Computers in Manufacturing Enterprises

Simulation and Modeling

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Simulation and Modeling - Introduction

- **Simulation**
  - imitation of the *operation* of a real-world process or system over time
  - first requires that a model be developed
  - model represents the key characteristics / functions of the system
- **Model**

  imitation of a *real system* which represents objects within the system and the rules that directs the interactions of the objects

  model represents the system itself, whereas the simulation represents the operation of the system over time

wikipedia

Types of Simulation

- **Continuous simulation**
  - Treats time as continuous
  - Expresses changes in terms of a set of differential equations that reflect the relationships among the set of characteristics
  - Meteorological models fall into this category
- **Discrete event simulation**

  Made up of *entities*, *attributes*, and *events*
  - **Entity** The representation of some **object** in the real system that must be explicitly defined
  - **Attribute** Some **characteristic** of a particular entity
  - **Event** An **interaction** between entities
  - for example
    - The arrival of an entity to a workstation, failure of a resource, completion of an activity or the end of a shift
    - A restaurant simulation because all of the state variables in the model, such as the number of customers in the restaurant

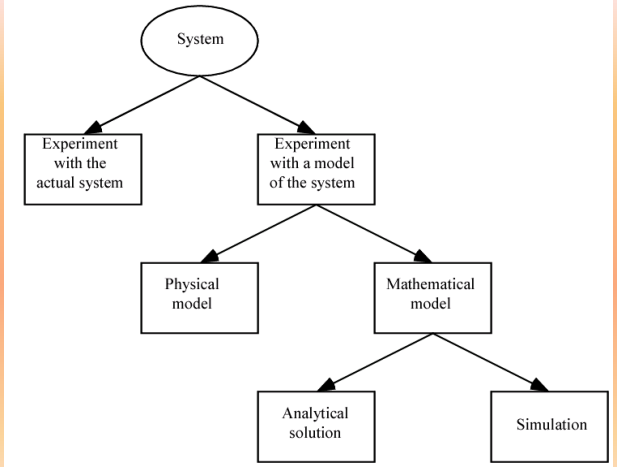
Types of Simulation

- **static simulation**
  - *not based on time*
  - *involves drawing* random samples to generate a statistical outcome, so it is sometimes called Monte Carlo simulation
  - used in finance to select a portfolio of stocks and bonds; given a portfolio, with different probabilistic payouts, it is possible to generate an expected yield
  - One material handling system supplier developed a static simulation model to calculate the expected time to travel from one rack location in a storage system to any other rack location. A random sample of 100 from-to relationships were used to estimate an average travel time
  - if every from-to trip been calculated, a 1,000-location rack would have involved 1,000 factorial calculations
- ***Dynamic simulation***
  - *includes the passage of time*
  - *looks at state changes* as they occur over time
  - A clock mechanism moves forward in time and state variables are updated as time advances
  - well suited for analyzing manufacturing and service systems since they operate over time

Reasons for Using Simulation

- generally cheaper and safer than conducting experiments with a prototype of the final product
  - computers simulate the detonation of nuclear devices and their effects in order to support better preparedness in the event of a nuclear explosion
  - efforts are conducted to simulate hurricanes and other natural catastrophes
- can often be even more realistic than traditional experiments, as they allow the free configuration of environment parameters found in the operational application field o f the final product
  - supporting deep water operation of the US Navy or the simulating the surface of neighbored planets in preparation of NASA missions
- can often be conducted faster than real time which allows for efficient test for different alternatives

Ways to study a system



Manufacturing Issues Addressed by Simulation

- **The need for and the quantity of equipment and personnel**
  - Number and type of machines to be used and physical arrangement of transporters, conveyors, and other support equipment (e.g., pallets and fixtures)
  - Location and size of inventory buffers
  - Evaluation of a change in product volume or mix
  - Evaluation of the effect of a new piece of equipment on an existing manufacturing system
  - Evaluation of capital investments and labour requirements
- **Performance evaluation**
  - Throughput analysis
  - Time-in-system analysis and Bottleneck analysis
- **Evaluation of operational procedures**
  - Production scheduling. inventory and Quality-control policies
  - Control strategies [e.g., for an automated guided vehicle system (AGVS)]
- **Performance measures**
  - Times parts spend in queue and Queue sizes
  - Timeliness of deliveries and Utilization of equipment or personnel

http://www.informs-sim.org/wsc97papers/0086.PDF

Simulation Softwares

- simulation languages are Arena, AweSim!, Extend, GPSS/H, Micro Saint, MODSIM III, SES/workbench, SIMPLE++, SIMSCRIPT II.5, SIMUL8, and SLX
- http://www.mathworks.in/videos/production-simulation-software-for-manufacturing-68930.html

Advantages of Simulation

- allows great flexibility in modeling complex systems, so simulation models can be highly valid
- Easy to compare alternatives
- Control experimental conditions
- Can study system with a very long time frame

Monte Carlo Simulation

- invented by scientists working on the atomic bomb in the 1940s, who named it for the city in Monaco famed for its casinos and games of chance
- core idea is to use **random samples** of parameters or inputs to explore the behavior of a complex system or process
- Monte Carlo methods have been applied to an incredibly diverse range of problems in science, engineering, and finance -- and business applications in virtually every industry
- **Why Should I Use Monte Carlo Simulation?**
  - When the need is to make an estimate, forecast or decision where there is significant uncertainty

http://www.solver.com/monte-carlo-simulation-overview#What_is_Monte_Carlo_Simulation

Example 1: portfolio return problem

Current Investment	1,00,000
Average return per year	11.2%
Standard Deviation of return (risk)	18%
Time to retire (in years)	30
Amount to invest (annually)	10,000.00

What that money will be worth after 30 years assuming variation in rate of return every year?

https://www.youtube.com/watch?v=Q5Fw2IRMjPQ

Example 2: project cost problem

- A project has 6 activities; A,B,C,D,E,F
- assumption
  - each activity has a total cost in the specified range and has a uniform distribution
  - cost of one activity is not influenced by the cost of other activity -> they are independent of each other
- total cost of the project is:
  - a random variable, value between minimum and maximum
  - normally distributed

Activity	Minimum	Maximum
A	10,000	20,000
B	15,000	15,000
C	7,500	12,000
D	4,800	6,200
E	20,000	25,000
F	5,000	7,000
Total	**62,300**	**85,200**

Find the total cost of the project in different scenarios.

http://www.projectsmart.co.uk/docs/monte-carlo-simulation.pdf