Lecture 3 Software Requirements Analysis I

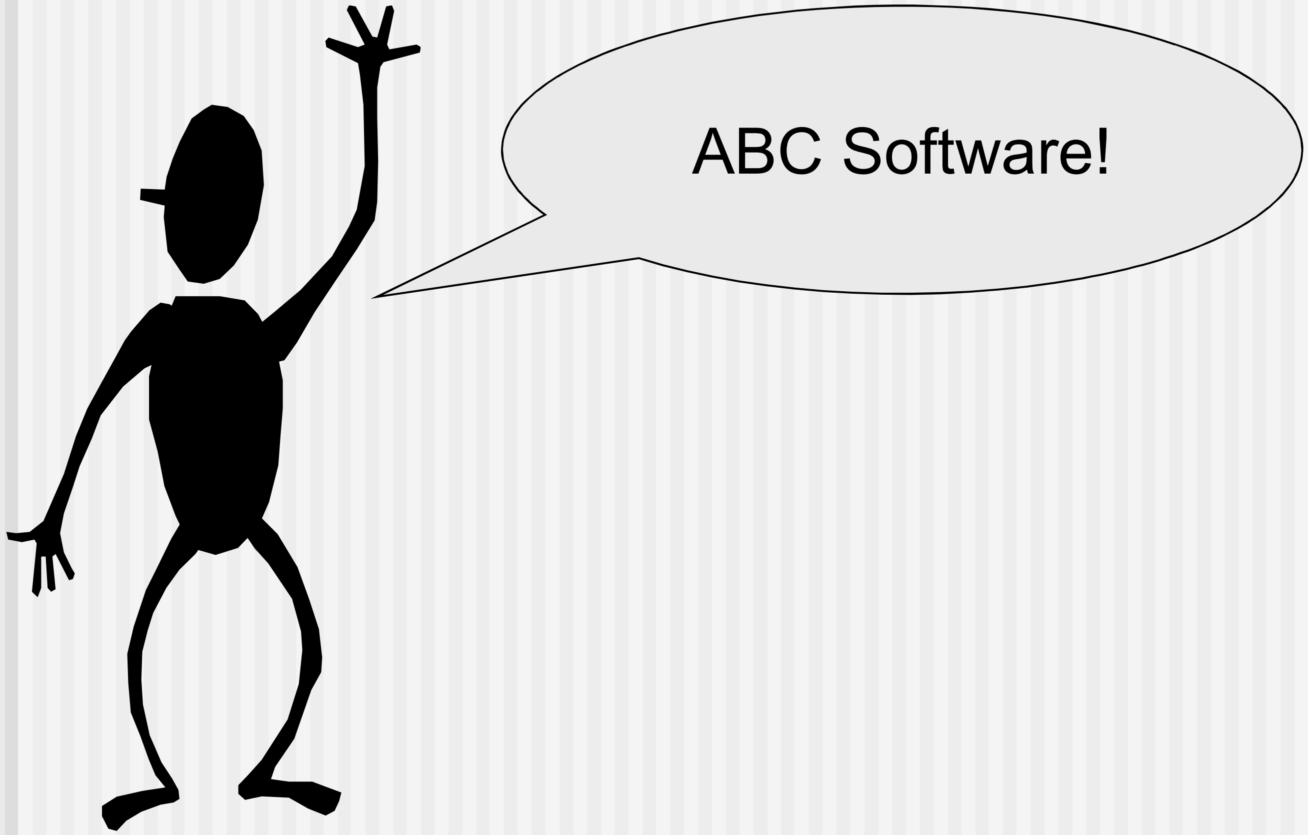
- **Software Requirements Engineering**

“How to find out what the customer wants?”

