Advanced Evacuation Analysis 3
DISCRETE EVENT SIMULATION (DES)

Dr. Trika Pitana
Dept. of Marine Engineering
Faculty of Marine Technology
Institute Teknologi Sepuluh Nopember (ITS)
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Outline

• The Purpose of Simulation
• Type of Simulation
• Discrete Event Simulation
• DES’s Components
• Simulation Software
• How to Deal With DES
• Example Application
The Purpose of Simulation

SYSTEM

Experiment with the actual System

Experiment with the model of System

Physical Model

Mathematical Model

Analytical Solution

Simulation

Source: Averil, L.M, Simulation, Modeling Analysis

SYSTEM, MODEL and Simulation

• System:
  – Collection of entities, e.g. people or machine, that act and interact together toward the accomplishment of some logical end.[1]
  – 2 types: Discrete and Continuous
Type of Simulation

• Continuous System
  – One of which the state variable change *continuously* with respect to time. (e.g. the movement of air plan, car etc, such position and velocity change continuously with time)

• Discrete System
  – One of which the state variable change instantaneously at separated point of time.
    • E.g. bank (number of customer, change only when customer arrive and depart)

Comparisons

• Exp. Actual System vs. Model
• Physical Model vs. Mathematical Model
• Analytical Model vs. Simulation
Simulation

- **Static vs. Dynamic**
  - Static: eg. Monte Carlo simulation
  - Dynamic simulation: represent a system evolves over time.

- **Deterministic vs. Stochastic**
  - Deterministic: not probabilistic
  - Stochastic: probabilistic

- **Continuous vs. Discrete**
  - A discrete model is not always represented as discrete simulation, and vice versa

Components of DES

- **System State**
  - The collection of state variables to describe the system at a particular time

- **Simulation Clock**
  - A variable giving the current value of simulated time

- **Event List**
  - A list containing the next time when each type of event will occur

- **Statistical Counters**
  - Variable used for storing statistical information about system performance

- **Initialization routine**
  - A sub program to initialize the simulation model at time 0
Components of DES

- **Timing Routine**
  - A sub program that determines the next event from the event list and the advances the simulation clock to the time when that event is occur

- **Event Routine**
  - A subprogram that updates the system state when a particular type of event occurs

- **Library Routine**
  - A set of subprograms used to generate random observation form probability distribution that were determined as part of the simulation model.

- **Report Generator**:  
  - A subprogram that computes estimates (from the statistical counter) of the desired measured of performance and produces a report when the simulation ends.

- **Main Program**:  
  - A subprogram that invokes the timing routine to determine the next event and the transfer control to the corresponding event routine to update the system state appropriately.

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Simulation of A single Server Queuing System

- A departing Customer
- Server
- Customer in services
- An Arriving Customer
Examples of Queueing Systems

<table>
<thead>
<tr>
<th>System</th>
<th>Servers</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank</td>
<td>Tellers</td>
<td>Customers</td>
</tr>
<tr>
<td>Hospitals</td>
<td>Doctors, Nurses, Beds</td>
<td>Patients</td>
</tr>
<tr>
<td>Airport</td>
<td>Runways, gates, security check in station</td>
<td>Travellers, Airplane</td>
</tr>
<tr>
<td>Evacuation</td>
<td>Gate, Door</td>
<td>Passengers/ Pedestrians</td>
</tr>
</tbody>
</table>

Component of A Queuing SYSTEM

- Arrival Process
- Server Mechanism = No of Servers
- Queueing
  - FIFO
    - First In First Out
  - LIFO
    - Last In Last Out
  - Priority
Notation for Queuing System

- $s$ servers in parallel and one FIFO queue feeding all servers
- $A_1, \ldots, A_N =$ \textit{interarrival time}, random variables
- $S_1, S_2, \ldots, S_N,$ mean \textit{service time}
- $A$ and $S$ are independent
  - Example System Notation
    - GI/G/s = refers to A/S/mo of server
    - GI = general independent Distribution
    - G = General
    - s= number of server

Simulation Software

- Generating Random Numbers, from Probability Distribution
- Generating Random Variates
- Advancing Simulated Time
- Determining the next event from the event list and passing control to the appropriate block of code
- Adding Record/Deleting Record
- Collecting Output Statistic
- Detecting error condition
Simulation Software

• Package Simulation Software vs. Developed Program

How to Deal with DES

• Observed the actual Condition
• Convert the actual System with Simulation Model
• Selecting the input probability distribution for Simulation
  – Several Statistic Test
    • Chi Square Test
    • Kolmogorov Smirnov Test
    • Anderson Darling Test
• Validate the Result of Simulation
Conversion the Actual System with Simulation

(a)

(b)

Probability Distribution

- **Principle:**
  - Ensuring that the collected data are fit with specific probability distribution.
  - Very important step to ensure that the simulation results are valid

- **Continuous Distribution**
  - Normal Distribution
  - Gamma Distribution
  - Log Normal Distribution
  - Uniform Distribution
  - Etc....
Conclusion

• You have known the principle of simulation and DES
• The next lecture
  – Review statistic Lecture
  – Review the probability distribution
  – Several Goodness of fit test

References: