Unit II

Understanding Requirements

Requirements Engineering-I

- Inception—ask a set of questions that establish …
  - basic understanding of the problem
  - the people who want a solution
  - the nature of the solution that is desired, and
  - the effectiveness of preliminary communication and collaboration between the customer and the developer
- Elicitation—elicit requirements from all stakeholders
- Elaboration—create an analysis model that identifies data, function and behavioral requirements
- Negotiation—agree on a deliverable system that is realistic for developers and customers

Requirements Engineering-II

- Specification—can be any one (or more) of the following:
  - A written document
  - A set of models
  - A formal mathematical
  - A collection of user scenarios (use-cases)
  - A prototype
- Validation—a review mechanism that looks for
  - errors in content or interpretation
  - areas where clarification may be required
  - missing information
  - inconsistencies (a major problem when large products or systems are engineered)
  - conflicting or unrealistic (unachievable) requirements.
- Requirements management

Inception

- Identify stakeholders
  - “who else do you think I should talk to?”
- Recognize multiple points of view
- Work toward collaboration
- The first questions
  - Who is behind the request for this work?
  - Who will use the solution?
  - What will be the economic benefit of a successful solution
  - Is there another source for the solution that you need?

Eliciting Requirements

- meetings are conducted and attended by both software engineers and customers
- rules for preparation and participation are established
- an agenda is suggested
- a "facilitator" (can be a customer, a developer, or an outsider) controls the meeting
- a "definition mechanism" (can be work sheets, flip charts, or wall stickers or an electronic bulletin board, chat room or virtual forum) is used
- the goal is
  - to identify the problem
  - propose elements of the solution
  - negotiate different approaches, and
  - specify a preliminary set of solution requirements

Elicitation Work Products (Outcome)

- a statement of need and feasibility.
- a bounded statement of scope for the system or product.
- a list of customers, users, and other stakeholders who participated in requirements elicitation
- a description of the system's technical environment.
- a list of requirements (preferably organized by function) and the domain constraints that apply to each.
- a set of usage scenarios that provide insight into the use of the system or product under different operating conditions.
- any prototypes developed to better define requirements.

Quality Function Deployment (QFD)

- Function deployment determines the “value” (as perceived by the customer) of each function required of the system
- Information deployment identifies data objects and events
- Task deployment examines the behavior of the system
- Value analysis determines the relative priority of requirements

Building the Analysis Model

- Elements of the analysis model
  - Scenario-based elements
    - Functional—processing narratives for software functions
    - Use-case—descriptions of the interaction between an “actor” and the system
  - Class-based elements
    - Implied by scenarios
  - Behavioral elements
    - State diagram
  - Flow-oriented elements
    - Data flow diagram

Use-Cases

- A collection of user scenarios that describe the thread of usage of a system
- Each scenario is described from the point-of-view of an “actor”—a person or device that interacts with the software in some way
- Each scenario answers the following questions:
  - Who is the primary actor, the secondary actor (s)?
  - What are the actor’s goals?
  - What preconditions should exist before the story begins?
  - What main tasks or functions are performed by the actor?
  - What extensions might be considered as the story is described?
  - What variations in the actor’s interaction are possible?
  - What system information will the actor acquire, produce, or change?
  - Will the actor have to inform the system about changes in the external environment?
  - What information does the actor desire from the system?
  - Does the actor wish to be informed about unexpected changes?

Negotiating Requirements

- Identify the key stakeholders
  - These are the people who will be involved in the negotiation
- Determine each of the stakeholders “win conditions”
  - Win conditions are not always obvious
- Negotiate
  - Work toward a set of requirements that lead to “win-win”

Validating Requirements - I

- Is each requirement consistent with the overall objective for the system/product?
- Have all requirements been specified at the proper level of abstraction? That is, do some requirements provide a level of technical detail that is inappropriate at this stage?
- Is the requirement really necessary or does it represent an add-on feature that may not be essential to the objective of the system?
- Is each requirement bounded and unambiguous?
- Does each requirement have attribution? That is, is a source (generally, a specific individual) noted for each requirement?
- Do any requirements conflict with other requirements?

Validating Requirements - II

- Is each requirement achievable in the technical environment that will house the system or product?
- Is each requirement testable, once implemented?
- Does the requirements model properly reflect the information, function and behavior of the system to be built.
- Has the requirements model been "partitioned" in a way that exposes progressively more detailed information about the system.
- Have requirements patterns been used to simplify the requirements model.
- Have all patterns been properly validated?
- Are all patterns consistent with customer requirements?

Chapter 6

- **Requirements Modeling: Scenarios, Information, and Analysis Classes**

Slide Set to accompany

Software Engineering: A Practitioner's Approach, 7/e

by Roger S. Pressman

Requirements Analysis

- Requirements analysis
  - specifies software's operational characteristics
  - indicates software's interface with other system elements
  - establishes constraints that software must meet
- Requirements analysis allows the software engineer (called an *analyst* or *modeler* in this role) to:
  - elaborate on basic requirements established during earlier requirement engineering tasks
  - build models that depict user scenarios, functional activities, problem classes and their relationships, system and class behavior, and the flow of data as it is transformed.

A Bridge

Rules of Thumb

- The model should focus on requirements that are visible within the problem or business domain. The level of abstraction should be relatively high.
- Each element of the analysis model should add to an overall understanding of software requirements and provide insight into the information domain, function and behavior of the system.
- Delay consideration of infrastructure and other non-functional models until design.
- Minimize coupling throughout the system.
- Be certain that the analysis model provides value to all stakeholders.
- Keep the model as simple as it can be.

Domain Analysis

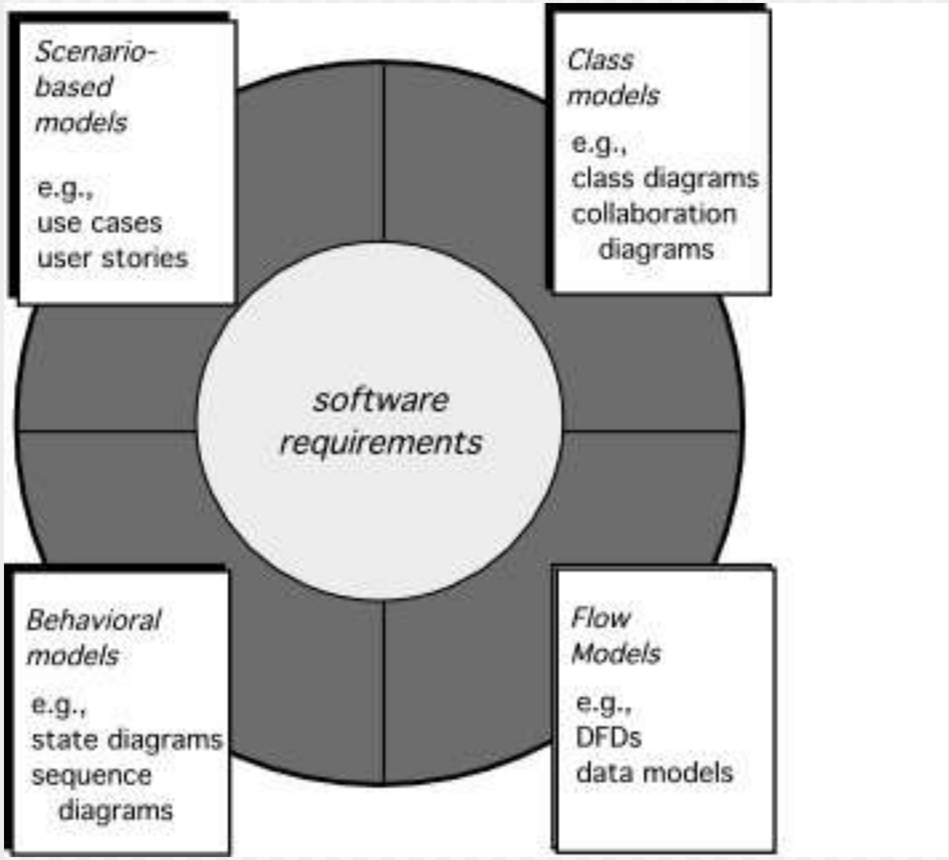
Software domain analysis is the identification, analysis, and specification of common requirements from a specific application domain, typically for reuse on multiple projects within that application domain . . . [Object-oriented domain analysis is] the identification, analysis, and specification of common, reusable capabilities within a specific application domain, in terms of common objects, classes, subassemblies, and frameworks . . .

Donald Firesmith

Domain Analysis

- Define the domain to be investigated.
- Collect a representative sample of applications in the domain.
- Analyze each application in the sample.
- Develop an analysis model for the objects.

Elements of Requirements Analysis



Scenario-Based Modeling

"[Use-cases] are simply an aid to defining what exists outside the system (actors) and what should be performed by the system (use-cases)." Ivar Jacobson

(1) What should we write about?

(2) How much should we write about it?

(3) How detailed should we make our description?

(4) How should we organize the description?

What to Write About?

- Inception and elicitation—provide you with the information you'll need to begin writing use cases.
- Requirements gathering meetings, QFD, and other requirements engineering mechanisms are used to
  - identify stakeholders
  - define the scope of the problem
  - specify overall operational goals
  - establish priorities
  - outline all known functional requirements, and
  - describe the things (objects) that will be manipulated by the system.
- To begin developing a set of use cases, list the functions or activities performed by a specific actor.

How Much to Write About?

- As further conversations with the stakeholders progress, the requirements gathering team develops use cases for each of the functions noted.
- In general, use cases are written first in an informal narrative fashion.
- If more formality is required, the same use case is rewritten using a structured format similar to the one proposed.

Use-Cases

- a scenario that describes a “thread of usage” for a system
- *actors* represent roles people or devices play as the system functions
- *users* can play a number of different roles for a given scenario

Developing a Use-Case

- What are the main tasks or functions that are performed by the actor?
- What system information will the the actor acquire, produce or change?
- Will the actor have to inform the system about changes in the external environment?
- What information does the actor desire from the system?
- Does the actor wish to be informed about unexpected changes?

