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

Review Last Lecture

Today's Lecture Plan

9. Discrete-Event Simulation

1. Change of state is discrete over time:
   - Arrival of a customer over time
   - Departure of a customer over time
   - Machine breaks down over time
   - Number of unites sold per customer over time
   - Accidents at a traffic intersection
   - Deaths in hospitals

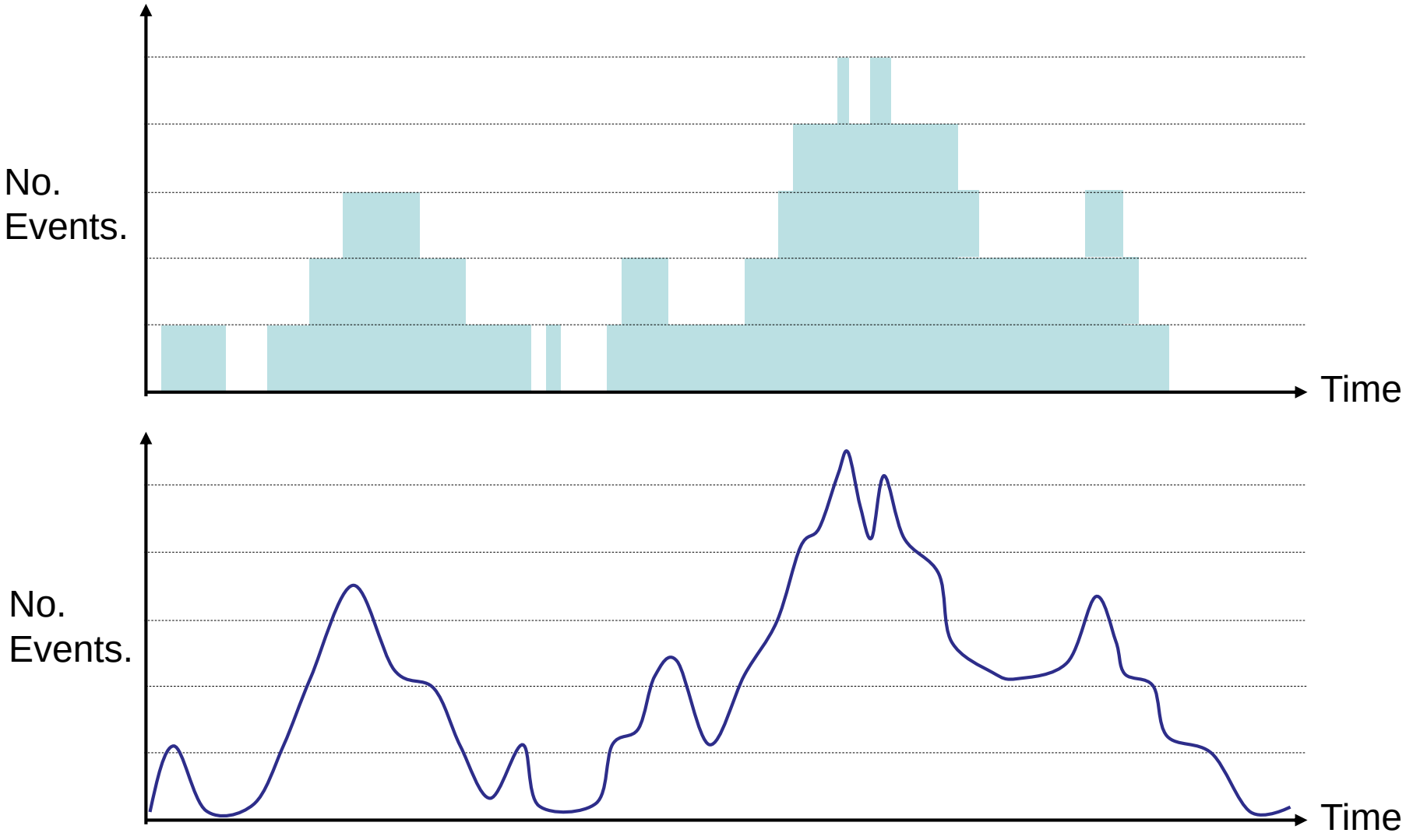
9. Discrete-Event Simulation

2. Why do we call it discrete event ?

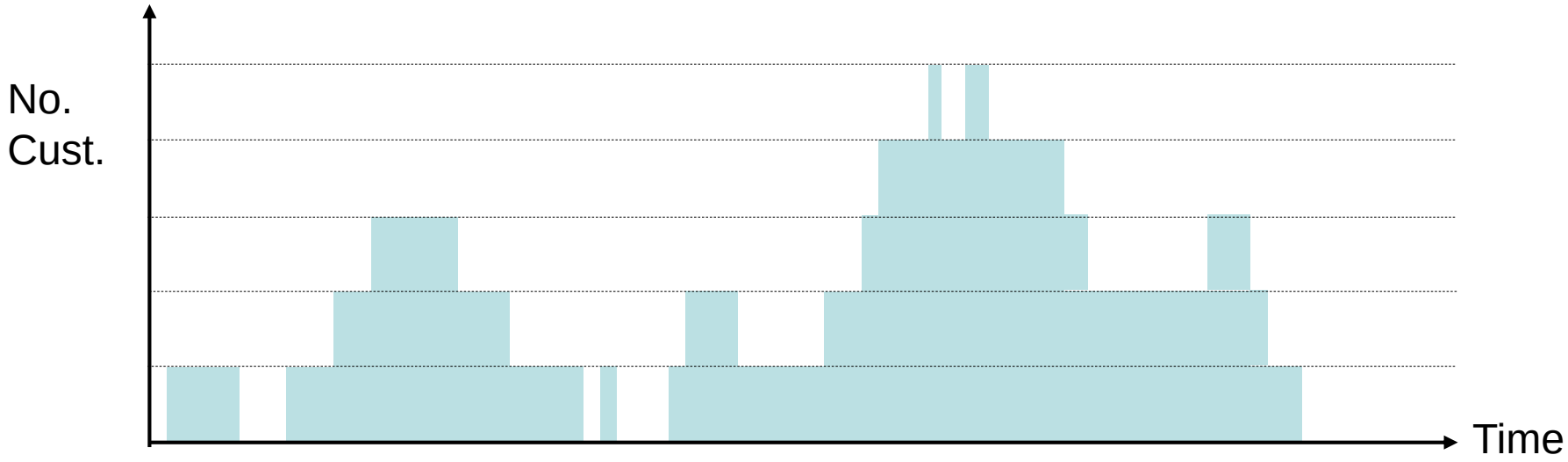
- Any changes on the state of the system occur at random points in time
- The behavior of the system is **jumps**

