Introduction to Modeling and Simulation

By

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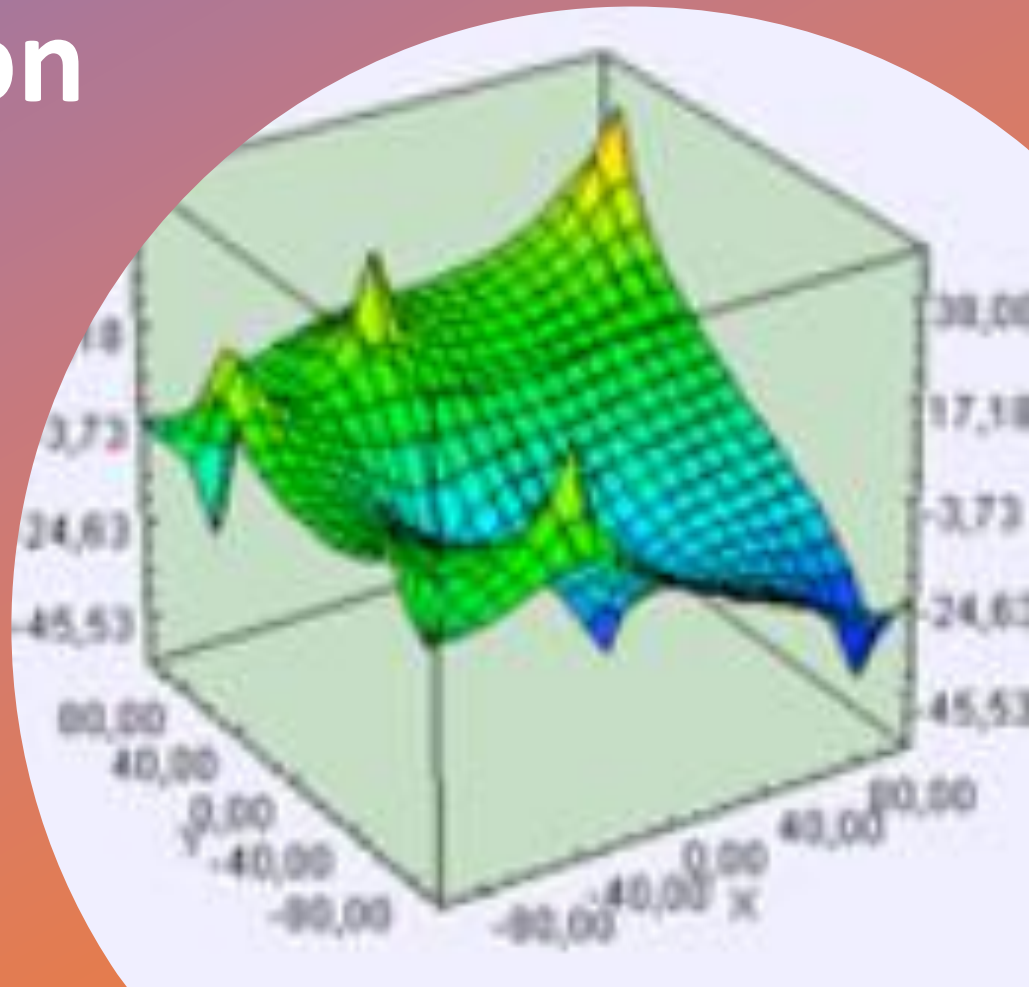

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Introduction

- Definition
- Brief History
- Applications
- “Real World” Applications
- The advantage of simulation
- The disadvantages of simulation

Definition:

"Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behavior of the system and/or evaluating various strategies for the operation of the system."

Brief History

Not a very old technique...

- World War II
  - "*Monte Carlo*" simulation: originated with the work on the atomic bomb. Used to simulate bombing raids. Given the security code name "Monte-Carlo".
  - Still widely used today for certain problems which are not analytically solvable (for example: complex multiple integrals…)

Why we need simulation ?

Because the real system is:

- too cumbersome
- too costly
- too dangerous
- too slow

Simulation allows us to:

- Model complex systems in a detailed way
- Describe the behavior of systems
- Construct theories or hypotheses that account for the observed behavior
- Use the model to predict future behavior, that is, the effects that will be produced by changes in the system
- Analyze proposed systems

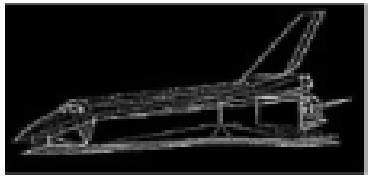
Simulating

"Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behavior of the system and/or evaluating various strategies for the operation of the system."

