Introduction to Software Engineering

(CS350)

Lecture 06

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Understanding Requirements

Requirement Eng. Overview

Requirements engineering remains one of the most problematic aspects of software-intensive systems development.

"So what's all the hub-bub,.... bub?"

Bugs Bunny (1940 -)

US Cartoon Character

Difficulties of Requirements

What is so hard about requirements?

- Everything!!!
  - Finding requirements
  - Writing down requirements
  - Measuring compliance
    - Verification
    - Validation

The Problem

"The hardest single part of building a software system is deciding what to build….No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later."

Frederick P. Brooks:
The Mythical Man-Month (2nd Edition), Addison-Wesley, 2001.

Requirements Defined: IEEE '90

1. A condition or capability needed by a user to solve a problem or achieve an objective
2. A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents
3. A documented representation of a condition or capability as in (1) or (2)

Requirement…

- A requirement is a clear description of
  - the purpose the software is to serve
  - what the software must do to serve that purpose

- Raw requirements are often written by and/or from the standpoint of users
  - function oriented
  - informal and incomplete
  - must be refined

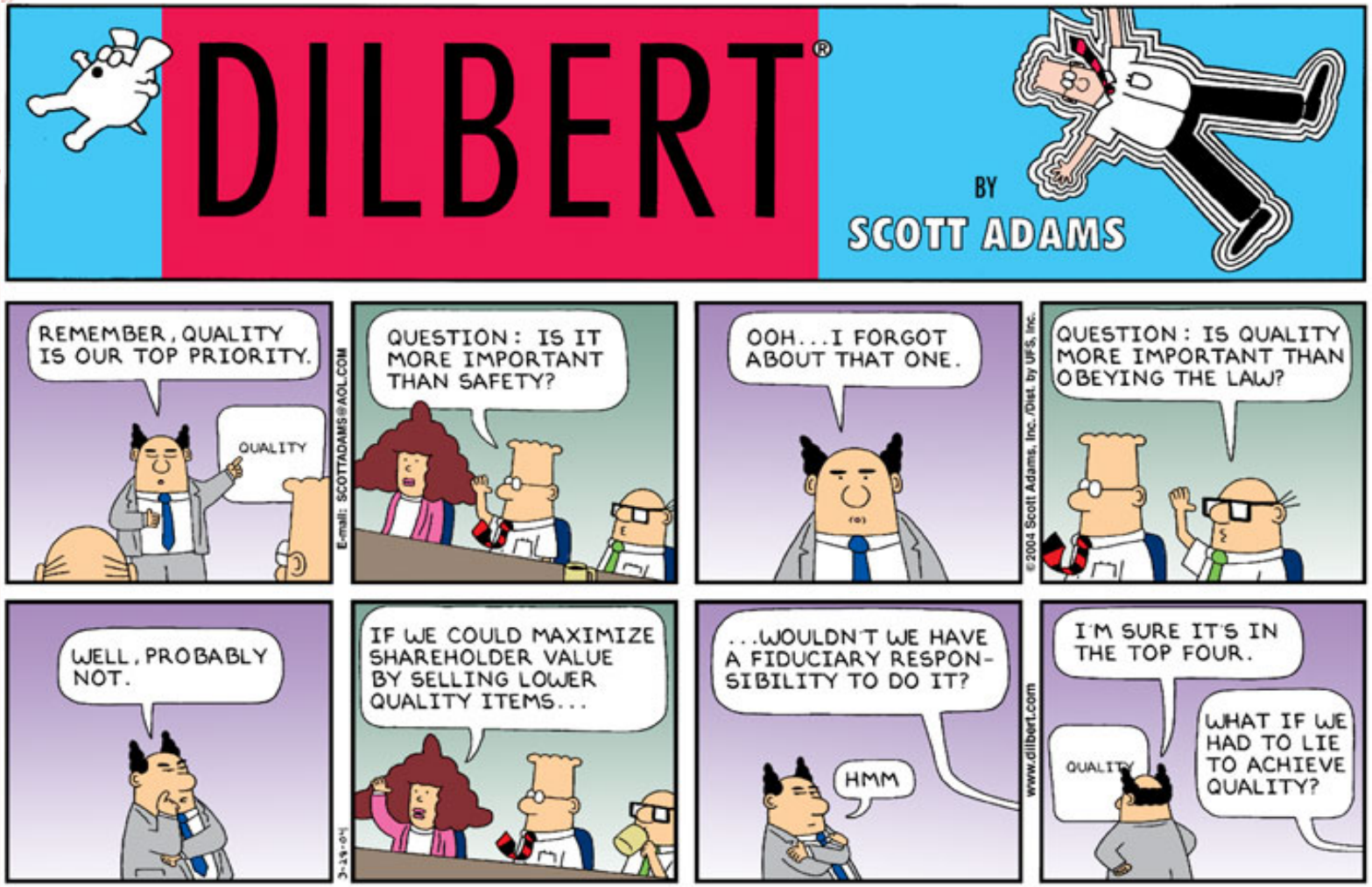
Constraints

- Designers and implementers do not have complete freedom to create as they please.
  - pre-made design decisions
  - rules, standards
  - budget, schedule

- These are *constraints* on how designers and implementers may satisfy the requirement.
  - constraints limit choices

Types of Requirements

- Functional (what)
  - "Input X produces Y"
- ~~Non Functional~~ (Christel and Kang)
  - **Quality Attributes**
  - Interfaces
  - Design constraints
- Implied (Very Nebulous…)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~~Non Functional~~

Quality Attributes

- Performance
- Modifiability
- Reusability
- Reliability
- Stability
- Security
- Extendibility
- Portability
- Usability
  - User friendly?
- Scalability
- Data integrity
- & more

Recent Favorites: “Wowability” & “Buildability

Requirements Engineering

- Systematic way of getting from need to specification – *must be planned*
  - elicit need
  - analyze
    - validate and quantify functional, quality attribute requirements, and constraints
    - set completion criteria
    - establish working agreement (**Statement of Work**)
  - document

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?

