ICS 52: Introduction to Software Engineering

Fall Quarter 2001

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Lecture Notes

Week 2: Requirements Engineering

http://www.ics.uci.edu/~taylor/ics52_fq01/syllabus.html

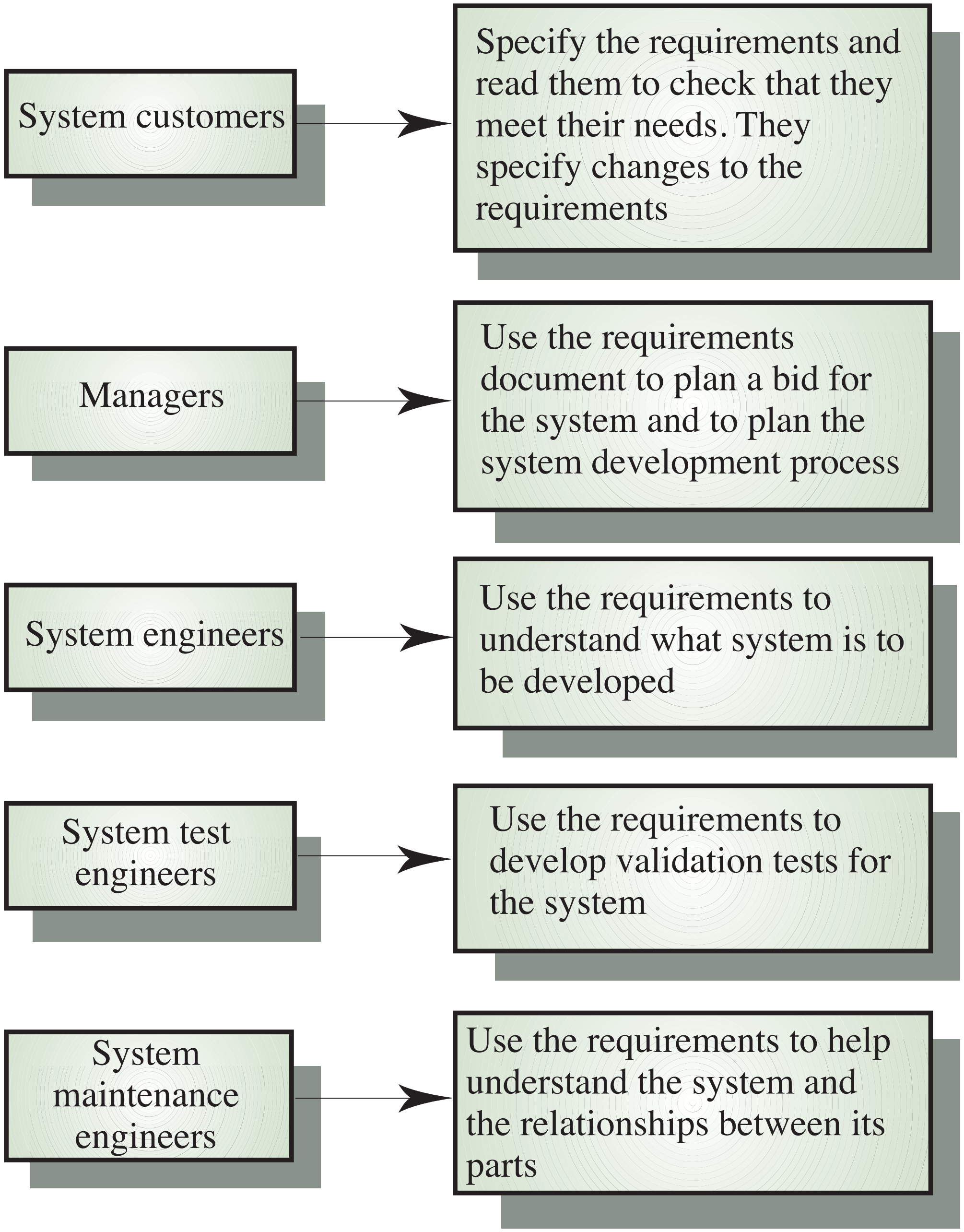
Requirements Engineering (the Activity)