To simulate any system we need at first to build a model for that system then simulate this model

Types of simulation models:

- Physical simulation models



- Mathematical simulation models
  - *Static* vs. *dynamic*
  - *Deterministic* vs. *stochastic*
  - *Continuous* vs. *discrete*

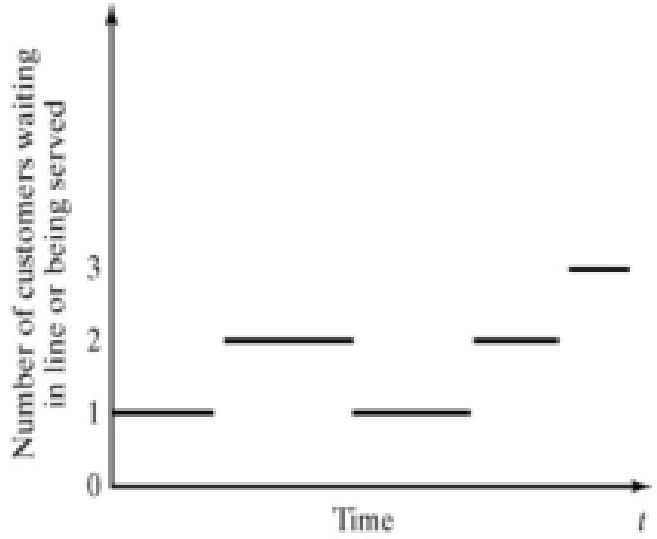
(Most operational models are dynamic, stochastic, and discrete – will be called *discrete-event simulation models)*

System

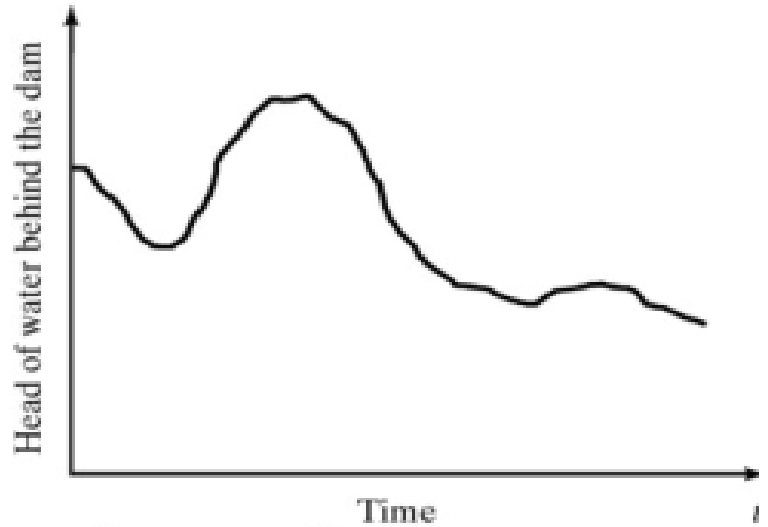
- *definition*: System is a collection of entities (people, parts, messages, machines, servers, …) that act and interact together toward some end (Schmidt and Taylor, 1970)
  - In practice, depends on objectives of study
  - Might limit the boundaries (physical and logical) of the system
  - Judgment call: level of detail (e.g., what is an entity?)
  - Usually assume a time element – *dynamic* system
- *State* of a system: Collection of variables and their values necessary to describe the system at that time
  - Might depend on desired objectives, output performance measures
  - Bank model: Could include number of busy tellers, time of arrival of each customer, etc.

Types of systems

- *Discrete*
  - State variables change instantaneously at separated points in time
  - Bank model: State changes occur only when a customer arrives or departs



- *Continuous*
  - State variables change continuously as a function of time
  - Head of water behind the dam : State variables Head amount change continuously



