CH04 Capturing the Requirements

- Understanding what the customers and users expect the system to do
- * The Requirements Process
- * Types of Requirements
- * Characteristics of Requirements
- * How to Express Requirements

TECH
Computer Science

Capturing the Requirements (continue)

- Additional Requirements Notations
- Prototyping Requirements
- Requirements Documentation
- Participants in the Requirements Process
- Requirements Validation
- Measuring Requirements
- Choosing a Requirements Specification Technique

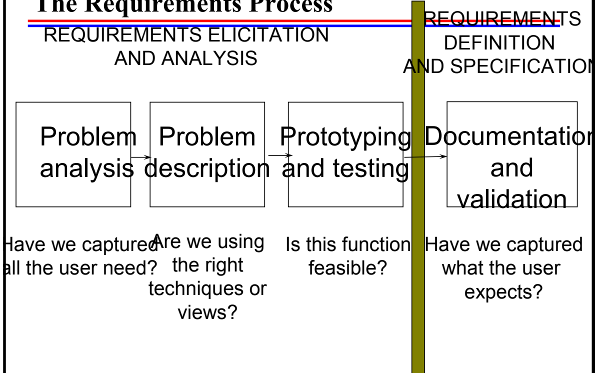
Requirements

- A **requirement** is a feature of the system or
- a description of something the system is capable of doing in order to fulfill the system's purpose.
- Three categories of requirements
  - **(1) absolutely must be met**
  - **(2) are highly desirable but not necessary**
  - **(3) are possible but could be eliminated**

Why are requirements important?

- The causes of failed projects (case study)
  - **1. Incomplete requirements (13.1%)**
  - **2. Lack of user involvement (12.4%)**
  - **3. Lack of resources (10.6%)**
  - **4. Unrealistic expectations (9.9%)**
  - **5. Lack of executive support (9.3%)**
  - **6. Changing requirements and specifications (8.7%)**
  - **7. Lack of planning (8.1%)**
  - **8. System no longer needed (7.5%)**

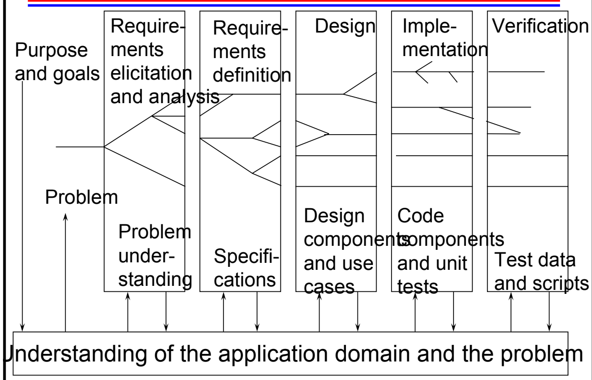
The Requirements Process



Requirements vs. Design

- requirements identify the **what** (the problem) of the system
- design identify the **how** (the solution)
- implementation-specific descriptions are not considered to be requirement unless mandated by the customer

Problem-solving and Software development



Configuration Management

- Tracing the correspondences in the development process
  - **requirements that define what the system should do**
  - **design modules that are generated from the requirements**
  - **program code that implements the design**
  - **tests that verify the functionality of the system**
  - **the documents that describe the system**

Functional and Nonfunctional Requirements

- A functional requirement describes an interaction between the system and its environment.
- A nonfunctional requirement or constraint describes a restriction on the system that limits our choices for constructing a solution to the problem.

Requirements Documents

- Requirements definition is a complete listing of everything the customer expects the proposed system to do.
- Requirements specification restates the requirements definition in technical terms appropriate for the development of a system design.
- Formal requirements elicitation, using the same language and the same meanings

Making Requirements Testable

- Specify a quantitative description for each adverb and adjective so that the meaning of qualifiers is clear and unambiguous.
- Replace pronouns with specific names of entities.
- Make sure that every noun is defined in exactly one place in the requirements documents.