Use-Case Diagram

Activity Diagram

Supplements the use case by providing a graphical representation of the flow of interaction within a specific scenario

Swimlane Diagrams

Allows the modeler to represent the flow of activities described by the use-case and at the same time indicate which actor (if there are multiple actors involved in a specific use-case) or analysis class has responsibility for the action described by an activity rectangle

Data Modeling

- examines data objects independently of processing
- focuses attention on the data domain
- creates a model at the customer’s level of abstraction
- indicates how data objects relate to one another

What is a Data Object?

- a representation of almost any composite information that must be understood by software.
  - *composite information*—something that has a number of different properties or attributes
- can be an external entity (e.g., anything that produces or consumes information), a thing (e.g., a report or a display), an occurrence (e.g., a telephone call) or event (e.g., an alarm), a role (e.g., salesperson), an organizational unit (e.g., accounting department), a place (e.g., a warehouse), or a structure (e.g., a file).
- The description of the data object incorporates the data object and all of its attributes.
- A data object encapsulates data only—there is no reference within a data object to operations that act on the data.

Data Objects and Attributes

A data object contains a set of attributes that act as an aspect, quality, characteristic, or descriptor of the object

object: automobile

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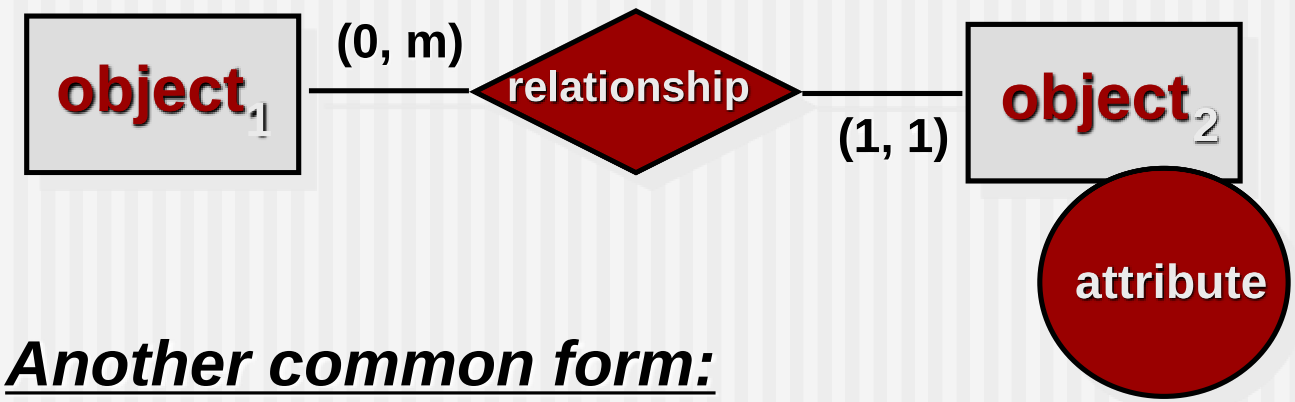
attributes:
- **make**
- **model**
- **body type**
- **price**
- **options code**

What is a Relationship?

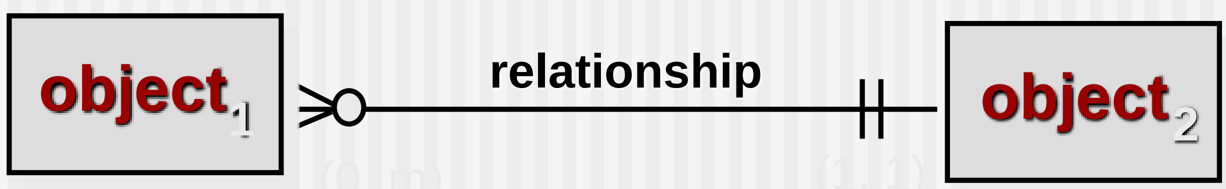
- Data objects are connected to one another in different ways.
  - A connection is established between **person** and **car** because the two objects are related.
    - A person *owns* a car
    - A person *is insured to drive* a car
- The relationships *owns* and *insured to drive* define the relevant connections between **person** and **car.**
- Several instances of a relationship can exist
- Objects can be related in many different ways

ERD Notation

One common form:



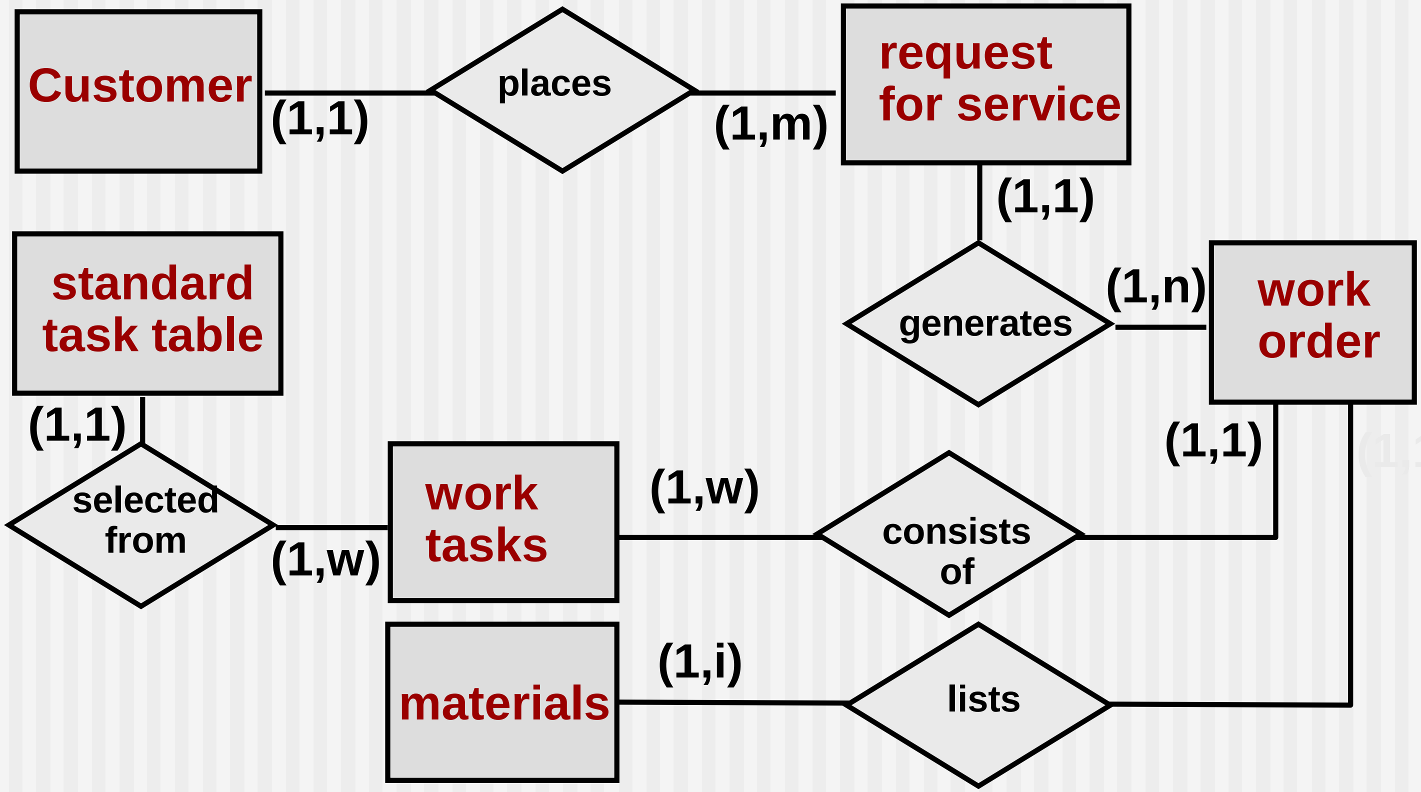
Another common form:



Building an ERD

- *Level 1*—model all data objects (entities) and their “connections” to one another
- *Level 2*—model all entities and relationships
- *Level 3*—model all entities, relationships, and the attributes that provide further depth

The ERD: An Example



Class-Based Modeling

- Class-based modeling represents:
  - objects that the system will manipulate
  - operations (also called methods or services) that will be applied to the objects to effect the manipulation
  - relationships (some hierarchical) between the objects
  - collaborations that occur between the classes that are defined.
- The elements of a class-based model include classes and objects, attributes, operations, CRC models, collaboration diagrams and packages.

Identifying Analysis Classes

- Examining the usage scenarios developed as part of the requirements model and perform a "grammatical parse" [Abb83]
  - Classes are determined by underlining each noun or noun phrase and entering it into a simple table.
  - Synonyms should be noted.
  - If the class (noun) is required to implement a solution, then it is part of the solution space; otherwise, if a class is necessary only to describe a solution, it is part of the problem space.
- But what should we look for once all of the nouns have been isolated?

Manifestations of Analysis Classes

- *Analysis classes* manifest themselves in one of the following ways:
  - *External entities* (e.g., other systems, devices, people) that produce or consume information
  - *Things* (e.g, reports, displays, letters, signals) that are part of the information domain for the problem
  - *Occurrences or events* (e.g., a property transfer or the completion of a series of robot movements) that occur within the context of system operation
  - *Roles* (e.g., manager, engineer, salesperson) played by people who interact with the system
  - *Organizational units* (e.g., division, group, team) that are relevant to an application
  - *Places* (e.g., manufacturing floor or loading dock) that establish the context of the problem and the overall function
  - *Structures* (e.g., sensors, four-wheeled vehicles, or computers) that define a class of objects or related classes of objects

Potential Classes

- *Retained information.* The potential class will be useful during analysis only if information about it must be remembered so that the system can function.
- *Needed services.* The potential class must have a set of identifiable operations that can change the value of its attributes in some way.
- *Multiple attributes.* During requirement analysis, the focus should be on "major" information; a class with a single attribute may, in fact, be useful during design, but is probably better represented as an attribute of another class during the analysis activity.
- *Common attributes.* A set of attributes can be defined for the potential class and these attributes apply to all instances of the class.
- *Common operations.* A set of operations can be defined for the potential class and these operations apply to all instances of the class.
- *Essential requirements.* External entities that appear in the problem space and produce or consume information essential to the operation of any solution for the system will almost always be defined as classes in the requirements model.

