FAST: A Large Scale Expert System for Application and System Software Performance Tuning

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1. Introduction

The FACS Advisor for System Tuning (PAST) is an expert system for tuning the performance of application and system software associated with the Facility Assignment and Control System (PACS). The FACS application consists of close to one million lines of C source code, making it one of the largest software systems in the world. FACS requires a dedicated mainframe configured with two or three 7 MIP processors, 50 Megabytes of main memory, and up to 75 disk packs on seven dual controllers. FACS is operational in many Bell Operating Companies, and site requests for tuning FACS have grown dramatically over the last two years. The FAST expert system encodes large amounts of application and system tuning expertise to assist production FACS sites in analyzing and improving the performance of their systems.

In this paper the FACS performance tuning domain is described, leading into a detailed example of how the structure of the domain is modeled by the FAST expert system to enable effective problem solving for diagnosis and repair of performance tuning problems.

2. The FACS Performance Tuning Domain

FAST reasons over data gathered by various performance monitors to identify the cause of performance problems concentrated in the following three areas:

- Mistaking a poorly tuned system for one that is out of CPU capacity
- 2. Inadvertent introduction of queueing delays
- End-user habits or system setup causing performance problems on systems with spare CPU capacity

Each of these categories of problems breaks down into other categories. For example, queueing delays, which are particularly insidious, can be traced to the I/O subsystem, data management routines, application databases, application caches, or software setup parameters. For certain problems, such as I/O subsystem imbalances, FAST will recommend

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explicit fixes for the problem: in this case, file balancing recommendations. Details about the diagnosis and repair of this particular type of problem are discussed in a later section. For other problems, FAST will identify the state of the FACS production system (eg saturated processors, queueing limitations) and the cause(s) of the sub-optimal performance.

Large amounts of different types of performance data are required to analyze FACS performance problems. The types of performance statistics used can be summarized as:

- Detailed I/O data
- · File placement information
- · CPU usage statistics
- · Application-level performance measurements
- · Data Management Routine (DMR) Statistics

A time-consistent snapshot² of the PACS system is created by invoking each of these performance monitoring tools, and the data produced is the input to the FAST system. Thus, FAST is not a real time monitor, but rather is invoked to solve existing performance problems much like the human FACS performance teners, or to tune a FACS system to prevent future performance problems.

3. Modeling the FACS Performance Tuning Domain

3.1 Implementation Environment

Large AI applications often require the use of multiple programming paradigms, or styles, to create robust, changeable implementations[1]. The programming paradigms used in PAST to accomplish this goal include procedural programming in Lisp, object-oriented programming, and ruleoriented programming. The FAST system is to be used in the field for tuning FACS systems, so the implementation must be flexible. The multiple paradigm programming environment used to develop this system has provided the flexibility required to converge on a robust implementation: the application requirements were well-understood from the start (accomplish what FACS performance tuners accomplish), but implementing elain. SYNDOOD has required incremental implementation and redesign.

3.2 Representing Performance Data and the Structure of the Domain

Frames (a group of attributes of an object) provide a form of knowledge representation which allow the representation of

This growth in tuning requests is commensurate with the growth in workload and conversion to the FACS software.

FAST chooses from data which has been collected during one 24 hour operational day. Specifically, it uses detailed I/O during the statistics from the system's busy hour, the placement information gathered at the end of the busy hour, and CPU usage statistics and application-level measurements compiled throughout the operational day.

