Chapter 8
Analysis Modeling, Part 2/2

Moonzoo Kim
CS Division of EECS Dept.
KAIST
moonzoo@cs.kaist.ac.kr
http://pswlab.kaist.ac.kr/courses/cs550-07

Overview of Ch 8. Building the Analysis Model

- April 10: ch 8.1- ch 8.5
  - 8.1 Requirement Analysis
  - 8.2 Analysis Modeling Approaches
  - 8.3 Data Modeling Concepts
  - 8.4 Object-Oriented Analysis
  - 8.5 Scenario-based modeling

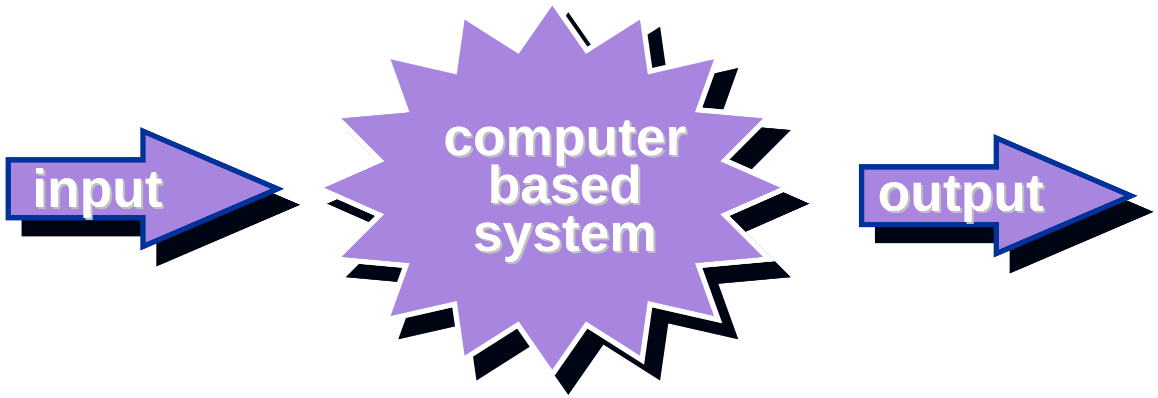
- April 12: ch 8.6- ch 8.8
  - 8.6 Flow-oriented modeling
  - 8.7 Class-based modeling
  - 8.8 Creating a behavioral model

Flow-Oriented Modeling

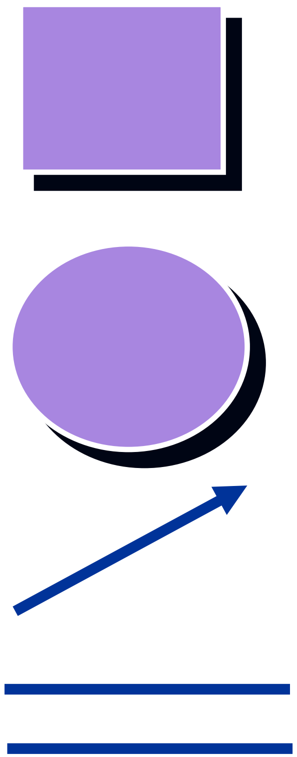
- Represents how data objects are transformed at they move through the system
- A data flow diagram (DFD) is the diagrammatic form that is used
- Considered by many to be an 'old school' approach
    - flow-oriented modeling continues to provide a view of the system that is unique—it should be used to 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

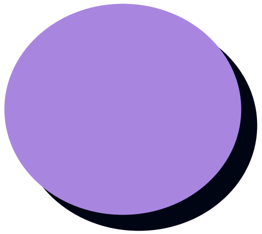
A producer or consumer of data

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



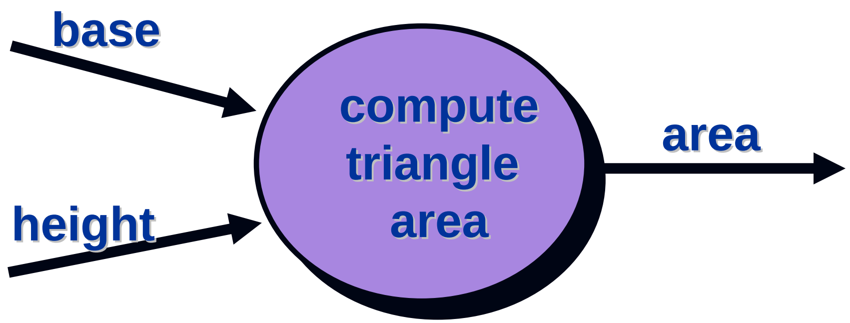
A data transformer (changes input to output)

