# Chapter 2: Introduction to Simulation Modeling

Refer to Text Book:

- "Operations Research: Applications and Algorithms" By Wayne L. Winston ,Ch. 21
- "Operations Research: An Introduction" By Hamdi Taha, Ch. 16

# Objectives

- To be able to describe what computer simulation is
- To be able to discuss why simulation is an important analysis tool
- To be able to list and describe the various types of computer simulations
- To be able to describe a simulation methodology

# 1. What is Simulation?

- **Simulation**

1. Technique that imitates the operation of a real-world system as it evolves *over time*
2. A numerical technique for conducting experiments on a digital computer which involves logical and mathematical relationships that interact to describe the behavior of a system *over time*
3. Using computer tools and techniques to monitor and evaluate the behavior of the real-world system.

# 1. What is Simulation Model?

- **Simulation Model**

A simulation model usually takes the form of a set of assumptions about the operation of the system, expressed as mathematical or logical relations between the objects of interest in the system

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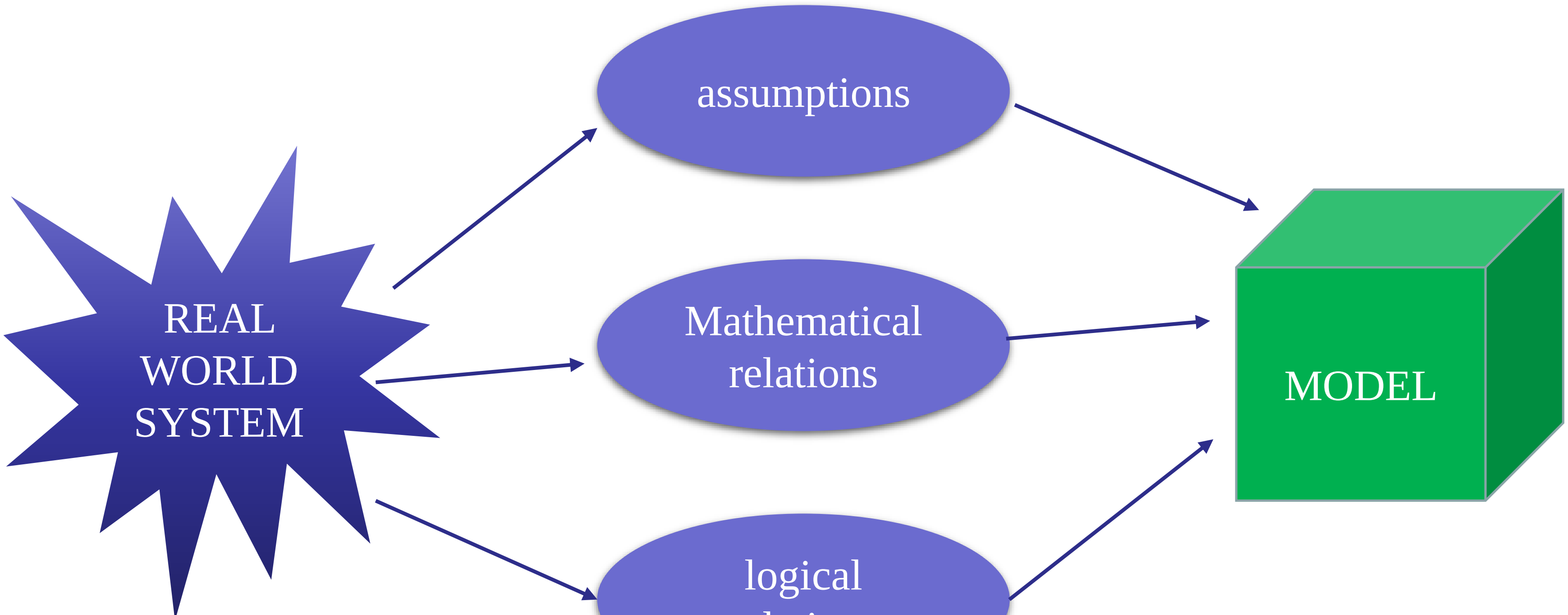
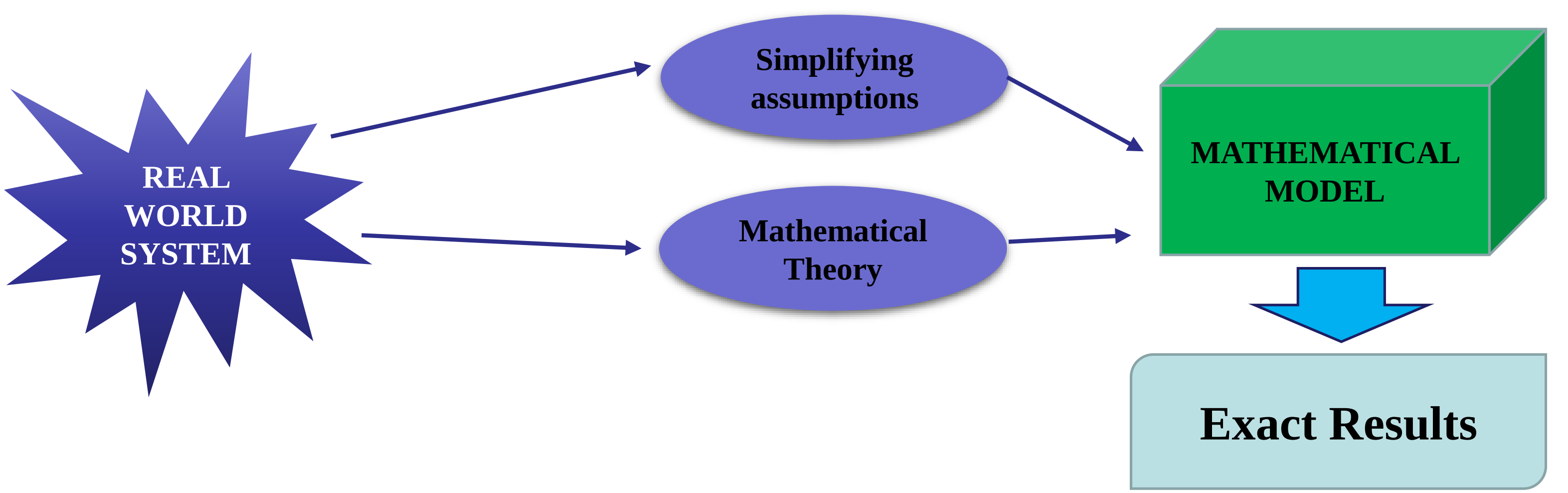