<u>Proceedings Of 1988 Conference On Measurement And Modeling Of Computer Systems</u>

Marco Cascella

Proceedings Of 1988 Conference On Measurement And Modeling Of Computer Systems:

Modeling Techniques and Tools for Computer Performance Evaluation Ramon Puigjaner, Dominique **Performance Evaluation: Origins and Directions** Günter Haring, Christoph Lindemann, Martin Potier, 2012-12-06 Reiser, 2003-06-29 This monograph like state of the art survey presents the history the key ideas the success stories and future challenges of performance evaluation and demonstrates the impact of performance evaluation on a variety of different areas through case studies in a coherent and comprehensive way Leading researchers in the field have contributed 19 cross reviewed topical chapters competently covering the whole range of performance evaluation from theoretical and methodological issues to applications in numerous other fields Additionally the book contains one contribution on the role of performance evaluation in industry and personal accounts of four pioneering researchers describing the genesis of breakthrough results The book will become a valuable source of reference and indispensable reading for anybody active or interested in performance evaluation Foundations of Dependable Computing Gary M. Koob, Clifford G. Lau, 2007-07-23 Foundations of Dependable Computing Models and Frameworks for Dependable Systems presents two comprehensive frameworks for reasoning about system dependability thereby establishing a context for understanding the roles played by specific approaches presented in this book s two companion volumes It then explores the range of models and analysis methods necessary to design validate and analyze dependable systems A companion to this book published by Kluwer subtitled Paradigms for Dependable Applications presents a variety of specific approaches to achieving dependability at the application level Driven by the higher level fault models of Models and Frameworks for Dependable Systems and built on the lower level abstractions implemented in a third companion book subtitled System Implementation these approaches demonstrate how dependability may be tuned to the requirements of an application the fault environment and the characteristics of the target platform Three classes of paradigms are considered protocol based paradigms for distributed applications algorithm based paradigms for parallel applications and approaches to exploiting application semantics in embedded real time control systems Another companion book published by Kluwer subtitled System Implementation explores the system infrastructure needed to support the various paradigms of Paradigms for Dependable Applications Approaches to implementing support mechanisms and to incorporating additional appropriate levels of fault detection and fault tolerance at the processor network and operating system level are presented A primary concern at these levels is balancing cost and performance against coverage and overall dependability As these chapters demonstrate low overhead practical solutions are attainable and not necessarily incompatible with performance considerations. The section on innovative compiler support in particular demonstrates how the benefits of application specificity may be obtained while reducing hardware cost and run time overhead Proceedings of the ACM SIGMETRICS Conference on Measurement and Modeling of Computer **Systems** Conference on Measurement and Modeling of Computer Systems, Association for Computing Machinery. Special

Interest Group on Measurement and Evaluation, 1988 The Cache Coherence Problem in Shared-Memory **Multiprocessors** Igor Tartalja, Veljko Milutinović, 1996-02-13 Almost all software solutions are developed through academic research and implemented only in prototype machines leaving the field of software techniques for maintaining the cache coherence widely open for future research and development This book is a collection of all the representative approaches to software coherence maintenance including a number of related efforts in the performance evaluation field The book presents a selection of 27 papers dealing with state of the art software solutions for cache coherence maintenance in shared memory multiprocessors It begins with a set of four introductory readings that provides a brief overview of the cache coherence problem and introduces software solutions to the problem The text defines and illustrates static and dynamic software schemes techniques for modeling performance evaluation mechanisms and performance evaluation studies. The book is intended for the experienced reader in computer engineering but possibly a novice in the topic of cache coherence It also provides an in depth understanding of the problem as well as a comprehensive overview for multicomputer designers computer architects and compiler writers In addition it is a software coherence reference handbook for advanced undergraduate and typical graduate students in multiprocessing and multiprogramming areas IBM Journal of Research and Development, 1991 Computer Sciences Technical Report ,2002 **Performance Engineering Reiner** Dumke, Claus Rautenstrauch, Andreas Schmietendorf, Andre Scholz, 2003-06-29 Initially computer systems performance analyses were carried out primarily because of limited resources Due to ever increasing functional complexity of computational systems and user requirements performance engineering continues to play a major role in software development This book assesses the state of the art in performance engineering Besides revised chapters drawn from two workshops on performance engineering held in 2000 additional chapters were solicited in order to provide complete coverage of all relevant aspects. The first part is devoted to the relation between software engineering and performance engineering the second part focuses on the use of models measures and tools finally case studies with regard to concrete technologies are presented Researchers professional software engineers and advanced students interested in performance analysis will find this book an indispensable source of information and reference **Technology for Large Space Systems** Languages and Compilers for Parallel Computing Keith Cooper, John Mellor-Crummey, Vivek Sarkar, 2011-02-24 ,1990 This book constitutes the thoroughly referred post proceedings of the 23rd International Workshop on Languages and Compilers for Parallel Computing LCPC 2010 held in Houston TX USA in October 2010 The 18 revised full papers presented were carefully reviewed and selected from 47 submissions. The scope of the workshop spans foundational results and practical experience and targets all classes of parallel platforms including concurrent multithreaded multicore accelerated multiprocessor and cluster systems Measurements and Instrumentation for Machine Vision Oleg Sergiyenko, Wendy Flores-Fuentes, Julio Rodriguez-Quiñonez, Jesús E Miranda-Vega, 2024-06-26 A comprehensive reference book that addresses