Defining Attributes

- *Attributes* describe a class that has been selected for inclusion in the analysis model.
  - build two different classes for professional baseball players
    - **For Playing Statistics software:** name, position, batting average, fielding percentage, years played, and games played might be relevant
    - **For Pension Fund software:** average salary, credit toward full vesting, pension plan options chosen, mailing address, and the like.

Defining Operations

- Do a grammatical parse of a processing narrative and look at the verbs
- Operations can be divided into four broad categories:
  - (1) operations that manipulate data in some way (e.g., adding, deleting, reformatting, selecting)
  - (2) operations that perform a computation
  - (3) operations that inquire about the state of an object, and
  - (4) operations that monitor an object for the occurrence of a controlling event.

CRC Models

- *Class-responsibility-collaborator (CRC) modeling* [Wir90] provides a simple means for identifying and organizing the classes that are relevant to system or product requirements. Ambler [Amb95] describes CRC modeling in the following way:
  - A CRC model is really a collection of standard index cards that represent classes. The cards are divided into three sections. Along the top of the card you write the name of the class. In the body of the card you list the class responsibilities on the left and the collaborators on the right.

CRC Modeling

Class Types

- *Entity classes*, also called *model* or *business classes*, are extracted directly from the statement of the problem (e.g., FloorPlan and Sensor).
- *Boundary classes* are used to create the interface (e.g., interactive screen or printed reports) that the user sees and interacts with as the software is used.
- *Controller classes* manage a “unit of work” [UML03] from start to finish. That is, controller classes can be designed to manage
  - the creation or update of entity objects;
  - the instantiation of boundary objects as they obtain information from entity objects;
  - complex communication between sets of objects;
  - validation of data communicated between objects or between the user and the application.

Responsibilities

- System intelligence should be distributed across classes to best address the needs of the problem
- Each responsibility should be stated as generally as possible
- Information and the behavior related to it should reside within the same class
- Information about one thing should be localized with a single class, not distributed across multiple classes.
- Responsibilities should be shared among related classes, when appropriate.

Collaborations

- Classes fulfill their responsibilities in one of two ways:
  - A class can use its own operations to manipulate its own attributes, thereby fulfilling a particular responsibility, or
  - a class can collaborate with other classes.
- Collaborations identify relationships between classes
- Collaborations are identified by determining whether a class can fulfill each responsibility itself
- three different generic relationships between classes [WIR90]:
  - the *is-part-of* relationship
  - the *has-knowledge-of* relationship
  - the *depends-upon* relationship

Composite Aggregate Class

Associations and Dependencies

- Two analysis classes are often related to one another in some fashion
  - In UML these relationships are called *associations*
  - Associations can be refined by indicating *multiplicity* (the term *cardinality* is used in data modeling
- In many instances, a client-server relationship exists between two analysis classes.
  - In such cases, a client-class depends on the server-class in some way and a *dependency relationship* is established

Multiplicity

Dependencies

Analysis Packages

- Various elements of the analysis model (e.g., use-cases, analysis classes) are categorized in a manner that packages them as a grouping
- The plus sign preceding the analysis class name in each package indicates that the classes have public visibility and are therefore accessible from other packages.
- Other symbols can precede an element within a package. A minus sign indicates that an element is hidden from all other packages and a # symbol indicates that an element is accessible only to packages contained within a given package.

Analysis Packages

Reviewing the CRC Model

- All participants in the review (of the CRC model) are given a subset of the CRC model index cards.
  - Cards that collaborate should be separated (i.e., no reviewer should have two cards that collaborate).
- All use-case scenarios (and corresponding use-case diagrams) should be organized into categories.
- The review leader reads the use-case deliberately.
  - As the review leader comes to a named object, she passes a token to the person holding the corresponding class index card.
- When the token is passed, the holder of the class card is asked to describe the responsibilities noted on the card.
  - The group determines whether one (or more) of the responsibilities satisfies the use-case requirement.
- If the responsibilities and collaborations noted on the index cards cannot accommodate the use-case, modifications are made to the cards.
  - This may include the definition of new classes (and corresponding CRC index cards) or the specification of new or revised responsibilities or collaborations on existing cards.

Requirements Modeling

- Flow based
- Behavior based
- Patterns based
- WebApps based

Requirements Modeling Strategies

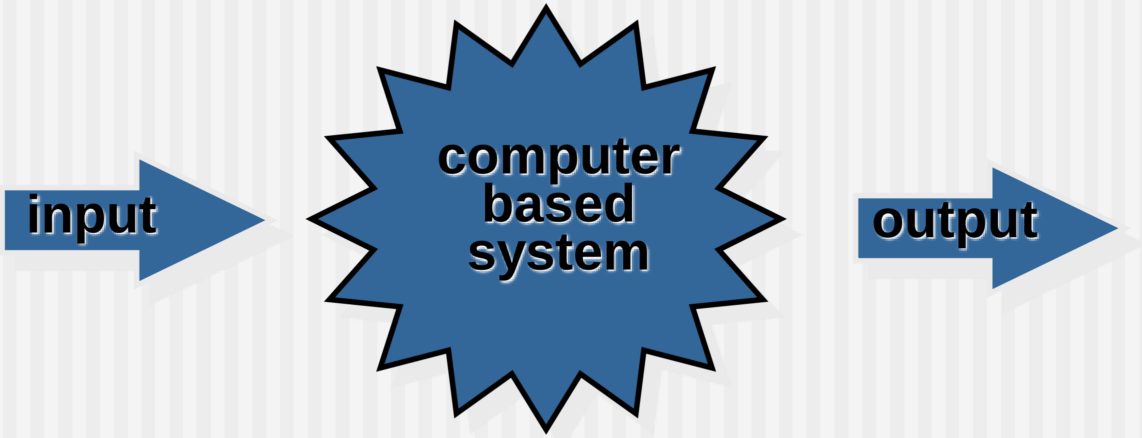
- One view of requirements modeling, called *structured analysis,* considers data and the processes that transform the data as separate entities.
  - Data objects are modeled in a way that defines their attributes and relationships.
  - Processes that manipulate data objects are modeled in a manner that shows how they transform data as data objects flow through the system.
- A second approach to analysis modeled, called *object-oriented analysis,* focuses on
  - the definition of classes and
  - the manner in which they collaborate with one another to effect customer requirements.

Flow-Oriented Modeling

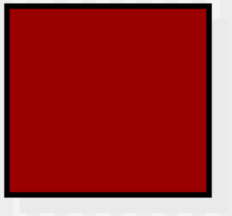
- Represents how data objects are transformed at they move through the system
- **data flow diagram (DFD)** is the diagrammatic form that is used
- Considered by many to be an "old school" approach, but continues to provide a view of the system that is unique—it should be used to supplement other analysis model elements

The Flow Model

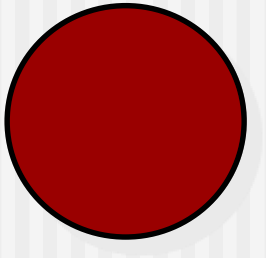
Every computer-based system is an information transform ....



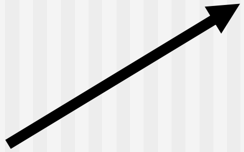
Flow Modeling Notation



external entity



process



data flow

data store

External Entity

A producer or consumer of data

Examples: a person, a device, a sensor
Another example: computer-based system

Data must always originate somewhere and must always be sent to something

Process

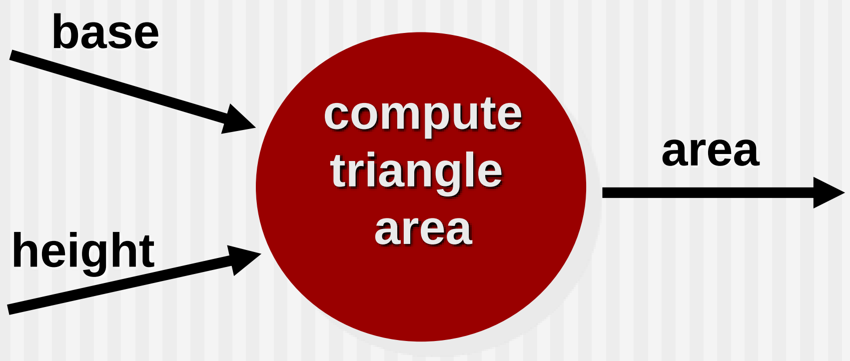
A data transformer (changes input to output)

Examples: *compute taxes, determine area, format report, display graph*

Data must always be processed in some way to achieve system function

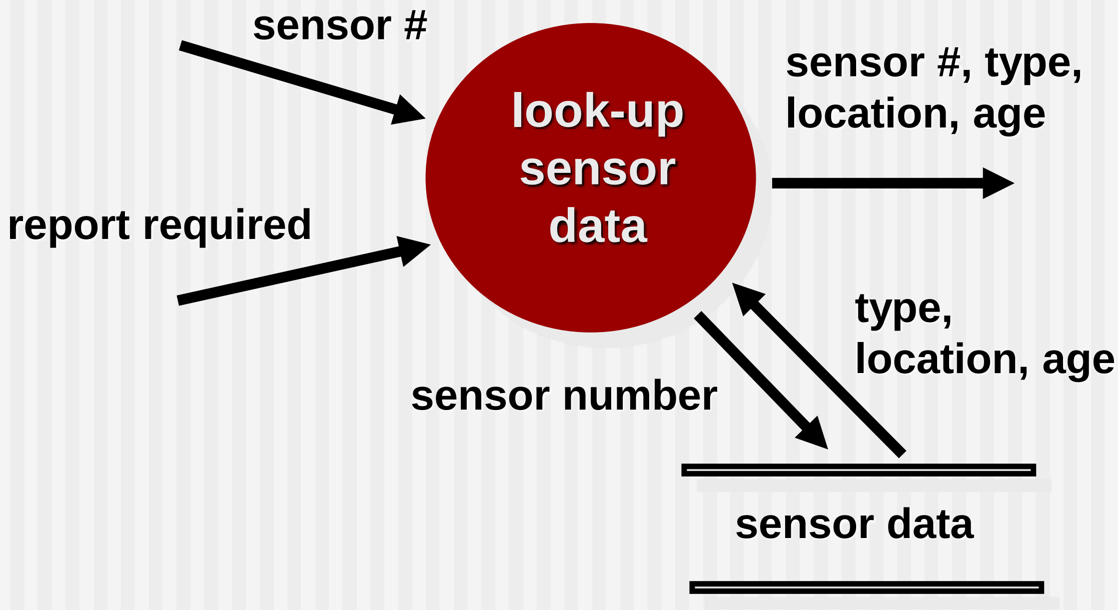
Data Flow

Data flows through a system, beginning as input and transformed into output.