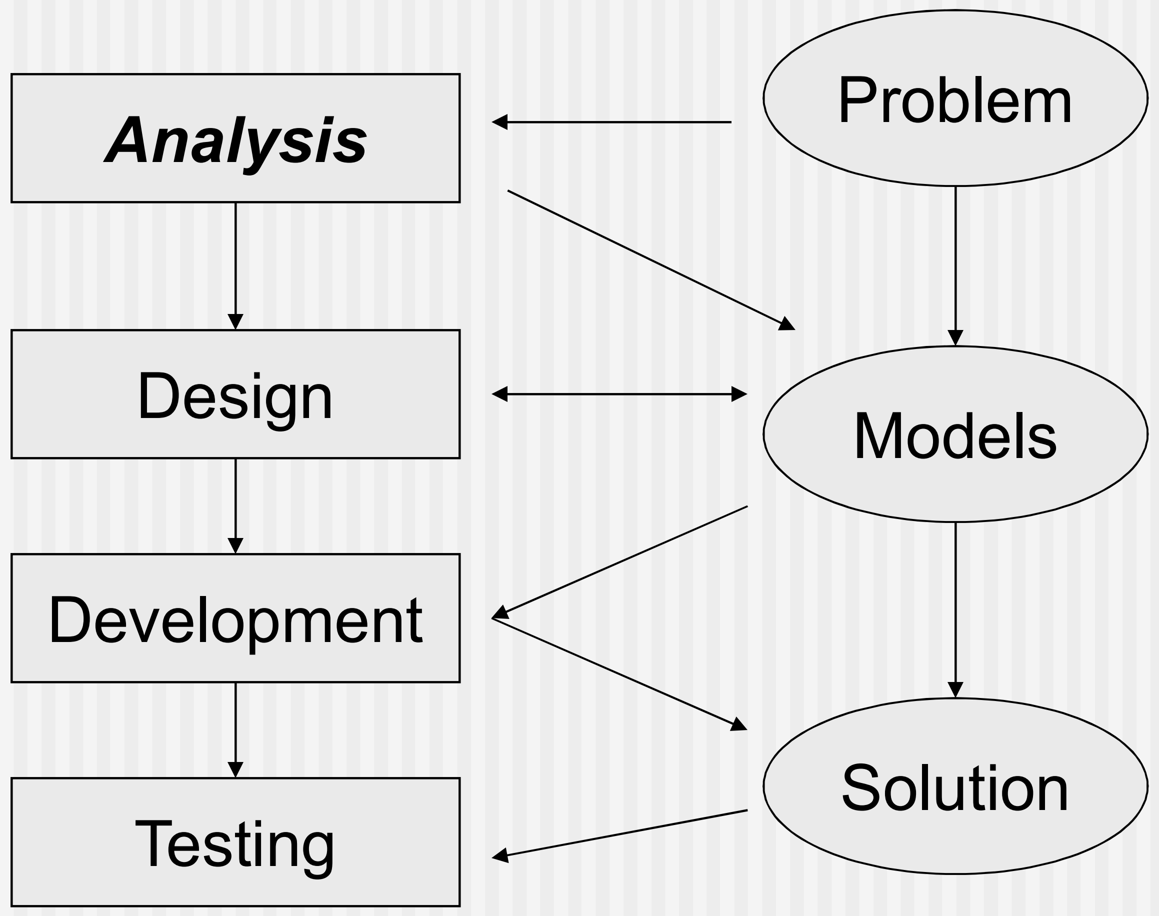
What Are Software Requirements?

- What the customers want?
- How end users will interact with the software?
- What the software should be processing?
- What is the technical environment of the software system?
- How the software fits into the business processes?

