Learn M & S: From B K Sharma

Subject Title: Modeling and Simulation

Subject Code: TCS- 506

Total Number of Units: 4

Maximum Marks: 50

Unit I: Contains 4 Chapters:

Introduction
System
Models and
DES & CES

Unit II: Contains 2 Chapters:

GPSS and
RNG

Unit III: Contains 1 Chapter:

RVG

Unit IV: Contains 1 Chapter:

Queuing Models

Modeling and Simulation (TCS-506)

Introduction

Unit I : Syllabus

- Introduction:
  - System
  - Models
  - Discrete event simulation and
  - Continuous simulation
- Discrete Event Simulation:
  - Time-Advance Mechanisms
  - Event Modeling of discrete dynamic systems
  - Single-Server Single-Queue Model
  - Event graphics
  - Monte Carlo Simulation

Model

Is an abstract/mathematical representation

of a real system

that has the ability to predict

the behavior of the real system

under a set of defined

operating conditions

and

simplifying assumptions.

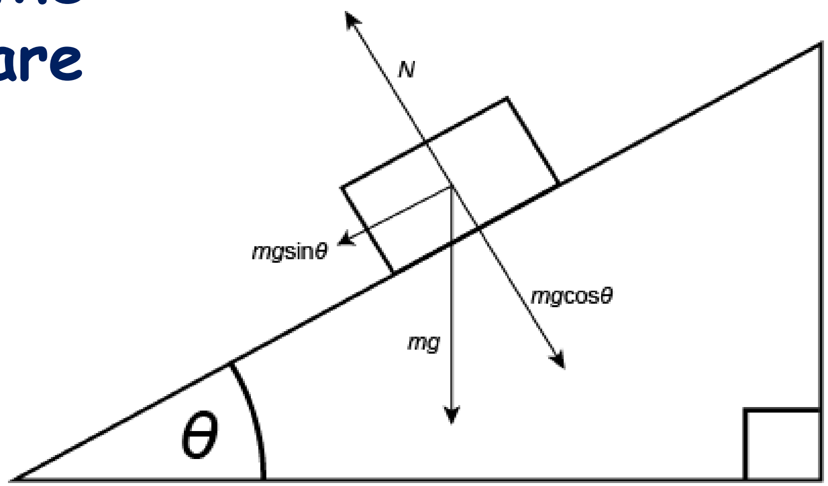
a set of conditions for operating a particular system or process.

Simple Model of Complex Real Thing for simplifying analysis as much as possible.

Simplifying Assumptions

AN EXAMPLE FROM PHYSICS: A BLOCK ON A FRICTIONLESS PLANE

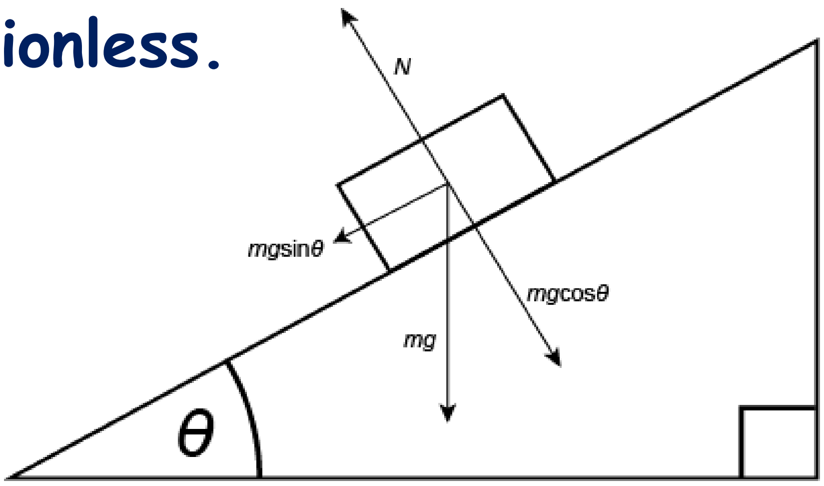
The details of the materials the block and plane are made of are ignored.



Simplifying Assumptions

AN EXAMPLE FROM PHYSICS:
A BLOCK ON A FRICTIONLESS PLANE

Assume that the plane is frictionless.