Types of Requirements

- **Physical Environment**
- **Interfaces**
- **Users and Human Factors**
- **Functionality**
- **Documentation**
- **Data**
- **Resources**
- **Security**
- **Quality Assurance**

Activities to find out what the customer wants:

- review the current situation
- apprentice with the user to understand context problems and relationships
- make a video to show how the new system might work
- dig through existing documents
- brainstorm with current and potential users
- observe structures and patterns

Characteristics of Requirements

- Check the requirements to insure
  - **correct**
  - **consistent**
  - **complete**
  - **realistic**
  - **needed**
  - **verifiable**
  - **traceable**

Checking for Completeness and Consistency

- Truth Table
  - **e.g. binary variable A, B,**
  - **define And function F**
  - **All cases**
  - **<u>A, B, F</u>**
  - **0, 0, 0**
  - **0, 1, 0**
  - **1, 0, 0**
  - **1, 1, 1**

How to Express Requirements

- Use formal notation to describe the system to be built
- Static Descriptions
  - **specify objects and their relationships with each other**
- Dynamic Descriptions
  - **specify states and transitions between states over time**

Static Descriptions

- Indirect Reference
- Recurrence Relations
- Axiomatic Definition
- Expression as a Language
- Data Abstraction

Indirect Reference

- implied but not stated directly
- Pointing to pointer, e.g.
  - **A points to P**
  - **where P is a pointer to something**

Recurrence Relations

- an initial condition is defined
- the transformation from one condition to the next is expressed in terms of previously defined conditions
- Fibonacci numbers e.g.
  - **F(0) = 1**
  - **F(1) = 1**
  - **F(n+1) = F(n) + F(n-1)   for n = 1, 2, 3, ...**

Axiomatic Definition

- Axiom
  - **a set of objects**
  - **a set of operations**
- Generate Theorems
  - **use axiom to generate more objects**
- Prove Theorems
  - **reduce (trace) a theorem down to axiom**

Expression as a Language

- Use formal languages
- Backus-Naur form, e.g.
  - **ASCII characters**
  - **<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9**
  - **<addop> ::= + | -**

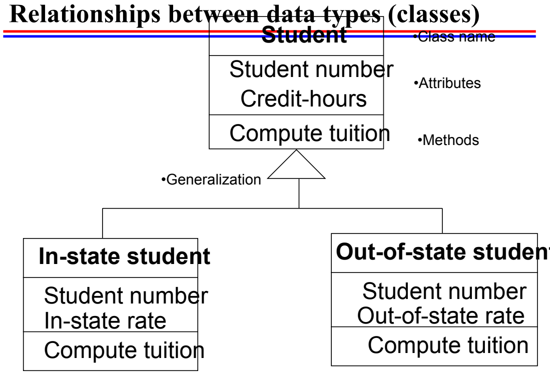
Data Abstraction

- Data manipulated by a system determine the kinds of actions taken
- Data abstraction is a technique to describing what data are for.
- To categorize data (objects) and group like elements together forming data types (class)
- Each object is then considered to be an instance of the class to which it belongs.

Methods

- actions permissible with the data and data types
- methods manipulate the data:
- **states** in which the data can be,
- **operations** to establish new states
- **probes** to report information about state

Relationships between data types (classes)



Dynamic Descriptions

- Decision Tables
- Functional Descriptions and Transition Diagrams
- Event Tables
- Petri Nets
- Object-oriented specification

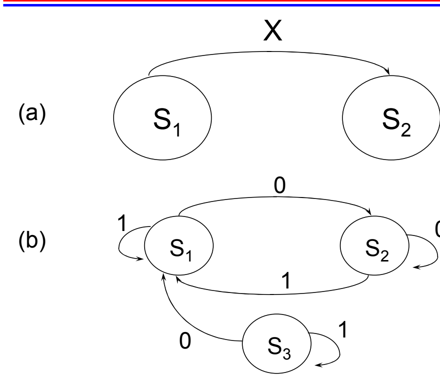
Decision Tables

- a set of possible conditions at a given time
- rules for reacting when certain conditions met
- actions to be taken
- e.g. Rule 1
  - **High standardized exam scores** **T**
  - **High grades** *
  - **A: Send admission forms** =