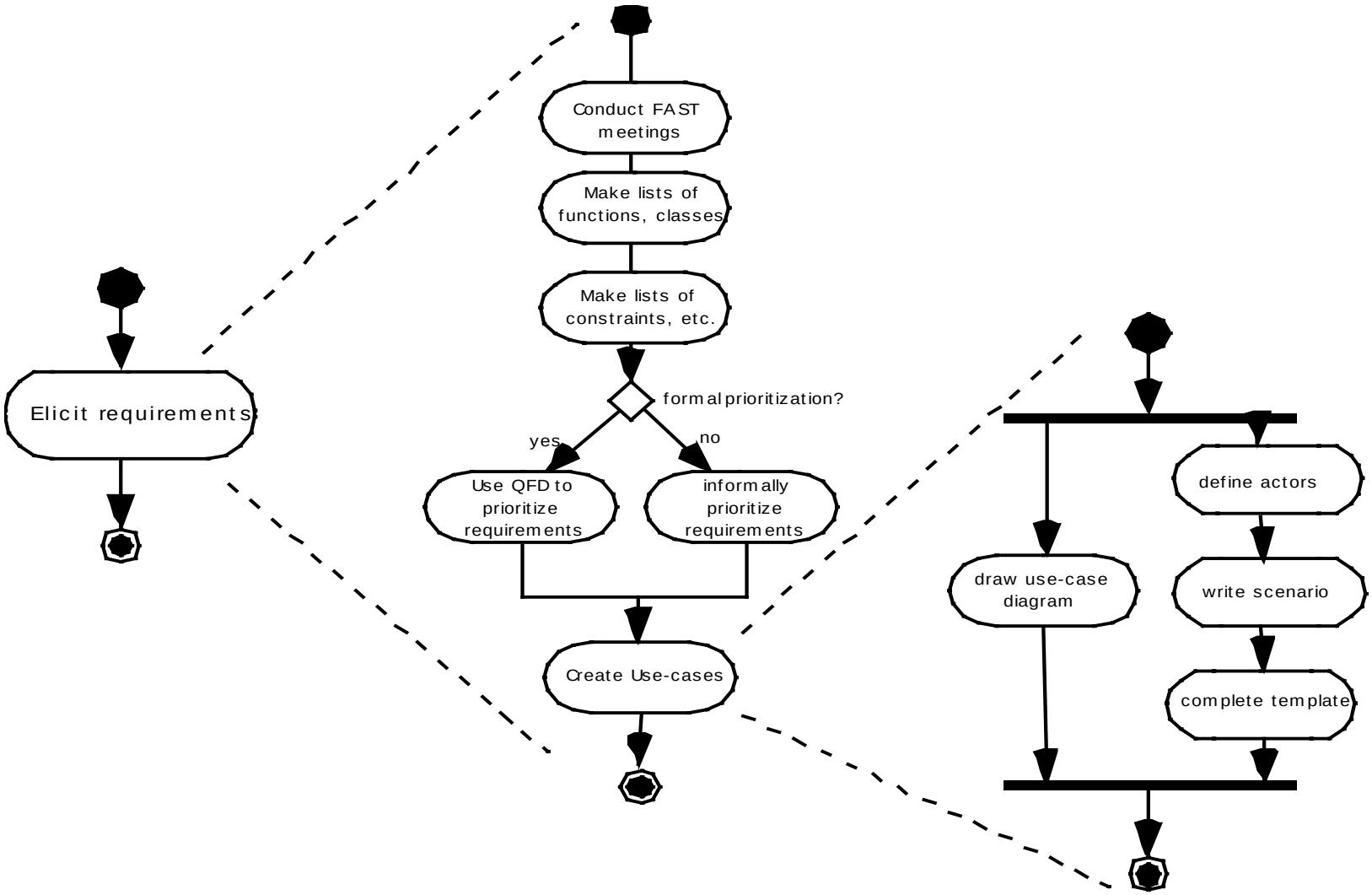
Eliciting Requirements

- 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

Requirements Elicitation: Job #1

- If you do not meet the needs of the true users, your product will fail.
- The first task of requirements elicitation is to identify those users.
- If you do not have access to the true users, you will not determine their needs.
- It is risky to do requirements elicitation at arm's length or through intermediaries.

Eliciting 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

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.

Problems

- Some major issues encountered when you elicit requirements include
  - inarticulateness
  - terminology
  - hidden assumptions
  - preconceived solutions

"You don't know what you don't know."

Inarticulateness – 1

- Many stakeholders (especially users) cannot explain what they do or what they need. They
  - remember the exception, and forget the routine
  - underemphasize the prominence of simple stuff
  - focus on what doesn't work, not what does work

- One articulate user can mislead other stakeholders and build a false consensus.

Inarticulateness – 2

- Quality attribute requirements are the most difficult for stakeholders to articulate.
  - One word descriptions such as "modifiable" are meaningless.
    - How do you measure modifiability?
    - How important is modifiability with respect to other quality attributes?
  - One stakeholder's modifiability is another stakeholders scalability.

Potential Solutions – 1

- Observation
  - Watch users work (covertly and overtly)
- Interviews with key stakeholders
  - Research interviewee?
- Logging
  - Have users write down what they do as they do it
  - Have them log their time on task
- Develop use case and quality attribute scenarios
  - One describes function one describe quality attribute characteristics

Potential Solutions – 2

- Use cases describe required *functionality*.
- Quality attribute scenarios describe required *quality attribute properties*.
- Which modifiability requirement is more meaningful?
  - *"The system shall be modifiable."*
  - *"Modify the system to utilize a different COTS discrete event generation package in 12 staff months."*

Terminology

- Stakeholders (especially users) have a different vocabulary from that of designers and developers.
  - Special cultures result from special terms used in special ways.
  - Developers must understand terms in the context of the stakeholders and their work
    - critical to understanding stakeholder needs

Potential Solutions

- Domain expert
  - Enlist a domain expert that also has a knowledge of software engineering
- Domain dictionary
  - Build a dictionary of key technical terms and their definition before you elicit requirements
- Domain training
  - Train software engineers in the domain or vice-versa

Hidden Assumptions (Implied)

- The stuff “everybody knows” often goes unstated.
  - The obvious may not be obvious to those lacking domain expertise.
  - A system that violates critical assumptions will fail.