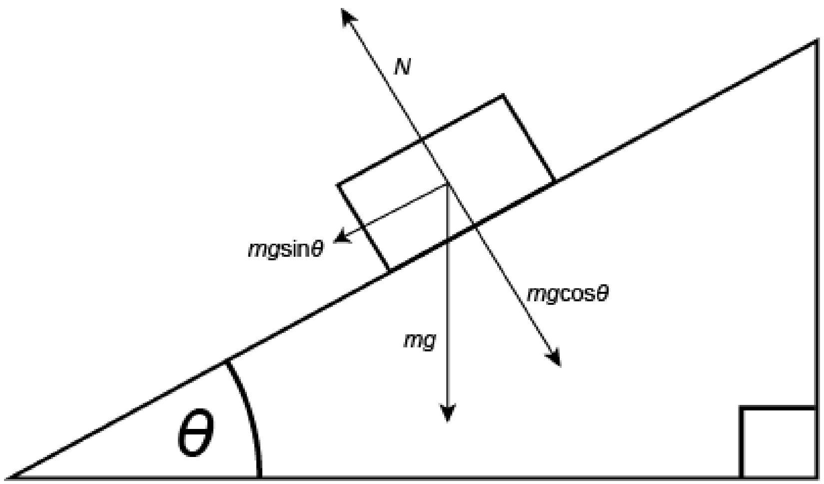
Simplifying Assumptions

AN EXAMPLE FROM PHYSICS: A BLOCK ON A FRICTIONLESS PLANE

The simplifying assumptions allow the student to *practice thinking* about:

how to balance the forces acting on the block when it is elevated in a gravity field and

the surface that it is sitting on is not perpendicular to the gravity vector (*mg*).



Simplifying Assumptions

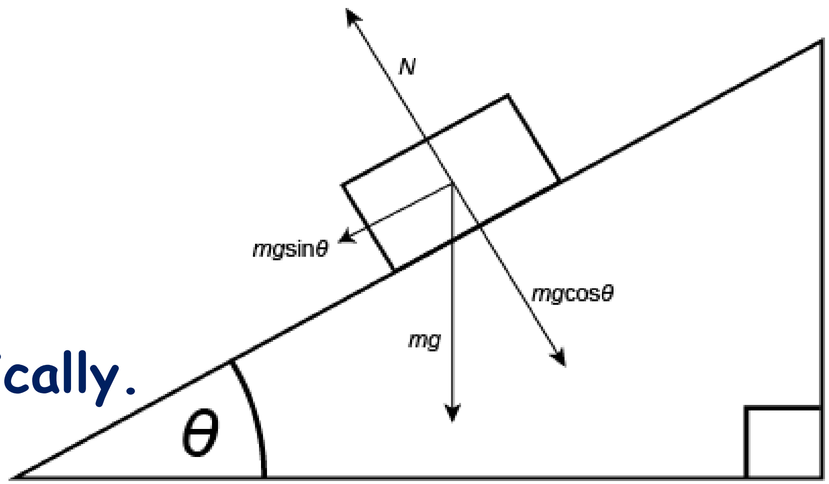
AN EXAMPLE FROM PHYSICS:
A BLOCK ON A FRICTIONLESS PLANE

This simplifies the math and

allows the student to focus on

the geometry of the model and

how to represent that mathematically.



Simplifying Assumptions

AN EXAMPLE FROM PHYSICS:
A BLOCK ON A FRICTIONLESS PLANE

This simplifies the math and allows the student to focus on the geometry of the model and how to represent that mathematically.

The model, and its simplifying assumptions, might do a reasonably good job of predicting the behavior of an ice cube sliding down an glass incline plane but would likely do a bad job of predicting the behavior of a wet sponge on an incline plane coated with sand paper.

The model would be oversimplified for the latter scenario.

Model

Simplifying Assumptions

Usually, in science and everyday life alike, simple models are preferred over complex ones.

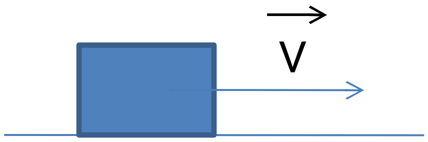
Creating simple models of complex real things requires us to make what are known as simplifying assumptions.