Data Stores

Data is often stored for later use.



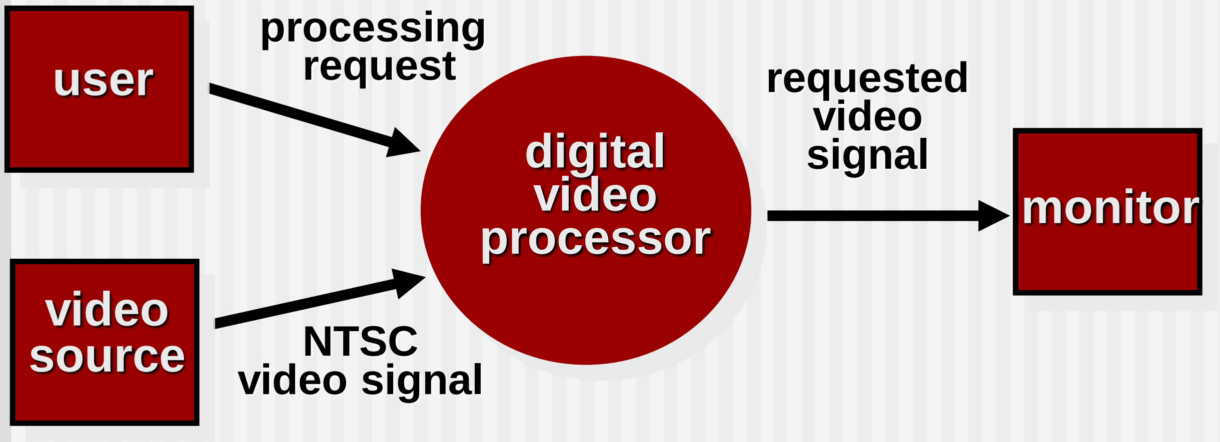
Data Flow Diagramming: Guidelines

- all icons must be labeled with meaningful names
- the DFD evolves through a number of levels in detail
- always begin with a context level diagram (also called level 0)
- always show external entities at level 0
- always label data flow arrows
- do not represent procedural logic

Constructing a DFD - I

- review user scenarios and/or the data model to isolate data objects and use a grammatical parse to determine “operations”
- determine external entities (producers and consumers of data)
- create a level 0 DFD

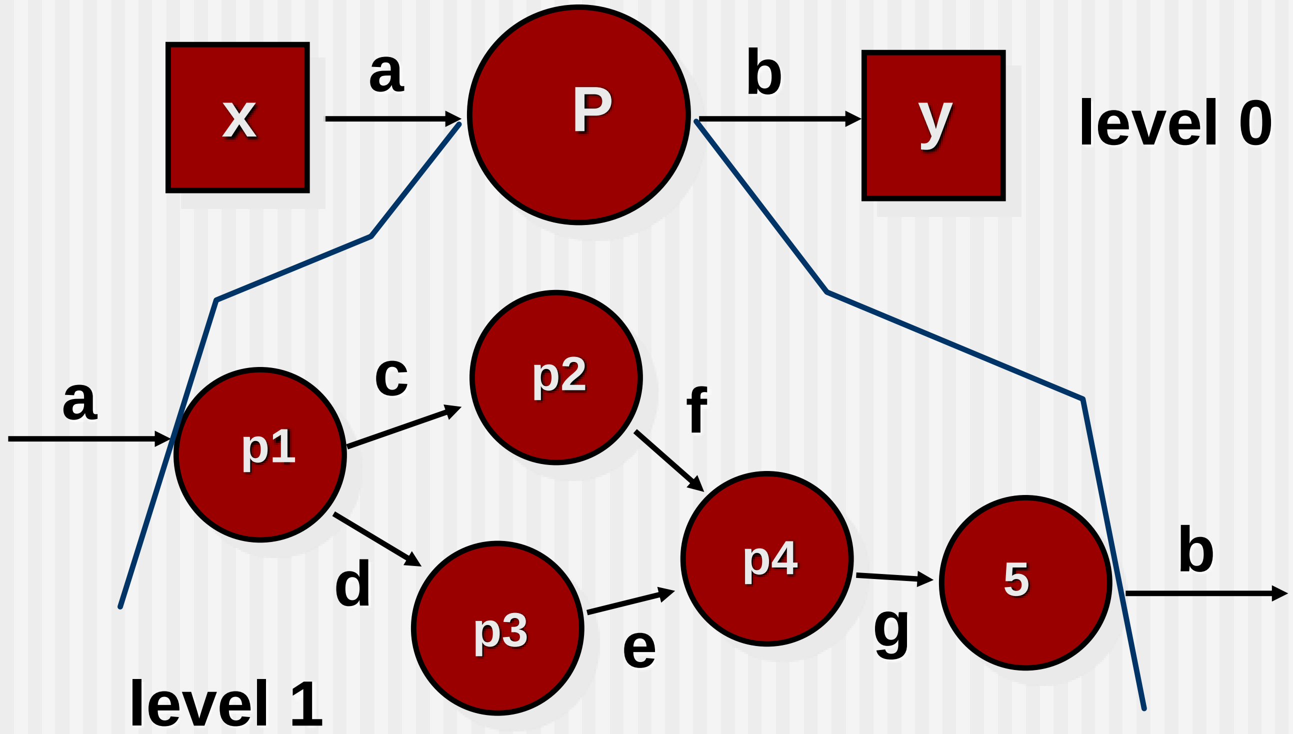
Level 0 DFD Example



Constructing a DFD—II

- write a narrative describing the transform
- parse to determine next level transforms
- “balance” the flow to maintain data flow continuity
- develop a level 1 DFD
- use a 1:5 (approx.) expansion ratio