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

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

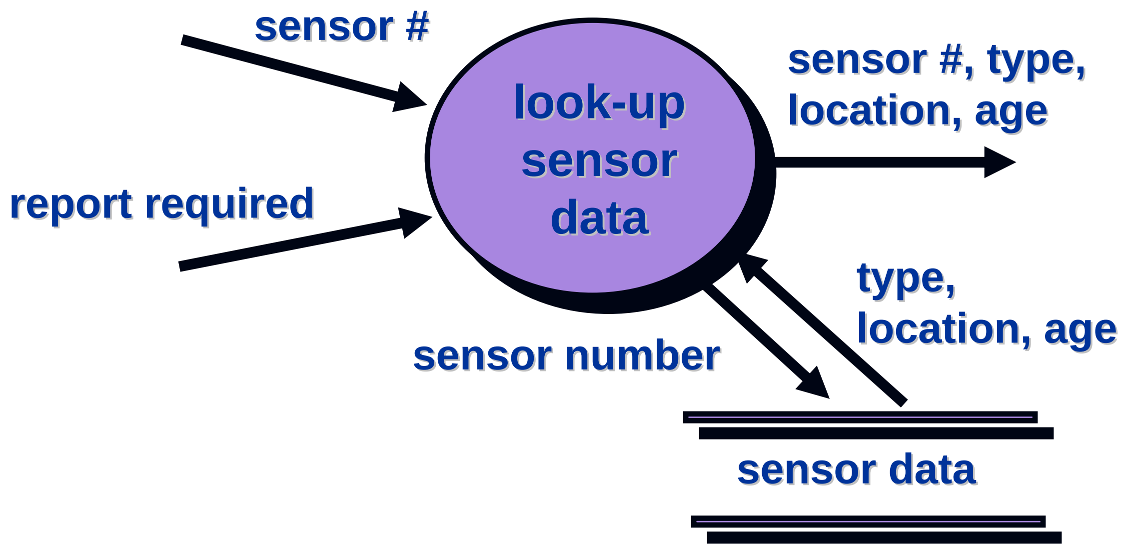
Data Flow

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



Data Stores

Data is often stored for later use.



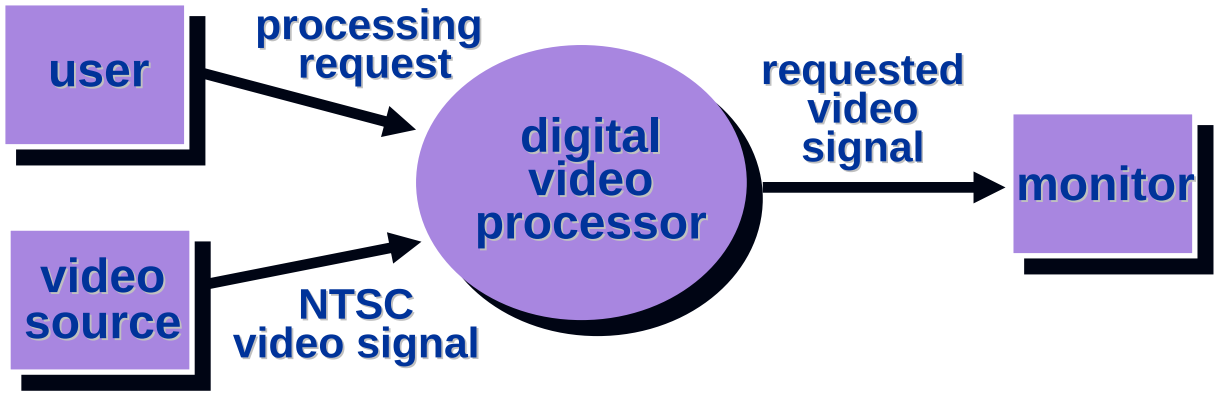
Data Flow Diagramming: Guidelines

- All icons must be labeled with meaningful names
- The DFD evolves through a number of levels of 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 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

