# BSM 420 – BİLGİSAYAR MİMARİ

Veri Sunumu Sanatı

11.Hafta

# Introduction

*It's not what you say, but how you say it.* – A. Putt

- An analysis whose results cannot be understood is as good as one that is never performed.

- General techniques
  - Line charts, bar charts, pie charts, histograms
- Some specific techniques
  - Gantt charts, Kiviat graphs …
- A picture is worth a thousand words
  - Plus, easier to look at, more interesting

# Outline

- Types of Variables
- Guidelines
- Common Mistakes
- Pictorial Games
- Special Purpose Charts
- Decision Maker's Games
- Ratio Games

# Types of Variables

- Qualitative (Categorical) variables
  - Have states or subclasses
  - Can be ordered or unordered
    - Ex: PC, minicomputer, supercomputer → ordered
    - Ex: scientific, engineering, educational → unordered
- Quantitative variables
  - Numeric levels
  - Discrete or continuous
    - Ex: number of processors, disk blocks, etc. is discrete
    - Ex: weight of a portable computer is continuous
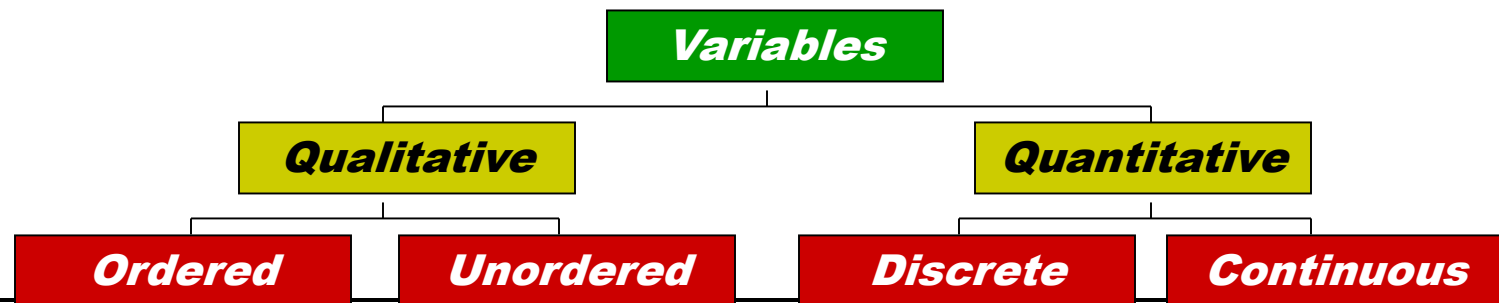
# Outline

- Types of Variables
- Guidelines
- Common Mistakes
- Pictorial Games
- Special Purpose Charts
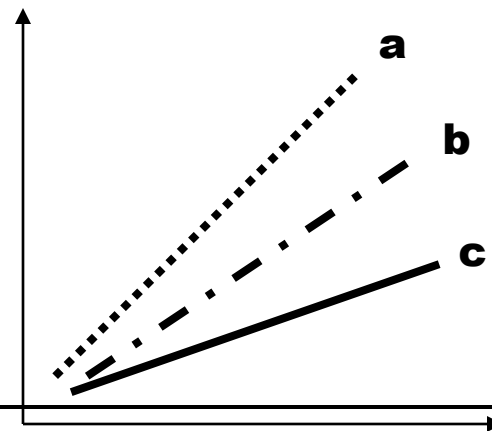- Decision Maker's Games
- Ratio Games

- Again, "art" not "rules". Learn with experience. Recognize good/bad when see it.

- *Require minimum effort from reader*
  - Perhaps *most* important metric
  - Given two, can pick one that takes less reader effort

Ex:
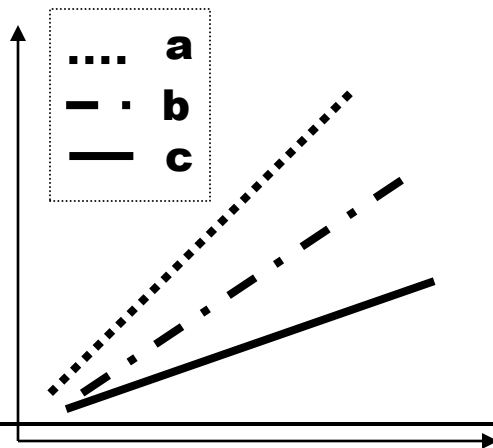


Direct Labeling          Legend Box

# Guidelines for Good Graphs (2 of 5)

- *Maximize information*
  - Make self-sufficient
  - Key words in place of symbols
    - Ex: "PIII, 850 MHz" and not "System A"
    - Ex: "Daily CPU Usage" not "CPU Usage"
  - Axis labels as informative as possible
    - Ex: "Response Time in seconds" not "Response Time"
  - Can help by using captions, too
    - Ex: "Transaction response time in seconds versus offered load in transactions per second."