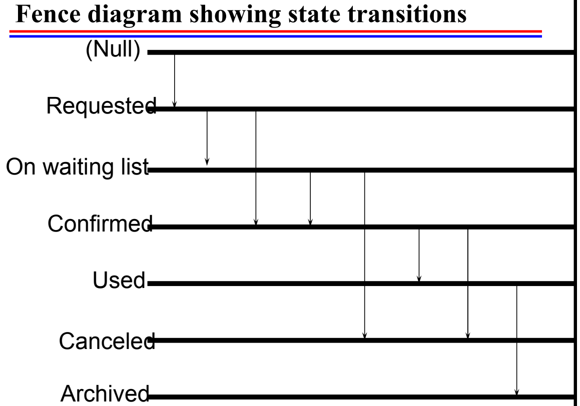
Functional Descriptions and Transition Diagrams

- A set of states, S
- A initial state, s0
- A set of inputs, I
- A state transition function, F
- A output function, H

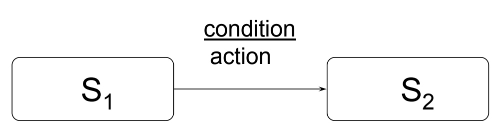
Transition among States



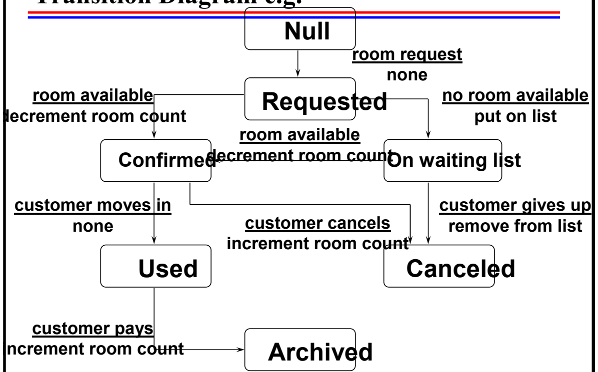
Fence diagram showing state transitions



I/O or Condition/action



Transition Diagram e.g.



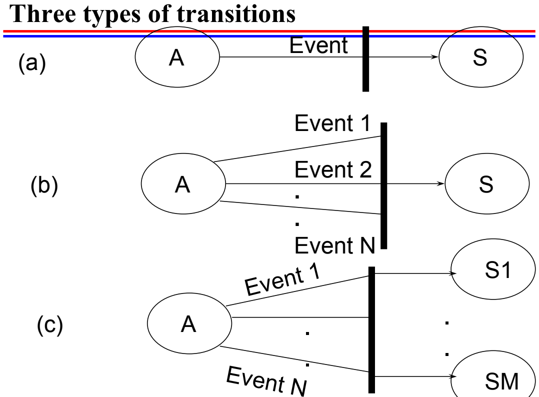
Event Tables (State Tables)

- Tabulate state transitions
- input
- State 0 1
- s0 s1, a1 s0, a0
- s1 s0, a0 s1, a0

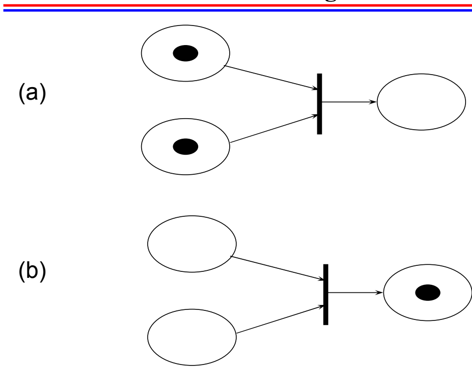
Petri Nets

- describe parallel processing
- describe synchronization
- **tokens**: each state is associated with a set of tokens
- **firing rules**: each firing rule expresses how tokens are associated with a state;
  when the correct number and type of tokens are present in one state, tokens are released to travel to another state.

