CSCI 5828: Foundations of Software Engineering

Lecture 11 and 12: Requirements

Slides created by Pfleeger and Atlee for the SE textbook

Some modifications to the original slides have been made by Ken Anderson for clarity of presentation

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Chapter 4

Capturing
the Requirements

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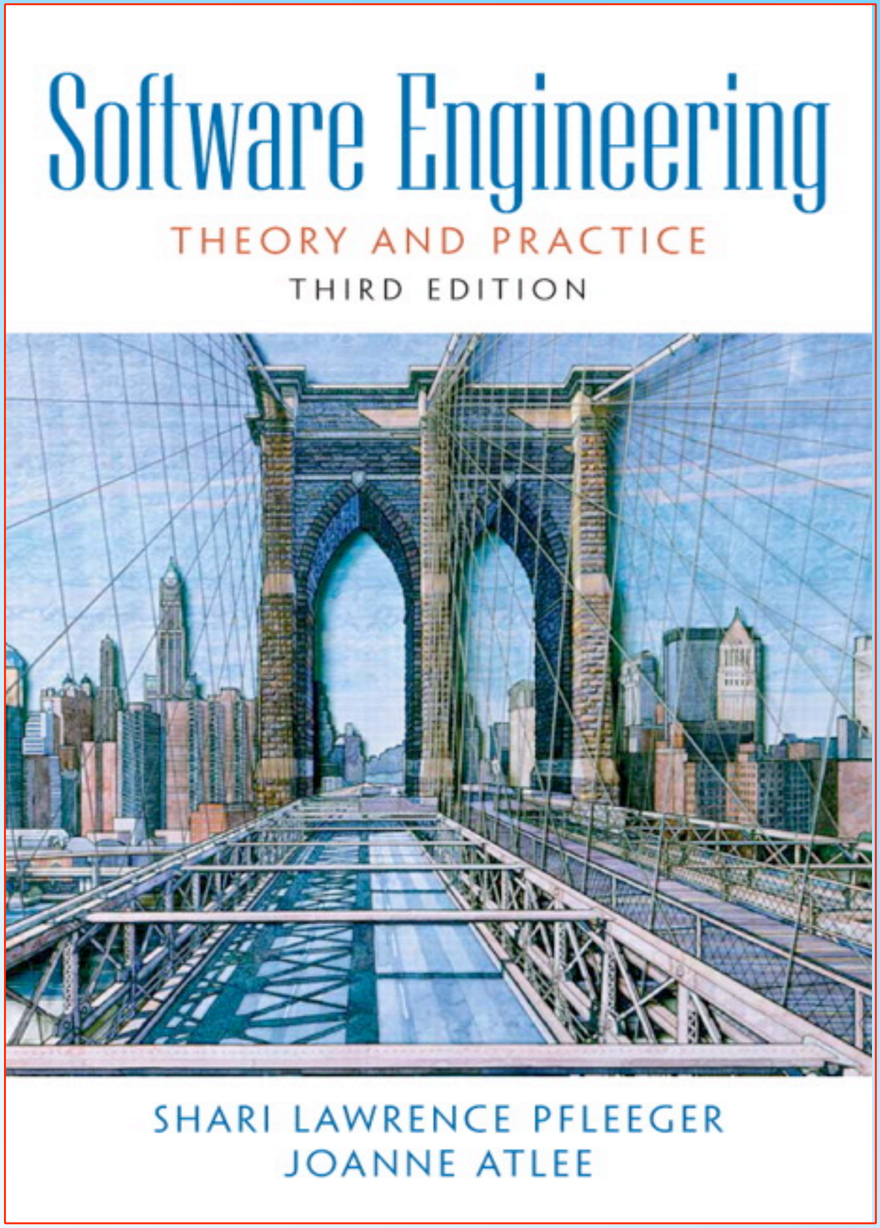


Contents

4.1 The Requirements Process
4.2 Requirements Elicitation
4.3 Types of Requirements
4.4 Characteristics of Requirements
4.5 Modeling Notations
4.6 Requirements and Specification Languages
4.7 Prototyping Requirements
4.8 Requirements Documentation
4.9 Validation and Verification
4.10 Measuring Requirements
4.11 Choosing a Specification Technique
4.12 Information System Example
4.13 Real Time Example

Chapter 4 Objectives

- Eliciting requirements from the customers
- Modeling requirements
- Reviewing requirements to ensure their quality
- Documenting requirements for use by the design and test teams

4.1 The Requirements Process

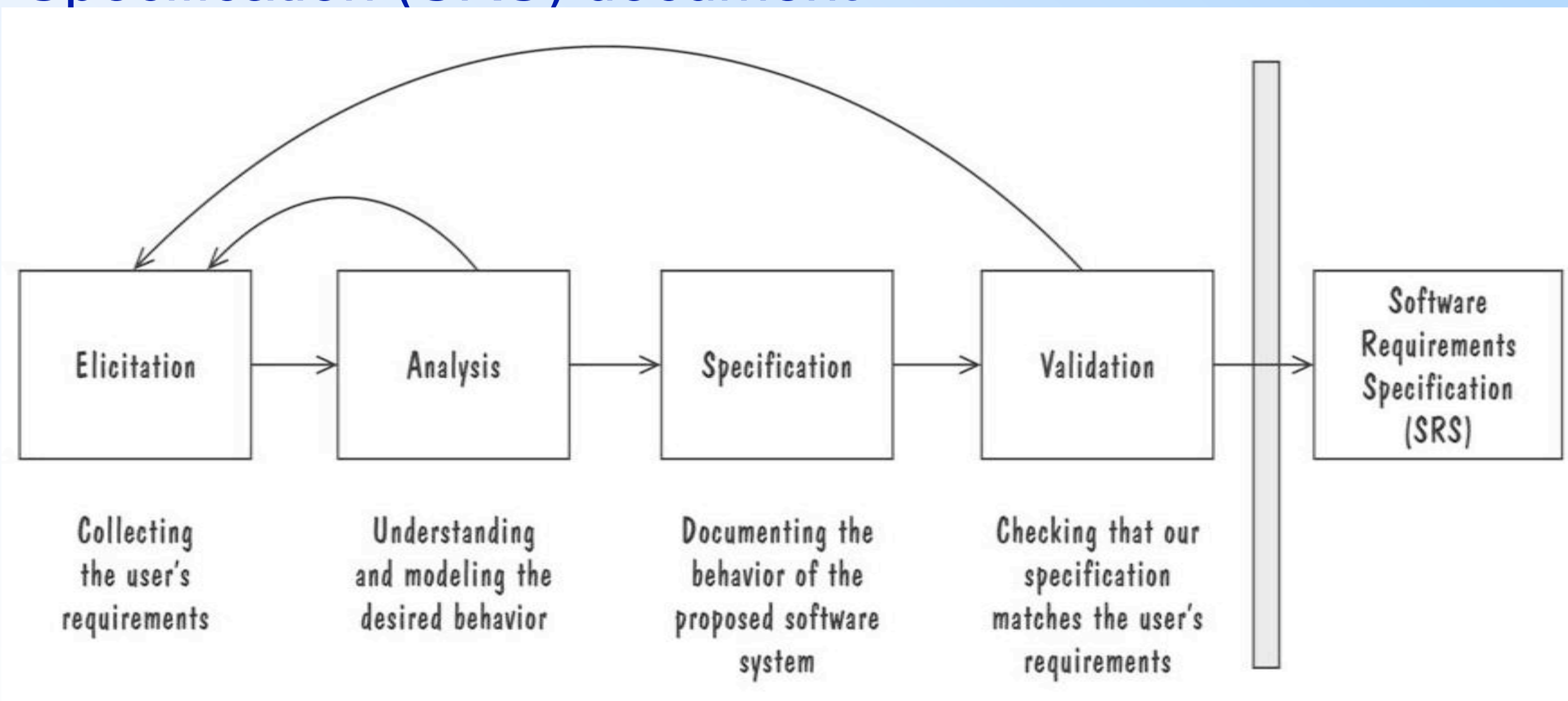
- A ***requirement*** is an expression of desired behavior
- A requirement deals with
  - objects or entities
  - the state they can be in
  - functions that are performed to change states or object characteristics
- Requirements focus on the customer needs, not on the solution or implementation
  - designate *what* behavior, without saying *how* that behavior will be realized

4.1 The Requirements Process
Sidebar 4.1 Why Are Requirements Important?

- Top factors that caused project to fail
  - Incomplete requirements
  - Lack of user involvement
  - Unrealistic expectations
  - Lack of executive support
  - Changing requirements and specifications
  - Lack of planning
  - System no longer needed
- Some part of the requirements process is involved in almost all of these causes
- Errors in Requirements can be expensive if not detected early

4.1 The Requirements Process
Process for Capturing Requirements

- Performed by the req. analyst or system analyst
- The final outcome is a Software Requirements Specification (SRS) document



4.1 The Requirements Process
Sidebar 4.2 Agile Requirements Modeling

- If requirements are tightly coupled and complex, we may be better off with a “heavy” process that empasizes up-front modeling
- If the requirements are uncertain, agile methods are an alternative approach
- Agile methods gather and implement the requirements in increments
- Extreme Programming (XP) is an agile process
  - The requirements are defined as we build the system
  - No planning or designing for possible future requirements
  - Encodes the requirements as test cases that the eventual implementation must pass

4.2 Requirements Elicitation

- Customers do not always understand what their needs and problems are
- It is important to discuss the requirements with everyone who has a stake in the system
- We are working to come up with an agreement on what the requirements are
  - If we can not agree on what the requirements are, then the project is doomed to fail

4.2 Requirements Elicitation
Stakeholders

- **Clients**: pay for the software to be developed
- **Customers**: buy the software after it is developed
- **Users**: use the system
- **Domain experts**: familiar with the problem that the software must automate
- **Market Researchers**: conduct surveys to determine future trends and potential customers
- **Lawyers or auditors**: familiar with government, safety, or legal requirements
- **Software engineers** or other technology experts

4.2 Requirements Elicitation
Means of Eliciting Requirements

- Interviewing stakeholders
- Reviewing available documentations
- Observing the current system (if one exists)
- Apprenticing with users to learn about user's task in more details
- Interviewing users or stakeholders in groups
- Using domain specific strategies, such as Joint Application Design, or PIECES
- Brainstorming with current and potential users

4.3 Types of Requirements

- **Functional requirement**: describes required behavior in terms of required activities
- **Quality requirement** or **nonfunctional requirement**: describes some quality characteristic that the software must possess
- **Design constraint**: a design decision such as choice of platform or interface components
- **Process constraint**: a restriction on the techniques or resources that can be used to build the system

4.3 Types of Requirements
Sidebar 4.4 Making Requirements Testable

- “Fit criteria” form objective standards for judging whether a proposed solution satisfies the requirements
  - It is easy to set fit criteria for quantifiable requirements
  - It is hard for subjective quality requirements
- Three ways to help make requirements testable
  - Specify a quantitative description for each adverb and adjective
  - Replace pronouns with specific names of entities
  - Make sure that every noun is defined in exactly one place in the requirements documents

4.3 Types of Requirements
Resolving Conflicts

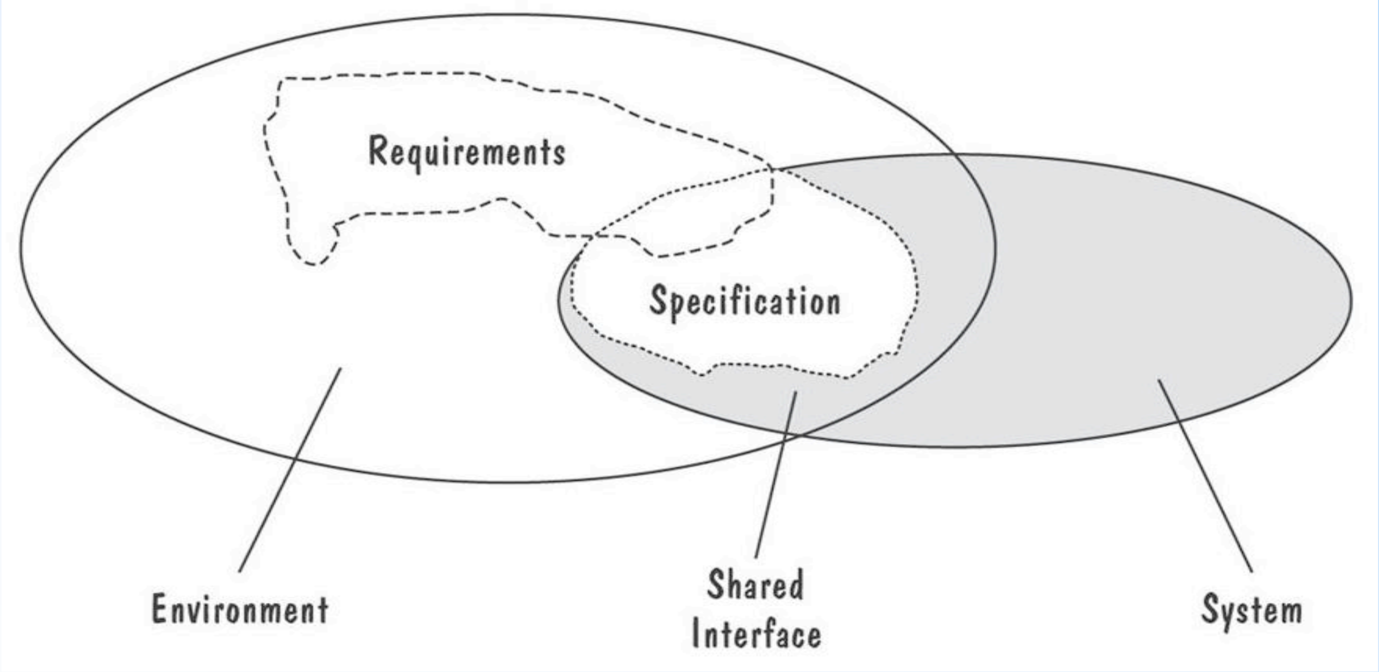
- Different stakeholders have different sets of requirements
  - with potentially conflicting ideas
- Need to prioritize requirements
- Prioritization might separate requirements into three categories
  - *essential*: absolutely must be met
  - *desirable*: highly desirable but not necessary
  - *optional*: possible but could be eliminated