- *Minimize ink*
    - Maximize information-to-ink ratio
    - Too much unnecessary ink makes chart cluttered, hard to read
        - Ex: no gridlines unless needed to help read
    - Chart that gives easier-to-read for same data is preferred

1

Availability

.1

Unavailability
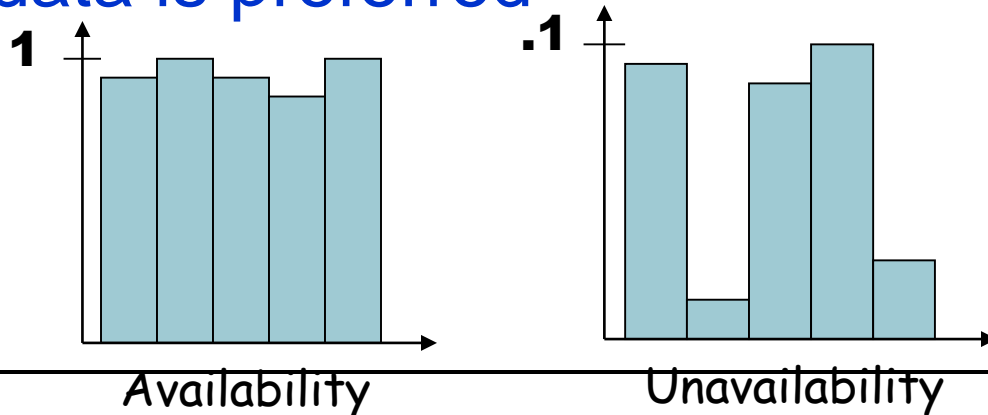
- Same data
- Unavail = 1 – avail
- Right better

# Guidelines for Good Graphs (4 of 5)

- *Use commonly accepted practices*
  - Present what people expect
  - Ex: origin at (0,0)
  - Ex: independent (cause) on x-axis, dependent (effect) on y-axis
  - Ex: x-axis scale is linear
  - Ex: increase left to right, bottom to top
  - Ex: scale divisions equal
- Departures are permitted, but require extra effort from reader so use sparingly

# **Guidelines for Good Graphs (5 of 5)**

- *Avoid ambiguity*
  - Show coordinate axes
  - Show origin
  - Identify individual curves and bars
  - Do not plot multiple variables on same chart

# Guidelines for Good Graphs (Summary)

- Checklist in Jain, Box 10.1, p. 143
- The more "yes" answers, the better
  - But, again, may consciously decide not to follow these guidelines if better without them
- In practice, takes several trials before arriving at "best" graph
- Want to present the message the most: accurately, simply, concisely, logically

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# Common Mistakes (1 of 6)

- *Presenting too many alternatives on one chart*
- Guidelines
  - More than 5 to 7 messages is too many
    - (Maybe related to the limit of human short-term memory?)
  - Line chart with 6 curves or less
  - Column chart with 10 bars
  - Pie chart with 8 components
  - Each cell in histogram should have 5+ values

- *Presenting many y-variables on a single chart*

    - Better to make separate graphs

    - Plotting many y-variables saves space, but better to requires reader to figure out relationship

        - Space constraints for journal/conf!
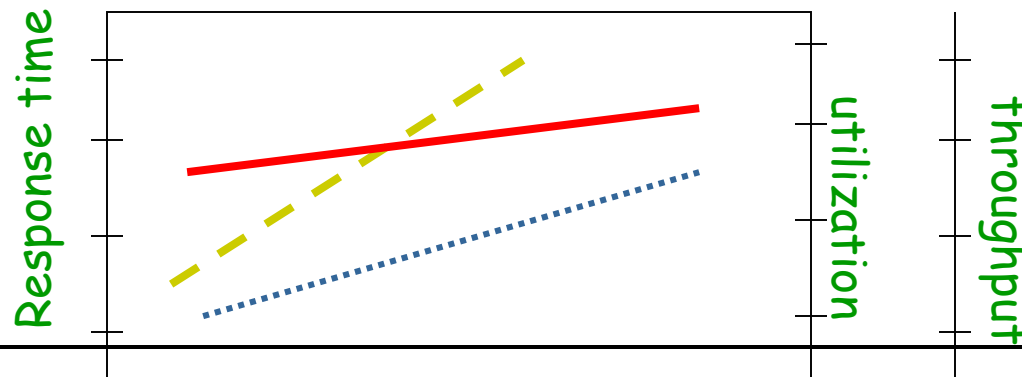
# Common Mistakes (3 of 6)

