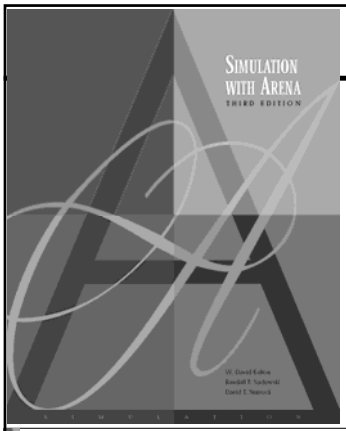


What is Simulation?

Chapter 1
Subset Only

Last revision June 7, 2003

Advantages of Simulation

- **Flexibility to model things as they are (even if messy and complicated)**
  - Avoid *looking where the light is* (a morality play):
    You're walking along in the dark and see someone on hands and knees searching the ground under a street light.
    You: "What's wrong? Can I help you?"
    Other person: "I dropped my car keys and can't find them."
    You: "Oh, so you dropped them around here, huh?"
    Other person: "No, I dropped them over there." (Points into the darkness.)
    You: "Then why are you looking here?"
    Other person: "Because this is where the light is."
- **Allows uncertainty, nonstationarity in modeling**
  - The only thing that's for sure: nothing is for sure
  - Danger of ignoring system variability
  - Model validity

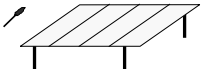
Advantages of Simulation (cont'd.)

- **Advances in computing/cost ratios**
  - Estimated that 75% of computing power is used for various kinds of simulations
  - Dedicated machines (e.g., real-time shop-floor control)
- **Advances in simulation software**
  - Far easier to use (GUIs)
  - No longer as restrictive in modeling constructs (hierarchical, down to C)
  - Statistical design & analysis capabilities

The Bad News

- **Don't get exact answers, only approximations, estimates**
  - Also true of many other modern methods
  - Can bound errors by machine roundoff
- **Get random output (*RIRO*) from stochastic simulations**
  - Statistical design, analysis of simulation experiments
  - Exploit: noise control, replicability, sequential sampling, variance-reduction techniques
  - Catch: "standard" statistical methods seldom work

Simulation by Hand: The Buffon Needle Problem



- **Estimate π (George Louis Leclerc, c. 1733)**
- **Toss needle of length *l* onto table with stripes *d* (>*l*) apart**
- ***P* (needle crosses a line) = $\frac{2l}{\pi d}$**
- **Repeat; tally $\hat{p}$ = proportion of times a line is crossed**
- **Estimate π by $\frac{2l}{\hat{p}d}$**

Why Toss Needles?

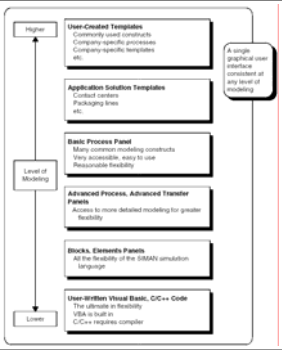
- **Buffon needle problem seems silly now, but it has important simulation features:**
  - Experiment to *estimate* something hard to compute exactly (in 1733)
  - *Randomness*, so estimate will not be exact; estimate the error in the estimate
  - *Replication* (the more the better) to reduce error
  - *Sequential sampling* to control error — keep tossing until probable error in estimate is "small enough"
  - *Variance reduction* (*Buffon Cross*)

Using Computers to Simulate (cont'd.)

- **Simulation languages**
  - GPSS, SIMSCRIPT, SLAM, SIMAN (on which Arena is based, and is included in Arena)
  - Popular, still in use
  - Learning curve for features, effective use, syntax
- **High-level simulators**
  - Very easy, graphical interface
  - Domain-restricted (manufacturing, communications)
  - Limited flexibility — model validity?

Where Arena Fits In

- **Hierarchical structure**
  - Multiple levels of modeling
  - Can mix different modeling levels together in the same model
  - Often, start high then go lower as needed
- **Get ease-of-use advantage of simulators without sacrificing modeling flexibility**



When Simulations are Used

- **Uses of simulation have evolved with hardware, software**
- **The early years (1950s-1960s)**
  - Very expensive, specialized tool to use
  - Required big computers, special training
  - Mostly in FORTRAN (or even Assembler)
  - Processing cost as high as $1000/hour for a sub-286 level machine

When Simulations are Used (cont'd.)

- **The formative years (1970s-early 1980s)**
  - Computers got faster, cheaper
  - Value of simulation more widely recognized
  - Simulation software improved, but they were still languages to be learned, typed, batch processed
  - Often used to clean up "disasters" in auto, aerospace industries
    - Car plant; heavy demand for certain model
    - Line underperforming
    - Simulated, problem identified
    - But demand had dried up — simulation was too late

When Simulations are Used (cont'd.)

- **The recent past (late 1980s-1990s)**
  - Microcomputer power
  - Software expanded into GUIs, animation
  - Wider acceptance across more areas
    - Traditional manufacturing applications
    - Services
    - Health care
    - "Business processes"
  - Still mostly in large firms
  - Often a simulation is part of the "specs"

When Simulations are Used (cont'd.)

- **The present**
  - Proliferating into smaller firms
  - Becoming a standard tool
  - Being used earlier in design phase
  - Real-time control
- **The future**
  - Exploiting interoperability of operating systems
  - Specialized "templates" for industries, firms
  - Automated statistical design, analysis
  - Networked sharing of data in real time
  - Integration with other applications
  - Distributed model building, execution