysis of water allocation policies revealed that the level of risk in policies shifts performance between satisfying current demands and protecting against future drought conditions. Potential changes by managers for improved performance and research needs are discussed.

Keywords: risk management, water allocation, resource allocation, resource management, system dynamics

Ford, D.N. and Andersen, J.M. "Risk-Aversion in Water Allocation Policies in Semi-Arid Regions" *Systems Research and Behavioral Science*. 25:769-782. Nov-Dec., 2008

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Construction Specification Framework for Utility Installations

Cesar Quiroga, David Ford, Timothy Taylor, Stanley Kranc, and Edgar Kraus

Utility accommodation policies nationwide contain requirements for the accommodation, location, installation, relocation, and maintenance of utility facilities on the state right-of-way. The policies normally cover basic requirements, making it necessary to use additional specifications and special provisions to handle situations not covered by the policies. Frequently, because of the lack of standard utility installation construction specifications at transportation agencies, many different versions of special specifications and special provisions exist. Closely related to the need to standardize construction specifications for utility installations is the need to standardize methodologies and procedures for determining the cost of utility relocation. This lack of standardization translates into difficulties such as how to verify the validity of the cost data submitted for reimbursement and how to prepare adequately for audits and other internal and external inquiries. This paper summarizes the work completed to develop a prototype framework of construction specification requirements for utility installations, with a focus on water, sanitary sewer, and communication specifications. The specification framework includes five groups of specifications: earth work, pipes and boxes, appurtenances, other, and general (including specifications such as mobilization and traffic control, which highway construction contracts typically include but are also relevant to the utility relocation process). The framework uses tables that summarize the main characteristics of proposed new and modified standard specifications and includes a listing of pay items, subsidiary items, and corresponding measurement units. The framework also includes specification requirements.

Quiroga, C., Ford, D.N., Taylor, T, Kranc, S., and Kraus, E. "Construction Specification Framework for Utility Installations" *Transportation Research Record, Journal of the Transportation Research Board*. 2060: 162-172. 2008.

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An Illustrative Case of Ethical Issues Arising on Construction Projects: The 1999 Texas A&M Bonfire

Nancy J. White and David N. Ford

This paper is a case study of selected practices of the 1999 Texas A&M Bonfire as compared to ethical practices of constructors. This paper identifies seven ethical practices of professional constructors which were not followed during the construction of the 1999 Texas A&M Bonfire. The seven ethical practices not followed during the 1999 Bonfire construction are: 1. Establish clear lines of responsibility and authority; 2. Manage risks; 3. Use a facility design prepared by professional engineers; 4. Comply with safety regulations 5. Supervise construction operations with trained and experienced persons; 6. Construction by persons trained to perform the tasks undertaken; and, 7. Obey the law.

Key Words: Ethics, Bonfire

White N. and David D.N., (2006) "An illustrative Case of Ethical issues Arising on Construction Projects," *The American Professional Constructor, Journal of the American Institute of Constructors*. 29 (1): 46-51.

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Product Development Resource Allocation with Foresight

Nitin R. Joglekar and David N. Ford

Shortening project duration is critical to product development project success in many industries. As a primary driver of progress and an effective management tool, resource allocation among development activities can strongly influence project duration. Effective allocation is difficult due to the inherent closed loop flow of development work and the dynamic demand patterns of work backlogs. The Resource Allocation Policy Matrix is proposed as a means of describing resource allocation policies in dynamic systems. Simple system dynamics and control theoretic models of resource allocation in a product development context are developed. The control theory model is used to specify a foresighted policy, which is tested with the system dynamics model. The benefits of foresight are found to reduce with increasing complexity. Process concurrence is found to potentially reverse the impact of foresight on project duration. The model structure is used to explain these results and future research topics are discussed.

Keywords: concurrent development, control theory, forecasting, product development, project management and scheduling, resource allocation, rework cycle, system dynamics

Joglekar, N. and Ford, D.N., "Product Development Resource Allocation with Foresight" European Journal of Operational Research. Vol. 160 No. 1, pp.72-87. Jan., 2005.

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Impacts of CAD on Iteration in Design Realization

James A. DeLapp, David N. Ford, John A. Bryant, and Joe Horlen

Complete and accurate design is critical for construction project success. Manifesting design intent in the constructed facility depends on coordinated design documents that are developed through design realization. This process evolves design intent from architects and engineers to contractors through the production and review of shop drawings and other submittals. Information technology has been promoted as a tool to improve this process but is not being fully utilized for this purpose. A case study investigates the impacts of CAD on design realization. Comparative analysis between shop drawings prepared by hand and those done with CAD quantify notes, corrections, and information transfer errors. Results support the hypothesis that utilizing CAD can improve design accuracy and lower project costs. Barriers to wider adoption, implications for practice, and further research are discussed.

Keywords: computer aided design (CAD), constructability, contract documents, design management, design realization, shop drawings, submittal process

De Lapp, J., Ford, D.N., Bryant, J., and Horlen, J. "Impacts of CAD on Iteration in Design Realization" *Engineering, Construction and Architectural Management*. 11(4): 284-291.