What We Are Doing



Requirements Engineering is The First Task



Requirements Engineering

- 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

- 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

- 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

- 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

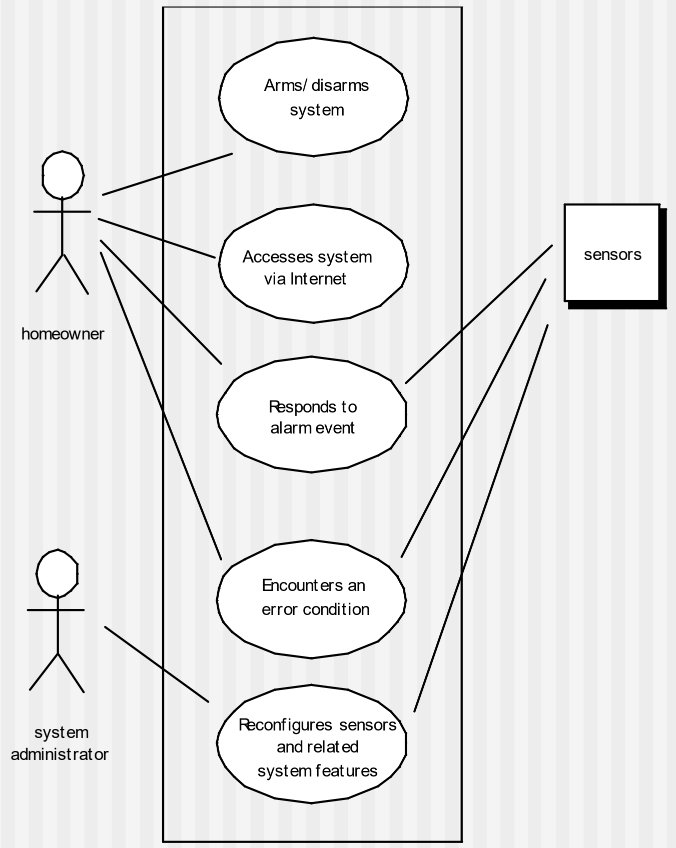
Non-Functional Requirements

- Non-Functional Requirment (NFR) – quality attribute, performance attribute, security attribute, or general system constraint. A two phase process is used to determine which NFR’s are compatible:
  - The first phase is to create a matrix using each NFR as a column heading and the system SE guidelines a row labels
  - The second phase is for the team to prioritize each NFR using a set of decision rules to decide which to implement by classifying each NFR and guideline pair as complementary, overlapping, conflicting, or independent

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?