4.3 Types of Requirements
Two Kinds of Requirements Documents

- **Requirements definition**: a complete listing of everything the customer wants to achieve
  - Describing the entities in the environment where the system will be installed
- **Requirements specification**: restates the requirements as a specification of how the proposed system shall behave

4.3 Types of Requirements
Two Kinds of Requirements Documents (continued)

- Requirements defined anywhere within the environment's domain, including the system's interface
- Specification restricted only to the intersection between environment and system domain



4.4 Characteristics of Requirements

- Correct
- Consistent
- Unambigious
- Complete
- Feasible
- Relevant
- Testable
- Traceable

4.5 Modeling Notations

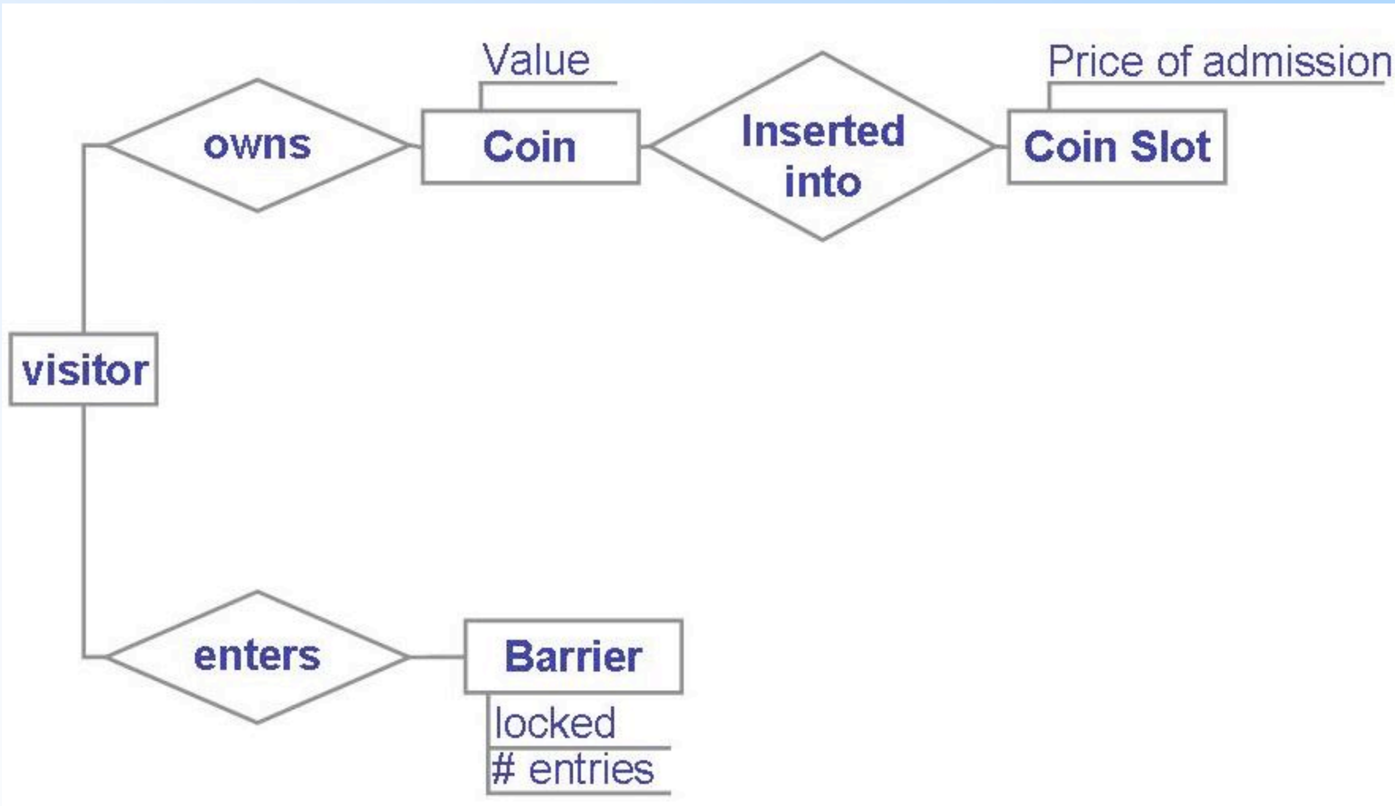
- It is important to have standard notations for modeling, documenting, and communicating decisions
- Modeling helps us to understand requirements thoroughly
  - Holes in the models reveal unknown or ambiguous behavior
  - Multiple, conflicting outputs to the same input reveal inconsistencies in the requirements

4.5 Modeling Notations
Entity-Relationship Diagrams

- A popular graphical notational paradigm for representing conceptual models
- Has three core constructs
  - An *entity*: depicted as a rectangle, represents a collection of real-world objects that have common properties and behaviors
  - A *relationship*: depicted as an edge between two entities, with diamond in the middle of the edge specifying the type of relationship
  - An *attribute*: an annotation on an entity that describes data or properties associated with the entity

4.5 Modeling Notations
Entity-Relationship Diagrams (continued)

- Entity diagram of turnstile problem



4.5 Modeling Notations
Entity-Relationship Diagrams (continued)

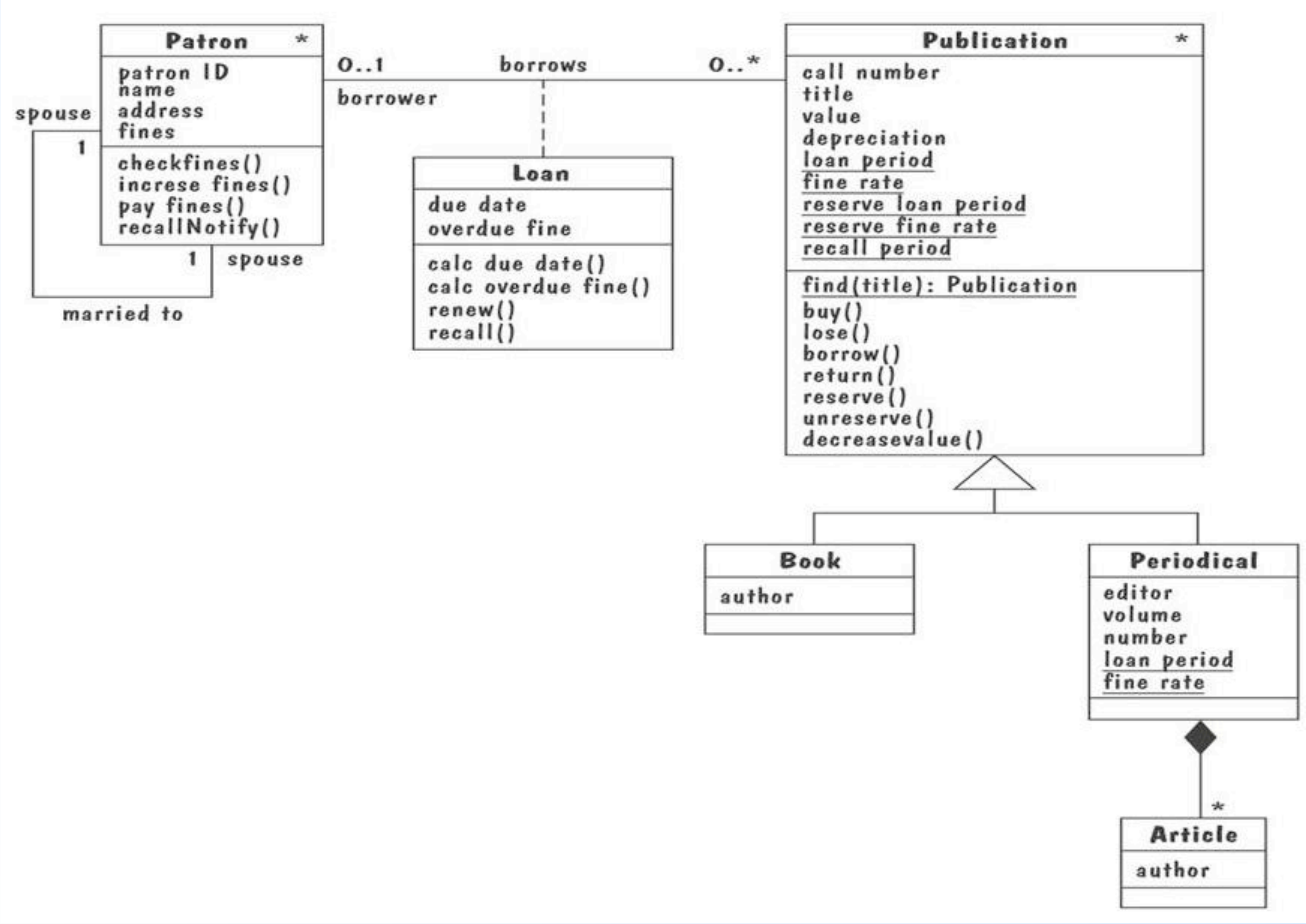
- ER diagrams are popular because
  - they provide an overview of the problem to be addressed
  - the view is relatively stable when changes are made to the problem's requirements
- ER diagram is likely to be used to model a problem early in the requirements process

4.5 Modeling Notations
ER Diagrams Example: UML Class Diagram

- **UML (Unified Modeling Language)** is a collection of notations used to document software specifications and designs
- It represents a system in terms of
  - *objects*: akin to entities, organized in classes that have an inheritance hierarchy
  - *methods*: actions on the object's variables
- The **class diagram** is the flagship model in any UML specification
  - A sophisticated ER diagram relating the classes (entities) in the specification

4.5 Modeling Notations

UML Class Diagram of Library Problem

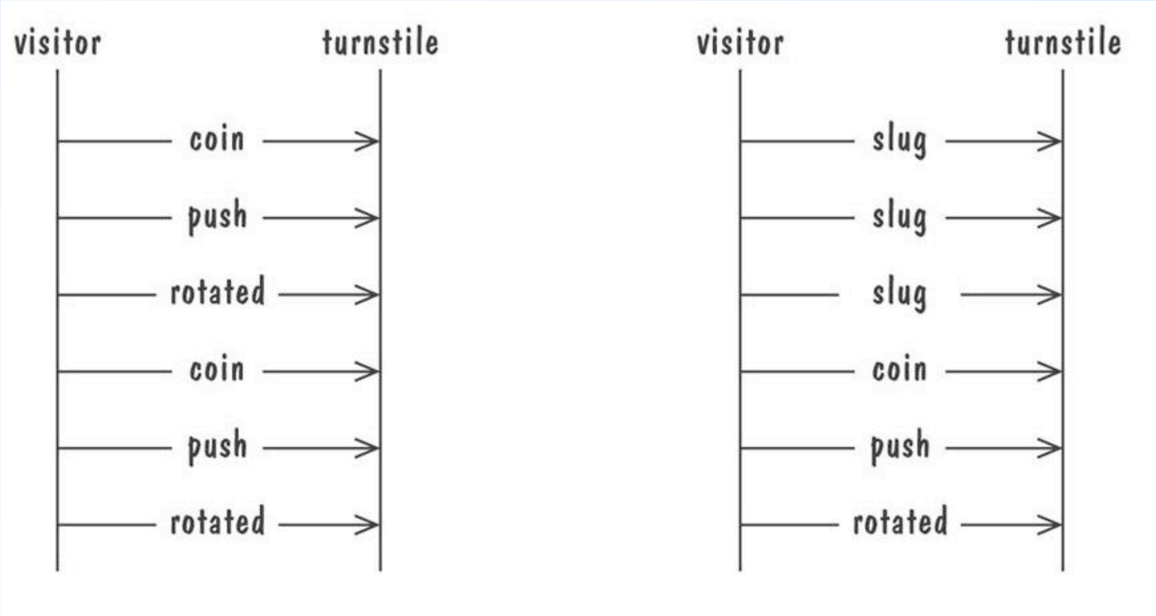


4.5 Modeling Notations
Event Traces

- A graphical description of a sequence of events that are exchanged between real-world entities
  - *Vertical line*: the timeline of distinct entity, whose name appears at the top of the line
  - *Horizontal line*: an event or interaction between the two entities bounding the line
  - Time progresses from top to bottom
- Each graph depicts a single trace, representing one of several possible behaviors
- Traces have semantics that are relatively precise, simple and easy to understand

