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Chapter 3
Simulation Software

CONTENTS

3.1 INTRODUCTION

- Activities common to most simulations:
  - Random-number generation … draws from U(0, 1) distribution
  - Random-variate generation … draws from probability distributions specified as part of the inputs to the model
  - Advancing simulated time
  - Determining the next event from the event list, and passing control to the appropriate event logic
  - Adding records to lists, deleting records from lists
  - Collecting output statistics and reporting results
  - Detecting error conditions
- Simulation software packages are designed to do these things (and more) for you

3.2 COMPARISON OF SIMULATION PACKAGES WITH PROGRAMMING LANGUAGES

- Advantages of simulation packages
  - Provide most modeling features, so "programming" effort, cost is reduced, often significantly
  - Natural framework for simulation modeling
  - Usually make it easier to modify models
  - Better error detection for simulation-specific errors
- Advantages of general-purpose programming languages
  - More widely known, available
  - Usually executes faster … if well written
  - May allow more modeling flexibility
  - Software cost is usually lower
  - Usage of object oriented feature of C++ and Java

3.3 CLASSIFICATION OF SIMULATION SOFTWARE

- General-purpose vs. application-oriented packages
  - Traditionally: *simulation languages* and *simulators*

    Languages were flexible but required programming, simulators were easy to use but not very flexible

    Model development using graphics, dialog boxes and pull-down menus.
  - Now, almost all simulation software uses graphical interface so is relatively easy to use, learn
  - Distinction now is between general-purpose simulation software and applications-oriented package

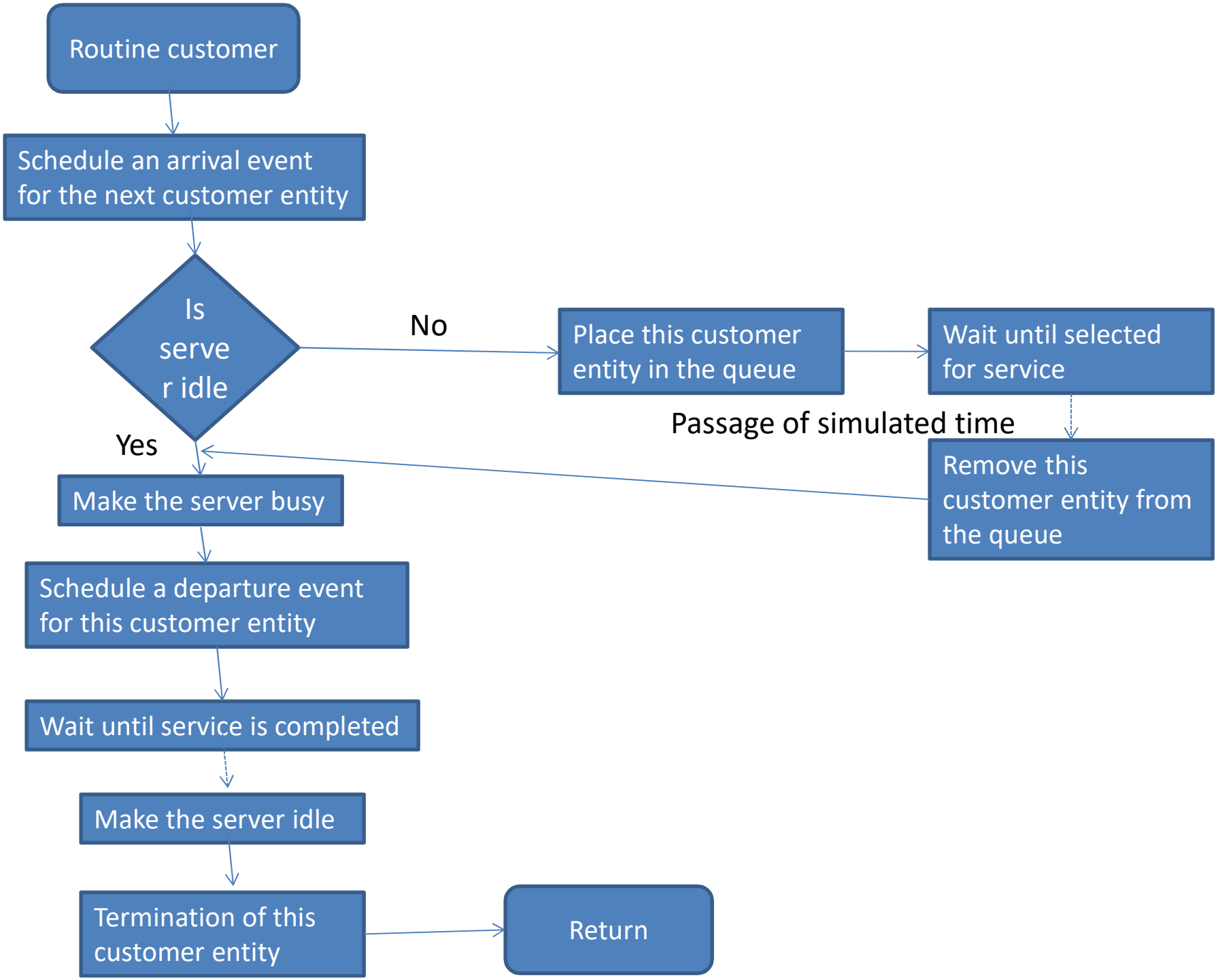
    General purpose application software can be used for any application