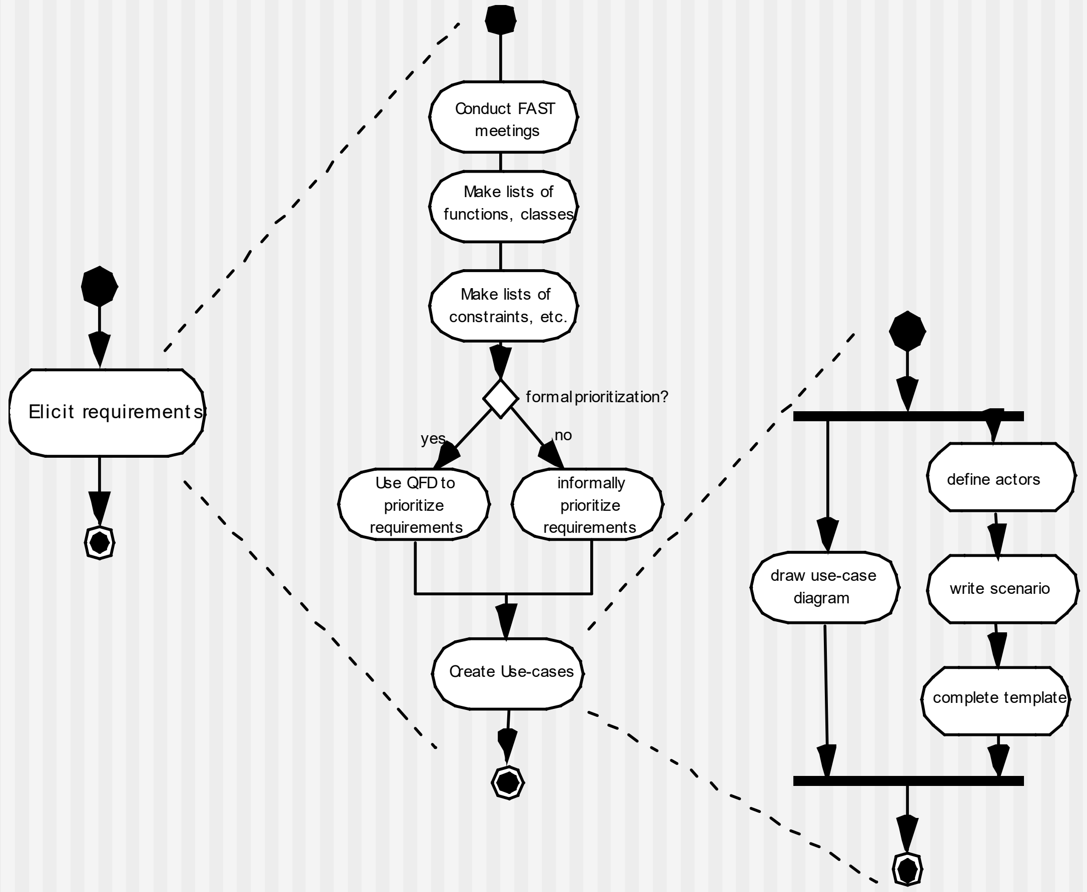
Use-Case Diagram


Arms/ disarms system
Accesses system via Internet
Responds to alarm event
Encounters an error condition
Reconfigures sensors and related system features
homeowner
system administrator
sensors

Building the Analysis Model

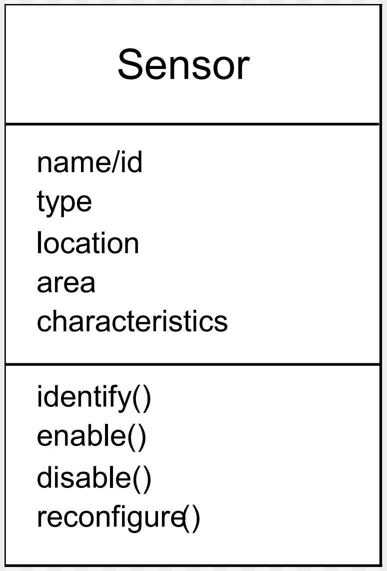
- Elements of the analysis model
  - Scenario-based elements
    - Functional—processing narratives for software functions
    - Use-case—descriptions of the interaction between an "actor" and the system
  - Class-based elements
    - Implied by scenarios
  - Behavioral elements
    - State diagram
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

Eliciting Requirements

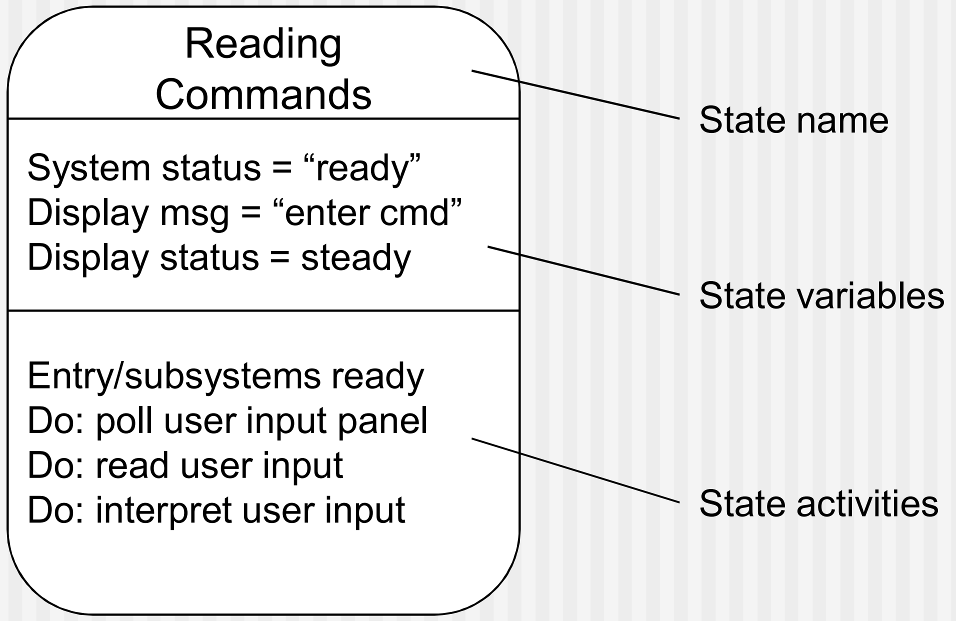


Class Diagram

From the *SafeHome* system …



State Diagram



Analysis Patterns

Pattern name: A descriptor that captures the essence of the pattern.