4.5 Modeling Notations
Event Traces (continued)

- Graphical representation of two traces for the turnstile problem
  - trace on the left represents typical behavior
  - trace on the right shows exceptional behavior

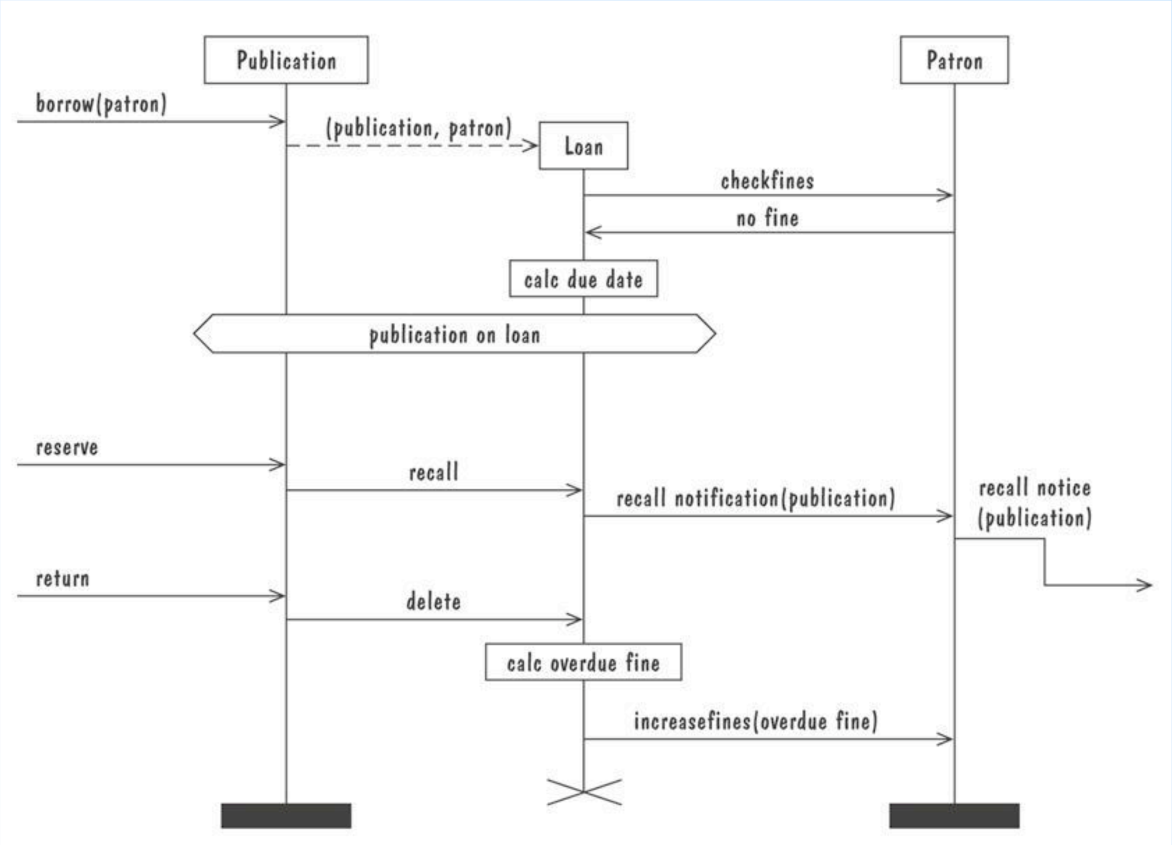


4.5 Modeling Notations
Event Traces Example: Message Sequence Chart

- An enhanced event-trace notation, with facilities for creating and destroying entities, specifiying actions and timers, and composing traces
  - *Vertical line* represents a participating entity
  - *A message* is depicted as an arrow from the sending entity to the receiving entity
  - *Actions* are specified as labeled rectangles positioned on an entity's execution line
  - *Conditions* are important states in an entity's evolution, represented as labeled hexagon

4.5 Modeling Notations
Message Sequence Chart (continued)

- Message sequence chart for library loan transaction

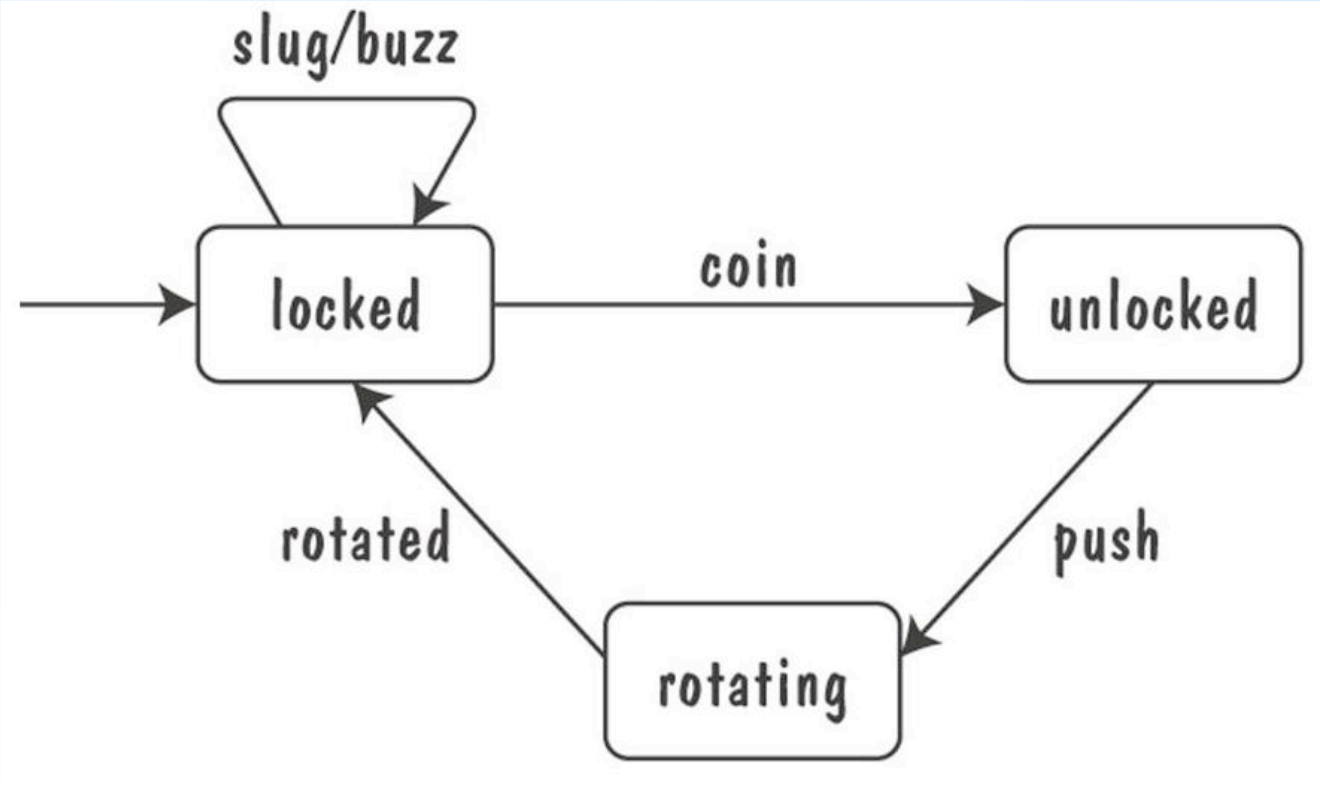


4.5 Modeling Notations
State Machines

- A graphical description of all dialog between the system and its environment
  - Node (*state*) represents a stable set of conditions that exists between event occurences
  - Edge (*transition*) represents a change in behavior or condition due to the occurrence of an event
- Useful both for specifying dynamic behavior and for describing how behavior should change in response to the history of events that have already occurred

4.5 Modeling Notations
State Machines (continued)

- Finite state machine model of the turnstile problem



4.5 Modeling Notations
State Machines Example: UML Statechart Diagrams

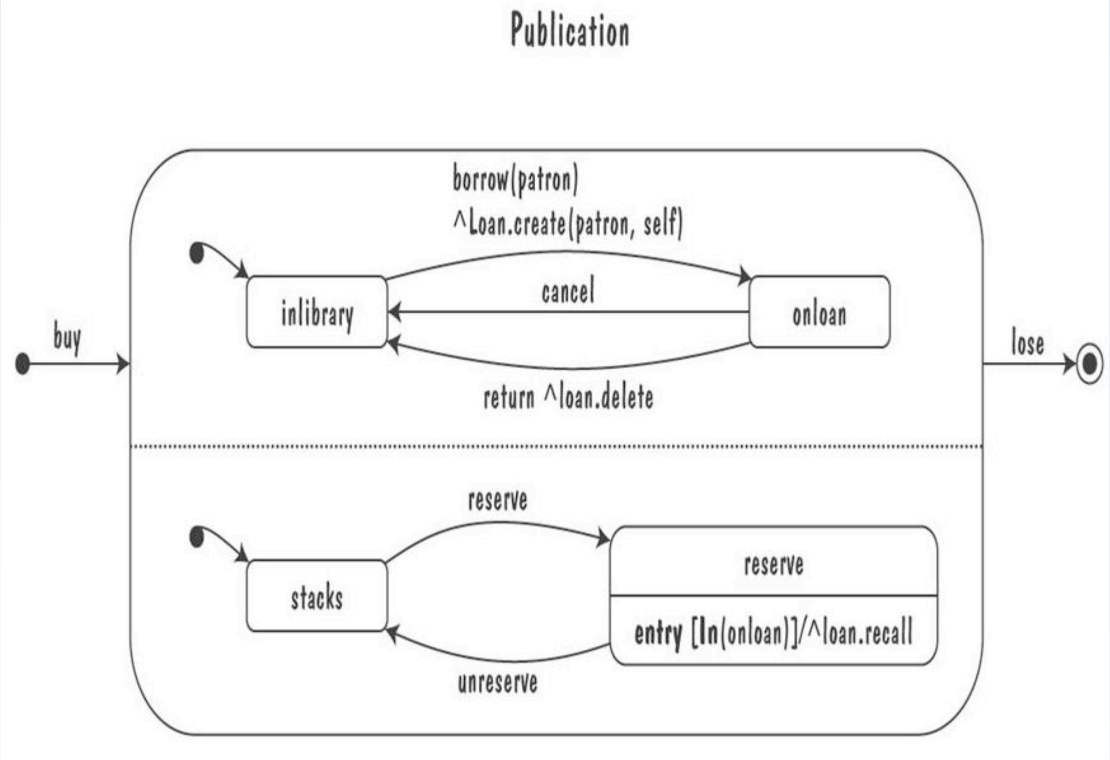
- A UML statechart diagram depicts the dynamic behavior of the objects in a UML class
  - UML class diagram has no information about how the entities behave, how the behaviors change
- A UML model is a collection of concurrently executing statecharts
- UML statechart diagram has a rich syntax, including state hierarchy, concurrency, and intermachine communication

4.5 Modeling Notations
UML Statechart Diagrams (continued)

- **State hierarchy** is used to unclutter diagrams by collecting into superstate those states with common transitions
- A **superstate** can actually comprise multiple concurrent submachines, separated by dashed lines
  - The submachines are said to operate *concurrently*