As their name implies, simplifying assumptions are assumptions that are included in the model to simplify the analysis as much as possible.

When a simplified model no longer predicts behavior of the real thing within acceptable bounds, too many simplifying assumptions have been made.

When little predictive value is gained from adding more details to a model, it is likely overly complex.

Examples: Movement of a system



This system can be modeled by the equation:

$$d = s * t$$

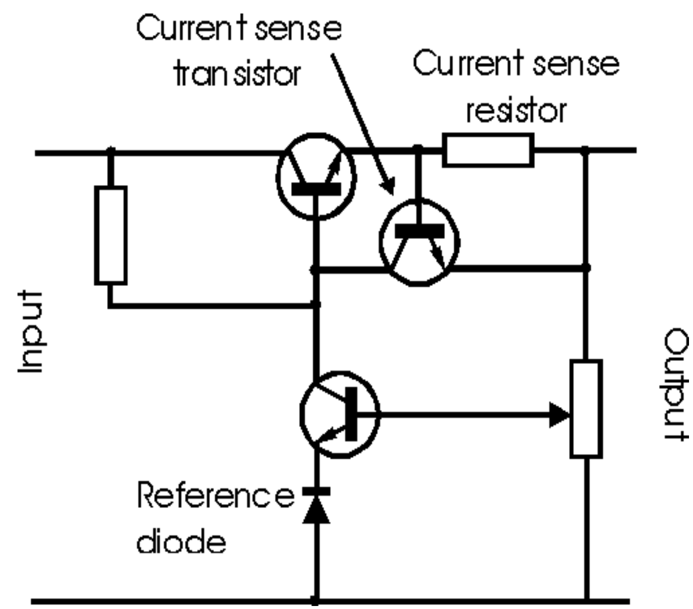
Where,

d is the distance run through

s is the speed of the object

t is the time that has been taken.