- No matter how obvious, critical assumptions must be explicitly stated and recorded.

Potential Solutions

- Observation (again watch them at work)
- Use Cases
- Role playing
  - have non-experts walk through key use cases and test them for completeness
- Prototypes
- Formal analysis
  - cast requirements into a formal specification that can be rigorously checked for completeness

Preconceived Solutions

- Some stakeholders think they know the answers to their problems.
  - Sometimes they describe their idea of a solution, not the problem
    - *"Just write the code, after all its only pictures,..."*
    - *"I need a Pentium with,..."*
- Sometimes they do, but these answers may not be the best.
  - Their ideas may be incomplete, out of date, or wrong

Potential Solutions

- Brainstorming
  - just get everything out on the table; distill raw data – separate problems from solutions
- Causal analysis
  - find out why users want each feature and quality attribute characteristic
- Fantasy
  - invite stakeholders to describe the perfect solution
- Prototypes

Refinement: Analysis

Look for:

- Consistency with objective
- Abstraction vs. detail
- Categorization (triage)
- Bounded and unambiguous
- Specific source (person)
- Conflicts with others
- Achievable
- Testable

Refinement: Negotiation

- Do customers want more than possible

  (cost, time, scope, quality)
- Prioritize by value and cost
  - Value to the customer
  - Value to other stakeholders?
  - Difficulty to achieve (do the hard first?)

Role of Analysis – 1

- Raw requirements tend to describe a desired product from an unstructured operational perspective such as
  - who will use it
  - what the user would like to have
  - in what context(s) it will be used
  - function and quality attribute necessities

- Unstructured wants and needs must be refined into a *requirements specification*.

Role of Analysis – 2

- *Requirements elicitation* is a *divergent* process that gathers more and more data.

- *Requirements Analysis* is a *convergent* process that
  - refines data rather than gathers it
  - structures information
  - prioritizes needs

Role of Analysis – 2

- Each functional requirement, quality attribute, and constraint must be
  - clarified – understandable by all stakeholders
  - quantified – measurable, testable
  - Prioritized
    - According to importance (to which stakeholder)
    - Consideration of difficulty to implement

Clarification – 1

- Each raw requirement must be refined to articulate the need and capture all that is relevant to designers and implementers
  - What is needed?
  - When is it needed?
  - How much of it is needed?
  - How badly is it needed?
  - For how long is it needed?
  - How likely is the need to change over time?

Clarification – 2

- Clarifying and refining requirements may feel a little like elicitation. Clarification
  - requires iteration with the stakeholders
  - may be slow, but should converge
- If you generate lots of new requirements, then you may need to revisit elicitation
  - Do you have the right/same stakeholders?
  - Have any environmental, technological, organizational, or personnel changes occurred?

Quantification

- Raw requirements tend to be unspecific and qualitative
  - Must be able to prove that a product satisfies a requirements
- Requirements specifications must say how big, how much, how fast often, and so forth.
  - If not, they you are setting the stage for failure and disappointment.

Example: Clarification

- Raw Requirement: *"The system shall be intuitively easy to use."*
  - This is un-testable!

- The system interface shall
  - be learnable to 90% proficiency in 2 weeks
  - have an avg. user error rate of less than 2%
  - score at least 85% on a user satisfaction test

Example: Clarification

- Raw Requirement:

  "The system shall be modifiable"

  (You will always loose with this requirement!)