- *Using symbols in place of text*

- More difficult to read symbols than text

- Reader must flip through report to see symbol mapping to text

  - Even if "save" writers time, really "wastes" it since reader is likely to skip!
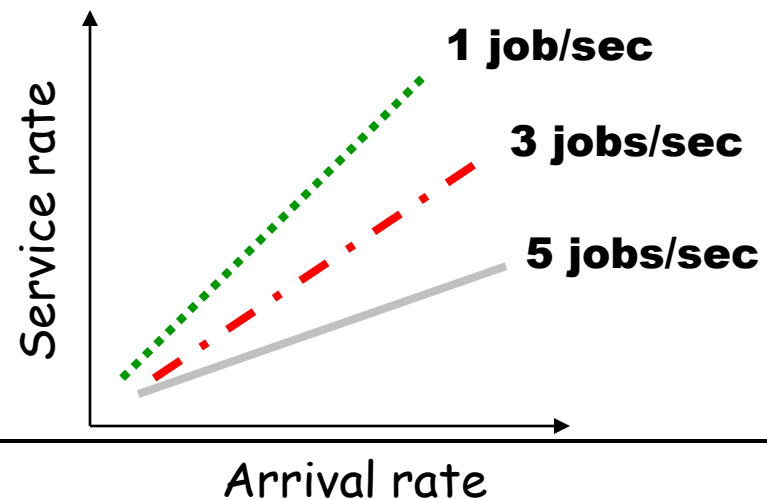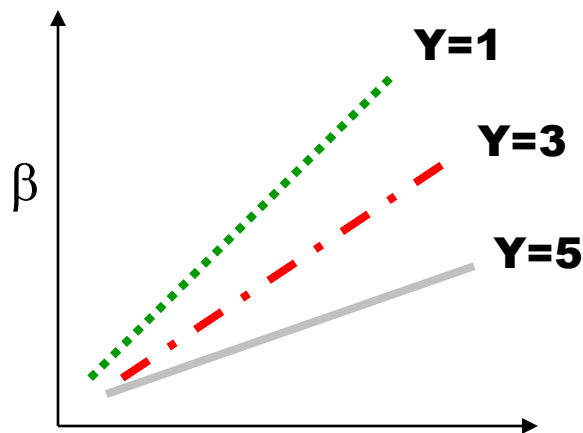
# Common Mistakes (4 of 6)

- *Placing extraneous information on the chart*
  - Goal is to convey particular message, so extra information is distracting
  - Ex: using gridlines only when exact values are expected to be read
  - Ex: "per-system" data when average data is only part of message required

- *Selecting scale ranges improperly*
  - Most are prepared by automatic programs (excel, gnuplot) with built-in rules
    - Give good first-guess
  - But
    - May include outlying data points, shrinking body
    - May have endpoints hard to read since on axis
    - May place too many (or too few) tics
  - In practice, almost always over-ride scale values

- *Using a Line Chart instead of Column Chart*
  - Lines joining successive points signify that they can be approximately interpolated
  - If don't have meaning, should not use line chart

MIPS

8000    8010    8020 8120
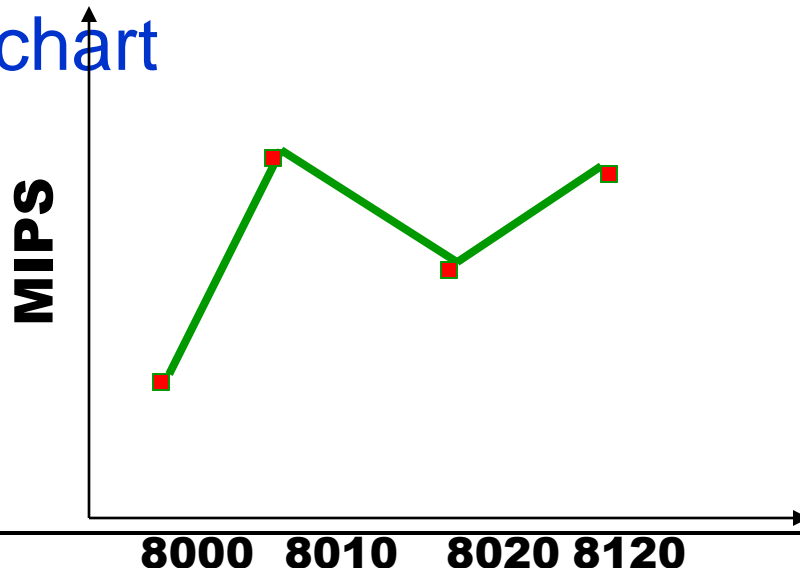
- No linear relationship between processor types!
- Instead, use column chart

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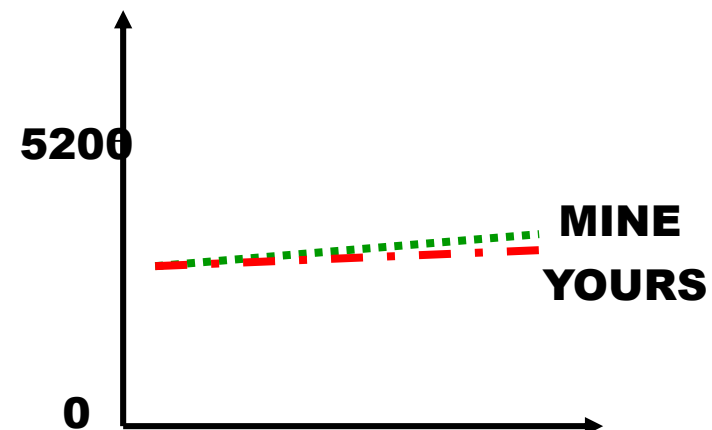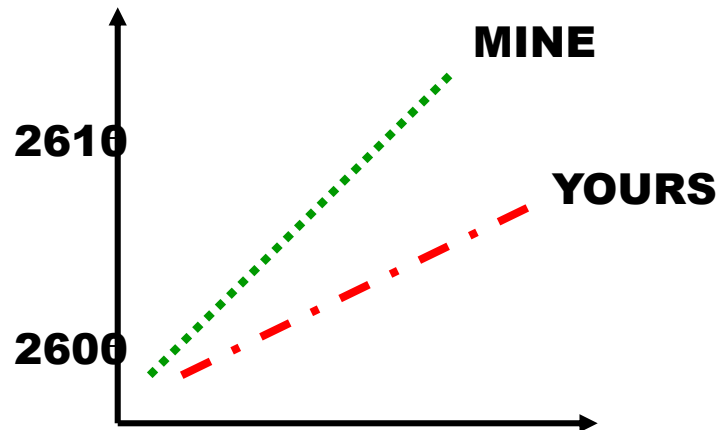- Decision Maker's Games
- Ratio Games