Intent: Describes what the pattern accomplishes or represents

Motivation: A scenario that illustrates how the pattern can be used to address the problem.

Forces and context: A description of external issues (forces) that can affect how the pattern is used and also the external issues that will be resolved when the pattern is applied.

Solution: A description of how the pattern is applied to solve the problem with an emphasis on structural and behavioral issues.

Consequences: Addresses what happens when the pattern is applied and what trade-offs exist during its application.

Design: Discusses how the analysis pattern can be achieved through the use of known design patterns.

Known uses: Examples of uses within actual systems.

Related patterns: On e or more analysis patterns that are related to the named pattern because (1) it is commonly used with the named pattern; (2) it is structurally similar to the named pattern; (3) it is a variation of the named pattern.

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"

Requirements Monitoring

Especially needes in incremental development

- *Distributed debugging* – uncovers errors and determines their cause.
- *Run-time verification* – determines whether software matches its specification.
- *Run-time validation* – assesses whether evolving software meets user goals.
- *Business activity monitoring* – evaluates whether a system satisfies business goals.
- *Evolution and codesign* – provides information to stakeholders as the system evolves.

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?

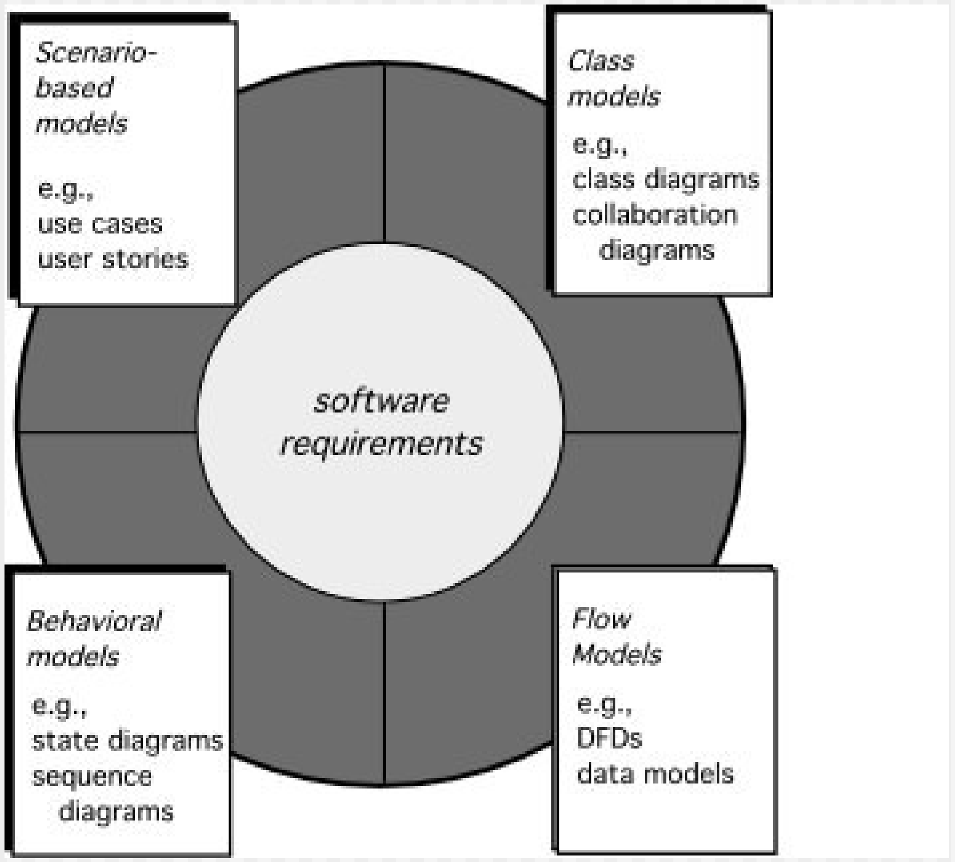
Validating Requirements - II

- 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?