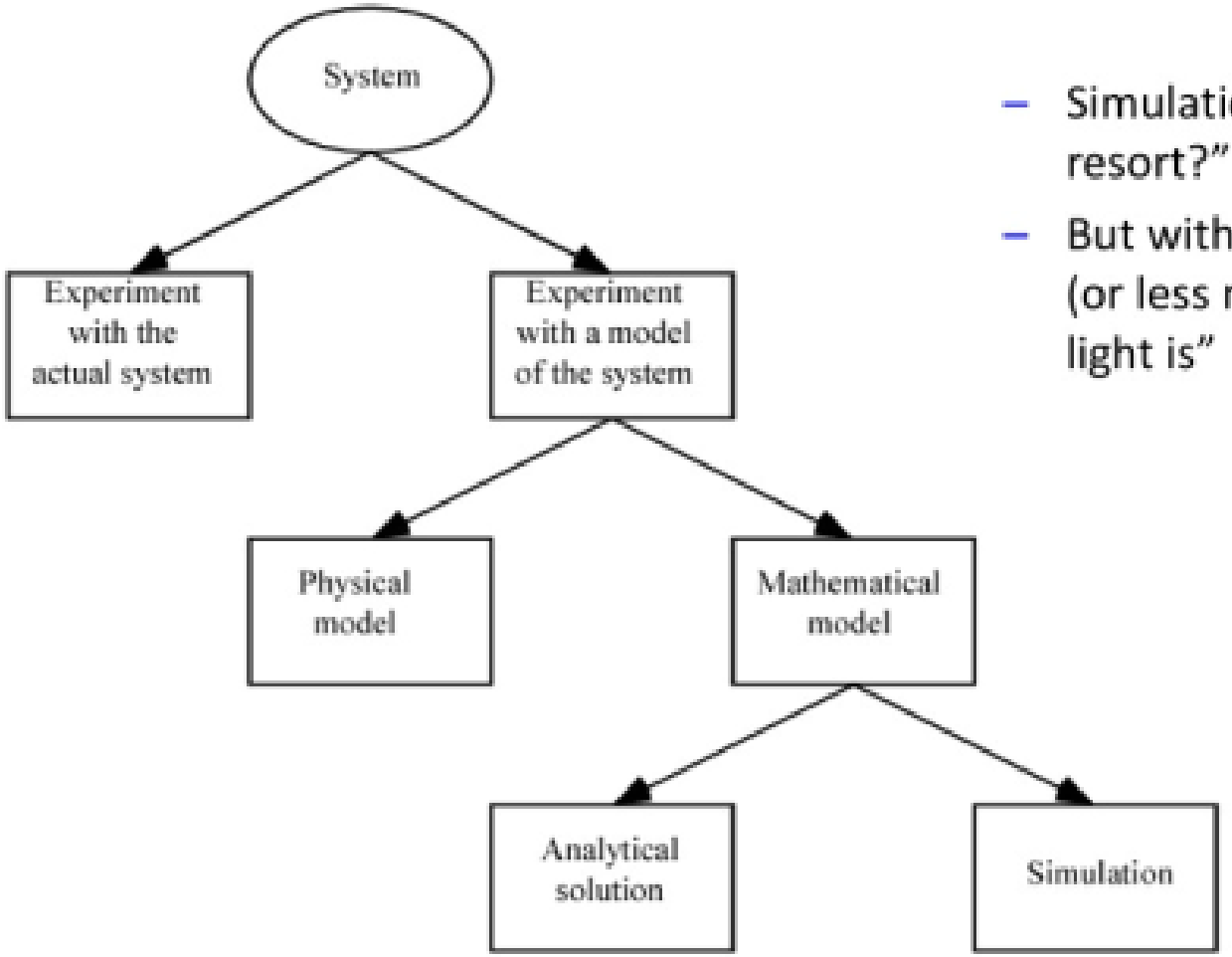
- Many systems are partly discrete, partly continuous

EXAMPLES OF SYSTEMS AND COMPONENTS

System	Entities	Attributes	Activities	Events	State Variables
Banking	Customers	Checking account balance	Making deposits	Arrival; Departure	number of busy tellers; number of customers waiting