# Pictorial Games

- Can deceive as easily as can convey meaning
- Note, not always a question of bad practice but should be aware of techniques when reading performance evaluation

# Non-Zero Origins to Emphasize (1 of 2)

- Normally, both axes meet at origin
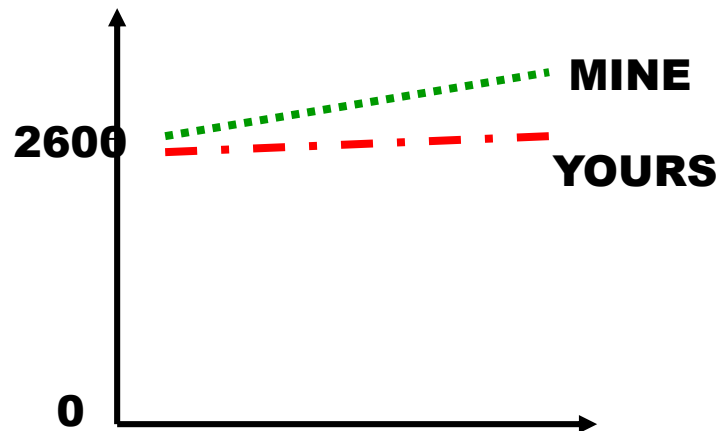- By moving and scaling, can magnify (or reduce!) difference



Which graph is better?
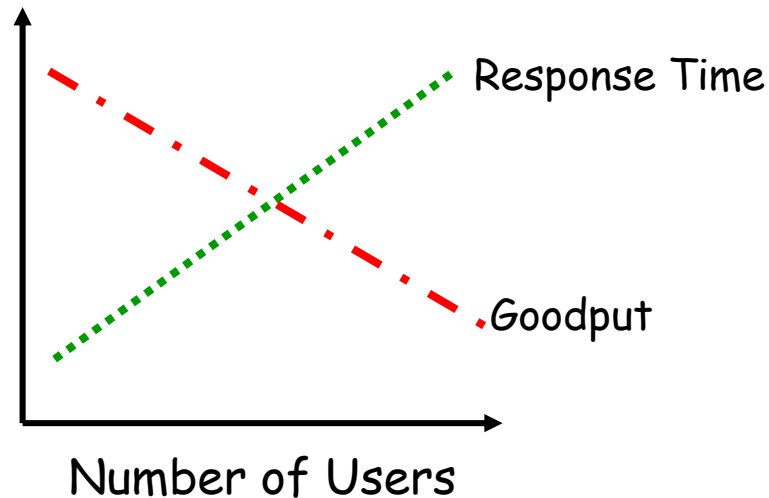
# Non-Zero Origins to Emphasize (2 of 2)

- Choose scale so that vertical height of highest point is at least ¾ of the horizontal offset of right-most point

  - Three-quarters rule

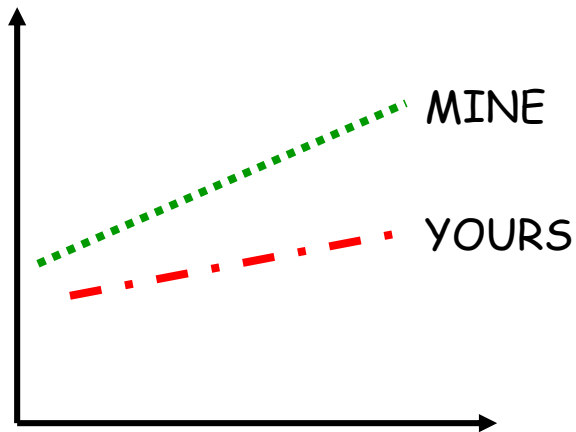- (And represent origin as 0,0)

# **Using Double-Whammy Graph**

- Two curves can have twice as much impact
  - But if two metrics are related, knowing one predicts other … so use one!