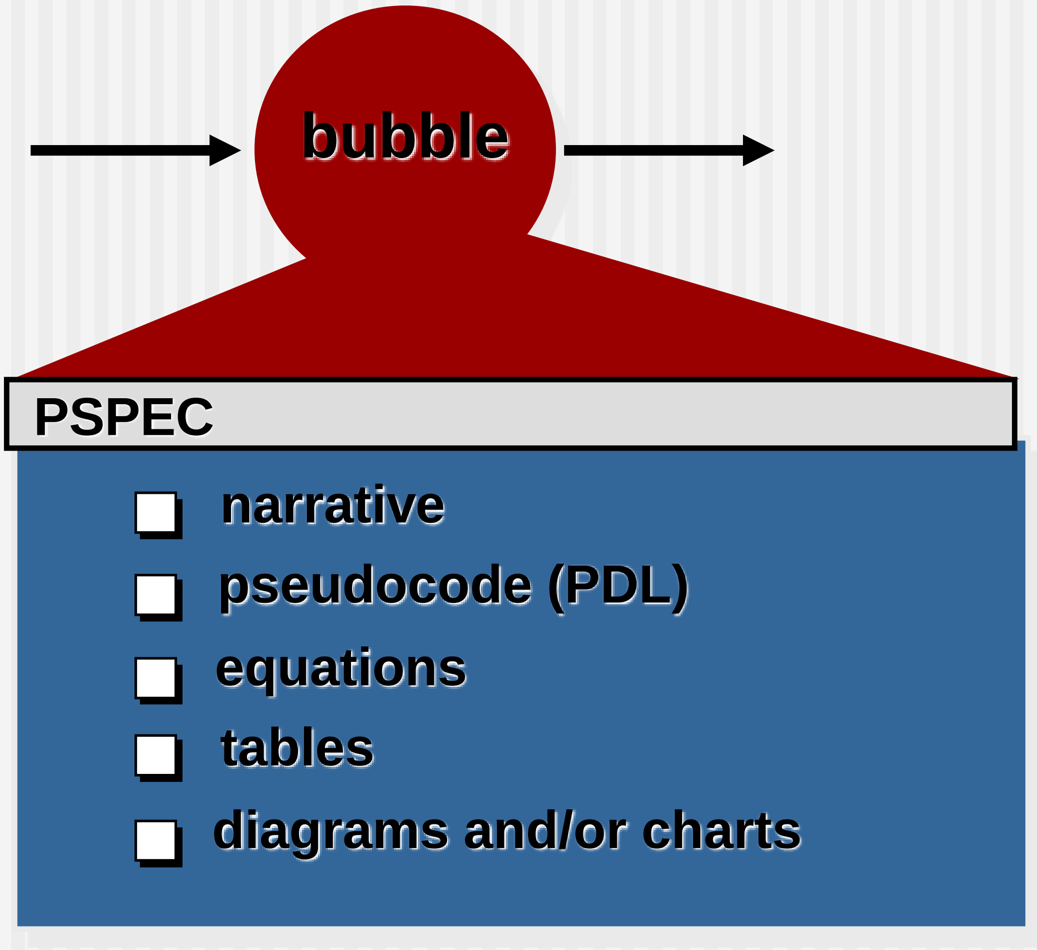
The Data Flow Hierarchy



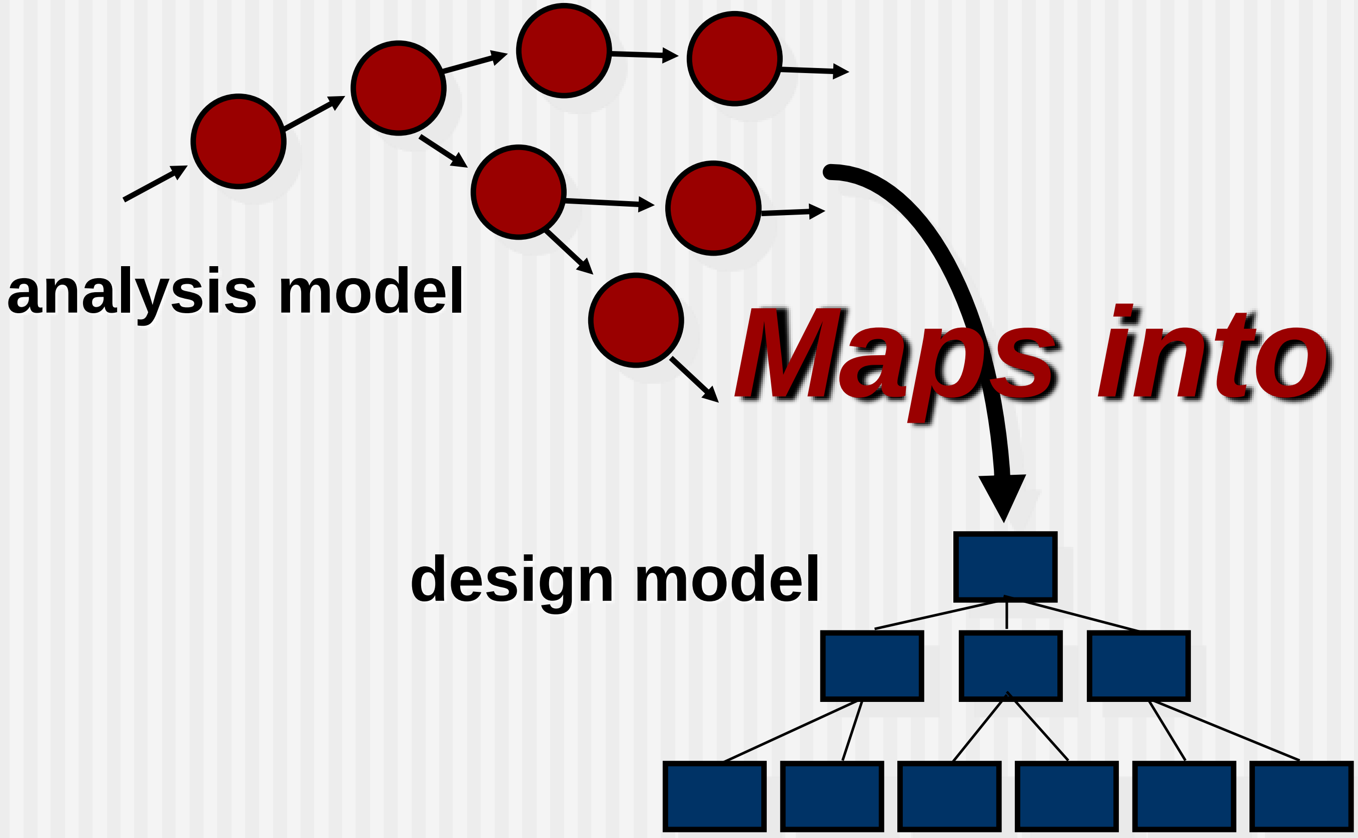
Flow Modeling Notes

- each bubble is refined until it does just one thing
- the expansion ratio decreases as the number of levels increase
- most systems require between 3 and 7 levels for an adequate flow model
- a single data flow item (arrow) may be expanded as levels increase (data dictionary provides information)

Process Specification (PSPEC)



DFDs: A Look Ahead



Control Flow Modeling

- Represents “events” and the processes that manage events
- An “event” is a Boolean condition that can be ascertained by:
  - listing all sensors that are "read" by the software.
  - listing all interrupt conditions.
  - listing all "switches" that are actuated by an operator.
  - listing all data conditions.
  - recalling the noun/verb parse that was applied to the processing narrative, review all "control items" as possible CSPEC inputs/outputs.

Control Specification (CSPEC)

The CSPEC can be:

- state diagram (sequential spec)
- state transition table
- decision tables
- activation tables

combinatorial spec

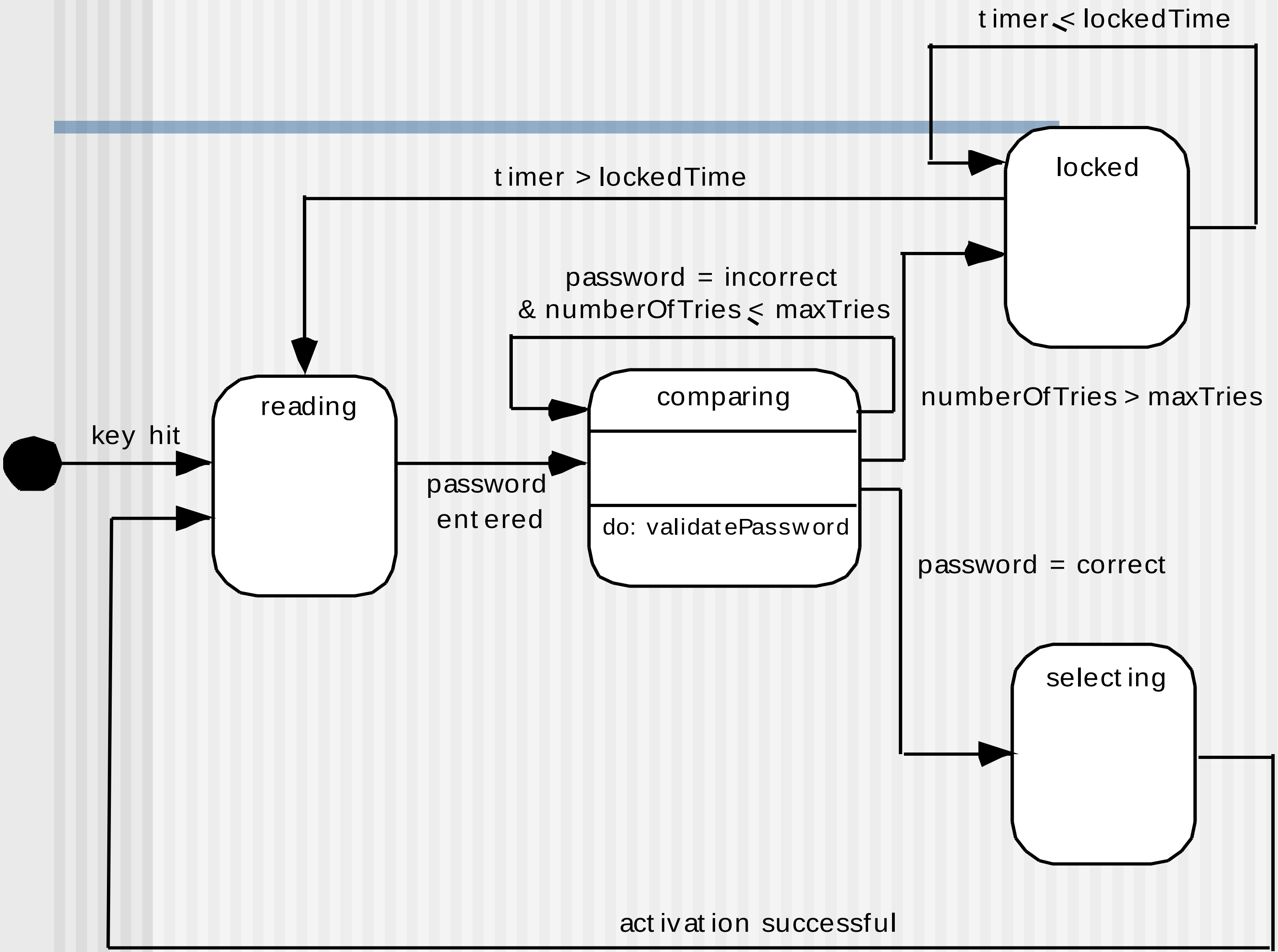
Behavioral Modeling

- The behavioral model indicates how software will respond to external events or stimuli. To create the model, the analyst must perform the following steps:
  - Evaluate all use-cases to fully understand the sequence of interaction within the system.
  - Identify events that drive the interaction sequence and understand how these events relate to specific objects.
  - Create a sequence for each use-case.
  - Build a state diagram for the system.
  - Review the behavioral model to verify accuracy and consistency.

State Representations

- In the context of behavioral modeling, two different characterizations of states must be considered:
  - the state of each class as the system performs its function and
  - the state of the system as observed from the outside as the system performs its function
- The state of a class takes on both passive and active characteristics
  - A *passive state* is simply the current status of all of an object's attributes.
  - The *active state* of an object indicates the current status of the object as it undergoes a continuing transformation or processing.

State Diagram for the Control Panel Class



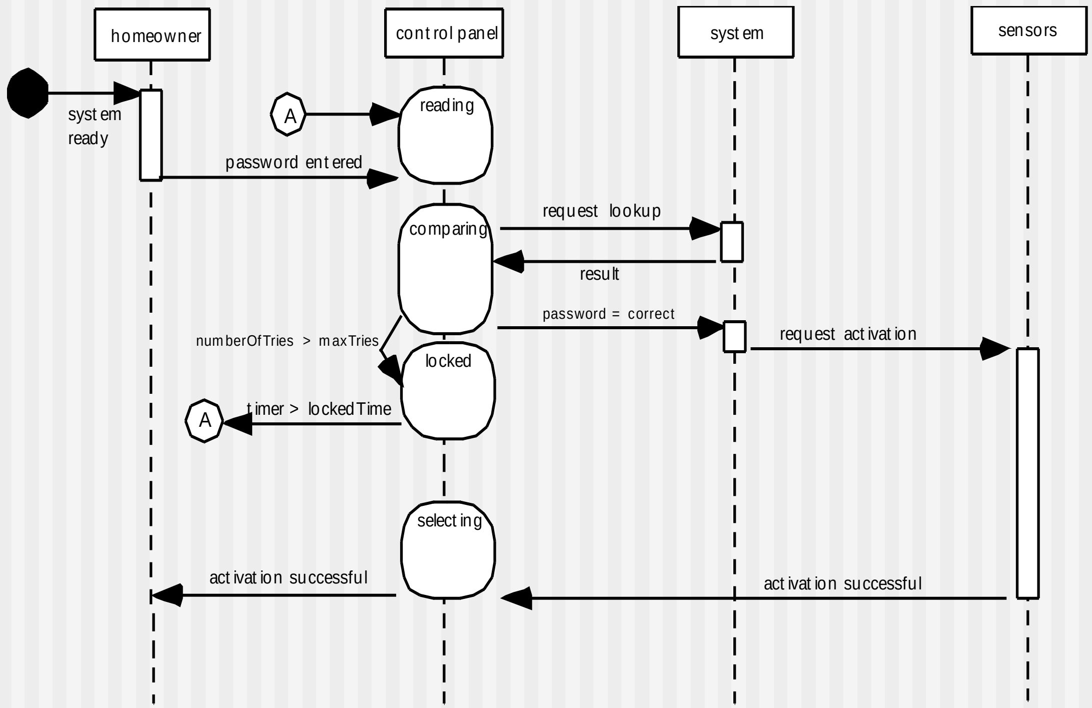
The States of a System

- state—a set of observable circum-stances that characterizes the behavior of a system at a given time
- state transition—the movement from one state to another
- event—an occurrence that causes the system to exhibit some predictable form of behavior
- action—process that occurs as a consequence of making a transition