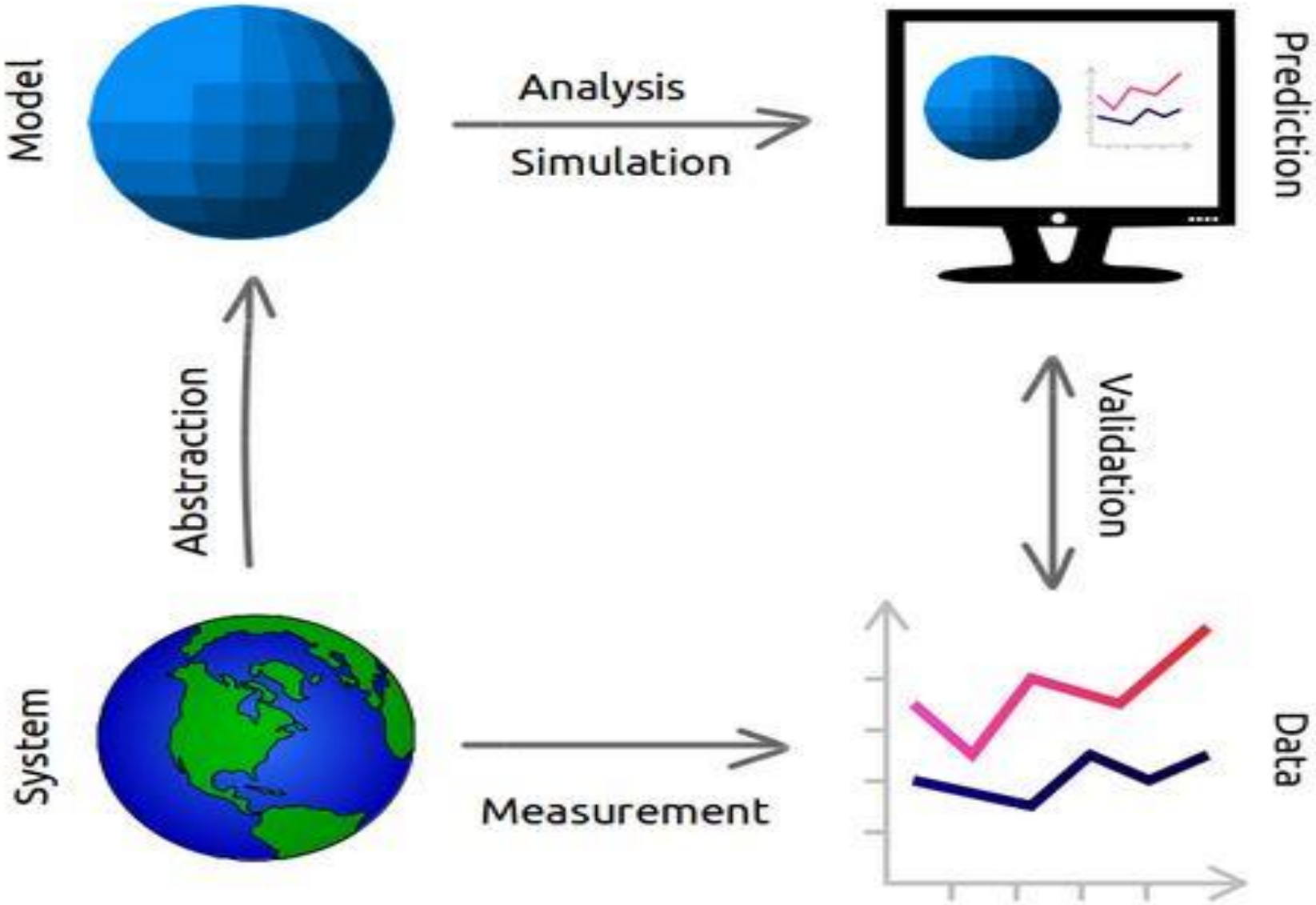
Exercise: Give examples of systems and components

- Ways to study a system



- Simulation is "method of last resort?" Maybe …
- But with simulation there's no need (or less need) to "look where the light is"

Modeling


Model
Analysis
Simulation
Prediction
Abstraction
Validation
System
Measurement
Data

Modeling

construct a conceptual framework that describes a system

Modeling is a way of looking at the world

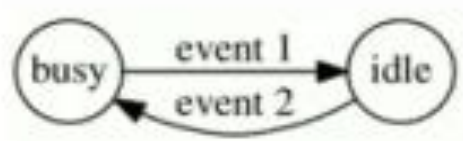
- *a system can have multiple contradictory models*
- *We need to use models because resources are limited*
- *Models simplified thing*
- *Using the appropriate model allows us to make decisions, even when the situation is complex or resources are limited*
- *We are always using models*

The Process of Simulation

Help-desk operator example

Help- desk operator has two states

1) Busy helping someone
2) waiting for a call to come in.



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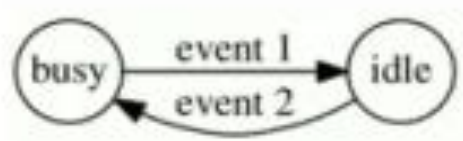

Events:

1) Customer starts describing problem to help desk
2) Customer completes telephone conversation

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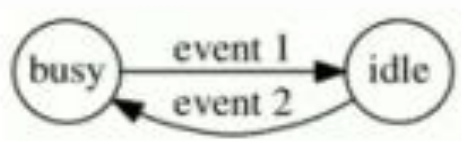

Events:

1) Customer starts describing problem to help desk
2) Customer completes telephone conversation

- Simulation starts at $t= t_0 = 0$
- First customer arrives at t_1, simulation time is now $t= t_0 + t_1$
- Help desk requires t_s to resolve issue
- First customer leaves at $t= t_0 + t_1 + t_s$
- Second customer arrives at t_2
  - If $t_2 < t_0 + t_1 + t_s$ then customer must wait
  - If $t_2 > t_0 + t_1 + t_s$ then customer starts services

Advantages of Simulation

1. Can be used to study existing systems without disrupting the ongoing operations.
2. Proposed systems can be "tested" before committing resources
3. Can handle large and complex systems
4. Can answer "what-if" questions
5. Does not interfere with the real system
6. Allows study of interaction among variables
7. "Time compression" is possible
8. Handles complications that other methods can't

Disadvantages of Simulation

1. Can be expensive and time consuming
2. Managers must choose solutions they want to try ("what-if" scenarios)
3. Each model is unique
4. Model building is an art as well as a science. The quality of the analysis depends on the quality of the model and the skill of the modeler (Remember: *GIGO*)
5. Simulation results are sometimes hard to interpret.
6. Should not be used when an analytical method would provide for quicker results.


thank you