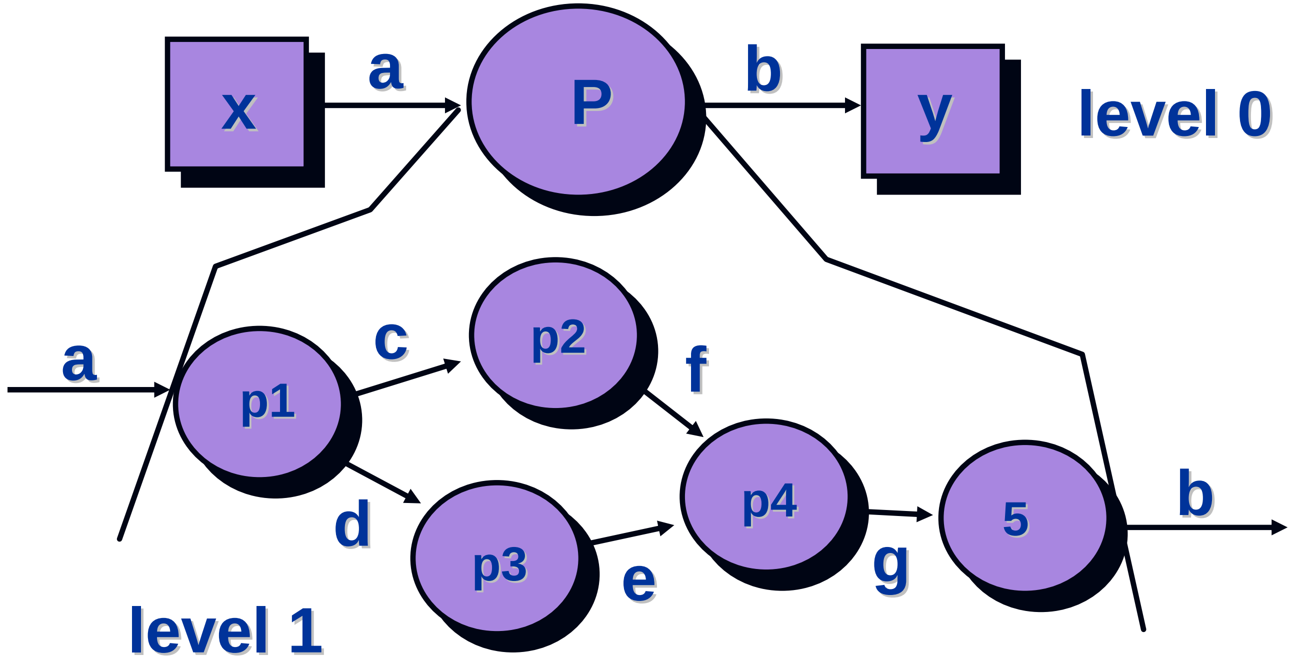
Level 0 DFD Example



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

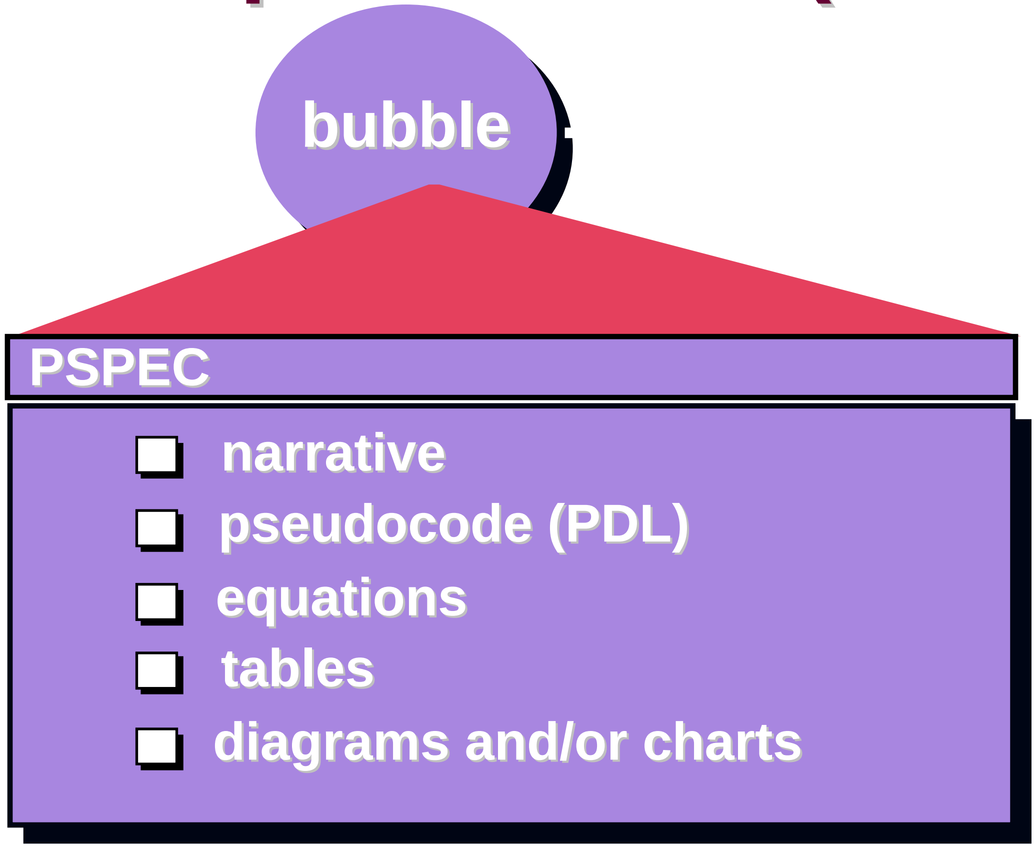
The Data Flow Hierarchy