- The system shall accommodate
  - changes in the user interface without impact to other elements of the system
  - changes to element X in Y staff hours

Priorities

- Some requirements are more important than other requirements
  - some functionality is urgently needed
  - some quality attributes are essential
  - some requirements are hard to achieve
- Prioritization in the specification is essential for
  - setting expectations, reasoning about technical tradeoffs, planning the work

Priorities - Example

- Involve stakeholders in prioritization
  - Quality Attribute Workshop (QAW)

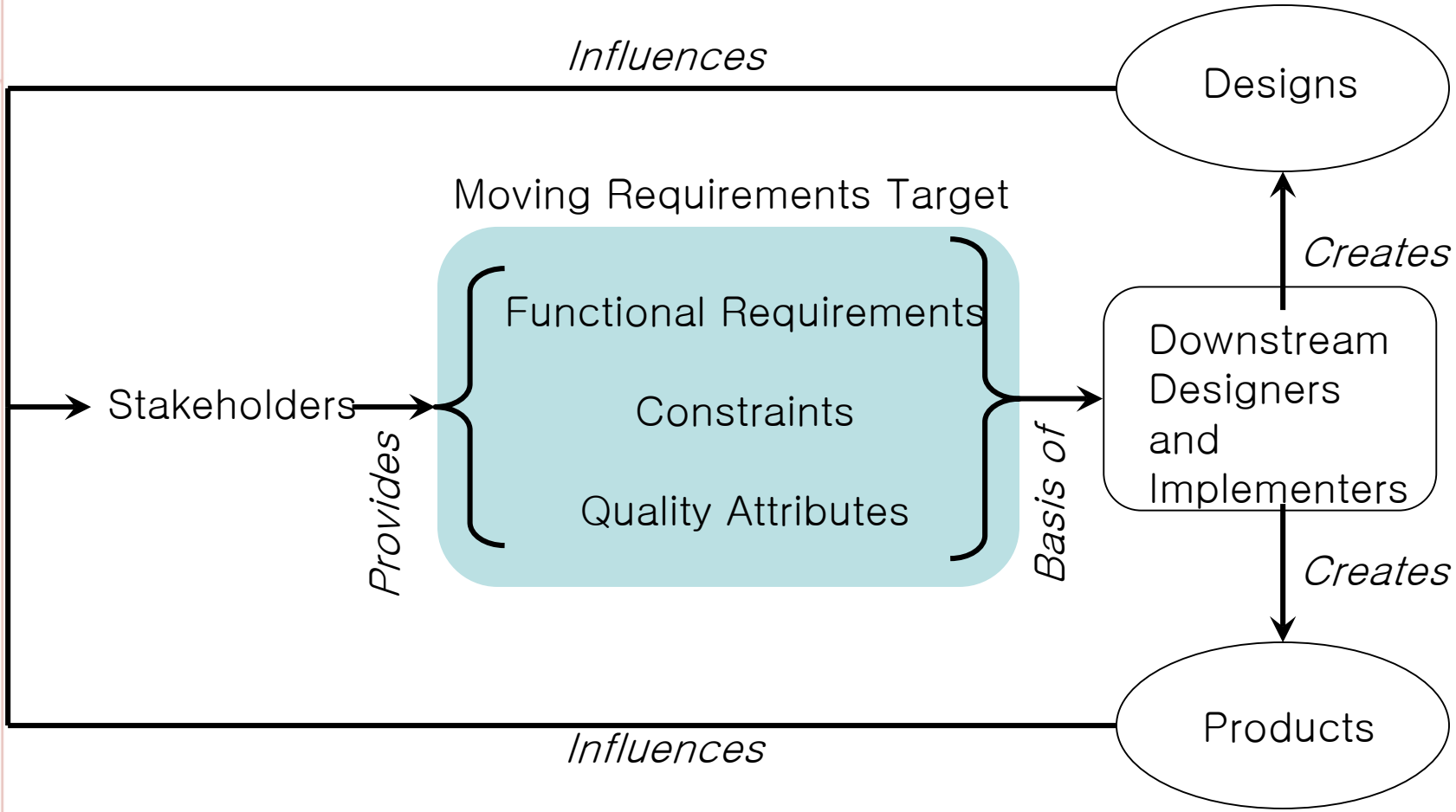
- Keep it simple…get creative…

"The system shall respond to external interrupts in 3ms."

