Performance Analysis

1. Why do performance analysis?
2. Improve performance of your applications.

Measure, interpret, communicate system size or speed vs. space performance.
1. How to do performance analysis?

2. Not always possible to set levels

1. Result is a limit to actual systems

- High external validity

Measure actual systems
3. Mathematics models are very simple and easy to express verbally.

But no systems are always simpler than simulation, even at lower level of index, even.
counts, the duration size of some parameter

performance matrix

math

approximate \( Y \) with measurable \( X \)

index: step performance

\( y \) and \( x \)

find relationship, linear and

Exponent
If \( y \) is a good apple, or \( y \)?

High extraneous variability.

\( x \) and \( y \).

Really is a relationship between between \( x \) and \( y \), and these if you are part of the relationship.

High inferential variability.
not rates, counts, time intervals

> scalar metrics

\[ \frac{\text{sec}}{\text{cycle or H}_2} \]

Example:

\[ \frac{\text{time}}{\text{count of something}} \]

rate metric or throughput

Maths
(3) Consistency

Recalculate

Redo experiment

Get same result

(2) Representativeness

if \( y_1 \neq y_2 \), then \( y_1 \neq y_2 \).

(1) Reliability

Characteristics of a good performance metric
Million of floating point ops/sec

MIPS

consistent? NO!
reproduce? Maybe
relies on? not really, no. ignores memory.

million instructions/sec

MIPS

Some more comments
3. Compute the geometric mean of normalized scores.

2. Normalize each time value by dividing by the time needed on a standard benchmark.

1. Measure time required to execute each program in a specific set of programs. Spec benchmark, Spec machine.
2. Cpu time
   — includes time spent on other tasks
   time at finish - time at start

3. Process time
   3. Respond time
   Not recognizable, doesn't account for memory delays

1. Wall clock time
   Scalar Machine
   Not reproducible
\[ \frac{1}{T_2} \Rightarrow Z \Rightarrow 5.1 \Rightarrow \text{Slowdown} \]

\[ T_2 < T_1 \Rightarrow Z_{21} > 1 \]

Example: Mips \( O = \) Million Instructions

Distance measurement:

\[ S_{21} = \frac{1}{T_2} = \frac{1}{T_1} = \frac{0}{A_2} = \frac{0}{A_1} \]

Speedup of system 2 w.r.t. system 1
H2. If cycles take twice as long,

\[ \text{mean should be } \frac{1}{2} \text{ as long} \]

\[ \text{proportional to the fourth power.} \]

Mean of rates should be inversely

\[ \begin{cases} 
1 + 1 + 1 & = 3 \\
2 + 2 + 2 & = 6 \\
3 + 3 + 3 & = 9 \\
\end{cases} \]

double \[ \Rightarrow \text{double } \times \]

i.e. directly proportional to the fourth power.

\[ \text{A good mean (in systems)} \]

\[ \text{Means} \]
For scalar measurements, like time,

\[ x \times \frac{3}{1} = \frac{x}{1} \]

True for \( x \neq 0 \), if \( x \neq 0 \) if \( x \neq 0 \).

\[ x = \frac{3}{1} \]

For \( x \neq 0 \), if \( x \neq 0 \).

\( n \leq \frac{1}{2} \) \( n \leq \frac{1}{2} \)

For rates:

\[ \frac{x}{k} \]

Well, \( x \neq 0 \).
Arithmetic mean

\[ x_{\text{A}} = \frac{1}{n} \sum_{i=1}^{n} x_i \]

\[ m = \frac{2}{3} \neq \frac{1}{3} \]

\[ n = 3 \]

\[ y \in \{ \text{sec}, \text{csc} \} \]

\[ \text{mod} \text{ on the cyc} \]

\[ \frac{1}{n} \leq \frac{2}{3} \]

\[ x_{\text{A}} = \frac{1}{3} \]

\[ 2 \text{ cyc} 6 \]

\[ \frac{5}{1} \]

\[ \text{Hz} 2 \]
\[ x = \sqrt[n]{x_1 x_2 \ldots x_n} \]

Geometric Mean - favors characteristics

Harmonic Mean

Two criteria for

Geometric Mean - good for ratios

Harmonic Mean

\[ x = \frac{1}{\frac{1}{x_1} + \frac{1}{x_2} + \ldots + \frac{1}{x_n}} \]
\[ x_c = \sqrt{2.6} = \sqrt{12} \]

\[ x_h = \frac{2 + \frac{9}{4}}{2} = \frac{3}{2} = 1.5 \]

Pythagorean Means:

\[ u = \frac{x_2}{x_1} = \frac{6}{2} = 3 \]

\[ x_1 = 2 \]

\[ x_2 = 6 \]
What are we measuring?

1. Count of events that a function is called.
2. Event metadata value as an event exits each start of function call.
3. Ex: measuring call stack depth at each start of function call.
4. Ex: proportion of time spent in Function F.
5. Time to complete some thing.
6. Profile: overall view of where its execution time is spent.
time

start event

get

call

get over hand

timer

examples

Measuring a system perturbs the system.

- cases: order of operations.

the actual measured.

the

the
These countries, because you collect and store all execution — slow down or affect program, measuring a system perturbs the system.
5. Sample: At certain times, interrupt program.

Dynamise project

Insert code into a running program.

3. Insert initial code handling.

to the executable

2. Smart compiler can add instruction

source code.

1. Insert measurement code into

Measurements.
Using only one sample proportion:

Shortcut: Compute a confidence interval

\[ \frac{800}{15^2} \]

Sample proportion is \( \frac{15}{800} \)

Sample size is 800 times 15? Times you’re in it.

Use sampling.

\[ \text{Sample in function of time? do you} \]

Proportions
A sample mean

\[ \frac{\text{not times you interrupt}}{\text{sum of Bernoulli variables}} \]

\[ p = \text{sample proportion of time in } F \text{ Bernoulli random} \]

\[ \emptyset \]

\[ I \]

ne or either in F or not in F

each time we interrupt the system.
\[
\sqrt{n \left( \frac{p \cdot 0.025}{p (1-p)} \right) ^ 2 + z^2 (0.025)}
\]

Compute a \( 95\% \) confidence interval with

\[
n = \frac{z^2}{p(1-p)}
\]

and\( \mu = p \) as \( n \to \infty \).

a normal distribution of the sample means as \( n \to \infty \).