4.5 Modeling Notations
UML Statechart Diagrams (continued)

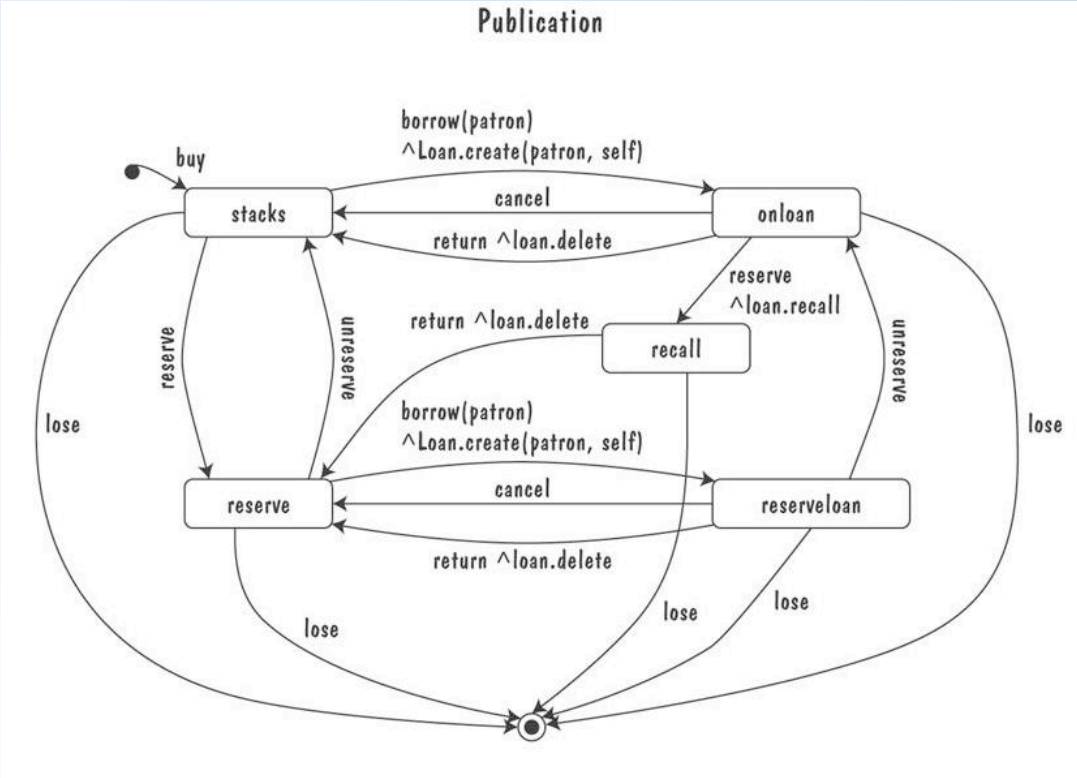
- The UML statechart diagram for the `Publication` class from the Library class model



4.5 Modeling Notations

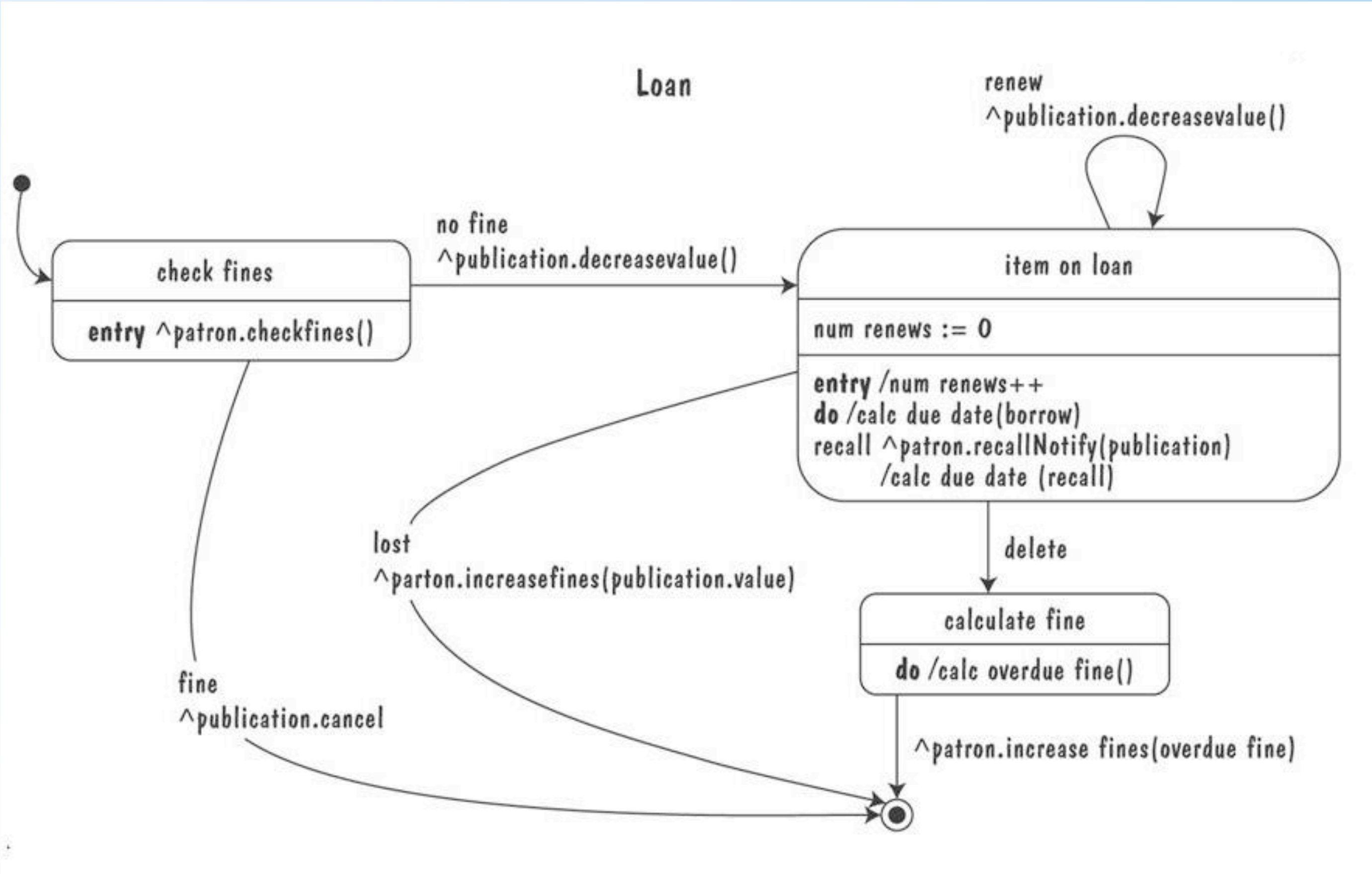
UML Statechart Diagrams (continued)

- An equivalent statechart for `Publication` class that does not make use of state hierarchy or concurrency
  - comparatively messy and and repetitive



4.5 Modeling Notations
UML Statechart Diagrams (continued)

- The UML statechart diagram for `Loan` association class illustrates how states can be annotated with local variables, actions and activities



4.5 Modeling Notations
State Machines: Ways of Thinking about State

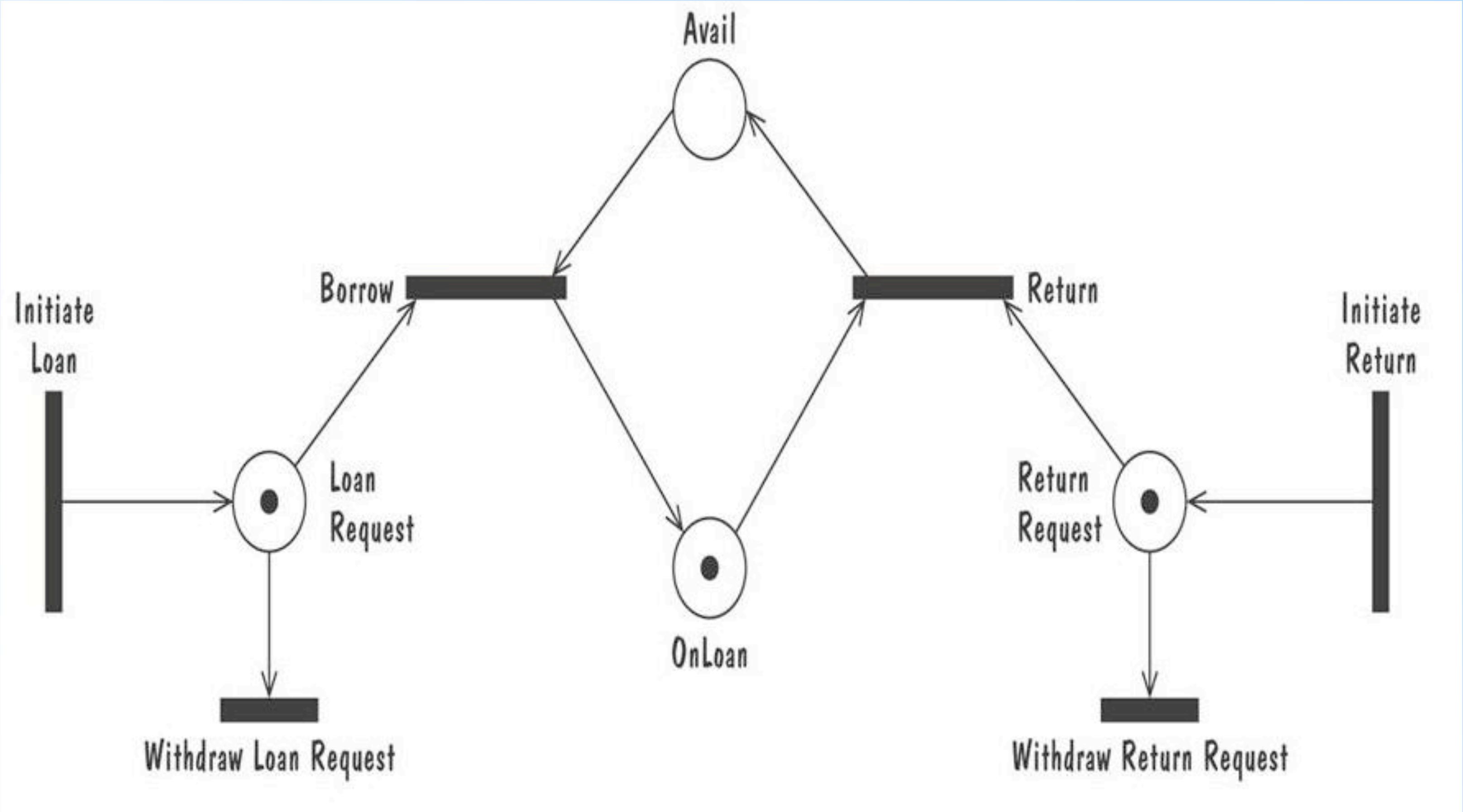
- Equivalence classes of possible future behavior
- Periods of time between consecutive event
- Named control points in an object's evolution
- Partition of an object's behavior

4.5 Modeling Notations
State Machines Example: Petri Nets

- A form or state-transition notation that is used to model concurrent activities and their interaction
  - Circles (*places*) represent activities or conditions
  - Bars represents *transitions*
  - *Arcs* connect a transition with its input places and its output places
  - The places are populated with *tokens,* which act as enabling conditions for the transitions
  - Each arc can be assigned *a weight* that specifies how many tokens are removed from arc's input place, when the transition fires

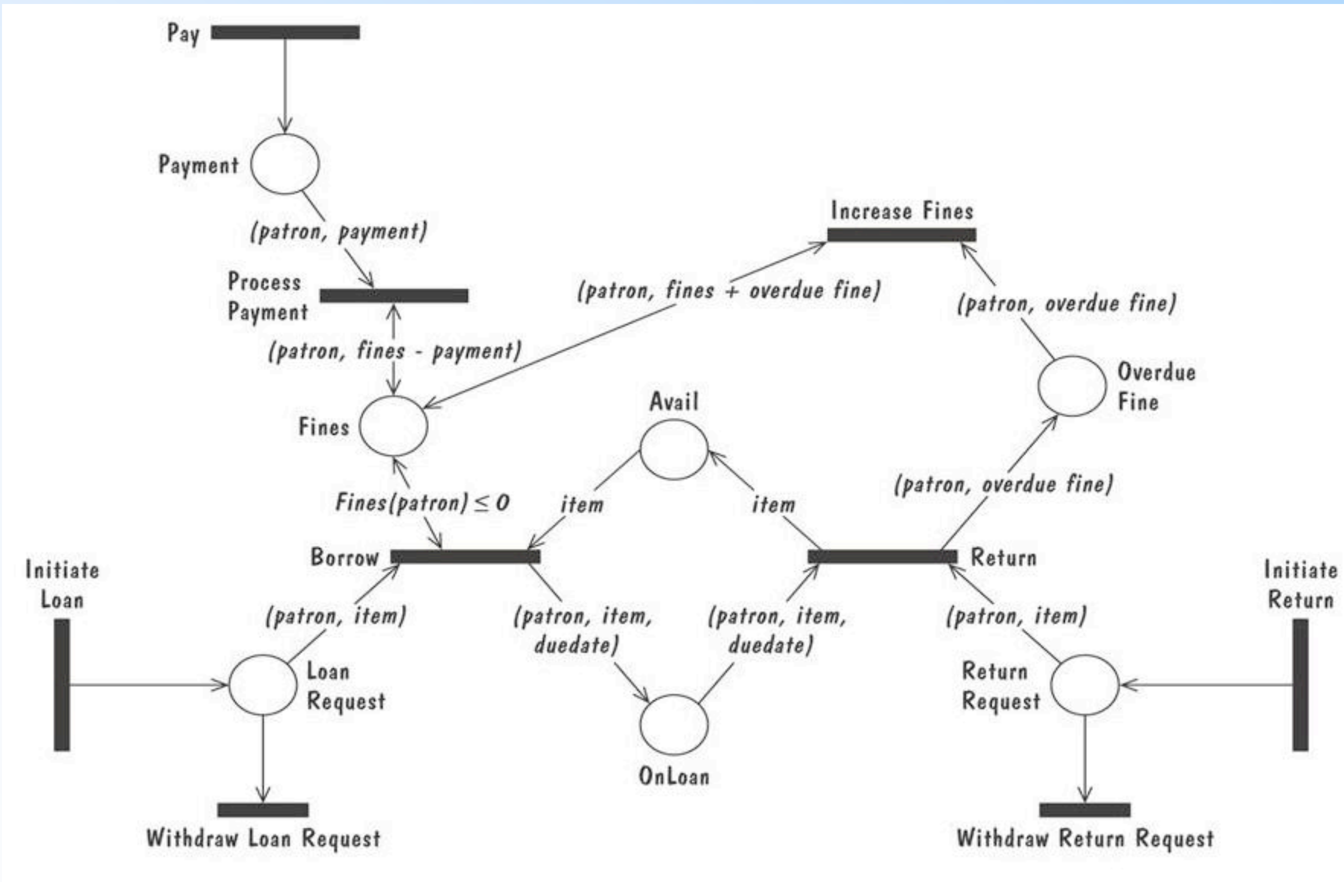
4.5 Modeling Notations
Petri Nets (continued)