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.

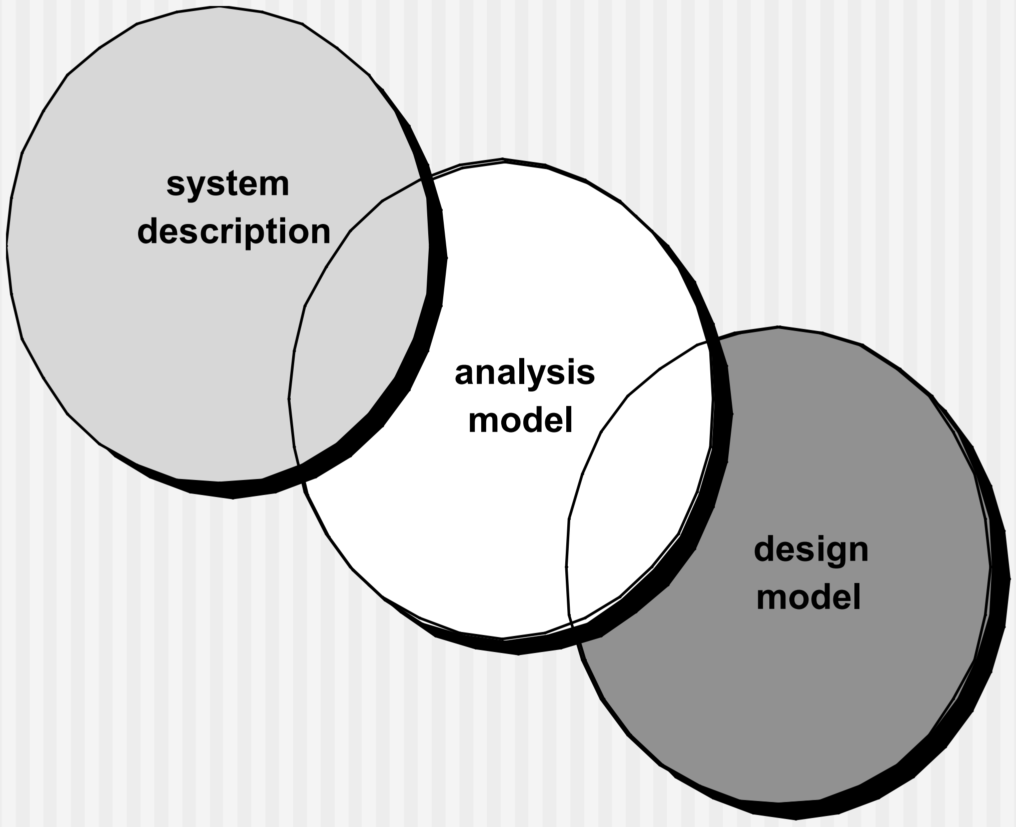
Elements of Requirements Analysis



Requirements Modeling

- Scenario-based
  - system from the user's point of view
- Data
  - shows how data are transformed inside the system
- Class-oriented
  - defines objects, attributes, and relationships
- Flow-oriented
  - shows how data are transformed inside the system
- Behavioral
  - show the impact of events on the system states

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.