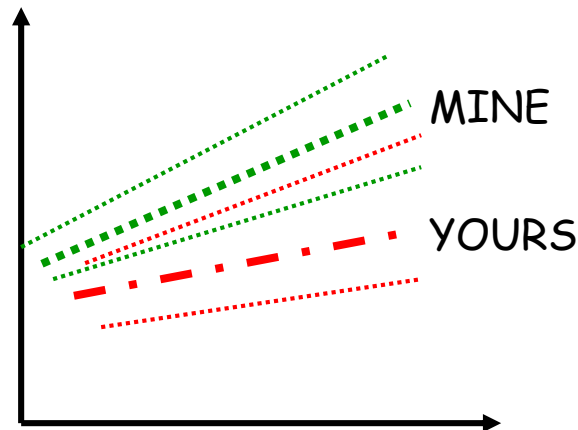# Plotting Quantities without Confidence Intervals

- When random quantification, representing mean (or median) alone (or single data point!) not enough



(Worse)                    (Better)

# Pictograms Scaled by Height

- **If scaling pictograms, do by area not height since eye drawn to area**
  - Ex: twice as good → doubling height quadruples area
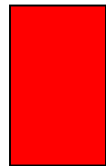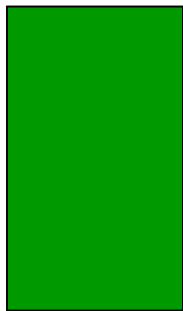


**MINE YOURS**

(Worse)
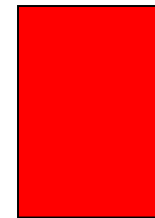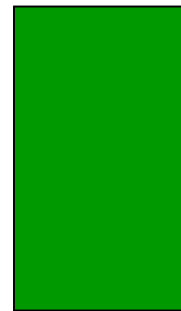
**MINE YOURS**

(Better)

# Using Inappropriate Cell Size in Histogram

- Getting cell size "right" always takes more than one attempt
  - If too large, all points in same cell
  - If too small, lacks smoothness
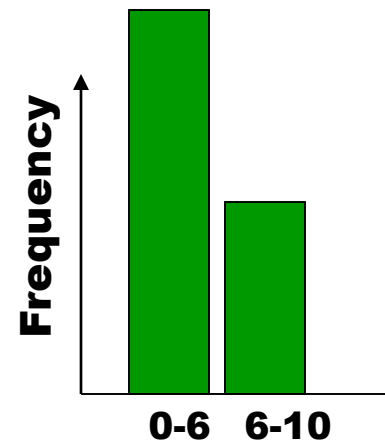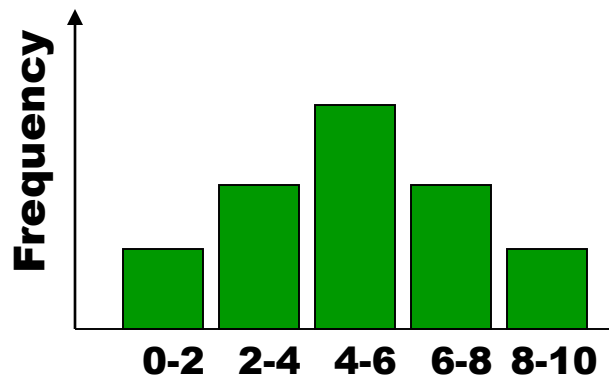


Same data. Left is "normal" and right is "exponential"

# Using Broken Scales in Column Charts

- By breaking scale in middle, can exaggerate differences
  - May be trivial, but then looks significant
  - Similar to "zero origin" problem
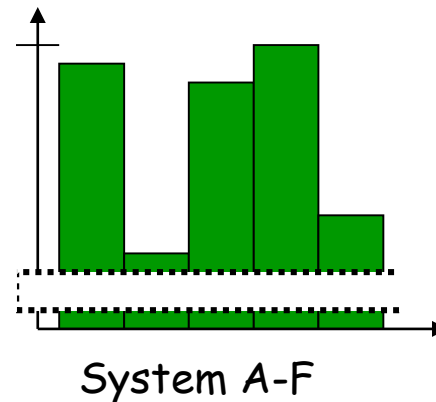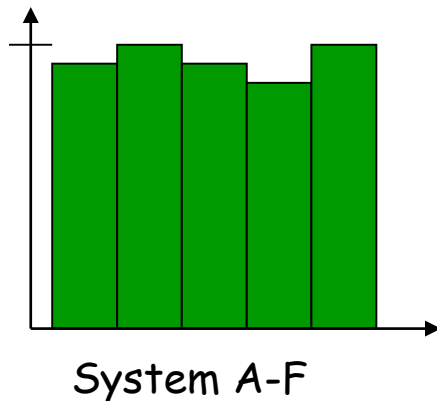


System A-F

System A-F

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# Scatter Plot (1 of 2)

- **Useful in statistical analysis**
- **Also excellent for huge quantities of data**
  - Can show patterns otherwise invisible
  - (Another example next)