- Petri net of book loan



4.5 Modeling Notations
Petri Nets (continued)

- A high level Petri net specification for the library problem

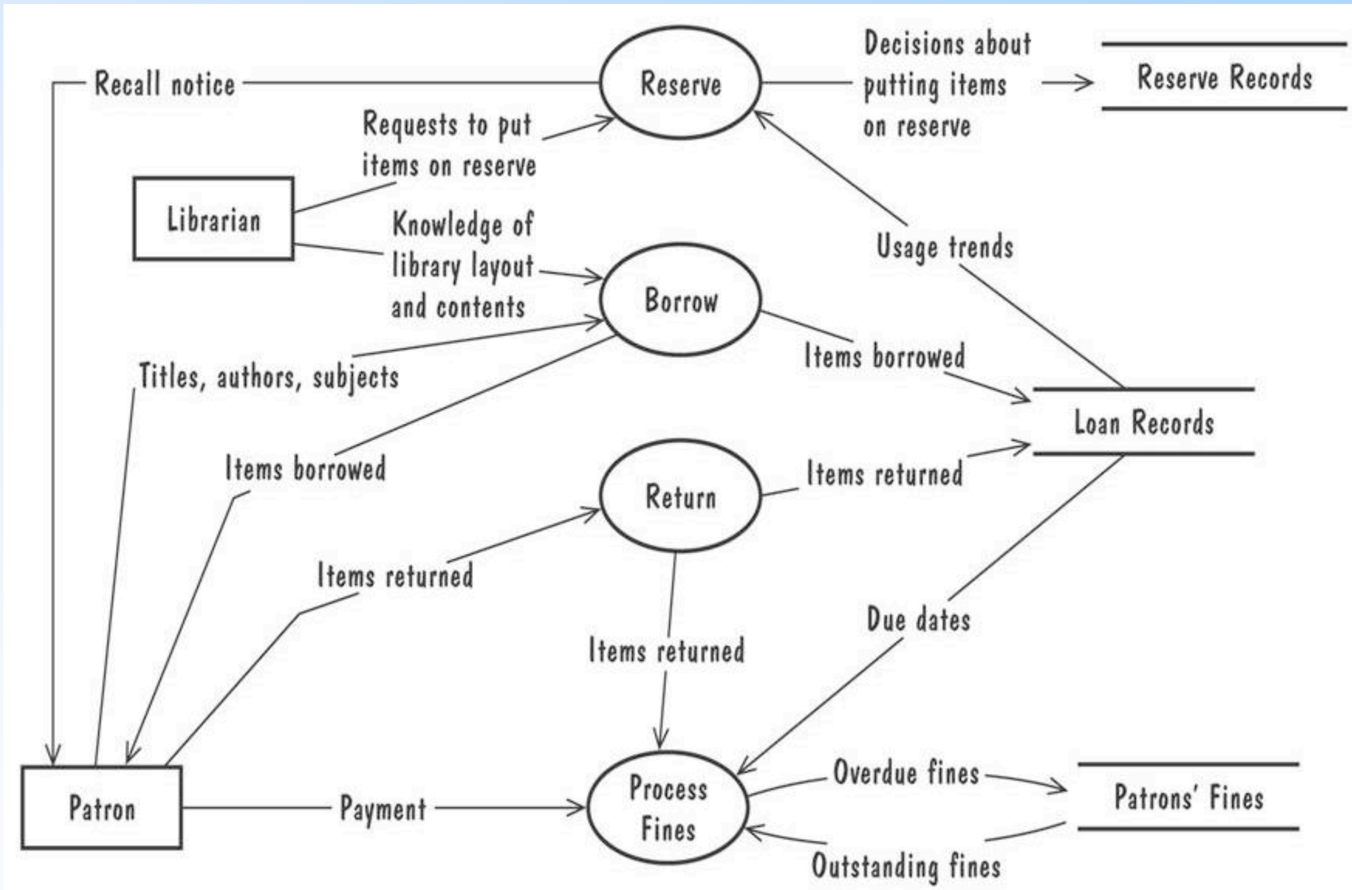


4.5 Modeling Notations
Data-Flow Diagrams

- ER diagram, event trace, state machines depict only lower-level behaviors
- A data-flow diagram (DFD) models functionality and the flow of data from one function to another
  - A bubble represents a *process*
  - An arrow represents *data flow*
  - A *data store*: a formal repository or database of information
  - Rectangles represent *actors*: entities that provide input data or receive the output result

4.5 Modeling Notations
Data-Flow Diagrams (continued)

- A high-level data-flow diagram for the library problem



4.5 Modeling Notations
Data-Flow Diagrams (continued)

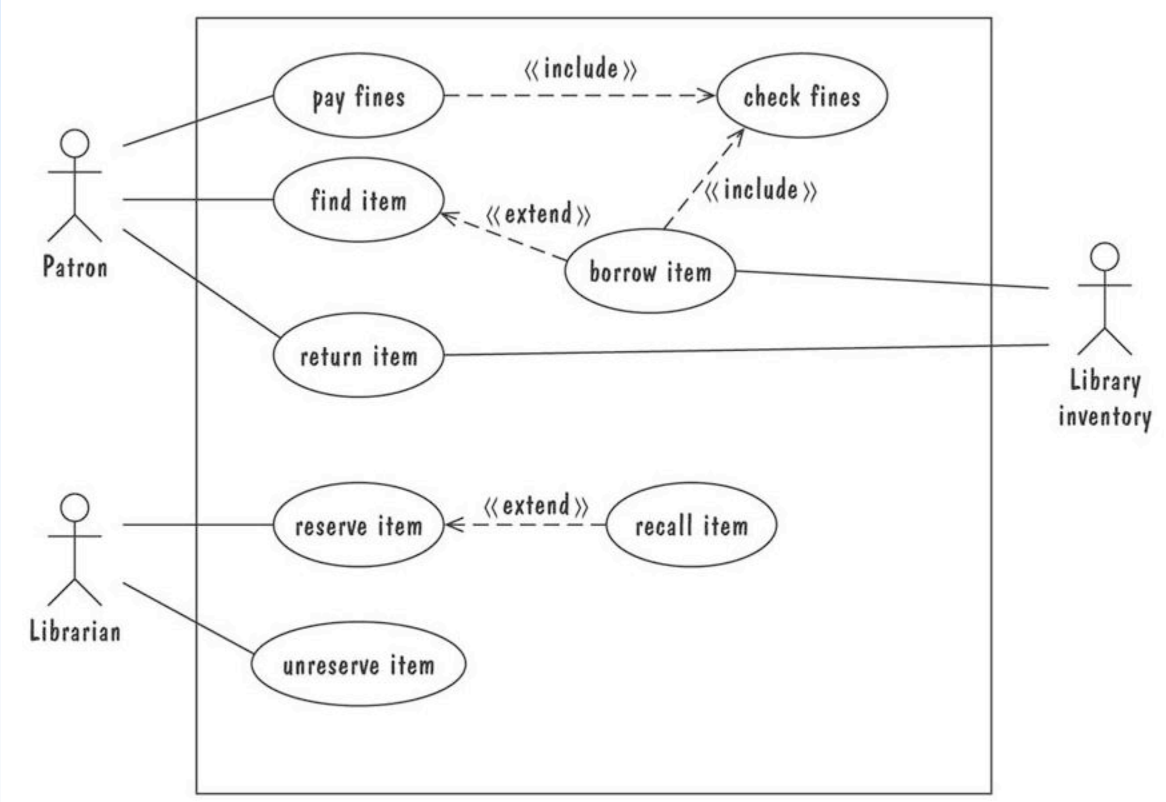
- Advantage:
  - Provides an intuitive model of a proposed system's high-level functionality and of the data dependencies among various processes
- Disadvantage:
  - Can be aggravatingly ambiguous to a software developer who is less familiar with the problem being modeled

4.5 Modeling Notations
Data-Flow Diagrams Example: Use Cases

- Components
  - A large box: *system boundary*
  - Stick figures outside the box: *actors*, both human and systems
  - Each oval inside the box: a use case that represents some major required functionality and its variant
  - A line between an actor and use case: the actor participates in the use case
- Use cases do not model all the tasks, instead they are used to specify user views of essential system behavior

4.5 Modeling Notations
Use Cases (continued)

- Library use cases including borrowing a book, returning a borrowed book, and paying a library fine



4.5 Modeling Notations
Functions and Relations

- **Formal methods** or **approach:** mathematically based specification and design techniques
- Formal methods model requirements or software behavior as a collection of mathematical **functions** or **relations**
  - Functions specify the state of the system's execution, and output
  - A relation is used whenever an input value maps more than one ouput value
- Functional method is consistent and complete

4.5 Modeling Notations
Functions and Relations (continued)

- Example: representing turnstile problem using two functions
  - One function to keep track of the state
  - One function to specify the turnstile output

$$NetState(s,e) = \begin{cases} unlocked & s=locked \text{ AND } e=coin \\ rotating & s=unlocked \text{ AND } e=push \\ locked & (s=rotating \text{ AND } e=rotated) \\ & \text{OR } (s=locked \text{ AND } e=slug) \end{cases}$$

$$Output(s,e) = \begin{cases} buzz & s=locked \text{ AND } e=slug \\ <none> & Otherwise \end{cases}$$

4.5 Modeling Notations

Functions and Relations Example: Decision Tables

- It is a tabular representation of a functional specification that maps events and conditions to appropriate responses or action
- The specification is informal because the inputs (events and conditions) and outputs (actions) may be expressed in natural language
- If there is *n* input conditions, there are 2^n possible combinations of input conditions
- Combinations map to the same set of results and can be combined into a single column

4.5 Modeling Notations
Decision Tables (continued)

- Decision table for library functions `borrow`, `return`, `reserve`, and `unreserve`

(event) borrow	T	T	T	F	F	F	F	F
(event) return	F	F	F	T	T	F	F	F
(event) reserve	F	F	F	F	F	T	T	F
(event) unreserve	F	F	F	F	F	F	F	T
item out on loan	F	T	-	-	-	F	T	F
item on reserve	-	-	-	F	T	-	-	-
patron.fines > $0.00	F	-	T	-	-	-	-	-
(Re-)Calculate due date	X						X	
Put item in stacks				X				X
Put item on reserve shelf					X	X		
Send recall notice							X	
Reject event		X	X					

4.5 Modeling Notations
Functions and Relations Example: Parnas Tables

- Tabular representations of mathematical functions or relations
  - The column and row headers are predicates used to specify cases
  - The internal table entries store the possible function results
  - An entry "X" either could be invalid under the specified conditions or the combination of conditions is infeasible
- Note: figure below has wrong headings, disregard

Calc due date(patron, publication, event, Today) =

	event ∈ {borrow, renew}		event = recall
	publication.In State	publication.In State	
patron.fine = 0	publication.reserve loan period	publication.loan period	Min(due date, publication.recall period)
patron.fine > 0	X	X	X

4.5 Modeling Notations
Logic

- An **operational notation** is a notation used to describe a problem or a proposed software solution in terms of situational behavior
  - Model of case-based behavior
  - Examples: state machine, event traces, data-flow diagram, functional method
- A **descriptive notation** is a notation that describes a problem or a proposed solution in terms of its properties or its variants
  - Example: logic

4.5 Modeling Notations
Logic (continued)

- A logic consists of a language for expressing properties and a set of inference rules for deriving new, consequent properties from the stated properties
- In logic, a property specification represents only those values of the property's variables for which the property's expression evaluates to true
  - The logic used for specifying software requirements is almost always first-order logic, with its typed variables, constants, functions, and predicates
  - Another common logic usd for software requirements is temporal logic

4.5 Modeling Notations
Logic (continued)

- Consider the following variables of the turnstile problem, with their initial value

```
num_coins : integer := 0;                  /* number of coins inserted */
num_entries : integer := 0;                /* number of half-rotations of turnstile */
barrier : {locked, unlocked} := locked;    /* whether barrier is locked */
may_enter : boolean := false;              /* event of coin being inserted */
push : boolean := false;                   /* turnstile is pushed sufficiently hard to rotate it one-half rotation */
```