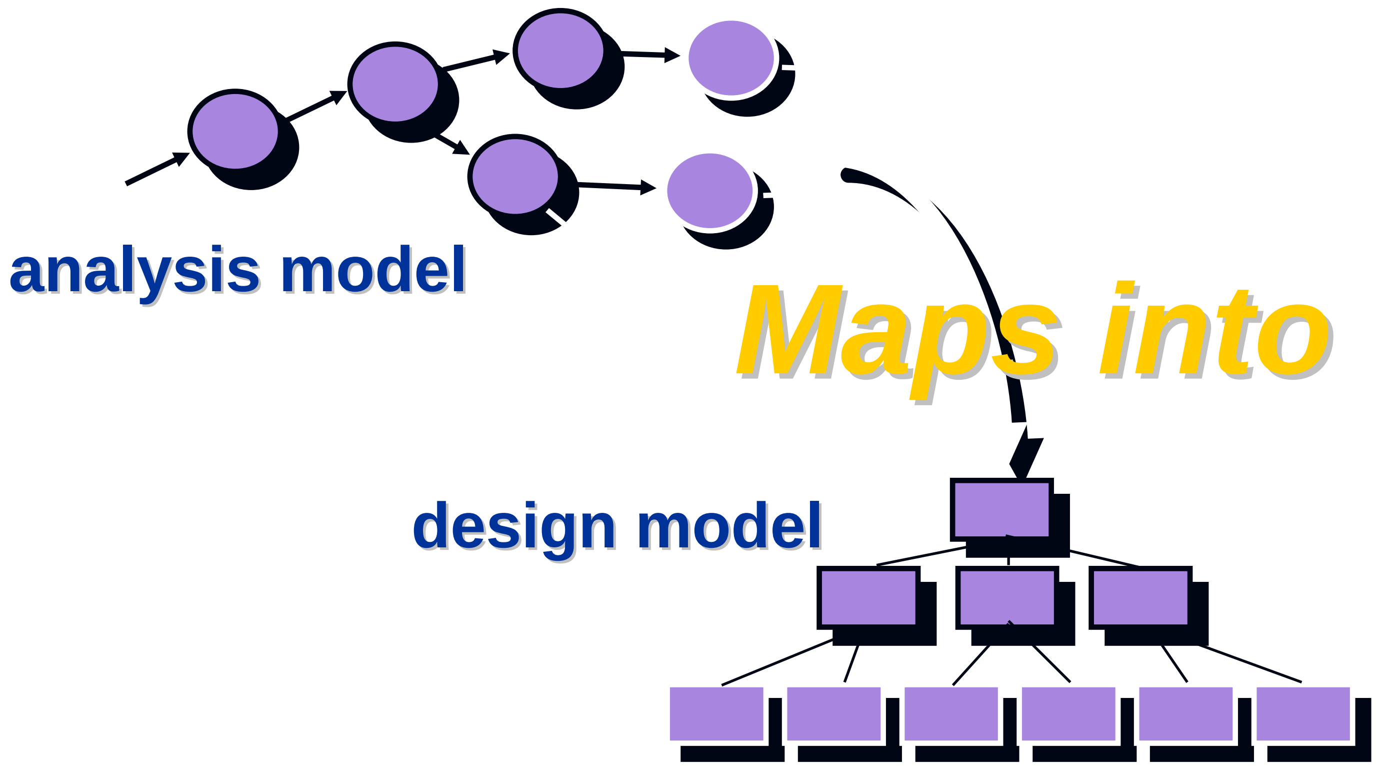
Flow Modeling Notes

- 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 Diagrams

- 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.