    Application oriented simulators are used for specific applications including manufacturing, call centers, telecommunications, etc.

3.3 Classification of Simulation Software

- Modeling approaches
  - *Event-scheduling* approach – as in Chaps. 1 and 2
    - Can uses general programming languages, or some simulation languages
    - During processing of an event, no simulated time passes, simulation evolves over time by executing events in increasing order of their time of occurrence
  - *Process-interaction* approach
    - Now used by most simulation software
    - Instead of identifying events, identify *entities* that are created, flow around or through the system, may be leave
    - May have multiple realizations of an entity/process
    - May have different kinds of entities/processes
    - "Program" consists of a description of what happens to the different kinds of processes (including their entry and exit)
    - Usually expressed graphically, like a flowchart
    - During processing of an entity/process, simulated time usually passes

Prototype customer process routine for a single server queuing system



3.3 Classification of Simulation Software (cont'd.)

- Common modeling elements
  - *Entities* – are created, travels through some part of the simulated system, then destroyed
  - *Attributes* – Information stored with each entity
    Usually, every individual entity has the same set of attributes, but the values differ to distinguish the entities
    Some attributes are automatic, others are user-defined and user-maintained
  - *Queues* – where entities wait if resources are not available

System	Entities	Attributes	Resources	Queues
Manufacturing	Part	Part number, due date	Machines, workers	Queues or buffers
Communication	Message	Destination, message length	Nodes, links	Buffers
Airport	Airplane	Flight number, weight	Runways, gates	Queues
Insurance agency	Application, claim	Name, policy number, amount	Agents, clerks	Queues

3.4 DESIRABLE SOFTWARE FEATURES

- **General capabilities**

  o Modeling flexibility – ability to drill down to lower levels of programming,

  o Ease of use- create custom modeling constructs

  o Hierarchical modeling- submodels containing submodels, etc. (combine basic modeling constructs into new higher level constructs.

  o Fast execution speed –Ability to create user-friendly front/back ends for template creation

  o Run-time version for wide distribution of model

  o Import/export data from/to other applications

  o Automatic execution of models for different input-parameter combinations

  o Combined discrete/continuous modeling

  o Ability to initialize in other than empty & idle state

  o Save state at end to re-start later

  o Affordable

3.4 Desirable Software Features (cont'd.)

- **Hardware and software requirements**
  - Matches platform/OS – Windows, UNIX, MacOS
- **Animation and dynamic graphics**

• Key elements are represented by icons that dynamically change position, size and color as the simulation progresses

  - Concurrent animation: Animation is being displayed at the same time simulation is running
  - Postprocessing animation: state changes in the simulation are saved to a disk file and graphics are drived after the simulation is over
  - 2D vs. 3D
  - Import CAD drawings
  - Display statistics, graphs dynamically during execution