- The first-order logic expressions

$$num\_coins \geq num\_entries$$

$$(num\_coins > num\_entries \Leftrightarrow (barrier = unlocked)$$

$$(barrier = locked) \Leftrightarrow \neg may\_enter$$

4.5 Modeling Notations
Logic (continued)

- Temporal logic introduces additional logical connectives for constraining how variables can change value over time
- The following connectives constrain future variable values, over a single execution
  - □f ≡ f is *true* now and throughout the rest of execution
  - ◇f ≡ f is *true* now or at some future point in the execution
  - ○f ≡ f is *true* in the next point in the execution
  - f W g = f is *true* until a point where g is true, but g may never be true
- Turnstile properties expressed in temporal logic

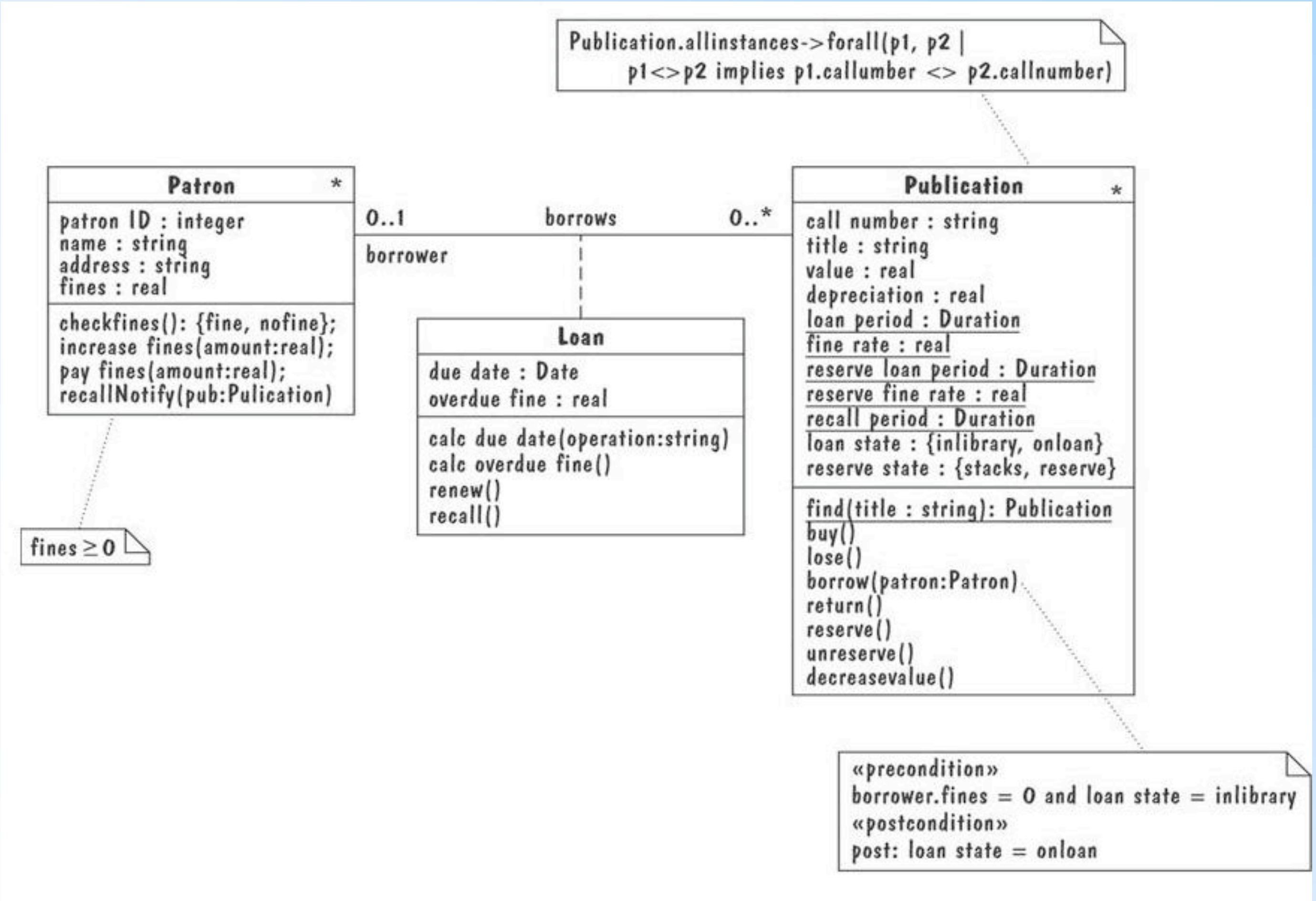
  □(insert_coin => ○ (may_enter W push))

  □(∀n(insert_coin ∧ num_coins=n) => ○(num_coins=n+1))

4.5 Modeling Notations
Logic Example: Object Constrain Language (OCL)

- A constraint language that is both mathematically precise and easy for non-mathematicians to read, write, and understand
- Designed for expressing constraints on object models, and expressing queries on object type

4.5 Modeling Notations
Library Classes Annotated with OCL Properties



4.5 Modeling Notations
Logic Example: Z

- A formal requirements-specification language that
  - structures set-theoretic definitions of variables into a complete abstract-data-type model of a problem
  - uses logic to express the pre- and post-conditions for each operation
- Methods of abstractions are used to decompose a specification into manageable sized modules, called schemas

4.5 Modeling Notations
Partial Z Specification for the Library Problem

```
[Patron, Item, Date, Duration]
LoanPeriod : Duration;
ReserveLoan : Duration;
DailyFine : ℕ;

┌ Library ──────────────────────
│ Catalogue, OnReserve : ℙ Item
│ Borrower: Item ⇸ Patron
│ DueDate: Item ⇸ Date
│ Fine: Patron ⇸ ℕ
├───────────────
│ dom Borrower ⊆ Catalogue
│ OnReserve ⊆ Catalogue
│ dom Borrower = dom DueDate
└──────────────────────────────

┌ InitLibrary ──────────────────
│ Library
├───────────────
│ Catalogue = ∅ ∧ OnReserve = ∅
│ dom Borrower = ∅
│ dom DueDate = ∅
│ dom Fine = ∅
└──────────────────────────────

┌ Get Due Date ────────
│ Ξ Library
│ i? : Item
│ due! : Date
├───────────────
│ i? ∈ dom Borrower
│ due! = DueDate(i?)
└──────────────────────

┌ Buy ──────────────────────────
│ Δ Library
│ i? : Item
├───────────────
│ i? ∉ Catalogue
│ Catalogue' = Catalogue ∪ {i?}
│ OnReserve' = OnReserve
│ Borrower' = Borrower
│ DueDate' = DueDate
│ Fine' = Fine
└──────────────────────────────

┌ Return ───────────────────────────────────────
│ Δ Library
│ i? : Item
│ p? : Patron
│ today? : Date
├───────────────
│ i? ∈ dom Borrower ∧ p? = Borrower(i?)
│ Borrower' = {i?} ⩤ Borrower
│ DueDate' = {i?} ⩤ DueDate
│ DueDate(i?) - today? < 0 ⇒
│    Fine' = Fine ⊕ {p? ↦ (Fine(p?) + ((DueDate(i?) - today?)*DailyFine)}
│ DueDate(i?) - today? ≥ 0 ⇒
│    Fine' = Fine
│ Catalogue' = Catalogue
│ OnReserve' = OnReserve
└──────────────────────────────────────────────
```

4.5 Modeling Notations
Algebraic Specifications

- To specify the behavior of operations by specifying interactions between pairs of operations rather than modeling individual operations
- It is hard to define a set of axioms that is complete and consistent and that reflects the desired behavior

4.5 Modeling Notations
Algebraic Specifications Example: SDL Data

- Partial SDL data specification for the library problem

```
NEWTYPE Library
LITERALS New;
OPERATORS
    buy: Library, Item → Library;
    lose: Library, Item → Library;
    borrow: Library, Item → Library;
    return: Library, Item → Library;
    reserve: Library, Item → Library;
    unreserve: Library, Item → Library;
    recall: Library, Item → Library;
    isInCatalogue: Library, Item → boolean;
    isOnLoan: Library, Item → boolean;
    isOnReserve: Library, Item → boolean;

/*generators are New, buy, borrow, reserve */

AXIOMS
FOR ALL lib in Library (
  FOR ALL i, i2 in Item (
    lose(New, i) ≡ ERROR;
    lose(buy(lib, i), i2) ≡ if i= i2 then lib;
                            else buy(lose(lib, i2), i);
    lose(borrow(lib, i), i2) ≡ if i = i2 then lose(lib, i2)
                               else borrow(lose(lib, i2), i);
    lose(reserve(lib, i), i2) ≡ if i = i2 then lose(lib, i2)
                                else reserve(lose(lib, i2), i);

    return(New, i) ≡ ERROR;
    return(buy(lib, i), i2) ≡ if i = i2 then buy (lib, i);
                              else buy(return(lib, i2), i);
    return(borrow(lib, i), i2) ≡ if i = i2 then lib;
                                 else borrow(return(lib, i2), i);
    return(reserve(lib, i), i2) ≡ reserve(return(lib, i2), i);
        ...
    isInCatalogue(New, i) ≡ false;
    isInCatalogue(buy(lib, i), i2) ≡ if i = i2 then true;
                                     else isInCatalogue(lib, i2);
    isInCatalogue(borrow(lib, i), i2) ≡ isInCatalogue (lib, i2);
    isInCatalogue(reserve(lib, i), i2) ≡ isInCatalogue (lib, i2);
        ...
  }
}
ENDNEWTYPE Library;
```

4.6 Requirements and Specification Languages

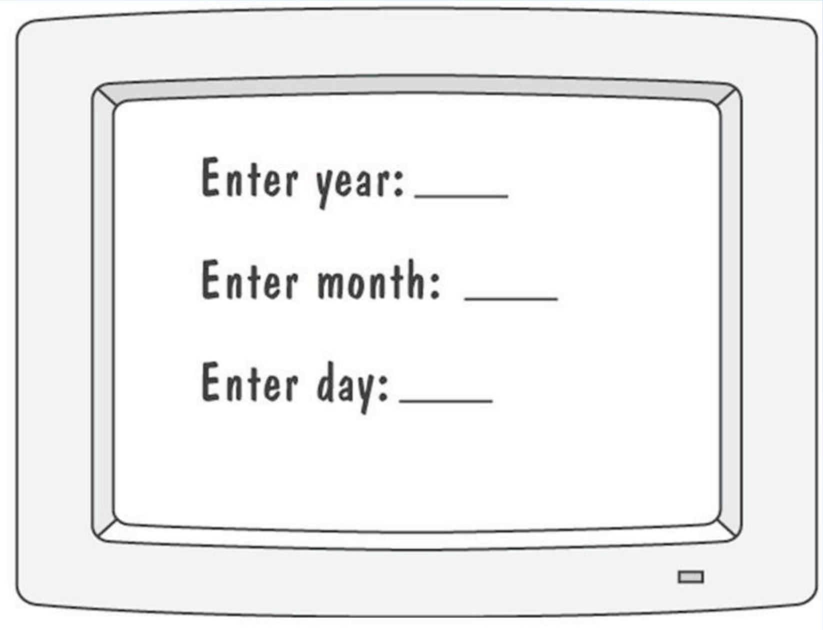
- Note: Skipping Section 4.6

4.7 Prototyping Requirements
Building a Prototype

- To elicit the details of proposed system
- To solicit feedback from potential users about
  - which aspects they would like to see improve
  - which features are not so useful
  - what functionality is missing
- Determine whether the customer's problem has a feasible solution
- Assist in exploring options for optimizing quality requirements

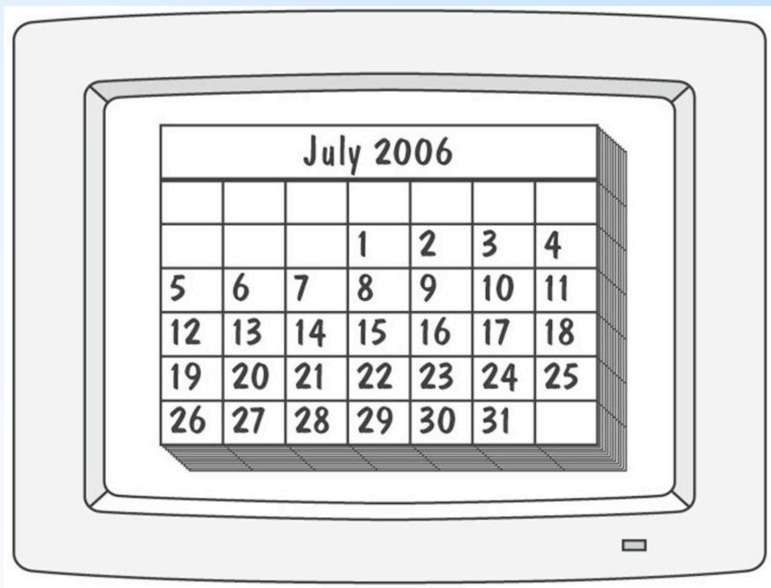
4.7 Prototyping Requirements
Prototyping Example