The Control Model

- the control flow diagram is "superimposed" on the DFD and shows events that control the processes noted in the DFD
- control flows—events and control items—are noted by dashed arrows
- a vertical bar implies an input to or output from a control spec (CSPEC) — a separate specification that describes how control is handled
- a dashed arrow entering a vertical bar is an input to the CSPEC
- a dashed arrow leaving a process implies a data condition
- a dashed arrow entering a process implies a control input read directly by the process
- control flows do not physically activate/deactivate the processes—this is done via the CSPEC

Class-Based Modeling

- Identify analysis classes by examining the problem statement
- Use a “grammatical parse” to isolate potential classes
- Identify the attributes of each class
- Identify operations that manipulate the attributes

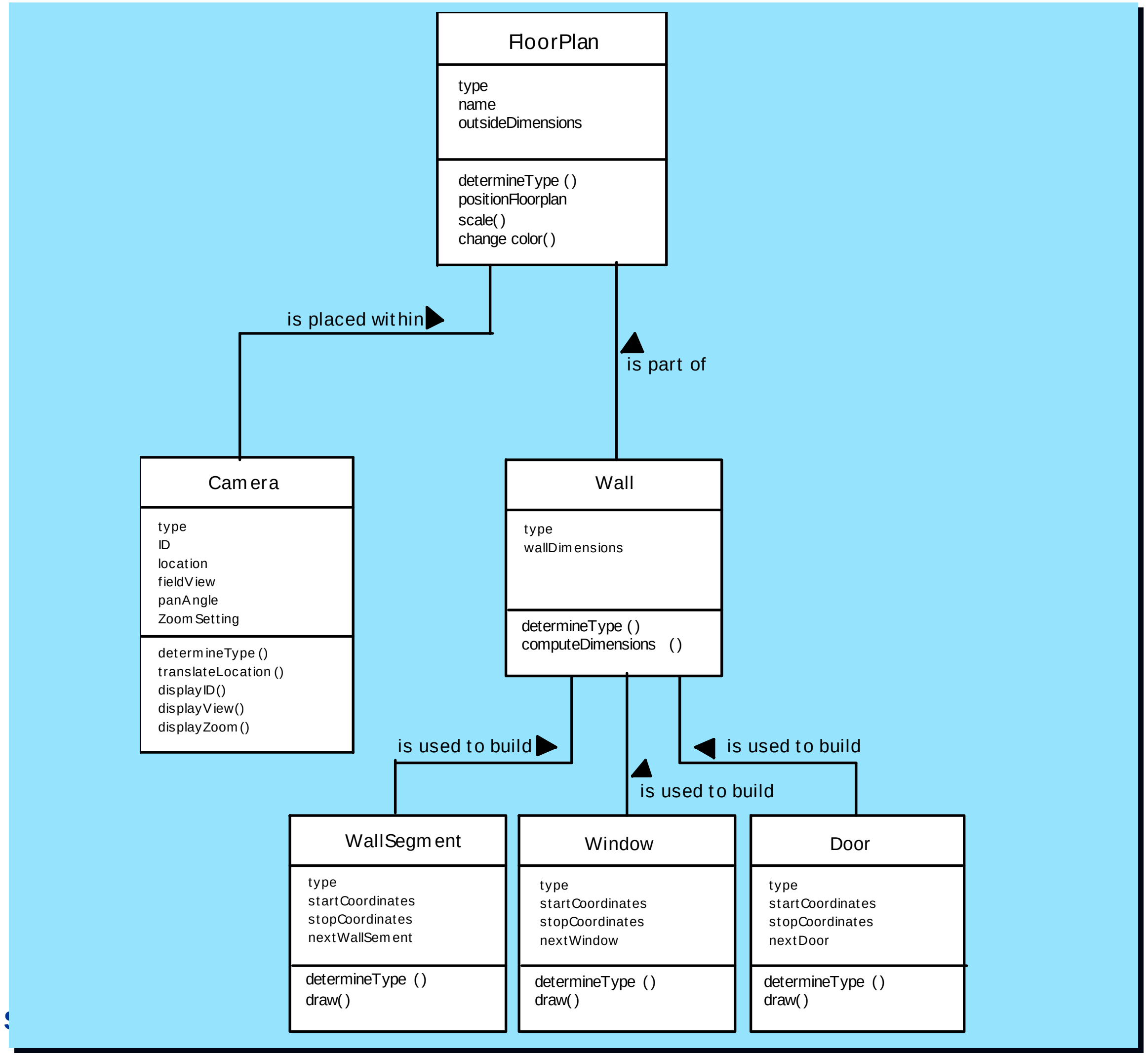
Analysis Classes

- *External entities* (e.g., other systems, devices, people) that produce or consume information to be used by a computer-based system.
- *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 of the system.
- *Structures* (e.g., sensors, four-wheeled vehicles, or computers) that define a class of objects or related classes of objects.

Selecting Classes—Criteria

- retained information
- needed services
- multiple attributes
- common attributes
- common operations
- essential requirements

Class Diagram



CRC Modeling

- Analysis classes have “responsibilities”
  - *Responsibilities* are the attributes and operations encapsulated by the class
- Analysis classes collaborate with one another
  - *Collaborators* are those classes that are required to provide a class with the information needed to complete a responsibility.
  - In general, a collaboration implies either a request for information or a request for some action.