Three types of transitions



Tokens associated with firing rules



Object-oriented specification

- focuses on the entities involved rather than on input/output transformation.
- Extending data-abstraction to ask
  - **What data structures define an entity?**
  - **How does an entity's state evolve over time?**
  - **What aspects of entities are persistent over time?**

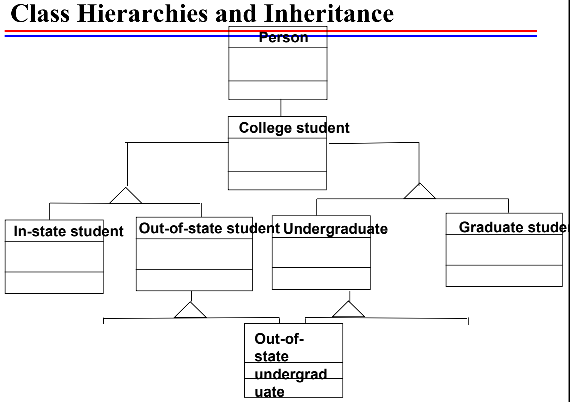
Object and Method

- Each entity in the system is an **object**.
- A **method** is an action that either can be performed by the object or can happen to the object.
- Only the methods of an object can change the state of the object.
- A method can be invoked only by sending the object a message.
- Encapsulation, Class Hierarchies, Inheritance, and Polymorphism.

Encapsulation

- forming a protective boundary
- one object has no access to internal representation of other objects
- objects “talk” to other objects by message

Class Hierarchies and Inheritance



Polymorphism //

- A method is polymorphic if it is defined for more than one object.
- One method for computing area, e.g.
  - **for triangle objects**
  - **for circle objects**

Additional Requirements Notations

- Hierarchical Techniques
- Data Flow Diagrams
- Software Requirements Engineering Methodology
- Structured Analysis and Design Technique
- Z

Hierarchical Techniques

Available pharmace -ticals

Non-prescription products

⊕

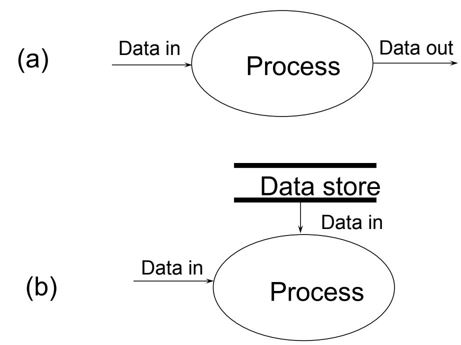
Products requiring a prescriptio

Barbiturates (n_1)
Narcotics
Steroids (n_3)
Other

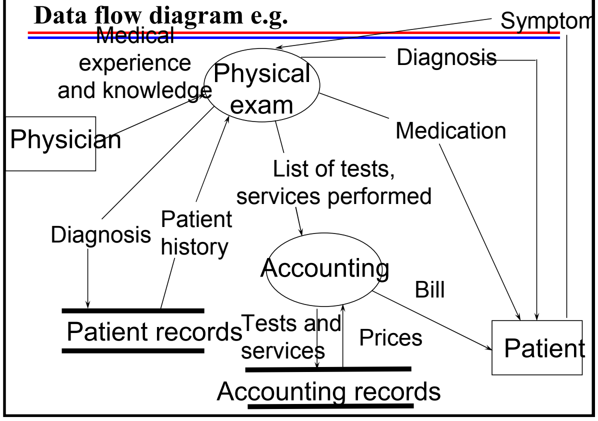
Data Flow Diagrams

- considering the system as a transformer of data
  - **how data flow into the system,**
  - **how they are transformed, and**
  - **how they leave the system**
- **data store** is a database
- An **actor** is an entity that provides or receives data

Symbols in data flow diagrams



Data flow diagram e.g.