*(Geoff Kuenning, 1998)*
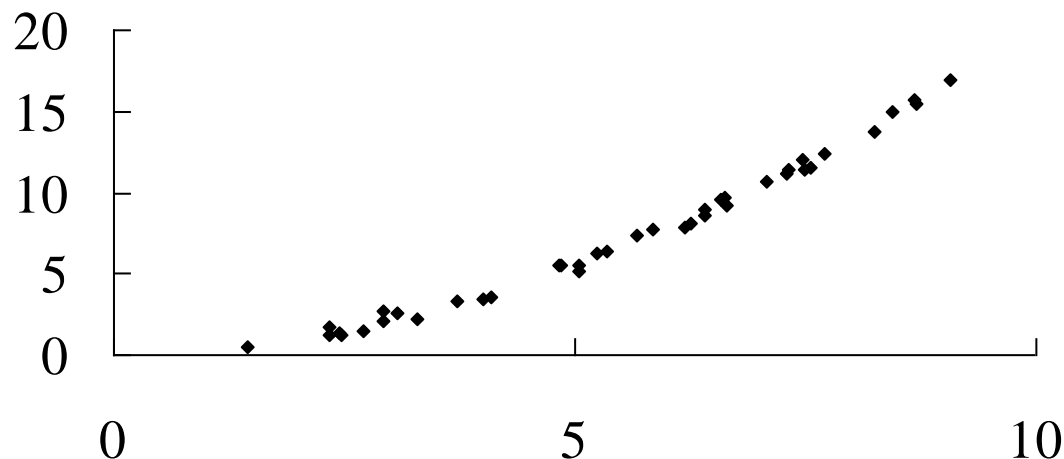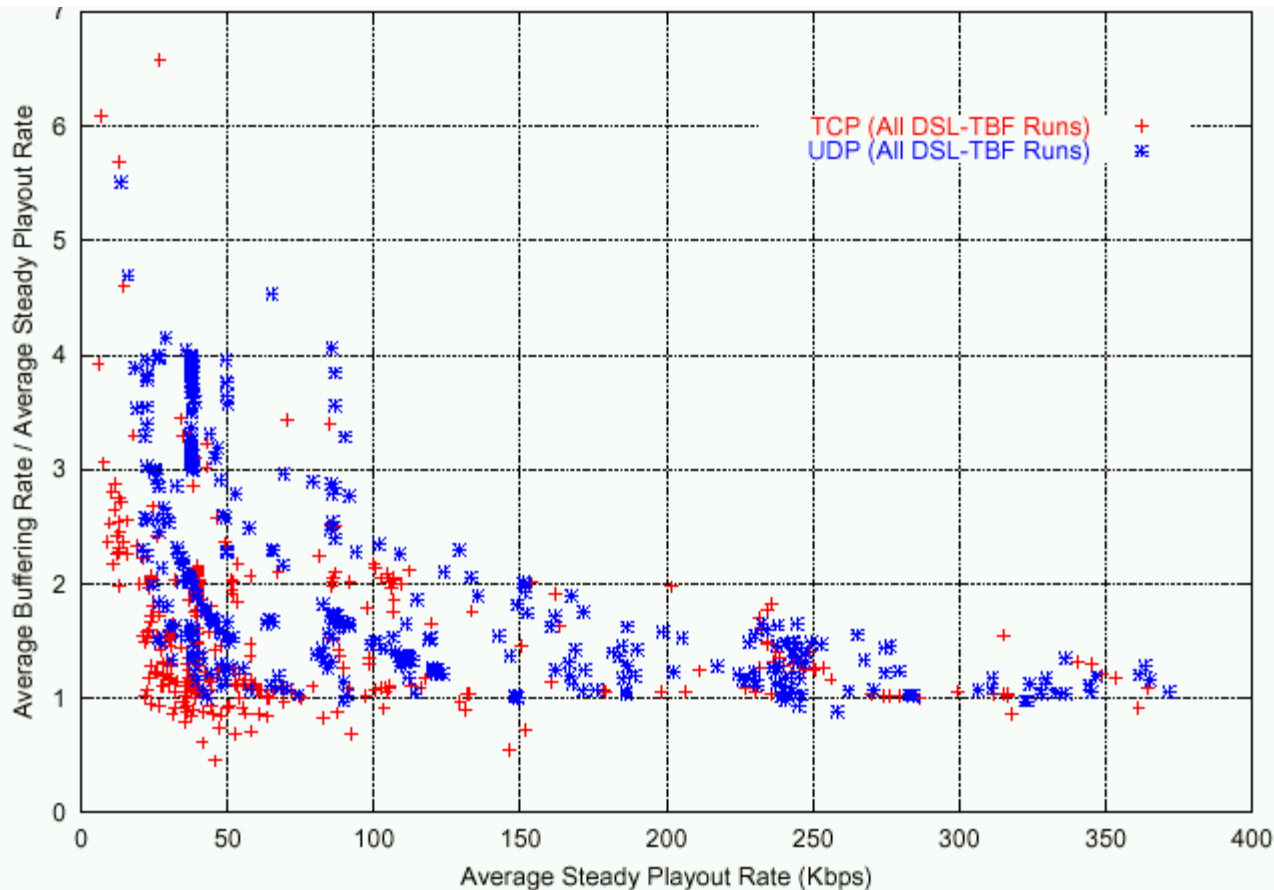
**Fig. 10.** Ratio of Average Buffering Rate to Average Steady Playout Rate versus Average Steady Playout Rate (All Runs)