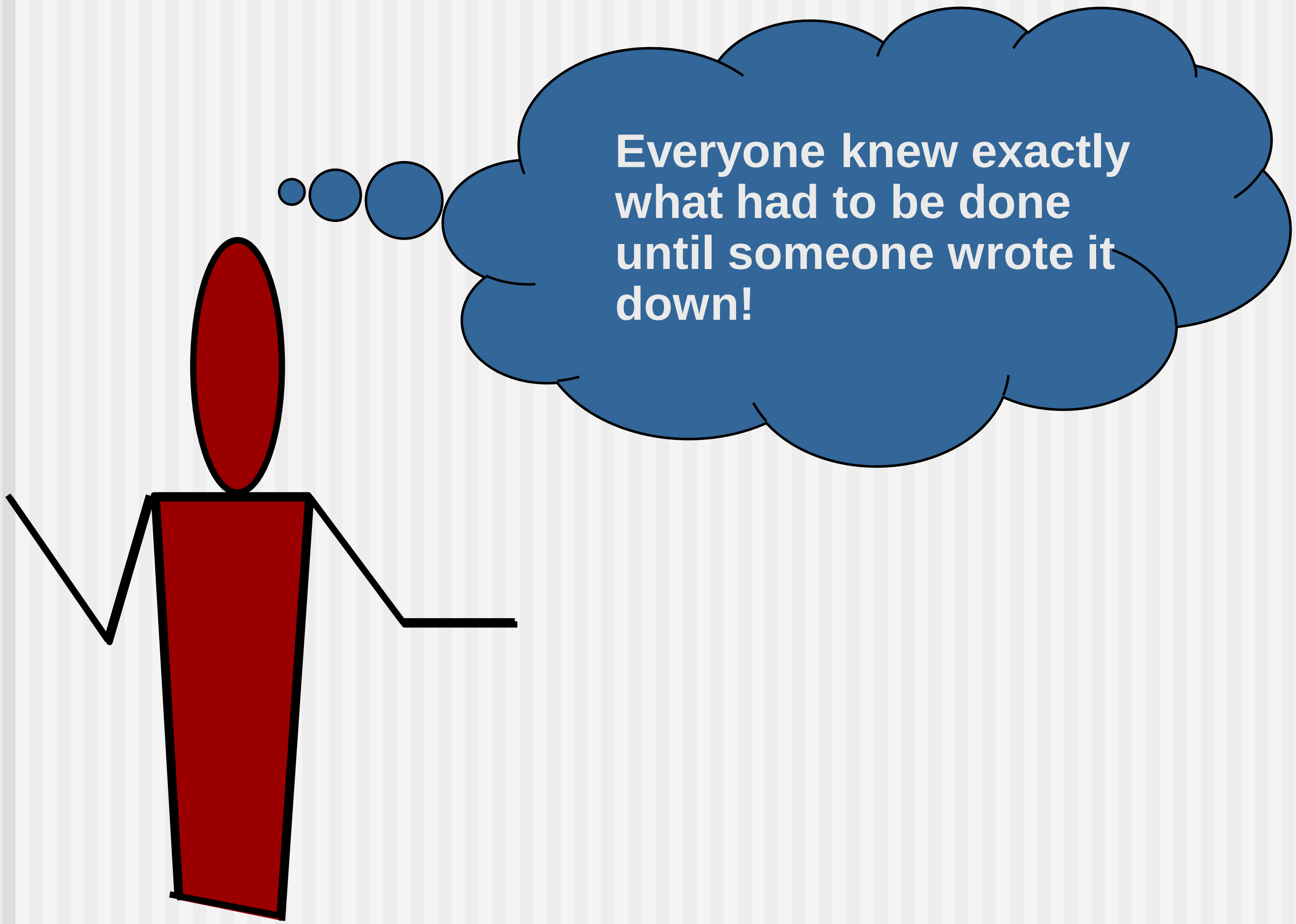
Behavioral Modeling

- make a list of the different states of a system (How does the system behave?)
- indicate how the system makes a transition from one state to another (How does the system change state?)
  - indicate event
  - indicate action
- draw a state diagram or a sequence diagram

Sequence Diagram



Writing the Software Specification



Patterns for Requirements Modeling

- Software patterns are a mechanism for capturing domain knowledge in a way that allows it to be **reapplied** when a new problem is encountered
  - domain knowledge can be applied to a new problem within the same application domain
  - the domain knowledge captured by a pattern can be applied by analogy to a completely different application domain.
- The original author of an analysis pattern does not “create” the pattern, but rather, *discovers* it as requirements engineering work is being conducted.
- Once the pattern has been discovered, it is documented

Discovering Analysis Patterns

- The most basic element in the description of a requirements model is the use case.
- A coherent set of use cases may serve as the basis for discovering one or more analysis patterns.
- A *semantic analysis pattern* (SAP) "is a pattern that describes a small set of coherent use cases that together describe a basic generic application."

An Example

- Consider the following preliminary use case for software required to control and monitor a real-view camera and proximity sensor for an automobile:

Use case: ***Monitor reverse motion***

Description:

1. When the vehicle is placed in *reverse* gear, the control software enables a video feed from a rear-placed video camera to the dashboard display.
2. The control software superimposes a variety of distance and orientation lines on the dashboard display so that the vehicle operator can maintain orientation as the vehicle moves in reverse.
3. The control software also monitors a proximity sensor to determine whether an object is inside 10 feet of the rear of the vehicle.
4. It will automatically break the vehicle if the proximity sensor indicates an object within 3 feet of the rear of the vehicle.

An Example

- This use case implies a variety of functionality that would be refined and elaborated (into a coherent set of use cases) during requirements gathering and modeling.
- Regardless of how much elaboration is accomplished, the use case(s) suggest(s) a simple, yet widely applicable SAP—the software-based monitoring and control of sensors and actuators in a physical system.
- In this case, the “sensors” provide information about proximity and video information. The “actuator” is the breaking system of the vehicle, can invoked if an object is very close to the vehicle.
- But in a more general case, a widely applicable pattern is discovered --> **Actuator-Sensor**

Actuator-Sensor Pattern—I

Pattern Name: ***Actuator-Sensor***

Intent: Specify various kinds of sensors and actuators in an embedded system.

Motivation: Embedded systems usually have various kinds of sensors and actuators. These sensors and actuators are all either directly or indirectly connected to a control unit. Although many of the sensors and actuators look quite different, their behavior is similar enough to structure them into a pattern. The pattern shows how to specify the sensors and actuators for a system, including attributes and operations. The *Actuator-Sensor* pattern uses a *pull* mechanism (explicit request for information) for **PassiveSensors** and a *push* mechanism (broadcast of information) for the **ActiveSensors**.

Constraints:

Each passive sensor must have some method to read sensor input and attributes that represent the sensor value.

Each active sensor must have capabilities to broadcast update messages when its value changes.

Each active sensor should send a *life tick*, a status message issued within a specified time frame, to detect malfunctions.

Each actuator must have some method to invoke the appropriate response determined by the **ComputingComponent**.

Each sensor and actuator should have a function implemented to check its own operation state.

Actuator-Sensor Pattern—II

Applicability: Useful in any system in which multiple sensors and actuators are present.

Structure:

1. A UML class diagram for the *Actuator-Sensor* Pattern is shown in Figure.

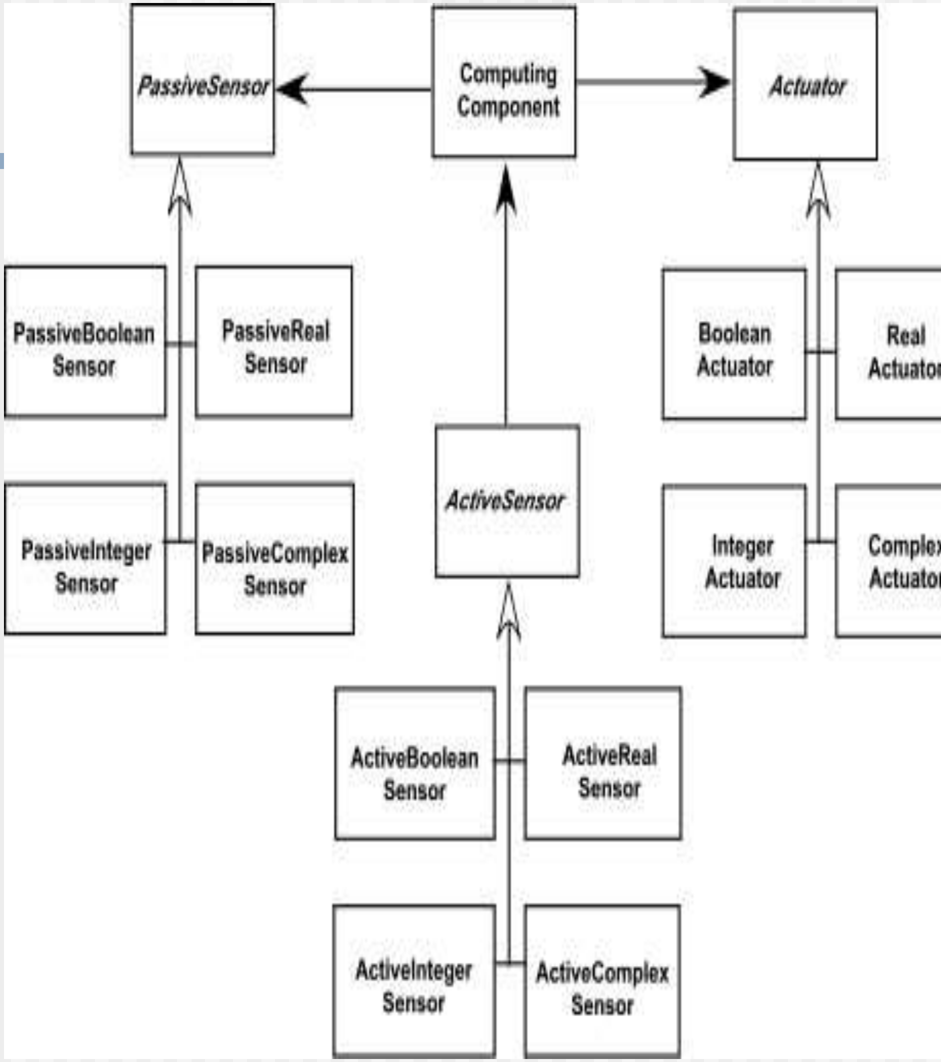
2. **Actuator, PassiveSensor** and **ActiveSensor** are abstract classes and denoted in italics.