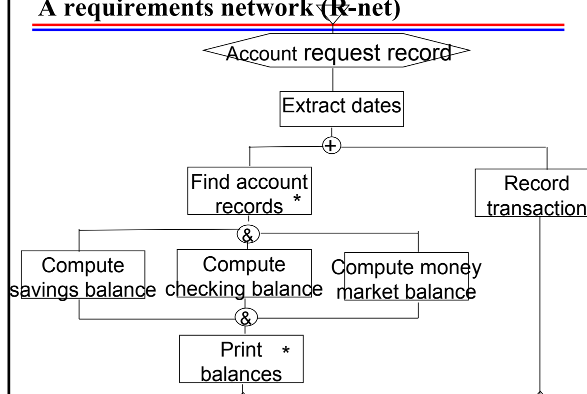
Software Requirements Engineering Methodology

- views the system as a finite-state machine
- writing requirements using a Requirements Statement Language
  - **describes the flow of processing in terms of what events initiate which processes**
- analyzing the requirements using Requirements Engineering Validation System
  - **produces variety of reports, simulates the critical processing of the system**

Requirements Statement Language

- first uses a flow-chart type graph called R-net to
  - **(plus) indicates a condition for branch**
  - **(ampersand) indicates parallel processing in any order**
  - **(triangles) indicates points of synchronization**
  - **(validation point*) indicates a point for taking measurement**
- next translate the components of R-net into statements

A requirements network (R-net)



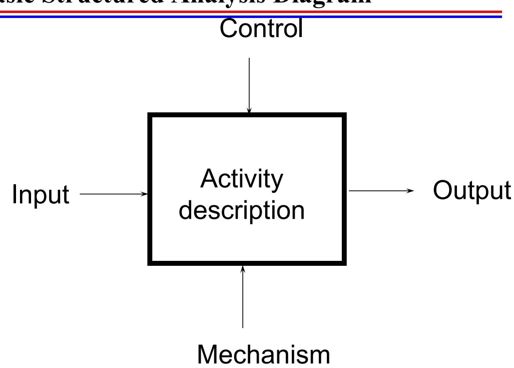
Requirements Engineering Validation System

- simulates the processing of the system
- depicts flow of data with a graphics package
- produces variety of reports

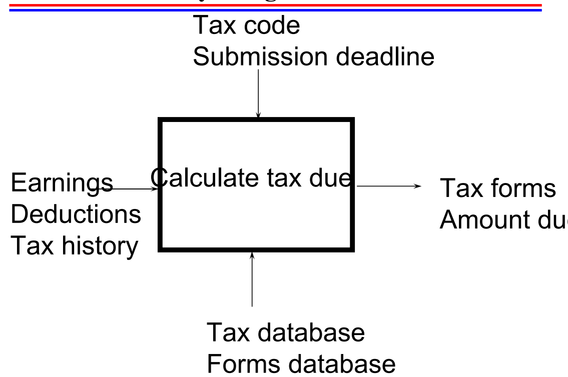
Structured Analysis and Design Technique

- Structured Analysis represents a system with an ordered set of diagrams
  - **each diagram represents a transformation, and at most six diagrams are used to describe a function**
- Design Technique explains how to interpret the diagrams

Basic Structured Analysis Diagram



Structured Analysis e.g.



Structured Analysis hierarchy

- high-level diagram is rewritten as several lower-level diagrams
- boxes within boxes (sub-boxes)
- forming a hierarchy of activities that describe all the steps our system is required to take

Z formal specification languages

- express requirements in a mathematical way
- evaluate using proofs and automated techniques
- provides a notation (its syntactic domain)
- provides a universe of objects (its semantic domain)
- provides a precise rule defining which objects satisfy each specification