3.4 Desirable Software Features (cont'd.)

- **Statistical capabilities**

- Adequate random number generator for basic U(0, 1) variates
  - Statistical properties, cycle length, adequate streams and substreams
  - RNG seeds should have good defaults, be fixed – not dependent on clock
  - Comprehensive list of input probability distributions
  - Continuous distributions: exponential, gamma, lognormal, normal, uniform, beta, triangular
  - Discrete distributions: binomial, geometric, negative binomial, poisson, discrete uniform
  - Empirical distributions: random numbers are used to sample from a distribution function constructed from observed system data.
  - Ability to make independent replications
  - Confidence-interval formation for output performance measures
  - To determine a value for Warmup period based on pilot runs
  - Experimental designs to find the effect of each factor
  - Optimum-seeking: run the simulation in an intelligent manner to determine a combination of decision variables that produces an optimal solution.

3.4 Desirable Software Features (cont'd.)

- **Customer support and documentation**
  - Public training
  - Customized training
  - Technical support
  - User guide or reference manual
- **Output reports and graphics**

– For each performance measure, average observed value, minimum observed value and maximum observed value are given

– Ability of generate variety of graphics

Histogram: graphical estimate of probability density functic

Time plot: one or more key system variables are plotted ove the length of simulation

Bar chart or pie chart

Coorelation: a way to measure the dependence in the output

Data produced form one simulation run

– Stored in database for post processing

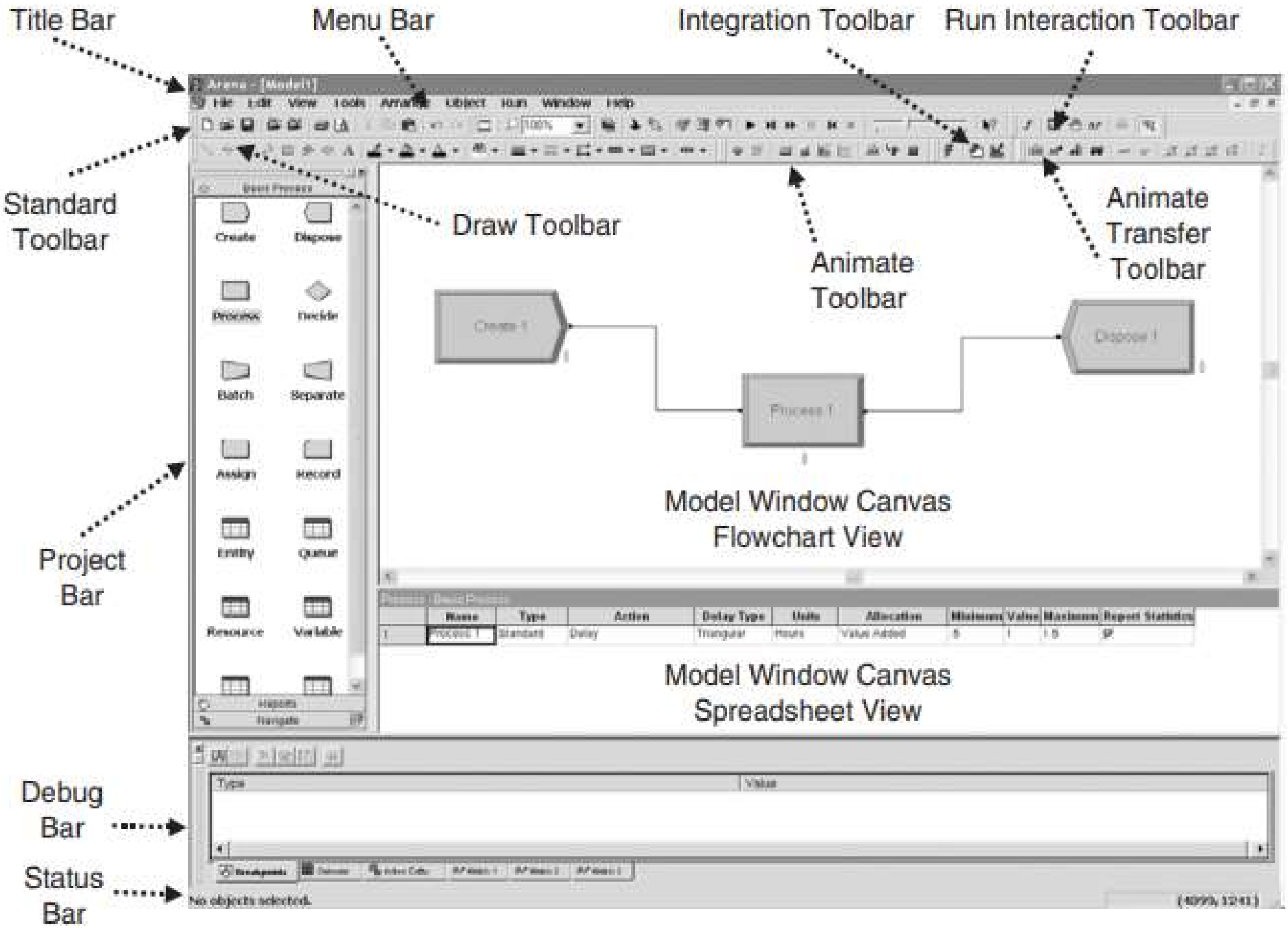
– Export individual model observation to other software