- System engineering v. software engineering
  - What role does software play within the full solution?
- Contract model v. participatory design
  - Contract: carefully specify requirements, then contract out the development
  - Participatory: ultimate users, users' agents, and software engineers work together throughout development

Requirements Specification (the Document)

- Purpose
  - Serve as the fundamental reference point between builder and buyer/"consumer " (contract)
  - Define capabilities to be provided, without saying how they should be provided
  - Define constraints on the software
    - e.g. performance, platforms, language
- Characteristics
  - Unambiguous
    - Requires precise, well-defined notations
  - Complete: any system that satisfies it is acceptable
  - Consistent
    - There should be no conflicts or contradictions in the descriptions of the system facilities
  - Verifiable (testable)
  - No implementation bias (external properties only)
    - "One model, many realizations"

Users of a requirements document



System customers → Specify the requirements and read them to check that they meet their needs. They specify changes to the requirements

Managers → Use the requirements document to plan a bid for the system and to plan the system development process

System engineers → Use the requirements to understand what system is to be developed

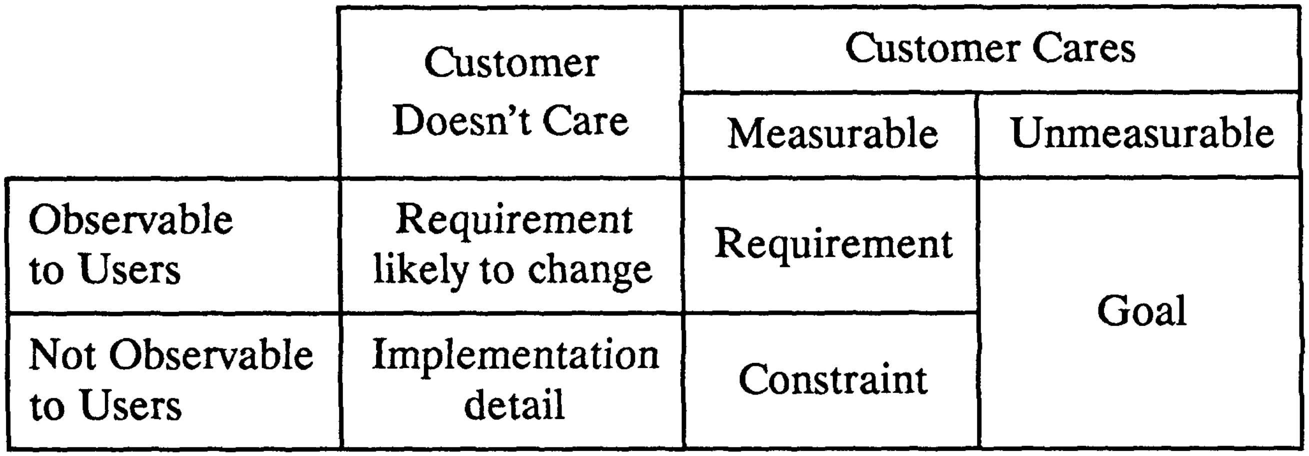
System test engineers → Use the requirements to develop validation tests for the system

System maintenance engineers → Use the requirements to help understand the system and the relationships between its parts

Lifecycle Considerations

- Serve as basis for future contracts
- Reduce future modification costs
  - Identify items likely to change
  - Identify fundamental assumptions
- Structure document to make future changes easy
  - e.g. have a single location where all concepts are defined

Requirements Volatility



	Customer Doesn’t Care	Customer Cares	
		Measurable	Unmeasurable
Observable to Users	Requirement likely to change	Requirement	Goal
Not Observable to Users	Implementation detail	Constraint	

Figure 4–1: Matrix of Requirements Terminology

Source: David Alex Lamb, Software Engineering, Planning for Change
Prentice Hall, 1988

Content of a Requirements Specification

- Application context
  - Describe the situations in which the software will be used. How will the situation change as a result of introducing the software system?
  - Identify all things (objects, processes, other software, hardware, people) that the system may, or will, affect.
  - Develop an abstraction for each of those things, characterizing their properties/behavior which are relevant to the software system. ("World model.")
  - How might this context change?