3. There are four different types of sensors and actuators in this pattern.

4. The Boolean, integer, and real classes represent the most common types of sensors and actuators.

5. The complex classes are sensors or actuators that use values that cannot be easily represented in terms of primitive data types, such as a radar device.

6. Nonetheless, these devices should still inherit the interface from the abstract classes since they should have basic functionalities such as querying the operation states.



Actuator-Sensor Pattern—III

Behavior:

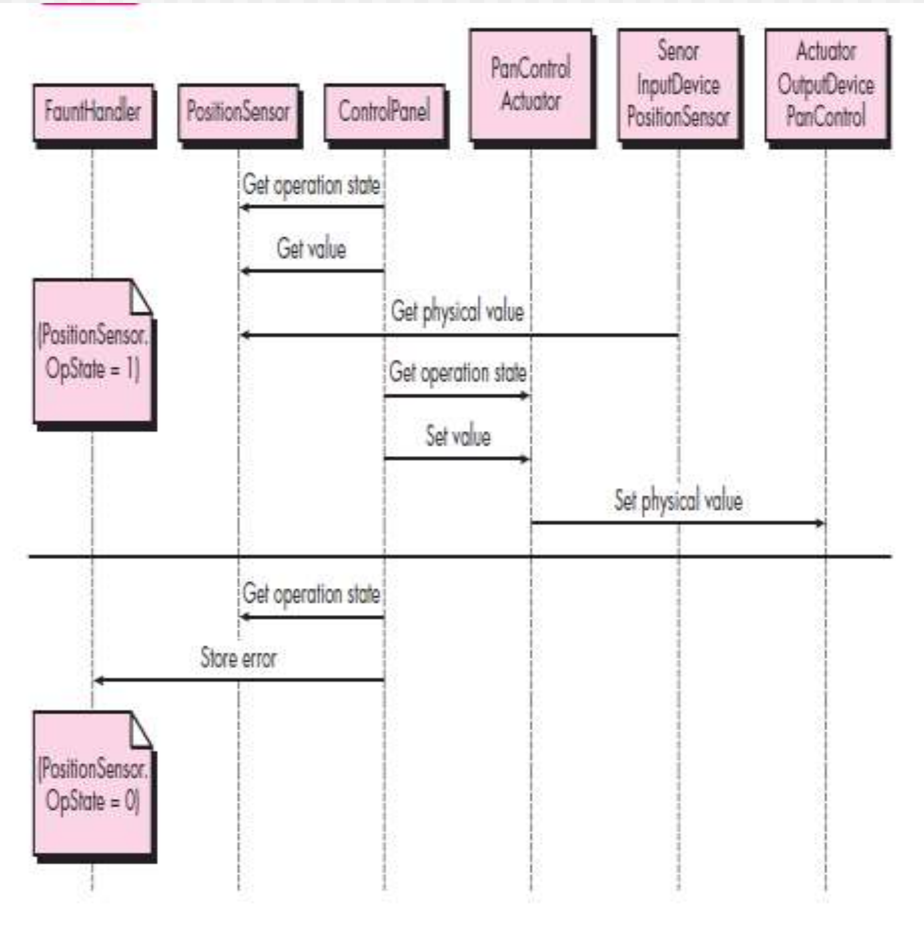
1. Figure presents a UML sequence diagram for an example of the *Actuator-Sensor* Pattern as it might be applied for the *SafeHome* function that controls the positioning (e.g., pan, zoom) of a security camera.

2. Here, the **ControlPanel** queries a sensor (a passive position sensor) and an actuator (pan control) to check the operation state for diagnostic purposes before reading or setting a value.

3. The messages *Set Physical Value* and *Get Physical Value* are not messages between objects.

4. Instead, they describe the interaction between the physical devices of the system and their software counterparts.

5. In the lower part of the diagram, below the horizontal line, the **PositionSensor** reports that the operation state is zero. The **ComputingComponent** then sends the error code for a position sensor failure to the **FaultHandler** that will decide how this error affects the system and what actions are required. it gets the data from the sensors and computes the required response for the actuators.



Requirements Modeling for WebApps

Content Analysis. The full spectrum of content to be provided by the WebApp is identified, including text, graphics and images, video, and audio data. Data modeling can be used to identify and describe each of the data objects.

Interaction Analysis. The manner in which the user interacts with the WebApp is described in detail. Use-cases can be developed to provide detailed descriptions of this interaction.

Functional Analysis. The usage scenarios (use-cases) created as part of interaction analysis define the operations that will be applied to WebApp content and imply other processing functions. All operations and functions are described in detail.

Configuration Analysis. The environment and infrastructure in which the WebApp resides are described in detail.

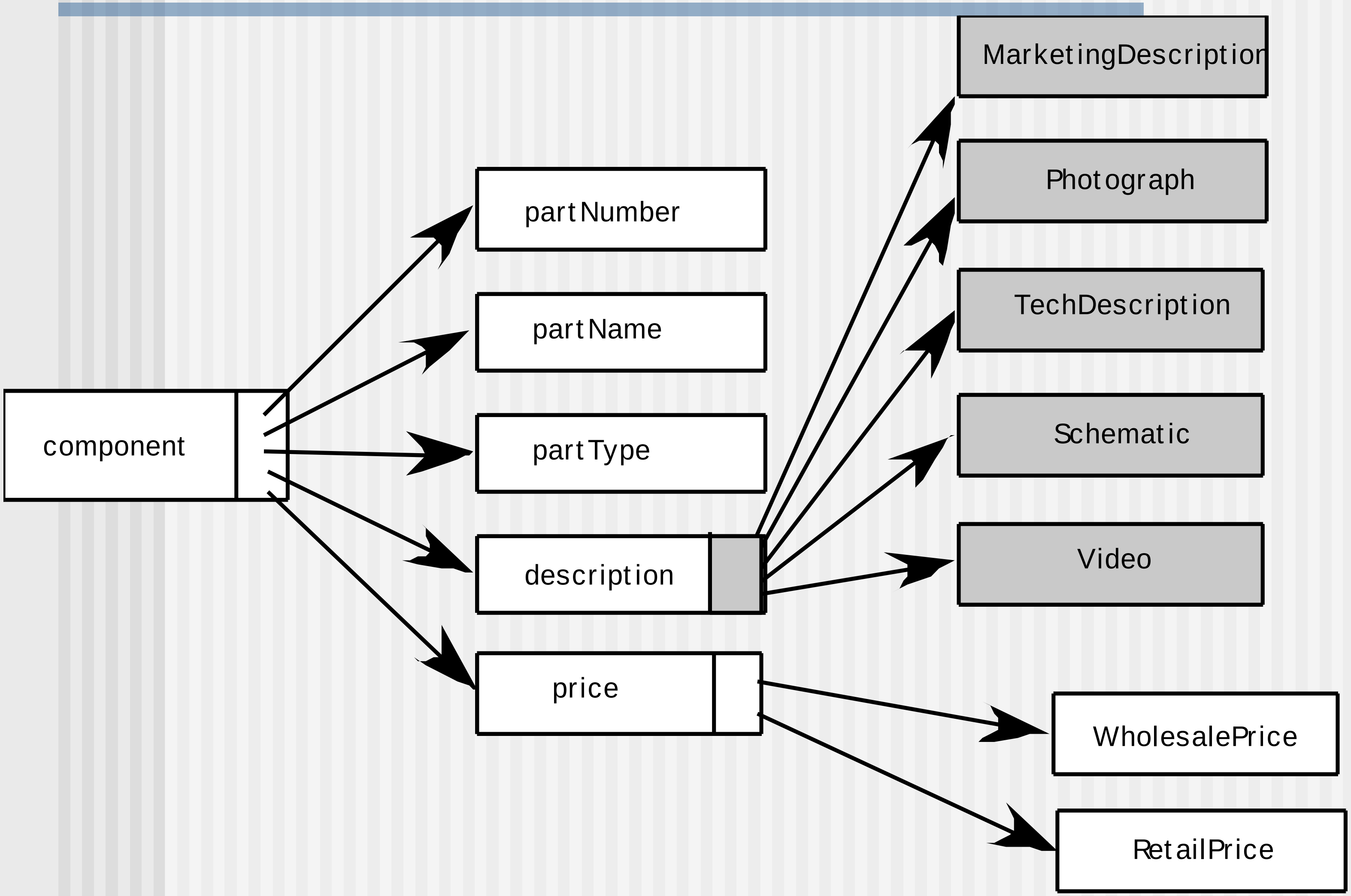
When Do We Perform Analysis?

