Chapter 6
Simulation Software

CONTENTS

6.1 Introduction to Simulation Software

6.2 Comparison of Simulation Packages with Programming Languages

6.3 Classification of Simulation Software

6.4 Desirable Software Features

6.5 General-Purpose Simulation Packages

6.6 Object-Oriented Simulation

6.7 Application-Oriented Simulation Packages

6.1 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

6.2 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

6.3 CLASSIFICATION OF SIMULATION SOFTWARE

- General-purpose vs. application-oriented packages
- Modeling Approaches
- Common Modeling Elements

6.3.1 General-purpose vs. application-oriented packages

- **Traditionally(Historically):** Simulation Languages and Simulators
  - Simulation Languages were flexible but required programming,
  - Simulation Languages: employing graphical model-building approach such as icons, dialog boxes
  - Simulators were easy to use but not very flexible
  - Simulators: allowing programming in certain model locations using an internal pseudo-language to Modify existing modeling constructs and to Create new constructs
- **Now(Recently) :** almost all simulation software uses graphical interface so is relatively easy to use, learn
- Distinction now is between general-purpose simulation package and applications-oriented package

  General-purpose simulation packages: **Arena, Extend**

  Application-oriented simulation packages: **Manufacturing, Communications Networks, Process Reengineering and Services, Health Care, Call Centers, Animation (standalone)**

6.3.2 Modeling approaches

- ***Event-scheduling* approach**
  - Identify characteristic events
  - 2. Write a set of event routines
  - 3. Execute events (no simulated time passes during its execution)
- ***Process-interaction* approach**
  - A process is a time-ordered sequence of interrelated events separated by intervals of time,which describes the entire experience of an “entity” as it flows through a “system”.