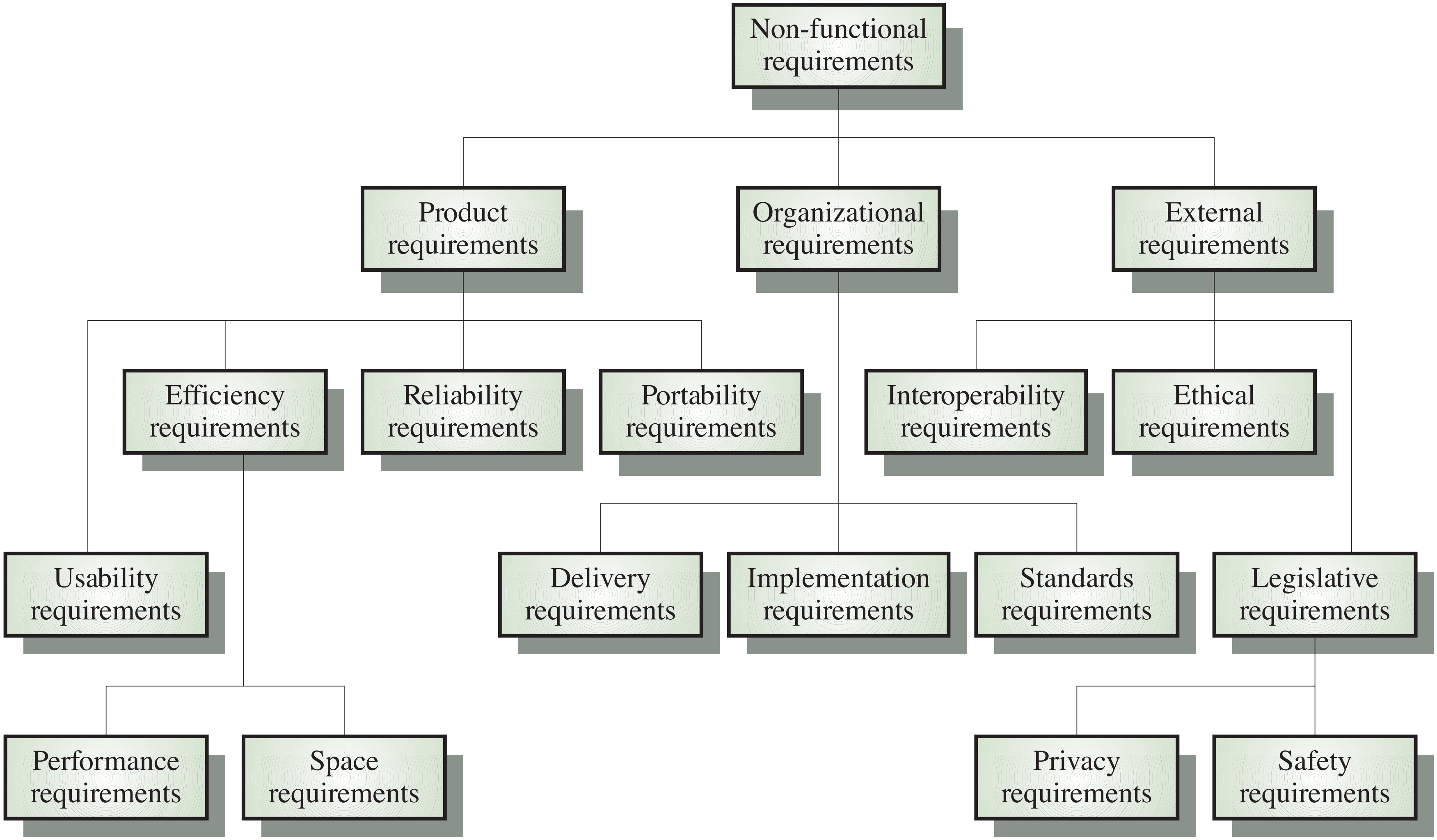
“Object-oriented analysis”

- Functional requirements ("features")
  - Identify all concepts (objects) that the system provides to the users.
  - Develop an abstraction for each of those concepts, characterizing their properties and functions which are relevant to the user.
    - » What is the system supposed to do?
    - » What is supposed to happen when something goes wrong?