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

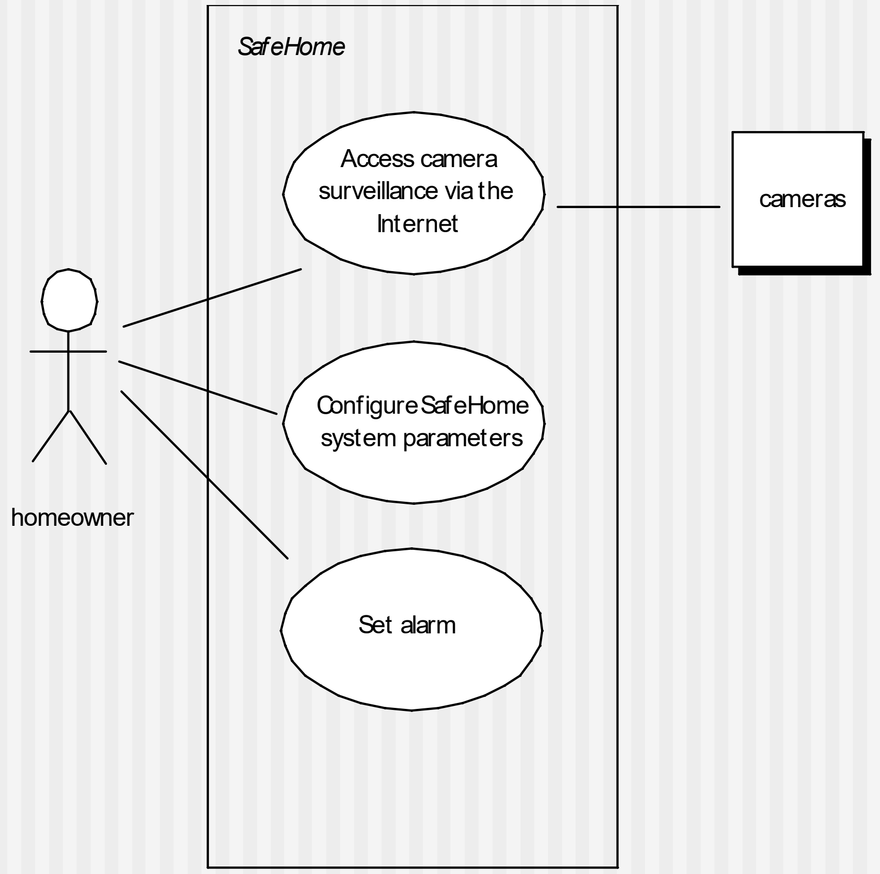
Developing a Use-Case

- 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?

Reviewing a Use-Case

- Use-cases are written first in narrative form and mapped to a template if formality is needed
- Each primary scenario should be reviewed and refined to see if alternative interactions are possible
  - Can the actor take some other action at this point?
  - Is it possible that the actor will encounter an error condition at some point? If so, what?
  - Is it possible that the actor will encounter some other behavior at some point? If so, what?