# 1. What is Simulation?

- **The mathematical model and Simulation**

➢ Exact mathematical solutions available with most analytical models under strong simplifying assumptions

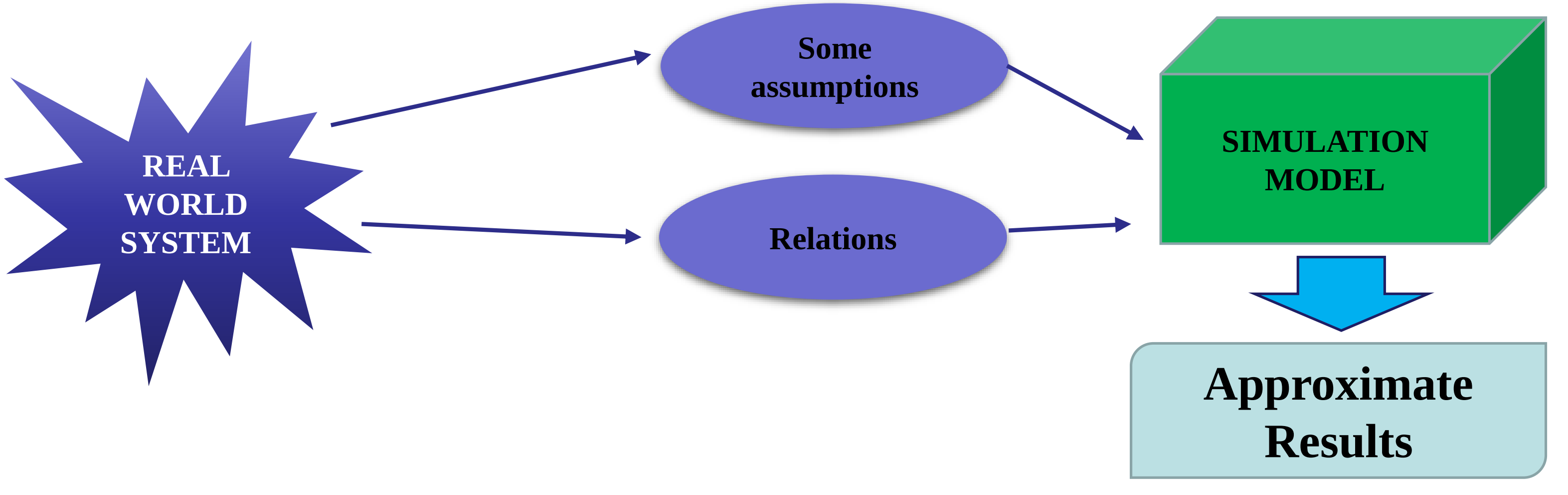
**Just plug-in parameters and get the answers**



# 1. What is Simulation?

- **The mathematical model and Simulation**

➢ The simulation process involves data collection by executing or running the model through time, usually on a computer, to generate representative samples of the measures of performance.