- Prototype for building a tool to track how much a user exercises each day
- Graphical respresentation of first prototype, in which the user must type the day, month and year



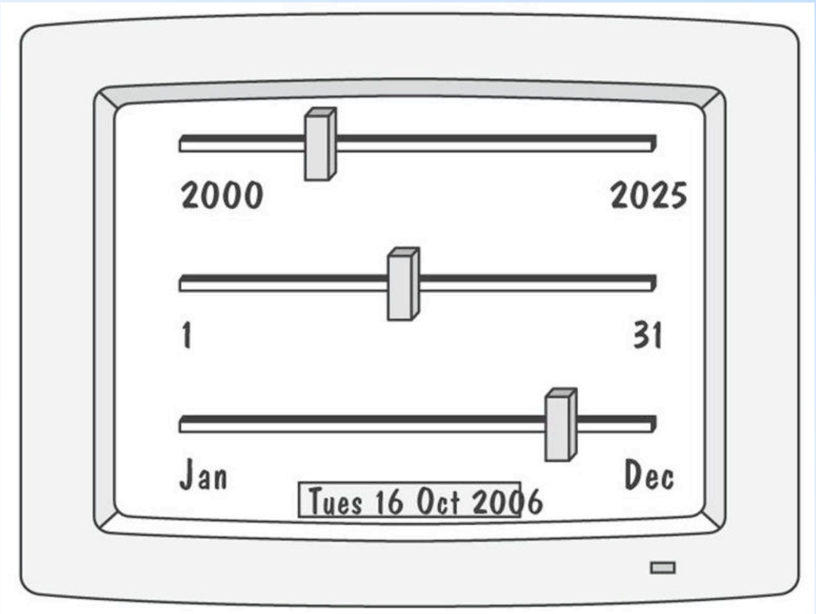
4.7 Prototyping Requirements
Prototyping Example (continued)

- Second prototype shows a more interesting and sophisticated interface involving a calendar
  - User uses a mouse to select the month and year
  - The system displays the chart for that month, and the user selects the appropriate date in the chart



4.7 Prototyping Requirements
Prototyping Example (continued)

- Third prototype shows that instead of a calendar, the user is presented with three slide bars
  - User uses the mouse to slide each bar left or right
  - The box at the bottom of the screen changes to show the selected day, month, and year



4.7 Prototyping Requirements
Approaches to Prototyping

- Throwaway approach
  - Developed to learn more about a problem or a proposed solution, and that is never intended to be part of the delivered software
  - Allows us to write "quick-and-dirty" software
- Evolutionary approach
  - Developed not only to help us answer questions but also to be incorporated into the final product
  - Prototype has to eventually exhibit the quality requirements of the final product, and these qualities cannot be retrofitted
- Both techniques are sometimes called rapid prototyping

4.7 Prototyping Requirements
Prototyping vs. Modeling

- Prototyping
  - Good for answering questions about the user interfaces
- Modeling
  - Quickly answer questions about constraints on the order in which events should occur, or about the synchronization of activities

4.8 Requirements Documentation
Requirements Definition: Steps Documenting Process

- Outline the general purpose and scope of the system, including relevant benefits, objectives, and goals
- Describe the background and the rationale behind proposal for new system
- Describe the essential characteristics of an acceptable solution
- Describe the environment in which the system will operate
- Outline a description of the proposal, if the customer has a proposal for solving the problem
- List any assumptions we make about how the environment behaves

4.8 Requirements Documentation
Requirements Specification: Steps Documenting Process

- Describe all inputs and outputs in detail, including
  - the sources of inputs
  - the destinations of outputs,
  - the value ranges
  - data format of inputs and outputs data
  - data protocols
  - window formats and organizations
  - timing constraint
- Restate the required functionality in terms of the interfaces' inputs and outputs
- Devise fit criteria for each of the customer's quality requirements

4.8 Requirements Documentation
IEEE Standard for SRS Organized by Objects

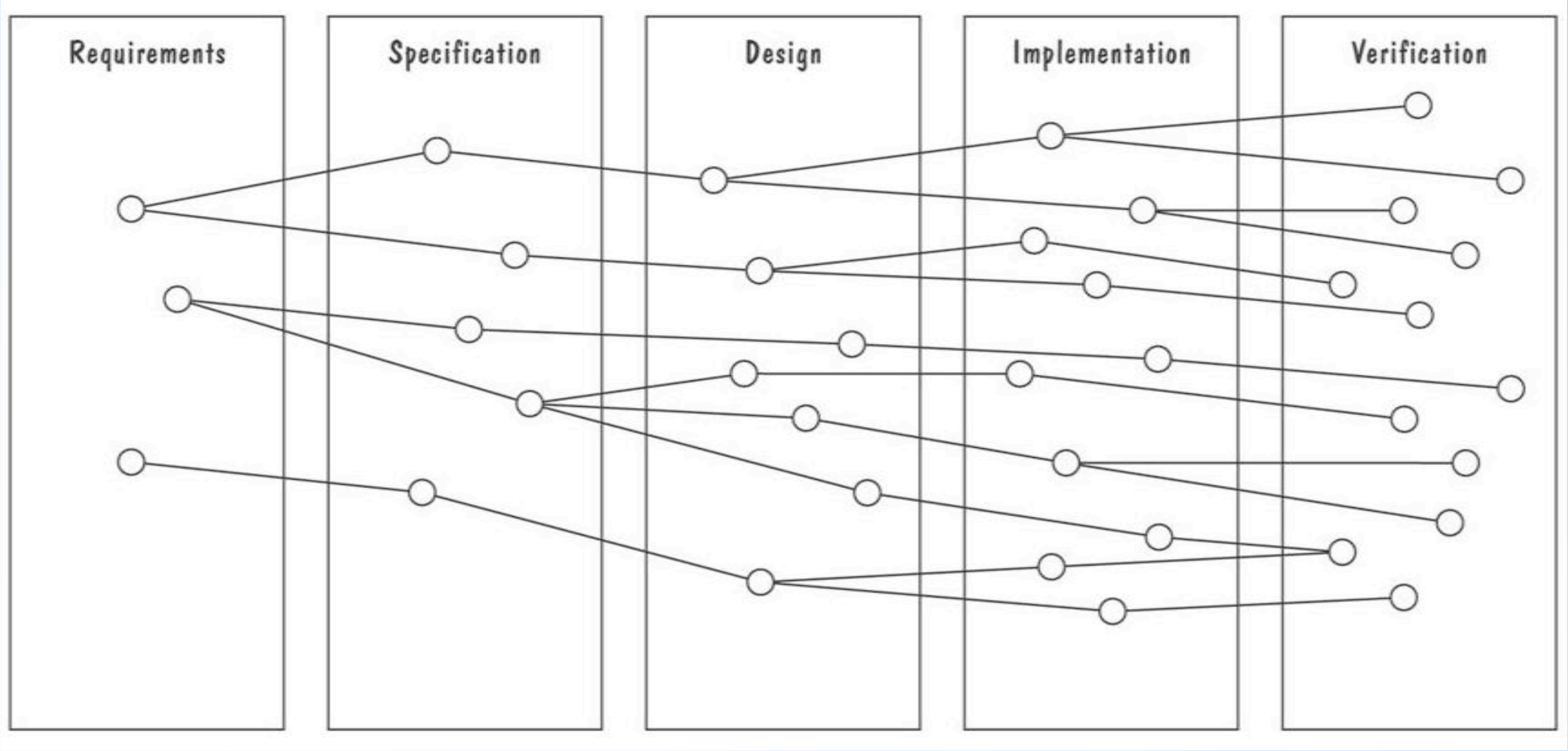
1. Introduction to the Document
    1.1 Purpose of the Product
    1.2 Scope of the Product
    1.3 Acronyms, Abbreviations, Definitions
    1.4 References
    1.5 Outline of the rest of the SRS
2. General Description of Product
    2.1 Context of Product
    2.2 Product Functions
    2.3 User Characteristics
    2.4 Constraints
    2.5 Assumptions and Dependencies
3. Specific Requirements
    3.1 External Interface Requirements
        3.1.1 User Interfaces
        3.1.2 Hardware Interfaces
        3.1.3 Software Interfaces
        3.1.4 Communications Interfaces
    3.2 Functional Requirements
        3.2.1 Class 1
        3.2.2 Class 2
        …
    3.3 Performance Requirements
    3.4 Design Constraints
    3.5 Quality Requirements
    3.6 Other Requirements
4. Appendices

4.8 Requirements Documentation
Process Management and Requirements Traceability

- Process management is a set of procedures that track
  - the requirements that define what the system should do
  - the design modules that are generated from the requirement
  - the program code that implements the design
  - the tests that verify the functionality of the system
  - the documents that describe the system
- It provides the threads that tie the system parts together

4.8 Requirements Documentation
Development Activities

- Horizontal threads show the coordination between development activities



4.9 Validation and Verification

- In requirements validation, we check that our requirements definition accurately reflects the customer's needs
- In verification, we check that one document or artifact conforms to another
- Verification ensures that we build the system right, whereas validation ensures that we build the right system

4.9 Validation and Verification
List of techniques to validate requirements

Validation	Walkthroughs
	Reading
	Interviews
	Reviews
	Checklists
	Models to check functions and relationships
	Scenarios
	Prototypes
	Simulation
	Formal inspections
Verification	Cross- referencing
	Simulation
	Consistency checks
	Completeness checks
Checking	Check for unreachable states or transitions
	Model checking
	Mathematical proofs

4.9 Validation and Verification
Requirements Review

- Review the stated goals and objectives of the system
- Compare the requirements with the goals and objectives
- Review the environment in which the system is to operate
- Review the information flow and proposed functions
- Assess and document the risk, discuss and compare alternatives
- Testing the system: how the requirements will be revalidated as the requirements grow and change

4.9 Validation and Verification
Sidebar 4.8 Number of Requirements Faults

- Jone and Thayes's studies show that
  - 35% of the faults attributed to design activities for projects of 30,000-35,000 delivered source instructions
  - 10% of the faults attributed to requirements activities and 55% of the faults attributed to design activities for projects of 40,000-80,000 delivered source instructions
  - 8% to 10% of the faults attributed to requirements activities and 40% to 55% of the faults attributed to design activities for projects of 65,000-85,000 delivered source instructions
- Basili and Perricone report
  - 48% of the faults observed in a medium-scale software project were attributed to “incorrect or misinterpreted functional specification or requirements”
- Beizer attributes 8.12% of the faults in his samples to problems in functional requirements

4.9 Validation and Verification
Verification

- Check that the requirements-specification document corresponds to the requirements-definition
- Make sure that if we implement a system that meets the specification, then the system will satisfy the customer's requirements
- Ensure that each requirement in the definition document is traceable to the specification

4.10 Measuring Requirements

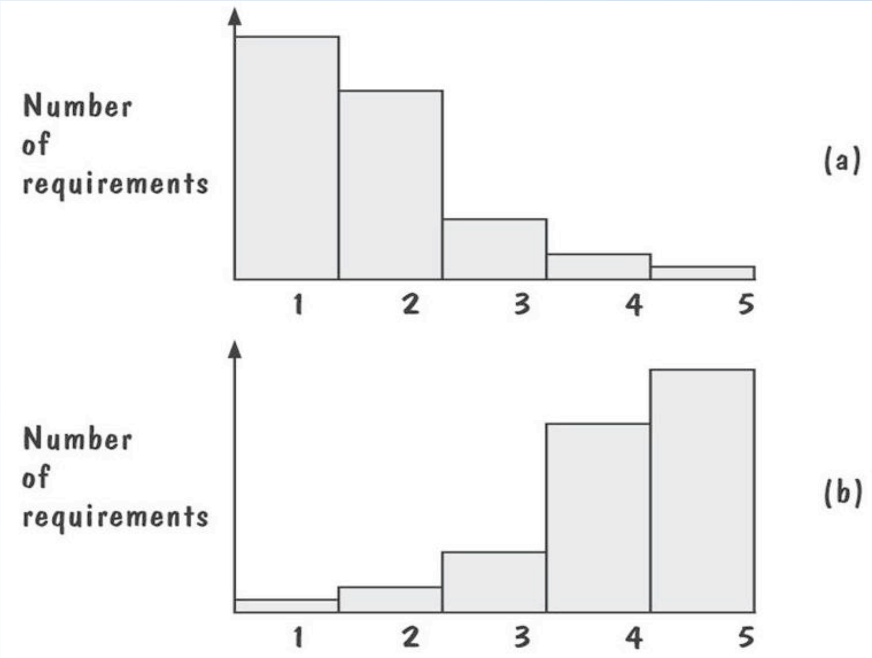
- Measurements focus on three areas
  - product
  - process
  - resources
- Number of requirements can give us a sense of the size of the developed system
- Number of changes to requirements
  - Many changes indicate some instability or uncertainty in our understanding of the system
- Requirement-size and change measurements should be recorded by requirements type