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Building Learning Organizations in Engineering Cultures: Case Study

David N. Ford, John J. Voyer and Janet M. Gould Wilkinson

The ability of organizations to learn is critical for success. Implementing organizational learning in engineering cultures can be difficult due to a focus on technology instead of people and imbalances among cultures within an organization. A project to transform a medium-sized engineering organization into a learning organization is reported, and the degree, nature, and causes of its success are evaluated. An implementation team developed skills in five disciplines of a learning organization. However the underlying organizational learning concepts were not embraced by the organization at large or incorporated into regular operations. Success was constrained by the organization's ability to share and utilize the knowledge acquired by the implementation team to generate organization wide commitment to organizational learning. The dominance of the engineering culture and the lack of organizational learning infrastructures and development process experimentation suggest that organizations with a balance among cultures may be more likely to succeed than those dominated by a single culture.

Ford, D.N. Voyer, J. and Wilkinson, J. "**Building Learning Organizations in Engineering Cultures: A Case Study**" ASCE Journal of Management in Engineering. 16(4), 72-83. July/Aug., 2000

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Effects of Time-Scale Focus on System Understanding in Decision Support Systems

David N. Ford and Dalton E.M. McCormack

Successfully managing dynamic complex systems requires an understanding of how structure influences both short- and long-term behavior. Therefore, decision support systems designed to improve performance by increasing user understanding require features that address both short and long time scales. The authors report the results of empirical research on effects of features that facilitate different time scale focusses by users of management flight simulators on system understanding. System understanding was measured in two ways: with questions about structural relationships and by performance measures pertaining to the management of a complex system. Participants were divided into two time scale groups. Results were disaggregated based on causal distance and the timing of impacts to relate time scale focus and system understanding. A second experiment evaluated and improved the hypothesis to include the interaction of the time scale of system control and the time scale focus on improving system understanding and performance in managing dynamic systems.

Keywords: decision support systems, time scales, management flight simulator, system dynamics, system understanding, learning.

Ford, D.N. and McCormack, D. "Effects of Time-Scale Focus on System Understanding in Decision Support Systems". *Simulation and Gaming, An Interdisciplinary Journal of Theory, Practice, and Research*. 31(3), 309-330. Sept., 2000.

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System Dynamics as a Strategy for Learning to Learn

David N. Ford

Following their formal education students face processes and organizations which are too varied, complex and dynamic to be designed and managed with solutions provided in school. To be successful students must learn independently and apply new knowledge throughout their careers. How do students learn how to learn? How can students develop the ability to learn about complex systems and challenges without the aid of experts? Our Master of Philosophy in System Dynamics program trains students from an wide variety of cultural and educational backgrounds how to independently learn about complex systems. Our goal is not to provide solutions but to develop the ability to build new solutions. This paper describes how the implementation of a simple experiential learning model with a combination of techniques including apprenticeship, reality-based cases and experimentation develops skills for independent learning. Barriers to learning to learn provide the basis for strategy improvement

Ford, D.N. "System Dynamics as a Strategy for Learning to Learn". *Proceedings of the International System Dynamics Conference. Quebec, Canada. July 20-23, 1998*

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Systemic Creation of Organizational Anxiety: An Empirical Study

John Voyer, Janet Gould and David N. Ford

Inquiry into a product development organization in the semiconductor industry revealed a high level of organizational anxiety. Using casual loop diagramming in conjunction with qualitative data analysis, inside members of a research team created a map of the organization's cognitive schema (or collective mental model) using data obtained from informants in the organization. The map showed how the organization's use of classic defense mechanisms to control organizational anxiety instead created feedback loops that amplified it. Suggestions for controlling anxiety systemically are offered.

Keywords: anxiety, cognitive organizational behavior, organizational rental model, system dynamics, schema

Voyer, J., Gould, J. and Ford, D.N. "Systematic Creation of Organizational Anxiety: An Empirical Study". *Journal of Applied Behavioral Science*. 33(4): 471-489. 1997. December, 1997.

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Anxiety in the Workplace, Using Systems Thinking to Deepen Understanding

John Voyer, Janet Gould and David N. Ford

We all know what it feels like to experience anxiety. Most of us have felt anxious at some point in our lives, especially when we've been faced with immediate physical danger. But many people also know what it is like to live with feelings of fear or apprehension in their day-to-day work lives. With the rapid change now going on in the business world, organizational anxiety has become one of the more pressing problems plaguing us today. Anxiety can be an insidious force: Not only does it sap energy levels and damage our health, it also eats away at job performance, stifles innovation and creativity, and reduces an organization's strategic adaptability and effectiveness. In this volume in our "Innovations in Management Series," we tell the story of how one company—Computer Chips International (CCI)—decided to use systems thinking tools to battle a stubborn case of organizational anxiety. As you will see, the CCI team used causal loop diagrams to gain insight into what was driving their anxiety and making it so pervasive. What's more, by using these powerful tools, the group generated ideas for actually reshaping the system that led to their problem. As the CCI story reveals, the team learned a pivotal lesson: Their attempts to control their anxiety instead aggravated it through the mental models they held about their company culture. Armed with this insight and their new, systemic view of their problem, the CCI team explored ideas for effective, enduring interventions. Perhaps most important, they came to see how they themselves held the key to their own future.

Voyer, J, Gould, J. and Ford, D.N. "Anxiety in the Workplace, Using Systems Thinking to Deepen Understanding". *Innovations in Management Series*. Pegasus Communications. Waltham, MA. 1997.

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