



Logistics Simulation with Arena

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Research Methodology-Big Picture



- ***Analytical Research***
 - **Mathematical models**
 - **Theoretical analysis**

- ***Empirical Research***
 - **Case study**
 - **Data study**
 - **Description Statistics**
 - **Regression, ANOVA, Factor analysis etc.**
 - **Simulation**
 - **Data types**
 - **Survey/Interview data**
 - **Archival data**
 - **Simulation data**



Simulation Is ...



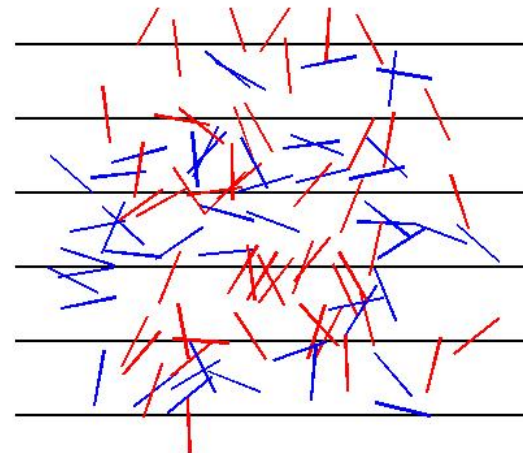
- ***Simulation*** are methods and applications to imitate or mimic real systems, usually via computer
- ***Computer simulation*** is usually used to
 - Numerically evaluate some policies on a computer
 - Use software to imitate the system's operations and features



Simulation without computer?



- **Can we carry on a simulation projects without computer?**
 - **Buffon and the Pai (ratio of the circumference of a circle to the diameter)**
 - **Setting for the experiment**
 - **The probability of intersects: $p = 2L/\pi d$**
 - **Results he got: $2212/704=3.142$**





When to use simulation?



When to use simulation?



- **When it's hard to play with the actual one**
 - **When the system doesn't exist and will be built;**
 - **When it would be too expensive, or dangerous to deal with real system. Simulation model is usually much easier, faster, cheaper & safer;**
- **When we want to try a brand new idea to improve**
 - **Making decisions for an alternative system**
 - **Try wide-ranging different parameters with the model;**
- **When we want to confirm or proof the accuracy of our theory**
 - **Use numerical study after the theoretical models had been built**



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."

- **The real power of simulation is in studying complex models**
 - **Allows uncertainty, nonstationarity in modeling**



Popularity of Simulation



- **Has been consistently ranked as the most useful, popular tool in the broader area of operations research / management science**
 - **1979: Survey 137 large firms, which methods used?**
 1. Statistical analysis (93% used it)
 2. Simulation (84%)
 3. Followed by LP, PERT/CPM, inventory theory, NLP, ...
 - **1980: (A)IIE O.R. division members**
 - First in utility and interest — simulation
 - First in familiarity — LP (simulation was second)
 - **1983, 1989, 1993: Longitudinal study of corporate practice**
 1. Statistical analysis
 2. Simulation
 - **1989: Survey of surveys**
 - Heavy use of simulation consistently reported
- **Since these surveys, hardware and software have improved, probably making simulation even more attractive**



The Bad News



- **Don't get exact answers, only approximations, estimates**
 - **Also true of many other modern methods**
 - **Can get confidence intervals with enough replications**
- **Rely on the development of power of computer when dealing with big complicated project.**



Different Kinds of Simulation



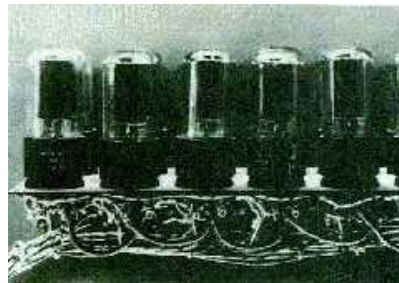
- **Static vs. *Dynamic***
 - Does time have a role in the model?
- **Continuous-change vs. *Discrete-change***
 - Can the “state” change continuously or only at discrete points in time?
- **Deterministic vs. *Stochastic***
 - Is everything for sure or is there uncertainty?
- **Most operational models:**
 - *Dynamic, Discrete-change, Stochastic*
 - Textbook: Chapter 2 discusses a static model, and Chapter 11 discusses continuous and combined discrete-continuous models



When Simulations are Used

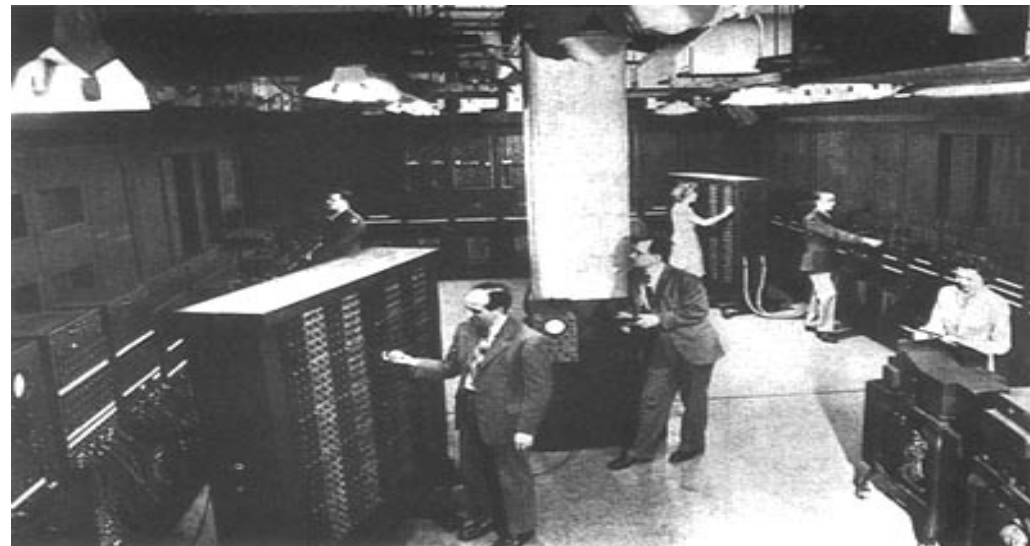


- **Uses of simulation have evolved with hardware, software**
- **The early years (1950s-1960s)**
 - **Very expensive, specialized tool to use**
 - **Required big computers, special training**
 - **Mostly in FORTRAN (or even Assembler)**
 - **Processing cost as high as \$1000/hour for a sub-286 level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



1946 ENIAC

First Computer



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**



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”——logistics**
 - **Still mostly in large firms**



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**





- **Thanks**
- **Q&A**