Contents of a Requirements Specification, cont..

- Performance requirements: speed, space
- Environmental requirements: platform, language, ...
- Subsets/supersets
- Expected changes and fundamental assumptions
- Definitions; reference documents

Non-functional requirement types



World Model (OOA) versus Simple Input/Output Characterizations as Reqt.s Specs

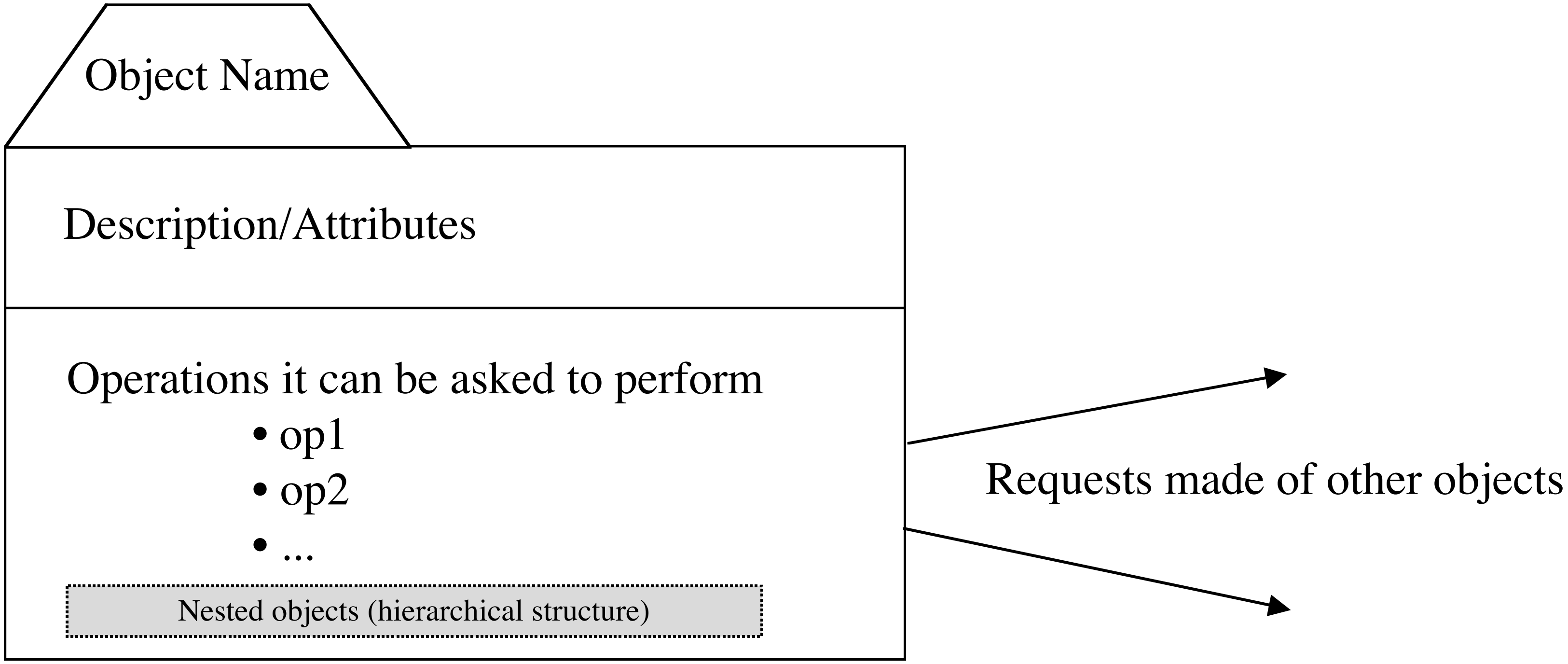
- The application context may change because of extrinsic factors
- The software system modifies the usage context

