Ratio Games

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Case Study 11.1: 6502 vs. 8080

Benchmark	System 6502	System 8080
Block	41.16	51.50
Sieve	63.17	48.08
Sum	104.33	99.58
Avg	52.17	49.79

1. Ratio of Totals

- Conclusion: 6502 is worse. It takes 4.7% more time than 8080.

6502 vs. 8080 (Cont)

2. 6502 as the base:

System 6502	System 8080
1.00	1.25
1.00	0.76
2.00	2.01
1.00	1.01

3. 8080 as the base:

System 6502	System 8080
0.80	1.00
1.31	1.00
2.11	2.00
1.06	1.00

1. Ratio of Totals: 6502 is worse.
   It takes 4.7% more time than 8080.
2. With 6502 as a base: 6502 is better.
   It takes 1% less time than 8080.
3. With 8080 as a base: 6502 is worse. It takes 6% more time.

Case Study 11.2: RISC vs. CISC

Benchmark	Processor RISC-I	Z8002	VAX-11/780	PDP-11/70	C/70
E-String Search	144	130	101	115	101
F-Bit Test	120	180	144	168	120
H-Linked List	176	141	211	299	141
K-Bit Matrix	288	374	288	374	317
I-Quick Sort	992	1091	893	1091	893
Ackermann(3,6)	144	302	72	86	86
Recursive Qsort	2736	1368	1368	1642	1642
Puzzle (Subscript)	2796	1398	1398	1398	1678
Puzzle (Pointer)	752	602	451	376	376
SED (Batch Editor)	17,720	17,720	10,632	8860	8860
Towers Hanoi (18)	96	240	77	96	67
Sum	25,964	23,546	15,635	14,505	14,281
Average	2360.36	2140.55	1421.36	1318.64	1298.27

- **Conclusion**: RISC-I has the largest code size. The second processor Z8002 requires 9% less code than RISC-I.

RISC vs. CISC (Cont)

Benchmark	Processor RISC-I	Z8002	VAX-11/780	PDP-11/70	C/70
E-String Search	1.00	0.90	0.70	0.80	0.70
F-Bit Test	1.00	1.50	1.20	1.40	1.00
H-Linked List	1.00	0.80	1.20	1.70	0.80
K-Bit Matrix	1.00	1.30	1.00	1.30	1.10
I-Quick Sort	1.00	1.10	0.90	1.10	0.90
Ackermann(3,6)	1.00	2.10	0.50	0.60	0.60
Recursive Qsort	1.00	0.50	0.50	0.60	0.60
Puzzle (Subscript)	1.00	0.50	0.50	0.50	0.60
Puzzle (Pointer)	1.00	0.80	0.60	0.50	0.50
SED (Batch Editor)	1.00	1.00	0.60	0.50	0.50
Towers Hanoi (18)	1.00	2.50	0.80	1.00	0.70
sum 11.00	13.00	8.50	9.99	8.00	
Average	1.00	1.18	0.77	0.91	0.73

- **Conclusion**: Z8002 has the largest code size and that it takes 18% more code than RISC-I. [Peterson and Sequin 1982]

Using an Appropriate Ratio Metric

Example:

Network	Throughput	Response
A	10	2
B	4	1

System	Throughput	Response	Power
A	10	2	5
B	4	1	4

1. Throughput: A is better
2. Response Time: A is worse
3. Power: A is better

Using Relative Performance Enhancement

- Example: Two floating point accelerators

Alternative	Without	With
A on X	2	4
B on Y	3	5

Alternative	Without	With	Ratio
A on X	2	4	2.00
B on Y	3	5	1.66

- Problem: Incomparable bases. Need to try both on the same machine

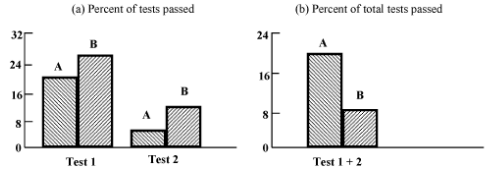
Ratio Games with Percentages

- Example: Tests on two systems

	Test	Total	Pass	% Pass
System A:	1	300	60	20%
	2	50	2	4%
	Total	350	62	20.6%
System B:	1	32	8	25%
	2	500	40	8%
	Total	532	48	9%

1. System B is better on *both* systems
2. System A is better overall.

Percentages (Cont)



- **Other Misuses of Percentages**:
  - 1000% sounds more impressive than 11-time. Particularly if the performance before and after the improvement are both small
  - Small sample sizes disguised in percentages
  - Base = Initial. 400% reduction in prices ⇒ Base = Final

Ratio Games Guidelines

1. If one system is better on *all* benchmarks, *contradicting* conclusions can not be drawn by any ratio game technique

Benchmark	System A	System B
I	0.50	1.00
J	1.00	1.50
Average	0.75	1.25

Benchmark	System A	System B
I	1.00	2.00
J	1.00	1.50
Average	1.00	1.75

Benchmark	System A	System B
I	0.50	1.00
J	0.67	1.00
Average	0.58	1.00

Guidelines (cont)

2. Even if one system is better than the other on all benchmarks, a better <u>*relative*</u> performance can be shown by selecting appropriate base.
   - In the previous example, System A is 40% better than System B using raw data, 43% better using system A as a base, and 42% better using System B as a base.
3. If a system is better on some benchmarks and worse on others, contracting conclusions can be drawn in some cases. Not in all cases.
4. If the performance metric is an LB metric, it is better to use your system as the base
5. If the performance metric is an HB metric, it is better to use your opponent as the base
6. Those benchmarks that perform better on your system should be elongated and those that perform worse should be shortened

Numerical Conditions for Ratio Games

- **Raw Data**:

Bench-mark	System A	System B
I	a	ax
J	b	by
Average	$\frac{a+b}{2}$	$\frac{ax+by}{2}$

- A is better than B iff

$$\frac{a+b}{2} > \frac{ax+by}{2}$$

$$y < -\frac{a}{b}x + \frac{a+b}{b}$$

- **With A as the Base**:

Bench-mark	System A	System B
I	1	x
J	1	y
Average	1	$\frac{x+y}{2}$

- A is better than B iff

$$\frac{x+y}{2} < 1$$

$$y < 2 - x$$

Numerical Conditions (Cont)

- **With B as the base**:

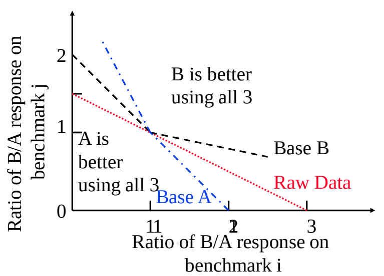
Bench-mark	System A	System B
I	$\frac{1}{x}$	1
J	$\frac{1}{y}$	1
Average	$\frac{1}{2}\left(\frac{1}{x}+\frac{1}{y}\right)$	1

- A is better than B iff

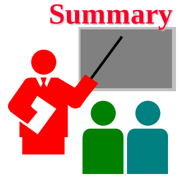
$$\frac{1}{2}\left(\frac{1}{x}+\frac{1}{y}\right) > 1$$

$$y < \frac{x}{2x-1}$$

Numerical Conditions (Cont)



Summary



- Ratio games arise from use of incomparable bases
- Ratios may be part of the metric
- Relative performance enhancements
- Percentages are ratios
- For HB metrics, it is better to use opponent as the base