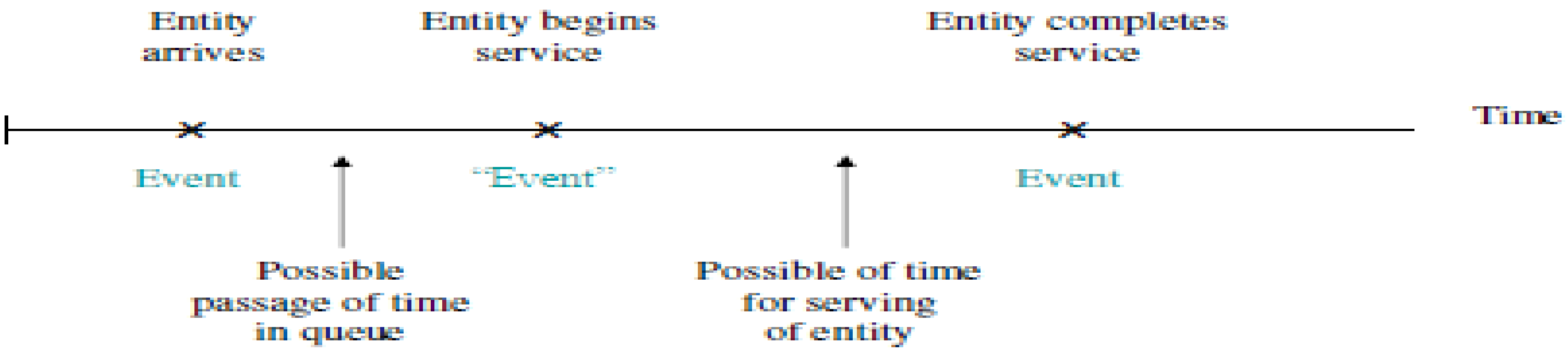


Figure 4.1

Process describing the flow of an entity through a system

Process Approach

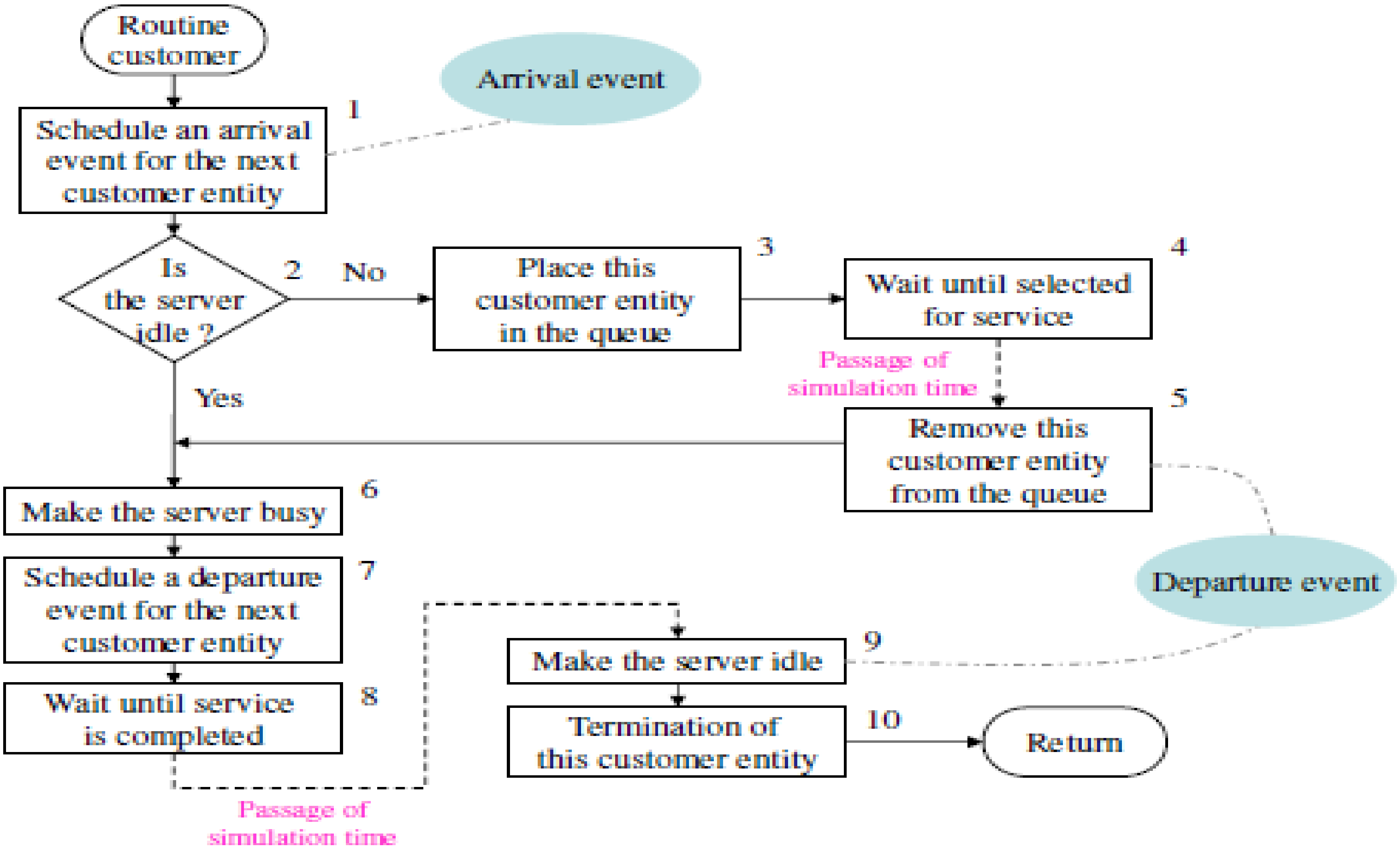
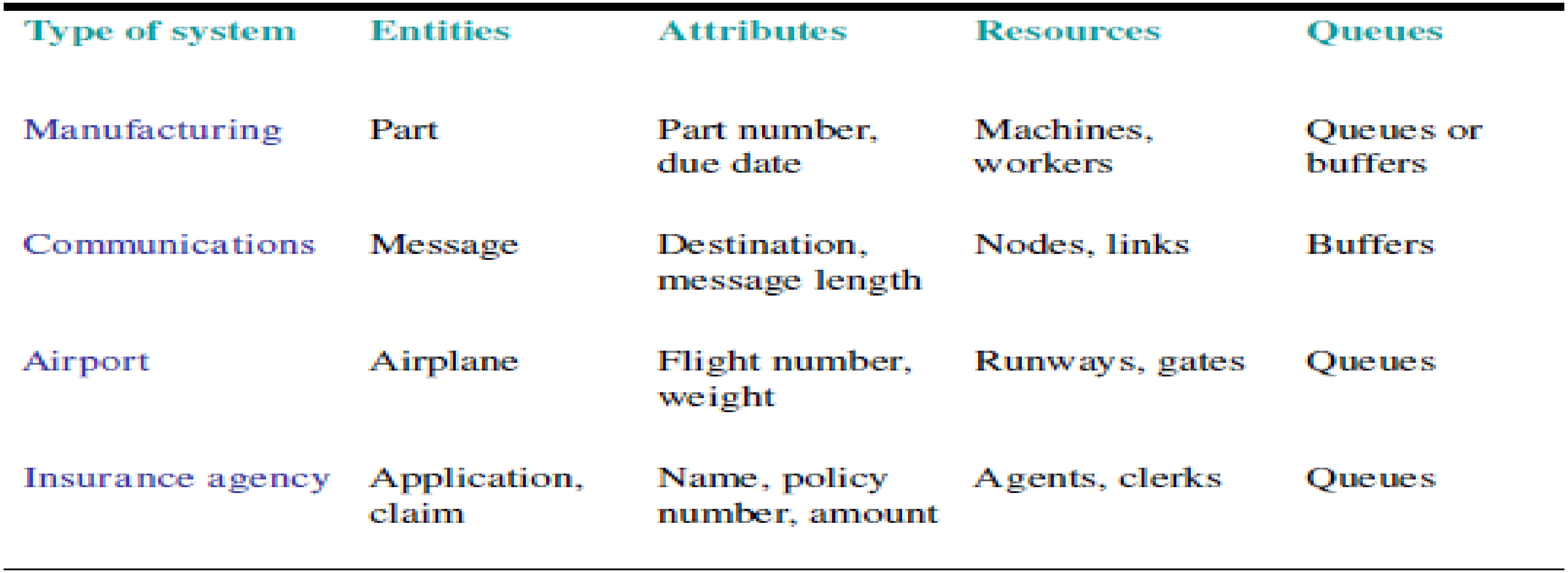