CRC Modeling

Class: FloorPlan

Description:

Responsibility:	Collaborator:
defines floor plan name/type	
manages floor plan positioning	
scales floor plan for display	
scales floor plan for display	
incorporates walls, doors and windows	Wall
shows position of video cameras	Camera

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.

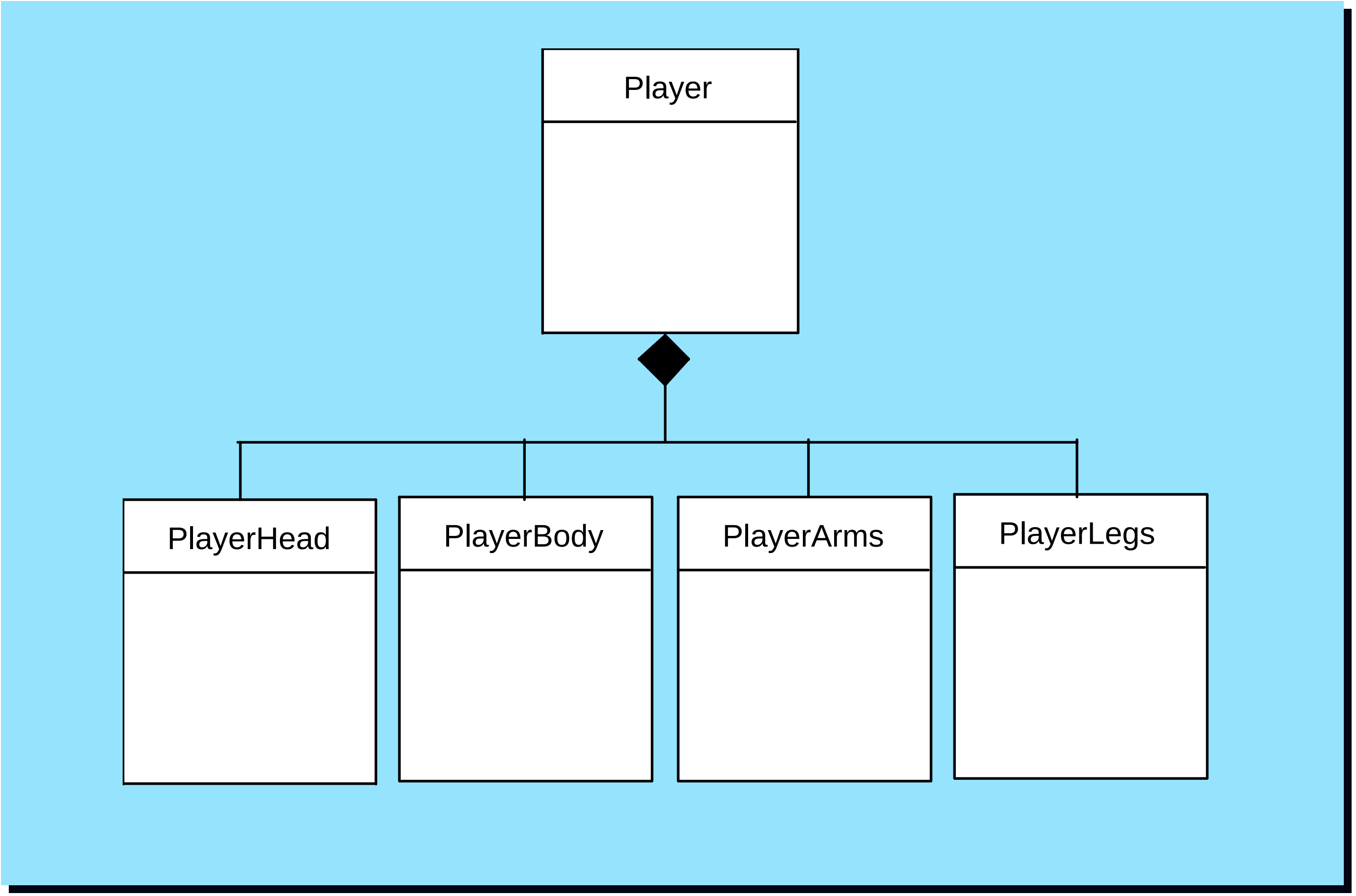
Responsibilities

- 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



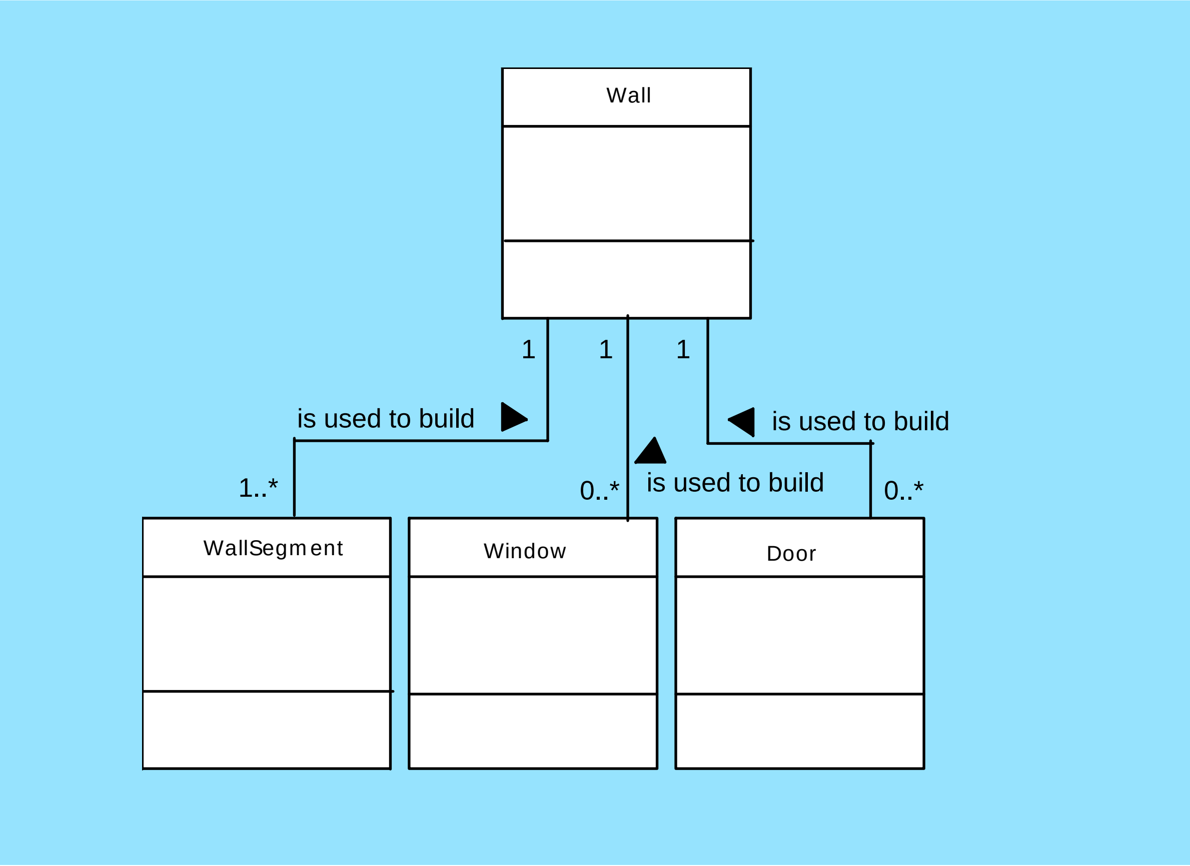
Reviewing the CRC Model

- 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.

