Performance of Computer System

Introduction To Performance of Computer System

Dr. Lina Xu
lina.xu@ucd.ie

School of Computer Science,
University College Dublin

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How You Should See the Problem

- What is system?
- Evaluation techniques
- Metrics to use
- Workload
- Parameters

What are Computer Systems

Strictly Definition:
A computer system is a basic, complete and functional computer, including all the hardware and software required to make it functional for a user. It should have the ability to receive user input, process data, and with the processed data, create information for storage and/or output.

- Compare the performance of window systems of two AI system
- Compare the performance of two processor interconnection networks.
- Analyze the performance of two microprocessors

What are Computer Systems

Definition in this Module:

We will focus on the software system part of the whole.

- Compare the performance of several routing algorithms.
- Compare the performance of two text-formatting programs.
- Compare the performance of two real time bus systems.

Since my background is IoT, you probably will hear a lot IoT examples.

Evaluation techniques

Criterion	Analytical Modeling	Simulation	Measurement
Stage	Any	Any	Post-prototype
Time required	Small	Medium	varies
Tools	Analysts	Programs	Instrumentation
Accuracy	Low	Moderate	varies
Trade-off Evaluation	Easy	Moderate	Difficult
Cost	Low	Medium	High
Saleability	Low	Medium	high

There are three evaluation techniques: measurement, simulation, and analytical modeling

Evaluation techniques — Analytical Modelling

Analytical models are mathematical models that have a closed form solution, i.e. the solution to the equations used to describe changes in a system can be expressed as a mathematical analytic function.

- A set of mathematical equations, such as
  - Queueing models
  - Optimisation models
- Analytical modeling will be used to justify the consistency of measured values for different parameters.
- Applied in many domains: business intelligence, marketing, stock investment, economic models

Evaluation techniques — Simulation

- Easy to modify and update
- Due to the cost of changing system configurations, simulation is preferred beforehand.
- With simulations, it may be possible to identify the optimal combination, but often it is not clear what the trade-off is among different parameters.
- Time consuming for a comprehensive simulation environment development, off the shell simulations tools:
  - Smart phone application simulator/emulator: Android Studio
  - Networking simulator: NS-3, Matlab
  - Transportation simulation: Simio

Evaluation techniques — Measurement

- Measurements are possible only if something similar to the proposed system already exists.
- Measurements generally take longer than analytical modeling but shorter than simulations.
- Measurement is the least desirable technique in performance evaluation due to highly variable environmental parameters.
- Saleability is the key justification when considering the expense and the labor of measurements.
- Often used when you are given a system, such as software tester:
  - Unit testing
  - Integration testing
  - Smoke testing

Overview on The Techniques

- Analytical modeling and simulation can be used for situations where measurement is not possible, but in general it would be more convincing to others if the analytical modeling or simulation is based on previous measurement.
- In most situations, results are required yesterday. If that is really the case, then analytical modeling is probably the only choice.
- The next consideration is the availability of tools: modeling skills, simulation languages, and measurement instruments.
- Level of accuracy desired is another important consideration.
  - analytical modeling requires so many simplifications and assumptions that if the results turn out to be accurate
  - Simulations can incorporate more details and require less assumptions than analytical modeling and, thus, more often are closer to reality.
  - Measurements, although they sound like the real thing, may not give accurate results simply because many of the environmental parameter

Combining Evaluation Techniques!

- **Analytical model:** find interesting range of parameters
- **Simulation:** study performance within parameter range
- **Measurement:** verify the analytical and simulation results if prototype exists
- Until validated, all evaluation results are suspect.
  - In all cases, result may be misleading or wrong.
  - Even real time measurements are susceptible to errors as other techniques.
  - Beware of counterintuitive results.

What Metrics We Can Use

The decision is highly depending on the system and context.
Commonly used metrics includes:

- **Nominal capacity:** maximum achievable under ideal conditions
- **Throughput:** request/unit time
- **Usable capacity:** max throughput for given response time limit
- **Efficiency:** usable capacity/nominal capacity
- **Utilisation:** resource busy time/duration
- **Reliability:** probability of errors
- **Availability:** system shutdown time
- **Scalability:** number of items the system can cope with

Types of Performance Metrics

- **Higher better:** Throughput
- **Lower better:** Response time
- **Nominal is best:** Utilisation
  - Too high: low response time
  - Too low: resource underused

Combination of Metrics for Evaluation

Classic Quality of Service (QoS) and Quality of Service (QoE)

- QoS:
  - Global metrics
  - From the service provider's perspective
- Quality of user Experience (QoE)
  - Individual users, most of the time, selfish users...
  - From the users' perspective

QoS = (Throughput * Correct transmission rate) / Average request delay
QoE = Average Round Trip Time * Average Allocated Bandwidth

Selecting Metrics

- Low variability
  - Low variability helps reduce the number of repetitions required to obtain a given level of statistical confidence.
- Non-redundancy
  - If two metrics give essentially the same information, it is less confusing to study only one.
- Completeness
  - The set of metrics included in the study should be complete.

What is Workload

The workload consists of a list of service requests to the system.

- It is essential that the workload be representative of the system usage in real life.
- To produce representative workloads, one needs to measure and characterise the workload on existing system.

Example: the workload for comparing several database systems may consist of a set of queries.

Workload Types

- Real workload
  - One observed during normal system operations
  - Non-repeatable
- Synthetic workload
  - Approximation of real workload
  - Can be applied repeatedly in a controlled manner
  - No large data files, no sensitive data
  - Easily modified and ported
  - Easily measured

Parameters

Parameters include **system parameters** and **workload parameters**

- Before evaluation design, list all the parameters that affect performance
  - System parameters include both hardware and software parameters, which generally do not vary among various installations of the system.
  - Workload parameters are characteristics of users' requests, which vary from one installation to the next.
- The list of parameters may not be complete. That is, after the first pass of the analysis, you may discover that there are additional parameters that affect the performance.

Parameters

Features of the parameters:

- Some parameters can vary and some are fiexed.
- The parameters to be varied are called **factors** and their values are called **levels**.

Good practice advices:

- It is better to start with a short list of factors and a small number of levels for each factor.
- For each of these two factors you may choose only two levels: small and large.
- Some of the factors can be set at fixed values at the initial experimental stage

Some Parameters Might Be Overlooked

- Natural Environment Parameters: temperature, humility, light, rain, wind
- Soundings: buildings, cars, radio signals
- Users
  - Human Computer Interaction (HCI)
  - User behaviour analysis and prediction

Exercise After Class

Choose a system for performance study. Briefly describe the system and list

- Services
- Performance metrics
- System parameters
- Workload parameters
- Factors and their ranges
- Evaluation technique
- Workload