4.10 Measuring Requirements
Rating Scheme on Scale from 1 to 5

1. You understand this requirement completely, have designed systems from similar requirements, and have no trouble developing a design from this requirement
2. Some elements of this requirement are new, but they are not radically different from requirements that have been successfully designed in the past
3. Some elements of this requirement are very different from requirements in the past, but you understand the requirement and can develop a good design from it
4. You cannot understand some parts of this requirement, and are not sure that you can develop a good design
5. You do not understand this requirement at all, and can not develop a design

4.10 Measuring Requirements Testers/Designers Profiles

- Figure (a) shows profiles with mostly 1s and 2s
  - The requirements are in good shape
- Figure (b) shows profiles with mostly 4s and 5s
  - The requirements should be revised



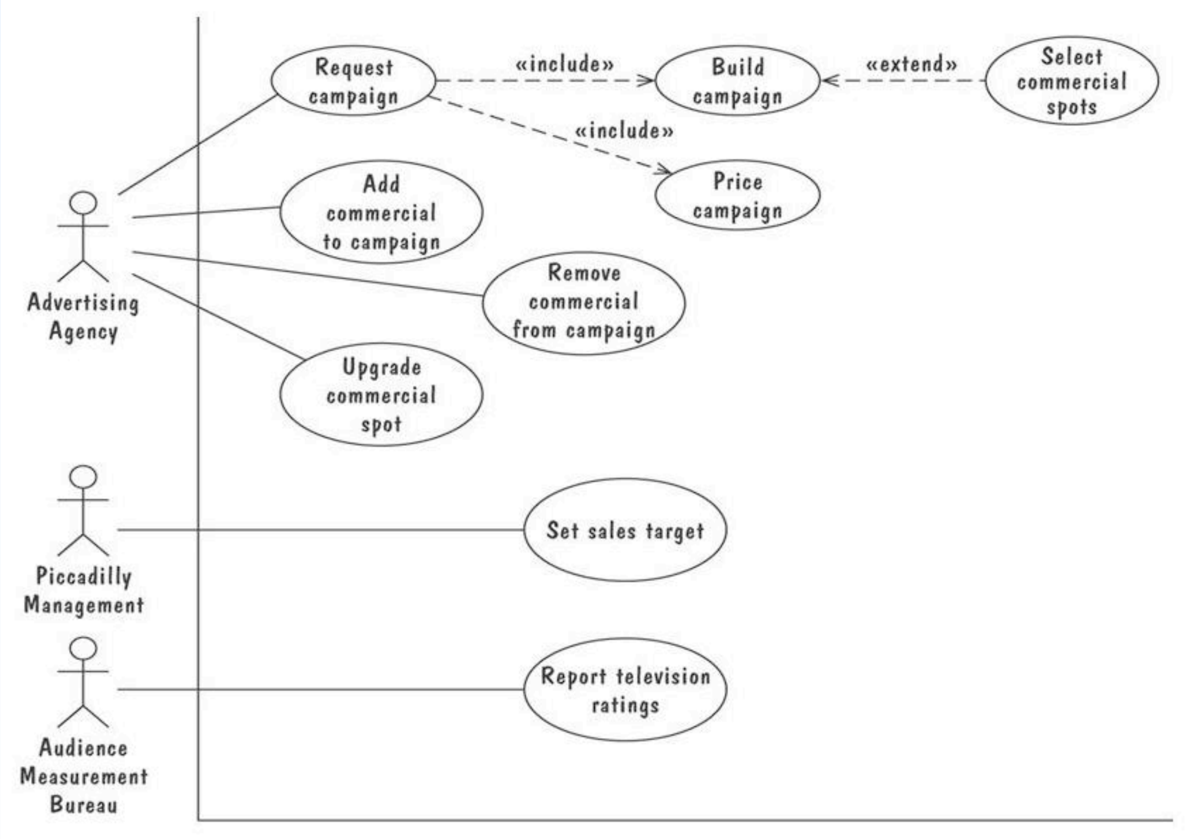
4.11 Choosing a Specification Technique

- Note: Skipping Section 4.11

4.12 Information System Example

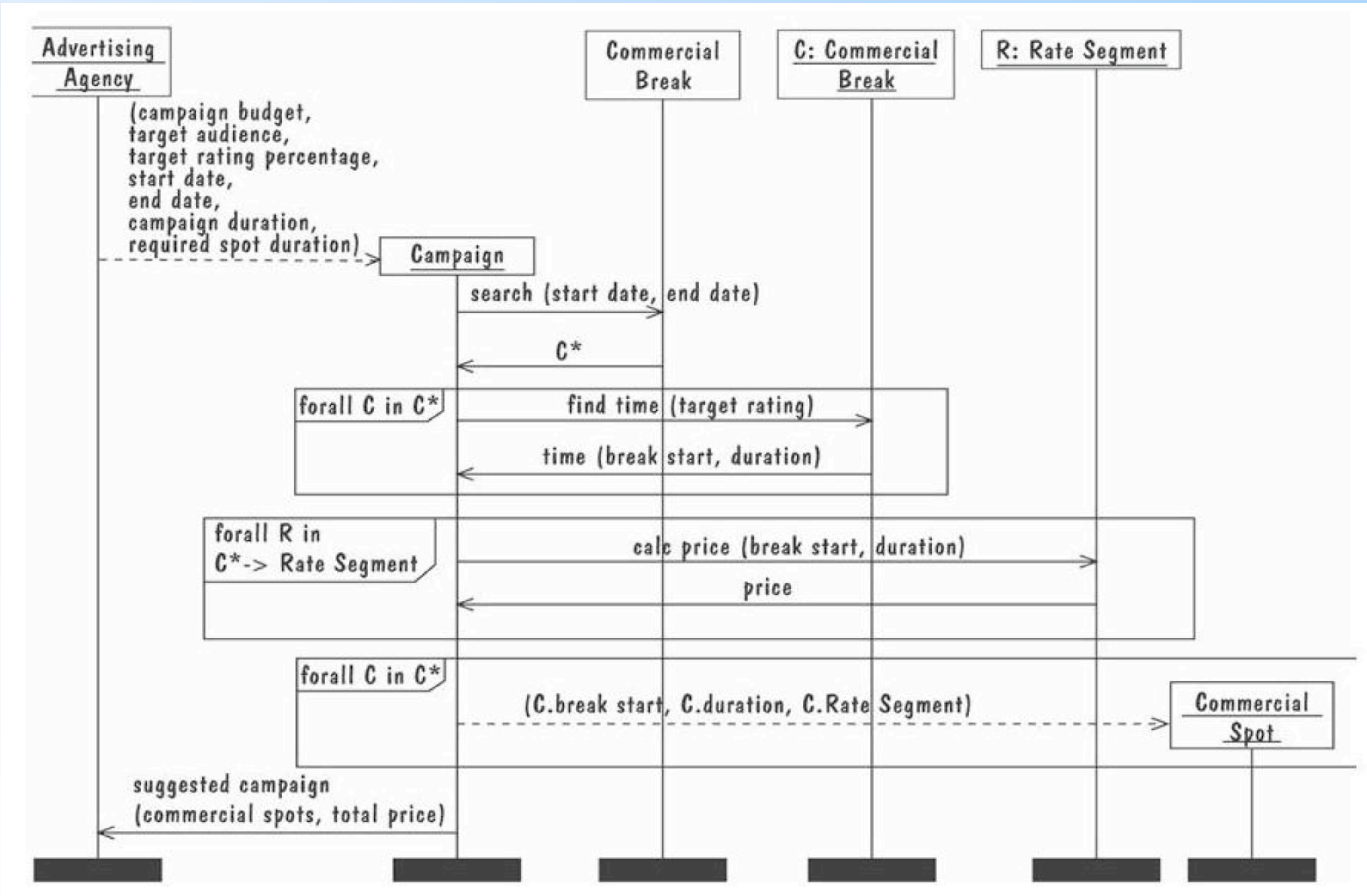
Picadilly Television System

- High-level diagram captures the essential functionality
  - Shows nothing about the ways in which each of these use cases might succeed or fail



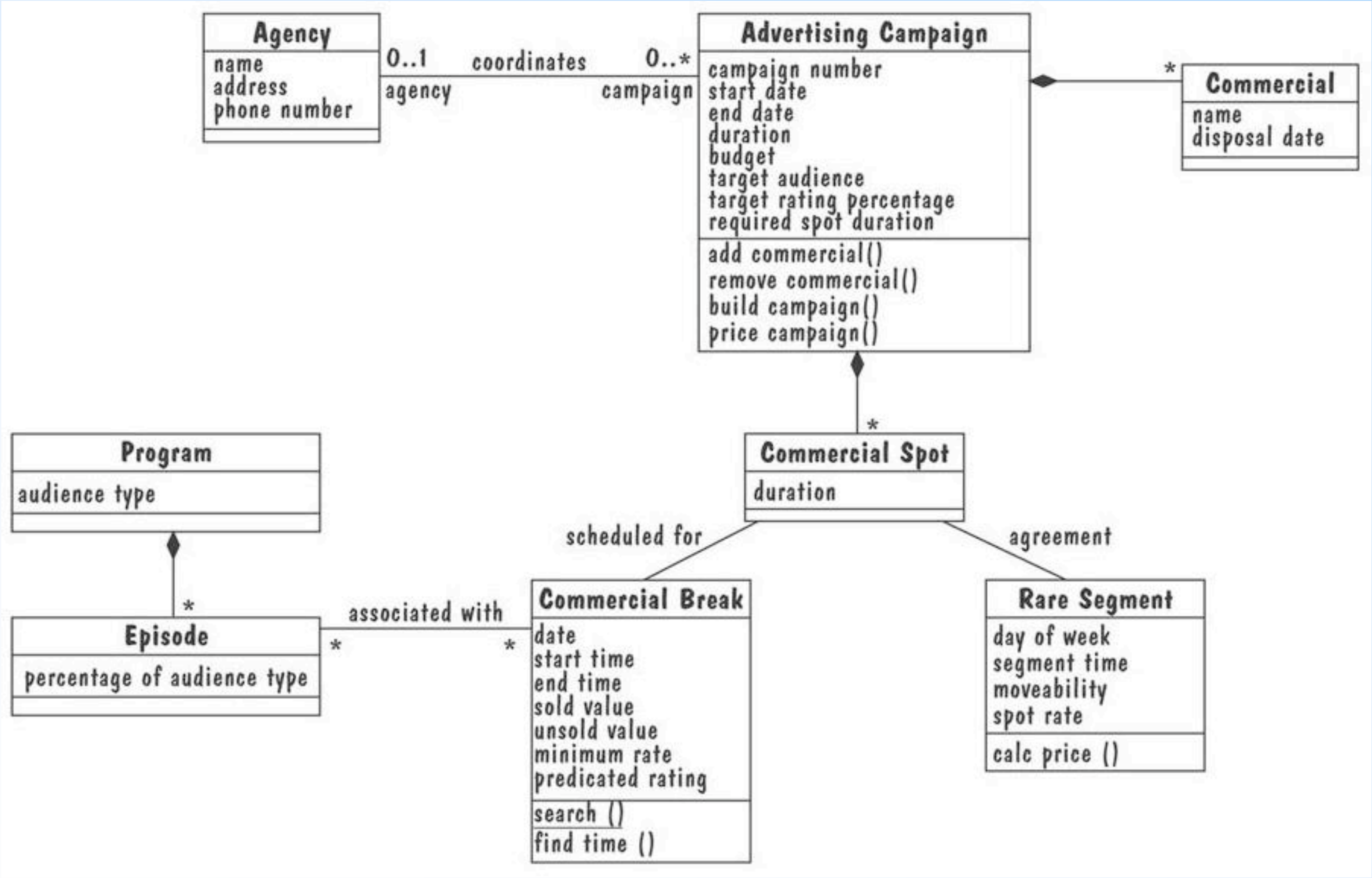
4.12 Information System Example

Picadilly Television System: Message Sequence Chart



4.12 Information System Example

Picadilly Television System: Partial UML Class Diagram



4.13 Real-Time Example

- Ariane-5 failed due to requirement validation not done properly
  - Requirements validation could have played a crucial role in preventing the rocket's explosion
- Two criteria that are especially important for specifying a system such as Ariane-5
  - Testability/simulation and runtime safety
  - SDL was rated “strong” for testability/simulation and runtime safety

4.14 What This Chapter Means for You

- It is essential that the requirements definition and specification documents describe the problem, leaving solution selection to designer
- There is a variety of sources and means for eliciting requirements
- There are many different types of definition and specification techniques
- The specification techniques also differ in terms of their tool support, maturity, understandability, ease of use, and mathematical formality
- Requirements questions can be answered using models or prototypes
- Requirements must be validated to ensure that they accurately reflect the customer's expectations