# 1. What is Simulation?

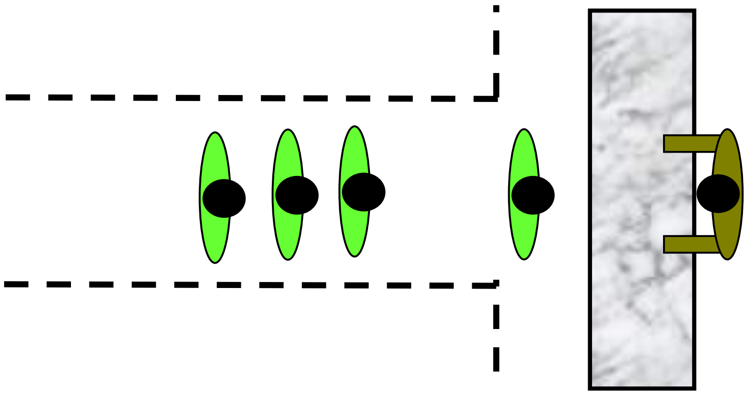
- **The mathematical model and Simulation**

- Results in simulation is not ***unique*** and not ***exact***
- Results in simulation change for every run or execution because sample data changes in every run.
- simulation may be seen as a sampling experiment on the real system, with the results being sample points.

# 1. What is Simulation?

- **The mathematical model and Simulation**

➢ Consider Single Server System



Mathematical Model:

1. Interarrival time: exponential with rate $\lambda$:

Arrival process is Poisson Process rate $\lambda$

2. Service times: exponential rate $\mu$

3. System size is infinite

4. Queue Discipline : FCFS

5. $\lambda < \mu$

$$\text{Average Customers in system} = \frac{\frac{\lambda}{\mu}}{1-\frac{\lambda}{\mu}}$$

# 1. What is Simulation?

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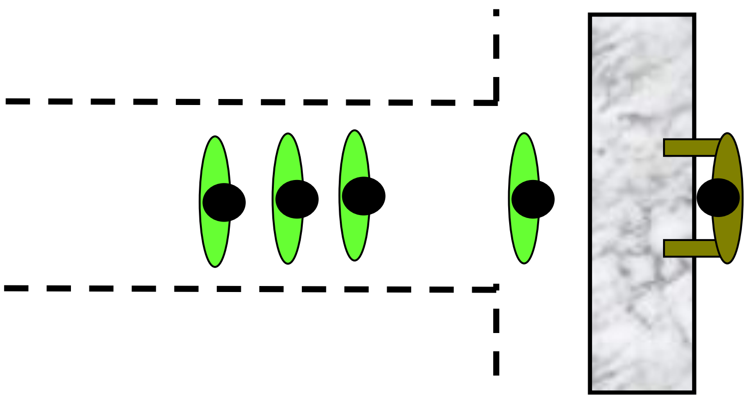


<u>Simulation Model:</u>

1. **<u>Any</u>** Interarrival time is possible
2. **<u>Any</u>** Service times is possible rate $\mu$
3. System size is infinite or finite
4. Any Queue Discipline : FCFS
5. Not necessary : $\lambda < \mu$

Average Customers in system $= \dfrac{\frac{\lambda}{\mu}}{1-\frac{\lambda}{\mu}}$

Has No Use

# 2. Daily Experience of Simulation

- Game of monopoly is a physical simulation
- Flight simulator a physical simulation
- Football practice is a physical simulation
- Fire drill (training) is a simulation

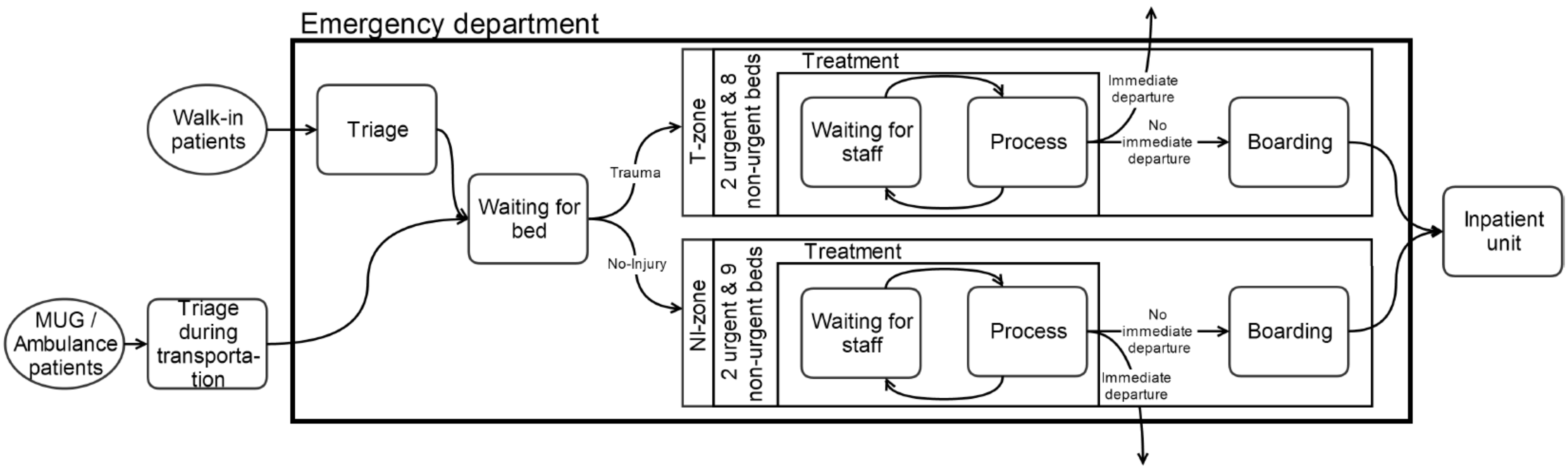
**Physical Representation of the real systems**