- I/O is only meaningful in a specific context
- "Input" and "output" may not be simple concepts
  - Cruise control systems: many sensors, complex conditions, and timing constraints only understandable in the application context

Techniques for Requirements Analysis

- Conduct interviews
- Build and evaluate prototypes
- Construct glossaries
- Separate concerns
- Focus on structure
  - Abstraction and hierarchical decomposition
- Use precise notation (be careful with diagrams!)
- Ask yourself:
  - Is it testable? Complete? Consistent?

Canonical Diagram for Requirements Objects



Object Name

Description/Attributes

Operations it can be asked to perform

- op1
- op2
- ...

Nested objects (hierarchical structure)

Requests made of other objects

Note: this will not be the appropriate notation for all application contexts!

Mailing List Manager

Mailing Address

A place where mail can be delivered.
Name, Title, Street, City, State, ZipCode.

Operations:
(1) change any of the specified attributes to have a particular value.
(2) read any or all of the attributes
(3) create/delete address

Note: are the values to the “puts” or received from the “gets” strings? Only strings?

Mailing List

A list of Mailing_Address objects.
Name (of list)

Operations:
(1) Add Mailing_Address to list
(2) Delete Mailing_Address from list
(3) Sort list
(4) “Print” list

Note: What about querying the list to see if a particular address --- or part of one -- is already a member?

Note: requests between objects not shown. Neither the application context nor the customer imposes any constraints on how these objects may interact.

Storage

An indexed set of places where chunks of ASCII data can be stored. Number of indices, size of data currently stored in each index

Operations:
(1) Fetch data at index
(2) Store data at index

Mailing List Set Ops

Supports manipulation of multiple mailing lists.

Operations:
(1) Union of two lists
(2) Intersection of two lists
(3) Subtraction of one list from another