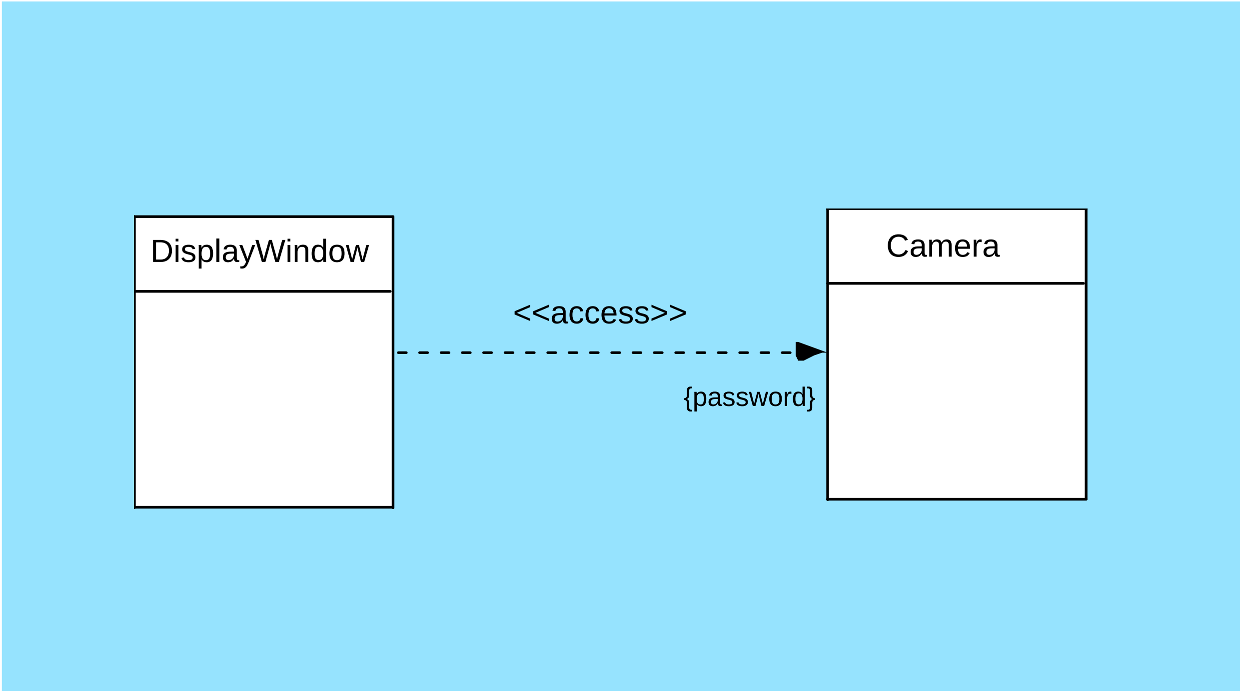
Associations and Dependencies

- 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



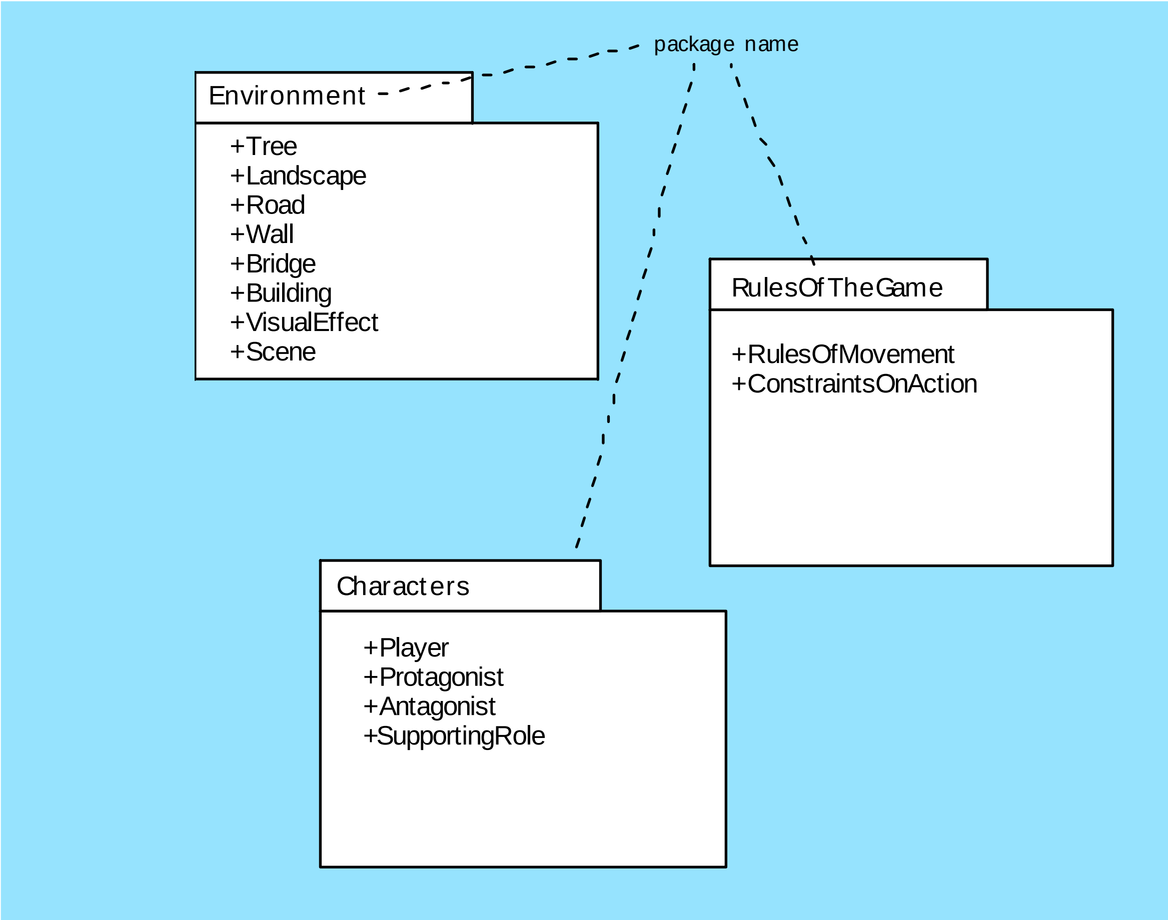
Dependencies



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 + 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



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 Diagram for the ControlPanel Class