Examples

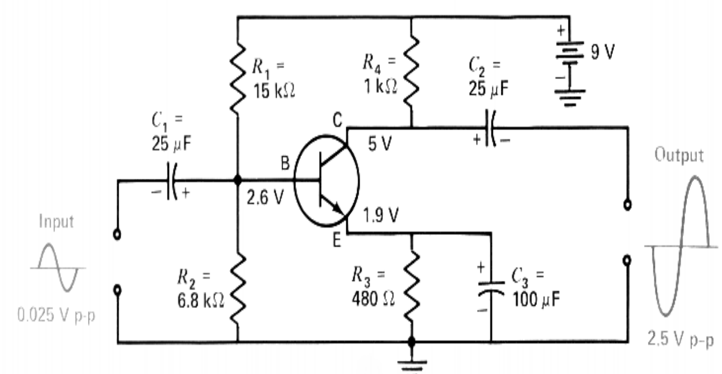


Models of the System

$$I = \frac{E}{R} \qquad E = IR$$

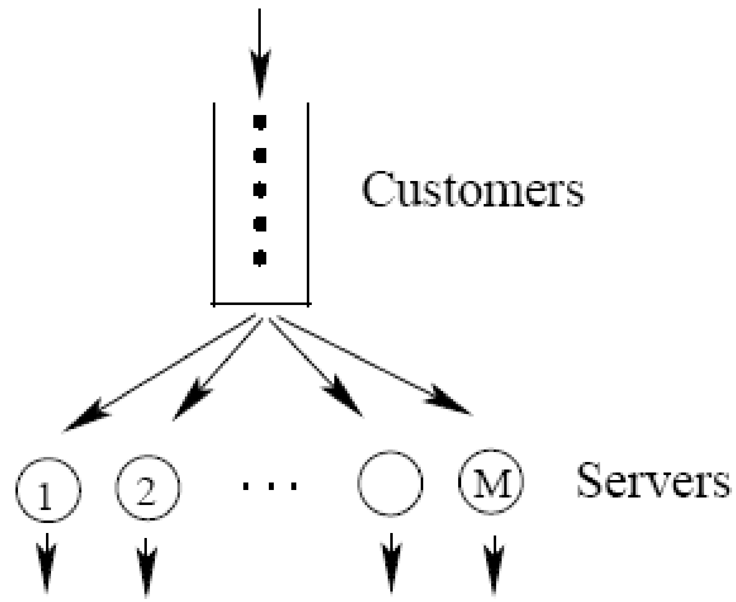
$$R = \frac{E}{I} \qquad P = EI$$

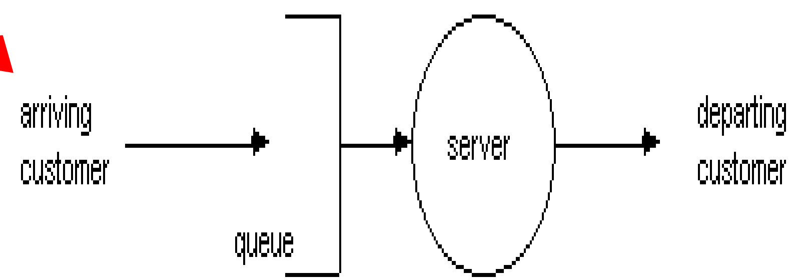
$$hfe = \frac{I_c}{I_b} \qquad I_b = \frac{I_c}{hfe}$$



Examples

Models of the System





Modeling

is the process of developing a model
with
a specific tool.

Modeling involves:

observing a system,

noting the various components,

then

developing a model (representation) of the system

that will allow for

further study of

or

experimentation on the system.

Modeling

Real-world process

A set of assumptions concerning the behavior of a system

Modeling & Analysis

Characteristics of a model

A model is **never equal to** the real system.

(Why?)

because it is always simpler than the reality.

The **accuracy** of a model is determined by its tendency to approach the real system.

Is that a problem?

Yes, if the model ignore important parameters of the real system (over simplification)

No, if the model takes into account the important parameters (ignoring some details is sometimes not problematic)

Why to use Models?

Implementation of real systems is very complex and costly.

Experimentation on real systems may be dangerous/hazardous/risky (e.g. chemical systems, Nuclear Bombs)

System does not physically exist (Upcoming Systems).

To aid in decision making process

To aid in thought

Prediction/Forecasting

If models adequately describes the reality, experimenting with them can save money and time, and reduce the development complexity.

Uses of Models : A Model Can be used

To investigate a wide variety of "What if questions about real world system"

- Potential changes to the system can be effected or not and predicate their impact on the system.
- Find adequate parameters before implementation.

Uses of Modeling: Modeling can be Used

For systems with some sort of uncertainty:

- Waiting time in a restaurant/airport.
- Time to go from home to the University.
- Response time and Throughput of a web server.
- The productivity of manufacturing systems.
- Design of multi-processor machine.

And Many More

My Dear !!!!

Simulation

is a numerical technique

for conducting experiments

with model

to gather data

in order to estimate

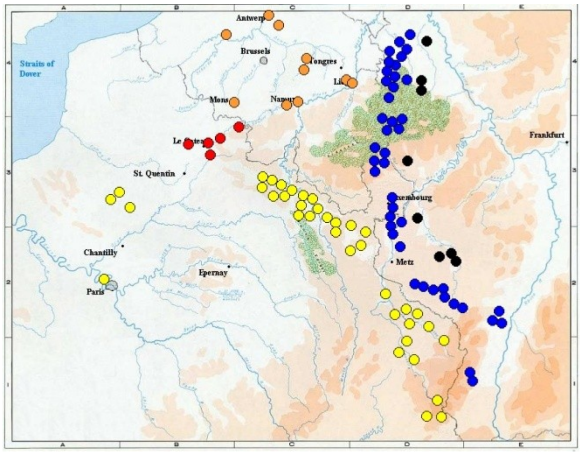
the desired characteristics of the model

on a digital computer

over extended periods of time.