"The system shall display warning messages in red."

Stakeholder votes	Critical	Important	Don't Care
Response time	20	10	2
Warning Messages	0	2	30
:	:	:	:

Moving Requirements Target



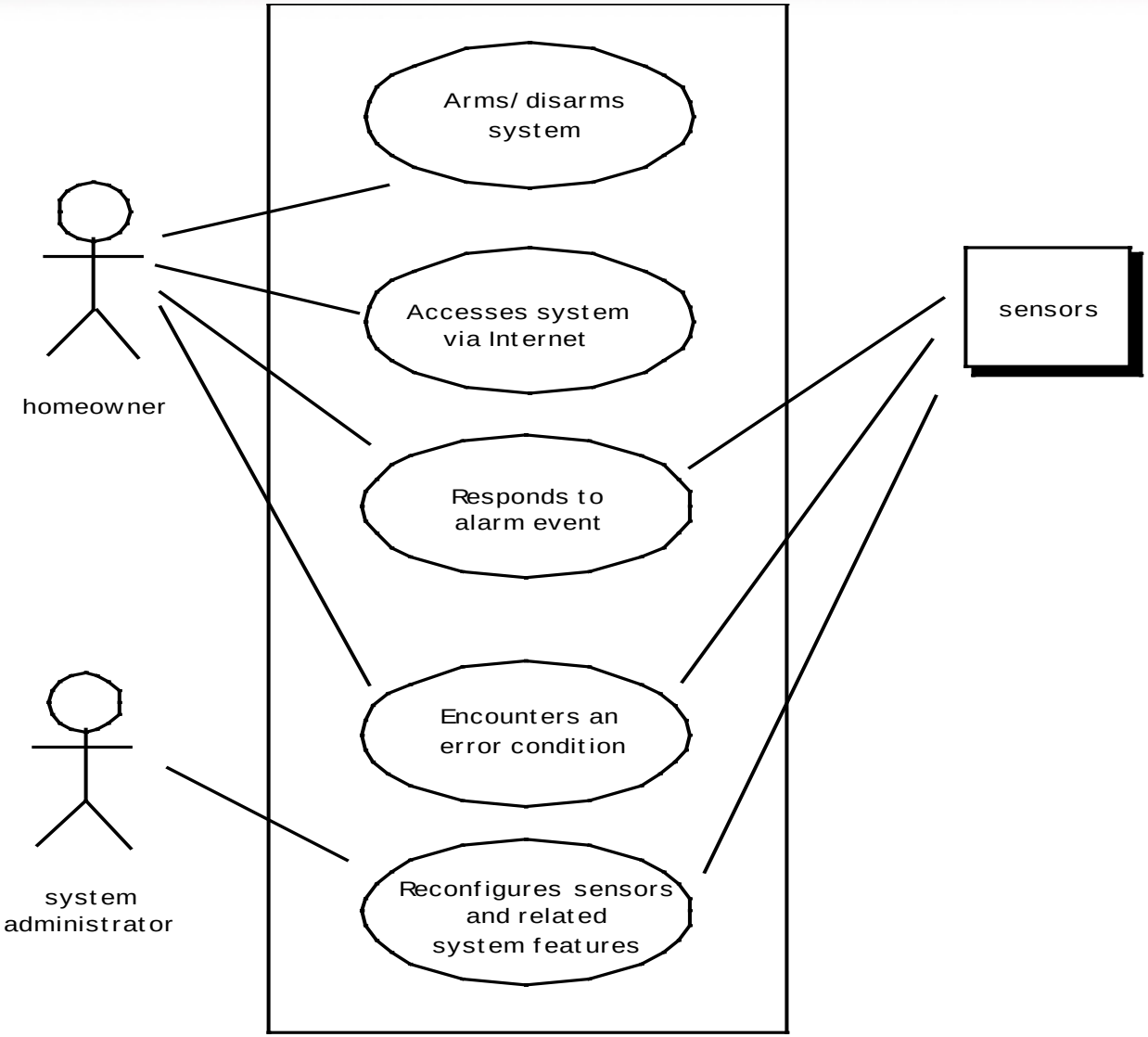
Building the Analysis Model

- 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

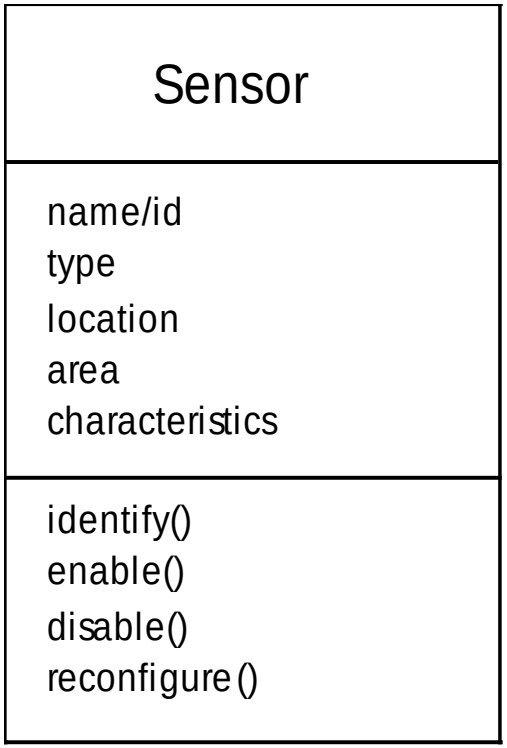
- A collection of user scenarios that describe the thread of usage of a system