# Box and Whisker's Plot

- Shows (range, median, quartiles) all in one:

minimum    quartile    median    quartile    maximum
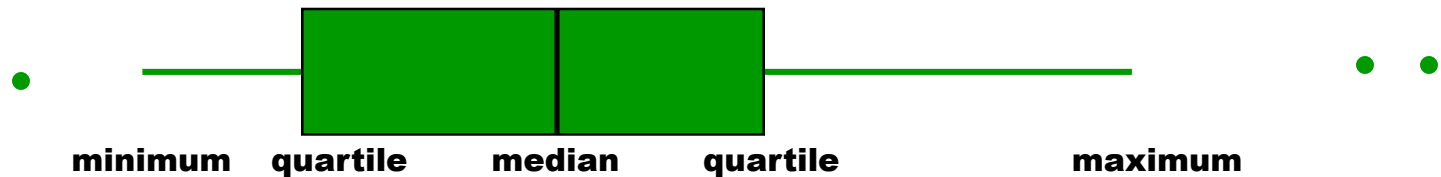
- Variations:

# Stem and Leaf Display

- "Histogram-lite" for analysis w/out software
- Scores: 34, 81, 75, 51, 82, 96, 55, 66, 95, 87, 82, 88, 99, 50, 85, 72

```
9| 6 5 9
8| 1 2 7 2 8 5
7| 5 2
6| 6
5| 1 5 0
4|
3| 4
```

# Gantt Charts (1 of 2)

- Resource too high is bottleneck

- Resource too low could be underutilization

- Want mix of jobs with significant overlap
  - Show with Gantt Chart

- In general, represents Boolean condition … *on* or *off*.  Length of lines represent busy.

**CPU**  60 ———————————

**I/O**  20  20 ———
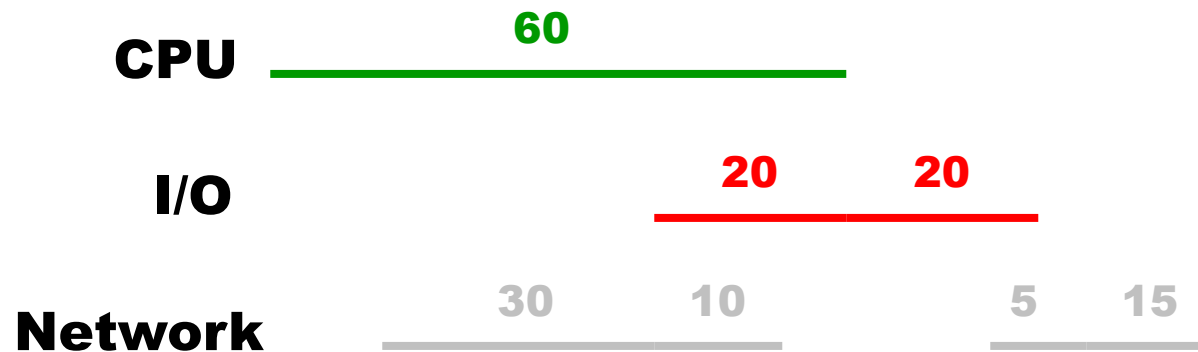
(Example 10.1 Page 151 Next)

**Network**  30  10  5  15

| A | B | C | D | Time | A | B | C | D | Time |
|---|---|---|---|------|---|---|---|---|------|
| 0 | 0 | 0 | 0 | 5    | 1 | 0 | 0 | 0 | 10   |
| 0 | 0 | 0 | 1 | 5    | 1 | 0 | 0 | 1 | 5    |
| 0 | 0 | 1 | 0 | 0    | 1 | 0 | 1 | 0 | 0    |
| 0 | 0 | 1 | 1 | 5    | 1 | 0 | 1 | 1 | 5    |
| 0 | 1 | 0 | 0 | 10   | 1 | 1 | 0 | 0 | 10   |
| 0 | 1 | 0 | 1 | 5    | 1 | 1 | 0 | 1 | 10   |
| 0 | 1 | 1 | 0 | 10   | 1 | 1 | 1 | 0 | 5    |
| 0 | 1 | 1 | 1 | 5    | 1 | 1 | 1 | 1 | 10   |

- Pattern is A and not-A first
- Rest are not-R and R

(Jain, Example 10.1 Page 151)

- Also called "star charts" or "radar plots"

- ½ are HB, ½ are LB

- Note, don't have to have all at 100% can be "10% busy", say

- Useful for looking at balance between HB and LB metrics ("Star" is best)