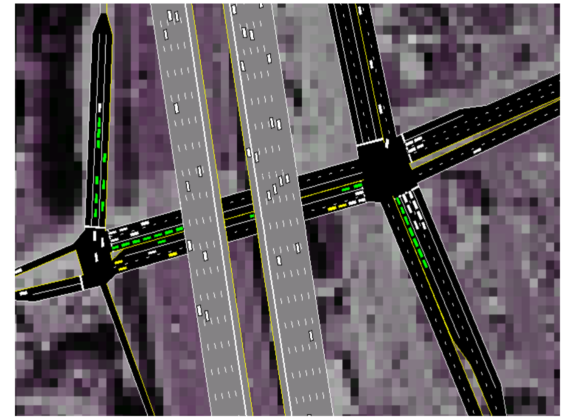
M & S : B K Sharma

Simulation :A Few Example Applications



War gaming: test strategies; training

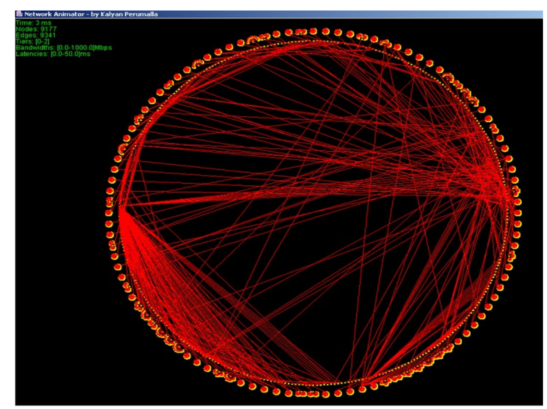
Flight Simulator



Transportation systems: improved operations; urban planning

Parallel computer systems: developing scalable software

Games



Computer communication network: protocol design

Simulation: Example

A manufacturing firm that is thinking to build a large extension onto one of its plants.

Question:

Will the potential gain in productivity justify the construction cost?

Problem:

It would not be cost effective to build the extension and then remove it later if it does not work out.

Solution:

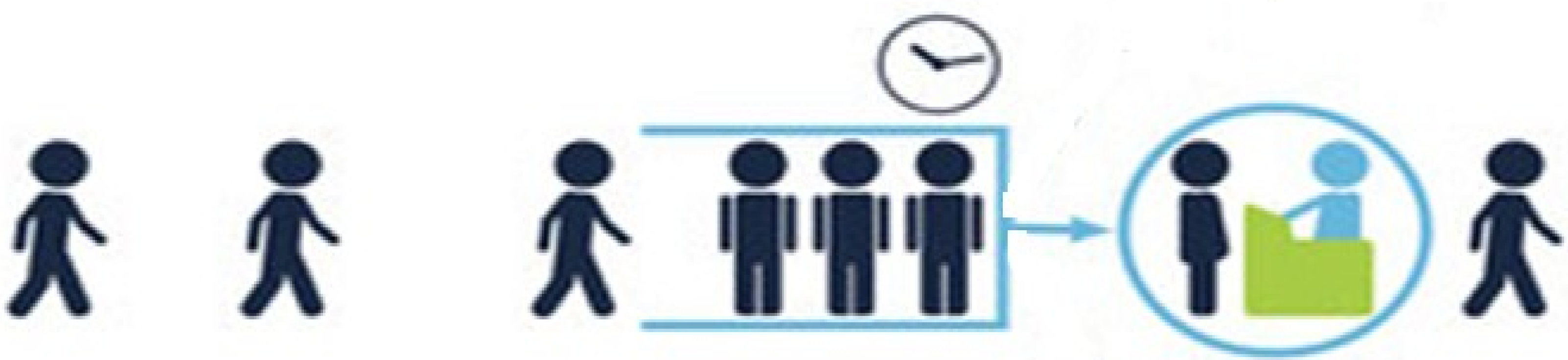
Simulation!