Use-Case Diagram

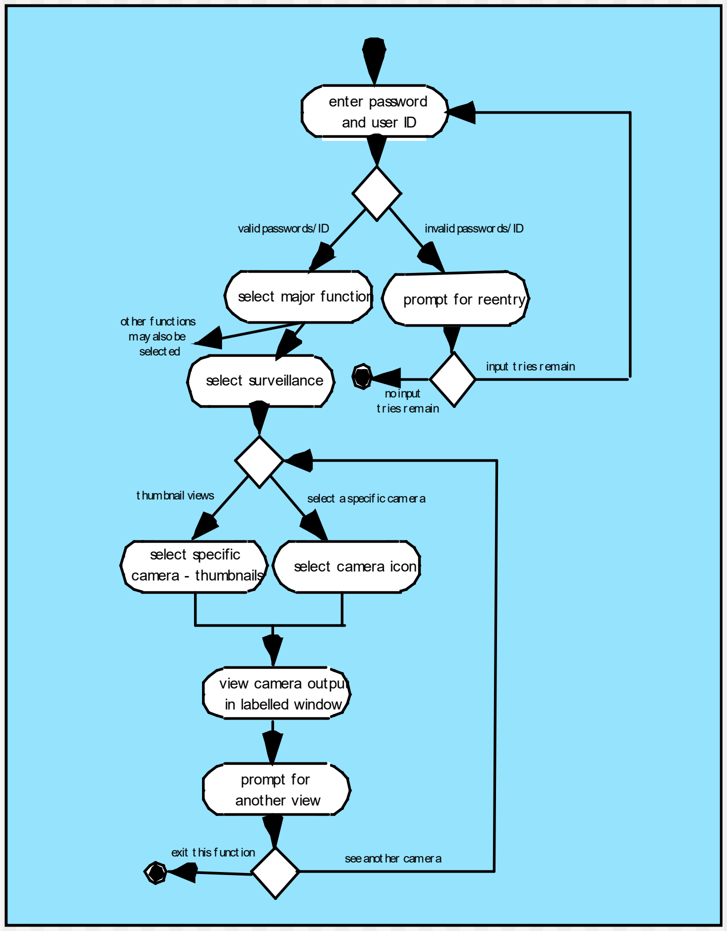

SafeHome
Access camera surveillance via the Internet
Configure SafeHome system parameters
Set alarm
cameras
homeowner

Exceptions

- Describe situations (failures or user choices) that cause the system to exhibit unusual behavior
- Brainstorming should be used to derive a reasonably complete set of exceptions for each use case
- Are there cases where a validation function occurs for the use case?
  - Are there cases where a supporting function (actor) fails to respond appropriately?
  - Can poor system performance result in unexpected or improper use actions?
- Handling exceptions may require the creation of additional use cases

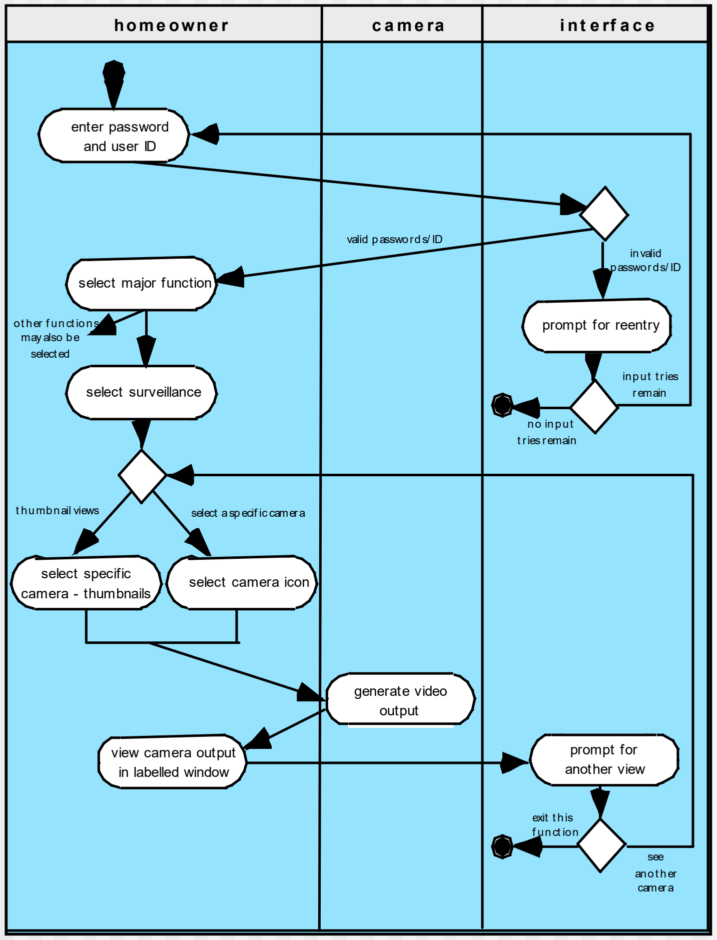
Activity Diagram

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


homeowner
camera
interface
enter password and user ID
valid passwords/ID
invalid passwords/ID
select major function
prompt for reentry
other functions may also be selected
input tries remain
no input tries remain
select surveillance
thumbnail views
select a specific camera
select specific camera - thumbnails
select camera icon
generate video output
view camera output in labelled window
prompt for another view
exit this function
see another camera