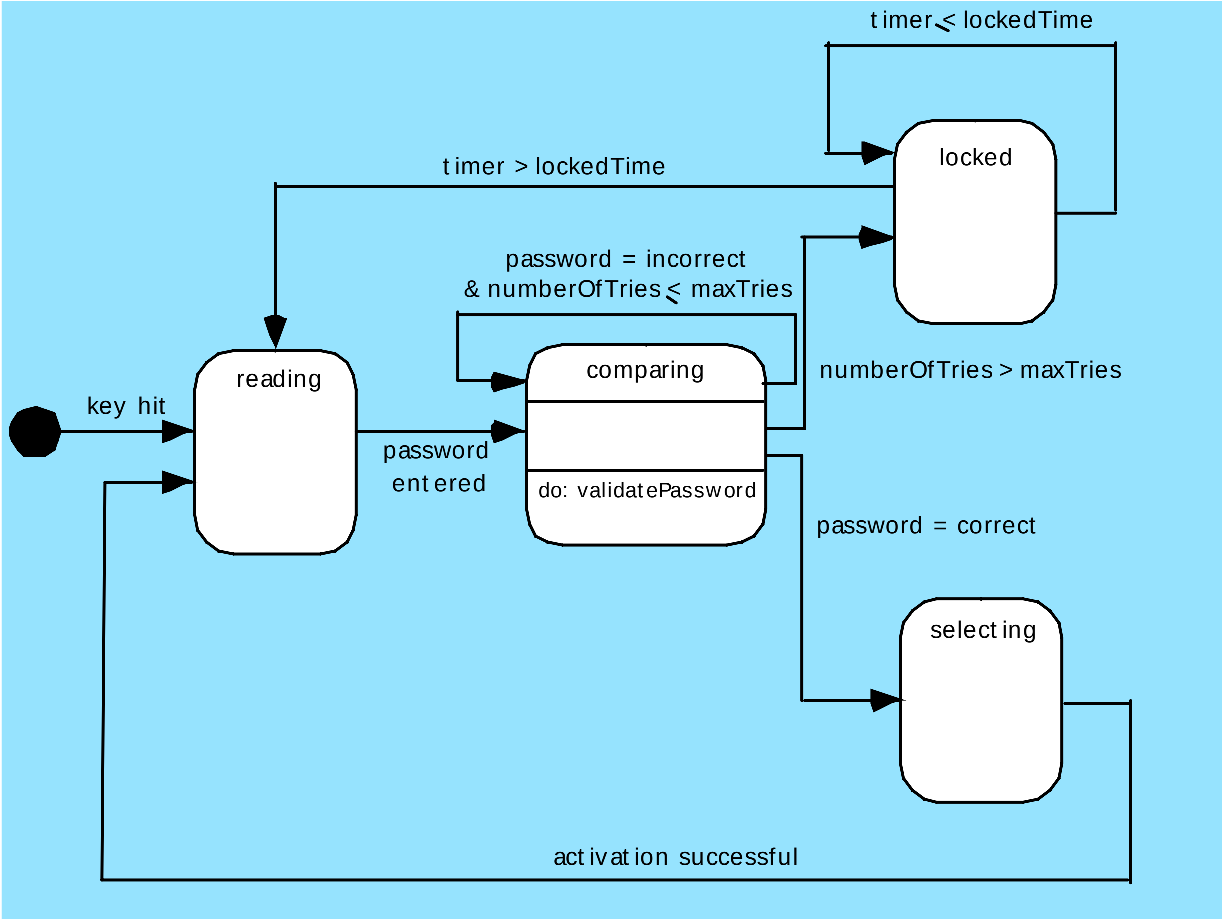


Fig 8.20 pg 251 in SEPA

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

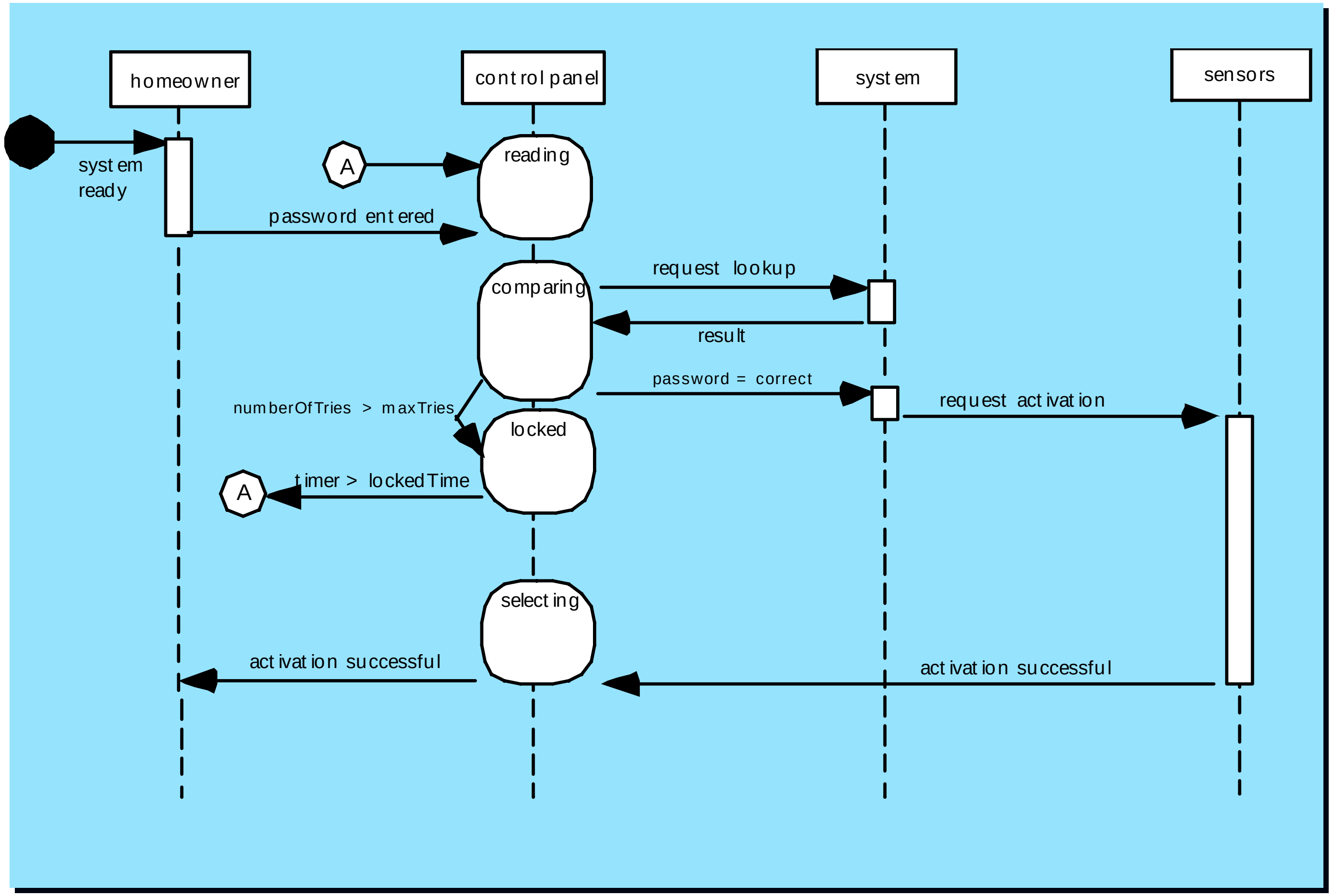


Figure 8.27 Sequence diagram (partial) for *SafeHome* security function

Specification Guidelines

- use a layered format that provides increasing detail as the "layers" deepen
- use consistent graphical notation and apply textual terms consistently (stay away from aliases)
- be sure to define all acronyms
- be sure to include a table of contents; ideally, include an index and/or a glossary
- write in a simple, unambiguous style (see "editing suggestions" on the following pages)
- always put yourself in the reader's position, "Would I be able to understand this if I wasn't intimately familiar with the system?"

Specification Guidelines

Be on the lookout for persuasive connectors, ask why?
keys: *certainly, therefore, clearly, obviously, it follows that ...*

Watch out for vague terms
keys: *some, sometimes, often, usually,ordinarily, most, mostly ...*

When lists are given, but not completed, be sure all items are understood
keys: *etc., and so forth, and so on, such as*

Be sure stated ranges don't contain unstated assumptions
e.g., *Valid codes range from 10 to 100.* Integer? Real? Hex?

Beware of vague verbs such as *handled, rejected, processed, ...*

Beware "passive voice" statements
e.g., *The parameters are initialized.* By what?

Beware "dangling" pronouns
e.g., *The I/O module communicated with the data validation module and its contol flag is set.* Whose control flag?

Specification Guidelines

When a term is explicitly defined in one place, try substituting the definition forother occurrences of the term

When a structure is described in words, draw a picture

When a structure is described with a picture, try to redraw the picture to emphasize different elements of the structure

When symbolic equations are used, try expressing their meaning in words

When a calculation is specified, work at least two examples

Look for statements that imply certainty, then ask for proof
  keys; always, every, all, none, never

Search behind certainty statements뾟e sure restrictions or limitations are realistic