Learn M & S : From B K Sharma

Simulation: Example

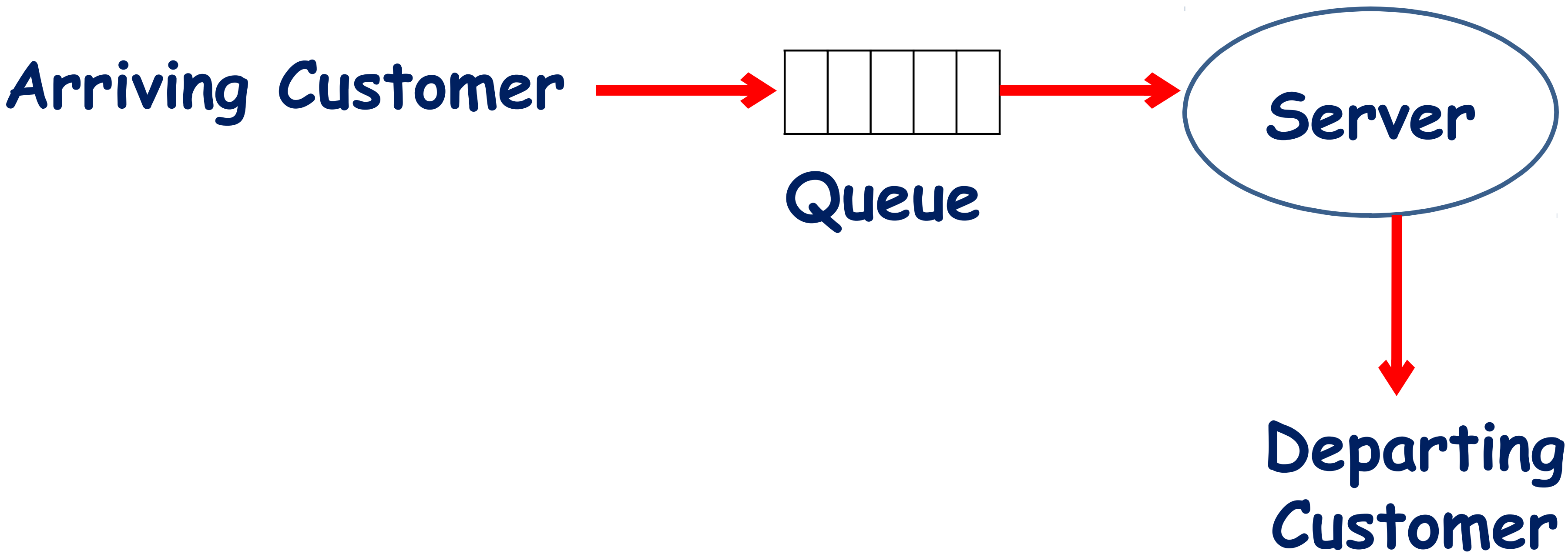
A Single-Server Queue

This is Real System.



Simulation: Example

This is Model of a Single-Server Queue



Simulation: Example

This is Mathematical Model.

1. Average waiting time for a customer

$$= \frac{\text{Total time customers wait in queue(minute)}}{\text{Total number of customers}}$$

2. Prob. that a customer has to wait in a queue

$$= \frac{\text{Number of customers who wait}}{\text{Total number of customers}}$$

Simulation: Example

This is Mathematical Model.

3. Proportion of idle time of the server

$$= \frac{\text{Total idle time of server(minute)}}{\text{Total run time of simulation(minute)}}$$

Findings from the Simulation

1. Average waiting time for a customer

$$= \frac{\text{Total time customers wait in queue(minute)}}{\text{Total number of customers}}$$

$$= \frac{56}{20} = 2.8 \text{ min}$$

Findings from the Simulation

2. Prob. that a customer has to wait in a queue

=

$$\frac{\text{Number of customers who wait}}{\text{Total number of customers}}$$

$$= \frac{13}{20} = 0.6$$

Findings from the Simulation

3. Proportion of idle time of the server

$$= \frac{\text{Total idle time of server(minute)}}{\text{Total run time of simulation(minute)}}$$

$$= \frac{18}{86} = 02$$

Thus, the probability of the server being busy is the complement of 0.21, or 0.79

Model, Simulate and Analyze

Model: construct an Abstract / a conceptual / a Mathematical framework that describes a system

Simulate: perform experiments using computer implementation of the model.

Analyze: draw conclusions from output that assist in decision making process

Simulation

The behavior of a system that evolves over time is studied by developing Simulation Model.

Simulation Can be used As:

Analysis tool for predicting the effect of changes.

Design tool to predict the design of new System.

Why we need to Simulate?

Many systems are highly complex, precluding (preventing) the possibility of analytical solution.

Analytical models may be very complex to evaluate, and may lead to over implications (repercussions/ inferences) of the real system.

The analytical solution are extraordinary complex, taking very much computing resources.

Why we need to Simulate?

Mathematical models too abstract for complex systems.

Simulation is a good compromise!

Simulation can be a good alternative to evaluate the system behavior very close to reality.

Why we need to Simulate?

Thus system should be studied by means of simulation:

Numerically exercising the model for inputs in question to see how they affect the output measures of performance.

