# [VR_MAD001] SIMULATION

## Chapter 4 Discrete Event Simulation (I)

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## Objectives

- We shall describe key concepts regarding system, model and modeling.
- We study the key class of discrete event simulation (DES) models.
- We provide a description of simulators and simulation languages.
- We make an introduction to Enterprise Dynamics.

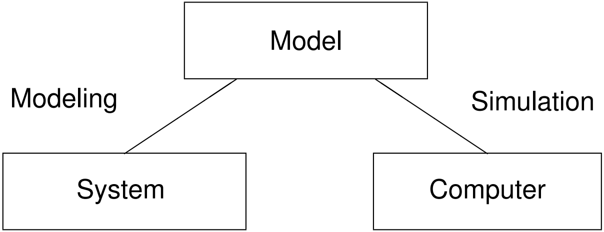
## Agenda

4. Discrete event simulation (I)
    - Modeling and simulation
    - Systems
    - Models
    - Basic Discrete event simulation (DES) concepts

## Modeling and simulation

- Through modeling and simulation we refer to the activities associated with building models of real systems and experimenting with them with the aid of a computer. The key elements are
  - *System:* relevant part of the world for the problem at hand, viewed as a set of interacting components with a common goal.
  - *Model:* simplified representation of a system as a set of instructions which are valid to generate data about its behaviour.
  - Both elements are interrelated and with the computer through *modeling* and *simulation*

# Modeling and simulation



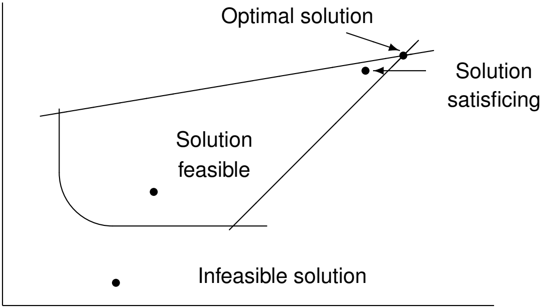
## Modeling and simulation

- Modeling tasks relate real systems with models and studies their *validity*, the extent to which a model represents the real system.
- Simulation relates models and computers and described the process of imitation of the key performance features of the system either in real, compressed or expanded time, based on constructing and experimenting a system model.
- In that sense, simulation is analogous to experimenting within a physical lab, in which we aim at better understanding a physical or chemical phenomenon, to develop a valid theory of such phenomenon.

## Modeling and simulation

- Modeling and computer simulation usually aims at satisficing solutions in practical problems.
- Generally speaking, the proposed solution will be satisficing, in the sense of being feasible and fulfilling certain standards.
- Such solution will not generally coincid with the optimal but will generally be reasonably close to it.

## Modeling and simulation



# Systems

- We view a real system as the *data source* for the behaviour of a part of interest of the real world.
- This part will consist of *elements* or *components* or *entities* which interact to attain a common purpose.
- Systems may be natural or artificial, *existing* or *planned for the future*.
- The entities have certain features or *attributes*, *parameters* and *variables*, which get numeric or logical values and are called the system *descriptive variables*.
- *Internal* relations connect the entities, whereas *external* relations connect the elements with the external world.

## Systems

- The interrelations between entities are expressed through variables and parameters. Any change which produces changes over the attributes is called *activity*.
- We may classify systems in many ways: *closed*, *open* or *with feedback*; *natural* or *artificial*; *dynamic* or *static* ; *stochastic* or *determinístic*; *adaptive* or *non adaptive*; *linear* or *non linear*,...
- They may also have variables which are *independent* or *dependent*; *non controllable* or *controllable*; *continuous*, *discrete* or *mixed*;...

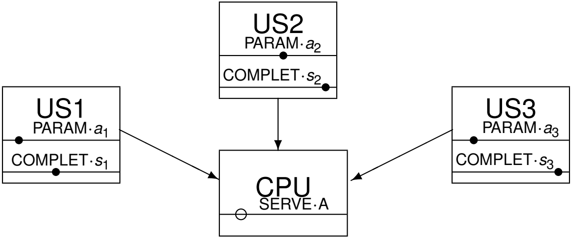
## Systems

- Several rules specify the interaction between the entities and determine how the system attributes evolve along time.
- For many models, we may just focus on a few of these attributes, the (*state variables*) from which the rest of variables may be inferred.
- At any *instant t* the state variables describe the *state of the system*.
- The system state may change because of *internal* or *endogenous* activities, or *external* or *exogenous* activities.
- Depending on whether the system state may be forecasted with certainty or not, we talk about *deterministic*, or *stochastic* systems.

## Models

- Model: is a simplified representation of a system, through which we aim at enhancing our understanding, make predictions and, possibly, aid in controlling and improving the system.
- Its purpose is to facilitate an individual to determine how one or more changes in features of the system modeled may be affected.
- *Modeling* is the process through which we may establish relations between the relevant entities of a system which are expressed in terms of goals, criteria and constraints.
- Modeling is used to represent the key system interactions without dwelling into much detail.
- We may use *influence diagrams* wit boxes for the entities, signs within them to show descriptive variables and parameters and arrows to show the influence or interaction among them.
- Example: a *processor sharing* system, which includes a CPU and three terminals, with descriptive variables and parameters (discrete, ◦; continuous, •).

## Models




- The CPU component contains the variable SERVE·A whose range is $\{1, 2, 3\}$ and the entities US$i$ have the variable COMPLET·$s_i$ with range $[0, 1]$, which indicates that user $i$ has completed a fraction $s_i$ of its task.
- Moreover, each user component has a parameter, PARAM·$a_i$, which is its completion rate US$i$.
- Finally, the existence of an arrow from the US$i$ components to the CPU component represent the sending of data.

## Basic concepts for Discrete event simulation (DES)

- *Continuous models* refer to systems whose state changes continuously in time. Normally, they are described through differential equations.
- *Discrete models* refer to systems whose state changes at given times. The rest of the time nothing relevant happens, from a statistical point of view.

# Basic concepts for Discrete event simulation (DES)

- Within DES we normally distinguish three types of variables
  - The *variable t* refers to simulation time.
  - The *counter variables*, track the evolution of events of interest.
  - The *state variables* are the minimum set of variables which describe the system state.
- The events defining the evolution are generated at various time instants and time evolution is controlled through the *simulation clock*.

## Basic concepts for Discrete event simulation (DES)

- Basically, there are two types of simulation clocks which identify two simulation strategies:
  - *synchronous simulation* or *interval oriented.* Time increments are fixed at $\Delta t$, after which statistics are updated and the system is changed. The process is repeated until a stopping condition is reached.
  - *asynchronous simulation* or *event oriented*. Time is advanced until the next event, instant in which the system state is updated and statistics are collected. The process is repeated until a certain stopping condition. A list of next future events and their timing is maintained, so that the clock advances until the first time in this list.

# Basic concepts for Discrete event simulation (DES)