# 3. Why Use Simulation ?

**For Example**, simulating new emergency room

- Patients arrive to emergency room at *random*.
- Arrival pattern changes over the day and over the week.
- Triage station to check patients condition.
- Critical patients take expedited service for bed. Immediate doctor check and nurse is available.
- Admission information taken later.
- Transfer to waiting for room area. Patient is under monitor in ER.
- During waiting other tests are performed MRI, X-ray, …
- Finally, the patient get his health condition stabilized and discharged or admitted in the hospital.

# 3. Why Use Simulation ?



# 3. Why Use Simulation ?

- The hospital wants to:
  1. Study the ER for improvement
  2. Study the quality of service for patients
  3. Study the utilization of recourse

- To investigate:
  1. The average of patients who wait
  2. The average waiting time of patients
  3. The total time patients remain in ER
  4. The average rooms required per hour
  5. Average utilization of doctors and nurses

# 3. Why Use Simulation ?

**Why not Using Historical data only??**

- Historical data of hospital can be used to compute some of the measures.
- Historical data used for current situation only.
- Historical data may not help for computing other measures that are not recorded in any electronic system.
- Affect of new alternatives cannot be measured before implementation.

# 3. Why Use Simulation ?

**Simulation Model:**

1. Modeling the entire system with *all complexities* and it enables the study and experimentation with internal interactions

2. A tool for *evaluating the performance* of the existing system

3. A tool for *predicting effect* of changes to the existing system

4. A tool for *estimating data* of unrecorded processes.

5. A tool to *predict performance* of new system under *varying conditions*

# 3. Why Use Simulation ?

**Simulation Model:**

6. Modeling and Study the *effect of changes on non-tangable factors*: Information, organizational and environmental and effect of these alterations on the system
7. The model can be useful to *trace the variables* of importance to the system and how they interact
8. Used to *experiment with new designs* prior to implementation

# 3. Why Use Simulation ?

**Simulation Model:**

8. Simulation models designed for *training allow learning* without the cost and disruption of on-the-job learning

9. Animation shows a system in simulated operation so that the plan can be *visualized*

10. Simulation is a good tool to study and *analyze modern complex systems* are best

11. Excellent to *model time-varying* (non-stationary) behavior must be examined

# 4. Do NOT Use Simulation

**Avoid using Simulation Model when:**

1. problem is simple and can be solved by common sense or analytically
2. it is easier to perform physical direct experiments
3. the costs of simulation is higher than implementing the new alternatives
4. The time of building the simulation model is longer than available time frame.
5. There is *no time* or *no experts* to analyze simulation output to obtain optimal decisions

# 4. Do NOT Use Simulation

**Avoid using Simulation Model when:**

6. the resources are not available: good computers, good simulation software, experienced programmer
7. there is less data or estimates available or there is not enough time or personnel available to verify the data.
8. managers have unreasonable expectations leading to overestimation of simulation results
9. the system behavior is too complex or cannot be defined.

# 5. Application Areas

- Manufacturing Systems

  - scheduling: risk of random duration of jobs
  - inventory: risk of random demand, random delivery

- Human Resource Planning:

  - staffing personal for future period
  - service operations quality
  - Banks, fast food, theme parks, Post Office, ...

- Distribution and logistics

  - Production Rate
  - raw materials

# 5. Application Areas

- Health Care
    - Emergency Department Operation
    - Operating rooms
    - Beds Operation
    - Doctors and Supporting Staff
- Computer systems
    - Client-Server design
- Telecommunications
    - No. of towers
    - Evaluation of service

# 5. Application Areas

- Military
  - Number of troops
  - Number military equipment's
  - Casualties estimation
  - Risk analysis
- Public Planning
  - Number of Courts
  - Number of prisons
  - Number of Police departments