To save money.

To do things you could not physically or morally do within the actual system.

When Simulation is an appropriate Tool?

Simulation can be used

to experiment with new

designs

or

policies

prior to implementation,

so as to prepare for

what may happen.

When Simulation is an appropriate Tool?

By changing simulation inputs

and

observing the resulting outputs,

valuable insight may be obtained about

which variables are most important

and

how variables interact.

When Simulation is an appropriate Tool?

By simulating different capabilities for a machine, requirements can be determined.

When Simulation is an appropriate Tool?

Simulation can be used to

verify analytic solutions.

When Simulation is an appropriate Tool?

Informational,

Organizational,

and

environmental changes

can be simulated

and

the effect of these alterations

on the model's behavior

can be observed.

When Simulation is an appropriate Tool?

The knowledge gained

in designing a simulation model

may be of great value

toward suggesting improvement in the system

under investigation.

When Simulation is an appropriate Tool?

Simulation models

designed for training

allow learning without

the cost and disruption of

on-the-job learning.

When Simulation is an appropriate Tool?

The modern system

is so complex that

the interactions can be treated

only through simulation.

When simulation is not appropriate?

When the problem can be solved using common sense.

When the problem can be solved analytically.

When it is easier to perform direct experiments.

When the simulation costs exceed the savings.

When the resources or time are not available.

When system behavior is too complex or can't be defined.

When there isn't the ability to verify and validate the model.

If Data is not available.

If users have unreasonable expectations.

Why simulation is not used more?

Cost.

Lack of familiarity.

People think their judgment or experience is good enough.

Uses of Simulations

Analyze systems (performance, behavior) before they are built

Reduce the number of design errors

Optimize design to improve the behavior

Analyze operational systems

Create virtual environments for training, entertainment

Applications of Simulations

Designing and analyzing manufacturing systems.

Evaluating H/W and S/W requirements for a computer system.

Evaluating a new military weapons system or tactics.

Determining ordering policies for an inventory system.

Designing communications systems and message protocols for them.

Applications of Simulations

Designing and operating transportation facilities such as freeways, airports, subways, or ports.

Evaluating designs for service organizations such as hospitals, post offices, or fast-food restaurants

Analyzing financial or economic systems

Advantages of Simulation

Hypotheses about

how or why certain phenomena occur can be tested for feasibility.

Insight can be obtained about

the interaction of variables.

the importance of variables to the performance of the system.

Advantages of Simulation

Bottleneck analysis can be performed

indicating where work-in-process, information, materials, and so on are being excessively delayed.

A simulation study can help in understanding

how the system operates rather than how individuals think the system operates.

"What-if" questions can be answered:

This is particularly useful in the design of new system.

Advantages of Simulation

New polices

Operating procedures

Decision rules

Information flows

Organizational procedures

and so on

can be explored without disrupting ongoing operations of the real system.

Advantages of Simulation

New hardware designs,

Physical layouts,

Transportation systems,

and so on,

can be tested without committing resources for their acquisition.

Disadvantages of Simulation

Model building requires special training.

It is an art that is learned over time and through experience.

Furthermore, if two models are constructed by two competent individuals, they may have similarities, but it is highly unlikely that they will be the same.

Simulation results may be difficult to interpret.

Disadvantages of Simulation

Since most simulation outputs are essentially random variables (they are usually based on random inputs), it may be hard to determine whether an observation is a result of system interrelationships or randomness.

Simulation modeling and analysis can be time consuming and expensive.

Skimping (holding back on) on resources for modeling and analysis may result in a simulation model or analysis that is not sufficient for the task

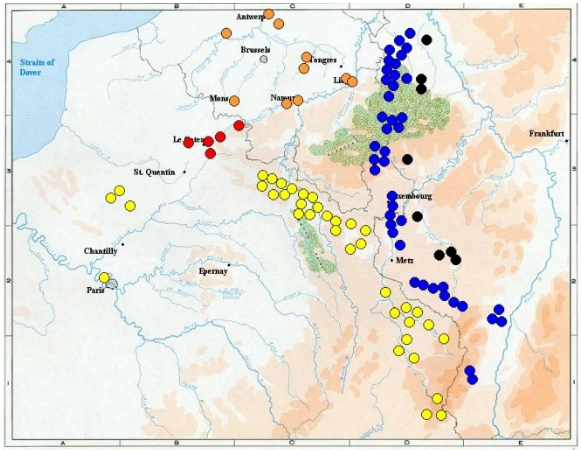
Disadvantages of Simulation

Simulation is used in some cases when an analytical solution is possible, or even preferable.