3.5 GENERAL-PURPOSE SIMULATION PACKAGES

- Two popular general-purpose simulation packages – Arena and Extend
  - In each, builds a model of a small manufacturing system
- Some additional general-purpose simulation packages
  - AweSim, Micro Saint, GPSS/SLX, SIMPLE++, SIMUL8, Taylor Enterprise Dynamics

Arena Simulation Software

- It is used for applications such as manufacturing, supply chains, defense, health care, and contact centers.
- Two different versions of Arena, namely,
- the Standard Edition and the Professional Edition.
- The “Basic Process” template contains modules that are used in virtually every model for modeling arrivals, departures,
- services, and decision logic of entities.
- The “Advanced Process” template contains modules that are used to perform more advanced process logic and to access external data files in Excel, Access, and SQL databases.
- “Visual Designer” is used to create concurrent three-dimensional (3-D) animations and “live-data dashboards
- AVI fi les can be generated directly from Arena
- It has access to 12 standard theoretical probability Distributions
- A number of plots are available, such as histograms, time plots, bar charts, and correlation plots.


Title Bar
Menu Bar
Integration Toolbar
Run Interaction Toolbar
Standard Toolbar
Draw Toolbar
Animate Toolbar
Animate Transfer Toolbar
Project Bar
Model Window Canvas Flowchart View
Model Window Canvas Spreadsheet View
Debug Bar
Status Bar

ExtendSim Simulation Software

- A model is constructed by selecting blocks from libraries (Item, Value, Plotter, etc.), placing the blocks at appropriate locations in the model window, connecting the blocks to indicate the flow of entities.
- A model can have an unlimited number of levels of hierarchy
- Supports 2D and 3D animation
- Each simulation model in ExtendSim has an associated "Notebook," which can contain pictures, text, dialog items, and model results.
- The user has access to 34 standard theoretical probability distributions and also to empirical distributions.
- A number of plots are available such as histograms, time plots, bar charts, and Gantt charts.
- ExtendSim's "Item" library contains blocks for performing discrete-event simulation (entity arrival, service, departure, etc.), as well as for material handling

3.6 OBJECT-ORIENTED SIMULATION

- OO programming and OO simulation originated in the same product – SIMULA, from the 1960s
- OO simulation has objects that interact as simulation progresses through simulated time
- Objects contain data, methods
- Also have encapsulation, inheritance, etc.
- Recent software product for OO simulation – MODSIM III

3.7 EXAMPLES OF APPLICATION- ORIENTED SIMULATION PACKAGES

- Oriented toward specific classes of applications
  - Manufacturing:
    - AutoMod
    - Enterprise Dynamics
    - FlexSim
    - Plant Simulation
    - ProModel
  - Communications networks:
    - OPNET Modeler
    - QualNet
  - Process reengineering and service systems
    - Process Simulator
    - Process model
  - Health care
  - Call centers