Routine customer
Arrival event
Schedule an arrival event for the next customer entity
1
Is the server idle ?
2
No
Place this customer entity in the queue
3
Wait until selected for service
4
Passage of simulation time
Remove this customer entity from the queue
5
Yes
Make the server busy
6
Schedule a departure event for the next customer entity
7
Wait until service is completed
8
Departure event
Make the server idle
9
Termination of this customer entity
10
Return
Passage of simulation time

Figure 4.2

Prototype customer-process routine for a single-server queueing system.

6.3.3 Common Modeling Elements

- ***Entities*** – represent customers, parts, messages, paperwork, airplane, etc.
- ***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
- ***Resources*** – servers, machines, workers, nodes, links, runways, gates, agents, clerks, etc.
- ***Queues*** – where entities wait if resources are not available



Type of system	Entities	Attributes	Resources	Queues
Manufacturing	Part	Part number, due date	Machines, workers	Queues or buffers
Communications	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

6.4 DESIRABLE SOFTWARE FEATURES

6.4.1 General capabilities

- Modeling flexibility – ability to drill down to lower levels of programming, create custom modeling constructs
- Ease of use
- Hierarchical modeling – submodels containing submodels, etc.
- Fast execution speed
- Ability to create user-friendly front/back ends for template creation
- Run-time version for wide distribution of model
- Import/export data from/to other applications
- Automatic execution of models for different input-parameter combinations
- Combined discrete/continuous modeling
- Ability to initialize in other than empty & idle state
- Save state at end to re-start later
- Affordable

4.4.2 Hardware and software requirements

- Computer platforms: Windows based PCs, UNIX,Workstations, Apple computers
- Required RAM: 128Mb
- Operating systems: Windows 98, Windows NT, UNIX

6.4.3 Animation and dynamic graphics

- Concurrent vs. postprocessing
- 2D vs. 3D
- Import CAD drawings
- Display statistics, graphs dynamically during execution

6.4.4 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, discrete, empirical
- Ability to make independent replications
- Confidence-interval formation for output performance measures
- Warmup
- Experimental design
- Optimum-seeking

6.4.5 Customer support and documentation

- Public and customized training at the client's site
- Good technical support for questions (tel. help)
- Good documentation
  - User's guide or reference manual, numerous detailed examples, context-dependent online help, library of mini examples
  - Detailed description of how each modeling construct works
  - Free demo disk
  - Free trail
  - Newsletter, yearly user's conference
  - Regular updates of the software

6.4.6 Output reports and graphics

- Standard reports for the estimated performance measures
- Customize reports
- Histogram
- Time plot
- Database
- Correlation plot
- Export individual model output observations to other software packages for further analysis and display.(spreadsheets, databases, statistics packages, and graphical packages)

6.5 GENERAL-PURPOSE SIMULATION PACKAGES

- See text for discussion of two popular general-purpose simulation packages – Arena, Extend
  - In each, builds a model of a small manufacturing system
- Mentions some additional general-purpose simulation packages
  - AweSim, Micro Saint, GPSS/SLX, SIMPLE++, SIMUL8, Taylor Enterprise Dynamics

6.6 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 and also have encapsulation, inheritance, etc.
- Recent software product for OO simulation – MODSIM III

Advantages :

It promotes code reusability
It helps manage complexity
It makes model changes easier
It facilitates large projects with several programmers.

Disadvantages:

Some O-O simulation packages may have a steep learning curve.
One must do many projects and reuse objects to achieve its full benefits.

6.7 EXAMPLES OF APPLICATION-ORIENTED SIMULATION PACKAGES

- Oriented toward specific classes of applications like:
  - Manufacturing
  - Communications
  - Process reengineering and service systems
  - Health care
  - Call centers
  - Standalone animation – links to multiple simulation-modeling packages