  - 1st cust. arrive after 3 min, 2nd cust. arrive after 5 min. …
  - Time between customers is uniform between [2,8] min
  - 1st cust. leave after 8 min, 2nd cust. leave after 6 min. …
  - 1st Machine break-down after 1:30 pm

9. Discrete-Event Simulation



9. Discrete-Event Simulation



3. A discrete-event simulation is one where changes in the state of the system occur instantaneously

4. The simulation clock changes when there is a change in state

9. Discrete-Event Simulation

Example

Consider a single line customer call center.

- If line is idle, any new call is accepted
- If line is busy, any new call is lost
- Some data are collected

Caller	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Calling Time	8:02	8:08	8:13	8:19	8:20	8:24	8:27	8:31	8:39	8:43	8:46
Expected Call Time (min)	2	5	3	2	2	7	2	3	3	4	2

How to model it as a discrete event simulation?

9. Discrete-Event Simulation

Example

Complete missing data

- There are many details in the system are missing
- Compute Departure time

Caller	1	2	3	4	5	6	7	8	9	10	11
Calling Time	8:02	8:08	8:13	8:19	8:20	8:24	8:27	8:31	8:39	8:43	8:46
Service Time (min)	2	5	3	2	2	7	2	3	3	4	2
Departure Time											

9. Discrete-Event Simulation

Example

Complete missing data

- There are many details in the system are missing
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Caller	1	2	3	4	5	6	7	8	9	10	11
Calling Time	8:02	8:08	8:13	8:19	8:20	8:24	8:27	8:31	8:39	8:43	8:46
Service Time (min)	2	5	3	2	2	7	2	3	3	4	2
Departure Time	8:04	8:13	8:16	8:21	lost	8:31	lost	8:34	8:42	8:47	lost

9. Discrete-Event Simulation

Example

2. Define the events

Caller	1	2	3	4	5	6	7	8	9	10	11
Calling Time	8:02	8:08	8:13	8:19	8:20	8:24	8:27	8:31	8:39	8:43	8:46
Service Time (min)	2	5	3	2	2	7	2	3	3	4	2
Departure Time	8:04	8:13	8:16	8:21	lost	8:31	lost	8:34	8:42	8:47	lost

9. Discrete-Event Simulation

Example

2. Define the events

Call Arrival , Call End , Call Lost , Idle Server, Busy Server

Caller	1	2	3	4	5	6	7	8	9	10	11
Calling Time	8:02	8:08	8:13	8:19	8:20	8:24	8:27	8:31	8:39	8:43	8:46
Service Time (min)	2	5	3	2	2	7	2	3	3	4	2
Departure Time	8:04	8:13	8:16	8:21	lost	8:31	lost	8:34	8:42	8:47	lost

9. Discrete-Event Simulation

Example: Call Arrival , Call End , Call Lost , Idle Server, Busy Server

3. Define System Behavior

Discrete-Event Simulation

System Time	Event
8:00	Start Service Idle Server
8:02	Call Arrive Busy Server
8:04	Call End Idle Server
8:08	Call Arrive
8:13	Call End Call Arrive
8:16	Call End Idle Server

System Time	Event
8:20	Call Arrive Call Lost
8:21	Call End Idle Server
8:24	Call Arrive Busy Server
8:27	Call Arrive Call Lost

System Time	Event

9. Discrete-Event Simulation

Example:

3. Define System Behavior

Discrete-Event Simulation

System Time	Event
8:00	Work Start (Idle Server)
8:02	Call Arrival
8:04	Call End
8:04	Idle Server
8:08	Call Arrival
8:13	Call End
8:13	Call Arrival

System Time	Event
8:16	Call End
8:16	Idle Server
8:19	Call Arrival
8:20	**New Call Lost**
8:21	Call End
8:21	Idle Server
8:24	Call Arrival
8:27	**New Call Lost**

System Time	Event
8:31	Call End
8:31	Call Arrival
8:34	Call End
8:34	Idle Server
8:39	Call Arrival
8:42	Call End
8:42	Idle Server
8:43	Call Arrival
8:46	**New Call Lost**
8:47	Call End

9. Discrete-Event Simulation

Quiz

Consider a single line customer service center.

- If line is idle, any new call is accepted
- If line is busy, any new call is lost

Caller	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Calling Time	8:05	8:09	8:13	8:15	8:19	8:22	8:27	8:30
Expected Call Time (min)	3	3	5	2	4	2	3	5