- In some WebE situations, analysis and design merge. However, an explicit analysis activity occurs when …
  - the WebApp to be built is large and/or complex
  - the number of stakeholders is large
  - the number of Web engineers and other contributors is large
  - the goals and objectives (determined during formulation) for the WebApp will effect the business' bottom line
  - the success of the WebApp will have a strong bearing on the success of the business

The Content Model

- Content objects are extracted from use-cases
  - examine the scenario description for direct and indirect references to content
- Attributes of each content object are identified
- The relationships among content objects and/or the hierarchy of content maintained by a WebApp
  - Relationships—entity-relationship diagram or UML
  - Hierarchy—data tree or UML

Data Tree

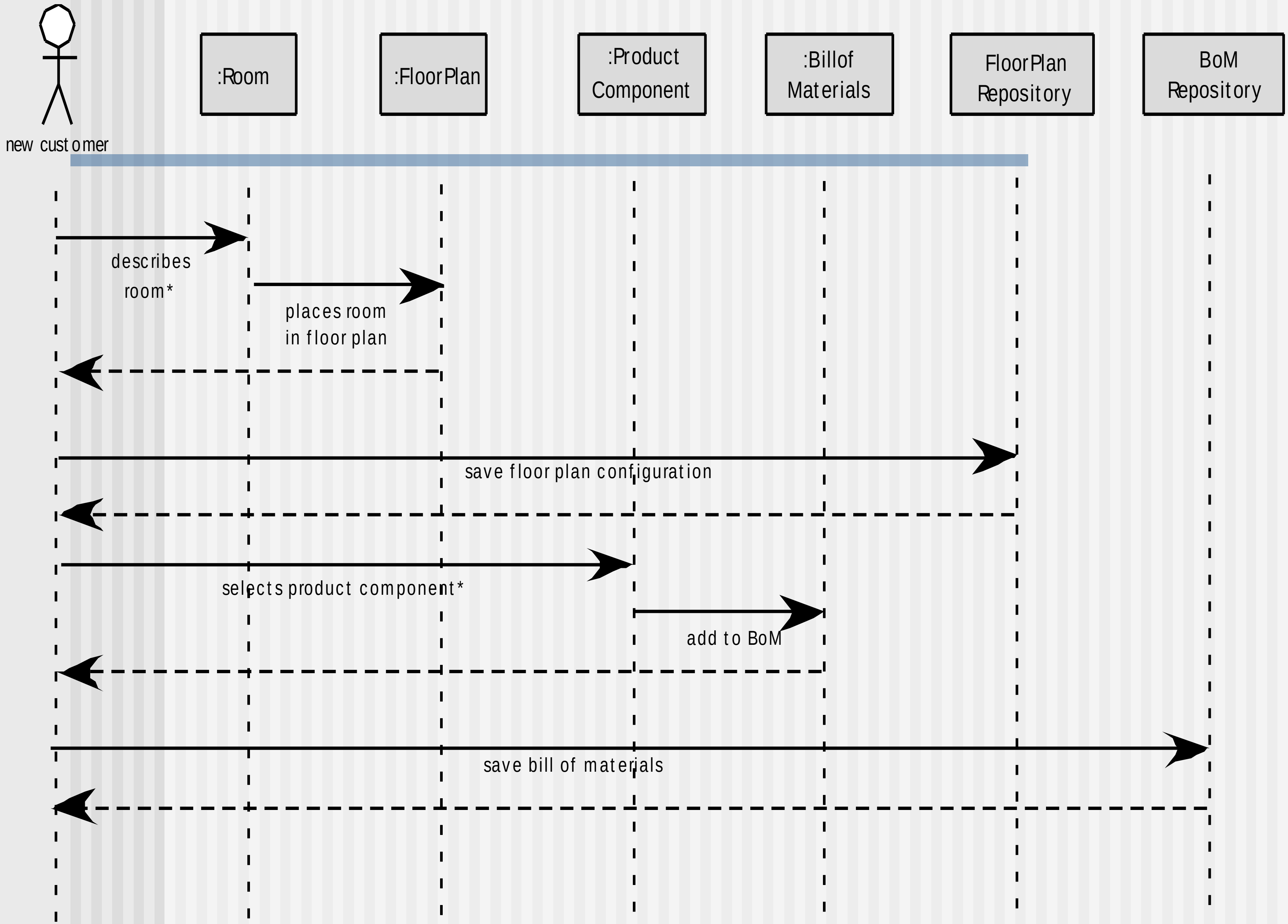


component
partNumber
partName
partType
description
price
MarketingDescription
Photograph
TechDescription
Schematic
Video
WholesalePrice
RetailPrice

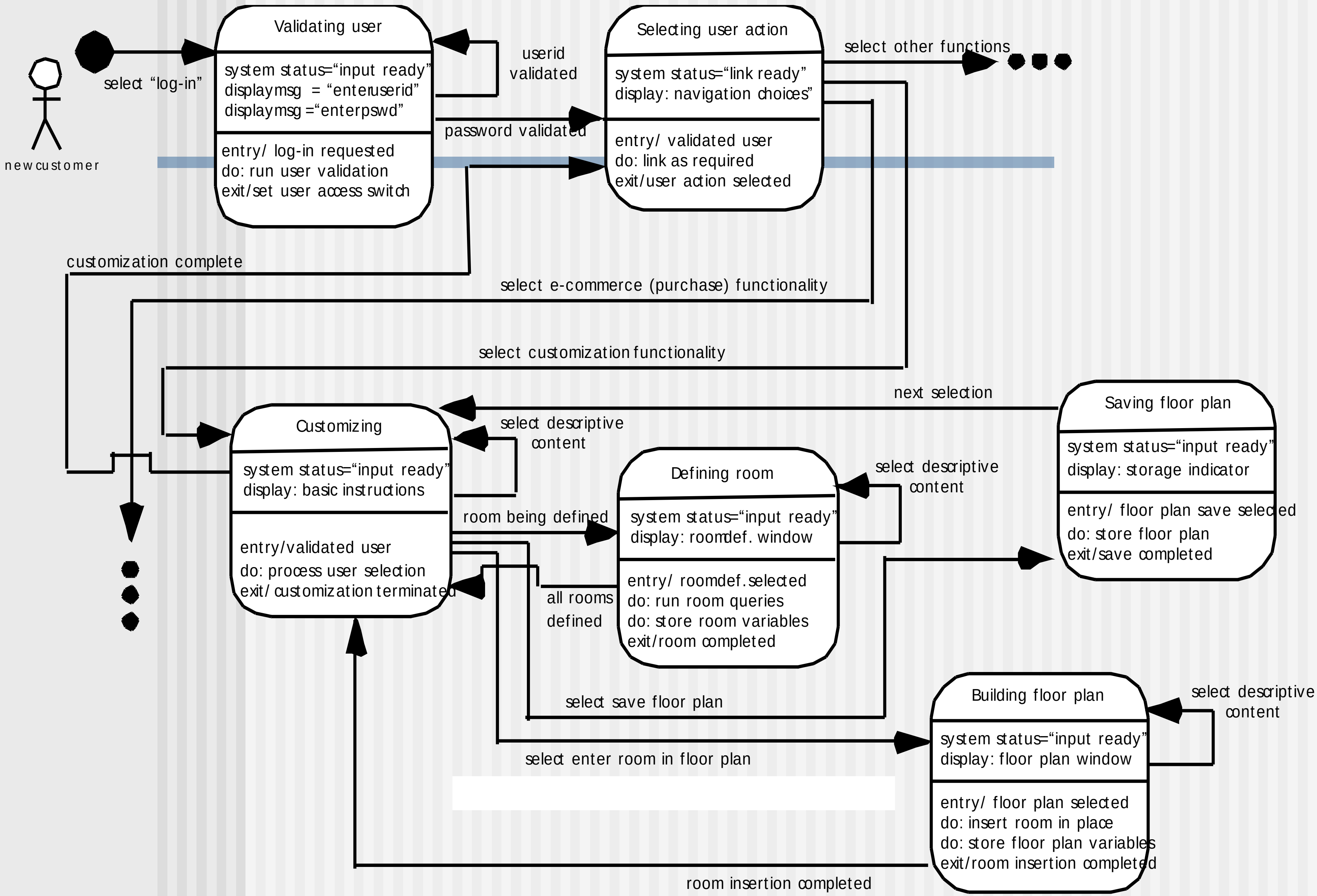
The Interaction Model

- Composed of four elements:
  - use-cases
  - sequence diagrams
  - state diagrams
  - a user interface prototype
- Each of these is an important UML notation and is described in Appendix I

Sequence Diagram



State Diagram



The Functional Model

- The functional model addresses two processing elements of the WebApp
  - user observable functionality that is delivered by the WebApp to end-users
  - the operations contained within analysis classes that implement behaviors associated with the class.
- An activity diagram can be used to represent processing flow

The Configuration Model

- Server-side
  - Server hardware and operating system environment must be specified
  - Interoperability considerations on the server-side must be considered
  - Appropriate interfaces, communication protocols and related collaborative information must be specified
- Client-side
  - Browser configuration issues must be identified
  - Testing requirements should be defined

Navigation Modeling

- Navigation modeling considers how each user category will navigate from one WebApp element (e.g., content object) to another.
- The mechanics of navigation are defined as part of design.
- In requirement modelling we should focus on overall navigation requirements.
- The questions should be considered as: *(refer next slide)*

Navigation Modeling-I

- Should certain elements be easier to reach (require fewer navigation steps) than others? What is the priority for presentation?
- Should certain elements be emphasized to force users to navigate in their direction?
- How should navigation errors be handled?
- Should navigation to related groups of elements be given priority over navigation to a specific element.
- Should navigation be accomplished via links, via search-based access, or by some other means?
- Should certain elements be presented to users based on the context of previous navigation actions?
- Should a navigation log be maintained for users?

Navigation Modeling-II

- Should a full navigation map or menu (as opposed to a single “back” link or directed pointer) be available at every point in a user’s interaction?
- Should navigation design be driven by the most commonly expected user behaviors or by the perceived importance of the defined WebApp elements?
- Can a user “store” his previous navigation through the WebApp to expedite future usage?
- For which user category should optimal navigation be designed?
- How should links external to the WebApp be handled? overlaying the existing browser window? as a new browser window? as a separate frame?