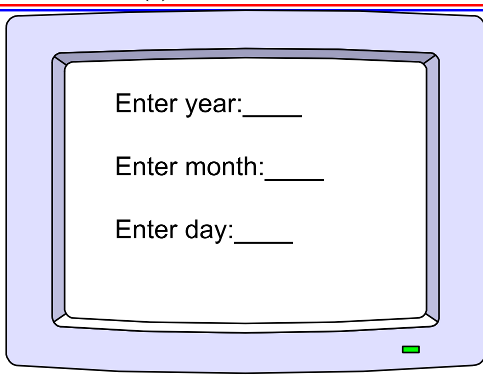
Z “Zed” language

- combines abstract data modeling with set theory, and first-order predicate logic
- used to specify system states and valid state changes
- automated tools
  - **check for incompleteness and inconsistency**
  - **find reachable states**
  - **check for deadlocks and non-determinism**
  - **generate a finite-state machine that implements the specification**

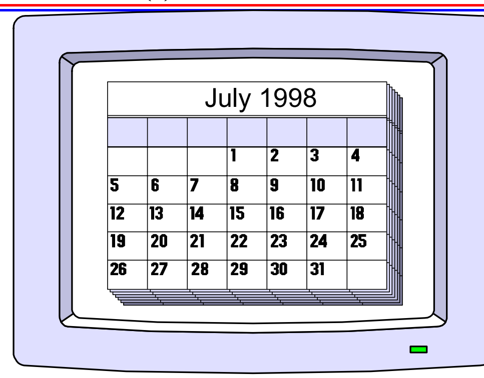
Prototyping Requirements

- **Rapid prototyping**: build sections (small piece)(usually user interface) of the proposed system to determine the necessity, desirability, or feasibility of requirements.
- throw-away, or evolutionary
- “Look and feel” of user interface.

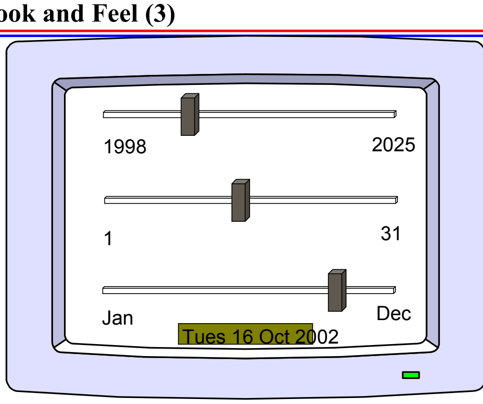
Look and Feel (1)



Look and Feel (2)



Look and Feel (3)



Requirements Documentation

- A complete listing of everything the customer expects the proposed system to do.
- Numbering each requirement, allows cross-reference, and tracking
- Requirements Definition Document
- Requirements Specification Document

Requirements Definition Document

- Record of requirements in the customer's terms
  - **1. Outline the general purpose of the system.**
  - **2. Describe the background and objectives of system development.**
  - **3. Outline approach (in general)**
  - **4. Define detailed characteristics of the proposed system, define system boundary and interfaces.**
  - **5. Discuss the environment in which the system will operate, e.g. hardware.**

Guideline for writing requirements

- Number each requirement
- Each clause should contain only one requirement.
- Avoid having one requirement refer to another requirement
- Collect like requirements together
- Testable
- Consult standards from IEEE

Requirements Specification Document//

- written from the developer's perspective
- may use technique notations

Participants in the Requirements Process

- Contract monitors
- Customers and users
- Business managers
- Designers
- Testers

Requirements Validation

- Provides a way for customers and developers to agree on what it is the system is to do.
- Manual techniques
  - **Reading, Manual cross-referencing,**
  - **Interviews, Reviews, Checklists**
  - **Manual Models to check functions and relationships**
  - **Mathematical proofs**
- Automated Techniques

Measuring Requirements

- number of changes to requirements
- rate each requirements on a scale,
  by designers, by testers

Choosing a Requirements Specification Technique

- No one approach is universally applicable to all systems
- May be necessary in some cases to combine several approaches to define the requirements completely.
- Master some tools and use them when the time is right!