Modelling and Simulation

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Simulation

Simulating systems

- Involves the generation of artificial history of a system and the observation of that artificial history to draw conclusions concerning the operating characteristics of the real system.
- The more we know about the system, better will be the simulation and therefore more reliable results.
- The behaviour of a system as it evolves over time is studied by developing a simulation model.

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- There are three major elements in modelling and simulation.
  - ✓ The real systems that has to be modelled.
  - ✓ The model or models themselves
  - ✓ The computer (or network of computers) on which to run the simulation.
- The concern is not only with the elements themselves but also with establishing certain relationships among them.
- There are two relations:
  - ✓ The modelling relation
  - ✓ The simulation relation

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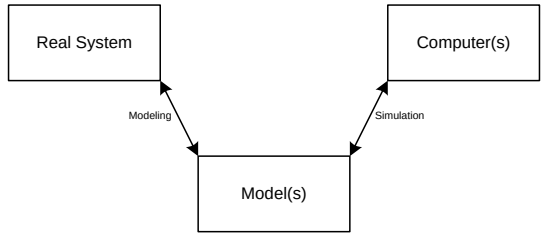
- Modelling deals primary with the relations between the real system and the models.
- Simulation deals with the relationships between the computers and the models.



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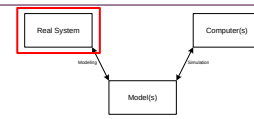

- The real system block represents some part of the real world which is of interest.
- The system may be natural, artificial, in existence or planned for the future.
- Examples
  - ✓ An engineer interested in improving trajectories for airliners
  - ✓ A natural scientist interested in the developmental process of flowers.

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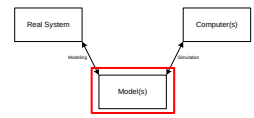
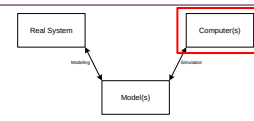


- A model is basically a set of instructions for generating the behavior data of the real system.
- Models provide *someone or something* for generating data.

The modeler him/herself

A computer program

Simulation



- A computer is therefore required for:
  - ✓ Generating behavioral data
  - ✓ Executing the programs with encoded model instructions
- A computer is also required to act as a platform for the models to run on
  - ✓ A simulation framework might be necessary.

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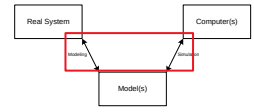

- The modeling relationship concerns the validity of the models:
  - ✓ How well the model represents the real system.
- The simulation relationship concerns the correctness with which the computer carries out the instructions (program) intended by the model.

Simulation models

What is a simulation model?

- A model is a representation of the construction and working of some system of interest.
- Although some times the model is simpler than the system it represents, it should:
  - Be a close approximation to the real system.
  - Incorporate most of its main features.
  - Not be so complex that it is imposable to understand/experiment with.
  - Be a trade-off between realism and simplicity.

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Simulation models

- Generally a simulation model is a mathematical model developed either with the help of simulation packages or with high level languages.
- Usually a model only models one real system. Therefore a sophisticated simulation can be composed by more than one model.

Simulation models

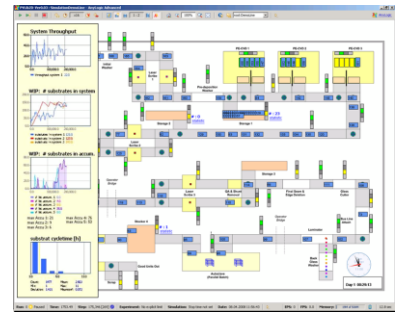
- For example, a very basic flight simulator is composed of the following systems:
  - The atmosphere
  - The airplane DOF
  - The airplane engines
  - The airplane emissions
  - The graphics rendering
- The above systems are totally independent from each other but should liaison with each other to simulate a realistic flight.

(Show some examples of real model programs)

Classification of models

Models can be classified as:

- Static or dynamic
- Stochastic or deterministic
- Continuous or discrete-event
- Local or distributed



Classification of models

Static or dynamic

- In dynamic models, state variables change over time.
  - ✓ Dynamic models are in the form of differential equations.
  - ✓ Can describe the dynamic relationships between the input and the output
- A static model models a snapshot as a single point in time.
  - ✓ Static models are in the form of algebraic equations.

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Classification of models

Stochastic or deterministic

- A stochastic model is a model whose behaviors cannot be entirely predicted.
  - ✓ Evolves randomly in time and space.
  - ✓ The behavior is non deterministic, since a system's subsequent state is determined by a random element.
- Deterministic models describe behavior on the basis of some physical law.
  - ✓ E.g. The planets move around the sun according to Newton's laws and their position can be predated with great accuracy well into the future.

Classification of models

Continuous or discrete

- Continuous models concerns the modeling of systems by representation in which state variables change continually with respect to time.
- In discrete-event models, models, the operation if a system is represented as a chronological sequence of events.
- Discrete simulation are more popular since they are usually faster while also providing a reasonably accurate approximation of a system's behavior.

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Classification of models

Local or distributed

- Local simulation is a type of simulation where all the elements that make up that particular simulation reside on one single machine only.
- Distributed simulations run on a network of interconnected hosts, also possibly through the internet.
  - ✓ Very useful where the models that make up the simulation are very computationally intensive.
  - ✓ There are several standards and protocols for distributed simulation, such as HLA, ALSP and DIS.

Bibliography

Papers

Anu, M. (1997). Introduction to modeling and simulation. *Proceedings of the 1997 Winter Simulation Conference*, (pp. 7-13).

K, Mohandas. P. Introduction to simulation.

Ricki, I. G. (2002). Introduction to Simulation. *Proceedings of the 2002 Winter Simulation Conference*, (pp. 7-16).

Books

Bratley, Paul, Fox, Bennett L and Schrage, Linus E. *A Guide to Simulation.* s.l. : Springer, 1987.