- Each scenario is described from the point-of-view of an “actor”—a person or device that interacts with the software in some way
- Each scenario answers the following questions:
  - Who is the primary actor, the secondary 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?

Use-Case Diagram

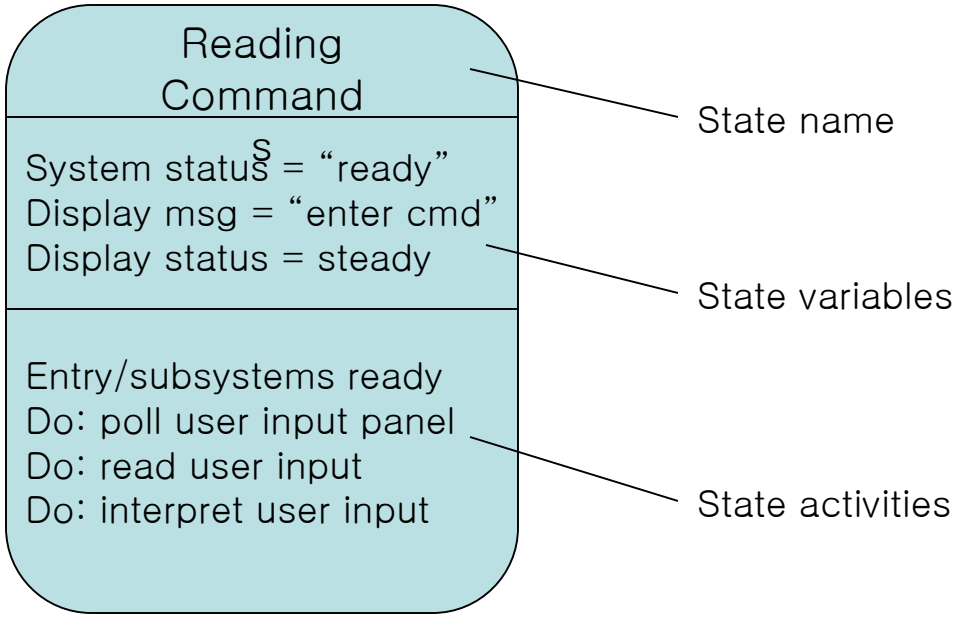


Class Diagram

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"

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?

Q & A