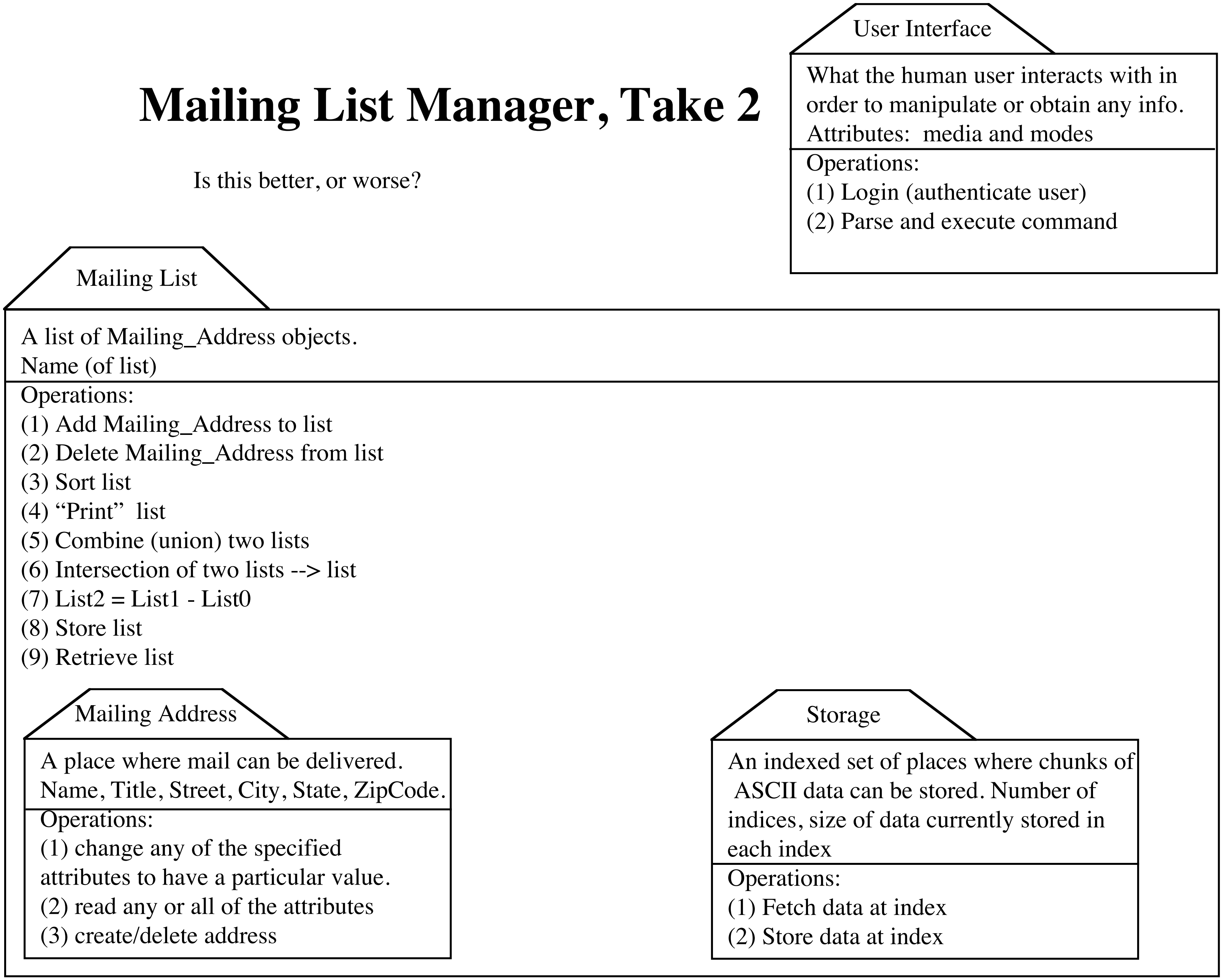
User Interface

What the human user interacts with in order to manipulate or obtain any info.
Attributes: media and modes

Operations:
(1) Login (authenticate user)
(2) Parse and execute command

Mailing List Manager, Take 2

Is this better, or worse?



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(4) “Print” list
(5) Combine (union) two lists
(6) Intersection of two lists --> list
(7) List2 = List1 - List0
(8) Store list
(9) Retrieve list