the field of machine vision and its significance in cyber physical systems It explores the multidisciplinary nature of machine vision involving electronic and mechatronic devices artificial intelligence algorithms embedded systems control systems robotics interconnectivity data science and cloud computing The book aims to provide advanced students early career researchers and established scholars with state of the art knowledge and novel content related to the implementation of machine vision in engineering scientific knowledge and technological innovation. The chapters of the book delve into various topics and applications within the realm of machine vision They cover areas such as camera and inertial measurement unit calibration technical vision systems for human detection design and evaluation of support systems using neural networks UV sensing in contemporary applications fiber Bragg grating arrays for medical diagnosis color model creation for terrain recognition by robots navigation systems for aircraft object classification in infrared images feature selection for vehicle non vehicle classification visualization of sedimentation in extreme conditions quality estimation of tea using machine vision image dataset augmentation techniques machine vision for astronomical images agricultural automation occlusion aware disparity based visual servoing machine learning approaches for single photon imaging and augmented visual inertial wheel odometry Each chapter is a result of expert research and collaboration reviewed by peers and consulted by the book s editorial board The authors provide in depth reviews of the state of the art and present novel proposals contributing to the development and futurist trends in the field of machine vision Measurements and Instrumentation for Machine Vision serves as a valuable resource for researchers students and professionals seeking to explore and implement machine vision technologies in various domains promoting sustainability human centered solutions and global problem solving Century of Excellence in Measurements, Standards, and Technology David R. Lide, 2018-02-06 Established by Congress in 1901 the National Bureau of Standards NBS now the National Institute of Standards and Technology NIST has a long and distinguished history as the custodian and disseminator of the United States standards of physical measurement Having reached its centennial anniversary the NBS NIST reflects on and celebrates its first century with this book describing some of its seminal contributions to science and technology Within these pages are 102 vignettes that describe some of the Institute s classic publications Each vignette relates the context in which the publication appeared its impact on science technology and the general public and brief details about the lives and work of the authors The groundbreaking works depicted include A breakthrough paper on laser cooling of atoms below the Doppler limit which led to the award of the 1997 Nobel Prize for Physics to William D Phillips The official report on the development of the radio proximity fuse one of the most important new weapons of World War II The 1932 paper reporting the discovery of deuterium in experiments that led to Harold Urey s1934 Nobel Prize for Chemistry A review of the development of the SEAC the first digital computer to employ stored programs and the first to process images in digital form The first paper demonstrating that parity is not conserved in nuclear physics a result that shattered a fundamental concept of theoretical physics and led to a Nobel Prize for T D Lee and

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Applied mechanics reviews ,1948 Stochastic Analysis of Computer and Communication Systems Hideaki Takagi,1990 Analytical techniques for evaluating the performance of computer and communication systems have evolved hand in hand with the progress in these systems since the late 1960 s and an enormous amount of knowledge has been accumulated in this interplay of applied mathematics and computer science This book includes nineteen lengthy surveys of the state of the art of performance evaluation techniques and an extensive bibliography The topics include stochastic processes and queueing

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