HB

LB

HB

LB
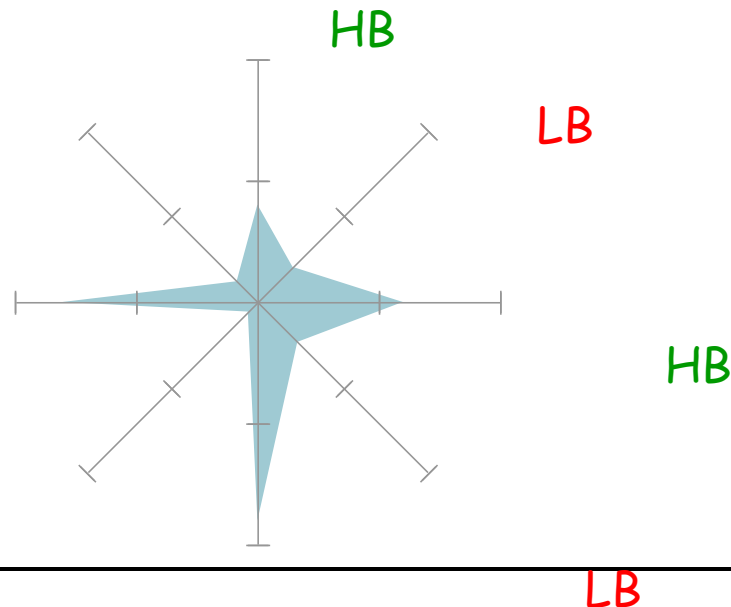
*(Geoff Kuenning, 1998)*

# Kiviat Graphs (2 of 2)

- Commonly occurring shapes can be useful to characterize system
  - "CPU keelboat" (CPU bound) (fig 10.19)
    - (A shallow, covered riverboat for freight)
  - "I/O wedge" (I/O bound) (fig 10.20)
  - "I/O arrow" (CPU + I/O) (fig 10.21)
- Most for data processing, but can be applied to other systems.  Ex: network

| HB Metrics | LB Metrics |
|---|---|
| App throughput | App response time |
| Link utilization | Link overhead |
| Router utilization | Router overhead |
| % packets arrive | # duplicates |
| % implicit acks | % packets with error |

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# Decision Maker's Games

- Even if perf analysis is correctly done, may not convince decision makers (boss, conference referees, thesis advisor…)
  - Box 10.2, p. 162 has list of reasons
- Most common:
  1) "*More analysis*." This is <u>always</u> true. Does not mean analysis done is not valuable.
  2) "*Alternate workload*". Since based on past, can always be questioned as good future workload
- Lead to endless discussion ("rat holes"). Can "head off" criticism by stating this.

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# Ratio Games (Ch 11)

*If you can't convince them, confuse them.* – Truman's Law

- A common way to play games with competitors
- Two ratios with different bases cannot be compared or averaged
  - Doing so is called "ratio game"
- Knowledge of "ratio games" will help protect ourselves, avoid doing

# Games with Base System

- Beware!
  - Normalize each system's performance for each workload by system A and average ratios
  - Normalize each system's performance for each workload by system B and average ratios

| System | Work-load 1 | Work-load 2 | Average |
|--------|-------------|-------------|---------|
| A      | 20          | 10          | 15      |
| B      | 10          | 20          | 15      |

| System | Work-load 1 | Work-load 2 | Average |
|--------|-------------|-------------|---------|
| A      | 2           | 0.5         | 1.25    |
| B      | 1           | 1           | 1       |

# Games with Ratio Metrics

- Choose a metric that is ratio of two other metrics. Power = thrput/respTime

| Network | Thrput | RespTime | Power |
|---------|--------|----------|-------|
| A | 10 | 2 | 5 |
| B | 4 | 1 | 4 |

- Suggests that A is better.
- But maybe it should be:

$$power = thrput/respTime^2$$

→ $Power_A = 2.5$, $Power_B = 4$

# Games with Relative Performance

- Metric may be specified but can still get ratio game if two are on different machines

- MFLOPS, System X-Y, accelerators A-B

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

(Base systems are different)

- **Percentages are really ratios, but disguised**
  - So can play games

| Test | A Runs | A Passes | A % | B Runs | B Passes | B % |
|------|--------|----------|-----|--------|----------|-----|
| 1 | 300 | 60 | 20 | 32 | 8 | 25 |
| 2 | 50 | 2 | 4 | 500 | 40 | 8 |
| Total | 350 | 62 | 18 | 532 | 48 | 9 |

- A is *worse* under both tests

  → but it looks *better* in Total!

- Percentages
  - Have bigger psychological impact
    - 1000% sounds bigger than 10-fold
  - Are great when both original and final performance are lousy
    - Ex: payment was $40 per week, is now $80
- When used, base should be *initial*, not *final* value
  - Ex: Price was $400, now $100
    - Drop of 400%!  But that makes no sense

# Strategies for Winning Ratio Game (1 of 2)

- (Again, don't do these, just be aware of them so no-one does them to you)

- If one system is better by all measures, a ratio game won't (usually) work
  - Although, remember percent-passes example!
  - And selecting the base also lets you change the magnitude of the difference

- If each system wins on some measures, ratio games might be possible
  - May have to try all bases

# Strategies for Winning Ratio Game (2 of 2)

| System | Work-load 1 | Work-load 2 | Base B | Base A |
|--------|---------|---------|--------|--------|
| A | 20 | 10 | 1.25 | 1 |
| B | 10 | 20 | 1 | 1.25 |

- For LB metrics, use your system as the base
  - Ex: response time
- For HB metrics, use the other system as a base
  - Ex: throughput
- If possible, adjust lengths of benchmarks
  - Run longer when your system performs best
  - Run short when your system is worst
  - This gives greater weight to your strengths

# Extra Credit for Next Class

- Bring in one either notoriously bad or exceptionally good example of data presentation
  - The bad ones may be more fun
- From proceedings, technical documentation, newspaper …
- Make copies before class or send to me and I'll make copies
- We'll discuss why good/bad