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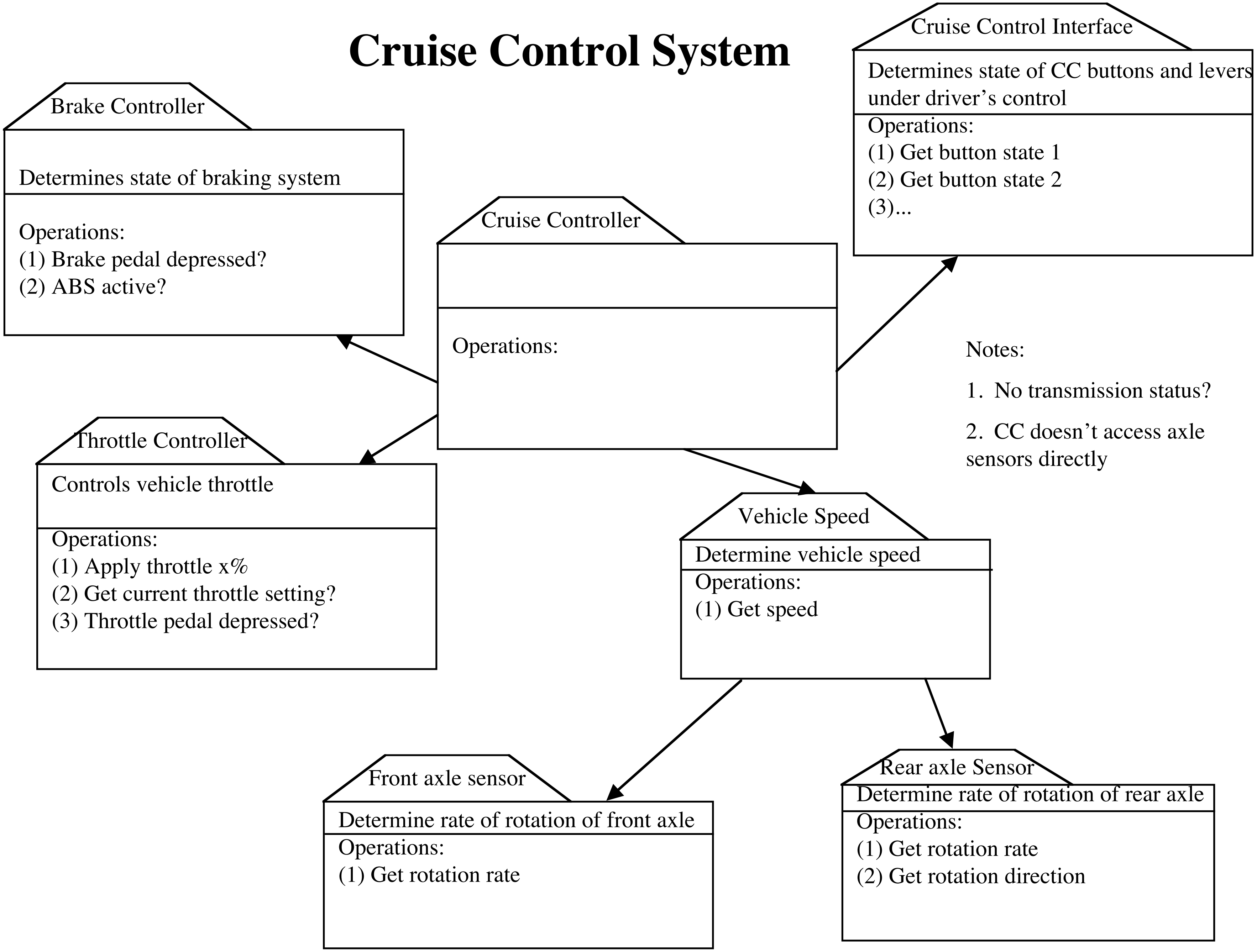
Cruise Control System



Brake Controller

Determines state of braking system

Operations:
(1) Brake pedal depressed?
(2) ABS active?

Cruise Controller

Operations:

Cruise Control Interface

Determines state of CC buttons and levers under driver’s control

Operations:
(1) Get button state 1
(2) Get button state 2
(3)...

Throttle Controller

Controls vehicle throttle

Operations:
(1) Apply throttle x%
(2) Get current throttle setting?
(3) Throttle pedal depressed?

Vehicle Speed

Determine vehicle speed

Operations:
(1) Get speed

Front axle sensor

Determine rate of rotation of front axle

Operations:
(1) Get rotation rate

Rear axle Sensor

Determine rate of rotation of rear axle

Operations:
(1) Get rotation rate
(2) Get rotation direction

Notes:

1. No transmission status?

2. CC doesn’t access axle sensors directly

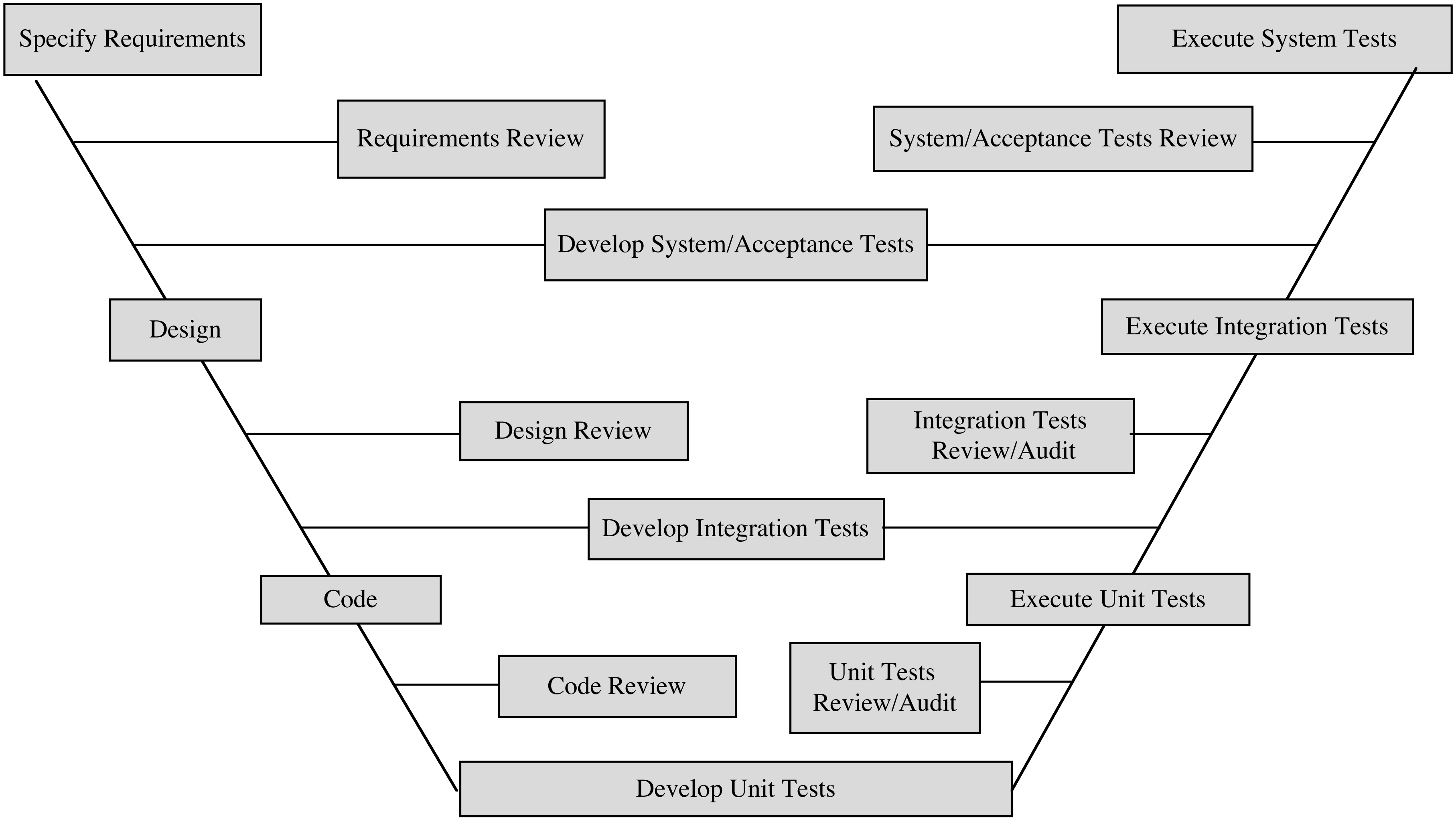
Different Circumstances, Different Techniques

- ◆Finite state machines
  - –telephony examples
  - –http://www.uclan.ac.uk/facs/destech/compute/staff/casey/integ/mscfsm.htm
- ◆Numerical systems
  - –e.g. matrix inversion package

Acceptance Test Plan

- An operational way of determining consistency between the requirements specification and the delivered system
- If the system passes the tests demanded by this plan, then the buyer has no (legal) basis for complaint
- Develop a plan for conducting test to examine
  - Functional properties
  - Performance properties
  - Adherence to constraints
  - Subsets
- Representative technique: Property/test matrix: for each test case, what properties/behaviors will be demonstrated?

V-Model of Development and Testing Activities



Incremental Development of Tests

- Acceptance test plan (and tests): develop during requirements analysis
- Integration test plan (and test): develop during system architecture and detailed design specification
- Unit test plan (and tests): develop during implementation

ICS 52 Requirements Analysis Exercise

- Develop a requirements specification and acceptance test plan for the class project
- TAs are the customer