

1 Modeling and Simulations

1.1 Modeling

1.1.1 Need for Modeling: Difficulties

- Understanding and predicting complex systems behaviour
 - Many properties
 - many input parameters
 - Various environmental conditions
 - Different constraints
 - Diverse outputs
- Building real-life systems during design or for testing
 - Expensive
 - Requires personnel
 - Difficult to modify
 - Not sure how

1.1.2 Modeling as a Solution

- Building an abstract representation of the real system
 - Reduced complexity
 - Important characteristics only
 - Cheaper
 - Highly modifiable

1.1.3 Model Definitions

- A representation of a system from a certain point of view and at a certain level of abstraction
 - CPU of a computer
- A representation containing the essential features of an object or event in the real world
 - Airplane, train network, weather system

1.1.4 Modeling Definition

- Process of building a model
- Designing and analyzing a representation of a system to study the effect changes to system variables have

1.1.5 Modeling Benefits

- Allows for investigation of the properties of the system
- Enables prediction of future systems behaviour and outputs

1.1.6 Modeling Limitations

- Most models are inherently inexact (due to the simplifications and assumptions made)
- Accuracy is limited as:
 - Most parameters and equations used only estimate the real world situation
 - Initial conditions are not known
 - Environment influence is either ignored or limited

1.1.7 Simulation Definition

- Process of performing experiments using a model in order to determine the outcome

1.1.8 Analysis Definition

- Processing and interpreting the results of experiments in order to draw conclusions

1.1.9 Studying a System

- Experiments with the actual system
- Experiments with a model of the system
 - Prototyping
 - Modeling
 - * Mathematical modeling
 - * Modeling and Simulation

1.1.10 Model Types

- Deterministic or Stochastic
 - Deterministic: all variables are deterministic
 - Stochastic: Some model variables or behaviours are random
- Static or Dynamic:
 - Static: the model does not change in time
 - Dynamic the model is modified in time
- Continuous or Discrete:
 - Continuous: the system state evolves continuously
 - Discrete: the system state changes at discrete points in time

1.1.11 Stages in Modeling - Take A

- Simplification and Abstraction
 - A model contains essential characteristics of real-life objects or events
 - This stage identifies relevant features of real system to be modeled
 - Assumptions are made
 - Input parameters are determined
 - Output measures are listed
- Representation and Measurements
 - Object, events, numbers and relationships in the real system are associated model components
- Manipulation
 - Implementation of real world objects and relationships are determined
 - New objects and relationships are represented
- Verification
 - Outcomes from the model are compared with real world outcomes
 - It is determined if the model is adequate for the desired purpose

1.1.12 Stages in Modeling - Take B

- Determine the goals and objectives
 - Level of abstraction
 - Relevant features to be modelled
 - Required input and expected output
- Build a conceptual model
 - Very high level
 - Determines how comprehensive the model will be
 - Determines state variables if they are dynamic, how important they are etc.
- Create the specification model
 - Average detailed level
 - May involve equations, pseudocode, etc.
 - Indicates input and output
- Convert into a computational model
 - Low detail level
 - Involves a general purpose or a simulation programming language

- It is the actual useful model
- Verification and validation
 - Verification
 - * Did we build the model right? According to Specification
 - Validation:
 - * Did we build the right model? Relative to the real system

1.2 Simulation

1.2.1 Network Simulators

- Network Simulator V2
 - Discrete event simulator
 - Includes many models for protocols at various network layers:
 - * TCP UDP RTP
 - * FTP CBR VBR
 - Support for wired and wireless delivery
 - Extended by many researchers worldwide
- Network Simulator version 3
 - Discrete event simulator
 - Includes increasing number of different protocols
 - Support for wired and wireless delivery