This might be particularly true in the simulation of some waiting lines where closed-form queuing models are available.

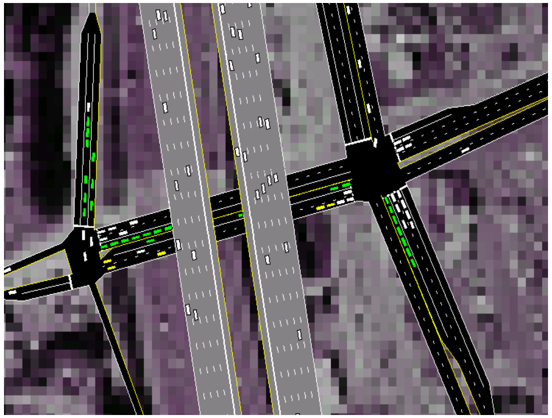
M & S : B K Sharma

Simulation :A Few Example Applications



War gaming: test strategies; training

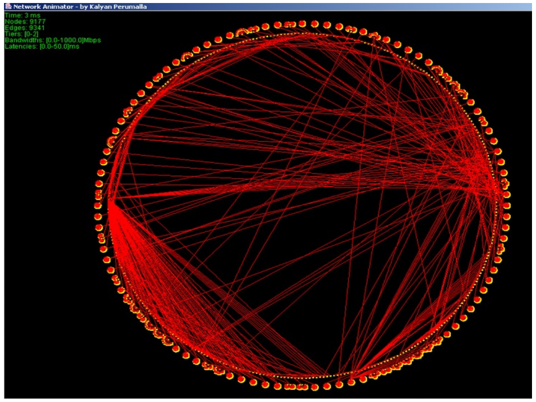
Flight Simulator



Transportation systems: improved operations; urban planning

Parallel computer systems: developing scalable software

Games



Computer communication network: protocol design

END OF INTRODUCTION

GOOD LUCK!

Areas of Applications of Simulation

- System Analysis
  - Telecommunication Networks (ATM, IP, TCP, UDP, WiFi …)
  - Transportation systems (Traffic, Urban planning, Metro Planning, …)
  - Electronic systems (e.g., microelectronics, computer systems)
  - Battlefield simulations (blue army vs. red army)
  - Ecological systems, Manufacturing systems, Logistics …

Areas of Applications of Simulation

- Virtual Environments
  - Physical phenomena (e.g. Trajectory of projectiles)
  - training and entertainment (e.g., military, medicine, emergency planning, flight simulation)

Areas of Applications of Simulation

- Manufacturing Applications
- Construction Engineering
- Military Application
- Logistics, Transportation, and Distribution Applications

Areas of Applications of Simulation

- Construction Engineering
  - Construction of a dam embankment
  - Trenchless renewal of underground urban infrastructures
  - Activity scheduling in a dynamic, multiproject setting
  - Investigation of the structural steel erection process
  - Special-purpose template for utility tunnel construction

Areas of Applications of Simulation

- Military Application
  - Modeling leadership effects and recruit type in an Army recruiting station
  - Design and test of an intelligent controller for autonomous underwater vehicles
  - Modeling military requirements for nonwarfighting operations
  - Multitrajectory performance for varying scenario sizes
  - Using adaptive agent in U.S Air Force pilot retention

Areas of Applications of Simulation

- Logistics, Transportation, and Distribution Applications
  - Evaluating the potential benefits of a rail-traffic planning algorithm
  - Evaluating strategies to improve railroad performance
  - Parametric modeling in rail-capacity planning
  - Analysis of passenger flows in an airport terminal
  - Proactive flight-schedule evaluation

Areas of Applications of Simulation

- Logistics issues in autonomous food production systems for extended-duration space exploration
- Sizing industrial rail-car fleets
- Product distribution in the newspaper industry
- Design of a toll plaza
- Choosing between rental-car locations
- Quick-response replenishment