Performance Analysis

CSE 410, Spring 2004

Computer Systems

http://www.cs.washington.edu/education/courses/410/04sp/

Readings and References

- Reading
  - » Chapter 2, *Computer Organization & Design*, Patterson and Hennessy
- Other References

Performance Analysis - When?

- Evaluation prior to system purchase
  - » deciding which system is right for the need
  - » very speculative and uncertain
    - unknown future workload, future capability
- Tuning prior to product release
  - » product must meet expectations or it won't sell
  - » very speculative and uncertain
    - sensitive to configuration, workload

Understand your Environment

- The question is "what system to buy?"
  - » or design to select, or vendor to hire, etc
- Performance analysis is fun
  - » you get to look at all sorts of machines and their inner workings
- It's very easy to analyze the wrong things ...

  ... and then your analysis will lead you to a wrong answer

Time to complete task

- The best metric is time to complete the task, as perceived by the user
- Total performance is the sum of many individual factors and perceptions
- Understand the task and the expectations
  - » write down the tasks to be accomplished
  - » write down the user expectations for performance

Evaluation tools

- Simulation
  - » necessary if there is no system in place yet
  - » accuracy of the simulation is critical
    - how is accuracy defined?
- Prototypes
  - » accuracy is critical - it looks real, but you don't have the real product in hand yet
    - where are the simplifications, are they important?

Benchmarks

- High potential for misleading results
- May not reflect actual operation at all
  - » reading from disk controller cache, not disk
  - » product vendor tweaked system for benchmark
- Simplified representation of the workload may completely miss critical factors
  - » eg, operating system performance under heavy user load

Better benchmarks

- Benchmarks derived from real applications
  - » Standard Performance Evaluation Corp (SPEC)
- Test hardware
  - » simulated users at simulated keyboards
- Prototype deployment
  - » actually build an initial version of the application and deploy it on a limited scale

Validate!

- Your users do not think of the system the same way you do - guaranteed!
- Document your assumptions
- Use several different types of benchmarks
- Keep an open mind
  - » pay attention to business issues too, or you will be surprised when your choice is not selected

SPEC Benchmarks

- "Establish, maintain, and endorse standardized set of relevant benchmarks and metrics for performance evaluation of computer systems"
  - » numeric computing
  - » web servers
  - » graphic subsystems
- Test the CPU, memory hierarchy, compilers
  - » Fortran, C, C++
  - » Integer and Floating Point sections

CPU 2000

Compression
FPGA circuit placement
C compiler
Combinatorial Optimizer
Chess
Word Processing
Visualization
Perl
Group Theory
OO Database
Place and route simulator
Quantum physics
Shallow water model
Multi-grid field
Partial Dif. Equations
3D Graphics
Fluid Dynamics
Image recognition
Seismic wave simulation
Image processing
Chemistry, Meteorology
Number theory

More SPEC Benchmarks

- Java Virtual Machines
- server-side Java
- shared-memory parallel programming
- SMTP and POP3 mail servers
- NFS (network file server) computers
- World Wide Web Servers
- System MultiTasking performance
- high-end industrial-style applications
- graphics performance

Tuning - Design for speed

- Think about performance early and often
- Good algorithms first
  - » throw faster hardware at it only when you can't think of anything else
- Product is almost ready, but ...
  - » particular data models cause problems
  - » many concurrent users cause problems
  - » etc

Tuning - The product is slow

- Let the numbers tell you what to work on
- Don't assume anything!
  - » I/O bottlenecks, memory thrashing, unusual data sets, unexpected usage patterns, ...
  - » the problems can be anywhere
  - » the solutions can be anywhere
- Make sure you are solving real performance issues as perceived by the real users

Tuning Tools

- Clock on the wall
  - » Remember your customer - web user with modem, corporate end user, sysadmin
- High level statistics from the program
  - » functions performed and time elapsed
- Profiling
  - » detailed information about instruction history
  - » logic analyzer tracing for embedded systems

Profiling

- Continuously sample CPU state
  - » built-in performance counters (eg I-cache miss)
  - » sample program counter and context
- Procedure level
  - » Where are we spending the most time?
- Instruction level
  - » What are we doing there?
  - » Why is it taking so long?